Internal Arcing Fault And Protection of Equipment And Personnel

Western Mining Electrical Association

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What is an Internal Arcing Fault
Definition

An unintentional discharge of electrical energy in air within the confines of a switchgear enclosure (IEEE Std C37.20.7-2001)
What is the magnitude of Arcing Fault Current?

- Source of fault current is the Serving Utility, electrical generating devices and large electrical motors
- The SC ratings of medium-voltage circuit breakers are: 12kA, 16kA, 25kA, 31.5kA, 40kA, 50kA and 63kA (2.4kV – 38kV)
- These can possibly the levels of arcing fault current
- LV (below 1000V) circuit breakers may have higher than 63kA SC current rating
What causes an Internal Arcing Fault?
• Gradual Insulation breakdown
• Poor Maintenance and Improper operation of equipment
• Foreign objects, rodents etc
• Overheating
• Mechanical and interlock failures
Effects of an Internal Arcing Fault

- Pressure increase in an enclosed compartment
- Rapid onset (10-15ms), explosive pressure waves
- Thermal effects: hot gases, possibly toxic
- Catastrophic to nearby personnel & equipment
An electrical arc fault is a bad thing!
What are other terms associated with Arcing Fault?

**Arc-flash Hazard:** A dangerous condition associated with the release of energy

**Arc-flash-Protection Boundary:** An approach limit, at a distance from live parts that are uninsulated or exposed within which a person could receive a second degree burn

**Shock Protection Boundaries**
- Limited Approach boundary
- Restricted Approach boundary
- Prohibited Approach boundary
What are other terms associated with Arcing Fault?

**Incident Energy:** The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event (Joules/cm², cal/cm² in CGS system)

**Shock Hazard:** A dangerous condition associated with the possible release of energy caused by contact or approach to live parts
Lee Method to calculate Energy
IEEE Std 1584-2002

\[ E = 5.12 \times 10^5 \, V \, I_{bf} \left( \frac{t}{D^2} \right) \]

- \( E \): Incident Energy (J/cm²)
- \( V \): System voltage (kV)
- \( t+ \): arcing time (sec)
- \( D \): distance from arc point to person (mm)
- \( I_{bf} \): bolted fault current
Lee Method to calculate Flash Protection Boundary

IEEE Std 1584-2002

\[ \text{Db} = [5.12 \times 10^5 \ V \ I_{bf} \ (t/E_B)]^{1/2} \]

- \( D_B \) = distance of the boundary from arcing point (mm)
- \( E_B \) = Incident Energy at the boundary distance (J/cm\(^2\))
- \( V \) = System voltage (kV)
- \( t^+ \) = arcing time (sec)
- \( I_{bf} \) = bolted fault current
Curable burn or second degree burn caused by incident energy (5J/cm², 1.2 Cal/cm²)

- Butane lighter held 1 cm away from a person’s finger for 1 sec and the finger is in the blue flame, a square centimeter area of the finger will be exposed to 5J/cm²
IEEE 1584-2002,

“Guide for Performing Arc Flash Hazard Calculations”

- Provides guidance for the calculation of incident energy and arc flash protection boundaries.
- It presents formulas for numerically quantifying these values.
- The IEEE 1584 Guide also includes an Excel Spreadsheet “Arc-Flash Hazard Calculator” which performs the actual calculations using the formulas stated in the Guide.
Personal Protective Equipment (PPE)  
(Courtesy of Eaton C-H)

- Cumbersome
- Hot
- Reduces Mobility
Solutions that Reduce Arc Flash Injuries and Damage

• **Label Equipment and Train Personnel** (HV signs, safety interlocks, non-load break devices)

• **Reduce available fault current** (High resistant grounding, C.L. Reactors)

• **Clear fault faster** using light sensing/fiber optic high speed tripping relays (50 ms Vs 500ms) and 3-cycle breakers
Solutions that Reduce Arc Flash Injuries and Damage

- Move people further away by using remote racking and remote close and trip using 25 ft long cable and/or using supervisory control
- Redirect blast energy using pressure release vents and plenum
Solutions that Reduce Arc Flash Injuries and Damage

• Prevent Fault by implementing routine maintenance, using fluidized epoxy bus insulation, not overloading and with adequate heating and ventilation)

• Use partial discharge sensing with on-line monitoring as preventive diagnostics
Remote Racking of MV Breakers
(Courtesy of Eaton C-H)

Remain physically outside the flash protection boundary. Therefore NO ARC FLASH HAZARD protection required!
Universal Remote Power Racking RPR-2 (Courtesy of Eaton C-H)
Arc-Resistant Switchgear
BushingGard (InsulGard G2)  
(Courtesy of Eaton C-H)

- Monitor Xfmr Bushings
  - Capacitance
  - Power Factor
InsulGard
(Courtesy of Eaton C-H)

• Monitor Insulation Integrity
  – Switchgear
  – Generators
  – Motors
InsulGard Relay – PD Monitoring
(Courtesy of Eaton C-H)

Shown Installed on front door

Shown Installed inside the compartment
Safety Related Solution Offerings
(Courtesy of Eaton C-H)

- Infrared Scanning Windows for LV/MV Assemblies
References

• NFPA 70E-2000, Electrical Safety Requirements for Employee Workplace
• NFPA 70-2002, National Electric Code
Questions?
DaveGohil@AZZ.com
Thank you!