Improving Safety and Reliability via Cost Effective Upgrades of Existing Systems

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Safety Keys

- Nuclear Industry Philosophy: ALARA
  As Low As Reasonably Achievable

- Time

- Distance

- Shielding
Electrical Safety Keys

- **Avoidance** – Minimizing at risk procedures
- **Duration of Fault** - Time
- **Exposure Proximity** - Distance
- **Available Fault Current** - Magnitude
- **Shielding**
Arc Flash Equation Open Air (Above 600 Volts)

- \( E = \frac{(793 \times F \times V \times t_A)}{D^2} \)

- \( E \) = Incident Energy in cal/cm\(^2\)
- \( F \) = Bolted fault short circuit current in kA
- \( V \) = phase-to-phase voltage in kV
- \( t_A \) = Arc Duration in Seconds
- \( D \) = Distance from the arc source in inches
What are the primary reliability interests

- Protection system
- Battery System
- Tripping Circuit
- Breaker & Switchgear Integrity
Labeling

- Front of Gear Mimic
- Protective “One Line” Nameplate
- Descriptive Labels for Components
  - Not just labeling fuse as FU-2 but label FU-2 CB Close Circuit
- Rear Door Labels
Protective Relay Upgrades

- Self Testing
- Trip Circuit Continuity
- Potential Circuit Integrity
- Oscillography and Sequence of Events
Smart Switchgear System

- Operating Distance / PPE
- Substation Monitoring and Notification
- History and Trending
- Diagnostics and Troubleshooting
- Switching Procedures
Alarm History

- Xfmr Fault
- Loss of Control Power
- Fire Alarm
- Ground Fault alarm on HRG
- Upstream breaker opened
- Condensate heaters
Notification

- Alarm window with common alarm to control house
- Email
- Pager
- Cellular Phone
Justification

• Take advantage of the information already available in the IED’s (intelligent electronic device) to create a safer operating environment.
Justification

• Safer substation
  – Less work performed inside the arc flash zone
  – At hand documentation improves technician performance of at risk tasks
  – Visualization of overall substation configuration
    • Mimic
    • Relay settings
    • Annunciator
Justification

• Soft credits based on
  – Faster response to alarms

• Hard credits
  – Less process down using reliability centered vs. time interval based maintenance
  – Less introduced problems due to longer maintenance intervals
  – Less process upsets than burn out / repair
Protective Relay Upgrades

**RESPONSE - TIME**

- Reduced Coordination margins – tighter time overcurrent intervals
- High speed back-up
  - Breaker Fail
  - ‘ZONE’ Interlock
- Add differentials to main bus
- Definite time curves
- Alternate settings for Maintenance or Switching – less compromises
On Line Diagnostics

- **Breaker Timing**
  - First time operation
  - Latch operation
  - Speed

- **Breaker Trip and close Coil**
  - Current vs voltage
On Line Diagnostics

- Xfmr gas and water Analysis
  - Oil Oxidation
  - Water
  - Over heating
  - Turn to turn arcing

- Battery System
  - Cell voltage
  - Plate decomposition
Documentation

- Permitting procedures
- PPE requirements
- Switching orders
- Training modules Safe work practices
- Spare parts inventory
- Instruction Bulletins
- Device “cut sheets”
Elimination of AC Control

- Typical Multiple Cap Trip Units
- Failure Method
- DC Upgrade Power for IED’s:
  - Multifunction Relays
  - Metering
Dc Control Requirements

- Battery System Sizing
- Space Requirements
- Gassing
- Trip and Close Coil Voltage Change
- Other Control Devices
- Disable 27 device
Medium Voltage Circuit Breaker
Replacement Circuit Breakers

- Determine condition before and after maintenance
  - Inspection
  - Trend Analysis
  - Dielectric Testing
  - Mechanical Life

- Circuit Breaker interrupting duty
Circuit Breaker Remote Racking

- Minimum Equipment Modification
- Racking System Must be in Good Condition
- Requires Training to Install and Use Units
Upgrading LV and MV Systems to High Resistance Grounding

- Arc Energy Reduction for Effectively Grounded
- Fault Location for Ungrounded
- Process Ride Through
- Reduced Equipment Damage
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<th>LV</th>
<th>MV</th>
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| **Solidly Grounded** | • Insert resister in Xo  
• Use isolation transformers to support line to neutral loads | • Insert transformer and resister  
• Install zero sequence ct’s and meters  
• Surge arrestors  
• Cable voltage rating  
• Grounded Neutral Cap Bank |
| **Un-Grounded** | • Derive neutral                          | • Derive neutral  
• Install zero sequence meters                          |
Low Voltage
Medium Voltage HRG

TO 2400V OR 4160V SYSTEM NEUTRAL

GROUNDING TRANSFORMER
2400V-120/240V

GROUND RESISTOR

MR

CT 10:5

AM
Low Voltage Derived Neutral
HRG

Diagram showing a schematic of a low voltage derived neutral with various components such as transformers, resistors, and a ground fault circuit interrupter. The diagram includes labels for CT (current transformer) and ground fault connections with specific ratings and configurations.
Medium Voltage Derived Neutral

Diagram showing electrical connections and components such as grounding transformers, a ground resistor, and a CT (Current Transformer) with a ratio of 10:5.
Fixed voltage measurement

- Non Contact voltage confirmation for MV
- MVMCC solution for de-energized circuit
Infrared Ports

- Monitoring without exposure
- Fixed mount for inaccessible high current density location
Existing Facilities can incorporate “Safety By Design” features at Low Relative Cost
The End
Contamination and Aging

- Reliability Center Maintenance
- Climate Controlled Substation
- Anti-Condensation Heaters
- Long Creep Paths
- Thermal Limits
- Mechanism Aging
  - Too many operation – mechanical wear
  - Too few operation – mechanical freezing
Relaying for Selectivity

- Annunciation
- Lockout zones
- Instantaneous protection for bus and transformers - Differentials
Substation Communications

CONTROL - DISTANCE
Ops at “safe” distance

KEY
- 10 BASE T CAT 5 CABLE
- SERIAL COMMUNICATIONS CABLE