Schneider Learning Series

Arc Flash Safety
Ensuring protection from arc fault incidents

Mining, Minerals and Metals
Presenters

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Please ask your questions throughout the presentation in the chat and we will aim to answer them at the end of the webinar
Agenda

1. What is Arc Flash?
2. What are the causes & consequences?
3. Norms & standards
4. How to reduce the risk of Arc Flash event and its consequences?
What is Arc Flash?
Why should we care about Arc Flash?

Electrical hazards cause more than **300 deaths** and **4,000 injuries** in the USA alone each year.

Electrical injuries are the **2nd most costly** worker’s compensation claim.

Electrical accidents rank **6th** among all causes of **work-related deaths** in USA.


Mining electrical fatality is **x4 bigger** than average fatality rate in USA.

Electrical accident holds **#4 position** in mining fatality in 2018 in USA.

Sources:
- Electrical Safety Foundation International (ESFI)
- Liberty Mutual Research Institute
- Review of Accident/Incident and Process Monitoring/Observation in Steel Plant (2018). 1,2SKS Institute of Technology and Science
- https://wwwn.cdc.gov/NIOSH-Mining
Arc Flash incidents

Why such a drama?

• Poor preparation of the intervention?
• Dropped tools or parts inside the cubicle?
• Improper use of tools?
• Improper handling?
• Procedures respected?
• Skills / know-how of electricians?
• State of electrical installations?
• Work environment?
• Right PPE?
• …
What is Arc Flash?
Definition of Arc Flash Hazard

“A source of possible injury or damage to health associated with the release of energy caused by an electric arc”

NFPA 70E – USA standard for electrical safety in the workplace

- **Arc:** Circulation of an electric current in the air
- **Flash:** Energy release associated with intense light
- **Risk:** Dangerous situation in the vicinity of an arc

**Where:** Connection or connection point or bare part

**When:** Arc Flash risk is linked to operations near energized parts (equipment with doors open)

**Point of attention:** Arc Flash is not the same phenomenon as internal arc withstand consideration
What are the causes & consequences?
Causes of an Arc Flash incident

Why?
- Aging of insulation, breakage of equipment, ...
- Vibration at connections, cable tightening problem, over-voltage
- Impact of dust, water, corrosive environment, animals
- Human errors: dropped tools or parts (screwdriver, screws, ...), improper use of tools or improper handling, procedures not / poorly followed (lock-out / tag-out, ...)

When?
- At any time due to aging
- In the event of abnormal operation (i.e. high temperature)
- On installation & commissioning
- During maintenance operations
- When working on other equipment (i.e. crushers) requiring operation of electrical equipment (circuit breakers, etc.) before

Where?
- UPS (batteries)
- Motors
- Transformers
- Distribution busbar
- LV circuit-breaker
- Busbar
- Arms & contacts
- TC / Cables
Consequences of an Arc Flash on MV switchgears
Consequences of an Arc Flash on people

- Death or very serious injuries
- Arc flash will kill up to distances of 3 m
- Burns (3rd degree) or death caused by the energy of the arc radiation and projection of molten metal. This is equivalent to a fireball (t°C ~ 20,000°C)
- Exposure to these extreme temperatures burns the skin and causes clothing to catch on fire
- Eye damage or glare caused by light intensity (flash)
- A risk of damage or loss of hearing due to noise and shock wave pressure (sound wave of about 165 dB)
- Injury from inhaling toxic fumes (vaporization of copper)
- Heated metal is expelled away from the arc at speeds exceeding 900 km/h
How much can an Arc Flash event cost?

- **Medical Costs**: Treatments for severe burns require an average of 1.5 days in the hospital per percentage of body burned: **1.3 M€ per injury**

- **Worker’s Compensation**: Injuries from arc flash can put employees off work for a year or more: **50,000 € per injury**

- **Legal Costs**: Legal costs after an arc flash event average in the millions and become higher based on incident severity: **15 M€ per incident**

- **Lost Production**: Following an arc flash incident, the facility can be shut down for days for cleanup and repairs: **Up to a week of lost production**

- **Damage & Losses**: Arc flash incidents are often extremely damaging to equipment and to the facility itself.

- **Regulatory Fines**: Arc flash incidents often result in fines for overlooked safety violations: **Tens of thousands of Euro**
Norms & standards
The National Fire Protection Association (NFPA) in the USA which refers in terms of Arc Flash risk, has defined NFPA 70E safety rules:

- obligation to carry out a risk analysis and to equip oneself accordingly against the thermal effects of arc faults
- the goal is to protect against the risk of 2nd degree burns
- method of calculating Arc Flash Incident Energy (AFIE) - in cal/cm² - and safety boundaries
- 4 categories to classify this risk and to inform users of the protection they need

OSHA pushes the NFPA70E standard and the NEC240.87, defining the means of protection against the risk of arc faults. US companies established abroad begin to apply this standard.
NFPA70E defines 4 categories of Personal Protective Equipment (PPE) based on Incident Energy

<table>
<thead>
<tr>
<th>Category</th>
<th>Arc Flash PPE Rating [Cal/cm²]</th>
<th>PPE minimum Arc Rating [kJ/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat 1</td>
<td>4 / 167.5</td>
<td></td>
</tr>
<tr>
<td>Cat 2</td>
<td>8 / 334.9</td>
<td></td>
</tr>
<tr>
<td>Cat 3</td>
<td>25 / 1046.7</td>
<td></td>
</tr>
<tr>
<td>Cat 4</td>
<td>40 / 1673.7</td>
<td></td>
</tr>
</tbody>
</table>

*ATPV: Arc Thermal Performance Value
Norms & Standards

Arc-Flash Incident Energy (AFIE) in cal/cm² at the arc location is closely linked to the effects and consequences for the nearby workers.

- **Intensity** - How much power the arc has: this is calculated using the system voltage, the equipment design structure, and the maximum prospective fault current.

- **Distance** - How close to the arc source workers can be: also known as the working distance.

- **Duration** - How long the arc will last: this is why it is important that the protection system and protective device tripping times are set in an optimized manner.

The formula for calculating AFIE is given by:

\[ E = 4.184C_f E_0 \left( \frac{t}{0.2} \right) \left( \frac{610^6}{D^2} \right) \]

\[ E = 2.142 \times 10^6 V_f \left( \frac{t}{D^2} \right) \]

Can be difficult to modify

Often a “Selectivity vs PPE” trade-off to decide on
Reduce Arc Flash Incident Energy

Need for an ultra-fast arc flash protection

Variation of the damages according to the fault clearing time (35ms, 100ms, 500ms)

Conventional protection system of MV/LV switchgear

- Earth-fault relay operation time
- Circuit-breaker tripping time

Typical arc duration: 130...450 ms depending on arc fault location

Ultra-fast Arc Flash protection

- AF Protection Relay
- Circuit-breaker tripping time

Arc interruption time < 80 ms minimizes risk of operator injuries and destruction of switchboard

Typical arc duration: 50...80ms
### Examples of required Personal Protective Equipment (PPE)

<table>
<thead>
<tr>
<th>Incident Energy in cal/cm²</th>
<th>1,2</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>25</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPE Category</td>
<td>1</td>
<td>2</td>
<td></td>
<td>3</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

**Protective Clothing Characteristics from Table 130.7(C) (16) of NFPA 70E**

**Arc-Rated Clothing**
- Arc-rated long-sleeve shirt and pants or arc-rated coverall
- Arc-rated face shield or arc flash suit hood
- Arc-rated jacket, parka, rainwear, or hard hat liner (AN)

**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating**
- Arc-rated long-sleeve shirt (AR)
- Arc-rated pants (AR)
- Arc-rated coverall (AR)
- Arc-rated arc flash suit jacket (AR)
- Arc-rated arc flash suit pants (AR)
- Arc-rated arc flash suit hood
- Arc-rated gloves
- Arc-rated jacket, parka, rainwear, or hard hat liner (AN)

**AN**: As needed (optional), **AR**: As required, **SR**: Selection required.
Arc Flash Phenomenon – Safety boundaries

Arc Flash Boundary - when an Arc Flash exists, distance limit out of which a worker would be exposed to “only” a curable 2\textsuperscript{nd} degree skin burn (i.e. around 1.2 cal/cm\(^2\) for 1s exposure, according to the Stoll model)

Note: other safety boundaries exist as per local country electrical safety codes. They usually depend on the system voltage and their access is linked to the qualification level of personnel
How to reduce the risk of Arc Flash event and its consequences?
Customer Challenge
• 1 fatality on a site due to Arc Flash: this is unacceptable!
• 70% of electrical installations in Europe are ageing and operators (employees and sub-contractors) are exposed to Arc Flash hazards when operating those equipments

Solutions
• Safety program at +50 sites in Europe targeting the main electrical risks and identifying the highest priority interventions
• Deep assessment supporting operations at the plants in understanding Arc Flash risks with a strong focus on:
  - determining the **Arc-Flash Boundaries**
  - predicting the **Arc-Flash Incident Energy** of the electrical equipments
  - helping the sites to select **which Personal Protective Equipment (PPE)** to use
  - proposing concrete solutions to **mitigate Arc Flash risks** at the plants

Customer Benefits
• Consistent approach and methodology with safety recommendations across all European sites
• Increased safety awareness of operators on sites
• More effective electrical safety at the production facilities

The Results: Life Is On with...
+50 sites deploying Arc Flash assessments in Europe to run operations with zero harm to people which is a core value of this customer
Some best practices to consider*

1. Technical analysis / Consulting
2. Trainings
3. Maintenance Practices
4. Modernization
5. Protection Relays
6. Thermal & Ambient Monitoring
7. Remote operation capabilities

* non exhaustive list
If you or your staff cannot currently get to site, why not consider using their time at home to learn new skills?

We have a range of safety e-learning programs that cater to every need. As well as theoretical learning formats, they allow learners to experience real life situation such as implementing arc flash process during operation, thanks to Serious Game.
Join more than 55,000 other e-Learners and take one of our Electrical Distribution courses, focusing on:

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Arc Flash Prevention

Click here for a demo

Worldwide, 3 languages

Electrical Crisis Management

Click here for a demo
Remote training

Register to our e-Learning programs, as well as remote training webinars and in class, in your Training Services Portal:

se.com/training

For a more global approach, just get back to F. Loctin
Want to learn more on Arc Flash?
Get a complimentary two-week access to our 3D training
“Arc Flash, a Serious Game”
(available only to participants to this webcast)
As a conclusion

• Arc Flash is a proven risk that can be fatal to people and installations - to be very seriously taken into consideration in Mining, Minerals and Metals industries

• Arc Flash risk analysis is still poorly regulated but highly recommended in industries such as Mining, Minerals and Metals

• Consider Low Voltage equipment also and not only Medium Voltage equipment

• Start your journey with se.com/training
Q&A

Please type your questions into the chat, we will try to answer as many as we can.
Useful « Arc Flash Solutions » links

➔ Arc Flash Protection
➔ MV & LV Arc Flash Protection Relays