Substation/Enclosed Switchgear/PCC Fundamentals

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PACS Industries
Let’s go Golfing
Swing = Energy
The Water Tank
Voltage
Impulse
Voltage
Nominal Current
Short Circuit Current
Electrical System

• Voltage
  – Steady State
  – Basic Impulse Level (BIL)

• Current
  – Nominal
  – Short Circuit
Dangerous Territory
Electrical Danger

• Electrical Current is Very Powerful
• Any Path to Ground Results in Electrical Current
• Less Than 100mA Can Kill
• Electrical Current Can Jump Between Conductors
• Arc Fault
Arc Flash
Arc Flash
Arc Flash

- Plasma Arc Can be Greater than 35,000 Degrees
- Copper Expands and Vaporizes by a Factor of 67,000
- Arc Blast at 160dB
- Flame, Metal, Smoke and Debris Expel at 600MPH
Arc Flash Boundaries

- Flash protection boundary
- Limited approach boundary
- Any point on an exposed, energized electrical conductor or circuit part
- Restricted approach boundary
- Prohibited approach boundary
- Prohibited space
Arc Flash Boundaries @ 13.8kV
System Model

Utility

Substation

Consumer
Power Grid
Electrical Substation

- Hub on the Power Grid
- Voltage Converter
- Distribution Point
- Link
Substation Components

• Transformer
• Circuit Switches/Breakers
• Command and Control System
• Communication Network
Circuit Breaker
Circuit Breaker
Circuit Breaker-Low Voltage
Circuit Breaker-Low Voltage
Circuit Breaker-Medium Voltage
Circuit Breaker-High Voltage
Circuit Breaker-Extra High Voltage
Command/Control Systems

• Breaker Control
• System Monitoring
• Circuit Protection/Logic
• Feedback
• Metering
Breaker Control
Control Switches
Current Monitoring

MAIN BUS,
13.8KV, 1200A,
60HZ, 3φ, 3W

LINE

LOAD

(3) CT
300:5A
C100

V.C.B.
52-NM
15KV, 1200A

(3) CT
300:5A
C100

52C/S
Current Transformer
Overcurrent Trip
Voltage Monitoring
Potential Transformer
Undervoltage Trip
Electromechanical Relays
Multi-Function Relay
Multi-Function Relay
Communication
Communication Network

- Multiple Communication Loops
- Internal/External
  - Status
  - Health
  - Data Collection
- Copper and Fiber Optic Connection
Communication Network
SCADA

- Supervisory Control And Data Acquisition
- Series of Inputs and Outputs
- Digital
- Analog
- Master CPU or PLC
- Communicates To/From Master Processor
SCADA
Substation Design Criteria

• IEEE/ANSI Standards/Guidelines
  – Equipment and Conductor Clearances
• Transmission 69kV – 765kV
• Distribution 5kV – 35kV
• Overhead Bus and Lines
• Large Sites with Civil Issues
  – Drainage
  – Grounding
  – Steel Foundations
Transmission Substation
Distribution Substation
Switchgear Design Criteria

- IEEE/ANSI Standards/Guidelines
  - Internal Bus Needs Phase to Phase/Ground Clearance
- Medium Voltage 5kV – 38kV
- High Current 1000A – 5000A
- Self Contained in One or More Lines of Cubicles
- Indoor or Outdoor
- Confined Space for Operation
- Metalclad
- Arc Resistant
Switchgear
Switchgear
Switchgear
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Switchgear
Switchgear
Design Considerations

• Space Allocation
  – Sufficient Arc Flash Boundary
  – Work Clearance per NEC
• Controllability
• Accessibility
• Maintainability
• Personnel/Arc Flash Protection
Warning Signs

Arc Flash and Shock Hazard

Flash Protection Boundary: 2.0 ft
Incident Energy: 2.5 Cal/cm²
Working Distance: 18 in
Required PPE Level: 1
Shock Hazard Voltage: 3450 VAC
Limited Approach: 10.0 ft
Restricted Approach: 2.2 ft
Prohibited Approach: 0.0 ft

Equlp. ID: Sub23
Personnel Protective Equipment (PPE)
Special Tools
Special Tools
Arc Resistant Switchgear
Power Control Centers
Power Control Centers
Power Control Centers
Switchgear Construction
Switchgear Construction
Switchgear Construction
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Switchgear Construction
Switchgear Construction
Switchgear Construction
Switchgear Construction
Switchgear Construction
Manufacturing
Manufacturing
Special Tools
PPE
Switchgear
Substations
Protection/Controls
Components
Arc Flash
Voltage/Current

- System Voltage
- BIL
- Nominal Current
- Short Circuit Current
Golf Time