Class E2 Medium-Voltage Controllers with Drawout Vacuum Contactors

5.0kV Voltage Class 400A and Class 800A
7.2kV Voltage Class 400A and Class 800A
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BEFORE ANY ADJUSTMENT, SERVICING, PARTS REPLACEMENT, OR ANY OTHER ACT IS PERFORMED REQUIRING PHYSICAL CONTACT WITH THE ELECTRICAL WORKING COMPONENTS OR WIRING OF THIS EQUIPMENT, THE POWER SUPPLY MUST BE DISCONNECTED. FAILURE TO FOLLOW THIS WARNING MAY RESULT IN INJURY OR DEATH.
THE INFORMATION IN THIS INSTRUCTION BULLETIN IS NOT INTENDED TO EXPLAIN ALL DETAILS OR VARIATIONS OF THE CLASS E-2 MEDIUM-VOLTAGE CONTROLLERS WITH DRAWOUT CONTACTORS, NOR TO PROVIDE FOR EVERY POSSIBLE CONTINGENCY OR HAZARD TO BE MET IN CONNECTION WITH INSTALLATION, TESTING, OPERATION, AND MAINTENANCE OF THE EQUIPMENT. FOR ADDITIONAL INFORMATION AND INSTRUCTIONS FOR PARTICULAR PROBLEMS, WHICH ARE NOT PRESENTED SUFFICIENTLY FOR THE USER’S PURPOSES, CONTACT POWELL ELECTRICAL MANUFACTURING COMPANY AT 1-800-480-7273.

I. INTRODUCTION

A. SCOPE

This information in this instruction bulletin describes the following Class E2 Medium-Voltage Controllers:

- 5.0 kV, and 7.2 kV Voltage Class for 400 A
- 5.0 kV, and 7.2 kV Voltage Class for 800 A

B. PURPOSE

The information in this instruction bulletin is intended to provide information required to properly operate and maintain the Medium-Voltage Controllers described in A. SCOPE.

This instruction bulletin provides:

1. Safety guidelines
2. General descriptions of the operation and maintenance of the medium-voltage controller
3. Instructions for installation and placing the medium-voltage controller into service
4. Instructions for part replacement
5. Information for ordering renewal parts

The illustrations contained in this document may not represent the exact construction details of each particular type of Class E2 Vacuum Controller. The illustrations in this document are provided as general information to aid in showing component locations.

To the extent required, the products described herein meet the applicable ANSI, IEEE, and NEMA Standards; however, no such assurance is given with respect to local codes and ordinances which may vary greatly.

C. INSTRUCTION BULLETINS AVAILABLE ELECTRONICALLY

Many Powell Electrical Manufacturing Company Instruction Bulletins are available through a link on the Web site, http://www.powellservice.com. For more information visit http://powellelectric.com. To contact the Powell Apparatus Service Division (PASD) call 1-800-480-7273 or 713-944-6900, or email PASD at info@powellservice.com.

II. SAFETY

Study this instruction bulletin and all other associated documentation before uncrating the medium-voltage controllers.

Each user has the responsibility to instruct and supervise all personnel associated with usage, installation, operation, and maintenance of this equipment on all safety procedures. Furthermore, each user has the responsibility of establishing a safety program for each type of equipment encountered.

The medium-voltage controllers described in this instruction bulletin are operated by a high-energy, high-speed mechanism that is interlocked to provide specific operating sequences. It is mandatory that the following rules be observed to ensure the safety of personnel associated with usage, installation, operation, and maintenance of these controllers.

THE SAFETY RULES IN THIS INSTRUCTION BULLETIN ARE NOT INTENDED TO BE A COMPLETE SAFETY PROGRAM. THE RULES ARE INTENDED TO COVER ONLY SOME OF THE IMPORTANT ASPECTS OF PERSONNEL SAFETY RELATED TO CLASS E2 MEDIUM-VOLTAGE CONTROLLERS.
A. GENERAL
1. Only supervised and qualified personnel trained in the usage, installation, operation, and maintenance of Medium-Voltage Controllers shall be allowed to work on this equipment. It is mandatory that this instruction bulletin, any supplements, and service advisories be studied, understood, and followed.
2. Maintenance programs must be consistent with both customer experience and manufacturer's recommendations, including service advisories and instruction bulletin(s). A well-planned and executed routine maintenance program is essential for Medium-Voltage Controller reliability and safety.
3. Service conditions and Medium-Voltage Controller applications shall also be considered in the development of safety programs. Variables include ambient temperature; humidity; actual continuous current; thermal cycling; number of operations; interrupting duty; and any adverse local conditions including excessive dust, ash, corrosive atmosphere, vermin, and insect problems.

B. SPECIFIC
1. DO NOT WORK ON AN ENERGIZED MEDIUM-VOLTAGE CONTROLLER. Before performing maintenance work on a Medium-Voltage Controller, de-energize and disconnect the power supply for the controller, and remove the Medium-Voltage Controller from service.
2. DO NOT WORK ON AN ENERGIZED MEDIUM-VOLTAGE VACUUM CONTACTOR. Before performing work on a vacuum contactor, remove the vacuum contactor from service and remove it from the Medium-Voltage Controller.
3. DO NOT WORK ON A MEDIUM-VOLTAGE CONTROLLER VACUUM CONTACTOR WHEN THE CONTROL CIRCUIT IS ENERGIZED.
4. EXTREME CARE MUST BE EXERCISED TO KEEP ALL PERSONNEL, TOOLS, AND OTHER OBJECTS CLEAR OF MECHANISMS WHICH ARE TO BE OPERATED, DISCHARGED, OR RELEASED. These medium-voltage vacuum contactors utilize high energy mechanisms. These mechanisms must be serviced only by skilled and knowledgeable personnel. Detailed information regarding these mechanisms is found in this instruction bulletin and in the instruction bulletin for the vacuum contactors.
5. DO NOT ATTEMPT TO CLOSE THE VACUUM CONTACTOR ON AN ENERGIZED CIRCUIT.
6. DO NOT USE AN OPEN VACUUM CONTACTOR AS THE SOLE MEANS OF ISOLATING A HIGH VOLTAGE CIRCUIT. FOR COMPLETE ISOLATION, THE ISOLATING SWITCH MUST BE IN THE OFF POSITION.
7. ALL COMPONENTS SHALL BE DISCONNECTED BY MEANS OF A VISIBLE BREAK AND SECURELY GROUNDED FOR THE SAFETY OF PERSONNEL PERFORMING MAINTENANCE OPERATIONS ON THE MEDIUM-VOLTAGE CONTROLLER.
8. Interlocks are provided to ensure the proper operating sequences of the Medium-Voltage Controller and vacuum contactors for the safety of the user. If for any reason an interlock does not function as described, DO NOT MAKE ANY ADJUSTMENTS, MODIFICATION, OR DEFORM THE PARTS. DO NOT FORCE THE PARTS INTO POSITION. CONTACT POWELL ELECTRICAL MANUFACTURING COMPANY FOR INSTRUCTIONS.

C. X-RAYS
X-Rays may be generated when high voltage is applied across the contacts of a vacuum interrupter. The intensity of x-radiation depends on the level of peak voltage and the size of the contact gap. At the normal operating voltage for this type of equipment, the x-radiation levels are negligible. At the voltages specified for testing, personnel shall be located no closer than one (1) meter (about 4 feet) from the vacuum contactor. THE VACUUM CONTACTOR SHALL BE EITHER FULLY OPEN, OR FULLY CLOSED WHEN MAKING HIGH POTENTIAL TESTS. DO NOT PERFORM TESTS WITH CONTACTS PARTIALLY OPEN.

D. SAFETY LABELS
The medium-voltage controller has DANGER, WARNING, CAUTION, and instruction labels attached to various locations. All equipment DANGER, WARNING, CAUTION, and instruction labels shall be observed when the medium-voltage controller is handled, operated, or maintained.
III. EQUIPMENT DESCRIPTION

A. GENERAL

Class E2 Medium-Voltage Controllers are designed to comply with NEMA STD ICS 3 Part 2 and UL 347. These controllers are described as metal-enclosed, high-interrupting capacity, drawout, motor starter equipment with manual isolation. Each controller and starter is designed for specific applications and the components and functions are determined by the purchaser’s specifications and needs. See Figure 1.

Starting, stopping, and overload protection are essential control functions for all types of Alternating Current (AC) motors. Short-circuit protection is a basic function included in Class E2 controllers. Additionally, a large variety of protective devices and functions can be included in each controller depending on the particular application and the type of motor being controlled, such as synchronous or wound-rotor motors.

These instructions are prepared as a general guide that provides the necessary general information for the Class E2 Medium-Voltage Controller’s type and function. These instructions also include a suggested method of installation with demonstrative techniques for the operation and maintenance of the equipment. Separate instructions covering particular equipment, devices, or components are not included in this instruction bulletin, but are available upon request. The purchaser should interpret these instructions for applicability to his particular controller by referring to the drawings supplied with the controller.

The basic P-46110 Vacuum Controller is an assembly of components and conductors for motor starting, arranged for convenient access in an enclosure which allows space and facilities for cable termination, with safety interlocking of the doors and isolator to prevent inadvertent entrance to high voltage parts. This equipment is rated 7200 volts maximum and may be used on distribution voltages from 2400 to 7200 volts. Installation, operation, and service should be performed only by experienced personnel trained and qualified in this class of equipment.

Figure 1. Typical Class E2 Medium-Voltage Controllers

a. Class E2 Medium-Voltage Controller Unit 400A  b. Class E2 Medium-Voltage Controller Unit 800A
B. CLASS E2 MEDIUM-VOLTAGE CONTROLLER

In general, the Class E2 Medium-Voltage Controller consists of one-high or two-high vertical sections (Figure 2) of medium voltage compartments. Each Medium-Voltage Controller consists of a high-voltage and low-voltage compartment (Figure 3). Also, each compartment has a separate door and interior barriers between the two compartments.

To open the high-voltage compartment door, the power must be disconnected by a sequence of manual operations which require opening medium-voltage vacuum contactor and de-energizing the load, operating the isolating device, and unlatching the door. The low-voltage compartment door may be entered without disconnecting the power.

CONTROL POWER MAY BE PRESENT IN THE LOW VOLTAGE COMPARTMENT. THE LOW-VOLTAGE COMPARTMENT SHALL ONLY BE ENTERED WITH EXTREME CARE.

Figure 2. Two-High Vertical Section Rear View (400 A)

Figure 3. High- and Low-Voltage Compartments

a. Type SL Medium-Voltage Vacuum Contactor 400A
b. High-Voltage Compartment
c. Low-Voltage Compartment
C. RATINGS

Refer to the specific job drawings for the detail rating applicable to a particular controller. The basic ratings equal or exceed NEMA STD ICS 3, and are summarized in Table A and Table B.

Table A. Horsepower, Current, and Voltage Ratings

<table>
<thead>
<tr>
<th>Continuous Current Amperes</th>
<th>2200 – 2400V</th>
<th>4000 – 08000V</th>
<th>6600 – 7200V</th>
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<tr>
<td></td>
<td>Induction</td>
<td>SYNC</td>
<td>Induction</td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>180</td>
<td>700</td>
<td>700</td>
<td>1250</td>
</tr>
<tr>
<td>360</td>
<td>1500</td>
<td>1500</td>
<td>2500</td>
</tr>
<tr>
<td>720</td>
<td>2500</td>
<td>2500</td>
<td>4500</td>
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Table B. Voltage and Interrupting Ratings of Class E2 Controllers

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<tr>
<th>Rated Insulation Voltage</th>
<th>Class E2 Interrupting Ratings (Fused)</th>
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<tr>
<td>Maximum Volts, rms</td>
<td>Amperes (rms), Symmetrical*</td>
</tr>
<tr>
<td>2500</td>
<td>40,000 or 50,000</td>
</tr>
<tr>
<td>5000</td>
<td>40,000 or 50,000</td>
</tr>
<tr>
<td>5000</td>
<td>40,000 or 50,000</td>
</tr>
<tr>
<td>7200</td>
<td>40,000 or 50,000</td>
</tr>
</tbody>
</table>

* The asymmetrical interrupting rating is 1.6 times the symmetrical values shown.

D. BASIC IMPULSE LEVEL

The basic impulse level is 60kV for the 5 and 7.2kV Class Controllers. The basic impulse level excludes control transformers, starting reactors, and autotransformers.

E. FACTORY PRODUCTION DIELECTRIC TEST

The Factory Production Dielectric Test is:

2.25 X Nominal Voltage Rating + 200VAC.

NOTE: Field Dielectric tests, if required, should be limited to 75% of Factory Dielectric Test Values.
F. MEDIUM-VOLTAGE CONTACTORS

Two types of medium-voltage vacuum contactors employed in the Class E2 Medium-Voltage Controller are the Type SL 400A (Figure 4) and the Type SJA 800 A (Figure 5). Each vacuum contactor has a feature that is designed to close and interrupt the AC power circuit under normal conditions or to interrupt the circuit under overload emergency conditions. Another feature of each design is short-circuit protection. This includes current-limiting fuses as specified for the application.

The Type SL 400A medium-voltage vacuum contactor and isolating switch combinations will accommodate the R-Type, and the E-Type clip mount hookeye fuses as specified in Tables I and J. The Type SL 400A and the Type SJA 800A medium-voltage vacuum contactors are similar in design with the exception that the Type SJA 800A design application consists of higher capacity current carrying parts. Fuse maintenance for the two applications is similar. The Type SJA 800A application uses the current-limiting fuse Types: ACLS, CLS70, and AHLE. A dual voltage rating allows the fuses to be used in both the 2400 and 4800 volt systems.

**NOTE:** A medium voltage vacuum 400A contactor and 800A contactor is not interchangeable.

Vacuum contactors are magnetically operated by the application of either AC or DC power, depending upon circuit requirements. The contactors may be operated by DC from rectifiers included with the equipment. The minimum closing voltage is 85% of the coil rated voltage. The dropout voltage will vary considerably between the AC and DC magnets, but the dropout voltage for the AC magnet could be as high as 60% of the coil-rated voltage.

A mechanically latched contactor function (optional) is used when the vacuum contactor must stay closed during severe under-voltage conditions. Applications include fire pumps and transformer feeders. The latched contactor is available with or without a manual or electrical release and latch.

G. MANUAL ISOLATING MECHANISM

P-46110 Controllers following the NEMA definition and contain means for manually isolating the power circuit by operation of a disconnecting device. The manual isolating mechanism of the Class E2 Medium-Voltage Controller enables personnel to isolate the power circuit with a manually operated three-pole,
primary circuit disconnecting device. The isolating mechanism consists essentially of non-load break finger type stab assemblies mounted on a drawout isolating switch. Operation of the handle mechanism disengages the line fingers from the primary bus.

The isolating switch is a non load-break device. It must never close or interrupt a power load. An electrical and mechanical interference interlock ensure that the contactor is open before the isolating mechanism can be operated. However, it does have a limited capacity for interrupting the single-phase control power and potential transformers exciting current. In terms of transformer ratings, the maximum load is the equivalent of an unloaded (exciting current only) 6 kVA transformer.

An insulated shutter linked to the operating mechanism covers the points of line bus exposure, thus effectively isolating all live parts inside the controller when the isolating switch mechanism is in the OFF or OFF and HORIZONTAL position. Load current is NOT interrupted by the finger stabs. A mechanical and electrical interference interlock ensures that the contactor is open before the isolating mechanism can be operated. The isolating switch handle positions are ON, OFF, and OFF and HORIZONTAL.

The isolating switch handle can be padlocked in the ON and OFF positions (Figure 6).

3. The OFF and HORIZONTAL or door opening position (Figure 12, D): The isolating switch is in the OPEN position, the controller is de-energized, grounded, and the high-voltage compartment door can be opened.

FORCIBLY MOVING THE ISOLATING SWITCH OPERATING HANDLE TO THE OFF POSITION WILL OPEN THE VACUUM CONTACTOR AND DISCONNECT THE LOAD FROM THE CIRCUITS.

H. MECHANICAL INTERLOCKING

The Class E2 Medium-Voltage Controller is designed for the medium-voltage vacuum contactor to perform normal load current interrupting. The power fuses are designed to interrupt fault currents.

NOTE: The manual isolator will not interrupt any fault current.

A mechanical interference system (mechanical interlock) is included in all Class E2 Medium-Voltage Vacuum Controllers. The interference system prevents opening of the manually operated isolating mechanism, unless the vacuum contactor is in the OPEN position. This is to ensure that the contactor has opened the power circuit and interrupted the current. The Control Power Interlock (CPI) Auxiliary Switch, which is located on the isolating switch, opens the main contactor control power when the isolating switch is in the OFF position. The manual isolator SHOULD NEVER BE FORCIBLY OPERATED.

WARNING

THIS MECHANICAL INTERFERENCE SYSTEM MUST NOT BE DEFEATED TO OPEN THE HIGH-VOLTAGE COMPARTMENT DOOR WITH THE CLASS E2 MEDIUM-VOLTAGE CONTROLLER ENERGIZED. DEFEATING THE INTERLOCK WILL EXPOSE ENERGIZED COMPONENTS AND MAY RESULT IN INJURY OR DEATH.
J. POWER FUSES

Current-limiting fuses, designed for motor starting service, are used for all high-interrupting capacity motor controllers and provide short-circuit protection.

The following is a brief description of the power fuses used in the P46110 design. More detailed information regarding power fuses can be found in Cutler-Hammer I.B. 48021 and Technical Data Bulletin TD02003001E.

Interrupting ratings are as shown in the earlier tables in these instructions (Table B).

The SL 400A vacuum contactor and isolating switch combinations will accommodate R-Type and E-Type fuses.

The Type SJA 800A utilizes the following current-limiting fuse types: ACLS, CLS70, and AHLE.

Transformer feeders frequently contain general purpose current-limiting fuses. Coordination information for fuses can be furnished upon request.

K. STARTING AUTOTRANSFORMERS OR REACTORS

Reduced-voltage starters include a reactor or autotransformer designed for starting duty in accordance with NEMA ICS 3. The duty cycle for the medium-duty application is three starts, 30 seconds apart, followed by a one-hour rest. A heavier-duty cycle will cause overheating and possible damage to the reactor or autotransformer.

L. DIMENSIONS

Refer to the equipment drawings for the specific dimensions and an outline of the equipment.

The Class E2 Medium-Voltage Controllers 400A application is normally a one-high or two-high construction with typical dimensions of 26" or 36" in width, 38" in depth, and 92" in height. The Class E2 Medium-Voltage Controllers 800A application is normally a one-high construction with typical dimensions of 28" in width, 38" in depth, and 92" in height. These dimensions exclude channel bases and lifting members for indoor construction. For typical outline dimensions refer to Figure 8.

NOTE: No emergency condition can justify forcible operation of the MANUAL ISOLATOR WITH the vacuum contactor in the CLOSED position. The MANUAL ISOLATOR MUST only be operated when the vacuum contactor is in the OPEN position.

The high-voltage compartment door is locked closed by a mechanical interference system linked to the manual isolating switch. The locking action prevents the door from being opened unless the isolating switch is OPEN. Exposure to high-voltage or live parts is also prevented.

I. AUXILIARY COMPARTMENTS

A variety of enclosure sizes and medium-voltage compartments are furnished in Class E2 Medium-Voltage Controller lineups for various applications. The following list contains examples of enclosures and compartments.

1. Bus transitions to metal-clad gear
2. Bus transitions to transformers
3. Cable entranced compartments
4. Starting reactor autotransformer compartments
5. Relay and metering compartments
6. Potential transformer compartments (Figure 7.)

**Figure 7. Tilt-Out Potential Transformer Compartment (Optional)**

a. Potential Transformer (PT) Compartment Door
b. Secondary Disconnect
c. Potential Transformers
d. Compartment Floor
e. Tilt-Out PT Support
Figure 8. Typical Dimensions for the Class E2 Medium-Voltage Controllers

NOTE: The drawings in Figure 8 SHOULD NOT be used for any construction purposes. For construction information, refer to the specific drawings furnished with the equipment.
IV. INSTALLATION

A. GENERAL

This section contains information on preparing equipment for operation including receiving, storage, handling, positioning, power connections, grounding, and mechanical operation tests.

B. RECEIVING

NOTE: Read paragraph D. HANDLING in this section before handling the controller(s). Class E2 Medium-Voltage Controllers are fabricated as rigid, floor-mounted, self-supporting steel unit vertical section(s). They are shipped in an upright position, and should be kept in an upright position when received.

NOTE: Any questions regarding equipment handling should be referred to Powell Electrical Manufacturing Company.

When controllers are received, the purchaser should check the material received with the shipping list to ensure that all parts have been included. If equipment damage is found or suspected, file claims as soon as possible with the transportation company and notify the nearest representative of Powell Electrical Manufacturing Company.

Some equipment, devices, or components may be shipped separately. Examples of items that may be shipped separately are top-mounted resistors or current potential transformers (CPT). These components are identified by a number coinciding with the number on the section on which they are to be mounted.

C. STORAGE

When equipment cannot be installed immediately, it should be stored in a clean, dry, and ventilated location to reduce condensation. Use a protective covering on stored equipment to prevent dirt and contaminated substances from depositing on the movable parts and electrical contact surfaces. When the equipment is subject to low temperatures or moisture, energize the anti-condensation heaters to prevent corrosion. There should be approximately 250W of heat per vertical section. Before energizing the heaters, remove all cartons and miscellaneous material from inside the units. No specific formula for the amount of heat per vertical section can be given as it varies greatly due to local climatic and storage conditions. The stored equipment should be inspected at regular intervals during the time it is stored for accumulation of moisture or evidence of condensation. If moisture or evidence of condensation is found, the amount of heat per vertical section should be increased.

D. HANDLING

INDOOR EQUIPMENT SHOULD NOT BE STORED OUTDOORS, EVEN IF IT IS COMPLETELY COVERED WITH A TARPALIN OR PLASTIC SHEET.

The Class E2 Medium-Voltage Controller should be lifted, positioned, and handled by suitable lifting devices of adequate load ratings. (See Figure 9.) A maximum of 3 units can be lifted together. During handling, the rigging lengths of lifting equipment, such as slings or cables, should be set or adjusted to compensate any unequal load distribution to maintain the equipment in an upright position. Refer to the job drawings for the specific lifting weight specifications.

Figure 9. Recommended Method for Lifting an Indoor Lineup
It is preferable to handle P-46100 Controllers with overhead cranes, by the lifting means provided. For outdoor non-walk-in equipment, lifting angles are provided on the side of the structure, near the top. For outdoor walk-in enclosures, lifting channels are provided which are attached to the base of the equipment. Spreaders should be used in the slings above the enclosure to prevent damage to the equipment top edges. Do not attempt to lift equipment by using the angles installed on the sides. The angles are provided only to insure that the equipment will not tip over if it is top heavy by tying it down during shipment. The angles are not intended to be used for lifting purposes. Slings should be tied to referenced angles to prevent tipping. If bases are furnished, the equipment may be moved on an even surface by the use of rollers or heavy duty pipe under the base. Any force to move or jack the equipment must be applied to the base and not the equipment.

The use of fork lift trucks is not recommended, since the forks may damage the enclosure or interior parts of the equipment. If no other method of handling is available, the forks must go under the base bottom to avoid damage to the equipment.

E. POSITIONING OF THE ENCLOSURE

To enable proper operation of equipment, it is essential to securely fasten the lineups in a true upright position on a smooth, level surface. The floor should be leveled to within 1/8" for every 10 linear feet. Figure 10 illustrates various Medium-Voltage Controller floor plans. The equipment position should allow for the proper removal of the medium-voltage vacuum contactor.

When three or more controller units are to be arranged in one continuous lineup, THE CENTER SHIPPING UNIT SHOULD BE THE FIRST LOCATED. The other shipping lineup should then be installed in successive order in each direction from the center of the structure.

After positioning the equipment, check the equipment to ensure it is level. If necessary, shims may be inserted beneath the equipment base to achieve a level condition.

When the equipment is in the proper position, it can be bolted to the floor by using the holes located at the front and rear bottom of the vertical sections (Figure 10). Refer to the job drawings for the specific floor plan which specifies the location of the access holes.
**Class E2 Medium-Voltage Controller (400A) - Two-High Construction Floor Plan**

- **FEEDER ENTRY/EXIT ABOVE AND BELOW**
- **CONTROL ENTRY/EXIT ABOVE AND BELOW**
- **T-LEAD FEEDER LANDING ON FEEDER ENTRY END**
- **SHELF DIVIDER CABLE OPENING**
- **T-LEAD FEEDER LANDING OPPOSITE FEEDER ENTRY END**

**Class E2 Medium-Voltage Controller (400A) - One-High Construction Floor Plan**

- **CONTROL EXIT BELOW ONLY**
- **FEEDER EXIT ABOVE ONLY**
- **CONTROL EXIT ABOVE ONLY**

**Class E2 Medium-Voltage Controller (800A) - One-High Construction**

- **T-LEADS BOTTOM ENTRY**
- **CONTROL EXIT ABOVE ONLY**
- **BOTTOM ENTRY VIEW**
- **TOP ENTRY VIEW**

**Figure 11. Typical Class E2 Medium-Voltage Controller Floor Plans**

**NOTE:** The drawings in Figure 11 should NOT be used for any construction purposes. For construction information, refer to the specific drawings furnished with the equipment.
F. REMOVING THE MEDIUM-VOLTAGE VACUUM CONTACTOR

**CAUTION**

DO NOT WORK ON A MEDIUM-VOLTAGE CONTROLLER, VACUUM CONTACTOR, WITH THE CONTROL CIRCUIT ENERGIZED.

1) Removing the Vacuum Contactor from the Lower High-Voltage Compartment

The vacuum contactor is equipped with four wheels and a bracket for inserting a contactor lift bar to enable removal of the vacuum contactor for inspection and maintenance. The two processes necessary to remove the vacuum contactor are opening the lower, high-voltage compartment door and removing the vacuum contactor. The process for opening the door and removing the vacuum contactor from the lower and upper compartments are explained in the following procedures.

a) Opening the High-Voltage Compartment Door

To open the high-voltage compartment door, refer to Figure 12 and the following procedures.

1. **On Position:** When isolating switch operating handle is in the ON position (Figure 12, A), the isolating switch is in the closed position, the high-voltage compartment door is interlocked shut, and the controller may be energized.

2. **OFF Position:** When the switch is in the OFF position (Figure 12, B), the isolating switch is in the OPEN position, the high-voltage compartment door is interlocked shut, and the controller is de-energized and grounded.

3. **HORIZONTAL** position: With the operating handle rotated 90° counterclockwise (Figure 12, C) to the HORIZONTAL position (Figure 12, D), the isolating switch is in the OPEN position, the controller is de-energized, grounded, and the high-voltage compartment door can be opened.

Figure 12. Opening High Voltage Compartment Door
b) Removing the Vacuum Contactor from the Lower Compartment.

![Image](92x334 to 246x449)

![Image](96x159 to 249x273)

![Image](352x389 to 509x503)

![Image](355x220 to 502x330)

1. Visually inspect the isolating switch to ensure it is in the **OPEN** position and that the insulating shutter displays the **CLOSED** indicating stripes. See Section N. SAFETY INTERLOCKS, 4) The Shutter Assembly Insulating Shutter.

2. Confirm that the fuses are de-energized.

3. Using a fuse puller, remove the power circuit fuses. (See Figure 13, b and Figure 14, b).

4. Disconnect the 12-point secondary control circuit plug from the right side of the vacuum contactor and stow it so that the cable will not be damaged.

5. Disconnect the two, three-point plugs on the right front of the isolating switch.

**NOTE:** **DO NOT** disconnect the control power interlock (CPI) wires from the terminals on the plugs located on the isolating switch. The terminal blocks are plug-in type. Simply disconnect the CPI auxiliary switch terminal blocks by unplugging them.

6. Lift the vacuum contactor detent latch (Figure 15, a) on the left side of the vacuum contactor. Carefully roll the vacuum contactor out of the high-voltage compartment to the detent position. The contactor detent latch stops the vacuum contactor from being completely removed from the compartment (Figure 16).

7. Press down on the contactor detent latch and carefully roll the vacuum contactor out of the high-voltage compartment and onto the floor. A contactor lift bar may be used when removing the vacuum contactor from the compartment as illustrated in Figure 17.

**NOTE:** Store the vacuum contactor in a safe location to prevent damage to it while it is outside of the compartment.
c) Removing the Vacuum Contactor from the Upper High-Voltage Compartment

![Image](image-url)

**Figure 17. Vacuum Contactor Removed from Compartment using Contactor Lift Bar**

It is recommended to use a lift truck to remove the vacuum contactor from the upper high-voltage compartment in a two-high vertical section.

To remove the vacuum contactor from the upper compartment perform the following procedures:

1. Visually inspect the isolating switch to ensure it is in the **OPEN** position and that the insulating shutter displays the **CLOSED** indicating stripes (Figure 20, b). See Section T. SAFETY INTERLOCKS, 5) The Shutter Assembly Insulating Shutter.

2. Confirm that the fuses are de-energized.

3. Using a fuse puller, remove the power circuit fuses. (See Figure 13, b and Figure 14, b).

4. Disconnect the 12-point the secondary control circuit plug from the right side of the vacuum contactor and stow it so that the cable will not be damaged.

5. Disconnect the two three point plugs on the right front of the isolating switch.

   **NOTE**: **DO NOT** disconnect the control power interlock (CPI) wires from the terminals on the plugs located on the isolating switch. The terminal blocks are plug-in type. Simply disconnect the CPI auxiliary switch terminal blocks by unplugging them.

6. Move the lift truck to the front of the compartment and align the two pins on the leading edge of the lift truck with the two holes in the upper high-voltage compartment clip.

   Ensure that the pins are securely fastened in the holes and the lift truck brake is set prior to rolling the vacuum contactor onto the lift truck.

7. Lift the vacuum contactor detent latch (Figure 15, a) on the left side of the vacuum contactor and carefully roll the vacuum contactor out of the high-voltage compartment to the detent position (Figure 16).

8. Press down on the contactor detent latch and carefully roll the vacuum contactor out of the high-voltage compartment onto the lift truck tray (Figure 18a and 18b).

9. With the contractor securely latched on the lift truck tray, release the lift truck brake and move the lift truck away from the compartment.

10. Lower the lift truck tray to just above the floor and move the lift truck to the required location. Lower the tray to floor level and remove the contactor.

   **NOTE**: Store the vacuum contactor in a safe location to prevent damage to it while it is outside of the compartment.

![Image](image-url)

**Figure 18 a. Contactor Removed from Upper Compartment using a PowlVac/AmpGuard Lift Truck (Amp Guard Lift Truck is also available)**
G. POWER CONNECTIONS

The Class E2 Medium-Voltage Controller must be grounded before power connections are made. See Section H. GROUNDING.

External power cable connections should be installed in the controller after the equipment is placed in the permanent location and the grounding connections described in Section H. GROUNDING are completed. Grounding cables must be connected to the equipment ground bus and all high-voltage terminals that must be handled or touched during the power connection and installation process.

To access the power cable connections, it may be necessary to remove the isolating switch and the vacuum contactor. The procedure(s) for removing the contactors are listed above. The following steps describe the procedure for removing the manual isolating switch and accessing the power connection.

1. De-energize and ground the equipment.
2. Remove the two retaining bolts from the isolating switch front cover. (See Figure 19, c.)
3. Disconnect the control power interlock (CPI) auxiliary switch terminal blocks.

**NOTE:** **DO NOT** disconnect the control power interlock (CPI) wires from the terminals on the plugs located on the isolating switch. The terminal blocks are plug-in type. Simply disconnect the CPI auxiliary switch terminal blocks by unplugging them.

4. Remove the controller with caution. There is no stop block to engage the controller as it rolls out of the cell, and the equipment is heavy. The 400A assembly weighs approximately 75 pounds and the 800A assembly weighs approximately 100 pounds.

5. To install the external power cable connections, see Section I. INCOMING POWER CONNECTIONS AND MOTOR CONNECTIONS.

H. GROUNDING

Before power connections can be made, the switchgear vertical sections must be grounded. A ground bus is furnished with lugs at each end for connection to the station grounding system (Figure 20).

The ground bus is bolted to the rear on the top of the center shelf. It is arranged so that connections to the station ground can be made in any unit. Where equipment is shipped in more than one group, the sections of ground bus must be connected by using the splice plates furnished with the equipment (Figure 21).

Assemble the ground bus joints as outlined under “Connections.” The switchgear ground bus must be connected to the station ground bus by a conductor having a current carrying capacity equal to that of the switchgear ground bus. It is very important that the equipment be adequately grounded to protect the operator from injury when short circuits or other abnormal occurrences take place and to insure that all parts of the equipment, other than live parts, are at ground potential.
It is recommended that the connection to the station ground have a cross section of 500,000 circular mils (240 mm²) or greater if the soil in which it is buried is of such character as to cause appreciable corrosion. This is especially true where electrolysis from stray currents or contact with dissimilar metals exists. The resistance of the soil surrounding a station ground depends on the condition of the soil, as well as its chemical content. Dry, loose, sandy, or frozen soils will have a high resistance as compared with moist soils or soils containing ashes, cinders, or salt solution. The IEEE Standard 142 states that grounding impedance in the range of 1 to 5 ohms is generally acceptable for industrial substations. Ground resistance testing is recommended to verify that the ground resistance falls within this range.

Figure 22 shows the grounding connection for the 400A controller equipment. Notice there is a ground clip located on the bottom, left, side rail (Figure 22, d). Figure 23 shows the grounding connection for the 800A controller.

Table C lists recommended maximum cable sizes and cables per phase for equipment with only front access. For equipment cable requirements that exceed the recommended maximum cable sizes, equipment rear access and rear cable extensions are needed. The extension depth shall be determined by the specific equipment requirements.
**Table C. General Guideline for Incoming Line**

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Continuous Amperes</th>
<th>Maximum Cable Size</th>
<th>Cable per Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-High Vertical Section</td>
<td>400 A</td>
<td>500 mcm</td>
<td>1</td>
</tr>
<tr>
<td>Two-High Vertical Section</td>
<td>400 A</td>
<td>500 mcm</td>
<td>1</td>
</tr>
<tr>
<td>One-High Vertical Section</td>
<td>800 A</td>
<td>500 mcm</td>
<td>2</td>
</tr>
</tbody>
</table>

**Note:** For construction type, one-high and two-high vertical section 400 A (only), 2 cables (4/o or smaller) at maximum cable size 500 mcm may be included per phase.

---

**Figure 22. Class E2 Medium Voltage Controller Unit 400A**

- a. Ground Connection
  (To circuit breaker or other equipment)
- b. Shutter Assembly
- c. Load Devices (3)
- d. Ground Clip (400A)

**Figure 23. Class E2 Medium Voltage Controller Unit 800A**

(The rear barrier is removed for illustration.)

- a. Ground Connection
- b. Line Devices (3)
- c. Interlock
- d. Load Devices (3)
I. CONNECTIONS

The main bus bars and other connection bars are copper. The connection surfaces are silver surfaced or equivalent. The silver plating used on bolted contact surfaces is approximately 0.0001" thick. All field assembled joints in primary conductors, regardless of method of insulation, should be made as follows:

1. Wipe the surface clean with a lint-free cloth. Do not use sandpaper or any abrasive on the plated surface. Avoid handling of cleaned surface as much as possible. If the surface is tarnished, clean it with silver polish and then wash it with denatured alcohol.

2. Join the clean contact surfaces by using the hardware provided. The correct length of bolt must be used in each joint to insure that electrical clearances at bolt locations are maintained. As a general rule, when using 1/2" diameter bolts, the bolt should be 1" longer than the combined thickness of the copper bars being bolted together. For example, if three 1/4"-thick copper bars are to be connected, the bolt should be 1-3/4" long. In addition to proper length bolts, the bolt assembly must include flat washers, split-ring lock washers, and nuts. All hardware must be SAE Grade 5 or better. See Figure 24 for the proper assembly of hardware.

3. In some cases, external connections are made to the equipment main bus by bars. The equipment bars are normally silver plated. Unplated bars, either copper or aluminum should not be used to connect to plated bars.

4. All field assembled primary conductor joints and terminations must be insulated for the operating voltage. There are two methods of insulating joints: taping joints or applying boots where applicable. A detailed procedure for joint insulation is described under Section K. MAIN BUS ASSEMBLY.

NOTE: All hardware must be tightened to the torque values listed in Table D.

Table D. Bolt Torque Values for PowlVac Class E2 Medium-Voltage Controllers

NOTE: The bolt head drawings in the following table are not to scale. Locate the Bolting Torque label on equipment for an accurate drawing of bolt sizes.

<table>
<thead>
<tr>
<th>BOLT DIA. (ACTUAL SIZE) FT-LBS (KG-M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8</td>
</tr>
<tr>
<td>1/2</td>
</tr>
<tr>
<td>3/8</td>
</tr>
<tr>
<td>1/4</td>
</tr>
</tbody>
</table>

CAUTION

ALL EXPOSED PRIMARY BUS AND CABLE JOINTS AND CONNECTIONS SHOULD BE INSULATED FOR THE CORRECT SYSTEM INSULATION RATING.
J. MAIN BUS ASSEMBLY INSULATION

To insulate the main bus assembly, remove the rear compartment covers. Then, bolt the splice plates and bus bars together, following assembly instructions as given under Section J. CONNECTIONS. Tighten bolts properly. See Table D.

---

**CAUTION**

THE OPERATING TEMPERATURE OF CONDUCTORS IN THE SWITCHGEAR MAY REACH 105°C. ANY INSULATING MATERIAL USED IN THE METAL-CLAD SWITCHGEAR MUST BE SUITABLE FOR THIS TEMPERATURE.

To provide adequate bus joint insulation, use any of the following methods:

- Wrapping bus joints, using tape or heat shrink material
- Applying PVC (polyvinyl chloride) boots

K. INCOMING POWER CONNECTIONS

Incoming power connections to the main bus may be connected in various configurations depending on the equipment application (Figure 25). Review the elevation drawings delivered with the equipment for site-specific connection details.

**NOTE:** Refer to site-specific project drawings for recommended and available conduit space for top or bottom access.

---

1) Wrapping Bus Joint

1. Fill all cavities around the contact nuts and connection bars with the Solar Compounds Corporation Solarite KM1592 compound. Form a smooth surface for taping, thus preventing air voids.

**NOTE:** The compound is not an insulating medium and should not be used for that purpose.

2. Wrap the bus joint with 3 layers, 2/3 lap, of Scotch Super 33+ black insulating tape, maintaining tension on the tape while wrapping. Where there are sharp angles, apply additional layers to obtain the equivalent of the insulation on the flat surfaces.

3. Over the black tape, apply 2 layers, 2/3 lap, of Scotch 35 red insulating tape (Figure 26).

**NOTE:** One layer wound 2/3 lap requires 3 turns around bar in one width of the tape. One layer thickness is 3 times tape thickness.

---

2) Applying PVC Boots

1. Prepare all joints as outlined under Section J. CONNECTIONS.

2. Place the PVC boot over the joint. The boot should fit snugly around all conductors, and flanges must contact each other in a smooth joint.

3. Secure the boot with the furnished nylon wire ties to complete the joint insulation.

**NOTE:** The PVC insulation boots are furnished for standard configurations. Special configuration conditions may require taped joints if PVC boots are not available.

4. Replace all covers previously removed.

---

Figure 25. Main Bus and Splices (Bus Barrier Removed)

Figure 26. Wrapping of Bus
3) Cleaning Bus Insulation

The main bus bar is insulated with a high-temperature thermoplastic or thermoset material that provides dielectric and mechanical properties. Clean the insulation to provide optimum insulation properties.

Only use denatured alcohol or isopropyl alcohol to clean the insulation. Wear protective gloves and goggles and clean the main bus bar in a well-ventilated area. Wipe dirt or other foreign matter from the insulation with a clean cloth saturated with only denatured or isopropyl alcohol.

M. MOTOR CONNECTIONS

Motor lead cables may enter or terminate from either the top or the bottom access openings of the vertical section. The load terminals (Figure 27, a) are located behind the low-voltage compartment. Access the load terminals through the front of the 400A two high, medium-voltage compartment, or the front or rear of the 800A vertical section. To easily access the load terminals through the compartment front, remove the vacuum contactor and the isolating switch if required. Remove the rear compartment barrier to access the load terminals from the equipment rear. After motor cables are terminated, insulating boots must be installed on the load terminals.

NOTE: Refer to site-specific project drawings for recommended and available conduit space for top or bottom access.

As an option, barriers may be installed so that the load cables between two vacuum contactors are isolated in the same vertical section.

N. POWER CABLE TERMINATION

Cables should be prepared for termination in accordance with the instructions of the cable manufacturer. However, the following general recommendations are given for proper cable termination in equipment.

1. Pull in the cables in accordance with the equipment outline diagram specifications. Position the cables for maximum clearance between the phases, ground, and other cables, or wire runs. Refer to the specific job drawings and this instruction bulletin for the recommended location for the incoming cables.

2. Prepare the cable for termination in accordance with the manufacturer’s instructions.

3. Bolt the cable terminals to the bus or other point of termination.

4. If contact between the cable and an adjacent bus cannot be avoided, tape the bus in the immediate vicinity of the cable contact point so that the surface creepage distance from the cable to the bare bus bar is at least three inches. Thus, the surface creepage from the bare bus where the cable terminates, to the bare part of the bus where the cable touches, will be a distance of at least seven inches. The thickness of tape on the bus should be approximately 5/32".
5. Terminate any ground return and cable shield drains to the compartment ground bus.

6. Run all the low-voltage wires so as to avoid any possible contact with high-voltage lines.

Before any primary cable connections are made, the cables should be identified to indicate their phase relationship with the switchgear connections. This is necessary to insure that motors will rotate in the proper direction and that the phase rotation is the same when interconnecting two different sources of power.

Normally, compression terminals are used to terminate primary cables. When shielded cables are used, proper stress relief must be provided at the cable termination. This may be done by the use of a commercially available cable terminator, many types of which are available, or by the use of a stress cone, which can be either hand-built or the prepackaged type. In all cases, carefully follow the cable manufacturer’s recommendations for installation of the type of cable being used. Normally, no insulation or stress relief materials are furnished for cable terminations.

O. INSULATING PRIMARY CABLES

All field assembled joints for primary cable terminations should be prepared as outlined under Section J. Connections. Upon completion of the cable termination, care must be exercised when taping the exposed termination. Section K. MAIN BUS ASSEMBLY INSULATION, can be used for guidance in insulating techniques. However, in all cases, carefully follow the manufacturer’s recommendations for insulating the type of cable termination being used.

P. GROUND FAULT CURRENT TRANSFORMERS (THROUGH TYPE)

Through-type current transformers are furnished where specified for sensitive protection against ground faults. These transformers may be installed in a horizontal position directly above or below the primary cable terminals, so that the primary cable or cables can pass through them.

Where armored cable is used, the armor must be terminated and grounded before the cable passes through the transformer. Armor clamps are furnished for this purpose when specified.
When lead or other conducting sheath cable, or cable with shielding tape or braid is used, it is recommended that the sheath or shield be grounded solidly to the switchgear ground bus. The ground lead should be bonded to the sheath or shield on the side of the current transformer away from the primary terminals. In cases where the ground cannot be applied before the cable passes through the transformer, bond the lead to the sheath or shield between the transformer and the primary terminals. The ground conductor must then be passed back along the cable path through the current transformer before being connected to the ground bus.

Q. CONTROL CABLES AND CONNECTIONS

The low-voltage compartment where control connections are made is completely isolated from the high-voltage compartment (Figure 28).

Available space for both the top and bottom control wiring conduits are designed for easy accessibility. Conduits should be placed in accordance with the outline drawings.

Control connections are made through terminal blocks in the low-voltage compartment (Figure 28). Refer to the schematic and wiring diagrams furnished for each specific job for connection of all field control wires to the designated terminal blocks. A continuous horizontal wire way opening (Figure 29, a), located at the top, allows for electrical control interconnections between the vacuum contactors throughout the vertical sections.

Figure 28. Low-Voltage Compartment

When control conduits enter the unit from below, the conduit should not extend more than 1 inch above the floor. The control cables may be pulled through the conduits before or after the switchgear is installed, whichever is more convenient. If the control conduits enter from above, drill the top cover of the enclosure to suit the conduits, being careful not to damage existing wire bundles. Fasten the conduits to the cover with locknuts.

Connect the cables to the terminal blocks in accordance with the wiring diagrams furnished for the specific job.

The cables from the control power source to the switchgear must be large enough to avoid excessive voltage drop when the controllers are operated.
Where units have been split for shipment, any control or other secondary leads that must be reconnected across the split will be arranged with terminal blocks in a convenient location so that the wires can be easily reconnected. The wires will be cut to length and formed before being folded back so that a minimum time will be required for reconnecting them. Refer to the schematic and wiring diagrams furnished for each specific job for connection of all control wires to the designated terminal blocks.

**R. SURGE PROTECTION**

It is the responsibility of the purchaser to provide suitable surge arrestors to protect the switchgear from damage due to lightning or other electrical surges. When surge arrestors are furnished as part of the switchgear, the primary cable termination is insulated at the factory unless it must be disconnected for shipment. When this connection is completed in the field, it is necessary to insulate the primary connection before the switchgear is energized. Normally, PVC boots are supplied to insulate these connections.

**S. MECHANICAL OPERATION CHECK**

**CAUTION**

FAILURE TO PERFORM THIS OPERATION COULD RESULT IN FAILURE OF THE UNIT TO operate safely and reliably.

To perform the mechanical operation check, it is necessary to reinstall any of the primary circuit components that were removed previously to facilitate assembly and cable terminations.

To reinstall the isolating switch, lift the assembly and slide it fully into the compartment rails. Connect the two, three-point plugs on the right front of the isolating switch. Install the two retaining bolts on the isolating switch front cover. Install the vacuum contactor using the contactor lift bar to assist and roll the vacuum contactor into the compartment.

**NOTE: Ensure that the contactor detent latch, which is located on the lower left side of the vacuum contactor end plate, is positioned behind the stop bracket mounted on the left side of the contactor rail.**

**T. SAFETY INTERLOCKS**

Before placing the Class E2 Medium-Voltage Controller into service, it is recommended that the user is familiar with the safety interlocks.

**CAUTION**

DUE TO ELECTRICAL CLEARANCE REQUIREMENTS, THE FOUR PHASE BARRIERS SUPPLIED WITH THE CONTACTOR MUST BE INSTALLED BEFORE THE CONTACTOR IS ENERGIZED.

1) Isolating Switch Operating Handle

**WARNING**

THE EQUIPMENT MUST BE DE-ENERGIZED AND GROUNDED PRIOR TO PERFORMING ANY TESTS OR CHECKS OF THE SAFETY INTERLOCKS DEScribed BELOW. FAILURE TO DE-ENERGIZE AND GROUND THE EQUIPMENT PRIOR TO PERFORMING THESE TESTS OR CHECKS MAY RESULT IN INJURY OR DEATH.

The isolating switch can be placed in the OPEN position by moving the operating handle through a vertical arc from the ON position to the OFF position. From the OFF position, the isolating switch may then be rotated 90 degrees counterclockwise to the HORIZONTAL position. Refer to Section IV. INSTALLATION, F. REMOVING THE MEDIUM-VOLTAGE VACUUM CONTACTOR and see Figure 12.

In both the ON and OFF positions, a portion of the operating handle housing extends over the high-voltage compartment door and prevents the high-voltage compartment door from being opened. To open the door, the operating handle must be placed in the HORIZONTAL position.
With the operating handle in the OFF position, either a single padlock or up to three padlocks, locked in place, will prevent the handle from being placed in either the ON or HORIZONTAL positions. Padlocks can be used to prevent unauthorized entry into the high-voltage compartment and any accidental closing of the isolating switch while maintenance work is performed.

2) Door Interlocks

With the isolating switch operating handle in the HORIZONTAL position, the high-voltage compartment door can be opened. As soon as the door opens, a mechanical interlock prevents movement of the operating handle. It is designed to prevent the user from accidentally operating the isolation switch handle and closing the starter on to the line with the enclosure door open.

The mechanical interlock is a spring-loaded plunger located just behind the door. When the door is opened, the interlock extends and prevents the operating handle from being placed in the OFF position accidentally. If the user wished to observe the operation of the isolation switch during installation or maintenance procedures, this interlock must be deliberately defeated to move the handle to the OFF position.

3) Contactor - Isolating Switch Mechanical Interlock

The isolating switch functions only as a disconnect and must never close on to or interrupt a power load. To prevent this, a mechanical interlock between the vacuum contactor and the isolating switch is provided. If the vacuum contactor is in the CLOSED position, the interlock lever on the vacuum contactor armature actuates a mechanical linkage which locks the operating handle operating mechanism of the isolating switch.

4) Door Interference

The SLA contactor is equipped with a projection bar attached to the upper front edge of the right-hand side sheet. Its function is to ensure that the contactor is properly racked into position by providing an obstacle to door closure if the load jaws are not fully engaged with the load stabs.

DO NOT OPERATE THE CONTACTOR IF THE DOOR INTERFERENCE PREVENTS DOOR CLOSING.

5) Line Stab Insulating Shutter

When an isolating switch is installed, both a shutter and a rear line stab barrier are in place in the controller structure and are intended to prevent accidental access to the line bus. As the isolating switch is opened, the sliding tray (Figure 30) mechanically drives the insulating shutter closed across the three line stab openings in the rear barrier. As the shutter closes the openings, green and white striped labels are uncovered to visually indicate that the shutter is closed. With the isolating switch in the fully open position, the fuse jaw finger assemblies and the line side of the main fuses are connected to the ground bar.

UNDER THESE CONDITIONS THE EXPOSED LINE TERMINAL STABS OF THE STARTER MAY BE ENERGIZED AT LINE POTENTIAL.
When the isolating switch is removed from the starter structure, a latch lever on the shutter assembly is activated. It is designed to hold the insulating shutter closed. This latch may be deliberately bypassed and the shutter moved to the open position.

The shutter assembly and ground connection are visible from the front of the medium-voltage compartment and proper operation of the shutter and ground connection should be checked prior to energizing the equipment.

Figure 30. Shutter Assembly

(a) Shutter Assembly (400A)
(b) Isolating stripes

(b) Shutter Assembly (800A)
VII. OPERATION

A. GENERAL

A test power interlock circuit enables each complete unit to be tested without applying power to the motor. After all control-circuit connections are made, the controller should be put through its complete operating sequence in the test position, as a final check. A wiring diagram, which indicates circuits and connections, is shipped from the factory with the Class E2 Medium-Voltage Controller. All external wiring from the controller must be connected in accordance with the wiring diagram.

B. PREPARATION OF THE CONTROLLER FOR OPERATION

1) Cleaning

Ensure that the Class E2 Medium-Voltage Controller is clean before operation begins. After the equipment is placed in the required location and the cables are connected, carefully clean the compartment and equipment.

Before the panel can be operated, even for a tryout without power, all devices must be placed in full operating condition. To protect equipment during shipment, blocks and ties were applied to parts such as the armature of many of the relays and vacuum contactors. Ensure all blocks and ties are removed to prepare the Class E2 Medium-Voltage Controller for full operating condition.

Inspect the compartment and equipment for loose hardware, wires, and tools that may have been inadvertently left inside the compartment during installation.

Clean away dirt and dust, and remove packing material which interferes with the operation of the controller’s devices. For cleaning, use a brush, soft cloth, or a vacuum cleaner. Do not use compressed air to clean the equipment. This may result in loose dirt or grit being blown into bearings or other critical parts, thus causing excessive wear. Do not use detergent for cleaning. Only use denatured alcohol or isopropyl alcohol to clean the insulation. See H. MAINTENANCE of this section for complete cleaning information.

Care should be taken during the cleaning operation to prevent any dirt from being blown into the inaccessible space of the devices.

2) Lubricating

The seating surfaces of laminated AC contactors, relay magnets, and the end of shafts may be coated with a heavy–grease rust preventative. Before operating the vacuum contactors, the rust preventative should be wiped off and the magnet seating surfaces should be coated with a thin film of light machine oil.

3) Manual Operation

Operate each device by hand to confirm that the moving parts operate freely without binding. Ensure electrical contact tips are clean, free of grease and contamination, and have a good surface contact.

4) Adjustments

The relays and contactors are carefully adjusted at the factory. However, if adjustments are needed, refer to the instruction documents for information on individual devices. The Class E2 Medium-Voltage Controller can be operated after all connections are made, parts are assembled, and equipment and components are thoroughly adjusted and inspected.
C. TEST POWER CIRCUIT

The procedures in this section describe how to manually check the operating condition of the Class E2 Medium-Voltage Controller without energizing the motor.

A complete operational check of the controller can be made without applying voltage to the motor or to the bus as follows:

1. The isolating-device handle must be in the OFF position. In the OFF position, contacts of the mechanically operated test-power interlock will open the secondary circuit of the control-power transformer, thereby isolating it.

2. For convenience during maintenance when it may be desirable to energize the contactor or the control circuit only, a control power test plug is provided. To use the test plug, simply disconnect it from its socket, (under the control transformer on the contactor), and plug it into a 60 cycle, 115 volt single phase power supply. Special plugs may be provided when specified by the user. When the male plug is transferred to the test power supply, it automatically disconnects from the control power transformer to prevent feedback of high voltage into the power circuits. Check to be sure no inadvertent bypass of this arrangement has been made in the wiring before relying on this safety feature.

D. CLASS E2 MEDIUM-VOLTAGE CONTROLLER COMMISSIONING

The Class E2 Medium-Voltage Controller and Vacuum Contactor Repair and Test Form (Appendix A) provides a list of items to be checked before the Class E2 Medium-Voltage Controller is commissioned.

E. PRE-OPERATION TEST

The information in this section gives instructions for preparing for the pre-operation test and performing the pre-operation test.

1) Preparing for the Pre-Operation Test

Use the following information to prepare for the pre-operation test:

1. Ensure the motor control center is de-energized.
2. Complete all power and control connections.
3. Install manual isolator switches, contactors, and fuses.
4. Remove the required safety grounds.
5. Disconnect the following elements from the circuits to be tested:
   • Control Transformers
   • Potential Transformers
   • Starting Reactors
   • Auto-Transformers
   • Motors

WARNING
THIS TEST PROCEDURE REQUIRES THAT THE MOTOR CONNECTION CABLES BE DISCONNECTED FROM THE MOTOR TERMINALS AND BE PROPERLY INSULATED OR ISOLATED TO WITHSTAND PRIMARY VOLTAGE AT THE MOTOR TERMINALS. THIS TEST SHALL ONLY BE PERFORMED BY QUALIFIED PERSONNEL TRAINED AND CERTIFIED IN HIGH-VOLTAGE TESTING PROCEDURES. ADHERENCE TO ALL SITE-SPECIFIC HIGH-VOLTAGE SAFETY PROCEDURES SHALL BE STRICTLY ENFORCED. FAILURE TO FOLLOW THIS SAFETY PRECAUTION MAY RESULT IN INJURY OR DEATH.
2) Performing the Pre-Operation Test

1. Perform an insulation resistance (megger) dielectric test between the phases at the motor terminals, and between phases and phase to ground of the main bus to ensure that no short circuits are present. Record all test values for future use.

2. Close all compartment doors and apply power to the medium-voltage motor control center.

3. Close the isolating switch by placing the operating handle in the extreme upper position until it latches into the \textit{ON} position (Figure 12, A). If the operating handle is not properly closed and latched, the contact marked control power interlock will not close.

\textbf{NOTE:} If the isolating switch operating handle cannot be placed in the \textit{ON} position, de-energize and ground the equipment. Check the mechanical interlocking of the isolating switch. In order to place the operating handle in the \textit{ON} position, the high-voltage compartment door must be fully closed and the vacuum contactor must be in the \textit{OPEN} position.

4. Operate the Class E2 Medium-Voltage Controller in the normal manner using the pilot devices (usually push buttons) provided.

5. After the operation tests are made, connect the motor and check it for proper rotation.

F. INSPECTION, MAINTENANCE, AND SERVICING THE VACUUM CONTACTOR

1) Medium-Voltage Vacuum Contactor Adjustments

All adjustments pertaining to the vacuum contactor are described in the following Cutler-Hammer Publications:

- 400 A, Type SL, 2.2 kV – 7.2 kV .... I.B.48021
- 800 A, Type SJA 2.2 kV – 7.2 kV .... I.B.48005

2) Isolating Switch Adjustment

Normally, the isolating switch will not require any adjustment; however, if parts are removed or replaced, it may be necessary to make adjustments in the mechanism. Refer to the Cutler-Hammer Publications I.B. 48021 and I.B 48005 for complete information. See Table E.

3) Power Fuse Inspection

Inspect the condition of all current-limiting fuses after every fault current condition. Visually inspect the power fuse blown fuse indicator (Figure 32, a). Or perform continuity tests to determine the condition of the fuses. When visually inspecting a fuse, if the colored indicator on top of the fuse extends outwards, the fuse is in the \textit{OPEN} position or blown. Compare the existing fuse resistance value to a new fuse value to determine the condition of the fuse.

Perform continuity tests to determine the condition of the control power transformer primary fuses and control power transformer secondary fuses. Compare the existing fuse resistance value to a new fuse value to determine the condition of the fuse.

As required, replace fuses only with new fuses with the same catalog number, type, voltage rating, current rating, frequency rating, and maximum interrupting rating. Refer to the \textit{Operating Instructions} label for complete instructions on fuse replacement. The operating instructions label is located on the inside compartment door of the medium-voltage controller.

\begin{table}[h]
\centering
\begin{tabular}{|l|l|}
\hline
\textbf{Storage and Handling} & I.B.48001 \\
\hline
\textbf{Class E2 Medium-Voltage Controllers} & \\
\hline
Isolating Switch 400 A & I.B.48021 \\
Isolating Switch 800 A & I.B.48005 \\
\hline
\textbf{Medium-Voltage Vacuum Contactor} & \\
Vacuum Bottle Subassembly & \\
Vacuum Contactor Latch & \\
Type L64 Auxiliary Contact & \\
Type SL 400A & \\
Type SJA 800A & \\
\hline
\end{tabular}
\caption{Cutler-Hammer Publication References}
\end{table}
G. MAINTENANCE

1) Maintenance Precautions

The equipment described in this information bulletin contains hazardous voltages and currents sufficient to cause death, electric shock, or severe injury for personnel. De-energize the equipment before performing any maintenance work. Lock out the disconnecting means in accordance with NFPA 70E, “Electric Safety Requirements for Employee Safety in the Workplace.”

2) Preventative Maintenance Guidelines

A preventative maintenance schedule, including cleaning, inspection, and testing should be established to obtain the best service and reliability from the Class E2 Medium-Voltage Controller. The frequency and interval of preventive maintenance should be scheduled according to operating and local conditions and established needs and trends as determined by periodic maintenance and test records. If assistance is required for setting up the proper interval schedule for maintenance, contact Powell Electrical Manufacturing Company.

During preventive maintenance and inspection, check equipment for the following deteriorating conditions:

1. Contamination by dirt and dust in the environment including wood fibers, coal dust, cement, lamp black, and lint
2. Contamination by chemicals in the environment such as sulfur dioxide, chlorine, hydrocarbons, hydrogen sulfide and salt water
3. Mechanical wear and fatigue on moving parts
4. Environmental heat and humidity
5. Loose hardware, connections, and joints

When needed, correct all adverse conditions as follows: clean equipment; protect equipment from adverse conditions; replace worn parts; lubricate specific parts; and properly tighten loose hardware, connections, and joints.

Inspect all sections of the Class E2 Medium-Voltage Controller, including the high-voltage compartment door interlock. The following list contains general recommendations for inspecting equipment.

1. Check for the presence of dust or dirt in the compartment and on equipment. Specifically check for accumulation of any dust or dirt contamination on the insulators. Voltage failures can result from tracking across contaminated insulating surfaces.
2. Check for abrasive material accumulated in the isolating switch mechanism and mechanical interlock bearing and cam surfaces.
3. Check for a buildup of dust or dirt that will reduce any air or surface voltage clearances.
4. Excessive heating can reduce spring tension on the primary connection stabs. Check stab spring tension regularly, especially during excessive heat conditions.
5. Excessive heat can cause the wiring and cable insulation to breakdown. Check all wires and cables for any evidence of melting, discoloring, and deterioration.
6. The isolating switch mechanism has a life expectancy of approximately 1000 operations. If the application requires that the mechanism operates more than twice each day, the mechanism should be checked at the end of each 1000 operations, otherwise a yearly inspection is recommended.
7. Periodic dimensional inspections of the isolating switch mechanism and mechanical interlocks are strongly recommended. Refer to the proper Cutler-Hammer Publication as found in Section VII. OPERATION, G. MAINTENANCE, 2) Preventive Maintenance Guidelines.
8. Check all dimensions when any part of the isolating switch mechanism and mechanical interlock is replaced to ensure that the system is in safe working order.
VI. RECOMMENDED RENEWAL PARTS AND REPAIR PROCEDURES

A. ORDERING INSTRUCTIONS

To order renewal parts from Powell Apparatus Service Division (PASD) visit the Web site at www.powellservice.com or call 1-800-480-7273. When ordering parts always specify the complete nameplate information, which includes the following:

- Controller Type
- Serial Number
- Rated Voltage
- Rated Amps
- Impulse Withstand
- Control Voltage (for control devices and coils)

To obtain part information, review the renewal parts tables in the appropriate instruction bulletin. When ordering parts, specify the part name, description, and part catalog number if the part is listed in a renewal parts table. If the part does not appear in an instruction bulletin Renewal Parts table, provide a description of the part along with a marked illustration from the instruction bulletin, a photo, or a sketch of the needed part.

B. RECOMMENDED RENEWAL PARTS

For timely and cost-effective replacement of worn, broken, or damaged parts, a sufficient supply of renewal parts should be purchased and stored appropriately. (See Section IV INSTALLATION, C. STORAGE.) Maintaining a supply of renewal parts enables the purchaser to replace damaged parts quickly with a result of reducing the amount of service interruption time. See Tables F, G, H, I, and J for a list of renewal parts for equipment described in this document.

1) Renewal Parts Quantity

The needed quantity of renewal spare parts varies. The purchaser should determine which parts and the quantity needed depending on their particular application and the following factors:

- Amount of time to acquire renewal parts
- Critical need for continuous operation
- Harsh environmental conditions that may affect part stability
- Severe service requirements that may affect part durability

The parts tables included in this instruction bulletin may list recommended quantities of renewal parts to be carried in stock. As a minimum, it is recommended that one set of renewal parts be stocked per unit.

Over time, improvements may be made to renewal parts. Therefore, spare or renewal parts may not be identical to the original parts. However, the furnished replacement parts are interchangeable with the original parts.

C. REPAIR PROCEDURES

Powell Electrical Manufacturing Company recommends that only qualified technicians perform maintenance on the equipment described in this instruction bulletin. Therefore, if vacuum contactors are installed in a location that is not maintained by a qualified technician, a spare vacuum contactor should be stored on site for vacuum contactor replacement. Thus, the spare vacuum contactor can be placed into service and the malfunctioning unit can be returned to the factory for reconditioning.
## Table F. Renewal Parts

<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog No.</th>
<th>Description</th>
<th>Catalog No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Stab Assembly 400A</td>
<td>2A96124G03</td>
<td>Load Stab Assembly 800A</td>
<td>STA-800A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>46910G01</td>
</tr>
<tr>
<td>Line Stab Assembly 400A</td>
<td>2A96124G02</td>
<td>Line Stab Assembly 800A</td>
<td>SJA 2044A50G28</td>
</tr>
<tr>
<td>Isolating Switch 400A</td>
<td>1A96056G11</td>
<td>Isolating Switch</td>
<td>SJA 786A50G01</td>
</tr>
<tr>
<td>Operating Arm 400A</td>
<td>3509C92G01</td>
<td>Fuse Puller 400A</td>
<td>827D924G01</td>
</tr>
<tr>
<td>Control Plug (12 pt.) 400A (14 ga)</td>
<td>46050G03</td>
<td>Fuse Puller 800A</td>
<td>3440D69G01</td>
</tr>
<tr>
<td>Control Plug (12 pt.) 800A (14 ga)</td>
<td>46050G05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Contact Powell Apparatus Service Division (PASD) for additional catalog numbers.*
<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum Interrupter Bottles</td>
<td>2147A58G02</td>
</tr>
<tr>
<td>Contactor PC Board</td>
<td>2147A58G03</td>
</tr>
<tr>
<td>Contactor Auxiliary Contacts</td>
<td></td>
</tr>
<tr>
<td>2 N/O and 2 N/C</td>
<td>2147A58G04</td>
</tr>
<tr>
<td>3 N/O and 3 N/C</td>
<td>2147A58G05</td>
</tr>
<tr>
<td>Contactor Coil Kit (main/dual)</td>
<td>2147A58G11</td>
</tr>
<tr>
<td>Contactor Phase Barrier Kit</td>
<td>2147A58G12</td>
</tr>
<tr>
<td>Bottle Clamp Assembly</td>
<td>2147A58G15</td>
</tr>
<tr>
<td>CPT Primary Fuse Clips and Mounting</td>
<td>2147A58G16</td>
</tr>
<tr>
<td>Fuse Support Tray and Barrier Support</td>
<td>2147A58G17</td>
</tr>
<tr>
<td>PT Primary Fuse Clips and Mounting</td>
<td>2147A58G18</td>
</tr>
<tr>
<td>Main Fuse Clip Kit</td>
<td>2147A58G20</td>
</tr>
<tr>
<td>Contactor Line Bus</td>
<td>2147A58G21</td>
</tr>
<tr>
<td>Return Spring Assembly</td>
<td>2147A58G22</td>
</tr>
<tr>
<td>Mechanical Latch Assembly</td>
<td>2147A58G24</td>
</tr>
<tr>
<td>Contactor Trip Coil (latch units)</td>
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</tr>
<tr>
<td>24 VDC</td>
<td>2147A58G25</td>
</tr>
<tr>
<td>48 VDC</td>
<td>2147A58G26</td>
</tr>
<tr>
<td>125 VAC - VDC</td>
<td>2147A58G27</td>
</tr>
<tr>
<td>250 VAC - VDC</td>
<td>2147A58G28</td>
</tr>
<tr>
<td>Contactor Line Fingers and Support Kit</td>
<td>2147A58G50</td>
</tr>
<tr>
<td>Contactor Load Fingers and Support Kit</td>
<td>2147A58G51</td>
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<tr>
<td>Control Power Transformer (CPT)</td>
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<tr>
<td>750 VA, 2400 V</td>
<td>C 75A1D1C2</td>
</tr>
<tr>
<td>750 VA, 4160 V</td>
<td>C 75E1D1C2</td>
</tr>
<tr>
<td>2000 VA, 2400 V</td>
<td>C 20A1D1C2</td>
</tr>
<tr>
<td>2000 VA, 4160 V</td>
<td>C 75E1D1C2</td>
</tr>
<tr>
<td>Control Power Transformer (CPT)</td>
<td>578D461G03</td>
</tr>
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</table>
### Table H. Medium-Voltage Vacuum Contactor Type SJA 800A Renewal / Replacement Parts

<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog No.</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum Interrupter Subassemblies</td>
<td>2147A87G03</td>
<td>Includes: shunt, load supports, load fingers.</td>
</tr>
<tr>
<td>Contactor Auxiliary Contacts (L-64)</td>
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</tr>
<tr>
<td>1 NO INC</td>
<td>843D943G21</td>
<td></td>
</tr>
<tr>
<td>2 NO</td>
<td>843D943G22</td>
<td></td>
</tr>
<tr>
<td>2 NC</td>
<td>843D943G23</td>
<td></td>
</tr>
<tr>
<td>Contactor Coil Kit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120 VAC</td>
<td>214A88G11</td>
<td></td>
</tr>
<tr>
<td>240 VAC</td>
<td>214A88G12</td>
<td></td>
</tr>
<tr>
<td>Contactor Phase Barrier Kit</td>
<td>2147A89G07</td>
<td></td>
</tr>
<tr>
<td>CPT Primary Fuse Clips and Mounting Set (3)</td>
<td>2147A47G16</td>
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<tr>
<td>Fuse Support Tray and Contactor Phase Barrier</td>
<td>2147A89G06</td>
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<tr>
<td>Support</td>
<td></td>
<td></td>
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<tr>
<td>Pt Primary Fuse Clips and Mounting Set (3)</td>
<td>2147A47G16</td>
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<tr>
<td>Main Fuse Clip Kit (Fuse Load Fingers)</td>
<td>2147A71G15</td>
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<tr>
<td>Mechanical Latch Assembly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120 VAC continuous – 48 VDC Intermittent</td>
<td>2147A88G22</td>
<td></td>
</tr>
<tr>
<td>230 VAC continuous – 125 VDC Intermittent</td>
<td>2147A88G23</td>
<td></td>
</tr>
<tr>
<td>Contactor Trip Coil (Latch Units)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>115 VAC</td>
<td>5259C73H01</td>
<td>Single trip coil assembly without interlocks, precable, or magnetic parts.</td>
</tr>
<tr>
<td>230 VAC</td>
<td>5259C73H02</td>
<td></td>
</tr>
<tr>
<td>Contactor Line Fingers and Support Kit (Qty. 3)</td>
<td>2147A89G01</td>
<td></td>
</tr>
<tr>
<td>Contactor Load/Line Fingers without Support Kit</td>
<td>2147A89G02</td>
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<tr>
<td>(Qty. 3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L-63 Interlock</td>
<td>578D461G03</td>
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### Table I. ACLS, CLS70 Current-Limiting Fuses (R-Type)

#### Type ACLS Current-Limiting Fuses for use with Class E2 Medium-Voltage Controllers (400 A)

<table>
<thead>
<tr>
<th>“R” Des</th>
<th>Amp Rating</th>
<th>Catalog No. Sym. (int.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2R</td>
<td>70</td>
<td>5ACLS-2R 50,000</td>
</tr>
<tr>
<td>3R</td>
<td>100</td>
<td>5ACLS-3R 50,000</td>
</tr>
<tr>
<td>4R</td>
<td>130</td>
<td>5ACLS-4R 50,000</td>
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<tr>
<td>5R</td>
<td>150</td>
<td>5ACLS-5R 50,000</td>
</tr>
<tr>
<td>6R</td>
<td>170</td>
<td>5ACLS-6R 50,000</td>
</tr>
<tr>
<td>9R</td>
<td>200</td>
<td>5ACLS-9R 50,000</td>
</tr>
<tr>
<td>12R</td>
<td>230</td>
<td>5ACLS-12R 50,000</td>
</tr>
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</table>

#### Type CLS70 Current-Limiting Fuses for use with Class E2 Medium-Voltage Controllers (800 A)

<table>
<thead>
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<th>“R” Des</th>
<th>Amp Rating</th>
<th>Catalog No. Sym. (int.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12R</td>
<td>230</td>
<td>5CLS70-12R 50,000</td>
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<tr>
<td>24R</td>
<td>450</td>
<td>5CLS70-24R 50,000</td>
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<tr>
<td>32R</td>
<td>600</td>
<td>5CLS70-32R 50,000</td>
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<tr>
<td>36R</td>
<td>650</td>
<td>5CLS70-36R 50,000</td>
</tr>
<tr>
<td>44R</td>
<td>700</td>
<td>5CLS70-44R 50,000</td>
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#### Type ACLS Current-Limiting Fuses for use with Class E2 Medium-Voltage Controllers (400 A)

<table>
<thead>
<tr>
<th>“R” Des</th>
<th>Amp Rating</th>
<th>Catalog No. Sym. (int.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12R</td>
<td>230</td>
<td>5ACLS-18R 50,000</td>
</tr>
<tr>
<td>24R</td>
<td>450</td>
<td>5ACLS-24R 50,000</td>
</tr>
<tr>
<td>26R</td>
<td>480</td>
<td>5ACLS-26R 50,000</td>
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#### Type ACLS Current-Limiting Fuses for use with Class E2 Medium-Voltage Controllers (800 A)

<table>
<thead>
<tr>
<th>“R” Des</th>
<th>Amp Rating</th>
<th>Catalog No. Sym. (int.)</th>
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</thead>
<tbody>
<tr>
<td>9R</td>
<td>390</td>
<td>7ACLS-9R 50,000</td>
</tr>
<tr>
<td>12R</td>
<td>450</td>
<td>7ACLS-12R 50,000</td>
</tr>
</tbody>
</table>
Table J. ACLE, AHLE, NCLPT Current-Limiting Fuses (E-Type)

**Type AHLE Current-Limiting Fuses for use with Class E2 Medium-Voltage Controllers (400 A)**

<table>
<thead>
<tr>
<th>Amp Rating</th>
<th>Catalog No.</th>
<th>Sym. (int.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250C</td>
<td>5AHLE-250E</td>
<td>63,000</td>
</tr>
</tbody>
</table>

**5.5 kV Max. (4.8 Nom.) 12” Clip Center**

<table>
<thead>
<tr>
<th>Amp Rating</th>
<th>Catalog No.</th>
<th>Sym. (int.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300E</td>
<td>5AHLE-300E</td>
<td>63,000</td>
</tr>
<tr>
<td>350E</td>
<td>5AHLE-350E</td>
<td>63,000</td>
</tr>
<tr>
<td>400E</td>
<td>5AHLE-400E</td>
<td>63,000</td>
</tr>
<tr>
<td>450E</td>
<td>5AHLE-450E</td>
<td>63,000</td>
</tr>
</tbody>
</table>

**7.2 kV Max. 12” Clip Center**

<table>
<thead>
<tr>
<th>Amp Rating</th>
<th>Catalog No.</th>
<th>Sym. (int.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40E</td>
<td>8AHLE-40E</td>
<td>50,000</td>
</tr>
<tr>
<td>50E</td>
<td>8AHLE-50E</td>
<td>50,000</td>
</tr>
<tr>
<td>65E</td>
<td>8AHLE-65E</td>
<td>50,000</td>
</tr>
<tr>
<td>80E</td>
<td>8AHLE-80E</td>
<td>50,000</td>
</tr>
<tr>
<td>100E</td>
<td>8AHLE-100E</td>
<td>50,000</td>
</tr>
<tr>
<td>125E</td>
<td>8AHLE-125E</td>
<td>50,000</td>
</tr>
<tr>
<td>150E</td>
<td>8AHLE-150E</td>
<td>50,000</td>
</tr>
<tr>
<td>180E</td>
<td>8AHLE-180E</td>
<td>50,000</td>
</tr>
<tr>
<td>200E</td>
<td>8AHLE-200E</td>
<td>50,000</td>
</tr>
<tr>
<td>250E</td>
<td>8AHLE-250E</td>
<td>50,000</td>
</tr>
<tr>
<td>300E</td>
<td>8AHLE-300E</td>
<td>50,000</td>
</tr>
<tr>
<td>350E</td>
<td>8AHLE-350E</td>
<td>50,000</td>
</tr>
</tbody>
</table>

**Type CLS70 Current-Limiting Fuses for use with Class E2 Medium-Voltage Controllers (800 A)**

<table>
<thead>
<tr>
<th>Amp Rating</th>
<th>Catalog No.</th>
<th>Sym. (int.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25E</td>
<td>5ACLE-25E</td>
<td>50,000</td>
</tr>
<tr>
<td>30E</td>
<td>5ACLE-30E</td>
<td>50,000</td>
</tr>
<tr>
<td>50E</td>
<td>5ACLE-50E</td>
<td>50,000</td>
</tr>
<tr>
<td>65E</td>
<td>5ACLE-65E</td>
<td>50,000</td>
</tr>
<tr>
<td>80E</td>
<td>5ACLE-80E</td>
<td>50,000</td>
</tr>
<tr>
<td>100E</td>
<td>5ACLE-100E</td>
<td>50,000</td>
</tr>
<tr>
<td>125E</td>
<td>5ACLE-125E</td>
<td>50,000</td>
</tr>
<tr>
<td>150E</td>
<td>5ACLE-150E</td>
<td>50,000</td>
</tr>
<tr>
<td>200E</td>
<td>5ACLE-200E</td>
<td>50,000</td>
</tr>
<tr>
<td>225E</td>
<td>5ACLE-225E</td>
<td>50,000</td>
</tr>
</tbody>
</table>

**8.3 kV Max. (7.2 Nom.) 12” Clip Center**

<table>
<thead>
<tr>
<th>Amp Rating</th>
<th>Catalog No.</th>
<th>Sym. (int.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>600E</td>
<td>5CLS70-600E</td>
<td>40,000</td>
</tr>
<tr>
<td>750E</td>
<td>5CLS70-750E</td>
<td>40,000</td>
</tr>
</tbody>
</table>

**Type NCLPT Current-Limiting Fuses for use with Control Power Transformer**

<table>
<thead>
<tr>
<th>Amp Rating</th>
<th>Catalog No.</th>
<th>Sym. (int.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1E</td>
<td>5NCLPT-1E</td>
<td>63,000</td>
</tr>
<tr>
<td>3E</td>
<td>5NCLPT-3E</td>
<td>63,000</td>
</tr>
<tr>
<td>5E</td>
<td>5NCLPT-5E</td>
<td>63,000</td>
</tr>
</tbody>
</table>
## Appendix

### Class E2 Medium-Voltage Controller and Vacuum Contactor Repair and Test Form

<table>
<thead>
<tr>
<th>Customer Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Location:</td>
<td>Ref. Powell S.O. # :</td>
</tr>
<tr>
<td>Customer P.O. :</td>
<td></td>
</tr>
<tr>
<td>Circuit I.D. :</td>
<td></td>
</tr>
</tbody>
</table>

### Vacuum Contactor Specifications

<table>
<thead>
<tr>
<th>Mfg./Model #</th>
<th>Ams, kV, kA</th>
<th>Serial #</th>
<th>Ref. Mfg. IB #:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contactor Rating:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close Voltage:</td>
<td>48 V DC</td>
<td>120 V DC</td>
<td>125 V DC</td>
</tr>
<tr>
<td>Trip Voltage:</td>
<td>48 V DC</td>
<td>120 V DC</td>
<td>125 V DC</td>
</tr>
<tr>
<td>System Voltage:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Capacity:</td>
<td>HP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum Contactor Type:</td>
<td>D.A.L. :</td>
<td>Soft-Start</td>
<td>Latch Trip Coil ?</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Class E2 Medium-Voltage Controller and Vacuum Contactor Start-up/Maintenance Checks

<table>
<thead>
<tr>
<th>Shipping Bracket Removed</th>
<th><em>Late-Break</em> Coil Contact Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleanliness</td>
<td>CoIl Resistor(s) Properly Sized</td>
</tr>
<tr>
<td>Phase Barriers / (Arc Chutes, if applicable.)</td>
<td>Contact Force Measurement</td>
</tr>
<tr>
<td>Primary Disconnecting Device:</td>
<td>Critical Adjustments Verified, (if applicable)</td>
</tr>
<tr>
<td>Shutter Assembly Operation</td>
<td>CPT Rating and Wiring Connections</td>
</tr>
<tr>
<td>Isolating Switch Operating Handle</td>
<td></td>
</tr>
<tr>
<td>Alignment</td>
<td></td>
</tr>
<tr>
<td>Interlock(s):</td>
<td>Primary</td>
</tr>
<tr>
<td>Door Interlock(s):</td>
<td>Secondary</td>
</tr>
<tr>
<td><em>&quot;Closed-Door&quot; Interlocks</em></td>
<td>CT Ratio and Polarity</td>
</tr>
<tr>
<td>Position Interlock(s)</td>
<td>Tightness of T-Lead Connection</td>
</tr>
<tr>
<td>Mechanical Latch (if applicable)</td>
<td>Ground Connections</td>
</tr>
<tr>
<td>Line Stabs:</td>
<td>Protective Relay Test(s)</td>
</tr>
<tr>
<td>Pressure</td>
<td>Electrical Function Test</td>
</tr>
<tr>
<td>Lubricant</td>
<td>&quot;Start-Run&quot; Vacuum Contactor Interlock Ckt.</td>
</tr>
<tr>
<td>Control Plug</td>
<td></td>
</tr>
<tr>
<td>Control Power Interlock (CPI) Auxiliary Switch</td>
<td></td>
</tr>
</tbody>
</table>

**Vacuum Contactor Primary Circuit Tests**

<table>
<thead>
<tr>
<th><em>Vacuum Interrupter Resistance</em></th>
<th>A phase</th>
<th>B phase</th>
<th>C phase</th>
<th><em>Vacuum Integrity</em></th>
<th>A phase</th>
<th>B phase</th>
<th>C phase</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>micro-ohms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Hi–Potential ac</em></td>
<td>5.0 kV – 13.2 kV AC</td>
<td>7.2 kV – 18.2 kV AC</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Hi–Potential dc</em></td>
<td>5.0 kV – 13.7 kV AC</td>
<td>7.2 kV – 25.6 kV AC</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Vacuum Contactor Tested in "Open" Position**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Top</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Vacuum Contactor Tested in "Closed" Position**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>A phase</th>
<th>B phase</th>
<th>C phase</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Maintenance Performed (give exact Description(s) and Location(s) of all Maintenance Performed):

### Parts Replacement (give exact Location(s), Quantit(ies), and Description(s) of all Parts to be Replaced):

### Comments:

### Tests by:

Note:  Items marked with an * are optional
Note:  Only the tests necessary to verify performance of the repair(s) are required (for repaired vacuum contactors).
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5.0 kV Voltage Class for SL 400A and SJA 800A
7.2 kV Voltage Class for SL 400A and SJA 800A