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#355 Arc flash assessment and electrical safe work place (EWSP) implementation

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Thursday, March 31, 2011
2:30 to 3:30 p.m.

Ohio Bureau of Workers' Compensation

IDC
Engineering, Inc.

Arc Flash and the NFPA 70E

A Common Sense Approach

Julie E. VanDyne, P.E.

WBENC

Arc Flash and the NFPA 70E

- First released in 1976
 - Intended as a “safe work practices” standard
- First version didn't contain “Arc Flash”
 - Added in subsequent versions
 - Arc Flash has become the central focus of the standard
 - Most difficult portion of the standard to apply
- Structure and issues
 - Arc Flash
 - Tabled Strategies
 - Calculation of Actual Values
 - Shock Hazard

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What is Arc Flash?

- When an electrical fault occurs, an arc is produced. Depending on the intensity of the arc, energy is given off in the form of light (radiant), sound (blast), and a shock wave.
 - The radiant energy is most often sufficient to cause fabric to ignite, skin to burn, blindness
 - The blast is most often sufficient to fragment equipment and expel shrapnel
 - The sound wave is capable of damaging hearing in extreme cases.
- One worker per day is estimated to die from flash incidents daily. The unlucky ones survive.
- In 1976, National Fire Protection Association recognized safe work practices and ultimately Arc Flash in the NFPA 70E
- In 2001, OSHA started to recognize and enforce NFPA 70E in select states (Ohio included).
- Arc flash compliance is now mandatory for certain types of equipment (new installations of medium voltage gear)
- Compliance is spreading nationally, state by state
- When accident happens, OSHA typically is not the primary concern

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History

- OSHA - No specific reference to NFPA 70E
 - 1910.269 (l) (6) (iii) The employer shall ensure that each employee who is exposed to hazards of flames or electric arcs does not wear clothing that, when exposed to flames or electric arcs, could increase the extent of injury that would be sustained by the employee.
 - OSH Act of 1970,
 - 5. Duties
 - (a) Each Employer
 - (1) Shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or likely to cause death or serious physical harm to his employees;
 - With the advent of NFPA 70E, Arc Flash was recognized as a hazard, and therefore Section 5 (a) (1) enforces protection of employees from arc flash.
 - In the State of Ohio, the OSHA enforcement officers are citing employers for lack of a comprehensive arc flash safety program.

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Intensity

- Is Arc Flash Really that intense?



Test # 01-028
8806-003-2001

Test Level:
34 cycles, 8.4 kA rms,
two mannequins at 12",
12" arc gap, 0.75 s electrodes

Test Object:
Man A: Poly-Cotton shirt over
cotton t-shirt; clear face-shield
Man B: Oberon 31 switching jacket
with Oberon 31 hood

Cotton/Polyester Shirt Test:
8,400 Amp test stand

Blanket Test:
25,000 Amp test stand

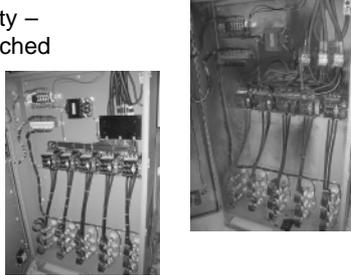
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Capacitor Bank Failure



- Industrial Facility – Actual fault reached ~65kA Peak or ~45,000 amps



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Cooking With Arc Flash



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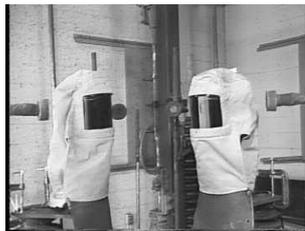


What Can Be Done?



- Personal Protective Equipment (PPE)

50 Cal/cm² ATPV Hood Test:
(ATPV = Arc Thermal Performance Value)
25,000 Amp test stand



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.... But why?



- Business Reasons:
 - OSHA Mandates – it's not really a choice
 - Fines for non-compliance can reach several thousand per incident.
 - Personal liability issues for supervisors and managers
- Social Reasons:
 - It's the right thing to do
 - Burn injuries are arguably the worst type of injury
 - Survival can be a curse
 - High divorce rate of victims
 - Employer's/supervisor's responsibility

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Dealing with Arc Flash



Two Methods contained in the standard:

- Tabled Methods – Task and circumstance oriented
 - Plus – Reasonably straight forward
 - Minus – More PPE than would be required with actual calculation for most areas, not enough in others
 - Conclusion – It is a compromise, but better than nothing
- Calculation – Engineering Solution
 - Plus – More accurate
 - Minus – Requires engineering expertise
 - Conclusion – Better method, but can be costly

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Table 130.8 (C) (9)



- Breaks equipment into 8 groups:
 - Panelboards or other equipment rated at 240 volts and below
 - Panelboards or Switchboards, >240V and < 600V
 - 600 V class Motor Control Centers (MCC's)
 - 600 V Class Switchgear (Circuit Breakers or Fused Switches)
 - Motor Starters (2.3 kV – 7.2 kV)
 - Metal Clad Switchgear (1 kV – 38 kV)
 - Arc Resistant Switchgear
 - Other Equipment (1 kV – 38 kV)
- PPE is Based on Task and Proximity

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Calculating Arc Flash Intensity

- Step one – short circuit analysis: Magnitude and Duration
 - Use point to point method
 - GE
 - Bussmann
 - Computer Programs
 - EDSA
 - ETAP
 - Calculate three phase symmetrical available fault at relevant points.
- Step two – Calculate approach distances
- Step three – Calculate flash intensity, determine the PPE required within the approach distance
- Step four – Documentation:
 - Labeling switchgear/preparation of central document repository
 - Training
 - Safety Program Integration

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Fault Clearing Time

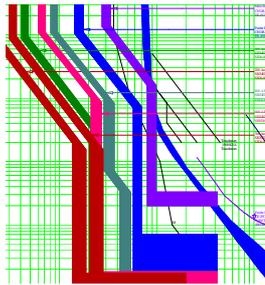
- Arc Assessments are dependent on not only the fault **MAGNITUDE**, but fault **DURATION**
- How long the fault is present has a significant impact on the flash intensity
- Calculations create a conflict between coordination/reliability issues and flash protection

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Instantaneous Settings

- Assume a 20,000 amp fault
 - 1,600 amp frame DS416; ~70 ms or < 5 cycles
 - 600 amp Siemens ND ~.018 seconds or just over 1 cycle

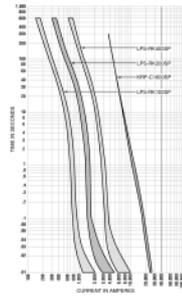


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Fuse Curves

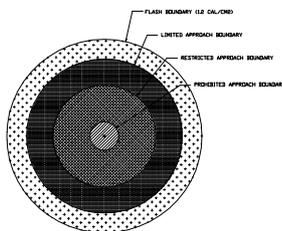
- Fairly simple
 - Minimum Melt
 - Maximum Clear
- Have Current Limiting Capability



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Approach Boundaries



- Qualified Individuals
- Those with formal training who are competent to work on electrical equipment
- Unqualified Individuals
- Those individual with no specific training to work on live electrical equipment

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Qualified Versus Unqualified

- Boundary restrictions (750 volts and below):
 - Unqualified persons must remain outside the limited approach boundary (3.5 to 10 ft).
 - Bear in mind that this may put the unqualified person at risk of burn injury
 - The Flash boundary can exceed the limited approach boundary. If the work is within the Flash boundary, but outside the limited approach boundary, protective clothing is required.
 - If an Unqualified person is near the boundary, they shall have a person available to watch him/her for inadvertent approach.
 - Qualified person may enter the limited approach boundary, but:
 - cannot enter the restricted approach boundary unless insulated
 - Flash protection must be in place
 - Unqualified person can work on electrical equipment that is "made safe" by LOTO.
 - Qualified person may enter the Restricted Approach boundary if appropriate insulated equipment is in place.
 - Qualified person may enter the Prohibited Approach boundary only if necessary, a job briefing is done, the risks considered, appropriate tools are used, and there are no other alternatives

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Basic Clothing Types

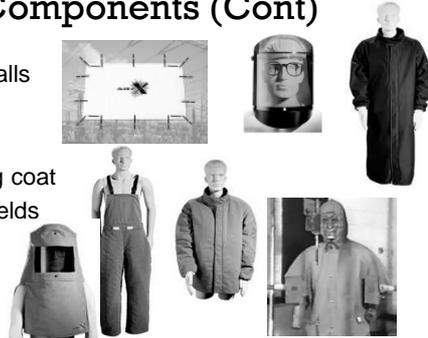
- Man-made fibers to be avoided:
 - Nylon, polyester, acetate, polypropylene, blends
- Natural Fibers should be favored
 - Cotton
 - Beware of thinking that natural fibers conform to OSHA 1910.269
- Specialty fibers
 - Chiefly Nomex, include fire resistant Cotton, PBI, Indura, Fire resistant blends
 - Self Extinguishing

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Components (Cont)

- Bib Overalls
- Jacket
- Hood
- Switching coat
- Face Shields
- Blankets



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Know the Limitations

- Equipment should be used within its design limitations
 - Using flash protective equipment beyond its limits can become a hazard itself
 - Violation of OSHA 1910.269 (l) (6) (iii) "The employer shall ensure that each employee who is exposed to hazards of flames or electric arcs does not wear clothing that, when exposed to flames or electric arcs, could increase the extent of injury that would be sustained by the employee."
- Welding garments/equipment does not provide protection from arc flash



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Competing Issues

- Provide Protection
 - Assure that the worker will be protected from:
 - Radiant energy
 - Super-heated Gases
 - Sound Pressure Level (SPL)
- Accommodate Human Issues
 - Excessive requirements invite non-compliance
 - PPE can be hot, especially in industrial environments
 - Limits vision, mobility, dexterity

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Review of work methods

- Thinking "Outside the Box"
 - Alternatives
 - Voltage readings – Install panel meters, fused leads, long handle extensions
 - Current Readings – new "fork type" current meters
 - Close examination – Binoculars
 - Breaker/ MCC Racking – Racking crank extensions
 - Manufactures
 - Remote Electrical racking means
 - Additional barriers
 - Compartmentalizing

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Strategy to Protection

Typical Protective Clothing Systems
NFPA 70E 2004 Table 130.7 (C) (11)

Hazard Risk Category	Clothing Description (Number of Layers given in Parentheses)	Total Weight (oz/yd ²)	Minimum Arc Thermal Energy Performance Exposure Value (ATPV) or Break-open Threshold Energy (EBT) Rating of PPE (Cal/cm ²)
0	Untreated Cotton (1)	4.5 – 7	
1	FR shirt and FR pants (1)	7 – 10	
2	FR shirt and FR pants (2)	9 – 12	8
3	Cotton underwear plus FR shirt, FR pants and FR coveralls (3)	16 – 20	25
4	Cotton underwear plus FR shirt, FR pants plus double layer switching coat and pants (4)	24 – 30	40

Complicated

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Simplification



- Simplification invites compliance
- Daily wear available up to 15 cal/cm²
- Face shields up to 12 cal/cm²
- 3 levels:
 - < 1.2 cal/cm² (Cotton Clothing)
 - 1.2 – 8 cal/cm² (Daily wear plus face shield)
 - > 8 – 65 cal/cm² (Flash Suit/ Hearing)
 - >65 No Entry
- Personal Garments



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Implementation



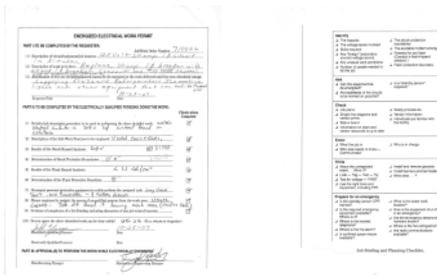
- Labeling Gear
 - Simple standard "Do not Open Without Proper Authorization" placard
 - Central repository for hazard assessment
 - Implement "Hot Work" Authorization system
 - Detailed placard with complete Arc Flash Hazard information
 - Outlines hazard and PPE requirements
- Training
 - Internal personnel (maintenance, production)
 - External contractors
- Auditing
 - Employers responsibility to assure that standard is followed



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Energized Work Permit



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Employers Responsibility



- NFPA 110.7 (B)

The electrical safety program shall be designed to **provide an awareness** of the potential electrical hazards to the employees who might from time to time work in an environment influenced by the presence of electrical energy. The program shall be developed to **provide the required self-discipline** to the employees who occasionally must perform work on or near exposed energized electrical conductors and circuit parts. The program shall instill safety principals and controls.

Not enough to simply put in place a safety program

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Thank You!

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Presentation Supplement



Arc Flash Table 130.8 for PPE

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- PPE is Based on Task and Proximity

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Panelboards or other equipment rated at 240 volts and below

Assume less than 25 kA fault or less with max 2 cycle clearing time

- Tasks for Cat 0 PPE:
 - Opening Hinged panel covers
 - Perform IR Thermography and other non-contact inspection >12" away
 - Operate Circuit Breaker covers on or covers off
- Tasks for Cat 1 PPE:
 - Remove Bolted panel covers
 - Work on energized equipment within the panelboard
 - Work on the energized equipment fed by the panelboard

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Panelboards or Switchboards, >240V and < 600V

Assume less than 65 kA fault or less with max 2 cycle clearing time

- Tasks for Cat 0 PPE:
 - Operate Circuit Breaker covers on
- Tasks for Cat 1 PPE:
 - Perform IR Thermography and other non-contact inspection >12" away
 - Operate Circuit Breaker covers off
 - Remove panel covers
- Tasks for Cat 2* PPE (*Enhanced – Use hearing protection)
 - Work on energized equipment within the panel/switchboard
 - Work on the energized equipment fed by the panel/switchboard

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600 V class Motor Control Centers (MCC's)

Assume less than 65 kA fault or less with max 20 cycle clearing time

- Tasks for Cat 0 PPE:
 - Operate fused switch or starter covers closed
 - Read panel meter while operating switch or starter
 - Work on control circuits in isolated cubicle (120 V only)
- Tasks for Cat 1 PPE:
 - Operate fused switch or starter covers open
 - Perform IR Thermography and other non-contact inspection >12" away
 - Open Hinged covers
- Tasks for Cat 2* PPE (*Enhanced – Use hearing protection)
 - Work on energized equipment within the MCC
 - Apply Safety Grounds AFTER voltage test
 - Work on energized equipment fed from the MCC
- Tasks for Cat 4 PPE:
 - Insert or Remove starter "bucket"
 - Open Bolted covers

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600 V Class Switchgear (Circuit Breakers or Fused Switches)

Assume less than 65 kA fault or less with max 60 cycle clearing time

- Tasks for Cat 0 PPE:
 - Operate fused switch or breaker covers closed
 - Read panel meter while operating switch or breaker
 - Work on control circuits in isolated cubicle (120 V only)
- Tasks for Cat 1 PPE:
 - Operate fused switch or starter covers open
- Tasks for Cat 2 PPE:
 - Perform IR Thermography and other non-contact inspection >12" away
 - Open Hinged covers
- Tasks for Cat 2* PPE (*Enhanced – Use hearing protection)
 - Work on energized equipment within the switchgear
 - Apply Safety Grounds AFTER voltage test
 - Work on energized equipment fed from the switchgear
- Tasks for Cat 4 PPE:
 - Insert or Remove (racking) circuit breaker from cubicle
 - Open Bolted covers

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