




# Handling, Installing & Maintaining Excitation Control Equipment

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*Instruction Manual*

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# Preface

This instruction manual provides information about handling, installing, and maintaining generator and motor excitation control equipment manufactured by Basler Electric. To accomplish this, the following information is provided:

- Equipment handling and storage,
- Installation guidelines,
- Maintenance recommendations, and
- A maintenance schedule.

## ***Conventions Used in this Manual***

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Important safety and procedural information is emphasized and presented in this manual through warning, caution, and note boxes. Each type is illustrated and defined as follows.

### **Warning!**

Warning boxes call attention to conditions or actions that may cause personal injury or death.

### **Caution**

Caution boxes call attention to operating conditions that may lead to equipment or property damage.

### **Note**

Note boxes emphasize important information pertaining to installation or operation.



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### Warning!

READ THIS MANUAL. Read this manual before installing, operating, or maintaining this equipment. Note all warnings, cautions, and notes in this manual as well as on the product. Keep this manual with the product for reference. Only qualified personnel should install, operate, or service this system. Failure to follow warning and cautionary labels may result in personal injury or property damage. Exercise caution at all times.

Basler Electric does not assume any responsibility to compliance or noncompliance with national code, local code, or any other applicable code. This manual serves as reference material that must be well understood prior to installation, operation, or maintenance.

For terms of service relating to this product and software, see the *Commercial Terms of Products and Services* document available at [www.basler.com/terms](http://www.basler.com/terms).

This publication contains confidential information of Basler Electric Company, an Illinois corporation. It is loaned for confidential use, subject to return on request, and with the mutual understanding that it will not be used in any manner detrimental to the interests of Basler Electric Company and used strictly for the purpose intended.

It is not the intention of this manual to cover all details and variations in equipment, nor does this manual provide data for every possible contingency regarding installation or operation. The availability and design of all features and options are subject to modification without notice. Over time, improvements and revisions may be made to this publication. Before performing any of the following procedures, contact Basler Electric for the latest revision of this manual.

The English-language version of this manual serves as the only approved manual version.

# Revision History

A historical summary of the changes made to this instruction manual is provided below. Revisions are listed in reverse chronological order.

Visit <http://www.basler.com> to download the latest hardware, firmware, and BESTCOMSPPlus® revision histories.

## Instruction Manual Revision History

Manual Revision, Date	Change
M, January 2021	<ul style="list-style-type: none"> <li>Added ground bus splice illustration to <i>Installation</i> chapter</li> </ul>
L, August 2020	<ul style="list-style-type: none"> <li>Added information and procedures to the <i>Installation</i> chapter for onsite equipment assembly and connection</li> </ul>
K, June 2020	<ul style="list-style-type: none"> <li>Added <i>Selenium Surge Suppressor Maintenance</i> chapter</li> <li>Renamed <i>Maintenance</i> chapter to <i>Preventive Maintenance</i></li> </ul>
J, July 2018	<ul style="list-style-type: none"> <li>Added rigging guidelines illustration for equipment hoisting</li> </ul>
I	<ul style="list-style-type: none"> <li>This revision letter not used</li> </ul>
H, August 2017	<ul style="list-style-type: none"> <li>Modified the maintenance schedule for MOVs to show only inspection at the prescribed intervals</li> <li>Added more detail to the information about moving equipment</li> </ul>
G, May 2017	<ul style="list-style-type: none"> <li>Added <i>Grounding for CE Compliance</i> to <i>Installation</i> chapter</li> </ul>
F, April 2016	<ul style="list-style-type: none"> <li>Added <i>Fastener Assembly and Torque</i> chapter</li> </ul>
E, January 2014	<ul style="list-style-type: none"> <li>Added storage and operating temperature range recommendations</li> </ul>
D, October 2013	<ul style="list-style-type: none"> <li>Corrected temperature reference listed under <i>Alternate Storage Procedures</i> of the <i>Equipment Handling</i> chapter</li> </ul>
C, April 2012	<ul style="list-style-type: none"> <li>Removed all references to using compressed air for cleaning purposes</li> </ul>
B, February 2012	<ul style="list-style-type: none"> <li>Added coverage of DECS-2100 systems</li> <li>Updated the style of the manual</li> </ul>
A, December 2009	<ul style="list-style-type: none"> <li>Modified the maintenance recommendations for rectifier bridges</li> </ul>
–, June 2007	<ul style="list-style-type: none"> <li>Initial release</li> </ul>



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# 1 • General Information

## ***Introduction***

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This publication serves as a general guide for the handling, storage, installation, and maintenance of generator and motor excitation control equipment manufactured by Basler Electric. The objective of this guide is to furnish guidelines that will promote and enhance a reliable installation.

## ***System Identification***

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Each excitation control system manufactured by Basler Electric is assigned a model, part, and serial number. The system part number must accompany any correspondence concerning the excitation system. When ordering parts from Basler Electric, be sure to specify the Basler part number, quantity, description, and system part number. The system part number can be found in the instruction manual as well as on the front panel of the system enclosure. An identification nameplate is affixed to the front of each enclosure.

## ***Instruction Manual***

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An instruction manual is supplied with every excitation system and should be referred to for information relating to the individual system requirements. The instruction manual contains important information and should be kept in a safe place for future reference. Typical instruction manual content includes:

- System specifications
- A functional description
- General operating instructions
- A list of system components
- System drawings
- Publications relevant to devices installed in the system

## ***Safety***

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### **Warning!**

Some components of the excitation system carry voltage at hazardous levels. Contact with these voltages can result in personal injury or death.

Only personnel who are thoroughly trained and who understand the hazards associated with working on excitation systems should carry out inspection and maintenance procedures. Plant personnel should become familiar with the schematic diagrams, wiring diagrams, and instruction manuals associated with this equipment.

Care must be exercised to comply with safety practices as well as local, state, and federal regulations for this class of equipment.

### **Caution**

Failure to inspect, clean, and maintain the excitation control system can reduce the life expectancy of the equipment or impair its operation.

As with all electrical equipment, appropriate safety measures should be taken whenever dealing with the excitation equipment. High voltage is present within the excitation cubicles; the magnitude of the voltage depends upon the particular system. Removing the voltage sources does not completely isolate the equipment from high voltages. As long as the machine is still physically connected to the system, there is a possibility that a safety hazard exists.

Every precaution must be taken when working with the excitation control equipment to ensure that all high voltages are isolated and avoided by personnel. In addition to the three-phase ac excitation source voltage, there may be other sources of power entering the cubicles. These sources can include 125/250 Vdc control power, 120/240 Vac station power, and 480 Vac used to supply certain devices. The field voltage is also present at the field ground detector. Due to capacitors in the shaft suppression network, there may be voltage present even when the field circuit breaker is open. A good rule to follow is to assume that all connections are live and dangerous until proven otherwise.

Before performing maintenance on the current transformer (CT) circuits, place a short-circuit across the secondary connections of the CT at the shorting-type terminal block.

On some DECS and ECS2100 systems, the ground detector (ground fault relay) is powered by a separate source. Both the ac power bus and dc field bus might be back-fed from this device with 120 Vdc. Therefore, it too must be disconnected when the excitation control equipment is serviced.

## 2 • Equipment Handling

### Receiving

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Basler excitation control equipment is carefully inspected and packed before leaving the factory. Upon receipt, the equipment should be examined for evidence of shipping damage. If damage is evident, the carrier (transportation company) and Basler Electric should be notified.

Only authorized personnel should be permitted to handle the equipment. Ensure that the equipment used to move the system components has sufficient lifting capacity.

### Storage

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Equipment that will not be installed immediately should be stored according to the following guidelines.

#### Recommended Storage Procedures

Note
Outdoor storage of the equipment is unacceptable. Do not leave the equipment outdoors exposed to the weather. All equipment should be protected from damage and vandalism.
Guidelines for moving the equipment into and out of storage is provided in the paragraphs under <i>Moving Equipment</i> .

All equipment should be stored in an environmentally-controlled building or shelter. The environment temperature must be within the range of  $-20^{\circ}\text{C}$  ( $-4^{\circ}\text{F}$ ) to  $60^{\circ}\text{C}$  ( $140^{\circ}\text{F}$ ) and the relative humidity must be below 40%.

If flooding is a concern, all equipment should be elevated on blocks or supports to prevent damage from water. To determine a safe elevation (height), the purchaser must rely on past experience and site conditions.

Following an initial inspection, prepare the equipment for storage by taking the following precautions:

- Restore all protective packing
- Identify, label, and secure any shipped-loose components
- Cover all openings to prevent the ingress of dust and insects
- Store all cartons/crates containing draw-out equipment flat to prevent strain and distortion of the assemblies

#### Alternate Storage Procedures

If the equipment must be stored in a structure without the necessary heating and ventilation, you must protect the equipment from condensation. The interior temperature of each cubicle must be maintained at no less than  $-20^{\circ}\text{C}$  ( $-4^{\circ}\text{F}$ ) and at least  $5^{\circ}\text{C}$  ( $9^{\circ}\text{F}$ ) above the ambient temperature surrounding the cubicle. Air circulation through the enclosure (in at the bottom and out at the top) must be maintained.

If the cubicles are equipped with heaters, these circuits should be energized during storage. If the cubicles are not equipped with heaters, temporary heaters should be used. Heater recommendations are:

- A 250-watt heater is recommended for a typical cubicle/compartment
- A 100-watt heater is recommended for each crate/carton containing draw-out equipment

**Caution**

Use care when applying heat near cardboard and packing material. Keep heaters far enough away so that these materials do not become overheated. Spontaneous combustion (fire) could result from continued heat buildup.

**Limits of Warranty**

The product warranty does not cover equipment damage related to the failure to observe the storage guidelines presented in this publication.

**Moving Equipment**

The method of moving the equipment depends on the configuration of the excitation equipment provided and the handling equipment available at the installation site. Check the shipping weight of the excitation equipment and verify that the lifting capacity of your handling equipment is adequate. Only trained personnel should attempt moving the equipment.

Use care when moving the equipment; do not drop or bump it. Delicate meters and instruments may be damaged and cable connections may be dislodged.

Excitation equipment may be supplied in an enclosure or cubicle sections or as equipment panels intended for installation in a suitable enclosure.

**Enclosures/Cubicles**

Protect door-mounted components and the enclosure finish at all times.

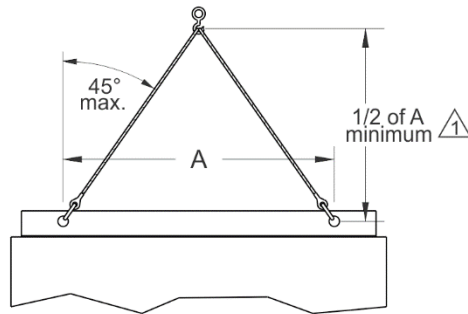
Keep cubicle sections upright during transit. If it becomes necessary to lay the cubicle sections down for any reason, contact Basler Electric for any specific precautions to be taken. Whenever possible, cubicle sections should remain secured to their shipping skid while being moved. The skid base adds extra rigidity to the frame and helps prevent distortion of the enclosure during moving. The skid also permits the use of a forklift or hydraulic pallet truck for moving. If rollers are used to move a cubicle section, the rollers should be placed under the shipping skid attached to the cubicle section. Always carefully balance and steady the load.

The top of each cubicle section is equipped with provisions for lifting the section. Overhead hoisting may be used when available. Follow the rigging guidelines illustrated in Figure 2-1 for overhead hoisting. The use of safety hooks and shackles connected directly to the lifting points (eyes) is recommended. Do not pass ropes or cables through the lifting eyes. The use of spreader or spanner bars will help prevent crushing or distorting the frame and paint finish.

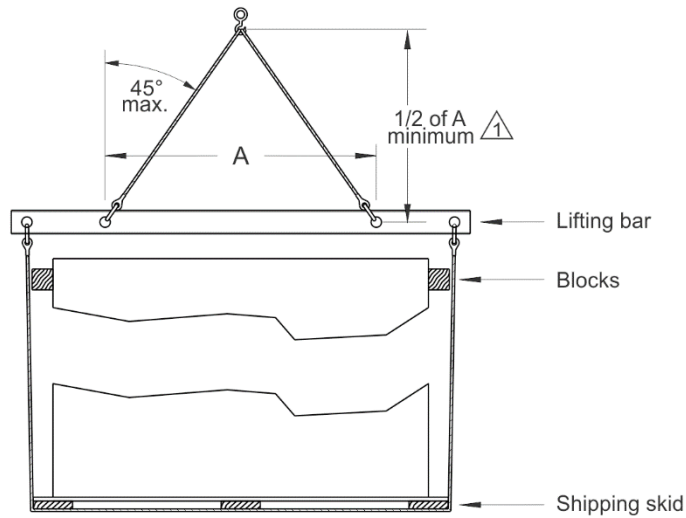
**Equipment Panels**

Equipment panels (pan chassis, mounting plates, etc.) with exposed components and wiring are vulnerable to damage if adequate care is not taken during moving and installation. To minimize the possibility of damage, equipment panels should be kept in their shipping crates until the time of installation.

When removing any equipment panel from its crate, ensure that no part of the panel comes into contact with the crate. A pan chassis equipped with lifting eyes may be removed from its crate using lifting equipment connected to the lifting eyes.

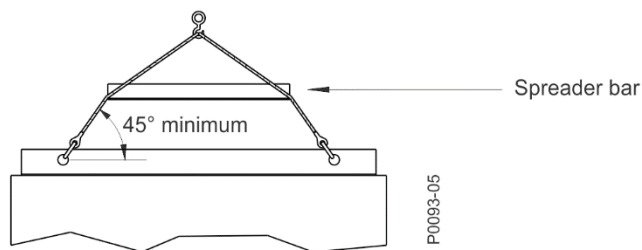


*Lifting with sling and cubicle lifting eyes*



*Lifting with sling, lifting bar, and shipping skid*

⚠ If this minimum dimension cannot be maintained, a spreader bar must be used as illustrated below.



*Spreader bar rigging*

**Figure 2-1. Rigging Guidelines for Equipment Hoisting**



## 3 • Installation

### Note

The excitation equipment is rated for operation in an environment with an ambient temperature range of 0°C (32°F) to 40°C (104°F).

### Introduction

Prior to shipment from the factory, an excitation system enclosure may be partially disassembled to avoid damage during shipping or to accommodate shipping or site size constraints. When received onsite, it may be necessary to:

- Align and reattach the cubicles that make up the system enclosure,
- Reconnect the bus bar conductors between cubicles,
- Reconnect the control signal wiring and fiber optic cable, and/or
- Reattach the enclosure components shipped separately.

Components shipped separately may include:

- Spare parts for system commissioning,
- Light bulbs,
- Vent frames and hoods,
- Line filter assemblies, and
- Lifting bar and clips for circuit breaker or Power Drawer.

### Preparation

Prepare the equipment for assembly and installation by observing the following guidelines.

#### Separate the Cubicles From the Shipping Skids

To separate the cubicles from their shipping skids (pallets), removed the bolts securing each cubicle to its pallet.

#### Cubicle Lifting

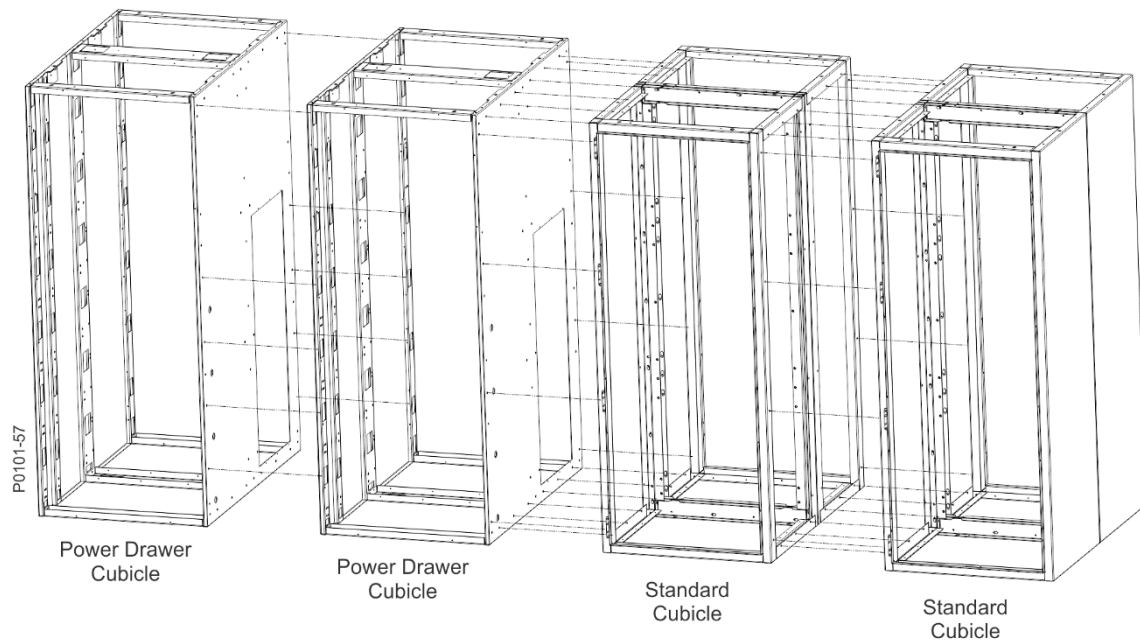
When unbolted, a cubicle can be lifted from its pallet using hoists, jacks, or other appropriate lifting devices. Refer to the *Equipment Handling* chapter for cubicle rigging and lifting guidelines.

#### Install the Mounting Channels, If Applicable

Mounting channels may be installed to the bottom of the excitation equipment for final installation and ease of handling. It is necessary to lift the section enough to safely bolt the mounting channels to the holes provided in the bottom of the enclosure. Often, the mounting channel is installed in the floor and the enclosure is lowered onto it. Be sure that the mounting channel is level. This is especially important if the equipment sections are long or if multiple sections must bolt together to form a common lineup.

#### Set the Equipment Sections in Place

Before placing and reattaching equipment cubicles, use the provided outline drawing to identify each cubicle's position in the enclosure lineup. The hardware used to reattach two cubicles is preinstalled in one of the mating cubicles. Locate and remove this hardware prior to mating the cubicles together. Figure 3-1 illustrates typical mounting points for an array of cubicles.



**Figure 3-1. Mounting Points Example for Cubicle Array**

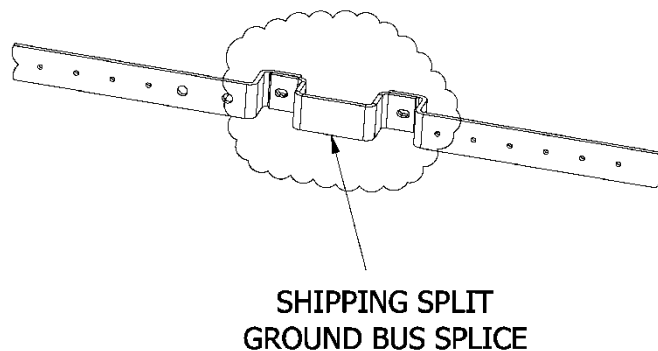
Carefully move each section into place over the floor mounting studs. When moving a cubicle, be sure to leave enough clearance above the conduit stubs and the projecting mounting studs in the floor. Align and secure the cubicles together using the previously-removed hardware. Torque the hardware according to the guidelines provided in the *Fastener Assembly and Torque* chapter. Ensure that all equipment sections are level and plumb.

### ***Reconnect the Bus Bars, If Applicable***

Bus bars that span more than one cubicle are reconnected onsite with supplied lengths of bus bars. These bus bars and their target connection points are identified by labeled tags. The connecting hardware is preinstalled in the sections of bus bar entering a cubicle. This hardware is removed onsite and used to connect the lengths of bus bar. A system may use stacked bus bars to carry the required level of current for the application. The orientation of these stacked bus bars is critical for safe and proper system operation. When onsite bus bar reassembly is required, separate system-specific instructions will be provided to guide the installer through the reassembly process. All bus bar hardware must be secured according to the guidelines provided in the *Fastener Assembly and Torque* chapter of this manual.

### **Ground Bus Splices**

Figure 3-2 illustrates a typical ground bus splice which is used in each cubicle where a shipping split exists.



**Figure 3-2. Ground Bus Splice**

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## ***Reconnect the Control Wiring and Fiber Optic Cables, If Applicable***

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Control wiring and fiber optic cable that span more than one cubicle are reconnected onsite. When onsite wiring and cable reconnection is required, separate system-specific instructions will be provided to guide the installer through this process.

### **Typical Methods of Control Wiring Reconnection**

For control wiring reconnection, one of the following three configurations is commonly used.

#### ***Two-Part Terminal Block***

In this configuration, two adjacent cubicles are reconnected by mating two labeled connectors.

#### ***Two Separate Terminal Blocks***

In this configuration, two identical terminal blocks are located adjacent to each other at a shipping split. To reconnect the two cubicles, jumpers are connected point to point between the two terminal blocks.

#### ***Terminal Block and Wiring Harness***

In this configuration, a two-row terminal block is mounted and wired in one of the cubicles adjacent to the shipping split. The two cubicles are reconnected by mating the wires from a bundle in the adjacent cubicle with the other cubicle's terminal block. Guidance for making these connections is provided in the instructions that accompany the system equipment.

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## ***Line Filter Assemblies***

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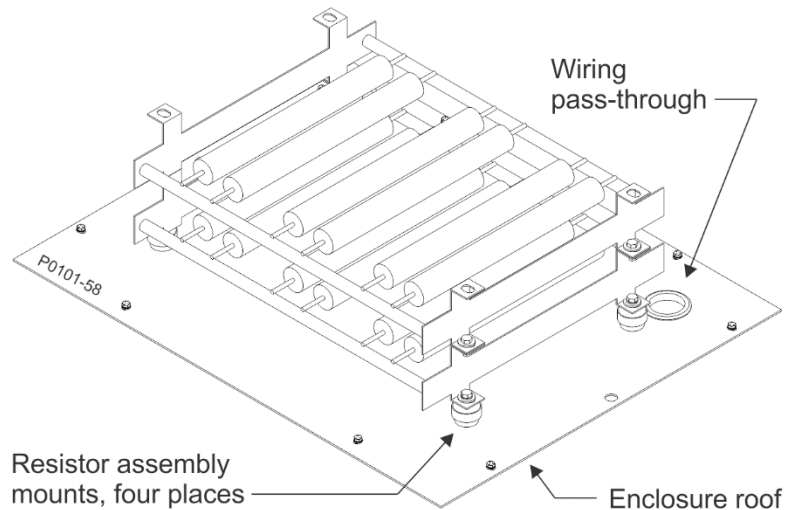
Some systems utilize ac line filter circuits consisting of capacitors mounted on a chassis within the enclosure and a resistor array shipped separately. Depending upon the system configuration, the resistor assembly will either be installed on the enclosure roof or in a location separate from the system enclosure. Reviewing the system enclosure outline drawing will reveal if an enclosure has a roof-mounted resistor assembly. For a system with a resistor assembly mounted separately from the enclosure, an additional outline drawing for this separate enclosure is provided to show its mounting dimensions. Once installation of the resistor assembly is complete, the installer will need to connect the resistors to their companion line filter capacitors within the enclosure.

### **Installing a Remotely-Mounted Resistor Assembly**

Using the supplied outline drawing (9508800920) as a guide, install the resistor assembly/enclosure in a suitable location that permits adequate resistor assembly heat dissipation. For these applications, the line filter assembly capacitors are prewired with 50-foot (15-meter) lengths of 8 AWG wire for connection to the resistor assembly.

### **Installing a Roof-Mounted Resistor Assembly**

An example of a roof-mounted resistor assembly is shown in Figure 3-3. Place the resistor assembly on the enclosure roof and secure the assembly to the roof using the preinstalled hardware.



**Figure 3-3. Typical Roof-Mounted Resistor Assembly**

### Resistor Assembly Connections

Line filter resistor connections are made with wires pre-connected to the capacitor panel within the system enclosure. These wires are bundled together inside the enclosure for use by the installer. The appropriate terminals within a resistor assembly are jumpered at the factory to provide the required series/parallel configuration.

The labeling of the line filter component wiring uses a format of  $LSxy$  and  $LSxyA$  where  $x$  identifies the instance of a particular line filter in the system (1, 2, etc.) and  $y$  identifies the electrical phase (1, 2, or 3). Two examples of line filter connections are illustrated in Figure 3-4 and Figure 3-5.

#### Roof-Mounted Resistor Assembly Connections

Pass the wiring from the line filter capacitor panel inside the enclosure through the enclosure roof opening and the resistor assembly pass-through hole. Then connect the wires to the resistor terminals. Where possible, twist each capacitor wire pair two turns per foot (30 centimeters).

#### Remotely-Mounted Resistor Assembly Connections

Pass the wiring from the line filter capacitor panel inside the enclosure through an opening in the enclosure and route it to the external resistor assembly. Remove the vented panels for access to the resistors and pass the wire through the pass-through holes in the bottom of the resistor enclosure. Then connect the wires to the resistor terminals. Where possible, twist each capacitor wire pair two turns per foot (30 centimeters).

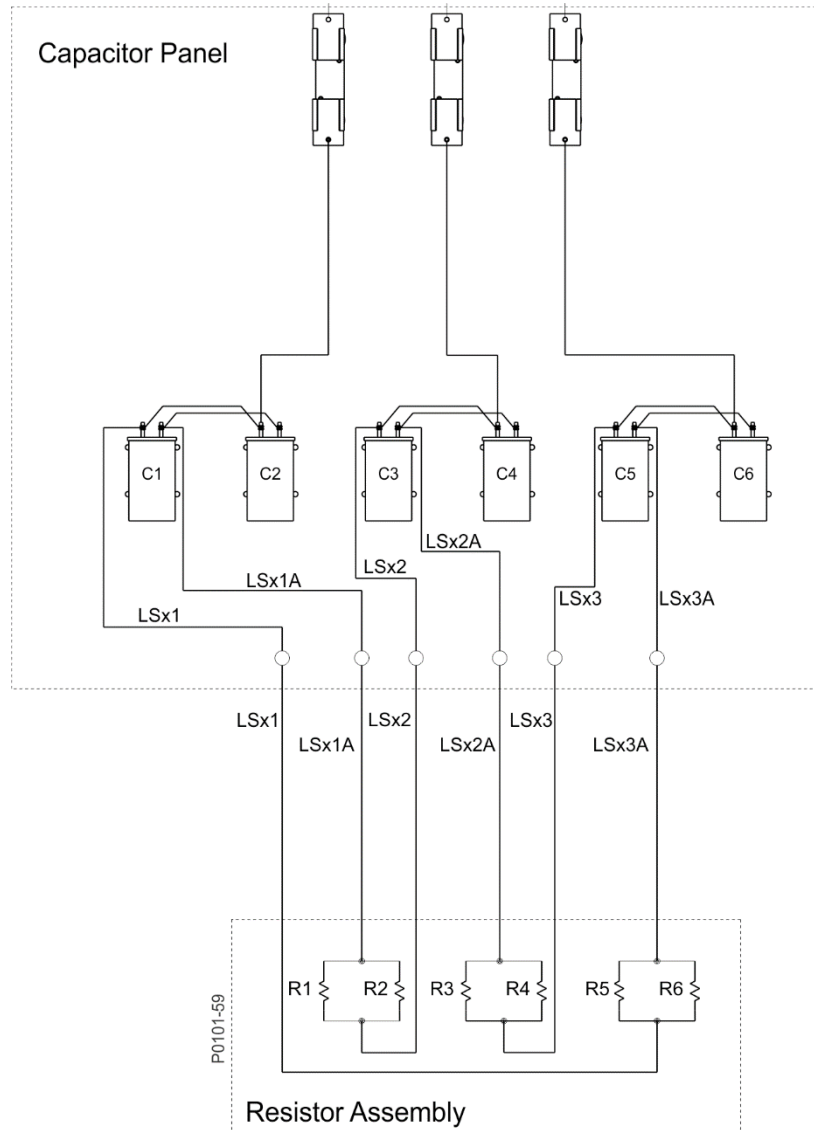


Figure 3-4. Line Filter Connections Example, 1 of 2

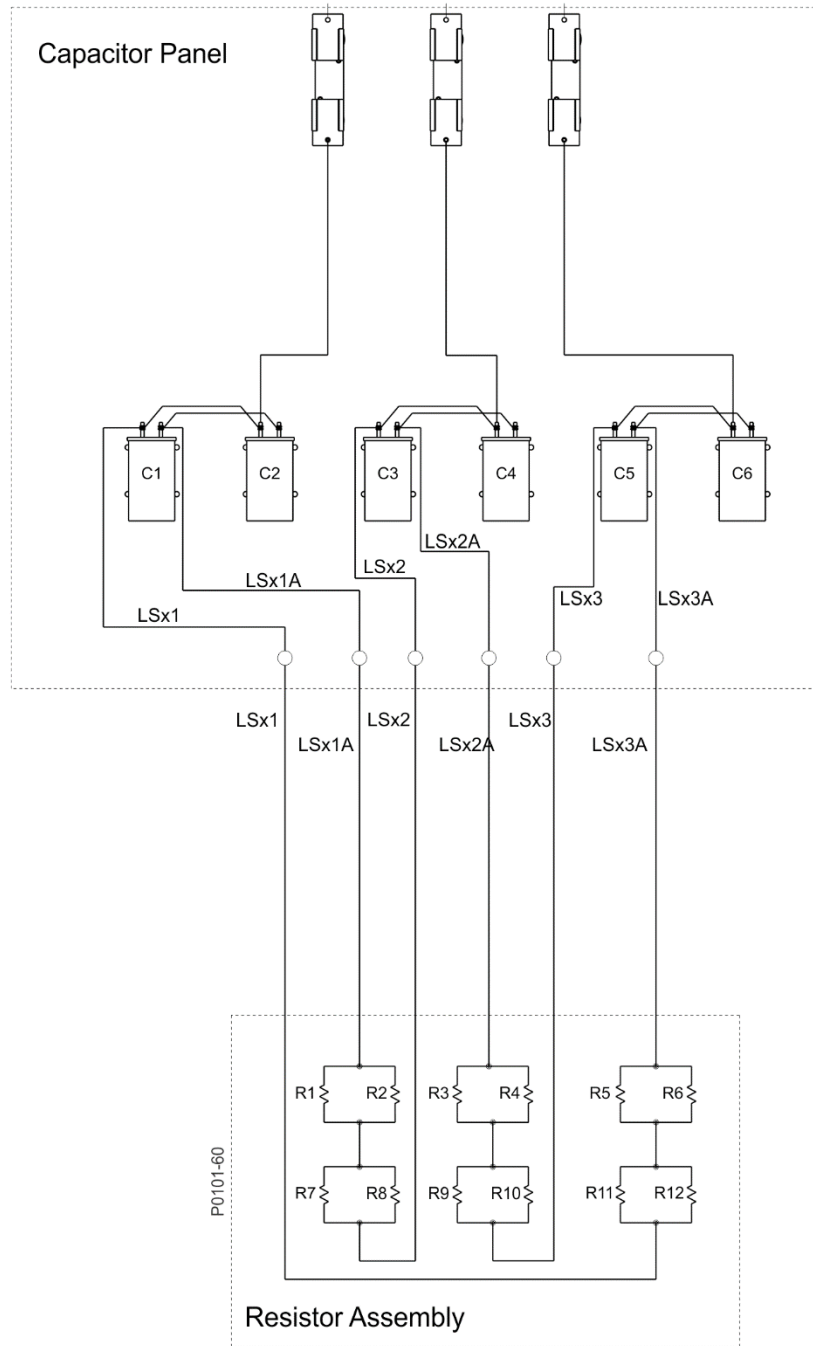


Figure 3-5. Line Filter Connections Example, 2 of 2

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## ***Enclosure Vent Hood/Top Hat Installation***

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If equipped, the vent cover/top hat is secured to the enclosure using the same hardware that secures the roof to the enclosure. Remove the lifting angles from the enclosure and remove the hardware securing the enclosure roof. Move the vent cover/top hat into place and align all mounting holes. Secure the vent cover/top hat (and roof) to the enclosure with the previously-removed hardware.

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## ***Light Bulbs***

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Light bulbs are supplied separately and should be installed in the sockets located in the enclosure cubicles.

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## ***Site Wire and Cable Installation***

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All external control wiring and cable connections are shown on the system connection diagrams. Remote devices, such as control switches, transformers, and alarm and status systems are shown generically. If a point-to-point, site-specific interconnection diagram is available, it should be used when making connections. Be sure to use only final, “as-built” drawings. Preliminary or “approval” type drawings should be destroyed. If no site-specific interconnection drawing is available, it is necessary to interpret the control functions required and locate the remote devices that perform the functions. Each of the remote system interconnection diagrams will be required to properly identify the terminal point connections that are to be wired to the primary excitation system enclosure. It is recommended that a final “as installed” point-to-point interconnection diagram be created and retained for future reference.

When making connections, use standard copper wire for all interface wiring. Run control wiring in conduit separate from the power cables.

### **Wire and Cable Sizing**

The installing contractor is responsible for selecting the wire size required for interconnecting the various pieces of equipment in the system. Ampere and voltage level requirements are indicated on the drawings supplied with the system. A minimum of 14 AWG wire is recommended for all control circuits. The current and voltage levels and the distance that the wire is run must be considered in all cases. Shielded or twisted wire must be used where specified on the system drawings.

### **Conduit Openings**

Holes or conduit knockouts are not supplied on standard systems. The installer has the flexibility of locating the conduit openings as required during installation. Holes may be punched or cut as the conditions at the jobsite dictate. Use adequately sized tools to cut or punch holes.

### **Testing Power Cables**

Installing power cables in conduit, cable troughs, and ceiling-suspended hangers often requires considerable force. The pulling of cables can damage insulation and stretch or break conductor strands. For this reason, after the cables are pulled into position and before they are connected, they should be tested to verify that they are not defective or have been damaged during installation. Perform a complete dielectric strength test in accordance with IEEE 421.3 or other standard approved by the authority having jurisdiction at the jobsite. Do not Megger® or hipot the voltage regulating units.

After the power cables have been tested, connect them to the appropriate terminals in the control sections. Make sure that the lugs are suitable for use with the cables being installed. Use care when stripping insulation from cables to avoid nicking or “ringing” the conductor. Tighten the cable lugs to the torque values recommended by the lug manufacturer.

### **Proper Phase Rotation**

Observe correct phase rotation (sequence) when connecting the power and sensing circuits. To determine the correct phase rotation, refer to the system drawings. The system will not function properly if the incorrect phase rotation is connected. Consult Basler Electric if necessary to alter the phase rotation.

## Current Transformers

The standard practice for installing current transformers is to be sure the side of a toroid type CT marked with a dot or “H1” is facing toward the source. Bar-type current transformers have a polarity mark (dot or H1). Secondary circuits also have polarity marks such as lead markings “X1”, “X2”, etc. Pay close attention to the polarity indications on the drawings and CTs when installing them. Also, ensure that the CT is installed on the correct phase as indicated on the interconnection diagram. Be sure to remove all jumpers or shorting bars on the CTs before operating the system. Never open-circuit a CT while current is flowing in the circuit. To perform maintenance on a live CT circuit, always short the CT secondary before disconnecting any circuit wires. A shorting type terminal board may be provided for this purpose. Otherwise, use a jumper wire. Bar type CTs are usually provided with a shorting “link” mounted on the CT terminals.

## Control Power

Control power should be connected as shown on the system drawings. Note the current and voltage requirements listed on the drawings. Batteries should be tested frequently and properly maintained. One of the most frequently reported causes of system failures and malfunctions is poorly or improperly maintained control system batteries. Follow all of the battery manufacturer’s recommended maintenance practices. It is recommended that circuit overcurrent devices be installed as closely as possible to the supply source. Disconnect devices are also recommended on the control sources to the system.

## Terminals and Lugs

It is recommended that all control wiring have terminal lugs of the solderless ring tongue, fork lock or similar type installed. Use properly sized lugs and crimping tools when installing the lugs. It is good practice to limit each terminal to not more than two wires per connection. Spare terminals are provided for convenience of installation. Ensure that all connections are tightened securely.

## Grounding

Make sure that all secondary wiring is connected to the system ground bus as indicated on the drawings. The ground bus should be connected to the system ground with as direct a connection as possible and should not be run in metal conduit unless the conduit is adequately bonded to the circuit. The grounding conductor should be sized to carry the maximum short-circuit current available. A permanent low-resistance ground is essential for adequate safety and protection.

### Grounding for CE Compliance

Excitation equipment installed in a locale governed by European Union (EU) directives must be connected to earth ground through two copper 6 AWG (16 mm<sup>2</sup>) conductors. For more information, refer to IEC 62477-1: 2012 *Safety requirements for power electronic converter systems and equipment – Part 1: General*.

## Protective Relays and Devices

Protective relays and devices have been tested at the factory for correct connections and operation. Factory settings are noted on the system drawings but are not to be considered the final or recommended settings. Factory settings are used only during functional testing of the equipment prior to delivery. All protective relay and device settings should be made and verified by qualified personnel before placing the equipment into service. The instruction manual for each device should be consulted when making settings and a settings record should be maintained for each device. Periodic equipment testing is recommended to verify device function and settings.

## Commissioning Spares

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An assortment of fuses may be provided with the equipment for use during commissioning of the system.

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## ***Documentation***

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The importance of good recordkeeping cannot be overstressed. Installation details should be recorded and securely filed for future use. The following list gives some examples of useful information that may be recorded or filed during equipment installation.

- Record the dielectric test results and insulation resistances.
- Create a detailed point-to-point installation interconnection diagram.
- Retain all instruction manuals and equipment drawings.
- Record all pertinent system variables obtained during startup and testing. These system variables can include current, voltage, kilowatt, power factor, and temperature readings.
- Post all normal operating and emergency operating procedures.
- Record all switch positions used during normal operation.
- Create a logbook to be used at shift breaks for recording system readings and switch positions.
- Create a log of maintenance procedures for each system device.
- Create a directory of telephone numbers for emergency and technical assistance.

The preceding list of suggestions should help establish a good recordkeeping procedure and operational history for the system.



## 4 • Fastener Assembly and Torque

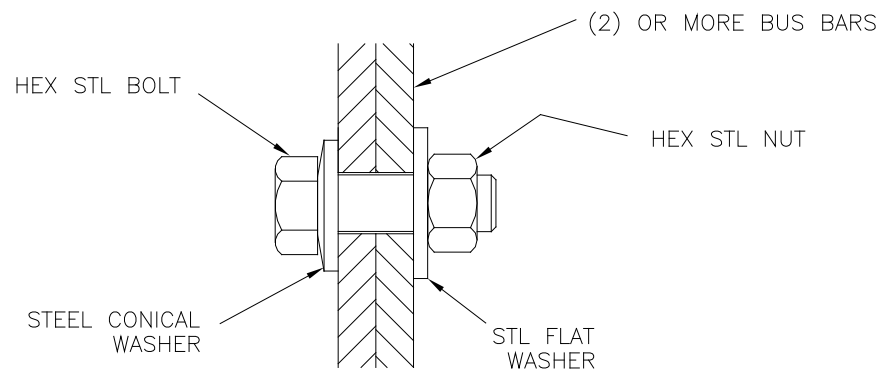
### Introduction

The following assembly and torque application guidelines are provided for the fastener hardware used in Basler Electric excitation systems. These guidelines should be observed especially when making bus bar connections.

### Fastener Hardware Assembly

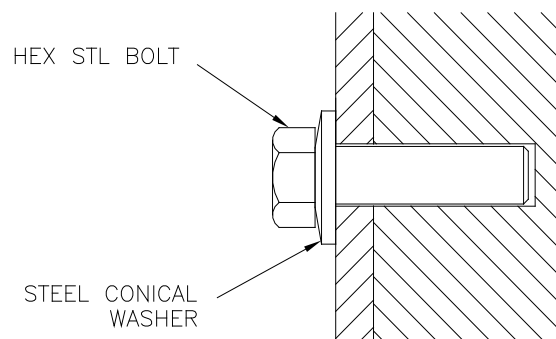
Typical fastener hardware configurations are illustrated in Figure 4-1 and Figure 4-2.

Figure 4-1 shows a typical bolted joint. Note the location and types of washers used.



**Figure 4-1. Typical Bolted Joint**

Figure 4-2 shows a typical screw joint.



**Figure 4-2. Typical Screw Joint**

When assembling fastener hardware, observe the following guidelines:

- Verify that the mounting components are clean and the mounting holes are free of debris
- Hardware should have no visible defects and there should be no obstructions between mating components
- Verify that no electrical insulation is pinched in the mechanical connection of wire and terminal connections

## Torque Application Guidelines

SAE fastener torque specifications are listed in Table 4-1 and metric fastener torque specifications are listed in Table 4-2. All torque values assume non-lubricated, dry hardware. When applying torque to fasteners, observe the following guidelines:

- Ensure that the torque tool is properly calibrated and has the proper range for the torque requirement
- When applying torque, continue until the desired torque is achieved. Do not partially torque a fastener and then return to it.
- The conversion factor for metric to SAE (or imperial units) is  $1 \text{ N}\cdot\text{m} = 8.851 \text{ in}\cdot\text{lb}$ .
- Divide in-lb values by 12 to convert to ft-lb values.
- Mark a line across a bolt and washer to identify that the hardware has been torqued properly

**Table 4-1. Torque Values for Selected SAE Fasteners (in-lb)**

Bolt Size		SAE Grade 0-2 Common Commercial (Low-Carbon) Steel	316 Stainless Steel	SAE Grade 5 High-Strength (Medium-Carbon, Heat-Treated) Steel	Brass	Nylon Screws	Self-Locking Run-Down Torque Nuts, Screws, and Bolts
#1	64 UNC 72 UNF	5 to 1.5 1 to 2	1.5 to 2.5 1.5 to 2.5	2 to 2.5 2 to 2.5	—	—	x to 0.7 x to 0.7
#2	56 UNC 64 UNF	2.5 to 3.5 2.5 to 4	2.5 to 4 2.5 to 4	3 to 4 3 to 4	1.5 to 2 1.7 to 2.5	0.4 to 0.6 0.5 to 0.8	0.1 to 1.6 0.1 to 1.5
#3	48 UNC 56 UNF	2.5 to 4.5 3 to 5	3 to 4 3.5 to 5	4 to 6 4 to 6	2.2 to 3.2 2.5 to 3.6	0.6 to 1.1 0.6 to 1.2	0.2 to 2.5 0.2 to 2.5
#4	40 UNC 48 UNF	4 to 6 5 to 7	4 to 6 5 to 7	6 to 8 6 to 9	3.0 to 4.3 4 to 5.4	0.8 to 1.4 1 to 1.7	0.5 to 3 0.5 to 3
#6	32 UNC 40 UNF	8 to 11 9 to 13	8 to 10 9 to 13	11 to 15 13 to 17	6 to 8 7 to 10	1.5 to 2.6 2 to 3.7	1 to 6 1 to 6
#8	32 UNC 36 UNF	16 to 21 18 to 24	16 to 21 17 to 23	21 to 27 21 to 29	12 to 19 14 to 18	3.5 to 6 4 to 6.6	1.5 to 9 1.5 to 9
#10	24 UNC 32 UNF	20 to 30 25 to 35	18 to 24 25 to 30	30 to 40 34 to 46	14 to 19 20 to 26	4 to 7 5 to 9	3 to 13 3 to 13
1/4	20 UNC 28 UNF	55 to 65 76 to 90	63 to 79 80 to 99	77 to 94 81 to 100	46 to 62 57 to 77	12 to 20 16 to 27	3.5 to 30 3.5 to 30
5/16	18 UNC 24 UNF	110 to 130 118 to 139	110 to 138 117 to 147	151 to 196 173 to 216	83 to 107 100 to 116	23 to 39 23 to 42	6.5 to 60 6.5 to 60
3/8	16 UNC 24 UNF	180 to 212 196 to 232	195 to 247 216 to 271	300 to 350 340 to 400	155 to 192 170 to 212	36 to 60 38 to 64	9.5 to 80 9.5 to 80
7/16	14 UNC 20 UNF	285 to 338 310 to 361	335 to 393 360 to 418	475 to 560 530 to 625	250 to 317 260 to 327	51 to 85 51 to 88	14 to 100 14 to 100
1/2	13 UNC 20 UNF	400 to 465 415 to 487	460 to 542 480 to 565	720 to 850 810 to 960	340 to 422 355 to 433	55 to 92 60 to 100	18 to 150 18 to 150
9/16	12UNC 18 UNF	520 to 613 570 to 668	610 to 713 665 to 787	1050 to 1230 1140 to 1350	470 to 558 520 to 615	—	24 to 200 24 to 200
5/8	11 UNC 18 UNF	850 to 1000 970 to 1140	980 to 1160 1100 to 1301	1440 to 1700 1610 to 1900	770 to 907 850 to 1016	—	32 to 300 32 to 300
3/4	10 UNC 16 UNF	1070 to 1259 1040 to 1230	1340 to 1582 1320 to 1558	2550 to 3000 2850 to 3350	1505 to 1249 1040 to 1220	—	50 to 400 50 to 400

**Table 4-2. Torque Values for Selected Metric Fasteners (in-lb)**

<b>Bolt Size</b>	<b>Class 5.8 Common Commercial (Low-Carbon) Steel</b>	<b>Class 8.8 High-Strength (Medium- Carbon, Heat-Treated) Steel</b>
M3 x 0.5	6 to 8	14 to 16
M4 x 0.7	16 to 18	18 to 20
M5 x 0.8	32 to 35	45 to 50
M6 x 1.0	55 to 60	75 to 85
M7 x 1.0	92 to 102	130 to 145
M8 x 1.0	145 to 160	195 to 215
M8 x 1.25	130 to 150	185 to 205
M10 x 1.5	295 to 325	420 to 470
M12 x 1.25	500 to 550	700 to 780
M12 x 1.5	475 to 525	680 to 755
M12 x 1.75	450 to 500	640 to 710
M14 x 1.5	765 to 850	1100 to 1225
M14 x 2.0	715 to 795	1015 to 1125



# 5 • Preventive Maintenance

## ***Introduction***

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Preventive maintenance requires equipment knowledge, equipment records, and careful planning.

Each excitation system is comprised of separate devices interconnected to form an integrated control system. Equipment knowledge is obtained from the instruction manuals provided with the equipment. Each device has an instruction manual describing the important operating features and adjustment guidelines pertinent to that device.

Good recordkeeping is essential in developing an operational history of the equipment. Refer to *Installation, Documentation* for recordkeeping guidelines.

Careful planning will ensure a successful maintenance program. Equipment repair almost always costs more than maintenance, and the loss of revenue due to equipment downtime can be severe.

## ***Maintenance Guidelines***

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Observing the following maintenance fundamentals and following the maintenance schedule of Section 5 will promote equipment reliability and longevity.

### **Keep It Clean**

Dirt, dust, and corrosives are prime enemies of electrical equipment. Excessive dust buildup hinders system cooling and causes higher operating temperatures. If possible, prevent dust and dirt from accumulating on the equipment. Otherwise, frequent cleaning will need to be performed. During regularly scheduled shut down for maintenance, the system should be vacuumed thoroughly (except for printed circuit boards). Do not use compressed air to clean electrical equipment. All filters should be inspected and replaced/cleaned according to the maintenance schedule as required by the conditions in the plant environment.

### **Keep It Cool**

Another prime enemy of electrical equipment is excessive heat. Do not allow vent openings to be blocked or restricted. Ensure that the ambient temperature of the cubicles is less than 40°C (104°F) unless otherwise indicated on system drawings. If equipped, check the heater and air conditioner power source and operation. Check for clogged air filters and proper cooling fan operation. Maintain proper blower motor lubrication.

### **Keep It Dry**

Moisture can cause equipment failure or erroneous operation. Dripping pipes, condensation, and other moisture sources should be eliminated. Anti-condensation heaters should be checked often and may be added if not originally equipped.

### **Eliminate Vibration**

Vibration tends to move or loosen electrical connections. Determine the cause of vibration and eliminate as much vibration as possible. Keep cubicle doors securely fastened and tighten any loose mounting hardware. Be alert to changing conditions; changing vibration patterns are usually the advance warning of an impending failure.

### **Keep Connections Clean and Tight**

Schedule inspections of electrical connections and clean or replace any corroded parts. When cleaning connections, use the appropriate cleaning fluid or solvent. Never use compressed air to clean electrical equipment.

## Keep Up with the Changes

Document any revisions, modifications, or additions made to the system. Keep all records safe and secure. The manufacturer's drawings are seldom revised after shipment, so any field changes are the responsibility of the user to document and file. Provide up-to-date drawings for any service personnel who are contracted to work on the system and insist on revised, detailed drawings from them if changes are made.

## Corrosion and Condensation

Inspect the equipment for corrosion and condensation semiannually.

Clean the exterior of the enclosures and touch up any scratches and abrasions using touchup paint.

If there is condensation inside the equipment enclosures, check the heater circuit. The heater thermostat should be set above the ambient dew-point temperature.

If excessive condensation is found inside the control or transformer cubicles, check for leaks or openings.

## *Inspection and Maintenance Notes and Procedures*

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The following notes are organized according to the inspection and maintenance needs of the excitation system components.

### Printed Circuit Boards

Remove accumulated dust from all circuit boards. Excessively dirty circuit boards should be removed from the equipment and cleaned with compressed air from a spray can of the type used for computer hardware cleaning. No contact should be made with the circuit board by a vacuum cleaner type of device as static electricity could damage the circuit board components.

Test and calibrate printed circuit boards according to the procedures listed in the associated instruction manuals.

### Bus, Cable, and Terminations

Check the general condition of connectors, terminations, and other current carrying parts. Inspect the bus connections and cable terminations for signs of thermal stress. Note any discoloration which would indicate excessive heating due to loose hardware, high current, or low contact force.

Inspect insulators and supports for breaks, cracks and burns. Clean the insulators and supports where abnormal conditions such as salt deposits, coal dust, cement dust, sand, or construction dirt prevail. This is necessary to avoid flashover. The insulators and supports should never be cleaned with an oily or dirty rag. Oil holds dirt particles which may cause arcing across the surface of insulators.

### Contactors

Inspect and maintain the contactor according to the contactor instruction manual. Observe the following maintenance notes.

Before the contactor is placed in service or following maintenance, operate the contactor slowly, by hand two or three times without power to check operation and alignment of the moving parts. If the contactor operates satisfactorily, then close and open it two or three additional times using the operator magnet, but with the main power circuit de-energized.

Note
Do not exceed the operation frequencies indicated in the contactor documentation.

If the contactor has been operated under heavy fault conditions, it should be inspected at the first opportunity after it has been de-energized.

Inspect and maintain the contacts according to the contactor instruction manual. Badly pitted, burned, or worn contacts should be replaced.

Examine the arc horns and arc chute walls for excessive arc erosion. Check the arc chute walls and grid plates for excessive metal deposits and cracks. Clean dust and other foreign mater from the arc chute chamber.

Check the general condition of connectors, shunts, and other current carrying parts. Inspect and clean the insulators and supports.

## **Fuses**

Inspect the fuses, fuse holders, and fuse contact surfaces for signs of overheating, as evidenced by distorted and discolored metal. There may be discoloration of copper and copper alloy surfaces. This is the result of oxidation and does not indicate overheating.

Check the main current carrying contacts for galling and surface imperfections. Minor imperfections can be burnished out.

Check the fuse holders for proper latching.

## **De-Excitation/Crowbar (DXCB) Module (ECS2100 and DECS-2100 Systems Only)**

The DXCB module should be inspected and its operation verified periodically. During verification of DXCB module operation, the  $\pm 24$  Vdc power supply voltage must be applied.

### Inspection and Cleaning

Completely remove accumulated dust from the assembly and the printed circuit boards. If the circuit boards appear dirty, they must be removed and cleaned. Verify that the module is free of rodent litter.

### Offline and Online LED Operation

When excitation is off, either offline or online, LEDs (D1 and D2) are off. D1 and D2 should light only when current is flowing through the DXCB module SCR (as is the case during a normal or immediate shutdown).

### DXCB Output Operation

With the generator shut down, press Test switch SW2 and verify that the CSRD output energizes the external relay. The MGR and M300 signals should change state. This test verifies that when the DXCB module has a current signal, it will output correctly.

### Operation During Normal Shutdown

During normal shutdown, observe that the DXCB module SCR fires and conducts. When the 41 ac breaker is opened and the DXCB module is fired, current that was flowing in the field will be conducted through the DXCB module. If the current is present for sufficient time, the DXCB module will provide a signal to the ECS2100 or DECS-2100 indicating that current was sensed.

### Break-Over Diode Operation

Verification of the break-over diode voltage firing level should be performed at startup and at the scheduled maintenance intervals for both the de-excitation module and the crowbar. This test verifies that the DXCB module will conduct at excessive field voltage levels but not conduct at normal field voltage levels. The crowbar module protects the rectifier chassis and generator field from the excessive voltage that develops during pole slip and certain fault conditions. The crowbar relies solely on the break-over diode firing. Therefore, it is important to verify break-over diode function.

**Warning!**

Expected trigger voltages are between 750 and 4,250 Vdc, depending on the DXCB module settings.

With both leads of the DXCB module disconnected from the field circuit, apply a dc voltage across the module. Start at a low value of voltage and increase the voltage to within 100 Vdc of the expected trigger voltage. Then, slowly increase the voltage until the trigger is reached and record the trigger level, verifying that the trigger value is within the expected tolerance. When the DXCB module is triggered, it will apply a short-circuit across the applied dc voltage. Ideally, a power source with at least 50 Adc short-circuit output would provide the required current to turn on the conduction monitor and cause LED D2 to light.

**Cooling Fans**

Cooling fan maintenance includes inspection and cleaning of the motor, fan blades, fan shutter, and fan shutter switch.

***Motors and Motor Control Equipment***

Inspect the fan motor for excessive vibration and noise. Excessive vibration can be caused by loose mounting hardware, improper shaft alignment, or a bent shaft. Excessive noise can be caused by worn bearings or a binding rotor.

Keep the motor and motor control equipment clean. In dirty operating environments, clean out dirt quarterly or semiannually, depending on site conditions. Check operation of the contactors and relays. Moving parts should operate without excessive friction. Look for loose pins, bolts, and bearings. A dirty control should be wiped or blown clean. Check contacts for pitting and signs of overheating (such as discoloration of metal or charred insulation). Make sure contact pressure is adequate (consult the manufacturer's specifications) and is the same on all poles. Inspect, clean, and check overload relays for proper setting. In general, maintenance requirements for these relays include checking that:

- The rating or trip setting takes into account ambient temperature as well as the higher inrush currents of modern, energy-efficient motors
- Contacts are clean and free from oxidation
- The relay will operate dependably when needed

To ensure reliable operation, test and calibrate the relays every three years.

***Fan Blades***

Ensure that the fan motor power supply is disconnected and padlocked prior to working on the fan blade assembly.

Inspect the fan blade assembly for excessive vibration. If excessive vibration is observed, check for loose mounting hardware, improper shaft alignment, or a bent shaft.

The fan blades should be inspected and cleaned annually.

***Fan Shutter Switch***

Verify that the switch functions when the fan is operating.

Check for vane damage and cracks.

The fan shutter switch should be cleaned annually.

**Fiber Optic and Ribbon Cable**

All fiber optic and ribbon cable connections should be clean and tight. Inspect the fiber optic and ribbon cables for damage.

## Ground Detector Module/Relay

Test the ground detector module/relay annually according to the device instruction manual. Check the ground detector power supply semiannually.

## Line Filter

Check all line filter fuses. If open fuses are found, check for a short-circuit and replace capacitors. Check the line filter capacitors for leaks or bulging cases. Contact Basler Electric if leaking or bulging capacitors are discovered.

If dirty, clean all line filter resistors. Check the resistors for damage from overheating.

Inspect all line filter wires and terminations for damage due to overheating.

## Metal-Oxide Varistors (MOVs)

Check all MOV fuses. If open fuses are found, check for a short-circuit and replace the MOV. Check all MOV wiring and terminations for damage due to overheating.

## Selenium Surge Suppressors

Selenium surge suppressors left de-energized for extended periods should be tested and reformed periodically. Yearly maintenance will ensure that a suppressor will provide the required level of protection when needed. Refer to the *Selenium Surge Suppressor Maintenance* chapter for detailed information and procedures.

## Protective Relays

Protective relays should be tested annually. Inspect, maintain, and calibrate each relay according to the device instruction manual.

## Display Panel (Touchscreen)

Use a clean, damp, nonabrasive cloth and any commercially-available window cleaner to clean the screen. The cleaning solution should be applied to the cloth rather than the screen surface.

Regular maintenance checks should be performed to ensure that the operator interface is functioning properly.

## Circuit Breaker

The circuit breaker should be periodically cleaned using a vacuum cleaner and/or lint-free cloth. Unless otherwise indicated, never use compressed air since dirt or foreign objects can be driven into undesired areas. Never use a wire brush to clean any part of the circuit breaker.

Refer to the circuit breaker instruction manual for specific inspection and maintenance recommendations.

## Rectifier Chassis (Power Drawer or Fixed Bridge)

Remove all accumulated dust from the rectifier chassis. (Draw-out rectifier chassis can be removed from the compartment for cleaning access.) accumulated dust should be removed from the heat sinks, SCRs, and circuit boards. On draw-out rectifier chassis, the contact fingers should be checked for cleanliness and mechanical integrity.

Inspect all snubber capacitors for leaks and bulges. Leaking or bulging capacitors must be replaced. Verify that the snubber resistors and wiring are in good condition.

Air-core reactors (if equipped) should be inspected to verify that they are not bent (due to excessive fault current). If the reactors are significantly bent, contact Basler Electric.

Remove accumulated dust from printed circuit boards per Printed Circuit Boards earlier in this section.

## Power Supplies

If equipped, verify power supply cooling fan operation.

Check for short-circuits if power supply fuses are blown.

### **Shaft Suppression Module/Components**

Inspect the capacitors for leaks. Leaking capacitors should be replaced.

Inspect the shaft suppression resistor for a broken element or signs of overheating.

Inspect all wiring for signs of damage or deterioration. Verify that the ground connection is sound.

### **Heaters**

Check operation of the thermostat and heater circuits. Inspect the surface areas around the heaters for evidence of overheating.

### **AC Surge Suppression Components (Where Equipped)**

Check all ac surge suppression components for cracks and burn marks.

### **Control Relays**

Visually inspect the control relays for burn marks and check the control relays for proper operation.

### **Equipment Enclosure**

Inspect the equipment enclosures for openings into the interior. Seal all openings with the appropriate material/weather stripping. Check the cable and bus entry areas, the enclosure roof, and access panels (doors). Check the rain flashing on top of any air conditioner duct openings.

Inspect the enclosure for signs of corrosion. Clean the exterior of the enclosures and touch up scratches and abrasions using primer and touchup paint.

Inspect and replace vent filters as required. In a dusty environment, filters should be inspected several times during the year to ensure sufficient ventilation for the equipment.

Lubricate the door locks and hinges.

### **Air Conditioning Units**

Inspect and clean the air conditioner according to the guidelines listed in the equipment documentation. Replace or clean filters periodically or as site conditions dictate. For corrosive or coastal environments, frequent washing of the air conditioner cabinet, fan blades, and coil with fresh water is recommended.

#### **Warning!**

Disconnect all power to the air conditioner before starting maintenance.

Check the rain flashing on top of any air conditioner duct openings.

### **Exciter Transformer**

Inspect and clean the transformer semiannually. Refer to the transformer manufacturer's instruction manual for maintenance recommendations. Supports, taps, terminal blocks, bushings, and other insulating surfaces should be cleaned with a dry cloth. Inspect bushings for cracks. If rust, corrosion, or paint deterioration is observed, it should be corrected.

#### Dry-Type Transformer

Clean the transformer windings with a vacuum cleaner.

If moisture is noted, it should be removed by drying with heated air from a blower. The temperature of the applied air should not exceed 110°C (230°F).

Inspect all insulators, bushings, and terminals for corona discharge (tracking), breaks, cracks, burns, and tightness of hardware.

#### Liquid-Filled Transformer

Verify that the oil level is satisfactory. Check the temperature gauge, liquid level gauge, pressure gauge, and other indicators. Record the readings quarterly. Check the temperature gauge drag pointer for evidence of excessive loading.

Check the pressure relief device. Check the sudden pressure relay circuit for proper operation and power supply.

Conduct a dielectric strength or power factor check of the insulation for comparison with previous observations. Record the findings semiannually.

#### **Field Flashing Circuit**

Check the condition of the flashing contactor and arc chute.

Verify the condition of the contacts by referring to the appropriate instruction manual. Typically, the arc chute must be removed to examine the contacts. The contactor should be replaced if it has excessively worn contacts.

Examine the arc chute. If it appears excessively black and has a lot of carbon buildup from interruption of flashing current, then the exciter should be checked for proper startup sequencing. The flashing contactor is required only to break dc current when voltage buildup does not occur and because the DXCB module has fired on an aborted flash. Therefore, the arc chute should not have to absorb much energy. The contactor should be replaced if arc chute damage is evident.

For systems having ac field-flashing, the condition of the flashing isolation transformer and contactor should also be checked.



# 6 • Selenium Surge Suppressor Maintenance

## ***Introduction***

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Selenium surge suppressors (Figure 6-1) left de-energized for extended periods should be tested and reformed periodically. These suppressors may be part of a stock of spare components or part of a complete system left idle for extended periods. Yearly maintenance will ensure that a suppressor will provide the required level of protection when needed.

This maintenance consists of identifying a suppressor's configuration and test parameters and then applying a controlled voltage to check the suppressor's current draw and reform its selenium cells.

## ***Configuration***

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A selenium surge suppressor's configuration can be dc, ac single-phase, ac three-phase delta, or ac three-phase wye. Determine the configuration by examining the device and the excitation system interconnection diagram. Figure 6-1 provides examples of each configuration.

## ***Test Voltage Rating***

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The test voltage is dependent upon the number of suppressor cells. A dc or ac single-phase suppressor will have a single bank of cells while an ac three-phase suppressor will have three banks of cells. See Figure 6-1 for a guide on identifying suppressor plates and cells.

### **DC Suppressor**

For a dc suppressor, the number of cells equals the number of plates. Count the number of suppressor plates and enter this as the number of cells in Table 6-1. Then, calculate and record the test voltage rating by multiplying the number of cells by the corresponding multiplying factor in Table 6-1.

### **AC Single-Phase Suppressor**

For an ac single-phase suppressor, the number of cells equals the number of plates divided by two. Count the number of plates, divide this value by two, and record the result in Table 6-1. As an example, the ac single-phase suppressor of Figure 6-1 has 10 plates so the cell count is 5. Then, calculate and record the test voltage rating by multiplying the number of cells by the corresponding multiplying factor in Table 6-1.

### **AC Three-Phase Delta Suppressor**

For an ac three-phase delta suppressor, the number of cells in each bank/phase equals the number of plates in the bank divided by two. For each bank/phase, count the number of plates, divide this value by two, and record the result in Table 6-1. As an example, the ac three-phase delta suppressor of Figure 6-1 has 10 plates in each bank/phase so the cell count for each bank/phase is 5. Then, calculate and record the test voltage rating by multiplying the number of cells by the corresponding multiplying factor in Table 6-1. Repeat this process for the two remaining banks/phases.

### **AC Three-Phase Wye Suppressor**

For an ac three-phase wye suppressor, the number of cells in each bank/phase equals the number of plates. For each bank/phase, count the number of plates and record the result in Table 6-1. Then, calculate and record the test voltage rating by multiplying the number of cells by the corresponding multiplying factor in Table 6-1. Repeat this process for the two remaining banks/phases.

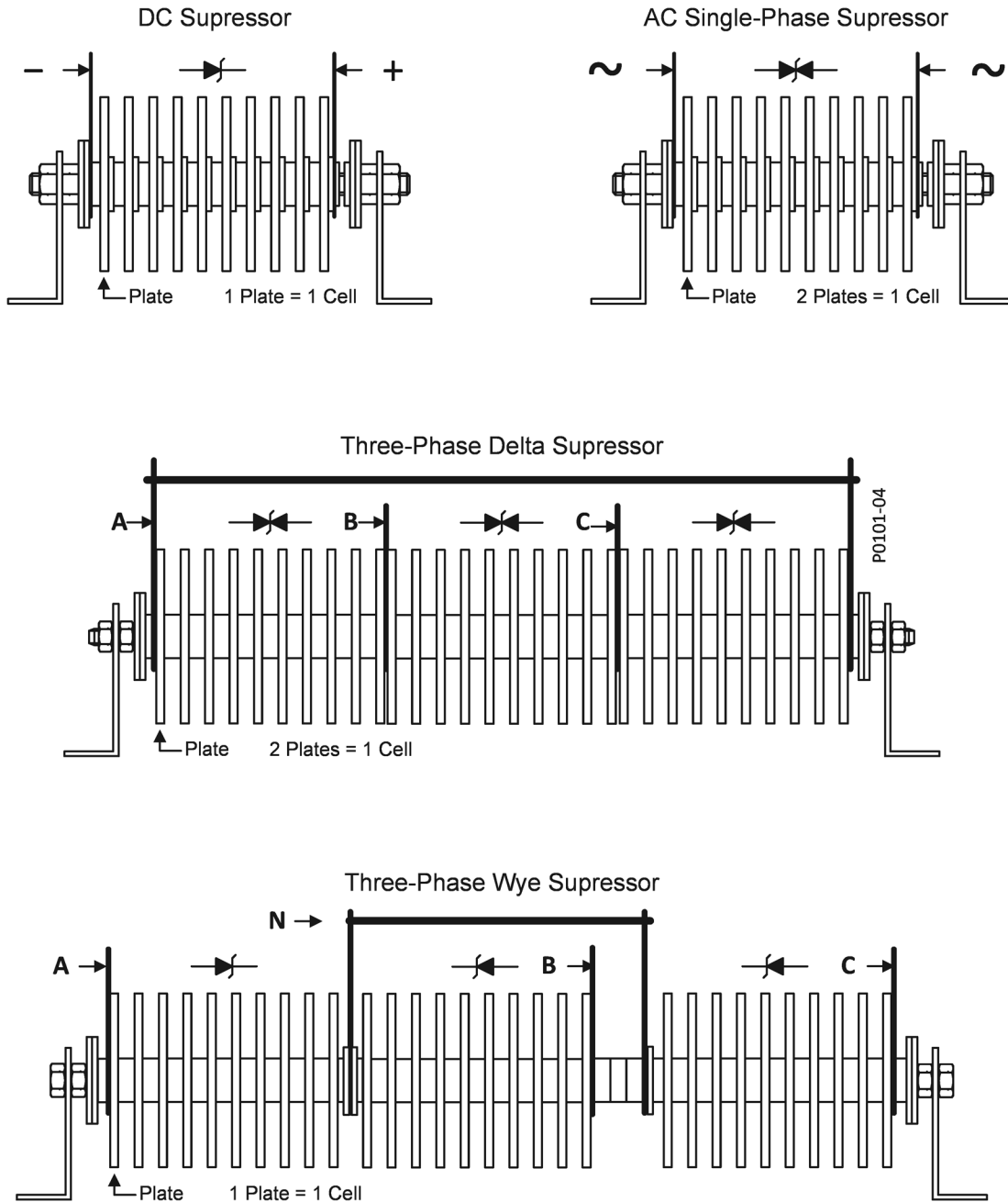


Figure 6-1. Selenium Surge Suppressor Type and Cell Identification

**Table 6-1. Suppressor Cell Count and Test Voltage**

Suppressor Type	Number of Cells	Multiplying Factor (Volts per Cell)	Test Voltage
DC		22.5	Vdc
AC Single-Phase		26	Vac
AC 3-Phase Delta, Phase A-B		26	Vac
AC 3-Phase Delta, Phase B-C		26	Vac
AC 3-Phase Delta, Phase C-A		26	Vac
AC 3-Phase Wye, Phase A-N		22.5	Vac
AC 3-Phase Wye, Phase B-N		22.5	Vac
AC 3-Phase Wye, Phase C-N		22.5	Vac

## Maximum Leakage Current Rating

Measure the suppressor plate size as shown in Figure 6-2. Use this measurement and Table 6-2 to identify the maximum allowable leakage current for the suppressor. Circle this value in Table 6-2.

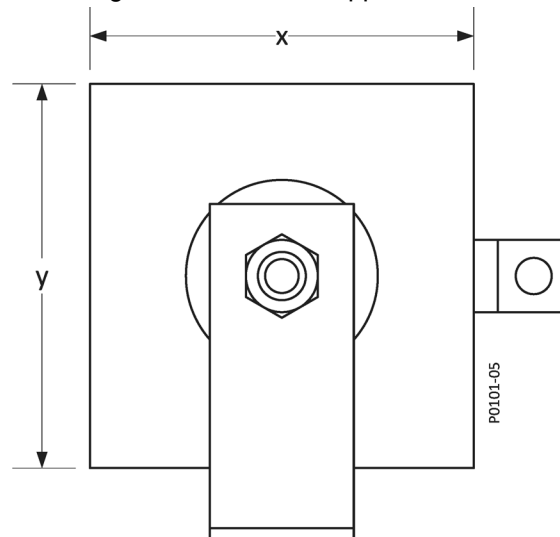
**Figure 6-2. Suppressor Plate Size****Table 6-2. Suppressor Leakage Current**

Plate Size in Inches (Millimeters)	Max Leakage Current		Measured Leakage Current (mA)
	DC (mAdc)	AC (mAac)	
0.25 (6) diameter	0.23	0.70	
0.375 (10) diameter	0.56	1.70	
0.5 (13) diameter	0.96	2.90	
0.75 (19) diameter	2.20	6.60	

Plate Size in Inches (Millimeters)	Max Leakage Current		Measured Leakage Current (mA)
	DC (mAdc)	AC (mAac)	
1.0 by 1.0 (25 by 25)	3.10	9.20	
1.25 by 1.25 (32 by 32)	5.60	16.8	
1.5 by 1.5 (38 by 38)	8.70	26.1	
1.75 by 1.75 (44 by 44)	10.2	30.6	
2.0 by 2.0 (51 by 51)	14.5	44.0	
2.0 by 3.0 (51 by 76)	22.5	67.5	
3.0 by 3.0 (76 by 76)	36.6	110.0	
4.0 by 4.0 (102 by 102)	69.5	209.0	
4.0 by 6.0 (102 by 152)	104.0	312.0	
4.0 by 12.0 (102 by 305)	215.0	645.0	
5.0 by 5.0 (127 by 127)	112.5	337.5	
5.0 by 6.0 (127 by 152)	133.0	398.0	
6.0 by 6.0 (152 by 152)	162.0	485.0	
6.0 by 7.25 (152 by 184)	202.0	606.0	
6.0 by 8.0 (152 by 203)	215.0	645.0	
6.0 by 10.0 (152 by 254)	273.0	818.0	
12.0 by 16.0 (305 by 406)	904.0	2,710.0	

## ***Suppressor Testing and Reforming***

The following equipment is required to test and reform a selenium surge suppressor:

- Variable dc or ac voltage source (dependent upon the suppression configuration and parameters)
- Digital multimeter (2)
- Stopwatch
- Cooling fan

### **Preparation**

Prepare the suppressor for testing and reforming by connecting it according to the appropriate diagram:

- DC suppressor: Figure 6-3
- AC single-phase suppressor: Figure 6-4
- AC three-phase delta suppressor: Figure 6-5
- AC three-phase wye suppressor: Figure 6-6

Place a cooling fan adjacent to the suppressor and orient it so that the fan will force air through the fins of the suppressor.

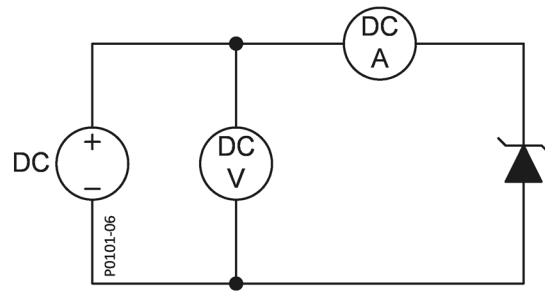


Figure 6-3. Test Connections, DC Suppressor

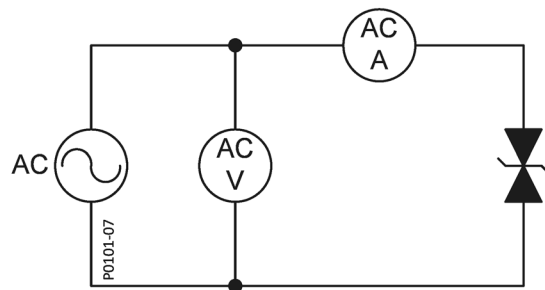


Figure 6-4. Test Connections, AC Single-Phase Suppressor

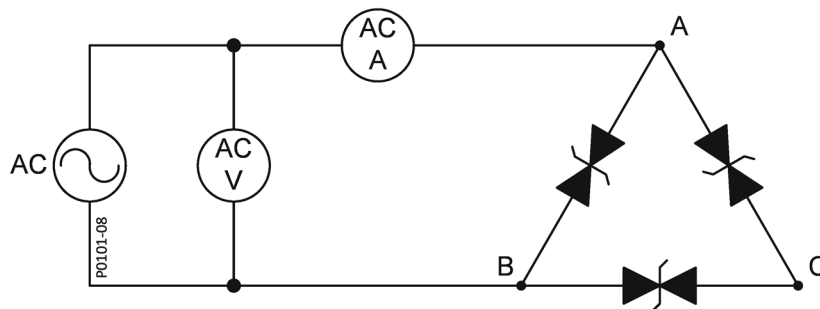


Figure 6-5. Test Connections, AC Three-Phase Delta Suppressor

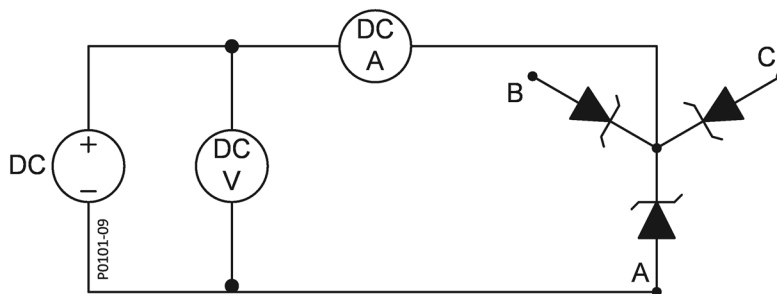


Figure 6-6. Test Connections, AC Three-Phase Wye Suppressor

### Testing and Reforming Procedure

1. Verify that the voltage source is set for zero output. Energize the cooling fan and the voltage source.
2. Slowly increase the voltage source output (no greater than 20 volts per second) until the calculated voltage rating from Table 6-1 is achieved. Start the stopwatch and monitor the level of current.
3. Verify that the monitored level of current is below the maximum value circled in Table 6-2. Record the value in Table 6-2. If the current exceeds the maximum value circled, the surge suppressor is defective and should be replaced. If the current takes more than two minutes to plateau, the surge suppressor is defective and should be replaced.
4. Reduce the voltage source to zero output and de-energize it. Make a record of the date, test voltage, and leakage current for future reference.
5. For a three-phase suppressor, repeat steps 1 through 4 for each of the remaining two phases.

# 7 • Maintenance Schedule

This section provides a recommended inspection schedule for the excitation system equipment. Each user's own experience, along with the conditions at the equipment site should determine the frequency of inspection. In the maintenance schedule of Table 7-1, inspection and maintenance operations are abbreviated as follows:

- C.....Change of component
- D.....Check for dirt/debris and clean
- F.....Check for open fuses
- I.....Inspect component/equipment
- O.....Torque bus and cable connections
- R.....Refurbish at factory
- T.....Test and/or calibrate component
- V.....Verify operation

**Table 7-1. Maintenance Schedule**

Maintenance Item	Routine				Length of Service in Years										
	Startup	Quarterly	Semiannually	Annually	2.5	5	7.5	10	12.5	15	17.5	20	22	25	27.5
AC Isolation Transducers	T			D	T	T	T	T	T	T	T	T	T	T	T
Air Conditioner	T	I		D	Inspect and maintain according to instruction manual.										
Air Filters	I/C/D														
Analog I/O Circuit Boards	T			D	T	T	T	T	T	T	T	T	T	T	T
Bridge Control Module (BCM)	T			D	T	T	T	T	T	T	T	T	T	T	T
Bridge Isolation Transducers	T			D	T	T	T	T	T	T	T	T	T	T	T
Bus Connections	I/O					I		I		I		I		I	I
Cable Terminations	I/O					I		I		I		I		I	I
Circuit Breaker	T			I/D	Inspect and maintain according to instruction manual.										
Conduction Monitors	V				V	V	V	V	V	V	V	V	V	V	V
Contactor, AC	T			I/D						C					
Contactor, DC	T			I/D						C					
Control Fuses	I/F			I/F											
Control Relays	V				V	V	V	V	V	V	V	V	V	V	V
Corrosion/Condensation	I		I												
Crowbar Module	T				T	T	T	T	T	T	T	T	T	T	T
DC Isolation Transducers	T			D	T	T	T	T	T	T	T	T	T	T	T
De-Excitation Module	T				T	T	T	T	T	T	T	T	T	T	T
Digital Controller (DECS)	T			D	Inspect and maintain according to instruction manual.										
Digital I/O Circuit Boards	T			D	T	T	T	T	T	T	T	T	T	T	T
Display Panel	T							C				C			
Dustiness	I	I		D											
Excitation Control Module (ECM-2)	T			D	T	T	T	T	T	T	T	T	T	T	T
Exciter Control Module (ECM)	T			D	T	T	T	T	T	T	T	T	T	T	T
Fan/Blower Motors	T			T				C				C			
Fan Blade Assemblies	I			I											
Fan Shutter Switch	I			I				C				C			

Maintenance Item	Routine				Length of Service in Years										
	Startup	Quarterly	Semiannually	Annually	2.5	5	7.5	10	12.5	15	17.5	20	22	25	27.5
Fiber Optic Connections	I			I											
Field Flashing Contactor	T			I											
Field Flashing Circuit	T			I											
Firing Control Module (FCIM)	T			D	T	T	T	T	T	T	T	T	T	T	T
Firing Module (IFM)	T			D	Inspect and maintain according to instruction manual.										
Ground Detector Module	T			T				C				C			
Insulators and Supports	I/D			I/D											
Line Filter Capacitors	I		I					C				C			
Line Filter Fuses	I/F			I/F											
Line Filter Resistors	I		I												
MOV Fuses	I/F			I/F											
MOVs	I			I	I	I	I	I	I	I	I	I	I	I	I
Rectifier Bridge (Drawer)	T/I/D	D				I/D		I/D		I/D		I/D		I/D	
Rectifier Bridge (Fixed)	T/I/D	D				I/D		I/D		I/D		I/D		I/D	
Power Supplies	T						C			C				C	
Protective Relays	T			T	Inspect and maintain according to instruction manual.										
Ribbon Cable Connections	I			I											
Sensor Input Module (SIM)	T			D	T	T	T	T	T	T	T	T	T	T	T
Shaft Suppression Capacitors	I			I				C				C			
Shaft Suppression Resistor	I		I												
Space Heater Circuit	T			D	T	T	T	T	T	T	T	T	T	T	T
Surge Suppression Components	I			I											
Surge Suppression Components, Selenium, Not in Service				T											
Temperature, Ambient	I			I											
Wiring	I			I											
Wiring Connections	I			I											





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