Advances in Medium Voltage Power Distribution
• MV Overview
• Relay Protection Overview
• Operator Safety
• Kirk Key Interlocking
• Maintainability
• Main Tie Main Auto Transfer Schemes
• Paralleling Switchgear
• Applicable Codes and Standards
MV Overview

• What is MV Switchgear?
  – Terms: Breakers, PTs, CTs, Bus Size, BIL, kA, LIS, Metering Section, transition section, pull section
  – Metal-Clad
  – Metal-enclosed
  – IEC
  – ANSI
  – UL/cUL

• Configuration
Terms

- Breakers
- PTs
- CTs
- Ground CT
- Surge Arrester
- Bus Size
- BIL
- kA
- LIS
- Metering Section
- Transition section
- Pull section
- NEMA 1
- NEMA 3R Non-walk-in
ANSI Standard
Standard Gear

**Standard Features**
- Manual Racking
- Breaker Control Switch w/ indicating lights at front of gear
- Local Operation only
- Overcurrent Protection through separate relay
- Heaters

**Optional Features/Accessories**
- Power Meter
- Breaker Test Cabinet
- Breaker Test Jumper
- Remote Racking
- Remote Control Cabinet
- Arc Flash Mitigation
- 3 Cycle Breaker
- Maintenance Switch (ARMS)
- Portable Breaker Operator
- Remote Operation
- Direct Roll-out
- Ground & Test Device
SPECS

- Voltage Class: 5kV, 15kV, 38kV
- Short Circuit: 25kA, 31.5kA, 40kA, 50kA, 63kA
- BIL: 60kV, 95kV, 150kV, 170kV
- Amperage: 1200A, 2000A, 3000A, 4000A
- Enclosure: NEMA 1, 3R non walk-in, Sheltered Aisle, in PDC
- Paint system, material of enclosure
NEMA 3R Non Walk-in
NEMA 1 Indoor SWGR in PDC
SWGR BLDG with MV Swgr and Cable Tray Routing
Bus
Relay Protection

- Basic 50/51
- Voltage Protection
- Line Protection
- Transformer/generator differential
- Bus differential
SEL-311C-1 Relay

- SELloc Control Equations
- Event Reports
- Sequential Events Recorder
- Breaker Wear Monitor
- Station Battery Monitor
- Additional I/O
- ONF3 Serial and LAN/VPN Outstation
- IEC 60850 Protocol
- SNTP
- Instantaneous, Demand, and Energy Metering
- Local Display
- Modbus RTU and TCP
- IEEE C37.118 Synchronphasors
- Remote and Local Control Switches
- SafeLock Trip/Close Pushbuttons
- Zone I Extension
- Fault Locator
- CVVT Transient Overreach Supervision

*Optional functions
SEL-311L Relay

Bus

Breaker

87L 21 67 50 51
Current Differential  Distance  Directional Overcurrent  Instantaneous Overcurrent  Time Overcurrent

81
Over-/Under-frequency

79
Auto-Reclosing

25
Synchronism Check

Communications to remote relay

81
DNP3 Level 2 Slave Protocol*

79
Remote and Local Control Switches

50
Station Battery Monitor

51
Breaker Wear Monitor

52
Advanced SELogic® Control Equations

1
Fault Locator

Line

25
CCVT Transient Overreach

*Optional Function
Operator Safety

- Remote Racking
- ARMS Switch
- 3 cycle breaker
- Arc Flash Mitigation
- Remote Operation/Control Panel
- Ground & Test Device
- Ground Studs/Neon Glow Tubes
- Kirk Key Interlock
- Shutters
- Lockout/Tagout
# Arc Flash

## NFPA 70E Table 13D.2 (C)

<table>
<thead>
<tr>
<th>NOMINAL SYSTEM VOLTAGE RANGE</th>
<th>LIMITED APPROACH BOUNDARY</th>
<th>LIMITED APPROACH BOUNDARY</th>
<th>RESTRICTIVE APPROACH BOUNDARY</th>
<th>PROHIBITIVE APPROACH BOUNDARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING CODE</td>
<td>EXPOSED MOVABLE CONDUCTOR</td>
<td>EXPOSED FIXED CIRCUIT</td>
<td>INCLUDES INADVERTENT MOVEMENT ADDER</td>
<td>INCLUDES REDUCED INADVERTENT MOVEMENT ADDER</td>
</tr>
<tr>
<td>PHASE TO PHASE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LESS THAN 50 V</td>
<td>NOT SPECIFIED</td>
<td>NOT SPECIFIED</td>
<td>NOT SPECIFIED</td>
<td>NOT SPECIFIED</td>
</tr>
<tr>
<td>50 TO 300 V</td>
<td>10 FEET 0 INCH</td>
<td>3 FEET 6 INCH</td>
<td>AVOID CONTACT</td>
<td>AVOID CONTACT</td>
</tr>
<tr>
<td>301 TO 700 V</td>
<td>10 FEET 0 INCH</td>
<td>3 FEET 6 INCH</td>
<td>2 FEET 4 INCH</td>
<td>0 FEET 1 INCH</td>
</tr>
<tr>
<td>751 TO 15 kV</td>
<td>10 FEET 0 INCH</td>
<td>5 FEET 0 INCH</td>
<td>2 FEET 7 INCH</td>
<td>0 FEET 10 INCH</td>
</tr>
<tr>
<td>15.1 TO 35 kV</td>
<td>20 FEET 0 INCH</td>
<td>6 FEET 0 INCH</td>
<td>2 FEET 7 INCH</td>
<td>0 FEET 10 INCH</td>
</tr>
</tbody>
</table>

**Determining PPE Hazard Risk Category**

<table>
<thead>
<tr>
<th>Category</th>
<th>Cal/cm²</th>
<th>Clothing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.2</td>
<td>Untreated cotton</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>Flame retardant (FR) shirt and FR pants</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>Cotton underwear, FR shirt, and FR pants</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>Cotton underwear, FR shirt, FR pants, and FR coverall</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>Cotton underwear, FR shirt, FR pants, and double-layer switching coat and pants</td>
</tr>
</tbody>
</table>

*Output category for personal protective equipment (PPE).
Source: NFPA 70E, Table 3-3.9.3
Remote Racking
ARMS Switch

CURRENT IN AMPERES

Energy Reducing Maintenance Switch

<table>
<thead>
<tr>
<th>Status</th>
<th>Bolted Fault Current (kA)</th>
<th>Arcing Fault Current (kA)</th>
<th>Clearing Time (ms)</th>
<th>Incident Energy (cal/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inactive</td>
<td>40</td>
<td>19.98</td>
<td>240</td>
<td>10.7</td>
</tr>
<tr>
<td>Active</td>
<td>40</td>
<td>19.98</td>
<td>50</td>
<td>2.23</td>
</tr>
</tbody>
</table>

Total Running Load + Transient Load = 5.92 kA

Arctflash Reduction Maintenance Switch Retrofit

Ref. Voltage: 480, Current Scale x10^2
3 cycle breaker
Arc Flash Mitigation
Remote Operation/Control Panel
G&T Device
Ground Studs
Kirk Key Interlocking
Shutters
Lockout/tagout
Maintainability

- Ammeters for Space heaters
- Breaker Test Cabinets
- Split Plug Jumpers
- IR windows
- Partial Discharge Monitors
Breaker Accessories

Breaker Test Cabinet

Split Plug Jumper
Infrared Window
PDM Monitor
Main Tie Main Auto Transfer

- Closed/Open Transition
- Through Relays
- Through PLC
- Scheme example
MTM Scheme Example

MAIN-TIE-MAIN INTERLOCKING AND TRANSFER PROCEDURE

BASIC OPERATION
1. Breaker S2-M1 is closed to supply power to Bus #1 FSR, BCR’s.
2. Breaker S2-M2 is closed to supply power to Bus #2 FSR, BCR’s.
3. Tie BKR, S2-T is open and mechanical interlocks with S2-M1 & S2-M2 breakers. Tie BKR, S2-T cannot be closed unless S2-M1 or S2-M2 is open.

TO TRANSFER BUS #2 TO BKR, S2-M1
1. Open BKR, S2-M2
2. Close tie BKR, S2-T

REVERSE SEQUENCE TO RESTORE SERVICE:
LOAD ON BUS #1 CAN BE SUPPLIED THROUGH BKR, S2-M2 IN A SIMILAR MANNER.

AUTO TRANSFER MODE (CONTROLLED BY 43S/S-R LOCATED IN MCR CONTROL PANEL BUILT BY OTHERS)

SCENARIO 1:
S2-M1=CLOSED, S2-M2=OPEN, S2-T=CLOSE, 43S/S=R=AUTO
Loss of undervoltage sensed by S2-M1 will OPEN S2-M1 & S2-T, CLOSE S2-M2, and RE=CLOSE S2-T.

SCENARIO 2:
S2-M1=OPEN, S2-M2=CLOSED, S2-T=CLOSE, 43S/S=R=AUTO
Loss of undervoltage sensed by S2-M2 will OPEN S2-M2 & S2-T, CLOSE S2-M1 and RE=CLOSE S2-T.

SCENARIO 3:
S2-M1=CLOSED, S2-M2=OPEN, S2-T=OPEN, 43S/S=R=AUTO
Loss of undervoltage sensed by S2-M1 will OPEN S2-M1 and CLOSE S2-T.
Loss of undervoltage sensed by S2-M2 will OPEN S2-M2 and CLOSE S2-T.

SCENARIO 4:
43S/S=R=MANUAL
BREAKER OPERATION IS CONTROLLED MANUALLY THROUGH CONTROL SWITCHES AT MCR CONTROL PANEL BUILT BY OTHERS.
Paralleling SWGR
Application

Single Unit Mains Parallel

- Engine start / stop
- Generator protection
- AMF (auto mains failure)
- Generator control
- Frequency / active power
- Voltage / power factor
- Parallel to mains
- Full Generator Breaker Control
- Full Mains Breaker Control
Applicable Codes and Standards

• ANSI C37.20.2
  – Standard for MV Switchgear
  – Governs ratings and required testing

• NEC
Thank you!