Installation

Marine Generator Sets

Models:

40-180EOZD
33-150EFOZD

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER® POWER SYSTEMS

TP-6513 9/07

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

WARNING

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

CAUTION

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

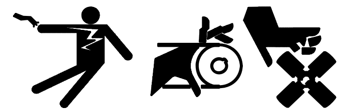
NOTICE

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

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

Accidental Starting

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 connected equipment, 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.

Engine Backfire/Flash Fire

WARNING

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.

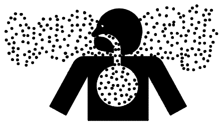
Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner/silencer removed.

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 severe injury or death.

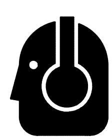
Use extreme care when handling, storing, and using fuels.

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

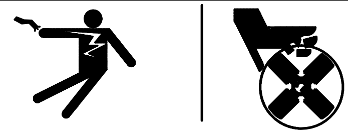


Hazardous noise.
Can cause hearing loss.

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

Hazardous Voltage/ Moving Parts

WARNING



Hazardous voltage. Moving parts.
Can 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 can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

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

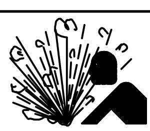
Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

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

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

Hot Parts

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.

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

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.

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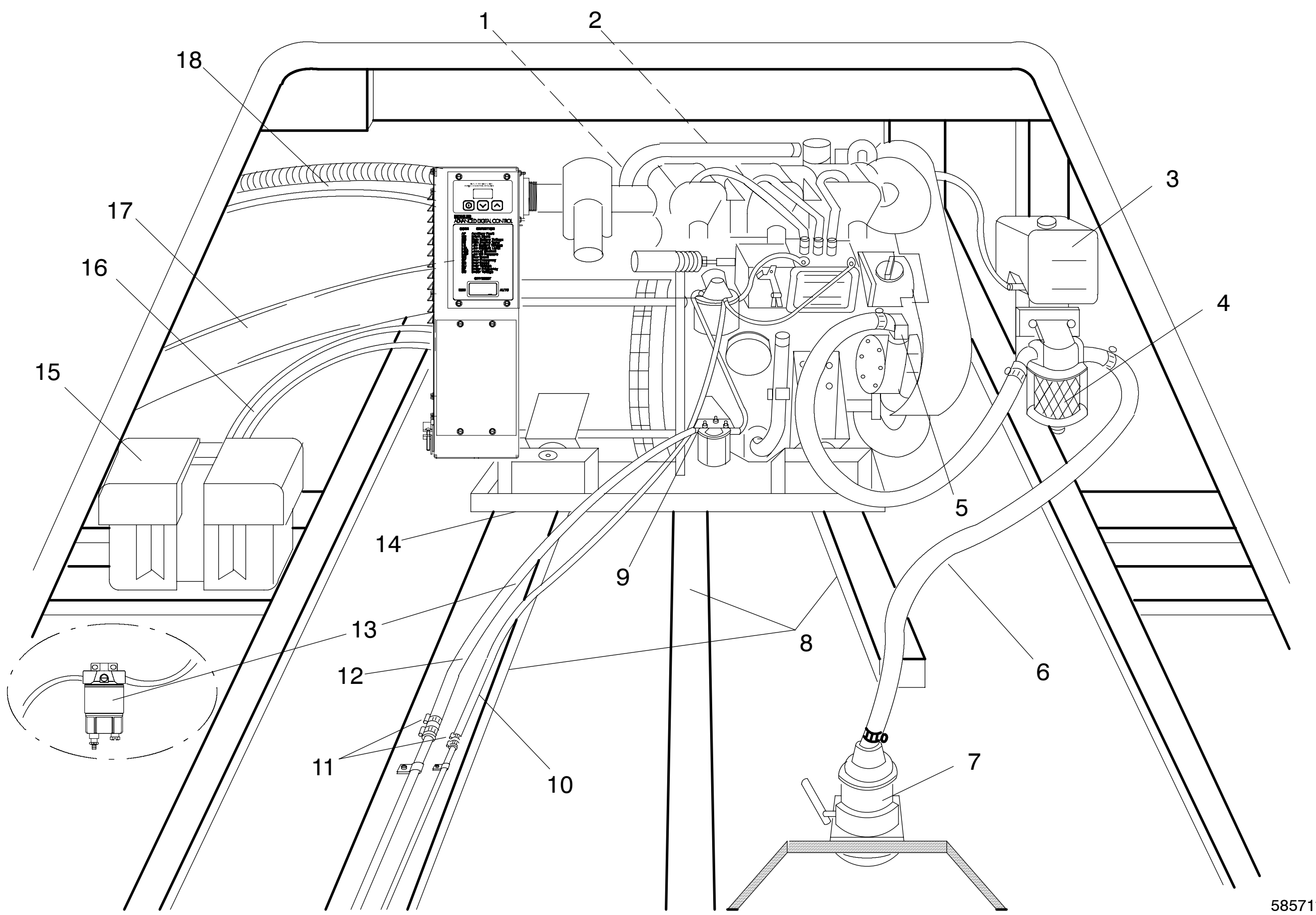
The safe and successful operation of a marine power system depends primarily on the installation. See Figure 1-1. Use this manual as a guide to install the marine generator set. For operating instructions, refer to the operation manual.

Note: Only qualified persons should install the generator set.

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

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



1. Exhaust mixer elbow (exhaust/water outlet) (not shown)
2. Heat exchanger (not shown)
3. Coolant recovery tank (located on the unit on some models)
4. Seawater strainer *
5. Seawater pump (seawater inlet)
6. Seawater line *
7. Seacock *
8. Craft stringers
9. Fuel feed pump (fuel inlet) *
10. Fuel return line *
11. Hose clamps
12. Fuel supply line *
13. Fuel/water separator (see Section 5 for more information)
14. Mounting tray (mounting skid on 33-150 kW models)
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.

Notes

2.1 General Considerations

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

Installation Location Considerations

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

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

2.2 Location

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

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.

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.

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

2.3 Mounting

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

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

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

For angular operating limits, consult the operation manual.

Notes

3.1 Ventilation

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

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

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

See the generator set specification sheet that shipped with the generator set for air requirements. The air intake silencer/cleaner provides combustion air to the engine. Do not compromise the recommended minimum clearance 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
40-180EOZD 33-150EFOZD	635 mm H_2O (6.23 kPa) or less

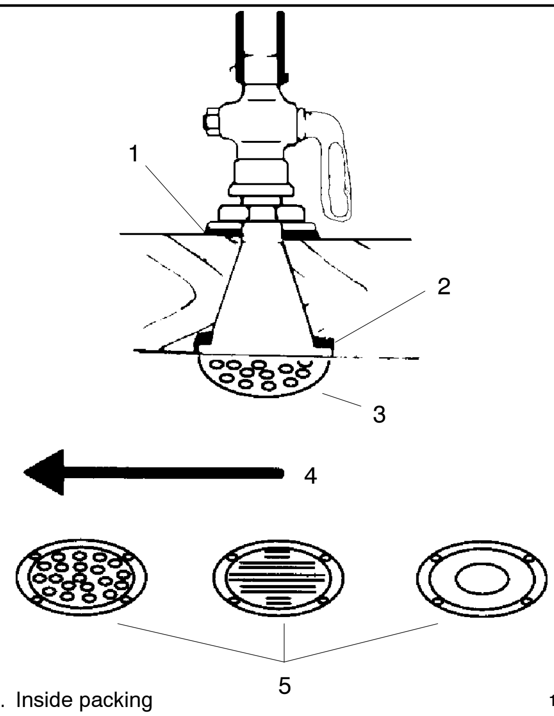
Figure 3-1 Combustion Air Intake Restriction

3.2 Cooling System Components

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

3.2.1 Intake Through-Hull Strainer (Seacock Cover)

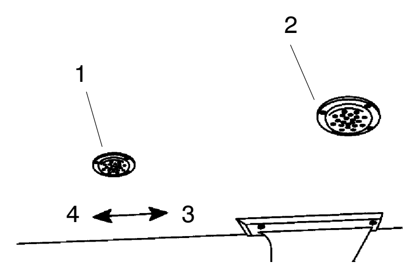
Install a screened-intake, through-hull strainer to prevent entry of foreign objects. Use perforated, slotted-hole, or unrestricted-hole design strainers. See Figure 3-2 for examples of typical strainers. The inner diameter of the strainer opening must be equal to or greater than the inner diameter of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



1. Inside packing
2. Outside packing
3. Seacock cover
4. Direction of vessel movement
5. Typical intake through-hull strainers

Figure 3-2 Seacock Installation

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



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

1-789

1. Generator set intake
2. Main engine 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 hull designs incorporating sea chests or other designs that provide a positive pressure to the raw water pump for the intake through-hull strainers. Positive pressure forces water past the raw water pump and into the engine. A sea chest is a concave molded-in-the-hull chamber that aligns to the direction of travel. A sea chest configuration applies a positive pressure similar to a scoop-type through-hull strainer.

3.2.2 Seacock

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

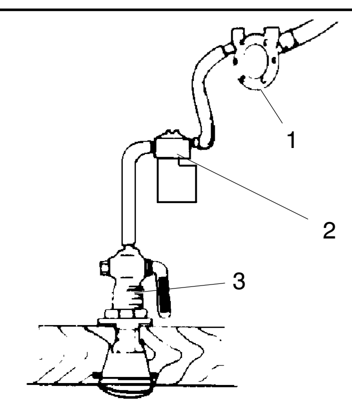
Avoid overcaulking the seacock. Excess caulk reduces water flow and, in some cases, develops a barrier that can force water upward, past the seawater pump, and into the engine cylinders when the vessel is moving and the generator set is shut down.

3.2.3 Seawater Strainer

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). Excessive pressure will cause water ingestion.



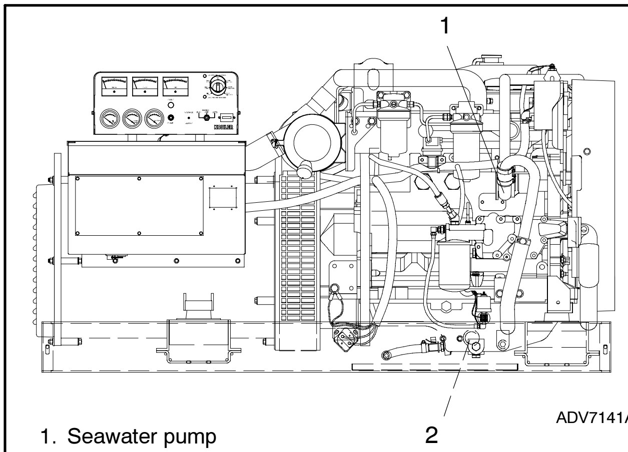
1. Seawater pump
2. Seawater strainer
3. Seacock

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 for vibrational motion of the generator set during operation. Support a nonflexible water line within 102 mm (4 in.) of its connection to the flexible section.

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

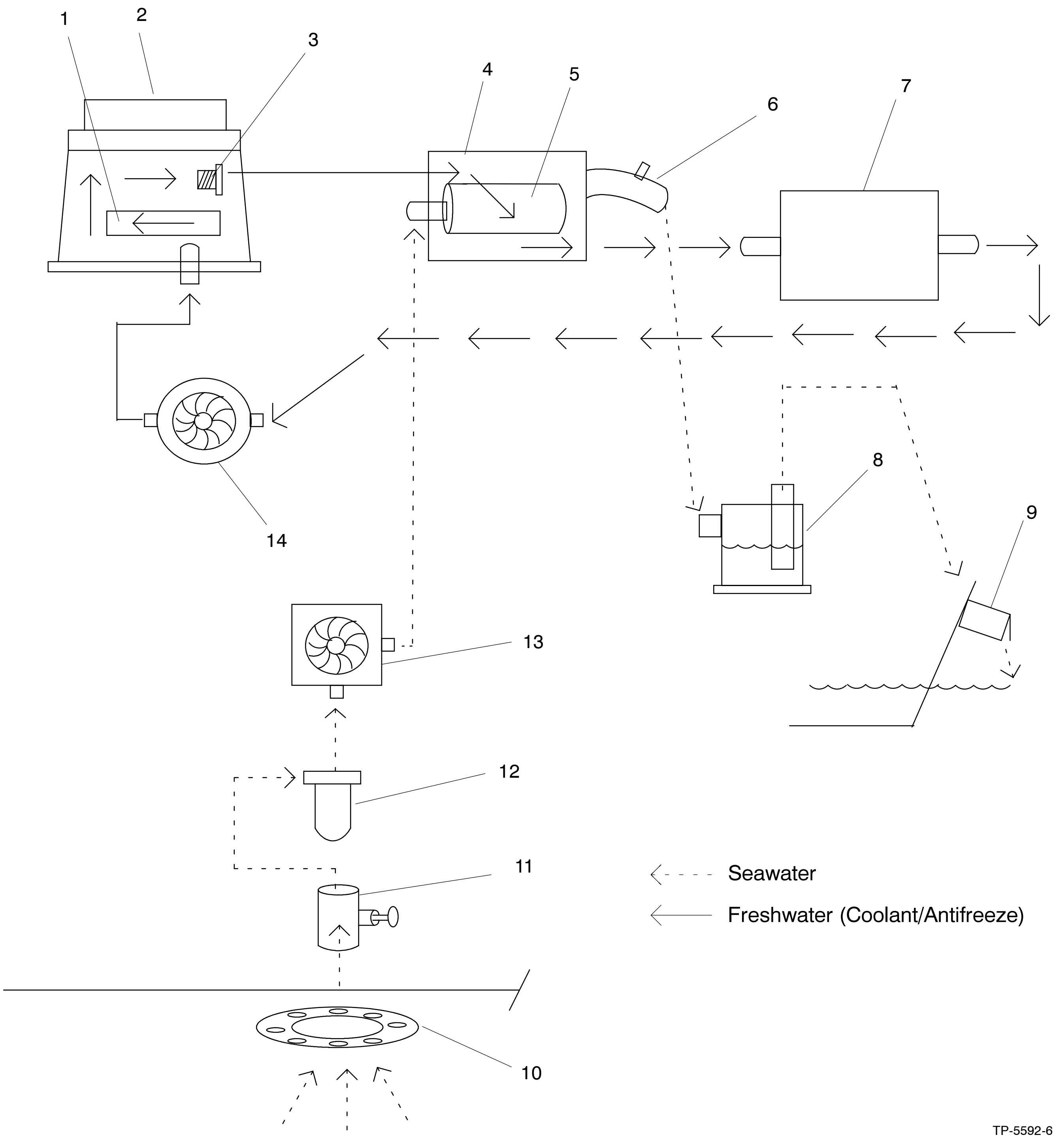


1. Seawater pump
2. Seawater inlet (opposite side)

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

3.2.5 Closed Heat Exchanger

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

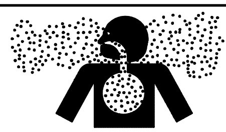


1. Oil cooler
2. Engine block
3. Thermostat
4. Water-cooled manifold
5. Heat exchanger
6. Exhaust mixer elbow
7. Water-cooled turbocharger
8. Silencer (customer-supplied)
9. Exhaust outlet
10. Intake strainer
11. Seacock
12. Seawater strainer
13. Engine-driven seawater pump
14. Engine-driven water pump

Figure 3-6 Typical Closed/Heat Exchanger Cooling System (40-180EOZD/33-150EFOZD Models)

Notes

⚠ 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.

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

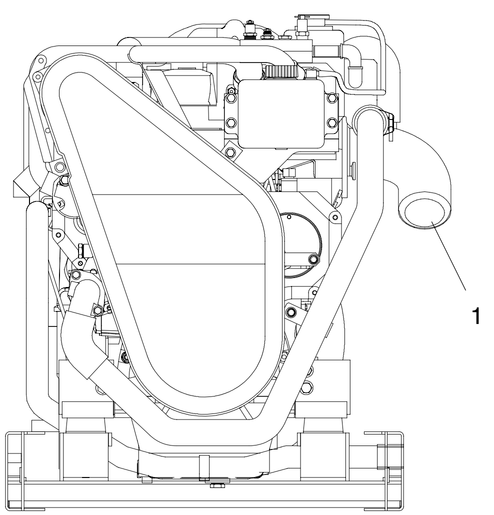
Use water-cooled exhaust lines in all marine installations. Keep the lines as short and straight as possible. NFPA 302 Fire Protection Standard for Pleasure and Commercial Motor Craft, Clause 4-3, recommends using two corrosion-resistant hose clamps with a minimum width of 13 mm (1/2 in.) on each end 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.

Engine-End View



1. Water/exhaust outlet

ADV6441

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.

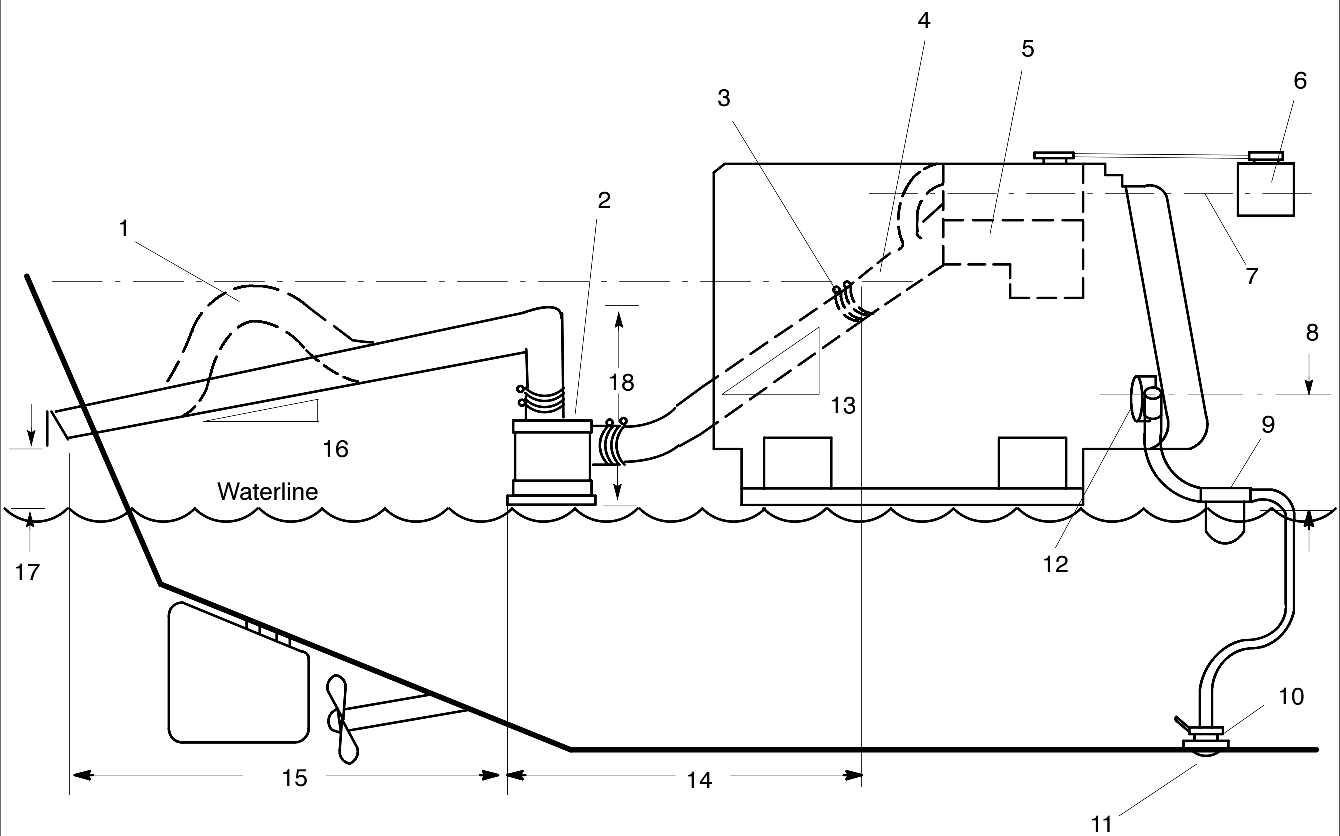
Exhaust system installation guidelines for various generator set locations follow. Information and illustrations of stern- (rear) exhaust installations also apply to side-exhaust installations. Where exhaust lines require passage through bulkheads, use port (left)- or starboard (right)- side exhaust 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 (mm H_2O)
40-180EOZD 33-150EFOZD	7.47 (762)

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. Locate the coolant recovery tank at the same height as the heat exchanger
8. Maximum seawater pump lift of 1 m (3 ft.)
9. Seawater strainer
10. Seacock
11. Intake strainer
12. Engine-driven seawater pump
13. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
14. Maximum distance between silencer and exhaust mixer elbow of 3 m (10 ft.)
15. Maximum distance between silencer and exhaust outlet of 1.5 m (5 ft.)
16. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
17. Minimum exhaust outlet distance above waterline of 10 cm (4 in.). Note: Vessel fully loaded.
18. Maximum silencer vertical lift of 1.2 m (4 ft.)

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.

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.

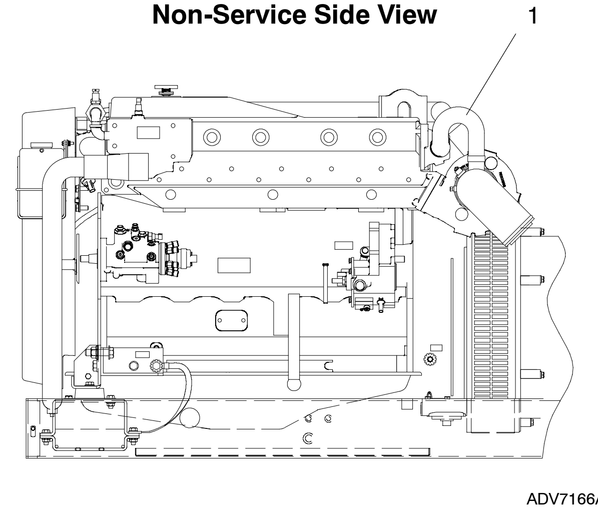
Note: An improperly installed siphon break will cause engine damage and may void the warranty.

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.

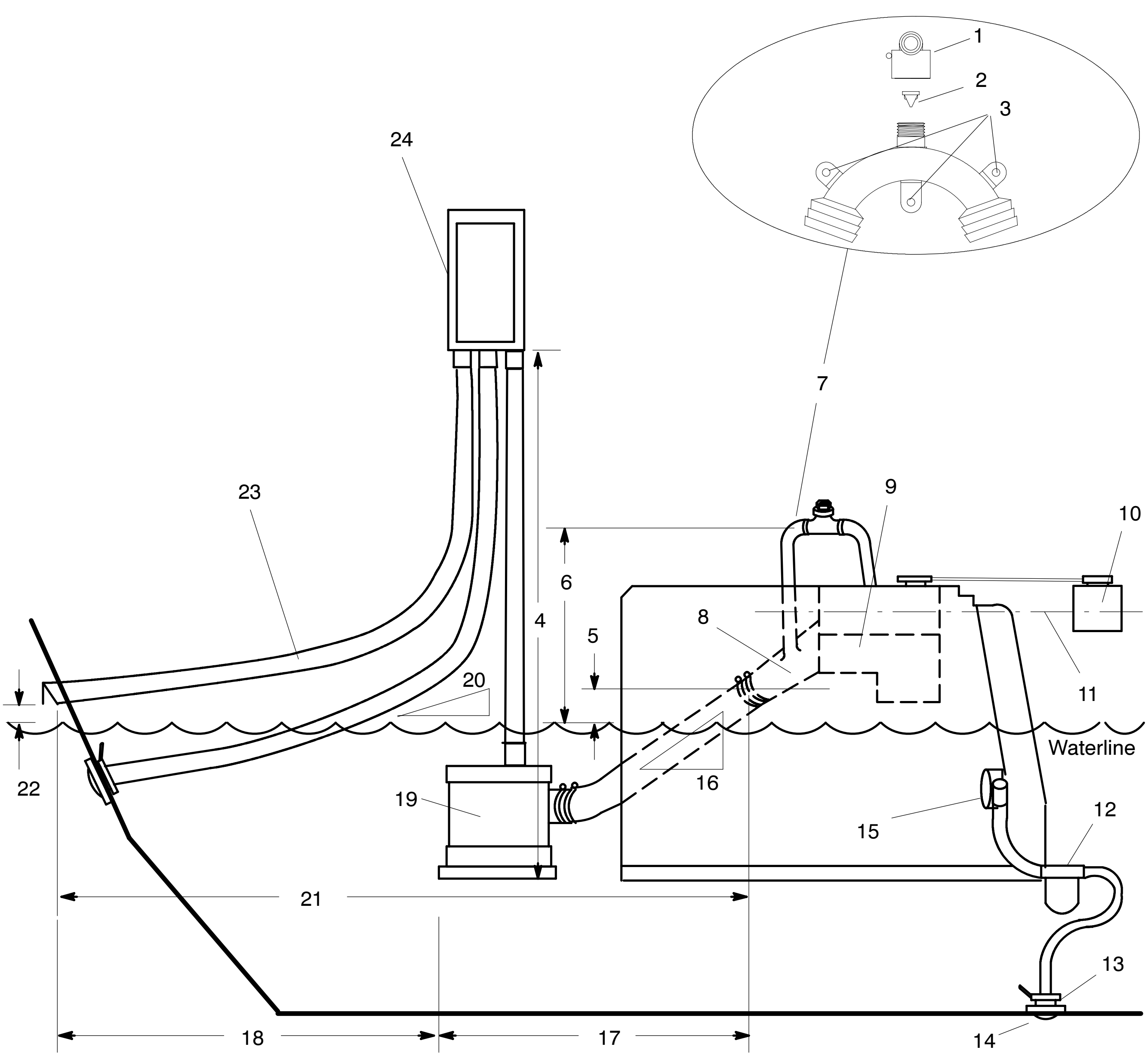
Non-Service Side View



1. Cut hose and connect siphon break and hardware

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

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



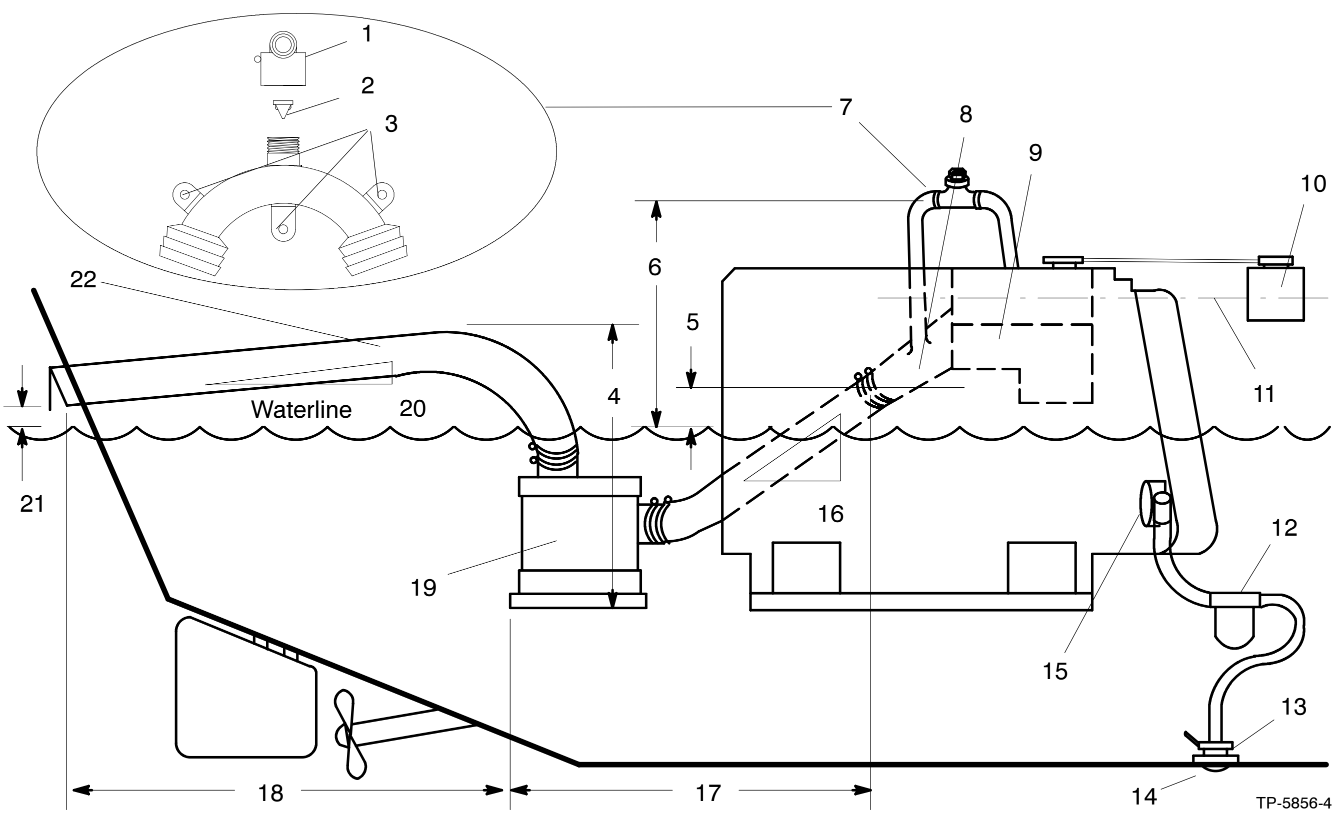
1. Cap
2. Reed valve
3. Mounting base
4. Maximum silencer vertical lift of 1.2 m (4 ft.)
5. Exhaust mixer elbow distance above waterline; if less than 23 cm (9 in.), a siphon break is required
6. Minimum siphon break distance above waterline of 30.5 cm (1 ft.)
7. Siphon break
8. Exhaust mixer elbow
9. Heat exchanger (locations vary by model)
10. Coolant recovery tank (located on the unit on some models)
11. Indicates the coolant recovery tank is at the same height as the heat exchanger
12. Seawater strainer
13. Seacock
14. Intake strainer
15. Engine-driven seawater pump
16. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
17. Maximum distance between silencer and exhaust mixer elbow of 3 m (10 ft.)
18. Maximum distance between silencer and exhaust outlet of 1.5 m (5 ft.)
19. Silencer (customer-supplied)
20. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
21. Maximum distance between exhaust outlet and generator of 4.6 m (15 ft.)
22. Minimum exhaust outlet distance above waterline of 10 cm (4 in.)
23. Exhaust hose (see Figure 4-7 for hose sizes)
24. Gas/water separator (optional). Install directly above the canister muffler.

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.

Figure 4-5 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. Indicates the coolant recovery tank is at the same height as the heat exchanger
12. Seawater strainer
13. Seacock
14. Intake strainer
15. Engine-driven seawater pump
16. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
17. Maximum distance between silencer and exhaust mixer elbow of 3 m (10 ft.)
18. Maximum distance between silencer and exhaust outlet of 1.5 m (5 ft.)
19. Silencer (customer-supplied)
20. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
21. Minimum exhaust outlet distance above waterline of 10 cm (4 in.)
22. Exhaust hose (see Figure 4-7 for 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.

Figure 4-6 Typical Mid- and Below-Waterline Installation

Models without Sound Shield	Models with Sound Shield	Exhaust Hose Diameter mm (in.)
40EOZD 33EFOZD	40EOZD 33EFOZD	89 (3.5)
50/65/80/99EOZD 40/50/70/80EFOZD	50/65/80/99EOZD 40/50/70/80EFOZD	102 (4.0)
125/150/180EOZD 100/125/150EFOZD	125/150/180EOZD 100/125/150EFOZD	127 (5.0)

Figure 4-7 Exhaust Hose Sizes

WARNING

Explosive fuel vapors.
Can cause severe injury or death.

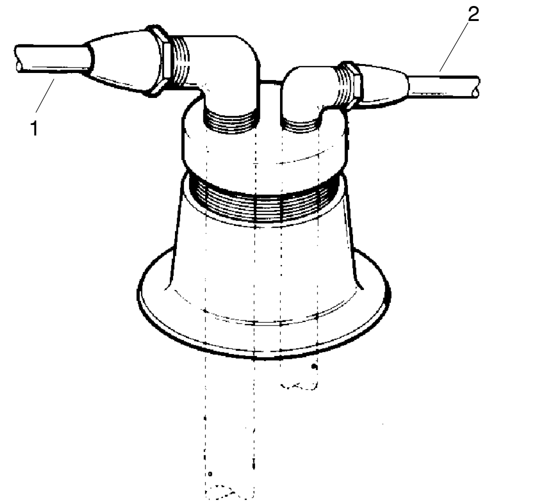
Use extreme care when handling, storing, and using fuels.

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

Note: Fuel system installations must conform to USCG regulations.

5.1 Fuel Tank

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



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

Figure 5-1 Multiple Dip Tube Arrangement

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5.2 Fuel Lines

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

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

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

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

Model	Fuel Line ID Size mm (in.)
40-180EOZD and 33-150EFOZD	9.7 (3/8)

Figure 5-2 Fuel Line ID Size

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

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

5.3 Fuel Filters

Conform to USCG regulations regarding inline fuel filters or strainers.

5.4 Fuel/Water Separator

A fuel/water separator is standard on 33-180 kW models.

5.5 Fuel Pump Lift

See Figure 5-3 for fuel pump lift capabilities.

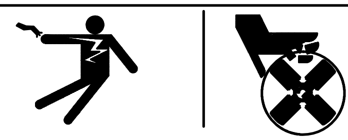
Model	Fuel Pump Lift m (ft.)
40-180EOZD 33-150EFOZD	3 (10)

Figure 5-3 Fuel Pump Lift

5.6 Fuel Consumption

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

WARNING



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

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

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

6.1 AC Voltage Connections

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

6.2 Circuit Protection

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

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

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

6.2.1 Circuit Breaker Considerations

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

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

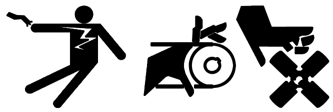
For circuit breaker application and selection information, contact an authorized distributor/dealer.

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

Amps	Max. Voltage	Number of Poles	Type	Model(s)
60	600	3	UL	40EOZD, 33EFOZD
70	600	3	UL	33EFOZD, 40EFOZD
80	480	3	UL	40EOZD, 40EFOZD
90	480	3	UL	55EOZD, 50EFOZD, 70EFOZD, 80EFOZD, 100EFOZD
100	480	3	UL	65EOZD, 50EFOZD, 80EOZD, 70EFOZD, 99EOZD, 80EFOZD, 125EOZD, 100EFOZD
125	600	3	UL	40EOZD, 33EFOZD, 55EOZD, 65EOZD
150	600	3	UL	40EOZD, 33EFOZD, 40EFOZD
175	600	3	UL	55EOZD, 40EFOZD, 50EFOZD, 70EFOZD, 80EFOZD, 100EFOZD
200	600	3	UL	55EOZD, 40EFOZD, 65EOZD, 50EFOZD, 80EOZD, 70EFOZD, 99EOZD, 80EFOZD, 125EOZD, 100EFOZD
250	480	3	UL	150EOZD, 125EFOZD
250	600	3	UL	55EOZD, 65EOZD, 50EFOZD, 80EOZD, 99EOZD, 125EOZD
400	600	3	UL	125EFOZD, 180EOZD, 150EFOZD
600	600	3	UL	150EOZD, 180EOZD, 150EFOZD

Figure 6-1 AC Circuit Breaker Ratings (33–180 kW Models), Listed By Amps

WARNING

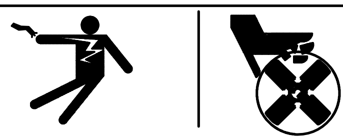


Accidental starting.
Can cause severe injury or death.

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) Place the generator set start/stop switch in the STOP position. (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.

WARNING



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

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

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

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

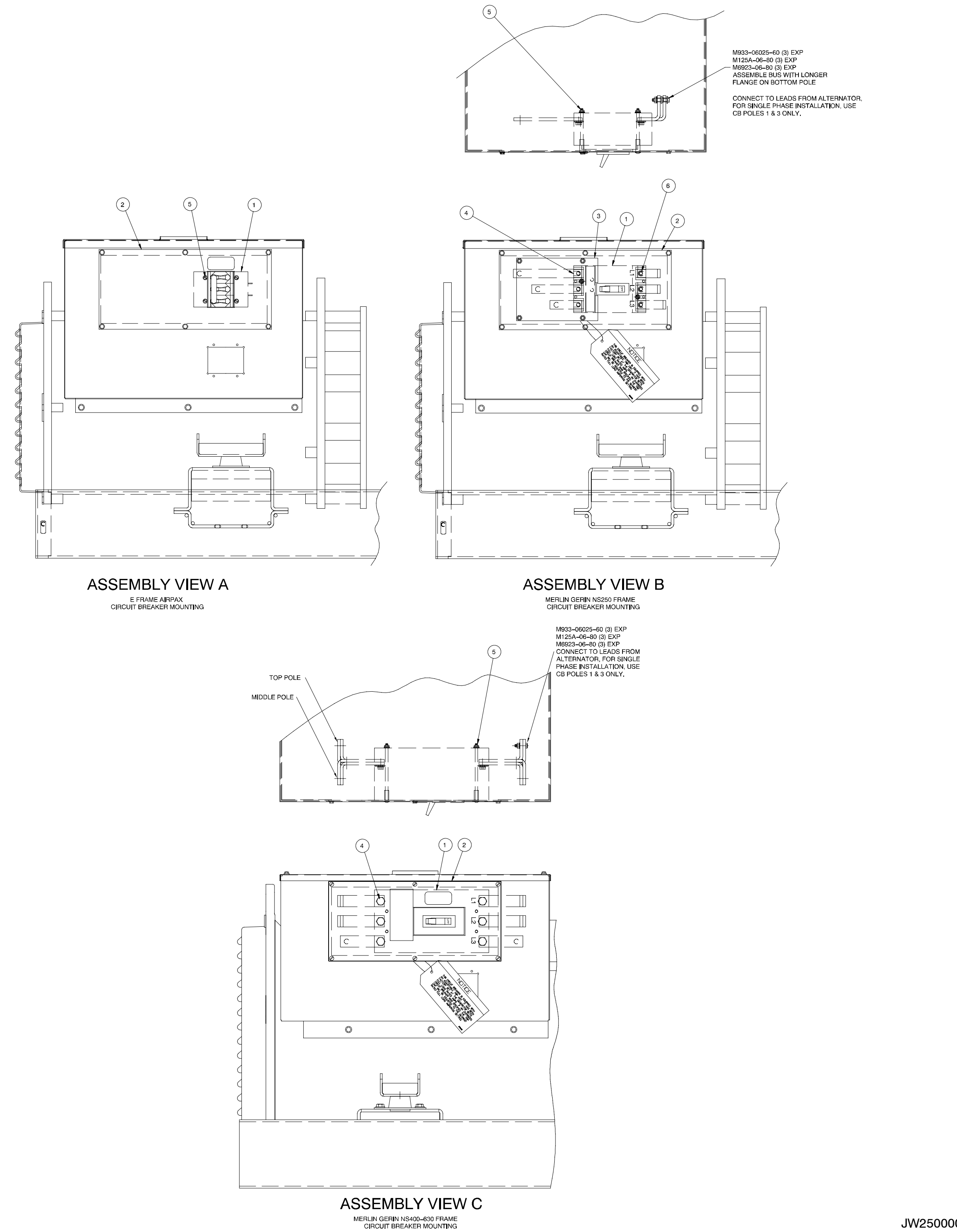
Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. Connect the generator set to the building/marina electrical system only through an approved device and after the building/marina main switch is turned off. Backfeed connections can cause severe injury or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

6.2.2 Circuit Breaker Installation (40–180EOZD and 33–150EFOZD Models)

1. Place the generator set master switch in the OFF position.
2. Disconnect the generator set engine starting battery, negative (–) lead first.
3. Remove the six screws from the right side junction box panel and remove the panel.
4. Install the circuit breaker on the new panel with the screws and washers. Position the ON side of the circuit breaker toward the rear of the junction box. See Figure 6-2.
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: Insulate leads with electrical tape after connecting extension leads to stator leads.
6. Connect the neutral connection stator leads to the L0 stud.

   Note: Verify that terminal positions and previously made line lead connections allow room for load connections to load studs.
7. Connect the load side of the circuit breaker to customer-supplied craft wiring. Connect the neutral lead to the L0 stud. See Figure 8-3.
8. Attach the new panel to the junction box using the original six screws. See Figure 6-2.
9. Check that the generator set master switch is in the OFF position. Reconnect the generator set engine starting battery, negative (–) lead last.



1. Circuit breaker
2. Circuit breaker mounting panel
3. Load lead access panel
4. Bus
5. Hardware
6. Bus line

Figure 6-2 Circuit Breaker Mounting (40-180EOZD Models)

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
40–65EOZD 33–50EFOZD	# 0	# 4	# 3/0	# 2
80–99EOZD 70–80EFOZD	# 2/0	# 2	# 4/0	# 1/0
125–150EOZD 100–125EFOZD	# 2/0	# 2	# 4/0	# 1/0
180EOZD 150EFOZD	# 2/0	# 2	# 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 –18°C (0°F) or 100 Amp. Hr.	
Models	**CCA**
40–65EOZD and 33–50EFOZD	640
80–180EOZD and 70–150EFOZD	800

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.

33-180EOZD/EFOZD Models: Various wiring harnesses, Y-connectors, pigtail harnesses, remote control panels, and remote annunciator panels (Decision-Maker™ 3+ only) are available. See Figure 6-5 and Figure 6-6 for wiring options.

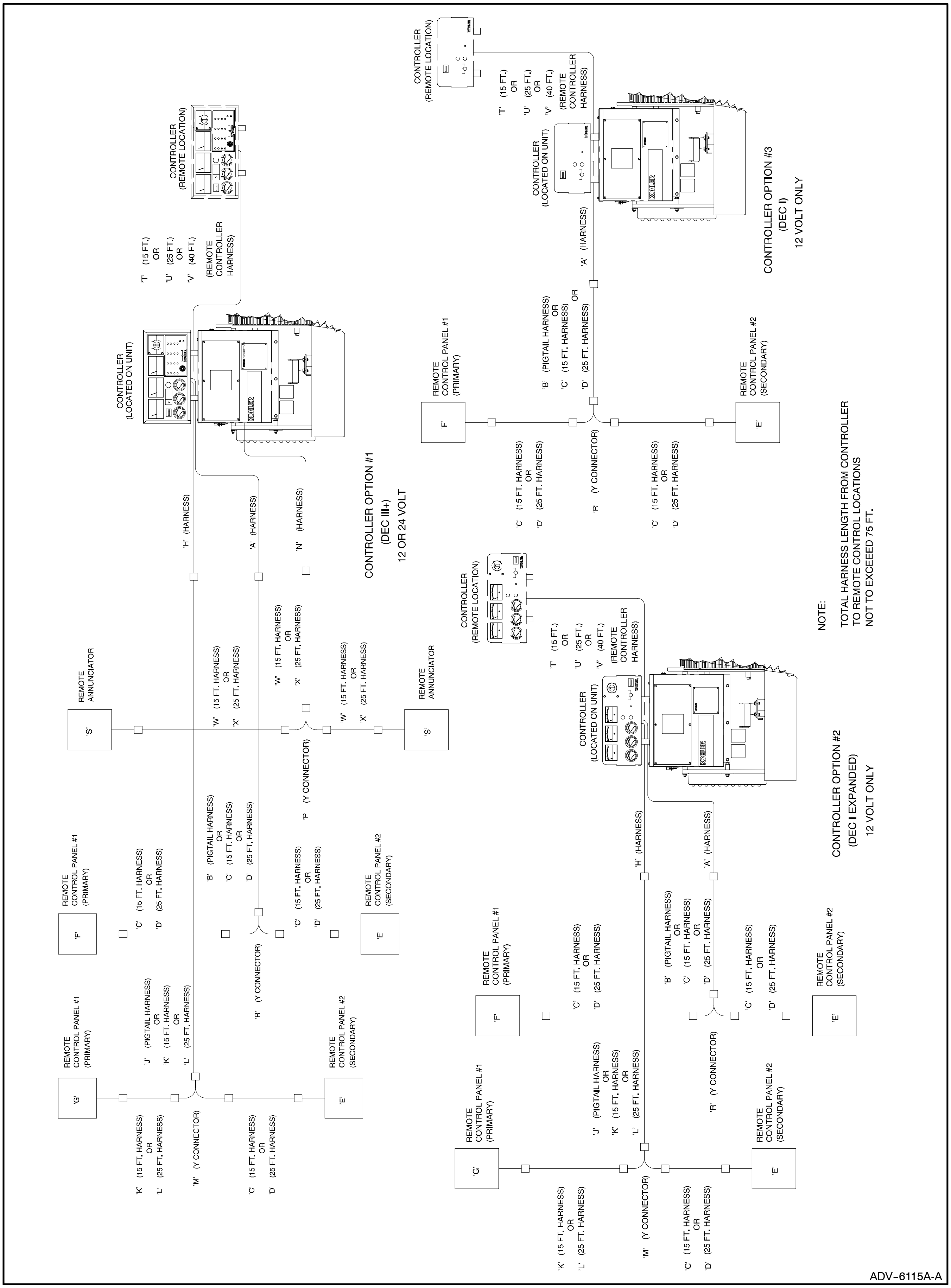


Figure 6-5 Remote Controller and Harness Options (33-180 kW Models)

COMMON TO ALL MODELS			
CONTROLLER	DEC I	DEC I EXPANDED	DEC III+
WIRING HARNESS 'A'	PA-344491/344491	PA-344491/344491	PA-344491/344491
PIGTAIL HARNESS 'B'	PA-249941	PA-249941	PA-249941
15 FT. WIRING HARNESS 'C'	PA-249334	PA-249334	PA-249334
25 FT. WIRING HARNESS 'D'	PA-249336	PA-249336	PA-249336
WIRING HARNESS 'H'	NOT AVAILABLE	PA-344493/344493	PA-344493/344493
PIGTAIL HARNESS 'J'	NOT AVAILABLE	PA-344414	PA-344414
15 FT. WIRING HARNESS 'K'	NOT AVAILABLE	PA-344415	PA-344415
25 FT. WIRING HARNESS 'L'	NOT AVAILABLE	PA-344416	PA-344416
Y CONNECTOR HARNESS 'M'	NOT AVAILABLE	PA-344417	PA-344417
WIRING HARNESS 'N'	NOT AVAILABLE	NOT AVAILABLE	PA-344492/344492
Y CONNECTOR HARNESS 'P'	NOT AVAILABLE	NOT AVAILABLE	PA-344437
Y CONNECTOR HARNESS 'R'	PA-344388	PA-344388	PA-344388
REMOTE ANNUNCIATOR 'S'	NOT AVAILABLE	NOT AVAILABLE	PA-344432
15 FT. REMOTE CONTROLLER HARNESS 'T'	PAA-344422	PAA-344422	PAA-344422
25 FT. REMOTE CONTROLLER HARNESS 'U'	PAA-344423	PAA-344423	PAA-344423
40 FT. REMOTE CONTROLLER HARNESS 'V'	PAA-344505	PAA-344505	PAA-344505
15 FT. WIRING HARNESS 'W'	NOT AVAILABLE	NOT AVAILABLE	PA-344501
25 FT. WIRING HARNESS 'X'	NOT AVAILABLE	NOT AVAILABLE	PA-344502

CONTROLLER KIT OPTION MATRIX																
MODEL		40COZ & 33CFOZ 40EOZ & 33EFOZ			50 & 60COZ, 40 & 50CFOZ 50, 65 & 80EOZ, 40, 55 & 70EFOZ			99EOZ 80EFOZ			125EOZ 100EFOZ			150EOZ 125EFOZ		
CONTROLLER		DEC I	DEC I EXPANDED	DEC III+	DEC I	DEC I EXPANDED	DEC III+	DEC I	DEC I EXPANDED	DEC III+	DEC I	DEC I EXPANDED	DEC III+	DEC I	DEC I EXPANDED	DEC III+
REMOTE PANEL 'E'	BASIC START/STOP 12 VOLT/24 VOLT	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396 PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401	PA-344396/ PA-344401
REMOTE PANEL 'F'	4 METER 12 VOLT/24 VOLT	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397 PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402	PA-344397/ PA-344402
REMOTE PANEL 'G'	FULL FEATURE 12 VOLT/24 VOLT	NOT AVAILABLE	PA-344406/ PA-344407	PA-344406/ PA-344407	NOT AVAILABLE	PA-344412 PA-344413	PA-344412/ PA-344413	NOT AVAILABLE	GM17007-KP1/ GM17008-KP1	GM17007-KP1/ GM17008-KP1	NOT AVAILABLE	GM16681-KP1/ GM16682-KP1	GM16681-KP1/ GM16682-KP1	NOT AVAILABLE	GM16683-KP1/ GM16684-KP1	GM16683-KP1/ GM16684-KP1

Figure 6-6 Remote Controller and Harness Options (33–180 kW Models)

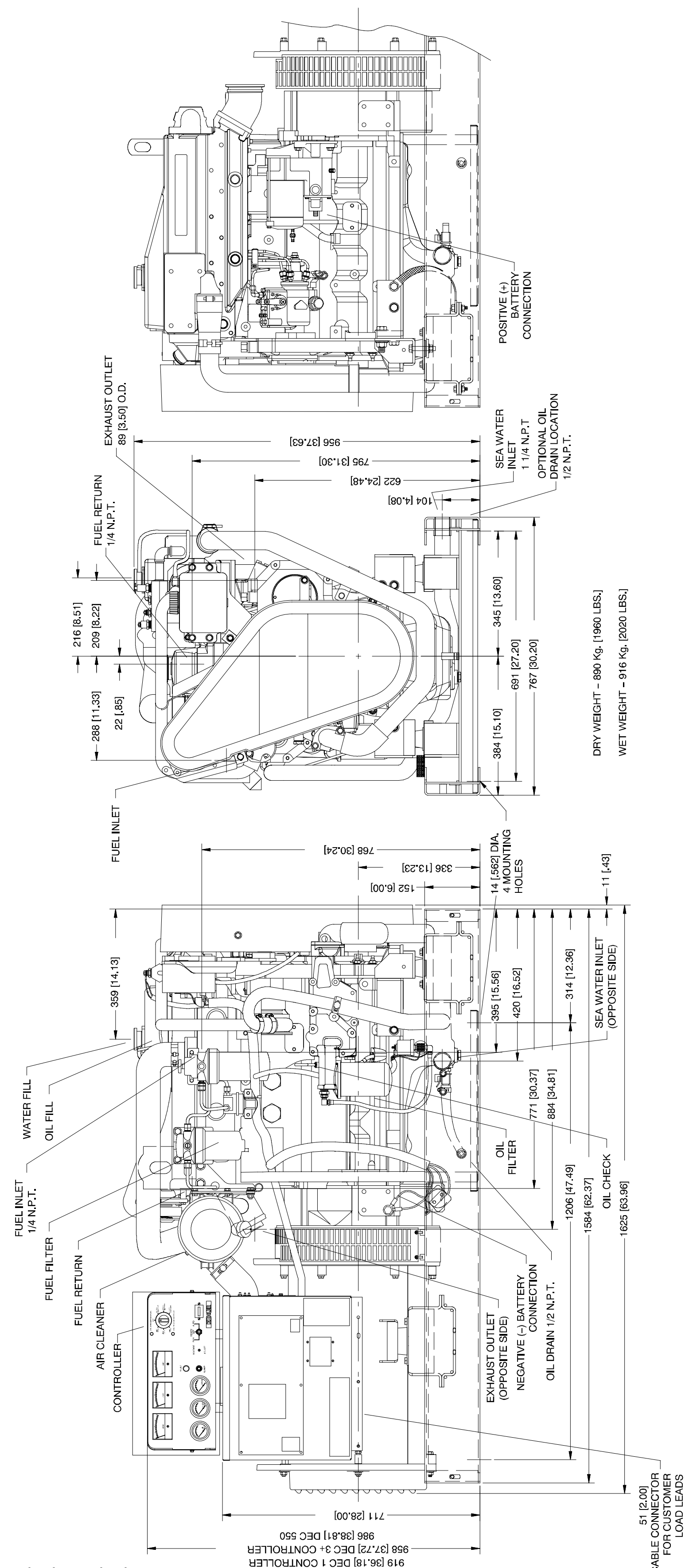
Notes

Section 7 Installation Drawings

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

Model No.	Drawing	Page
40EOZD and 33EFOZD	ADV-7139A-A	34
with dry exhaust elbow	ADV-7139B-A	35
with sound shield	ADV-7139C-A	36
with electric clutch	ADV-7139D-A	37
with keel cooling	ADV-7139E-A	38
55/65EOZD and 45/50EFOZD	ADV-7141A-B	39
with dry exhaust elbow	ADV-7141B-B	40
with sound shield	ADV-7141C-B	41
with electric clutch	ADV-7141D-B	42
with keel cooling	ADV-7141E-B	43
80/99EOZD and 70/80EFOZD	ADV-7166A-	44
with dry exhaust elbow	ADV-7166B-	45
with sound shield	ADV-7166C-	46
with electric clutch	ADV-7166D-	47
with keel cooling	ADV-7166E-	48
125/150EOZD and 100/125EFOZD	ADV-7142A-A	49
with sound shield	ADV-7142B-A	50
with dry exhaust elbow	ADV-7142C-A	51
with keel cooling	ADV-7142D-A	52
180EOZD and 150EFOZD	ADV-7136A-A	53
with sound shield	ADV-7136B-A	54
with dry exhaust elbow	ADV-7136C-A	55
with keel cooling	ADV-7136D-A	56

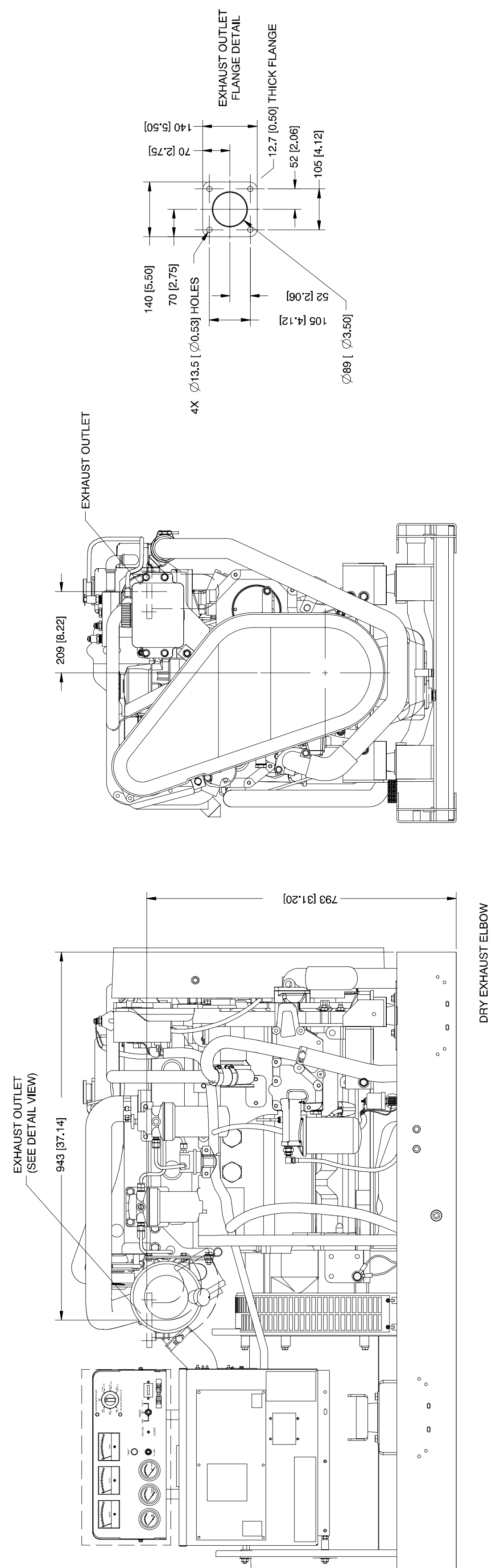
Figure 7-1 Installation Drawings (33–180 kW Models)



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7139A-A

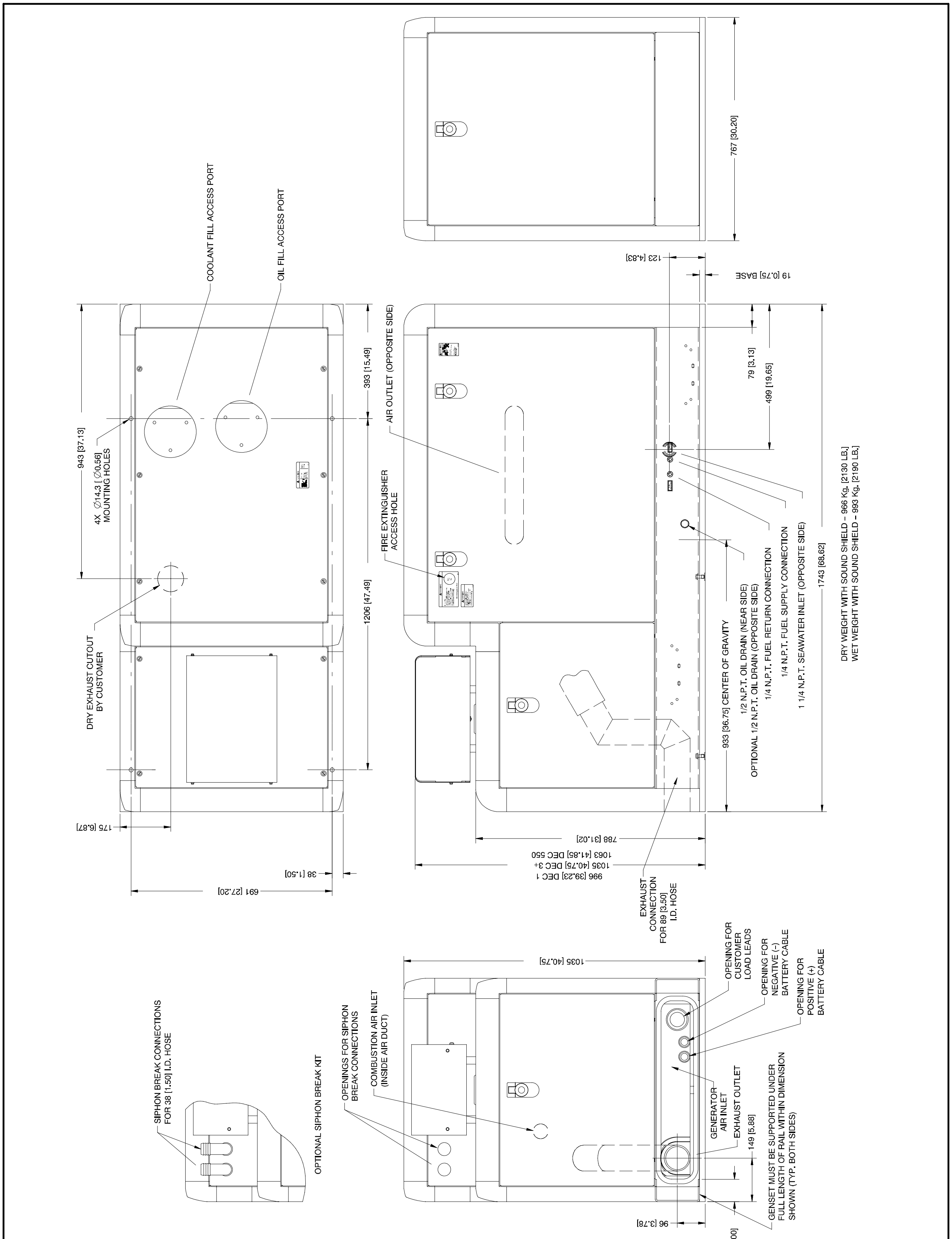
Figure 7-2 Dimension Drawing, 40EOZD and 33EFOZD



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7139B-A

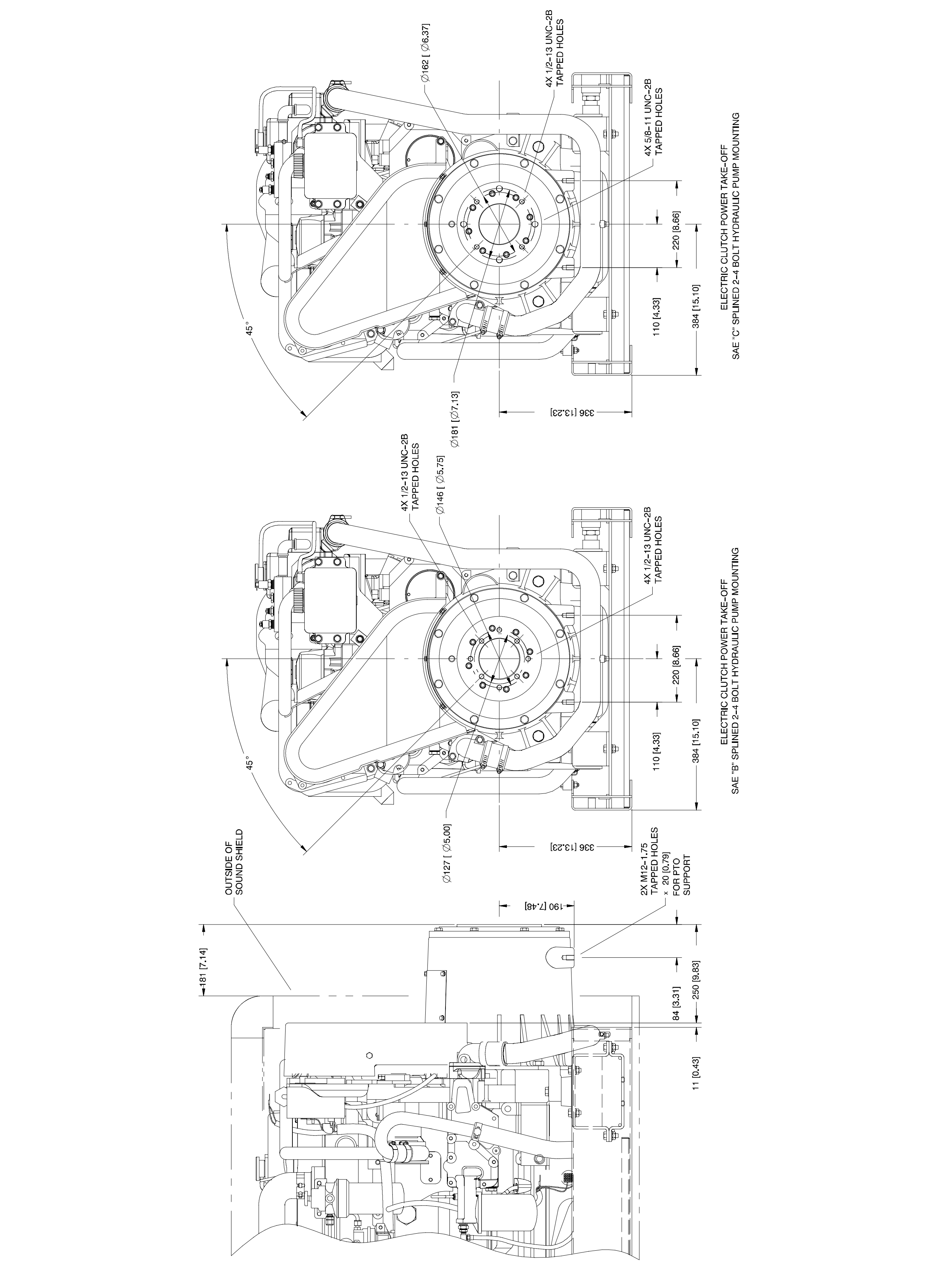
Figure 7-3 Dimension Drawing, 40EOZD and 33EFOZD with Dry Exhaust Elbow



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7139C-A

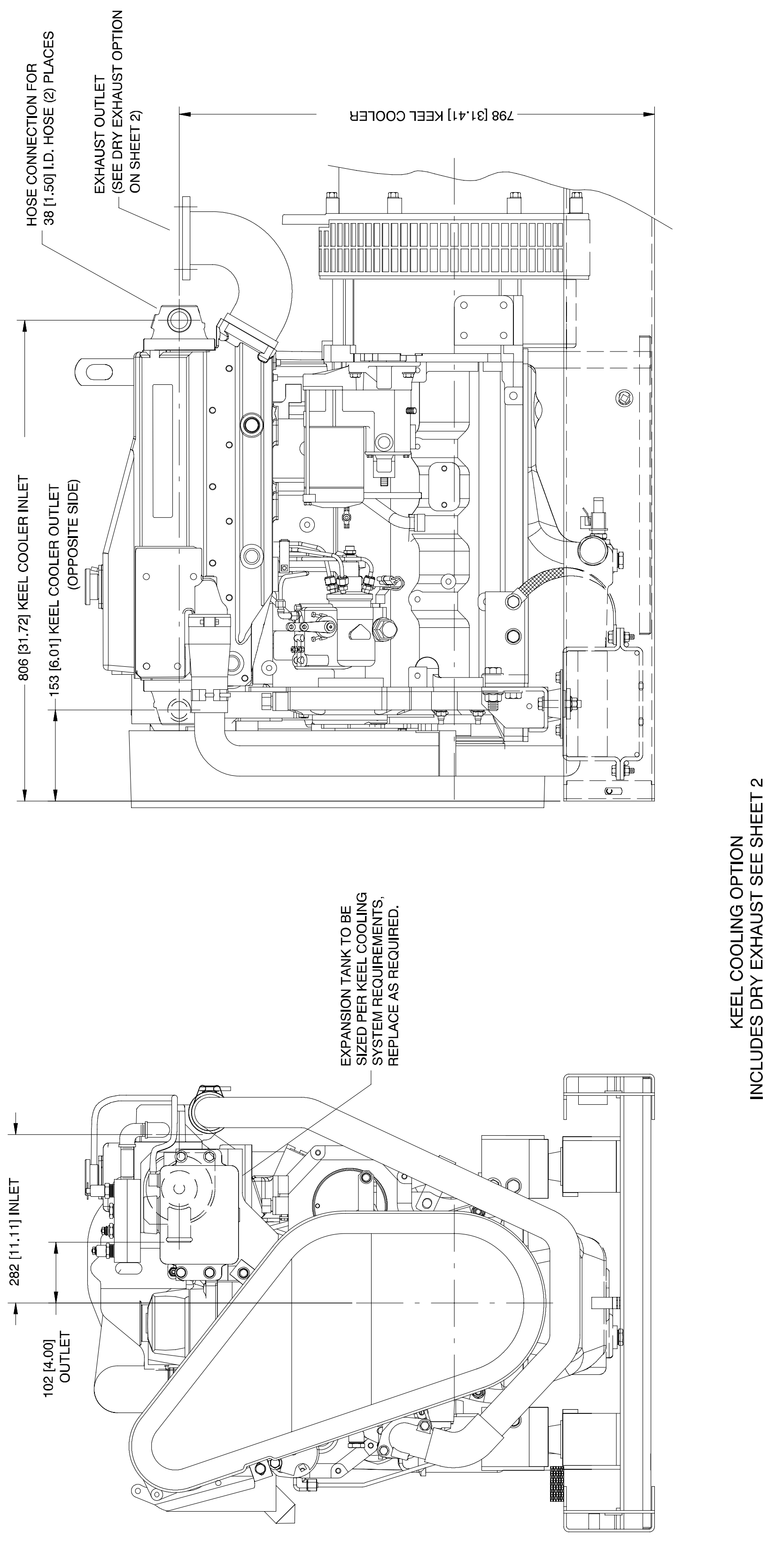
Figure 7-4 Dimension Drawing, 40EOZD and 33EFOZD with Sound Shield



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7139D-A

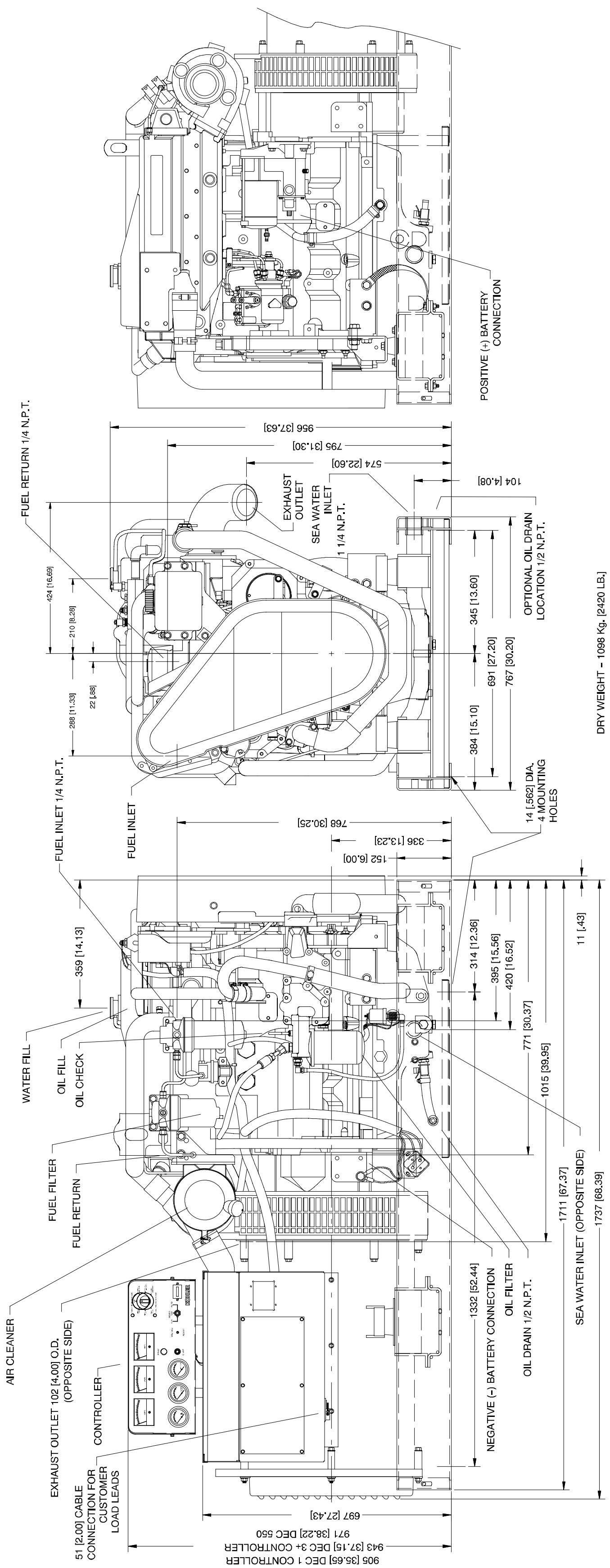
Figure 7-5 Dimension Drawing, 40EOZD and 33EFOZD with Electric Clutch



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7139E-A

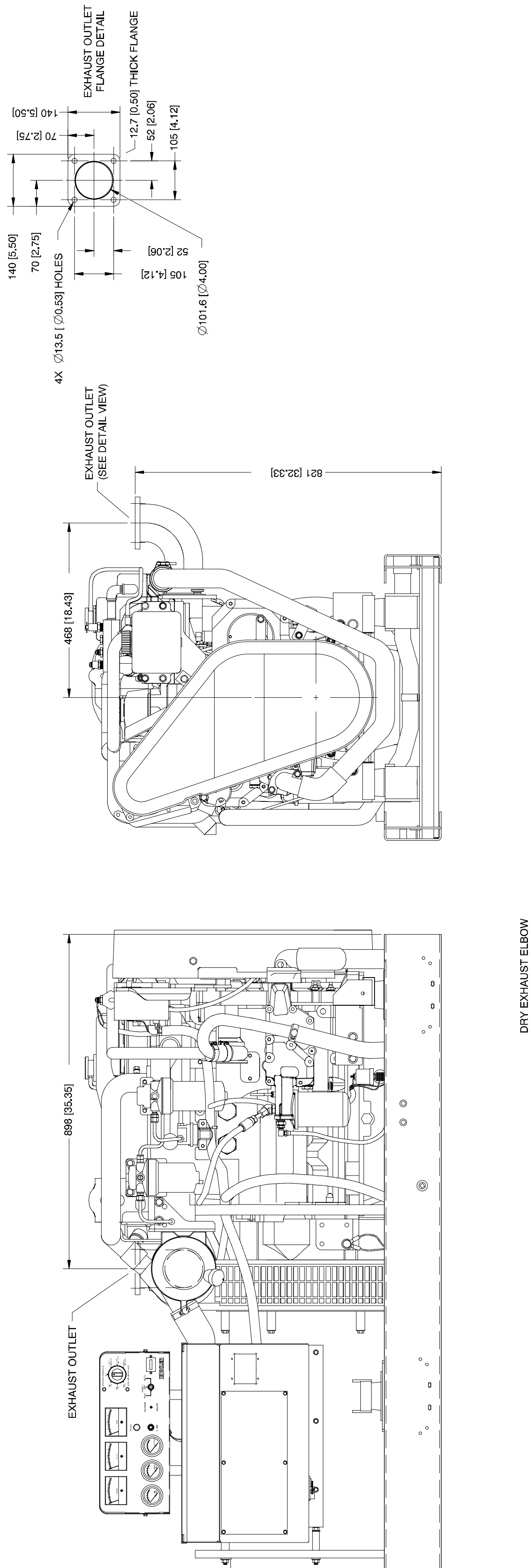
Figure 7-6 Dimension Drawing, 40EOZD and 33EFOZD with Keel Cooling



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7141A-B

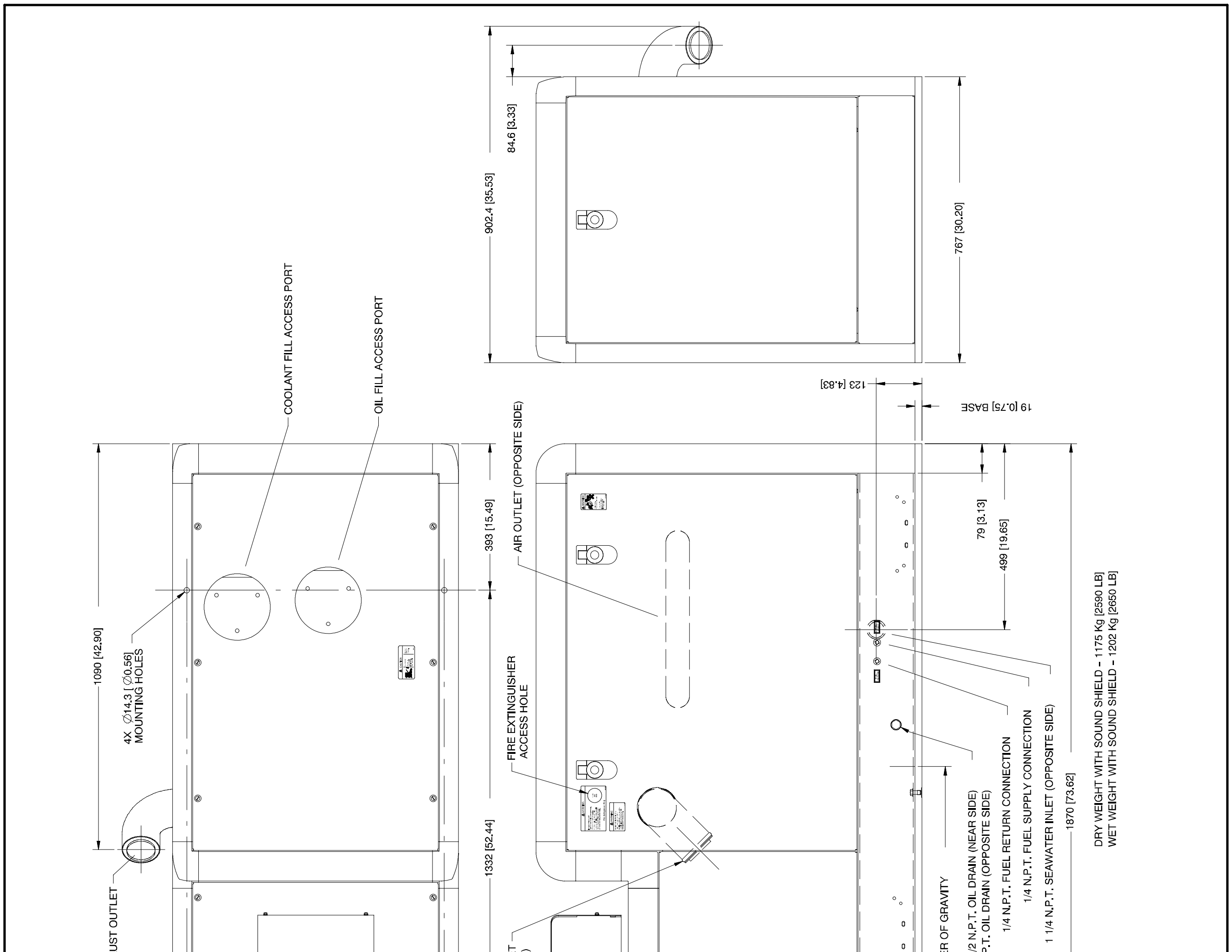
Figure 7-7 Dimension Drawing, 55/65EOZD and 45/50EFOZD



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7141B-B

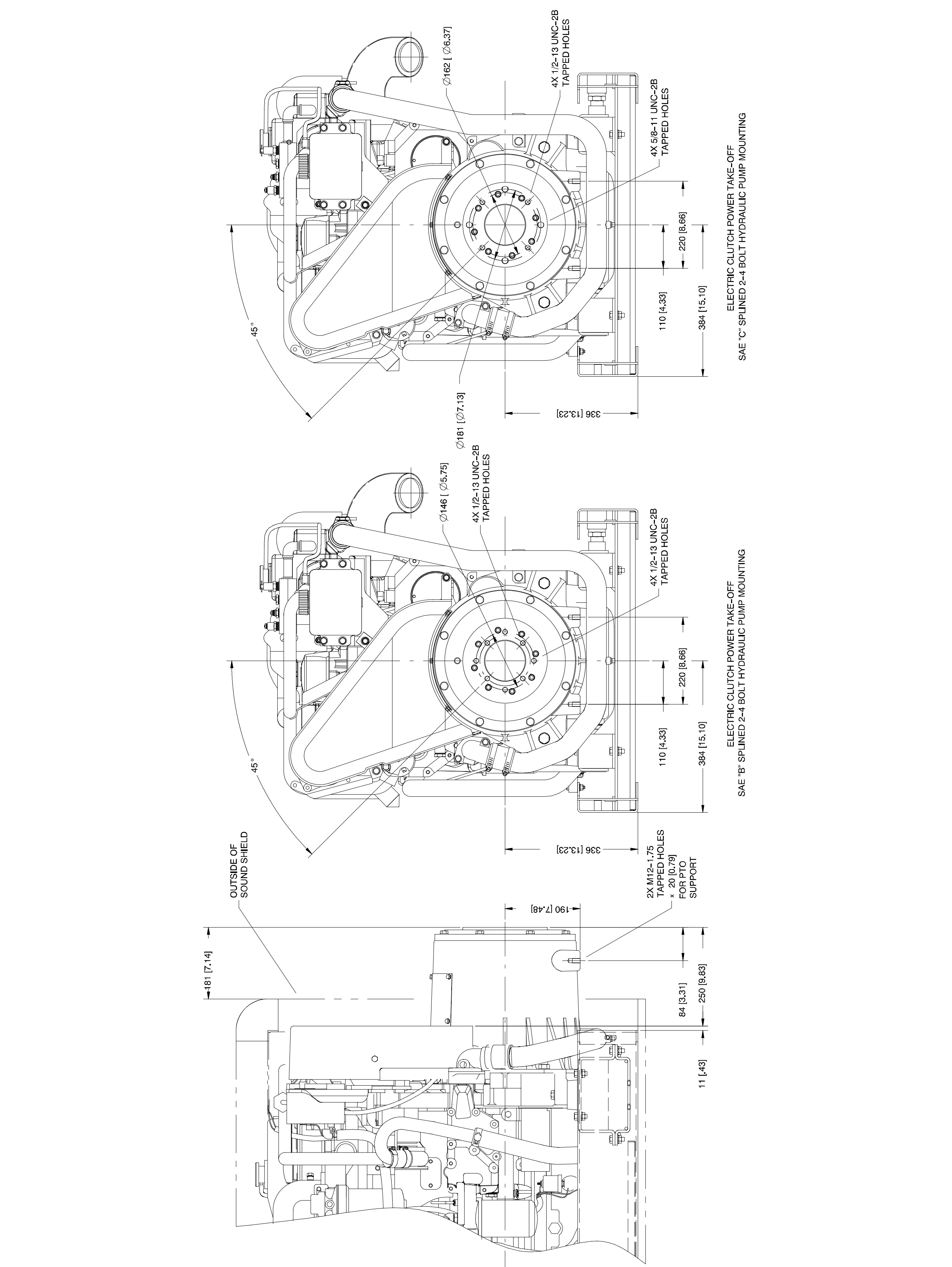
Figure 7-8 Dimension Drawing, 55/65EOZD and 45/50EFOZD with Dry Exhaust Elbow



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7141C-B

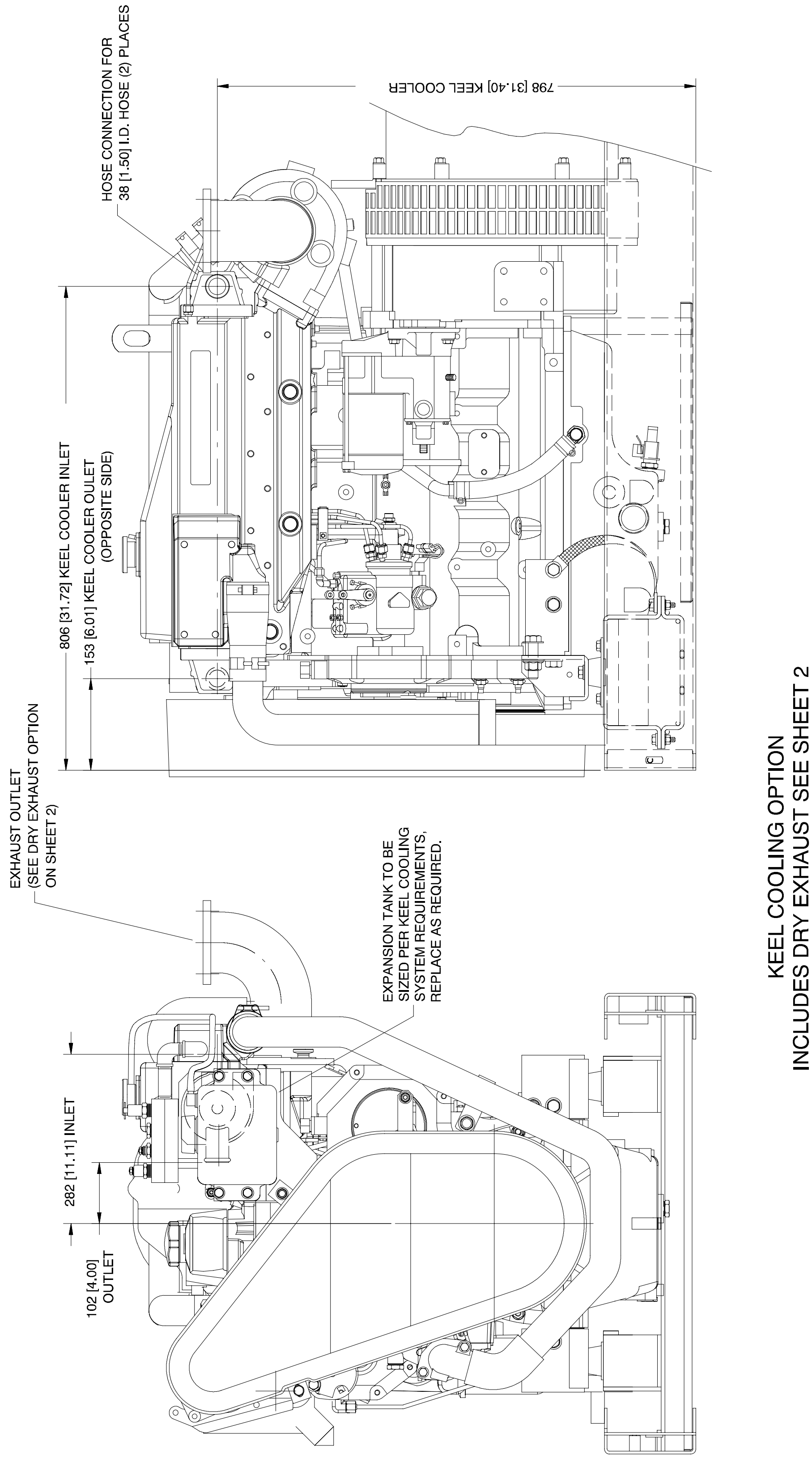
Figure 7-9 Dimension Drawing, 55/65EOZD and 45/50EFOZD with Sound Shield



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7141D-B

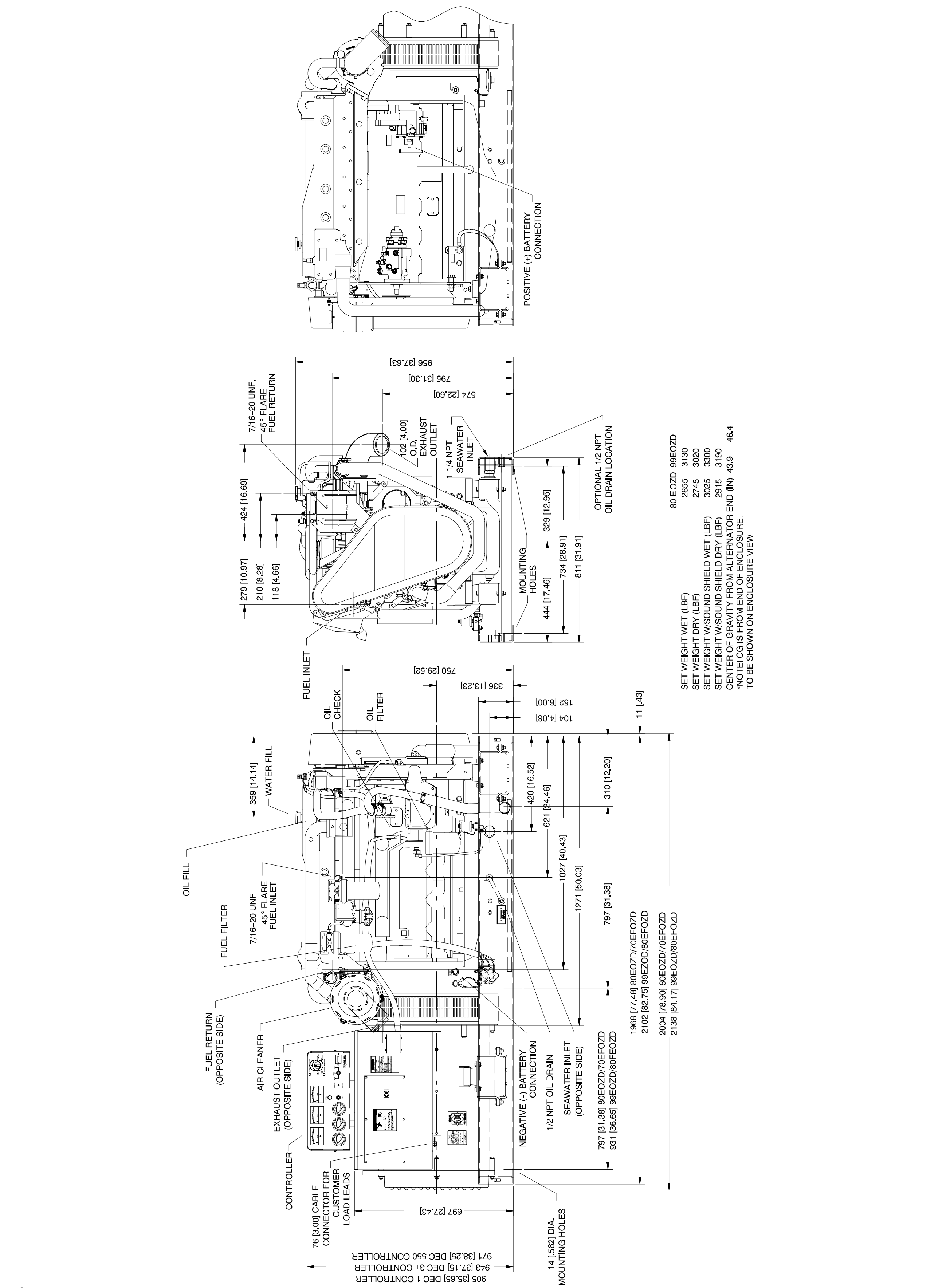
Figure 7-10 Dimension Drawing, 55/65EOZD and 45/50EFOZD with Electric Clutch



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7141E-B

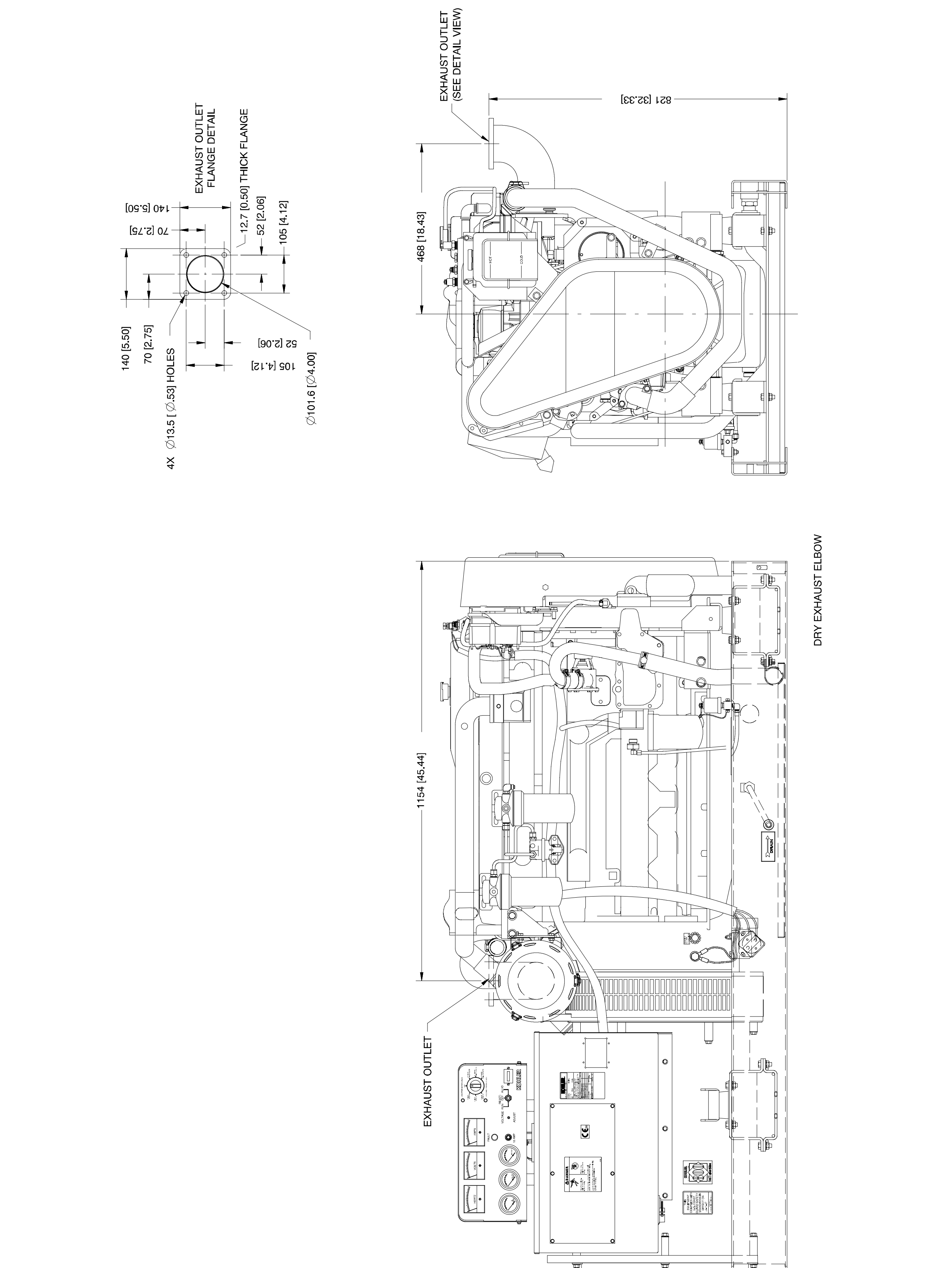
Figure 7-11 Dimension Drawing, 55/65EOZD and 45/50EFOZD with Keel Cooling



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7166A-

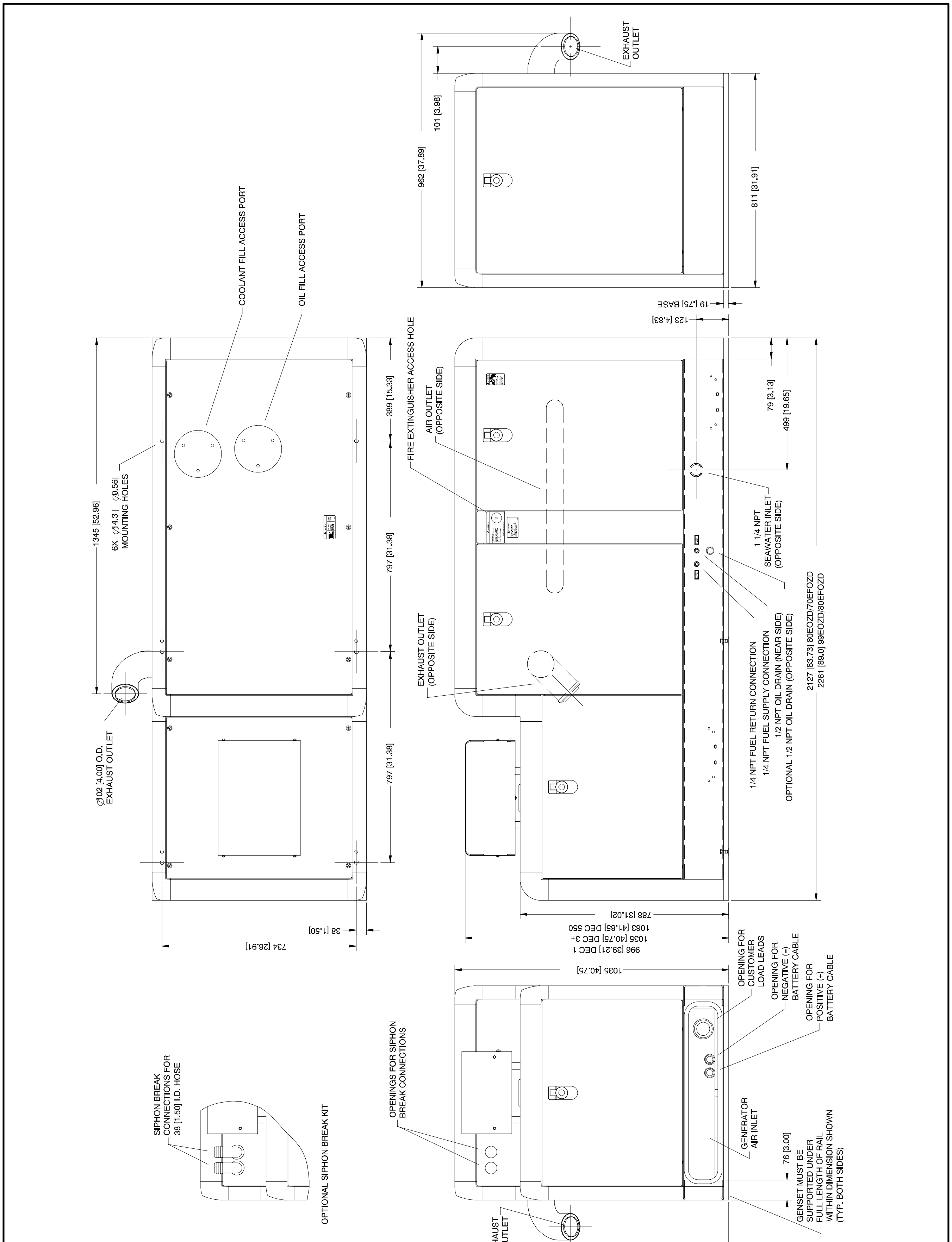
Figure 7-12 Dimension Drawing, 80/99EOZD and 70/80EFOZD



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7166B-

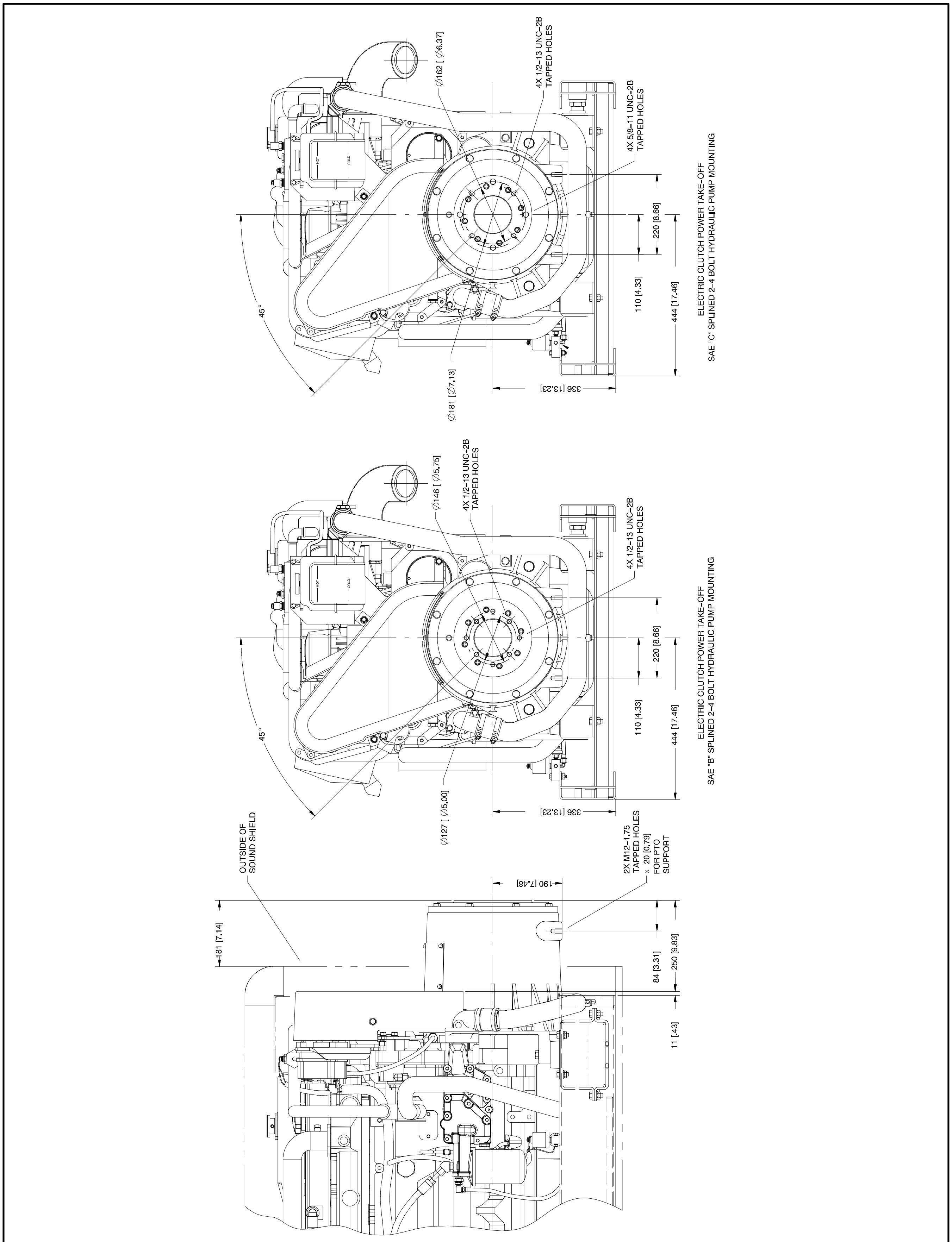
Figure 7-13 Dimension Drawing, 80/99EOZD and 70/80EFOZD with Dry Exhaust Elbow



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7166C-

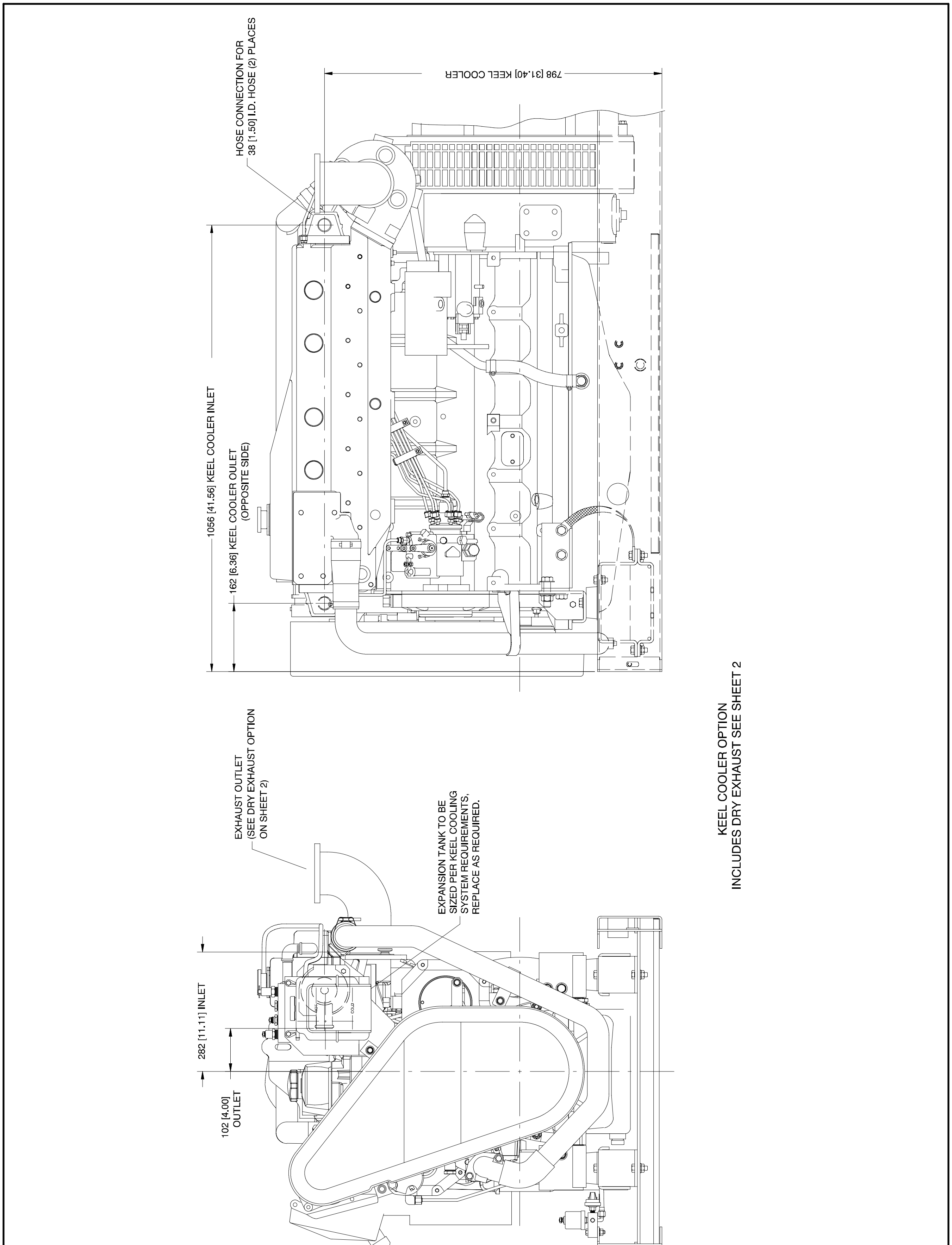
Figure 7-14 Dimension Drawing, 80/99EOZD and 70/80EFOZD with Sound Shield



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7166D-

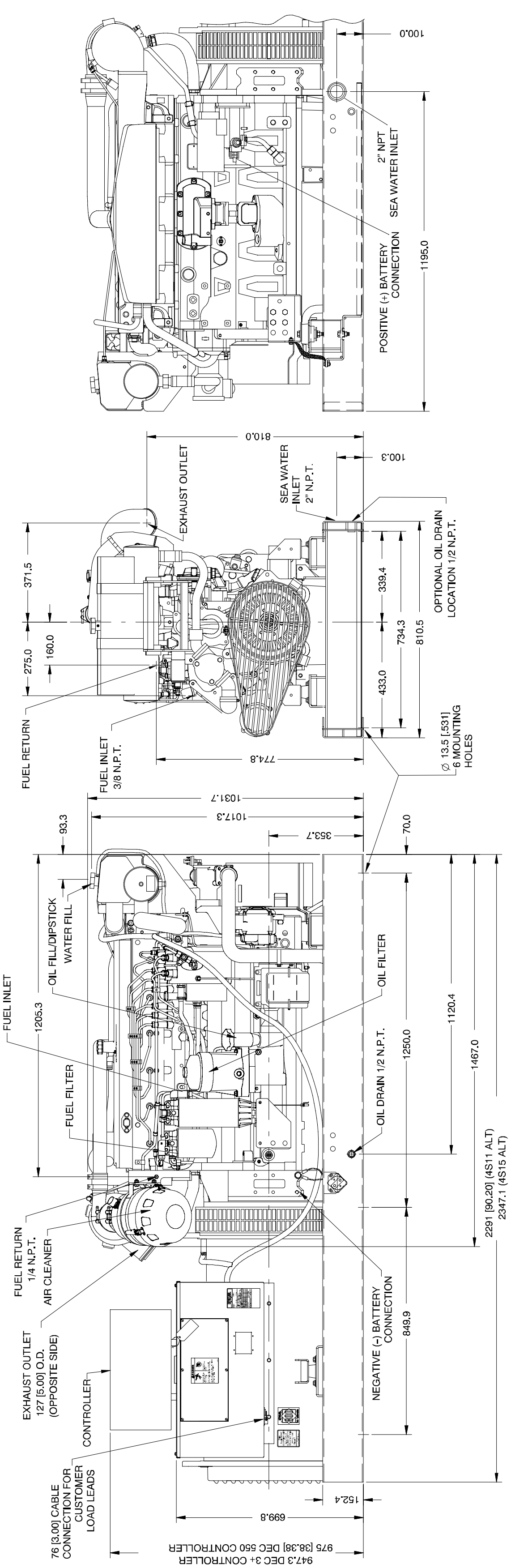
Figure 7-15 Dimension Drawing, 80/99EOZD and 70/80EFOZD with Electric Clutch



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7166E-

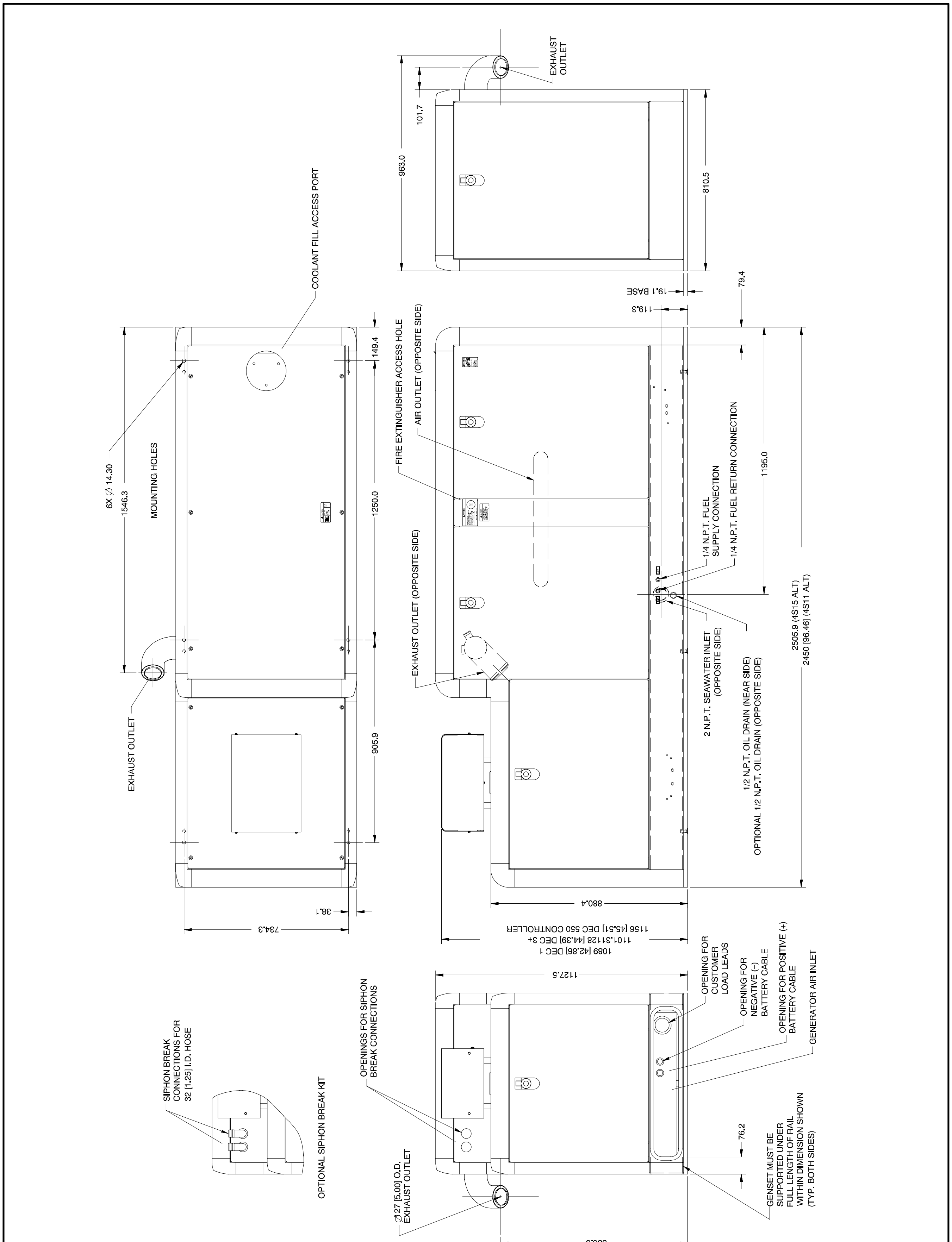
Figure 7-16 Dimension Drawing, 80/99EOZD and 70/80EFOZD with Keel Cooling



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7142A-A

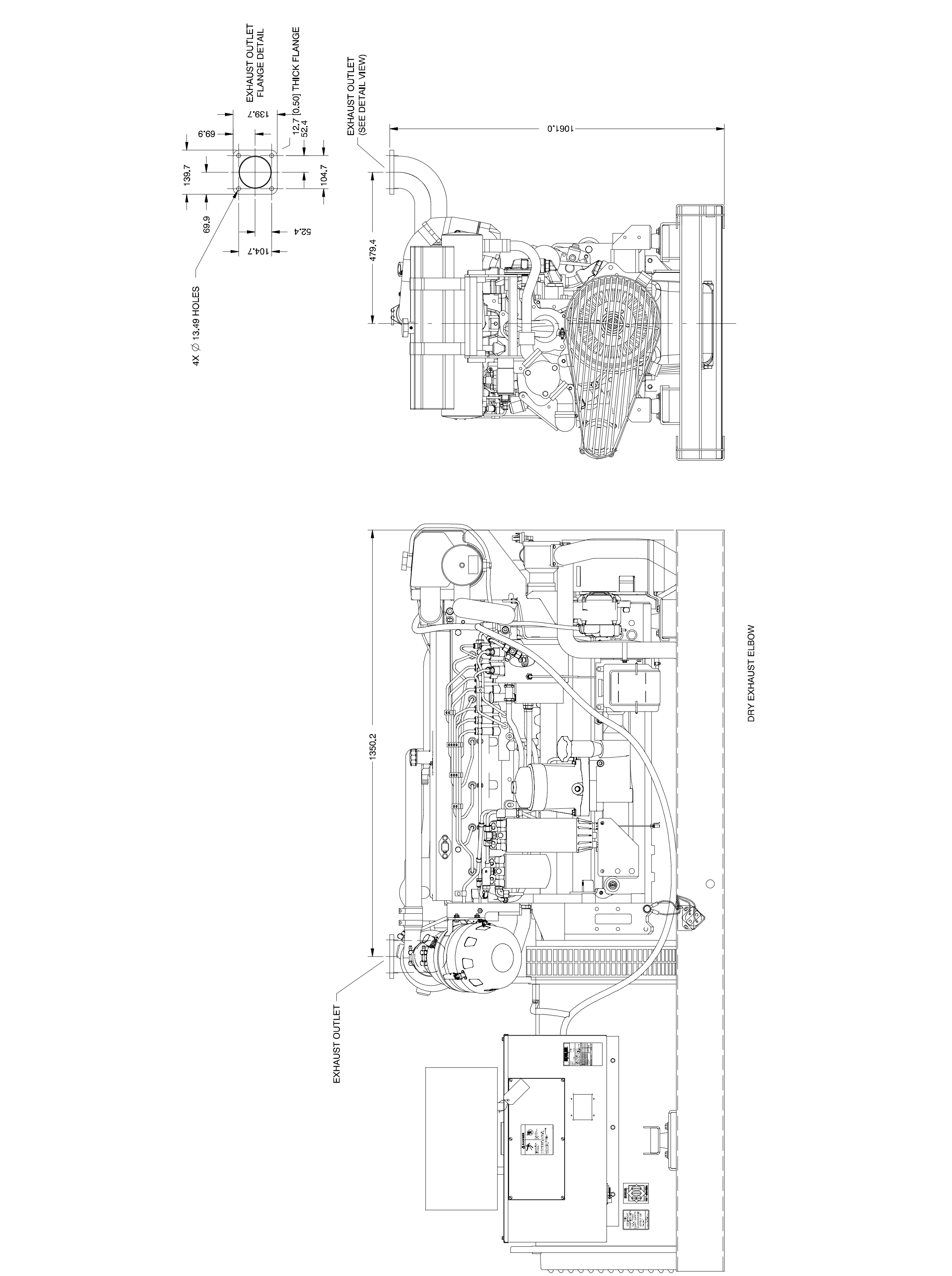
Figure 7-17 Dimension Drawing, 125/150EOZD and 100/125EFOZD



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7142B-A

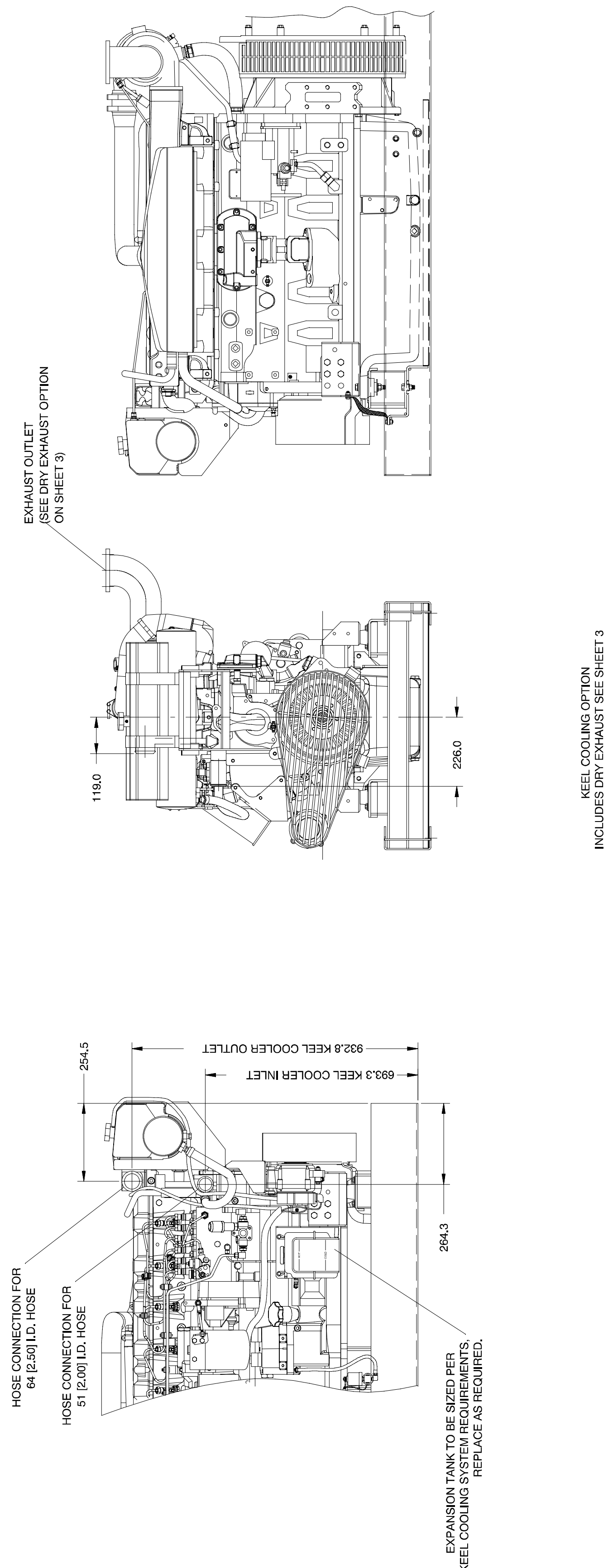
Figure 7-18 Dimension Drawing, 125/150EOZD and 100/125EFOZD with Sound Shield



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7142C-A

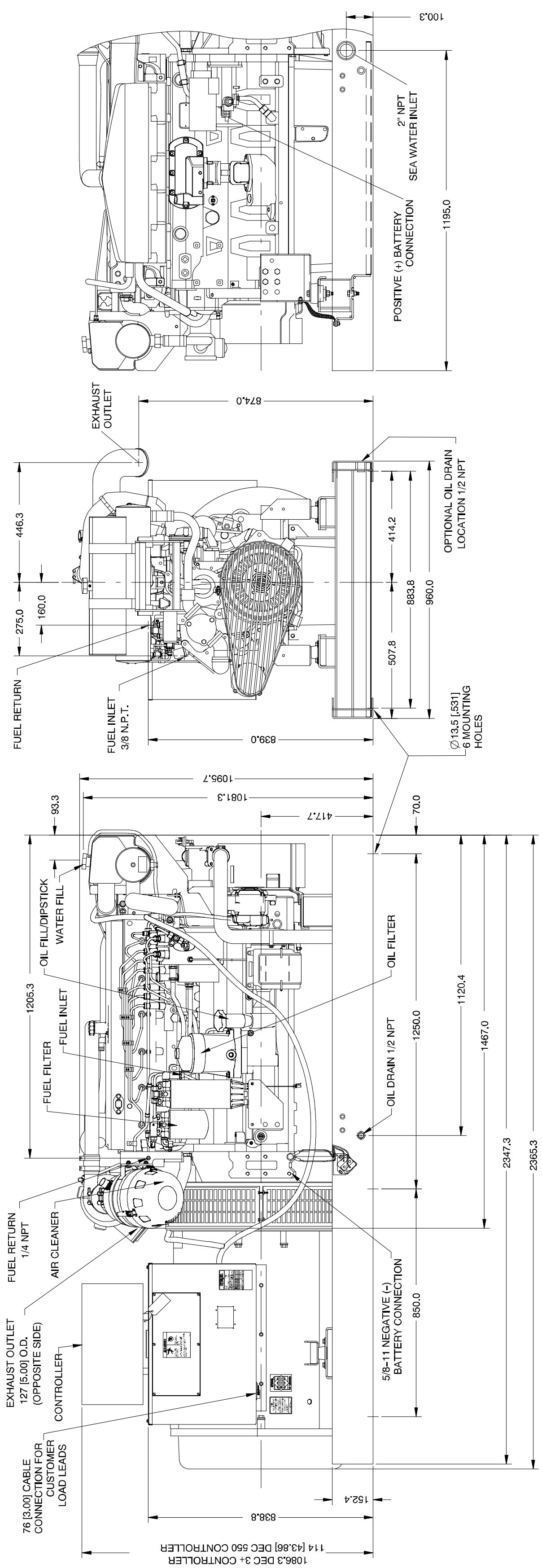
Figure 7-19 Dimension Drawing, 125/150EOZD and 100/125EFOZD with Dry Exhaust Elbow



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7142D-A

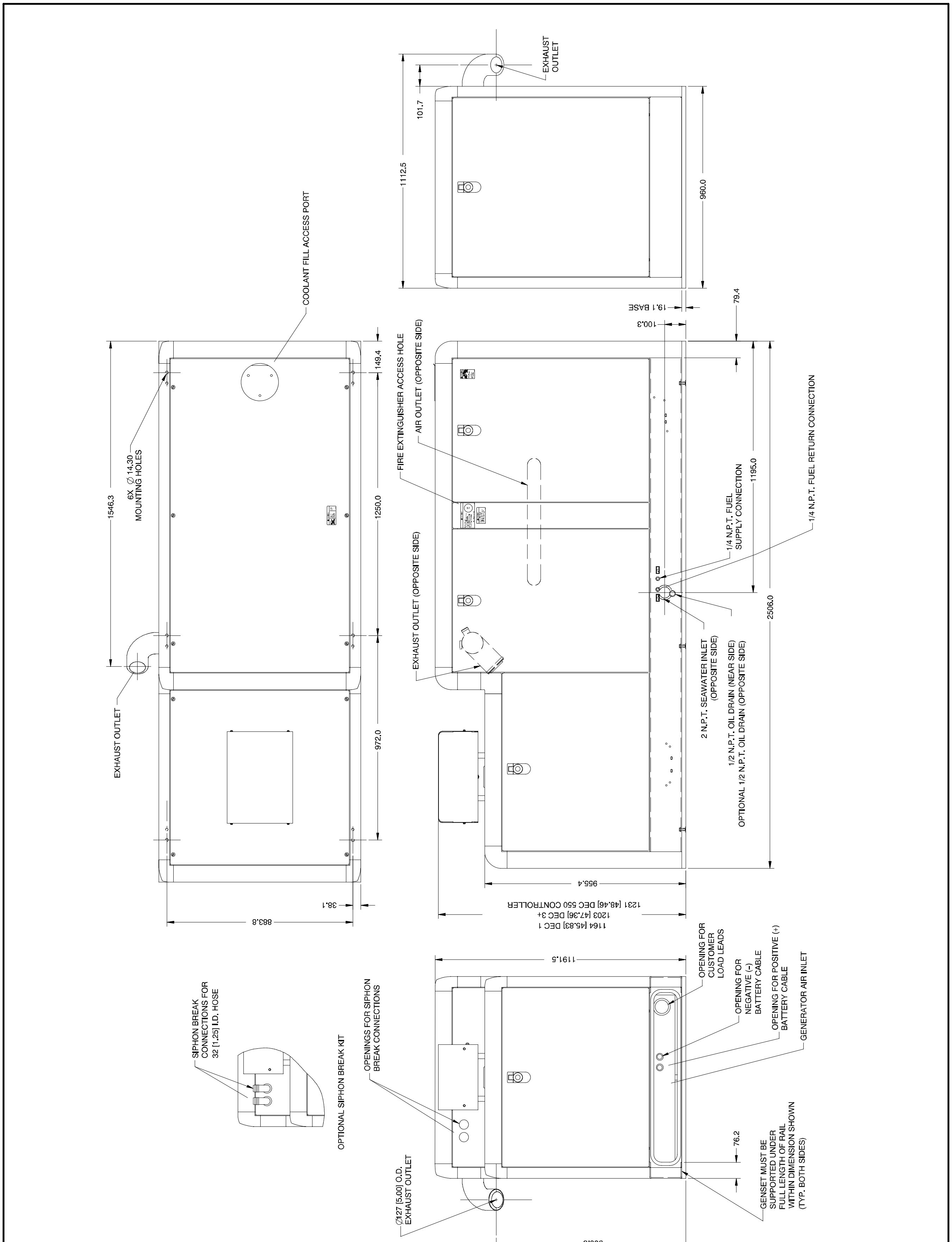
Figure 7-20 Dimension Drawing, 125/150EOZD and 100/125EFOZD with Keel Cooling



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7136A-A

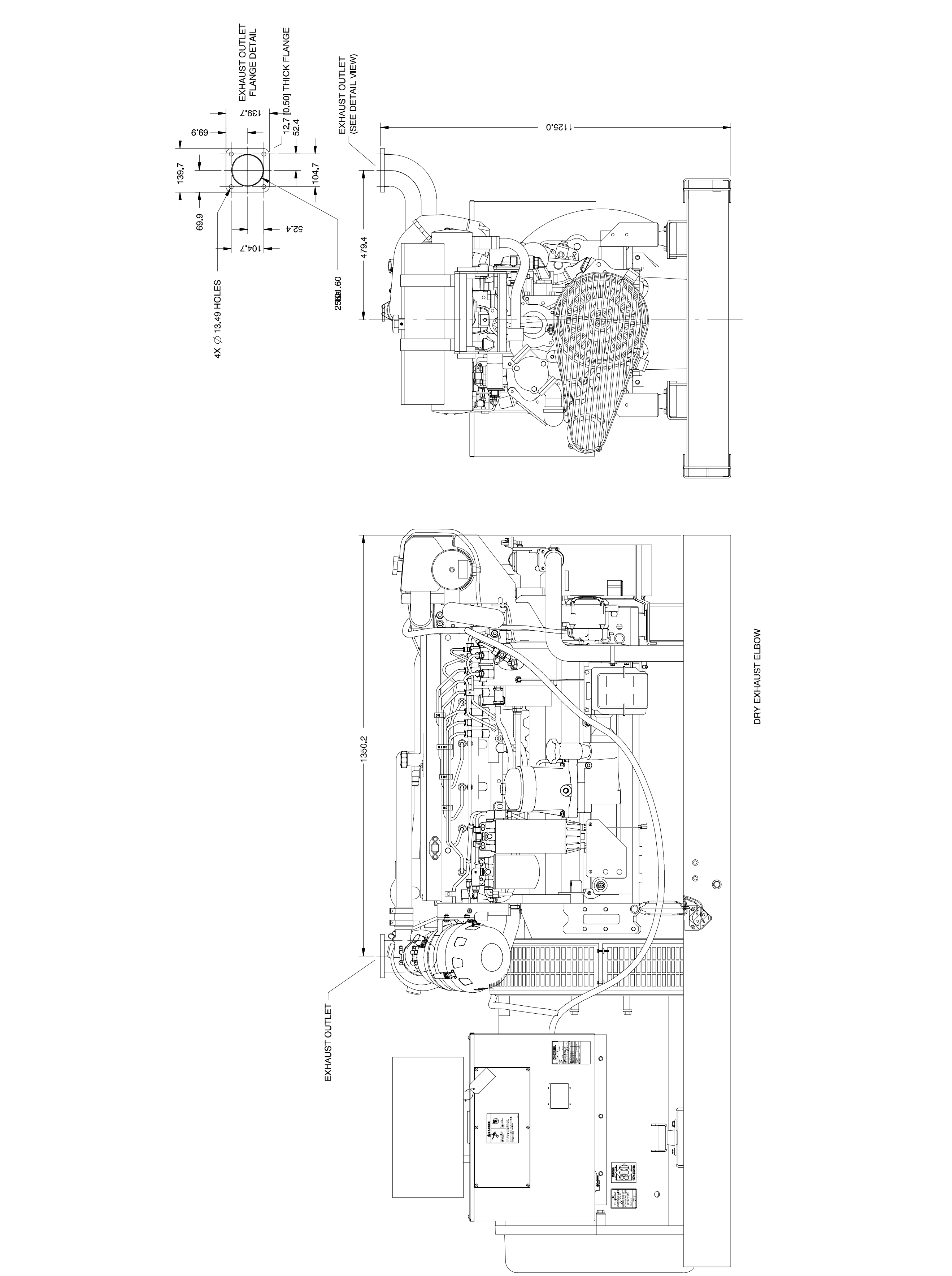
Figure 7-21 Dimension Drawing, 180EOZD and 150EFOZD



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7136B-A

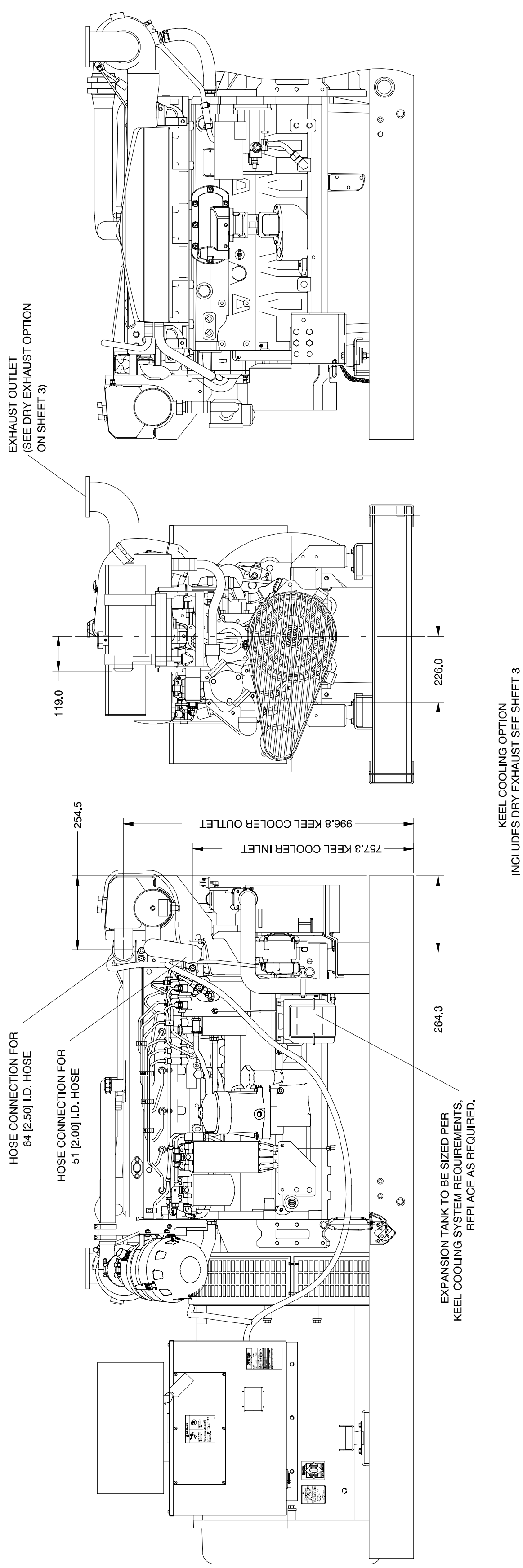
Figure 7-22 Dimension Drawing, 180EOZD and 150EFOZD with Sound Shield



NOTE: Dimensions in [ ] are inch equivalents.

ADV-7136C-A

Figure 7-23 Dimension Drawing, 180EOZD and 150EFOZD with Dry Exhaust Elbow

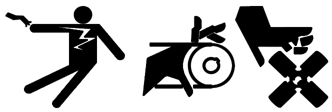


NOTE: Dimensions in [ ] are inch equivalents.

ADV-7136D-A

Figure 7-24 Dimension Drawing, 180EOZD and 150EFOZD with Keel Cooling

WARNING

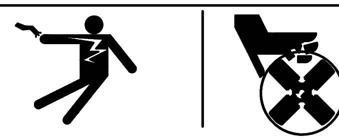


Accidental starting.
Can cause severe injury or death.

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 connected equipment, 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.

WARNING



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

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

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. 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.

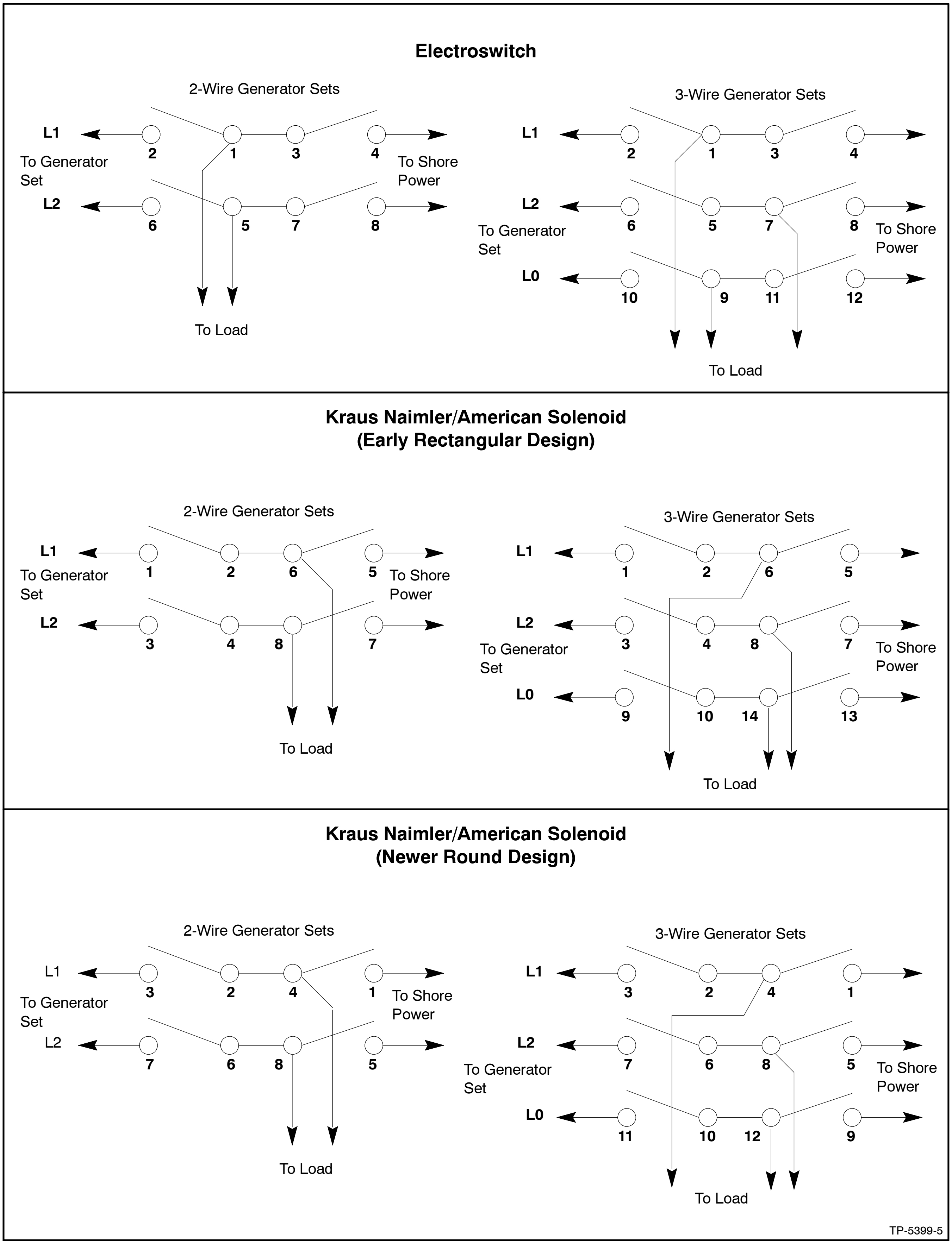


Figure 8-1 Marine Manual (Ship-to-Shore) Transfer Switch

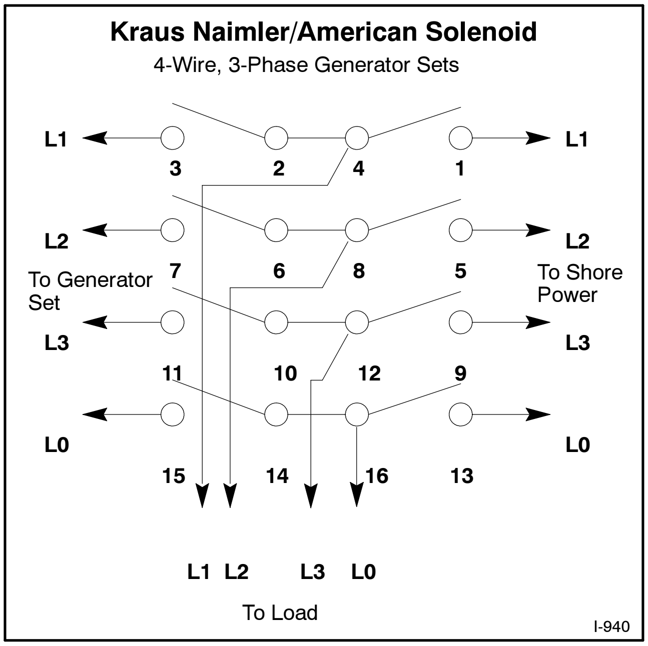


Figure 8-2 Marine Manual (Ship-to-Shore) Transfer Switch, continued

8.1 Twelve-Lead Reconnection

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

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

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

NOTICE

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

Twelve-Lead Reconnection Procedure

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

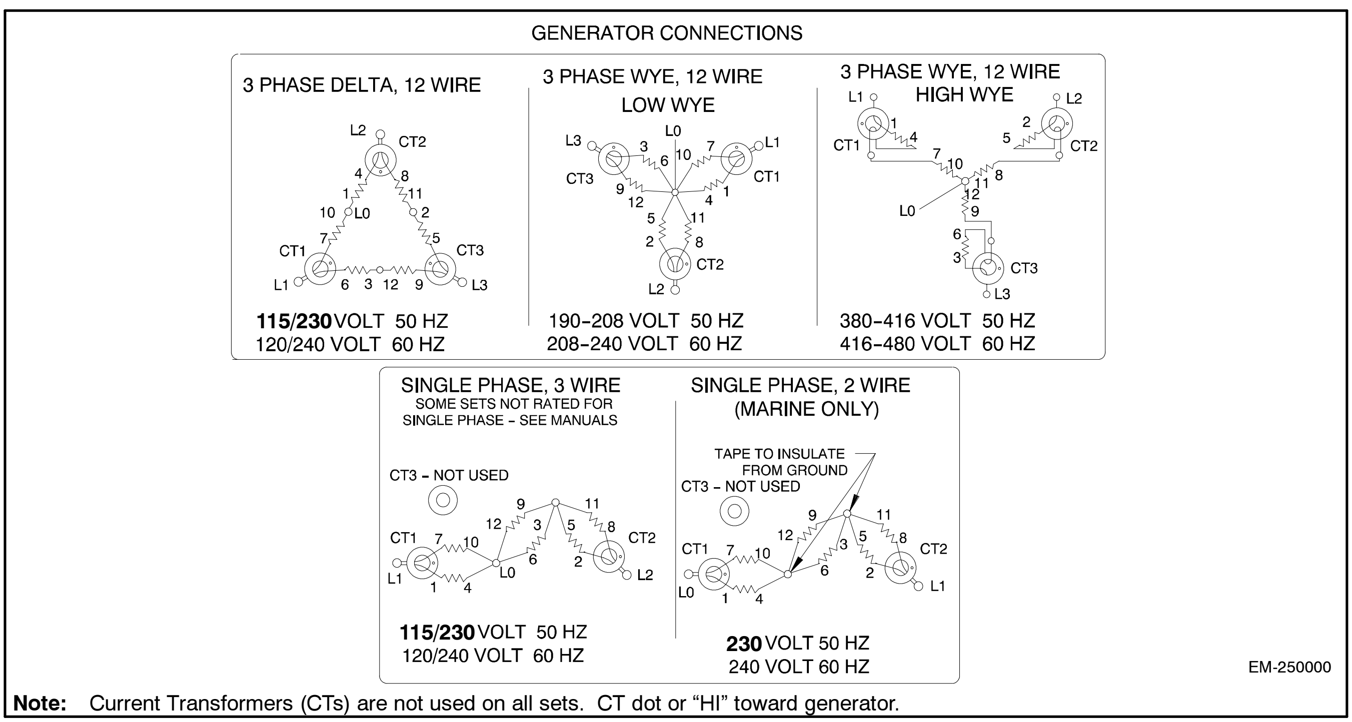
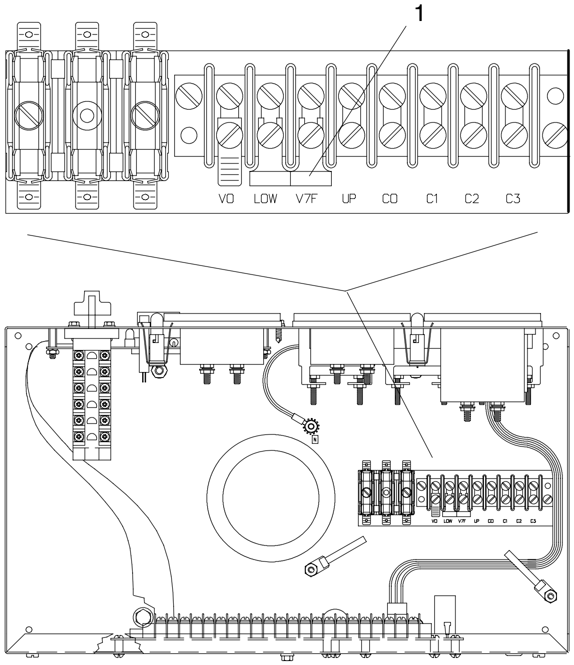


Figure 8-3 Generator Reconnection

Note: Position the current transformers with the dot or HI side CT marking toward the generator set.

Note: Only generator sets equipped with AC meter controllers and/or safeguard circuit breakers require CTs.

5. If the controller has meters, remove the controller cover and reposition the meter scale lamp jumper (see Figure 8-4) matching the position of the desired voltage (shown in Figure 8-3).



1. Lamp Jumper

Figure 8-4 Meter Scale Lamp Jumper

6. The overvoltage shutdown is standard on Decision-Maker™ 3+ controllers. The **139/240-volt (low wye)** and **277/480-volt (high wye)**, 3-phase, 4-wire, 60 Hz configurations use different overvoltage shutdown settings than all other configurations. Recalibrate the overvoltage shutdown if the reconnection changes the voltage to or from one of these configurations. See Section 8.3, Decision-Maker 3+ Controller, Overvoltage Shutdown Adjustment. Do not recalibrate the overvoltage adjustment for other voltage changes.

7. If the controller has meters, set the phase selector switch to the L1-L2 position (1-phase or 3-phase configuration depending on generator set connection). Connect a voltmeter across leads L1 and L2 if the controller has no meters.

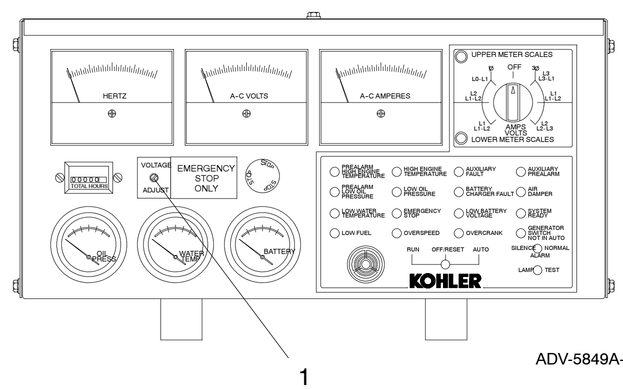
Note: **Equipment damage.** Verify that the voltage ratings of the transfer switch, line circuit breakers, and other accessories match the desired line voltage.

8. Reconnect the starting battery, negative (–) lead last. Place the generator set master switch in the RUN position to start the generator set. Observe the voltmeter and verify that the unit has the desired line voltage connection.

   Adjust the voltage using the voltage adjustment potentiometer on the generator controller front panel. See Figure 8-5.

9. Stop the generator set after completing the voltage adjustment.

10. Disconnect the external voltmeter if used. Replace the controller cover.



1. Output voltage adjustment potentiometer

Figure 8-5 Voltage Adjustment

This is bpid

8.2 Decision-Maker 3+ Controller (40-180EOZD/33-150EFOZD Models)

The Decision-Maker 3 + Controller had a change to the 16-light microprocessor controller circuit board. The new circuit board GM28725 is different in appearance and has additional functions but is a **direct replacement for earlier version circuit boards including A-336415**. Identify the new circuit board using the following items:

- Red circuit board as the previous versions are green.
- Terminal strips (TB1, TB2, and TB3)
- DIP switches (8 switches)
- Communication connector P21 for Modbus® or remote serial annunciator RS-485 communication
- Communication connector P22 for J1939 engine communication
- Downloading new application software

Note: After setting DIP switches to the generator set application, be sure to *power down* and then *power up* the controller (disconnect the battery and then reconnect the battery of the generator set) or use the prime power switch, if equipped. The controller will NOT acknowledge the DIP switch change until after the generator set controller is *powered up*.

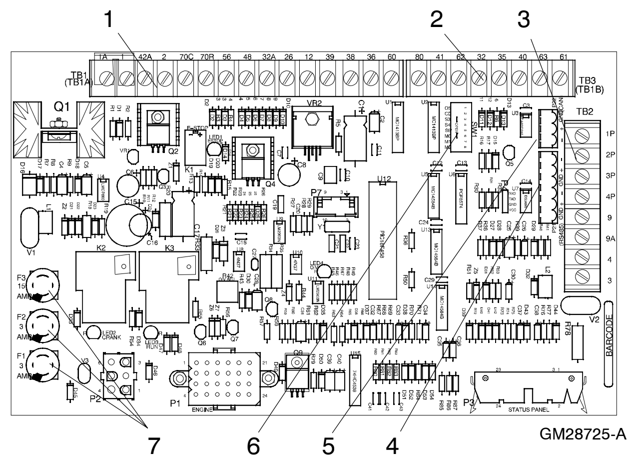
Features

The following information summarizes the features of the new circuit board.

Terminal Strips and Connections

Terminal Strip	Description
TB1/TB3	Terminal strip for connecting generator set accessories such as an emergency stop switch, a remote start/stop switch, audiovisual alarms, etc. Refer to the wiring diagrams for information on connecting accessories to the TB1 terminal strip.
TB2	Terminal strip for selecting the remote start/stop switch inputs and prime power mode.
P22	J1939 communication connection.
P21	Modbus® or remote serial annunciator RS-485 communication connection.

Figure 8-6 Controller Terminal Strips/Connections



1. TB1 (TB1A) terminal strip
2. TB3 (TB1B) terminal strip
3. TB2 terminal strip
4. P21 for Modbus® RS-485 communication connection
5. P22 for CAN (engine) communication connection
6. DIP Switches (8 Positions)
7. Fuses

Figure 8-7 Controller Circuit Board with DIP Switches

DIP Switches

The controller circuit board contains eight DIP switches, see Figure 8-7 and Figure 8-8. Push down the end of the DIP switch near the OPEN label to open the switch, or push down the other end to close it. See Figure 8-9. Be sure to select the correct DIP switch configuration for each generator set application.

Overspeed Frequency (DIP Switch 1). The generator set overspeed frequency is set using DIP switch 1. Select 70 Hz for 60 Hz voltages and 60 Hz for 50 Hz voltages.

Temperature Cooldown (DIP Switch 2). The generator set will continue to run during a five-minute cooldown cycle or shut down immediately. The choice is made using DIP switch 2.

Engine Cranking (DIP Switch 3). The controller is factory-set for cyclic cranking. To change the continuous cranking mode, use DIP switch 3.

Engine Configuration (DIP Switches 4 and 5). See Figure 8-8 for the DIP switch positions based on engine configurations regarding ECM, MDEC, and J1939 engine communication selections.

Modbus® Address (DIP Switches 6-8). Each Modbus® device requires a unique address. Address numbers are created using a binary number system with DIP switches 6-8. Figure 8-10 shows the DIP switch position for each address number.

Modbus® is a registered trademark of Schneider Electric.

Application Software Upgrade

Should a software upgrade be needed, use the KOHLER*net* to download program loader and application program software on your PC *as directed during troubleshooting and/or when adding specific accessories*.

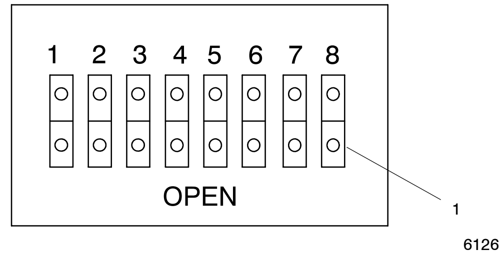
Go to www.KohlerNet.com and use your SecurID® to access the KOHLER*net* and click on the TechTools, Marine, Software to view the files to download.

If KOHLER*net* is not available, send an e-mail request to PowerSystemsTechTools@Kohler.com. The e-mail subject line must include text indicating Program Loader and Application Program Software.

Dip Switch	Description	Switch Position	
		Open	**Closed**
1	Overspeed selection	60 Hz	70 Hz
2	Temperature Cooldown Enable	Cooldown Disabled	Cooldown Functional
3	Crank Mode Selection	Cyclic	Continuous
4	Engine Comm. Setting	See selections for DIP switch 4 and DIP switch 5 below	
5	Engine Comm. Setting		
6	Modbus® Address Bit 0	Value = 0	Value = 2
7	Modbus® Address Bit 1	Value = 0	Value = 4
8	Modbus® Address Bit 2	Value = 0	Value = 8
4	No ECM	Open	
5		Open	
4	MDEC Comm.	Closed	
5	Isochronous	Open	
4	J1939 Comm.	Open	
5		Closed	
4	MDEC Comm.	Closed	
5	Variable Speed Governor (VSG)	Closed	

Figure 8-8 DIP Switch Functions

SecurID® is a registered trademark of RSA Security Inc.



1. Push this side down to open circuit.

Figure 8-9 DIP Switch Open Position

Modbus® Address	DIP Switches		
	6	**7**	**8**
	Value = 2	**Value = 4**	**Value = 8**
1	Open	Open	Open
3	Closed	Open	Open
5	Open	Closed	Open
7	Closed	Closed	Open
9	Open	Open	Closed
11	Closed	Open	Closed
13	Open	Closed	Closed
15	Closed	Closed	Closed

Figure 8-10 Modbus® Device Address

8.3 Decision-Maker 3+ Controller, Overvoltage Shutdown Adjustment (40-180EOZD/33-150EFOZD Models)

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

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

Overvoltage Shutdown Adjustment Procedure

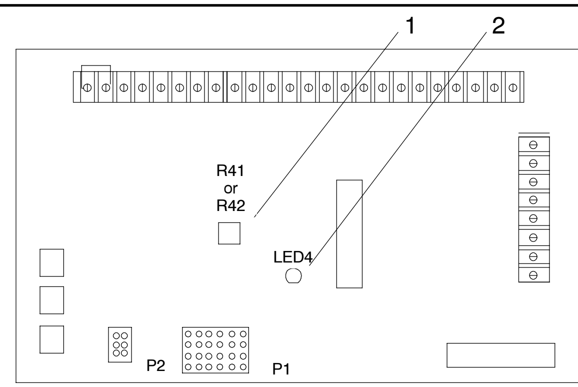
1. Disconnect the generator set engine starting battery, negative (-) lead first. Disconnect power to the battery charger (if equipped).
2. With the generator set shut down, open the output line circuit breaker to disconnect the load from the generator set.
3. Remove the controller cover.
4. Wrap the shaft of an insulated-handle screwdriver with electrical tape to insulate the metal shaft. Turn the overvoltage potentiometer (R41 or R42) on the main circuit board fully clockwise. See Figure 8-11.

Note: The overvoltage potentiometer is R41 or R42. R41 is found on A-336415 circuit boards. R42 is found on GM28725 circuit boards with the DIP switches and communication ports.

5. Connect a digital AC voltmeter (or other 1% minimum accuracy voltmeter) to terminals V0 and V7 on the controller terminal block. See Figure 8-4.
6. Reconnect the battery, negative (-) lead last.
7. Start the generator set by placing the generator set master switch in the RUN position.
8. Adjust the output voltage to 115% of the nominal output voltage using the voltage adjustment potentiometer. If the voltage configuration is 139/240 volts (low wye) or 277/480 volts (high wye), 3-phase, 4-wire, 60 Hz, adjust output voltage to 160 volts across terminals V0 and V7. For all other voltages, adjust the output to 140 volts across terminals V0 and V7.

   Adjust the voltage using the voltage adjustment potentiometer on the generator controller front panel. See Figure 8-5.

9. Use the insulated screwdriver to slowly rotate the overvoltage adjustment potentiometer (R41 or R42) counterclockwise until red LED4 lights. See Figure 8-11. The generator set should shut down on an overvoltage fault in approximately 2 seconds.



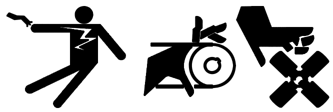
1. Overvoltage adjustment potentiometer (R41 or R42)
2. LED4 (red)

Figure 8-11 Overvoltage Shutdown Adjustment on Main Circuit Board

10. Turn the voltage adjustment potentiometer counterclockwise to reduce output voltage. Restart the generator set. Slowly increase the voltage by turning the voltage adjustment potentiometer clockwise. Verify the shutdown voltage point (115% of the nominal output voltage) by observing the voltmeter and noting when LED4 lights. The generator set should shut down on overvoltage fault in approximately 2 seconds. If the shutdown voltage point is not 115% of nominal voltage, repeat the calibration output procedure; otherwise, continue to step 11.
11. Turn the voltage adjustment potentiometer counterclockwise to reduce output voltage. Restart the generator set. Readjust the generator set output to the nominal voltage using the voltage adjustment potentiometer.
12. Stop the generator set by placing the generator set master switch in the OFF/RESET position. Seal the overvoltage adjustment potentiometer (R41 or R42) with RTV sealant or equivalent. Replace the controller cover.

Notes

⚠ WARNING

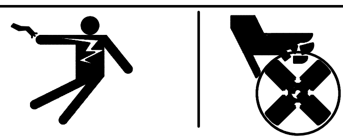


Accidental starting.
Can cause severe injury or death.

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 connected equipment, 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.

⚠ WARNING



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

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

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. 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

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

- Paralleling basics
- Configuring a generator set for parallel operation
- Setting up a generator set for parallel operation

9.1 Paralleling Basics

9.1.1 Why Parallel Generator Sets

Some reasons to parallel generator sets are:

- Redundancy
- Combine output power
- Peak sharing
- Soft transfers
- Increased reliability
- Greater flexibility

9.2 Paralleling Functions

9.2.1 Synchronizing

Before a generator set can operate in parallel with another generator set or the utility (shore power), 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

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

9.2.2 Real (kW) Load Control

Isochronous Load Sharing

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

Parallel to Utility (Shore Power)

When a generator set is paralleled to the utility (shore power), the load controller will monitor the generator set's kW output and adjust it based on its mode of operation and load control setpoints.

9.2.3 Reactive (kVAR) Control

Isolated Bus

When generator sets are paralleled, the voltage output of each generator set must be equal. Some type of 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. **Passive Control.** The voltage regulators are connected in droop or cross current compensation. There is no active control from the switchgear.
2. **Active Control.** The reactive load controller in the switchgear communicates (analog or digital) to the other reactive load controllers in the switchgear to maintain the same proportional kVAR output while maintaining the system's nominal voltage.

Parallel to Utility (Shore Power)

When a generator set is paralleled to the utility (shore power), the utility (shore power) sets the voltage and the generator set operates in VAR control mode or PF control mode. This can be programmed into the voltage regulator and activated by a contact closure in the switchgear or the paralleling switchgear can monitor the VAR/PF output of the generator set and actively control it.

9.2.4 Cross Current

Cross current compensation is used to divide reactive kVA equally between generators operating in parallel and is accomplished by a current transformer. Division of reactive kVA between AC generators operating in parallel is a function of generator excitation. When operating AC generators in parallel it is desirable to have the reactive kVA outputs of the individual generators be equalized. If the excitation levels (internal generated voltage levels) are not equal, the higher level generators will provide higher reactive load (kVARS) while lower level generators will provide lower reactive load and may even absorb reactive current. A CT is commonly used to sense the load current. A burden resistor across the CT converts the current signal to a voltage. This voltage is added, in series, to the voltage sensing signal. As load increases, the additional voltage causes the excitation level to droop. The CT is connected in a way to be more responsive to reactive load (kVAR) than real load (kW). This is called Reactive Droop. If the output for the CTs for all the generators are connected in series, each generator will see a signal indicating the difference from it's proportion of the total load. This is called Cross Current Compensation. If one generator is supplying more reactive load than the others, the signal will result in lower excitation or droop. If one generator is supplying less reactive load than the others, the signal will cause higher excitation. If all the generators are supplying equal proportions, the signals will be zero and no droop will occur.

9.3 Paralleling Considerations

9.3.1 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.

Line Circuit Breaker

If a generator set has a line circuit breaker, the line circuit breaker should have auxiliary contacts. The contacts are used to provide the paralleling switchgear with status information from this circuit breaker.

Often the switchgear manufacturer opens the paralleling breaker in the switchgear if the line circuit breaker opens and will not allow the generator set paralleling breaker in the switchgear to close if the line circuit breaker is open.

Speed Control

The speed control must accept an input from the paralleling controller. This is the way the paralleling switchgear adjusts the frequency and controls the power output of the generator set.

Verify the generator set ordered has the ability to accept a remote speed adjust input. If you are unsure of the input range, contact the factory. Some common speed adjust inputs:

- 0.5-4.5 VDC (JDEC)
- ±3 VDC (Woodward)

Voltage Regulator

The voltage regulator needs to be capable of accepting remote input for voltage adjustment. If not, utilize a reactive droop kit.

Parallel to Utility (Shore Power)

If the generator set will parallel to the utility (shore power), order the voltage regulator with a VAR/PF control option, if available. If this is not an option, ensure that there is a VAR/PF controller in the system.

Verify the generator set ordered has the ability to accept a remote voltage adjust input. If you are unsure of the input range, contact the factory. Some common voltage adjust inputs:

- Digital—Raise/Lower or Up/Down
- ±1 VDC
- ±3 VDC
- ±9 VDC
- 4-20mA

9.3.2 Generator Set Protection

Reverse Power Relay

A reverse power relay senses the direction of power flow. One is connected in each generator circuit as a protective device. If any unit in the system has a malfunction causing current 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 as a motor, causing extensive damage to the unit.

Ground Fault Protection

If ground fault protection is required on the generator set mounted line circuit breaker and it is to be paralleled with other generator sets, coordinate the overall system grounding scheme.

Differential Protection

Differential (87) protection is used to detect when the current flow between two points is not the same. Generator set differential protection is done with the CTs mounted on the neutral side of the generator set windings and the CTs in the paralleling switchgear.

9.3.3 Supervisory Control (Paralleling Gear)

Stopping and Starting Generator Set

The paralleling switchgear must be able to start and stop the generator set. A set of normally open contacts in the switchgear is wired to the engine remote start/stop input.

Frequency and Real (kW) Power

Depending on the state of the paralleling breaker, the paralleling switchgear controls the frequency or kW output of the generator set by sending a signal to the generator set's speed control.

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

Voltage and Reactive (kVAR) Power

The paralleling switchgear controls the generator set's output voltage in one of two ways:

1. In an analog application, sends an analog signal to the voltage regulator's remote adjust input.
2. In a digital application, closes normally open contacts wired to the voltage regulator's remote raise or lower input.
3. The voltage may be controlled via communications in some instances.

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

- **Paralleling Breaker Open.** If the paralleling breaker is open, the output voltage will change. This would be the case while synchronizing.
- **Paralleling Breaker Closed.** If the paralleling 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.

Generator Set Configuration

When a generator set is used for paralleling, it is important that it is configured for parallel operation.

Note: Coordinate the configuration of the generator set with the paralleling switchgear manufacturer.

Engine Run Relay (ERR)

The engine run relay provides the paralleling switchgear status information about the generator set and is often used as an interlock with the generator set paralleling breaker. The generator set paralleling breaker will trip (not be allowed to close) if the engine running relay is not energized.

9.4 Configuration Quick Checklist

- ❑ Generator set mounted line circuit breaker has auxiliary contacts.
- ❑ Generator set speed controller will accept input from a load control device.
- ❑ Voltage regulator can operate in droop mode and, if required, droop kit has been ordered. Voltage regulator is capable of accepting a remote voltage adjust input.
- ❑ If system parallels to the utility (shore power), voltage regulator has an internal VAR/PF controller or is capable of accepting a remote voltage adjust input.
- ❑ Generator set dry contacts kits/wiring have been coordinated with the paralleling switchgear manufacturer.

9.5 Engine Speed Biasing

9.5.1 Overview

There are two basic methods used to parallel generator sets. The first method is droop, where speed decreases with load. The second method is isochronous, where speed remains constant.

Isochronous

Isochronous means equal in length of time. Isochronous type governors maintain constant speed regardless of changing load.

Droop

Droop means a drop or decrease in speed and/or voltage. A certain amount of speed droop is desirable to prevent hunting. Voltage must droop with generators connected in parallel to lagging power factor loads but it must be balanced to allow proper load sharing.

Engine Speed (Frequency) Bias		
Generator Set Model	**Decision-Maker™ 3+ with FRII Enhanced Voltage Regulator**	**Decision-Maker™ 550 with Standard 0-5 VDC**
40EOZD 33EFOZD	See Section 9.5.2	
55EOZD 40EFOZD	See Section 9.5.3 and See Figure 9-25	See Section 9.5.3 and See Figure 9-26
65EOZD 50EFOZD		
80EOZD 70EFOZD		
99EOZD 80EFOZD		
125EOZD 100EFOZD		
150EOZD 125EFOZD		
180EOZD 150EFOZD		

Figure 9-1 Reference Table for Engine Speed (Frequency) Bias

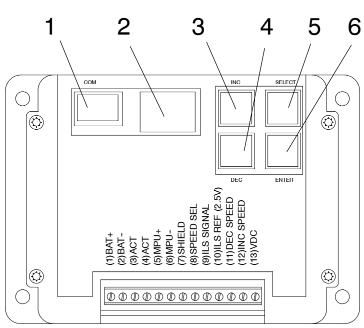
9.5.2 Overview Paralleling (40EOZD/33EFOZD)

Features and Specifications

The microprocessor-based, digital isochronous governor allows adjustment of set speed and gain. Other adjustments include acceleration, deceleration, ramp rates, idle speed set, and hold time. The COMM port provides simple programming when connected to the user's PC. See Figure 9-2 for specifications and Figure 9-3 for governor controller illustrations.

Specifications	Value
Maximum controlled output current	7 amps
Maximum current surge	14 amps for 10 seconds
Input signal from magnetic pickup	2.0 VAC RMS min. during cranking
Ambient operating temperature	-40°C to +85°C (-40°F to +185°F)
Environmental protection	Oil, water, dust resistant via conformal coating and die cast enclosure
Electrical connections	Euro-style terminal strip
ILS input voltage measurement range	2.375-2.625 VDC
ILS input speed adjust range	±3% around the set speed
Droop adjustment range	0-10% of the set speed
Droop setting resolution	Tenth of a percent

Figure 9-2 Specifications



GM17644-B

1. RJ11 connector
2. LED display
3. Increase
4. Decrease
5. Select
6. Enter

Figure 9-3 Governor Controller Functions

Other features include:

- 0.25% frequency control.
- Reverse battery protection.
- 9-30 VDC input.
- Smoke control on startup.
- Serial communication port.
- Droop operation with 0%-10% set speed with 0.10% resolution.
- Parallel input.
- Speed adjustment and voltage measurement ranges.

Keypad Functions

The governor controller keypad provides functions as described below. Refer to Figure 9-3 illustrations.

All values can be changed using the governor controller keypad on paralleling models.

Paralleling Model

The user interface operates in two modes—Parameter Select Mode and Parameter Edit Mode.

The Parameter Select Mode provides the user selection of viewing and editing parameters. This mode is active when the 2-digit value display is flashing (blinks). The value is the parameter identification (ID) number. The governor controller label lists each user-adjustable parameter and the corresponding ID number.

The Parameter Edit Mode provides the user with the selected parameter's value and allows the changing of a value. This mode is active when the 2-digit value display is steady on. The value displayed is the selected parameter's current value. The decimal point display has several meanings:

- Decimal point flashing indicates the value can be edited.
- Decimal point not flashing indicates the value cannot be edited. The selected parameter is locked and values are viewable only. This situation occurs when the password protection is active and the unlocking code has not been entered.
- The right digit's decimal point is ON—the lower two digits of a parameter's 4-digit value are displayed.
- The left decimal point is ON—the greater two digits of a parameter's value are displayed. The upper two digits of a parameter are always view only and cannot be modified directly. The upper two digits will change when the lower digits transition from 99 upward or 00 downward.

The keypad consists of four pushbuttons—Enter, Select, INC, and DEC. See Figure 9-4 for a summary of functions by mode selection.

Parameter Select Mode	
LED Display	The ID number of a parameter listed on the label is flashing.
INC key	Increase the parameter ID number by 1.
DEC key	Decrease the parameter ID number by 1.
Select key	Activate the Parameter Edit Mode on the parameter number flashing.
Enter	Display the version number of the governor's programming.
INC and DEC simultaneously	Turn on all LED segments as a test.
Parameter Edit Mode	
LED Display	The value of the selected parameter is displayed. A flashing decimal point indicates the value can be changed.
INC key	Increase the selected parameter's value.
DEC key	Decrease the selected parameter's value.
Select key	Return to Parameter Select Mode and ignore the changes made to the parameter value.
Enter	Save the parameter's new value and return to the Parameter Select Mode.
INC and DEC simultaneously	Use to display the upper digits of values greater than 99.

Figure 9-4 Keypad Function Summary

Enter key. Use the Enter key to exit the Parameter Edit Mode and return to the Parameter Select Mode while the new value gets saved to nonvolatile memory. In the Parameter Select Mode, pressing the Enter key displays the version number of the governor's programming.

Select key. Use the Select key to enter the Parameter Edit Mode from the Parameter Select Mode after a particular parameter has been selected for editing.

Also use the Select key to escape the Parameter Edit Mode and return to the Parameter Select Mode without saving a change in the parameter's value. The parameter value reverts back to the value present when the Parameter Edit Mode was entered.

INC (Increase) key. Use the INC key to increase the displayed parameter ID or value depending upon mode selection.

In the Parameter Select Mode, each press of the INC key causes the display of the next higher parameter ID. After the maximum parameter ID is reached, the display loops back to the first display.

In the Parameter Edit Mode, each press of the INC key increases the current value. Holding the INC key down automatically causes the values to rise at an increasing rate until the INC key is released or the parameter's maximum value is reached.

DEC (Decrease) key. Use the DEC key to decrease the displayed parameter ID or value depending upon mode selection.

In the Parameter Select Mode, each press of the DEC key causes the display of the next lower parameter ID. After the minimum parameter ID is reached, the display loops back to the last display.

In the Parameter Edit Mode, each press of the DEC key decreases the current value. Holding the DEC key down automatically causes the values to fall at an increasing rate until the DEC key is released or the parameter's minimum value is reached.

INC and DEC keys together. In the Parameter Select Mode, pressing and holding the two keys at the same time causes the LED segments to go ON. This serves as a test for the LED segments. Release the keys to resume displaying the parameter ID number.

In the Parameter Edit Mode, pressing and holding the two keys at the same time permits viewing the upper two digits of a 4-digit number. The left digit's decimal point is turned on indicating that the thousands and hundreds digits are displayed.

Note: Not all parameters have four digit values, in which case the upper digits will display 0.0 (zero decimal point zero).

Release the keys and the tens and ones digits are again displayed. The right digit's decimal point is flashing when editing is allowed or steady on indicating that editing is not allowed.

LED Display Functions (Paralleling Model only)

The governor controller LED display provides two 7-segment LEDs with digit's corresponding decimal point to display values and indicate mode of operation. Refer to Figure 9-3 illustration for the paralleling model.

When the LED display value flashes, the Parameter Select Mode is active.

When the LED display value is steady on, the selected parameter's value is displayed and the user interface is in the Parameter Edit Mode. The decimal points also indicate which half of a 4-digit value is displayed and whether editing is allowed.

The right digit's decimal point indicates that the lower 2 digits of a value (tens and ones) are displayed. When the right decimal point flashes, the values can be changed using the INC and DEC keys. When the right digit is steady on, no editing is allowed or is password protected.

The left digit's decimal point indicates that the upper 2 digits of a value (the thousands and hundreds) are displayed. The greater 2 digits are always view only so the right decimal point does not flash.

When values exceed four digits, the LED display uses the hexadecimal numbering system to represent the value of the thousands position. See Figure 9-5 and the following examples.

Note: For generator set applications, the values will not exceed 9999. This text is for informational purposes only in the event that a value is inadvertently entered above 9999.

Decimal Value	Hexadecimal Equivalent
10	A
11	B
12	C
13	D
14	E
15	F

Figure 9-5 Decimal to Hexadecimal Conversion Chart

Example A

The desired set value is 10069 Hz. The upper two digits should display A.0 and the lower two digits should display 69.

Example B

The desired set value is 10972 Hz. The upper two digits should display A.9 and the lower two digits should display 72.

Terminal Descriptions:

No.	NAME	FUNCTION
1	BAT+	Battery positive (9-30 VDC) *
2	BAT-	Battery negative *
3	ACT	Actuator drive output
4	ACT	Actuator drive return
5	MPU+	Magnetic pickup signal input
6	MPU-	Magnetic pickup ground
7	SHIELD	Ground connection for cable shielding
8	SPEED SEL	Digital input used to select the target set speed
9	ILS SIGNAL	ILS input used to adjust speed ±3%
10	ILS REF (2.5V)	Supply voltage around which ILS operates
11	DEC SPEED	Digital input used to decrease the selected set speed remotely
12	INC SPEED	Digital input used to increase the selected set speed remotely
13	+5 VDC OUT	Supply voltage for the digital inputs

* DC power bus cable must be less than 10 m (32.8 ft.).
All other cables must be less than 30 m (98.43 ft.).

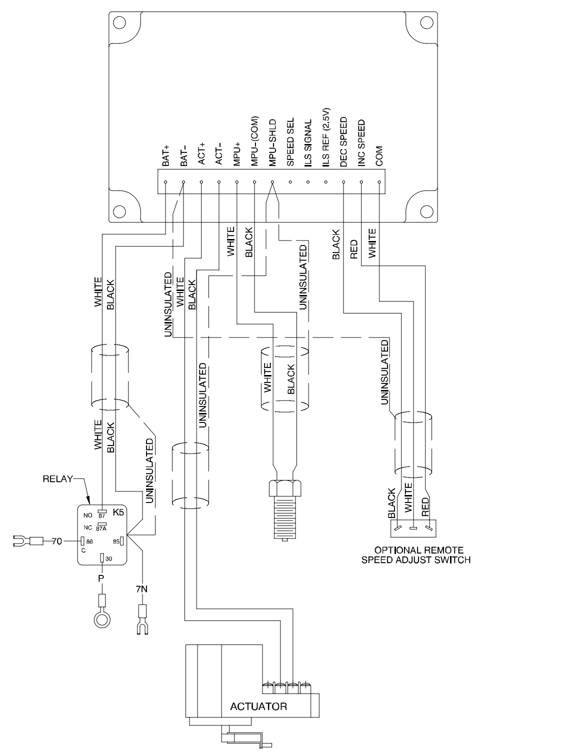


Figure 9-6 Typical Governor Control Schematic

Troubleshooting

See **Appendix D, Diagnostics and Troubleshooting,** for help in diagnosing generator set/engine problems relating to the governor controller.

Appendix A Parameter Definitions

Use this appendix for definitions of each of the calibration values. **Appendix B, Parameter Defaults Reference** lists the default settings.

When changing values using the keypad, the KPST software display on the user's PC will not automatically update. To refresh the KPST software display, the user must select a different parameter with the PC mouse and then go back to the desired value. The KPST software provides *Read All* button that will refresh all of the parameter values.

1. **Number of flywheel teeth.** Enter the value from the Governor Parameter Summary. This display is not required. Displayed speeds can be changed between Hz and rpm.

2. **Set Speed A.** Enter the value from the Governor Parameter Summary.

3. **Set Speed B (paralleling model only).** Use the default value.

4. **Idle Speed.** Enter the value from the Governor Parameter Summary.

5. **Proportional.** Enter the value from the Governor Parameter Summary.

   A speed change creates a speed error (the difference between the target speed and the actual speed.) The Proportional gain controls the size of the governor output response to a step change in the speed error. See Figure 9-7.

6. **Integral.** Enter the value from the Governor Parameter Summary.

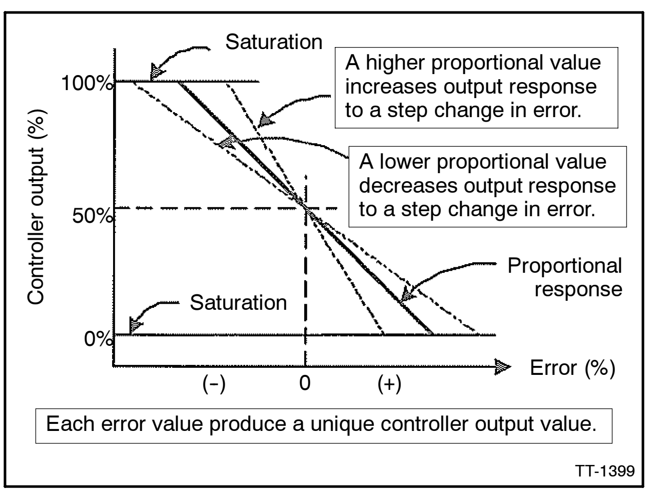


Figure 9-7 Proportional Value

The Integral value acts to drive the speed error to zero. In a Proportional only control with constant load, there will be a constant speed error that inversely relates to the Proportional gain of the system.

The Integral value is key to isochronous speed control. This value eliminates the difference between the programmed set speed and the actual speed. The Integral gain changes the time it takes to drive the error to zero. The Integral value eliminates the speed offsets due to Proportional gain and should not be set to zero. See Figure 9-8.

7. **Derivative.** Enter the value from the Governor Parameter Summary. See Figure 9-9.

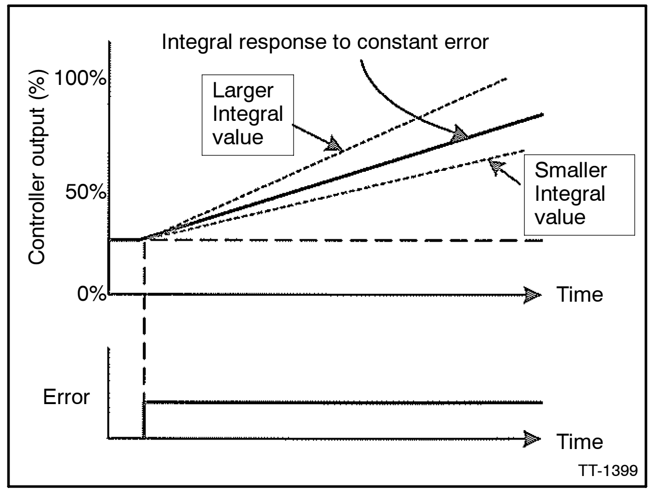


Figure 9-8 Integral Value

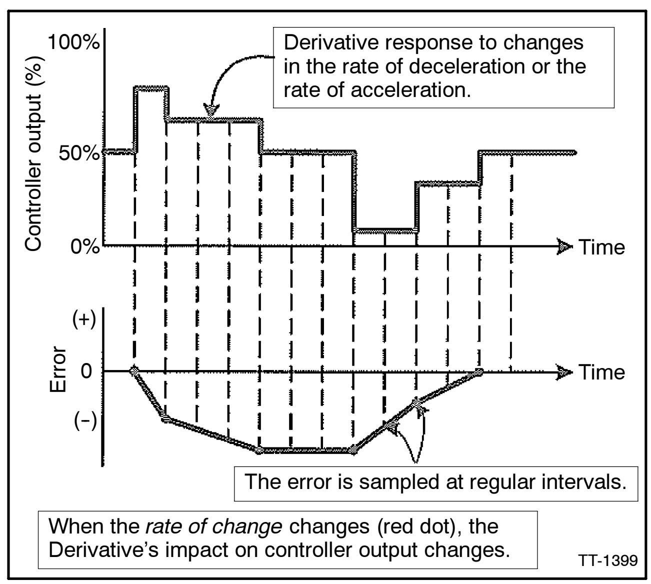


Figure 9-9 Derivative Value

The Derivative responds to the rate of change in the speed error. This parameter is primarily used to dampen very rapid oscillations resulting from large speed changes. The Derivative responds to engine acceleration or deceleration. When the engine speed approaches the target speed at a fast rate, the Derivative acts to minimize or eliminate overshoot. A zero value is allowed but systems typically require some Derivative gain to improve overall engine speed control.

8. **Overall Gain (OVG) @ Set Speed A.** Set the default setting from the Governor Parameter Summary.

   This gain value acts as a multiplier on the three Proportional, Integral, and Derivative (PID) values of Speed A.

9. **Overall Gain (OVG) @ Set Speed B (paralleling model only).** Use the default value.

   This gain value acts as a multiplier on the three PID values of Speed B.

10. **Overall Gain (OVG) @ Idle.** Enter the value from the Governor Parameter Summary.

    This gain value acts as a multiplier on the three PID values when the idle speed is the active target speed. The idle speed set point is active only during startup when the Idle Hold Timer is running.

11. **Gain Factor.** Enter the value from the Governor Parameter Summary.

    The Gain Factor permits more range of adjustment from the PID values. When any of the PID reaches their adjustment limit, the Gain Factor can be modified for more range of the PID and OVG values.

12. **Speed Filter.** Enter the value from the Governor Parameter Summary.

    Value indicates the number of speed signal pulses to use when calculating an average engine speed and is used to dampen out speed measurement variations that can make PID tuning difficult.

    Too much filtering slows down the governor's response to speed change and too little filtering can make the governor overly sensitive and tuning difficult. As a general rule, less filtering is needed when the number of engine cylinders increases because there is less time for the engine speed to slow down before the next engine cylinder firing.

    Note: Use 24 for three- or four-cylinder engines and 16 for six- or eight-cylinder engines.

13. **Idle Hold Time.** Use the default value.

    The Idle Hold Time specifies how long after starting the engine stays at idle speed before finishing the ramp to the target speed. The time value has a resolution of one-tenth of a second.

    During the startup sequence, the governor increases the engine speed from the engine's crank speed to the active target speed at the Startup Rate specified. When the Idle Hold Time is nonzero, the initial target speed will be the idle speed. After the Idle Hold Time times out, the governor uses the Startup Rate to ramp the engine to the selected Set Speed (A or B). The startup sequence is complete after the engine speed reaches the specified set speed.

14. **Accel Rate.** Use the default value.

    This value specifies how fast the governor should increase the engine's speed when a new higher speed is made active.

15. **Decel Rate.** Use the default value.

    This value specifies how fast the governor should decrease the engine's speed when a new higher speed is made active.

16. **Startup Rate.** Enter the value from the Governor Parameter Summary.

    This value achieves a smooth controlled engine start. On diesel engines, this value minimizes exhaust smoke at startup. When used in conjunction with the idle speed and Idle Hold Time, a brief warmup cycle can be programmed.

    The Startup Rate specifies how fast the governor should increase the engine speed when the engine is started. The governor increases the engine speed from the engine's crank speed to the active target speed at the rate specified. The governor brings the engine to the idle speed for the Idle Hold Time, then continues increasing the engine speed at this same ramp rate until the engine reaches the selected target speed (Set Speed A or B).

    Note: In cases where the target speed is less than the idle speed and the Idle Hold Time is nonzero, the startup ramp sequence ends when the idle speed is reached. The Decel Rate is then used to ramp the engine speed down to the target speed from the idle speed.

The ramp up pauses at the Startup Speed until the governor senses an magnetic pickup (MPU) signal greater than the Startup Speed. This prevents the startup ramp from reaching completion before the engine has started.

The governor treats MPU frequencies below the Startup Speed as an indication that the engine is cranking but has not yet started. The governor treats MPU frequencies above the Startup Speed as an indication that the engine has started and the governor increases the engine speed until the selected set speed is reached.

Note: In cases where the target speed is less than the Startup Speed, the startup ramp sequence ends when the target speed is reached.

During the startup sequence, the governor increases the engine speed from the engine's crank speed to the active target speed at the Startup Rate specified. When the Idle Hold Time is nonzero, the initial target speed is the idle speed. After the Idle Hold Time times out, the governor uses the Startup Rate to ramp the engine to the selected set speed (Set Speed A or B). The startup sequence is complete after the engine speed reaches the selected set speed.

17. **Startup Limit (paralleling model only).** Use the default value.

The Startup Limit parameter limits the fuel supplied to the engine during startup. This value is useful in reducing smoke when starting diesel engines.

Note: The engine may not start if the value is set too low.

18. **Torque Limit (paralleling model only).** Use the default value.

The Torque Limit parameter limits the fuel supplied to the engine during heavy generator set loads or generator set overloads.

Note: The engine may not be able to carry its rated load if the value is set too low.

19. **Integral Low Limit.** Use the default value.

The Integral Low Limit value reduces underspeed duration after a long or sustained overspeed condition was present. The low limit helps reduce the duration and amount of engine underspeed by maintaining a minimum actuator position.

Note: Setting an improper value can prevent the governor from reaching target speed.

20. **Integral High Limit.** Enter the value from the Governor Parameter Summary.

The Integral High Limit value reduces overspeed duration after a long or sustained underspeed condition was present. The high limit helps reduce the duration and amount of engine overspeed by maintaining a maximum actuator position.

Note: Setting an improper value can prevent the governor from reaching target speed.

21. **Percent (%) Droop (paralleling model only).** Use the default value.

The percent droop value selects droop mode operation and specifies the percentage of droop required. When the percent droop parameter is set to zero (default setting), droop is not active. Droop mode is active when this parameter is set to any value from 1 to 100, which corresponds to 0.1% to 10.0% droop. The following formula determines the no load droop speed:

[(selected_set_speed)/((1000-value_of_%_DROOP)/1000)] = no_load_droop_speed

For example: If 5% droop is desired, set the percent droop value to 50. Now if the selected set speed is 1800 rpm then the no load droop speed will be:

[(1800 rpm)/((1000-50)/1000)] = 1800 rpm/0.95 = 1895 rpm

Note: This value can only be changed during the Droop Calibration Procedure detailed in Appendix C.

Droop mode relies on knowing the actuator position. The actuator's position corresponds to the amount of fuel being delivered to the engine. The governor controller senses electrical current flow through the actuator to determine its position. This method of position sensing does not work with all actuators.

22. **No Load Calibration (paralleling model only).** Use the default value.

    The No Load Calibration value is determined during the Droop Calibration Procedure and should not be set manually. Once calibrated, the no load calibration value indicates the percentage of electrical current, relative to the measurable maximum, that must flow through the actuator to run the engine at the no load droop speed.

    The factory default value is zero, so if droop mode is used, this parameter must be calibrated. The no load calibration value must be less than the full load calibration value for proper droop operation. If after performing the Droop Calibration Procedure the no load calibration value is greater than the full load calibration then the droop function cannot be used. Some actuators may have a current versus position curve that is incompatible with this governor controller's method of determining actuator position.

    Note: This value can only be changed during the Droop Calibration Procedure detailed in Appendix C.

23. **Full Load Calibration (paralleling model only).** Use the default value.

    The Full Load Calibration value is determined during the Droop Calibration Procedure and should not be set manually. Once calibrated, the full load calibration value indicates the percentage of electrical current, relative to the measurable maximum, that must flow through the actuator to run the engine at the selected set speed when a full load is being applied to the generator.

    The factory default value is 1000, so if droop mode is used, this parameter must be calibrated. The full load calibration value must be greater than the no load calibration value for proper droop operation. If after performing the Droop Calibration Procedure the full load calibration value is less than the no load calibration value then the droop function cannot be used. Some actuators may have a current versus position curve that is incompatible with this governor controller's method of determining actuator position.

    Note: This value can only be changed during the Droop Calibration Procedure detailed in Appendix C.

24. **Password.** Use the default value.

    The password feature provides protection against inadvertent parameter changes that can occur when keys are pressed and a parameter modification is not intended. The password parameter has three possible settings: Disabled, Locked, and Unlocked.

    Disabled. This setting turns off any password protection. Use this setting if password protection is not desired. This is the default setting from the factory. Enter a value of 99 to set the password protection parameter to the Disabled mode.

    Paralleling model only. When the password protect parameter is selected, the governor controller LED display shows *Pd* for 2 seconds, indicating the password-disabled mode; then the value *00.* is displayed. The user can then edit the value.

    Locked. This setting means that password protection is active and only parameter viewing is allowed (parameter editing is disabled). Enter a value of 22 to set password protection to the Locked mode.

    Paralleling model only. For 2 seconds after selection of the password protection parameter, the LED display shows *PE* for this mode and the rightmost decimal point will be steady ON (not flashing), then the value *00.* is displayed. The user can edit the value.

    Unlocked. This setting means that password protection is active but parameter editing is allowed.

    Paralleling model only. Entering a value of *30* in the Locked mode will unlock parameter editing. The user is free to edit parameters. If there is no governor controller keypad activity for 5 minutes, the governor controller returns to the Locked mode. If not already in the Unlocked mode, the user must get into the Unlocked mode in order to enter *99* to disable password protection.

25. **Overspeed limit.** Use the default value.

    This value determines the engine speed that triggers the governor output minimum fuel. The parameter's value is in terms of a percentage over the highest set speed.

    Note: The governor controller must be turned off to clear the overspeed detection before the engine can be restarted.

26. **Set Speed A Min.** Enter the value from the Governor Parameter Summary.

    Use Set Speed A minimum to set the lowest value allowed for adjustments of Set Speed A.

27. **Set Speed A Max.** Enter the value from the Governor Parameter Summary.

    Use Set Speed A maximum to set the highest value allowed for adjustments of Set Speed A.

28. **Set Speed B Min. (paralleling model only).** Enter the value from the Governor Parameter Summary.

    Use Set Speed B minimum to set the lowest value allowed for adjustments of Set Speed A.

29. **Set Speed B Max. (paralleling model only).** Enter the value from the Governor Parameter Summary.

    Use Set Speed B maximum to set the highest value allowed for adjustments of Set Speed A.

30. **Idle Speed Min.** Enter the value from the Governor Parameter Summary.

    The idle speed minimum value is the lowest value allowed for adjustments of idle speed.

31. **Idle Speed Max.** Enter the value from the Governor Parameter Summary.

    The idle speed maximum value is the lowest value allowed for adjustments of idle speed.

32. **Duty Cycle Limit.** Enter the value from the Governor Parameter Summary.

    The duty cycle maximum value sets the absolute maximum amount of drive signal to the actuator and serves as a mechanism for fuel limiting. Fuel limiting is achieved by setting the maximum duty-cycle or ontime allowed during one cycle of the pulse width modulation (PWM) signal controlling the actuator drive circuit.

33. **Startup Speed.** Use the default value.

    The Startup Speed value allows the governor to determine whether the engine is cranking or running whenever an engine speed signal is present.

    The Startup Speed value should be at least 10% higher that the fastest engine cranking speed but lower than the engine's idle speed.

    If the Startup Speed is too low (less than crank speed) the governor's target speed is ramped to the active Set Speed (Idle, Set Speed A or B) before the engine has started. When the engine does not start, it may overspeed or output excessive smoke because the startup ramp, having already completed, no longer controls the rate of engine speed increase.

    If the Startup Speed is too high (above the active set speed) then the Startup Speed becomes the target speed that the governor must reach before the governor considers the startup sequence complete. Typically, the startup sequence ends when the engine speed reaches the active set speed. The active set speed is the idle speed if the Idle Hold Time parameter is a nonzero value or the selected set speed (either Set Speed A or B).

34. **Startup Duty Cycle.** Enter the value from the Governor Parameter Summary.

    The Startup Duty Cycle value is used to preload the PID values with a PWM duty cycle value that provides an actuator output signal sufficient to allow enough fuel to idle the engine.

    If the Startup Duty Cycle value is too low, the engine crank time may be longer than desired because the governor's actuator output starts from a value much smaller than needed to begin opening the fuel valve.

    If the Startup Duty Cycle value is too high, the engine may overspeed because the actuator opens more that needed to start the engine.

Appendix B Parameter Defaults Reference

Parameter Minimum/Maximum Values

No.	Parameter Name	Paralleling Only	Minimum	Maximum
1	No. of flywheel teeth		0	572
2	Set Speed A (Hz)		Set Speed A Min.	Set Speed A Max.
3	Set Speed B (Hz)	Yes	Set Speed B Min.	Set Speed B Max.
4a	Idle Speed (Hz)		Idle Speed Min.	Idle Speed Max.
4b	Idle Speed (Hz)	Yes	Idle Speed Min.	Idle Speed Max.
5	Proportional		1	99
6	Integral		0	99
7	Derivative		0	99
8	OVG @ Set Speed A (gain potentiometer)	Yes	1	99
9	OVG @ Set Speed B	Yes	1	99
10	OVG @ Idle		1	99
11	Gain Factor		1	99
12	Speed Filter		1	24
13	Idle Hold Time (sec.)		0	9999
14	Accel Rate (Hz/sec.)		1	11000
15	Decel Rate (Hz/sec.)		1	11000
16	Startup Rate (Hz/sec.)		1	11000
17	Startup Limit	Yes	0	1000
18	Torque Limit	Yes	0	1000
19	Integral Low Limit		0	Integral High Limit
20	Integral High Limit		Integral Low Limit	99
21	% Droop	Yes	0	100
22	No Load Calibration	Yes	0	1000
23	Full Load Calibration	Yes	0	1000
24	Password		0	99
25	Overspeed limit (Hz)		0	6000
26	Set Speed A Min. (Hz)		10	Set Speed A
27	Set Speed A Max. (Hz)		Set Speed A	11000
28	Set Speed B Min. (Hz)	Yes	10	Set Speed A
29	Set Speed B Max. (Hz)	Yes	Set Speed B	11000
30	Idle Speed Min. (Hz)		10	Idle Speed
31	Idle Speed Max. (Hz)		Idle Speed	11000
32	Duty Cycle Limit		10	95
33	Startup Speed (Hz)		10	11000
34	Startup Duty Cycle		5	95

Parameter Default Settings

No.	Parameter Name	Paralleling Only	Default Settings
1	No. of flywheel teeth		0
2	Set Speed A (Hz)		1000
3	Set Speed B (Hz)	Yes	1000
4a	Idle Speed (Hz)		–
4b	Idle Speed (Hz)	Yes	500
5	Proportional		1
6	Integral		0
7	Derivative		0
8	OVG @ Set Speed A (gain potentiometer)	Yes	20
9	OVG @ Set Speed B	Yes	20
10	OVG @ Idle		20
11	Gain Factor		1
12	Speed Filter		16
13	Idle Hold Time (sec.)		0
14	Accel Rate (Hz/sec.)		1000
15	Decel Rate (Hz/sec.)		1000
16	Startup Rate (Hz/sec.)		1000
17	Startup Limit	Yes	1000
18	Torque Limit	Yes	1000
19	Integral Low Limit		0
20	Integral High Limit		99
21	% Droop	Yes	0
22	No Load Calibration	Yes	0
23	Full Load Calibration	Yes	1000
24	Password		0
25	Overspeed limit (Hz)		6000
26	Set Speed A Min. (Hz)		1000
27	Set Speed A Max. (Hz)		5000
28	Set Speed B Min. (Hz)	Yes	1000
29	Set Speed B Max. (Hz)	Yes	5000
30	Idle Speed Min. (Hz)		500
31	Idle Speed Max. (Hz)		5000
32	Duty Cycle Limit		10
33	Startup Speed (Hz)		1000
34	Startup Duty Cycle		5

Appendix C Calibration Instructions

Basic Adjustments

The governor controller is programmed at the factory with default setting parameter settings. These settings allow the controller to operate but usually require some further adjustments to obtain the best system performance. In order to bring the engine up to a single speed for the first time, the user needs to adjust the parameters shown in Figure 9-10. Use the Calibration Instructions only when the Governor Parameter Summary does **not** include a specific generator set/ engine combination.

The parameters listed in Figure 9-10 are the primary items to get the governor controller tuned and the engine running smoothly. It is recommended that the default settings in Figure 9-10 be initially used and then adjusted to satisfy the generator set/engine application. Leave all other parameters at their default settings until the primary parameter settings are determined.

Note: To use droop, a calibration sequence must be performed first.

Calibration Techniques

After the engine is running, use the following procedure to determine optimum values for the Proportional, Integral, and Derivative (PID) values and the Overall Gain Parameters (OVG). The goal is to find PID values that allow the governor controller to govern the engine optimally at all loads while only requiring gain adjustment. Use the following steps:

1. Calibration Procedure.

   The governor controller default programming provides the values shown in Figure 9-10. It is recommended to connect a load bank to the generator set in an effort to provide varying loads.

   Note: Steps 1.f. through 1.j. require varying the generator set load to cause engine speed changes. Start with small load variations and continue with greater load changes to provide a better overall performance test.

   With Integral, a speed error may persist after a load-on load-off transition. During steps 1.c. through 1.i., temporarily increase the Integral to get the engine speed back to the set speed, and then reset the Integral to a lower value again while working to find good Proportional and Derivative values.

   Repeat steps 1.f. through 1.k. as needed to find Proportional, Integral, and Derivative values that work well with a variety of overall gain values and different load transients. See Figure 9-11.

   a. Open the line circuit breaker to disconnect the load from the generator set.

   b. Place the generator set master switch in the RUN position to start the generator set.

   c. Set the Set Speed A to 1800 rpm for 60 Hz models and 1500 rpm for 50 Hz models.

   d. Set the Integral and Derivative values to 0.

   e. Set the Overall Gain low (less than 20).

   f. Increase the Proportional value until the engine shows continuous oscillations greater than 2 Hz.

   g. Reduce the Proportional value by 25%–50%.

Parameter No.	Parameter Name	Default Value
2	Set Speed A	1000
5	Proportional	25
6	Integral	50
7	Derivative	25
8	OVG @ Set Speed A	20
11	Gain Factor *	20
12	Speed Filter †	18

* Modify the Gain Factor only when the PID or OVG values reach their min./max. parameters.
† The Speed Filter value should be set to 24 for 3- or 4-cylinder engines. Use a value of 16 for 6- or 8-cylinder engines.

Figure 9-10 Primary Parameter Setup

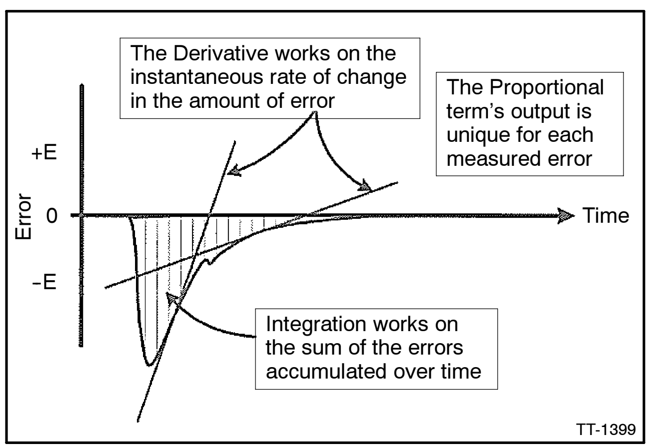


Figure 9-11 Relationships of DIP

h. Close line circuit breakers to connect load to the generator set.

i. Make small Derivative value changes to dampen out *ringing* in response to load transients.

j. Increase the Integral to eliminate any steady-state error in the engine's speed and help decrease error recovery time.

k. Increase the Overall Gain to improve response time while keeping the ratios of the PID values relative to each other constant.

2. Droop Calibration Procedure (paralleling model only).

   If droop calibration is required, go to step 2.a.

   If droop calibration is not required, go to step 3.

   Use this calibration procedure when droop is required.

   After droop calibration, the difference between the No Load Cal and the Full Load Cal parameter values should be greater than 100 for best operation of droop. The droop function may still work for smaller differences but with less accuracy.

   a. Open the line circuit breaker to disconnect the load from the generator set.

   b. Place the generator set master switch in the RUN position to start the generator set.

   c. Set the Set Speed A to 1800 rpm for 60 Hz models and 1500 rpm for 50 Hz models if not already completed.

   d. Enter a value of 41 in the Password parameter allowing editing of the droop related parameters.

   e. Select the % Droop parameter and adjust the value to:

      Selected Set Speed / [(1000 – Value of % Droop) / 1000]

   f. Allow the engine to stabilize at the No Load droop speed and then press the governor controller's Enter key to set the percent droop. No Load Calibration is now complete.

   g. Select the Full Load Calibration procedure. The engine speed will return to the selected set speed.

   h. Apply full load to the engine and allow the speed to stabilize.

   i. Wait 5 seconds and then press the governor controller's Enter key to record the calibration value. Full Load Calibration is now complete.

   j. Remove the load from the generator set. The engine speed will increase to the no load droop speed. Droop calibration is now complete.

   k. Place the generator set master switch in the OFF position to stop the generator set.

3. Update the governor controller and save the files.

   a. Select WRITE ALL. The updated program is then sent to the governor controller.

   b. Save and store this modified KPST software file on your PC hard drive, floppy disk, and/or CD-ROM for future reference.

   c. In an effort to help us build a more complete data base, we request you share your calibration values by filling out the Governor Parameter Detail form. E-mail or fax the completed form to us and after our review, we will include the data in the Governor Parameter Summary.

   E-mail: generatorfieldservice@Kohler.com

   Fax number: 920-803-4977.

4. Disconnect the governor controller from the user-supplied PC.

   a. Check that the generator set master switch is in the OFF position.

   b. Move the white lead/70A from the normally closed K5 contact back to the normally open K5 contact. See Figure 9-6.

   c. Disconnect the supplied cable included in the kit from the user-supplied PC 9-pin RS-232 serial port and the governor controller RJ11 connector (telephone jack).

   d. Store the cable and CD-ROM together for later use as needed.

Appendix D Diagnostics and Troubleshooting

Introduction

Use the troubleshooting chart to help diagnose generator set/engine problems relating to the governor controller.

Display Codes (Paralleling Model)

Code	Fault
E0	Controller memory failure. Replace governor controller.
E1	Loss of remote speed potentiometer signal.
E2	Overspeed detected. Governor controller must be turned off and reset to allow an engine restart.
E3	Actuator drive overcurrent detected. Check wiring. Check actuator loading and linkage.

Troubleshooting Chart

Symptom	Possible Cause	Remedy
LED display does not light up when the governor controller is powered	BAT+ and BAT- leads are reversed.	Check and correct wiring.
	Battery voltage is too low. Governor controller supply voltage should be 9-30 VDC.	Charge or replace the battery.
	Governor controller is inoperative.	Replace governor controller.
Unable to modify parameters	The parameter's value is the maximum value allowed.	Enter acceptable value.
	The parameter's value is the minimum value allowed.	Enter acceptable value.
	A display code is active (paralleling model).	Refer to the Display Codes section above.
	Password protection is enabled (paralleling model).	Enter Password.
	Keypad is inoperative.	Replace governor controller.
Engine does not start	Actuator leads not connected or shorted.	Check and correct actuator wiring.
	No fuel source.	Check fuel supply, fuel line, and shutoff valves.
	Battery voltage is low.	Charge or replace the battery.
	Set speed is lower than crank speed.	Increase the set speed value.
	Startup rate setting is too low. The target speed ramps up too slow.	Increase the startup rate value.
	Startup limit is too low, limiting the actuator drive signal too much.	Increase the startup limit value.
	No magnetic pickup (MPU) speed signal present. Magnetic pickup should be 2.0 VRMS minimum.	Adjust the MPU gap. Try reversing the MPU leads; otherwise, replace the MPU.
	If a speed signal is present, measure the actuator output duty cycle.	If not greater than 5%, restore all parameter values to factory default settings and crank the engine again.
Engine overspeeds at startup	The proportional value is too low.	Increase the proportional value.
	The appropriate overall gain (OVG) value is too low.	Increase the appropriate OVG value.
	The startup limit is incorrect (paralleling model).	Adjust the startup limit value.
	The startup ramp rate is too high.	Decrease the startup ramp rate value.
Engine does not reach set speed	Improper Proportional, Integral, and Derivative (PID) tuning values.	Check and adjust the PID values.
	Integral value is too low or zero.	Increase the integral value.
	Derivative value is too low or zero (paralleling model).	Increase the derivative value.
	PID values are too low. A tuning that is too soft can prevent the governor from delivering the needed actuator drive signal to reach the set speed.	Check and adjust the PID values.
	PID values are too high. Tuning is too hot or oversensitive to small speed errors causing the governor to make large, rapid changes in actuator drive signal, creating an average signal that is inadequate.	Decrease PID tuning values.
	The integral low limit setting is too high.	Return the integral low limit value to the default setting of zero.
	The integral high limit setting is too low.	Return the integral high limit value to the default setting of 99.
Engine takes too long to reach the set speed	Improper PID tuning values.	Check and adjust the PID values.
	Integral setting is too low.	Increase the integral value.
	Startup rate setting is too low.	Increase the startup rate value.
	Accel rate setting is too low.	Increase the Accel rate value.
	Speed filter setting is too high.	Decrease the speed filter value.

Symptom	Possible Cause	Remedy
Engine does not track speed setting changes	Is the LED decimal point flashing (paralleling model)?	If yes, enter password.
	Is the selected set speed parameter being modified?	If yes, speed setting display is unavailable during changes.
	A PID value or an OVG value is too high.	Decrease the PID values or OVG value.
	A PID value is too low or zero.	Increase the PID value.
	Accel rate is set too low.	Increase the Accel rate value.
	Decel rate is set too low.	Increase the Decel rate value.
Excessive smoke at startup	Improper PID tuning values.	Check and adjust the PID values.
	The startup rate is too high.	Use a lower startup rate value.
	The startup limit is too high.	Use a lower startup limit value.
	No/low MPU speed signal present. MPU should be 2.0 VRMS minimum.	Adjust the MPU gap. Try reversing the MPU leads; otherwise, replace the MPU.
Slow response to load changes	Gain value set too low.	Decrease the gain value.
	Improper PID tuning values.	Check and adjust the PID values.
	Speed filter setting is too high.	Decrease the speed filter value.
Engine instability with no load	Improper PID tuning values.	Check and adjust the PID values.
	Speed filter setting is too low.	Increase the speed filter value.
	Fuel flow is restricted.	Check actuator linkage.
	Battery voltage is too low.	Charge or replace the battery.
Engine instability with load	Improper PID tuning values.	Check and adjust the PID values.
	Fuel flow is restricted.	Check actuator linkage.
	Battery voltage is too low.	Charge or replace the battery.
Engine unable to carry rated load	PID values may be too high, causing the governor to overreact and make large, rapid changes in PWM duty cycle output to the actuator.	Check and decrease the PID values.
	Improper PID tuning values.	Check and adjust the PID values.
	Torque limit is set too low (paralleling model).	Increase the torque limit.
	Fuel flow is restricted.	Check actuator linkage.
Paralleling does not work (paralleling model)	No/low ILS input signal present. ILS should be 2.375-2.625 VDC.	Check ILS wiring; otherwise, replace the ILS.
	ILS signal wiring having electrical interference problems.	Use shielded wiring.
Droop does not work (paralleling model)	The no load and full load values are not calibrated.	Perform the droop calibration procedure.
	Difference between no load and full load calibration values is too small. Should be >100 for best performance.	Adjust the no load and/or full load calibration values.
	Actuator linkage range too small.	Modify or adjust actuator linkage to increase range of actuator loading.

9.5.3 Overview Paralleling (55-180EOZD/40-150EFOZD)

Isochronous Governing

Most gen-sets are normally operated with the isochronous governor selected. Isochronous governing is intended for use with either stand alone gen-sets, or gen-sets that are paralleled using a commercial load sharing module.

For stand alone gen-sets, either prime or standby, the throttle switch can be left in the fast-idle position and/or the analog (adjustable) throttle should be turned all the way up to the max speed position. With the throttle in the fast idle position, the governor will try to maintain exactly 1800 rpm (or 1500 rpm for 50 Hz units).

The isochronous governor programmed into gen-set ECUs is non-linear. It does not increase speed evenly as the throttle is turned up. For an 1800 rpm gen-set, it follows the curve shown below.

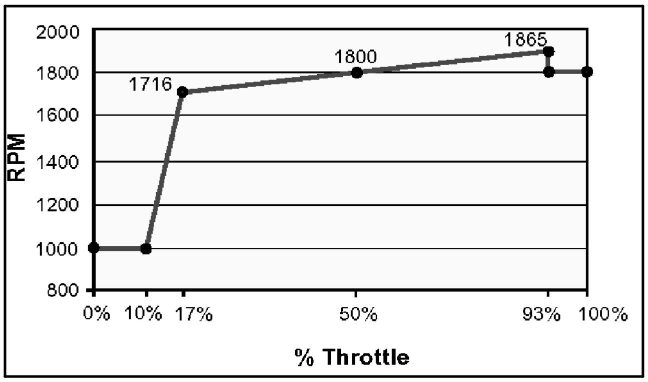


Figure 9-12 Isochronous Governor (55-99EOZD and 40-80EFOZD Models)

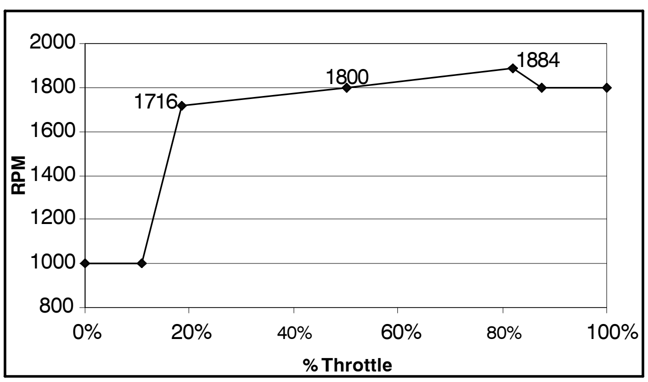


Figure 9-13 Isochronous Governor (125-180EOZD and 100-150EFOZD Models)

The 1500 rpm ECU behaves similarly. Most of the throttle travel is used to adjust speed within plus or minus 84 rpm of rated speed. This allows very fine adjustment of speed in that range if needed, and it meets the requirements of commercially available load sharing modules. If throttle travel exceeds 82%, speed will reduce until it reaches rated speed at 87.5% travel. Because of this feature, the gen-set will operate at rated speed (1800 or 1500 rpm) when the throttle switch is in the "fast idle" position, or if the analog throttle is turned all the way up, or in the event of a throttle wiring failure, or if no analog or 2-state throttle is installed.

This isochronous governor can be used directly with commercially available load sharing modules. When two or more engines are being controlled by a load sharing module, the load sharing module output can be connected directly to the analog throttle input to the ECU, as shown in the analog throttle wiring section later in this document.

Standard Droop Governing

Standard droop governing is intended for use when sharing load between two John Deere electronically controlled engines without the aid of a commercial load sharing module.

With a gen-set engine in standard droop mode and the throttle control at fast idle, the engine will operate with breakaway at exactly 1800 rpm as shown below (or 1500 rpm on 50 Hz units). Fast idle speed will be 20-60 rpm above rated speed, depending on governor droop for your particular engine. Governor droop for each engine is listed on the certified performance curve.

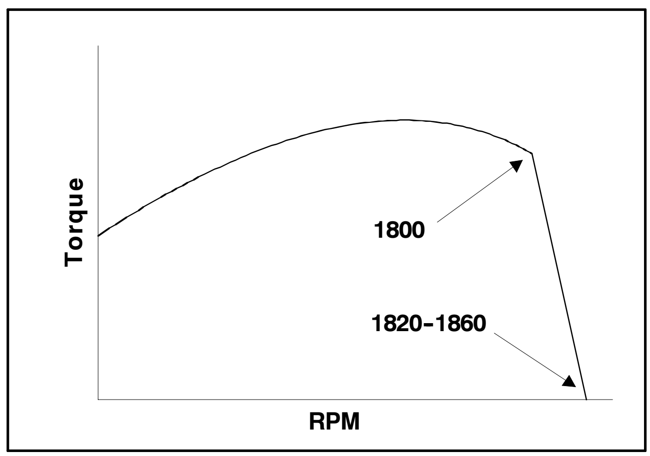


Figure 9-14 Standard Droop Governor

Multiple John Deere engines with JDEC controls operated in this mode and wired directly in parallel will automatically share load, although frequency will vary with load. This mode is intended for use with other electronically controlled John Deere engines in the same operating mode. It is not intended to be used to parallel with other models of engines, or to parallel with the utility grid directly. To share load at exactly 1800 rpm (60 Hz), a commercial load sharing module must be used.

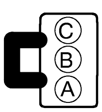
Analog Throttle Potentiometer

You must complete this circuit for all industrial applications, even if you don't use the analog throttle feature. If you don't use an analog potentiometer, you must install a throttle emulator (Resister Bridge) that sets the throttle in the low idle range.

Note: 55-180EOZD and 40-150EFOZD marine models come equipped with a factory-installed resistor bridge. See Figure 9-19 for resistor removal when paralleling.

If this circuit is not connected on industrial applications, a fault code will be generated. The warning lamp will light and the system will revert to the secondary analog throttle and/or adjustable 2-state throttle inputs. If no throttle input is present on industrial applications, the system will revert to low idle. No connection is required on gen-set applications that are intended to run at rated speed only with no adjustability.

The connector shown below will fit the analog throttle or the throttle emulator. The harness connection is a Packard Weather Pack 3-cavity, female connector, #12020829, with male terminals, #12124582, and cable seals installed. Note that these are the opposite terminals usually used with this connector.



Pin	Circuit	Color	Size	Destination
C	911	Brown	18AWG	to Pin M on 21-Pin Connector
B	915	Orange	18AWG	to Pin L on 21-Pin Connector
A	914	Yellow	18AWG	to Pin C on 21-Pin Connector

Figure 9-15 Analog Throttle Potentiometer

If you do not use an analog potentiometer, you must install a resister bridge that sets the throttle in the low idle range. You can either use the throttle emulator with the connector shown above, or you can wire your own equivalent resister bridge into the appropriate pins on the 21-pin connector as shown below. The exact size of the resisters is not important, as long as total resistance is 2,000-15,000 Ohms, and the small resister is 6% to 20% of the large resister size.

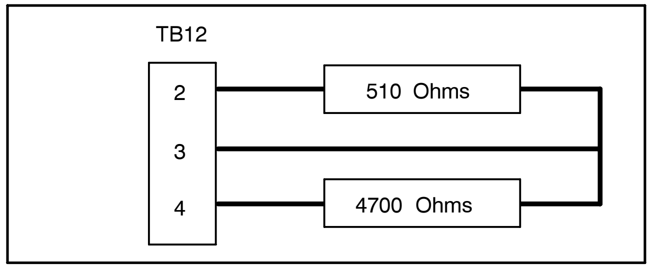


Figure 9-16 Throttle Emulator (or Equivalent)

The analog throttle should be a multi-turn 5000-Ohm potentiometer throttle designed for stationary applications. Many other throttle styles, including various foot pedal throttles are available from Morse, Williams Controls, and other suppliers. Any potentiometer-style analog throttle will work, as long as total resistance is in the 2,000-15,000 Ohm range.

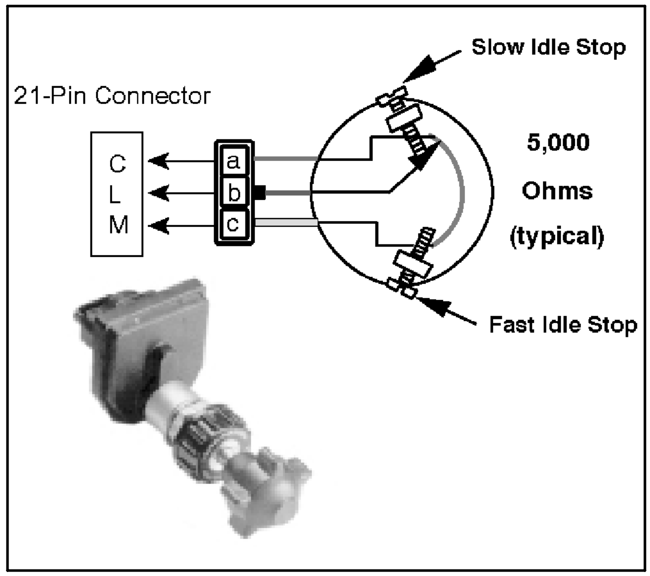


Figure 9-17 Analog Throttle

Gen-Set Load Sharing Modules

A commercial gen-set load sharing module that can provide a throttle input signal in the 1 to 4 volt range can be wired directly to the analog throttle input (Pin 3, TB12). If the load sharing module provides for a reference voltage connection, a 5-volt reference voltage should be taken from Pin 2, TB12. Sensor ground (Pin 4, TB12) should not be used to ground the load sharing module. Engine speed stability problems can result under some circumstances. The load sharing module should be grounded directly to the engine cylinder block, or to the negative terminal of the battery.

Throttle Potentiometer Pre-Adjustment Procedure

On industrial applications, if the voltage on Pin 3, TB12 goes above 4.75 volts or below 0.25 volts, the ECU will generate a fault code and return the engine to slow idle. It does this so that a break or short circuit in the wire does not cause the engine to go to fast idle unexpectedly.

To prevent error codes and unexpected changes in speed, the fast and slow idle stops on the throttle potentiometer must be adjusted so that the voltage on Pin 3, TB12 cannot go below 0.25 volt or above 4.75 volts.

Before plugging it into the wiring harness, adjust the throttle potentiometer using the following procedure:

1. With the potentiometer against the slow idle stop, adjust the stop so that the resistance measured between the ground and wiper connections of the potentiometer (Pins 3 and 4 on TB12) is between 6% and 20% of overall potentiometer resistance.
2. With the potentiometer against the fast idle stop, adjust the stop so that the resistance measured between the power and wiper connections of the potentiometer (Pins 2 and 3 on TB12) is also between 6% and 20% of overall potentiometer resistance.

This does not have to be a precise adjustment. The Auto-Cal feature will make a precise adjustment automatically. Once it has been done a few times, you will probably find that adjusting each throttle stop screw a predetermined number of turns is accurate enough.

Potentiometer Without Mechanical Adjustment Stops

If a potentiometer without fast and slow idle stops is used, additional fixed resistors can be wired in series with 21-pin connector Pins 2 and 4 as shown below to prevent the analog throttle voltage from going outside the upper and lower limits and generating a fault code.

For the Auto-Cal system to work properly, each added resistor should be between 6%-20% of the nominal throttle potentiometer resistance. Total resistance of the potentiometer and both resistors should be in the range of 2000 to 15,000 Ohms.

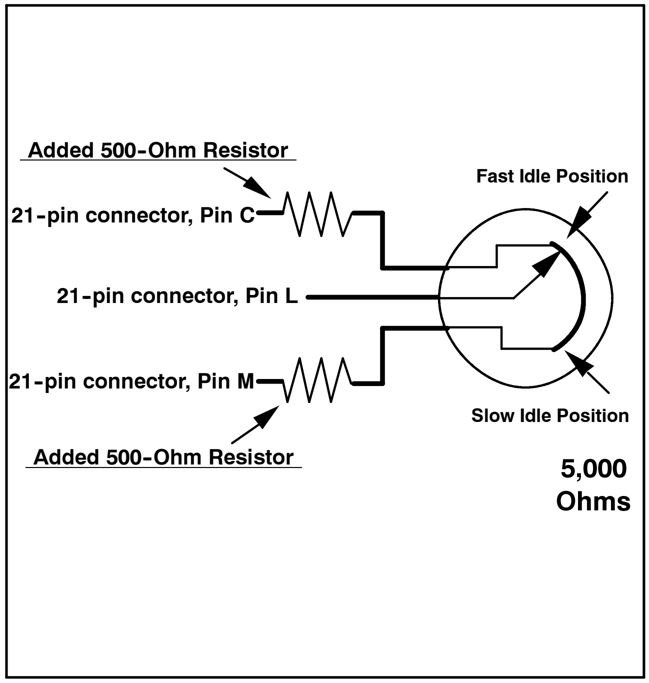


Figure 9-18 Potentiometer Without Mechanical Adjustment Stops

Connection (55-180EOZD/40-150EFOZD)

TB12 is the hookup for the external speed control. Remove the resistors/wires that are looped between TB12 positions 2, 3, and 4 for parallel operation. Refer to Section 9.5.3.

Note: This is typical speed biasing control regardless of controller used.

CONNECTION CHART

	TB12 TERMINAL POSITION	SIGNAL DESCRIPTION	
		CONNECTED	NOT CONNECTED
DROOP SELECT	1	ISOCHRONOUS	DROOP
ANALOG THROTTLE CONTROL	2*	+5 VDC REF	
	3*	SIGNAL (+2.5 VDC NORM)	
	4*	SENSOR RETURN	

* REMOVE RESISTORS IF PARALLELING

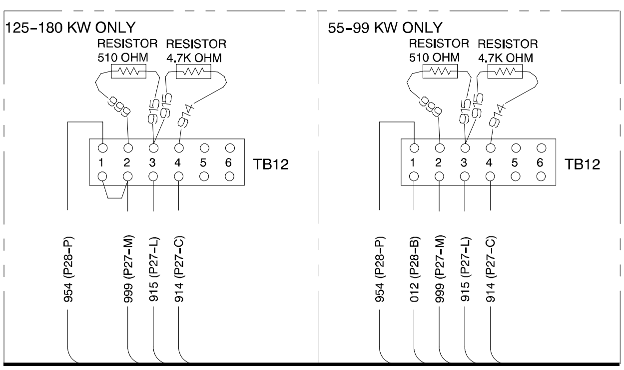


Figure 9-19 TB12 Connections

TB12 Position (Lead Code)	Lead Description
1 (954)	Isochronous governor (disconnect for Droop Mode)
2 (999)	+5VDC reference speed
3 (915)	Speed input line Note: Voltage input is 0.5-4.5VDC. (Nominal voltage 2.5VDC ±0.05% or 1500 rpm ±75 rpm)
4 (914)	Return speed sensor signal

9.6 Generator Voltage Biasing

9.6.1 Overview

Kohler generators accommodate use of reactive droop and/or external VAR/PF control. External control inputs allow control of voltage or reactive load from some supervisory controller i.e. switchgear.

Reactive Droop

Reactive droop is a method of reducing excitation, or generated voltage, as reactive load increases. It provides a means to divide reactive load when operating in parallel. No cross current connection between generators is required.

When generator sets are connected in parallel, governors control the engine power so each generator set carries its proportionate share of the total load. Similarly, the generator field excitation or voltage regulators control the sharing of reactive load. If the excitation level is higher on one generator, it will provide more reactive load. If the excitation level is lower on one generator, it will provide less reactive load. If the excitation level is too low, the generator may actually absorb reactive load—like a motor. Imbalance of these reactive loads result in circulating currents (cross current) between the generators

To minimize this effect, a compensation circuit is used to balance the reactive loads by supplying an error signal to the voltage regulator.

A current transformer, or CT, is used to sense the generator current. Generator load current is directed through the primary of the CT. The secondary is connected across the resistive burden (rheostat) and a voltage signal is created. The CT is connected in such a way that the voltage signal created is 90 degrees out of phase with the primary voltage sensing signal. For example, in a WYE connection; the primary voltage sensing may be Phase A to Phase B. The current in Phase C line is 90 degrees out of phase with AB Voltage. This voltage, across the rheostat, is vectorially added to the voltage regulator sensing voltage. This causes the sensed voltage to increase with generator load, resulting in voltage droop. Because of the 90 degree phase difference, reactive loads (kVAR) will cause much greater voltage droop than resistive loads (kW). If reactive current were to flow into the alternator, the sensed voltage would decrease and the excitation control would attempt to raise the voltage.

When reactive droop is used in paralleling applications, all of the generators would have droop compensation kits installed. This provides a means for each regulator to independently control the excitation level to balance or share the reactive load. If one generator begins to provide more reactive load (kVAR), the regulator will reduce excitation. If one generator begins to provide less reactive load, the regulator will increase excitation.

For non-inductive loads, the voltage across the rheostat remains out of phase with the main voltage sensing input. Therefore, little voltage droop is realized.

9.6.2 Voltage Regulator Adjustments Paralleling Applications (Reactive Droop) for Decision-Maker™ 550

Reactive Droop Enable (Decision-Maker™ 550)

For Decision-Maker™ 550 controllers, a menu allows the user to ENABLE the reactive droop feature. A YES entry turns the feature on and the display shows ENABLED YES. A NO entry turns the feature off and the display shows ENABLED NO. Use reactive droop in a generator set to generator set paralleling application. The reactive droop feature in the Decision-Maker™ 550 is specially designed to eliminate droop for resistive (real kW) loads.

Voltage Droop (Decision-Maker™ 550)

The amount of reactive droop is entered as a percentage of system voltage when applying full rated load, at 0.8 PF. The entry is made as precise as one tenth of a volt. This entry determines how much the voltage droops when the alternator provides reactive current. The actual amount the voltage changes is equal to the voltage droop setting times the VAR load as a fraction of the rated VARs at 0.8 PF.

If the generator set provides full rated load at 0.8 PF, the expected voltage change equals the voltage droop setting as an entered percentage of system voltage. A voltage droop setting of zero will in effect disable the reactive droop feature. The default value is 4% droop at full rated load at 0.8 PF.

Prior to paralleling, test the droop by applying reactive load. Check the droop by comparing the realized voltage droop to the calculated droop as above.

Because the voltage droop setting may be changed via communications, the setting is displayed for reference. As this setting changes via the remote communications, the display value changes.

9.6.3 Voltage Regulator Adjustments Paralleling Applications with Utility for Decision-Maker™ 550

VAR or PF Control Enable

In order for the VAR control or Power Factor control function to operate, it must be enabled. Entering YES at this menu turns the feature on. Because the function is designed to operate while in parallel with the utility, it also requires the proper indication that all tying circuit breakers are closed. This is done through the user programmable digital inputs. Because VAR control cannot be enabled at the same time that PF control is enabled, the action of turning VAR Control on (ENABLED) turns the PF control off (DISABLED) if it was previously ENABLED. Conversely, enabling PF control disables VAR control

To activate the VAR or PF modes, a digital input to TB-4 is required. This input should indicate the generator set is paralleled to the utility i.e. the circuit breaker is closed. After the digital input is grounded, VAR control is active.

TB-4-17 is the default input for VAR or PF enable. When the VAR control is enabled, the unit will not shut down when TB-4-17 is grounded.

kVAR Adjust

The kVAR adjustment is used to set the desired operating value for the generator set reactive load when in a utility paralleling application. Enter the desired generator set load directly as kVARs. The value entered may be as low as zero or as high as the rated value (rated kW x 0.75). Any entry beyond this will not be accepted and a RANGE ERROR message is displayed. The default value for kVAR adjust is zero. Any time the system rated kW is changed, the kVAR adjust will revert to this default value. Because the kVAR adjust may be changed via other inputs, digital input or via communications, the display setting changes.

Generating/Absorbing

While operating in the VAR control mode, the generator load may be specified to be out of (generating) or into (absorbing) the generator. This setting is made through the generating/absorbing menu. Because the normal flow of reactive current is out of the generator, the default value for this setting is generating. If absorbing is desired, a NO entry at this menu will change the control mode to absorbing. When absorbing is selected, another NO entry will revert back to generating. It is assumed that this mode will not be changed when the generator set is running. Therefore, an attempt to change the mode while running will return a RANGE ERROR message. Shut down the generator set to change this setting.

Power Factor (PF) Adjust

Use the PF adjust to set the desired operating relationship for the generator set voltage and current when connected in parallel with the utility. The regulated excitation maintains a PF that is equal to the entered value. The value entered may be as low as 0.7 for leading PFs to 0.6 for lagging PFs. Any entries outside these limits cause a RANGE ERROR message display. The default value for PF adjust is 0.8 lagging. Whenever the system rated kW changes, the PF adjustment reverts to the default value. If the PF adjustment is changed via other inputs, the display setting changes.

Lagging/Leading

It is possible to select either a leading or lagging PF for utility parallel applications. The controller displays the selected mode. A NO entry switches the controller to use the opposite relationship for regulation purposes. This may only be changed while the generator set is not running. Lagging is the default value because the most common mode of operation has a lagging PF.

9.6.4 Voltage Regulator Adjustments Paralleling Applications (Reactive Droop) for Decision-Maker™ 3+

Reactive Droop Adjustment (Decision-Maker™ 3+)

To test and adjust the reactive droop compensator, proceed as follows. Read the entire procedure before beginning.

1. With the reactive droop rheostat set at minimum (full counterclockwise position), record the rpm or frequency and voltage at 1/4 load steps to full load on unit #1. Repeat Step 1 for unit #2.

2. Compare the readings and make final adjustments so that the voltage is within 1 volt at each load step and the speed is within 3 rpm or the frequency is within 0.1 Hz for each unit. Adjust the voltage using the local or remote voltage adjusting potentiometer. Adjust the speed at the governor or at the remote speed adjusting potentiometer.

3. Check the droop compensation on each unit as follows:

   a. With unit #1 operating at the correct speed and voltage, apply a lagging power factor load. This load should preferably be 1/2 to full load and must be inductive, as resistance loads cannot be used.

   b. Observe the voltmeter on unit #1 with the reactive droop rheostat set at minimum. As the rheostat is turned clockwise, the voltmeter should show a decrease in voltage. If a larger voltage is obtained when the reactive droop rheostat is turned clockwise, shut down the system and reverse the direction of the generator load line through the current transformer, or reverse the secondary leads of the CT. Recheck the droop.

   c. Adjust the reactive droop rheostat to a value at approximately 4% below rated voltage at full load. As an example, the voltage should droop (decrease) 19.2 volts on a 480-volt system at full load or 9.6 volts at 1/2 load. To determine voltage droop at other than full load, use the following formula:

      Note: Rated Voltage x 0.04 x Actual Load (expressed as a percent of full load) = Voltage Droop

      Note: With full load 0.8 power factor, a droop of 3%-5% should be adequate for paralleling.

   d. Repeat Steps 3 a., b., and c. for unit #2 and be certain the amount of voltage droop is equal at the same load point as on unit #1.

   e. With this procedure, the two units will share reactive currents proportionately.

4. In addition to Steps 1-3, it is desirable to use the following procedure to check that the units are sharing the reactive load correctly.

   a. Parallel the units at 1/2 to full load. Check the wattmeters to determine that each unit is carrying equal kW load or a load proportional to its capacity. If the loads are incorrect, adjust and recheck the governor throttle control to correctly balance loading. Engine speed will determine load sharing ability.

      Note: Use wattmeters, not ammeters, to verify load balance.

   b. With the load balanced, check the ammeters to see that equal current is being produced or the current is proportional according to capacity of each generator set. If the currents are incorrect, adjust the reactive droop rheostat to reduce the current of the unit(s) that has the highest reading. Adjust the rheostat to increase current on the unit(s) with the lower reading. Continue making minor adjustments until each unit supplies current proportional to its capacity as a proportion of the total system capacity.

   c. As a result of performing Steps 4 a. and b., the governors have been adjusted to balance the load and the reactive droop rheostat has been adjusted to balance the current. These settings would be optimum for parallel operation.

      Note: The voltage must droop on lagging power factor loads (inductive loads). A little change in voltage is acceptable on unity power factor loads (resistive loads).

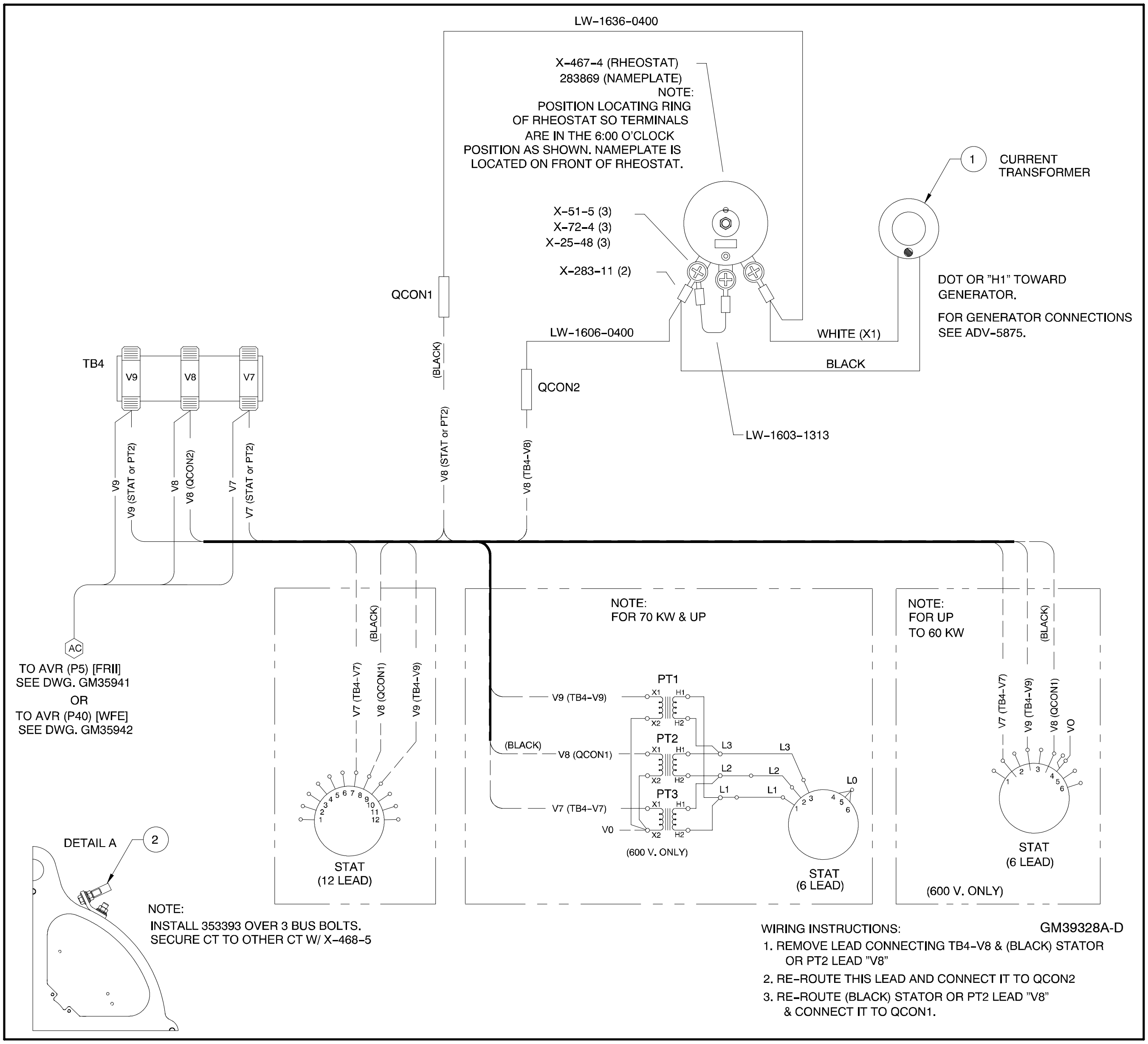


Figure 9-20 Reactive Droop Wiring Diagram

Generator Set Model	Voltage Bias			
	Without Reactive Droop		With Reactive Droop	
	Decision-Maker™ 3+ with FRII Enhanced Voltage Regulator	Decision-Maker™ 550 with Standard 0-5 VDC	Decision-Maker™ 3+ with FRII Enhanced Voltage Regulator	Decision-Maker™ 550 with Standard 0-5 VDC
40EOZD 33EFOZD	See Section 9.6.6	See the Operation Manual (TP-6441) shipped with the generator set and See Section 9.6.5	See Section 9.6	
55EOZD 40EFOZD				
65EOZD 50EFOZD				
80EOZD 70EFOZD				
99EOZD 80EFOZD				
125EOZD 100EFOZD				
150EOZD 125EFOZD				
180EOZD 150EFOZD				

Figure 9-21 Reference Table for Voltage Bias

9.6.5 Decision-Maker™ 550 Controller

General

The Decision-Maker™ 550 controller features:

- Built-in voltage regulator functionality
- Keypad for user setup
- Parameter file for generator information
- Accommodates digital adjust or 0-5V for active control
- Built-in reactive droop capability

TB2 Connections

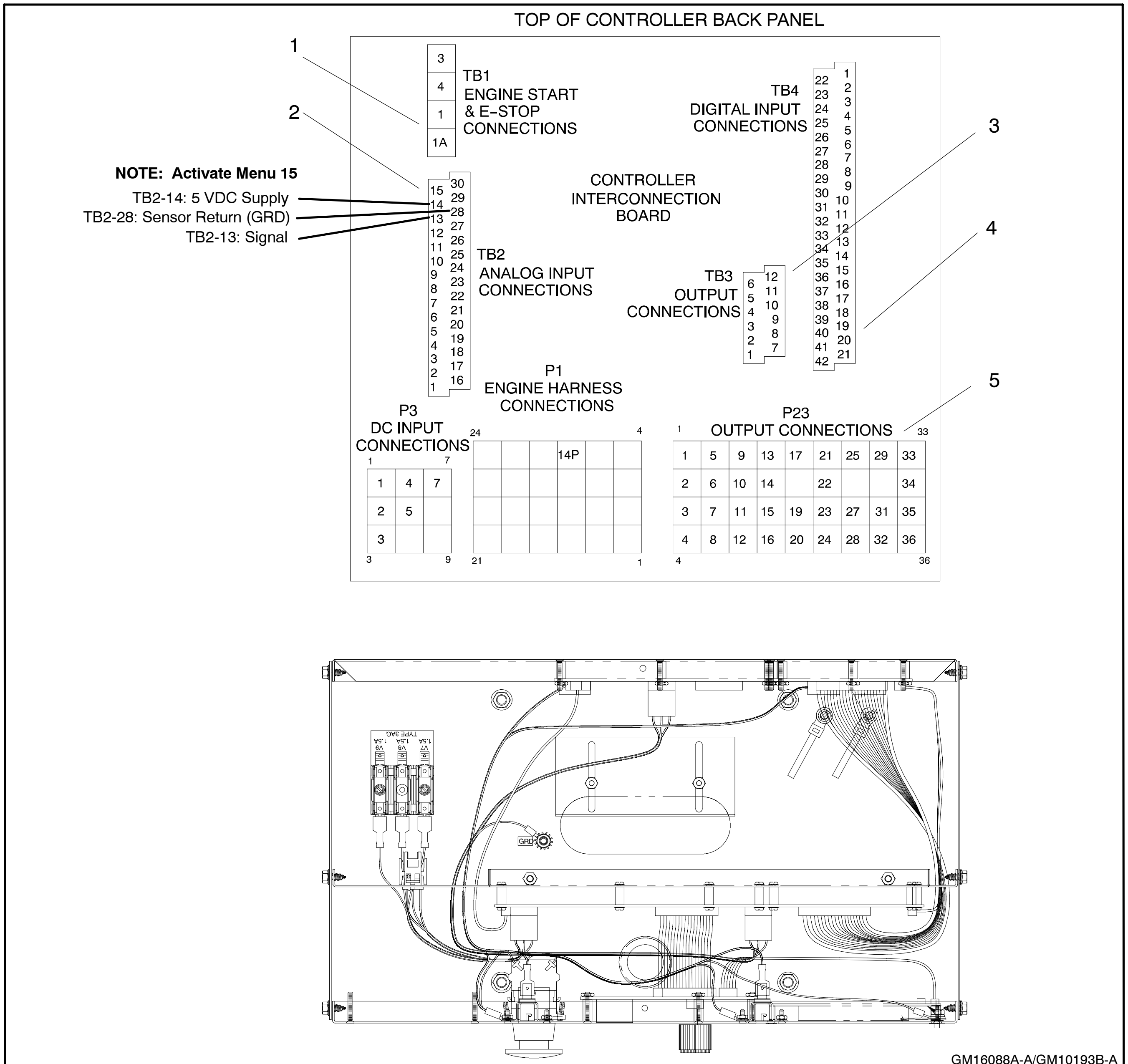
The voltage regulator internal to the Decision-Maker™550 has voltage biasing of 0-5VDC as standard. Refer to the operation manual (TP-6441) shipped with the generator set for more information.

TB2 Analog Inputs

TB2 provides 0-5 VDC analog signal inputs for customer connections. The installer must scale and calibrate each analog input before the input value becomes a warning or shutdown trip point value. See Figure 9-22. Analog inputs 1-7 are available for user-defined applications on ECM-engine models. Non-ECM engines have analog inputs 3-7 available for optional applications, while inputs 1-2 are reserved for oil pressure and coolant temperature. On ECM engines, oil pressure and coolant temperature come from the ECM.

The oil pressure input is responsible for low oil pressure warning and shutdown functions and for the oil pressure value (menu 2). The coolant temperature sender is responsible for high coolant temperature warning and shutdown functions, low coolant temperature warning, and coolant temperature value (menu 2).

Analog inputs 1-2 for non-ECM units do not have access for adjustment or calibration. The oil pressure and coolant temperature parameters and calibration are part of the factory-installed personality program for the controller, and no further adjustment is necessary.



1. TB1 terminal strip
2. TB2 terminal strip
3. TB3 terminal strip
4. TB4 terminal strip
5. P23 Connector

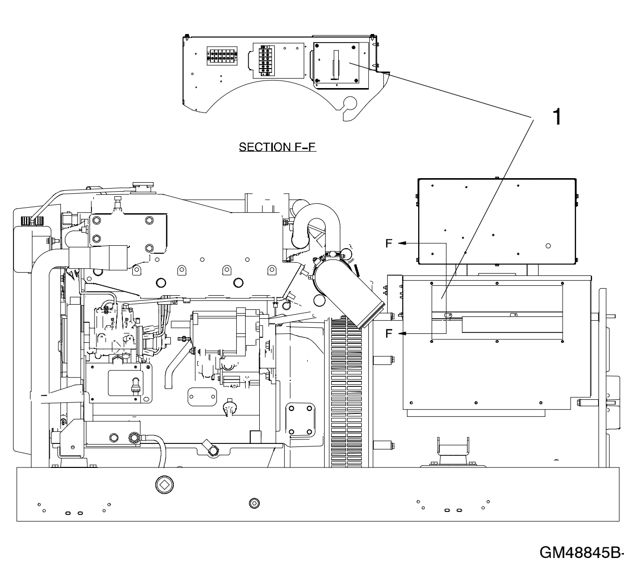
Figure 9-22 TB2 Analog Inputs

9.6.6 Decision-Maker™ 3+ Controllers

General

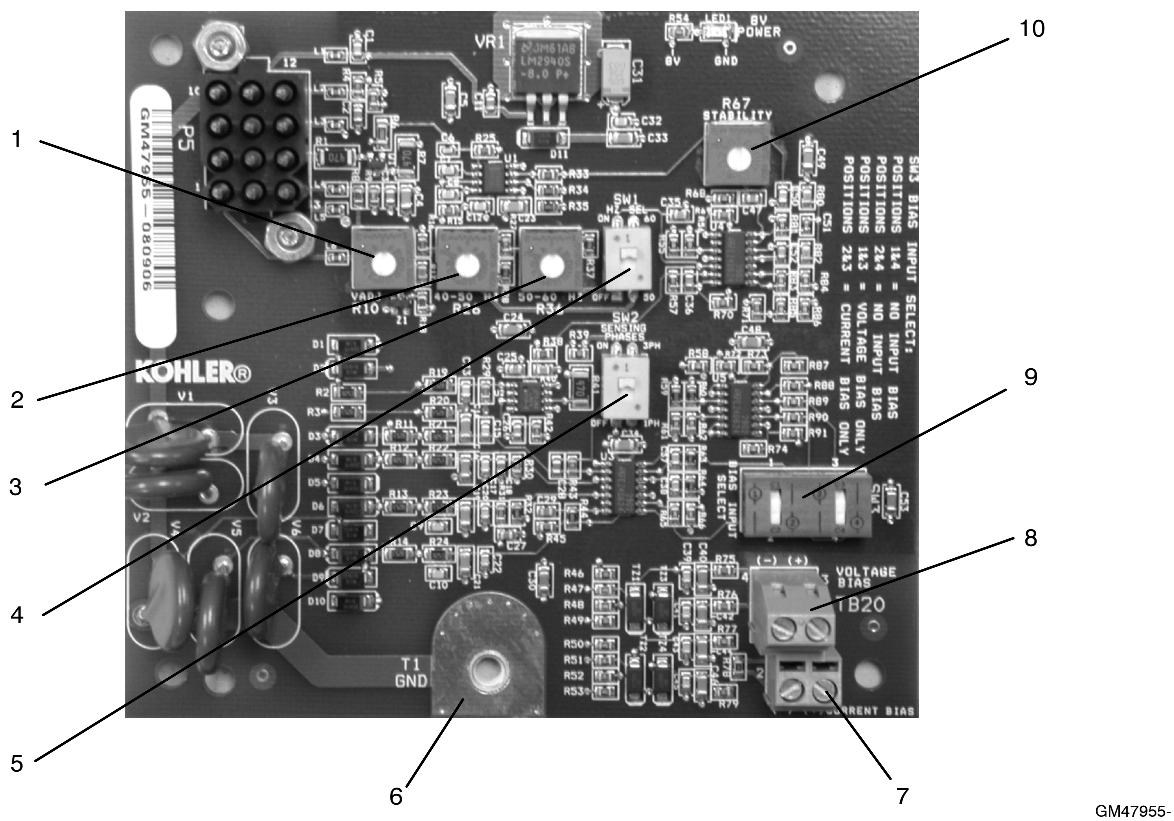
The Decision-Maker™ 3+ controller features:

- An external analog regulator (FR™ II enhanced voltage regulator)
- Setup by use of potentiometers and DIP switches
- Accommodates 0-5 V or 4-20mA input for active control
- Works with external reactive droop kit



1. Voltage regulator location

Figure 9-23 Kohler FR™ II Enhanced Voltage Regulator Location



1. Voltage adjustment potentiometer
2. 50 Hz V/Hz adjustment potentiometer
3. 60 Hz V/Hz adjustment potentiometer
4. Switch #1—Frequency select
   On = 60 Hz
   Off = 50 Hz
5. Switch #2—Phase sensing
   On = 3 Phase
   Off = 1 Phase
6. Grounding pad
7. 4-20mA current bias lead input
8. Voltage bias lead input
9. Dip switch for bias input select
   1 & 4 = No input bias
   2 & 4 = No input bias
   1 & 3 = 0-5 VDC voltage bias only
   2 & 3 = 4-20mA current bias only
10. Stability potentiometer

Figure 9-24 Kohler FR™ II Enhanced Voltage Regulator (GM47955)

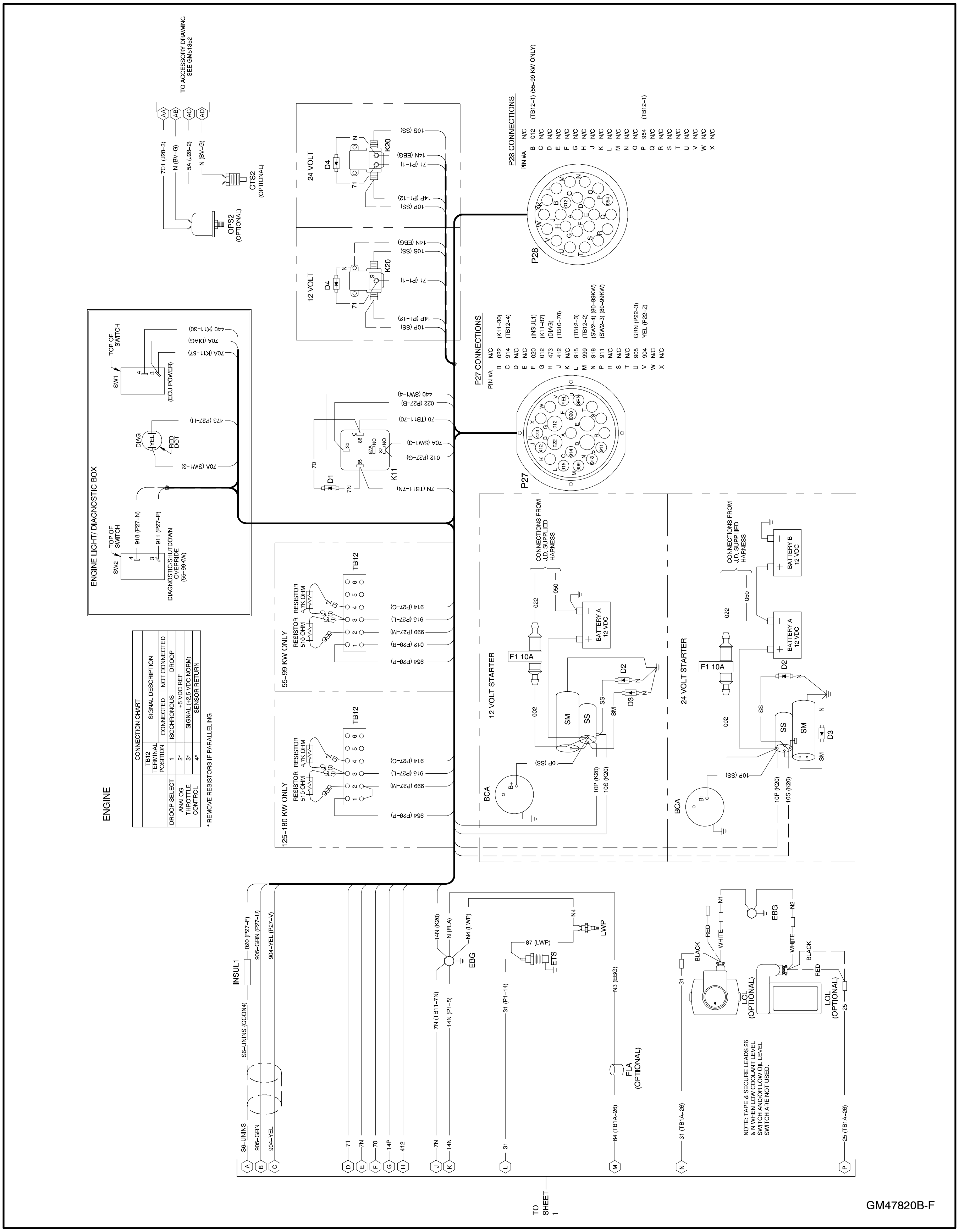


Figure 9-25 Wiring Diagram for Decision-Maker™ 3+ (55–180kW)

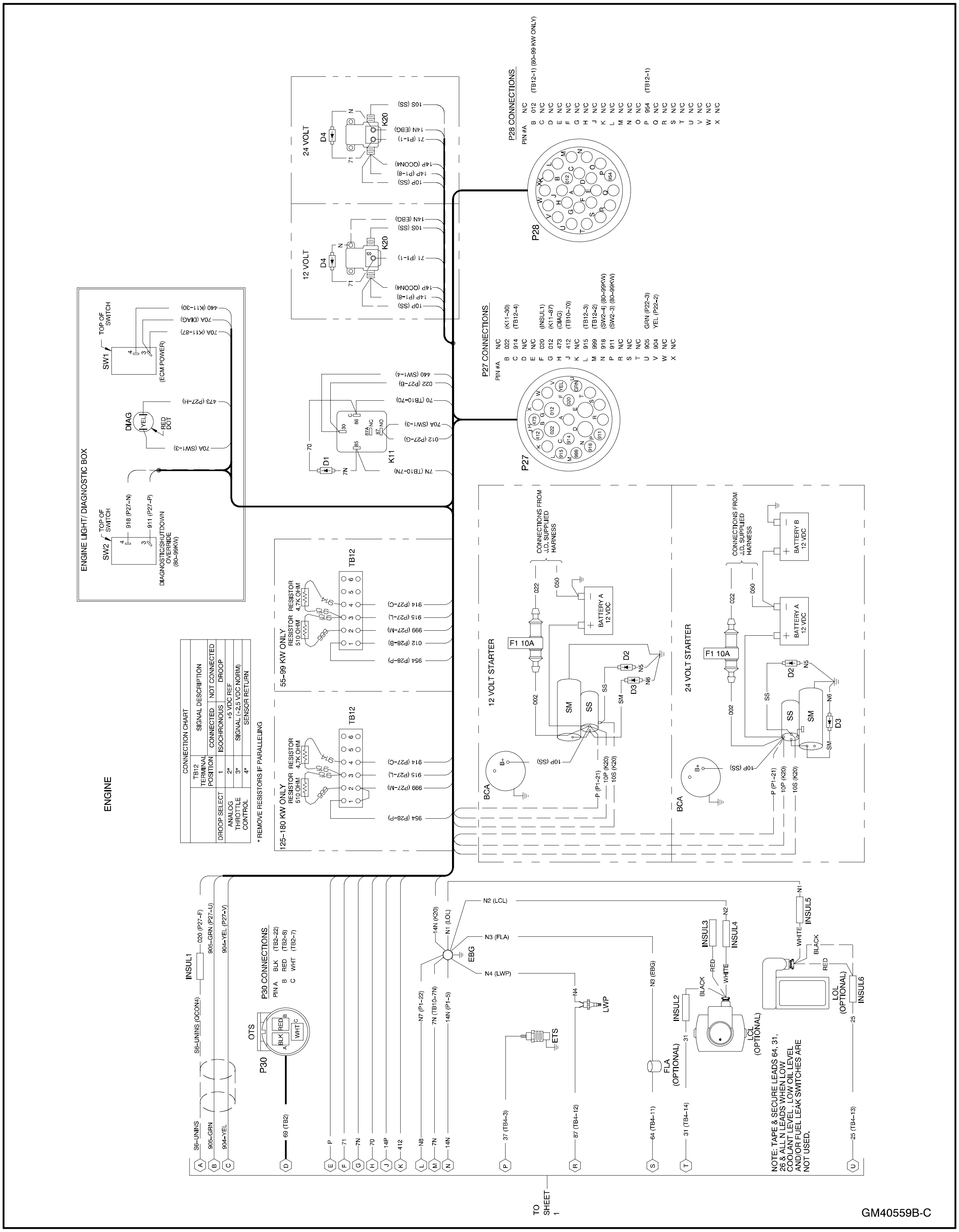


Figure 9-26 Wiring Diagram for Decision-Maker™ 550 (55–180kW)

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

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