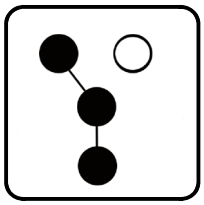
Operation and Installation

Automatic Transfer Switches



Models:

RDT-HFNA-0100B

RDT-HFNC-0200A

Electrical Controls:

MPAC™ 300

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-6539 10/07b

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 _____

Accessory Number	Accessory Description

Table of Contents

Table of Contents, continued

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/ Electrical Shock

⚠ 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.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

This equipment must be installed and serviced by qualified electrical personnel.

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

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

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. 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.

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)*

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

Airborne particles.
Can cause severe injury or blindness.

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

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

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 RDT automatic transfer switches with MPAC™ 300 electrical controls listed on the front cover.

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.

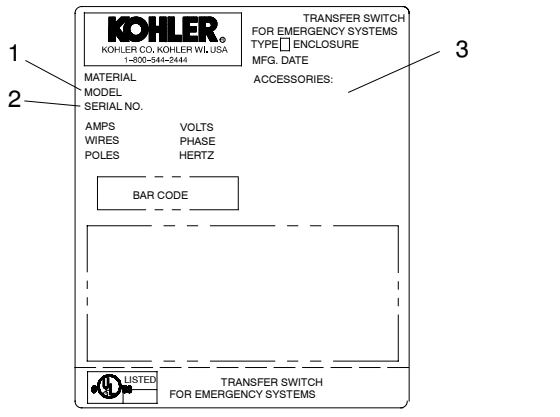
The equipment service requirements are very important to safe and efficient operation. Inspect parts often and perform required service at the prescribed intervals. Obtain service from an authorized service distributor/ dealer to keep equipment in top condition.

Nameplate

A nameplate attached to the inside of the enclosure cover includes a model designation, a serial number, ratings, and other information about the transfer switch. See Figure 1.

Check the transfer switch model number from the transfer switch nameplate and verify that it matches the model shown on the front cover of this manual before proceeding with installation.

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

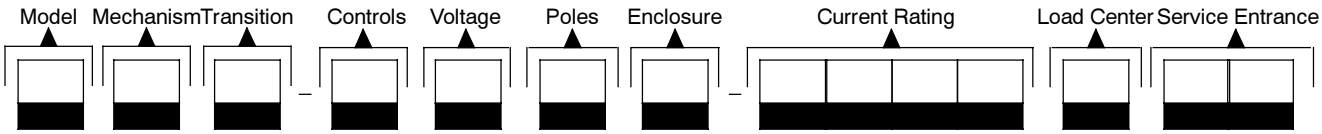


1. Model designation
2. Serial number
3. Factory-installed accessory numbers

Figure 1 Typical Transfer Switch Nameplate

Model Code

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



Only the following models are available:

RDT-HFNA-0100B, 240V/60Hz, 100 amps with NEMA 1 enclosure and load center
RDT-HFNC-0200A, 240V/60Hz, 200 amps with NEMA 3R enclosure and no load center

SAMPLE MODEL DESIGNATION

RDT-HFNA-0100B

Model
R: Model R automatic transfer switch

Mechanism
D: Specific-breaker rated

Transition
T: Standard transition

Electrical Controls
H: MPAC™ 300 (Microprocessor ATS Control)

Voltage/Frequency
F: 240 Volts/60 Hz

Number of Poles/Wires
N: 2-pole, 3-wire, solid neutral

Enclosure
A: NEMA 1
C: NEMA 3R

Current Rating: Numbers indicate the current rating of the switch in amperes:
0100: 100 amps 0200: 200 amps

Load Center
A: Without load center
B: With load center

Service Assistance

For professional advice on generator set 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
ZI Senia 122
12, rue des Hauts Flouviers
94517 Thiais Cedex
France
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Power Systems Asia Pacific Regional Office
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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

Notes

1.1 Transfer Switch Description

An automatic transfer switch (ATS) transfers electrical loads from a normal source of electrical power to an emergency source when the normal source voltage or frequency falls below an acceptable level. The normal source is typically utility power. The emergency source is usually a generator set.

When the normal source fails, the ATS signals the emergency source generator set to start. When the emergency source reaches acceptable levels and stabilizes, the ATS transfers the electrical load to the emergency source.

The ATS continuously monitors the normal source and transfers the load back when the normal source returns and stabilizes. After transferring the load back to the normal source, the ATS removes the generator start signal, allowing the generator set to shut down.

Figure 1-1 shows a typical installation block diagram.

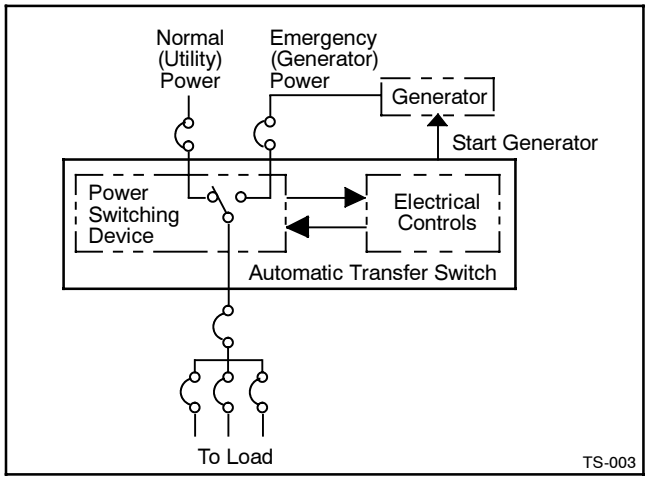


Figure 1-1 Typical ATS Block Diagram

1.2 Load Centers

The 100 amp transfer switch is equipped with a built-in Square D Homeline load center. 200 amp models do not include a load center and require the installation of a separate load panel.

Loads. The transfer switch can be connected to supply all of the electrical loads in the home, or only the essential loads such as the furnace, refrigerator, well pump, and selected light circuits. Identify the essential circuits that must be supplied during a power outage. Verify that the generator set and transfer switch are adequately rated to supply all of the selected loads.

Circuit breakers. Because the size and number of circuit breakers required will vary with each application, circuit breakers are not provided with the transfer switch load center.

Determine the circuits that will be connected to the transfer switch (essential loads). Identify the breakers for those circuits in the main distribution panel.

The ATS load center requires Square D Homeline breakers. If the main distribution panel uses the same type of breakers, the breakers can be moved from the main panel to the load center. Otherwise, obtain new Square D Homeline circuit breakers. For each circuit, the rating of the load center circuit breaker must match the rating of the existing breaker in the main panel.

Verify that the total rating for all of the breakers used in the load center does not exceed the rating of the transfer switch.

Notes

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. Protect the switch against damage before and during installation.

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 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 cold or damp areas where moisture could condense on the unit. See Figure 2-1 for acceptable storage temperatures.

2.2.3 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.

See Figure 2-2 or the dimensional drawing for the weight of the 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. Close and latch the enclosure door before moving the unit.

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. Use a vacuum cleaner or a dry cloth to 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.

Item	Specification
Storage Temperature	-40°C to 70°C (-40°F to 158°F)
Operating Temperature	-20°C to 70°C (-4°F to 158°F)
Humidity	5% to 95% noncondensing
Altitude	0 to 3050 m (10000 ft.) without derating

Figure 2-1 Environmental Specifications

Amps	Enclosure Type	Weight kg	Weight (lb.)
100	NEMA 1	12.3	(27.0)
200	NEMA 3R	15.0	(33.0)

Figure 2-2 Transfer Switch Weights

2.3 Installation

NOTICE

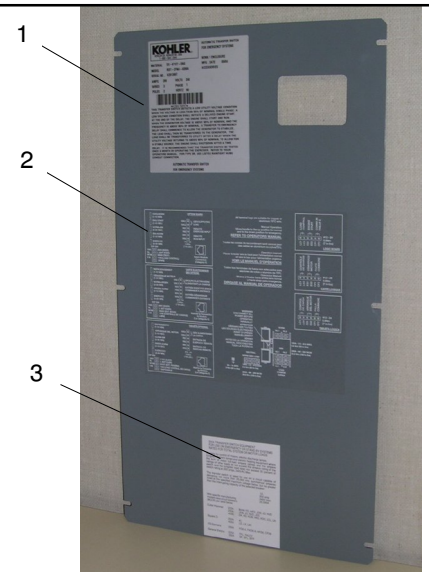
Foreign material contamination. Cover the transfer switch during installation to keep dirt, grit, metal drill chips, and other debris out of the components. Cover the solenoid mechanism during installation. After installation, use the manual operating handle to cycle the contactor to verify that it operates 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 voltage and frequency are different from the normal (utility) source voltage and frequency or the emergency source voltage and frequency shown on the generator set nameplate.

Plan the installation. Use the dimensions given on the enclosure dimension (ADV) drawings in Section 5. 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 open the enclosure and service the switch.



1. Nameplate
2. Connection instructions
3. Rating label

Figure 2-3 Enclosure Door or Inner Panel

Wall mounting. Mount the transfer switch to a wall or other rigid vertical supporting structure. Use the template provided with 100 and 200 amp switches to locate the mounting holes in the wall. Level the template before marking and drilling the holes.

Cover or remove the transfer switch's internal components to protect them from drill chips or debris during installation. Use a vacuum cleaner to remove debris from the enclosure. Tighten the mounting screws to 2.9 Nm (26 in. lb.) when reinstalling the components.

Note: Do not use compressed air to clean the switch. Cleaning with compressed air can cause debris to lodge in the components and cause damage.

Clearance holes through the back of each enclosure are provided for mounting. Use shims to plumb the enclosure.

NEMA 3R enclosures. To remove the enclosure's front panel, support the panel while removing the screws. Pull the bottom of the panel out and down until the top clears the enclosure. Remove the inner panel to access the transfer switch components.

200 amp NEMA 3R enclosures have locking tabs at the bottom of the enclosure and the door. While the enclosure is open, turn the locking tab out so that the door can be locked with a padlock after installation is complete.

Note: The mounting holes on NEMA 3R enclosures have gaskets to seal out moisture. Use washers with the mounting screws to protect the gaskets.

Recessed Mounting. 100 amp NEMA 1 enclosures can be recess-mounted between 16 in. O.C. wall studs.

Remove the ATS components from inside the enclosure to protect them from drill chips and debris. Drill four mounting holes in one side of the enclosure. Mark and drill matching mounting holes in the wall stud. The enclosures are 330.2 mm (13 in.) wide. Add a stud to provide support on both sides of the transfer switch, if desired.

Finish Mounting the Enclosure. Mount the transfer switch enclosure. Use a vacuum cleaner to remove debris from the enclosure. Reinstall the internal components and tighten the mounting screws to 2.9 Nm (26 in. lb.).

2.4 Manual Operation Check

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

Check the manual operation before energizing the transfer switch. Verify that the contactor operates smoothly without binding. Do not place the transfer switch into service if the contactor does not operate smoothly.

After checking the manual operation, place the contactor in the Normal (utility) position.

Manual Operation, 100 and 200 Amp Switches

Note: Never manually operate the transfer switch when the power is connected. Disconnect both power sources before manually operating the switch.

1. Move the handle up to place the transfer switch in the Normal Source position and down to place the contactor in the Emergency Source position. See Figure 2-4.

2. Move the handle up to place the transfer switch in the Normal Source position for normal operation.

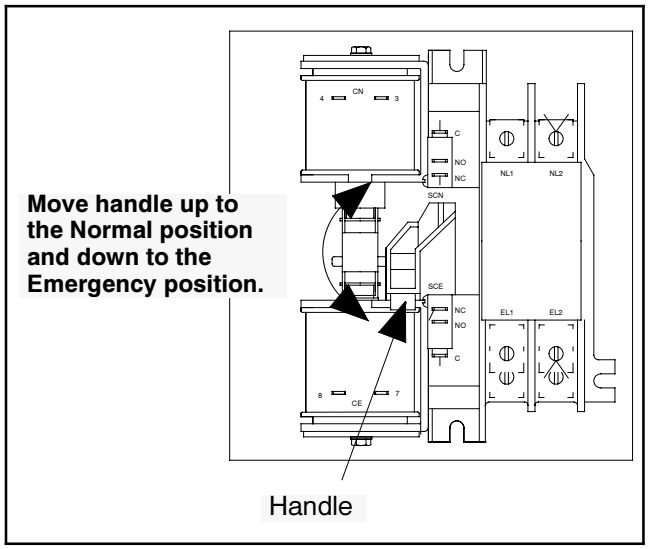


Figure 2-4 Manual Operation, 100 and 200 Amp Switches

2.5 Electrical Wiring

The connection drawings in Figure 2-7 and Figure 2-8 show examples of essential load and whole-house configurations. All wiring must comply with applicable national, state, and local electrical codes. Use separate conduit for AC power wiring and low-voltage DC, control, and communication system wiring.

Refer to the connection diagrams on the transfer switch enclosure door (see Figure 2-3) and the wiring diagrams in Section 5 during installation.

⚠ 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.

2.5.1 Load Center Circuit Breakers

The ATS load center uses Square D Homeline breakers. In an essential load application, the breakers can be moved from the main panel to the load center if the main distribution panel uses the same type of breakers. Otherwise, obtain and install new Square D Homeline circuit breakers. The rating of the load center circuit breaker must match the rating of the existing breaker in the main panel for each circuit. If circuit breakers are removed from the load panel, install cover plates over the vacant positions. Cover plates can be obtained from a local Square D supplier.

Verify that the total rating for all breakers used in the load center does not exceed the rating of the transfer switch.

2.5.2 Contactor Ratings with Coordinated Circuit Breakers

The transfer switches are UL listed at 240 VAC maximum. Figure 2-6 lists contactor withstand current ratings (WCR) for 100 and 200 ampere non-service entrance rated switches with specific manufacturer's circuit breakers per UL and Canadian safety standards.

Install a circuit breaker to protect the normal (utility) side of the transfer switch. For a rating of 22,000 amps, select a circuit breaker from Figure 2-6.

2.5.3 AC Power Connections

Determine the cable size. Refer to Figure 2-5 to determine the cable size required for the transfer switch. Make sure the lugs provided are suitable for use with the cables being installed.

Cable Sizes		
AL/CU UL-Listed Solderless Screw-Type Terminals for External Power Connections		
Switch Size, Amps	Normal, Emergency, and Load Terminals	
	Cables per Pole	Range of Wire Sizes, Cu/Al
100	1	#12 to 1/0 AWG
200	1	#6 AWG to 250 MCM

Figure 2-5 Cable Sizes

Conduit. Use the knock-outs provided in the enclosure for cables. Use separate conduit for AC power wiring and low-voltage DC, control, and communication system wiring. Watertight conduit hubs may be required for outdoor use.

Select the proper cable clamp or use other approved methods for securing the cable or conduit to the enclosure.

Connect the source and load cables. 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 the connection diagrams on the transfer switch enclosure door (see Figure 2-3) and the wiring diagrams in Section 5.

Connect the Normal source (typically the utility power) to the lugs labeled NA and NB. Connect the Emergency source (typically the generator set) to the lugs labeled EA and EB.

On models without built-in load centers, connect the load to the lugs labeled LA and LB.

On models with built-in load centers, the LA and LB lugs are factory-wired to the load center. Connect the load leads to the circuits in the load center and tighten the connections. Check the labels on the breakers for the tightening torques.

Connect the neutral from the main panel to the neutral lug in the ATS enclosure.

Note: The neutral connection is required for transfer switch operation.

Ground the system according to NEC and local codes.

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. Carefully wipe off any excess joint compound after tightening the terminal lugs.

Switch Rating, Amps	WCR, RMS Symmetrical Amps	Manufacturer	Type or Class	Maximum Size, Amps
100	22,000	Cutler-Hammer	FCL, FB	100
			QCHW	125
			FDC	150
		Square D	FI	100
		Siemens	ED4, CED6, ED6, HED4, HED6	125
200	22,000	Cutler-Hammer	BHW, FD, HFD, JD, JDB, HJD	225
			JD, JDB, HJD, JDC	250
			DK, KD, KDB, HKD, KDC, LCL, LA	400
		Square D	KI	250
			LE, LX, LXI	400
		Siemens	FD6-A, FXD6-A, HFD6, CFD6	250
		GE	TFL, THLC2	225
			SF, SFL, SFP	250

Note: Suitable for control of motors, electric discharge lamps, tungsten filament lamps and electric heating equipment where the sum of motor full-load ampere ratings and the ampere ratings of other loads do not exceed the ampere rating of the switch and the tungsten load does not exceed 30 percent of switch rating.

Figure 2-6 Withstand Current Ratings (WCR) with Specific Manufacturer's Molded-Case Circuit Breakers

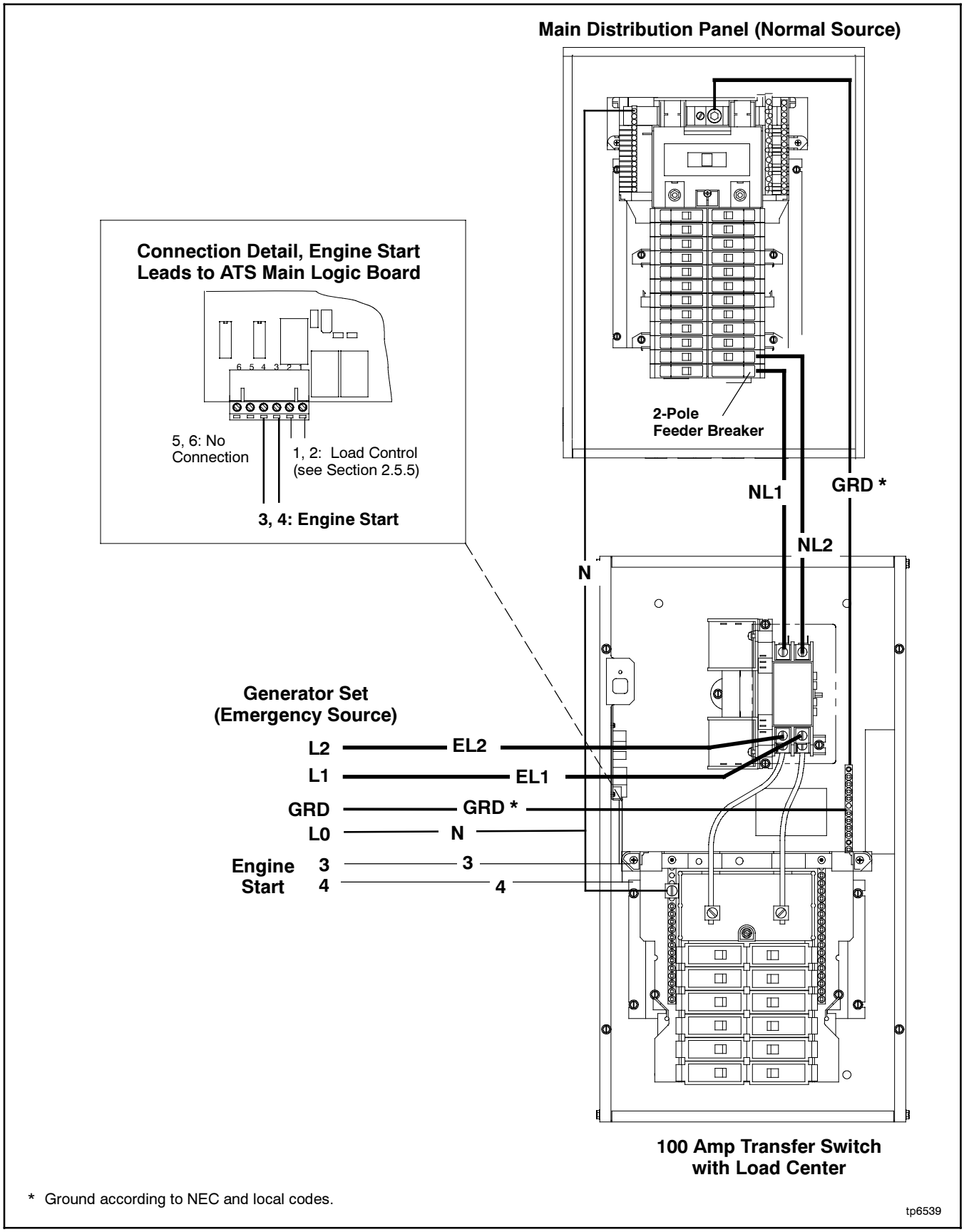


Figure 2-7 Connection Diagram, Essential Loads Configuration, 100 Amp ATS with Load Center Shown

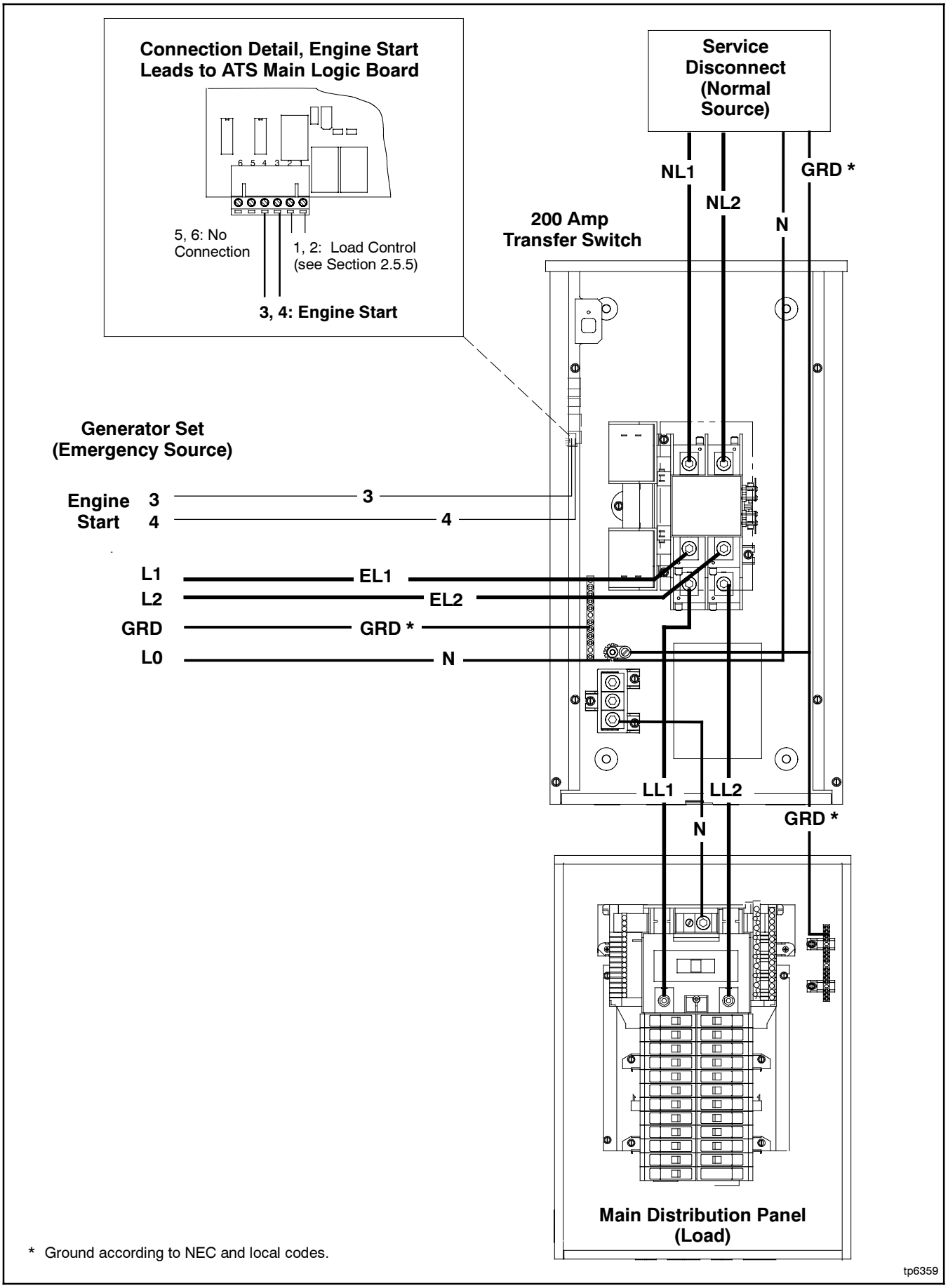
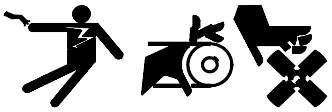


Figure 2-8 Connection Diagram, Whole House Configuration, 200 Amp ATS without Load Center Shown

2.5.4 Engine Start Connections

⚠ 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.

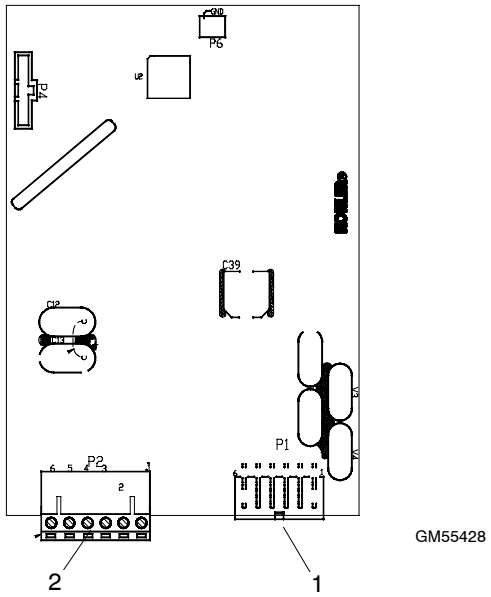
Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove 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.

Connect the engine start leads from the generator set to terminals 3 and 4 on the green 6-pin connector labeled P2 on the controller's main logic board. See Figure 2-9 for the location of the engine start contacts. See Figure 2-10 for contact ratings and wire size information.

2.5.5 Optional Controller Connections

The green 6-pin connector P2 on the controller's main logic board provides connection points for an optional load control circuit. See Figure 2-9 for the connector location. See Figure 2-10 for contact ratings, connection, and wire size information.

Load Control Contact. Provides a delayed contact closure to allow startup of selected loads 5 minutes after transfer to the emergency power source (generator set). Use this contact to delay startup of equipment with large motor-starting loads such as air conditioners.



1. Contactor harness connection P1
2. Customer connection terminal P2 (green):
   1-2 Load control output
   3-4 Engine start
   5-6 No connection

Figure 2-9 Controller Board Connections

Description	Terminals	Contact Rating	Wire Size	Tightening Torque	Max. Distance
Load Control	P2-1 and P2-2	10 A @ 120 VAC SPST normally open (NO)	#12-24 AWG	0.8 Nm (7 in. lb.)	213 m (700 ft.)
Engine Start	P2-3 and P2-4	0.5 A @ 125 VAC; 2 A @ 30 VDC SPST normally closed (NC)	#12-24 AWG	0.8 Nm (7 in. lb.)	213 m (700 ft.)

Figure 2-10 Controller Main Logic Board Customer Connections (P2)

2.6 Test

2.6.1 Automatic Operation Test

Use the procedure below to test the transfer switch's automatic operation. The test sequence starts the generator set, and transfers the load to the emergency source. When the test ends, the transfer switch transfers the load back to the normal source and removes the engine start signal.

Refer to Section 3.7 for a description of the transfer switch sequence of operation.

Note: Install the front panel(s) or close and lock the enclosure door before starting the test procedure.

⚠ 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)

Test Procedure

1. Use a digital voltmeter with insulated probes to check for line voltage at the normal source lugs.

2. Verify that the generator set master switch is in the AUTO position.

   Note: See Section 3.7 for a description of the operation sequence and related time delays.

3. Disconnect the utility power from the transfer switch by opening the upstream circuit breaker.

4. Verify that the generator set engine starts.

5. Listen for the transfer switch to transfer the load to the emergency source (generator set). Verify that the essential loads connected to the transfer switch are powered.

6. Close the upstream circuit breaker to reconnect utility power to the transfer switch.

7. After a 5-minute time delay, listen for the transfer switch to transfer the load to the normal (utility) source.

8. After the engine cooldown time delay (5 minutes), the generator set shuts down. Verify that the generator set stops running.

   Note: The generator set may have an additional engine cooldown time delay that causes the engine to run after the transfer switch engine start signal is removed.

2.6.2 Immediate Test

An immediate test can be performed by pressing the exerciser button. Hold the exercise button for 3–5 seconds for an unloaded test or 6+ seconds for a loaded test. The exercise sequence runs for 20 minutes. Press the exercise button again to stop the test early, if desired.

Note: Pressing the exercise button resets the exerciser to the current time and day.

See Section 3.3 for more information about the exercise sequence.

2.7 Set the Exerciser

Set the exerciser to run the generator set every week for 20 minutes. See Section 3.3 for instructions to set the exerciser.

2.8 Startup Notification

Complete the Startup Notification Form and submit to the manufacturer within 60 days of the initial startup date. The Startup Notification Form covers all equipment in the standby system, including the generator set and the automatic transfer switch. Standby systems not registered within 60 days of startup are automatically registered using the manufacturer's ship date as the startup date.

3.1 Introduction

The controller's user interface panel is accessible through an opening in the transfer switch cover (or through the inner panel on NEMA type 3R enclosures). Figure 3-1 shows the location of the user interface.

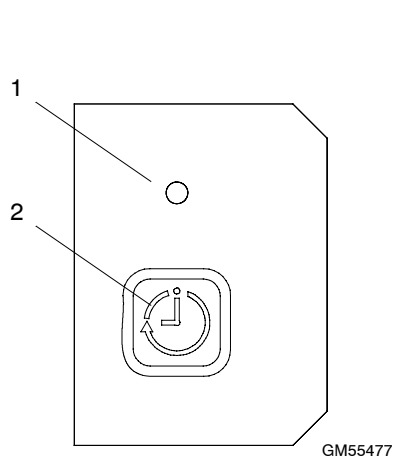
The transfer switch uses fixed settings for time delays, voltage and frequency pickup and dropout, and other system settings.

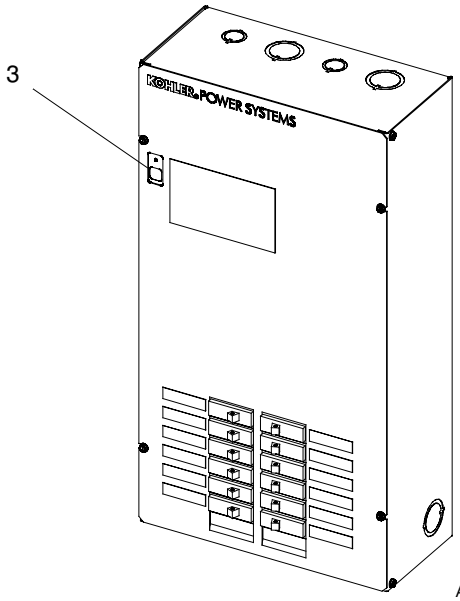
3.2 Controls

The user interface contains a red LED indicator and a pushbutton for the exerciser. See Figure 3-1.

The pushbutton starts an exercise run and sets the exercise timer. See Section 3.3 for exercise button operation instructions.

The LED lights steadily or flashes to indicate different ATS conditions as shown in Figure 3-2. See Section 3.4 for more information on fault conditions.





1. LED indicator (see Figure 3-2)
2. Exercise button (see Section 3.3)
3. User interface location

Figure 3-1 User Interface Panel

Condition	LED Indication
Generator set not running, load connected to utility power	LED off
Generator set running, load connected to utility power	LED lights steadily
Unloaded exercise	LED lights steadily
Loaded exercise	LED flashes on 0.5 second, off 2 seconds
Failure to acquire standby source fault	LED flashes 2 times/second
Failure to transfer fault	LED flashes 2 times/second
Auxiliary switch failure fault	LED flashes 2 times/second

Figure 3-2 LED Indication

3.3 Exerciser

3.3.1 Setting the Exercise Timer

Follow the instructions below to set the exercise timer to automatically start and run the generator set for 20 minutes every week. The exerciser can be set for loaded or unloaded exercise runs. Figure 3-3 explains the operation of the exercise button.

The exercise time and day are set to the time that the Exercise button is pushed. The exerciser will run at the same time on the same day each week.

Exercise	Instructions
Unloaded	Press and hold Exercise button for 3–5 seconds
Loaded	Press and hold Exercise button for 6+ seconds

Figure 3-3 Exercise Button Operation

Unloaded exercise. The generator set runs, but the electrical load is not transferred. Press and hold the Exercise button for approximately 3 seconds until the GEN Available LED flashes to start an unloaded exercise and set the time and date of the next exercise run. The GEN available LED continues to flash throughout the exercise run to indicate an unloaded exercise.

Loaded Exercise. The generator set runs and the ATS transfers the electrical load to the generator set. Hold the button for at least 6 seconds until the GEN available and GEN position LEDs flash to start a loaded exercise and set the time and date of the next exercise run. The GEN available and GEN position LEDs continue to flash throughout the exercise run to indicate a loaded exercise.

An exercise run can be ended early by pressing the exercise button. Ending the current exercise period early does not affect future exercise runs.

The exercise button can also be used to run a test. See Section 2.6.2 for instructions.

3.3.2 Resetting or Clearing the Exerciser

To reset the exercise timer to run at a new day and time, press and hold the exerciser button at the desired day and time as described in Section 3.3.1. The old setting is replaced by the new day and time.

To clear the exerciser setting, disconnect all power from the transfer switch for at least 20 minutes. Turn the generator set OFF and open the main circuit breaker to disconnect utility power.

Note: If the ATS is without power for 20 minutes or more (i.e. utility power is lost and the generator set is not running), the exerciser setting will be lost. Reset the exerciser as described in Section 3.3.1.

3.4 Faults

The LED flashes as shown in Figure 3-2 to indicate a fault. Contact an authorized distributor/dealer for service.

3.4.1 Failure to Acquire Emergency Source Warning

The Failure to Acquire Emergency Source fault occurs if the transfer switch does not sense voltage from the generator set within 78 seconds after signalling the generator set to start. Check the generator set operation and the connections from the generator set to the ATS in the case of this fault.

The Failure to Acquire Emergency Time Delay is set for 78 seconds to allow for three complete generator engine starting attempts.

The fault clears when the system acquires the emergency source.

3.4.2 Failure to Transfer Warning

The Failure to Transfer warning occurs if a signal to transfer is sent to the contactor and the position-indicating contacts do not indicate a complete transfer.

The controller will attempt to transfer three times before indicating the fault. If the transfer switch is in the Normal position, the Engine Cooldown time delay is executed and then the engine start contacts open to stop the generator set.

Reset the controller to clear the fault condition. See Section 3.5.

3.4.3 Auxiliary Switch Fault

An Auxiliary Switch fault occurs if the position-indicating contacts indicate that the ATS position changed when no transfer was called for. If the transfer switch is in the Normal position, the Engine Cooldown time delay is executed and then the engine start contacts open to stop the generator set.

An Auxiliary Switch fault also occurs if both auxiliary switches are open or closed so that the controller is unable to determine the transfer switch position.

Reset the controller to clear the fault condition. See Section 3.5.

3.5 Fault Reset

Always identify and correct the cause of a fault condition before resetting the ATS controller. To clear the fault, press and hold the Exercise button for three seconds. The LED turns off when the fault is cleared.

Note: Pressing the Exercise button to clear a fault will reset the exerciser to the current day and time. See Section 3.3.1 for instructions to reset the exerciser.

If the fault condition has not been corrected, the fault will not clear and the LED will not turn off. Contact an authorized distributor/dealer for service.

3.6 Source Sensing

The transfer switch controller monitors the utility power source voltage, and initiates the transfer sequence if the source voltage falls below the voltage dropout setting. Retransfer is initiated when the utility source rises above the voltage pickup settings and remains stable for at least 6 minutes. See Figure 3-4.

- Single-phase voltage sensing on both sources, ±5%.
- Line-to-line frequency sensing on emergency (GEN) source, ±2%.

Source Sensing	
Undervoltage dropout	80%
Undervoltage pickup	85%
Underfrequency dropout *	90%
Underfrequency pickup *	96%
* Emergency (GEN) source only	

Figure 3-4 Source Sensing

3.7 Transfer Sequence

Figure 3-5 illustrates the transfer sequence when the normal source fails and Figure 3-6 illustrates the sequence when it returns. Time delays before load transfer prevent nuisance transfers during brief power interruptions. See Figure 3-7. Events such as the failure of the generator set to start can change the sequence of operation.

The Failure to Acquire Emergency Time Delay is set for 78 seconds to allow for three complete engine starting attempts.

The load control function allows delayed connection of selected loads to the emergency source generator set. The load control contact opens before transfer to disconnect the load, then closes 5 minutes after transfer to connect the load to the emergency source.

If the emergency source fails and the normal source is not available, the transfer switch controller powers down until one of the sources returns.

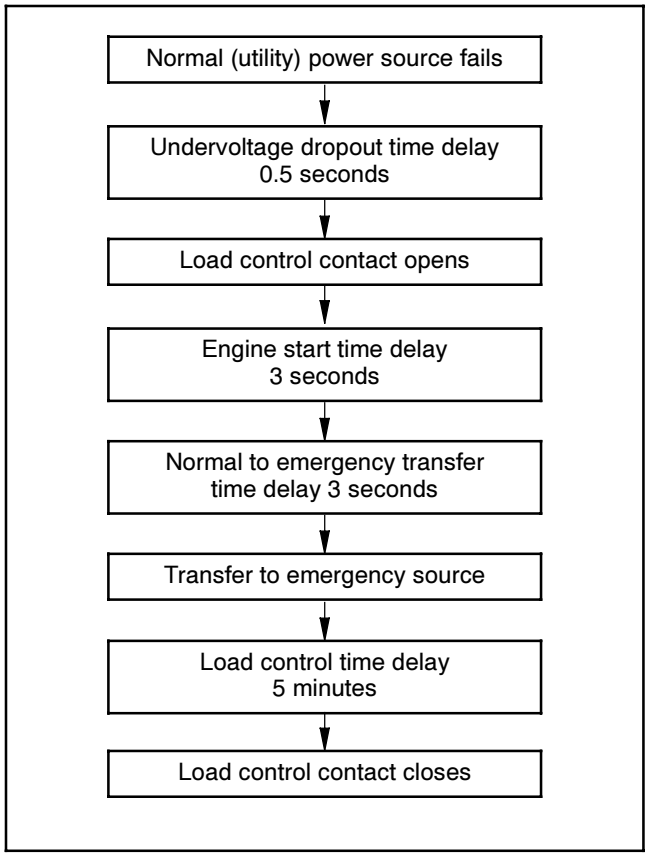


Figure 3-5 ATS Sequence of Operation, Transfer to Emergency

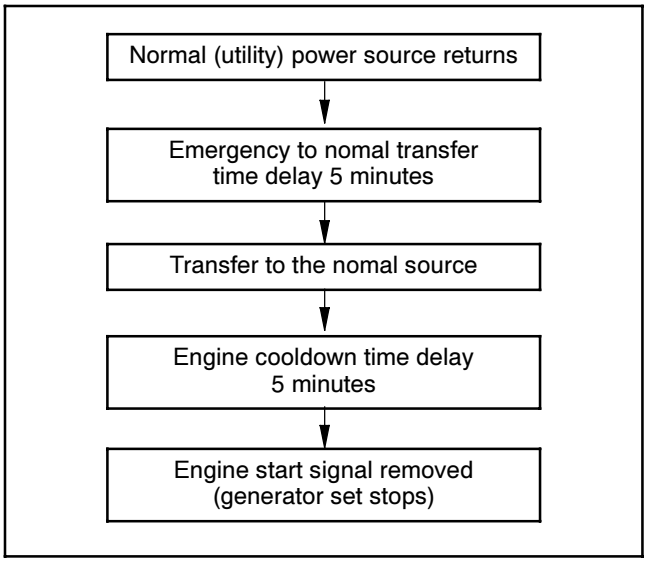


Figure 3-6 ATS Sequence of Operation, Retransfer to Normal

Time Delays	
Time Delay	**Factory Setting**
Engine Start	3 sec.
Transfer from Normal to Emergency	3 sec.
Retransfer from Emergency to Normal	5 min.
Engine Cooldown	5 min.
Failure to Acquire Emergency *	78 sec.*
Load Control	5 min.
Undervoltage Dropout Time	0.5 sec.
Underfrequency Dropout Time †	1 sec.
* Allows for three engine start attempts. † Emergency source only	

Figure 3-7 Time Delays

4.1 Introduction

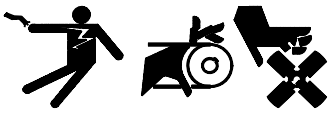
Regular preventive maintenance ensures safe and reliable operation and extends the life of the transfer switch. Preventive maintenance includes periodic testing, cleaning, inspection, and replacement of worn or missing components. Section 4.4 contains a service schedule for recommended maintenance tasks.

A local authorized distributor/dealer can provide complete preventive maintenance and service to keep the transfer switch in top condition. Unless otherwise specified, have maintenance or service performed by an authorized distributor/dealer in accordance with all applicable codes and standards. See the Service Assistance section in this manual for how to locate a local distributor/dealer.

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.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

This equipment must be installed and serviced by qualified electrical personnel.

⚠ 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.

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.

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.

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.

4.2 Testing

4.2.1 Weekly Generator Set Exercise

Use the exerciser to start and run the generator set under load once a week to maximize the reliability of the emergency power system. See Section 3.3 for exerciser instructions.

During the exercise, refer to Section 3.7 for the expected sequence of operation and check the following:

- Verify that the expected sequence of operations occurs as the switch transfers the load to the emergency source.
- Watch and listen for signs of excessive noise or vibration during operation.
- After the switch transfers the load to the emergency source, end the test and verify that the expected sequence of operations occurs as the transfer switch retransfers to the normal source and signals the generator set to shut down after the engine cooldown period.

4.2.2 Immediate Test

An immediate test can be performed by pressing the exerciser button. Hold the exercise button for 3–5 seconds for an unloaded test or 6+ seconds for a loaded test. During the test, check the operation as described in Section 4.2.1.

The exercise runs for 20 minutes. Press the exercise button again to stop the test early, if desired.

Note: Pressing the exercise button resets the exerciser to the current time and day.

See Section 3.3 for more information about the exercise sequence.

4.3 Inspection and Service

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

4.3.1 General Inspection

External Inspection. Keep the transfer switch clean and in good condition by performing a weekly general external inspection of the transfer switch for any condition of vibration, leakage, excessive temperature, contamination, or deterioration. 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.

Note: Do not use compressed air to clean the transfer switch because it can cause debris to lodge in the components and damage the switch.

Tighten loose external hardware. Replace any worn, missing, or broken external components with manufacturer-recommended replacement parts. Contact a local authorized distributor/dealer for specific part information and ordering.

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

Contact an authorized distributor/dealer to inspect and service the transfer switch if any of the following conditions are found inside the transfer switch.

- Accumulations of dirt, dust, moisture, or other contaminants.
- Signs of corrosion.
- Worn, missing, or broken components.
- Loose hardware.
- Wire or cable insulation deterioration, cuts, or abrasion.
- Signs of overheating or loose connections: 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 application does not allow a power interruption for the time required for the internal inspection, have an authorized distributor/dealer perform the internal inspection.

4.3.2 Other Inspections and Service

Have an authorized distributor/dealer perform scheduled maintenance, service, and other maintenance that ensures the safe and reliable operation of the transfer switch. See Section 4.4, Service Schedule, for the recommended maintenance items and service intervals.

Have an authorized distributor/dealer repair or replace damaged or worn internal components with manufacturer-recommended replacement parts.

4.4 Service Schedule

Follow the service schedule below for the recommended service intervals. Have all service performed by an authorized distributor/dealer except for activities designated by an X, which may be performed by the switch operator.

System Component or Procedure	See Section	Visually Inspect	Check	Adjust, Repair, Replace	Clean	Test	Frequency
Electrical System							
Check for signs of overheating or loose connections: discoloration of metal, melted plastic, or a burning odor	4.3.1	X	X				Y
Check the contactor's external operating mechanism for cleanliness; clean and relubricate if dirty *	4.3.1	X			D (clean and lube)		Y
Inspect wiring insulation for deterioration, cuts, or abrasion. Repair or replace deteriorated or damaged wiring	4.3.1	X	D	D			Y
Tighten control and power wiring connections to specifications	2.5		D			D	Y
Check the transfer switch's main power switching contacts' condition; clean or replace the main contacts or replace the contactor assembly as necessary	S/M	D		D	D		Y
Control System							
Exercise the generator set under load	3.3					X	W
General Equipment Condition							
Inspect the outside of the transfer switch for any signs of excessive vibration, leakage, high temperature, contamination, or deterioration *	4.3	X			X		M
Check that all external hardware is in place, tightened, and not badly worn	4.3	X	X	X			M
Inspect the inside of transfer switch for any signs of excessive vibration, leakage, high temperature, contamination, or deterioration *	4.3	D	D		D		Y
Check that all internal hardware is in place, tightened, and not badly worn	4.3	X	D	D			Y

* Service more frequently if the transfer switch is 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.

Adjust, Repair, Replace: Includes tightening hardware and lubricating the mechanism. 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 distributor/dealer.

Symbols used in the chart:

X= The transfer switch operator can perform these tasks.
D=An authorized distributor/dealer must perform these tasks.
W=Weekly
M=Monthly
Q=Quarterly
S=Semiannually (every six months)
Y=Yearly (annually)
S/M=Service Manual
W/D=Wiring diagram

Section 5 Diagrams and Drawings

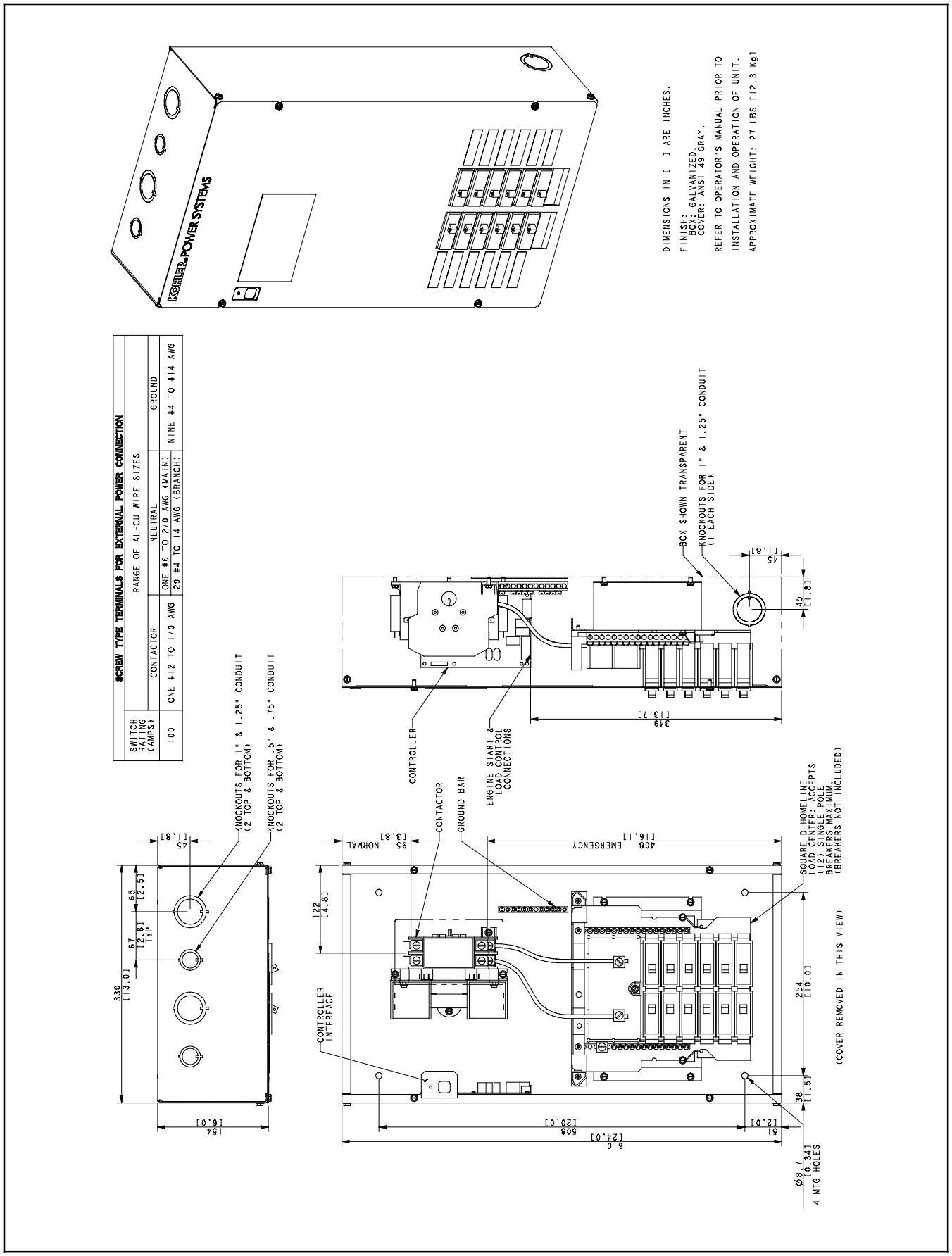


Figure 5-1 Dimension Drawing, 100 Amp NEMA Type 1 Enclosure with Load Center, ADV-7406

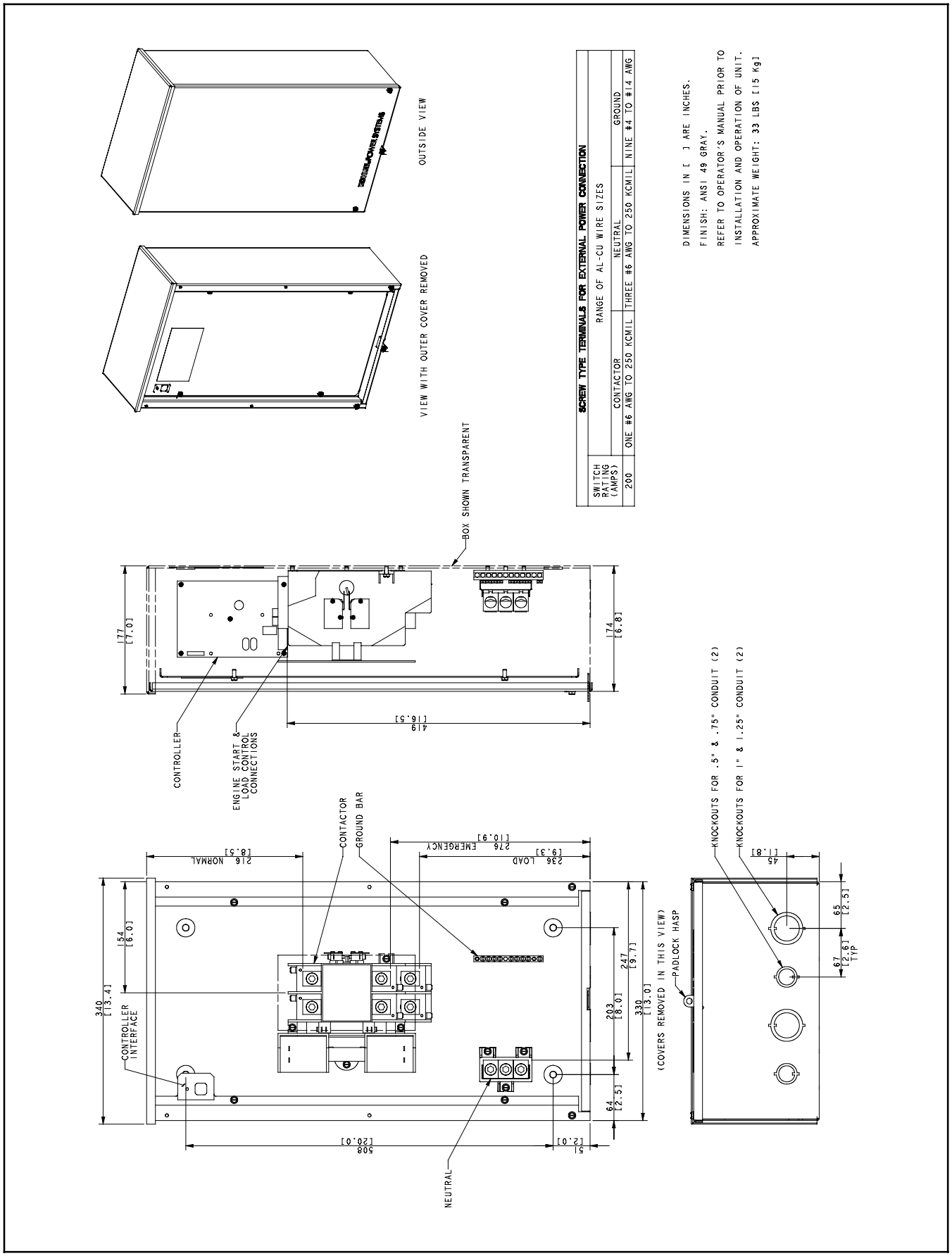


Figure 5-2 Dimension Drawing, 200 Amp NEMA Type 3R Enclosure without Load Center, ADV-7405

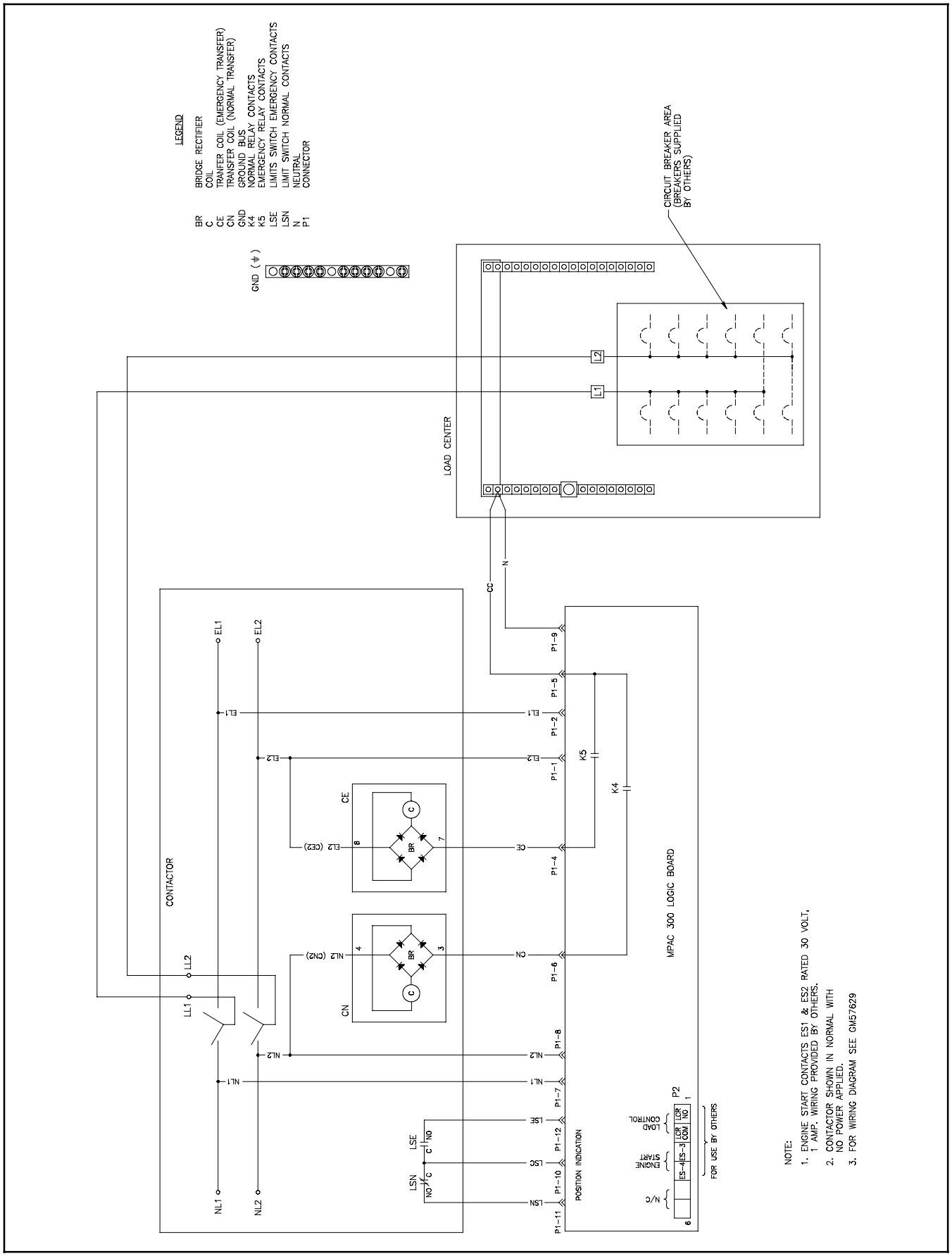


Figure 5-3 Schematic Diagram, 100 Amp with Load Center, GM57626

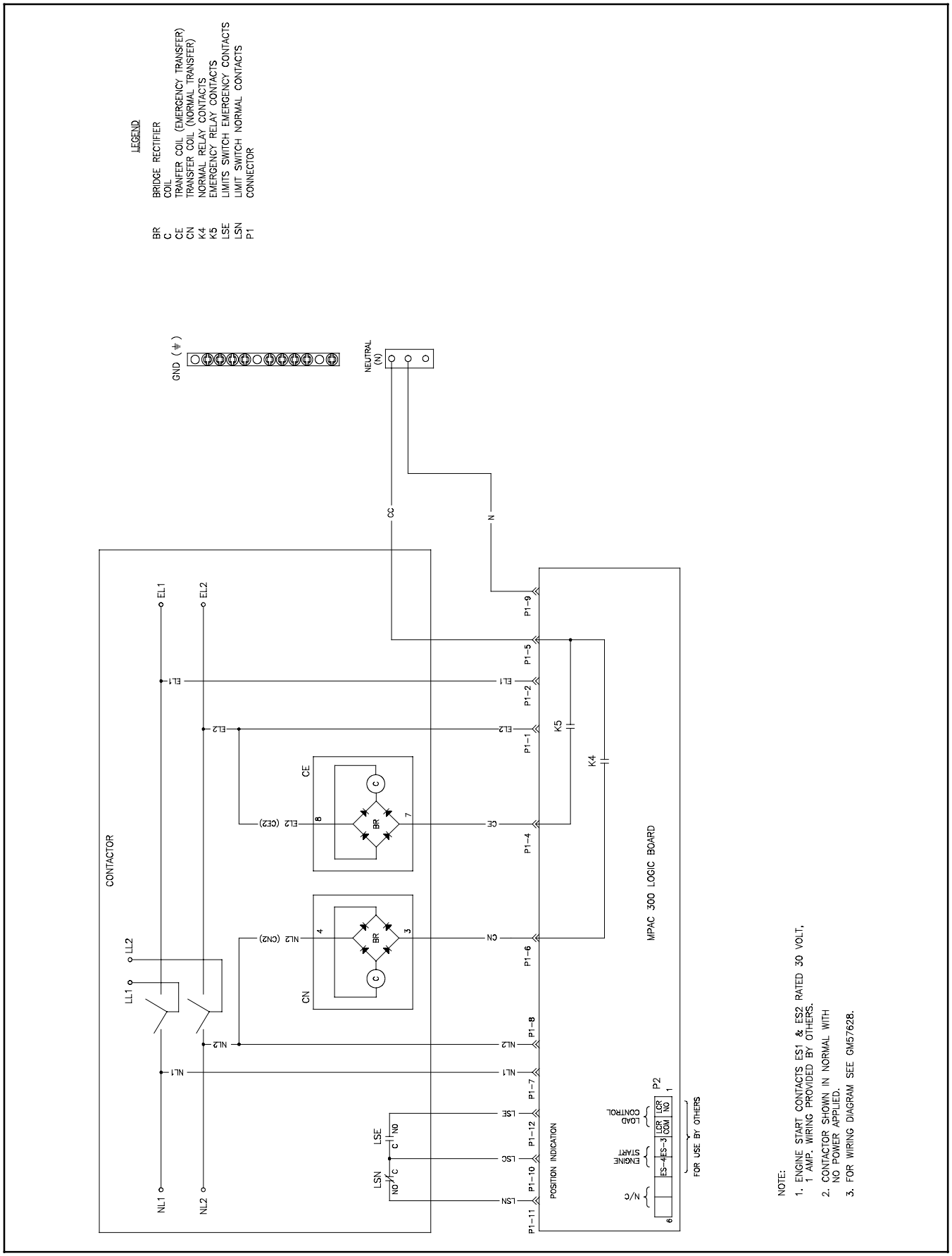


Figure 5-4 Schematic Diagram, 200 Amp without Load Center, GM57627

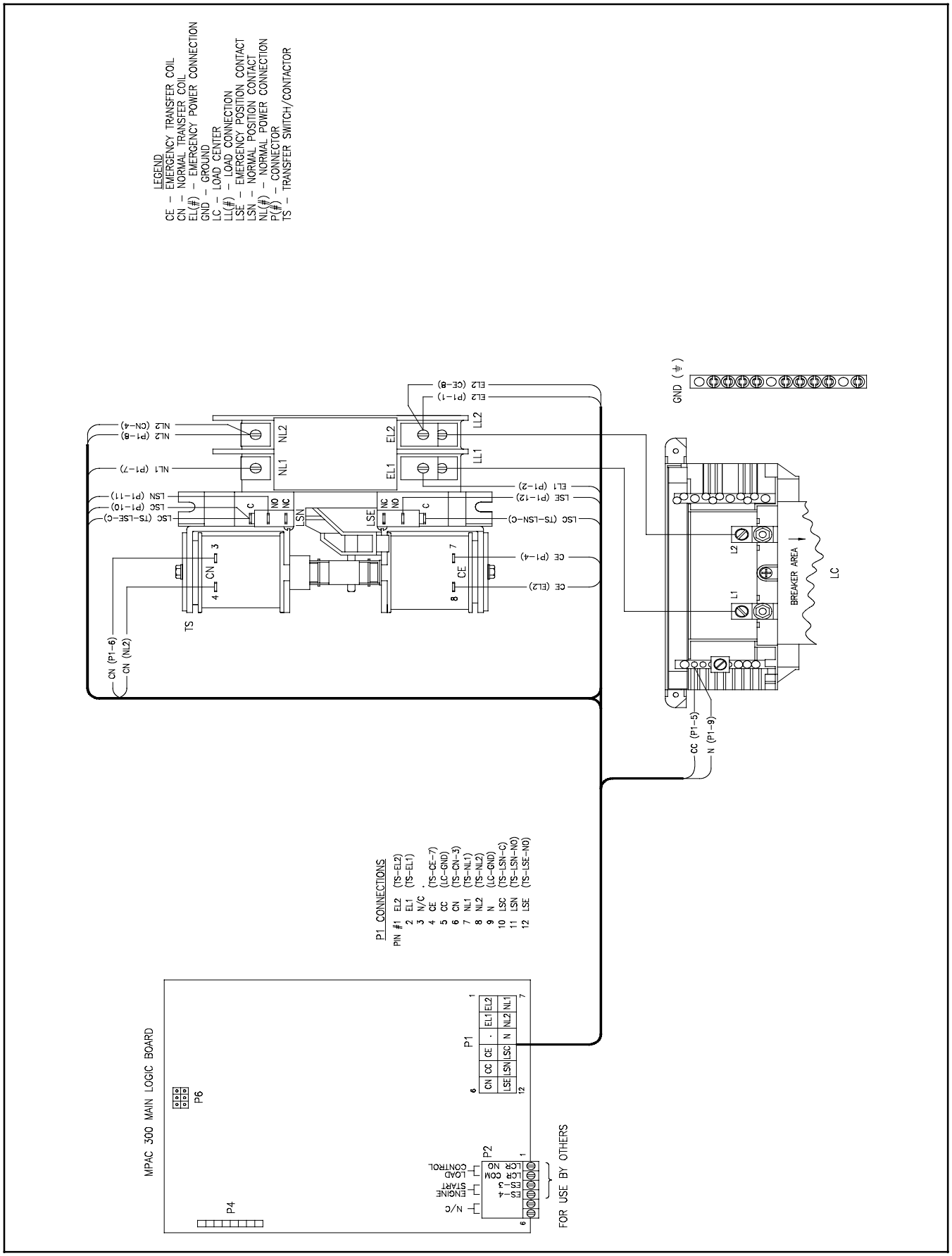


Figure 5-5 Wiring Diagram, 100 Amp with Load Center, GM57629

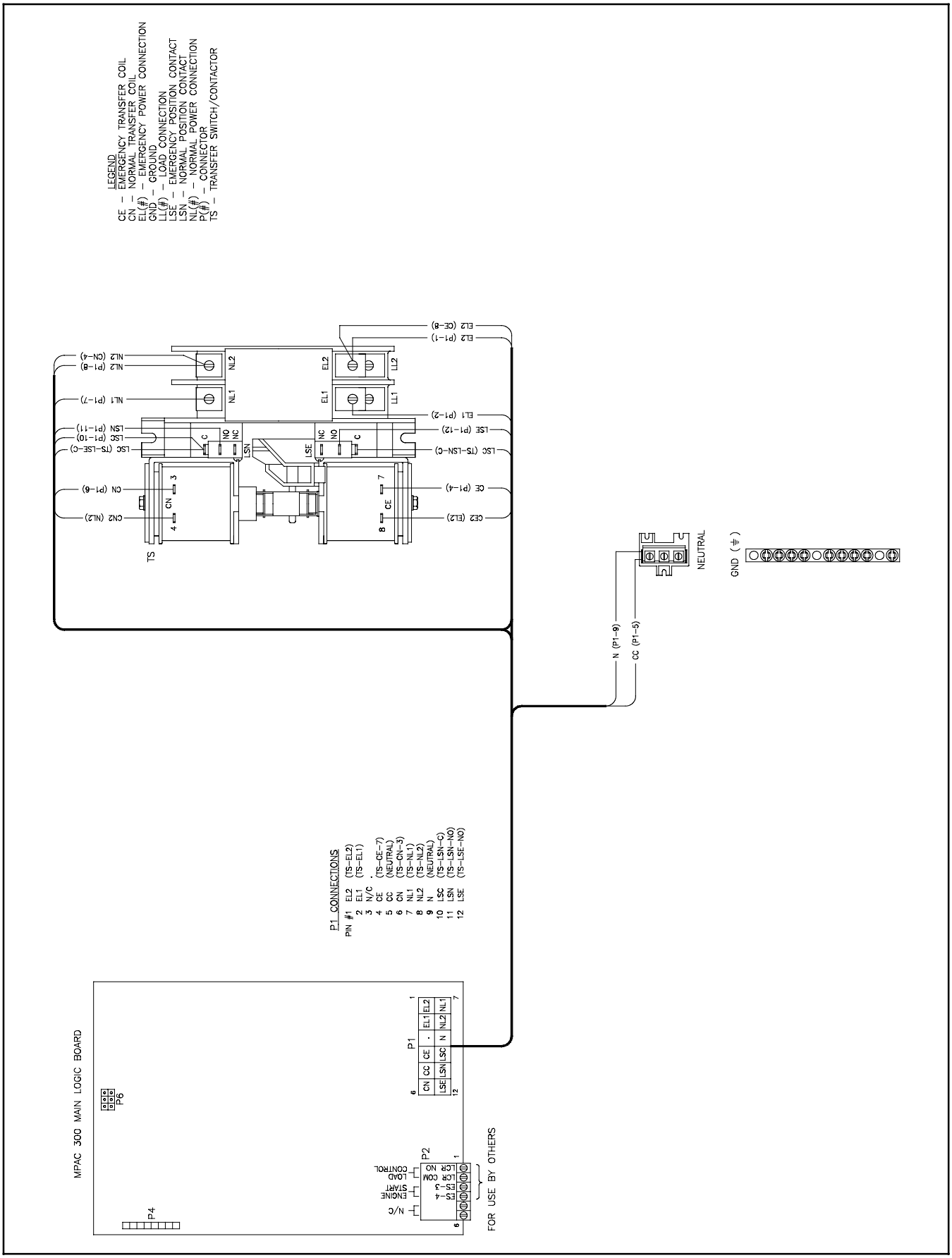


Figure 5-6 Wiring Diagram, 200 amp without Load Center, GM57628

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	audiovisual
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
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)
cogen.	cogeneration
com	communications (port)
coml	commercial
Coml/Rec	Commercial/Recreational
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. lb.	foot pounds (torque)
ft./min.	feet per minute
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
GND, ⏚	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
GRD	equipment ground
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temperature, high engine 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. lb.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard
k	kilo (1000)
K	kelvin

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

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