Service

Transfer Switches

Models:

SDT/SMT/SDP/SMP

Power Switching Device:
Open-Transition 100 to 600 Amperes
Programmed-Transition 100 to 600 Amperes

Electrical Controls:
DXPower 1000™

MP-6226 7/04

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

x:in:007:001

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.

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.

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 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.

Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

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.

Battery short circuits. Explosion can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

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.

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

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Only authorized personnel should open the enclosure.

⚠ WARNING

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

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

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

Welding on the generator set. Can cause severe electrical equipment damage. Before welding on the generator set perform the following steps: (1) Remove the battery cables, negative (–) lead first. (2) Disconnect all engine electronic control module (ECM) connectors. (3) Disconnect all generator set controller and voltage regulator circuit board connectors. (4) Disconnect the engine battery-charging alternator connections. (5) Attach the weld ground connection close to the weld location.

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

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

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

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.

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)

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

Heavy Equipment

⚠ WARNING

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

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

Moving Parts

⚠ WARNING

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

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

⚠ WARNING

Spring-loaded parts.
Can cause severe personal injury or property damage.

Wear protective goggles when servicing spring-loaded parts. Hold parts securely during disassembly.

Disassembling the solenoid. Spring-loaded parts can cause severe personal injury or property damage. The spring in the solenoid assembly exerts substantial force on the coil. Hold the coil assembly securely when removing the screws.

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.

Introduction

This manual provides service and parts information for DDC/MTU Power Generation Model SDT/SMT and SDP/SMP transfer switches equipped with DXPower 1000™ electrical controls. It includes operation, troubleshooting, repair, and maintenance procedures for the transfer switches and electrical controls.

A personal computer and Setup Program software are essential for troubleshooting the transfer switch. The DXPower™ Setup Program Software Operation and Installation Manual part number is shown in Figure 1.

The information included in this manual is intended solely for use by trained and qualified service personnel of authorized service distributors/dealers.

Information in this publication represents data available at the time of print. The manufacturer of DDC/MTU Power Generation products 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.

Figure 1 lists the part numbers for related literature. Separate operation and installation manuals contain operation and installation information not provided in this manual. Refer to the parts catalog for instructions to obtain replacement parts.

Document	Document Part Number
ATS Operation and Installation Manual	MP-6225
DXPower™ Setup Program Operation Manual	MP-6135
Parts Catalog	MP-6158
Wiring Diagram Manual	MP-6169

Figure 1 Related Literature

Service Assistance

For professional advice on generator power requirements and conscientious service, please contact your nearest DDC/MTU Power Generation distributor.

- Consult the Yellow Pages under the heading Generators—Electric
- Visit the DDC/MTU Power Generation website at ddcmtupowergeneration.com
- Look at the labels and stickers on your DDC/MTU Power Generation product or review the appropriate literature or documents included with the product

1.1 Introduction

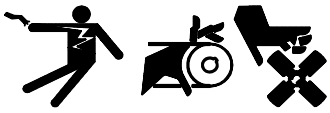
Regular preventive maintenance ensures safe and reliable operation and extends the life of the transfer switch. Preventive maintenance includes periodic testing, cleaning, inspecting, and replacing of worn or missing components. Section 1.4 contains a service schedule of recommended maintenance tasks.

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.

Keep records of all maintenance or service.

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

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

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

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

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Disconnect all power sources before opening the enclosure.

(600 volts and under)

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

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

(600 volts and under)

⚠ WARNING

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

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

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

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

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

(600 volts and under)

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

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove 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)

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.

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

NOTICE

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

NOTICE

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

NOTICE

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

1.2 Inspection and Service

1.2.1 General Inspection

External Inspection. Inspect the transfer switch weekly.

- Look for signs of vibration, leakage, excessive noise, high temperature, contamination, or deterioration.
- Remove accumulations of dirt, dust, and other contaminants from the transfer switch's exterior 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 damage the switch.*
- Replace any worn, missing, or broken external components with manufacturer-recommended replacement parts. Contact a local authorized distributor/dealer for part information and ordering.
- Tighten loose external hardware.

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

1.2.2 Internal Inspections and Maintenance

Internal Inspection. Have an authorized distributor/dealer perform an annual inspection of the transfer switch. Inspect the switch more frequently if it is located in a dusty or dirty area or when any condition noticed during an external inspection may have affected internal components. Disconnect all power sources, open the transfer switch enclosure, and inspect internal components. Look for:

- 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 abrasions
- 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

Cleaning. Use a vacuum cleaner or a dry cloth or brush to remove contaminants from internal components. *Do not use compressed air to clean the switch because it can cause debris to lodge in the components and damage the switch.*

Lubrication. Maintain the transfer switch lubrication. If the transfer switch is subject to extremely dusty or abnormal operating conditions, relubricate all movements and linkages yearly. Relubricate the solenoid operator if the TS coil is replaced. Do not use oil; order the lubrication kit shown in the Parts Catalog.

Disconnect power and manually operate the transfer switch mechanism to verify that it operates smoothly without binding. If lubricating the outer mechanism of the transfer switch does not eliminate binding, replace the transfer switch assembly.

Periodically oil the enclosure door locks and screws.

Part Replacement and Tightening. Replace worn, missing, broken, deteriorated, or corroded internal components with manufacturer-recommended replacement parts. Contact a local authorized distributor/dealer for part information and part ordering. Tighten loose internal hardware.

Terminal Tightening. Loose connections on the power circuits can lead to overheating or explosion. Tighten all lugs to the torque values shown on the label on the switch. Tighten engine start, input/output, and auxiliary connections to the torque indicated on the decals affixed to the unit.

Signs of Overheating. Replace components damaged by overheating and locate the cause of the overheating. Overheating could be caused by loose power connections, overloading, or a short circuit in system. After tightening the power terminals, perform a millivolt drop test to locate areas with high contact resistance. See Section 1.3.3. Check the line circuit breakers in the system to be sure that they do not allow the load to exceed the switch rating. Use the controller troubleshooting and schematics to locate a control circuit short.

Wire Repair or Replacement. Replace wiring when there is any doubt about its condition or when there is extensive damage or deterioration. If the damaged or deteriorated wires are part of a wiring harness, replace the entire wiring harness.

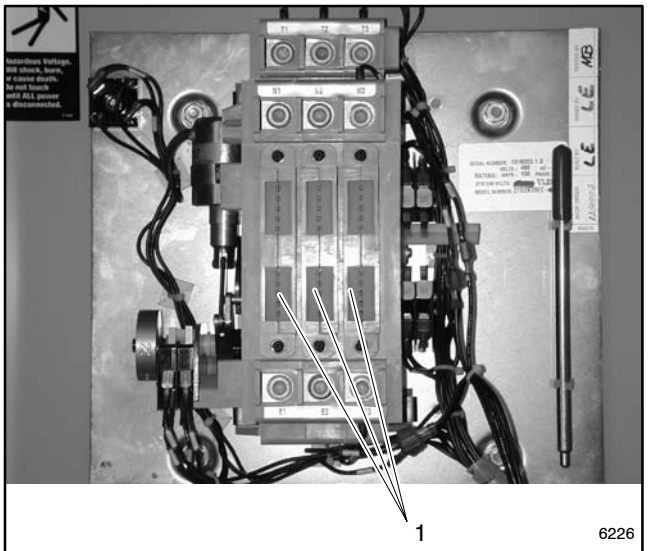
Power Circuit Wiring. Have damage to line voltage and power circuit wiring evaluated and repaired or replaced by a qualified electrician.

Control Circuit Leads. Repair minor damage to leads in low power and control circuits operating up to 250 volts. Carefully splice and insulate the connections. Tape minor control circuit wire insulation cuts or abrasions. Repair moderately damaged leads, where conductors are cut or insulation is damaged over sections shorter than about 100 mm (4 in.) or less than about 25% of the length of the wire, by cutting out the damaged section and splicing in wire of the same type. Use UL-listed insulated (250 V minimum) connectors and follow the connector manufacturer's instructions. Fabricate new leads using the same type of wire and UL-listed insulated (250 V minimum) connectors and follow the connector manufacturer's instructions.

Transfer Switch Inspection. Remove the arc chute assemblies or covers at the front of the transfer switch and inspect the main contacts inside the transfer switch. See Figure 1-1 through Figure 1-3.

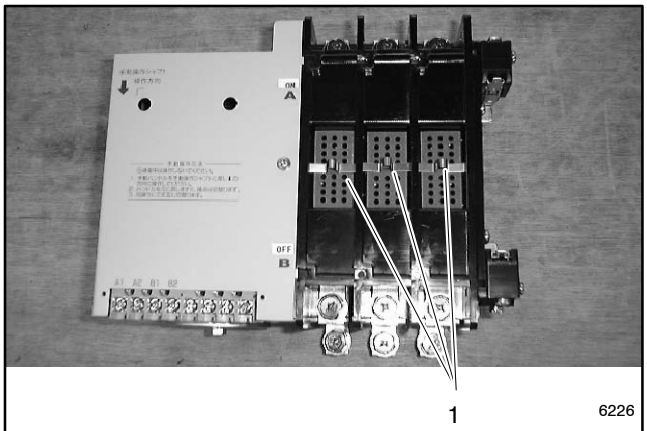
Note: A clamp or fixture must be attached before removing the arc chutes on 600-amp Model SDP/SMP programmed-transition switches. See Section 6.3.7 for complete instructions.

Remove surface deposits with a clean cloth. *Do not use an emery cloth or a file.* Discoloration of the contact surface does not affect performance. If the contacts are pitted, show signs of overheating, or are worn, replace the contacts. The contacts are worn if the contact surface material, a layer of silvery-colored metal, is worn through to the metal below. Check the condition of the arc chutes. If arc chutes show signs of disintegration, replace the arc chute assembly.



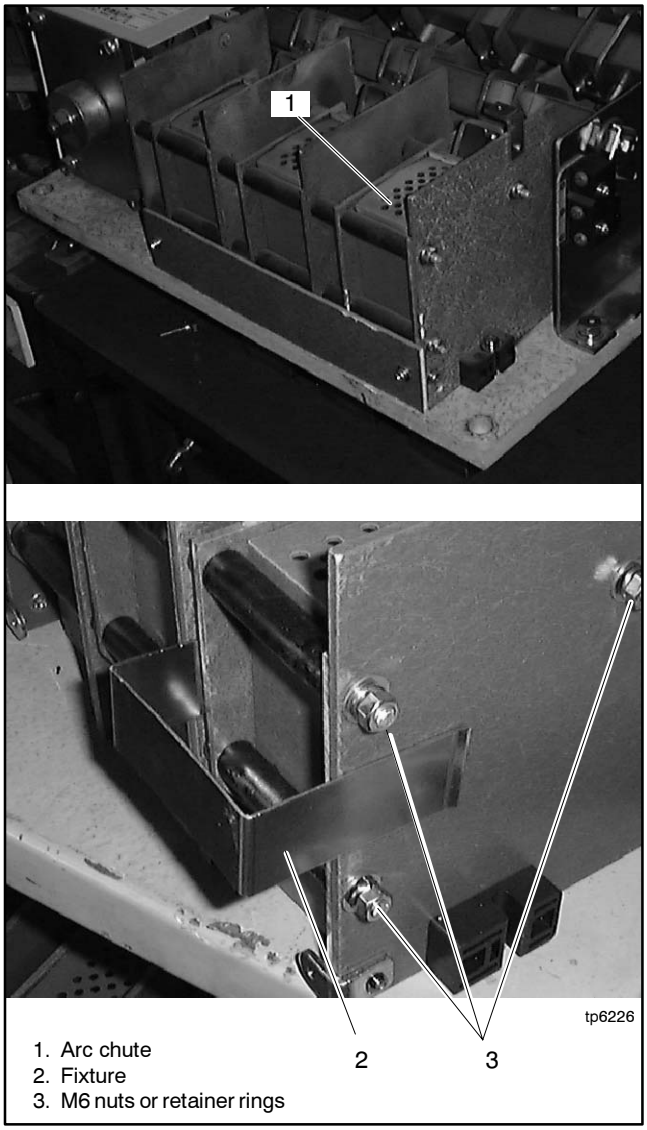
1. Arc chute assemblies

Figure 1-1 Typical Arc Chute Assemblies, Model SDT/SMT Open-Transition Switches



1. Arc chute retainer clips

Figure 1-2 Typical Arc Chute Assemblies, 100–400-Amp Model SDP/SMP Programmed-Transition Switches



1. Arc chute
2. Fixture
3. M6 nuts or retainer rings

Figure 1-3 Removing Arc Chutes, 600-Amp Model SDP/SMP Programmed-Transition Switches

1.3 Testing

Periodic testing is important in any transfer switch application. It helps to ensure that the generator set will start and the transfer switch mechanisms and control circuits will operate when needed.

1.3.1 Weekly Generator Set Exercise

Use the plant exerciser to start and run the generator set once a week to maximize the reliability of the emergency power system. See the transfer switch operation and installation manual for additional information about the exerciser.

1.3.2 Monthly Automatic Operation Test

Test the transfer switch's automatic control system monthly. See Section 3.5 or the transfer switch operation and installation manual for the test procedure. Verify that the expected sequence of operations occurs as the switch transfers the load to the emergency source when a normal source failure occurs or is simulated. 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 available normal source and signals the generator set to shut down after a cooldown period.

Note: The ATS will not transfer the load during the test sequence if the test DIP switch is set to the unloaded position.

1.3.3 Other Tests

Every Year

Measure the voltage drop to help locate high-resistance contacts in the ATS. The test procedure measures the voltage drop across a contact and the current in the circuit, then uses those measured values to find the contact resistance.

The purpose of the test is to locate any contact that has significantly higher resistance than others. An unusually high voltage across one set of contacts may signal unacceptably high resistance in the contacts.

Run the test with the ATS under a moderate and balanced load. Use the following procedure to take voltage measurements and calculate resistances for each phase of both Source N and Source E.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove 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)

Millivolt Drop Test Procedure

1. Apply a balanced load of at least 10% of the switch rating. (Currents of 10 amps or greater will give more accurate results than lower currents.)

2. Carefully measure the voltage on each phase of both sources from the source lug to the load lug. Take several readings to ensure accuracy. The readings may be erratic because of the small voltage measured, load fluctuations, and meter circuit contact resistances.

   Note: To obtain accurate readings, keep the meter as far as possible from current-carrying conductors and the meter leads as short, direct, and at right angles to current-carrying conductors as possible. This minimizes the effect of induced voltages (transformer effect) in the vicinity of the current-carrying conductors.

3. Use an ammeter to measure the current flow through the circuit.

4. Calculate the contact resistance using the following formula:

$$R = V \div I$$

Where:
V = measured voltage in *millivolts*
I = measured current in amps
R = calculated resistance in milliohms

Compare the calculated values for resistance (R) to the values in the table in Figure 1-4. If the calculated resistance is significantly higher (2 times larger or more) than the value shown in the table, disconnect power, check the connections and lug torques, and repeat the test. If the second measurement also indicates that the resistance is too high, replace the contact. See the ATS MPparts catalog for replacement part ordering information. Refer to the table of contents in the front of this manual to locate the contact replacement procedure for your switch.

Transfer Switch Rating, Amps	Maximum Contact Resistance, Milliohms (mΩ)
30–200	0.250
225–400	0.200
600–800	0.175
1000–1200	0.085
1600–3000	0.050

Figure 1-4 Maximum Contact Resistance

Every Three Years

Test the wire insulation. Use the following procedure to check for insulation breakdown and replace any faulty components.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove 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)

Wire Insulation Breakdown Test Procedure

1. Disconnect all power sources by opening upstream circuit breakers or switches to the transfer switch. Disconnect the load from the transfer switch by opening circuit breakers or switches leading from the transfer switch. Disconnect the transfer switch wiring harness from the controller at connector P1.

2. Use a hi-pot tester or meggar to check the insulation resistance phase-to-phase and phase-to-neutral, and phase-to-ground if neutral and ground are isolated. For a hi-pot tester, the maximum potential is 500 VAC and the maximum test time is 1 second.

3. Verify that the measured insulation resistance exceeds 1.24 megohms (MΩ).

4. If the hi-pot tester indicates wire insulation breakdown or if the measured resistance is less than 1.24 MΩ, isolate the leakage current using an instrument designed for this purpose. Replace the faulty components.

   Note: You may need to disconnect power conductors from the lugs to isolate the problem. If you disconnect the power conductors, see transfer switch operation and installation manual for reconnection instructions.

Every Five Years

Check the normal and emergency source setpoint calibration according to the procedures in Section 3.7, System Settings.

1.4 Service Schedule

Follow the service schedule below for the recommended service intervals. The transfer switch operator can perform tasks marked by an X. Have an authorized distributor/dealer inspect the switch annually and perform all service marked by a D.

System Component or Procedure	See Section	Visually Inspect	Check	Adjust, Repair, or Replace	Clean	Test	Interval
Electrical System							
Check for signs of overheating or loose connections: discoloration of metal, melted plastic, or a burning odor.	1.2.2	X	X				Y
Check the transfer switch's external operating mechanism for cleanliness. Clean and relubricate if dirty.*	1.2.2	X		D	D		Y
Check wiring insulation for deterioration, cuts, or abrasion. Repair or replace wiring to regain the properties of the original wiring.	1.2.2	X					Y
		D	D	D			Y
Check the transfer switch's main power switching mechanisms' mechanical operation and integrity.	1.2.2	D	D			D	Y
Tighten control and power wiring connections to specifications.	1.2.2		D	D			Y
Check the transfer switch's main power switching contacts' condition. Clean or replace the main contacts or replace the transfer switch assembly as necessary.	1.2.2	D		D	D		Y
Perform a millivolt drop test to check for high contact resistances on power circuits. Tighten connections, clean main contacts, or adjust or replace main contacts or transfer switch assembly to eliminate high contact resistances.	1.3.3		D	D	D	D	Y
Test wire and cable insulation for electrical breakdown.	1.3.3					D	Every 3 Years
Check calibration of voltage-sensing circuitry and setpoints, and recalibrate circuitry as necessary.	1.3.3		D			D	Every 5 Years
Control System							
Test the transfer switch's automatic control system.	O/I/M	X				X	M
Test all LED indicators, time delays, and remote control systems for operation.	O/I/M	D	D	D		D	Y
General Equipment Condition							
Inspect the outside of the transfer switch for any signs of excessive vibration, leakage, high temperature, contamination, or deterioration.*	1.2.1	X			X		M
Check that all external hardware is in place, tightened, and not badly worn.	1.2.1	X	X	X			M
Inspect the inside of the transfer switch for any signs of vibration, leakage, noise, high temperature, contamination, or deterioration. Check for metal discoloration, melted plastic, or a burning odor.*	1.2.2	X					M
		D	D		D		Y
Check that all internal hardware is in place, tightened, and not badly worn.	1.2.2	X					M
		D	D				Y

***** Service more frequently if the ATS operates in extremely 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, or 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:

O/I/M=See the transfer switch operation/installation manual.
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)

Notes

2.1 Introduction to Troubleshooting

Use a personal computer (PC) running the DXPower Setup Program as a troubleshooting tool. The program's event log and system setting displays are useful tools for identifying the cause of most problems. Refer to the setup program operation manual for instructions throughout this Troubleshooting section.

Refer to the wiring diagrams provided with the switch or the wiring diagram manual when troubleshooting the transfer switch and controller.

Disconnect power to the transfer switch before opening the enclosure to connect a PC. Read and follow all safety precautions.

⚠ 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.

⚠ DANGER

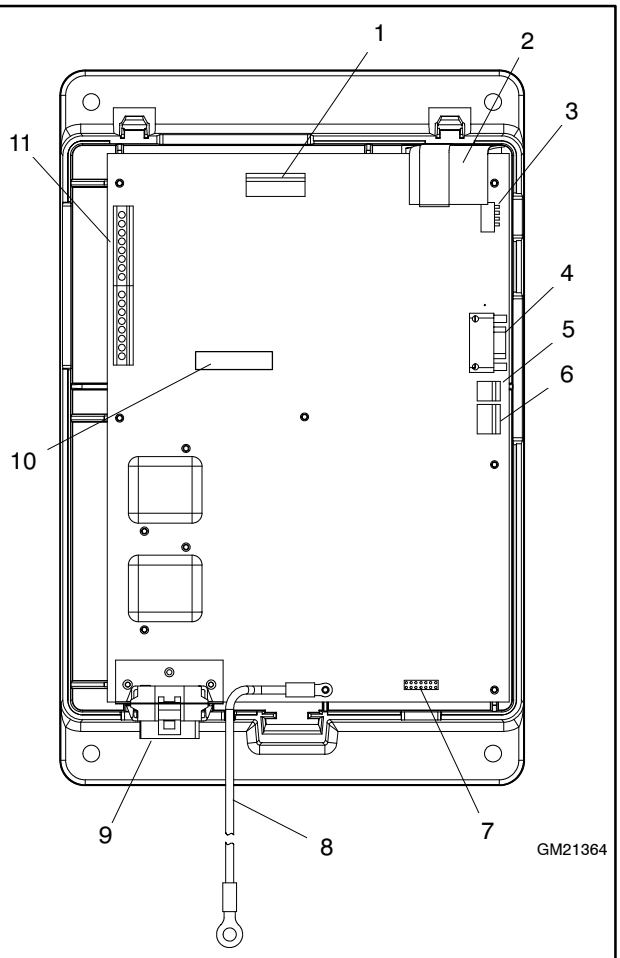
Hazardous voltage.
Will cause severe injury or death.

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)

2.2 PC Connection

Refer to the setup program operation manual for hardware requirements and communication information. Use a null modem cable to connect a PC to the controller's serial port, P6. See Figure 2-1.



1. I/O board connection (P3)
2. User interface connections
3. DIP switches
4. Serial port for PC connection (P6)
5. Preferred source switch connection (P7)
6. Supervised transfer switch connection (P8)
7. Programmed-transition interface board (PTIB) connection (factory connection) (P9)
8. Ground wire
9. Transfer switch harness connection
10. Serial number decal
11. Terminal strip (inputs, output, Modbus connections) (TB1)

Figure 2-1 Controller Board Component Locations (cover removed)

Note: The controller must have power in order to communicate with the PC. A cable to 120-volt controllers through a 120 VAC wall outlet is available. See Section 3.4.3.

To verify that the controller is communicating with the PC, open the Source Information window in the Setup Program and check the source voltages. If no voltage is shown, there is no communication. Verify that the controller has power and that *Connect* has been toggled on in the Setup Program. Check the COM port used by the computer. If necessary, select a different COM port and check for voltage readings again and repeat until communication is established. Refer to MP-6135, Setup Program Operation Manual, for more information.

Note: Do not start a transfer test with the enclosure door open.

Before starting a test sequence, disconnect the PC from the controller or bring the null modem cable out of the enclosure at the bottom of the door. Use a straight 9-pin extension cable, if necessary, to a maximum length of 15 m (50 ft.) Close and lock the door. Tighten the door screws, checking to make sure that the communication cable is not pinched by the door. See Section 3.5 for test procedures. Follow all safety precautions when running a test.

2.3 Event History

Use the DXPower Setup Program to view the event history log. The log lists the 100 most recent transfer switch events, including transfers and DIP switch setting changes as well as faults and alarms. Refer to MP-6135, Setup Program Operation Manual, for instructions to view the event history.

The following tables list the faults and alarms that may be included in the event history log, the possible causes for each problem, and suggested procedures to identify and correct the source of the problem. The event history log also lists transfers and other normal events not shown in these tables.

The event history log can be saved to an electronic file. Refer to the setup program operation manual for instructions to save the event log to a file.

System Events and Faults		
Fault or Event Message	**Possible cause**	**Check**
Overfrequency, Underfrequency	Frequency settings	Check that the system frequency setting matches the actual source frequency (50 or 60 Hz).
		Check the over/underfrequency pickup and dropout settings. See Section 3.7.3 and the setup program operation manual.
		Check that the frequency debounce setting is long enough to prevent nuisance faults caused by brief frequency variations.
	Source availability, stability	Check that the source frequency matches the nominal system frequency and stays within the range of the pickup and dropout settings.
	Source connections	Check for loose connections. Check wiring.
Overvoltage, Undervoltage	Voltage settings	Check that the system voltage setting matches the actual source voltage.
		Check the over/undervoltage pickup and dropout settings. See Section 3.7.3 and the setup program operation manual.
		Check that the voltage debounce setting is long enough to prevent nuisance faults caused by brief voltage dips or spikes.
	Source availability, stability	Check that the source voltage matches the nominal system voltage and stays within the range of the pickup and dropout settings.
	Source connections	Check for loose connections. Check wiring.
	Calibration error	Check the ATS meter calibration. See MP-6135, Setup Program Operation Manual.
Loss of Phase	Single-/three-phase setting	Check that the controller single-/three-phase setting matches the source.
	One phase of the source has been lost	Check that all phases of the source are available.
	Source connections	Check for loose connections.
Phase Rotation Error	Phase rotation setting	Check that the controller phase rotation setting matches the source phase rotation (ABC or CBA). Check the source connections to the transfer switch and verify that A,B, and C are connected to the appropriate lugs. Change the controller phase rotation setting or rewire the source connections, if necessary.
Failure to Transfer	Source not available	Check source voltage, frequency, stability.
	Controller does not recognize an available source	Check switches, circuit breakers for open circuit.
		Check voltage and frequency settings (see above) and compare to measured source parameters.
		Check source connections to the ATS.
	Transfer switch mechanism problem	See Section 4.1.
Auxiliary Switch Fault or Auxiliary Switch Open	Controller cannot determine the transfer switch position	Check wiring and connections to position microswitches. See the schematic drawing for connections.
		Test position microswitch operation. Replace microswitch, if necessary.
		Transfer switch in intermediate position. Manually operate the transfer switch, following safety precautions and instructions in the ATS operation/installation manual. Check the control contact operation. Inspect for signs of coil damage or overheating and replace coil, if necessary. See the table of contents for coil and control contact test procedures for your unit.

Fault or Event Message	Possible cause	Check
Failure to Acquire Standby	Generator set did not start	See *Failure to Start Generator Set,* below.
	Open circuit breaker	Check and close ATS source and generator set circuit breakers.
	ATS does not recognize the standby source	Check source voltage, frequency, phase rotation settings and compare to actual values.
		Check for loose source connections.
		Check for open switch or circuit breaker.
		Check ATS meter calibration.
Failure to Start Generator Set	Generator set master switch not in AUTO position	Move generator set master switch to the AUTO position.
	Loose engine start connection	Check connections.
	No engine start command from ATS	See Section 3.9.
	Other generator set problem	Troubleshoot the generator set. See generator set service manual.
I/O Module Not Found	The controller does not detect an I/O module at the expected address	Check I/O module connections and address DIP switch settings. See Section 2.5.6.
I/O Module Not Installed	Controller detects a connected I/O module that has not been set up through the setup program	Use the Setup Program to check the number of I/O modules configured. Check the I/O module address DIP switches. See Section 2.5.6.
I/O Module Comms Lost	Communication to an installed I/O module has been lost	Check I/O module connections. See Section 2.5.6.
Low Battery Voltage	Low generator set engine starting battery	Check battery voltage and connections. See generator set manuals.

Figure 2-2 Event History

2.4 Troubleshooting Transfer Switch Operation

Problem	Possible Cause	Check
Generator set engine does not start	Engine start time delay is running	Check the time delay LED on the user interface. Wait for time delays to expire. Check time delay settings. See Section 3.8.
	Loose engine start connection	Check connections. Tighten connections and/or replace wiring, if necessary.
	No engine start signal from the ATS	Normal source available.
		Exerciser inhibited.
		Maintenance DIP switch enabled (see Section 3.6).
	Generator set master switch not in the AUTO position	Move generator set master switch to the AUTO position.
	Other generator set problem	Troubleshoot the generator set. See the generator set operation and service manuals.
Generator set engine runs when it should not	ATS does not recognize the Normal source	Check connections, voltage and frequency settings, phase rotation, calibration. Check for open switches or circuit breakers.
	ATS not in the expected position	Check the ATS position LEDs. Check the position of the preferred source selector switch, if equipped.
	Exerciser is running	Check the Exercise LED on the controller user interface. Push the Exercise button to end an exercise run.
	A test sequence is running	Check the Test LED on the controller user interface. Push the Test button to end a test sequence.
	Engine cooldown time delay operating	Check the Time Delay LEDs on the ATS controller user interface and the active time delay window. Check the ATS controller engine cooldown time delay setting. See Section 3.8.
		Check generator set controller engine cooldown setting. See the generator set controller operation manual.
	Engine start connection closed	Check wiring and connections. Also see Section 3.9.
	Generator set master switch not in AUTO position	Move the generator set master switch to the AUTO position.
	Other generator set problem	Disconnect the engine start leads from the ATS. If the engine continues to run, troubleshoot the generator set. See the generator set operation and service manuals.
In-phase monitor does not operate	In-phase monitor function not enabled	Check that the in-phase monitor option on the ATS controller is selected. See the setup program operation and installation manual.
	Transfer angle setting	Check the transfer angle setting. See the setup program operation and installation manual.
	In-phase monitor option not available (programmed-transition models)	Not available on programmed-transition models. Center-OFF position makes the in-phase monitor option unnecessary.
Exerciser does not start generator set	Exerciser not set	Press exercise button to set time. Check exercise mode and calendar settings.
	Exercise run duration is set to zero	Check the exercise run duration setting. Use the Setup Program to check exerciser settings.
	Loose or open engine start connection	Check wiring and connections.
	Engine start problem	See *Generator set engine does not start* in this table. Also see Section 3.9.
Exerciser does not run regularly or at all	Exerciser not set	Press exercise button to set time. Check exercise mode and calendar settings.
	Exercise DIP switch #3 set to disable	Check and change DIP switch setting.

Problem	Possible Cause	Check
	Exercise interval different than expected	Check 1 week/2 week DIP switch and calendar settings.
ATS does not transfer	Unloaded test or exercise	Check DIP switch positions.
	Pretransfer load control time delays operating	Check Time Delay and Load Control Active LEDs and Active Time Delay window in the Setup Program. Check the time delay settings.
	Supervised transfer control switch (optional) in manual position	Move to Transfer or AUTO position. See the ATS Operation Manual, MP-6126.
	Maintenance DIP switch enabled	Check DIP switch position. See Section 3.6.
	Connected source available	Check the Source Available LEDs.
	Preferred source switch (optional) in emergency position and emergency available	Check the position of the preferred source switch and the Source Available LEDs.
	Supervised transfer control switch (optional) in the manual position	Check the position of the supervised transfer control switch, if equipped. Move the switch to the TRANSFER or AUTO position, as appropriate for the application. See the transfer switch operation and installation manual for more detailed information.
	Transfer switch problem	Troubleshoot the transfer switch. See Section 4 for instructions.
No LEDs illuminated	No power to the controller	Check that the transfer switch harness is connected to the controller.
	No power to the transfer switch	Check source connections.
		Check that source switches or circuit breakers are closed.
		Check that one source is available.
	One or more faulty LEDs	Press the Lamp Test button to check the operation of all LEDs. Replace the controller if one or more LEDs do not light. If no LEDs light, troubleshoot power and connections to the controller.
	Controller needs resetting	Reset the controller and then press Lamp Test. See Section 3.3.
Source available LED off when Source is available	Malfunctioning LED	Press the Lamp Test button to check the operation of all LEDs. Replace the controller if one or more LEDs do not light. If no LEDs light, troubleshoot power and connections to the controller.
	Source settings do not match actual source parameters	Check settings. See Section 3.7.
	Incorrect ATS meter calibration	Check calibration. See Section 3.7.4.
Position LED not lit	Position microswitch malfunction	Check the operation of the position microswitches.
	Transfer switch in intermediate position	Manually operate the transfer switch and check the position LED operation. Follow the safety precautions and instructions in the ATS operation/installation manual. Check the control contact operation; See the table of contents for control contact test procedures for your unit. Check for evidence of solenoid coil damage. Replace the coil, if necessary. See the table of contents to locate coil replacement procedures for your model transfer switch.
	LEDs not functioning	See *No LEDs illuminated* in this table.

Figure 2-3 Transfer Switch Troubleshooting

2.5 Faults

This section describes transfer switch faults indicated by the Service Required LED on the controller's user interface. Refer to the table in Section 2.3 for recommendations for correcting the faults described below.

2.5.1 Service Required LED

The following faults cause the Service Required LED to flash, indicating that immediate service is required:

- Auxiliary switch fault
- Auxiliary switch open
- Failure to acquire standby source
- Failure to transfer
- Phase rotation fault
- Input/output module faults

Find and correct the cause of the fault before trying to reset the controller. The cause of the fault may be shown by the other LEDs on the user interface; check the Source Available, Position, Load Control, Time Delay, Exercise, and Test LEDs to diagnose the cause of the faults. If the LEDs do not reveal the cause of the fault condition, connect a PC to the controller and use the Setup Program to view the event history. The event history lists fault conditions and transfers. See the software operation manual for more information and instructions.

After correcting the fault condition, press the Lamp Test button for approximately 5 seconds until the LEDs flash twice to clear the Service Required LED.

2.5.2 Auxiliary Switch Faults

An Auxiliary Switch Fault occurs if the controller cannot determine the transfer switch position. The Service Required LED flashes.

Check the transfer switch position and compare it to the position LED indicators on the controller's user interface.

The fault clears when the controller can detect the switch position. Depress the Lamp Test button until the LEDs flash to clear the Service Required LED.

2.5.3 Failure to Acquire Standby Source

A fault occurs if the unit attempts to start the generator set but the standby source does not appear after the Acquire Standby Source to Failure time delay. The Service Required LED illuminates. Some conditions that may cause this fault are failure of the generator set to start, no voltage output from the generator, or an error in sensing the voltage output from the generator set.

The fault clears when the system acquires a standby source. Depress the Lamp Test button until the LEDs flash to clear the Service Required LED.

2.5.4 Failure to Transfer

If the unit fails to transfer on command, the controller waits 1 second and then initiates another 200 msec attempt to transfer. If the in-phase monitor is operating, the system waits 1 second and then begins monitoring the source phases in preparation for transfer. When the sources are in phase, the system attempts to transfer. After three unsuccessful attempts to transfer, the system stops attempting to transfer and generates a fault. The Service Required LED illuminates.

The fault clears when the transfer switch transfers successfully. Depress the Lamp Test button until the LEDs flash to clear the Service Required LED.

2.5.5 Phase Rotation Faults

A fault occurs if the phase rotation of an input channel does not match the system's phase rotation direction setting (ABC or CBA). The unit will not transfer to a source if the source's phase rotation does not match the system setting. If the system detects a phase rotation fault in the connected source, it attempts to transfer to an alternate source that has the correct phase rotation. The controller logs phase rotation faults in the event history.

If the system detects phase rotation faults on both sources, the Service Required LED lights. The system does not transfer from the connected source.

2.5.6 I/O Module Faults and Diagnostics

When power is applied to the system, the controller attempts to initiate communication with each connected I/O board. The following faults may occur on powerup if the I/O modules are not correctly installed, addressed, or configured in the setup software. Check the LED on each I/O module for diagnostic information in the case of a fault.

Diagnostic LED. Each I/O module has a diagnostic LED that lights or flashes to indicate the I/O board status as described in Figure 2-4.

I/O Module Not Found. If the system does not detect an I/O module at an expected address, the Service Required LED flashes and the software logs the message, *I/O Module Not Found.* Check that the number of I/O modules installed matches the number expected by the setup program. Check that the I/O modules are connected and the address DIP switches are set correctly. Check the diagnostic LED to verify that the module is receiving power and communicating with the controller.

I/O Module Not Installed. If the software detects an I/O module that is connected but not expected by the setup program, the Service Required LED flashes and the software logs the message, *I/O Module Not Installed.* The system ignores the board if it does not find the setup definition. Check that the number of I/O modules expected in the Setup Program matches the number of modules installed on the transfer switch. Check that the I/O module address DIP switches are set correctly. Check the diagnostic LED.

I/O Module Communications Lost. If communication to an I/O module that was previously installed and working is lost, the Service Required LED flashes and the software logs the message *I/O Module Communications Lost.* Check the I/O module connections and diagnostic LED.

I/O Board Status	**Diagnostic LED**
Unpowered	Off
Operating correctly	On, Steady
Power but no communication with control board	Quick Flash (2 Hz)
No defined program at I/O module address	Slow Flash (0.5 Hz)

Figure 2-4 I/O Module Diagnostic LED

3.1 Initial Tests

Perform these initial tests to check the ATS controller operation.

Figure 3-2 shows the locations of the pushbuttons and LEDs on the controller's user interface.

3.1.1 Lamp Test

If no LEDs on the controller's user interface are illuminated, press the LAMP TEST button. If the controller has power, all LEDs on the user interface will light when the button is pressed.

If no LEDs light when the LAMP TEST button is pressed, proceed to Section 3.4.1 to check for power to the transfer switch and controller.

3.1.2 Service Required Reset

Hold the LAMP TEST button for approximately 5 seconds until the LEDs flash to reset the Service Required LED.

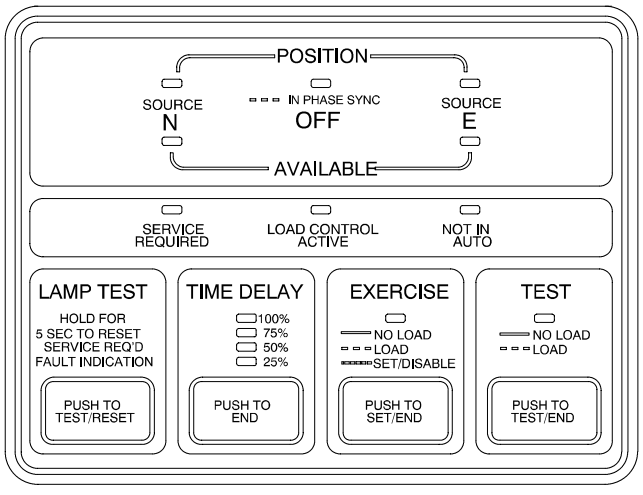
3.2 Controller LEDs

Check the Service Required LED for fault indication. See Figure 3-1. To reset the service required LED, press and hold the LAMP TEST button until all LEDs flash, which takes approximately 5 seconds.

Use the LEDs on the controller's user interface to check the status of the transfer switch. Watch the LEDs during test and exercise sequences to track the transfer switch operation. See Figure 3-3.

Service Required LED Illumination	Fault (See Section 2.5)
Flashing	Auxiliary Switch Fault
	Auxiliary Switch Open
	Failure to Acquire Standby Source
	Failure to Transfer
	I/O Module Communications Lost
	I/O Module Not Installed
	I/O Module Not Found
	Phase Rotation Fault
	Remote Common Fault
Steady	External Low Battery

Figure 3-1 Service Required LED



1. User interface panel location, typical

GM211077A

Figure 3-2 User Interface Panel

LED Indicator	Color	LED Illumination
Exercise	Amber	**Steady:** Unloaded exercise is running. **Slow Flash:** Loaded exercise is running. **Rapid Flash:** When EXERCISE button is pressed and held, rapid flashing indicates the exercise has been started and set. Rapid flashing at any other time indicates that the exercise is inhibited by the Exerciser Disable/Enable DIP switch setting.
Load Control Active	Amber	**Steady:** Pre/post-transfer load control or peak shave functions are operating.
Not in Auto	Red	**Rapid Flash:** ATS is not set for automatic operation or a load shed (forced transfer to OFF) sequence is active.
Position N	Green	**Steady:** Transfer switch is in Normal position.
Position E	Red	**Steady:** Transfer switch is in Emergency position.
Position Off/ In-Phase Sync	Amber	**Steady:** Transfer switch is in OFF position (programmed-transition models only). **Rapid Flash:** In-phase monitor is operating (open-transition models only).
Service Required	Red	**Steady**: Fault. Non-emergency maintenance is required. **Rapid Flash:** Fault. Immediate maintenance is required.
Source N Available	Green	**Steady:** Source N is available.
Source E Available	Green	**Steady**: Source E is available.
Test	Red	**Steady:** Unloaded test is running. **Slow Flash:** Loaded test is running.
Time Delay LED Bar	Amber	**LEDs step down** to indicate time remaining in an active time delay or exercise period.

Figure 3-3 User Interface LED Indicators

3.3 Controller Reset

If the controller is not responding and you have verified that there is power to the transfer switch controller, try resetting the controller. The controller can be reset without disconnecting power. Use the following procedure.

Controller Reset Procedure

1. Hold the LAMP TEST button until the LEDs flash. Do not release the button.
2. Continue to hold the LAMP TEST button in and press the END TIME DELAY button. The LEDs will flash when the controller resets.

3.4 Power Supply

⚠ 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. 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.

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)

3.4.1 Transfer Switch Power

If no LEDs light when the LAMP TEST button is pressed, check for power to the controller and the transfer switch. Verify that the transfer switch wiring harness is connected to the controller. See Figure 3-4. Check for open circuit breakers or switches. Follow the voltage check procedure in Section 3.7.2 to check voltage at the Source N (normal) or Source E (emergency) lugs.

3.4.2 Controller Power Supply

Check for voltage to the controller using the following procedure.

Procedure to Check Voltage to the Controller

1. Disconnect power to the transfer switch by opening circuit breakers or switches.
2. Disconnect the transfer switch wiring harness from the controller at the 24-pin connector.
3. Reapply power to the transfer switch.
4. Check for voltage across the wiring harness pins. Observe all safety precautions when checking the voltage.
   a. If Source N is available, check for line voltage across pins 4 and 12 of the transfer switch wiring harness connector.
   b. If Source E is powering the transfer switch, check for line voltage across pins 6 and 7 of the connector.

If there is no power to the pins checked in step 4, check the wiring harness and replace it, if necessary.

1. Transfer switch harness connection to controls, controller connector P1

Figure 3-4 Transfer Switch Harness Connection to Control Board, Typical

3.4.3 Powering the Controller for Testing (Service Kit GM25479)

It is sometimes useful to supply power directly to the controller for bench testing. Service kit GM25479 can be used to supply power to 120-volt controllers from a 120 VAC wall outlet.

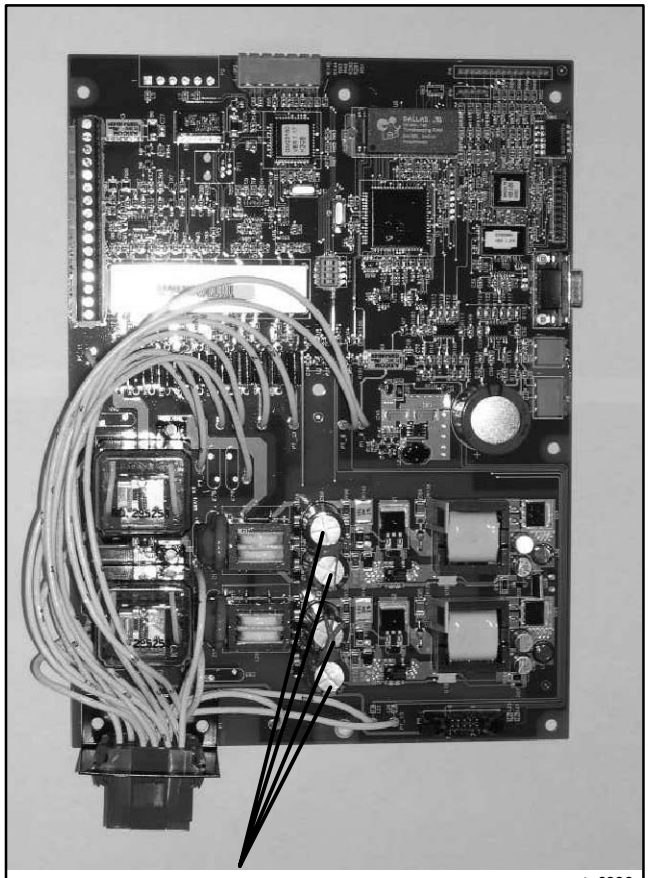
Note: Controllers with 240-volt boards shown in Figure 3-5 cannot be powered directly.

Controllers with 120-volt circuit boards shown in Figure 3-6 can be powered directly for testing.

Circuit Board Identification

Compare the controller's circuit board to the photographs in Figure 3-5 and Figure 3-6.

The 240-volt board shown in Figure 3-5 has four (4) capacitors in the power supply area of the circuit board. **These boards cannot be powered directly with 120 VAC.**



1. Four (4) capacitors (for identification of 240-volt controllers)

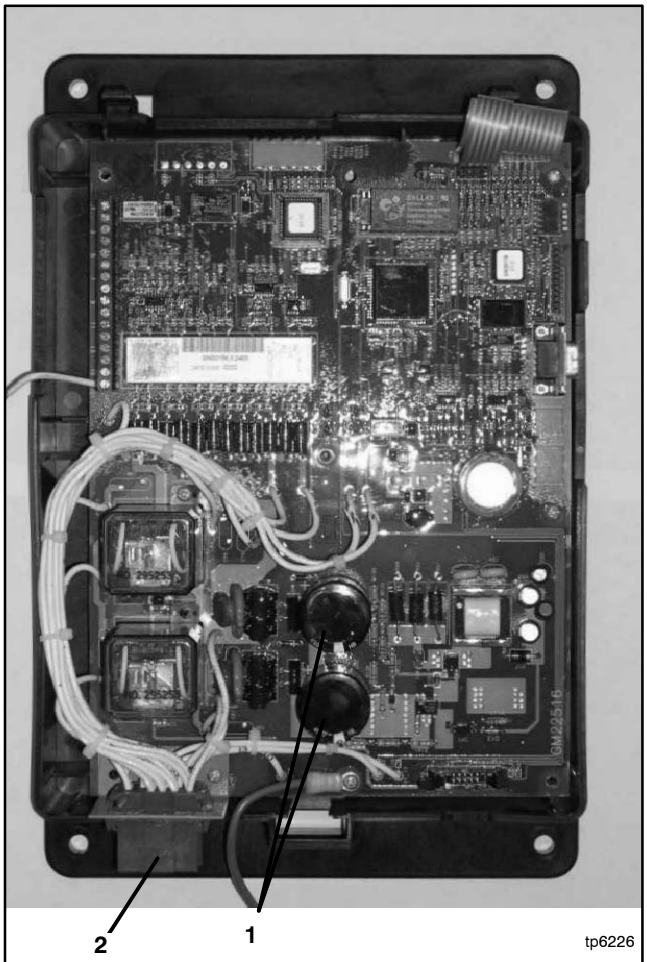
Figure 3-5 240-Volt Circuit Board. **Cannot be directly powered with 120 VAC.**

The 120-volt board shown in Figure 3-6 has two (2) capacitors in the power supply area of the circuit board. These boards can be powered directly from a 120 VAC wall outlet using service kit GM25479 .

Connecting Power

Disconnect the controller from the transfer switch and connect cable GM25481 (included in the service kit) to the controller's P1 connector. See Figure 3-6. Plug the cable into a 120 VAC wall outlet to power the controller during testing.

Note: Do not connect 120 VAC power to any other location on the controller.



1. Two (2) capacitors (for identification of 120-volt controllers)
2. Service kit power cable connection location (controller connector P1)

Figure 3-6 120-Volt Circuit Board with 120 VAC Power Connection Location (P1)

3.5 Test Sequence

Use the following procedure to run a test to check the transfer switch operation. Watch the LEDs on the controller's user interface as the time delays run and Source E becomes available when the generator set starts. The TEST LED flashes to indicate a loaded test, or lights steadily to indicate a test without load. For a loaded test, watch the position LEDs to verify that the ATS transfers the load.

To set the TEST DIP switch for a loaded or unloaded test, refer to Section 3.6 for instructions on setting the controller DIP switches.

To monitor the individual time delays during the test, connect a personal computer (PC) running the Setup Program. Close and lock the transfer switch door before initiating a test sequence. Use the Active Time Delay window to monitor the time delays as they run. See the setup program operation manual for further instructions.

The test sequence simulates a loss of the normal source, starts the generator set, and transfers the load to the emergency source (if the TEST DIP switch is set for a loaded test), executing all time delays that are set up to operate during a loss of the normal source. When the test is ended in step 8 of the procedure, the transfer switch transfers the load back to the normal source and removes the engine start signal, executing all programmed time delays.

Note: If the standby source fails during a test, the ATS will immediately attempt to transfer to the preferred source.

Optional Switches. If the ATS is equipped with a preferred source switch, check the switch position before proceeding with the automatic operation test. The test procedure assumes that Source N is the preferred source.

If the transfer switch is equipped with a supervised transfer switch, verify that it is set to the AUTO position.

See the transfer switch operation and installation manual for more information about optional switches.

Note: 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.

Automatic Operation Test Procedure

1. Close and lock the transfer switch enclosure door. Tighten the door screws.

2. Check the controller LED indicators to verify that the Position N and Source N Available indicators are lit.

3. Press the LAMP TEST button and check that all controller LEDs illuminate.

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

5. Press the TEST button on the controller to start the test. If the TEST LED lights steadily, the ATS controller is set up to run the test without transferring the load. The test sequence will start the generator set but will not transfer to Source E. The flowchart in Figure 3-7 shows the sequence of operation without load transfer.

   The TEST LED flashes to indicate that the ATS controller is set up to transfer the load during the test. The flowchart in Figure 3-8 shows the sequence of operation with load transfer.

6. Verify that the generator set starts after the engine start delay times out. Check that the Source E Available LED lights.

7. Verify that the switch transfers the load to Source E.

   a. Open-Transition Models: After the preferred-to-standby time delay, verify that the Position N LED goes out and the Position E LED lights, indicating that the switch has transferred the load to Source E.

b. Programmed-Transition Models: After the preferred-to-off time delay, verify that the Position N LED goes out and the Position OFF LED lights. After the off-to-standby time delay, check that the Position E LED lights, indicating that the switch has transferred the load to Source E.

8. Push the TEST button to end the test.

9. Verify that the switch transfers the load back to Source N.

   a. Open-Transition Models: After the standby-to-preferred time delay, verify that the Position E LED goes out and the Position N LED lights, indicating that the switch has transferred the load to Source N.

   b. Programmed-Transition Models: After the standby-to-off time delay, verify that the Position E LED goes out and the Position OFF LED lights. After the off-to-preferred time delay, check that the Position N LED lights, indicating that the switch has transferred the load to Source N.

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

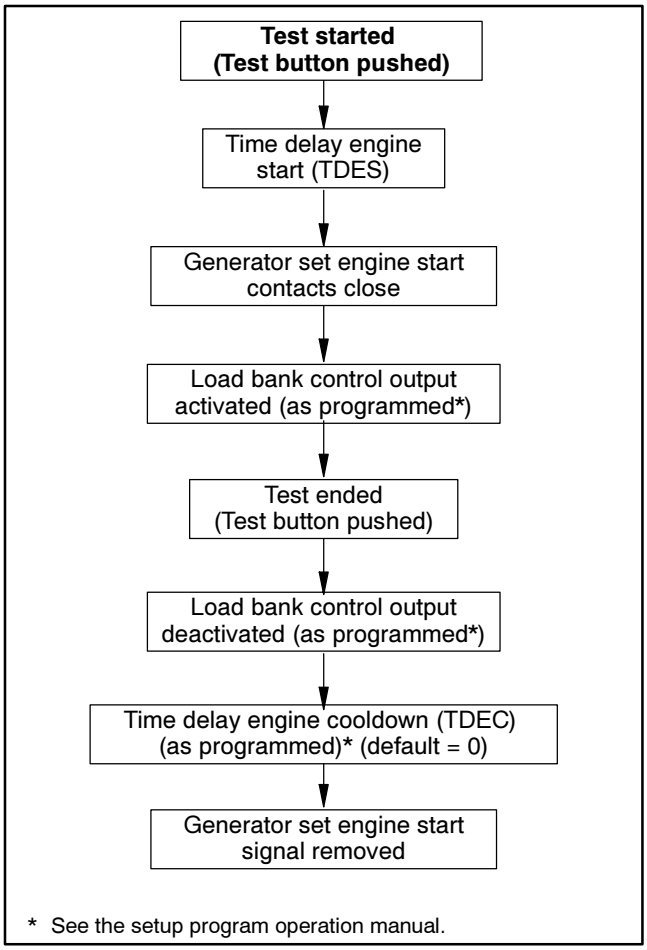


Figure 3-7 Test Without Load Transfer

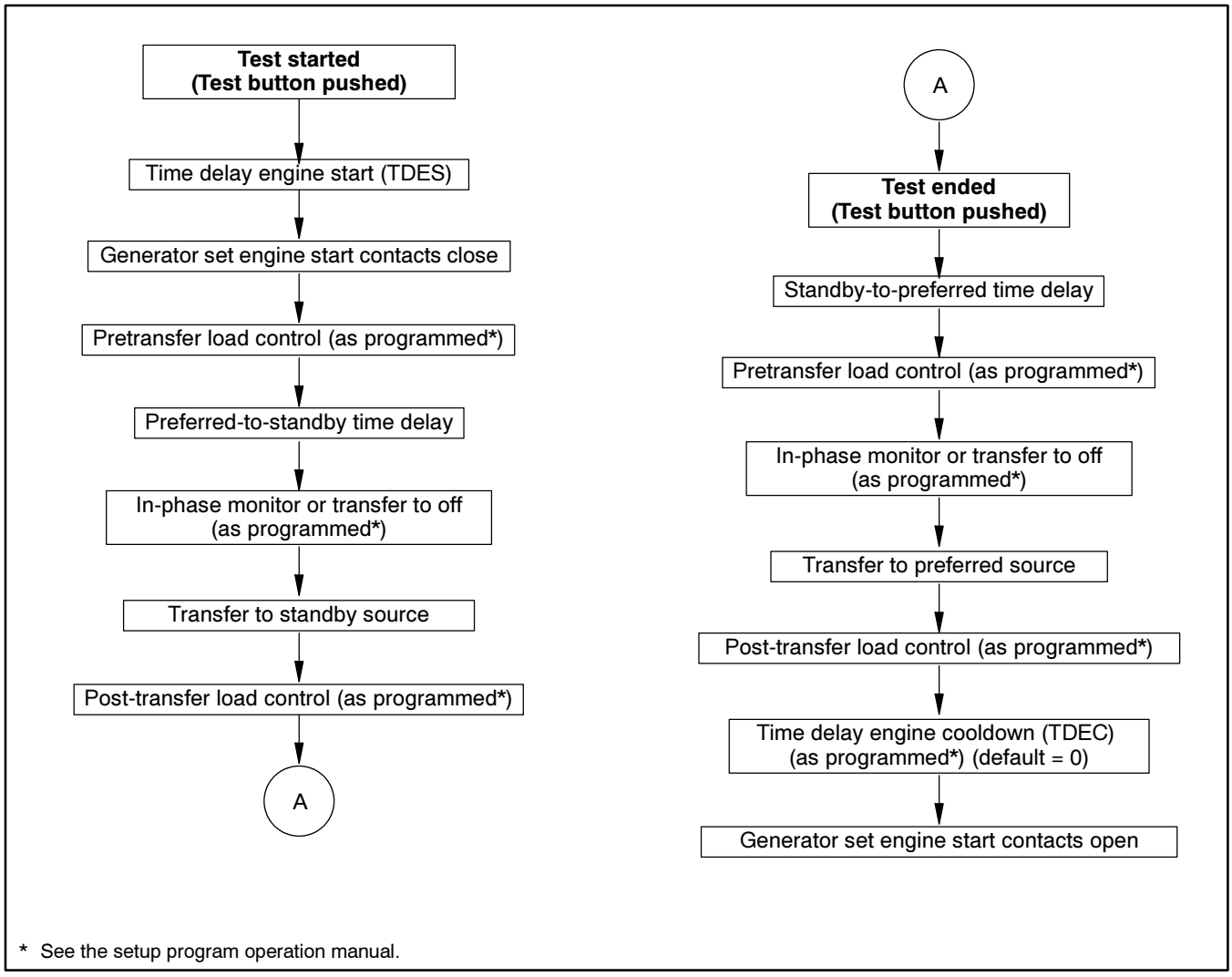


Figure 3-8 Test with Load Transfer

3.6 DIP Switch Positions

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

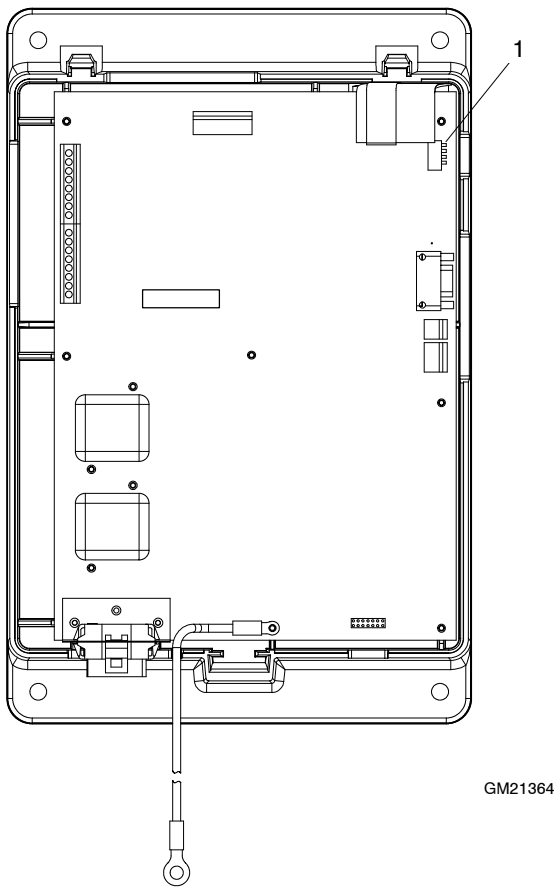
DIP switches on the main logic board control the test and exercise functions. The factory settings for the DIP switches are shown in Figure 3-10.

The Maintenance DIP switch inhibits transfer during ATS service.

Before opening the transfer switch enclosure to check or change the DIP switch settings, open the circuit breakers to disconnect the power to the transfer switch.

The DIP switches are located on the controller's main logic board on the inside of the enclosure door. Figure 3-9 shows the locations of the switches on the controller circuit board. A decal on the logic assembly housing shows the DIP switch positions and settings (see Figure 3-10). It is not necessary to remove the logic assembly cover to see or adjust the DIP switches. Check the DIP switch settings and adjust, if necessary, for the application. Close and lock the enclosure door before energizing the transfer switch.

Note: Changing the position of the 1 week/2 week exercise DIP switch after the exerciser has been set does not change the time of the *next* scheduled exercise. The new DIP switch setting becomes effective *after* the next scheduled exercise. See the ATS operation and installation manual for more information about the exerciser.



1. DIP switches

Figure 3-9 Controller Board DIP Switch Location (cover removed)

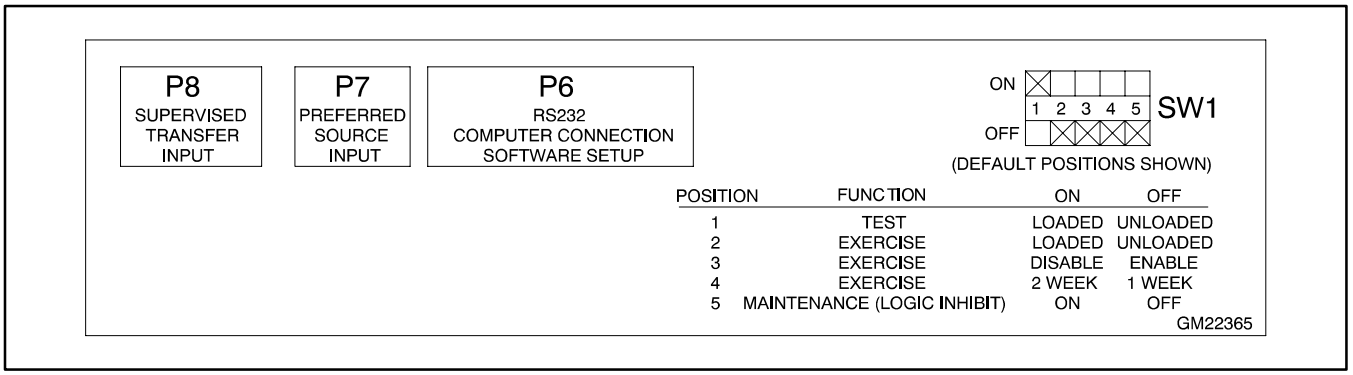


Figure 3-10 Logic Assembly Decal Showing DIP Switch Settings

3.7 System Settings

If the ATS does not recognize the source, check that the source voltage and frequency settings on the controller match the actual source parameters.

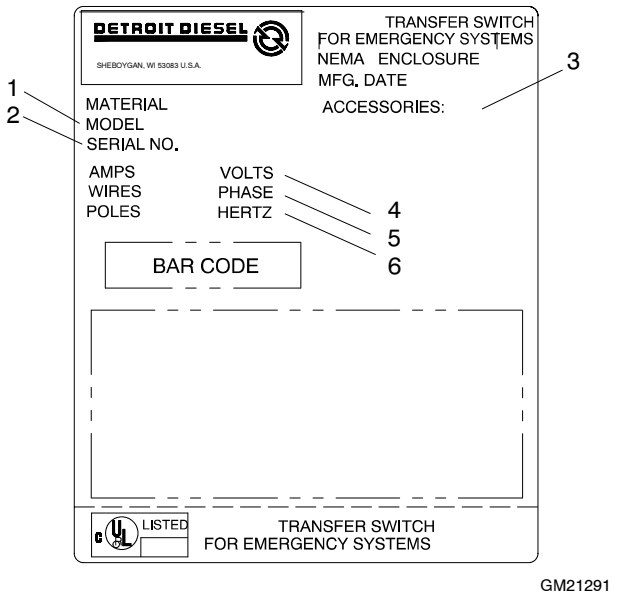
Compare the controller settings to the ratings on the ATS nameplate and to the measured source parameters using the following instructions.

3.7.1 Controller Source Settings

Use a PC running the Setup Program to check the controller's source voltage, frequency, and phase settings in the Source Information window. See MP-6135, Software Operation and Installation Manual, for instructions.

Check the controller settings and compare them to the voltage rating, frequency rating, and number of phases shown on the ATS nameplate. The nameplate is attached to the cover of the controller assembly, which is mounted on the inside of the transfer switch door. See Figure 3-11 for an illustration of the nameplate.

Note: The system voltage and frequency shown on the ATS nameplate must match the Source N and Source E voltage and frequency settings. Do not enter settings that do not match the nameplate ratings of the ATS.



1. Model designation
2. Serial number
3. Factory-installed accessory numbers
4. Voltage rating
5. Frequency rating
6. Number of phases (single or three)

Figure 3-11 Typical Transfer Switch Nameplate

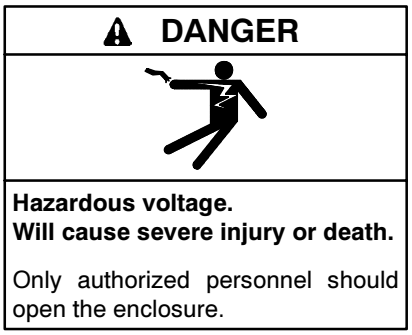
Use the procedure in the next section to measure the source voltage, frequency, and phase rotation and compare the measured values to the controller settings. Follow the instructions in the Software Operation and Installation manual to change the controller settings if they do not match the measured source parameters and nameplate.

3.7.2 Voltage, Frequency, and Phase Rotation Checks

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

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

Note: Source N is the source connected to the normal side of the transfer switch. Source E is the source connected to the emergency side of the transfer switch.



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)

The voltage check procedure requires the following equipment:

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

Voltage, Frequency, and Phase Rotation Measurement Procedure

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

1. Verify that the generator set master switch is in the OFF position and both power sources are disconnected from the transfer switch.
2. Disconnect the power switching device and controller wiring harnesses at the inline disconnect plug, if they are connected.
3. Manually operate the transfer switch to position E. See the transfer switch operation and installation manual for manual operation instructions.
4. If Source N is a generator set, move the generator set master switch to the RUN position. The generator set should start.
5. Close the Source N circuit breaker or switch.
6. Use a voltmeter to check Source N (normal) phase-to-phase and phase-to-neutral (if applicable) terminal voltages and frequency.
   a. If Source N is the utility and the measured input does not match the voltage and frequency shown on the transfer switch nameplate, *STOP!* The transfer switch does not match the application—order the correct transfer switch.
   b. If Source N is a generator set and the generator set output voltage and frequency do not match the nominal system voltage and frequency shown on the transfer switch nameplate, follow the manufacturer's instructions to adjust the generator set. The automatic transfer switch will only function with the rated system voltage and frequency specified on the nameplate.
7. Use a phase rotation meter to check the phase rotation at the Source N (normal) terminals. Rewire the transfer switch Source N terminals to obtain the correct phase sequence, if necessary.

   Note: The default setting for the phase rotation on the controller is ABC. If the application uses a phase rotation of CBA, use the Setup Program to change the phase rotation setting on the controller.
8. If the source is a generator set, stop the generator set by moving the master switch to the OFF position.
9. Disconnect Source N by opening upstream circuit breakers or switches.
10. Manually operate the transfer switch to position N.
11. Repeat steps 4 through 8 for Source E. Then proceed to step 12.
12. Disconnect both sources to the transfer switch by opening the circuit breakers or switches.
13. Connect the power switching device and controller wiring harnesses together at the inline disconnect plug.

    Note: Do not connect or disconnect the controller wiring harness when the power is connected.
14. Close and lock the transfer switch enclosure door.
15. Reconnect both power sources by closing the circuit breakers or switches.
16. Move the generator set master switch to the AUTO position.

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

3.7.3 Voltage and Frequency Pickup and Dropout Settings

Figure 3-12 illustrates the relative values of the voltage pickup and dropout settings. Typical frequency pickup and dropout settings relate to the nominal source frequency in a similar way.

If the source voltage rises above the overvoltage dropout setting or falls below the undervoltage dropout setting for a time longer than the debounce time, the controller will consider the source as failed. The source voltage must return to a level within the range of the

pickup values for the controller to recognize the source as restored.

Choose pickup and dropout settings that allow a tolerable variation in the source parameters to prevent nuisance transfers caused by small changes in the source voltage and frequency.

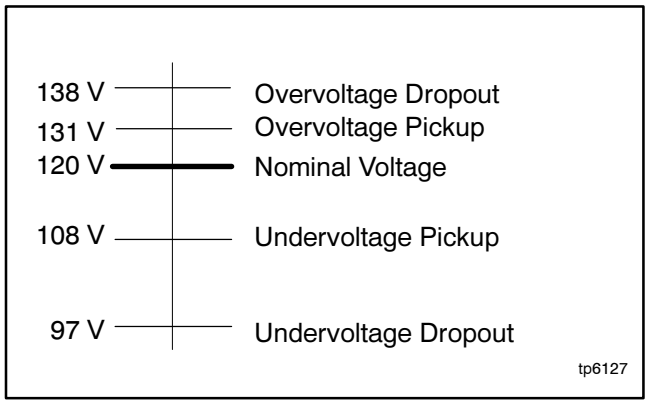


Figure 3-12 Relationship Between Voltage Pickup and Dropout Settings (default settings shown)

Parameter	Default	Adjustment Range
Overvoltage dropout	115% of nominal	105%–135% of nominal
Overvoltage pickup	95% of dropout	95%–100% of dropout
Undervoltage pickup	90% of nominal	85%–100% of nominal
Undervoltage dropout	90% of pickup	75%–98% of pickup
Voltage dropout time	0.5 sec.	0.1–9.9 sec.

Figure 3-13 Voltage Settings

Parameter	Default	Adjustment Range
Overfrequency dropout	101% of pickup	101%–105% of pickup
Overfrequency pickup	110% of nominal	105%–120% of nominal
Underfrequency pickup	90% of nominal	80%–95% of nominal
Underfrequency dropout	99% of pickup	95%–99% of pickup
Frequency dropout time	3 sec.	0.1–15 sec.

Figure 3-14 Frequency Settings

3.7.4 Meter Calibration

The transfer switch controls are calibrated at the factory and should not require recalibration in the field. However, if recalibration is necessary, measure the source voltages as instructed in Section 3.7.2, record the measured values, and then enter the measured values into the appropriate spaces in the Meter Calibration window in the Setup Program. See MP-6135, Software Operation and Installation Manual, for more information about using the Setup Program.

3.8 Time Delays

Check the time delays when troubleshooting problems with the transfer switch operation.

Use the Active Time Delay Window in the Setup Program and observe the time delay LEDs on the controller's user interface to identify which time delays are executing at any given time. Open the Active Time Delay window and then press the TEST button on the controller's user interface to initiate a test and observe as each programmed time delay executes. Compare the operation to the test sequence illustrated in the flowcharts in Figure 3-7 or Figure 3-8.

Some time delays run serially (one after another) and others run at the same time, so that the Time Delay LEDs on the controller interface may appear to reach zero and then start stepping down again to track another time delay.

Use the Time Delay and Load Control Time Delay windows in the Setup Program to check the settings for the adjustable time delays. Figure 3-15 shows the factory settings and adjustment ranges for the adjustable time delays.

Adjustable Time Delays		
Time Delay	**Default**	**Adjustment Range**
Engine start	3 sec.	0–6 sec.*
Preferred to standby	1 sec.	0–60 min.*
Standby to preferred	15 min.	
Engine cooldown	0 min.	
Failure to acquire standby source	1 min.	
Pretransfer to preferred signal	3 sec.	
Pretransfer to standby signal	3 sec.	
Post-transfer to preferred signal	0 sec.	
Post-transfer to standby signal	0 sec.	
Off to standby (programmed-transition only)	1 sec.	
Off to preferred (programmed-transition only)	1 sec.	
* Adjustable in 1 second intervals		

Figure 3-15 Factory Settings, Time Delays

3.9 Engine Start

⚠ 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)

Check for continuity across the engine start contacts during a test or exercise sequence. Refer to the transfer switch schematic diagram provided with the unit or to the wiring diagram manual. Refer to the flowchart in Figure 3-16 or Figure 3-17 for the exercise operation sequence. Allow time for the engine start and engine cooldown time delays (if not set to zero) if checking the engine start signal during a test.

Start with the transfer switch in the Source N position.

Engine Start Test Procedure

1. Connect an ohmmeter or test lamp across pins 8 and 9 of connector P1 (the transfer switch harness-to-controller connection). See Figure 3-18.
2. Verify that the engine start contacts are open before starting the test.
3. Press the TEST button to initiate a test sequence and verify that the engine start contacts close after the engine start time delay.
4. Press the TEST button again to end the test. Verify that the engine start contacts open after the engine cooldown time delay (if not set to zero).
5. Press the EXERCISE button to initiate an exercise run and verify that the engine start contacts close.
6. Press the EXERCISE button again to end the exercise run. Verify that the engine start contacts open.

If the ATS engine start contacts do not close during the Engine Start Contact Test Procedure, replace the ATS controls.

If the generator set engine does not start, check the engine start connections to the generator set. Verify that the generator set master switch is in the AUTO position. Troubleshoot the generator set if the engine start connections are good but the engine does not start.

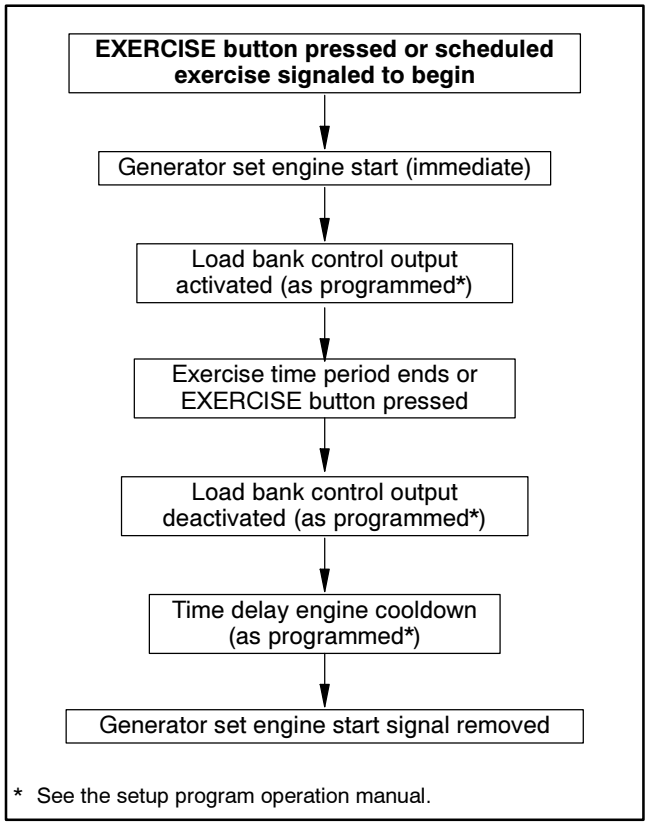


Figure 3-16 Exercise without Load Sequence

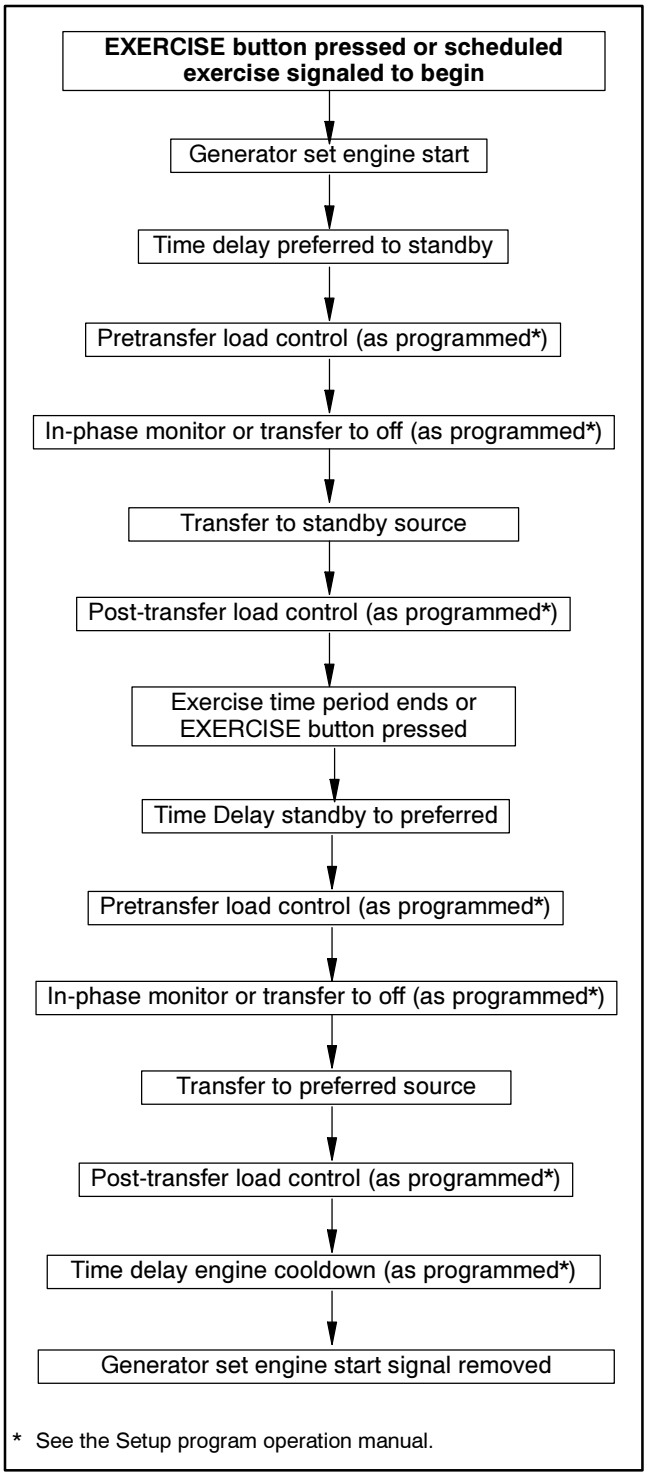
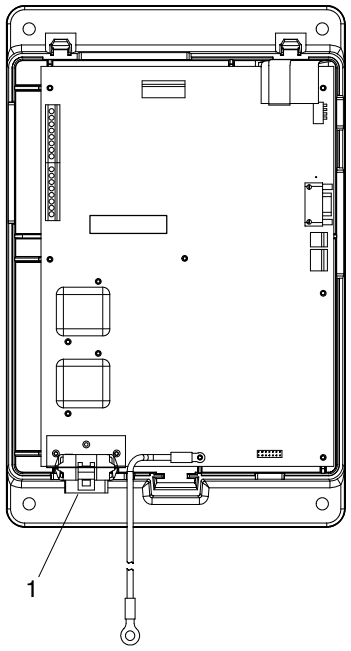


Figure 3-17 Exercise with Load Sequence



1. Transfer switch harness connection, P1

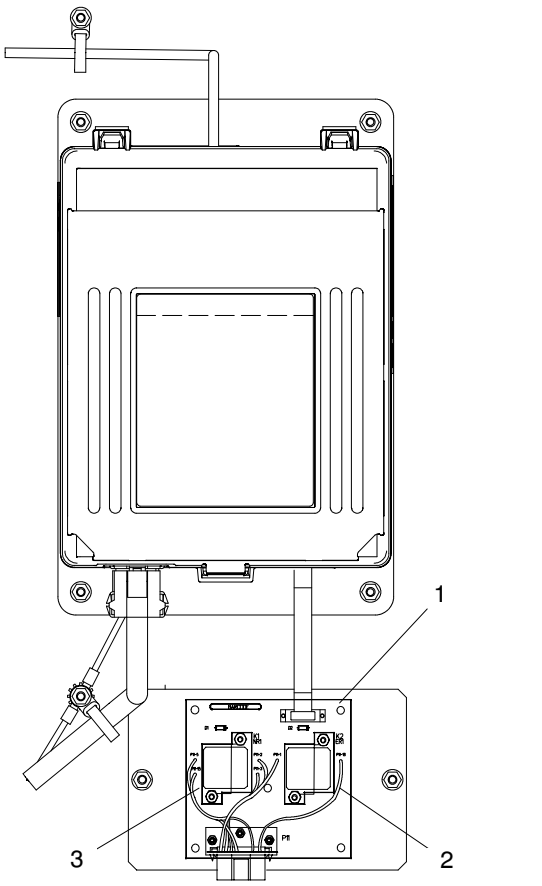
Figure 3-18 Transfer Switch Harness-to-Controller Connection, P1

3.10 Position Microswitch Test

When troubleshooting position-indication errors, check the operation of the position-indicating microswitches. Disconnect power to the transfer switch and use an ohmmeter or test lamp to check the operation of the position-indicating microswitches. Manually operate the switch and check for continuity across pins 10 and 13 of connector P1 for Source E and pins 10 and 14 for Source N.

3.11 Programmed-Transition Interface Board

Model SDP/SMP switches are equipped with the programmed-transition interface board (PTIB). The (PTIB) contains two replaceable 10-amp relays, K1 (NR1) and K2 (ER1). See Figure 3-19. Refer to the operation sequence diagrams in Section 4.5.2 and to the schematic diagram provided with the transfer switch to troubleshoot the relays.



1. Programmed-Transition Interface Board (PTIB)
2. K2 (ER1) Relay
3. K1 (NR1) Relay

Figure 3-19 Programmed-Transition Interface Board

3.12 Controller Replacement

Always check for open switches or circuit breakers, loose connections, or faulty wiring before replacing any parts. Reset the controller as described in Section 3.3 before replacing it. Replace the controller only if the troubleshooting and test procedures in this manual indicate conclusively that the controller is damaged or inoperative.

Replace the entire controller assembly and plastic housing. Controller parts are not offered separately. Save the old controller's plastic cover, which includes the transfer switch nameplate, for use with the new controller.

New controllers are shipped with factory default settings for the system settings including voltage, frequency, number of phases, phase rotation, and other user-adjustable settings. After installing a new controller, use a PC running the Setup Program to change the settings, if necessary. Refer to the setup program operation and installation manual for instructions.

Disconnect power to the transfer switch before starting to disconnect the controller. Observe the following safety precautions to avoid injury or equipment damage.

⚠ 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. 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.

Controller Replacement Procedure

1. Move the generator set master switch to the OFF position.
2. Disconnect the generator set engine starting battery, negative (-) lead first.
3. Disconnect power to the transfer switch by opening switches or circuit breakers to the switch.
4. Open the transfer switch enclosure.
5. Check the voltage at the source connections to verify that the power is off.
6. Disconnect the transfer switch harness at the connector on bottom of the controller. See Figure 3-9.
7. Disconnect the programmed-transition board, if equipped, from the controller at connector P9.
8. Label each input/output lead connected to the main logic board terminal strip and then disconnect the I/O leads.
9. Disconnect I/O modules (if equipped) at connector P3.
10. Disconnect the preferred source switch and supervised transfer switch (if equipped) from the controller board connectors P7 and P8.
11. Disconnect the controller ground wire at the ring terminal on the enclosure door.
12. Support the controller assembly and remove four nuts at the corners.
13. Carefully remove the controller assembly, including the user interface panel, which is part of the assembly.

14. Remove the plastic cover from the old controller and save it to install on the new controller assembly. To remove the cover, depress the latch at the bottom of the cover. Swing the cover open on its hinges and lift it off. See Figure 3-20.

    Note: The old cover includes the transfer switch nameplate, which must remain with the transfer switch.

15. Replace the entire assembly with a new controller. Secure the four nuts at the corners and tighten them to no more than 6.8 Nm (5 ft. lb. or 60 in lb.) torque.

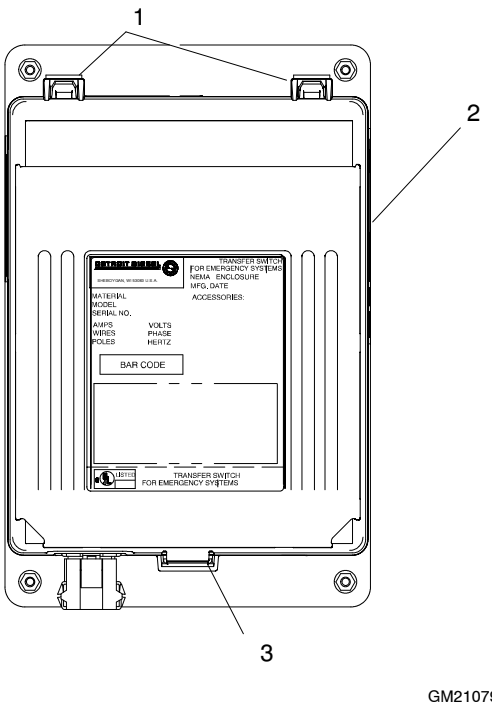
16. Connect the controller ground wire at the ring terminal on the enclosure door.

17. Connect the programmed-transition board, if equipped, to the controller at connector P9.

18. Connect the I/O leads to the main logic board terminal strip, using the labels attached in step 8 to connect the leads to the appropriate terminals.

19. Connect I/O modules (if equipped) at connector P3.

20. Connect the preferred source switch and supervised transfer switch (if equipped) to the controller board connectors P7 and P8.



1. Hinges
2. Access openings to DIP switches and PC connection
3. Latch

Figure 3-20 Controller Housing Cover

21. Connect the transfer switch harness to the connector on the bottom of the controller.

22. Check the controller's DIP switch settings and adjust them, if necessary.

23. Remove the plastic cover from the new controller and replace it with the cover from the old assembly.

24. Connect the controller communication ribbon cable to controller serial port P6 and bring the other end of the cable out the door through the bottom of the enclosure.

25. Close and lock the transfer switch enclosure door.

26. Reconnect power to the transfer switch by closing circuit breakers or switches.

    Note: Power to the controller is required in order to check and adjust controller settings. If all the power sources are generator sets, reconnect normal source generator set engine starting battery and move the generator set master switch to the AUTO position.

27. Connect a PC and use the Setup Program to check the system settings and adjust them, if necessary. Check the system voltage, frequency, number of phases, phase rotation, time delays, and other user-adjustable settings. Set up inputs/outputs and the in-phase monitor, if applicable. Refer to the setup program operation and installation manual for instructions.

28. Disconnect power to the transfer switch by opening circuit breakers or switches.

29. Open the enclosure door and remove the communications cable.

30. Close and lock the enclosure door. Tighten any screws that secure the door.

31. Reconnect the generator set engine starting battery, negative (-) lead last.

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

33. Reconnect power to the transfer switch.

34. Press the LAMP TEST button on the front of the controller and verify that all LEDs light.

35. If the calendar mode exerciser is not being used, press the EXERCISE button on the controller user interface to set the exercise time and start an exercise run. The generator set should start. Refer to the transfer switch operation and installation manual for more information about the exerciser.

4.1 Transfer Switch Troubleshooting

When troubleshooting the transfer switch mechanism, always check for simple causes first: broken or loose wires, corroded contacts, exposure to dirt or foreign material, etc.

Check the time delays, source settings, and other system parameters as described in Sections 2 and 3 before concluding that there is a mechanical problem with the transfer switch. Many transfer problems can be traced to inappropriate controller settings.

Verify that the voltage on the nameplate matches the actual nominal source voltage. Use the procedure in Section 3.7.2 to measure the source voltage. Observe safety precautions when taking voltage measurements. Verify that the measured voltage matches the transfer switch rated voltage.

4.2 Troubleshooting Table

Use the table in Figure 4-1 to diagnose transfer switch problems. For service procedures, refer to Section 5 for open-transition models or Section 6 for programmed-transition models.

4.3 Contacts

Use the millivolt drop test in Section 1.3.3 to identify damaged contacts. If the contacts are damaged or have high resistance, replace the power panel assembly. For service procedures, refer to Section 5 for Model SDT/ SMT open-transition switches or Section 6 for Model SDP/ SMP programmed-transition switches.

Condition	Possible Cause	Check for
Failure to transfer	Mechanical binding	Loose hardware.
		Accumulation of dirt or other foreign material.
		Jammed main contacts. Check for foreign object.
		Jammed or damaged solenoid.
		Faulty or worn core spring.
		Bent main contact shaft.
	Electrical malfunction	Damaged or wrong coil. Check for signs of overheating.
		Damaged or wrong rectifier.
		Damaged or wrong resistor (not used on all models).
		Loose or broken wires.
		Corroded or fused contacts.
		SCE/SCN limit switch connections and operation.
		Improperly wired harness.
		Wrong voltage. Check system voltage, controller system voltage and over/undervoltage pickup and dropout settings, and controller meter calibration. See Sections 2 and 3.
Chattering noise when attempting to transfer	Control contact operation	SCE/SCN limit switch connections and operation.
	Low voltage	Check source voltage and connections.
	Wrong coil	Check coil voltage rating.

Figure 4-1 Transfer Switch Troubleshooting

4.4 Rectifier Test

Use an ohmmeter or a diode checker to test the rectifiers on model SDT/SMT open-transition switches when instructed to do so in service procedures in Section 5.

Note: The rectifiers on model SDP/SMP programmed-transition switches are built into the solenoid coils and are not accessible for testing.

Disconnect all leads to the bridge rectifier and test each rectifier (diode) in the bridge individually using an ohmmeter (R x 1 scale) or diode checker. See Figure 4-2 and Figure 4-3. The diodes should exhibit a reverse resistance of at least 100 times the forward resistance. If the reverse resistance is low, replace the damaged rectifier assembly.

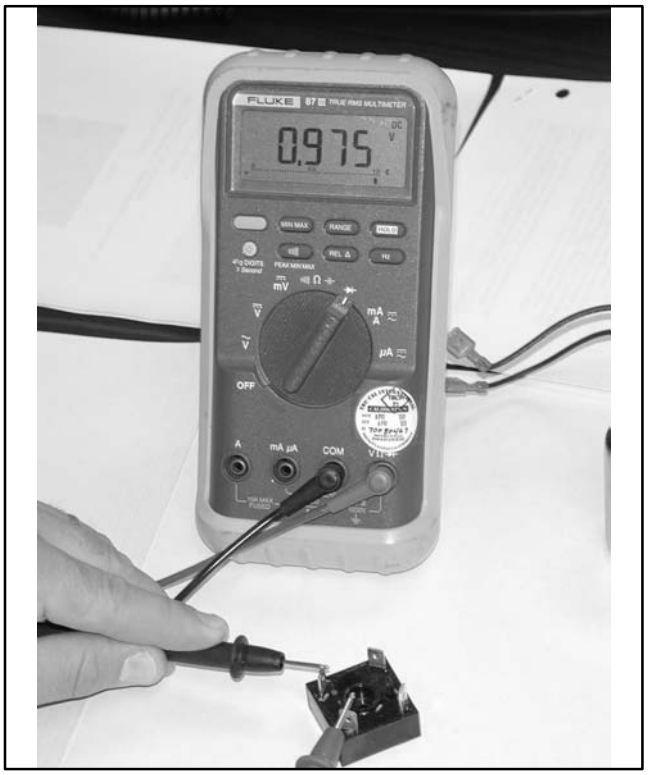
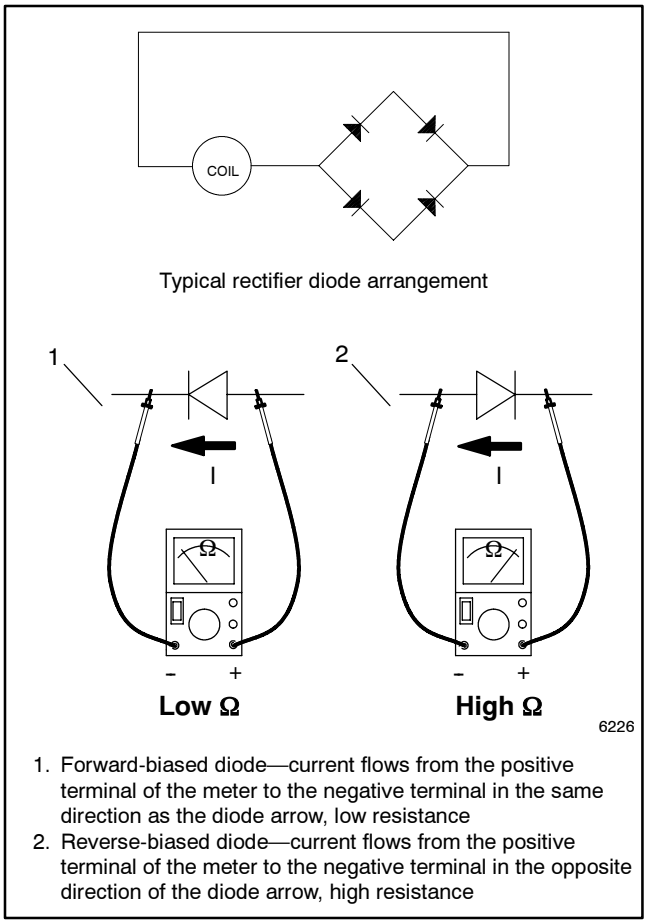


Figure 4-2 Checking Rectifier Diode Operation (model SDT/SMT switches only)

Coil resistances for model SDT/SMT open-transition switches are listed in Figure 4-4. Replace the coil if an open circuit, a short circuit, or a resistance value significantly different from the resistance shown in the table is found.



1. Forward-biased diode—current flows from the positive terminal of the meter to the negative terminal in the same direction as the diode arrow, low resistance
2. Reverse-biased diode—current flows from the positive terminal of the meter to the negative terminal in the opposite direction of the diode arrow, high resistance

Figure 4-3 Testing Diodes (model SDT/SMT switches only)

4.5 Solenoid Tests

4.5.1 Solenoid Coil Resistance

Use an ohmmeter to measure the coil resistance on model SDT/SMT open-transition switches. Most damaged coils will result in an open circuit (very high resistance) or a shorted coil (near zero resistance).

Note: Because coils for model SDP/SMP programmed-transition switches have integral rectifiers, the coil resistance on those units cannot be easily measured. Check coil operation according to the diagrams in Section 4.5.2. If the coil does not operate correctly, replace it.

Coil Resistance for Open-Transition Switches		
Amps	**Voltage**	**Coil Resistance (ohms) ±10% @ 20°C**
40–260	208	18.1
	240	28.8
	380/415	62.8
	480	89.6
400–600	208	2.0
	240	5.6
	415	16.4
	480	27.9
	600	33.0

Figure 4-4 Coil Resistances, Model SDT/SMT Open-Transition Switches Only

4.5.2 Solenoid Operation

This section contains descriptions and diagrams of the solenoid coil operation. For complete diagrams, refer to the schematic diagrams provided with the transfer switch.

The ATS controller monitors the connected source and detects source failure, either a complete loss of the source or a source parameter that is outside the acceptable range. The controller starts the engine start time delay. If power is restored before the time delay ends, the controller resets the time delay and continues to monitor the source. If the source failure persists and the time delay ends, the controller closes the engine start contacts to signal the Source E generator set to start.

When Source E (or the standby source) becomes available, the controller starts the preferred-to-standby time delay (if not set to zero). When the time delay ends, relay K2 (ER) in the controller closes, applying power to the solenoid coil and initiating transfer.

When Source N (or the preferred source) is restored, the controller starts the standby-to-preferred time delay. When the time delay ends, the controller's K1 (NR) relay closes, applying power to the solenoid coil and initiating transfer back to Source N (or the preferred source).

Note: The K1 (NR) and K2 (ER) relays are energized for only 250 milliseconds to initiate transfer.

On 40–225 amp model SDT/SMT open-transition switches, control contacts SCN and SCE control the amount of time that power is applied to the solenoid coil. The contacts open before the operating mechanism reaches Top Dead Center (TDC). Inertia carries the mechanism through TDC, and a spring in the solenoid assembly moves the mechanism into the Source E (or standby) position.

Model SDP/SMP programmed-transition models stop in the OFF position for a programmed length of time during transfer. The transfer-to-OFF sequence is controlled by the NR1 and ER1 relays on the programmed-transition interface board (PTIB).

The controller K1 and K2 relays and the PTIB relays are replaceable.

Note: Always check all wiring and connections before replacing parts.

The solenoid power circuits vary for different ATS models. The following sections describe and illustrate the transfer sequence for the different models.

Figure 4-5 explains the notation used in the solenoid operation diagrams in the following coil operation diagrams.

ATS1:	Trip switch, Normal *	NR, ER:	Controller relays. Energized for 250 milliseconds to initiate transfer.
AX:	Coil clearing switch, Normal *	NR1, ER1:	Programmed-transition interface board relays. *
BTS1:	Trip switch, Emergency *	SCN, SCE:	Coil control contacts (microswitches)
BX:	Coil clearing switch, Emergency *	SC:	Select coil *
CC:	Closing coil *	S1:	Bridge rectifier *
EA, EC:	Emergency source	TC:	Trip coil *
LS:	Line select switch *		
NA, NC:	Normal source		

Power through the coil circuit.

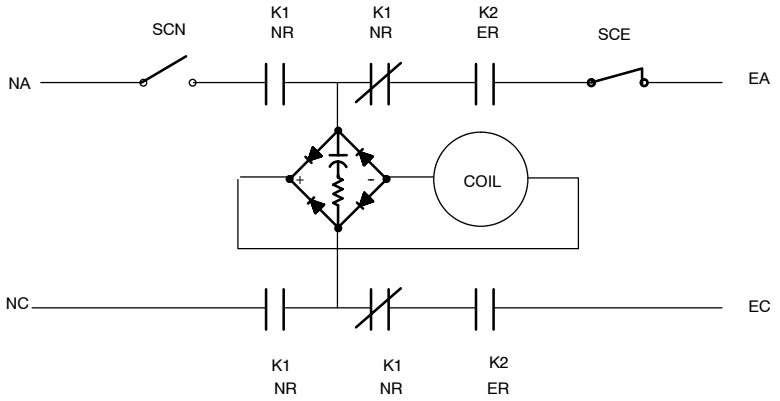
= closed contacts = open contacts

* Used on programmed-transition switch diagrams

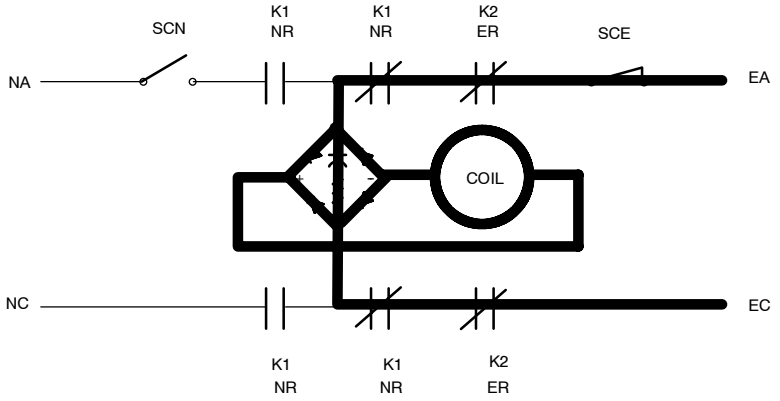
Figure 4-5 Legend for Solenoid Operation Diagrams

4.5.3 Solenoid Operation Diagrams, 40–225 Amp Model SDT/SMT Open Transition Switches

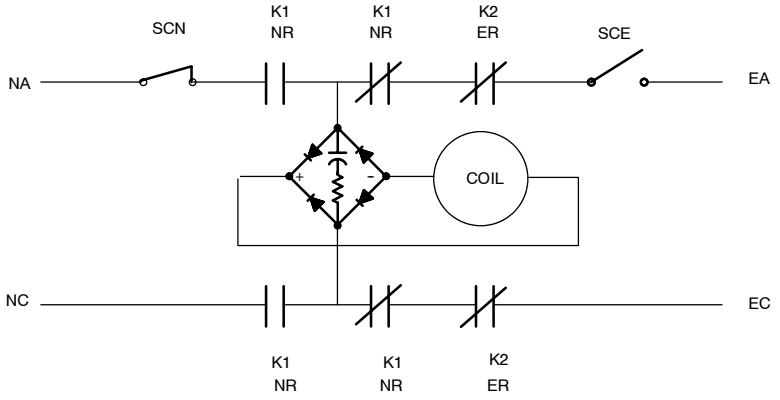
Source N position, Source N available. The solenoid coil is not energized.



Source N position, Source N lost. The coil is energized if Source E is available. The transfer switch is ready to transfer to Source E.



Source E position, Source E available. The solenoid coil is not energized.



Source E position, Source N available. The controller is calling for transfer to Source N. The coil is energized and the transfer switch will transfer to Source N.

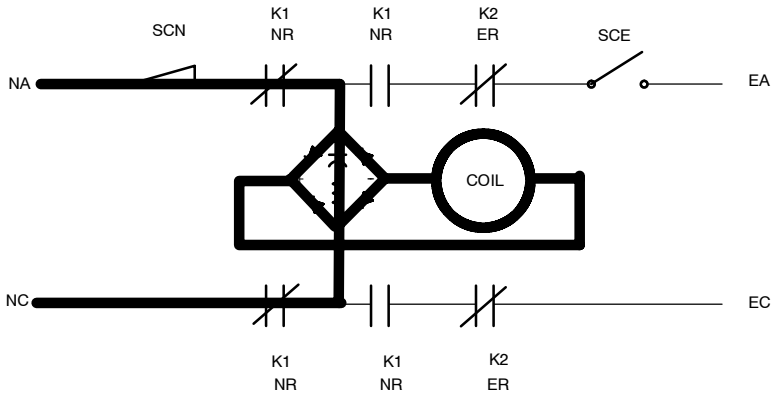
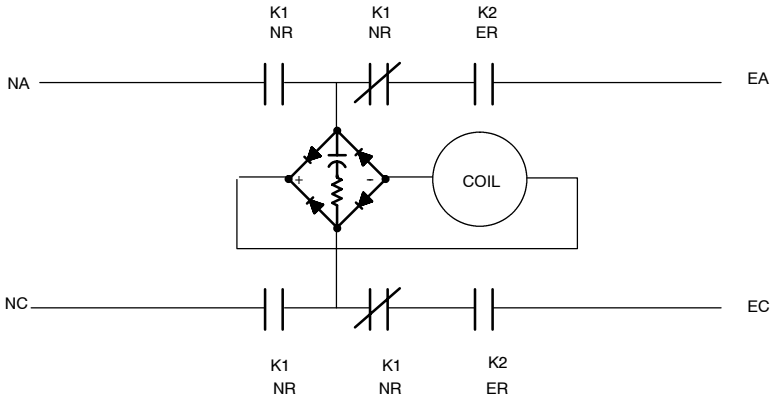


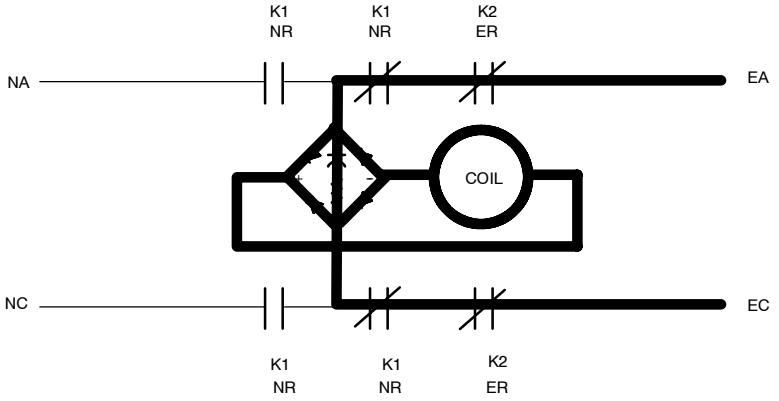
Figure 4-6 40–225 Amp Model SDT/SMT Open-Transition Switches, Solenoid Operation

4.5.4 Solenoid Operation Diagrams, 400–600 Amp Model SDT/SMT Open Transition Switches

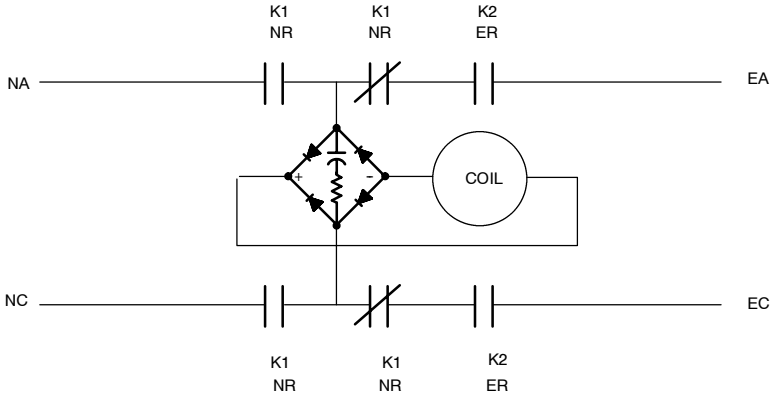
Source N position, Source N available. The solenoid coil is not energized.



Source N position, Source N lost. The coil is energized if Source E is available. The transfer switch is ready to transfer to Source E.



Source E position, Source E available. The solenoid coil is not energized.



Source E position, Source N available. The controller is calling for transfer to Source N. The coil is energized and the transfer switch will transfer to Source N.

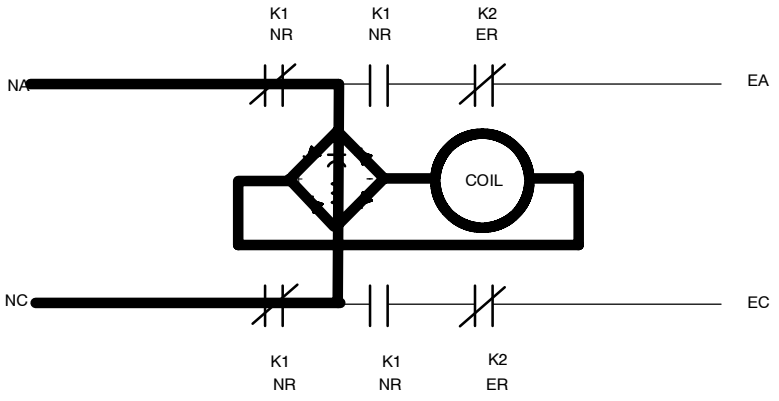


Figure 4-7 400–600 Amp Model SDT/SMT Open-Transition Switches, Solenoid Operation

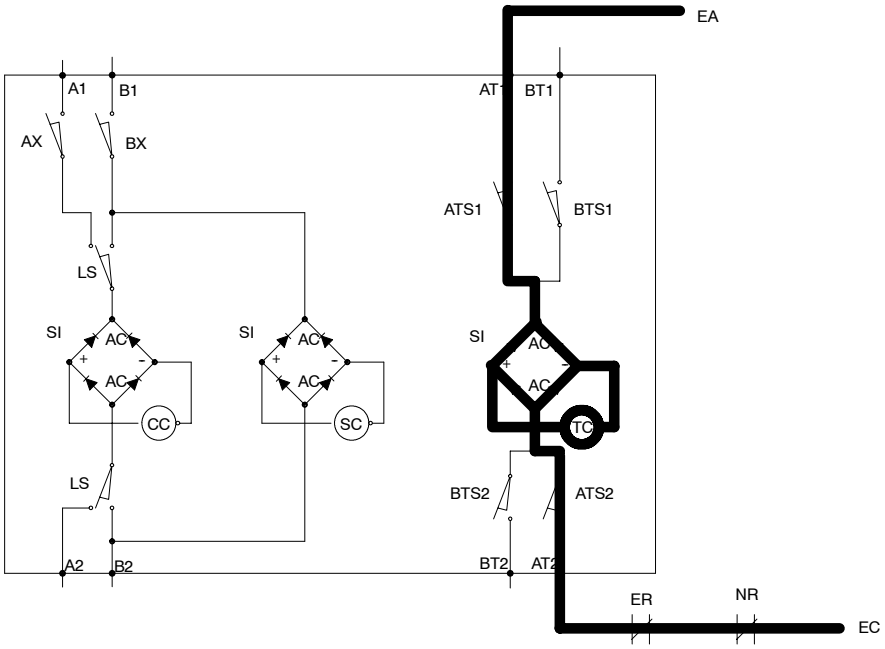
4.5.5 Solenoid Operation Diagrams, Model SDP/SMP Programmed-Transition Models

Normal to OFF

Source N position
Source N is lost
Emergency available

ER is pulsed for 250 ms to energize trip coil TC.

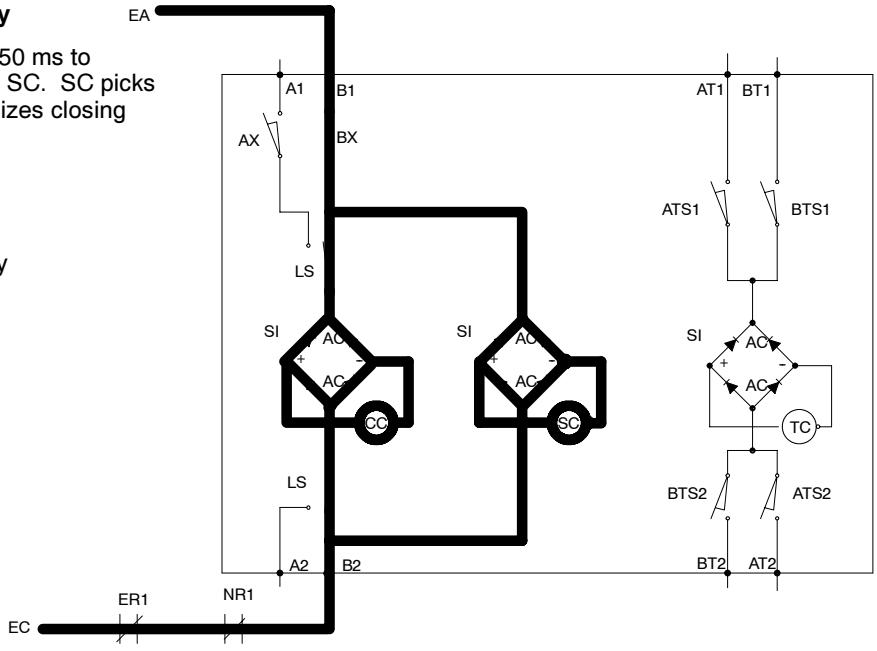
ATS1 AND ATS2:
Closed in Normal
Open in OFF



OFF to Emergency

ER1 is pulsed for 250 ms to energize select coil SC. SC picks up LS, which energizes closing coil CC

BX:
Closed in OFF
Open in Emergency



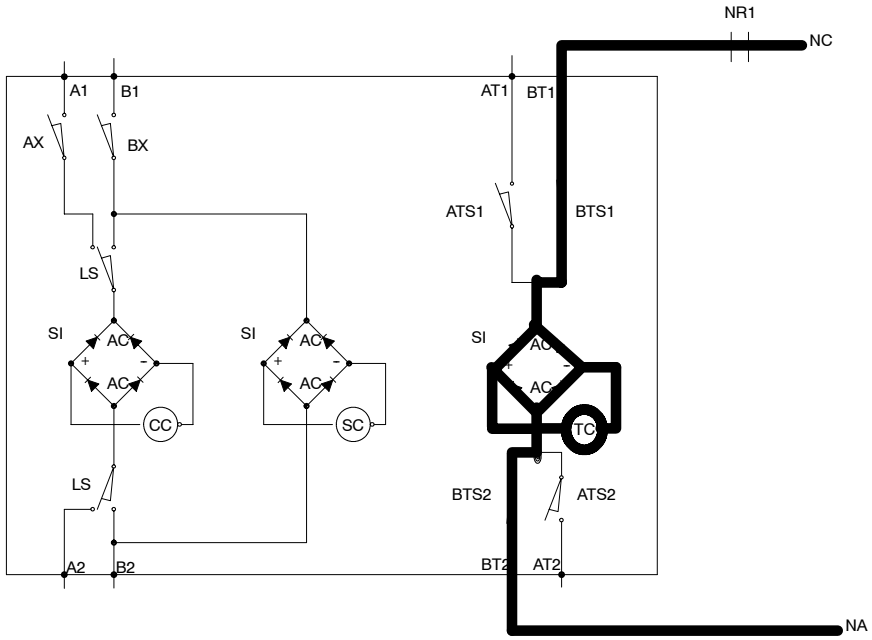
6226

Figure 4-8 Model SDP/SMP Programmed-Transition Switches, Transfer from Normal to Emergency

Emergency to OFF

NR1 is pulsed for 250 ms to energize trip coil TC.

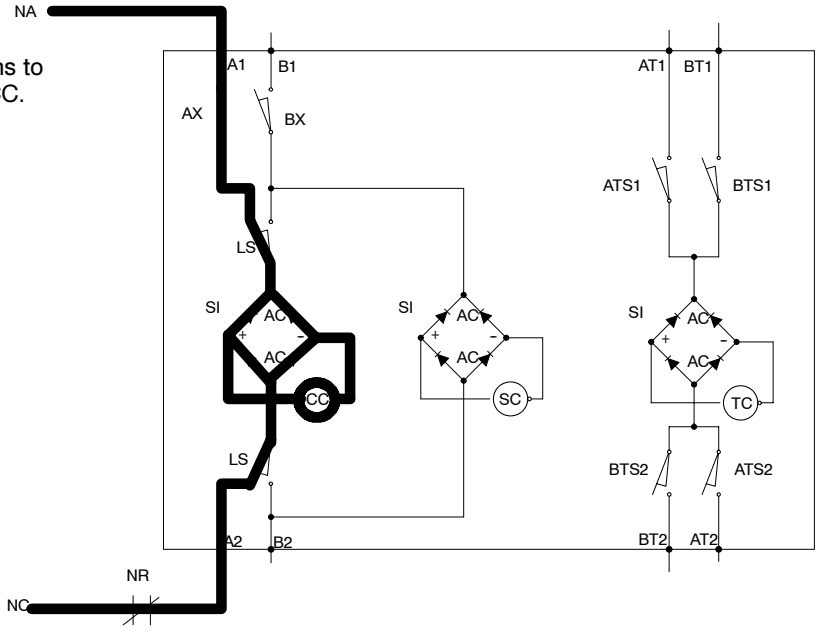
BTS1 and BTS2: Closed in Emergency Open in OFF



OFF to Normal

NR is pulsed for 250 ms to energize closing coil CC.

AX is closed in OFF.



#

Figure 4-9 Model SDP/SMP Programmed-Transition Switches, Transfer from Emergency to Normal

Notes

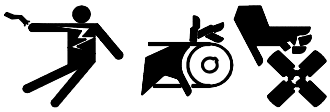
Section 5 Component Replacement, Model SDT/SMT Switches

5.1 Introduction

This section contains instructions for component replacement on model SDT/SMT open-transition transfer switches. See Section 6 for programmed-transition switches.

Observe the following safety precautions when performing any service procedures on the transfer switch.

⚠ 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.

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)

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.

5.2 Microswitch Replacement

Required tools and equipment:
Basic electricians hand tools
Microswitch
Required protective equipment:
Rubber insulating gloves class 0
Safety glasses
Electrical hazard safety shoes

5.2.1 40–260 Amp

Microswitch Replacement Procedure

1. Prevent all connected generator sets from starting.
   a. Place the generator set master switch in the OFF position.
   b. Disconnect the power to the battery charger, if equipped.
   c. Disconnect the generator set engine starting battery(ies), negative (–) lead first.

      Note: On systems with multiple transfer switches connected to a single generator set, disconnect all power sources to the generator set before proceeding.
2. Disconnect power to the transfer switch.
3. Open the transfer switch enclosure.
4. Verify zero volts across each phase.
5. Note the location of the fast-on connectors to the microswitch terminals. See Figure 5-1.

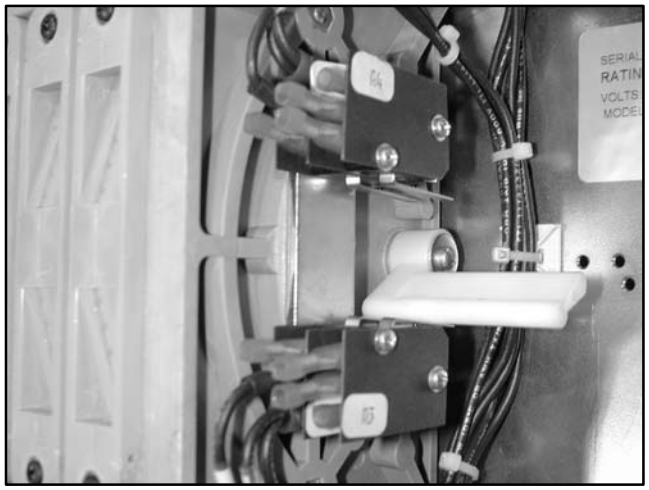


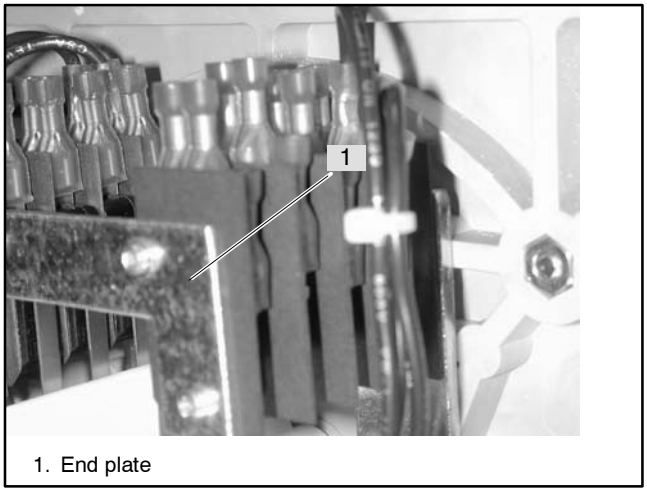
Figure 5-1 Microswitches

6. Disconnect the fast-on connectors.
7. Remove the holding screws.
8. Remove the suspect microswitch.

   Note: For SN/SE assemblies that have four microswitches, you must remove the end plate to access the microswitches. See Figure 5-2.
9. Install the new microswitch.

   Note: For SN/SE assemblies that have four microswitches, you must install an end plate for stability. See Figure 5-2.
10. Install the holding screws.
11. Tighten the holding screws to 0.3 Nm (3 in. lb.).
12. Connect the fast-on connections to the microswitch terminals. See Figure 5-1.

    Note: The terminals used were noted in step 5.
13. Close the ATS enclosure.
14. Connect power to the ATS.
15. Enable the generator set.
    a. Check that the generator set master switch is in the OFF position.
    b. Reconnect the generator set engine starting battery, negative (–) lead last.
    c. Reconnect power to the battery charger, if equipped.



1. End plate

Figure 5-2 End Plate (required for assemblies with four microswitches)

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

17. Test the transfer switch operation by performing the Automatic Operation Test described in Section 3.5.

    Note: Do not leave the transfer switch in the Test mode.

5.2.2 400–600 Amp

Microswitch Replacement Procedure

1. Prevent all connected generator sets from starting.

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

   b. Disconnect the power to the battery charger, if equipped.

   c. Disconnect the generator set engine starting battery(ies), negative (–) lead first.

      Note: On systems with multiple transfer switches connected to a single generator set, disconnect all power sources to the generator set before proceeding.

2. Disconnect power to the transfer switch.

3. Open the transfer switch enclosure.

4. Verify zero volts across each phase.

   Note: A3/A4 microswitches can still be energized with customer power. The microswitches may be used for primary alarm circuits or primary controlling devices. Verify that all power is disconnected before proceeding.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

5. Note the location of the fast-on connectors to the microswitch terminals. See Figure 5-3.

6. Disconnect the fast-on connectors. See Figure 5-4.

7. Remove the microswitch holding screws. See Figure 5-5.

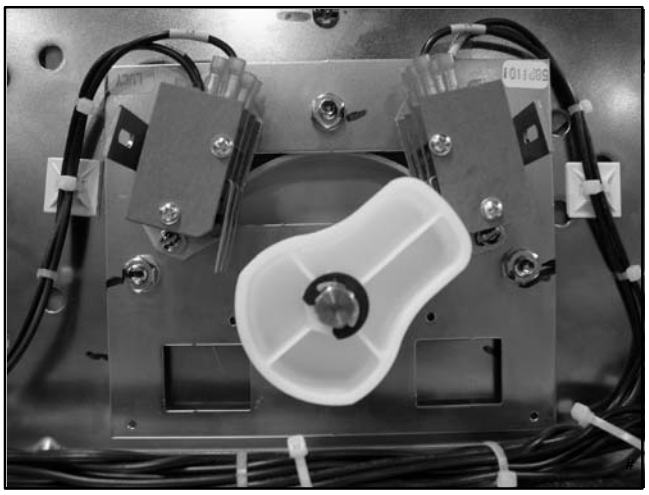


Figure 5-3 Microswitches

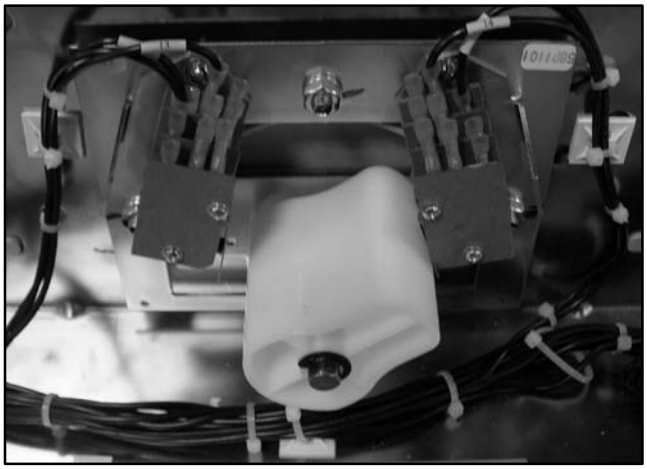


Figure 5-4 Microswitch Fast-On Connectors

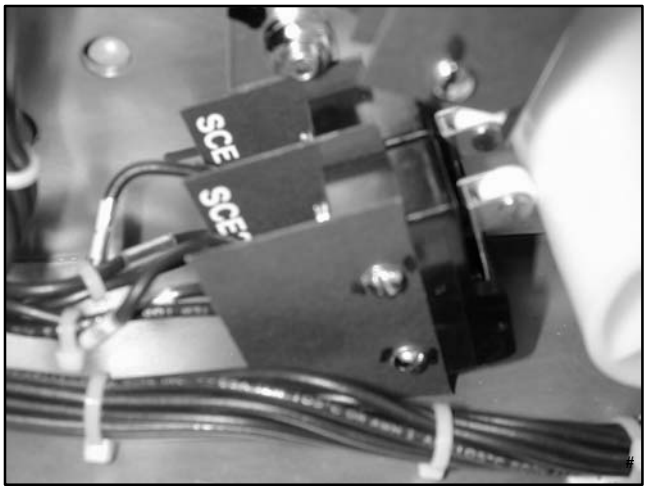


Figure 5-5 Microswitch Holding Screws

8. Remove the suspect microswitch.
9. Install the new microswitch.
10. Install the holding screws.
11. Tighten the holding screws to 0.3 Nm (3 in. lb.).
12. Connect the fast-on connections to the microswitch terminals as noted in step 5.
13. Close the transfer switch enclosure.
14. Connect power to the ATS.
15. Enable the generator set startup.
    a. Check that the generator set master switch is in the OFF position.
    b. Reconnect the generator set engine starting battery, negative (–) lead last.
    c. Reconnect power to the battery charger, if equipped.
16. Test the transfer switch operation by performing the Automatic Operation Test described in Section 3.5.

    Note: Do not leave the transfer switch in the Test mode.

5.3 Power Panel Replacement

Required tools and equipment:
Basic electricians hand tools
Multimeter digital or analog
Wiring harness
Tie wraps
Required protective equipment:
Rubber insulating gloves class 0
Safety glasses
Electrical hazard safety shoes

Power Panel Replacement Procedure

1. Disable all connected generator sets.
2. Disconnect primary and emergency power to the transfer switch.
3. Open the enclosure.
4. Check for zero volts on the normal and emergency power lugs.
5. Remove the tie wraps securing the harness.
6. Disconnect the power panel harness from the controller harness.

   Note: The replacement power panel is shipped with a factory-wired power panel harness.
7. Disconnect the engine start leads from the ATS engine start terminals.
8. Disconnect the emergency power supply cables from the switch.

   Note: Mark each cable as to its position as it is removed from the switch. Example: E1, E2 and E3 for the emergency side of the switch.
9. Disconnect the normal power supply cables from the switch, marking the cables as they are removed.
10. Disconnect the load cables from the switch, marking the cables as they are removed.
11. Remove the four nuts securing the power panel.
12. Remove the power panel.
13. Install the new power panel onto the studs in the back of the enclosure. See Figure 5-6.
14. Fasten the power panel with flat washers, lock washers and nuts.
15. Torque the nuts to 7.3 Nm (65 in. lb.).
16. Connect the power panel harness to the controller harness at the inline connector.
17. Connect the load cables to the T terminals.
18. Tighten the connecting bolts to 16.3 Nm (12 ft. lb.).
19. Connect the normal cables to the N terminals.

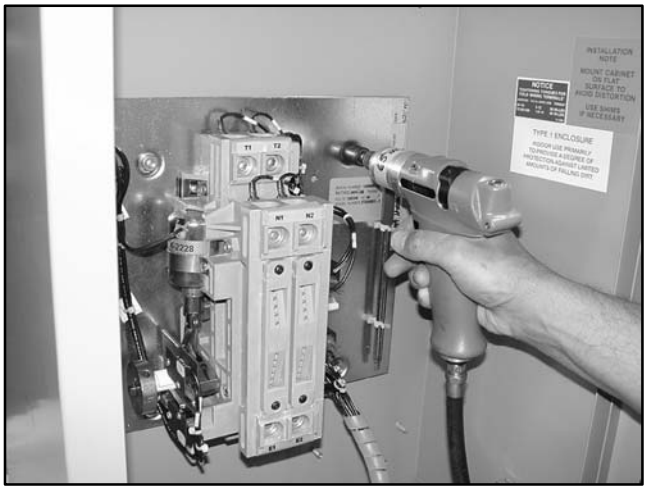


Figure 5-6 Installing the Power Panel

20. Tighten the connecting bolts to 16.3 Nm (12 ft. lb.).

21. Connect the emergency supply cables to the E terminals.

22. Tighten the connecting bolts to 16.3 Nm (12 ft. lb.).

23. Install tie wraps as needed to secure the harness.

24. Connect the generator set engine start leads.

25. Close the transfer switch enclosure.

26. Connect power to the ATS.

27. Enable the generator set.

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

    b. Reconnect the generator set engine starting battery, negative (-) lead last.

    c. Reconnect power to the battery charger, if equipped.

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

29. Test the transfer switch operation by performing the Automatic Operation Test described in Section 3.5.

    Note: Do not leave the transfer switch in the Test mode.

5.4 Arc Chute Replacement

Required tools and equipment:
Basic electricians hand tools
Arc chute
Required protective equipment:
Rubber insulating gloves class 0
Safety glasses
Electrical hazard safety shoes

Arc Chute Replacement Procedure

1. Prevent all connected generator sets from starting.

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

    b. Disconnect the battery charger, if equipped.

    c. Disconnect the generator set engine starting batter(ies), negative (-) lead first.

2. Disconnect power to the transfer switch.

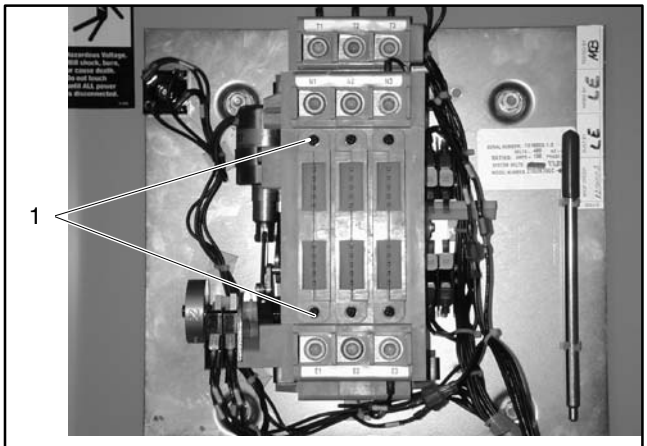
3. Open the transfer switch enclosure.

4. Verify zero volts across each phase.

5. Remove the arc chute hold down screws. See Figure 5-7.

6. Remove the arc chute.

7. Inspect the movable contact for damage. See Figure 5-8. If damage is found, order a replacement power panel and continue to Step 8.



1. Arc chute hold down screws

Figure 5-7 Arc Chute Screws

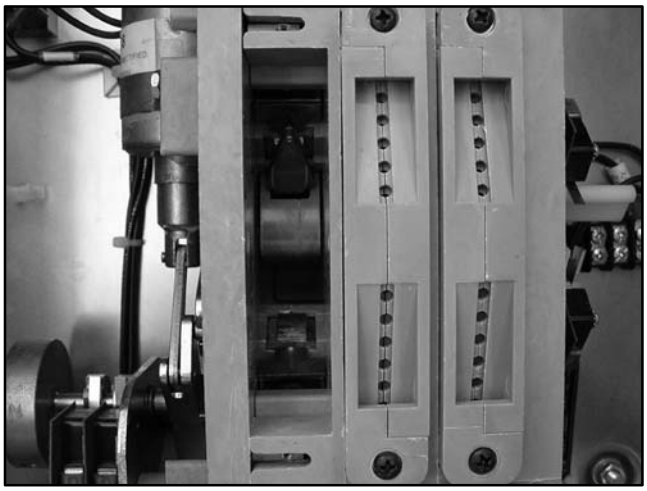


Figure 5-8 Movable Contacts (arc chute removed)

8. Install the new arc chute.
9. Install the holding screws and washers.
10. Torque screws to 2.8 Nm (25 in. lb.).
11. Manually operate the switch several times to ensure that it does not stick. See Figure 5-9.
12. Close the enclosure.
13. Reconnect power to the ATS.
14. Enable the generator set.
    a. Check that the generator set master switch is in the OFF position.
    b. Reconnect the generator set engine starting batter(ies), negative (–) lead last.
    c. Reconnect the battery charger, if equipped.
15. Move the generator set master switch to the AUTO position.
16. Test the transfer switch operation by performing the Automatic Operation Test Procedure described in Section 3.5.

    Note: Do not leave the transfer switch in the Test mode.

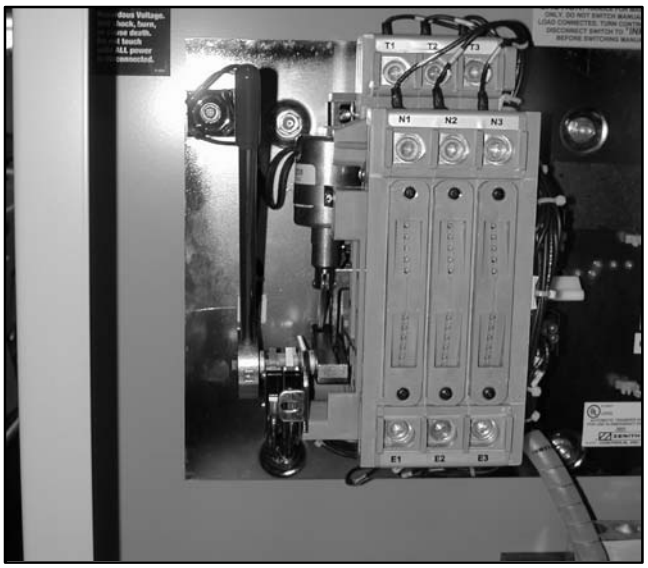


Figure 5-9 Manual Operation Handle Inserted

5.5 Limit Switch Assembly Replacement

Required tools and equipment:
Basic electricians hand tools
Multimeter digital or analog
Limit switch
Required protective equipment:
Rubber insulating gloves class 0
Safety glasses
Electrical hazard safety shoes

Procedure

1. Prevent all connected generator sets from starting.
    a. Place the generator set master switch in the OFF position.
    b. Disconnect the battery charger, if equipped.
    c. Disconnect the generator set engine starting batter(ies), negative (–) lead first.
2. Disconnect power to the transfer switch.
3. Open the transfer switch enclosure.
4. Verify zero volts across each phase.
5. Note the location of the fast-on connections to the SCN/SCE microswitch terminals.
6. Disconnect the fast-on connectors. See Figure 5-10.

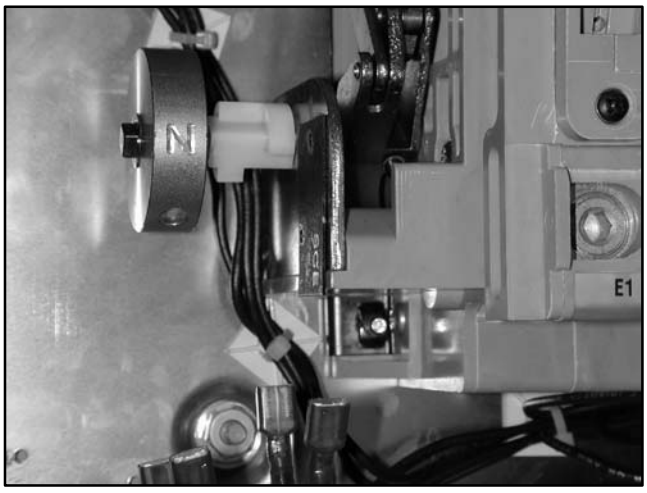


Figure 5-10 Microswitch Fast-On Connectors

7. Remove the holding screws. Note the microswitch labels on the insulators. See Figure 5-11.

8. Remove the microswitch assembly.

9. Remove the suspect microswitch. See Figure 5-12.

10. Install the new microswitch into the assembly.

    Note: Replace SCN/SCE insulators in the correct order. Normally, the SCE is closest to the base.

11. Reinstall the microswitch assembly. See Figure 5-13.

    a. Install the holding screws.

    b. Tighten the holding screws.

    c. Connect the fast-on connections to the microswitch terminals as noted in step 5.

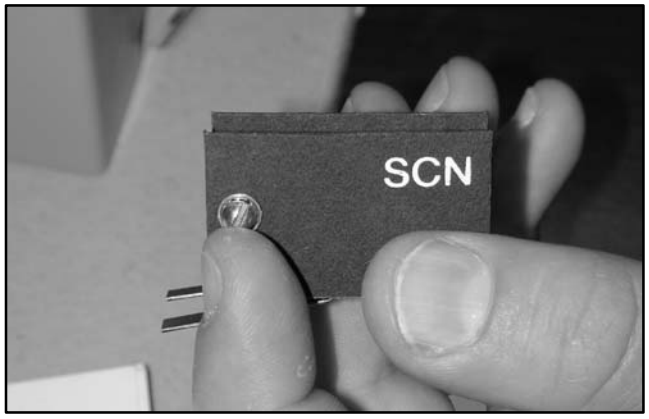


Figure 5-11 Microswitch Insulator with Label

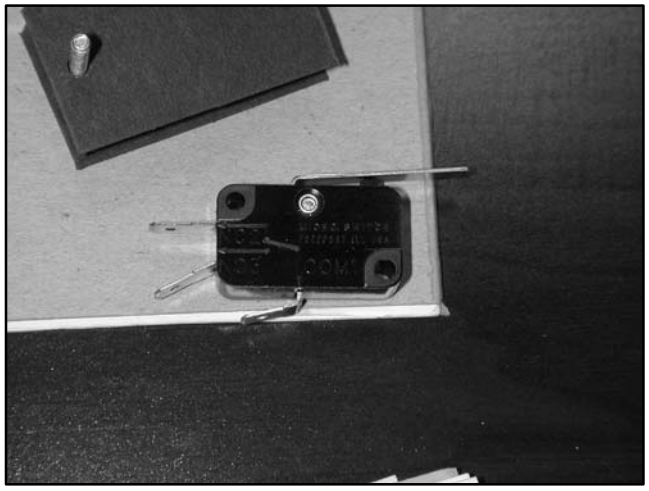


Figure 5-12 Microswitch

12. Clean the inside of the ATS.

13. Close and lock the enclosure.

14. Connect power to the ATS.

15. Enable the generator set startup.

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

    b. Reconnect the generator set engine starting batter(ies), negative (–) lead last.

    c. Reconnect the battery charger, if equipped.

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

17. Test the transfer switch operation by performing the Automatic Operation Test Procedure described in Section 3.5.

    Note: Do not leave the transfer switch in the Test mode.

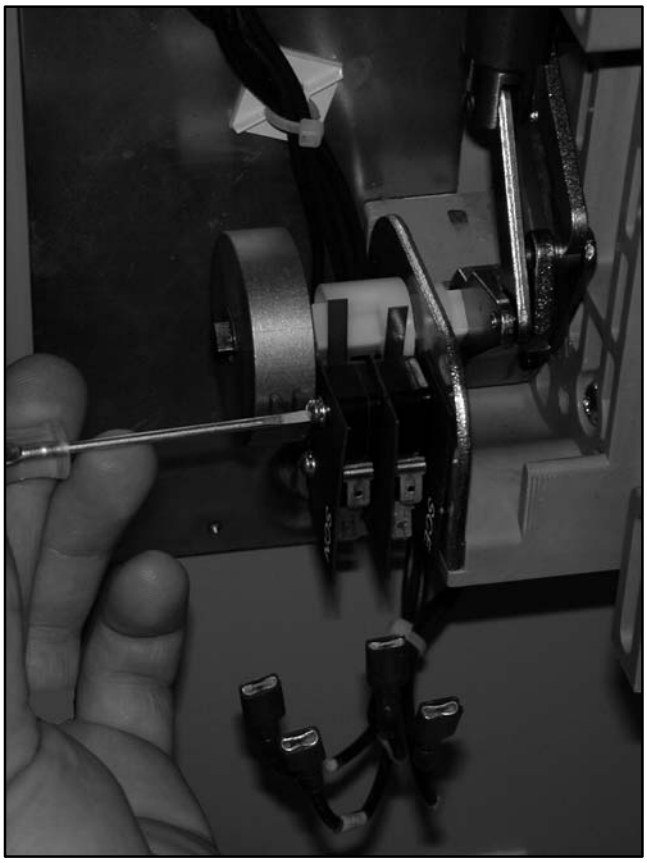


Figure 5-13 Microswitch Installation

5.6 Solenoid and Rectifier Replacement

5.6.1 Solenoid and Rectifier Replacement, 40–225 Amp Models

Required tools and equipment:
Basic electricians hand tools
Multimeter digital or analog
Solenoid
Tie wraps
Required protective equipment:
Rubber insulating gloves class 0
Safety glasses
Electrical hazard safety shoes

Procedure

1. Open the ATS enclosure.
2. Prevent all connected generator sets from starting.
   a. Place the generator set master switch in the OFF position.
   b. Disconnect the battery charger, if equipped.
   c. Disconnect the generator set engine starting batter(ies), negative (–) lead first.
3. Disconnect main power.
4. Verify zero volts across each phase.
5. Remove DC fast-on connections from the rectifier terminals. See Figure 5-14.

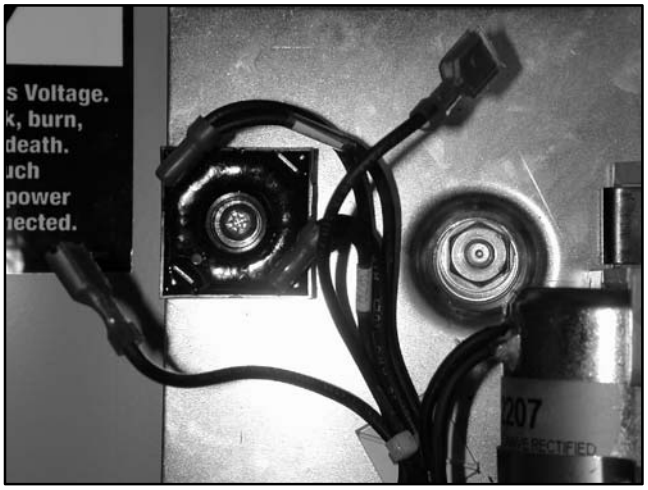


Figure 5-14 Rectifier Connections (DC solenoid leads shown disconnected)

6. Check the coil resistance. See Figure 5-15.

   Note: If the resistance reading is infinite or shorted, replace the coil.

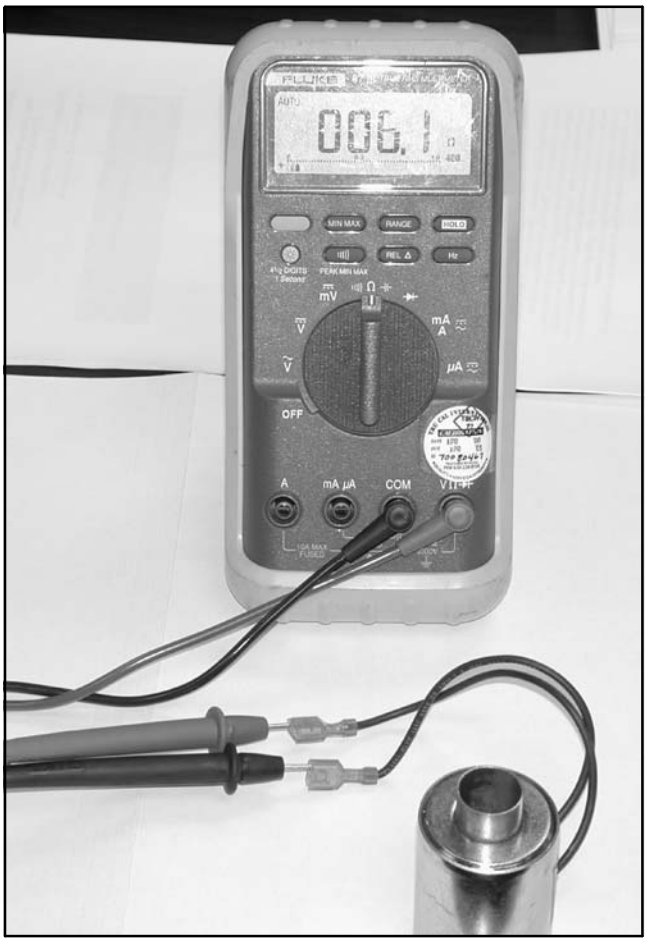


Figure 5-15 Checking Coil Resistance

Rectifier Check and Replacement

7. Remove the AC fast-on connections from the AC terminals of the rectifier.
8. Check the diode operation of the rectifier. See Figure 5-16 and Section 4.4 for rectifier test instructions. If the rectifier is good, go to step 11. If the rectifier is bad, continue on.
9. Remove the faulty rectifier.
10. Install the new rectifier so that the red dot is in the upper right corner.
11. Connect the AC fast-on connections to the AC terminals.

    Note: The AC terminals are in the upper left and lower right hand corners.

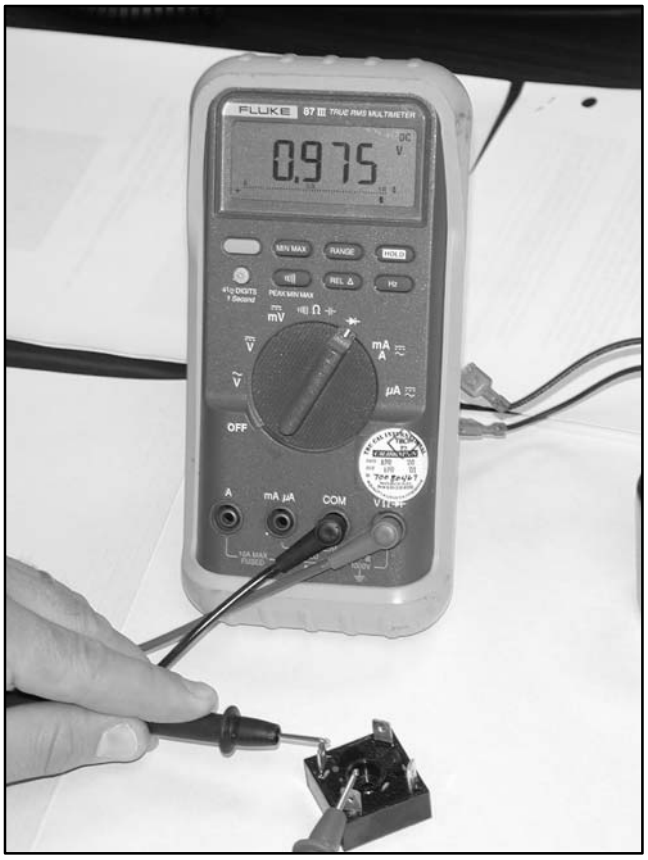


Figure 5-16 Checking Diode Operation of Rectifier

Solenoid Replacement

⚠ WARNING

Spring-loaded parts.
Can cause severe personal injury or property damage.

Wear protective goggles when servicing spring-loaded parts. Hold parts securely during disassembly.

Disassembling the solenoid. Spring-loaded parts can cause severe personal injury or property damage. The spring in the solenoid assembly exerts substantial force on the coil. Hold the coil assembly securely when removing the screws.

12. Remove tie wraps, as necessary.

    Note: Do not cut the insulation on the wiring.

13. Remove the front bolt of the coil securing the strap. See Figure 5-17.

14. Loosen the rear bolt of the coil securing the strap.

15. Remove the coil.

    Note: The plunger assembly is spring-loaded. See Figure 5-18.

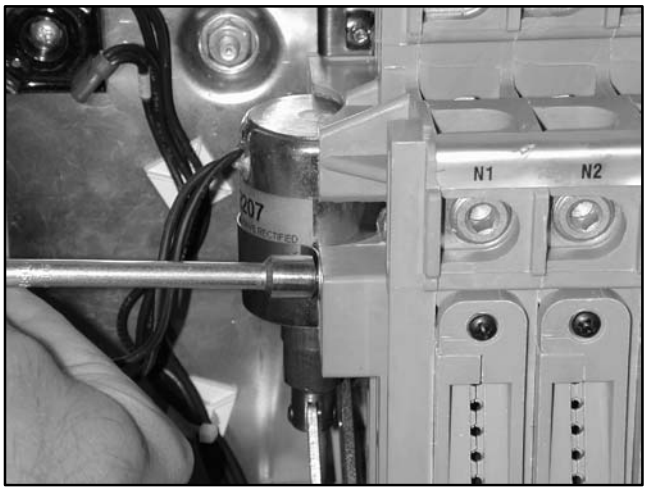


Figure 5-17 Coil Securing Strap

Figure 5-18 Spring and Plunger Assembly

16. Lubricate the spring and plunger assembly.

17. Insert the spring into the new coil.

    Note: Insert and seat the spring into the spring holder of the coil. The spring should be centered in the hole. See Figure 5-19.

Figure 5-19 Spring Holder in Coil

18. Install the plunger into the new coil.

    Note: The spring will slide into the plunger. See Figure 5-18.

19. Install the new coil into the coil slot.

20. Install the coil holding strap.

21. Tighten the bolts for the coil holding strap. See Figure 5-17.

22. Connect the DC fast-on connections to the DC terminals of the rectifier.

    Note: The DC terminals are in the lower left and upper right hand corners.

23. Install any required tie wraps.

24. Close the enclosure.

25. Reconnect power to the ATS.

26. Enable the generator set startup.

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

    b. Reconnect the generator set engine starting batter(ies), negative (-) lead last.

    c. Reconnect the battery charger, if equipped.

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

28. Test the transfer switch operation by performing the Automatic Operation Test Procedure described in Section 3.5.

    Note: Do not leave the transfer switch in the Test mode.

5.6.2 Solenoid and Rectifier Replacement, 400-600 Amp Models

Required tools and equipment:
Basic electricians hand tools
Multimeter digital or analog
Solenoid
Tie wraps
Required protective equipment:
Rubber insulating gloves class 0
Safety glasses
Electrical hazard safety shoes

Procedure

1. Prevent all connected generator sets from starting.

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

    b. Disconnect the battery charger, if equipped.

    c. Disconnect the generator set engine starting batter(ies), negative (-) lead first.

2. Disconnect main power and open the ATS enclosure.

3. Verify zero volts across each phase.

4. Remove the DC fast-on connections from the rectifier terminals. See Figure 5-20.

   Note: A red dot identifies one DC terminal. The other DC terminal is at the opposite corner of the rectifier.

5. Check the coil resistance.

   Note: If reading is infinite or shorted, replace coil.

Figure 5-20 Rectifier Fast-On Connectors (contactor shown on the bench)

Rectifier Check and Replacement

6. Remove the AC fast-on connections from the AC terminals of the rectifier.

7. Check the diode operation of the rectifier. See Figure 5-21 and Section 4.4 for rectifier test instructions. If the rectifier is bad, replace it. If the rectifier is good, proceed to step 9.

8. Replace the rectifier. Orient the new rectifier so that the red dot is in the upper right corner when the contactor is mounted in the enclosure.

9. Connect AC fast-on connections to AC terminals.

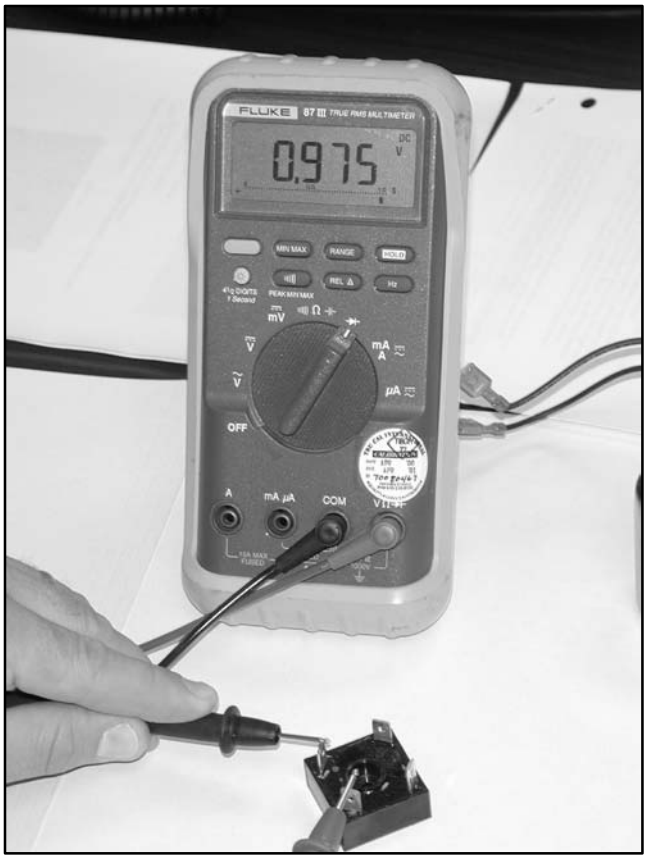


Figure 5-21 Checking Rectifier Diode Operation

Solenoid Replacement

⚠ WARNING

Spring-loaded parts.
Can cause severe personal injury or property damage.

Wear protective goggles when servicing spring-loaded parts. Hold parts securely during disassembly.

Disassembling the solenoid. Spring-loaded parts can cause severe personal injury or property damage. The spring in the solenoid assembly exerts substantial force on the coil. Hold the coil assembly securely when removing the screws.

10. Note the rectifier connections and disconnect the AC leads. See Figure 5-22.

11. Remove tie wraps as necessary.

    Note: Be careful to avoid cutting the insulation on the leads.

12. Place the switch in the Normal position.

13. Mark the location of the solenoid assembly mounting bracket.

14. Hold the solenoid coil firmly and remove the four screws and washers. See Figure 5-22.

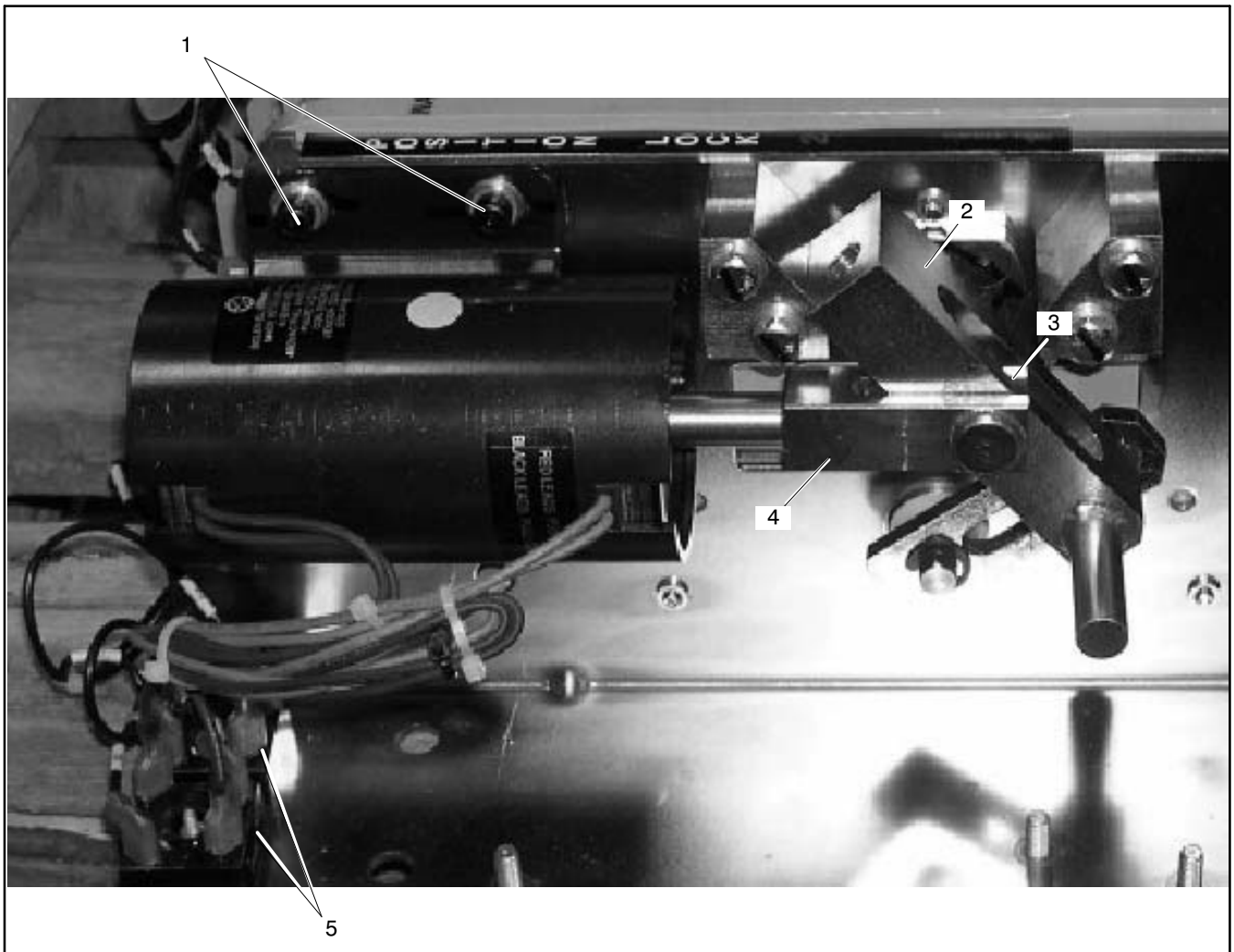
15. Pull the solenoid assembly with the attached linkage away from the contactor.

    Note: The sealed solenoid coil assembly contains the coil and the plunger. Do not attempt to remove the plunger from the coil assembly.

16. Remove the clip that secures the plunger to the linkage and remove the linkage from the coil assembly.

17. Use the clip to attach the linkage to the new coil assembly.

18. Place the new solenoid assembly into position, aligning the linkage pins with the mechanism slots. See Figure 5-22.



1. Mounting screws with washers (4 ea.)
2. Linkage
3. Clip location (not visible this view)
4. Plunger
5. Rectifier connections

Figure 5-22 Solenoid Assembly (shown on the bench)

19. Insert four mounting screws with washers and align the mounting bracket with marks made in step 13.

20. Tighten all four bolts to 10.8 Nm (96 in. lb).

21. Connect the DC fast-on connections to the DC terminals of the rectifier. See Figure 5-23.

    Note: A red dot identifies one DC terminal. The other DC terminal is at the opposite corner.

22. Install any required tie wraps. See Figure 5-23.

23. Close the ATS enclosure.

24. Reconnect power to the ATS.

25. Enable the generator set startup.

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

    b. Reconnect the generator set engine starting batter(ies), negative (-) lead last.

    c. Reconnect the battery charger, if equipped.

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

27. Test the transfer switch operation by performing the Automatic Operation Test Procedure described in Section 3.5.

    Note: Do not leave transfer switch in Test mode.

Figure 5-23 Rectifier Connections and Tie Wraps

Notes

6.1 Introduction

This section contains instructions for component replacement on Model SDP/SMP programmed-transition transfer switches.

Illustrations in this section show the transfer switch removed from the enclosure and placed on a bench. Remove the transfer switch from the enclosure if necessary to access components.

Read and follow all safety precautions before servicing the transfer switch.

⚠ 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.

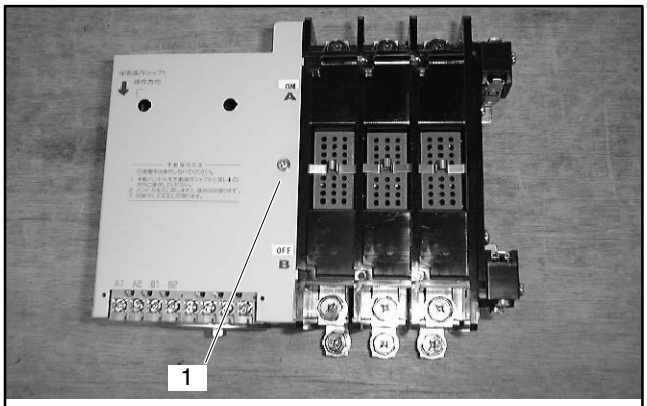
Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Open the main circuit breakers of all transfer switch power sources and disable all generator sets as follows: (1) Move all generator set master controller switches to the 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.

6.2 Component Replacement, 100-400 Amp Models

6.2.1 Disassembly, 100-400 Amps

Disassemble the mechanical unit and the current-carrying unit.

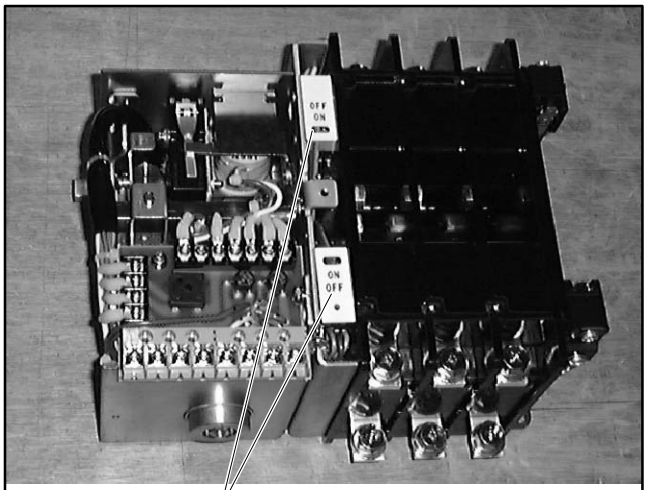
1. Loosen the M4 bolt and remove the cover from the mechanical unit. See Figure 6-1.



1. M4 bolt

Figure 6-1 Removing Cover

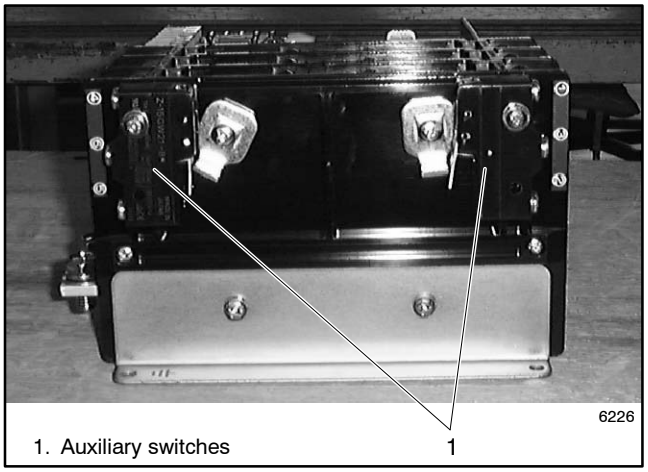
2. Remove the ON/OFF indicators. Save the indicators for installation during reassembly. See Figure 6-2.



1. ON/OFF indicators

Figure 6-2 ON/OFF Indicators

3. Remove the auxiliary switches. See Figure 6-3.

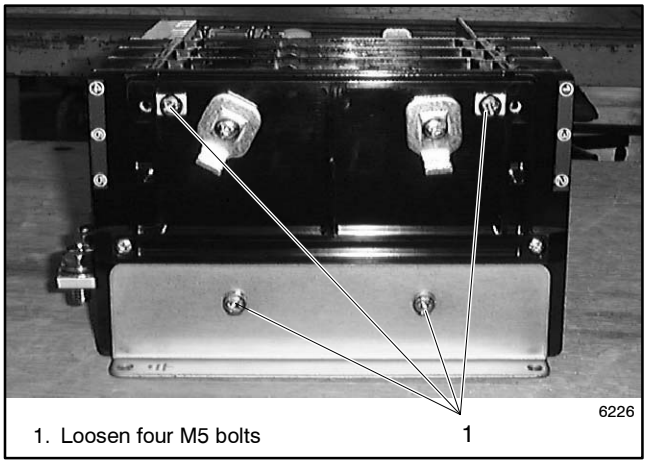


1. Auxiliary switches

Figure 6-3 Auxiliary Switches

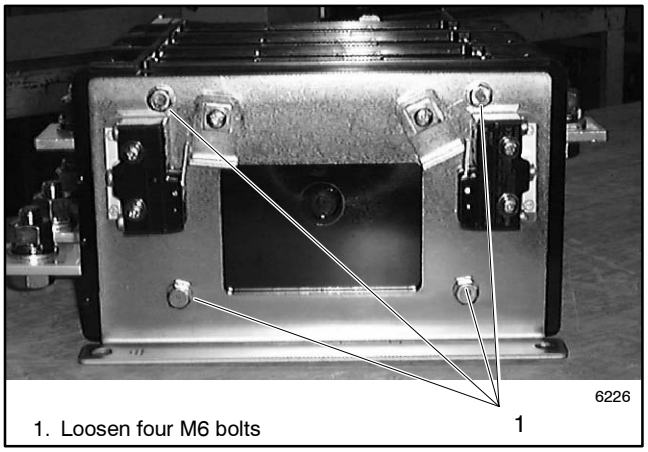
4. Loosen four bolts and separate the mechanical unit from the current-carrying unit. See Figure 6-4, Figure 6-5, and Figure 6-6.

   Note: The current-carrying unit on 400-models is made up of sections that will separate when disassembled.



1. Loosen four M5 bolts

Figure 6-4 Separating Units, 100 and 200 Amp



1. Loosen four M6 bolts

Figure 6-5 Separating Units, 400 Amp

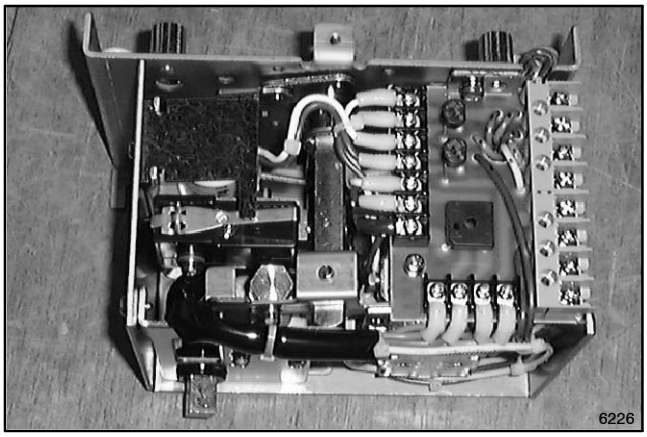


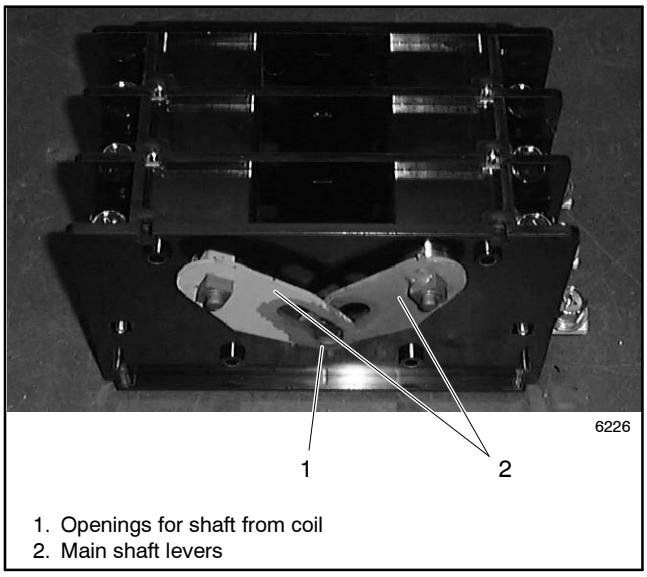
Figure 6-6 Mechanical Unit

6.2.2 Reassembly, 100–400 Amps

Reassemble the mechanical unit and the current-carrying unit.

1. Assemble the current-carrying unit and the mechanical unit. Make sure that the shaft from the mechanical unit goes through both main shaft levers. See Figure 6-7.

   On 400-amp units, the current-carrying unit is made up of separate sections. Make sure that the sections are flush across the front when reassembling.

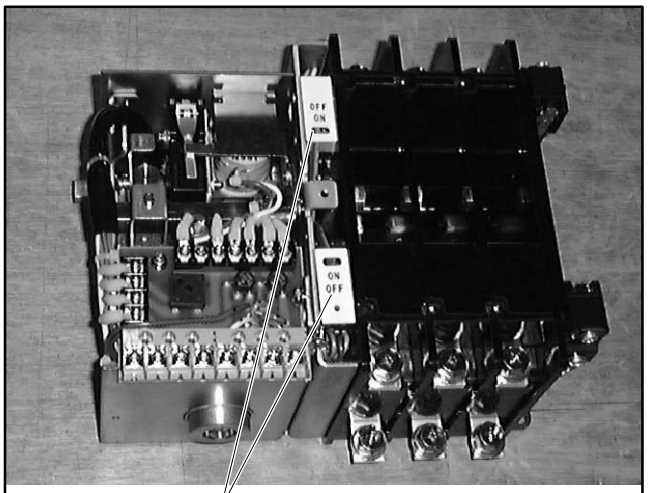


1. Openings for shaft from coil
2. Main shaft levers

Figure 6-7 Current-Carrying Unit

2. Replace the ON/OFF indicators and the cover.

Note: The ON/OFF indicators are not identical. Locate them as shown in Figure 6-8.

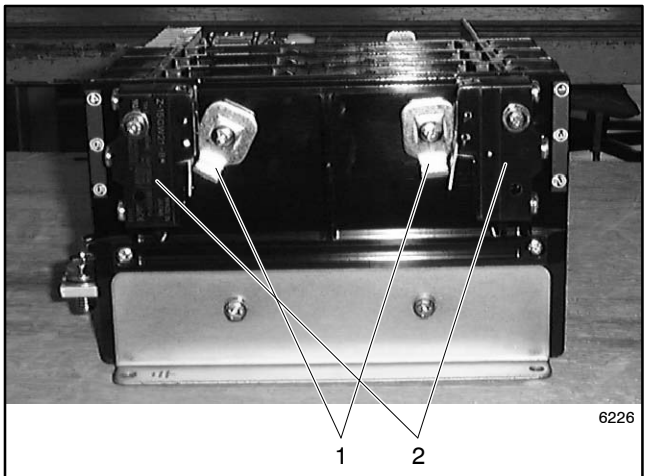


1. ON/OFF indicators

Figure 6-8 Assembled Units

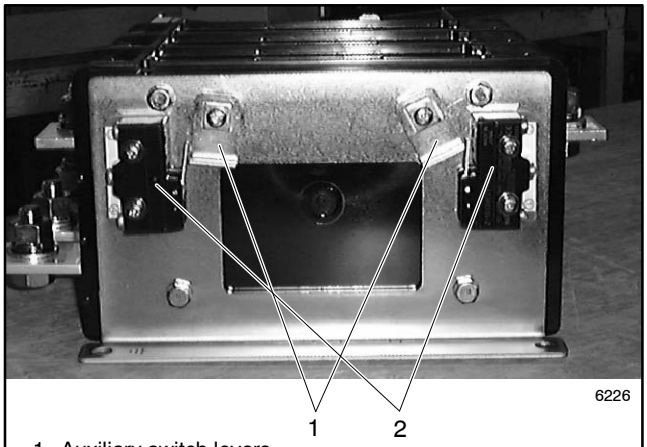
3. Reinstall the auxiliary switch levers, if removed, aligning the square indentation with the end of the square shaft. See Figure 6-9 and Figure 6-10.

4. Reinstall the auxiliary switches, if removed. The 100 and 200 amp models use one bolt and one alignment pin per switch. See Figure 6-9. Larger models use two bolts per switch. See Figure 6-10.



1. Auxiliary switch levers
2. Auxiliary switches

Figure 6-9 100 and 200 Amp Models



1. Auxiliary switch levers
2. Auxiliary switches

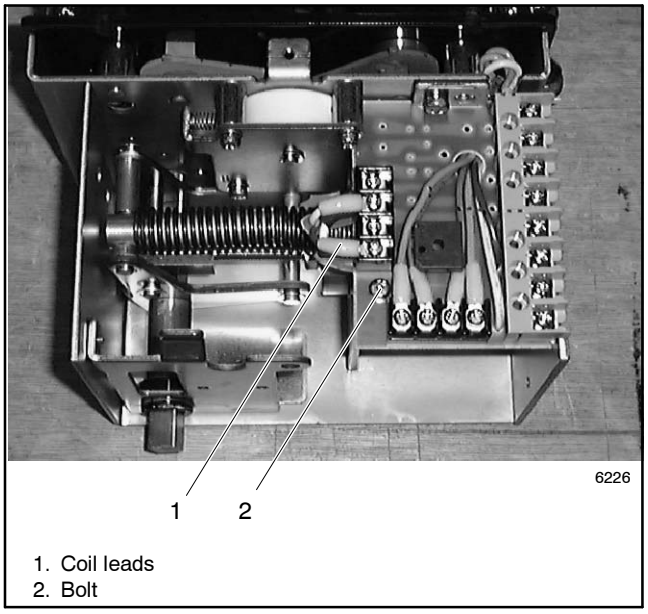
Figure 6-10 400 Amp Models

6.2.3 Printed Circuit Board Replacement, 100–400 Amps

Separate the current-carrying unit from the mechanical unit. See Section 6.2.1.

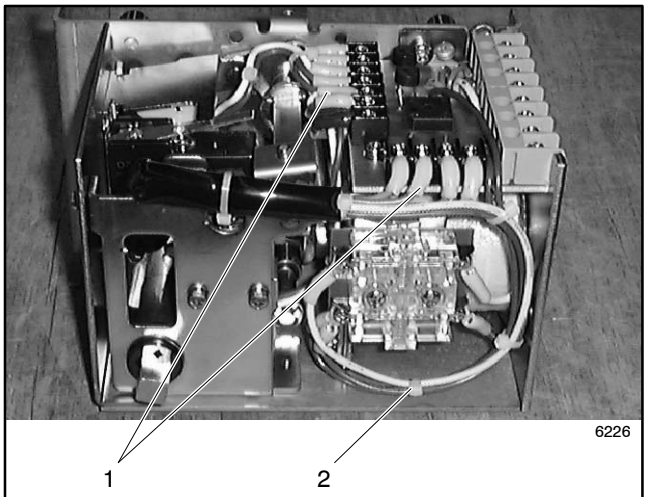
1. Note the connections (for reconnection later) and disconnect the printed circuit board leads. See Figure 6-11 or Figure 6-12.
2. Disconnect the control switch leads at three terminals. See Figure 6-12.

   Note: Hold the terminals while loosening the screws to avoid damage.
3. Note the connections (for reconnection later) and disconnect the control switch leads at eight locations. See Figure 6-13.
4. Remove the bolt and replace the printed circuit board. See Figure 6-11.
5. Reconnect all leads as noted during step 1.



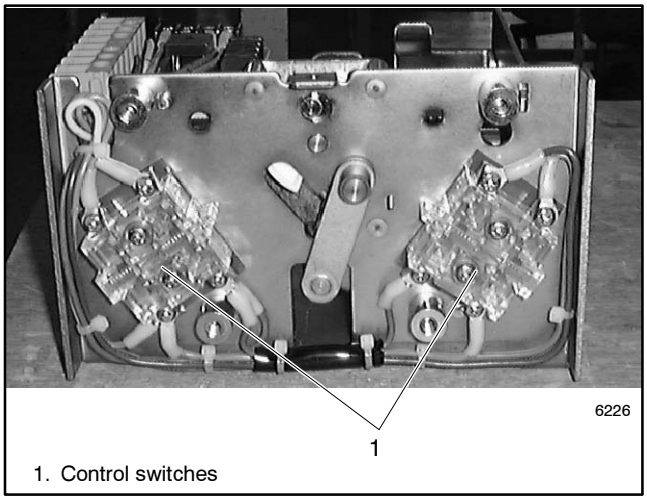
1. Coil leads
2. Bolt

Figure 6-11 Circuit Board Connections



1. Printed circuit board leads
2. Switch leads

Figure 6-12 Control Switch Wiring



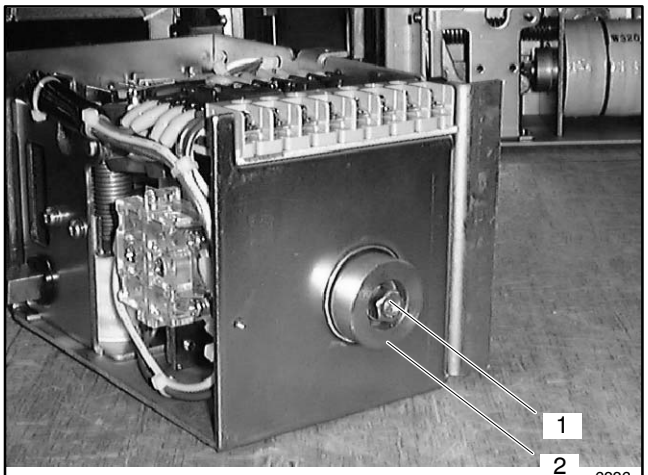
1. Control switches

Figure 6-13 Control Switches

6.2.4 Closing Coil Replacement, 100–400 Amps

1. Push the trip button.

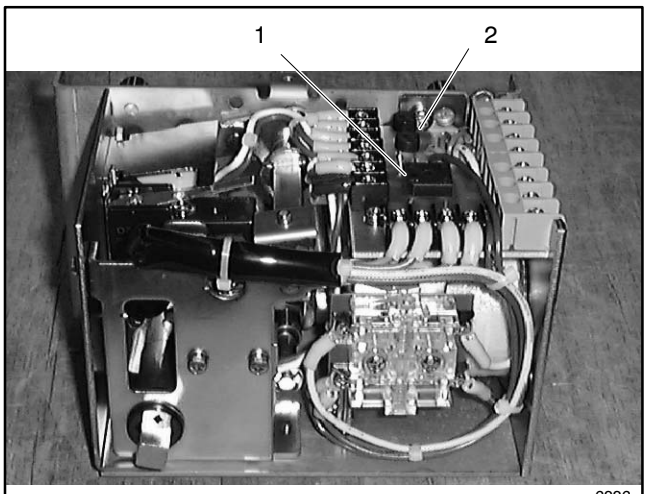
2. Remove the M6 nut and washer. Turn the movable steel shaft counterclockwise to remove it. See Figure 6-14.



1. M6 nut and washer
2. Movable steel shaft

Figure 6-14 Movable Steel Shaft, 100–400 Amp Models

3. Remove the printed circuit board. See Figure 6-15 and Section 6.2.3.

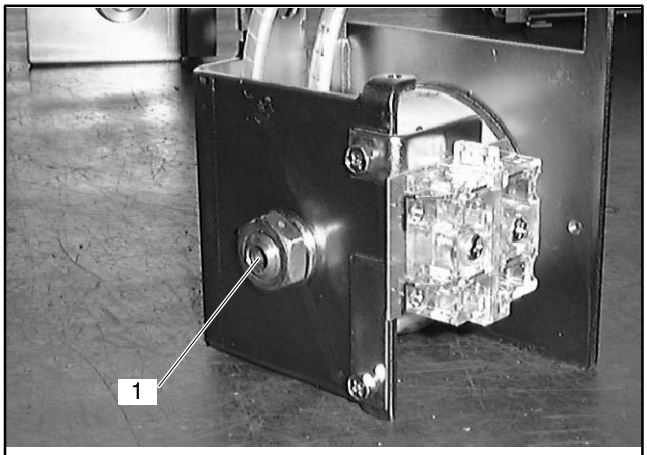


1. Printed circuit board
2. M6 bolt location

Figure 6-15 Printed Circuit Board and M6 Bolt (for closing coil)

4. Loosen the M6 bolt and remove the frame with the coil. See Figure 6-15 and Figure 6-16.

5. Loosen the M12 nut and replace the closing coil. See Figure 6-16.



1. M12 nut

Figure 6-16 Closing Coil with Frame, 100–400 Amp Models

6. Reinstall movable steel shaft. To adjust the shaft:

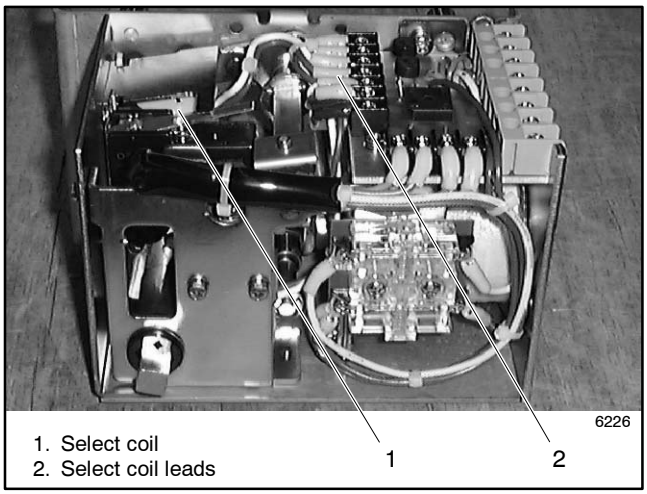
   a. Turn the large round shaft in (clockwise) until mechanism just latches when operated with the manual handle. If turned too far, it won't latch.

   b. Back the shaft out (counterclockwise) one full rotation from the limit of the switching range.

   c. Install the washer and nut. Hold the shaft to prevent it from turning while tightening the nut.

6.2.5 Select Coil Replacement, 100–400 Amps

1. Note connections and disconnect select coil leads. See Figure 6-17. Cut the cable tie, if necessary.



1. Select coil
2. Select coil leads

Figure 6-17 Select Coil Connections

2. Remove two M4 bolts shown in Figure 6-18 and remove the select coil assembly.

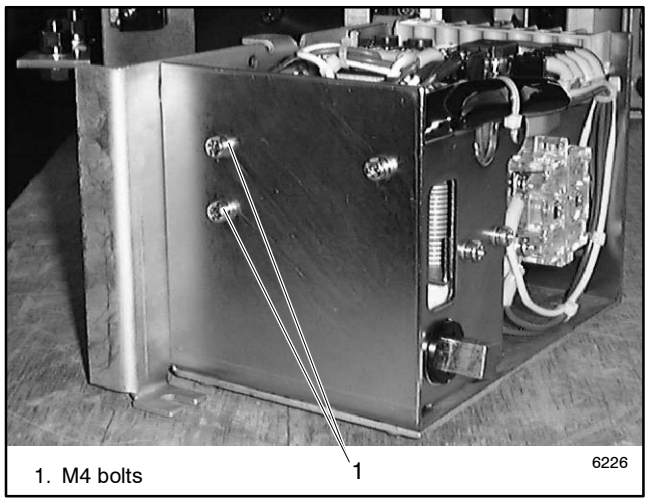


Figure 6-18 Select Coil Assembly Bolts

3. Remove the upper plate from the select coil assembly. See Figure 6-19.

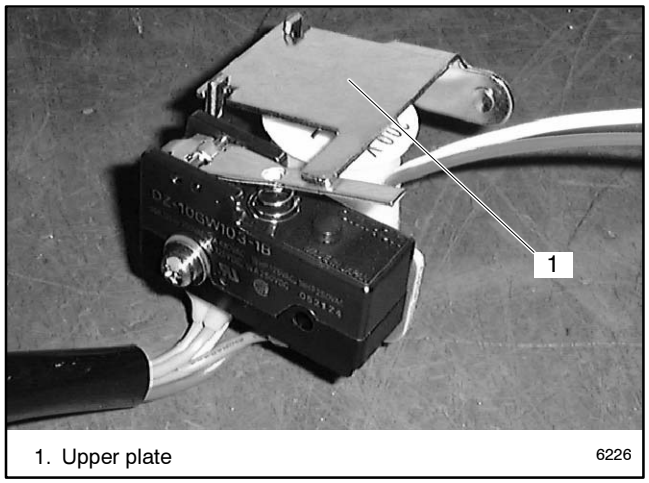


Figure 6-19 Select Coil Assembly

4. Replace the select coil. See Figure 6-20.

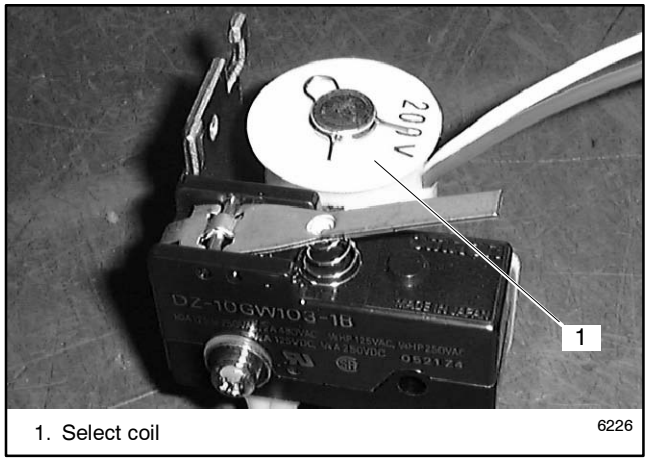


Figure 6-20 Select Coil

6.2.6 Trip Coil Replacement, 100–400 Amps

Note: Remove the select coil first for easier access to the trip coil. See Section 6.2.5.

1. Locate the trip coil. See Figure 6-21.

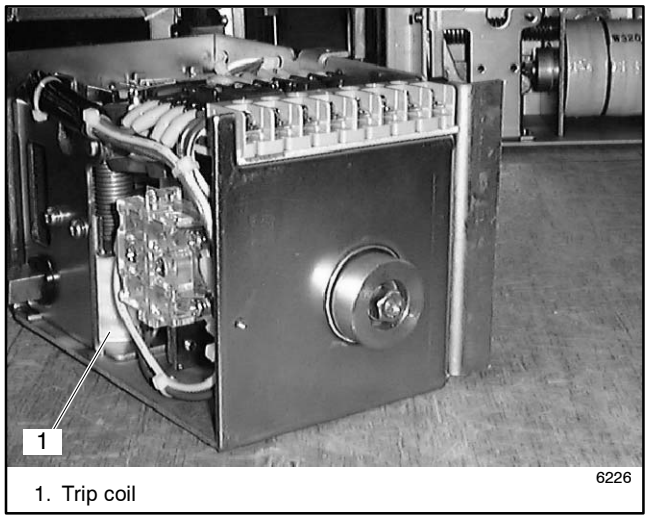


Figure 6-21 Trip Coil Location

2. Note the connections and disconnect the trip coil leads from the printed circuit board. See Figure 6-22.

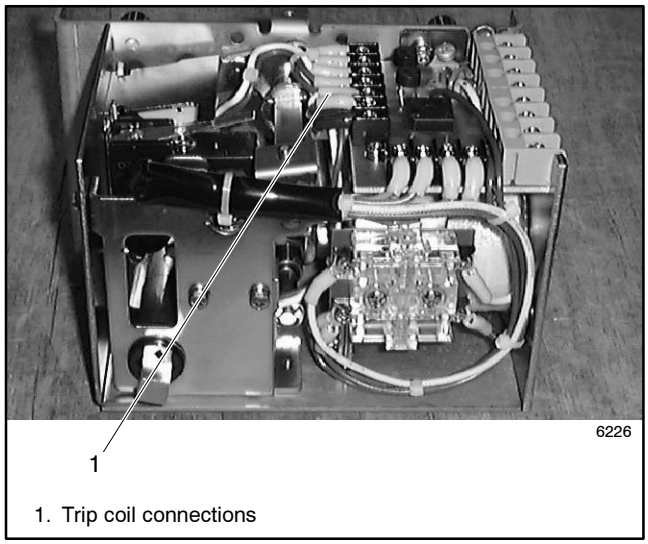
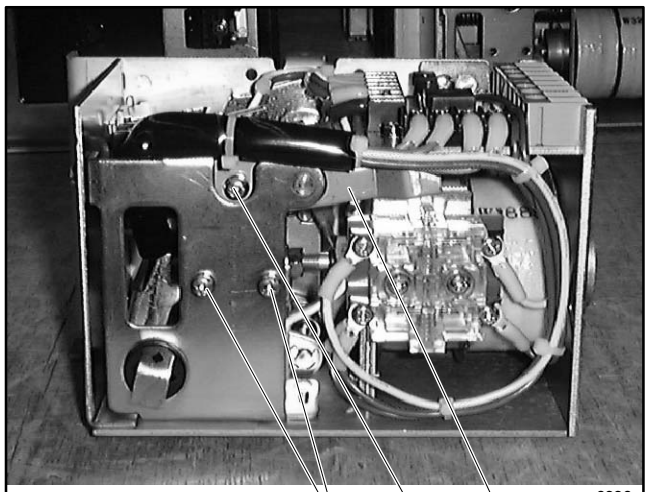


Figure 6-22 Trip Coil Connections

3. Remove two M4 bolts that secure the trip coil. See Figure 6-23.



1. Trip coil M4 bolts (2)
2. Trip shaft M4 bolt (and ring, not visible in this view)
3. Trip lever

Figure 6-23 Trip Coil and Trip Shaft Bolts

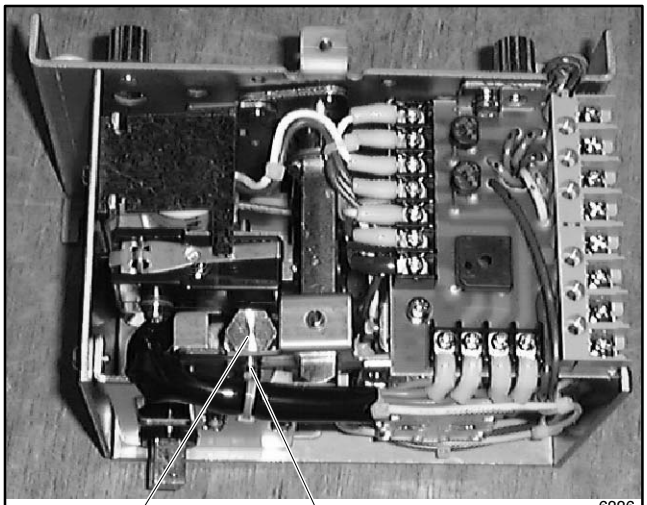
⚠ WARNING

Spring-loaded parts.
Can cause severe personal injury or property damage.

Wear protective goggles when servicing spring-loaded parts. Hold parts securely during disassembly.

4. The trip shaft is spring-loaded. Hold the shaft securely while removing the trip shaft bolt. See Figure 6-24. Remove the M4 bolt with ring, trip shaft, spring, and L-shaped bracket. See Figure 6-25. Keep the parts for reassembly later.

5. Loosen three bolts shown in Figure 6-26, remove the side plate, and replace the trip coil. See Figure 6-26.



1. Trip shaft
2. M4 bolt

Figure 6-24 Trip Shaft Location

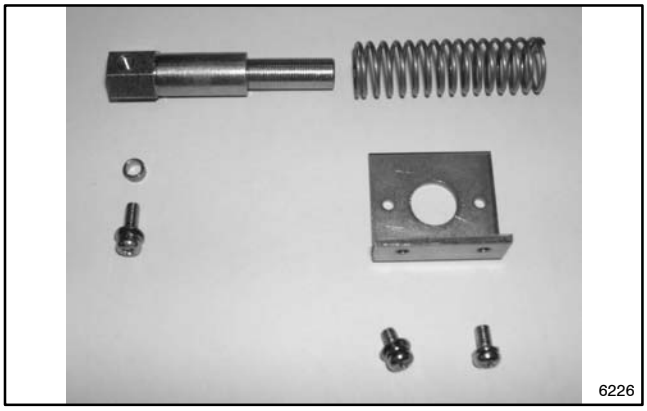
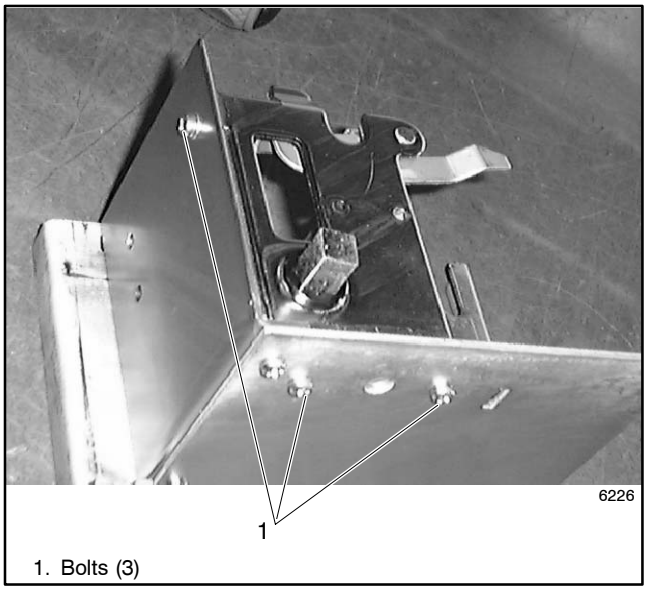


Figure 6-25 Trip Shaft Parts



1. Bolts (3)

Figure 6-26 Side Plate Bolts

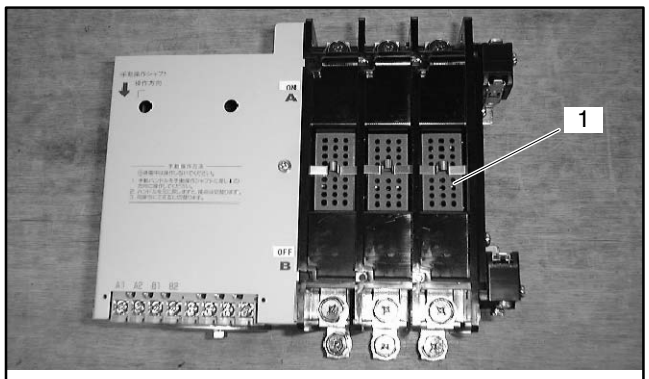
6. Reassemble in reverse order:

   Align the bosses on the coil with the holes in the L-shaped bracket.

   Be sure to reinstall the ring on the trip shaft bolt and align the parts so that the ring fits into the hole on the trip lever.

6.2.7 Arc Chute Replacement, 100–400 Amps

Remove the retainer clips shown in Figure 6-27 and replace the required arc chute. Reinstall the retainer clips.



1. Arc chute retainer clips

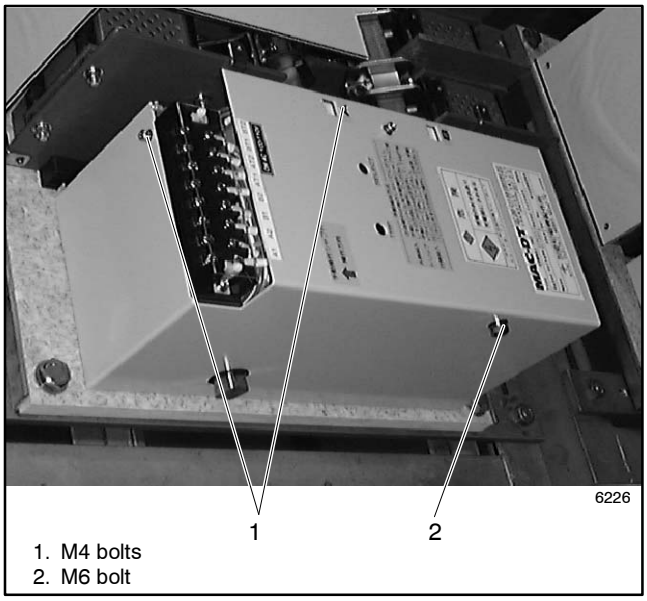
Figure 6-27 Arc Chutes

6.3 Component Replacement, 600 Amp Models

6.3.1 Closing Coil Replacement, 600 Amp Models

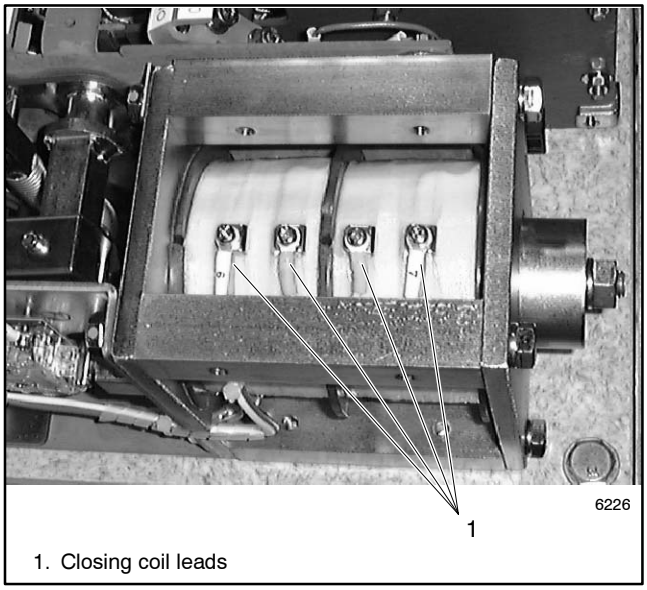
1. Remove the M4 bolts and the M6 bolt. Remove the cover from the mechanical unit. See Figure 6-28.

2. Note the connections shown in Figure 6-29 and disconnect the closing coil leads at four locations.



1. M4 bolts
2. M6 bolt

Figure 6-28 Removing the Cover



1. Closing coil leads

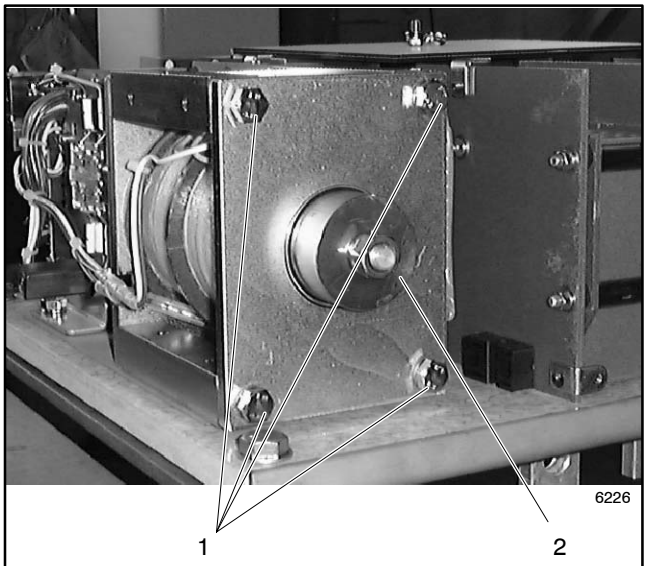
Figure 6-29 Closing Coil Connections

⚠ WARNING

Spring-loaded parts.
Can cause severe personal injury or property damage.

Wear protective goggles when servicing spring-loaded parts. Hold parts securely during disassembly.

3. The closing coil is spring-loaded. Hold the closing coil securely and remove four M8 bolts. Remove the closing coil. See Figure 6-30.



1. M8 bolts
2. Nut, movable steel shaft

Figure 6-30 Closing Coil Bolts and Nut

4. Replace the closing coil.
   a. Reuse the spring from the original coil.
   b. Align the boss on the coil into the recess in the frame.
   c. Replace the four M8 bolts. See Figure 6-30.
   d. Reconnect four leads shown in Figure 6-29.
5. Adjust the movable steel shaft as described in the following procedure.

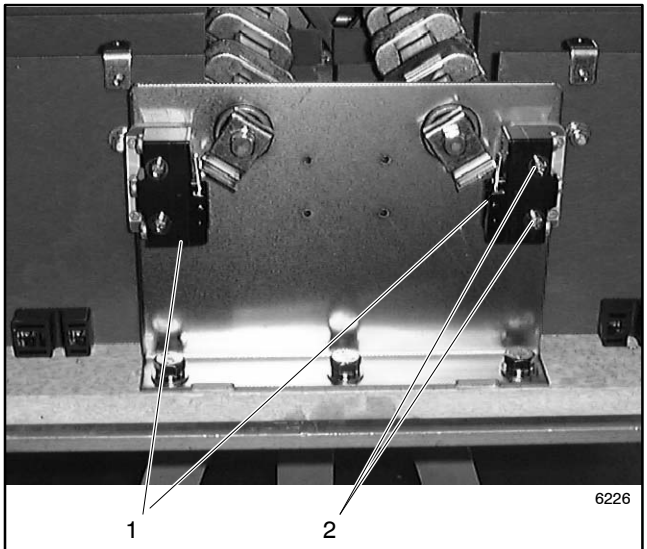
6.3.2 Shaft Adjustment, 600 Amp Models

Note: It is not necessary to remove the movable steel shaft when replacing the closing coil.

1. Turn the large round shaft in (clockwise) until the mechanism just latches when operated with the manual handle. If turned too far, it won't latch.
2. Turn the shaft back 1.5 rotations from the limit of the switching range.
3. Hold the shaft and tighten the nut.
4. Replace the cover on the mechanical unit.

6.3.3 Auxiliary Switch Replacement, 600 Amp Models

Loosen the M4 bolts and replace the auxiliary switches. Tighten the mounting screws to 0.14 Nm (1 in. lb.), maximum. See Figure 6-31.

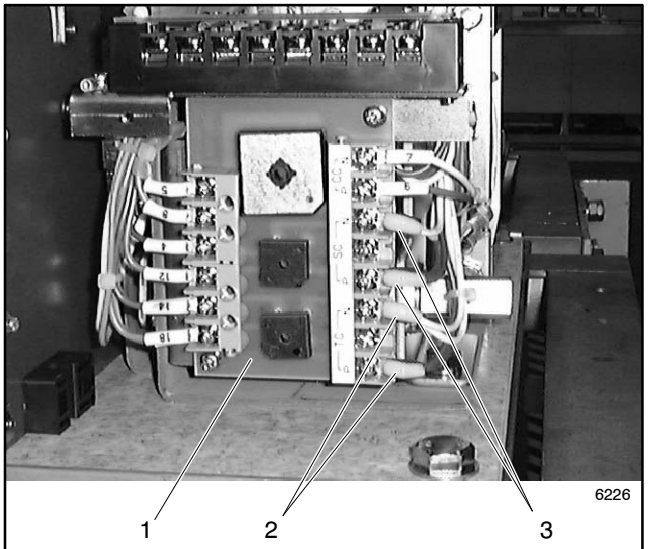


1. Auxiliary switches
2. M4 bolts

Figure 6-31 Auxiliary Switches, 600 Amp Models

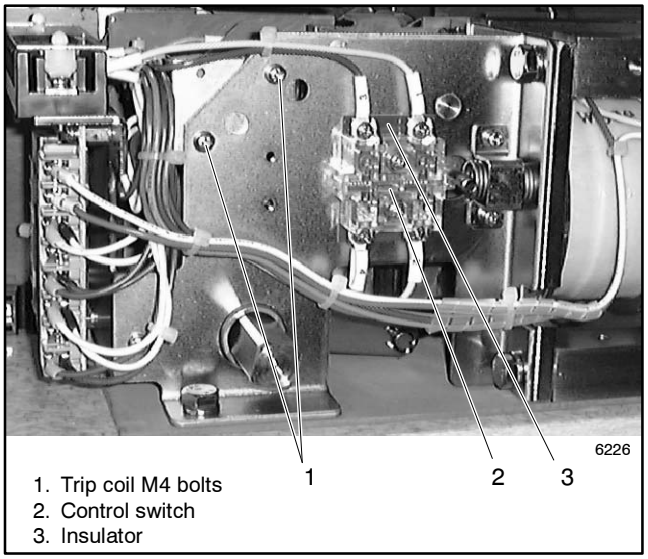
6.3.4 Trip Coil Replacement, 600 Amp Models

1. Note the connections and disconnect the trip coil leads from the printed circuit board and the control switch. See Figure 6-32 and Figure 6-33.



1. Printed circuit board
2. Trip coil (TC) leads
3. Select coil (SC) leads

Figure 6-32 Circuit Board Connections

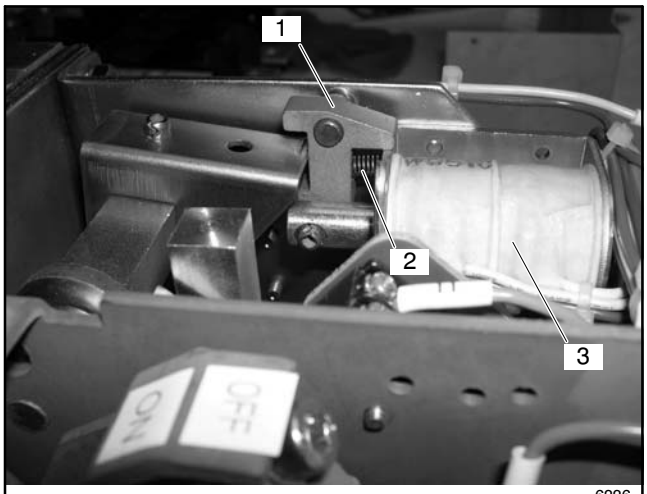


1. Trip coil M4 bolts
2. Control switch
3. Insulator

Figure 6-33 Trip Coil Replacement, 600 Amp Models

2. Remove two M4 bolts and replace the trip coil. Retain the small spring for the trip coil lever. See Figure 6-33 and Figure 6-34.

3. Connect the trip coil leads to the printed circuit board and control switch as noted during disassembly. Tighten control switch connections to 0.14 Nm (1 in. lb.), maximum.



1. Trip lever
2. Spring
3. Trip coil

Figure 6-34 Trip Coil

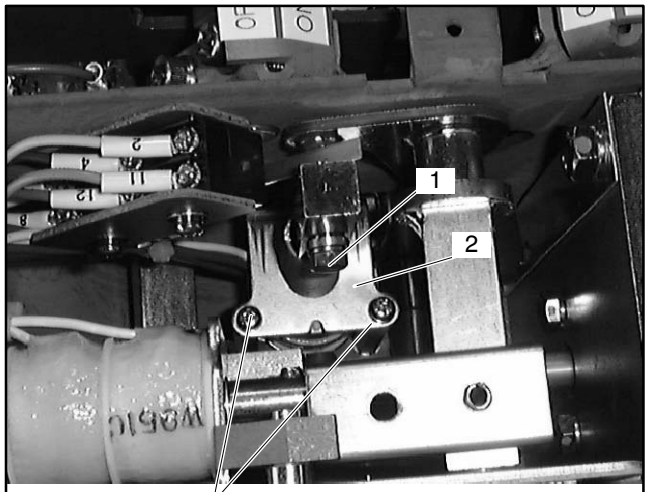
6.3.5 Select Coil Replacement, 600 Amp Models

1. Note the connections and disconnect the select coil leads from the printed circuit board and the control switch. See Figure 6-32 and Figure 6-33.

2. Loosen the M5 bolt and remove the select coil movable steel shaft and the spring. See Figure 6-35 and Figure 6-36.

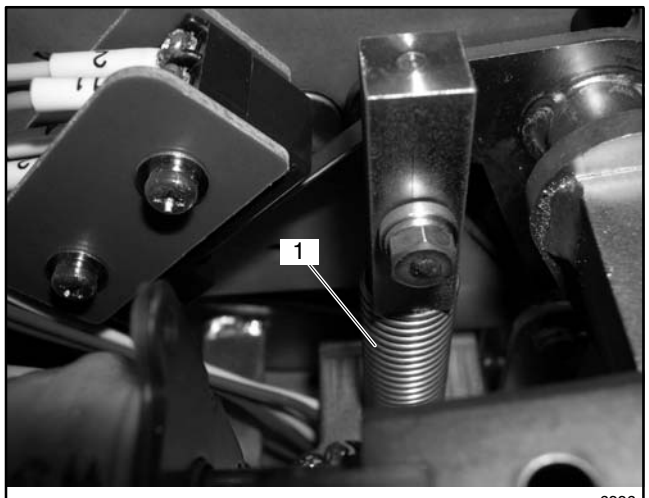
3. Loosen the M4 bolts and replace the select coil. See Figure 6-35.

4. Connect the select coil leads to the control switch and circuit board.



1. Steel shaft (and spring, see Figure 6-36)
2. Select coil
3. Select coil M4 bolts

Figure 6-35 Select Coil Replacement, 600 Amp Models



1. Spring

Figure 6-36 Spring Location

6.3.6 Printed Circuit Board Replacement, 600 Amp Models

Note: The individual rectifiers are not replaceable. Replace the entire printed circuit board in the case of rectifier failure.

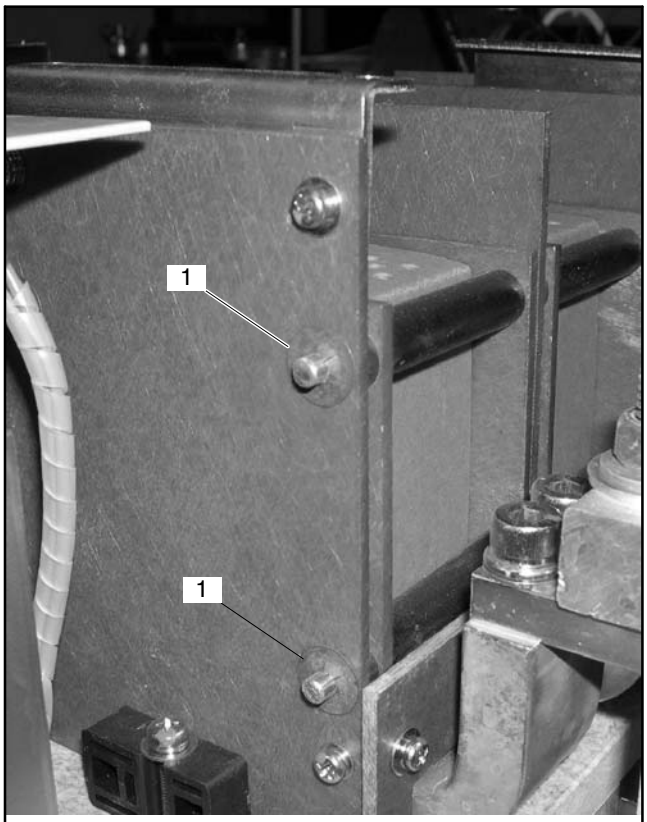
1. Note the connections and disconnect all leads to the circuit board. See Figure 6-32.

2. Loosen the M4 bolts to replace the printed circuit board.

3. Reconnect all leads.

6.3.7 Arc Chute Replacement, 600 Amp Models

Note: Some units use retainers (part number 295010) instead of M6 nuts. See Figure 6-37. Obtain new retainers before disassembly.



1. Retainer

Figure 6-37 Retainer

1. Remove the insulation plate. See Figure 6-38.

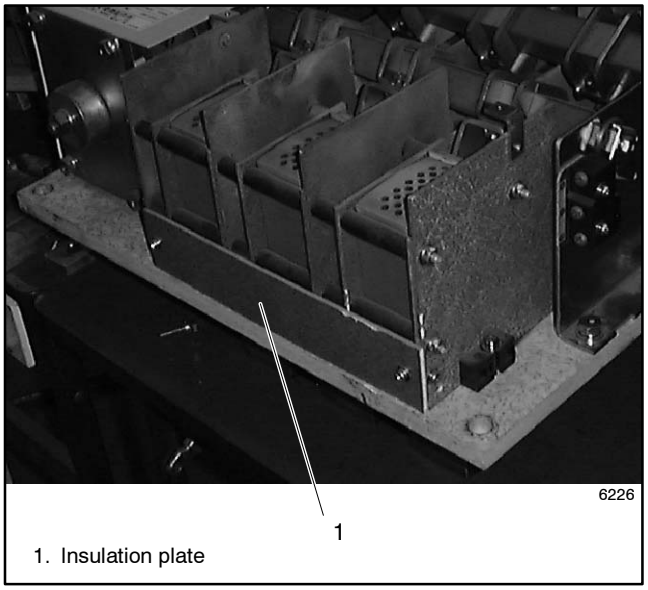


Figure 6-38 600 Amp Contactor

2. Attach a clamp or fixture similar to the one shown in Figure 6-39.

   Note: The transfer switch will come apart if the parts are not clamped as shown before the nuts or retainers are removed.

3. Loosen the M6 nuts or remove the retainers. See Figure 6-39.

4. Remove the upper rod shown in Figure 6-39.

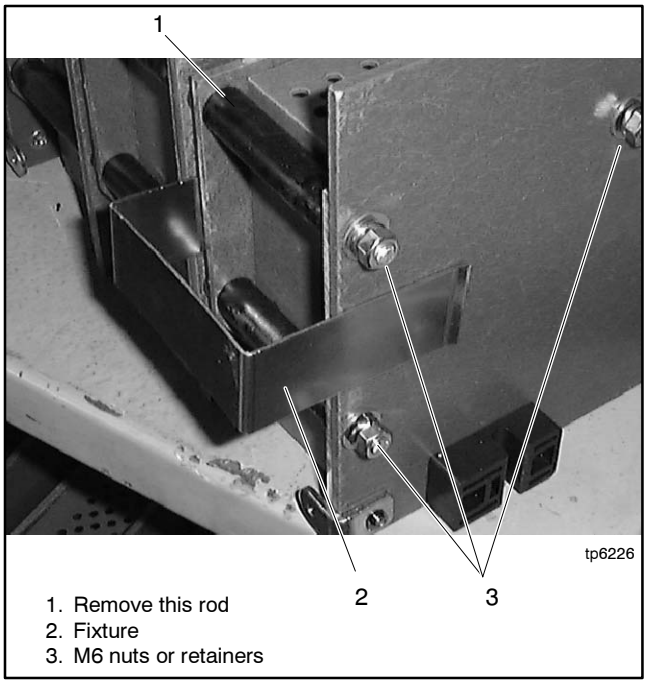


Figure 6-39 Fixture or Clamp, 600 Amp Models

5. Replace the arc chutes.

6. Replace the rod.

7. Reinstall and tighten the M6 nuts or install new retainers and then remove the clamp.

8. Reinstall the insulation plate.

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

Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

Bolt/Screw Length: When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

Washers and Nuts: Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spiralock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See Appendix C, General Torque Specifications, and other torque specifications in the service literature.

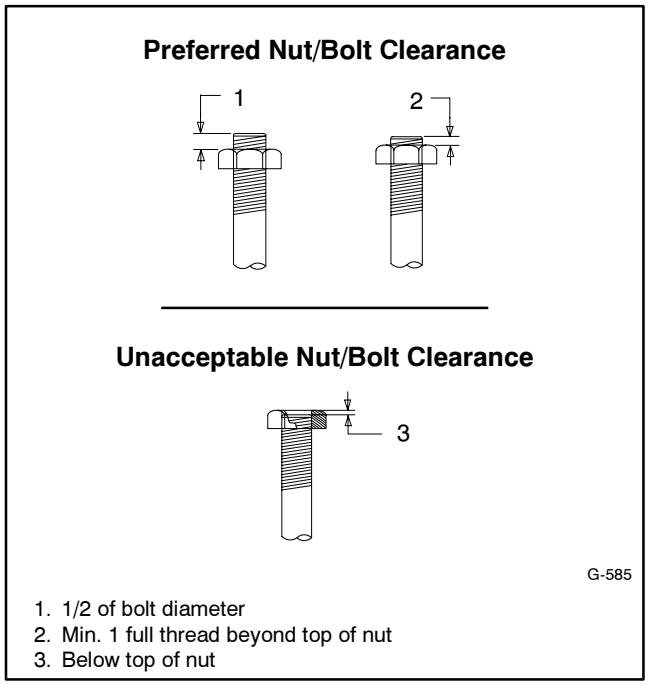


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

   For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spiralock nut. See Figure 2.
3. Follow these SAE washer rules after determining exit hole type:
   a. Always use a washer between hardware and a slot.
   b. Always use a washer under a nut (see 2 above for exception).
   c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.

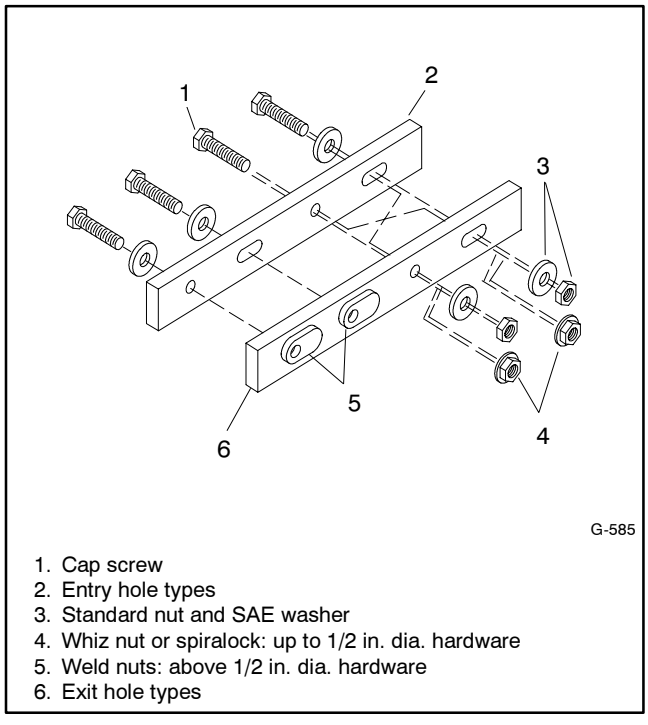


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

Use the following torque specifications when service literature instructions give no specific torque values. The charts list values for new plated, zinc phosphate, or oiled threads. Increase values by 15% for nonplated threads. All torque values are +0%/–10%.

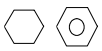
American Standard Fasteners Torque Specifications					
		Assembled into Cast Iron or Steel			Assembled into Aluminum
Size	Torque Measurement	Grade 2	Grade 5	Grade 8	Grade 2 or 5
8-32	Nm (in. lb.)	1.8 (16)	2.3 (20)	—	1.8 (16)
10-24	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	2.9 (26)
10-32	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	2.9 (26)
1/4-20	Nm (in. lb.)	6.8 (60)	10.8 (96)	14.9 (132)	6.8 (60)
1/4-28	Nm (in. lb.)	8.1 (72)	12.2 (108)	16.3 (144)	8.1 (72)
5/16-18	Nm (in. lb.)	13.6 (120)	21.7 (192)	29.8 (264)	13.6 (120)
5/16-24	Nm (in. lb.)	14.9 (132)	23.1 (204)	32.5 (288)	14.9 (132)
3/8-16	Nm (ft. lb.)	24.0 (18)	38.0 (28)	53.0 (39)	24.0 (18)
3/8-24	Nm (ft. lb.)	27.0 (20)	42.0 (31)	60.0 (44)	27.0 (20)
7/16-14	Nm (ft. lb.)	39.0 (29)	60.0 (44)	85.0 (63)	—
7/16-20	Nm (ft. lb.)	43.0 (32)	68.0 (50)	95.0 (70)	—
1/2-13	Nm (ft. lb.)	60.0 (44)	92.0 (68)	130.0 (96)	—
1/2-20	Nm (ft. lb.)	66.0 (49)	103.0 (76)	146.0 (108)	—
9/16-12	Nm (ft. lb.)	81.0 (60)	133.0 (98)	187.0 (138)	—
9/16-18	Nm (ft. lb.)	91.0 (67)	148.0 (109)	209.0 (154)	—
5/8-11	Nm (ft. lb.)	113.0 (83)	183.0 (135)	259.0 (191)	—
5/8-18	Nm (ft. lb.)	128.0 (94)	208.0 (153)	293.0 (216)	—
3/4-10	Nm (ft. lb.)	199.0 (147)	325.0 (240)	458.0 (338)	—
3/4-16	Nm (ft. lb.)	222.0 (164)	363.0 (268)	513.0 (378)	—
1-8	Nm (ft. lb.)	259.0 (191)	721.0 (532)	1109.0 (818)	—
1-12	Nm (ft. lb.)	283.0 (209)	789.0 (582)	1214.0 (895)	—

Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.)				
	Assembled into Cast Iron or Steel			Assembled into Aluminum
Size (mm)	Grade 5.8	Grade 8.8	Grade 10.9	Grade 5.8 or 8.8
M6 x 1.00	5.6 (4)	9.9 (7)	14.0 (10)	5.6 (4)
M8 x 1.25	13.6 (10)	25.0 (18)	35.0 (26)	13.6 (10)
M8 x 1.00	21.0 (16)	25.0 (18)	35.0 (26)	21.0 (16)
M10 x 1.50	27.0 (20)	49.0 (35)	68.0 (50)	27.0 (20)
M10 x 1.25	39.0 (29)	49.0 (35)	68.0 (50)	39.0 (29)
M12 x 1.75	47.0 (35)	83.0 (61)	117.0 (86)	—
M12 x 1.50	65.0 (48)	88.0 (65)	125.0 (92)	—
M14 x 2.00	74.0 (55)	132.0 (97)	185.0 (136)	—
M14 x 1.50	100.0 (74)	140.0 (103)	192.0 (142)	—
M16 x 2.00	115.0 (85)	200.0 (148)	285.0 (210)	—
M16 x 1.50	141.0 (104)	210.0 (155)	295.0 (218)	—
M18 x 2.50	155.0 (114)	275.0 (203)	390.0 (288)	—
M18 x 1.50	196.0 (145)	305.0 (225)	425.0 (315)	—

Appendix D Common Hardware Identification

Screw/Bolts/Studs	
Head Styles	
Hex Head or Machine Head	
Hex Head or Machine Head with Washer	
Flat Head (FHM)	
Round Head (RHM)	
Pan Head	
Hex Socket Head Cap or Allen™ Head Cap	
Hex Socket Head or Allen™ Head Shoulder Bolt	
Sheet Metal Screw	
Stud	
Drive Styles	
Hex	
Hex and Slotted	
Phillips®	
Slotted	
Hex Socket	

Nuts	
Nut Styles	
Hex Head	
Lock or Elastic	
Square	
Cap or Acorn	
Wing	
Washers	
Washer Styles	
Plain	
Split Lock or Spring	
Spring or Wave	
External Tooth Lock	
Internal Tooth Lock	
Internal-External Tooth Lock	

Hardness Grades	
American Standard	
Grade 2	
Grade 5	
Grade 8	
Grade 8/9 (Hex Socket Head)	
Metric	
Number stamped on hardware; 5.8 shown	

Allen™ head screw is a trademark of Holo-Krome Co.

Phillips® screw is a registered trademark of Phillips Screw Company.

Sample Dimensions

American Standard (Screws, Bolts, Studs, and Nuts)

1/4-20 x 1

- Length In Inches (Screws and Bolts)
- Threads Per Inch
- Major Thread Diameter In Fractional Inches Or Screw Number Size

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

- Length In Millimeters (Screws and Bolts)
- Distance Between Threads In Millimeters
- Major Thread Diameter In Millimeters

Plain Washers

9/32 x 5/8 x 1/16

- Thickness
- External Dimension
- Internal Dimension

Lock Washers

5/8

- Internal Dimension

Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

American Standard

Part No.	Dimensions
Hex Head Bolts (Grade 5)	
X-465-17	1/4-20 x .38
X-465-6	1/4-20 x .50
X-465-2	1/4-20 x .62
X-465-16	1/4-20 x .75
X-465-18	1/4-20 x .88
X-465-7	1/4-20 x 1.00
X-465-8	1/4-20 x 1.25
X-465-9	1/4-20 x 1.50
X-465-10	1/4-20 x 1.75
X-465-11	1/4-20 x 2.00
X-465-12	1/4-20 x 2.25
X-465-14	1/4-20 x 2.75
X-465-21	1/4-20 x 5.00
X-465-25	1/4-28 x .38
X-465-20	1/4-28 x 1.00
X-125-33	5/16-18 x .50
X-125-23	5/16-18 x .62
X-125-3	5/16-18 x .75
X-125-31	5/16-18 x .88
X-125-5	5/16-18 x 1.00
X-125-24	5/16-18 x 1.25
X-125-34	5/16-18 x 1.50
X-125-25	5/16-18 x 1.75
X-125-26	5/16-18 x 2.00
230578	5/16-18 x 2.25
X-125-29	5/16-18 x 2.50
X-125-27	5/16-18 x 2.75
X-125-28	5/16-18 x 3.00
X-125-22	5/16-18 x 4.50
X-125-32	5/16-18 x 5.00
X-125-35	5/16-18 x 5.50
X-125-36	5/16-18 x 6.00
X-125-40	5/16-18 x 6.50
X-125-43	5/16-24 x 1.75
X-125-44	5/16-24 x 2.50
X-125-30	5/16-24 x .75
X-125-39	5/16-24 x 2.00
X-125-38	5/16-24 x 2.75
X-6238-2	3/8-16 x .62
X-6238-10	3/8-16 x .75
X-6238-3	3/8-16 x .88
X-6238-11	3/8-16 x 1.00
X-6238-4	3/8-16 x 1.25
X-6238-5	3/8-16 x 1.50
X-6238-1	3/8-16 x 1.75
X-6238-6	3/8-16 x 2.00
X-6238-17	3/8-16 x 2.25
X-6238-7	3/8-16 x 2.50
X-6238-8	3/8-16 x 2.75
X-6238-9	3/8-16 x 3.00
X-6238-19	3/8-16 x 3.25
X-6238-12	3/8-16 x 3.50
X-6238-20	3/8-16 x 3.75
X-6238-13	3/8-16 x 4.50
X-6238-18	3/8-16 x 5.50
X-6238-25	3/8-16 x 6.50

Part No.	Dimensions
Hex Head Bolts, cont.	
X-6238-14	3/8-24 x .75
X-6238-16	3/8-24 x 1.25
X-6238-21	3/8-24 x 4.00
X-6238-22	3/8-24 x 4.50
X-6024-5	7/16-14 x .75
X-6024-2	7/16-14 x 1.00
X-6024-8	7/16-14 x 1.25
X-6024-3	7/16-14 x 1.50
X-6024-4	7/16-14 x 2.00
X-6024-11	7/16-14 x 2.75
X-6024-12	7/16-14 x 6.50
X-129-15	1/2-13 x .75
X-129-17	1/2-13 x 1.00
X-129-18	1/2-13 x 1.25
X-129-19	1/2-13 x 1.50
X-129-20	1/2-13 x 1.75
X-129-21	1/2-13 x 2.00
X-129-22	1/2-13 x 2.25
X-129-23	1/2-13 x 2.50
X-129-24	1/2-13 x 2.75
X-129-25	1/2-13 x 3.00
X-129-27	1/2-13 x 3.50
X-129-29	1/2-13 x 4.00
X-129-30	1/2-13 x 4.50
X-463-9	1/2-13 x 5.50
X-129-44	1/2-13 x 6.00
X-129-51	1/2-20 x .75
X-129-45	1/2-20 x 1.25
X-129-52	1/2-20 x 1.50
X-6021-3	5/8-11 x 1.00
X-6021-4	5/8-11 x 1.25
X-6021-2	5/8-11 x 1.50
X-6021-1	5/8-11 x 1.75
273049	5/8-11 x 2.00
X-6021-5	5/8-11 x 2.25
X-6021-6	5/8-11 x 2.50
X-6021-7	5/8-11 x 2.75
X-6021-12	5/8-11 x 3.75
X-6021-11	5/8-11 x 4.50
X-6021-10	5/8-11 x 6.00
X-6021-9	5/8-18 x 2.50
X-6239-1	3/4-10 x 1.00
X-6239-8	3/4-10 x 1.25
X-6239-2	3/4-10 x 1.50
X-6239-3	3/4-10 x 2.00
X-6239-4	3/4-10 x 2.50
X-6239-5	3/4-10 x 3.00
X-6239-6	3/4-10 x 3.50
X-792-1	1-8 x 2.25
X-792-5	1-8 x 3.00
X-792-8	1-8 x 5.00

Part No.	Dimensions	Type
Hex Nuts		
X-6009-1	1-8	Standard
X-6210-3	6-32	Whiz
X-6210-4	8-32	Whiz
X-6210-5	10-24	Whiz
X-6210-1	10-32	Whiz
X-6210-2	1/4-20	Spiralock
X-6210-6	1/4-28	Spiralock
X-6210-7	5/16-18	Spiralock
X-6210-8	5/16-24	Spiralock
X-6210-9	3/8-16	Spiralock
X-6210-10	3/8-24	Spiralock
X-6210-11	7/16-14	Spiralock
X-6210-12	1/2-13	Spiralock
X-6210-15	7/16-20	Spiralock
X-6210-14	1/2-20	Spiralock
X-85-3	5/8-11	Standard
X-88-12	3/4-10	Standard
X-89-2	1/2-20	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
X-25-46	.125	.250	.022	#4
X-25-9	.156	.375	.049	#6
X-25-48	.188	.438	.049	#8
X-25-36	.219	.500	.049	#10
X-25-40	.281	.625	.065	1/4
X-25-85	.344	.687	.065	5/16
X-25-37	.406	.812	.065	3/8
X-25-34	.469	.922	.065	7/16
X-25-26	.531	1.062	.095	1/2
X-25-15	.656	1.312	.095	5/8
X-25-29	.812	1.469	.134	3/4
X-25-127	1.062	2.000	.134	1

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Part No.	Dimensions
Hex Head Bolts (Partial Thread)	
M931-05055-60	M5-0.80 x 55
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06060-SS	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06070-SS	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-06145-60	M6-1.00 x 145
M931-06150-60	M6-1.00 x 150
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-60	M8-1.25 x 55
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-08110-60	M8-1.25 x 110
M931-08120-60	M8-1.25 x 120
M931-08130-60	M8-1.25 x 130
M931-08140-60	M8-1.25 x 140
M931-08150-60	M8-1.25 x 150
M931-08200-60	M8-1.25 x 200
M931-10040-82	M10-1.25 x 40*
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10050-82	M10-1.25 x 50*
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10080-82	M10-1.25 x 80*
M931-10090-60	M10-1.50 x 90
M931-10090-82	M10-1.50 x 90*
M931-10100-60	M10-1.50 x 100
M931-10110-60	M10-1.50 x 110
M931-10120-60	M10-1.50 x 120
M931-10130-60	M10-1.50 x 130
M931-10140-60	M10-1.50 x 140
M931-10180-60	M10-1.50 x 180
M931-10235-60	M10-1.50 x 235
M931-10260-60	M10-1.50 x 260
M960-10330-60	M10-1.25 x 330
M931-12045-60	M12-1.75 x 45
M960-12050-60	M12-1.25 x 50
M960-12050-82	M12-1.25 x 50*
M931-12050-60	M12-1.75 x 50
M931-12050-82	M12-1.75 x 50*
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12060-82	M12-1.75 x 60*
M931-12065-60	M12-1.75 x 65
M931-12075-60	M12-1.75 x 75
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110

Part No.	Dimensions
Hex Head Bolts (Partial Thread), continued	
M960-16090-60	M16-1.50 x 90
M931-16090-60	M16-2.00 x 90
M931-16100-60	M16-2.00 x 100
M931-16100-82	M16-2.00 x 100*
M931-16120-60	M16-2.00 x 120
M931-16150-60	M16-2.00 x 150
M931-20065-60	M20-2.50 x 65
M931-20090-60	M20-2.50 x 90
M931-20100-60	M20-2.50 x 100
M931-20120-60	M20-2.50 x 120
M931-20140-60	M20-2.50 x 140
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160
M931-24200-60	M24-3.00 x 200
Hex Head Bolts (Full Thread)	
M933-04006-60	M4-0.70 x 6
M933-05030-60	M5-0.80 x 30
M933-05035-60	M5-0.80 x 35
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06012-60	M6-1.00 x 12
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06030-60	M6-1.00 x 30
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-07025-60	M7-1.00 x 25
M933-08010-60	M8-1.25 x 10
M933-08012-60	M8-1.25 x 12
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-08030-82	M8-1.25 x 30*
M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M961-10025-60	M10-1.25 x 25
M933-10025-82	M10-1.50 x 25*
M961-10030-60	M10-1.25 x 30
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-10035-82	M10-1.50 x 35*
M961-10040-60	M10-1.25 x 40

Part No.	Dimensions
Hex Head Bolts (Full Thread), continued	
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M961-12020-60F	M12-1.50 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M961-12030-60	M12-1.25 x 30
M933-12030-82	M12-1.75 x 30*
M961-12030-82F	M12-1.50 x 30*
M933-12030-60	M12-1.75 x 30
M933-12035-60	M12-1.75 x 35
M961-12040-82	M12-1.25 x 40*
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*
M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-14050-82	M14-1.50 x 50*
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M961-16030-82	M16-1.50 x 30*
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M961-16040-60	M16-1.50 x 40
M933-16040-60	M16-2.00 x 40
M961-16045-82	M16-1.50 x 45*
M933-16045-82	M16-2.00 x 45*
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-16070-60	M16-2.00 x 70
M933-18035-60	M18-2.50 x 35
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60
M933-20050-60	M20-2.50 x 50
M933-20055-60	M20-2.50 x 55
M933-24060-60	M24-3.00 x 60
M933-24065-60	M24-3.00 x 65
M933-24070-60	M24-3.00 x 70
Pan Head Machine Screws	
M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04010-20	M4-0.70 x 10
M7985A-04016-20	M4-0.70 x 16
M7985A-04020-20	M4-0.70 x 20
M7985A-04050-20	M4-0.70 x 50
M7985A-04100-20	M4-0.70 x 100
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12
M7985A-05016-20	M5-0.80 x 16
M7985A-05020-20	M5-0.80 x 20
M7985A-05025-20	M5-0.80 x 25
M7985A-05030-20	M5-0.80 x 30
M7985A-05080-20	M5-0.80 x 80
M7985A-05100-20	M5-0.80 x 100
M7985A-06100-20	M6-1.00 x 100
Flat Head Machine Screws	
M965A-04012-SS	M4-0.70 x 12
M965A-05012-SS	M5-0.80 x 12
M965A-05016-20	M5-0.80 x 16
M965A-06012-20	M6-1.00 x 12

* This metric hex bolt's hardness is grade 10.9.

Metric, continued

Part No.	Dimensions	Type
Hex Nuts		
M934-03-50	M3-0.50	Standard
M934-04-50	M4-0.70	Standard
M934-04-B	M4-0.70	Brass
M934-05-50	M5-0.80	Standard
M934-06-60	M6-1.00	Standard
M934-06-64	M6-1.00	Std. (green)
M6923-06-80	M6-1.00	Spiralock
M982-06-80	M6-1.00	Elastic Stop
M934-08-60	M8-1.25	Standard
M6923-08-80	M8-1.25	Spiralock
M982-08-80	M8-1.25	Elastic Stop
M934-10-60	M10-1.50	Standard
M934-10-60F	M10-1.25	Standard
M6923-10-80	M10-1.50	Spiralock
M6923-10-62	M10-1.50	Spiralock†
M982-10-80	M10-1.50	Elastic Stop
M934-12-60	M12-1.75	Standard
M934-12-60F	M12-1.25	Standard
M6923-12-80	M12-1.75	Spiralock
M982-12-80	M12-1.75	Elastic Stop
M982-14-60	M14-2.00	Elastic Stop
M6923-16-80	M16-2.00	Spiralock
M982-16-80	M16-2.00	Elastic Stop
M934-18-80	M18-2.5	Standard
M982-18-60	M18-2.50	Elastic Stop
M934-20-80	M20-2.50	Standard
M982-20-80	M20-2.50	Elastic Stop
M934-22-60	M22-2.50	Standard
M934-24-80	M24-3.00	Standard
M982-24-60	M24-3.00	Elastic Stop
M934-30-80	M30-3.50	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
M125A-03-80	3.2	7.0	0.5	M3
M125A-04-80	4.3	9.0	0.8	M4
M125A-05-80	5.3	10.0	1.0	M5
M125A-06-80	6.4	12.0	1.6	M6
M125A-08-80	8.4	16.0	1.6	M8
M125A-10-80	10.5	20.0	2.0	M10
M125A-12-80	13.0	24.0	2.5	M12
M125A-14-80	15.0	28.0	2.5	M14
M125A-16-80	17.0	30.0	3.0	M16
M125A-18-80	19.0	34.0	3.0	M18
M125A-20-80	21.0	37.0	3.0	M20
M125A-24-80	25.0	44.0	4.0	M24

† This metric hex nut's hardness is grade 8.

DDC/MTU Power Generation
605 North 8th Street, Suite 501
Sheboygan, Wisconsin 53081 USA
Phone 920-451-0846, Fax 920-451-0843
ddcmtupowergeneration.com

MP-6226 7/04

© 2004. All rights reserved.