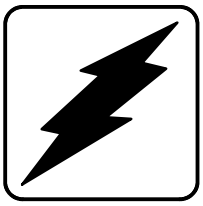
Operation and Installation

Automatic Transfer Switches



Models:

G120
G220

Controls:
Solid-State

Power Switching Device:
100 and 200 Amperes

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-5990 11/03c

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

A transfer switch, like any other electromechanical device, can pose potential dangers to life and limb if improperly maintained or operated. The best way to prevent accidents is to be aware of potential dangers and act safely. Please read and follow the safety precautions and instructions below to prevent harm to yourself and others. This manual contains several types of safety precautions and instructions which are explained below. SAVE THESE INSTRUCTIONS.

⚠ 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***.

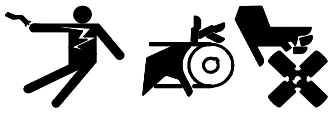
NOTICE

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

Safety decals affixed to the transfer switch in prominent places advise the operator or service technician of potential hazards and how to act safely. The decals are reproduced here to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

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

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

Battery

⚠ WARNING

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

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

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

⚠ WARNING

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

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

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

Hazardous Voltage/ Electrical Shock

⚠ 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.

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

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

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

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

NOTICE

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

NOTICE

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

NOTICE

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

Notes

Introduction

This manual provides operation and installation instructions for Kohler® Model G120 and G220 transfer switches with solid-state electrical controls.

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.

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 KohlerPowerSystems.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

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

Asia Pacific
Power Systems Asia Pacific Regional Office
Singapore, Republic of Singapore
Phone: (65) 264-6422
Fax: (65) 264-6455

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

X:in:008:001a

Notes

1.1 Purpose

An automatic transfer switch (ATS) transfers critical electrical loads from a normal (preferred) source of electrical power to an emergency (standby) source when the normal source fails to maintain a minimum voltage level.

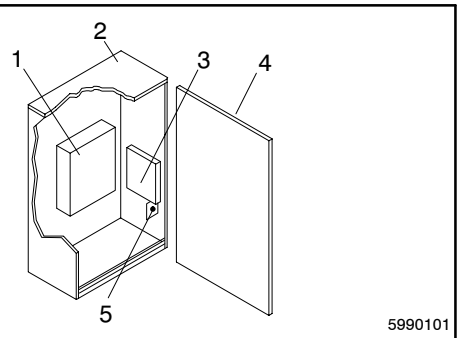
When the normal source fails, the ATS signals the generator set(s) to start. When the emergency source reaches a minimum voltage level, the ATS transfers the load from the normal source to the emergency source. The ATS continuously senses the normal source and transfers the load back to the normal source when the normal source returns. After transfer of the load back to the normal source, the ATS removes the generator set start signal, allowing the generator set(s) to shut down.

1.2 Component Overview

The ATS components include the power switching device (contactor), the electrical controls, and the exerciser. See Figure 1-1.

The power switching device transfers power from the normal or emergency sources to the load. See Figure 1-2. The electrical controls electrically actuate the switch to select a power source, and the switch mechanically latches into the selected position. The switch also includes a provision for manual mechanical operation in emergency nonpowered conditions.

The electrical controls monitor power sources, control the contactor, and signal the generator to start when needed. The exerciser runs the generator set weekly if enabled.



1. Power switching device (contactor)
2. Enclosure
3. Electrical controls (solid-state)
4. Enclosure cover
5. Exerciser switch

Figure 1-1 ATS Components

The power switch contains two sets of multipole contacts. One set of contacts selects power from the normal source and the other set selects power from the emergency source. Mechanical interlocks within the switch ensure that only one set of contacts is closed at a time ensuring load servicing without cross-coupling of power sources.

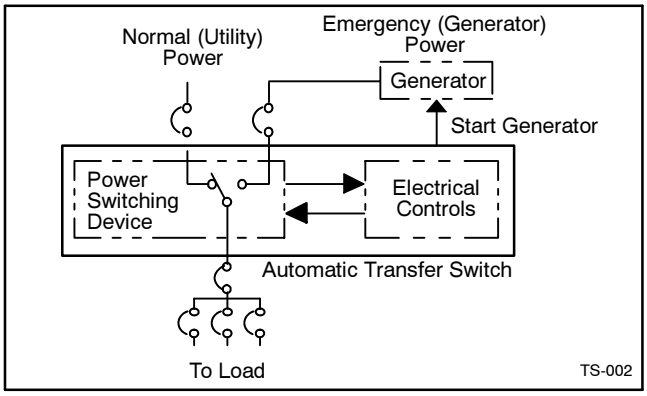


Figure 1-2 Typical ATS Block Diagram

1.3 Nameplate

A nameplate is attached to the inside of the ATS enclosure cover. See Figure 1-3. The nameplate label includes a model and serial number and provides characteristic and rating information that affects installation and operation.

Copy the model and serial number from the nameplate into the spaces provided in the Service Assistance section of this manual for use when requesting service or parts.

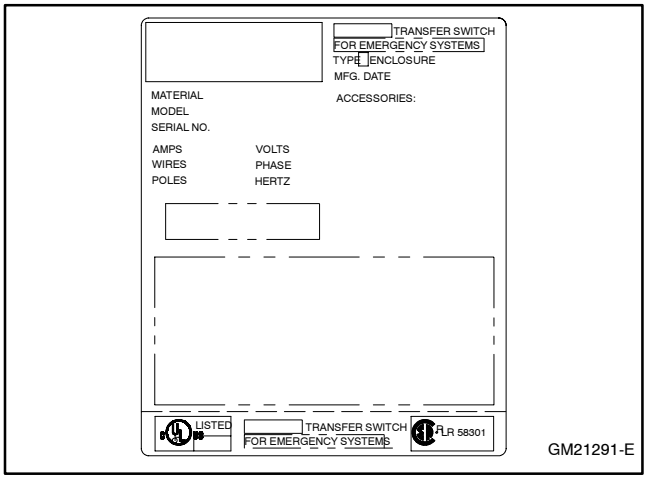
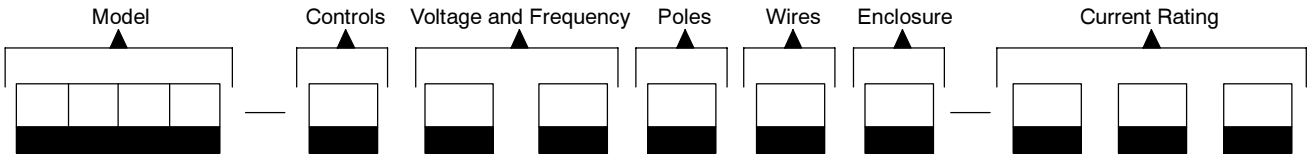


Figure 1-3 Typical Transfer Switch Nameplate

1.4 Model Number

Use Figure 1-4 to record and interpret the transfer switch model number.

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



Kohler®® Model Number Key

This chart explains the Kohler® transfer switch model number code. The sample model number shown is for a Model G120 automatic transfer switch that uses a 250-volt maximum contactor power switching device with solid-state electrical controls rated at 240 volts, 60 hertz, 1 phase, 2 pole, and 3 wires in a NEMA Type 1 enclosure with a current rating of 200 amperes. Not all possible combinations are available.

SAMPLE PART NUMBER

G120-164233-0200

Model
G120: Model G120 transfer switch, 250-volt maximum contactor *
G220: Model G220 transfer switch, 250-volt maximum contactor

Electrical Controls
1: Solid-state

Voltage and Frequency
63: 220 Volt, 50 Hz
64: 240 Volt, 60 Hz
68: 208 Volt, 60 Hz (G120 only)

Number of Poles and Phases
2: 2 Pole, 1 Phase
3: 3 Pole, 3 Phase (G120 only)

Number of Wires
3: 3 Wire
4: 4 Wire

Enclosure
3 = NEMA type 3R

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

* To be discontinued

Figure 1-4 Transfer Switch Model Number Code

1.5 Standard Features

- G120 transfer switches are UL 1008 listed and CSA certified
- G220 transfer switches are UL 1008 listed and UL listed to Canadian safety standards
- Contactors are rated 250 VAC maximum, 60 or 50 Hz
- The G120 ATS is available with 2 or 3 poles, single- or three-phase
- The G220 ATS is a 2-pole, single-phase transfer switch only
- NEMA type 3R enclosure
- Integrated solid-state logic controller with conformally coated printed circuit board for protection against harsh environments
- Single-phase switches: normal source dropout fixed at 160 VAC and pickup fixed at 190 VAC
- Three-phase switches: normal source dropout fixed at approximately 80% of nominal for single-phase failure and pickup fixed at approximately 90% of nominal (G120 only)
- Emergency source voltage sensing one phase: dropout fixed at 160 VAC and pickup fixed at 190 VAC
- Time Delay Engine Start (TDES) fixed at 3 seconds
- Time Delay Normal to Emergency (TDNE) fixed at 2 seconds
- Time Delay Emergency to Normal (TDEN) fixed at 12 seconds
- Time Delay Engine Cooldown (TDEC) fixed at 2 minutes
- User-enabled generator exerciser: starts and runs the generator unloaded for a 20-minute period once a week
- Contactor electrically and mechanically interlocked
- Contactor manually operable for maintenance purposes
- Ambient operating temperature range -4° to 140°F (-20° to 60°C)
- Ambient storage temperature range -22° to 158°F (-30° to 70°C)
- Humidity range 5 to 85% noncondensing
- Provision for test switch

1.6 Application Data

See Figure 1-5 for application data including the range of wire sizes for transfer switch power terminals.

UL-Listed Solderless Screw-Type Terminals for External Power Connections		
Switch Rating, amps	Normal, Emergency, and Load Terminals	
	Cables per Pole	Range of Wire Sizes
100	1	#8 to 3/0 (copper or aluminum)
200	1	#8 to 3/0 (copper only)

Figure 1-5 Application Data

1.7 Ratings

1.7.1 G120 Ratings

The following tables provide contactor withstand and closing current ratings (WCR) per UL 1008 standards. Figure 1-6 provides WCR when used with given types of fuses and circuit breakers. Figure 1-7 provides WCR for 100 and 200 ampere switch sizes when coordinated with specific manufacturer's circuit breakers.

Switch Rating (amps)	Withstand and Closing Ratings per UL 1008 and CSA, Maximum Current (amps)		
	When Used With 400 Amps Maximum Class J, RK5, or RK1 Fuse	When Coordinated With Molded-Case Circuit Breakers	
		Any, 400 Amps Maximum	Specific Manufacturer's (see Figure 1-8)
100	200,000	10,000	22,000
200	200,000	10,000	22,000
* UL 1008 listed and CSA certified at 240 vac maximum.			

Figure 1-6 G120 Withstand and Closing Current Ratings

WCR, RMS Symmetrical Amperes	Specific Manufacturer's Molded-Case Circuit Breakers *		
	Manufacturer	Type or Class	Maximum Size (amps)
22,000	Cutler-Hammer/ Westinghouse	FCL, FB Tripac	100
		FD, FDC, HFD	150
		HJD, JD, JDB, JDC	250
		HKD, KD, KDB, KDC, LA Tripac, LCL, DK	400
	Square D	FC, FH, FI	100
		KA, KC, KH, KI	250
		LA, LC, LE, LH, LI, LX, LXI	400
	ITE/Siemens	CED6, ED6, HED4, HED6, ED4	125
		CFD6, FD6, FXD6, HFD6	250
		CJD6, HJD6, HHJD6, HHJXD6, JD6, JXD6, SCJD6, SHJD6, SJD6	400
	GE	TB1	100
		SEL, SEP, TEL, THED, THLC1	150
		TFK, TFL, THFK, THLC2	225
		SFL, SFP, TFJ	250
		SGL4, SGP4, TB4, THJK4, THLC4, TJJ, TJK4, TLB4	400
* UL 1008 listed and CSA certified at 240 vac maximum.			

Figure 1-7 G120 Withstand and Closing Current Ratings (WCR) With Coordinated Circuit Breakers, 240 V Maximum, UL and CSA Listings

1.7.2 G220 Ratings

Figure 1-8 lists contactor withstand and closing ratings (WCR) for 100 and 200 ampere switches with specific manufacturer's circuit breakers per UL 1008 standards. The ATS is 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 at 240 VAC maximum.

Specific Manufacturer's Molded-Case Circuit Breakers*					
Transfer Switch Model	Switch Rating, Amps	WCR, RMS Symmetrical Amperes	Manufacturer	Type or Class	Maximum Size (amps)
G220	100	22,000	Cutler-Hammer	FCL, FB	100
				QCHW	125
				FDC	150
			Square D	FI	100
			ITE/Siemens	ED4, CED6, ED6, HED4, HED6	125
	200	22,000	Cutler-Hammer	BHW, FD, HFD, JDB, JD, HJD	225
				JD, JDB, HJD, JDC	250
				DK, KD, KDB, HKD, KDC, LCL, LA	400
			Square D	KI	250
				LE, LX, LXI	400
			ITE/Siemens	FD6-A, FXD6-A, HFD6, CFD6	250
			GE	TFL, THLC2	225
				SF, SFL, SFP	250
* UL 1008 listed at 240 vac maximum.					

Figure 1-8 G220 Withstand and Closing Current Ratings With Coordinated Circuit Breakers, 240 V Maximum, UL and CSA Listings

2.1 Automatic Operation

The ATS controller monitors the normal and emergency power sources and determines when a power source has failed or is acceptable and controls the system accordingly. Built-in time delays ensure that the power source is stable before the load is transferred.

Failure of a power source occurs when its voltage on one or more phases falls below the dropout voltage level. A power source is acceptable when its voltage on one or more phases rises above the pickup voltage level and stays above the dropout voltage level. A power source is restored when it becomes acceptable again after failure. See Section 1.5, Specifications, for voltage sensing and pickup and dropout voltage specifications.

Typical ATS operation occurs in two separate automatic sequences.

- **Failure of normal power** and the resulting transfer to emergency power.
- **Restoration of normal power** and the resulting transfer back to normal power.

2.1.1 Failure of Normal Power

When the normal power source fails, the controller starts a time delay called Time Delay Engine Start (TDES). See Figure 2-1 for ATS time delays. TDES prevents unnecessary generator start-up during short normal power interruptions. If the normal power source is restored before TDES ends, the controller resets the time delay. If the normal power failure persists and TDES ends, the controller issues a signal to start the standby (emergency) generator to produce the emergency power source.

After signalling the generator to start, the controller monitors the emergency power source. When the controller determines that the emergency source is acceptable, the controller starts a time delay called Time Delay Normal to Emergency (TDNE). TDNE allows emergency power source stabilization before load connection. When TDNE ends, the controller signals the contactor to connect the load to the emergency source.

After load transfer the switch mechanically latches in the emergency position, supplying emergency source power to the load until normal power source restoration and stabilization.

2.1.2 Restoration of Normal Power

When the normal power source is restored, the controller starts a time delay called Time Delay Emergency to Normal (TDEN). If the normal source fails before TDEN ends, the time delay resets. TDEN ensures normal power source stabilization before load reconnection.

When the controller determines that the normal power source has maintained an acceptable level and TDEN ends, the controller signals the contactor to reconnect the load to the normal source.

After load transfer the switch mechanically latches in the normal position and the controller starts a 2-minute time delay called Time Delay Engine Cooldown (TDEC). TDEC allows the engine and generator to run unloaded and cool down before shutdown. When TDEC ends, the controller signals the generator set to shut down.

Time Delay	Duration
Engine Start (TDES)	3 seconds
Normal to Emergency (TDNE)	2 seconds
Emeergency to Normal (TDEN)	12 seconds
Engine Cooldown (TDEC)	2 minutes

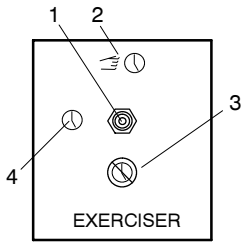
Figure 2-1 Time Delays

2.2 Exerciser Function

The exerciser function, when enabled, automatically starts and runs the generator set unloaded (the ATS does not transfer the load to the emergency source) for 20 minutes once a week. Exercising the generator set helps to ensure that the generator set starts when emergency power is needed. An exerciser switch selects exerciser functions. Automatic operation overrides the exerciser function. The loss of all power sources for an extended period can result in the loss of the exerciser set time. See Section 2.2.2, Exerciser Power Requirements.

2.2.1 Exerciser Switch

An exerciser switch is located inside the ATS enclosure. See Figure 1-1 and Figure 2-2.



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1. Exerciser switch
2. Set position
3. Disable position
4. Run position

Figure 2-2 Exerciser Switch

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

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.

Note: The exerciser switch is set during installation and normally does not require adjustment. Line voltage is present on some components inside the ATS enclosure when power sources are applied. Only trained and qualified personnel should open the ATS enclosure when power is present. Read and follow all safety decals inside the enclosure and avoid contact with line voltage.

The exerciser switch selects the following exerciser functions when power is available. See Section 2.2.2, Exerciser Power Requirements.

- **Set ( ).** Placing the switch in the set position and releasing the switch sets the exerciser: the exerciser's internal one-week timer is reset and the exerciser starts and runs the generator set for a 20-minute period. Subsequent weekly 20-minute exercise periods start at the same day and time the exerciser was set.

- **Run ( ).** Returning the switch to the run position enables the exerciser. The controller starts and runs the generator set unloaded for 20 minutes on the same day and time each week the exerciser was set.

- **Disable ( ).** Placing the switch in the disable position prevents the exerciser from starting and running the generator. The exerciser's internal one-week timer continues to run and the exerciser's set day and time are not lost. The ATS, however, starts the generator automatically when the normal power source fails.

Replace the enclosure cover on the ATS enclosure and tighten the screws that hold it in place after viewing or making changes to the exerciser switch setting.

2.2.2 Exerciser Power Requirements

An internal one-week timer for the exerciser function maintains its setting for up to 90 seconds after power loss on both the normal and emergency sources. When the normal power source fails, the generator must start and run to provide emergency power within approximately 90 seconds or the system loses the previously set day and time for the exerciser.

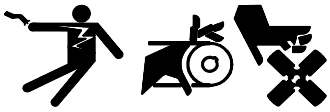
When power loss on both the normal and emergency power sources lasts longer than approximately 90 seconds, the exerciser is set to the day and time that either power source returns. Then, if the exerciser switch is in the Run ( ) position, the controller starts and runs the generator set unloaded for 20 minutes one week from the day and time of power source return and on subsequent weeks at the same day and time.

2.3 Manual Operation

To test or troubleshoot the transfer switch, manually operate the contactor as described in the procedure below.

Note: 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 manually operate smoothly without binding; contact an authorized service distributor to service the contactor.

⚠ 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.

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

Manual Operation Procedures

1. Prevent the generator set that provides the emergency power source to the transfer switch from starting.

   a. Move the generator set master switch to the OFF position.

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

   c. Disconnect all generator engine start batteries, negative (-) leads first.

2. Disconnect or turn off both the normal and emergency power sources by opening upstream circuit breakers or switches to the transfer switch.

   Note: The manual operation handle is provided for maintenance purposes only. Do not attempt to use the manual operation handle to transfer the load.

3. Remove the cover on the front of the transfer switch enclosure. Use Procedure 1 for Model G120 switches. Use Procedure 2 for Model G220 switches.

Procedure 1, for Model G120 transfer switches, shown in Figure 2-3

1. Insert a #2 Phillips screwdriver or similar tool with an electrically-insulating handle into the hole located on the flywheel at the left of the contactor. See Figure 2-3. A mark on the outer part of the flywheel shows the switch position when viewed

from the front of the enclosure. The letter E is visible if the switch is in the emergency position (load is connected to the emergency [standby] power source). The letter N is visible if the switch is in the normal position (load is connected to the normal [utility] power source).

2. Move the tool's handle up to rotate the flywheel to manually operate the switch into the emergency position. Move the tool's handle down to rotate the flywheel to manually operate the switch into the normal position. See Figure 2-3.
3. Manually operate the switch to select the normal position for automatic operation.
4. Remove the tool used to manually operate the switch.

Procedure 2, for Model G220 transfer switches, shown in Figure 2-4

1. Slide the large end of the manual operation handle over the manual operation lever on the left side of the contactor. See Figure 2-4. Move the handle up to place the transfer switch in the Normal Source position, or down to place the contactor in the Emergency Source position.

   Note: Do not attempt to move the manual operation lever without using the handle.

2. Move the handle up to place the transfer switch in the Normal Source position for normal operation.
3. Remove the handle and store it in a convenient location near the tansfer switch.

Procedure to return the transfer switch and generator set to automatic operation

1. Replace the cover on the transfer switch enclosure and tighten the screws that hold it in place.
2. Reconnect power supplies to the transfer switch.

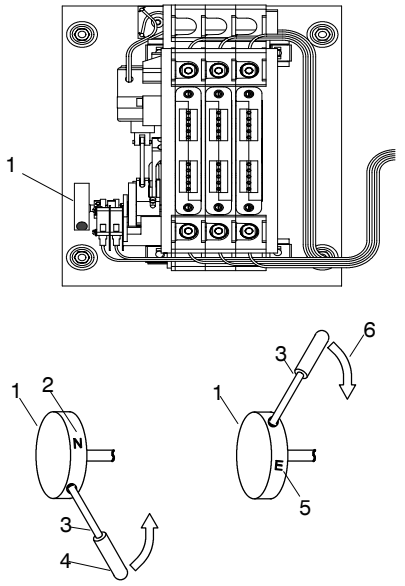
   Note: When power is applied to the transfer switch, the engine start contacts remain closed until Time Delay Engine Cooldown (TDEC) ends.

3. Return the generator set to automatic operation.

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

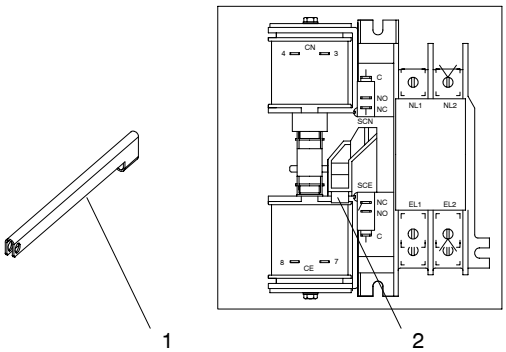
   b. Reconnect power to the generator engine start battery charger, if installed.

   c. Move the generator set master switch to the AUTO (automatic) position. The generator set may start and run until the Time Delay Engine Cooldown (TDEC) ends (see NOTE above).



1. Flywheel
2. Mark shows switch in the normal position
3. Tool inserted into hole in flywheel
4. Move up to select the emergency position
5. Mark shows switch in the emergency position
6. Move down to select the normal position

Figure 2-3 Model G120 Contactor with Flywheel (Procedure 1)



1. Manual operation handle
2. Manual operation lever

Figure 2-4 Model G220 Contactor with Manual Operation Handle (Procedure 2)

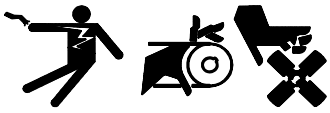
3.1 Maintenance

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.

Keep the outside of the transfer switch clean and dry. Have any other maintenance and service performed only by trained and qualified personnel following all applicable codes and standards. Keep a record of all maintenance and service.

Your local authorized distributor/dealer can provide complete preventive maintenance and service to keep the transfer switch in top condition. Contact your local authorized distributor/dealer for additional information.

⚠ 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.

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

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.

Have an authorized service distributor/dealer perform periodic (at least annual) preventive maintenance of the transfer switch including the following.

Preventive Maintenance

- Clean and inspect the transfer switch.
- Tighten control and power terminals to torque specifications.
- Clean the contactor external operating mechanism when contaminated by debris and relubricate the mechanism using the lubricant recommended by the manufacturer.
- Perform any other maintenance, tests, or service that maintains the safe and reliable operation of the switch.

3.2 Testing

Start and run the generator set weekly. See Section 2.2, Exerciser Function, to set and enable the exerciser function to start and run the generator set once a week for 20 minutes.

Test the transfer switch operation monthly. To test, disconnect the normal power source by opening circuit breakers or switches to cause the transfer switch to automatically start the generator set and transfer the load to the emergency power source. When the switch has transferred the load to the emergency power source, reconnect the normal power source and verify that the transfer switch retransfers to the normal power source and shuts down the generator set after TDEC ends. See Section 2.1, Automatic Operation.

Check the transfer switch nameplate to determine the model number for your transfer switch. See Figure 4-1 and Figure 4-2. Then locate the appropriate drawings in Figure 4-3.

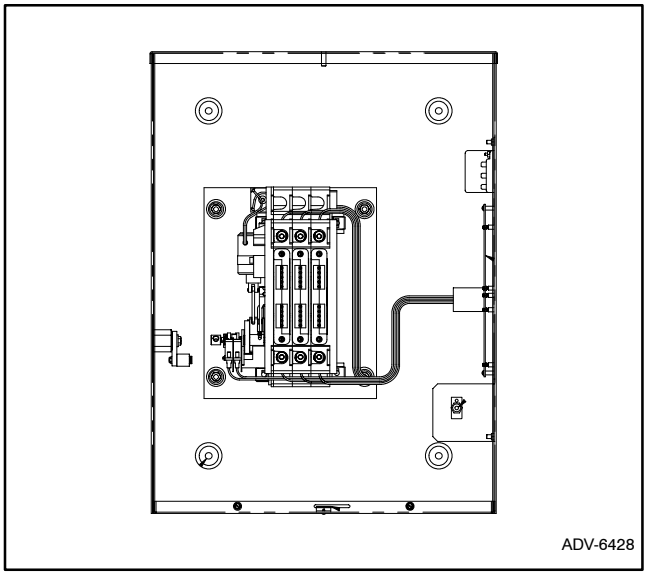


Figure 4-1 Model G120 Transfer Switch

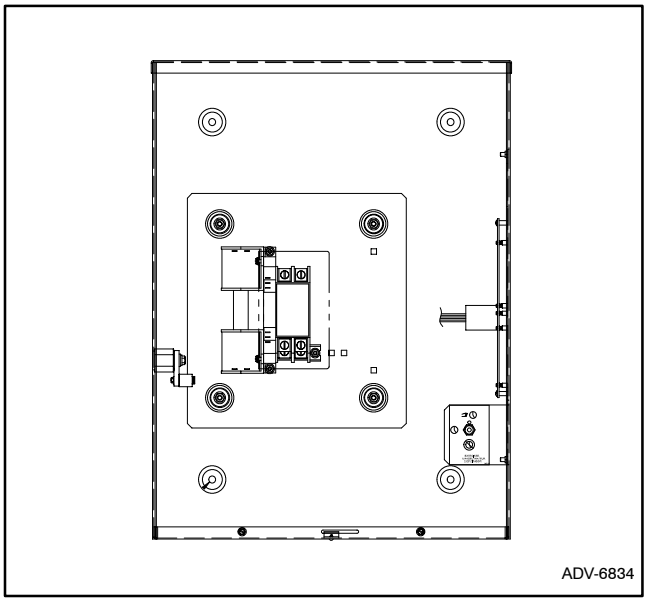
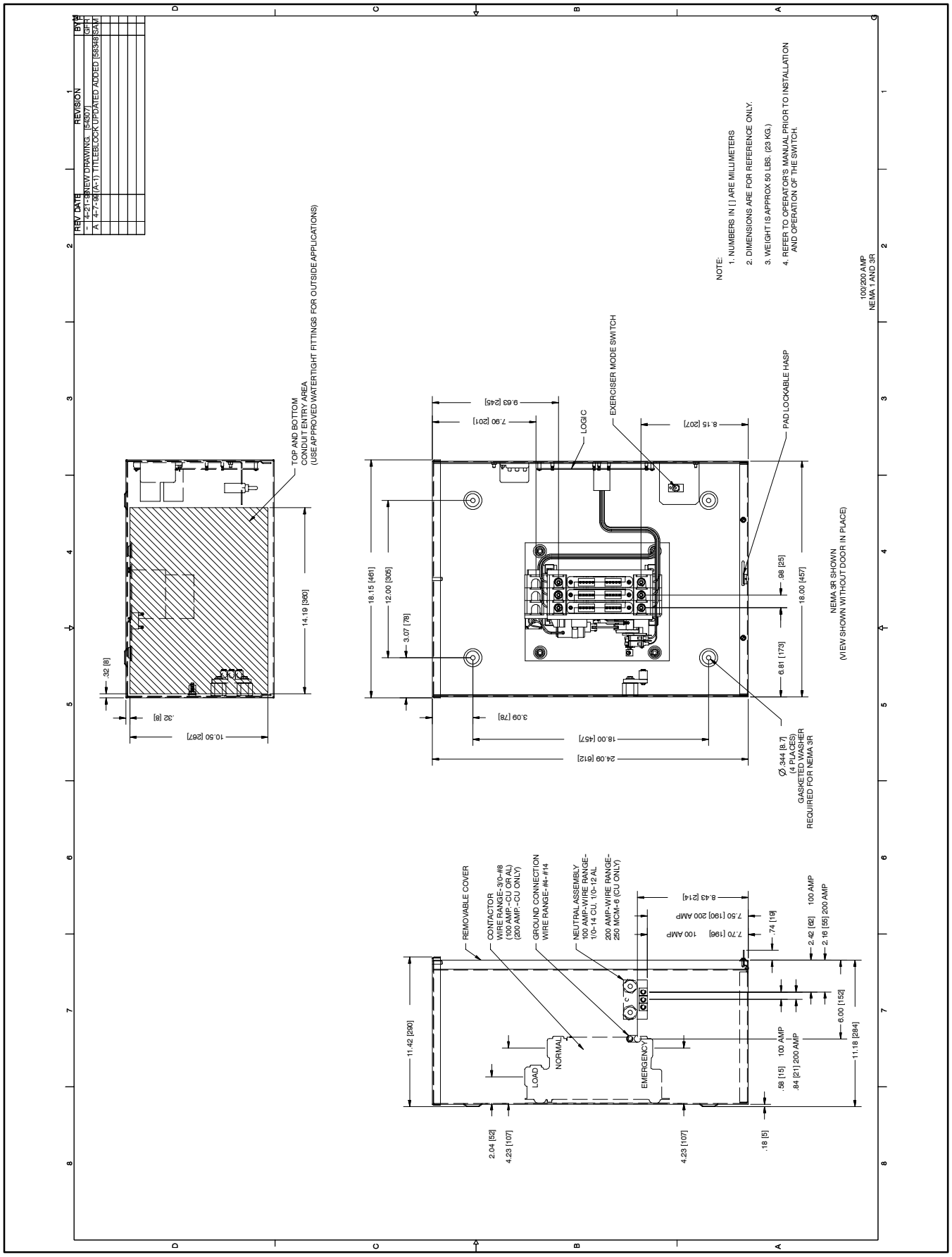


Figure 4-2 Model G220 Transfer Switch

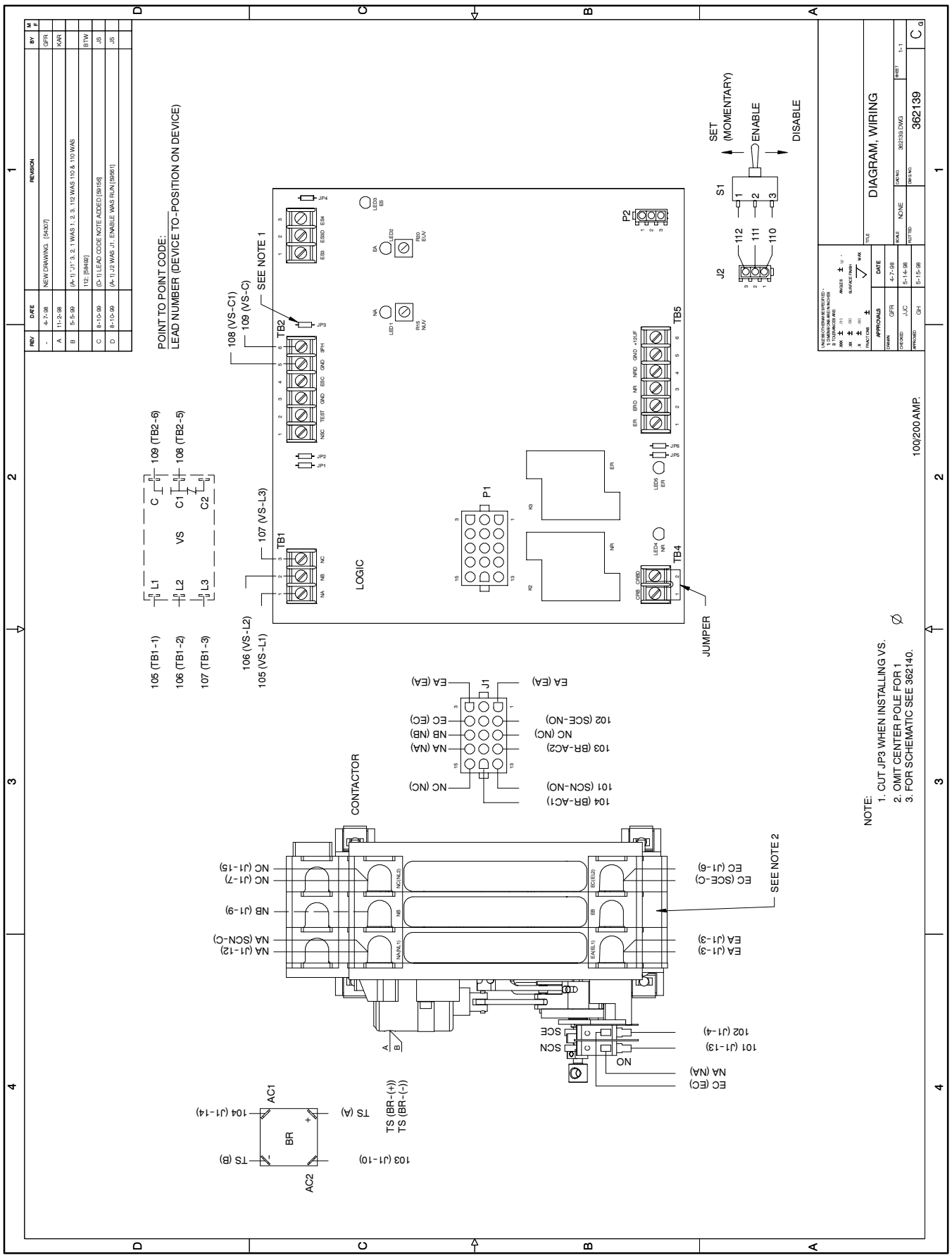
Transfer Switch Model	Diagram or Drawing	Drawing No.	Page
G120	Enclosure Dimensions	ADV-6428-A	13
	Wiring Diagram	362139-D	14
	Schematic Diagram	362140-C	15
G220	Enclosure Dimensions	ADV-6834	16
	Wiring Diagram	GM25943-A	17
	Schematic Diagram	GM25944-A	18

Figure 4-3 Drawing Numbers and Locations

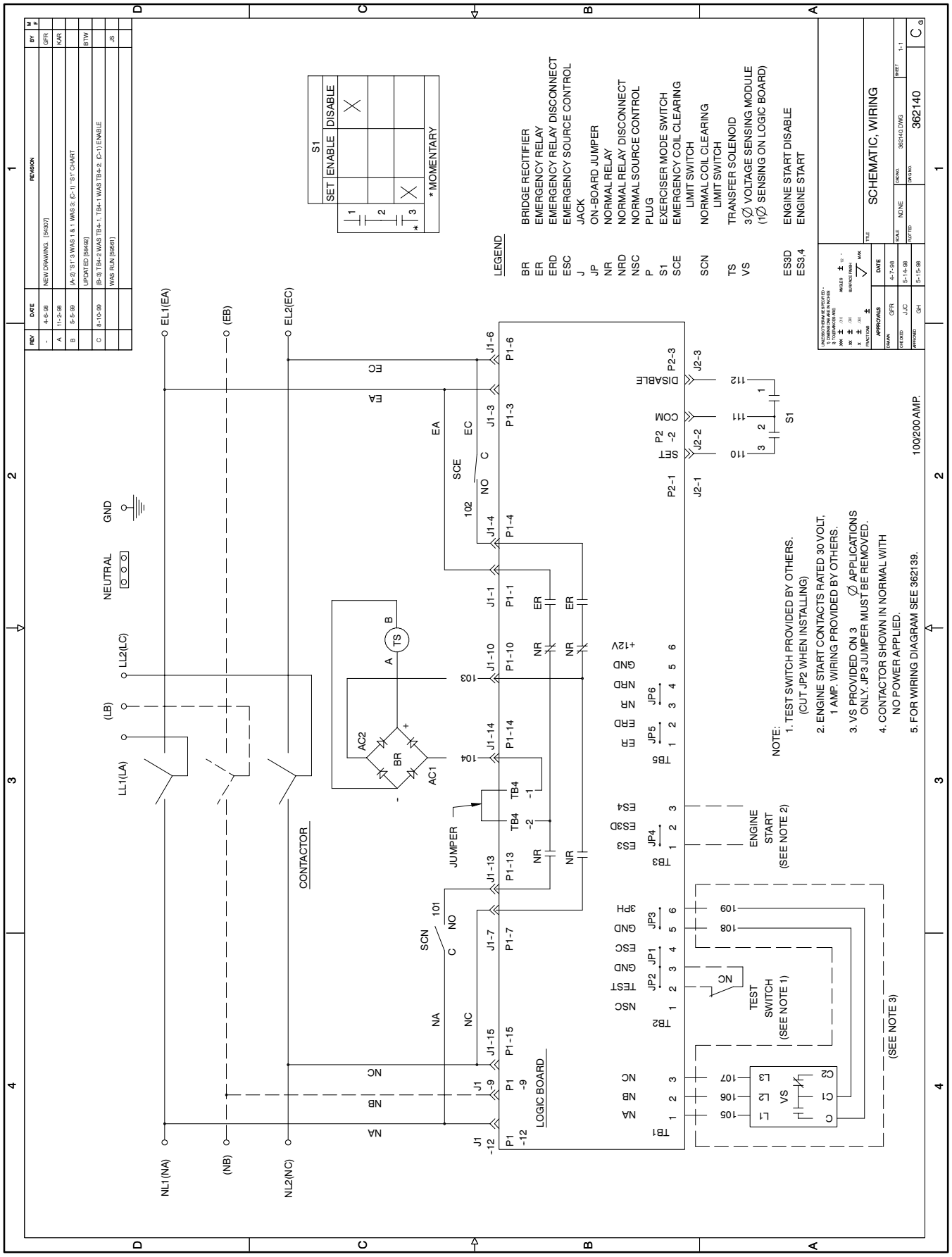
Notes



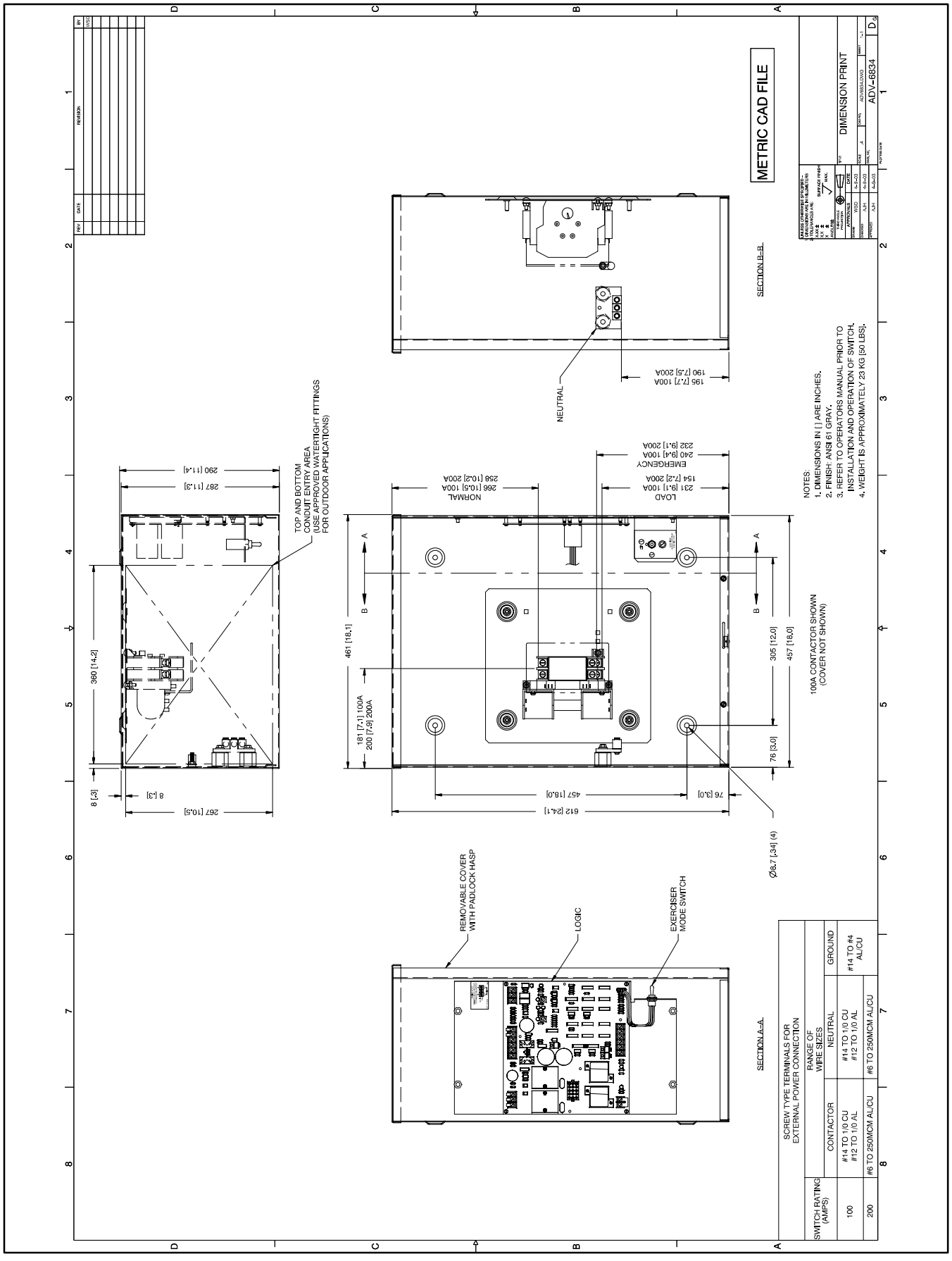
Enclosure Dimension Drawings, NEMA 1 and 3R, 100 and 200 Amp, Model G120, ADV-6428-A



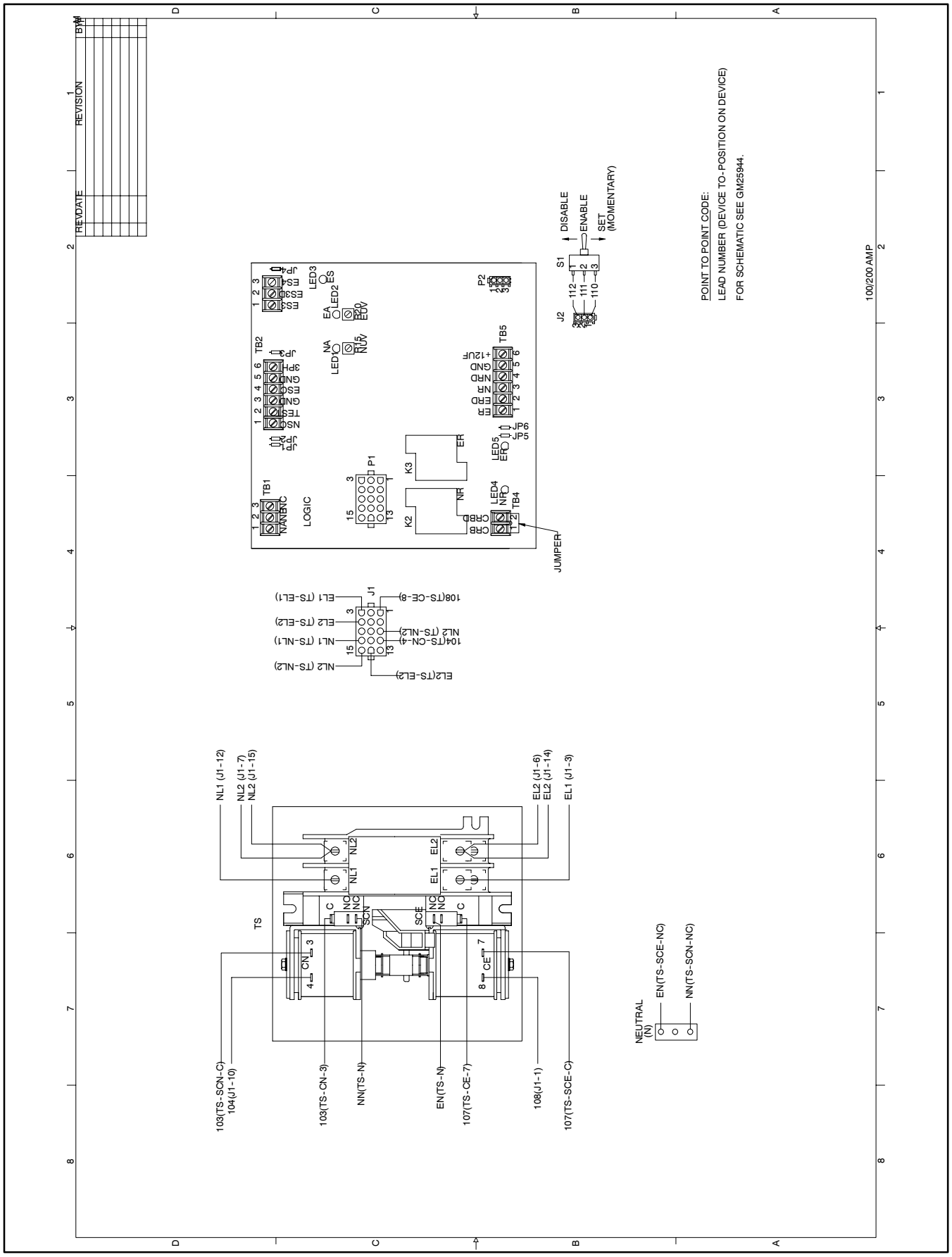
Wiring Diagram, 100 and 200 Amperes, Model G120, 362139-D



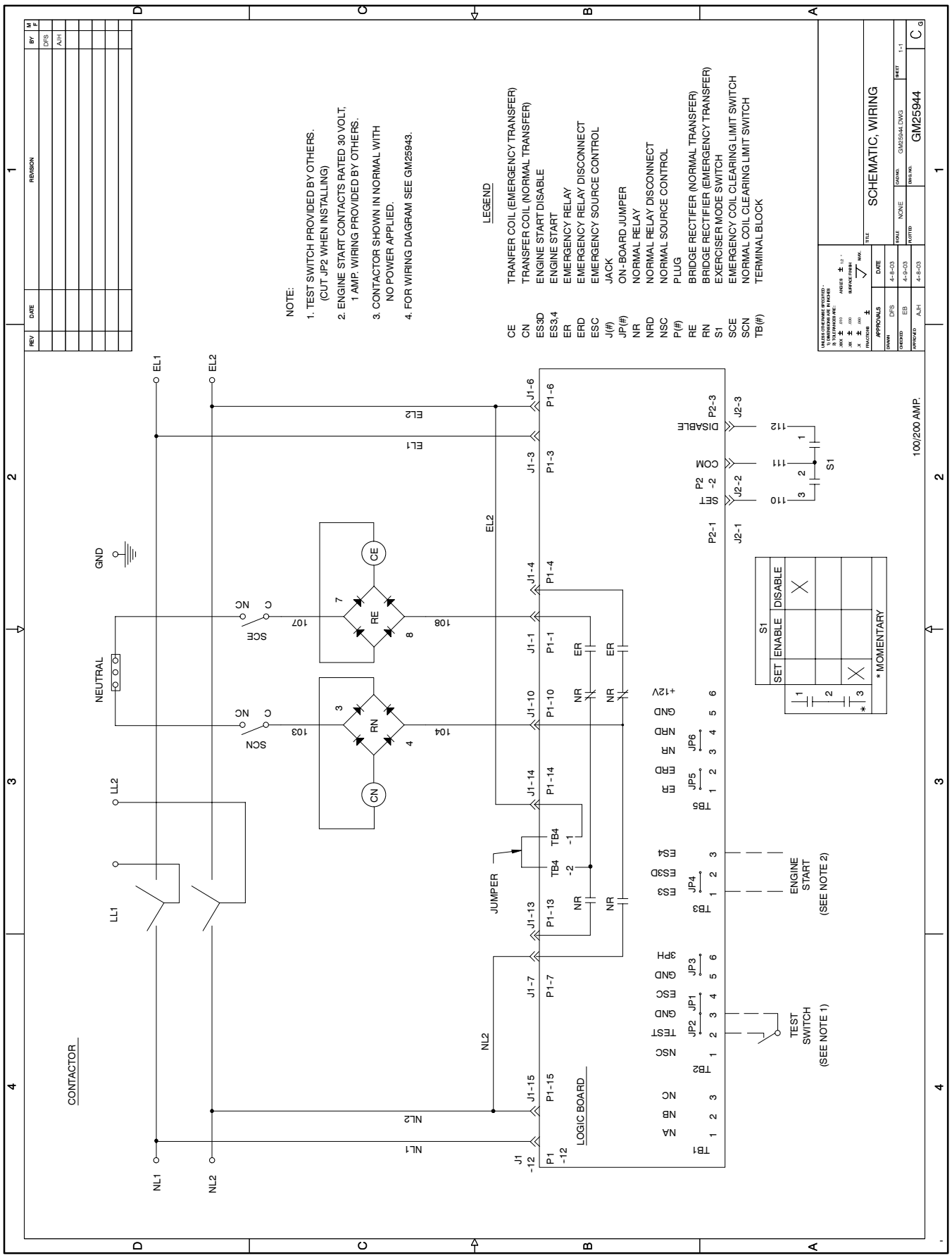
Schematic Diagram, 100 and 200 Amperes, Model G120, 362140-C



Enclosure Dimension Drawing, Model G220, ADV-6834



Wiring Diagram, 100 and 200 Ampere, Model G220, GM25943-A



Schematic Diagram, 100 and 200 Amperes, Model G220, GM25944-A

Kohler® transfer switches are shipped factory wired and tested, ready for installation. The installation process includes mechanical mounting; electrically wiring the unit to the normal and emergency power sources, to the load circuits, and to the generator; and initial setup and testing. Have installation performed only by trained and qualified personnel following all applicable codes and standards.

5.1 Upon Receipt of Unit

5.1.1 Inspection

At time of delivery, inspect the transfer switch for signs of shipping damage. If damage and/or rough handling is evident, file a damage claim immediately with the transportation company and promptly notify the distributor/dealer.

5.1.2 Lifting

⚠ WARNING

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

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

See Figure 5-1 for the approximate weight of each transfer switch covered in this manual. Carefully lift the enclosure to avoid damage to the transfer switch. Ensure that the front cover is in place and that the cover screws are tight when moving the unit.

Transfer Switch Rating, amps	Poles, No.	Approximate Weight, kg (lb.)
100	2	21 (46)
	3	22 (48)
200	2	21 (47)
	3	22 (48)

Figure 5-1 Approximate Transfer Switch Weight

5.1.3 Unpacking

Unpack the transfer switch immediately after receipt and inspect for shipping damage. Failure to perform an immediate inspection impedes recovery of losses caused by shipping damage. Use care when unpacking to avoid damaging any transfer switch components. Remove dirt and packing material that may have accumulated in the transfer switch or any of its components.

If the equipment has been stored at cold temperatures, allow equipment to warm to room temperature for 24 hours (minimum) before unpacking to prevent condensation on the electrical apparatus.

5.1.4 Storage

Do not remove the protective packing until ready for final installation. Protect the transfer switch at all times from excessive moisture, construction grit, and metal chips. Avoid storage in low temperature and high humidity areas where condensation could occur on the unit.

5.2 Mechanical Installation

⚠ WARNING

Airborne particles.
Can cause severe injury or blindness.

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

To plan the installation, use the dimensions given on the enclosure dimension drawings in Section 4. Select the mounting site to comply with electrical code restrictions for the enclosure type. Mount the transfer switch as close to the load and power sources as possible. Ensure adequate space for transfer switch servicing and opening of the enclosure.

Vertically mount the 100- or 200-ampere automatic transfer switches covered in this manual to a rigid supporting structure, such as a wall, using 1/4-inch hardware. For mounting, use the four holes on the top and bottom of each unit. When mounting the unit, plumb the enclosure to avoid any distortion of the enclosure.

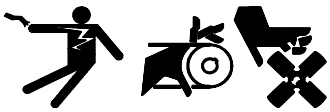
Place washers behind the key holes to shim the enclosure to a plumb condition. Seal the mounting holes for installing the unit outdoors.

5.3 Contactor Manual Operation Test

Follow steps 1 through 3 in Section 2.3 to manually operate the contactor power switching device to verify that it operates smoothly without binding. If the contactor does not operate smoothly without binding, stop the test and call an authorized service distributor to service the contactor before proceeding.

5.4 Electrical Wiring

⚠ 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.

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

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

All internal electrical connections are prewired. The only wiring necessary for installing the transfer switch is to connect the transfer switch to external devices and power sources.

Observe all applicable national, state, and local electrical codes during installation. See Section 4 for schematic diagrams and enclosure drawings.

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

5.4.1 Line Connections

All conductors should enter the enclosure at the locations shown on the drawings. When drilling entry holes for any conductors, cover the transfer switch components for protection from metal chips and construction grit. Remove any debris from the enclosure with a vacuum cleaner—using compressed air for this purpose can lodge contaminants in components and cause damage.

Use watertight conduit hubs approved for outdoor use for installing the transfer switch outdoors.

Cable sizes are shown in Section 1.6, Application Data, and on the transfer switch specification sheet.

Before connecting wiring cables to terminal lugs, remove surface oxides from cables by cleaning with a wire brush. If using aluminum conductors, apply a joint compound to cables. After tightening terminal lugs, carefully wipe off excess joint compound.

Connection points for the normal power, emergency power, and load are clearly marked on the transfer switch and drawings. See Section 4. Be sure to heed the phase markings (A, B, C, and N).

Note: Connect source and load phases as indicated by the markings and drawings. Improper connections may cause short circuits or cause phase-sensitive load devices to malfunction or operate in reverse.

Note: When making power connections to the power switching device, leave sufficient slack in the power leads to reach all of the power connecting lugs.

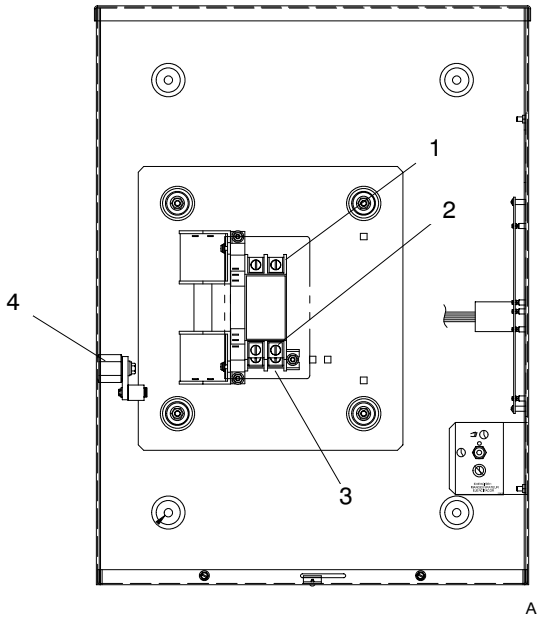
Connect the normal, emergency, and load conductors to the clearly marked terminals on the contactor. Verify that all connections are consistent with drawings before tightening the contactor terminal lugs. Tighten the connections to the torque values shown in Figure 5-3.

Connect the neutral wires to the neutral terminals and tighten the lugs to the torque values shown in Figure 5-3.

Connect the ground wires to the ground terminal and tighten to the torque values shown in Figure 5-4.

Neutral Connections for 120VAC Coils, Model G220 Switches

Model G220 coils operate at 120 VAC. Refer to Figure 5-2 and the wiring diagrams in Section 4 for required neutral connections.



1. Normal source connection
2. Emergency source connection
3. Load connection
4. Neutral connection

Figure 5-2 Model G220 Connections (also see the wiring diagram in Section 4)

Wire Size (AWG or MCM)	Torque		
	Nm	In. Lb.	Ft. Lb.
8	8.5	75	6.2
6	12	110	9.2
4	12	110	9.2
2	17	150	13
1	17	150	13
1/0	20	180	15
2/0	20	180	15
3/0	28	250	21

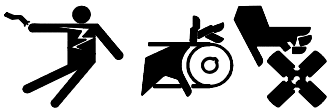
Figure 5-3 Tightening Torque for Terminal Lugs

Wire Size (AWG or MCM)	Torque		
	Nm	In. Lb.	Ft. Lb.
14	4.0	35	2.9
12	4.0	35	2.9
10	4.0	35	2.9
8	4.5	40	3.3
6	5.1	45	3.8
4	5.1	45	3.8

Figure 5-4 Tightening Torque for Ground Screw Terminal

5.4.2 Generator 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.

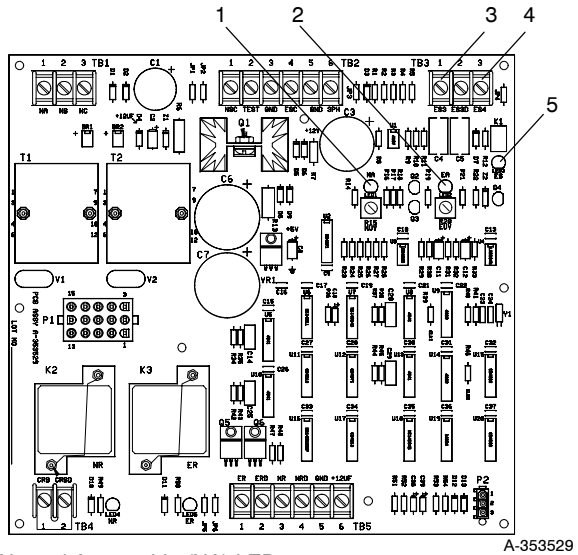
NOTICE

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 transfer switch controller provides a contact closure across terminals ES3 and ES4 to signal the generator set to start. See Figure 5-5. The location of the terminal block is marked by an orange decal within the enclosure.

Procedure to Connect the Generator Engine Start Circuit

1. Prevent the emergency power source generator set from starting:
   a. Move the generator set master switch to the OFF position.
   b. Disconnect power to the generator engine start battery charger, if installed.
   c. Disconnect all generator engine start battery cables, negative (-) leads first.
2. Connect the generator set remote engine start signal inputs to the engine start terminals ES3 and ES4 on the transfer switch controller circuit board. See Figure 5-5.
3. Tighten the terminal screws to 1.0 Nm (9 in. lb.) of torque.



1. Normal Acceptable (NA) LED
2. Emergency Acceptable (EA) LED
3. Engine start terminal ES3
4. Engine start terminal ES4
5. Engine Start (ES) LED

Figure 5-5 Controller Terminals and LEDs

5.5 Initial Startup and Setup

Perform the following procedures before placing the transfer switch into normal service.

5.5.1 Manually Select the Normal Position

Manually operate the contactor to the normal position by following steps 1 through 3 in Section 2.3.

5.5.2 Select the Exerciser Function and Close the Enclosure

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

Move the exerciser switch to the Run (⏲) position to enable the weekly generator exerciser. Move the exerciser switch to the Disable (⊘) position to disable the weekly exerciser. See Section 2.2. Replace the transfer switch enclosure cover and tighten the screws that hold it in place.

5.5.3 Prepare the Generator Set for Operation

⚠ WARNING

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

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

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

Reconnect generator engine start battery cables, negative (–) leads last; reconnect power to the generator engine start battery chargers, if installed; and move the generator set master switch to the AUTO (automatic) position. The generator set should start.

5.5.4 Connect the Power Sources

Note: Close and secure the transfer switch enclosure cover before applying power.

Connect the normal and emergency power sources to the transfer switch by closing upstream circuit breakers or switches.

When power is applied to the transfer switch, the engine start contacts remain closed and the generator set continues to run at least until Time Delay Engine Cooldown (TDEC) ends.

If the transfer switch determines that the normal power source is acceptable, the transfer switch runs the generator set for TDEC and then signals the generator set to shut down by opening the engine start contacts. The Engine Start LED lights.

If the transfer switch determines that the normal power source is unacceptable at any time, the transfer switch begins an automatic sequence to transfer the load to the emergency source as if TDES had ended. The engine start contacts remain closed and the generator set continues to run. See Section 2.1.1.

The transfer switch sets the exerciser function when power is first applied. If the exerciser switch is in the Run (⏲) position, the first exercise period occurs one week after power is first applied and on subsequent weeks at the same day and time. See Section 2.2.

5.5.5 Perform a System Test

With normal power present, test the system by disconnecting the normal power source and verifying that the system responds as described in Section 2.1.1, starting the generator set automatically and transferring the load to the emergency power source. When the transfer switch has transferred the load to the emergency source, reconnect the normal power source and verify that the system operates as described in Section 2.1.2, retransferring the load to the normal source and shutting down the generator set after TDEC.

5.5.6 Complete the Installation

Ensure that the normal and emergency power sources are connected to the transfer switch. To set the exerciser to a different day and time, see Section 2.2. Replace the cover on the transfer switch enclosure and tighten the screws that hold it in place.

5.5.7 Ensure Warranty Registration

The transfer switch seller must complete a Start-up Notification Form and submit it to the manufacturer within 60 days of the initial start-up date. The Start-up Notification Form covers all equipment in the standby system. Standby systems not registered within 60 days of the initial start-up date are automatically registered using the manufacturer's ship date as the start-up date.

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. lbs.	foot pounds (torque)
ft./min.	feet per minute
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
GND, ⏚	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
GRD	equipment ground
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temperature, 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. lbs.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard

k	kilo (1000)
K	kelvin
kA	kiloampere
KB	kilobyte (2^{10} bytes)
kg	kilogram
kg/cm^2	kilograms per square centimeter
kgm	kilogram-meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz
kJ	kilojoule
km	kilometer
kOhm, kΩ	kilo-ohm
kPa	kilopascal
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt ampere
kVAR	kilovolt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
kWm	kilowatt mechanical
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound, pounds
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
ld. shd.	load shed
LED	light emitting diode
Lph	liters per hour
Lpm	liters per minute
LOP	low oil pressure
LP	liquefied petroleum
LPG	liquefied petroleum gas
LS	left side
L_{wa}	sound power level, A weighted
LWL	low water level
LWT	low water temperature
m	meter, milli (1/1000)
M	mega (10^6 when used with SI units), male
m^3	cubic meter
m^3/min.	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCM	one thousand circular mils
MCCB	molded-case circuit breaker
meggar	megohmmeter
MHz	megahertz
mi.	mile
mil	one one-thousandth of an inch
min.	minimum, minute
misc.	miscellaneous
MJ	megajoule
mJ	millijoule
mm	millimeter
mOhm, mΩ	milliohm
MOhm, MΩ	megohm
MOV	metal oxide varistor
MPa	megapascal
mpg	miles per gallon
mph	miles per hour
MS	military standard
m/sec.	meters per second
MTBF	mean time between failure
MTBO	mean time between overhauls
mtg.	mounting
MW	megawatt
mW	milliwatt
μF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
OC	overcrank
OD	outside diameter
OEM	original equipment manufacturer
OF	overfrequency
opt.	option, optional
OS	oversize, overspeed
OSHA	Occupational Safety and Health Administration
OV	overvoltage
oz.	ounce
p., pp.	page, pages
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph., ∅	phase
PHC	Phillips head crimptite (screw)
PHH	Phillips hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent-magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read-only memory
psi	pounds per square inch
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart, 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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Kohler Power Systems
Asia Pacific Headquarters
7 Jurong Pier Road
Singapore 619159
Phone (65)264-6422, Fax (65)264-6455

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