

**INERTIA**  
**ENGINEERING**



# HIGH VOLTAGE SWITCHGEAR & AUTOMATION EQUIPMENT

## SECTION 5 Switch Automation Equipment

CAT. NO: 040930G  
May, 2008



---

# AUTOMATION EQUIPMENT

- **MSO Motorized Switch Operator** 5.10-5.13
  - **MSO, Reciprocating (↑↓) Operator**
    - Features/Benefits** 5.20
    - Purchasing Specification** 5.30
    - Engineering Specification** 5.40
  - **MSO, Reciprocating Operator Drawings**
    - 9350M 35 kV SCADA Switch Package with Line Sensors and MSOR 5.50
    - 9331M 25 kV Horizontal Switch Package & Retrofit Components List 5.51
    - 9408M 35 kV SCADA Riser Switch Package with MSOR 5.52
-

The INERTIA MSO, motorized switch operator, meets or exceeds ANSI certification standards for substation, transmission and distribution Supervisory Control And Data Acquisition (SCADA). It works as a stand alone, locally controlled device, or it can be fit with a wide variety of SCADA communication equipment including your choice of RTU, modem, radio, antenna, cabling, and analog insulators with current, voltage and fault sensing capabilities.

Two MSO models available:

- MSOD- reciprocating output for distribution switches 15 kV-35 kV
- MSOT- reciprocating output for transmission switches 46 kV-72.5 kV.

The INERTIA MSO is built with interchangeable communication control modules for upgrading on the shop bench instead of in the field. A basic pushbutton operating device can be upgraded with a variety of SCADA systems in the future. A new or modified module, with your choice of remote control features, can be easily bench tested on an existing MSO series and quickly apply the upgrade in the field.

The INERTIA MSO gives the flexibility needed for your changing remote switching requirements. Inertia's interchangeable modules allow for easy upgrades on the shop bench; not up on the pole.

### Physical Characteristics

The INERTIA MSO is light enough to be installed with any lifting equipment capable of 225 lbs. The nominal cabinet measurements are 15 ½" W x 19½" H x 23"D. Manual switch operation capability is provided on the back of the unit. No synchronizing is required after a manual operation as is the case with some equipment.

### • Perpetual Position Alignment

The patented clutch assembly in the INERTIA MSO provides factory adjusted output travel that **never** needs resetting in the field. Once the MSO has been installed and the switch rod adjusted, the operator **never** requires realignment.

### • Modular Construction

The slide-in control modules are up-gradable and easily interchangeable in the field. If the RTU or radio needs replacement, the bench work can be done in the shop and the control module exchanged in the field by the troubleman.

### • Unitized Construction

The drive mechanism is isolated from the main cabinet by a sealed bulkhead, providing isolation of the mechanical drive components from the electronic components.

### • Operating Speed

These reciprocating units operate in 0.5 to 0.7 seconds.

### • Front panel/Local Intelligence

The front panel of the MSO provides both on-site and remote information, and prevents inadvertent contact with the electrified components.

### • Clearance Point Safety

There are four clearance points:  
1.) The toggle switch is moved to the local position to disable remote control. 2.) the patented clutch system is decoupled disengaging the motor from the drive mechanism. 3.) the interlock pin is removed to break the circuit to the drive motor. 4.) the interlock pin is placed through the drive shaft and encompassed by a collar that secures the drive shaft with the switch in either the open or closed position. If all prior steps are defeated, the switch position cannot change.





# Closer Look From The Outside. . . . .



The MSO is available in a choice of powder-coated mild steel or stainless steel enclosures. All enclosures have the following features:

- Drive mechanism in a partitioned subcabinet to isolate the drive components in the subcabinet from the electronic components.
- Four full inches of belt clearance between the pole and the MSO
- One inch conduit hole (plugged) provided for AC power
- Twelve-pin receptacle provided in the bottom of the cabinet, pre-wired for external equipment, e.g. sensors, fault indicators etc.
- Pad-lockable door and drive collar (clearance point)
- Integrated manual operating mechanism
- Auto-regulating heater for humidity control
- Single point lifting eye for easier mounting
- Easy access to operator/module without removal from crate

# Closer Look On The Inside . . . . . CONTROL PANEL

The inside panel isolates the user from the energized components during a routine maintenance check and during normal local operation.

\* **Power Supply Lamp** indicates a functioning power supply that charges the 24 VDC battery pack.

\* **Low Battery Lockout Lamp** illuminates when the voltage monitor has detected a voltage too low to properly operate the switch. If low voltage is detected, the battery successfully pass a deep draw discharge test either locally, remotely, or automatically prior to operation. There is no override.

★ **Battery Test/Reset Toggle Switch** is a momentary switch that initiates a 5 second battery test. The battery voltage must be sufficient to allow a reset.

\* **Door Sensor** turns off lamps when the door is closed and initiates an alarm status when open.

• **Lamp Test Pushbutton** energizes all lamps when depressed to check for burned out lamps.

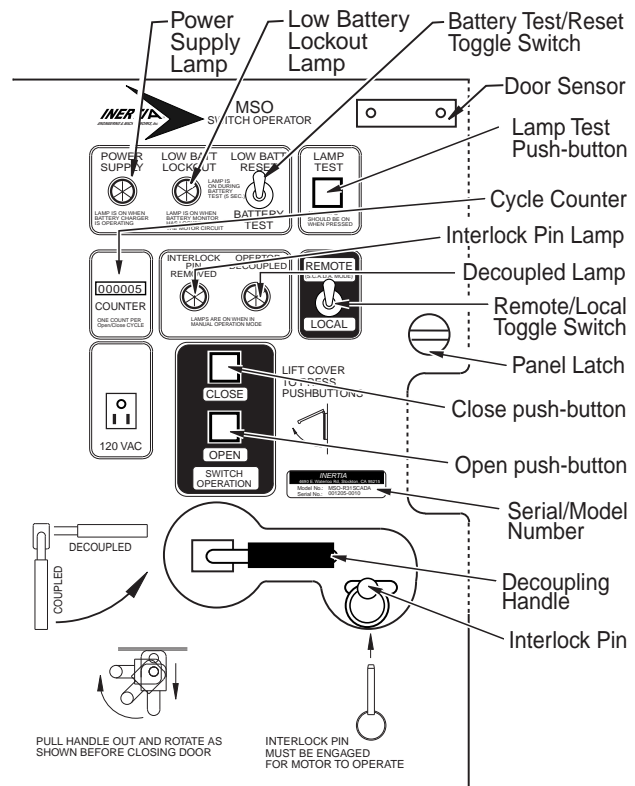
• **Cycle Counter** counts each closing cycle.

\* **Interlock Pin lamp** illuminates whenever the interlock pin is removed from its control panel location. The motor circuit cannot be energized when the interlock pin lamp is illuminated (pin is removed). This is the first clearance point step.

\* **Decoupled Lamp** illuminates whenever the motor is decoupled from the output linkage via the decoupling handle. The second clearance point step.

\* **Remote/Local Toggle Switch** allows control to be initiated from the control panel, only when in the local position; or remotely, only when in the remote position. This is a third clearance point step.

★★ **Open & Close Pushbuttons** are covered to prevent inadvertent contact and are illuminated to



indicate the current switch position. The illuminated buttons indicate the switch position remotely and locally, whether operated manually or by the motor.

\* **Decoupling Handle** physically disengages the motor from the output mechanism. The motor can be run in the local mode by pressing either the open or close pushbutton without operating the switch.

\* **Interlock Pin:** The interlock pin is the “Key” to the unit. It must be fully inserted into its position on the control panel for the motor to operate. It is the same pin required for using the manual handle. In a clearance, it creates a physical stop/fourth clearance point step, if other clearance steps are breached.

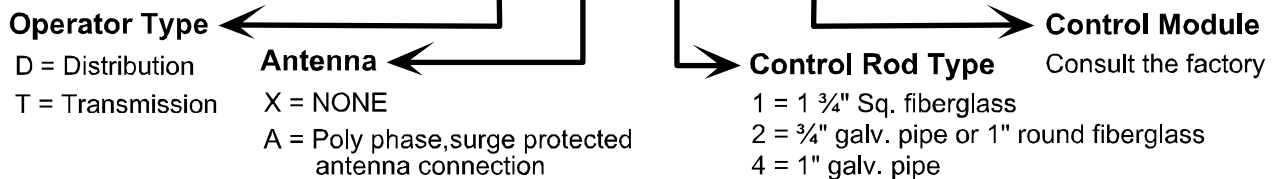
# Behind The Panel . . . . . Modularity



The slide-in battery and control modules provide easy access for upgrades. Battery-pack changeouts are made quickly and easily by separating the power plug and removing it. The *INERTIA* control module is custom tailored for the customer's requirements. No field wiring of the operator is required. The control modules are interchangeable, so if an upgrade is desired, a backup unit can be programmed and tested in the shop and sent out to the site for replacement. The replaced module can then be returned to the shop for bench testing. There is no need to troubleshoot the module on the pole. Since the modules are interchangeable, the operator never becomes obsolete. As your requirements change, an upgraded module with different capabilities can be inserted with the same ease without the need to take a clearance.

## Selection: Select the operator antenna connection and the control rod type.

# MSODA2CM



**MSODA2CM** is a motorized switch operator for distribution switches (15 kV-35 kV) with a surge suppressed antenna connection that can be used with either 3/4" galvanized pipe or 1" round fiberglass

**MSOTX1CM** is a motorized switch operator for transmission switches (46 kV-72 kV) without an antenna connection (hard-wired communication) provided that can be used with 1 3/4" square fiberglass

### Control Modules

MSO control modules are designed with "open architecture" and are adaptable to customer selected specifications for power input, SCADA status and control, and communication and fault sensing devices.

#### Substation applications:

The control module can be a "hard-wired" unit without RTU or communications device for substation applications.

#### Field applications:

The control module can be supplied with factory mounted and wired RTU, communication device or both. When customer supplied, the factory will predrill the control module frame to accept the form factor of the device(s) to be customer installed. The RTU and/or communication device(s) can also be installed external to the MSO in factory supplied weatherproof boxes or it can be supplied with an umbilical cord (instrumentation/control cable) with customer specified connectors.

Control module input, control and status point information:

- External power requirement: 720 watts minimum
- Supply voltage input: 120/240 VAC or 24-125 VDC
- Control and drive power: 24 VDC
- Auxiliary power: 12 VDC, 4.5 A
- Control points\* (24 VDC Form-A "wetted relays)
- Status points\*\* (24 VDC Form-A "wetted relays)

\* Form-A "dry" contact relays are available.

\*\* Status points can be grouped for "Condition Alarm" as requested.

The Inertia MSO's mechanical and electro-mechanical drive components are designed to last for decades. It is not likely that any technological or material advances will improve this drive system. Battery, RTU and communications technologies are very likely to change in the future. The removable battery pack and control module systems allow easy upgrades without field wiring. Future upgrades of the RTU or communications device will be done in the shop on replacement modules. Pretested, pre-programmed modules can then be hot-swapped in the field without taking a clearance.

# Design Tests

The following tests have been conducted on the Inertia MSO switch operator in accordance to the applicable ANSI/IEEE standards. Additional tests are included that are not part of the ANSI/IEEE test standards.

## Insulation Withstand (high potential)

Input line to ground and common to ground tested at 1,500 and 2,600 volts.

Dielectric withstand voltage, (input to output 1 minute): 2,500 VAC.

Insulation resistance, (input to output): 10 M ohm minimum with leakage current, less than 0.83 mA.

## Line Voltage Variation

Input voltage-AC: 85-145 VAC      Input frequency-AC: 47-63 Hz

Brown out protection (lowest input voltage that regulation is maintained): 85 VAC

Power supply drop out voltage:  $40 \pm 5$  VAC

Power supply pick up voltage:  $85 \pm 5$  VAC

The battery failure backup system maintained all control and status I/O and system operability during test

## Power Failure Backup

Time to 'no-go' (0.6 amp. load): 50 hours      Recovery time (successful battery test), 25 minutes

## Temperature Cycle

Five 24 hour cycles at  $-20^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ . (one cycle without the switch operator's heater on)

Five 24 hour cycles at  $+20^{\circ}\text{C}$  to  $+91^{\circ}\text{C}$ . The test was conducted with an additional 2.3 ohm load to simulate radio and RTU power consumption. One temperature cycle was conducted without 120 VAC input to the power supply.

## Humidity cycle

Relative humidity: non-condensing to  $70^{\circ}\text{C}$  at 95% relative humidity with the door open.

## Surge Withstand      Per ANSI C37.90.1-1989

3.0 kV, 100 kHz oscillatory waveshape, positive and negative polarities, injected into the AC mains and enclosure.

4.0 kV, 100 kHz fast transient waveshape, positive and negative polarities, injected into the AC mains and enclosure.

## Powerline Surge Voltage and Current      Per ANSI C62.41-1991

100 kHz Ring waveshape both positive and negative polarities injected into the AC mains and the enclosure, and  $1.2 \times 50 \mu\text{s}$ ,  $8 \times 20 \mu\text{s}$  surge waveshape, positive and negative polarities injected into the AC mains and the enclosure.

4 kV amplitude, over 0-540 degrees phase, 15 degree phase increments

5 kV amplitude, over 0-180 degrees phase, 15 degree phase increments

6 kV amplitude, over 0-180 degrees phase, 15 degree phase increments

## Electrostatic Susceptibility      ESD per MIL STD. DOD-HDGK-263, Schaffner 430 ESD Gun

Test all surfaces, switches, buttons and safety neutral terminals or grounds that will be contacted by personnel during operation or installation of the device per the following:

a: Test voltage at 10 kV: Discharge the test device on all the above surfaces.

b: Test voltage at 15 kV: Move the probe 0.5 inches above all contact surfaces (avoiding discharge).

## Power On/Off Transition

Input voltage is varied from +20 %, -10%, -15%, -20%, -50% , -100% and nominal while the voltage is rapidly toggled on and off eight cycles. All device functions are verified to be operating correctly at all input voltage settings.

Power supply ratings:      Turn-on delay: 1 Sec.

Charger hold up time (110 VAC): 20 mS min.

Operating frequency (switching frequency of main transformer: 22 kHz nom.

## Brown-Out and Single Phase

Verify correct device operation at nominal input voltage, and after the following:

a: Nominal input voltage -20% for six hours.    b: Nominal input voltage - 50% for six hours.

## EMI/RFI Susceptibility      Per S.A.M.A. Std. PMC 33.1-1978 (Radiate frequencies from front, right and left sides)

14 kHz-512 kHz, 10V/m, operator energized with 120 VAC, door closed

512 kHz-10GHz, 5V/m, operator energized with 120 VAC, door open

## Electromagnetic Radiation

Conducted per FCC part 15 Class B limits

## Battery Life

36 amp-hour lead acid batteries (VRL), powering the control module only, for 22 hours prior to low voltage lockout. A battery shutdown algorithm is employed to prevent deep discharging the batteries during a sustained outage.

## Mechanical Operation

Mechanically tested on 35 kV gang switch 3,500 operations, 300 without power supply, no maintenance was performed on the switch or the operator during the test. No appreciable wear or damage was identified.



The INERTIA MSO reciprocating switch operator is the single answer to your changing remote switching requirements. The MSOT and MSOD motorized switch operators can operate virtually any reciprocating, moving blade transmission or distribution switch with reciprocating (up/down) control. It is the safest and most reliable of all of the MSO operator designs. The MSOD and MSOT have interchangeable control/communication modules that will allow upgrades and repairs to be made on the shop bench instead of in the field. It can operate any ninety degree opening sidebreak or line tension switch. The control module can be supplied with either or both the RTU and communication device of your choice. If radios or other com-

munication devices are to be recycled or customer installed, the control module can be predrilled at the factory to accept all devices commonly used in your system.

Installing and setting up the operator is simple. Install the switch as you would a manual handle. The MSO weighs approximately 225 lbs. so it can be easily set in place using a bucket truck. Two through-bolts are all that is required to secure the MSO to the pole. Operate the switch to the closed position, install the adjustable coupling, and set the handle to provide moderate control rod compression while allowing toggle-over.

The automated switch is now ready for remote operation.



*Operator shown in the open position, engaged and operational, with the collar padlocked*

### MANUAL OPERATION & CLEARANCE POINT SEQUENCE



1. Remove the interlock pin from the front panel and insert it into the output shaft and padlock in place. Decouple the operator.



2. Remove the padlock and rotate the collar out of the way. Place handle over the exposed shaft and insert interlock pin. Switch is now operated like any manual switch.



3. For a clearance, repeat step 1, and place interlock pin through shaft. Replace collar to capture the interlock pin at a mechanical stop. Padlock collar for final clearance point

#### Description:

Pole mounted 24 VDC reciprocating (↑↓) output motorized switch operator for 4 kV- 138 kV overhead gang operated air break switches. This equipment shall meet or exceed all applicable A.N.S.I./I.E.E.E., F.C.C. , S.A.M.A. and I.E.C. test standards.

#### General specifications:

1. Operating stroke must be a fourteen inch (14½") nominal and fully operate the switch open or closed within 0.5-0.7 seconds. A sealed DC motor capable of 5,000 lb. stall torque coupled with a multi disk clutch shall provide the output to the switch control rod.
2. Stroke limits (once set) should not require re-setting after manual operation or motor running maintenance.
3. Operator linkage must toggle over center at both extremes of the stroke to: 1) place control rod compression on a mechanical stop in the closed position and 2) prevent accidental movement from the open position.
4. Switch position status must be indicated locally on the control panel and transmitted via SCADA remotely when in either local/manual or remote/motor operating mode.
5. Single point lifting is to be provided on a powder coated welded stainless steel enclosure with stainless steel hardware and safety handle.
6. A visible air gap must be attainable between the control rod and output shaft of the motor operator in the open position. No adjustments shall be required to re-engage the operator and the control rod. The switch position must be lockable during a clearance (user safety point).
7. It shall not be necessary to disengage the control rod to perform a manual operation of the switch.
8. The manual handle shall require the use of an interlocking device which, when removed for use with the manual handle, shall break the electrical circuit to the motor (user safety point).

#### Control and SCADA Specifications:

1. The operator shall have a control panel with the following controls and status indications:
  - Switch Close pushbutton and LED status indication
  - Switch Open pushbutton and LED status indication
  - Battery test/reset toggle switch control
  - Low battery motor lockout lamp
  - Power supply "ON" lamp
  - Remote/local toggle switch
  - Motor disengaged (decoupled) lamp (user safety point)
  - Motor circuit interlock pin removed lamp (user safety point)
  - Operations counter
  - Door sensor
  - Motor interlock pin (user safety device)
  - Decoupling handle (user safety device)
  - 120 VAC, 6 Amp convenience receptacle
  - Lamp test pushbutton



## Control and SCADA Specifications (continued):

2. The operator electronic controls shall have the following minimum features:
  - 12-pin analog input plug
  - 120 VAC regulated heater
  - removable battery pack
  - weather-tight panel separating mechanical output linkage mechanisms.
  - removable control logic, RTU, and communications module with the following features:
    - Battery monitoring and automatic timed test
    - Low voltage motor lockout
    - Low voltage system disconnect
    - All status and control outputs shall be connected to a test terminal block.
    - DC startup test pushbutton
    - Fused 120 VAC input, and 24 VDC power supply
    - Minimum control points
      - Open switch
      - Close switch
      - Battery test/reset
    - Minimum digital status outputs
      - Switch open
      - Switch closed
      - Low battery lockout
      - Power supply failure
      - Local/Remote control
      - Operator decoupled
      - Interlock pin removed
    - Minimum analog outputs:
      - Six analog outputs shall be provided to interface with line post, or other sensors
      - Fused 24 VDC and 12 VDC outputs for the radio, RTU or other equipment .

**Scope:** This material description covers the minimum acceptable requirements for 4 kV-138 kV G.O.A.B. reciprocating switch controllers and stored energy operators. The switch controller is to be mounted below the switch assembly.

The controller shall be able to accommodate the various applications, including, but not limited to:

- Encrypted, secured and codable 900 MHz handheld remote control.
- External S.C.A.D.A. with, or without current or current/voltage sensors or remote faulted circuit indicators via RTU and radio or other communication media of the customer's choice, through a bulkhead receptacle.

### Mechanical and manual operation

- The switch operator must be designed to open and close all the types of manufacturers' reciprocating switches of sufficient force in 0.5 to 0.7 seconds.
- The operating mechanism and enclosure must be G.O.-95 compliant.
- All linkage components are to be of nonferrous anticorrosive materials and be physically and be environmentally isolated from the electronic components by a bulkhead.
- Means shall be provided to enable the motor to be coupled or decoupled from the output linkage in any position without realigning the motor linkage to the output shaft or repositioning the output linkage to its original position prior to manual operation.
- Switch position status is to be indicated when operated either by motor or when operated manually.
- A motor de-energizing interlock, physical linkage stop in a padlockable collar are to be provided for clearance point verification.
- The operator enclosure is to be of welded NEMA 4X construction of 14 gauge, stainless steel with ANSI 71 grey powder-coated 3 mil. minimum.
- A thermostatically controlled heater shall be provided to reduce condensation in the operator.
- The operator enclosure shall be a maximum of 16 inches wide for traffic and pedestrian safety.
- All ferrous components and hardware shall be hot-dip galvanized per ASTM A123.

### Controller:

- The operator controller must be easily replaceable and upgradable, and provide a terminal block with 24 and 12 VDC power outputs for RTU with status and control points and communication devices.
- The operator controller, RTU and communication equipment are to be enclosed in a modular unit, which can be exchanged with a comparable module. Control module exchange and replacement shall be hot-swap capable, i.e. module can be replaced or removed for upgrade or repair without taking an outage.
- Control module exchange and replacement shall not require rewiring of the controller, analog inputs or the power supply.
- Controller shall be isolated by a separate control panel, to protect the user from inadvertent contact with energized parts. "Open" and "Close" switches shall be covered to prevent inadvertent accidental contact.
- Controller shall have the following points:

- |         |                                  |   |
|---------|----------------------------------|---|
| Status: | 1. Switch open                   | 6. Interlock pin removed (motor circuit disable)      |
|         | 2. Switch closed                 | 7. Low battery lockout                                |
|         | 3. Local enabled                 | 8. Power supply fail                                  |
|         | 4. Remote enabled                | 9. Door open (optional)                               |
|         | 5. Manual mode (motor decoupled) | 10. Local and/or remote operations counter (optional) |

- |          |                 |                                  |
|----------|-----------------|----------------------------------|
| Control: | 1. Open switch  | 3. Battery test                  |
|          | 2. Close switch | 4. Fault detect reset (optional) |

### **Front Panel User Interface:**

- Display/operation panel shall be hinged and latchable, and have the following attributes:
  1. Panel displays:

a) Battery test in progress lamp	e) Operator decoupled lamp
b) Low battery lockout lamp	f) Motor interlock pin removed lamp
c) Power supply lamp	g) Cycle counter for switch operations
d) Open pushbutton (covered & illuminated)	h) Close pushbutton (covered & illuminated)
  2. Provided controls:

a) Lamp test pushbutton	e) Open pushbutton (covered & illuminated)
b) Battery test switch	f) Close pushbutton (covered & illuminated)
c) Battery reset switch	g) Motor decoupler
d) Local/Remote toggle switch	h) Motor interlock

### **Power Supply:**

- The power supply shall have the following minimum characteristics:
  - Input voltage range: 110-240 VAC (50-60 Hz).
  - Output current and voltage: 4.6/4 A, 24/28 VDC temperature compensating.
  - Minimum switching frequency, 20 kHz, 1% peak-to-peak ripple.
  - Inrush surge, EFT/burst, radiated susceptibility tested to: EN61000-4-2,3,4 and 5.
  - Electromagnetic interference, conducted: FCC title 47, class B as applicable.
  - The power supply is to be fused on both the input and output.

### **Motor and operation:**

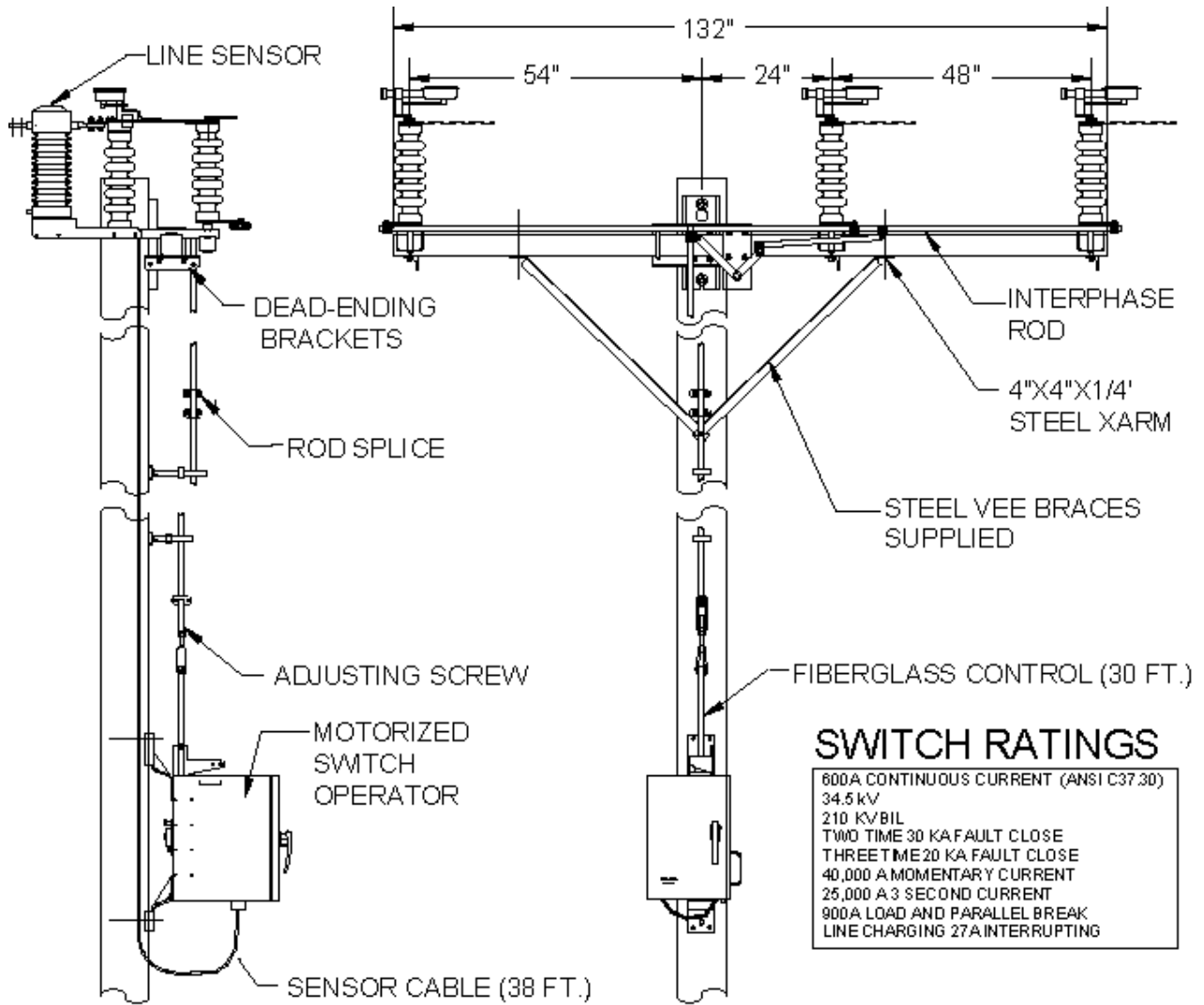
1. A 24 VDC sealed motor shall be powered by an easily replaceable 24 VDC/24 amp-hour maintenance-free, lead acid battery pack capable of sustaining 250 mA communication and RTU equipment for 36 hours, and four motor operations during the first 24 hours upon loss of the AC supply.
2. The motor shall be capable of being exercised via local control without effecting the switch position.
3. The motor is to be protected with thermal trip/reset breakers and overload torque limiting means to sense and reduce damage to iced or locked switches.
4. Motor contactors, relays, timers and battery management electronics shall prevent lazy or partial switch operation.

### **Documentation:**

1. Each operator shall be supplied with an installation and operation manual that includes:
  - Remote and local control and manual operation.
  - RTU and radio installation.
2. Factory acceptance test certificates with associated serial numbers shall also be included.
3. All components shall be warranted the first year for on site repair of all parts and labor, and for an additional two years as returned to the factory. Warranty does not apply to battery replacement. RTUs and radios shall be warranted separately by their respective manufacturer(s).

The foregoing information is provided to help ensure specifying the highest possible quality motorized switch operator.

The information provided herein is intended solely as a guideline to create a specification that best suits the end user's application. Some portions may, or may not be applicable to your requirements and environment.



**SWITCH RATINGS**

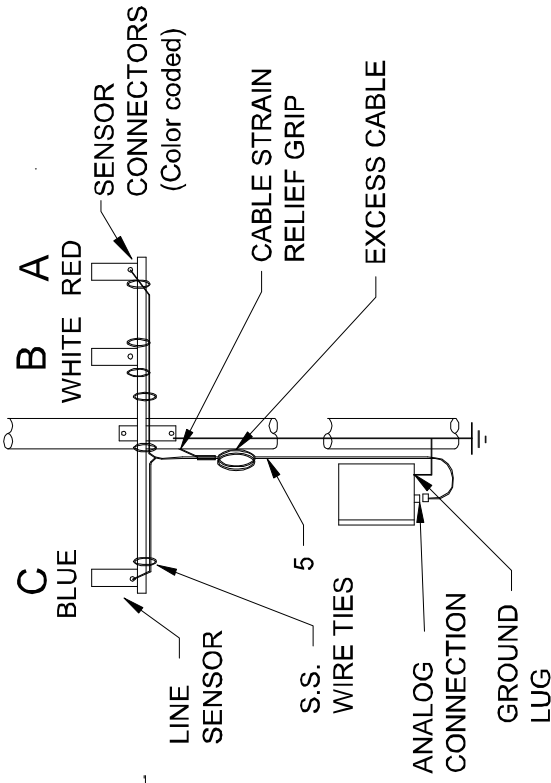
600A CONTINUOUS CURRENT (ANSI C37.30)  
 34.5 kV  
 210 KV/BIL  
 TWO TIME 30 KA FAULT CLOSE  
 THREE TIME 20 KA FAULT CLOSE  
 40,000 A MOMENTARY CURRENT  
 25,000 A 3 SECOND CURRENT  
 900A LOAD AND PARALLEL BREAK  
 LINE CHARGING 27A INTERRUPTING

This drawing is for illustrative purposes only and therefore; may, or may not reflect the current revision of this drawing. Please request the current revision from the factory.



Material:		Description:	
Finish:		35 kV Sidebreak SCADA Switch	
Scale:	None	Drawing No:	Revision:
Drawn by:			
Date:	09/11/03	<b>9350M</b>	<b>0</b>





SENSOR CONNECTIONS TO SWITCH, MSO AND GROUND

PART NO. DESCRIPTION

1	6077-ASSY	BELL CRANK ASSEMBLY
2	I-1590P	CONNECTING LINK, 24" FIBERGLASS
3	91-154	CONTROL ROD, 10 FT. FIBERGLASS, RND.
4	I-88	SPLICE, CONTROL ROD
5	MSO-38X8-4.5/2W	THREE PHASE, 38 FT. CURRENT SENSOR CABLE ASSY.
6	I-28A	ADJUSTING SCREW ASSEMBLY, MSOR
7	MSOR14-XX	MOTORIZED SWITCH OPERATOR

This drawing is for illustrative purposes only and therefore; may, or may not reflect the current revision of this drawing. Please request the current revision from the factory.



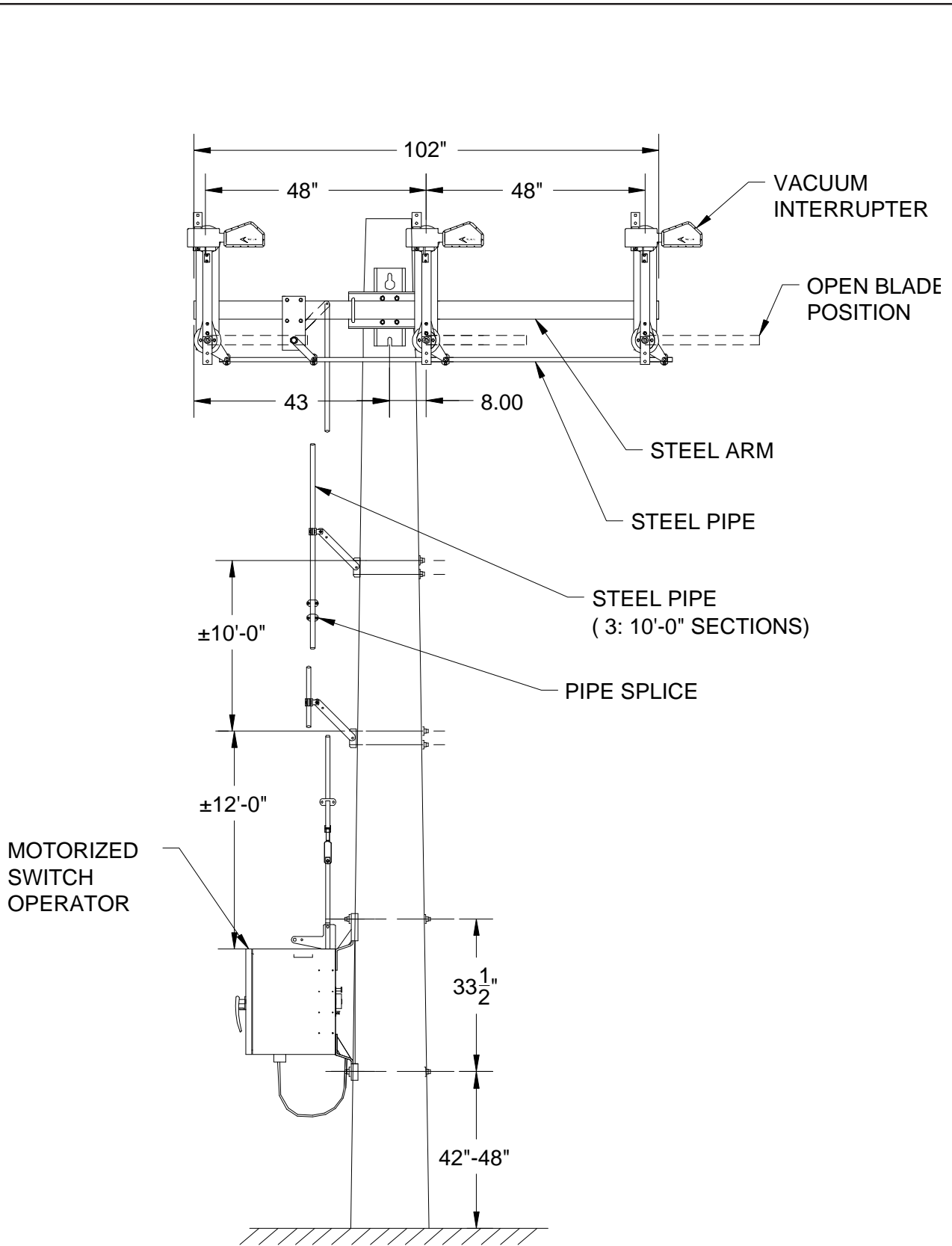
Material: Finish: Scale: NTS

Description: MSO Sensor upgrade p[ackage]


Drawn by: Date: 09/30/04

Revision: 0

Drawing No: 9333-1M



This drawing is for illustrative purposes only and therefore; may, or may not reflect the current revision of this drawing. Please request the current revision from the factory.

	Material:		Description:	
	Finish		35 kV Riser Sidebreak SCADA Switch	
	Scale:	None	Drawing No:	
	Drawn by:		9408M	
	Date:	07/28/04	Revision:	
			0	