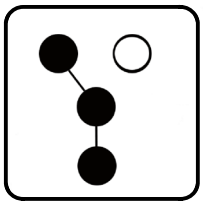
Installation

Automatic Transfer Switches



Models:

KCS/KCP

30 to 4000 Amperes

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-6446 10/12e

Product Identification 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 Designation _____

Serial Number _____

Accessories

- ❑ Alarm Board
- ❑ Current Monitoring
- ❑ Battery Module
- ❑ Standard I/O Module (max. 4) qty:_____
- ❑ High Power I/O Module (max. 4) qty:_____
- ❑ Line-Neutral Monitoring
- ❑ Supervised Transfer Switch
- ❑ Digital Power Meter
- ❑ Battery Charger
- ❑ Logic Disconnect Switch
- ❑ Load Shed
- ❑ _____
- ❑ _____
- ❑ _____
- ❑ _____

Controller Identification

Record the controller description from the generator set operation manual, spec sheet, or sales invoice.

Controller Description _____

Software Version Number

Record the software version number.

Software Version Number _____

Table of Contents

Notes

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.

Hazardous Voltage/ Moving Parts

DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

DANGER

Hazardous voltage.
Will cause severe injury or death.

Only authorized personnel should open the enclosure.

WARNING

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

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

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

Removing the transfer switch from bypass/isolation models. Hazardous voltage can cause severe injury or death. Bypass and isolate the transfer switch before removing it from the enclosure. The bypass/isolation switch is energized. Do not touch the isolation contact fingers or the control circuit terminals.

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).

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

Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Turn off 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 all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Test circuits with a voltmeter to verify that they are deenergized.

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.

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.

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

⚠ WARNING

Airborne particles.
Can cause severe injury or blindness.

Wear protective goggles and clothing when using power tools, hand tools, or compressed air.

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.

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

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® Model KCS/KCP Automatic Transfer Switches. A separate manual provided with the transfer switch covers the transfer switch controller operation. See List of Related Materials for the document part number.

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.

List of Related Materials

A separate manual covers the transfer switch controller and related accessories. Separate manuals contain service and parts information for transfer switch power switching devices and electrical controls.

The following table lists the part numbers for related literature.

Literature Item	Part Number
Specification Sheet, Model KCS/KCP	G11-106
Operation Manual, MPAC™ 1500 Controller	TP-6714
Parts Catalog, Transfer Switch and Controller	TP-6433
Service Manual, Model KCS/KCP/KBS/KBP	TP-6460

Service Assistance

For professional advice on generator power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Consult the Yellow Pages under the heading Generators—Electric.
- Visit the Kohler Power Systems website at KohlerPower.com.
- Look at the labels and stickers on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

Headquarters Europe, Middle East, Africa (EMEA)
Kohler Power Systems
3 rue de Brennus
93200 Saint Denis
France
Phone: (33) 1 49 178300
Fax: (33) 1 49 178301

Asia Pacific
Power Systems Asia Pacific Regional Office
Singapore, Republic of Singapore
Phone: (65) 6264-6422
Fax: (65) 6264-6455

China
North China Regional Office, Beijing
Phone: (86) 10 6518 7950
(86) 10 6518 7951
(86) 10 6518 7952
Fax: (86) 10 6518 7955

East China Regional Office, Shanghai
Phone: (86) 21 6288 0500
Fax: (86) 21 6288 0550

India, Bangladesh, Sri Lanka
India Regional Office
Bangalore, India
Phone: (91) 80 3366208
(91) 80 3366231
Fax: (91) 80 3315972

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

Latin America
Latin America Regional Office
Lakeland, Florida, USA
Phone: (863) 619-7568
Fax: (863) 701-7131

1.1 Purpose

An automatic transfer switch (ATS) transfers electrical loads from a normal (preferred) source of electrical power to an emergency (standby) source when the normal source falls outside the acceptable electrical parameters.

When the normal (preferred) source fails, the ATS signals the emergency (standby) source generator set to start. When the emergency (standby) source reaches acceptable levels and stabilizes, the ATS transfers the load from the normal (preferred) source to the emergency (standby) source. The ATS continuously monitors the normal (preferred) source and transfers the load back when the normal (preferred) source returns and stabilizes. After transferring the load back to the normal (preferred) source, the ATS removes the generator start signal, allowing the generator set to shut down.

Figure 1-2 shows a typical installation block diagram.

Figure 1-1 Automatic Transfer Switch

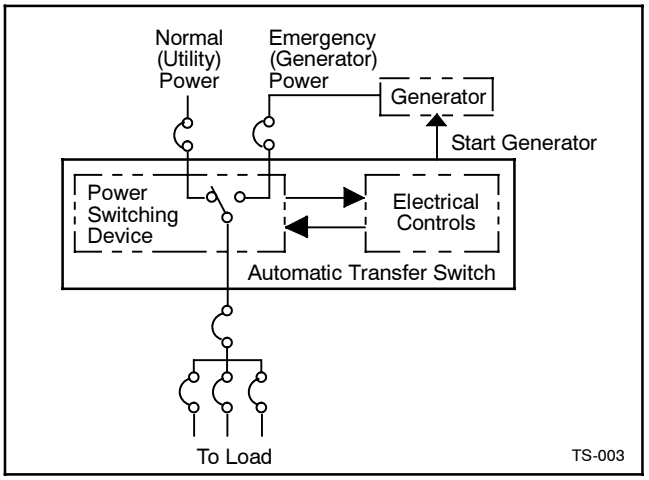


Figure 1-2 Typical ATS Block Diagram

1.2 Nameplate

A nameplate attached to the controller cover on the inside of the enclosure door includes a model designation, a serial number, ratings, and other information about the transfer switch. See Figure 1-3. The serial number is also shown on a label inside the transfer switch enclosure.

Copy the model designation, serial number, and accessory information from the nameplate to the spaces provided in the Product Identification Information section inside the front cover of this manual for use when requesting service or parts.

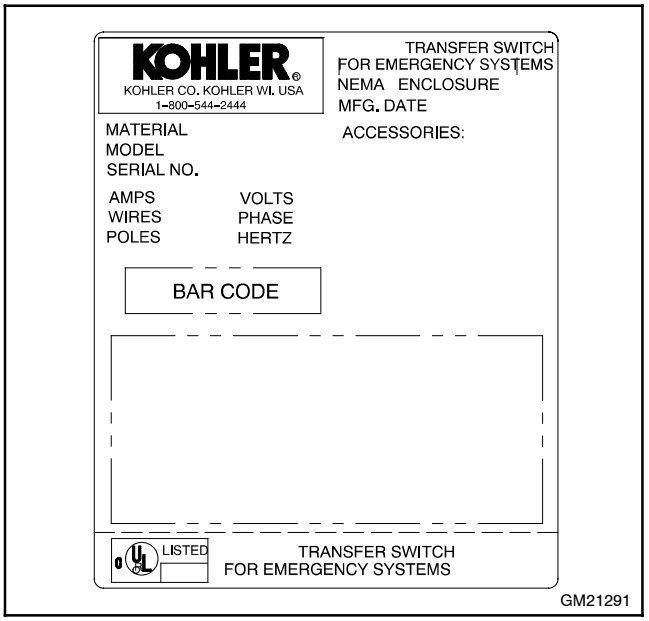
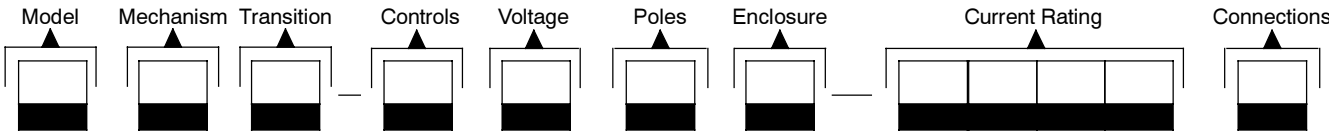


Figure 1-3 Typical Transfer Switch Nameplate

1.3 Model Designation



Record the transfer switch model designation in the boxes. The transfer switch model designation defines characteristics and ratings as explained below.

Sample Model Designation: KCS-DNTA-0400S

Model
K: Kohler Transfer Switch

Mechanism
C: Standard

Transition
S: Standard
P: Programmed-Transition

Controls
D: MPAC™ 1500
Microprocessor Controls, Automatic
F: MPAC™ 1500
Microprocessor Controls, Non-Automatic

Voltage/Frequency
C: 208 Volts/60 Hz
D: 220 Volts/50 Hz
F: 240 Volts/60 Hz
G: 380 Volts/50 Hz
H: 400 Volts/50 Hz
J: 416 Volts/50 Hz
K: 440 Volts/60 Hz
M: 480 Volts/60 Hz
N: 600 Volts/60 Hz
P: 380 Volts/60 Hz
R: 220 Volts/60 Hz

Number of Poles/Wires
N: 2-pole, 3-wire, solid neutral
T: 3-pole, 4-wire, solid neutral
V: 4-pole, 4-wire, switched neutral
W: 4-pole, 4-wire, overlapping neutral
Z: 3-pole, 4-wire, integral solid neutral *

* Integral solid neutral is mounted on the contactor. Not available on all amperages.

Enclosure
A: NEMA 1†
B: NEMA 12§
C: NEMA 3R‡
D: NEMA 4§
F: NEMA 4X§
G: Open unit
H: NEMA 3R SS **

† Standard on 30–4000 A models.
‡ Available to order on 30–3000 A models. Contact the factory for 4000 A units.
§ Available to order on 30–1000 A models. Contact the factory for larger units.
** NEMA 3R SS available only through special order.

Current Rating: Numbers indicate the current rating of the switch in amperes:

0030	0230 (KCS)	1200
0070	0260	1600
0104	0400	2000
0150	0600	2600
0200 (KCS)	0800	3000
0225 (KCP)	1000	4000

Power Connections
S: Standard
F: Front bus (available on 1600 and 2000 A models only)

2.1 Introduction

Kohler® transfer switches are shipped factory-wired, factory-tested, and ready for installation. Have the equipment installed only by trained and qualified personnel, 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.
- Verifying that the transfer switch voltage and frequency ratings match the voltages and frequencies of the sources.
- Mounting the transfer switch.
- Checking the manual operation.
- 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.
- Connecting and initializing the electrical controls, as required.
- Checking voltages and operation.

Protect the switch against damage before and during installation.

The functional tests in Section 3 are a necessary part of the installation. Be sure to perform the functional tests, which include voltage checks and operation tests, before putting the transfer switch into service.

2.2 Receipt of Unit

2.2.1 Inspection

At the time of delivery, inspect the packaging and the transfer switch for signs of shipping damage. Unpack the transfer switch as soon as possible and inspect the exterior and interior for shipping damage. If damage and/or rough handling is evident, immediately file a damage claim with the transportation company.

2.2.2 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.

Refer to Figure 2-1 for the approximate weight of the transfer switch in a Type 1 enclosure. For other enclosures, refer to the specification sheet or the dimension drawing. 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. Close and latch the enclosure door before moving the unit.

Amps	Weight kg (lb.)		
	2-Pole	3-Pole	4-Pole
Standard-Transition Models			
30-200	28 (62)	30 (65)	31 (68)
230	52 (115)	56 (123)	59 (131)
260-600	179 (395)	183 (403)	188 (414)
800-1000	220 (485)	231 (510)	238 (525)
1200	—	356 (785)	379 (835)
1600-2000	—	472 (1040)	494 (1090)
2600-3000	—	649 (1430)	679 (1495)
4000	—	1043 (2300)	1089 (2400)
Programmed-Transition Models			
150-600	179 (395)	183 (403)	188 (414)
800-1000	220 (485)	231 (510)	238 (525)
1200	—	463 (1020)	485 (1070)
1600-2000	—	533 (1175)	556 (1225)
2600-3000	—	735 (1620)	765 (1685)
4000	—	1115 (2457)	1160 (2557)

Figure 2-1 Approximate Weights, Type1 Enclosures

2.2.3 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. See Figure 2-2 for acceptable storage temperatures.

Environmental Specifications	
Operating Temperature	-20°C to 70°C (-4°F to 158°F)
Storage Temperature	-40°C to 85°C (-40°F to 185°F)
Humidity	5% to 95% noncondensing

Figure 2-2 Environmental Specifications

2.2.4 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 transfer switch components. Remove dirt and packing material that may have accumulated in the transfer switch or any of its components.

Note: 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.

For 600–800 amp transfer switches, remove the lag screws that secure the transfer switch to the shipping skid. For 1000–4000 amp transfer switches, open the enclosure door to remove the lag screws that secure the transfer switch to the skid.

2.3 Installation

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

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.

Check the system voltage and frequency. Compare the voltage and frequency shown on the transfer switch nameplate to the source voltage and frequency. See Figure 2-3. 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.

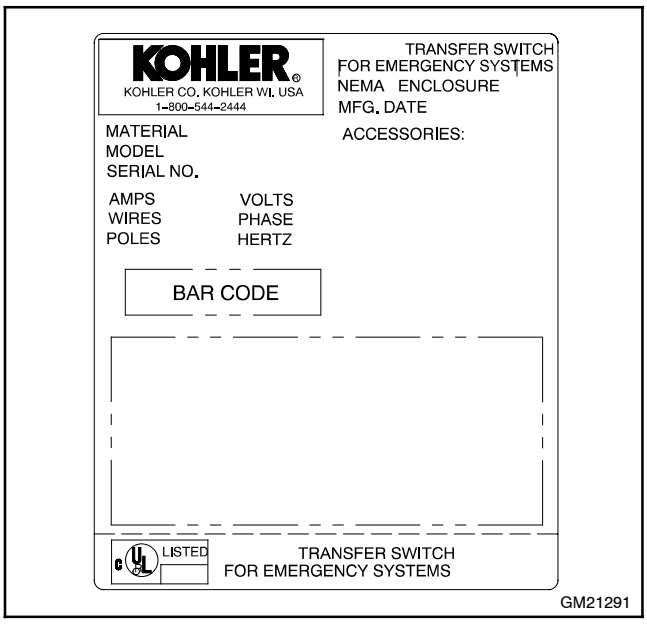


Figure 2-3 Nameplate

Plan the installation. Use the dimensions given on the enclosure dimension (ADV) drawings. Select a mounting site that complies with local electrical code restrictions for the enclosure type. Mount the transfer switch as close to the load and power sources as possible. Allow adequate space to fully open the enclosure and to service the switch. Provide cable bending space and clearance to live metal parts.

Outdoor installations. Transfer switches with NEMA 3R, 4, or 4X enclosures can be installed outdoors. In locations with very high ambient temperatures, installation in a shaded area or a location with the enclosure door facing away from direct sunlight is recommended.

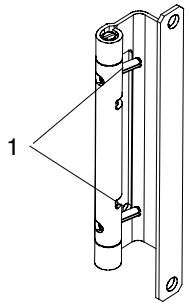
Installation of seismically certified transfer switches. See the notes in Section 2.4 and the ADV drawings provided with the transfer switch for additional installation requirements for transfer switches with seismic certification.

Prepare the foundation. Ensure that the supporting foundation for the enclosure is level and straight. For bottom cable entry, if used, install conduit stubs in the foundation. Refer to the enclosure dimension drawing for the conduit stub locations. When pouring a concrete floor, use interlocking conduit spacer caps or a wood or metal template to maintain proper conduit alignment.

Install the ATS. For easy access during installation and wiring, remove the front door of the enclosure. For 30–200 amp switches, support the door and remove the two screws at the bottom. Slide the door down until the

top clears the enclosure. Open the door wide enough to reach the controller wiring on the inside of the door. Disconnect the cable plug that connects the front door components to the internal components and disconnect the grounding wire between the door and the enclosure. Set the door out of the way to protect the controls.

For units with hinged doors, open the door and disconnect the cable plug that connects the front door components to the internal components. Disconnect the grounding wire between the door and the enclosure. Squeeze the release pins on each hinge together and remove the door. See Figure 2-4. Set the door out of the way to protect the controls.



1. Hinge release pins

Figure 2-4 Hinge

Vertically mount 30- through 400-amp transfer switches to a wall or other rigid vertical supporting structure. Use the template on the shipping carton to locate the mounting holes in the wall. Level the template before marking and drilling the holes. Clearance holes through the back of each enclosure are provided for mounting. Use shims to plumb the enclosure. Verify that the door hinges are vertical to avoid distortion of the enclosure or door.

Bolt 600- through 4000-amp automatic transfer switches directly to floor mounting pads. Shim the enclosure so that the enclosure is plumb.

2.4 Seismic Certification

Automatic transfer switches with seismic certification must be installed according to the the instructions in this section.

Abbreviations:

ACI: American Concrete Institute

IBC: International Building Code®

S_{DS}: Design spectral response acceleration at short period, as determined in Section 1615.1.3 of the IBC

R_p: Equipment response modification factor

I_p: Equipment importance factor

a_p: In-structure equipment amplification factor

Refer to the International Building Code® for more information.

Parameters, IBC 2006 and 2009:

Below grade and grade through roof-top installations permitted when:

$S_{DS} \leq = 2.0$, $I_p = 1.5$, $a_p = 2.5$, $R_p = 6.0$

Below grade and at grade installations permitted when:

$2.0 < S_{DS} \leq 2.5$, $I_p = 1.5$, $a_p = 2.5$, $R_p = 6.0$

Parameters, IBC 2000 and 2003:

Below grade and grade through roof-top installations permitted when:

$S_{DS} \leq 2.0$, $I_p = 1.5$, $a_p = 1.0$, $R_p = 2.5$

Below grade and at grade installations permitted when:

$2.0 < S_{DS} \leq 2.5$, $I_p = 1.5$, $a_p = 1.0$, $R_p = 2.5$

For applications where S_{DS} is greater than 2.0 and the equipment is installed above grade level, consult the factory.

General Seismic Installation Notes:

- Anchors used for seismic installation must be designed and rated to resist seismic loading in accordance with ACI 355.2-04 and documented in a report by a reputable testing agency (ex. the Evaluation Service Report issued by the International Code Council). Suggested manufacturers include Simpson, Ramset, and Hilti.
- Anchors must be installed to a minimum embedment of 8x the anchor diameter.
- Anchors must be installed in minimum 4000 psi compressive strength normal weight concrete. Concrete aggregate must comply with ASTM C33. Installation in structural lightweight concrete is not permitted unless otherwise approved by the structural engineer of record.
- Anchors must be installed to the required torque specified by the anchor manufacturer to obtain maximum loading.
- Anchors must be installed with spacing and edge distance required to obtain maximum load unless otherwise approved by the structural engineer of record.

- Wide washers must be installed at each anchor location between the anchor head and equipment for tension load distribution. See applicable ADV drawing for specific anchor information and washer dimensions.

- Equipment installed on a housekeeping pad requires the housekeeping pad thickness to be at least 1.5x the anchor embedment depth.

- All housekeeping pads must be seismically designed and dowelled or cast into the building structure as approved by the structural engineer of record. Rebar reinforcing in the housekeeping pad is required for all installations.

- Rebar reinforcement in concrete must be designed in accordance with ACI 318-05.

- Wall mounted equipment must be installed to a rebar reinforced structural concrete wall that is seismically designed and approved by the engineer of record to resist the added seismic loads from components being anchored to the wall. When installing, rebar interference must be considered. Equipment attached to any structural wall other than those constructed of structural concrete and designed to accept the seismic loads from the mounted equipment are beyond the scope of this specification.

- Floor mounted equipment (with or without a housekeeping pad) must be installed to a rebar reinforced structural concrete floor that is seismically designed and approved by the engineer of record to resist the added seismic loads from components being anchored to the floor. When installing, rebar interference must be considered. Equipment attached to any structural floor other than those constructed of structural concrete and designed to accept the seismic loads from the mounted equipment are beyond the scope of this specification.

- Installation to light-weight concrete over steel decking is beyond the scope of this specification and should be evaluated by a structural engineer.

- Installation to concrete block or cinder block walls is beyond the scope of this specification and should be evaluated by a structural engineer.

2.5 Manual Operation Check

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

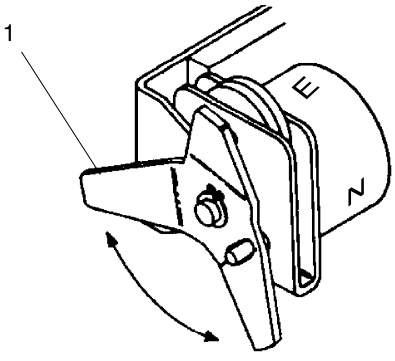
Note: A manual operation handle is provided on the transfer switch *for maintenance purposes only*. Do not use the manual operation handle to transfer the load with the power connected.

Use the manual operation handle to check the manual operation before energizing the transfer switch. On programmed-transition models, check the operation of both the Normal and Emergency operators. Use the following manual operation procedures to verify that the contactor operates smoothly without binding.

Note: A contactor in normal and serviceable condition operates smoothly without binding. Do not place the transfer switch into service if the contactor does not operate smoothly; contact an authorized distributor/dealer to service the contactor.

2.5.1 Manual Operation, 30-200 Amp Standard-Transition Switches

The 30-200 amp standard-transition models have an attached manual operating handle. See Figure 2-5.



1. Handle

Figure 2-5 Manual Operation Handle, 30-200 Amp Standard-Transition Switches

Manual Operation Test Procedure, 30–200 Amp Transfer Switches

1. Turn the attached handle to manually operate the transfer switch. See Figure 2-5. It should operate smoothly without any binding. If it does not, check for shipping damage or construction debris.

2. Return the transfer switch to the Normal position.

2.5.2 Manual Operation, 225–4000 Amp Standard-Transition Switches

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

The 225–4000 amp standard-transition models use a detachable manual operating handle.

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.

Manual Operation Test Procedure, 225–4000 Amp Standard-Transition Transfer Switches

1. Remove the maintenance handle from the clip(s) on the left side of the transfer switch frame. See Figure 2-6.

2. **225–600 amp switches: See Figure 2-8.** Insert the maintenance handle into the hole in the shaft on the left side of the operator.

   800–1200 amp switches: See Figure 2-9. Insert the maintenance handle into the hole in the molded hub on the left side of the operator.

   1600–2000 amp switches: See Figure 2-10. Slide the hub onto the shaft and insert the maintenance handle into the hole in the hub.

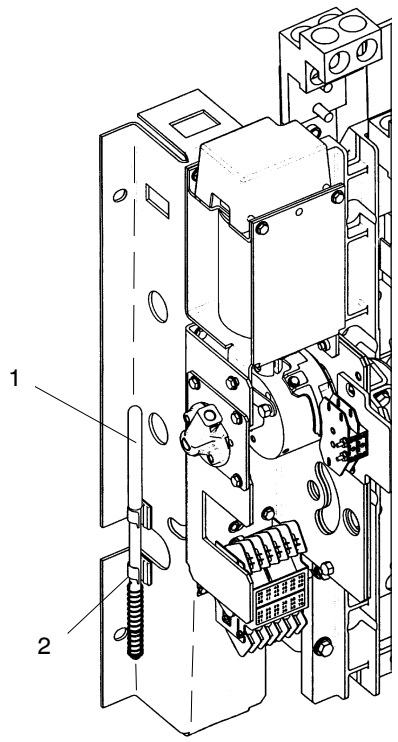
   3000 and 4000 amp switches: See Figure 2-11. Insert the maintenance handle into the hole in the weight.

3. Move the maintenance handle up or down as shown to manually operate the transfer switch. It should operate smoothly without any binding. If it does not, check for shipping damage or construction debris. See Figure 2-7.

4. Return the transfer switch to the Normal position.

5. Remove the maintenance handle and store it on the frame in the clips provided.

Note: Verify that the maintenance handle has been removed before proceeding.



1. Maintenance handle
2. Storage clip(s)

Figure 2-6 Manual Handle Storage (typical)

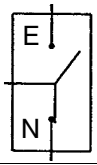
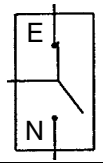
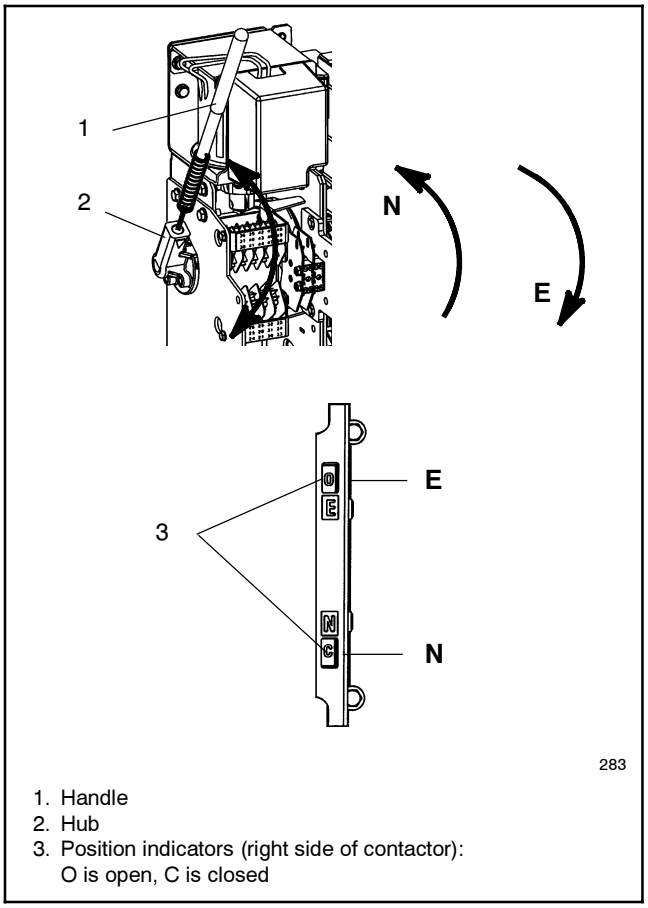
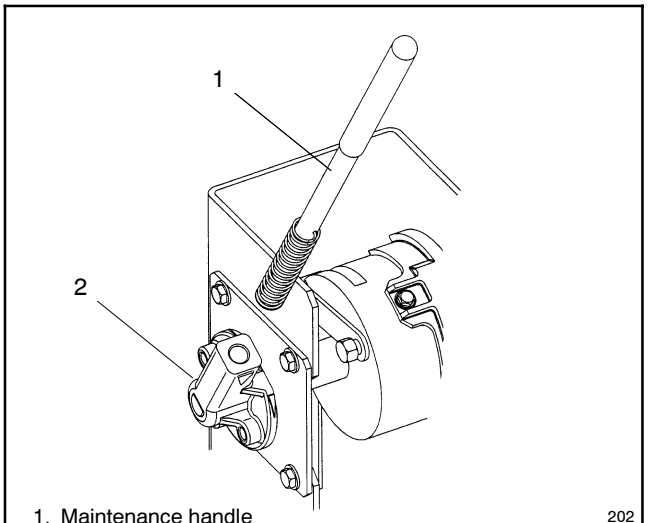
ATS Position		Handle	Indicators
Normal		Up 	E = O upper contacts open N = C lower contacts closed
Emergency		 Down	E = C upper contacts closed N = O lower contacts open
Note: If Normal and Emergency connections are reversed, this operation is also reversed.			

Figure 2-7 Maintenance Handle Positions, 225–600 Amp Standard-Transition Switches



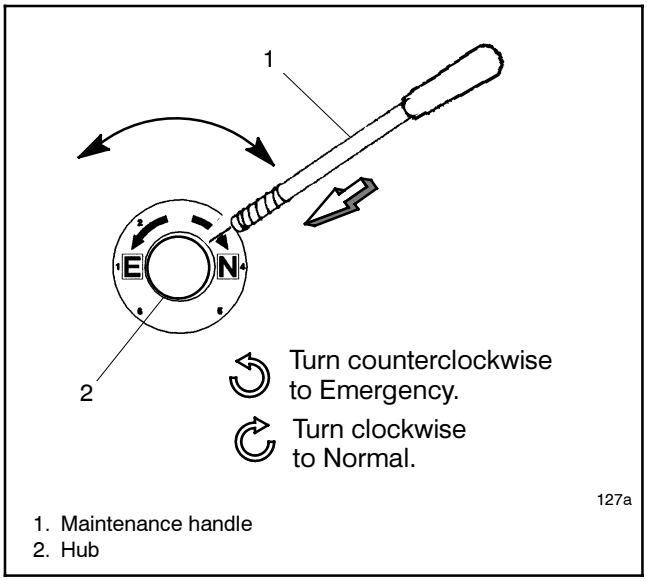
1. Handle
2. Hub
3. Position indicators (right side of contactor): O is open, C is closed

Figure 2-8 Manual Operation, 225–600 Amp Standard-Transition Switches



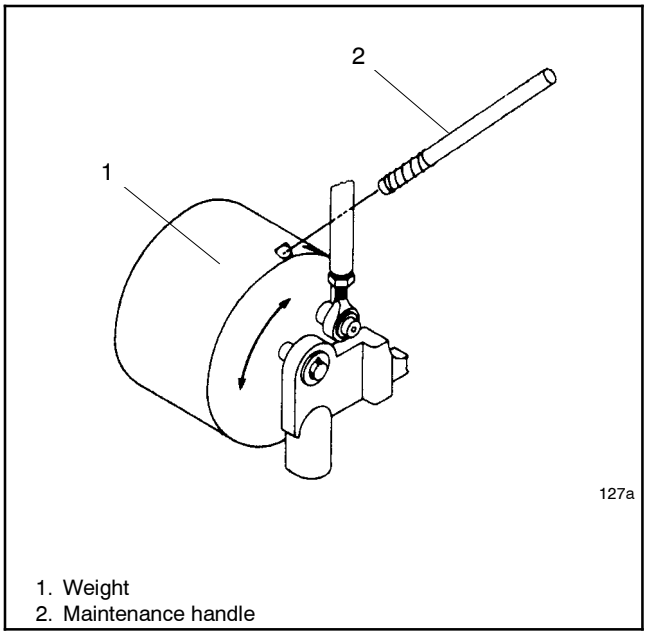
1. Maintenance handle
2. Hub

Figure 2-9 Manual Operation, 800–1200 Amp Switches



1. Maintenance handle
2. Hub

Figure 2-10 Manual Operation, 1600–3000 Amp Switches



1. Weight
2. Maintenance handle

Figure 2-11 Manual Operation, 4000 Amp Switches

2.5.3 Manual Operation, Programmed-Transition Switches

Programmed-transition switches have two operators, Normal and Emergency, on the left side of the contactor assembly. Mechanical interlocks prevent closing both operators at the same time. Refer to Figure 2-12 for typical locations of the Normal and Emergency operators.

Position indicators on the right side of the contactor assembly show the positions of the operators. See Figure 2-12.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

NOTICE

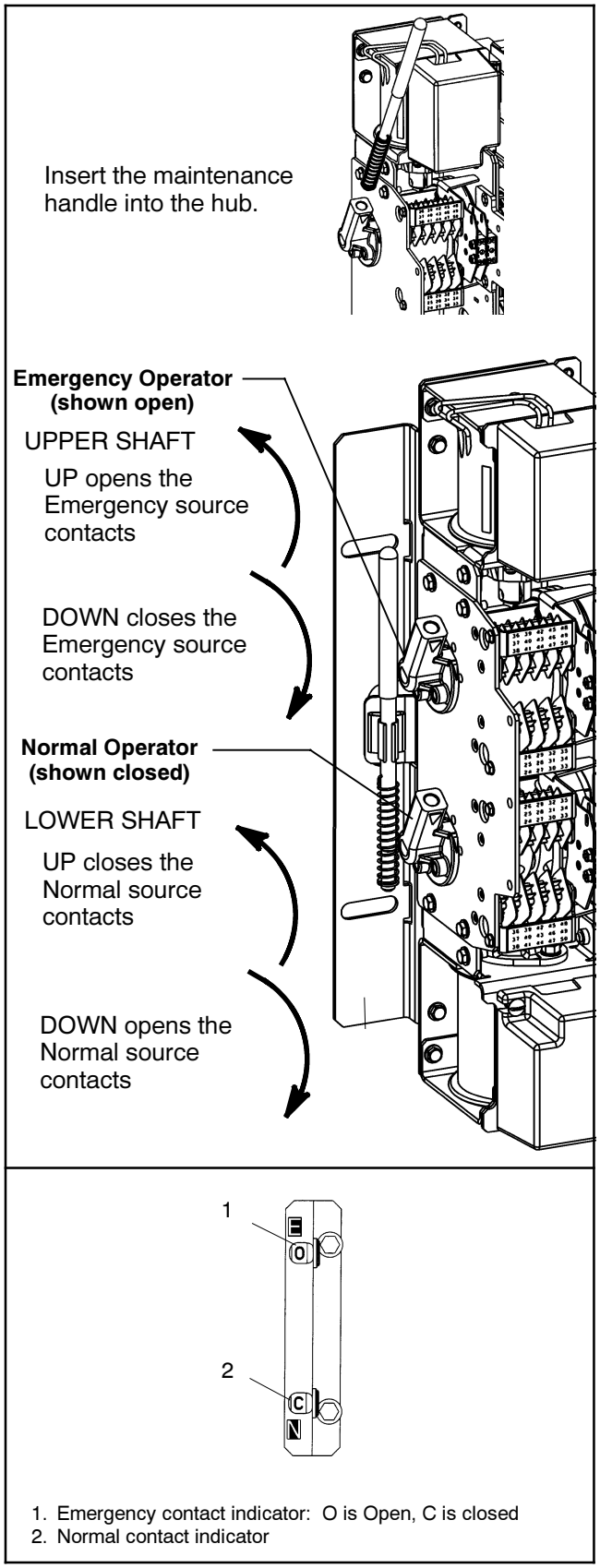
Improper operator handle usage. Use the manual operator handle on the transfer switch for maintenance purposes only. Return the transfer switch to the normal position. Remove the manual operator handle, if used, and store it in the place provided on the transfer switch when service is completed.

Manual Operation Test Procedure, 150–4000 Amp Programmed-Transition Transfer Switches

Programmed-transition models use a detachable manual operating handle. Refer to Figure 2-12 and Figure 2-13 during the following procedure.

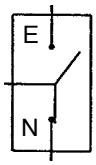
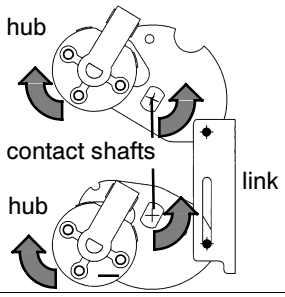
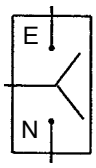
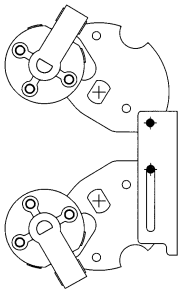
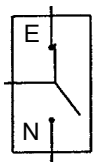
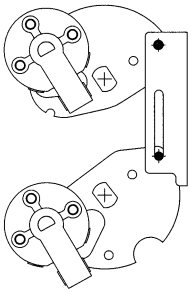
Check the operation of both operators by following the instructions in Section 2.5.2 for both the Normal and Emergency operators in the following sequence:

1. Starting with the contactor in the Normal position, use the maintenance handle to move the Normal operator from the closed to the open position.
2. Move the Emergency operator from the open position to the closed position.
3. Return the Emergency operator to the open position and the Normal operator to the closed position.
4. Remove the maintenance handle and store it in the place provided on the switch.



1. Emergency contact indicator: O is Open, C is closed
2. Normal contact indicator

Figure 2-12 Programmed-Transition Switch Manual Operation

Transfer Switch Position		Interlocked Shafts	Maintenance Handle	Shaft Indicators
Normal			 	E = O upper contacts open N = C lower contacts closed
Load Disconnected			 	E = O upper contacts open N = O lower contacts open
Emergency			 	E = C upper contacts closed N = O lower contacts open

Note: The link between contact shafts prevents closing both N and E contacts. The hub and contact shaft turn in opposite directions through a cam follower mechanism.

Note: If Normal and Emergency connections are reversed, this operation is also reversed.

Figure 2-13 Maintenance Handle Positions. **ALL POWER MUST BE OFF !**

2.6 Controller

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

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.

The controller's logic board is mounted in a plastic housing on the inside of the transfer switch enclosure door.

2.6.1 Controller Connection

Verify that the contactor harness is connected to the controller (through the logic disconnect switch, if equipped). See the controller Operation manual. See list of Related Materials in the Introduction for document numbers.

Note: Verify that the power is disconnected before connecting or disconnecting the contactor harness.

2.6.2 Controller Ground

Verify that the grounding wire is connected from the controller to the stud on the door and to the inside of the enclosure. This connection provides proper grounding that does not rely upon the door hinges.

2.6.3 Other Connections

Refer to the transfer switch wiring diagram or the controller Operation Manual for the following controller and accessory connections.

- Inputs and outputs
- Communications connections
- Accessory connections

2.7 Electrical Wiring

All internal electrical connections are factory-wired and tested. Field installation includes connecting the sources, loads, generator start circuit(s), and auxiliary circuits, if used.

Refer to the wiring diagrams provided with the transfer switch. Observe all applicable national, state, and local electrical codes during installation.

Install DC, control, and communication system wiring in separate conduit from AC power wiring.

It is not necessary to remove pole covers from the transfer switch for cabling. If you do remove them, reinstall them carefully.

⚠ 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.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

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.

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

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.

2.7.1 Source and Load Connections

Determine the cable size. Refer to the transfer switch dimension drawing to determine the cable size and number of cables required for the transfer switch. Make sure that the cables are suitable for use with the transfer switch lugs. Watertight conduit hubs may be required for outdoor use.

Drill the entry holes. Cover the transfer switch to protect it from metal chips and construction grit. Then drill entry holes for the conductors at the locations shown on the enclosure drawings. Remove debris from the enclosure with a vacuum cleaner. *Do not use compressed air to clean the switch because it can cause debris to lodge in the components and cause damage.*

Install and test the power cables. Leave sufficient slack in the power leads to reach all of the power connecting lugs on the power switching device. Test the power conductors before connecting them to the transfer switch. Installing power cables in conduit, cable troughs and ceiling-suspended hangers often requires considerable force. Pulling cables can damage insulation and stretch or break the conductor's strands. Test the cables after pulling them into position and *before* they are connected to verify that they are not defective and that they were not damaged during installation.

Install the cable spacers provided with 30–200 amp switches as shown in Figure 2-14.

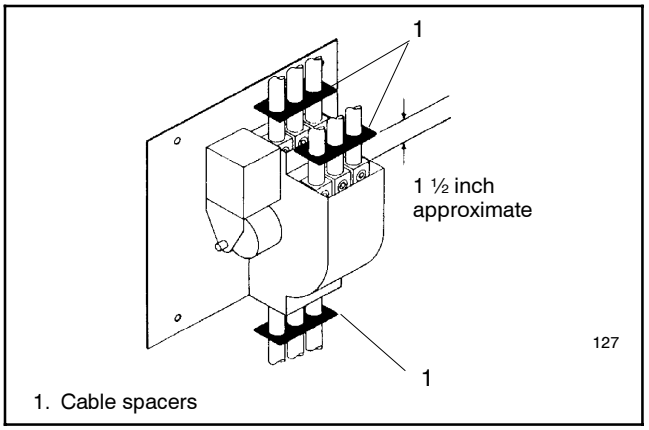


Figure 2-14 Cable Spacers for 30–200 Amp Switches

Connect the cables. Be careful when stripping insulation from the cables; avoid nicking or ringing the conductor. Clean cables with a wire brush to remove surface oxides before connecting them to the terminals. Apply joint compound to the connections of any aluminum conductors.

Refer to Figure 2-17, Interconnection Diagram, and the wiring diagram provided with the switch.

The connection points on the contactor are labeled Normal, Emergency, and Load. Be sure to follow the phase markings (A, B, C, and N). For single-phase systems, connect to A and C.

Note: Connect the source and load phases as indicated by the markings and drawings to prevent short circuits and to prevent phase-sensitive load devices from malfunctioning or operating in reverse.

Tighten the lugs. Verify that all connections are consistent with drawings before tightening the lugs. Tighten all cable lug connections to the torque values shown on the label on the switch. (See Figure 2-16 for a typical rating/torque label.) Carefully wipe off any excess joint compound after tightening the terminal lugs.

For load connections to bus bars, use a compression washer, flat washer, and a minimum grade 5 bolt and torque the connections to the values in Figure 2-15.

Bolt Size, inches	Bolt Torque	
	ft. lb.	Nm
1/4	7	9.5
5/16	12	16.3
3/8	20	27.1
1/2	50	67.8
5/8	95	128.8
3/4	155	210.2

Figure 2-15 Tightening Torque for Bus Bars

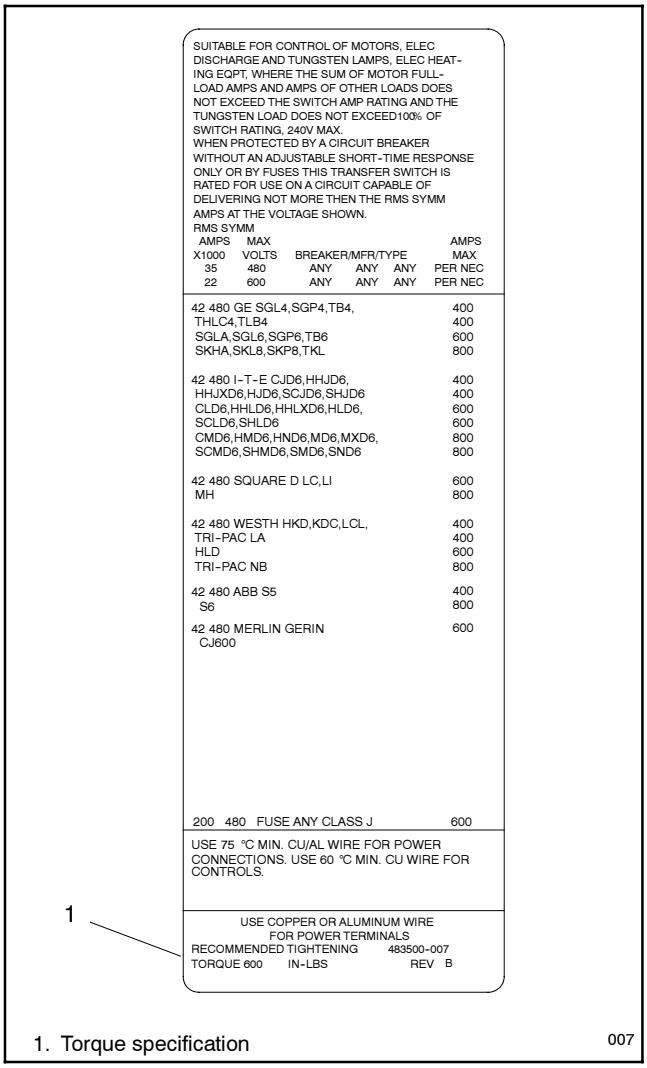


Figure 2-16 Typical Rating/Torque Label

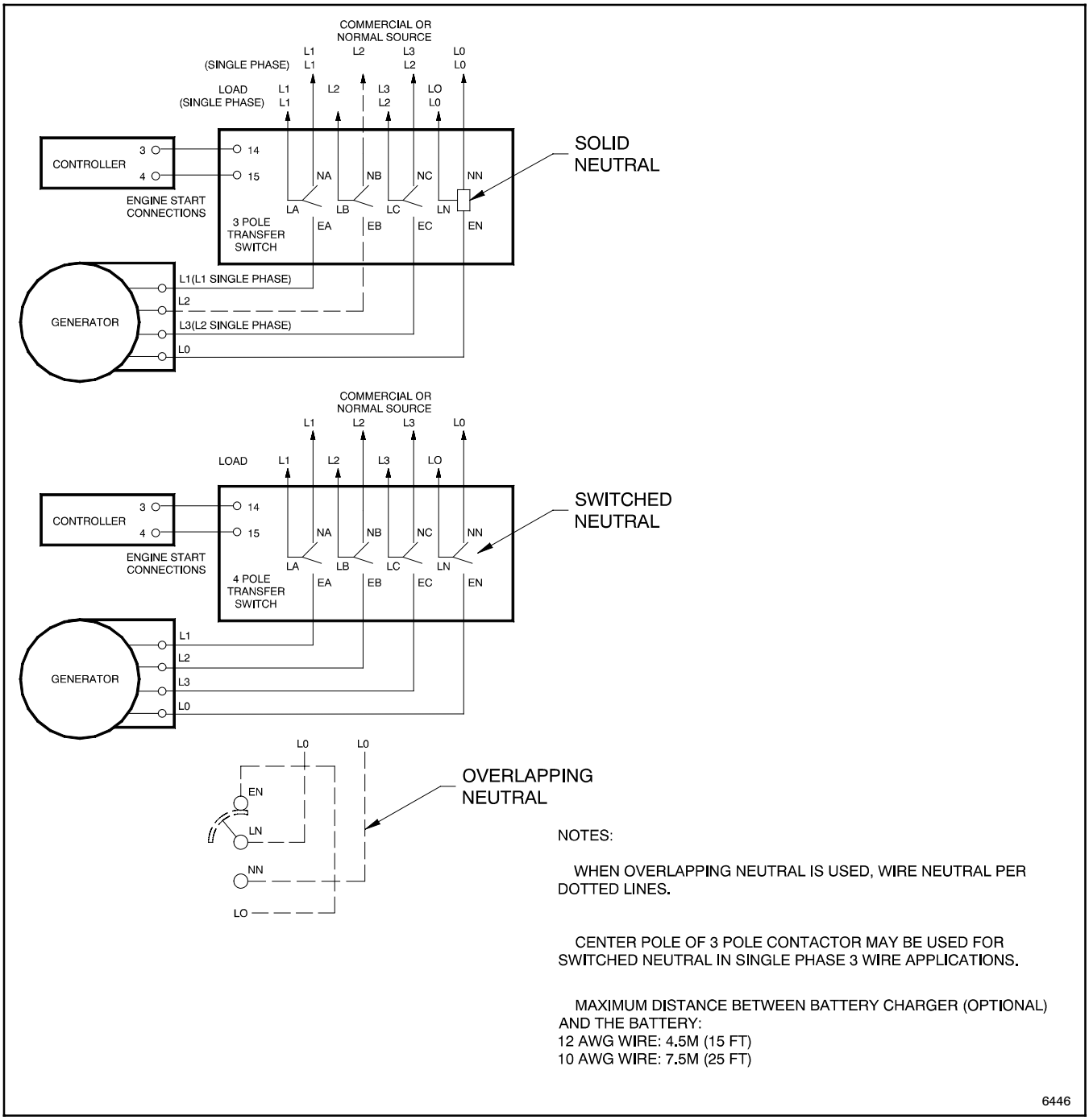
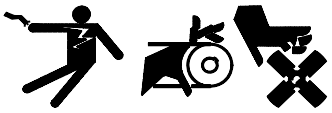


Figure 2-17 Interconnection Diagram

2.7.2 Engine Start Connection

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

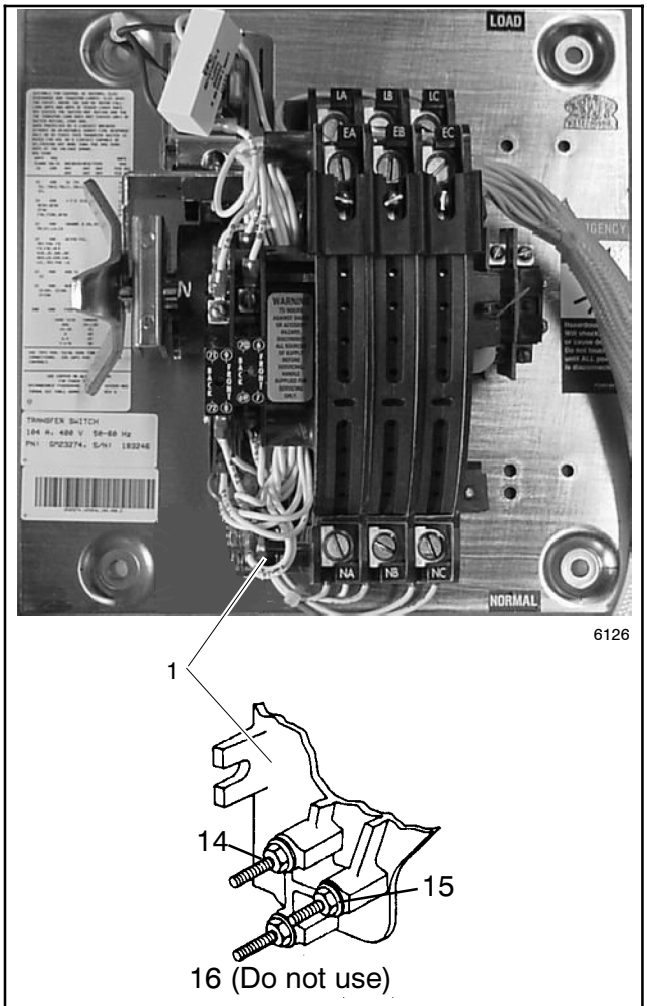
Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

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.

Prevent the generator set 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 battery cables, negative (-) leads first.

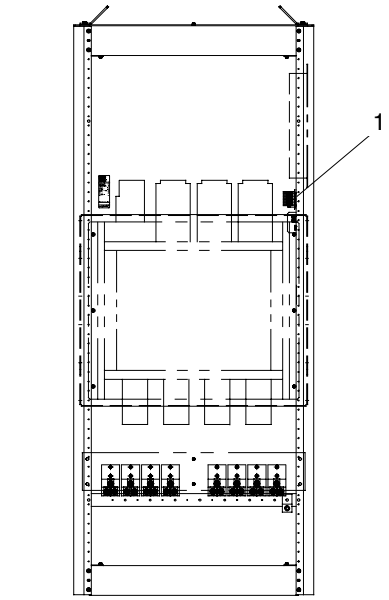
Connect the generator set remote starting circuit to the engine start connections located on the transfer switch contactor assembly. The engine start terminals are labeled with a red decal. See Figure 2-18 or Figure 2-19 for the location of the engine start contacts. Refer to the generator set installation manual for wire size specifications.

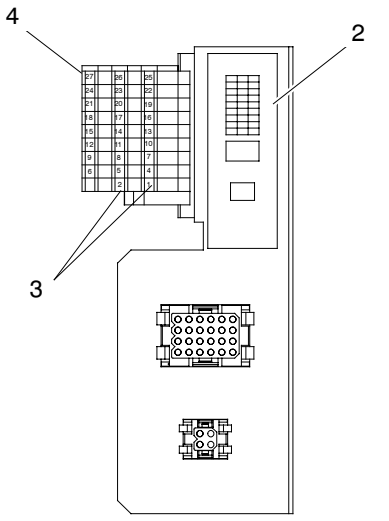
Engine Start Contacts	
Contact Rating	2 A @ 30 VDC/250 VAC



1. Engine start contacts 14 and 15

Figure 2-18 Engine Start Contacts, 30–200 Amp Switches





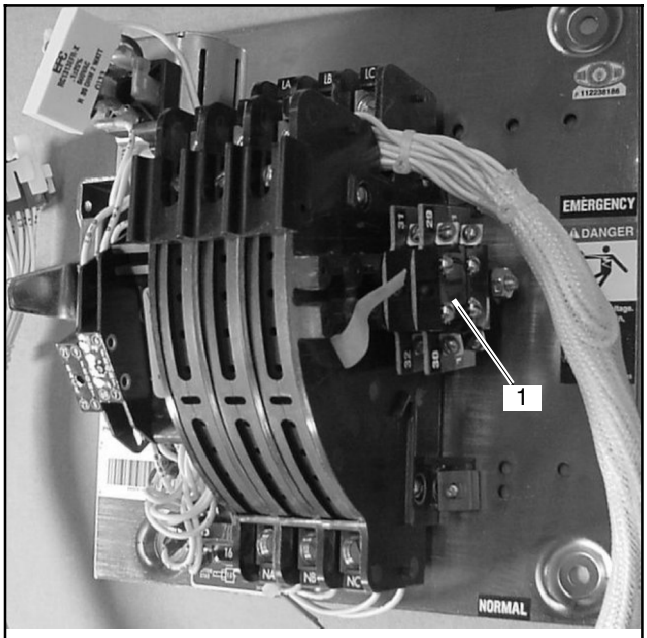
1. Typical terminal block location
2. Decal
3. Engine start contacts 1 and 2
4. Auxiliary contacts 4–27 (see the schematic diagram for contacts closed on Normal or closed on Emergency)

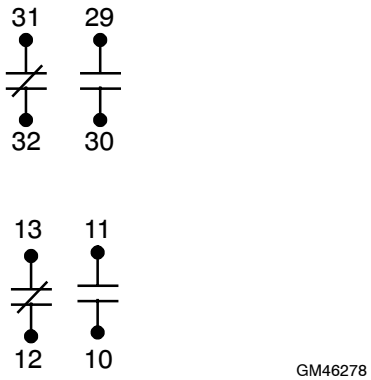
Figure 2-19 Engine Start and Auxiliary Contact Terminal Block, 230–4000 Amp Transfer Switches

2.7.3 Auxiliary Contacts

Connect the auxiliary contacts to customer-supplied alarms, remote indicators, or other devices. Auxiliary contacts provide contacts that close when the transfer switch is in the Normal position and contacts that close when the transfer switch is in the Emergency position. Refer to the schematic diagram provided with the transfer switch for auxiliary contact connection information.

Figure 2-19 and Figure 2-20 show the locations of the auxiliary contacts for different models.





1. Auxiliary contacts 10–13 and 29–32 (contacts shown with contactor in Normal position)

Figure 2-20 Auxiliary Contacts, 30–230 Amp Standard-Transition Models

Figure 2-21 lists the number of contacts available.

Follow the wire size and tightening torque specifications shown on the decal on the transfer switch.

Auxiliary Position Indicating Contacts (rated 10 amps @ 32 VDC/250 VAC)		
	Number of Contacts Indicating Normal, Emergency	
Switch Rating, amps	Standard-Transition	Programmed-Transition
30-230	2, 2	See 150-600
260-600	8, 8	See 150-600
150-600	See 30-230 or 260-600	8, 8
800-1200	8, 8	8, 8
1600-3000	8, 8	7, 7
4000	4, 4	6, 6

Figure 2-21 Auxiliary Contacts

2.8 Accessories

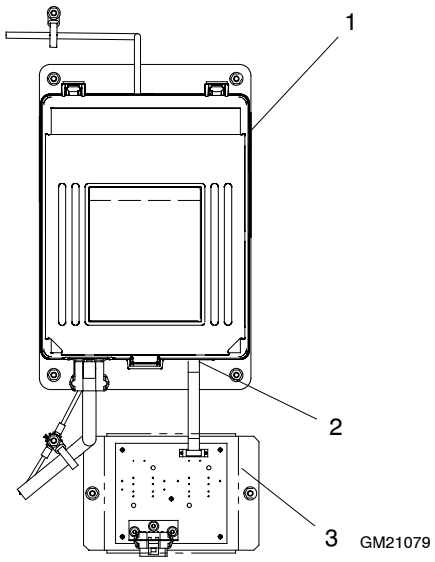
Refer to the following documentation for instructions to install, connect, and operate optional accessories.

- Controller Operation Manual. See List of Related materials in the Introduction section of this manual for document numbers.
- Transfer switch wiring diagrams.
- Installation instructions provided with loose accessory kits.

2.9 Programmed-Transition Interface Board (PTIB)

Programmed-transition model transfer switches use a programmed-transition contactor and a programmed-transition interface board (PTIB). The PTIB is mounted on the inside of the enclosure door.

Verify that the PTIB wiring harness is connected to the main logic board. See Figure 2-22 for the PTIB connection to the MPAC 1500 controller. The PTIB is factory-wired and requires no additional wiring in the field.



1. Controller assembly (located inside the enclosure door; MPAC 1500 shown)
2. PTIB connection
3. PTIB

Figure 2-22 Programmed-Transition Interface Board (PTIB)

2.10 Functional Tests

Perform the functional tests described in Section 3 before putting the transfer switch into operation.

2.11 System Setup

Set the controller's current time and date. See the controller Operation Manual for instructions.

The transfer switch is factory-set with default settings for time delays and other parameters. See the controller Operation Manual for instructions to view and change settings, if necessary.

Note: Use caution when changing transfer switch settings. The source voltage and frequency settings must match the values shown on the transfer switch nameplate.

2.12 Exerciser Setup

Set the exerciser to start and run the generator set at least once a week. See the controller Operation manual for instructions.

2.13 Startup Notification

Complete a Startup Notification Form and submit it to the manufacturer within 60 days of the initial startup date. The Startup Notification Form covers all equipment in the power system. Power systems not registered within 60 days of startup are automatically registered using the manufacturer's ship date as the startup date.

3.1 Introduction

Be sure to perform all of the functional tests described in this section before putting the transfer switch into operation.

The functional tests include the following checks:

- Manual Operation Test
- Voltage Checks
- Lamp Test
- Automatic Operation Test

Note: Perform these checks in the order presented to avoid damaging the ATS.

Read all instructions on the labels affixed to the automatic transfer switch before proceeding.

3.2 Manual Operation Test

If you have not already done so, test the contactor manual operation before proceeding to the voltage check and electrical operation test.

Note: Disable the generator set and disconnect the power by opening the circuit breakers or switches for both sources before manually operating the transfer switch.

Follow the instructions in the Installation Section to check the transfer switch manual operation.

A contactor in normal and serviceable condition transfers smoothly without binding when operated manually. Do not place the transfer switch into service if the contactor does not operate smoothly without binding; contact an authorized distributor/dealer to service the contactor.

3.3 Voltage Check

The voltage, frequency, and phasing of the transfer switch and the power sources must be the same to avoid damage to loads and the transfer switch. Compare the voltage and frequency ratings of the utility source, transfer switch, and generator set, and verify that the ratings are all the same.

Use the voltage check procedure explained in this section to verify that the voltages and phasing of all power sources are compatible with the transfer switch before connecting the power switching device and controller wire harnesses together.

Follow the instructions provided with the generator set to prepare the generator set for operation.

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

Note: Source N is the source connected to the normal side of the contactor. Source E is the source connected to the emergency side of the contactor. Verify that the source leads are connected to the correct lugs before proceeding.

The voltage check procedure requires the following equipment:

- A digital voltmeter (DVM) with electrically insulated probes capable of measuring the rated voltage and frequency
- A phase rotation meter

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Only authorized personnel should open the enclosure.

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

Voltage Check Procedure

1. If Source N is a generator set, move the generator set master switch to the RUN position. The generator set should start.
2. Close the Source N circuit breaker or switch.

3. Use a voltmeter to check the Source N (normal) phase-to-phase and phase-to-neutral (if applicable) terminal voltages and frequency.

   a. If Source N is the utility and the measured input does not match the voltage and frequency shown on the transfer switch nameplate, *STOP!* Do not proceed further in installation because the transfer switch is not designed for the application—call your distributor/dealer to order the correct transfer switch.

   b. If Source N is a generator set and the generator set output voltage and frequency do not match the nominal system voltage and frequency shown on the transfer switch nameplate, follow the manufacturer's instructions to adjust the generator set. The automatic transfer switch will only function with the rated system voltage and frequency specified on the nameplate.

4. Use a phase rotation meter to check the phase rotation at the Source N (normal) terminals. Rewire the transfer switch Source N terminals to obtain the correct phase sequence if necessary.

   Note: The default setting for the phase rotation on the controller is ABC. If the application uses a phase rotation of BAC, use the Source Setup screen to change the phase rotation setting on the controller.

5. If the source is a generator set, stop the generator set by moving the master switch to the OFF position.

6. Disconnect Source N by opening upstream circuit breakers or switches.

7. Repeat steps 1 through 5 for Source E. Then proceed to step 8.

8. Disconnect both sources to the transfer switch by opening the circuit breakers or switches.

9. Close and lock the transfer switch enclosure door.

10. Reconnect both power sources by closing the circuit breakers or switches.

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

    Note: If the engine cooldown time delay setting is not set to zero (default setting), the generator set may start and run until the Time Delay Engine Cooldown (TDEC) ends.

12. Perform the lamp test and then proceed to the automatic operation test.

3.4 Lamp Test

Refer to the controller Operation Manual for instructions to perform a lamp test. Verify that all controller LEDs or lamps light during the test.

3.5 Automatic Operation Test

Check the transfer switch's automatic control system immediately after the voltage check. Refer to the controller Operation Manual for instructions to run the automatic operation test.

Note: Close and lock the enclosure door before starting the test procedure.

This completes the functional tests.

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	advanced digital control; analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
Ah	amp-hour
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
APDC	Air Pollution Control District
API	American Petroleum Institute
approx.	approximate, approximately
APU	Auxiliary Power Unit
AQMD	Air Quality Management District
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
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
CAN	controller area network
CARB	California Air Resources Board
CAT5	Category 5 (network cable)
CB	circuit breaker
CC	crank cycle
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cert.	certificate, certification, certified
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
CMOS	complementary metal oxide substrate (semiconductor)
com	communications (port)
coml	commercial
Coml/Rec	Commercial/Recreational
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cUL	Canadian Underwriter's Laboratories
CUL	Canadian Underwriter's Laboratories
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dB(A)	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^2PROM, EEPROM	electrically-erasable programmable read-only memory
E, emer.	emergency (power source)
ECM	electronic control module, engine control module
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
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lb.	foot pounds (torque)
ft./min.	feet per minute
ftp	file transfer protocol
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
GND, ⏚	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
GRD	equipment ground
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temp., high engine temp.
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)
IBC	International Building Code
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. lb.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	internet protocol
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard
k	kilo (1000)
K	kelvin
kA	kiloampere
KB	kilobyte (2^{10} bytes)
KBus	Kohler communication protocol
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
kWth	kilowatt-thermal
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound, pounds
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
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
$m^3/hr.$	cubic meters per hour
$m^3/min.$	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCCB	molded-case circuit breaker
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
ms	millisecond
m/sec.	meters per second
mtg.	mounting
MTU	Motoren-und Turbinen-Union
MW	megawatt
mW	milliwatt
μF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
OC	overcrank
OD	outside diameter
OEM	original equipment manufacturer
OF	overfrequency
opt.	option, optional
OS	oversize, overspeed
OSHA	Occupational Safety and Health Administration
OV	overvoltage
oz.	ounce
p., pp.	page, pages
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph., ∅	phase
PHC	Phillips® head Crimptite® (screw)
PHH	Phillips® hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read-only memory
psi	pounds per square inch
psig	pounds per square inch gauge
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart, quarts
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RDO	relay driver output
ref.	reference
rem.	remote
Res/Coml	Residential/Commercial
RFI	radio frequency interference
RH	round head
RHM	round head machine (screw)
rly.	relay
rms	root mean square
rnd.	round
RO	read only
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTDs	Resistance Temperature Detectors
RTU	remote terminal unit
RTV	room temperature vulcanization
RW	read/write
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
SMTP	simple mail transfer protocol
SN	serial number
SNMP	simple network management protocol
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec	specification
specs	specification(s)
sq.	square
sq. cm	square centimeter
sq. in.	square inch
SMS	short message service
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TB	terminal block
TCP	transmission control protocol
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
THD	total harmonic distortion
TIF	telephone influence factor
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
UF	underfrequency
UHF	ultrahigh frequency
UIF	user interface
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
URL	uniform resource locator (web address)
US	undersize, underspeed
UV	ultraviolet, undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
WO	write only
w/o	without
wt.	weight
xfmr	transformer

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