Internal Arcing Fault And Protection of Equipment And Personnel

Western Mining Electrical Association

June 8, 2006

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 compart
- 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?

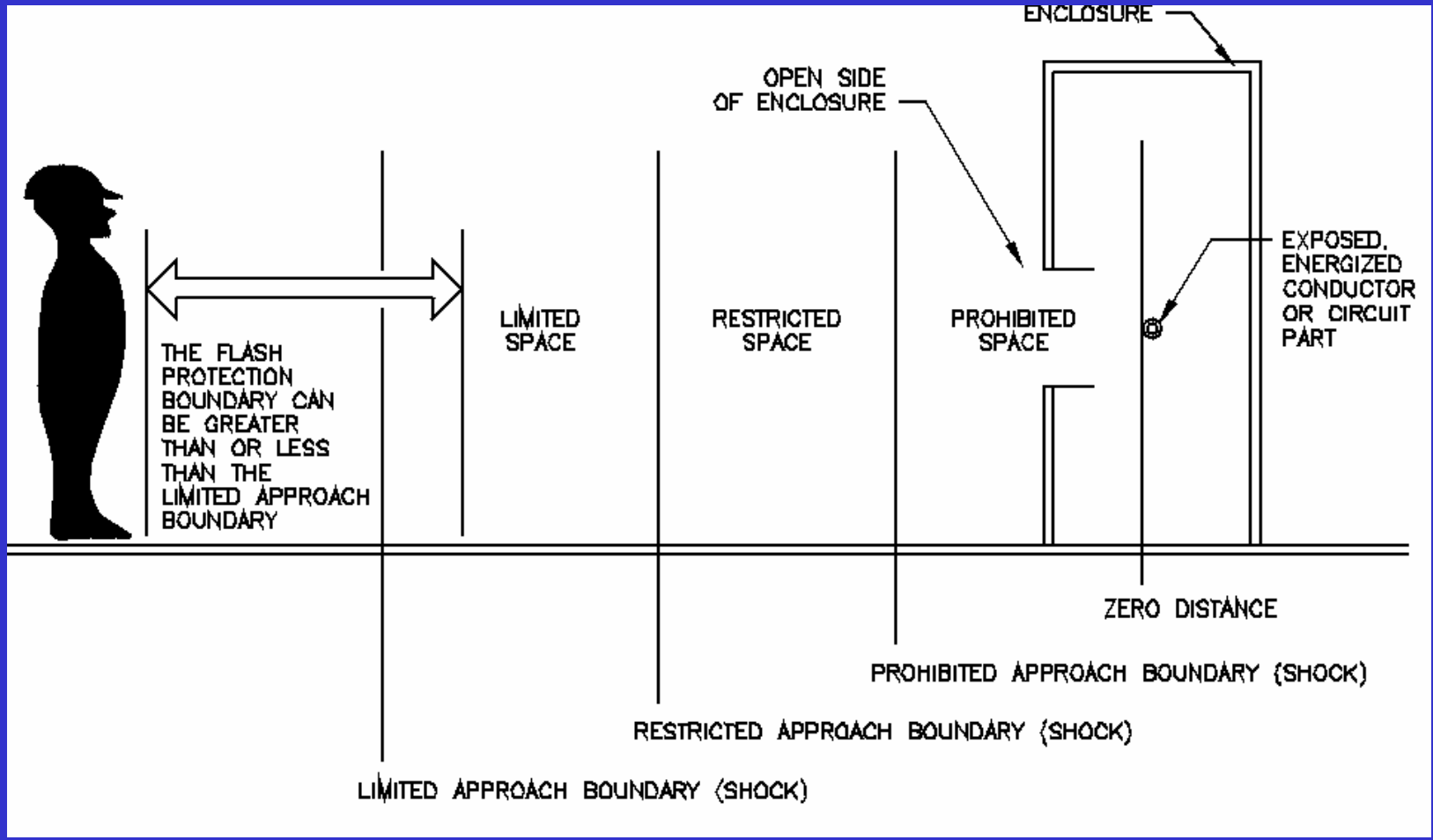
Arc-flash Hazard: A dangerous condition associated with the release of energy

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

Flash Boundaries



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/cm^2, cal/cm^2 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

$E=5.12 \times 10^5 V I_{bf} (t/D^{2)}$

E= Incident Energy (J/cm^2)

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

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

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/cm^2, 1.2 Cal/cm^2)

- 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/cm^2

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

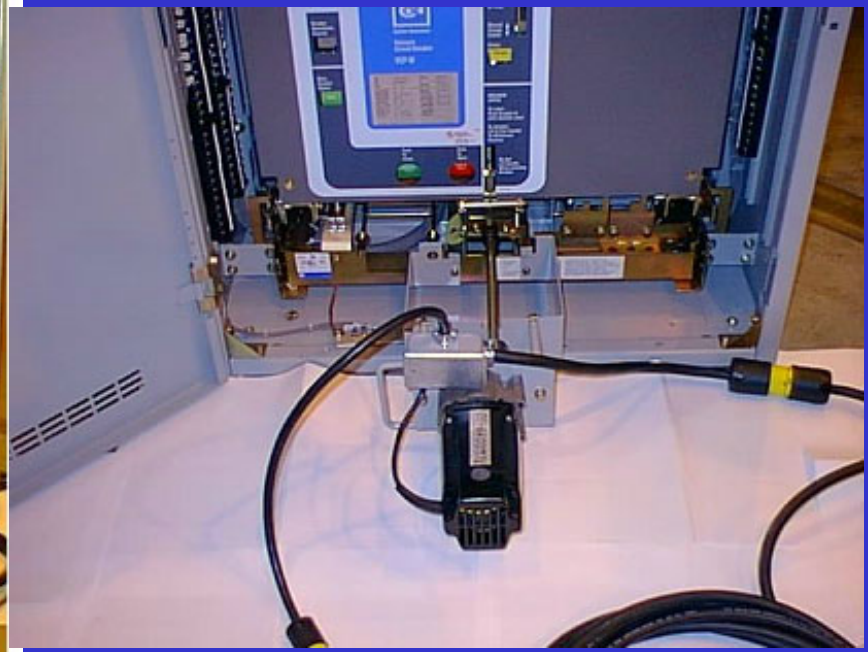
Solutions that Reduce Arc Flash Injuries and Damage

- 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)

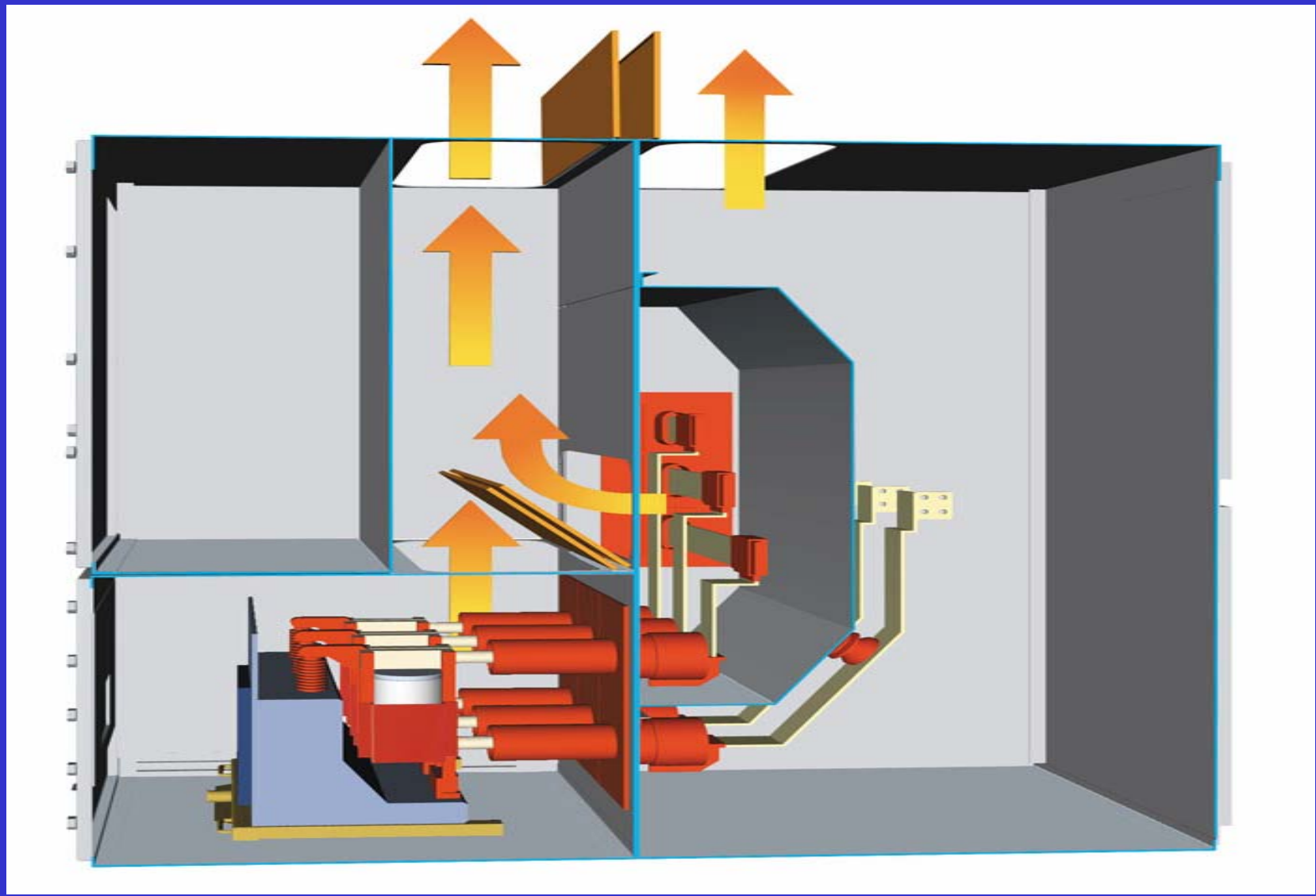


Remain physically outside the flash protection boundary. Therefore NO ARC FLASH HAZARD protection required!

Universal Remote Power Racking RPR-2 (Courtesy of Eaton C-H)

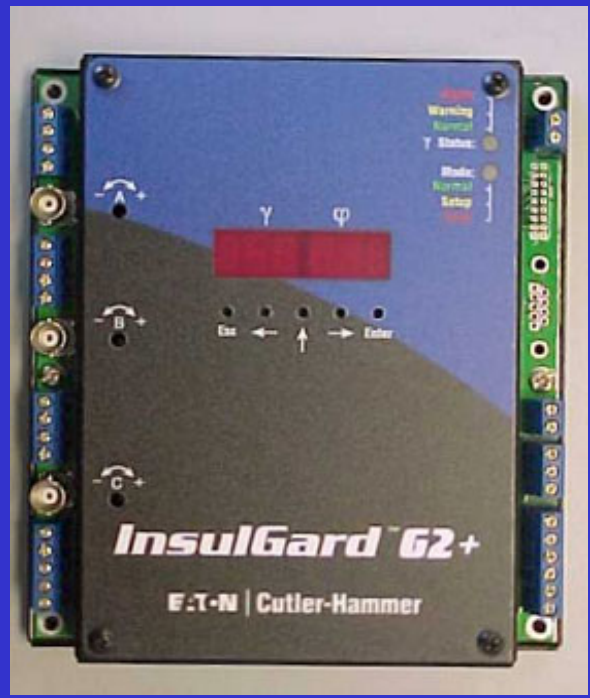
VS.

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

- IEEE Std 1584-2002, IEEE Guide for performing Arc-Flash Hazard Calculations
- IEEE Std C37.20.7-2001, IEEE Guide for Testing Medium-Voltage Metal-Enclosed Switchgear for Internal Arcing Faults
- NFPA 70E-2000, Electrical Safety Requirements for Employee Workplace
- NFPA 70-2002, National Electric Code

Questions?

DaveGohil@AZZ.com

Thank you!