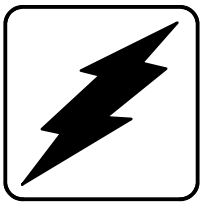
Operation and Installation

Automatic Transfer Switches



Models:

MMS/MNS
MMT/MNT

Electrical Controls:
E33+ Solid-State

ISO 9001
KOHLER GENERATORS
INTERNATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-5662 2/00d

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***.

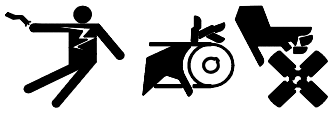
NOTICE

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.

Battery

⚠ WARNING

Sulfuric acid in batteries.
Can cause severe injury or death.

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

⚠ WARNING

Explosion.
Can cause severe injury or death.
Relays in the battery charger cause arcs or sparks.

Locate the battery in a well-ventilated area. Isolate the battery charger from explosive fumes.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove wristwatch, rings, and other jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

Hazardous Voltage/ Electrical Shock

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Disconnect all power sources before opening the enclosure.

(600 volts and under)

⚠ WARNING

Hazardous voltage. Moving rotor.
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. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Installing the battery charger. Hazardous voltage can cause severe injury or death. An ungrounded battery charger may cause electrical shock. Connect the battery charger enclosure to the ground of a permanent wiring system. As an alternative, install an equipment grounding conductor with circuit conductors and connect it to the equipment grounding terminal or the lead on the battery charger. Install the battery charger as prescribed in the equipment manual. Install the battery charger in compliance with local codes and ordinances.

Connecting the battery and the battery charger. Hazardous voltage can cause severe injury or death. Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

Installing accessories to the transformer assembly. Hazardous voltage can cause severe injury or death. To prevent electrical shock disconnect the harness plug before installing accessories that will be connected to transformer assembly primary terminals 76, 77, 78, and 79. Terminals are at line voltage. *(Models with E33+, S340, S340+, 340, R340, and R33 controls only)*

Installing accessories to the transformer assembly. Hazardous voltage can cause severe injury or death. To prevent electrical shock disconnect the harness plug before installing accessories that will be connected to the transformer assembly primary terminals on microprocessor logic models. Terminals are at line voltage.

Making line or auxiliary connections. Hazardous voltage can cause severe injury or death. To prevent electrical shock deenergize the normal power source before making any line or auxiliary connections.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Disconnect all power sources before servicing. Install the barrier after adjustments, maintenance, or servicing.

(600 volts and under)

Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Open the main circuit breakers of all transfer switch power sources and disable all generator sets as follows: (1) Move all generator set master controller switches to the OFF position. (2) Disconnect power to all battery chargers. (3) Disconnect all battery cables, negative (–) leads first. Reconnect negative (–) leads last when reconnecting the battery cables after servicing. Follow these precautions to prevent the starting of generator sets by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer. Before servicing any components inside the enclosure: (1) Remove rings, wristwatch, and jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Test circuits with a voltmeter to verify that they are deenergized.

Servicing the transfer switch controls and accessories within the enclosure. Hazardous voltage can cause severe injury or death. Disconnect the transfer switch controls at the inline connector to deenergize the circuit boards and logic circuitry but allow the transfer switch to continue to supply power to the load. Disconnect all power sources to accessories that are mounted within the enclosure but are not wired through the controls and deenergized by inline connector separation. Test circuits with a voltmeter to verify that they are deenergized before servicing.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

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 wristwatch, rings, and jewelry before servicing the equipment.

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 rings, wristwatch, and 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)

Heavy Equipment

⚠ WARNING

Unbalanced weight.
Improper lifting can cause severe injury or death and equipment damage.

Use adequate lifting capacity.
Never leave the transfer switch standing upright unless it is securely bolted in place or stabilized.

Moving Parts

⚠ WARNING

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

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

Notice

NOTICE

Hardware damage. The transfer switch may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

When replacing hardware, do not substitute with inferior grade hardware. Screws and nuts are available in different hardness ratings. To indicate hardness, American Standard hardware uses a series of markings, and metric hardware uses a numeric system. Check the markings on the bolt heads and nuts for identification.

NOTICE

Improper operator handle usage. Use the manual operator handle on the transfer switch for maintenance purposes only. Return the transfer switch to the normal position. Remove the manual operator handle, if used, and store it in the place provided on the transfer switch when service is completed.

NOTICE

Foreign material contamination. Cover the transfer switch during installation to keep dirt, grit, metal drill chips, and other debris out of the components. Cover the solenoid mechanism during installation. After installation, use the manual operating handle to cycle the contactor to verify that it operates freely. Do not use a screwdriver to force the contactor mechanism.

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

This manual provides operation and installation instructions for Kohler® transfer switches with E33+ electrical controls.

t:in:002:001

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

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect parts often and perform required service at the prescribed intervals. Obtain service from an authorized service distributor/dealer to keep equipment in top condition.

x:in:002:002

List of Related Materials

This manual covers operation and installation information for the transfer switch's electrical controls. See the power switching device operation and installation manual to decode the transfer switch model number and verify that the transfer switch model and electrical controls match the models shown on the front cover of this manual before proceeding with operation or installation.

A separate operation and installation manual that covers the transfer switch's power switching device completes the operation and installation instructions for the transfer switch. The transfer switch model number shows which power switching device is installed on the switch. The following table lists the available power switching devices and the related operation and installation manual part numbers.

Models (Power Switching Device)	Operation/ Installation Manual
Model MMS/MNS (molded-case circuit breaker or switch 40 to 1250 amp)	TP-5658
Model MMS/MNS (circuit breaker or switch 1600 to 4000 amp)	TP-5678
Model MMT/MNT (molded-case circuit breaker or switch 40 to 1250 amp)	TP-5973

Separate manuals cover service and parts information for transfer switch power switching devices and electrical controls. The following table(s) list the available manual part number(s).

Models (Power Switching Device)	Service/ Parts Manual
Model MMS/MNS (molded case circuit breaker or switch 40 to 4000 amp)	TP-5666
Model MMT/MNT (molded-case circuit breaker or switch 40 to 1250 amp)	TP-5974

Electrical Controls (Type)	Service/ Parts Manual
E33+ (Solid-State)	TP-5670

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Service Assistance

Please contact a local authorized distributor/dealer for sales, service, or other information about Kohler Generator Division products.

Service Information

To locate a local authorized distributor/dealer inside the U.S.A. and Canada

- Look on the product or in the information included with the product
- Consult the Yellow Pages under the heading Generators— Electric
- Visit the Kohler Generator Division web site at www.kohlergenerators.com
- Call 1-800-544-2444

To locate a local authorized distributor/dealer outside the U.S.A. and Canada

- Look on the product or in the information included with the product
- Consult the telephone directory under the heading Generators—Electric
- Visit the Kohler Generator Division web site at www.kohlergenerators.com
- Contact the nearest regional office

Africa, Europe, Middle East
London Regional Office
Langley, Slough, England
Phone: (44) 1753-580-771
Fax: (44) 1753-580-036

Australia
Australia Regional Office
Queensland, Australia
Phone: (617) 3893-0061
Fax: (617) 3893-0072

China
China Regional Office
Shanghai, People's Republic of China
Phone: (86) 21-6482 1252
Fax: (86) 21-6482 1255

India, Bangladesh, Sri Lanka
India Regional Office
Bangalore, India
Phone: (91) 80-2284270
(91) 80-2284279
Fax: (91) 80-2284286

Japan
Japan Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

Latin America
Latin America Regional Office
Lakeland, Florida, U.S.A.
Phone: (941) 619-7568
Fax: (941) 701-7131

South East Asia
Singapore Regional Office
Singapore, Republic of Singapore
Phone: (65) 264-6422
Fax: (65) 264-6455

Product Information

Product identification numbers determine service parts. Record the product identification numbers in the spaces below immediately after unpacking the products so that the numbers are readily available for future reference. Record field-installed kit numbers after installing the kits.

Transfer Switch Identification Numbers

Record the product identification numbers from the transfer switch nameplate.

Model Number _____

Serial Number _____

Accessory Number	Accessory Description

Section 1 Specifications

The following specifications are for Kohler® transfer switches with the E33+ electrical control system. See the power switching device operation and installation manual for power switching device specifications and other transfer switch features. See List of Related Materials in the Introduction section of this manual.

1.1 Standard Features

- Solid-state electrical controls for Kohler® Model MMS/MNS and MMT/MNT transfer switches.
- Normal source single-phase voltage sensing fixed at 70% for dropout and 90% for pickup.
- Emergency source single-phase sensing pickup fixed at 85% of rated voltage and 95% of rated frequency.
- Test switch maintained—simulates a normal source power failure.
- Lamps indicating normal and emergency source availability and switch position.
- Engine-start contacts provided.
- Time delay engine start (TDES) fixed at 3.0 seconds.
- Time delay emergency-to-normal (TDEN) fixed at 5 minutes.
- Program transition available. Individual time adjustment of 2 to 40 seconds off-to-emergency (TDOE) and off-to-normal (TDON). Switch will stop in the Off position (neither source connected) for the TDOE or TDON time.
- All printed circuit boards conformally coated for environmental protection.

1.2 Optional Features

See Section 3, Accessories, for details of optional features selected. The transfer switch's nameplate includes a list of factory-installed accessories.

- Plant exerciser, solid-state, digital display, 7- or 14-day, no load.
- Battery charger, 2-ampere float, 12- and 24-volt.
- 3-phase sensing, normal source fixed at 70% for dropout and 90% for pickup for all phases.

Notes

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Disconnect all power sources before opening the enclosure.

(600 volts and under)

Schedule preventive maintenance on the transfer switch at regular intervals after installation. See Section 4 for preventive maintenance.

Contact an authorized service center to inspect and service the transfer switch when any wear, damage, deterioration, or malfunction of the transfer switch or its components is evident or suspected; *do not energize the switch.*

2.1 Startup

Perform the following powerup procedure after maintenance or service of the standby system when power sources were disconnected from the transfer switch, *not for initial startup.*

For initial startup, follow the instructions in the installation section of the operation and installation manual for the power switching device and Section 5, Installation, in this manual.

Read and understand documentation provided with the switch and labels affixed to the switch. Review the operation of installed accessories.

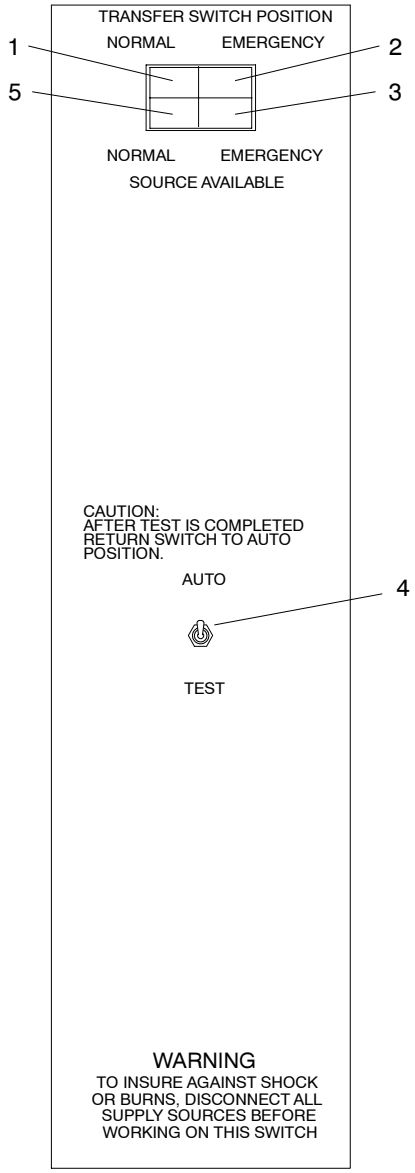
Follow the steps below to power up the transfer switch and prepare it for automatic operation.

Powerup Procedure

1. Place the generator set master switch in the OFF position to prevent starting the generator set.
2. Disconnect *both* the normal and emergency power sources by opening circuit breakers or switches leading to the transfer switch.
3. Open the transfer switch enclosure door and check that the wire harnesses for the power switching device and the controller are plugged together at the inline disconnect plug P1. See Figure 5-1.
4. Follow the manual operation procedure to prepare the transfer switch for automatic operation. See the power switching device operation and installation manual for instructions.
5. Close and lock the transfer switch enclosure door. Replace and tighten any fastening screws on the enclosure door.
6. Prepare the standby generator set for operation. Check the oil level, coolant level, fuel supply, batteries, and items specified by the generator set prestart checklist or similar instructions in the operation manual.
7. Place the generator set master switch in the AUTO position. The generator set should start.
8. When loads are ready to be energized, close circuit breakers or switches leading to the transfer switch.
9. Perform an automatic operation test. See Section 5.6.2.

2.2 Controls and Indicators

Some of the switches and indicators located on the transfer switch enclosure door may be optional accessories. See Figure 2-1.



1. **Normal Position (green)** lights when the load is connected to the normal source.
2. **Emergency Position (red)** lights when the load is connected to the emergency source.
3. **Emergency Source Available (white)** lights when the emergency source is acceptable.
4. **Test Switch.** The normal position allows automatic transfer switch operation. The test position signals the generator set to start.
5. **Normal Source Available (white)** lights when the normal source is acceptable.

Figure 2-1 Transfer Switch Controls and Indicators

2.3 Manual Operation

Manually operate the power switching device to prepare the transfer switch for automatic operation, to reset a tripped circuit breaker, or to test or troubleshoot the unit.

Refer to the power switching device operation and installation manual to operate the transfer switch *manually*.

2.4 Automatic Operation

Controller circuitry, programming, or accessories determine when a power source is acceptable, has failed, or is restored and operates accordingly. A power source is acceptable when the voltage and/or frequency on all sensed phases rise above preset levels. Failure of a power source occurs when the voltage and/or frequency on one or more sensed phases fall below preset levels. A power source is restored when it becomes acceptable after failing. Typical ATS operation is divided into two sequences:

- **Failure of the normal power source** and the resulting transfer to the emergency source or Emergency.
- **Restoration of the normal power source** and the resulting transfer back to the normal source or Normal.

The following sections explain these automatic sequences of operation for a standard controller with a limited number of accessories that affect the sequence of operation. Installed controller accessories can change the sequence of operation given here; review the operation of any optional accessories on the transfer switch. See Section 3, Accessories.

2.4.1 Normal Power Source Failure

The following sequence describes the system response to a normal power source failure. See Figure 2-2.

1. **Normal Power Source Fails.** The normal source acceptable relay (K2) on the controller's main logic circuit board deenergizes when the voltage on any sensed phase of the normal power source falls below the dropout level. The normal source available indicator lamp turns off. See Figure 2-1 and Figure 5-2.

2. **NR Relay Deenergizes and Engine Start Time Delay Starts.** When the K2 relay deenergizes, the NR relay on the interface circuit board

deenergizes. Also, the time delay engine start (TDES) relay, located on the main controller circuit board, begins its timing cycle. See Figure 5-2 and Figure 5-3. TDES prevents nuisance starting of the generator set during brief power outages. If the normal source voltage on all sensed phases rises above the pickup level before the TDES relay times out, the K2 and NR relays reenergize and the controller resets all circuits for any future normal source failure.

3. **Generator Signalled to Start.** When the TDES relay times out, it deenergizes and the engine start contact closes to signal the generator set to start. Controller circuitry monitors the emergency power source for acceptability.

4. **Emergency Source Becomes Acceptable and Starts a Time Delay to Transfer to Emergency.** Controller circuitry energizes the emergency source acceptable relay K1, located on the main logic circuit board, when the voltage and frequency on one sensed phase of the emergency source reach the pickup levels. The emergency source available lamp lights. See Figure 2-1 and Figure 5-2.

5. **Switch Transfers Load to Emergency.** When the emergency source is acceptable, the emergency relay (ER) on the interface circuit board energizes. See Figure 5-3. When the ER relay energizes, the power switching device transfers the load to the emergency source. The transfer switch is now supplying the load from the emergency source and remains latched in this position until the normal source is restored.

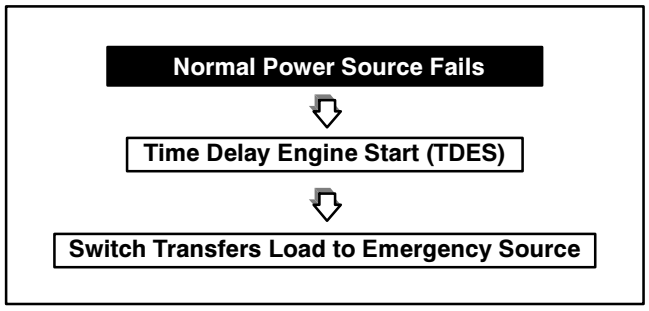


Figure 2-2 ATS Sequence of Operation, Normal Power Source Failure

2.4.2 Normal Power Source Restoration

The following sequence describes system response to normal source restoration. See Figure 2-3. In this sequence of operation, if the emergency power source fails and the normal source is acceptable, the ATS bypasses all time delays in the sequence and transfers the load immediately to the normal source.

1. **Normal Power Source Returns.** Controller circuitry starts the time delay emergency-to-normal (TDEN) when the normal source is acceptable. The normal source is acceptable when the voltage level on all sensed phases rise above the voltage pickup level. TDEN allows time for the normal source to stabilize before load reconnection. If the emergency source fails (voltage or frequency on one phase falls below the dropout level) during this timing cycle, the K1 relay deenergizes and the controller signals the power switching device to immediately transfer the load to the normal source, if the normal source is acceptable.

2. **Switch Transfers Back to Normal** When TDEN times out, the K2 relay energizes which, in turn, energizes the NR relay, and the ER relay deenergizes. The power switching device transfers the load back to the normal source.

3. **Generator Set Receives Signal to Shut Down** When the K2 relay energizes it causes the time delay engine start (TDES) relay to energize, which signals the generator set to shut down by opening the engine start contact. All circuits reset for any future normal source failure.

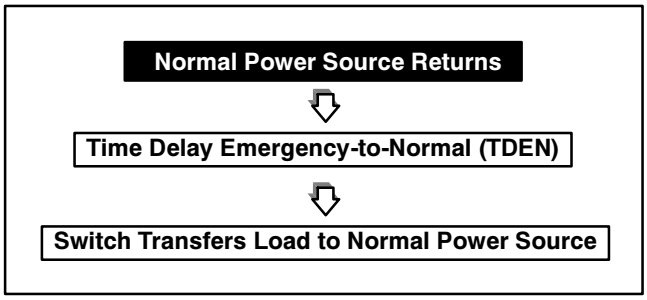


Figure 2-3 ATS Sequence of Operation, Normal Power Source Restoration

2.5 Programmed Transition Switch

2.5.1 Normal Power Source Failure

The sequence for programmed transition follows. See Figure 2-4. Refer to Section 5.8.2 for the programmed transition relay timing adjustment procedure.

1. The normal power source fails.
2. The TDES (time delay engine start) timer begins.
3. The TDES ends timing, indicating the engine has been signalled to start.
4. The generator power source becomes acceptable after the generator reaches rated voltage and frequency.
5. The switch transfers to the Off position. The load is disconnected from both power sources.
6. The TDOE (time delay off-to-emergency) timer begins.
7. The TDOE timer ends.
8. The switch transfers the load to the emergency source.

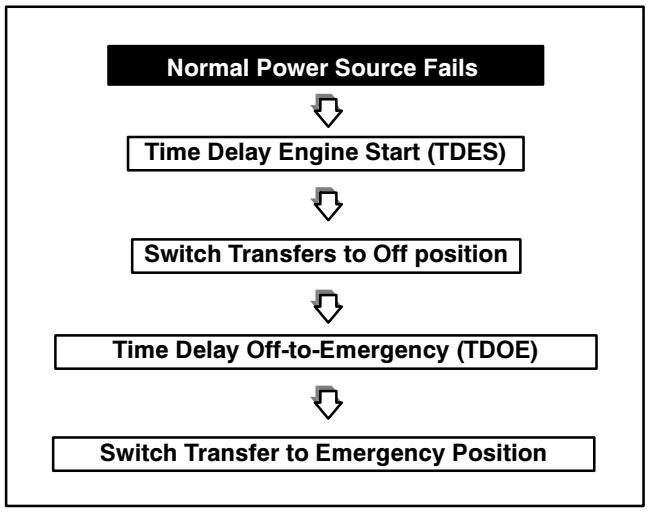


Figure 2-4 ATS Sequence of Operation, Normal Power Source Failure

2.5.2 Normal Power Source Restoration

The sequence for programmed transition follows. See Figure 2-5.

1. The normal power source is acceptable.
2. The TDEN (time delay emergency-to-normal) timer begins.
3. The TDEN timer ends.
4. The switch transfers to the Off position. The load is disconnected from both power sources.
5. The TDON (time delay off-to-normal) timer begins.
6. The TDON timer ends.
7. The switch transfers the load to the normal source.

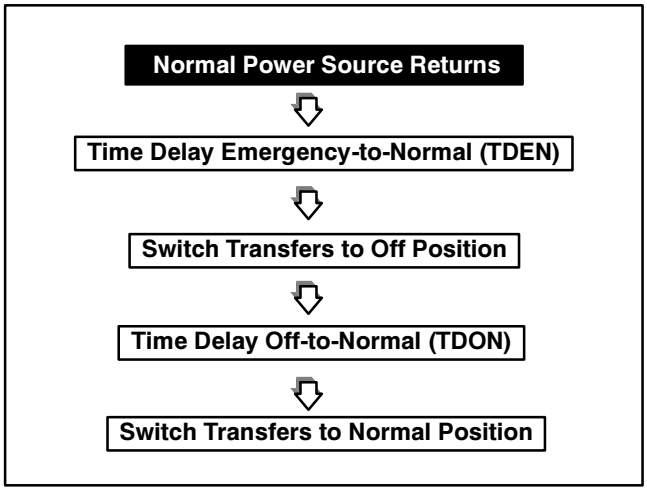


Figure 2-5 ATS Sequence of Operation, Normal Power Source Restoration

Determine factory-installed accessories by examining the transfer switch nameplate. This section describes optional accessories available on Kohler® Model MMS/MNS and MMT/MNT transfer switches with E33+ solid-state electrical controls. All accessories are UL1008 listed.

⚠ 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.
Can cause severe injury or death.

Disconnect all power sources before opening the enclosure.

(600 volts and under)

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

Installing the battery charger. Hazardous voltage can cause severe injury or death. An ungrounded battery charger may cause electrical shock. Connect the battery charger enclosure to the ground of a permanent wiring system. As an alternative, install an equipment grounding conductor with circuit conductors and connect it to the equipment grounding terminal or the lead on the battery charger. Install the battery charger as prescribed in the equipment manual. Install the battery charger in compliance with local codes and ordinances.

Connecting the battery and the battery charger. Hazardous voltage can cause severe injury or death. Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

Installing accessories to the transformer assembly. Hazardous voltage can cause severe injury or death. To prevent electrical shock disconnect the harness plug before installing accessories that will be connected to transformer assembly primary terminals 76, 77, 78, and 79. Terminals are at line voltage. *(Models with E33+, S340, S340+, 340, R340, and R33 controls only)*

Making line or auxiliary connections. Hazardous voltage can cause severe injury or death. To prevent electrical shock deenergize the normal power source before making any line or auxiliary connections.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Disconnect all power sources before servicing. Install the barrier after adjustments, maintenance, or servicing.

(600 volts and under)

Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Open the main circuit breakers of all transfer switch power sources and disable all generator sets as follows: (1) Move all generator set master controller switches to the OFF position. (2) Disconnect power to all battery chargers. (3) Disconnect all battery cables, negative (–) leads first. Reconnect negative (–) leads last when reconnecting the battery cables after servicing. Follow these precautions to prevent the starting of generator sets by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer. Before servicing any components inside the enclosure: (1) Remove rings, wristwatch, and jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Test circuits with a voltmeter to verify that they are deenergized.

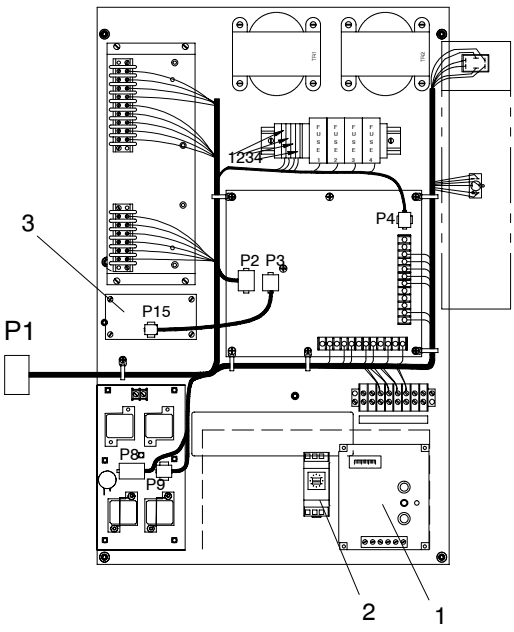
Servicing the transfer switch controls and accessories within the enclosure. Hazardous voltage can cause severe injury or death. Disconnect the transfer switch controls at the inline connector to deenergize the circuit boards and logic circuitry but allow the transfer switch to continue to supply power to the load. Disconnect all power sources to accessories that are mounted within the enclosure but are not wired through the controls and deenergized by inline connector separation. Test circuits with a voltmeter to verify that they are deenergized before servicing.

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

3.1 Typical Mounting Locations

See Figure 3-1 for typical mounting locations for accessories. The mounting locations of accessories may vary when the transfer switch has multiple accessories. See Figure 2-1 for a closeup view of controls and indicators on the front of the enclosure.



1. DA-24—Battery charger, 12 or 24 VDC
2. DA-23—Plant exerciser timer
3. DA-26—3-Phase sensing accessory

Figure 3-1 Typical E33+ Inner Panel Accessory Mounting Locations

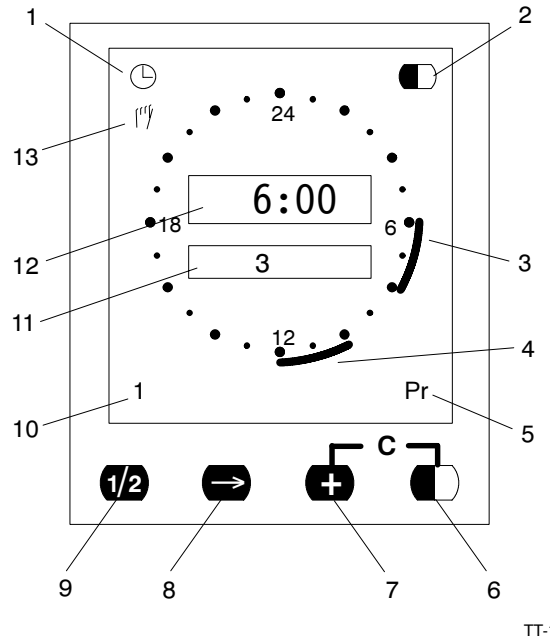
3.2 DA-23—Plant Exerciser

Accessory DA-23-Z plant exerciser contains a 14-day programmable timer that periodically runs the emergency source generator set. The exerciser timer is mounted below the main logic circuit board on the inner panel of the enclosure door.

Exercising the generator set under load once a week for a minimum of 30 minutes helps to maximize the reliability of the emergency power system.

The plant exerciser closes the engine start contacts directly, operating the generator set unloaded. The transfer switch only transfers to the emergency source if the normal source fails during the exercise period.

The plant exerciser has a liquid crystal display (LCD) panel that shows various exerciser information and four pushbuttons to enter information. See Figure 3-2. The following sections detail how to set the exerciser.



1. Blinking clock symbol = set time of day.
   Constant clock symbol = time switch running.
2. Generator start contact state, half shaded = on, no shading = off.
3. Segment display of first program, 1 segment = 15 min.
4. Segment display of second program, 4 programs per day max.
5. Symbol of program input.
6. Set button stores the programs to memory. Also used to override the program.
7. Plus button increases time in increments for programs.
8. Arrow button changes from day to hour:minute. Copy start and shutdown times from one day to the next.
9. Week button alternates between week one and week two.
10. Displays week one or week two.
11. Actual day of the week or program day.
12. Real time, set start time or set shutdown time.
13. Hand symbol blinking = continuous manual operating.
14. Hand symbol constant = manual override.

Figure 3-2 Exercise Timer

3.2.1 Clock Resetting Procedure

1. Lift the bottom flap of the timer's front cover to open.
2. Simultaneously press and hold the ARROW (→), PLUS (+), and SET (◐) buttons for 10 seconds. See Figure 3-2.
3. Continue to depress the ARROW (→) button and simultaneously release the PLUS (+) and SET (◐) buttons.
4. Release the ARROW (→) button when all segments of the LCD display appear.

3.2.2 Initial Setup (Time and Day) Procedure

1. Press the ARROW (→) button once. The clock symbol and the program day flash.
2. Press and release the PLUS (+) button until the current day of the week displays. Monday is day 1, Sunday is day 7.
3. Press the ARROW (→) button once when the current day displays.
4. Press and release the PLUS (+) button to increase the hour. Press the ARROW (→) button once to enter the hour. The timer runs from 1 to 24 hours, not am/pm.
5. Press and release the PLUS (+) button to increase the minutes. Hold the PLUS (+) button to increase the minutes by 5.
6. Press the ARROW (→) button once to enter the minute. After the minute has been entered, PR (program) flashes on the exerciser's display, and the number 1 in the display's lower left corner indicates the week.

3.2.3 Plant Exercise and Shutdown Timers Programming Procedure

1. Press and release the ARROW (→) button to advance to the desired exercise day. If the exercise day is in week 1, proceed to step 2. If the exercise day is in week 2, continue with step 1a.
   a. Press and release the ARROW (→) button to advance to day 7.
   b. Press the ARROW (→) button once.
   c. Press the WEEK (1/2) button once. The number 2 in the display's lower left corner indicates the week.
   d. Press and release the ARROW (→) button four times to advance to the desired exercise day.
2. Press or hold the PLUS (+) button to set the exercise start time.
3. Press the SET (◐) button to save the exercise start time.
4. Press or hold the PLUS (+) button to set the exercise shutdown time. Bar segments fill the display to identify the start time.
5. Press the SET (◐) button to save the exercise shutdown time.
6. Press the ARROW (→) key to advance to the next exercise day.
7. Press the PLUS (+) and SET (◐) buttons simultaneously to clear the setting if the exercise start and shutdown times are different from the previous day or do not apply to the current day. Repeat steps 2–6 to set the exercise start and shutdown times for each day of the week.
8. Press the ARROW (→) button once to complete programming when day 7 of week 1 or week 2 displays. The program is complete and ready to run when the clock icon is in the upper left corner of the exerciser's display.

3.2.4 Time Resetting Procedure

1. Perform Initial Setup (Time and Day) Procedure steps 1 to 5 (Section 3.2.2).

2. Press and release the ARROW (→) button eight times until the clock icon appears.

3.2.5 Reviewing the Program

Continue to press and release the ARROW (→) button to review the programmed start and shutdown times.

3.2.6 Modifying an Existing Program

Use one of the following procedures to reprogram a previously entered program.

Reprogramming Procedure for Setting Weeks and Days

1. Press the WEEK (1/2) button to choose week 1 or week 2.

2. Press the ARROW key (→) four times.

3. Perform the procedure listed under Plant Exercise and Shutdown Timers Programming Procedure.

4. Cancel the entered program for every day by pressing the PLUS (+) and SET (◐) buttons simultaneously.

5. Enter the new program for every day

Reprogramming Procedure for Resetting the Clock

1. Reset the clock as described under Time Resetting Procedure.

2. Perform the steps listed under Setup (Time and Day) Procedure (Section 3.2.2).

3.2.7 Manual Override Procedure

Use the following procedure to manually override the exercise timer and start or stop the generator.

1. Press and release the SET (◐) button once. The generator start contact changes state.

2. Press and release the SET (◐) button again to end manual override. The generator start contact changes state. If manual override is not ended, the timer automatically continues with the program at the next preset on or off time.

3.2.8 Continuous Manual Operation

Perform the following steps for continuous manual operation of the generator.

1. Press the SET (◐) button for two seconds until the hand icon (☞) flashes.

   If the generator start contact is on (◐), the segmented display appears. If the generator start contact is off (○), the segmented display does not appear.

2. Press and release the SET (◐) button to cause the generator start contact to change state.

3.2.9 Ending Continuous Manual Operation

To end continuous manual operation, press the SET (◐) button for two seconds until the clock icon appears in the display.

3.3 DA-24—Battery Charger

Automatic, adjustable-float battery chargers are mounted below the main logic circuit board on the inner panel of the enclosure door. See Figure 3-3 for component identification. Available chargers include:

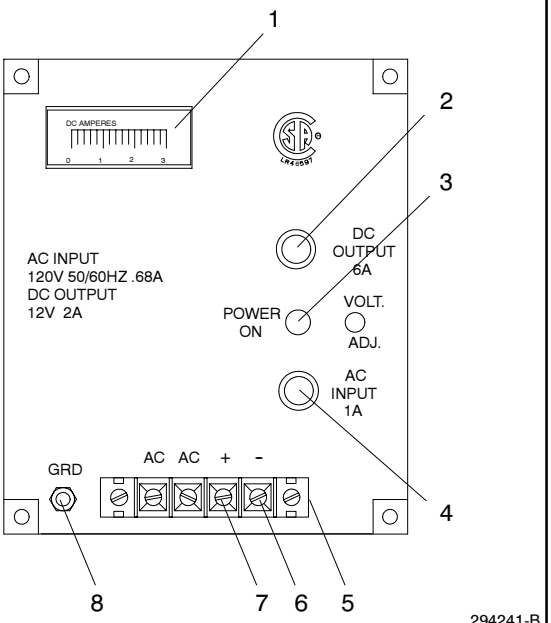
- **DA-24-xxA** 12-volt Charger
- **DA-24-xxB** 24-volt Charger

Where xx is a voltage- and frequency-dependent code.

Note: The battery chargers included in the transfer switch are designed strictly for use in the transfer switch. Read the following instructions before using the battery chargers.

3.3.1 Specifications

The battery charger automatically charges and maintains the charge on lead-acid, automotive-type batteries. Circuits on the control circuit board regulate and limit the output of the battery charger to provide current-limited output, AC line compensation, reverse-polarity protection, ambient-temperature compensation, and a constant-voltage charging mode. The control circuit board continuously monitors the battery and load conditions to maintain the battery's proper state of charge. The charger is factory-adjusted to maintain the battery at the proper float voltages. The 12-volt charger maintains a 6-cell lead-acid battery and requires no user adjustment. The 24-volt charger maintains a 12-cell lead-acid battery and requires no user adjustment.



1. Ammeter
2. DC output fuse
3. POWER ON lamp
4. AC input fuse
5. Terminal block
6. DC negative (-) output terminal
7. DC positive (+) output terminal
8. Ground terminal

Figure 3-3 Typical Battery Charger Components

3.3.2 Installation Connections

Note: Battery charger damage. Verify that the battery charger output voltage matches the battery voltage rating.

Wire Type. Use #10 AWG stranded copper wire, 600 V, 105°C vinyl plastic insulation, UL style 1015, CSA type TEW for the DC output leads from the battery charger to the battery.

Wire Length. See Figure 3-4 for the maximum distance of leads from the battery charger to the battery. Greater distances may result in excessive voltage drop, particularly when a battery ages and requires more current to maintain a float charge. Excessive voltage drop results in an undercharging condition that can lead to battery damage and/or failure of the generator to start.

Battery Voltage	Maximum Distance*, m (ft.)
12	45 (150)
24	90 (300)

* Measurements are based on #10 AWG stranded copper wire, 0.1/0.2 volt maximum voltage drop on each lead to the battery on 12/24 volt systems. Output current is 0.5 amps maximum, and ambient temperature 75°C (167°F) maximum.

Figure 3-4 Maximum Distance from Battery Charger to Battery

Grounding. Ensure that the metal frame or ground terminal of the battery charger is connected to a grounded, metal, permanent wiring system or an equipment-grounding conductor. Ensure that all battery charger connections comply with all applicable electrical codes and standards.

Charger Installation Connection Procedure

1. Prevent the emergency power source generator set from starting.
   a. Place the generator set master switch in the OFF position.
   b. Disconnect power to the generator set battery charger, if installed.
   c. Remove the generator set engine start battery cables, negative (–) leads first.
2. Disconnect or turn off *both* the normal and emergency power sources by opening circuit breakers or switches leading to the transfer switch. The POWER ON lamp on the battery charger should turn off.
3. Battery leads are not provided due to the variety of generator installations. Install, prepare, and connect leads as follows:
   a. Install a red wire for the positive (+) lead and a black wire for the negative (–) lead from the battery charger to the battery. Do not exceed the maximum distance given in Figure 3-4.
   b. Strip the insulation from both ends of both leads.
   c. Install a ring terminal on one end of the positive (+) lead. Attach the ring terminal to the generator set at a location connected to the positive (+) terminal of the battery, typically the engine starter solenoid. (Direct connection to the battery terminal can lead to terminal corrosion.) Connect the other end of the red lead to the DC positive (+) terminal on the battery charger's terminal block. Secure the same end of the red lead by tightening the lock screw.
   d. Install a ring terminal on one end of the negative (–) lead. Attach the ring terminal to the generator set at a location connected to the negative (–) terminal of the battery, typically the engine block. Connect the other end of the black lead to the DC negative (–) terminal on the battery charger's terminal block. Secure the same end of the black lead by tightening the lock screw.
   e. Reinstall the barrier on the battery charger's terminal strip.
4. Reconnect power supplies to the transfer switch. The POWER ON lamp on the battery charger should light.
5. Allow the emergency power source generator set to start.
   a. Reconnect the generator engine start battery cables, negative (–) leads last.
   b. Reconnect power to the generator set battery charger, if installed.
   c. Place the generator set master switch in the AUTO (automatic) position. The generator may start and run for a while.

3.3.3 Disconnecting the Charger Before Replacing or Servicing the Battery

1. Prevent the emergency power source generator set from starting.

   a. Place the generator set master switch in the OFF position.

   b. Disconnect power to the generator set battery charger, if installed.

   c. Remove the generator set engine start battery cables, negative (–) leads first.

2. Disconnect or turn off *both* the normal and emergency power sources by opening circuit breakers or switches leading to the transfer switch. The POWER ON lamp on the battery charger should turn off.

3. Remove the charger connection leads from the battery charger terminal block, black or negative (–) lead first. Wrap each of the charger connection leads with electrically-insulating tape.

4. Reconnect power supplies to the transfer switch. The POWER ON lamp on the battery charger should light.

5. Allow the emergency power source generator set to start.

   a. Reconnect the generator engine start battery cables, negative (–) leads last.

   b. Reconnect power to the generator set battery charger, if installed.

   c. Place the generator set master switch in the AUTO (automatic) position. The generator may start and run for a while.

3.3.4 Reconnecting the Charger After Replacing or Servicing the Battery

1. Prevent the emergency power source generator set from starting.

   a. Place the generator set master switch in the OFF position.

   b. Disconnect power to the generator set battery charger, if installed.

   c. Remove the generator set engine start battery cables, negative (–) leads first.

2. Disconnect or turn off *both* the normal and emergency power sources by opening circuit breakers or switches leading to the transfer switch. The POWER ON lamp on the battery charger should turn off.

3. Reconnect the charger connection leads to the battery charger terminal block, black or negative (–) lead last.

4. Reconnect power supplies to the transfer switch. The POWER ON lamp on the battery charger should light.

5. Allow the emergency power source generator set to start.

   a. Reconnect the generator engine start battery cables, negative (–) leads last.

   b. Reconnect power to the generator set battery charger, if installed.

   c. Place the generator set master switch in the AUTO (automatic) position. The generator may start and run for a while.

3.3.5 Charging Lead-Acid Batteries

Charge 6- or 12-cell (12- or 24-volt) lead-acid batteries according to the following procedure:

1. Inspect the battery for defective cables, loose posts, and loose terminals. For efficient charging, ensure that the battery terminals and battery charger connectors are tight and free of all corrosion.

2. If the battery is not sealed, check the fluid level in each cell. If the fluid level is low, add distilled water to bring the fluid level up to the battery manufacturer's recommended level.

3. An automatic charger does not operate properly on dry-charge batteries not given a conditioning charge. Give a dry-charge battery a conditioning charge immediately after adding electrolyte fluid. *This battery charger cannot provide the voltage and current required to provide a conditioning charge.* Follow the battery manufacturer's recommendations for the length of the conditioning charge and required charger specifications.

4. Reconnect power supplies to the transfer switch. The POWER ON lamp on the battery charger should light.

5. The ammeter indicates the charging current that the charger delivers to the battery. The charger control circuit limits the maximum charging current to 2 amps. A generator set does not require a cranking disconnect because the charger output is overload-protected. A battery in good condition is nearly fully charged when the following occurs:

- **Charging current approaches zero** as a battery becomes charged and the battery voltage approaches the control voltage setting. The ammeter needle may fluctuate, indicating a continuous supply of pulsating current that automatically keeps the battery in a charged condition.

- **The specific gravity of the battery electrolyte is between 1.250 and 1.285 corrected to a temperature of 26.7°C (80°F).** See the generator set or engine operation manual for the procedure to measure the specific gravity of battery electrolyte.

- **Bubbles appear at the surface of the battery fluid.** Bubbles indicate a battery that is 80 to 85% charged. Vigorous bubbling occurs when the battery nears full charge.

3.3.6 Charging Nickel-Cadmium Batteries

Charging recommendations vary among manufacturers of nickel-cadmium batteries. Contact the manufacturer of the nickel-cadmium battery for charging and maintenance instructions. If the voltage setting recommended by the battery manufacturer is different from the battery charger's factory setting, contact an authorized service center to adjust the battery charger.

3.3.7 Charger Voltage Adjustment

The battery charger's output settings are factory set and normally require no customer adjustment. If the battery charger requires adjustment, contact an authorized service center to adjust the battery charger. See Figure 3-5 for factory output settings.

Charger Voltage	Float Voltage	Current Limit (Amps)
12	13.2	2
24	26.4	2

Figure 3-5 Factory Output Settings

3.3.8 Charger and Battery Maintenance

See the generator set or engine operation manual for battery maintenance details. Include the following items when maintaining the system:

Important Charger and Battery Maintenance Items

- Check the battery terminals and charger connectors for clean contact surfaces. Clean corroded battery terminals and charger connectors with a mild baking soda/water solution.

- Check the battery fluid level regularly and maintain the level to the battery manufacturer's recommendations by adding distilled water (nonsealed batteries only).

3.4 DA-26—3-Phase Sensing

Accessory DA-26 is a circuit board assembly mounted inside the transfer switch which allows 3-phase sensing of the normal source. See Figure 3-6. A wiring harness connects the optional circuit board to the P3 connector on the main logic circuit board. See Figure 3-1. Adjustment pots N/AB and N/BC for sensing circuits and jumpers on the main logic circuit board have been factory-set for normal source 3-phase sensing and normally requires no further adjustment.

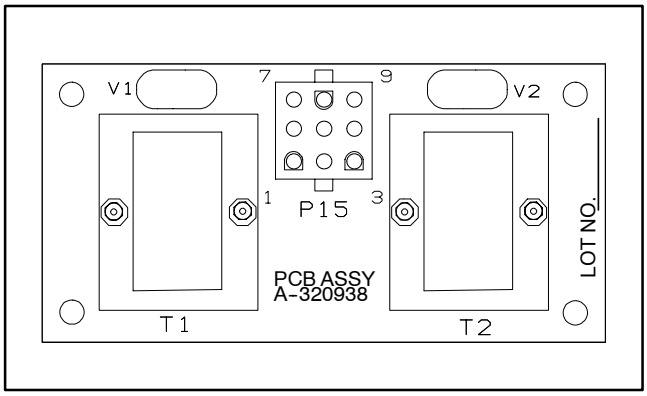


Figure 3-6 3-Phase Sensing Accessory

Read this entire section carefully before attempting any maintenance or service. Unless otherwise specified, have maintenance or service performed by an authorized service center that has trained and qualified personnel who follow all applicable codes and standards.

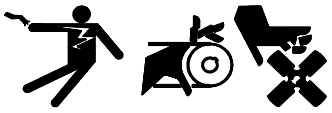
Scheduled preventive maintenance ensures safe and reliable operation and extends the life of the transfer switch. Preventive maintenance includes periodic testing, cleaning and inspection of the switch, and replacement of worn or missing components.

An authorized service center can provide complete preventive maintenance and services to keep the transfer switch in top condition. Contact a local distributor/dealer for additional information. See the Service Assistance section in this manual for how to locate a local service center.

Keep records of all maintenance or service.

Replace all barriers and close and lock the enclosure door after maintenance or service and before reapplying power.

⚠ 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.
Can cause severe injury or death.

Disconnect all power sources before opening the enclosure.

(600 volts and under)

⚠ WARNING

Hazardous voltage. Moving rotor.
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. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Disconnect all power sources before servicing. Install the barrier after adjustments, maintenance, or servicing.

(600 volts and under)

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 wristwatch, rings, and jewelry before servicing the equipment.

Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Open the main circuit breakers of all transfer switch power sources and disable all generator sets as follows: (1) Move all generator set master controller switches to the OFF position. (2) Disconnect power to all battery chargers. (3) Disconnect all battery cables, negative (–) leads first. Reconnect negative (–) leads last when reconnecting the battery cables after servicing. Follow these precautions to prevent the starting of generator sets by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer. Before servicing any components inside the enclosure: (1) Remove rings, wristwatch, and jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Test circuits with a voltmeter to verify that they are deenergized.

Servicing the transfer switch controls and accessories within the enclosure. Hazardous voltage can cause severe injury or death. Disconnect the transfer switch controls at the inline connector to deenergize the circuit boards and logic circuitry but allow the transfer switch to continue to supply power to the load. Disconnect all power sources to accessories that are mounted within the enclosure but are not wired through the controls and deenergized by inline connector separation. Test circuits with a voltmeter to verify that they are deenergized before servicing.

NOTICE

Hardware damage. The transfer switch may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

When replacing hardware, do not substitute with inferior grade hardware. Screws and nuts are available in different hardness ratings. To indicate hardness, American Standard hardware uses a series of markings, and metric hardware uses a numeric system. Check the markings on the bolt heads and nuts for identification.

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

4.1 Inspection and Service

Contact an authorized service center to inspect and service the transfer switch when any wear, damage, deterioration, or malfunction of the transfer switch or its components is evident or suspected.

4.1.1 General Inspection

External Inspection. Keep the transfer switch clean and in good condition by performing a general external inspection of the transfer switch at the recommended intervals for damage, deterioration, or contamination caused by vibration, leakage, noise, temperature, dirt, dust, or condensation. Remove accumulations of dirt, dust, and other contaminants from the transfer switch's external components or enclosure with a vacuum cleaner or by wiping with a dry cloth or brush. *Do not use compressed air to clean the switch because it can cause debris to lodge in the components and cause damage.* Replace any worn, missing, or broken external components with manufacturer-recommended replacement parts. Contact an authorized service center for specific part information and part ordering. Tighten loose external hardware.

Internal Inspection. Disconnect all power sources, open the transfer switch's enclosure door, and inspect internal components at the recommended intervals or when any condition noticed during an external inspection may have affected internal components.

Contact an authorized service center to inspect and service the transfer switch if any of the following conditions are found inside the transfer switch:

- Accumulations of dirt, dust, or contaminants
- Signs of corrosion
- Worn, missing, or broken components
- Loose hardware
- Deterioration, cuts, or abrasion of wire or cable insulation
- Signs of overheating or loose connections, such as discoloration of metal, melted plastic, or a burning odor
- Other evidence of wear, damage, deterioration, or malfunction of the transfer switch or its components.

If the power interruption required to perform an internal inspection is unacceptable in the application, have an internal inspection performed by an authorized service center.

4.1.2 Other Inspections and Service

Contact an authorized service center to perform scheduled maintenance, service, and other maintenance that ensures the safe and reliable operation of the transfer switch. See Section 4.3, Service Schedule, for the recommended maintenance items and service intervals.

Have an authorized service center repair or replace components inside the transfer switch's enclosure with manufacturer-recommended replacement parts.

4.2 Testing

4.2.1 Weekly Generator Set Exercise

Use a plant exerciser or manual test to start and run the generator set under a load once a week to maximize the reliability of the emergency power system. See Sections 2 and 3 for test switch and plant exerciser information.

4.2.2 Monthly Automatic Operation Test

Test the transfer switch's automatic control system monthly. See Section 5.6.2.

4.3 Service Schedule

Follow the service schedule in the power switching device operation and installation manual for the recommended service items and intervals. See List of Related Materials in the Introduction section. If the operation and installation manual does not have a service schedule, use the general schedule below. Have all service performed by an authorized service center except for activities designated by an X.

System Component or Procedure	See Section	Visually Inspect	Check	Change	Clean	Test	Interval
ELECTRICAL SYSTEM							
Check for signs of overheating or loose connections: discoloration of metal, melted plastic, or a burning odor	4.1.1	X	X				M
	4.1.2	D	D				S
Check wiring insulation for deterioration, cuts, or abrasion. Repair or replace damaged wiring.	4.1.1	X		D, R (wiring)			M
	4.1.2	D	D				S
Check the power switching device's external operating mechanism for cleanliness. Clean and relubricate if dirty. *	4.1.1	X		D, R (lubricant)	D		M
	4.1.2	D	D				S
Check the mechanical operation and integrity of the transfer switch's main power switching mechanisms and contacts. Clean, repair, or replace the power switching mechanisms or contacts as necessary.	4.1.2	D	D	D, R	D	D	A
Tighten control and power wiring connections according to specifications.	4.1.2, P		D			D	A
Perform a thermal scan or millivolt drop test to check for high contact resistances on power circuits. Tighten connections, clean main contacts, adjust or replace main contacts or power switching device assembly to eliminate high contact resistances.	4.1.2		D	D, R	D	D	A
Test wire and cable insulation for electrical breakdown.	4.1.2					D	Every 3 Years
Test calibration of voltage-sensing circuitry and setpoints. Recalibrate circuitry as necessary.	4.1.2					D	Every 5 Years
CONTROL SYSTEM							
Exercise the generator set under load.	4.2.1					X	W
Test the transfer switch's automatic control system.	4.2.2	X				X	M
Test all indicators (incandescent lamps and LEDs) and all remote control systems for operation.	4.1.2	D	D	D, R		D	A
GENERAL EQUIPMENT CONDITION							
Inspect the outside of the transfer switch for damage, deterioration, or contamination from such factors as vibration, leakage, noise, temperature, dirt, dust, or condensation to keep the transfer switch clean and in good condition. *	4.1.1	X			X		W
Check that all external hardware is in place, tightened, and not badly worn.	4.1.1	X	X	R			W
Inspect the inside of the transfer switch for damage, deterioration, or contamination from such factors as vibration, leakage, noise, temperature, dirt, dust, or condensation to keep the inside of the transfer switch clean, dry, and in good condition. *	4.1.1	X					M
	4.1.2	D	D		D		S
Check that all internal hardware is in place, tightened, and not badly worn.	4.1.1	X	X				M
	4.1.2	D	D				S

* Service more frequently if operated in dusty or dirty areas.

See Section Read these sections carefully for additional information before attempting maintenance or service.

Visually Inspect Examine these items visually.

Check Requires physical contact with or movement of system components, or the use of nonvisual indications.

Change May require replacement of components depending upon the severity of the problem.

Clean Remove accumulations of dirt and contaminants from external transfer switch's components or enclosure with a vacuum cleaner or by wiping with a dry cloth or brush. *Do not use compressed air to clean the switch because it can cause debris to lodge in the components and cause damage.*

Test May require tools, equipment, or training available only through an authorized service center.

P See the transfer switch power switching device operation and installation manual for more information.

D Have service performed by an authorized service center.

X Operator action.

R May require replacement of components.

W=Weekly
M=Monthly
Q=Quarterly
S=Semi annually
A=Annually

Kohler® transfer switches are shipped factory wired and tested and ready for installation. Ensure that only trained and qualified personnel install the equipment, and verify that the installation complies with applicable codes and standards. Switch installation includes the following steps:

- Unpacking and inspecting the transfer switch upon receipt.
- Protecting the switch against damage before and during installation.
- Mounting the transfer switch.
- Wiring the normal power source (utility), emergency power source (generator set), and load circuits.
- Wiring the generator set engine start connection.
- Connecting accessories, if provided.
- Checking voltages and functions.
- Connecting and initializing the electrical controls, as required.

This section contains electrical controls installation details. Begin installation by following the instructions in the power switching device operation and installation manual packed with the transfer switch. The power switching device manual contains mechanical installation instructions, power connection details, electrical ratings, and other power switching device specifications. See the List of Related Materials in the Introduction section of this manual.

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5.1 Receipt of Unit

5.1.1 Inspection

At the time of delivery, inspect the packaging and the outside of the transfer switch for signs of shipping damage. See Section 5.1.4 for unpacking instructions. Unpack the transfer switch as soon as possible and inspect it for shipping damage. If damage and/or rough handling is evident, immediately file a damage claim with the transportation company.

See Section 5.1.3 for storage instructions.

t:is:001:002

5.1.2 Lifting

⚠ WARNING

Unbalanced weight.
Improper lifting can cause severe injury or death and equipment damage.

Use adequate lifting capacity.
Never leave the transfer switch standing upright unless it is securely bolted in place or stabilized.

The power switching device operation and installation manual lists the approximate weight of each transfer switch. Use a spreader bar to lift the transfer switch. Attach the bar only to the enclosure's mounting holes or lifting brackets; do not lift the unit any other way. Replace, close and latch the enclosure door before moving the unit.

t:is:001:003

5.1.3 Storage

Store the transfer switch in its protective packing until final installation. Protect the transfer switch at all times from moisture, construction grit, and metal chips. Avoid storage in low-temperature and high-humidity areas where moisture could condense on the unit.

t:is:001:004

5.1.4 Unpacking

Allow the equipment to warm to room temperature for at least 24 hours before unpacking to prevent condensation on the electrical apparatus. Use care when unpacking to avoid damaging the transfer switch components. Remove dirt and packing material that may have accumulated in the transfer switch or any of its components. Do not use compressed air to clean the switch. Cleaning with compressed air can cause debris to lodge in the components and damage the switch.

t:is:001:005

5.2 Mechanical Installation

Check the system voltage and frequency shown on the transfer switch nameplate. Do not install the transfer switch if the system voltage and frequency are different from the nominal normal (utility) source voltage and frequency or the nominal emergency source voltage and frequency shown on the generator set nameplate.

The electrical controls of enclosed transfer switches are mounted on the enclosure door. Refer to the power switching device operation and installation manual for transfer switch mounting instructions. Mount the transfer switch on the wall or the floor as described in the power switching device manual.

t:is:001:006

5.3 Check Manual Operation

Follow the *manual* operation procedure in the power switching device operation and installation manual to verify that the switch operates smoothly without binding. Then prepare the switch for automatic operation. If the power switching device does not operate smoothly without binding, *STOP!* Call an authorized service center to service the unit before proceeding.

5.4 Electrical Wiring

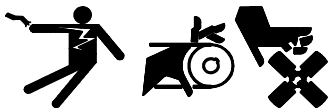
The factory prewires all internal electrical connections. The only wiring necessary to install the transfer switch is connection to external devices and power sources.

Observe all applicable national, state, and local electrical codes during installation.

Do not install DC, control, and communication system wiring in the same raceways, cables, or conduit as AC power wiring.

The power switching device service and parts manual provides schematic diagrams and enclosure drawings.

⚠ 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.
Can cause severe injury or death.

Disconnect all power sources before opening the enclosure.

(600 volts and under)

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Disconnect all power sources before servicing. Install the barrier after adjustments, maintenance, or servicing.

(600 volts and under)

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

Installing the battery charger. Hazardous voltage can cause severe injury or death. An ungrounded battery charger may cause electrical shock. Connect the battery charger enclosure to the ground of a permanent wiring system. As an alternative, install an equipment grounding conductor with circuit conductors and connect it to the equipment grounding terminal or the lead on the battery charger. Install the battery charger as prescribed in the equipment manual. Install the battery charger in compliance with local codes and ordinances.

Connecting the battery and the battery charger. Hazardous voltage can cause severe injury or death. Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

Installing accessories to the transformer assembly. Hazardous voltage can cause severe injury or death. To prevent electrical shock disconnect the harness plug before installing accessories that will be connected to transformer assembly primary terminals 76, 77, 78, and 79. Terminals are at line voltage. *(Models with E33+, S340, S340+, 340, R340, and R33 controls only)*

Making line or auxiliary connections. Hazardous voltage can cause severe injury or death. To prevent electrical shock deenergize the normal power source before making any line or auxiliary connections.

NOTICE

Hardware damage. The transfer switch may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

5.4.1 AC Power Connections

See the power switching device operation and installation manual for power connection information and ratings.

5.4.2 Controller Logic

The E33+ electrical control system (logic controller) is mounted on the inside of the enclosure door. See Figure 5-1.

The power switching device and the logic controller each has its own wiring harness that terminates with an inline disconnect plug. See Figure 5-1. The factory sends the transfer switch with the inline disconnect plugs disconnected.

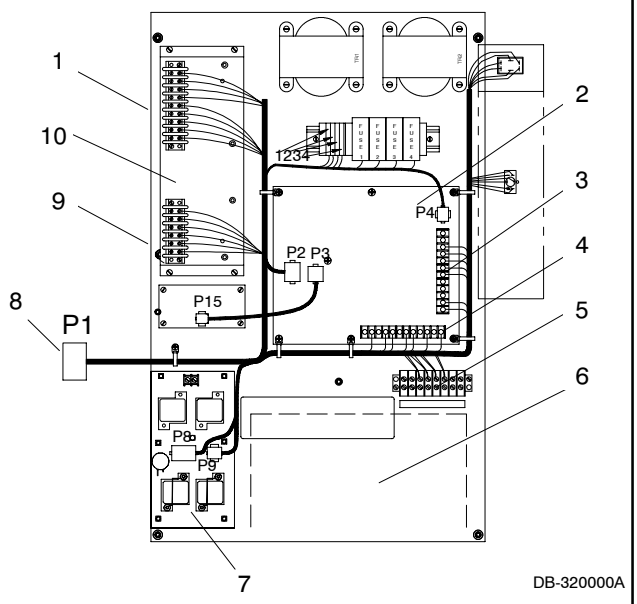
Do not connect the controller to the power switching device until a voltage check is performed. See Section 5.6.1.

The main controller circuit board provides the standard features listed in Section 1, Specifications. It also provides a terminal strip and connectors that allow connection to the system using a wiring harness.

Terminal strips TB1 and TB2, located on the main controller circuit board, provide connection terminals for the system and various accessories.

Accessory terminal strip TB6 provides connection terminals for various accessories.

The power sensing transformer assembly has power transformers that power the controller and allow power source sensing. The number of transformers required depends upon the number of phases and the accessories requested. A terminal strip on the assembly connects the primaries of the transformers to the emergency and normal sources through the wiring harness. Another terminal strip connects the outputs of transformer secondaries and connects to controller inputs through the wiring harness.



1. Transformer secondary terminal strip (terminals T1–T9)
2. Main controller circuit board
3. Terminal strip TB1 (terminals 1–12)
4. Terminal strip TB2 (terminals 1–12)
5. Accessory terminal strip TB6 (terminals 74–81)
6. Accessory mounting area
7. Interface circuit board (if mounted on inner panel)
8. Inline disconnect plug P1
9. Transformer primary terminal strip (terminals NA, NB, NC, EA, EB, and EC)
10. Power sensing transformer assembly

Figure 5-1 Typical E33+ Inner Panel Electrical Controls

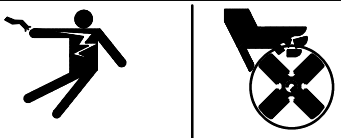
5.4.3 Accessory and Control Connections

Make the generator engine start signal connections. See the power switching device operation and installation manual for details.

Note optional accessories installed on the transfer switch and make connections to those accessories. See Section 3 for accessories.

5.5 Generator Set Preparation

⚠ WARNING



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

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

Disconnect all power sources to the transfer switch by opening upstream circuit breakers or switches to the transfer switch.

Prepare the generator set that provides the emergency power source to the transfer switch for operation. Check the oil level, coolant level, fuel supply, batteries, and items specified by the generator set installation instructions, operation checklist, or manual.

Move the generator set master switch to the OFF position; reconnect generator engine start battery cables, negative (–) leads last; and reconnect power to the generator engine start battery chargers, if installed.

5.6 Functional Tests

5.6.1 Voltage Check

Follow the instructions in the power switching device operation and installation manual for the voltage check procedure to complete installation of the power switching device. If the power switching device operation and installation manual does not have a voltage check procedure, use the following general procedure. See Figure 5-1 to locate the controller's inline disconnect plug.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

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 rings, wristwatch, and 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)

Read and understand all instructions on installation drawings and labels affixed to the switch. Note any optional accessories that have been furnished with the switch and review their operation.

Note: Perform voltage check in the order given to avoid damaging the transfer switch.

Voltage Check Procedure

1. Disconnect all power sources before opening the transfer switch enclosure by opening circuit breakers or switches leading to the transfer switch.

2. Disconnect the power switching device and logic controller wire harnesses at the inline disconnect plug (P1). See Figure 5-1.

3. Move the generator set master switch to the OFF position to inhibit generator set starting.

4. *Manually* transfer the load to the emergency source. Refer to power switching device operation and installation manual for information on manual transfer of the load.

5. Reapply the normal source by closing circuit breakers or switches leading to the transfer switch.

6. Use an accurate voltmeter to check the normal source phase-to-phase and phase-to-neutral terminal voltages. Use accurate test equipment to check the phase rotation at the normal source terminals. If the nominal normal source voltage or frequency does not match the value shown on the transfer switch nameplate, *STOP.* Do not continue the installation because the transfer switch is not designed for the application. Call a local service distributor to order the correct transfer switch.

7. Disconnect *both* the normal and emergency power sources by opening circuit breakers or switches leading to the transfer switch.

8. *Manually* transfer the load to the normal source. Refer to power switching device operation and installation manual for information on manual transfer of the load.

9. Reapply the emergency power source by closing the circuit breakers or switches leading to the transfer switch.

10. Move the generator set master switch to the RUN position. The generator set should start.

11. Use an accurate voltmeter to check the emergency source phase-to-phase and phase-to-neutral terminal voltages. Use accurate test equipment to check the phase rotation at the emergency-source terminals. Rewire the transfer switch emergency source terminals if the emergency source phase rotation is not the same as the normal source.

12. Follow the generator set manufacturer's instructions to adjust the generator output voltage and frequency to match the nominal system voltage and frequency shown on the transfer switch nameplate if they are different. The automatic transfer switch will operate correctly only to the rated system voltage and frequency specified on the nameplate.

13. Move the generator set master switch to the AUTO position.

14. Disconnect the emergency power source by opening circuit breakers or switches leading to the transfer switch.

15. Follow the manual operation procedure to prepare the transfer switch for automatic operation. See the power switching device operation and installation manuals for instructions.

16. Connect the power switching device and controller wiring harnesses together at the inline disconnect plug. See Figure 5-1.

17. Close and lock the transfer switch enclosure door. Replace and tighten any fastening screws on the enclosure door.

18. Reconnect power sources to the transfer switch.

Leave the generator set master switch in the AUTO (automatic) position after performing the voltage check.

5.6.2 Automatic Operation Test

An automatic operation test verifies the transfer switch's electrical control system operation.

Begin an automatic operation test with the system in its normal state of operation:

- Normal power source available.
- Circuit breakers or switches leading to the transfer switch closed.
- Load connected to the normal source.
- The generator set ready to operate, master switch in the AUTO (automatic) position, and shut down.

Close circuit breakers or switches only when loads can be safely energized. Observe indicators and time delays during the sequences of operation and compare them to expected operation. See Section 2.4, Automatic Operation.

Automatic Operation Test Procedure

1. Operate the transfer switch's test switch to select the test mode. The generator set should start and run after TDES completes timing. The emergency source available indicator should light when the generator set is up to rated voltage and speed.

2. Programmed transition switches should transfer the load to the emergency source after TDOE completes timing. Non-programmed transition switches should immediately transfer the load to the emergency source.

3. Operate the test switch to select the automatic mode. The transfer switch retransfers the load to the normal source after TDEN (TDON) completes timing. The generator set should shut down when any cooldown function in the generator set controller completes its timing.

The automatic operation test completes functional tests of the transfer switch. Leave the generator set master switch in the AUTO (automatic) position.

5.7 Controller Setup

The main circuit board of the controller contains undervoltage, underfrequency, and time delay circuits. See Figure 5-2. These circuits are factory-set and normally will not require readjustment. See Section 1 for factory settings.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Disconnect all power sources before servicing. Install the barrier after adjustments, maintenance, or servicing.

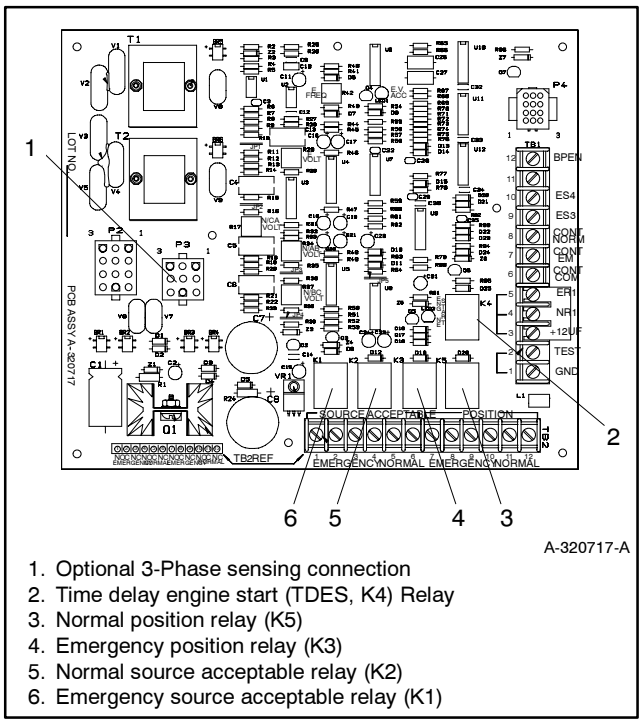
(600 volts and under)

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. 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 wristwatch, rings, and jewelry before servicing the equipment.

Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Open the main circuit breakers of all transfer switch power sources and disable all generator sets as follows: (1) Move all generator set master controller switches to the OFF position. (2) Disconnect power to all battery chargers. (3) Disconnect all battery cables, negative (–) leads first. Reconnect negative (–) leads last when reconnecting the battery cables after servicing. Follow these precautions to prevent the starting of generator sets by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer. Before servicing any components inside the enclosure: (1) Remove rings, wristwatch, and jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Test circuits with a voltmeter to verify that they are deenergized.

Servicing the transfer switch controls and accessories within the enclosure. Hazardous voltage can cause severe injury or death. Disconnect the transfer switch controls at the inline connector to deenergize the circuit boards and logic circuitry but allow the transfer switch to continue to supply power to the load. Disconnect all power sources to accessories that are mounted within the enclosure but are not wired through the controls and deenergized by inline connector separation. Test circuits with a voltmeter to verify that they are deenergized before servicing.



1. Optional 3-Phase sensing connection
2. Time delay engine start (TDES, K4) Relay
3. Normal position relay (K5)
4. Emergency position relay (K3)
5. Normal source acceptable relay (K2)
6. Emergency source acceptable relay (K1)

Figure 5-2 Typical E33+ Inner Panel Electrical Controls

Refer to Section 3 for additional controller accessory adjustments.

If the switch is equipped with programmed transition, proceed to Section 5.8. Otherwise, controller setup is complete. Perform an automatic operation test to verify controller operation including time delays. See Section 5.6.2.

5.8 Programmed Transition Setup

5.8.1 Description

Switches equipped with programmed transition have a power switching device with an OFF position and two time delay relays on the interface circuit board. See Figure 5-3. With programmed transition, power transfers occur from the normal-to-emergency or emergency-to-normal sources of power in three steps:

1. The switch transfers to the OFF position. The load is disconnected from both power sources.
2. A delay period, adjustable from 2 to 40 seconds, allows any residual voltage in the load circuit to decay.
3. The switch transfers the load to the new power source.

5.8.2 Timing Adjustment for Programmed Transition

Two separate timing relays are used. One relay, TDOE, produces the time delay for the normal-to-emergency power transfer. The other relay, TDON, produces the time delay for the emergency-to-normal power transfer. Each relay has a separate adjustment. To make the adjustment, proceed as follows:

⚠ WARNING

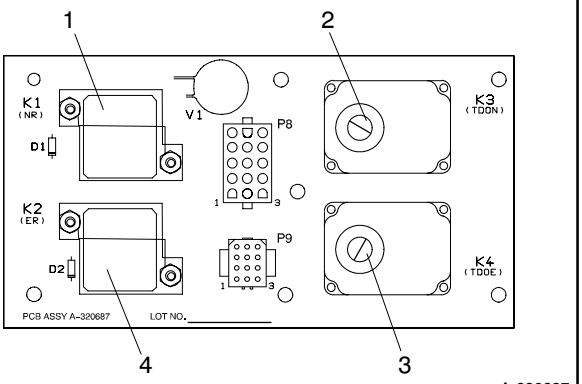
Hazardous voltage.
Can cause severe injury or death.

Disconnect all power sources before servicing. Install the barrier after adjustments, maintenance, or servicing.

(600 volts and under)

Time Delay Off Adjustment Procedure

1. Prevent the generator set, which provides the emergency power source to the transfer switch, from starting by moving the generator set master switch to the OFF position, disconnecting power to the generator engine start battery charger, if installed, and disconnecting all generator engine start batteries, negative (-) leads first.
2. Disconnect *both* the normal and emergency power sources by opening circuit breakers or switches leading to the transfer switch.
3. Open the transfer switch enclosure door.
4. Locate the appropriate time delay relay on the interface circuit board. See Figure 5-3.
5. Adjust time delays by turning the adjustment clockwise to increase the time delay and counterclockwise to decrease the time delay.
6. Reinstall barriers removed to access adjustments.
7. Close and lock the transfer switch enclosure door. Replace and tighten fastening screws on the enclosure door.
8. Reconnect power supplies to the transfer switch.
9. Reconnect the generator engine start battery cables, negative (-) leads last, reconnect power to the generator engine start battery charger, if installed, and move the generator set master switch to the AUTO (automatic) position. The generator may start and run for a while.
10. Controller setup is complete. Perform an automatic operation test to verify controller operation including time delays. See Section 5.6.2.



1. NR relay
2. TDON time delay relay adjustment
3. TDOE time delay relay adjustment
4. ER relay

Figure 5-3 Interface Circuit Board with Time Delay Off Relays

5.9 Ensure Warranty Registration

The transfer switch seller must complete a Startup Notification Form and submit it to the manufacturer within 60 days of the initial startup date. A Startup Notification Form is included with generator sets and covers all equipment in the standby system. Standby systems not registered within 60 days of the initial date are automatically registered using the manufacturer's ship date as the startup date.

Notes

Appendix A 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	audio/visual
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
cmm	cubic meters per minute
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
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
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
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
O/C	overcrank
OD	outside diameter
OEM	original equipment manufacturer
O/F	overfrequency
opt.	option, optional
O/S	oversize, overspeed
OSHA	Occupational Safety and Health Administration
O/V	overvoltage
oz.	ounce
p., pp.	page, pages
PA	packed accessory
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)
U/F	underfrequency
UHF	ultrahigh frequency
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
U/S	undersize, underspeed
UV	ultraviolet
U/V	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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