Vacuum Electric Switch Co.

Switches for Special Applications

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34 or 46 kV 600 A Single Pole, page 5 & 6
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34 kV 600 A Harmonic Filter Switch, page 13

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Vacuum Electric Switch Company™ products can be hazardous

Vacuum Electric Switch Co.™ products are high voltage equipment with the potential to kill or injure individuals not following appropriate procedures. Personnel must be trained according to an established standard such as NFPA 70E, Standard for Electrical Safety in the Workplace available from the National Fire Prevention Association 1 Battery march Park, P.O. Box 9101 Quincy, MA 02269-9101 USA or www.nfpa.org. This standard establishes appropriate safety training and procedures for servicing this equipment.

Vacuum Electric Switch products are not personnel safety devices. They should never be used to isolate high voltages from equipment being serviced by personnel because they do not provide isolation with a visible break.

All equipment must be de-energized, locked out, grounded, and proven de-energized prior to performing maintenance. Switches have two sources of energy. One is from the high voltage source, and the other is from the control through the control cable. Switches contain stored energy in springs. Completely de-energizing a switch requires removing both sources of energy and immobilizing the springs in the switch mechanism.

Controls have both a source of energy as well as stored energy in capacitors. Controls require locking out their electric power source, and removing the stored energy in their capacitors prior to servicing.

Hi-pot testing is part of switch maintenance that uses dangerous high voltages. Safe hi-pot testing requires a cleared area between the equipment under test and personnel as specified by NPFA 70E.
Vacuum Electric Switch Co.

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*The Vacuum Electric Switch Co. manufactures vacuum switches which are suitably interchangeable with Joslyn Hi-Voltage’s vacuum switches of the same rating. The Joslyn designations VBM*, VBT*, and VBU* are abbreviations for the descriptive phrases vacuum breaker miniature, vacuum breaker transformer, and vacuum breaker up-right respectively. The Vacuum Electric Switch Co.’s switches and parts are of its own design and methods of manufacturer which may not be the same as employed by Joslyn. Where product performance is reported, it is from testing of Vacuum Electric Switch Co.’s products and is not necessarily indicative of the performance of comparable products wholly manufactured by Joslyn. The Vacuum Electric Switch Co. is not endorsed or associated with the Joslyn Hi-Voltage Corp. or any of its affiliates.

* VBM, VBU, and VBT are trademarks of the Joslyn Holding Co.
The common uses of this switch are sectionalizing and arc furnace or capacitor bank switching. This switch may have either a motor or solenoid operated mechanism. These two mechanisms differ in the complexity of the required control systems, control current demand, available operating voltages, mechanical life, and the precision of the timing of switch contact closing.

Motor operated switches are used for capacitor bank switching and sectionalizing but not arc furnace switching. They can have simple control systems since control current demand is less than six amperes. The motor mechanism cannot be used where simultaneous contact closure in more than one switch is required. The motor mechanism has a limited life of about 30,000 operations which is much less than the more than 200,000 operations achievable by a solenoid mechanism. Motor operated switches with 15 or 35 pin connectors have two each form A (e.g. normal open) and B (e.g. normal closed) or six each form A and B contacts respectively. A common error which may damage the motor operator is to connect it to the wrong control voltage. A switch’s control voltage can be determined by examining its relay panel. Relay panels are shown starting on page 36. Repair parts for this switch are found beginning on page 45 and for the motor mechanism beginning on page 54.

Common uses of the solenoid operated switch are both capacitor and also arc furnace switching. Uncommonly, two or more of these switches may be used along with three resistor modules to form a resistor insertion switch. The solenoid operated switch can be operated with three modules connected in parallel. Each module’s current rating is de-rated to 500 A when connected in parallel for a total current of 1500 A. Three separate switches are then required to make a three phase set. Solenoid operated switches have one form A (e.g. normal open) and one form B (e.g. normal closed) contact. The solenoid operator requires a more elaborate control because each solenoid requires a current in the range of 60 to 65 amperes peak for 1-1/2 cycles. The requirement for a large current source can be overcome by using a stored energy control shown on page 18. The controls for arc furnace switching are shown starting on page 20. The resistor module for building a resistor insertion switch is shown on page 15.
This switch is used for both capacitor and arc furnace switching. It is solenoid operated because it is used in three phase sets requiring simultaneous contact closure. It can close at zero voltage for capacitor switching or at peak voltage for arc furnace switching. Its solenoid operating current is 60 to 65 amperes peak for 1-1/2 cycles. An inadequate current supply is a common cause of improper operation. This switch has one form A (e.g. normal open) and one form B (e.g. normal closed) auxiliary contact. The controls for capacitor switching are shown on page 19. Repair parts are shown beginning on page 45.

Multiple switches are used in parallel for arc furnaces with up to 4000 amperes primary current. The switch current rating is derated to 500 A when used in parallel. Arc furnace controls that can operate from one to six switches per phase are shown on page 21. An arc furnace transformer control can optionally be operated using either resistor insertion or peak voltage closing to reduce in-rush currents.

Accessories available for this switch include both current limiting reactors and also resistor modules. The 30 micro henry reactor replaces the buss bar between the two modules. The reactor is used to limit in-rush currents when two capacitor banks are installed in parallel on a single buss. This switch also can be adapted as a resistor insertion switch by installing two 80 ohm resistor modules, one each, on top of the two vacuum interrupter modules. The two resistor modules are then series connected with the buss bar and have a total series resistance of 180 ohms. The controls required are shown starting on page 21. The reactors and resistors are shown on page 15.

<table>
<thead>
<tr>
<th>SWITCH CONFIG.</th>
<th>BIL KV (T:T:T:G)</th>
<th>VOLTAGE RATING kV</th>
<th>CURRENT RATING A</th>
<th>OPERATING MECHANISM TYPE</th>
<th>CONTROL VOLTAGE</th>
<th>OUTLINE DRAWING</th>
<th>VES SWITCH PART NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 POLE</td>
<td>200-200</td>
<td>34</td>
<td>600</td>
<td>SOLENOID</td>
<td>120 VAC</td>
<td>1001565</td>
<td>1000776G1</td>
</tr>
</tbody>
</table>
This switch is principally used for arc furnace switching but also has limited use for capacitor switching. The switch is solenoid operated because it is used in three phase sets requiring simultaneous contact closure. Capacitor switching is limited to switching solidly grounded 46 kV systems having RMS currents of 200 amperes maximum. The switch can be used to switch an arc furnace at 46 kV. Its current capacity can be increased by connecting switches in parallel. Switches connected in parallel are de-rated to 500 A. This switch has one form A (e.g. normal open) and one form B (e.g. normal closed) auxiliary contact. Capacitor switching is best done with a stored energy control shown on page 19. An arc furnace control is shown on page 21. This switch’s repair parts are shown beginning on page 45.
### Switches with .160 Inch Gap Comparable to Joslyn™ Switches With Similar Ratings

<table>
<thead>
<tr>
<th>SWITCH CONFIG.</th>
<th>BIL kV (T:T-T:G)</th>
<th>VOLTAGE RATING kV</th>
<th>CURRENT RATING A</th>
<th>OPERATING MECHANISM TYPE</th>
<th>CONTROL VOLTAGE</th>
<th>OUTLINE DRAWING</th>
<th>VES SWITCH PART NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>15 PIN MOTOR</td>
<td>24 VDC</td>
<td>1003256</td>
<td>1003315G1</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>15 PIN MOTOR</td>
<td>48 VDC/120 VAC</td>
<td>1003256</td>
<td>1002521G1</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>15 PIN MOTOR</td>
<td>125 VDC</td>
<td>1003256</td>
<td>1002521G2</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>15 PIN MOTOR</td>
<td>220 VAC</td>
<td>1003256</td>
<td>1003315G6</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>35 PIN MOTOR</td>
<td>24 VDC</td>
<td>1003256</td>
<td>1003316G1</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>35 PIN MOTOR</td>
<td>48 VDC/120 VAC</td>
<td>1003256</td>
<td>1003252G1</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>35 PIN MOTOR</td>
<td>125 VDC</td>
<td>1003256</td>
<td>1003252G2</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>35 PIN MOTOR</td>
<td>220 VAC</td>
<td>1003256</td>
<td>1003316G2</td>
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<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>SOLENOID</td>
<td>120 VAC</td>
<td>1003256</td>
<td>1002201G1</td>
</tr>
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</table>

### Switches with .160 inch Gap with Grading Capacitors and Having No Known Joslyn™ Equivalent

<table>
<thead>
<tr>
<th>SWITCH CONFIG.</th>
<th>BIL kV (T:T-T:G)</th>
<th>VOLTAGE RATING kV</th>
<th>CURRENT RATING A</th>
<th>OPERATING MECHANISM TYPE</th>
<th>CONTROL VOLTAGE</th>
<th>OUTLINE DRAWING</th>
<th>VES SWITCH PART NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>15 PIN MOTOR</td>
<td>24 VDC</td>
<td>1003256</td>
<td>1003315G5</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>15 PIN MOTOR</td>
<td>48 VDC/120 VAC</td>
<td>1003256</td>
<td>1002521G5</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>15 PIN MOTOR</td>
<td>125 VDC</td>
<td>1003256</td>
<td>1002521G6</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>15 PIN MOTOR</td>
<td>220 VAC</td>
<td>1003256</td>
<td>1003315G6</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>35 PIN MOTOR</td>
<td>24 VDC</td>
<td>1003256</td>
<td>1003316G5</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>35 PIN MOTOR</td>
<td>48 VDC/120 VAC</td>
<td>1003256</td>
<td>1003252G5</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>35 PIN MOTOR</td>
<td>125 VDC</td>
<td>1003256</td>
<td>1003252G6</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>35 PIN MOTOR</td>
<td>220 VAC</td>
<td>1003256</td>
<td>1003316G6</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>300</td>
<td>SOLENOID</td>
<td>120 VAC</td>
<td>1003256</td>
<td>1002201G2</td>
</tr>
</tbody>
</table>
The Vacuum Electric Switch Co. is offering this switch in three different versions to improve restrike re-
sistance during capacitor switching. The improvements in restrike resistance are achieved by first adding grading
capacitors and second by increasing the open gap between the vacuum contacts from .160 to .320 inches.

The geometric configuration of this switch may result in the parasitic capacitance in parallel with each vacuum
interrupter being unequal. This is most likely to occur when this switch is used on poles where objects in close
proximity will most likely cause a larger portion of the recovery voltage to appear across the upper module and
reduce its capacitor switching capability. Grading capacitors tend to equalize the capacitance across each vacuum
interrupter and diminishing the effect of parasitic capacitance. The recovery voltage withstand capability is further
improved by increasing the contact open gap from .160 to .320 inches. Opening the switch to the larger gap re-
quires more energy than is available from a solenoid mechanism so that the larger gap is only possible with motor
operated switches.

The common uses of this 34 kV switch are either capacitor switching or sectionalizing. It can have either a
solenoid or motor operated mechanism. The principal differences between switches with the two mechanisms are
the complexity of control, control current demand, available operating voltages, and mechanical life. A motor
operated switch requires a simple control system because the control current is less than 6 amperes. Motor operat-
ed switches are available with a variety of control voltages. The VES motor operator has a limited life of approxi-
mately 30,000 operations as compared to the 200,000 operations for the solenoid operator.

Motor operated switches with 15 or 35 pin connectors have two each form A (e.g. normal open) and B (e.g.
normal closed) or six each form A and B contacts respectively. A common error which may damage a motor oper-
ator switch is to connect it to the wrong control voltage. The appropriate voltage for a motor operator switch can
be determined by examining the relay panel installed on the motor operator. Relay panels are shown on pages 36,
37, & 38. Motor operator repair parts are found starting on page 54.

When this switch is solenoid operated, large operating currents in the range of 120 to 130 amperes peak for 1-
1/2 cycles are required. An inadequate current supply is a frequent cause of improper operation which may be diff-
cult to diagnose. Either a substantial ac current source with suitable current switching capability or a stored ener-
gy control must be used. This problem can be overcome by using a stored energy control such as shown on page
18 which can be operated on 48 Vdc, 120 Vac, 125 vdc, and 220 Vac. This control has two form A and two form
B auxiliary contacts. Switch repair parts are shown starting on page 45.
The 46 and 69 kV switches shown above are commonly used for capacitor bank switching in substations. They are solenoid operated because they are used in three phase sets requiring simultaneous contact closure. These switches can precisely close at zero voltage to reduce capacitor bank in-rush currents. The solenoid operating current is 60 to 65 amperes peak for 1-1/2 cycles per switch mechanism. An inadequate supply of control current can cause of improper operation. They are best operated with a stored energy control as shown on page 19. These switches have one form A (e.g. normal open) and one form B (e.g. normal closed) auxiliary contact. Repair parts are shown beginning on page 45.
This switch is used for both arc furnace and capacitor switching and is generally known by the Joslyn Hi-Voltage* trademark VBU* because there is no other widely known generic name for this switch. The 2000 and 3000 A modules are original products of the Vacuum Electric Switch Co. and are used for very large arc furnaces at 34 kV. At 69 kV and above this switch may be the only switch available with a practical operating life for switching arc furnaces. A mechanical operating life of 200,000 operations is practical between module and switch mechanism rebuilds. The Vacuum Electric Switch Co. remanufactures Joslyn’s VBU* modules and switch operating mechanisms. The Vacuum Electric Switch Co. builds a special control for switching VBU* switches for both capacitor and arc furnace switching applications. Controls are available that can switch six VBU* poles in parallel or a total of eighteen switches. Vacuum Electric Switch remanufactured VBU* modules and VBU* switch mechanisms are shown on page 44. Controls are shown on page 22.

* VBU is a trademark of the Joslyn Holding Corp.
This solenoid operated two pole switch has two applications. The first is to achieve 1000 amperes of current capacity at 15 kV by connecting the two modules in parallel with buss bars. In this configuration it is used for arc furnace switching. When the modules are connected in parallel, three separate switch mechanisms are required to make a three phase set. This switch’s controls for arc furnace switching are shown starting on page 21. The second application is in conjunction with the transverse single pole switch shown below for switching capacitor banks at zero voltage. The control required for this application is found on page 19. Repair parts are the same as for a 15 kV three pole switch and are found starting on page 45.

<table>
<thead>
<tr>
<th>SWITCH CONFIG.</th>
<th>BIL kV (T:T-T:G)</th>
<th>VOLTAGE RATING kV</th>
<th>CURRENT RATING A</th>
<th>OPERATING MECHANISM TYPE</th>
<th>CONTROL VOLTAGE</th>
<th>OUTLINE DRAWING</th>
<th>VES SWITCH PART NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 POLE T</td>
<td>150</td>
<td>15</td>
<td>600</td>
<td>SOLENOID</td>
<td>120 VAC</td>
<td>1000641</td>
<td>1000579G1</td>
</tr>
<tr>
<td>1 POLE L</td>
<td>150</td>
<td>15</td>
<td>600</td>
<td>SOLENOID</td>
<td>120 VAC</td>
<td>1000374</td>
<td>1001178G3</td>
</tr>
</tbody>
</table>

This single pole switch is used for synchronous closing of capacitor banks to reduce in-rush currents. It is available with two terminal pad orientations. With the terminal pads perpendicular to the length of the switch it is used with the two pole switch above to switch capacitor banks at zero voltage. The longitudinal form above is used in three phase sets to switch capacitor banks at zero voltage. These switches contains one form A (e.g. normal open) and one form B (e.g. normal closed) auxiliary contact. The required controls are shown starting on page 19. The repair parts are the same as for the three pole 15 kV switch and are found beginning on page 45.
This switch is used for sectionalizing 34 kV solidly grounded systems only. The switch is motor operated because it is used as a sectionalizing switch in remote locations where a limited current supply is available and a simple control is an advantage. The control current is only 6 amperes. Switches with 15 or 35 pin connectors have two each form A (e.g. normal open) and form B (e.g. normal closed) or six each form A and form B contacts respectively.

<table>
<thead>
<tr>
<th>SWITCH CONFIG.</th>
<th>BIL kV (T:T-G)</th>
<th>VOLTAGE RATING kV</th>
<th>CURRENT RATING A</th>
<th>OPERATING MECHANISM TYPE</th>
<th>CONTROL VOLTAGE</th>
<th>OUTLINE DRAWING</th>
<th>VES SWITCH PART NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>600</td>
<td>15 PIN MOTOR</td>
<td>24 VDC</td>
<td>1002870</td>
<td>1003313G1</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>600</td>
<td>15 PIN MOTOR</td>
<td>48 VDC/120 VAC</td>
<td>1002870</td>
<td>1002867G1</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>600</td>
<td>15 PIN MOTOR</td>
<td>125 VDC</td>
<td>1002870</td>
<td>1002867G2</td>
</tr>
<tr>
<td>3 POLE</td>
<td>200:200</td>
<td>34</td>
<td>600</td>
<td>15 PIN MOTOR</td>
<td>220 VAC</td>
<td>1002870</td>
<td>1003313G2</td>
</tr>
</tbody>
</table>

This switch is used to short insertion resistors on an arc furnace having a 69 kV primary voltage. This switch is solenoid operated because to prevent overheating the resistors the resistors must be shorted at 100 milliseconds after being energized. Only the solenoid operated switch has the precision to meet this timing requirement. This switch contains one form A (e.g. normal open) and one form B (e.g. normal closed) auxiliary contact. A control for operating this switch is shown on page 22. The repair parts except for the pull rods and the line-to-ground insulatorst are the same as for the 34 kV switch shown on page 45.

<table>
<thead>
<tr>
<th>SWITCH CONFIG.</th>
<th>BIL kV (T:T-G)</th>
<th>VOLTAGE RATING kV</th>
<th>CURRENT RATING A</th>
<th>OPERATING MECHANISM TYPE</th>
<th>CONTROL VOLTAGE</th>
<th>OUTLINE DRAWING</th>
<th>VES SWITCH PART NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 POLE</td>
<td>350</td>
<td>46</td>
<td>600</td>
<td>SOLENOID</td>
<td>120 VAC</td>
<td>1002864</td>
<td>1002863G1</td>
</tr>
</tbody>
</table>
The above switch is solenoid operated for use in a laboratory where versatility is an advantage. The switch can be either a 34 kV 600 A or a 15 kV 1000 A switch by removing or installing the lower buss bar respectively. The double solenoid version of this switch has twice as many solenoids in order to increase the speed of contact closure. This switch contains one form A (e.g. normal open) and one form B (e.g. normal closed) auxiliary contact. The controls for these switches are shown on page 18. The repair parts except for the modules are the same as for the 34 kV switch shown on page 45.

<table>
<thead>
<tr>
<th>SWITCH CONFIG.</th>
<th>BIL KV (T:T-G)</th>
<th>VOLTAGE RATING kV</th>
<th>CURRENT RATING A</th>
<th>OPERATING MECHANISM TYPE</th>
<th>CONTROL VOLTAGE</th>
<th>OUTLINE DRAWING</th>
<th>VES SWITCH PART NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 POLE</td>
<td>110/200-200</td>
<td>15/34</td>
<td>1000/600</td>
<td>SOLENOID</td>
<td>120 VAC</td>
<td>1002860</td>
<td>1002831G1</td>
</tr>
<tr>
<td>1 POLE</td>
<td>110/200-200</td>
<td>15/34</td>
<td>1000/600</td>
<td>DOUBLE SOLENOID</td>
<td>120 VAC</td>
<td>1002860</td>
<td>1002831G2</td>
</tr>
</tbody>
</table>

This switch is for switching harmonic filters up to and including the 12th Harmonic. Unlike the Joslyn™ switch of a similar design the modules on the Vacuum Electric Switch Co.’s harmonic filter switch contain grading capacitors to assure even distribution of the recovery voltage over the three modules. Modules with and without grading capacitors cannot be combined on the same switch and are special for this switch. The switch is solenoid operated and comes with the buss bars on either the left or right hand sides. This switch contains one form A (e.g. normal open) and one form B (e.g. normal closed) auxiliary contact. A control for operating this switch is shown on page 19. The repair parts except for the modules are the same as for the 34 kV switch shown on page 45.

<table>
<thead>
<tr>
<th>SWITCH CONFIG.</th>
<th>BIL KV (T:T-G)</th>
<th>VOLTAGE RATING kV</th>
<th>CURRENT RATING A</th>
<th>OPERATING MECHANISM TYPE</th>
<th>CONTROL VOLTAGE</th>
<th>OUTLINE DRAWING</th>
<th>VES SWITCH PART NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 POLE RH</td>
<td>200-200</td>
<td>34</td>
<td>600</td>
<td>SOLENOID</td>
<td>120 VAC</td>
<td>1003377</td>
<td>1003355G1</td>
</tr>
<tr>
<td>1 POLE LH</td>
<td>200-200</td>
<td>34</td>
<td>600</td>
<td>SOLENOID</td>
<td>120 VAC</td>
<td>1003376</td>
<td>1003354G1</td>
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Right Hand Configuration

Left Hand Configuration
Ratings for Vacuum Electric Switches

<table>
<thead>
<tr>
<th>Design Voltage Nominal/Maximum (kV)</th>
<th>15/15.5</th>
<th>34.5/38</th>
<th>46/48.5</th>
<th>69/72.5</th>
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</thead>
<tbody>
<tr>
<td>Continuous current (RMS Amperes)</td>
<td>600(^5)</td>
<td>600(^5)</td>
<td>300</td>
<td>600(^4,5)</td>
</tr>
<tr>
<td>Fault Interrupting Current (RMS Amperes) Max.</td>
<td>4000</td>
<td>4000</td>
<td>3000</td>
<td>4000</td>
</tr>
<tr>
<td>Momentary Current (RMS Amperes, Asymmetric)</td>
<td>20,000</td>
<td>20,000</td>
<td>15,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Frequency (Hz)(^3)</td>
<td>50/60</td>
<td>50/60</td>
<td>50/60</td>
<td>50/60</td>
</tr>
<tr>
<td>Two-Second Current (RMS Amperes)</td>
<td>12,500</td>
<td>12,500</td>
<td>12,500</td>
<td>12,500</td>
</tr>
<tr>
<td>Four-Second Current (RMS Amperes)</td>
<td>9000</td>
<td>9000</td>
<td>9000</td>
<td>9000</td>
</tr>
<tr>
<td>Impulse Withstand, Terminal-to-Terminal (kV) Line-to-Ground (1.2 X 50 Positive Wave)</td>
<td>110(^1)/150</td>
<td>200(^1)/200</td>
<td>200(^1)/200</td>
<td>200(^1)/250</td>
</tr>
<tr>
<td>Maximum 60-Cycle Withstand Line-to-Ground (kV)</td>
<td>101</td>
<td>138</td>
<td>138</td>
<td>178</td>
</tr>
<tr>
<td>One Minute Dry Ten Seconds Wet</td>
<td>74</td>
<td>119</td>
<td>119</td>
<td>176</td>
</tr>
<tr>
<td>Maximum Peak Inrush Current (RMS Amperes)</td>
<td>20,000(^2)</td>
<td>20,000(^2)</td>
<td>15,000(^2)</td>
<td>20,000(^2)</td>
</tr>
</tbody>
</table>

\(^1\)The terminal-to-terminal BIL is not established by a visible open gap and therefore cannot be used to establish safety clearance for personnel.

\(^2\)When switches are used for capacitor bank switching, restrike probabilities are determined by the magnitude of the in-rush current, the contact open gap, and the contact material. This is explained in a Toshiba paper found in IEEE Transactions on Power Delivery Vol 10, No. 2 April 1995. Using reactors to reduce in-rush current reduces restrike probability. In back-to-back capacitor switching peak currents should be limited by reactors to a switch’s fault interrupting rating. The contact material used in these switches is copper tungsten the same as reported to have the lowest restrike probability in this Toshiba paper. In aged switches with high operation counts contact welding may occur if the in-rush currents are not limited.

\(^3\)Switching a harmonic filter requires special considerations. Consult the factory about these applications.

\(^4\)For capacitor bank switching only, this switch is limited to being used on solidly grounded systems and solidly grounded capacitor banks with currents of less than 200 amperes.

\(^5\)When switches are used in parallel, the continuous current rating is reduced to 500 amperes to account for unequal current distribution between switches.

\(^6\)When switches are used for capacitor bank switching, restrike probabilities are determined by the magnitude of the in-rush current, the contact open gap, and the contact material. This is explained in a Toshiba paper found in IEEE Transactions on Power Delivery Vol 10, No. 2 April 1995. Using reactors to reduce in-
Switch Accessories

80 Ohm Resistor Module

The 80 ohm resistor module is used to build resistor insertion switches for reducing in-rush currents. It has an arc horn to protect it from over voltages in the event the in-rush current is so large that its withstand voltage was exceeded. Its VES part number is: 1002256G1.

30 Micro-Henry Reactor

The above 30 micro-henry reactor is used to limit in-rush current when switching back-to-back (two capacitor banks installed in parallel on the same buss) capacitor banks. It is designed to be installed in place of the buss bar on the 34 kV switch shown on page 5. Its VES part number is: 1002284G1

Joslyn™ Cable

<table>
<thead>
<tr>
<th>Number of Pins</th>
<th>Length</th>
<th>Indoor Part No.</th>
<th>Outdoor Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>20</td>
<td>1000415G1</td>
<td>1000576G1</td>
</tr>
<tr>
<td>15</td>
<td>25</td>
<td>1000415G4</td>
<td>1000576G4</td>
</tr>
<tr>
<td>15</td>
<td>30</td>
<td>1000415G2</td>
<td>1000576G2</td>
</tr>
<tr>
<td>35</td>
<td>20</td>
<td>1002156G1</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>25</td>
<td>1002156G2</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>30</td>
<td>1002156G3</td>
<td></td>
</tr>
</tbody>
</table>

The above cable is for use with a Joslyn™ switch control. The outdoor cable has a cable drip angle. It has either a 15 or 35 pin connector on one end and loose wires on the other for connecting to a terminal strip.

Vacuum Electric Switch Cable

<table>
<thead>
<tr>
<th>Number of Pins</th>
<th>Length ft.</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>15</td>
<td>1000775G8</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>1000775G2</td>
</tr>
<tr>
<td>15</td>
<td>30</td>
<td>1000775G3</td>
</tr>
<tr>
<td>15</td>
<td>35</td>
<td>1000775G4</td>
</tr>
<tr>
<td>15</td>
<td>40</td>
<td>1000775G5</td>
</tr>
</tbody>
</table>

The above cable has one end a 15 pin connector for connecting to a Joslyn™ switch. The opposite end has a connector for connecting to a Vacuum Electric Switch control.
## Vacuum Switch Service Tool Kit

Vacuum Switch Service Tool Kit Part No. 1001533G1

<table>
<thead>
<tr>
<th>Description of Tools in Kit</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuity light box with 4 circuits for synchronizing switches - 1001618G1</td>
<td>1</td>
</tr>
<tr>
<td>3° gauge for measuring the maximum link angle—1001104P1</td>
<td>1</td>
</tr>
<tr>
<td>1° gauge for measuring the minimum link angle—1001104P2</td>
<td>1</td>
</tr>
<tr>
<td>.060”, .075’, .090” step gauge for setting solenoid nylon pin gap 1001105P1</td>
<td>1</td>
</tr>
<tr>
<td>Adjustment wedge for synchronizing module contacts —1001538P1</td>
<td>1</td>
</tr>
<tr>
<td>Digital dial indicator assembly for measuring mechanism travel and contact over travel—1001536G1</td>
<td>1</td>
</tr>
<tr>
<td>Philips No. 3 screwdriver—1001673</td>
<td>1</td>
</tr>
<tr>
<td>50 in-lb torque wrench —1001541</td>
<td>1</td>
</tr>
<tr>
<td>25 in-lb torque wrench—1001539</td>
<td>1</td>
</tr>
<tr>
<td>1/4” drive ratcheting torque wrench—1001617</td>
<td>1</td>
</tr>
<tr>
<td>socket 1/2” 6 pt 1/4” drive standard —1001668</td>
<td>1</td>
</tr>
<tr>
<td>Socket 9/16” 6 pt. 1/4” drive standard—1001669</td>
<td>1</td>
</tr>
<tr>
<td>Socket 7/16” 6 pt. 1/4” drive standard—1001667</td>
<td>1</td>
</tr>
<tr>
<td>Socket 7/16” 6 pt 1/4” drive deep—1001667</td>
<td>1</td>
</tr>
<tr>
<td>Box end wrench 7/16” 1/2” deep offset—1001672</td>
<td>1</td>
</tr>
<tr>
<td>Open end wrench 3/4” X 7/8”—1001548</td>
<td>1</td>
</tr>
</tbody>
</table>
Service Parts Kit for VBM™*VBT™* Switches

This kit was originally designed to meet the Vacuum Electric Switch’s service technician’s parts needs when performing service in a foreign country. One of these parts kits could be shipped ahead of the technician’s arrival, and the technician could be confident that it contained every part that could be conceivably required except vacuum interrupter modules. Companies doing their own service work may find purchasing this kit to be more convenient than ordering parts individually. The kit can be restocked as parts are consumed.

The service parts kit shown above is more than enough parts to service an arc furnace with a total of twelve switches. The difference between the 15 kV and 34 kV kits are the length of the pull rods supplied. The parts are grouped in individual numbered boxes. The entire kit is itemized in a spreadsheet and indexed by description, part number, and its numbered box. The kit is packaged in a Pelican Storm™ case for convenient shipment and storage. An itemized list of the parts in the kit is available on request.

Description | Part No.
---|---
Field service parts kit for Joslyn™* VBT™* 15 kV switches used for arc furnace switching | 1003182G1
Field service parts kit for Joslyn™* VBT™* 34 kV switches used for arc furnace switching | 1003182G2

Switch Service Stand

The above picture shows a switch service stand. When a switch is mounted to the stand, it can be flipped over to work on it right side up or upside down. The field service stand can be purchased either completely assembled or as a kit ready for welding. The stand is much easier and less costly to ship as a kit.

Description | Kit Part No. | Assembled Stand Part No.
---|---|---
Field service stand for a 15 or 34 kV switch | 1000247G2 | 1000247G1
Field service stand for a 46 or 69 kV switch | 1003557G2 | 1003557G1

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Capacitor Bank Switch Controls

The capacitor switch controls shown on these pages are different from other controls commonly used to operate Joslyn switches. First, they have extremely low power demands. Second, the control is very precise in timing switch contact opening and closing. Third, the controls are connected to the switches with a cables having connectors on both ends to speed installation.

The power demand is low because both the single and multiple switch controls are powered by switching power supplies with 10 and 25 watts ratings respectively. At these low power levels the peak current demand is easily under three amperes and the maintenance charging current is a trickle. Since the power demand is so low, voltage drops in long runs of wire to the control do not cause operating problems. The controls can accept 12 Vdc, 48 Vdc, 120 Vac, 125 Vdc, or 220 Vac. inputs.

These controls are very precise in controlling switching time because the basic electronic circuitry used in all the controls was designed for closing switches at zero voltage. The precision is achieved both by electronic switching and also having a closely regulated voltage on the stored energy capacitors. The zero voltage switching feature is optional, but even if this option is not elected the precision is retained by the electronics.

The controls are easy to diagnosis and repair. They are a modular assembly of circuit boards, wiring harnesses, and cables all of which can be quickly unplugged and replaced. This enables a person who is not familiar with the details of the circuitry and operation of the control to quickly isolate and determine what components are not working properly by substituting whole assemblies.

Single Switch Capacitor Bank Controls

The two controls shown above are for solenoid operated switches shown on pages 4, 7, & 13. The control circuitry is identical except that one control has twice as many capacitor as the other. The energy in the additional capacitors is required to operate the double solenoids on switches 1002201G1 and 1002858G2.
Two Switch Zero Voltage Control

The two switch control shown to the left is for switching capacitor banks at zero voltage using the one two pole switch along with one single pole transverse switch shown on page 11. This control has calibration test leads which are connected to the de-energized switches to measure the switch timing. A laptop computer with a special program is connected to the control and is used to measure and set the switch timing.

<table>
<thead>
<tr>
<th>Control Type</th>
<th>Control Voltage</th>
<th>Control Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Voltage</td>
<td>48 VDC</td>
<td>10003370G1</td>
</tr>
<tr>
<td>Zero Voltage</td>
<td>120 VAC</td>
<td>1003370G2</td>
</tr>
<tr>
<td>Zero Voltage</td>
<td>125 VDC</td>
<td>1003370G3</td>
</tr>
<tr>
<td>Zero Voltage</td>
<td>220 VAC</td>
<td>1003370G4</td>
</tr>
</tbody>
</table>

Three Switch Control

The three switch control shown can operate a three phase set of any single pole solenoid operated switch in this catalog except the VBU* switch. It can be either a zero voltage or a regular control depending on the firmware installed. The three switches will achieve simultaneous contact closure within 2 milliseconds with minimal adjustment effort. The use of this control will substantially reduce the effort required to adjust switches for simultaneous operation when operated on 125 Vdc.

When this control is used for zero voltage closing, sense leads are run out to the de-energized switches to measure their closing times. A laptop computer with a special program is connected to the control and is used to measure the closing time and to set the calibration.

<table>
<thead>
<tr>
<th>Control Type</th>
<th>Control Voltage</th>
<th>Control Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Voltage</td>
<td>48 VDC</td>
<td>1003365G1</td>
</tr>
<tr>
<td>Zero Voltage</td>
<td>120 VAC</td>
<td>1003177G1</td>
</tr>
<tr>
<td>Zero Voltage</td>
<td>125 VDC</td>
<td>1003177G2</td>
</tr>
<tr>
<td>Zero Voltage</td>
<td>220 VAC</td>
<td>1003177G3</td>
</tr>
<tr>
<td>Conventional</td>
<td>48 VDC</td>
<td>1003365G2</td>
</tr>
<tr>
<td>Conventional</td>
<td>120 VAC</td>
<td>1003369G1</td>
</tr>
<tr>
<td>Conventional</td>
<td>125 VDC</td>
<td>1003278G1</td>
</tr>
<tr>
<td>Conventional</td>
<td>220 VAC</td>
<td>1003369G2</td>
</tr>
</tbody>
</table>
Electric Furnace Controls

Induction Furnace Resistor Insertion Switch Control

This control operates two 15 kV 600 A three pole switches in a resistor insertion switch arrangement for transient in-rush control. The control first closes one switch through 80 ohm resistor modules. One hundred milliseconds later the control closes a second switch bypassing the resistors.

Arc Furnaces 15 kV or 15 MVA and Less

This control is for arc furnaces that are operated by one 15 kV 600 A three pole switch. It is a stored energy control with a fast charging circuit to enable frequent operation of the furnace switch. The use of this control prevents problems caused by an inadequate current source to operate the control. A single solenoid operated switch requires 60 to 65 amperes peak for one and one half cycles to operate properly. If this current is not available, it will operate slowly and may have intermittent malfunctions and failures which are difficult to explain.

Schweitzer™ Relays Can Prevent Catastrophic Switch Failures on Small Arc Furnaces

Catastrophic switch failures are common on small arc furnaces as a result of a switch’s attempting to interrupt a current exceeding its interrupting rating of 4000 amperes. These failures happen because in an effort to save money a circuit breaker is not installed in series with the vacuum switch. Over current relays are then connected to the vacuum switch in the absence of the breaker. Since normal switch currents are less than 600 amperes, this arrangement works well most of the time because fault currents are usually less than the vacuum switch’s rating. But occasionally the rating is exceeded, and the result is catastrophic.

The number of failures of this type can be substantially reduced by installing a Schweitzer™ over current relay as part of the above control. The intelligence in the Schweitzer relay can recognize whether a fault current is within the capability of the switch. If the current is too large, the Schweitzer relay prevents the vacuum switch from opening and allows a fuse up stream from the vacuum switch to do the interruption. The prevention of a single switch failure will pay for having a Schweitzer™ relay.
Arc Furnaces 15 to 46 kV and Greater Than 15 MVA

The control to the right is for an arc furnace with 3000 amperes primary current at 15 kV or 1500 amperes at 34/46 kV. It can operate nine switches total or three per phase. It is a direct replacement for a Joslyn™ arc furnace control. The control shown is representative of a whole range of controls available which are capable of operating from three to eighteen switch mechanisms. The control is modular for easy diagnosis and repair.

This control can minimize transient in-rush current either with resistor insertion switches or synchronous closing with the alternating current sine wave.

The control is operated by an Allen Bradley™ MicroLogix™ 1100 PLC. The PLC has diagnostics built into its PLC program. The control can detect a switch mechanical malfunction and initiate an emergency trip so as to prevent single phasing of the furnace transformer. Single phase power on a furnace transformer is a frequent cause of exploding arrestors.

The control has a reset function which can reset the control following an intermittent switch malfunction. This feature enables a furnace to continue operating without down time while deferring the maintenance on switches to a convenient down day.

The MicroLogix™ PLC has an Ethernet connection for remote monitoring with a PanelView™ monitor. The PanelView™ monitor graphically displays individual switch open or closed status and maintains a date and time stamped log of switch malfunctions which resulted in the control being reset.

<table>
<thead>
<tr>
<th>Number of Switches Per Phase</th>
<th>Control Transformer</th>
<th>Control Voltage</th>
<th>Control Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5 KVA at 3.5% max impedance or 10 KVA at 7% max impedance</td>
<td>120 VAC</td>
<td>1001711G13</td>
</tr>
<tr>
<td>2</td>
<td>10 KVA at 3.5% max impedance or 20 KVA at 7% max impedance</td>
<td>120 VAC</td>
<td>1001712G13</td>
</tr>
<tr>
<td>3</td>
<td>15 KVA at 3.5% max impedance or 30 KVA at 7% max impedance</td>
<td>120 VAC</td>
<td>1001713G13</td>
</tr>
<tr>
<td>4</td>
<td>20 KVA at 3.5% max impedance</td>
<td>120 VAC</td>
<td>1001714G13</td>
</tr>
<tr>
<td>5</td>
<td>25 KVA at 3.5% max impedance</td>
<td>120 VAC</td>
<td>1001715G1</td>
</tr>
<tr>
<td>6</td>
<td>30 KVA at 3.5% max impedance</td>
<td>120 VAC</td>
<td>1001716G1</td>
</tr>
</tbody>
</table>
Controls for Arc Furnaces using VBU* Switches

The control to the right is a direct replacement for a Joslyn* VBU* control. VBU switches shown on page 10 can be used at primary voltages of 69 to 145 kV. They can also be used at 34 kV with 2000 and 3000 A modules. The control shown operates two VBU poles per phase, but it can be expanded to operating up to five VBU* poles per phase.

The control is modular in design for easy diagnosis and repair. A person who does not know all the details of the control can diagnose a problem by substitution. The control is connected to the VBU* switch by a cable with a connector on both ends to reduce wiring at installation. A adaptor kit is provided to install a receptacle on each VBU pole.

This control can minimize transient in-rush current either with a resistor insertion switch shown on page 12 or by synchronous closing.

The control operates on stored energy for both closing and opening. It is operated by an Allen Bradley™ MicroLogix™ 1100 PLC which has diagnostics built into its program. The control can detect a switch mechanical malfunction and initiate an emergency trip so as to prevent single phasing of the furnace transformer. Single phase power on a furnace transformer is a frequent cause of exploding arrestors.

The control has a reset function which can reset the control following an intermittent switch malfunction. This feature enables a furnace to continue operating without down time while deferring the maintenance on switches to a convenient down day.

The MicroLogix™ PLC has an Ethernet connection for remote monitoring with a PanelView™ monitor. The PanelView™ monitor graphically displays individual switch open or closed status and maintains a date and time stamped log of switch malfunctions which resulted in the control being reset.

<table>
<thead>
<tr>
<th>VBU Poles per Phase</th>
<th>Control Voltage</th>
<th>Control Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>120 VAC</td>
<td>1003223G3</td>
</tr>
<tr>
<td>2</td>
<td>120 VAC</td>
<td>1003223G1</td>
</tr>
<tr>
<td>3</td>
<td>125 VAC</td>
<td>1003223G5</td>
</tr>
</tbody>
</table>
Inspection, Testing, and Adjustment of Switches

1. Begin the inspection by recording the switch nameplate and module data. Make copies of the sample forms shown on pages 29 and 30 to aid in recording this data.
2. Close the switch and measure the resistance of all modules using a micro-ohm meter.
3. Open the switch and hi-pot each module using a 30 kV ac hi-pot and record the leakage current at 30 kV.
4. When doing work on switches, use the bolt torque values shown on page 28. Torque wrenches and tools for this purpose are contained in the tool kit shown on page 16.
5. Invert the switch, remove the switch cover, and place the switch in the closed position as shown in figure 1. Place a paper towel or rag in the space between the insulator and pull rod to prevent objects from accidentally falling into the module.
6. Measure and adjust the link angle as shown below. Note that the allowable link angles on switches with regular and double stack modules are different as shown on the inspection record sheets.

To Check the “Link Angle”

1. Start by using 1001104P1 (3 degree measuring tool) or the 1001104P2 (1 degree measuring tool) by placing it on the far end of the handle side of the support bar and against the linkage bar as shown in Figs. 3 & 4.
2. The minimal gap between the link and the tool indicates the angle of the link corresponds to the angle of the tool.

To Adjust the “Link Angle”

1. The link angle is controlled by the closing bumper which is one of two bumpers shown in figure 5.
2. Mark the position of the closing bumper and then open the switch.
3. Loosen the two 1/2 bolts that fasten the closing bumper and move it in a direction to increase or decrease the link angle as required.
4. Retighten 1/2” bolts, flip the switch back to the closed position and recheck the link angle.
5. Repeat steps 2-4 until the desired degree link angle is achieved.
To Check the “Full Travel”

1. Flip the switch into the closed position, and place the dial indicator gage near the far end by the bumper block as shown in figure 5.
2. Zero the dial, flip switch to the open position, and record the dial reading. A properly adjusted switch has full travel between 0.200” and 0.210” as shown in figure 8.

To Adjust the “Full Travel”

1. Move the switch to the closed position. Mark the position of the opening bumper.
2. Loosen and move the bumper to increase or decrease the full travel as required. Tighten the bolts.
3. Repeat steps 1 and 2 until the travel is within range.

0.185” is not in Range of Full Travel

To Check the Synchronism Between Vacuum Bottles

1. Hook any type of continuity device (light box, ohm meter, beeper box, or etc.) to the top (red lead) and bottom (black lead) terminal pad of each module.
2. Flip switch to the closed position and zero the dial indicator.
3. Place a 3/4” open end wrench on the center link, and pull the switch open while noting the dial indicator reading for each module at moment at which continuity is lost. It should be between .036 and .044 for a properly adjusted switch.

To Adjust Contact Synchronism

1. With the switch in the closed position loosen all pull rod bolts as shown in Figure 2.
2. Force the adjustment wedge (1001538P1) between the closing bumper block and housing until the dial indicator reads 0.040”+/-.004” as shown in figure 10.
3. Insert and tighten the pull rod bolts and then remove the wedge.
4. Measure and record the sync of each module the same as in step 3 above.
5. Repeat steps 1-4 until all modules loose continuity between .036 and .044” of travel.
Adjustments for Solenoid Operated Switches Only

To Check the Auxiliary Switch Travel

1. Place the switch in the closed position, zero the dial indicator, and clamp the operating handle to the handle cover with a c-clamp so that handle does not move.
2. Apply a 3/4" open-end wrench to the center link and open the switch by moving the wrench away from the solenoid.
3. Listen for a click sound indicating the Eaton auxiliary switch has changed state. It should change state before .175" of travel.
4. Record the dial indicator reading at the change of state.
5. Once the click is heard return the wrench to its starting position while listening for a click again. It should change state again before the travel decreases to .025".
6. Record the dial indicator reading at the second change of state.
7. The auxiliary switch must change state before 0.175" on opening and again before 0.025" on the closing.

To Adjust the "Auxiliary Switch Travel"

1. With the switch in the closed position mark a line on the support bar to indicate the position of the auxiliary switch mounting bracket.
2. Slightly loosen the two 1/4-20 bolts, move the bracket to the desired position, and retighten screws as shown in figure 12.
3. Check the auxiliary switch travel by repeating steps 2-5 above.
4. Repeat the readjustment until the auxiliary switch changes state be-

To Check and Adjust Solenoid "Pin Gap"

1. Place the switch in the closed position and measure pin gap for the opening solenoid by sliding thickness gages between the nylon and metal pins as shown in Figure 13.
2. Place the switch in the open position and similarly measure the pin gap for the closing solenoid.
3. The pin gaps must be between 0.060" and 0.090".
4. To adjust the gap remove solenoid assembly mounting bolts one at a time and add or removing shims (1000754P1) between the solenoid mounting plate and the zinc plated spacers. This gap controls switch speed. Larger and smaller gaps increase or decrease switch speed respectively.
Maintenance of Motor Operated Switches

Motor operated switches have the same modules, pull rods, and linkages as the solenoid operated switches. The link angle, full travel, and over travel adjustments are made in the same manner as for the solenoid operated switch. Motor operated switches are different from the solenoid operated switches in that the energy to open and close the switch is supplied by the motor operator mechanism. Relatively weak extension springs are installed between the toggle link and the control yoke instead of the heavy compression springs used with the solenoid operated switches.

The operation of the switch handle or the motor does not directly change the switch’s state from open to closed, but its action charges a spring which then is used to open or close the switch. Motor operator switches can operate on different voltages which are determined by what relay panel is installed in the switch along with which field jumpers are installed. The relay panels and required jumpers are shown on pages 36, 37, & 38.

The four major assemblies which distinguish the motor from the solenoid operated switch are:

1. **Motor Mechanism**—this mechanism consists of links, levers, shafts, and springs all held together by two side plates. This whole mechanism is somewhat like a clock mechanism and is difficult to disassemble and reassemble. Purchasing a remanufactured motor mechanism assembly is an easier alternative to disassembling and reassembling a motor mechanism. The part number of the motor mechanism without the motor assembly is 1002673G1.

2. **Motor Assembly**—removal and replacement of the motor assembly is comparably easy. The motor assembly consists of a universal 48 Vdc electric motor, worm gear, speed reducing worm wheel, and cams to drive the ratcheting clutches in the motor mechanisms. Occasionally 24 vdc motors are used in place of the 48 vdc motor. Frequent failures which occur are the worm wheel and shaft bearing journals. The Vacuum Electric Switch Co. has redesigned the motor assembly by changing materials and adding lubrication as shown on page 41. The part number of the motor assembly is 1002399G1.

3. **Relay Panel**—the relay panel is mounted on the side of the motor mechanism, and it determines the operating voltage of the switch. Having the wrong relay panel installed or the wrong jumpers selected for the applied control voltage is a common cause of resistor burn out and motor failure. Many different relay panels exist, and the three most common are shown on pages 36, 37, & 38. Relay panels can be easily changed.

4. **Wiring harness**—wiring harnesses are available with 15 or 35 pin connectors. The connector with more pins offers more auxiliary contacts for customer connections. These are moderately difficult to replace because of the large number of wires.

5. **Auxiliary switches**—several different types of auxiliary switches have been used with Joslyn* motor operated switches. Two of them are shown on page 43 along with the Vacuum Electric Switch designed Allen Bradley™ contact block replacement. The Allen Bradley™ contacts are easily replaceable. Anyone contemplating replacing an auxiliary switch should call to discuss their switch’s compatibility with the Allen Bradley™ contact block replacement.
Instructions for Motor Operated Switches Only

To Check the Motor Mechanism

1. Position the min cams on the motor assembly to a vertical position. Measure the large springs to verify they are 3” to 3.125' long.
2. Crank the handle of the switch 20-35 times until the switch flips to the closed position. Then slap the handle to trip the switch into the open position. If the switch cannot be changed to the open or closed state, the mechanism needs adjustment.

To Adjust the Motor Mechanism

1. Start with the switch in the open position, and unscrew the 1/4-20 trip screw (1002415) until it is retracted into the middle linkage (1002031P1) and screw in the 3/8-16 stop bolts (1000480) until the heads are touching the side plate ears as shown in figure 15.
2. Crank the handle 20-35 times until the switch closes, advance the stop bolts until they are 0.010” to 0.020” from the shaft, and then tighten the jam nut to hold in place.
3. Screw in the trip screw until the switch opens, then back it off 1 to 1-1/2 turns, and tighten the jam nut to hold it in place.
4. Repeat steps 1-3 until the switch can be operated by the handle alone. Finally apply a small amount of thread locker on both the trip screw and stop bolts.

To Check the Allen Bradley™ Contact Blocks

1. With the switch in the open position, use a continuity device to determine aux switch state. Flip the switch to the closed position and determine that the aux switches have changed state.
2. If contacts do not change state, adjust mounting bracket to correct.

To Adjust the Allen Bradley™ Contacts

1. With the switch in the open position, draw a line on the support bar as shown in figure 16.
2. Slightly loosen the mounting bolts and adjust aux switch.
3. Recheck with the continuity device.
4. Repeat steps 1-3 until all aux contacts fully open and close when the switch changes state.
Fastener Torque Requirements

NOTE:
VARYING IN (PLACES) DEPENDS ON HOW MANY STACKS, COVER MOUNTING HOLES, OR NUMBER OF CONTACT BLOCKS

SECTION A-A

© The Vacuum Electric Switch Co. 2014
<table>
<thead>
<tr>
<th>Name Plate Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBT™ Serial Number</td>
</tr>
<tr>
<td>Cat. No.</td>
</tr>
<tr>
<td>Continuous Current Rating (AMPS)</td>
</tr>
<tr>
<td>KV Rating</td>
</tr>
<tr>
<td>G.O. No.</td>
</tr>
<tr>
<td>Terminal-to-terminal BIL (KV)</td>
</tr>
<tr>
<td>Terminal-to-ground BIL (KV)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Recorded Switch Data</th>
<th>Module Data</th>
<th>Left</th>
<th>Center</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module Serial No.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum Interrupter Serial No.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sync – normal .040” ± .004</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance micro ohms - normal less than 200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hi-pot - current normal 1 ma or less at 30 KV Reject at greater than 2 ma</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanism Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500 vac control wiring test</td>
</tr>
<tr>
<td>Link angle – normal is 1 to 3 deg. toward opening</td>
</tr>
<tr>
<td>Full travel – normal .200” to .210”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Switch Counter reading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Auxiliary Switch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

| Pin gap adjustment of nylon pins for open and close coils – normal is 0.060” to 0.090” |  |

<table>
<thead>
<tr>
<th>Solenoid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motor Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

| Number of handle cranks to closing 20 to 35 times is normal |  |
| Slap handle once to open switch ok or reject |  |
| Time for motor to run to close 3 sec for ac, 5 sec for dc control voltages |  |
| Electrical trip ok or reject |  |
## Name Plate Data

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBT™ Serial Number</td>
</tr>
<tr>
<td>Cat. No.</td>
</tr>
<tr>
<td>Continuous Current Rating (AMPS)</td>
</tr>
<tr>
<td>KV Rating</td>
</tr>
<tr>
<td>G.O. No.</td>
</tr>
<tr>
<td>Terminal-to-terminal BIL (KV)</td>
</tr>
<tr>
<td>Terminal-to-ground BIL (KV)</td>
</tr>
</tbody>
</table>

## Recorded Switch Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Left</th>
<th>Center</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double stack modules</td>
<td>upper</td>
<td>lower</td>
<td>upper</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>lower</td>
<td></td>
<td>lower</td>
</tr>
<tr>
<td>Module Serial No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum Interrupter Serial No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance micro ohms - normal less than</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hi-pot - normal 1 ma or less at 30 KV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reject at greater than 2 ma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sync – normal .040” ± .004</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Mechanism Data

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1500 vac control wiring test</td>
<td></td>
</tr>
<tr>
<td>Full travel – normal .200” to .210”</td>
<td></td>
</tr>
<tr>
<td>Link angle – normal is 1 deg. toward open-</td>
<td></td>
</tr>
<tr>
<td>Switch Counter reading</td>
<td></td>
</tr>
</tbody>
</table>

## Auxiliary Switch

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aux. switch adjustment - operate before .175” of mechanism travel on opening and before .025” on closing</td>
<td></td>
</tr>
<tr>
<td>Form A (no) contacts continuity 1, 2, or 6</td>
<td></td>
</tr>
<tr>
<td>Form B (nc) contacts continuity 1, 2, or 6</td>
<td></td>
</tr>
</tbody>
</table>

## Solenoid Data

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin gap adjustment of nylon pins for open and close coils – normal is 0.060” to 0.090”</td>
<td></td>
</tr>
</tbody>
</table>

## Motor Operator Data

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of handle cranks to closing 20 to 35 times is normal</td>
<td></td>
</tr>
<tr>
<td>Slap handle once to open switch ok or reject</td>
<td></td>
</tr>
<tr>
<td>Determine motor operator control voltage by inspecting relay panel</td>
<td></td>
</tr>
<tr>
<td>Motor run time to close 3 sec for ac, 5 sec for dc control voltages</td>
<td></td>
</tr>
<tr>
<td>Electrical trip ok or reject</td>
<td></td>
</tr>
</tbody>
</table>
## Failure Diagnostic Charts

### Capacitor Banks In General

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Possible Causes</th>
<th>Possible Corrective Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blown capacitor fuse or capacitor can rupture with repeated occurrences.</td>
<td>Switch restrike following switching caused by leaking vacuum interrupter, excessive inrush current on closing, or parasitic capacitance reducing recovery withstand voltage of switch. For switches with mechanically separate mechanisms, the contacts in all three phases may not be closing or opening at the same time.</td>
<td>Even if vacuum interrupters pass hi-pot test replace them with vacuum interrupters with known leak tightness. Install reactors to limit in-rush current because high inrush currents can increase restrike probability. Remove physical objects close to the vacuum interrupter modules or install vacuum interrupters with grading capacitors. Install a stored energy control to assure that all switches close at the same time.</td>
</tr>
</tbody>
</table>

### ARC Furnaces In General

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Possible Cause</th>
<th>Corrective Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploding phase-to-ground arrestor</td>
<td>An exploding phase-to-ground arrestor is caused by applying single or two phase power to a transformer which has transient suppression capacitors connected to the transformer bushings resulting in ferroresonance.</td>
<td>The solution to this problem is to install a new control which will prevent single or two phase power from being applied to the transformer</td>
</tr>
<tr>
<td>Exploding phase-to-ground arrestors</td>
<td>When the furnace switches are connected to the transformer by long cables, applying power to only one or two phases can cause and over voltages by ferroresonance</td>
<td>The solution to this problem is to install a new control which will prevent single or two phase power from being applied to the transformer</td>
</tr>
<tr>
<td>Counts on the phase-to-ground arrestor discharge counters</td>
<td>Counts on the phase-to-ground arrestors is caused by ferroresonance resulting from brief periods of loss of power to one or two phases on a transformer with transient suppression capacitors connected to the transformer bushings.</td>
<td>The solution to this problem is to install a new control which will prevent single to two phase power from being applied to the transformer</td>
</tr>
<tr>
<td>Counts on phase-to-phase arrestors.</td>
<td>On a transformer with transient suppression capacitors a transient discharge is occurring through a power factor correction capacitor bank in the local substation</td>
<td>Install a damping resistor in series with the transient suppression capacitor to make the capacitor discharge overdamped.</td>
</tr>
<tr>
<td>Catastrophic module explosion in two phases with no prior indication of module failure.</td>
<td>Exceeding switch’s 4000 ampere interrupting rating as a result of having over current relays or emergency stop button connected to the Joslyn switches</td>
<td>Connect over current relays &amp; emergency button to back up breaker. Alternatively on small furnaces install a control with a Schweitzer over current relay to prevent opening the switch at excessive current.</td>
</tr>
<tr>
<td>Catastrophic module explosion in two phases without prior indication of module failure.</td>
<td>Failure to detect vacuum loss failure in one phase before a vacuum loss occurred in a second phase.</td>
<td>Hi-pot test vacuum interrupters every three months.</td>
</tr>
</tbody>
</table>
## Vacuum Switch Failures in General

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Possible Causes</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi-pot failure of vacuum interrupter</td>
<td>Air leak into the vacuum interrupter</td>
<td>Replace Joslyn™ module with a Module having a Mitsubishi™ vacuum interrupter. VES modules are warranted to 60,000 operations and have a recommended useable life of 250,000 operations.</td>
</tr>
<tr>
<td>High resistance failure of Joslyn™ vacuum interrupter</td>
<td>Relaxation of mechanical electrical connections inside the module</td>
<td>VES modules are built with Belleville spring washers on all mechanical electrical connections to keep resistance low by maintaining the bolt tension.</td>
</tr>
<tr>
<td>Welding together of vacuum interrupter contact buttons</td>
<td>Excessive wear resulting in improper over travel setting on vacuum interrupter module so as to result in excessive contact resistance or contacts barely touching on closing.</td>
<td>Disassemble switch and replace bearings every 100,000 switch operations. Replace Joslyn™ pull rods, and pull rod screws with VES equivalent replacement parts. Prevent pull rod slippage by using grade 8 fasteners, flat washer, lock washers, and thread locker to clamp pull rod clevis securely. The VES parts reduce wear by replacing aluminum material with stainless steel.</td>
</tr>
</tbody>
</table>

## Solenoid Operated Switches in General

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Possible Causes</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blowing fuses in the control</td>
<td>Link angle adjustment is out of spec due to bumper assembly wear</td>
<td>Replace Joslyn bumper assemblies with VES bumper assemblies made with more wear resistant urethane bumpers</td>
</tr>
<tr>
<td>Blowing fuses in the control</td>
<td>Supply transformer is too small</td>
<td>A 5 kVA 3.5% max impedance transformer is required for each 3 phase set of switches. The transformer must be installed next to the control.</td>
</tr>
<tr>
<td>Fracture in pull rod clevis</td>
<td>A cyclic fatigue failure at the clevis corners</td>
<td>Replace pull rod with VES pull rod having structural support to prevent flexing at clevis corners</td>
</tr>
<tr>
<td>Thread pull out in pull rod plug</td>
<td>The aluminum material has poor wear characteristics</td>
<td>Replace pull rod with VES pull rod having stainless threaded plugs</td>
</tr>
<tr>
<td>Control yoke fracture at point of yoke bumper stop contact</td>
<td>Cyclic fatigue due to yoke bumper stop impact on control yoke</td>
<td>Replace Joslyn yoke bumper stops with VES all rubber bumper stops</td>
</tr>
<tr>
<td>Control yoke fracture next to nylon pin contact pad</td>
<td>Cyclic fatigue fracture due to nylon pin impact</td>
<td>In the field replace control yoke every 100,000 operations. In the shop change handle shaft from 1/2 to 3/4 inch dia.</td>
</tr>
<tr>
<td>DECCO solenoid coil failure</td>
<td>Shorted turns in coil</td>
<td>Replace coils with vacuum impregnated coils</td>
</tr>
<tr>
<td>Mushrooming of nylon pin ends</td>
<td>Control malfunctioning due to excessive voltage drop in electrical supply to control or excessively high voltage being supplied to the control.</td>
<td>Correct the supply voltage to the control or increase KVA rating of supply transformer and wire size from transformer to control.</td>
</tr>
<tr>
<td>Failure Mode</td>
<td>Possible Cause</td>
<td>Corrective Action</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>----------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fractured and bent nylon pins</td>
<td>Wear in the solenoid has decreased the air gap so that the solenoid sticks due to residual magnetism</td>
<td>Replace solenoid with new solenoid assembly having a .030” air gap</td>
</tr>
<tr>
<td>Spring assembly or spring retaining clevis pin failure</td>
<td>Lack of lubrication</td>
<td>Install felt lubricating washers and lubricate</td>
</tr>
<tr>
<td>Spring assembly or spring retaining clevis pin failure</td>
<td>Lack of lubrication</td>
<td>Install felt lubricating washers and lubricate</td>
</tr>
<tr>
<td>Toggle link bearing journal wear</td>
<td>No lubrication on bearing journal</td>
<td>Replace toggle link with link having an oil impregnated sintered bronze bearing</td>
</tr>
<tr>
<td>DECCO™ fractured solenoid side plate</td>
<td>Cyclic fatigue of side plate</td>
<td>Replace side plates with stress relieved side plates.</td>
</tr>
<tr>
<td>DECCO™ sticking solenoid armatures</td>
<td>Loss of air gap resulting in residual magnetism causing sticking</td>
<td>Replace armature with new armature having a .030” air gap</td>
</tr>
<tr>
<td>Namco™ solenoid binding of armature</td>
<td>Galling of stainless solenoid armature bearing plates</td>
<td>Replace stainless steel bearing plates with bronze bearing plates</td>
</tr>
<tr>
<td>Solenoid mounting bolts vibrating loose</td>
<td>Failure to maintain bolt tension in mounting bolts</td>
<td>Install Screwlock™ Helicals™ in aluminum mechanism casting</td>
</tr>
<tr>
<td>Auxiliary switch failure</td>
<td>Eaton™ Aux switch failure</td>
<td>Replace Eaton™ switch every 250,000 operations</td>
</tr>
<tr>
<td>Square D™ aux switch fracture</td>
<td>Wear in bumper assembly caused the switch adjustment to change resulting in impact forces on the plastic housing</td>
<td>Replace bumper assembly with VES bumper assembly having a urethane rubber bumper. Replace Square D™ switch with Eaton™ switch</td>
</tr>
<tr>
<td>Spring pin failure in handle or control yoke</td>
<td>Excessive impact forces on spring pins</td>
<td>Replace Joslyn™ handle with VES low inertia handle</td>
</tr>
<tr>
<td>Switches trip open immediately on closing</td>
<td>The emergency trip capacitors are tripping the switches open because one switch is slower than the others.</td>
<td>This problem can be diagnosed by disconnecting the emergency trip capacitors to prevent the emergency trip on closing. Then close the switches electrically and observe which switch is not properly closing. Then install new bumpers assemblies and readjust link angle, full travel, and overtravel.</td>
</tr>
</tbody>
</table>
## Motor Operated Switch Failures in General

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Possible Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor runs but switch does not close</td>
<td>Fiber worm wheel gear or bearing journals at the end of worm wheel shaft are worn out</td>
<td>Replace motor assembly with a new motor assembly having a brass worm wheel and bronze journals for the worm wheel shaft that are lubricated with felt lubricating washers.</td>
</tr>
<tr>
<td>Motor operated switch takes too long to charge springs</td>
<td>Ratcheting cams are slipping in aluminum boomerang journals. The ratcheting cams are mounted in too soft aluminum boomerang material.</td>
<td>Replace the aluminum boomerangs with boomerangs made from stainless steel. Alternatively replace the entire motor assembly.</td>
</tr>
<tr>
<td>Motor operator switch trips immediately on closing.</td>
<td>The trip mechanism is out of adjustment possibly because the trip link is worn because it is made from soft aluminum.</td>
<td>Replace trip link with a trip link made from steel and readjust switch.</td>
</tr>
<tr>
<td>Spring bolt fractured</td>
<td>Bending stress in the bolt is concentrated at the locking nuts</td>
<td>Replace bolt assembly with a new bolt assembly having an eye bolt to attach the spring to the switch mechanism. These parts remove the stress concentration.</td>
</tr>
<tr>
<td>Motor armature fails in approximately 100 operations</td>
<td>The wrong voltage is applied or the wrong relay panel is installed, or the wrong jumpers are installed.</td>
<td>Determine the voltage to be applied and then select the correct relay panel, and jumpers.</td>
</tr>
<tr>
<td>Spring tab on motor operator sideplate fractured</td>
<td>Cyclic fatigue failure of fillet weld</td>
<td>Replace both side plates with new side plates having brazed rather than fillet welded tabs.</td>
</tr>
<tr>
<td>Motor does not want to start after a long period of being idle</td>
<td>Corrosion on its armature bars interferes with the flow of current though the armature</td>
<td>Spray contact cleaner on armature bars to get motor started. Install adhesive mounted heater on motor to prevent corrosion on armature bars.</td>
</tr>
<tr>
<td>Square D™ auxiliary switches crack and fail</td>
<td>Caused by excessive wear in the bumper assembly</td>
<td>Replace both bumper assemblies with bumpers having more wear resistant urethane bumper. Replace Square D™ auxiliary switches. Alternatively replace Square D™ auxiliary switches with the Allen-Bradley™ auxiliary switch shown on page 43.</td>
</tr>
</tbody>
</table>
This schematic is of the wiring harness in solenoid operated switches. The photograph to the left is of the Eaton™ switch depicted in this schematic. Over a fifty year time interval the Eaton switch is one of several different auxiliary switches which were used. The Vacuum Electric Switch Co. manufacturers replacement a wiring harnesses using the Eaton™ switch.
A motor operated switch having the relay panel shown to the left operates on 48 Vdc or 120 Vac. The relay panel can be identified by its two resistors, one fixed and the other adjustable. The above schematic shows both the customer and internal switch wiring for operating the switch on 48 Vdc. Two field installed jumpers are required as shown in the schematic.
A motor operated switch having the relay panel shown to the left can be operated on 48 vdc or 120 Vac. The relay panel can be identified by its two resistors, one fixed and the other variable. The above schematic shows both the customer and internal switch wiring for operating the switch on 120 Vac. One field installed jumper is required as shown in the schematic.
A motor operated switch having the relay panel shown to the left is operated on 125 Vdc. The relay panel can be identified by its three resistors. The third resistor is visible behind the other two. The above schematic shows both the customer and internal switch wiring to operate the switch on 125 Vdc. Two jumpers installed in the field are required as shown in the schematic.
Joslyn™* Switch Cable Color Codes

Fifteen Pin Connector Cable Color Codes

Thirty-Five Pin Connector Cable Color Codes

The thirty-five pin connector is only used with motor operated switches. The color code and function of the first fifteen conductors in the thirty-five pin connector are identical to the colors and functions of the conductors of the fifteen pin cable. The cable cost for the thirty-five conductor cable is about six times as expensive as the fifteen conductor cable. Where only the first fifteen conductors are being used, money can be saved by ordering a thirty-five pin connector with the fifteen conductor cable attached.
Switch Module Improvements

Fracture Resistant Modules

The picture to the left shows a crack in a module housing caused by over tightening a module mounting bolt. This crack can progress into a fracture as shown in the next picture. A module with a fractured flange is insecurely mounted and could cause a failure. The picture to the left shows how fracture resistance is improved by contouring the module housing around the bolt hole.

Mitsubishi™ Vacuum Interrupter

The Vacuum Electric Switch Co. uses Mitsubishi™ vacuum interrupters to build its vacuum interrupter modules. Mitsubishi’s™ vacuum interrupter failure rate is less than three vacuum interrupters per 100,000 vacuum interrupters per 100,000 hours of operation.
Motor Operator Reliability Improvements

Motor Assembly

Two common reasons for motor assembly failure are loss of gear teeth on the worm wheel and wear in the bearing journals in the side plates.

First, the worm wheel gear has been changed to a continuously lubricated bronze gear. An oil saturated felt washer shown in the picture continuously supplies lubrication to the worm and the wheel.

Second, bearing journal wear where the worm wheel’s shaft rides on the side plate has been reduced both by choosing a more wear resistant material combination and also adding an oil infused felt washer between the cam and side plate. The shaft is now bronze running a steel journal in the side plate.

These design changes eliminate switch failure requiring motor assembly replacement.

Ratcheting Cams

When a motor operated switch operates slowly both mechanically and electrically, one of the ratcheting cams has failed.

Fixing this problem is time consuming and difficult because disassembling the motor mechanism is like disassembling a clock. A better solution is to purchase a new motor mechanism assembly.

When this failure occurs, cams do not grip the shaft. Energy cannot be stored in the springs and the switch will not operate. This failure occurs because of one or two causes.

First, the cam bearings are not gripping the shaft because the cam bearings are mounted in soft aluminum journals. The soft material cannot maintain dimensional tolerances the cams require to properly operate. This failure is prevented by changing the material from aluminum to stainless steel.

Second, the journal is in a boss which is welded to the ratcheting cam. When a weld fails, the cam will not work. When the ratcheting cams are made from stainless steel, the boss is keyed to the ratcheting cam and braised together.
Bolt Failure

The spring shown to the left is used to store energy for the motor operator mechanism. Bolts are used to fasten the energy storage springs to the motor mechanism. Cyclic fatigue can cause the bolt holding the spring to fail between the shaft and the jam nut. This failure can result in the bolt and the spring becoming dangerous projectiles. This failure is prevented by redesigning the parts holding spring as a rod end as shown to the left. The rod end has a larger diameter than the bolt formerly used and increases its ability to resist the bending force created by the spring. Fatigue failures are then prevented.

Spring Tab Failure

The picture to the left shows highlighted in red the ears and boss attached to the motor mechanism side plate. The welds holding the red highlighted parts can fail in fatigue. The pictures below show the difference between using a fillet weld and a keyed and brazed connection. The fillet weld can fail in cyclic fatigue, but the keyed parts are strong enough for this application even without the brazing. The brazing secures the tabs but is not required for structural integrity.

A second design change was to add a groove to the tab to provide a seat for locating the spring. When the energy is release during the tripping of the switch, the spring decompresses and bounces. This bounce causes the spring to unseat itself and become loose. The groove holds the spring in place and reduces bending forces on the rod end and side plate ears.
Motor Operator Trip Free Failure

The above picture shows the trip link and the trip adjustment screw in the motor mechanism assembly. The trip link to the above left is made from aluminum and the screw from steel. The trip adjustment screw can wear an indentation into the trip link causing the motor mechanism to go out of adjustment and not operate properly. Correcting this problem requires the switch to be opened and readjusted.

The Vacuum Electric Switch Co. offers as a replacement part the link shown to the right. It has the same weight and is functionally as the link to the left, but it is made of steel. The steel screw on a steel link provides a much better wear combination and eliminates the need for frequent readjustment.

Motor Operator Contact Blocks

The motor operator contact blocks have had many previous versions two of which are pictured to the left. The upper picture was the original design which performed well. It is no longer manufactured and replacement parts are difficult to find. The lower left picture shows a recent contact block made from Square D™ contact assemblies. The Square D™ contact assemblies frequently failed by cracking in the plastic housing.

The picture to the lower right is Vacuum Electric Switch Co’s new contact block which has the foot print and functionally of the original block shown in the picture to the upper left. This new block uses Allen Bradley™ contacts, housing, and yoke. An additional advantage of this contact blocks is the ability to individually remove and replace bad contacts without having to replace the entire block or to readjust the positioning of the block.
Vacuum Breaker Up-right Switch Parts

Remanufactured VBU* module VES part No. 1000212G1 showing how a Mitsubishi™ vacuum interrupter is installed in the module.

The VBU* mechanism above VES part No. 1001466G1 has been reverse engineered and remanufactured to be like the original Joslyn mechanism design. The adjustment cams have been reincorporated the same as in the original design. The cam can be seen in the above picture. The Square D™ contact blocks shown to the upper far left have been replaced with Allen-Bradley™ contactors as shown in the center above. They are mounted on the side of the VBU* mechanism as shown to the above right.

When VBU* switches are used on arc furnaces, the causes of down time can be categorized as being attributed to modules, operating mechanisms, and controls. Design changes in remanufactured modules have eliminated almost all routine failures in modules. Design changes in the reverse engineered mechanism above have enabled that mechanism to exceed 100,000 operations in life testing. The control problems have been addressed by the control shown on page 22. Diagnostics are part of this control’s program. This control is an adaptation of the control on page 21 for which there are more twenty installations.
Switch Replacement Parts

15 kV  600 Ampere Three Pole Vacuum Switch

34 or 46 kV  600 Ampere Single Pole Vacuum Switch
46 kV 300 Ampere Single Pole Vacuum Switch
69 kV 300 Ampere Single Pole Vacuum Switch
34 kV 300 Ampere 3 Pole
Vacuum Switch
Housings and Solenoids

Mechanism for 15 or 34 kV Single Pole and 46 or 69 kV switch with DECCO™ Solenoids

Exploded DECCO™ Solenoid and Associated Installation Parts
Mechanism for 15 kV, 34 kV Single Pole and 46 or 69 kV switches with NAMCO™ Solenoids

Exploded NAMCO™ Solenoid and Associated Installation Parts
Cross Sections Details from Views on Pages 49 & 50

Section A-A

Section B-B

Only for switches with no center pole.

Section C-C

Section E-E

Sections D-D & F-F

Bumper Assembly Section G-G
Counters and Position Indicators

The three different types of counters which have been used in manufacturing the VBM™ switch include a counter attached to the manual operating handle cover, the internal five digit counter, and the externally visible six digit counter. The five and six digit counters are shown above. The handle cover counter is not available.

Five-Digit to Six-Digit Position Indicator Counter Conversion

During switch overhauls at the Vacuum Electric Switch Co.™ old switches without externally visible counters are modified to use the new externally visible six digit counter with a position indicator. This upgrade makes it easier to track switch operations for purposes of scheduling maintenance. The modification can only be done in the shop because it requires welding in a boss and re-machining the switch mechanism casting. The window for the new counter and position indicator is sometimes located where the existing name plate is located. In this instance the Vacuum Electric Switch Co.™ also replaces the old name plate with a new name plate having the old serial number.
Mechanism for 34 kV 3 Pole Switch with DECCO™ Solenoids

Linkage Assemblies for a 34 kV 3 Pole Switch with Removed Parts Shown in Phantom
Mechanism Housing for 15 or 34 kV 3 Pole Motor Operator Switches

Section H-H

Section J-J

Section L-L

Section K-K

Section M-M
Motor Operator Rear Mounting Bracket Assembly

Motor Operator Standard Motor Assembly
Motor Operator Left Side Motor Plate Assembly
Motor Operator Right Side Motor Plate Assembly
Toggle Link Components in ..........................

Clutch Arm Cam Assembly ..........................
.......................... Motor Mechanism Assembly

.............................. in Motor Mechanism Assembly
Replacement Parts for Joslyn™ Controls

The two Joslyn™ circuit boards shown above are used by Joslyn™ in both their zero-voltage control for capacitor banks and also their Point-of-Wave™ controls for arc furnaces. Shown opposite the Joslyn™ boards are the Vacuum Electric Switch foot-print and plug-for-plug compatible replacement boards. The SCR boards are functionally equivalent except that the VES board part No. 1002100G1 has transient suppression components on the board whereas the Joslyn™ board requires that they be installed at the terminal connections during the board installation.

The timing boards while functionally equivalent are designed using different concepts. The Joslyn™ timing board has analog circuitry to control the timing. The timing adjustments are made by turning three trip potentiometers on the board. The Vacuum Electric Switch timing board has digital circuitry. The timing is controlled with crystal oscillator, and the switch timing can be digitally set in increments of 25 microseconds. The VES digital board has an RS232 connection which can be connected to a computer used to measure and set switch timing.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>VES part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 vac</td>
<td>1002121G1</td>
</tr>
<tr>
<td>125 vdc</td>
<td>1002121G2</td>
</tr>
<tr>
<td>24 vdc</td>
<td>1002121G4</td>
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</tbody>
</table>
## Replacement Parts List

### Delivery Color Code
- **Red**: Orders received before 12:00 PM EST will ship the same day.
- **Green**: Ship date three business days after receipt of order.
- **Blue**: Ship date ten business days after receipt of order.
- **Black**: Ship date determined at order placement.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Joslyn™ Part No.</th>
<th>Remanufactured VES™ Part No.</th>
<th>New VES™ Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mechanism Assembly 15 KV</td>
<td>3021X0242 P001</td>
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<tr>
<td>2A</td>
<td>Fracture resistant vacuum interrupter module 15 KV 600 amp without pull rod</td>
<td>3021X0242 P003</td>
<td>1001959G1</td>
<td>1000674G1</td>
</tr>
<tr>
<td>2B</td>
<td>Fracture resistant vacuum interrupter module 34 KV 600 amp without pull rod</td>
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<td>1000674G1</td>
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<td>2D</td>
<td>Double stack module silicone rubber sheds 300 amp</td>
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</tr>
<tr>
<td>2E</td>
<td>Single module with silicone rubber sheds 300 amp</td>
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<tr>
<td>3</td>
<td>Bolt, hex head 1/4-20 X 2-1/2&quot; SST</td>
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<td>Bolt, hex head 1/4-20 X 1&quot; SST</td>
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<td>1001225</td>
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<td>Bolt, hex head 1/4-20 X 1-1/2&quot; SST</td>
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<tr>
<td>4</td>
<td>Belleville washer SST</td>
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<tr>
<td>5</td>
<td>Washer, flat 9/32 ID X 5/8&quot; OD X 1/16&quot; alum.</td>
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<tr>
<td>6</td>
<td>Gasket obsolete</td>
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<td>7</td>
<td>Nut, hex 1/4-20 SST</td>
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<tr>
<td>8</td>
<td>Insulator 15 KV skirted</td>
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<td>1000062</td>
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<td>9</td>
<td>Bolt hex head 1/4-20 X1-1/4&quot; SST</td>
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<td>Bolt, hex head 1/4-20 X 1&quot; long Gr. 8</td>
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<td>11</td>
<td>Lock washer split 1/4&quot; standard Gr. 5 &amp; 8</td>
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<td>11A</td>
<td>1/4&quot; SAE flat washer</td>
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<td>Nut, hex 1/4-20 standard Gr. 8</td>
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<td>14A</td>
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<td>Mechanism cover 10 hole</td>
<td>3021X0242 P021</td>
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<td>1000568P1</td>
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<td>15A</td>
<td>Mechanism cover 12 hole</td>
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<td>1001809P1</td>
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<tr>
<td>16</td>
<td>Screw, Fillister head, 1/4-20 X 1&quot; long</td>
<td>3021X0242 P022</td>
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<td>Lock washer split 1/4&quot; SST standard</td>
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<td>18</td>
<td>Screw, indented hex head 6-32 X 3/8&quot; L SST</td>
<td>3021X0242 P024</td>
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<tr>
<td>19</td>
<td>Drierite™ desiccant 2 oz calcium sulfate in sealed bag</td>
<td>3021X0242 P025</td>
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<td>20</td>
<td>Bolt, hex head, 3/8-16 X 1&quot; L</td>
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<td>21</td>
<td>Lockwasher, split. 3/8&quot; standard</td>
<td>3021X0242 P027</td>
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<td>22</td>
<td>Closure plate</td>
<td>3021X0242 P101</td>
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<td>1001996P1</td>
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<td>Item No.</td>
<td>Description</td>
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<td>Remanufactured VES™ Part No.</td>
<td>New VES™ Part No.</td>
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<tr>
<td>23</td>
<td>Clamping plate 1/4-20 tapped hole (use with parts 10A &amp; 23 11)</td>
<td>3021X0242 P102</td>
<td>1000644P1</td>
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<td>23A</td>
<td>Clamping plate 3/8-16 tapped hole (use with parts 20 &amp; 21)</td>
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<td>24</td>
<td>Breather bag</td>
<td>3021X0242 P103</td>
<td>1000114P1</td>
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<tr>
<td>24A</td>
<td>Sheetmetal shroud covers breather bag</td>
<td>3021D0113P2</td>
<td>1000580P1</td>
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<tr>
<td>24B</td>
<td>Schrader valve</td>
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<td>1000534</td>
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<tr>
<td>24C</td>
<td>Screw, pan Hd 1/4-20 x 5/8” plastic, Blk.</td>
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<tr>
<td>24D</td>
<td>Bolt, hex Hd. 1/4-20” x 1/2” SST</td>
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<td>1001823</td>
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<td>24E</td>
<td>Flat washer 1/4&quot; ID 1/2&quot; OD SST</td>
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<td>25</td>
<td>Screw, slotted head, 10-32 X 3/8”L SST</td>
<td>3021X0242 P104</td>
<td>1000507</td>
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<tr>
<td>26</td>
<td>Handle cover with three screw holes</td>
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<td>1000578P2</td>
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<tr>
<td>26A</td>
<td>Handle cover with two screw holes</td>
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<td>1000578P3</td>
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<tr>
<td>26B</td>
<td>5 digit counter for handle cover</td>
<td>1000925</td>
<td>1000926</td>
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<tr>
<td>27</td>
<td>Mechanism assembly 34 &amp; 46 KV</td>
<td>3021X0242 P106</td>
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<tr>
<td>28</td>
<td>Bolt, hex head, 1/2-13 X 1-1/4” L SST</td>
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<td>29</td>
<td>Belleville washer 1/2” SST</td>
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<td>1000055</td>
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<td>30</td>
<td>Nut, Hex 1/2-13 standard, SST</td>
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<tr>
<td>30A</td>
<td>1/2” SST thick flat washer</td>
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<tr>
<td>30B</td>
<td>Noalox™ 8 oz</td>
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<tr>
<td>30C</td>
<td>Connecting bar for 34 kV harmonic filter switch</td>
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<td>1000544P1</td>
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<tr>
<td>30D</td>
<td>Connecting bar for 46 kV double stack switch</td>
<td>3021X0242 P106</td>
<td>1000544P1</td>
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<tr>
<td>31</td>
<td>Connecting buss bar for 34, 46 &amp; 69 kV 600 A switches</td>
<td>3021X0242 P110</td>
<td>1000508P2</td>
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<tr>
<td>32</td>
<td>3-1/2 ID x 3-3/4”ODx1/8” Dash 238 O-ring</td>
<td>3021X0242 P111</td>
<td>1000638</td>
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<tr>
<td>33</td>
<td>Insulator, 34 KV skirted</td>
<td>3021X0242 P112</td>
<td>1000666 W</td>
<td>1000661</td>
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<tr>
<td>33A</td>
<td>Insulator, 46 KV skirted</td>
<td>3021X0242 P113</td>
<td>1000667 W</td>
<td>10001940</td>
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<td>34</td>
<td>Bolt, hex head 1/4-20 X 1-3/4” LG. SST.</td>
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<td>1000684</td>
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<tr>
<td>35</td>
<td>Gasket, Teflon</td>
<td>3021X0242 P115</td>
<td>1000121P1</td>
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<tr>
<td>36</td>
<td>Mechanism housing for 15 kV or 34 kV 3 pole</td>
<td>3021X0242 P116</td>
<td>1000372 W</td>
<td>1000564P1</td>
</tr>
<tr>
<td>37</td>
<td>Mech. housing 34, 46, or 69 kV 2 hole</td>
<td>3021X0242 P117</td>
<td>1000373 W</td>
<td>1000563P1</td>
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<tr>
<td>38</td>
<td>Control yoke</td>
<td>3021X0242 P118</td>
<td>1000500P2</td>
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<tr>
<td>38A</td>
<td>1/2” ID X .031” Nylatron washer</td>
<td>3021X0242 P118</td>
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<tr>
<td>39</td>
<td>Nylon pin</td>
<td>3021X0242 P119</td>
<td>1000376P1</td>
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<tr>
<td>40</td>
<td>Dust cap</td>
<td>3021X0242 P120</td>
<td>1000124</td>
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<tr>
<td>41</td>
<td>Connector obsolete</td>
<td>3021X0242 P121</td>
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<tr>
<td>42</td>
<td>Pull rod clevis</td>
<td>3021X0242 P122</td>
<td>1000023G1</td>
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<tr>
<td>42A</td>
<td>Pull rod clevis for handle side of 34 kV 3 pole switch</td>
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<td>1001125G1</td>
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<tr>
<td>42B</td>
<td>Pull rod clevis for position indicator counter side of 34 kV 20 A 3 pole switch</td>
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<td>1000112G1</td>
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<tr>
<td>42C</td>
<td>Clevis shaft for use with 42A &amp; 42B</td>
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<td>1001121P1</td>
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<td>43</td>
<td>Bolt, hex head 3/8-16 X 2-1/4” Lg. Gr. 8 Std.</td>
<td>3021X0242 P123</td>
<td>1000602</td>
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<td>43A</td>
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<td>43B</td>
<td>3/8 split lock washer Gr. 8</td>
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<tr>
<td>43C</td>
<td>3/8-16 screw-lock Helicoil used with 43A</td>
<td>3021X0242 P124</td>
<td>1000012</td>
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<tr>
<td>44</td>
<td>Actuator bar link</td>
<td>3021X0242 P124</td>
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<tr>
<td>44A</td>
<td>Actuator bar link for 34 kV 3 pole switch</td>
<td>3021X0242 P125</td>
<td>1000514G1</td>
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<tr>
<td>45</td>
<td>Actuator bar without screw holes for aux switch plate</td>
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<td>1000513G1</td>
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<tr>
<td>45A</td>
<td>Actuator bar with screw holes for aux switch actuator plate</td>
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<td>New VES Part Number</td>
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<tr>
<td>46</td>
<td>Support bar with mounting holes for Eaton™ aux switch</td>
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<td>46A</td>
<td>Support bar for 34 kV 3 pole 300 A switch</td>
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<td>47</td>
<td>Ty-wrap</td>
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<td>48</td>
<td>Bolt, hex head 3/8-16 X 1-3/4&quot; Lg. obsolete</td>
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<td>49</td>
<td>Nut, hex standard obsolete</td>
<td>3021X0242 P202</td>
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<td>Solenoid assembly DECCO™</td>
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<td>DECCO™ plunger (replace as matched set with 50C)</td>
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<td>DECCO™ push pin (replace as matched set with 50B)</td>
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<td>50D</td>
<td>DECCO™ side plate (replace all four at one time)</td>
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<td>50E</td>
<td>1/2&quot; dia X 1-1/4&quot; Lg.,DECCO™ solenoid spacer for 1/4&quot; hex cap screw</td>
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<td>1/4-20 X 2&quot; gr 5 hex cap scr</td>
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<td>50G</td>
<td>1/4&quot; ID .010&quot; thick brass shim washer</td>
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<td>50H</td>
<td>DECCO™ field stack</td>
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<td>50I</td>
<td>Screw</td>
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<td>50J</td>
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<td>Lockwasher</td>
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<td>Spring</td>
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<td>50M</td>
<td>Stop plate</td>
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<td>50N</td>
<td>Shock absorbers</td>
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<td>Mounting pad</td>
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<td>Solenoid shim</td>
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<td>Spring</td>
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<td>Vibra-Tite Formula 3™ thread locker</td>
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<td>Bearing plate bronze NAMCO™</td>
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<td>Bearing plate support, right NAMCO™</td>
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<td>Bearing plate support, left NAMCO™</td>
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<td>Coil clip NAMCO™</td>
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<td>50Y</td>
<td>U shim, switch solenoid 0.020&quot;</td>
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<td>Field stack NAMCO™</td>
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<td>50AC</td>
<td>Armature NAMCO™</td>
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<td>Top plate NAMCO™</td>
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<td>50AE</td>
<td>Stand off short</td>
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<td>50AF</td>
<td>Stand off long</td>
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<td>50AG</td>
<td>Socket hd. cap screw</td>
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<td>50AH</td>
<td>1/4-20 hex X 4&quot; lg. gr. 8</td>
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<td>50AM</td>
<td>DECCO™ double solenoid for 34 kV 3 pole 300 A switch</td>
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<td>51</td>
<td>Yoke bumper stop all rubber for DECCO™ solenoid only</td>
<td>3021X0242P204</td>
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<td>51A</td>
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<td>51B</td>
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<td>52</td>
<td>Aluminum expansion plug</td>
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<td>53</td>
<td>Bushing 1/2&quot; ID X 5/8&quot; OD X 3/4&quot; LG.</td>
<td>3021X0242 P206</td>
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<td>Description</td>
<td>Joslyn™ Part No.</td>
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<td>54</td>
<td>Shaft (SHORT) 1/2&quot; dia</td>
<td>3021X0242 P207</td>
<td>1000511P1</td>
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<td>55</td>
<td>Bushing 1/2&quot; ID X 5/8&quot; OD X 1&quot; LG.</td>
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<td>Seal for 1/2&quot; dia. Shaft</td>
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<td>Shaft (LONG) 1/2&quot; dia.</td>
<td>3021X0242 P210</td>
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<td>58</td>
<td>Actuating arm Joslyn™ design for 1/2&quot; dia. Shaft</td>
<td>3021X0242 P211</td>
<td>1000498P2</td>
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<td>59</td>
<td>Cotter pin (MONEL) 1/4&quot; dia</td>
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<td>Cotter pin (MONEL) 1/8&quot;X1-1/2&quot;</td>
<td>3021X0242 P213</td>
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<td>61</td>
<td>Washer</td>
<td>3021X0242 P214</td>
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<td>62</td>
<td>Lockwire, 303 SST .032 dia 1/8 hard</td>
<td>3021X0242 P215</td>
<td>1000387</td>
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<td>63</td>
<td>Cotter pin (MONEL) 1/16&quot; X 1/2&quot;</td>
<td>3021X0242 P216</td>
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<td>64</td>
<td>Nylatron spacer washer .062&quot; thick</td>
<td>3021X0242 P217</td>
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<td>65</td>
<td>Nylatron spacer washer .015&quot; thick</td>
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<td>Nylatron spacer washer .032&quot; thick</td>
<td>3021X0242 P219</td>
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<td>66</td>
<td>Toggle link</td>
<td>3021X0242 P220</td>
<td>1000499G1</td>
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<td>67</td>
<td>Plain bearing 1/4&quot; X 3/8&quot; X1/4 LG.</td>
<td>3021X0242 P221</td>
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<td>68</td>
<td>Link pivot pin (SHORT PIN) 1/4&quot; dia.</td>
<td>3021X0242 P222</td>
<td>1000024P3</td>
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<td>69</td>
<td>Clevis pin, spring retaining 1/8&quot; dia. X 7/8&quot;</td>
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<td>69A</td>
<td>Wool felt washer .062&quot; thick</td>
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<td>Wool felt washer .125&quot; thick</td>
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<td>70</td>
<td>Spring assembly for 15, 34, 46, kV 600 A switch and 46 &amp; 70 69 kV 300 A switch</td>
<td>3021X0242 P226</td>
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<td>70A</td>
<td>Spring assembly for 34 kV 300 A 3 pole switch</td>
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<td>Clevis pin 1/4&quot; dia.</td>
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<td>71A</td>
<td>Locking Plate 1.25&quot;x0.0625&quot;x0.125&quot;</td>
<td>3021X0242 P229</td>
<td>1000059P1</td>
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<td>72</td>
<td>Bolt, hex head 1/4-20 X 3/4&quot; gr. 8</td>
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<td>73</td>
<td>Washer, flat 1/4&quot; Nom. 9/16&quot; OD Zn plt steel</td>
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<td>74</td>
<td>Wiring harness, Eaton™ auxiliary switch, &amp; environmental connector with bracket and crimp connectors on wires</td>
<td>3021X0242 P232</td>
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<td>plate, switch actuating</td>
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<td>75A</td>
<td>Screw slotted Rd. Hd. 6-32 X 3/8&quot; Lg.</td>
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<td>3021X0242 P235</td>
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<td>Loctite 290™ green</td>
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<td>Screw, Fillister head</td>
<td>3021X0242 P237</td>
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<td>Lock washer split No. 6 standard</td>
<td>3021X0242 P238</td>
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<td>Gasket (RECEPTACLE)</td>
<td>3021X0242 P239</td>
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<td>Spacer</td>
<td>3021X0242 P240</td>
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<td>80</td>
<td>Tapped bar</td>
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<td>Bumper assembly</td>
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<td>82</td>
<td>Bolt, hex head 5/16-18 X 2-1/4&quot; L gr 8</td>
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<td>Lock washer split 5/16&quot; standard</td>
<td>3021X0242 P244</td>
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<td>Spacer bar</td>
<td>3021X0242 P245</td>
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<td>85</td>
<td>Nylon spacer obsolete</td>
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<td>Insertion resistor 80 ohm</td>
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<td>Six digit counter &amp; position indicator assy.</td>
<td>3021X0242 P248</td>
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<td>Counter Spring for 5 digit counter</td>
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<td>Counter Spring for 6 digit counter</td>
<td>3021X0242 P250</td>
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<td>6 digit counter</td>
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<td>5 digit counter</td>
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<td>86E</td>
<td>Screws for attaching 5 digit counter</td>
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<td>86G</td>
<td>5 digit counter actuator plate</td>
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<td>1000758P1</td>
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<td>86H</td>
<td>Bracket, position indicator</td>
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<td>86K</td>
<td>Faceplate, position indicator</td>
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<td>86L</td>
<td>Position indicator pointer</td>
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<td>86M</td>
<td>Screw, 4-40 x 3/8” LG. ZN. PL. STL. RD. Head</td>
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<td>Lock washer, split No 4 STD. ZN. PL. STL.</td>
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<td>86Q</td>
<td>Window retaining ring 5/8” for thin wall casting</td>
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<td>Window retaining ring 3/4” for thick wall casting</td>
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<td>Glass</td>
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<td>Insulator 69 kV</td>
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<td>Pull rod assembly 15 kV 600 ampere module</td>
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<td>Pull rod assembly 34 kV 600 ampere module</td>
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<td>Pull rod assembly 46 kV 600 ampere module</td>
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<td>Pull rod assembly 69 kV 600 ampere module</td>
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<td>Pull rod outer 34 kV 3 pole 300 A with Joslyn™ module</td>
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<td>Pull rod outer 34 kV 3 pole 300 A with VES™ module</td>
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<td>Pull rod inner 34 kV 3 pole 300 A with Joslyn™ module</td>
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