Arc Flash Hazard and Electrical Safety

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Introduction

• Arc Flash
  – Arc flash is a sudden release of heat and energy caused by an electric arc.
  – The result of the violent event can cause destruction of equipment, fire, and injury not only to the worker but also to nearby people.
Introduction

- Arc Flash
  - 3-phase Arc in the Open Air

- Cloud of hot gas
- Plasma "dust" (CuO smoke)
- molten droplet shower

arcs driven away from source of supply by magnetic forces
### Risk Category

- **Risk Category**

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Maximum cal/cm²</th>
<th>Clothing Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>[&lt;1.2]</td>
<td>Natural fabric, 4.5+ oz/yd²</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>FR shirt/pants or FR coverall</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>FR shirt/pants or FR coverall</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>FR shirt/pants or FR coverall &amp; flash suit</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>FR shirt/pants or FR coverall &amp; flash suit</td>
</tr>
</tbody>
</table>

0 – 4 Safety glasses/goggles, Hearing protection
1 – 4 Hard hat, Leather gloves, Face shield/flash suit hood
2 – 4 Leather shoes
Personal Protection Equipment

- Risk Category
  - Sample PPE

Source: http://GraphicProducts.com
IEEE 1584-2002

- Available Configurations

Source: IEEE Std. 1584-2002
Important Factors to be Considered

- Bolted fault current level.
- Duration of the arc.
- Voltage level.
- Electrode Orientation/Configuration (VCB, VCB-Barrier, HCB, VOA, HOA).
- Gap width between electrodes.
- Calorimeter arrangement and measurement locations.
- Distance between electrode and back panel*.
- Dimensions of the metal enclosure**.
Available Configurations for the Proposed New Model

Vertical Electrodes in the Cubic Box
Electrodes are Terminated in the Middle of the Box (VCB)

Vertical Electrodes in the Cubic Box
Electrodes are Terminated at the Bottom of the Box (VCBB)
Available Configurations for the Proposed New Model

Vertical Electrodes in the Open Air (VOA)

Horizontal Electrodes in the Open Air (HOA)
Available Configurations for the Proposed New Model

Horizontal Electrodes in the Cubic Box (HCB)
Observation from the Testing

- Plasma Trajectories for Horizontal (HOA) and Vertical (VOA) Configurations
Observation from the Testing

- Plasma Trajectory for Vertical (VCBB) Configuration
Newly Developed Iarc, IE, Arc Flash Protection Boundary Calculator
Non-Thermal Related Hazards
Sound

- Peak Sound Pressures for Medium-Voltage (2700V) Testing Series.
- Hearing protection should be included as part of PPE.
Light

- Recorded light intensity level in lux at 3m, 4.5m and 6m from the arcing point.

Typical bright sunlight is around 110K lux
Pressure

- Sample results of pressure measurement
  - The estimated pressure reached 0.715 psi (103 lbs/ft$^2$) at the working distance of 18”
Something That Calorimeter Can Not Measure

- Face Shield is Recommended for Environment that Arc Flash May Happen

Copper on the surface of the insulation Board of the calorimeter

Lens was damaged by the melted copper. (10 feet from the arc point)
Simulation of DC Arc Flash
DC Arc Flash Simulation

- System Voltage: 480V, Bolted Faulted
- Current: 21744A, Gap: 25.4mm

<table>
<thead>
<tr>
<th>Description</th>
<th>Arc Current (Amps)</th>
<th>Arc Voltage (Volts)</th>
<th>Arc Power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEMA Arc Test</td>
<td>15.81</td>
<td>131</td>
<td>2.071</td>
</tr>
<tr>
<td>Theoretical Method (Maximum Power Method)</td>
<td>10.872</td>
<td>240</td>
<td>2.609</td>
</tr>
<tr>
<td>Iterative Method (Stokes and Oppendlander)</td>
<td>16.89</td>
<td>107.25</td>
<td>1.811</td>
</tr>
<tr>
<td>MHD Simulation</td>
<td>16.00</td>
<td>126.76</td>
<td>2.028</td>
</tr>
</tbody>
</table>

Faraday Cage Arc Flash Test

Electrode

Gap

Lorentz Force
Thank You !!!