T104 - Arc Flash Hazards and Arc Resistant Equipment- Understanding the Standards
Agenda

1. Background
2. Related Electrical Safety Standards
3. Arc Resistant Equipment Rating Basics
4. Field Implementation of Arc Resistant Equipment
5. Minimizing Exposure to Arc Flash Hazards
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Arc Flash & Arc Blast

- Intense Heat
- Up to 35,000°F/19,500°C
- Molten Metals
- Shrapnel
- Intense Light
- Sound/Pressure Waves (Expansion rate 67,000 times)
Summary of Electrical Hazards

- **Electrical Shock**
  - When electrical current enters and exits the body – through a conductive path

- **Arc Flash**
  - The conditions associated with the energy released by an electric arc
    - Includes a broad spectrum of electromagnetic energy, heat, plasma, smoke & a spray of molten materials

- **Arc Blast**
  - The pressure wave caused by the expansion of gases and conducting materials within the flying molten materials
Why the interest?

- Workers are still injured or killed each year by arc flash events while working on or near energized equipment.
- Many of these casualties are as a result of burn injuries related to the arc flash event.
- Unfortunately, working on energized equipment still is commonplace in many industries.
- Some still ignore the need for proper personal protective equipment (PPE).
Why is there such focus on Electrical Safety?

Injuries and Fatalities Associated with Electrical Hazards

- Electrocution is the third leading cause of workplace fatalities in the USA
- Electric Shock and burns are still a leading cause for lost time
  - [Arc flash injuries are counted as burn Injuries]
- ~2,000 workers are treated in specialized burn trauma centers each year as a result of reported Arc Flash injuries.
- ~every 40 minutes, a worker suffers an electrical injury that requires time-off work!

Information that is derived from Industry Surveys, the NFPA, ESFi, The National Safety Council, Bureau of Labor Statistics and CapSchell, Inc.
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Agencies & Standards that Govern Electrical Safety

- **OSHA Requirements**
  - The general guidelines & enforcement policies

- **NFPA 70®**
  - Guidance for the proper installation & wiring of equipment

- **NFPA 70E**
  - Protection from electrical hazards in the workplace

- **IEEE Standards Association**
  - Consensus standard development
State and Federal Regulations

- Occupational Safety & Health Act – USA
  - OSHA 1910 Subpart S
- Electrical Safety Related Work Practices
  - Title 29 (CFR), Part 1910.331 → .335
- Design Safety Standards for Electrical Systems
  - Title 29 (CFR), Part 1910.302 → .308

In Canada:
- Provincial Occupational Health & Safety Acts
- Each individual Canadian Province has their own act
  - No common act across the whole country
Installation Codes & Standards

National Electrical Code (NEC)- 2017 (NFPA 70)

Canadian Electrical Code (CEC) - 2015 (C22.1)

- Electric codes and other safety codes are primarily concerned with protection from fire, electrocution and shock hazard
- Arc flash hazards first introduced in 2002 editions
- On-going refinements have improved these standards regarding arc flash
- Now contain direct links to other safety standards like NFPA-70E and Z-462
NFPA-70E

- First published in 1979 as “NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces”
- 2004 (seventh edition), name changed what we know today
- Now updated on a 3-year cycle
So what’s changed in NFPA-70E 2018?

- The 2018 edition is now in effect... previous editions become obsolete
- So what’s changed...
  - A modified arc flash hazard identification table 130.7(C)(15)(A)(a)]*
    - Easier to determine the likelihood that an arc flash could occur
  - Article 120 reorganizes the requirements for establishing an electrically safe work condition in a logical order of application
  - Article 320 introduces voltage thresholds of 100 Vdc for batteries and battery rooms to cover unique battery situations
  - Article 330 extensively revised to focuses on safety-related issues for laser-based systems
So what’s changed in NFPA-70E 2018?

- Term- “Second degree burn” has been removed and replaced with “at which the incident energy equals 1.2 cal/cm\(^2\)” (Stoll Curve)

- The 2015 edition stated that when the incident energy exceeded 40 cal/cm\(^2\) that “greater emphasis was needed for de-energizing”
  - Has been deleted and replaced with a strong emphasis being placed on de-energizing at all times!
  - This does not only apply to 40 cal/cm\(^2\) and above

- And hundreds of smaller changes/revisions*
  - Previous references may be different now!
Canadian Electrical Safety Standard - CSA Z462

- CSA-Z462 was originally developed in parallel with and harmonized to NFPA 70E-2009
- Directly referenced in the Canadian Electrical Code (CEC) and is consistent with OSHA data

Z462-15 aligned to NFPA 70E-2015
Z462-18 to be available in early 2018
Understanding the Regulatory Framework in the USA

- Interplay between OSHA's electrical safety regulations, the NEC, and NFPA-70E should be the basis of your electrical equipment systems and safety programs.

- OSHA's electrical safety regulations draw heavily on the consensus standards like NFPA-70 (NEC) and NFPA-70E, but there are some important distinctions.

- Compliance with the NEC and NFPA-70E does not always equate to full compliance with all OSHA regulations!

OSHA 1910 Subchapter S = “Shall”

NFPA-70E = “How & When”
How are OSHA and NFPA-70E linked?

- “…Industry consensus standards can be evidence that there is a hazard for which PPE is "necessary." While the NFPA 70E consensus standard has not been adopted as an OSHA standard, it is relevant as evidence that Arc Flash is a recognized hazard and that PPE is necessary to help protect against that hazard….” OSHA

- “…A flash hazard analysis shall be done to help protect personnel from the possibility of injury by an Arc Flash. The analysis shall determine the Flash Protection Boundary and the Personal Protective Equipment that people within the Flash Protection Boundary shall use…” OSHA & p/o. NFPA-70E

Failure to help protect workers will result in OSHA using its authority to prosecute to the fullest extent of the law, based on these premises.
What is Needed for Full Compliance?

- A well written and audited electrical safety program
  - Policies and procedures aligned to the standards
  - Electrical safety training program
- An arc flash assessment per NFPA-70E-2018 sec. (130.5)
- Tasks involving an arc flash hazard
- Proper equipment installation & maintenance/records (Ref NFPA-70B)
- Clearly defined methods to identify electrical hazards
  - Labeling, color coding, pictograms, etc.
- Proper electrical personal protective equipment based on the arc flash assessment
Compliance Requirements in NFPA 70E-2018

- Your Electrical Safety Program must be audited at intervals not to exceed 3 years
  [70E-2018, Sec. 110.1(K)(1)]*

- Safety Retraining and Assessments for all electrical workers every 3 years or less *
  [70E-2018, Sec. 110.2(A)(3)]

- Arc Flash Risk Assessments (Study) at intervals not to exceed 5 years*
  [70E-2018, Sec. 130.5(2)(f)]

* You must be able to prove compliance to these points if OHSA audits your sites
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What is Arc Resistant Equipment?

- Controls the exposure and release of the dynamic elements associated with an arc flash/blast event
- Capabilities defined by how;
  - The arc flash elements are extinguished or controlled
  - The equipment helps prevent serious injuries to personnel
  - The equipment helps prevent propagating of the event
- Generally, protection applies only when all equipment doors are closed and latched
  - Our MV ArcShield™ products provide an enhanced level of arc resistant capabilities
- Testing must be done to validate the level of protection
- Defined by the Accessibility Level, for example, Type 2B
Common Arc Resistant Testing Guides & Standards

- **CSA C22.2 NO. 0.22-11** “Evaluation Methods for Arc Resistance ratings of Enclosed Electrical Equipment”
- **EEMAC G14-1-1987** “Procedure for Testing the Resistance of Metal-Clad Switchgear under Conditions of Arcing Due to an Internal Fault”
- **IEC 62271-200:2011** “AC Metal-Enclosed Switchgear and Controlgear for Rated Voltages Above 1 kV and up to and Including 52 kV”, Annex A - Internal Fault
- **IEC 61641-2014** “Enclosed low-voltage switchgear and controlgear assemblies – Guide for testing under conditions of arcing due to internal fault”
- **IEEE C37.20.7-2007** "IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults"

Many global guides, procedures and standards are available for AR equipment testing.
IEEE C37.20.7-2007 Testing Guide

IEEE C37.20.7-2007 “IEEE guide for testing metal-enclosed switchgear rated up to 38 kV for internal arcing faults”

• Primarily a medium voltage testing guide
• Expanded to include some low voltage switchgear components
• Defines test criteria and compliance assessment
• Defines the levels of Arc Flash protection
• Sets expectations of arc resistance performance related to the interaction with personnel

IEEE C37.20.7-2007 is the most recognized North American Testing Guide that applies to MV and some LV equipment
Advantages of Arc Resistant Equipment-NFPA 70E-2018 compliance

- Table 130.7(C)(15)(A)(b)- ref. Arc Flash PPE Category

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Arc-Flash PPE Category</th>
<th>Arc-Flash Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arc-resistant switchgear 1 kV through 15 kV [for clearing times of less than 0.5 sec (30 cycles) with an available fault current not to exceed the arc-resistant rating of the equipment], and metal-enclosed interrupter switchgear, fused or unfused of arc-resistant-type construction, 1 kV through 15 kV</td>
<td>N/A (doors closed)</td>
<td>N/A (doors closed)</td>
</tr>
<tr>
<td>Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)</td>
<td>4 (doors open)</td>
<td>12 m (40 ft)</td>
</tr>
<tr>
<td>Other equipment 1 kV through 15 kV</td>
<td>4</td>
<td>12 m (40 ft)</td>
</tr>
</tbody>
</table>

Recognition of AR equipment began in the 2012 edition…
Now fully defined in 2018!
Arc Resistant Rating Basics

- So how do you know what rating is the correct rating for your system?
  - Consider the short circuit current level at the point of the equipment’s use, your arc flash assessment (study) will give you this info

- How long do you think your system can sustain an arcing fault?
  - Longer the time = greater release of energy
  - Longer the time = higher degrees of internal damage

- A complete arc flash assessment, including a coordination study, provides the incident energy levels (data for labeling)
Items to Consider When Writing Your Specifications for AR Equipment

- Duration Rated or Device Limited?
- What arc current rating and what duration do you need?
  - 20kA- 100ms, 30kA- 200ms, 40kA- 500ms, 50kA- 500ms…etc.
- What Accessibility Type works best for your Safety Program?
  - Type 1, 2, 2B, etc.
- Will there be a mix of equipment from various vendors?
- Can I still get top & bottom entry cables?
  - Some vendors cannot support both
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Arc Resistant Installation Considerations

- More preparatory planning required
- Where is the equipment to be installed?
  - Existing or new room/building?
  - Overhead clearances required?
- For MV equipment, overhead clearance required to accommodate arc plenums or arc ducting system-duct outside or inside?
  - Are there existing cables, conduits or HVAC ducting in the area?
  - Will there be non-arc resistant equipment in the same area?
  - How will the differences be identified to workers?
Arc Resistant Installation Considerations

- Has your contractor ever installed arc resistant equipment before?
  - Make sure your installation specifications outline the equipment design and installation requirements
  - Inform your contractor that no holes can be cut without approval
  - Verify all cover plates are reinstalled per the manufacturers recommendations
  - Do not compromise the safety integrity of your investment!
  - Audit the final installation (req. NFPA-70E-18)
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Are the Standard & Equipment Changes Making an Impact?

Fatal

Non-Fatal

Number of fatal electrical injuries, by Event Code, all ownerships, 1992-2015

Number of nonfatal electrical injuries, by Event, Private Industry, 1992-2015

How can Rockwell Automation support your needs?

- Rockwell Automation can also provide comprehensive services to assess and enhance the Arc Flash Safety within your facilities
  - Arc Flash Risk Assessments
  - Power System Coordination Studies
  - Electrical Hazard Risk Assessments
  - Field Labeling Review/Implementation
  - Mitigation/Re-Engineering Services
  - Arc Flash Program Agreements
  - Training & Maintenance Agreements

For more information, visit our Services & Support Booth
NEMA ArcShield™ MV MCC Arc Resistant Controls (to 7.2 kV)

- Tested to IEEE C37.20.7
  - 40kA or 50 kA (@ 7.2 kV), for ½ second
  - Type 2B Accessibility
    - Protection maintained even with LV doors open
    - Personnel are shielded at the front, rear and sides of enclosure

Broader Range of MV Arc Resistant Control Products compliant to IEEE C37.20.7 Type 2B accessibility level
OneGear™ IEC Arc Resistant Controls Medium Voltage Soft Starters to 15 kV

- OneGear IEC 15 kV Controlgear
  - Arc resistant to IEC 602271-200
  - 31.5 kA @ 14.4 kV, ½ sec.
  - Accessibility- AFLR

IEC arc resistant products for your global requirements
Arc Resistant Medium Voltage ASD

- First AR MV Drive with full regeneration capabilities
- Tested to IEEE C37.20.7
- 40kA or 50kA arc resistant systems available
- Up to 7.2 kV rated

Our newest arc resistant product
ArcShield NEMA and IEC Low Voltage Motor Control Centers

- **CENTERLINE® 2100 Low Voltage NEMA**
  - First arc resistant NEMA low voltage MCC
    - IEEE C37.20.7 **Type 2** Accessibility

- **CENTERLINE 2500 Low Voltage IEC**
  - Personnel and assembly protection per,
    - IEC 61641:2008
    - IEC/TR 61641, Edition 3.0 2014
Bulletin 857/865 Protection Systems

- Bulletin 865
  - Differential Protection System
- Bulletin 857
  - Motor/Feeder Protection System
- Both available with an available Arc Flash Detection option
  - Combined optical and current signature sensing technology
Minimize Exposure with ArcShield & IntelliCENTER® Technology

Monitor, configure & troubleshoot remotely

- Enhanced network capabilities
- EtherNet/IP based
- IntelliCENTER software allowing for remote monitoring, configuring and troubleshooting remotely - No need to be near the equipment
Summary

- These standards, regulations and arc resistant control products are **Enhancing Personnel Safety, creating a safer work environment for all!**
- Ultimately we are reducing the number of injuries and fatalities caused by electrical hazards!

Rockwell Automation has the products, the technical knowledge, the global teams and infrastructure to help you with all of your safety and automation needs no matter where you’re located!
Thank You!

Let us tell you more about our complete line of arc resistant equipment solutions!

Contact your local Rockwell Automation sales office or distributor for more details.
Summary - some references

- Sound Safety principles in action
- Arc Flash/Blast are explosive events
- 4X hotter than the sun
- Sources >125 KVA = greater risk
- 480V @ 10kA fault = 8 sticks of TNT
- Employees need to be educated of the risks
- Your electrical equipment must be labeled and maintained
- You must perform an arc flash risk assessment per NFPA 70E-18, ref: sec.130.5
- Reducing time and increasing space
- The right equipment installed the correct way
- To err is human!
Some Milestones in History

- 1897—The National Electrical Code created
- 1956—Dalziel and electric shock research completed
- 1969—Burn research—Stoll Curve developed
- 1970—OSHA legislated into effect in USA
- 1976—NFPA 70E first published
- 1982—Arc flash and Ralph Lee’s paper reviewed
- 1995—NFPA 70E first references arc flash added
- 2000—NFPA 70E PPE requirements and hazard risk tables
- 2000—Incident energy calculations developed
- 2002—IEEE 1584 first version is published
- 2002—NEC and arc flash warning labels defined
- 2007—NESC—Arc flash and electric utilities standards
- 2009—NFPA 70E additional defined label requirements
- 2015—Removal of level 0 PPE
The steps for proper labeling?

1. Obtain **ALL** Cable, Feeder & Load Equipment Data
2. **Power System Coordination Study**
   - **Arcing Fault Currents (Incident Energy)**
   - **Device Operating Times**
3. **Short Circuit Fault Study**
4. **Arc Flash Study** (IEEE 1584 or similar)
5. **3 Phase Bolted Fault Current**
6. **Data for Creating Arc Flash Labels**
Thank You!