# EFCOG Electrical Safety Task Group (ESTG)
# 2019 Summer Workshop
# Best Practices and Accomplishments

**25 September 2019**
**Host: Moriah Ferullo**

Office of Worker Safety and Health Policy (AU-11)
Office of Environment, Health, Safety and Security
U.S. Department of Energy

Office of Environment, Health, Safety and Security

# Worker Safety and Health Policy

- Technical Standards
  - standards.doe.gov
- Directives
  - directives.doe.gov
- Response Line
  - responseline.doe.gov

- AU-11 – (301)903-6061
  - James Dillard, Director
  - Robin Keeler, Senior IH
  - Anjali Lamba, Industrial Hygienist
  - Steve Singal, Safety Manager
  - Moriah Ferullo, Safety Manager
  - Maurice Haygood, Safety Manager
  - Carlos Coffman, IH/FEOSH
  - Bob Czincila, Ergonomics
  - John Blaikie, Radiation Protection
  - Carlitta Foster-Hayes, Admin

# AU-11 Updates

- Technical Standards
  - Published: DOE-STD-1112, *DOELAP for Radiobioassay*
  - Pending REVCOM: DOE-STD-1145, *Radiological Safety Training for Pu Facilities - Cancellation*
  - Pending REVCOM: DOE-STD-1128, *Good Practices for Radiation Protection at Pu Facilities - Reaffirmation*
- S&H Response Line – responseline.doe.gov
  - Silica Exposure Monitoring Options and Clarification

# Announcements

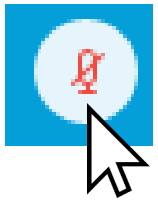
- October is National Fire Prevention Month
- NFPA Fire Protection Week is October 6-12
- Firepreventionweek.org

- Next Web Conference
  - November 2019
  - Watch for Web Invitation
  - Topic and Date TBD

- 2020 Web Conference
  - Currently Developing Schedule
  - Email Robin Keeler with suggestions

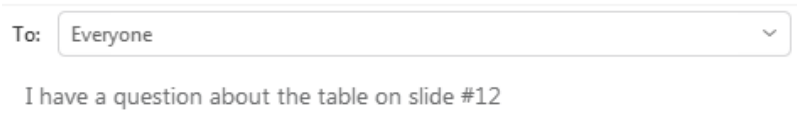
# Audio Considerations

- Always Mute WebEx Phone When Not Speaking



**CTRL + M** ***6**

- Use Chat Function

# Participation

- Q and A at the end of the presentation
  - Use chat function
  - Unmute self at end
- Any problems
  - Speak up now
  - Use chat
  - During Presentation – dial 202-680-2688
- We are not recording

EFCOG
Electrical Safety Task Group

# AU-11 Electrical Safety WebEx

## EFCOG Electrical Safety Task Group

## 25 September 2019

## Chair: Dave Mertz, Fermilab

EFCOG promotes excellence in all aspects of the operation, management, and integration of DOE facilities in a safe, environmentally sound, efficient and cost-effective manner through the ongoing exchange of information on lessons learned.

# Agenda:

- Overview of the EFCOG Electrical Safety Working Group
- Reports by ESTG Groups
- Opportunity for questions

# EFCOG is the Energy Facility Contractors Group.

- The EFCOG mission statement is “EFCOG promotes excellence in all aspects of the operation, management, and integration of DOE facilities in a safe, environmentally sound, efficient and cost-effective manner through the ongoing exchange of information on lessons learned.”
- More information is found at www.efcog.org
- The *Electrical Safety Task Group* is part of EFCOG’s *Worker Safety & Health Subgroup*, which is part of the *Safety Working Group.*

# Electrical Safety Task Group Mission:

- Assisting DOE sites in complying with 10 CFR 851 electrical safety requirements, including referenced third-party standards
- Developing products (Best Practices and Position Papers) to improve electrical safety
- Tracking electrical safety performance within DOE
- Interfacing with and affecting the products of external groups (NFPA, IEEE) whose standards affect electrical work at DOE facilities
- Sharing of recent incidents and lessons learned

# Electrical Safety Task Group Activities include:

- Monthly teleconferences
- Spring planning meeting
- Summer electrical safety workshop meeting
- Continued year-round work on topics of particular concern or urgency
- Work on these topics is organized by the creation of working groups

# ESTG working groups

- Determined at the spring meeting
- Concentrated effort during the summer workshop
- Continued efforts during the year
- Existing working groups may be closed if work on their topic(s) is substantially complete
- New working groups created when opportunities for collaborative progress are identified
- Ad hoc teams can be created to respond to urgent concerns, such as the review of electrical portions of DOE-STD-1212, Explosives Safety

## 2019 groups:

- DC Hazardous Energy
- Hazardous Energy Control
- Training
- NFPA 70E & 1584 Standards
- Utility Standards Interface

Electrical Safety Task Group

# DC Electrical Hazards and Controls

Gary Dreifuerst, AIS-LLNL

Kyle Carr, LANL

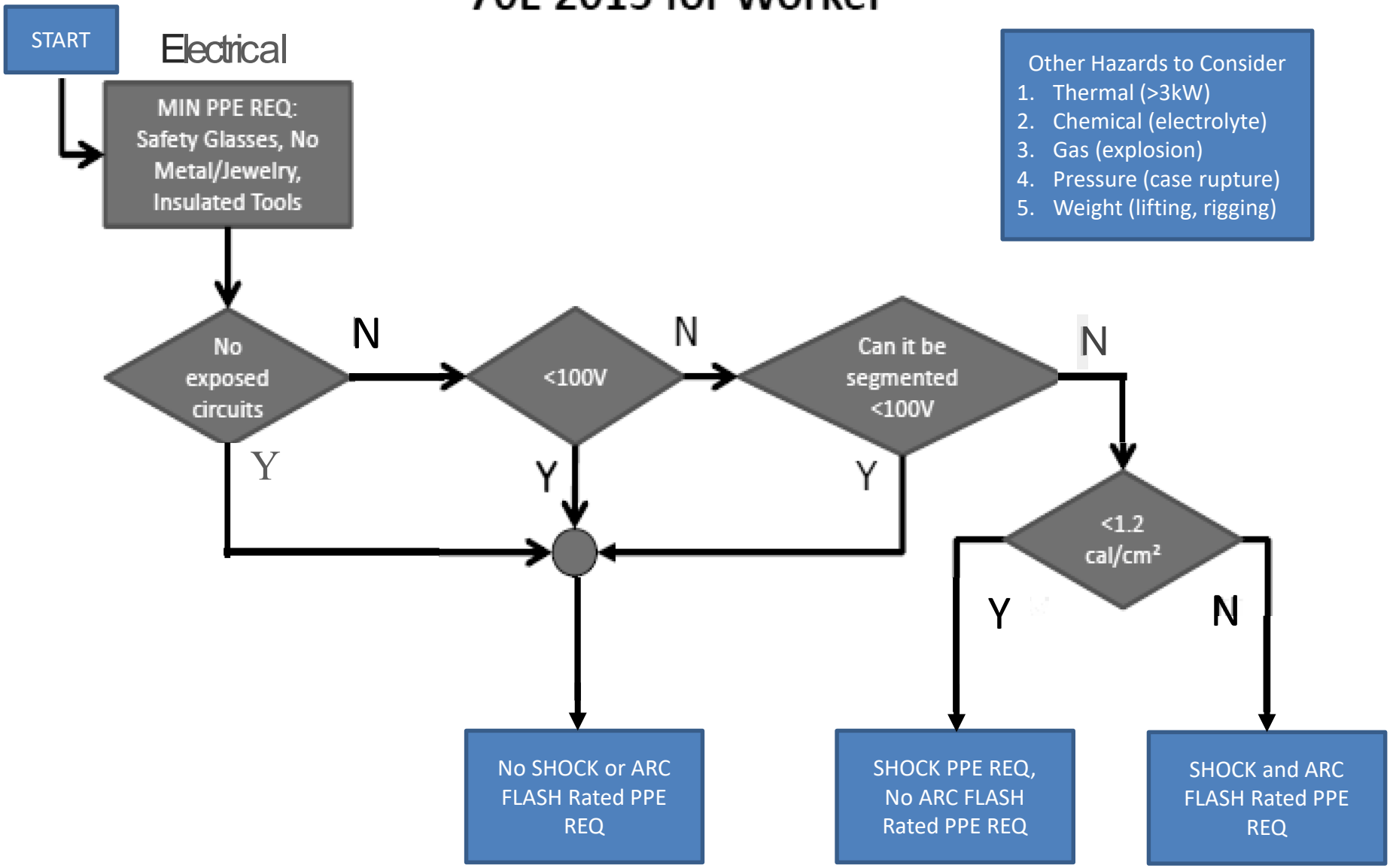
EFCOG promotes excellence in all aspects of the operation, management, and integration of DOE facilities in a safe, environmentally sound, efficient and cost-effective manner through the ongoing exchange of information on lessons learned.

# Accomplishments 2019

- Ready to release - Battery PPE Assessment BP
- To be finalized CY2019 - Lithium Ion BP
- To be finalized CY2019 - Ground Hook (Stick) BP
- To be finalized CY2019 - Arc Flash Spreadsheet (BP194) with new inductor tab

# Battery PPE Assessment Flowchart

## 70E 2015 for Worker



# 2019 work for EFCOG ESTG

- **Done - Review the NFPA 70E2021 submissions for Article 360 and Annex R on Capacitors**
  - WG discussions question the 50V or 100V thresholds for capacitors applications
- **Wait - for the DC evaluations for the IEEE 1584 committee**
- **Review & support the development of Best Practices:**
  - Lithium Ion Battery Energy Storage Systems (**BESS**)
  - Non-residential Vehicle Charging Safety, **no BP**
    - Reference NEC Article 625, Electric Vehicle Charging System
    - Reference NEC Article 626, Electrified Truck Parking Spaces

# Lithium Ion BP – page 1

- **New group to develop a best practice for safe installation, operation, maintenance and storage of Lithium-ion energy storage systems.**
- **Scope:**
  - Does not include laptops or portable electronics
  - Does not include consumer power tool battery systems
  - Commercially-available batteries – NRTL assembly
  - Research and emerging batteries –and mitigation based on above codes
    - Inspections, commissioning, monitoring
  - Test and maintenance equipment – per manufacturer's recommendations
    - IEEE P2030.2.1 – BESS guidance – draft since 2013
- **Risk assessment**
- **Safe Removal and Disposal of Batteries**
  - State and local rules
  - IPC, UPC, IFC
  - Energy Storage System Safety - Codes and Standards SNL Rosewater 201508 – excellent set of codes & standards

# Lithium Ion BP – page 2

- Codes & Standards that apply, at a minimum
  - IEEE P2030.2.1 – BESS guidance – draft since 2013
  - NFPA 855 – Battery Energy Storage Systems (BESS)– pending release 201909
  - UL9540A - thermal runaway testing
  - UL9540 – FMEA, Fire Risk Assessment NFPA551, IFC/NFPA1 (e.g. 660kW-hr)
  - UL1973 – battery unit
  - UL1642 - cell
  - UN38.3 – transportation rules
  - Limit occupancy ratings
  - Fire rated facility with Fire AHJ evaluation
  - Energy Storage System Safety - Codes and Standards SNL Rosewater 201508 – excellent se codes & standards
    - https://www.sandia.gov/ema_sp/_assets/documents/EMA_2_5_SAND_ESS_Codes_and_Standards_1130_Rosewater_Day_2m.pdf
- BESS container/enclosure needs to ensure earth bonding

# Lithium Ion BP – page 3

- **Primary Focus:**
  - The gaps in safety from the codes and standards are addressed by following engineering due diligence
  - Understanding the characteristics of batteries as an element of a system requires knowledge of the chemistry as well as engineering evaluation for integration of the sub-assemblies into the system. This is especially true for Lithium Ion batteries.

# Ground Hook (Stick) BP

## Ground Hook (Stick) EFCOG Best Practice
## High Energy used in Pulsed Power Applications

**Version 1, 2019**

Contents

# 2019 work for EFCOG ESTG (cont'd)

- **Arc Flash Spreadsheet (BP194)**
  - Done - Verify that the DOE Handbook capacitor hazard evaluations and ESW2019 Gordon paper are the same as the spreadsheet
  - Present and discuss the new magnet field calculation approach tab to include defined magnetic field devices. Superconducting systems will be covered.

# 2020 plans for EFCOG ESTG

- **Handbook to revisit Hazard Classifications for stored energy in supercapacitors and modern lithium ion batteries (BESS)**
- **Discuss adding a PV-Ammerman tab BP194 to incorporate the McNutt paper (ESW2019-13) results (decreasing the AF value)**

EFCOG

Electrical Safety Task Group

# Hazardous Energy Control


Co-Chairs:

Stephanie Collins - LBNL

Tommy Martinez - LANL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# HEC Group Purpose

- **Work towards consistent and effective hazardous energy control (LOTO) programs at DOE sites which are in compliance with standards such as NFPA 70E and 29 CFR 1910.147.**
  - Developing Best Practices, Guides, Position Papers
- **Determines the Electrical Safety Month topic and develops training and presentation materials.**
- **Provides input to standards-making bodies when justified.**
- **Responds to Electrical Safe Work Practice concerns as the need arises.**

# 2019 Workshop Tasks - HEC

- Draft response to OSHA regarding the use of control circuit devices that could safely be used to control hazardous electrical energy. Deadline for submission August 18, 2019. Done
- Expand BP#211 Managing Hazards of Multi-wire Branch Circuits Installed Before the 2008 NEC from 2018 and include steps for how to place electrical systems with shared neutrals into an Electrically Safe Work Condition. Submitted for inclusion pre-REVCOM DOE Handbook
- Develop a position paper discussing danger tagging devices used to prevent re-accumulation hazards in LO/TO. Work in progress. REVCOM submission required
- 2020 Electrical Safety Month topic. GFCI Protection & NEC code changes.
- Develop a Best Practice for controlling hazardous energy associated with capacitors, including formal written procedure requirements to ensure worker safety. This work will incorporate proposed changes for 2021 edition of NFPA 70E and the revised (2019) DOE Electrical Safety Handbook. Work in progress
- Clarify appropriate use of LOTO locks, Administrative locks and configuration control processes.

# HEC Task – OSHA LOTO RFI Status

**Comments submitted. Nathan Ybarrolaza & Scott Semianson listed as primary authors. Due to short turnaround and deadlines, comments signed off on by LBNL Engineering Division, LBNL ESO/HEC co-chair.**

# DOE Handbook Section 3.8.2

3.8.2 Mode 1 – Establishing an Electrically Safe Work Condition

1.To achieve Mode 0, an electrically safe work condition, a worker conducts Mode 1 work. If the Mode 1 process exposes the worker to any hazard, the activity should be covered by work control procedures, and a risk assessment should be performed. The work is energized electrical work, as covered by Mode 1, until an electrically safe work condition is achieved (Mode 0). To establish an electrically safe work condition, a qualified person should use the following steps:

2.Determine all sources of electrical supply to the specific equipment.

3.Check applicable drawings, diagrams, and identification tags, including equipment specific lockout/tagout (LOTO) procedures.

4.Turn off equipment.

5.Don correct personal protective equipment (PPE) and establish barricades, as necessary, for access control.

6.Open the disconnecting means (e.g., plug, breaker, or disconnect device).

7.If possible, visually verify that the plug is fully removed, all blades of the disconnecting devices are fully open, or that draw-out type circuit breakers are withdrawn to the fully disconnected position.

8.If applicable, test the controls and attempt to restart the equipment.

9.Apply LOTO devices, ensure that the plug is in total control of the worker, or use other engineering controls (such as capture key control systems) that are permitted by LOTO regulations.

10.If stored electrical energy exists (e.g., capacitors), or the dc voltage is greater than 1000 V dc discharge or remove the stored energy remotely or using ground sticks and apply grounds to the normally energized conductors. (see Annex R in the 2021 NFPA 70E)

11.If grounds have not been applied and the voltage is less than 1000 V, use a correctly rated voltmeter to test each normally energized conductor or circuit part to verify they are de-energized, (Note: for high- voltage or large capacitive systems using a correctly rated voltmeter may not be a safe procedure. Correct procedures for these cases are covered in Article 360 and Annex R of the 2021 NFPA 70E.)

12.Prior to lifting or breaking neutral conductor(s), test each individual neutral conductor with a clamp-on ammeter. If current is detected work should be paused and the circuit investigated.

CAUTION: This technique should be used with caution since current will only flow on the neutral conductor if one or more of the circuit(s) sharing the neutral has a load energized at the time the measurement is taken. If the load on the other circuit is “off” during the measurement, the current detector will not indicate a shared neutral even though the load could be switched “on” later.

13.Where neutral conductors must be un-spliced or removed or lifted from a terminal, measure for absence of voltage to ground immediately after the conductors have been lifted. Suitably guard, isolate, or insulate each neutral conductor individually prior to removing PPE since the testing for current as provided in #12 above can only detect a shared neutral when load on the other circuit is “on”. (Note: Don PPE again to re-make the termination or re-terminate the neutral conductor if necessary.)

If voltage is found after lifting a neutral conductor, stop work, notify supervision and develop a plan to determine the circuit supplying the voltage. After opening additional circuits or the main disconnecting switch/circuit breaker for the panel, recheck for voltage. Caution: In rare cases, the neutral may have been tapped from a different panel.

14.If the possibility of induced voltages exists, apply grounds to the normally energized conductors or circuit parts before touching them.

# HEC Task – TG/TPG's(PPG's)

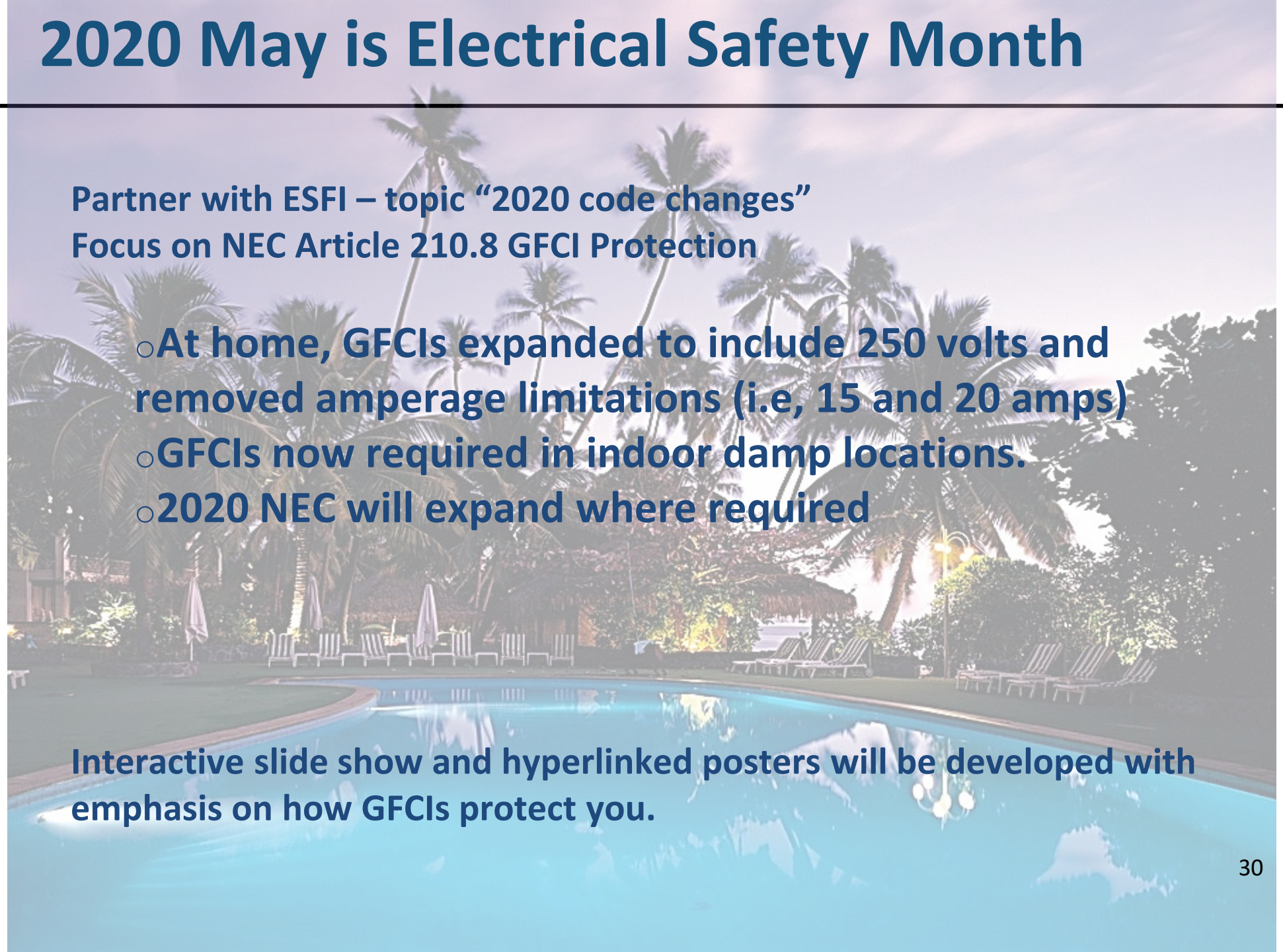
## How To Identify & Track Temporary Grounds

How to identify temporary grounds.

*When implemented, temporary grounds are located near/adjacent to work areas, allowing immediate identification if temporary grounds are displaced. Other administration controls are encouraged (e.g. barricades).*

*Temporary grounds should be inspected prior to use.*

# 2020 May is Electrical Safety Month



Partner with ESFI – topic “2020 code changes”
Focus on NEC Article 210.8 GFCI Protection

- At home, GFCIs expanded to include 250 volts and removed amperage limitations (i.e, 15 and 20 amps)
- GFCIs now required in indoor damp locations.
- 2020 NEC will expand where required

Interactive slide show and hyperlinked posters will be developed with emphasis on how GFCIs protect you.

# HEC Task - Capacitors

- Develop a Best Practice for controlling hazardous energy associated with capacitors, including formal written procedure requirements. This work will incorporate proposed changes for 2021 edition of NFPA 70E and the revised (2019) DOE Electrical Safety Handbook.
- Comparison between at least 2 Labs to give ideas on how to manage and execute elements

# HEC Task - Capacitors

- Using revised Hazard Classification tables
- Required formal written procedures and elements to meet Article 360 to ensure worker safety
- Communicating hazards & limiting access to prevent untrained/unqualified workers from accidental contact with capacitors
- AHJ determines appropriate method to be used on a case by case basis

# LBNL – Complex LOTO/ESWPs slides

- **Complex LOTO Procedures or ESWP – both include step by step procedures, qualifications, supportive documentation**

## 2. ENERGY ISOLATION CHECKLIST

I agree that the scope of work described in Section 1 falls within the LOTO Safe Zone established by the isolations in Section 2. I have witnessed the implementation of the LOTO according to this permit and that zero energy state was properly verified. By signing here I confirm that the LOTO has been fully established.

LOTO Established:_____ LOTO Cleared:_____

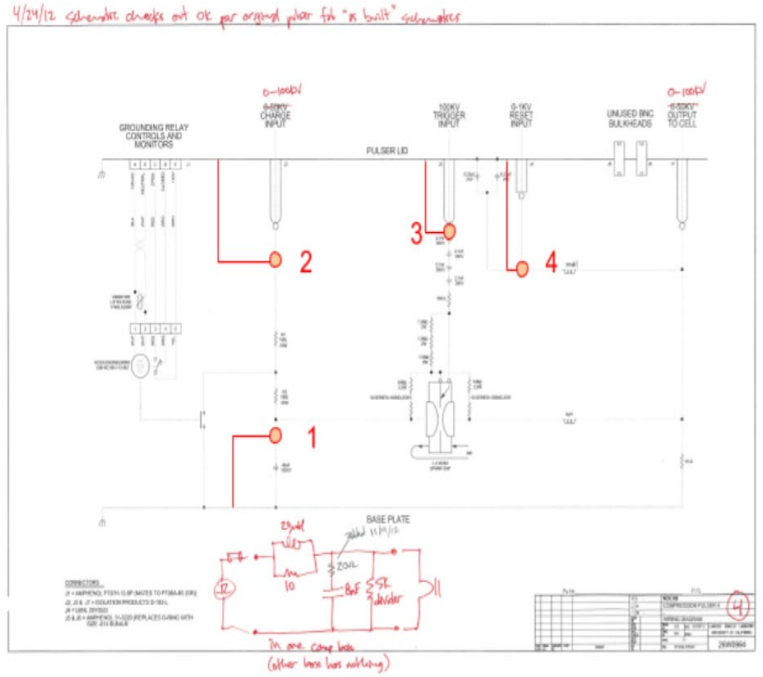
**Electrical Isolations**

| # | Equipment Descriptor | Isolation Point | Isolation Type | Voltage | AC/DC | AF Energy | AF Boundary | AF PPE | Isolation Position |
|---|---|---|---|---|---|---|---|---|---|
| 1 | solenoid pulser rack: SRK01 | 649A3A-5 | Circuit Breaker | 208V | AC | <1.2-Cal/cm^2 | 4" | Minimum PPE | Locked Open |

**Energy dissipation devices**

| # | Equipment Descriptor | Dissipation Point | Stored Energy Type | Magnitude | PPE | Device ID Number | Device |
|---|---|---|---|---|---|---|---|
| 1 | Solenoid rack ground hook in rack SRK01 | grounding points labeled "SOFT GROUND" and "HARD GROUND" | electrical | 5 kV, 25 kJ | Minimum PPE and hearing protection | ATAP-GH-013 | Ground hook https://lbnl.quickbase.com/db/bifswvd9b?a=dr&r=q&rl=jsy |

Shorts that need to be added:




Apply

# LANL – Integrated Work Documents

- **Need to include step by step procedures, qualifications, supportive documentation**

IWD – Umbrella document that points to other reference documents. Personnel are expected to use reference documents for detailed information

**Best Practice remains to be drafted**

Los Alamos NATIONAL LABORATORY EST.1943

Form 2100

Integrated Work Document (IWD) Part 1, Activity Specific Information

IWD #: NHMFL-35-294-301-00-1 Revision #: 5 Activity/Task Title Operation of the 100 Tesla capacitor bank

| **Work Tasks/Steps** Identify work steps/tasks in sequence when such sequencing contributes to safety, security, and/or environmental protection. | **Hazards, Concerns, and Potential Accidents/Incidents** Identify both activity and work-area hazards for each task/step. | **Controls, Preventive Measures, and Bounding Conditions** Specify preventive measures, controls for each hazard (e.g., lockout/tagout points, specific Personal Protective Equipment [PPE], Tamper Indicating Devices [TIDs], alarms, safes, recycle, | **Reference Documents** List permits, operating manuals, security plans, and other reference | **Training** List training and qualification requirements. (P300, Integrated Work Management, Section 6.1 |
|---|---|---|---|---|
| Task 4: Manual Bank Shut Down for repairs or reconfiguration:<br><br>Full shutdown occurs when bank configuration changes are needed, or the bank needs to be serviced. This process manually places the capacitor bank into a zero energy, safed, state. | Electrical hazard.<br><br>Pneumatic hazard.<br><br>Mechanical pinch hazard.<br><br>Monitoring equipment on the front, East side has 120V isolation transformers, thus electrical hazard is 120 Volts.<br><br>Capacitors are not individually voltage monitored and voltage can be nonzero.<br><br>*Control systems electronics cabinet have 120V open frame DC power supplies.*<br><br>*Mechanical switches can cause pinch hazard if moved when personnel are in contact with them.* | Turn off electronics and disconnect equipment using plug control.<br><br>If disassembling bank individual capacitors, apply ground sticks and individually short capacitors waiting RC time constants.<br><br>Maintenance and repair of capacitor bank: After the bank has been brought to a zero energy state, inspections of bank components, make necessary repairs, alterations.<br><br>Electrical hazard class 1.2a,<br><br>AC, V 50-120 volts P<-125 KVA, page 84<br><br>Mode 0, Use plug control.<br><br>Mode 0, 1; Shock hazard analysis for 120 V trouble shooting.<br><br>Maintenance and inspection of the upper level capacitors must be conducted by the | P101-13, page 88<br><br>See Shock Hazard and Arc Flash analysis by RC time constants.<br><br>100T Cap Bank RC_Time_Constants_Ver001.pdf<br><br>See maintenance procedure O/I-6 (Maintenance of the 100T capacitor bank)<br><br>Use the maintenance procedure | P300-1, Competent Worker.<br><br>Energized Electrical Worker TP 2876<br><br>Ground Stick DoP completion.<br><br>CPR/AED for Electrical Workers at LANL<br>TP 9099 |

# HEC Task – Dual Lock Systems: LOTO vs others

LOTO locks (worker locks) are to protect workers when they are working downstream. But what about all the other times when a system must be; or remain de-energized.

A paper has been written that explores these issues, has developed recommendations, and has detailed scenarios as to how a dual-lock system can be successfully implemented.

Worker locks – OSHA 1910.147/NFPA 70E

System locks – OSHA 1910.145(f)

Position paper remains to be drafted

# Two Habits That Work

FCG FCOG

Electrical Safety Task Group

# Electrical Training

Ray Joggerst – LANL
Vince Bollinger - NREL

# Qualification

- Training
- Education
- **Experience**

# Experience

1. R&D
2. Crafts
3. Subcontractor

# 1. R&D Experience

- Mentorship
- Demonstration
- Documentation

# Mentorship and Demonstration

- **Risk based approach**
- **Use site recognized experts/leaders**
- **Mentoring Process**
  1. Watch work being performed by expert
  2. Perform work under supervision of expert
  3. Demonstrate proficiency

# Documentation

- Learning Management System (LMS)
- Work Control Documentation
- Qual Form

# 2. Crafts

- State License or Equivalent
- Mentorship

# State License

- **Journeyman's License**

1. Electrician
2. Instrument tech
3. HVAC

# 3. Subcontractor

- Work with a qualified worker
  - Qualified worker performs hazardous electrical tasks
- Become qualified locally at the site
  - Local training and qualification program
- AHJ/ESA evaluation and approval of training and qualification

# Summary

- Classroom training should only be one part of the process to qualify a worker to perform a hazardous task.
- We propose the formalization of the mentoring process in addition to classroom training.
- Each site can document and track the training and qualifications of workers through a site specified process
- Each worker should maintain these qualifications as detailed in their sites electrical safety programs
- Implementation process can vary from site to site depending on the judgement of the AHJ/ESA

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# NFPA 70E C-AHJ/ESA Qualifications

Heath Garrison – NREL
Jennifer Martin – RL

Presenter: Gary Becken - WTCC

# CY18 Work

**This working group developed Best Practice #221 last year for assignment of the Contractor AHJ.**

- **Includes template for assignment letter**
- **Published on EFCOG website**
  - https://efcog.org/wp-content/uploads/2018/12/EFCOG-Best-Practice-221-AHJ.pdf

# Objective / Direction

## NFPA 70E 2018

- Working group to discuss suggested minimum qualifications for performing the C-AHJ/ESA functions for NFPA 70E, Electrical Safety in the Workplace.

- Discussed the inspection of each employee and the field work audit to ensure safety-related work practices required in NFPA 70E are being followed.

- Discussed the term “Supervised Industrial Installations” – no formal document being developed from this group. Each site to address independently. Neither 70E or 70 define what this means. This task group may work in the future to submit changes to NFPA 70E for adding a definition.

# GOAL

**Products:**

1. **Develop a best practice for qualifying C-AHJ/ESAs.**
   - ❖ This best practice will compliment the AHJ assignment best practice #221.
2. **Develop a checklist/guide for performing employee inspections and field audits to validate safety-related work practices are being followed.**

# Best Practice

**Best Practice Title:**
**Qualifications for the Contractor Authority Having Jurisdiction (C-AHJ) / Electrical Safety Authority (ESA) related to Electrical Safety in the Workplace (NFPA 70E)**

- Knowledge
- Skills
- Training
- Certifications (CESCP)
- Continued Training and Proficiency

# NFPA 70E Employee Inspections

**This is in the qualified worker training section, meant to evaluate the worker.**

**110.2(A)(1)(f)** The employer shall determine through regular supervision or through inspections conducted on at least an annual basis that each employee is complying with the safety-related work practices required by this standard.

# Employee Inspection Guide

| FCOG | Qualified Electrical Worker<br>Annual Inspection<br>NFPA 70E 2018 110.2(A)(1)(f) | | LOCKOUT BEFORE WORK / TEST BEFORE TOUCH |
|---|---|---|---|
| Date of Assessment | Print Name/ Employee Number | | Signature |
| | Employee(s): | | |
| Qualification Level | Assessor: | | |
| | Procedure: | | Additional Training Necessary? |
| Location: | | | ☐ Yes ☐ No |

| | | Pass / Fail / NA | Assessor Notes |
|---|---|---|---|
| **PART 1: PPE INSPECTION** | | | |
| 1. **Voltage Glove Inspection**<br>• Properly stored upon arrival<br>• Voltage class (max usage and max test) and type<br>• Inspection date and serial number | | | |

# NFPA 70E Field Work Audits

**This is in the electrical safety program section, meant to evaluate the program elements are being performed in the field as expected.**

**110.1(K)(2) Field Work Audit.** Field work shall be audited to verify that the requirements contained in the procedures of the electrical safety program are being followed. When the auditing determines that the principles and procedures of the electrical safety program are not being followed, the appropriate revisions to the training program or revisions to the procedures shall be made. Audits shall be performed at intervals not to exceed one year.

*The electrical safety program audit (3 year) is covered in BP#121, Electrical Safety Assessment Criteria Document 110.1(K)(1).*

# FUTURE TASKS

FY19 Workshop Efforts

- Best Practice and guide/checklist products posted before 2020 Spring meeting.

Future Workshops

- Impact analysis for 2020 NEC
- Impact analysis for 2021 70E
- Public Inputs for 2024 70E
  - e.g. Supervised Industrial Locations definition

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U.S. DEPARTMENT OF ENERGY

# Low Voltage 208Y/120V & 240V Arc Sustainability

## IEEE 1584

Presenter: John Whipple - INL

# IEEE 1584-2018 What has changed?

- 125 kVA Threshold Removed
- Different Electrode Configurations
- Over 1200 Tests = More Comprehensive
- Continuous Voltage Spectrum
- Enclosure Size Adjustment Factor
- Minimum Arcing Current Adjustment
- Grounded vs. Ungrounded

# Purpose

- This best practice provides guidance for arc flash risk assessment of low voltage systems (208Y/120V and 240V) and for electrode configuration.
- Based on IEEE 1584-2018 changes, low voltage arc sustainability studies, and accident studies

# IEEE 1584-2018 Low Voltage Arc Flash Hazards

- Lab testing demonstrated that although not very common, it may be possible to sustain arcs briefly at lower levels of short circuit current resulting in a greater incident energy.

- Based on the results of additional testing, the 125 kVA language has been deleted.

# The language change…..

## IEEE 1584-2002 Edition “125 kVA transformer exception” stated:

- *“Equipment below 240 V need not be considered unless it involves at least one 125 kVA or larger low-impedance transformer in its immediate power supply”*

## IEEE 1584-2018 New language states:

- *“Sustainable arcs are possible but less likely in three-phase systems operating at 240 V nominal or less with an available short-circuit current less than 2000 Amps”*

# Low Voltage Arc Sustainability

- Studies indicate that it is unlikely that an arc can be sustained on 208Y/120V and 240V systems unless certain conditions are present.
- At arc gap > 0.5in, faults cleared within 0.5 cycle
- At arc gap = 0.5in, faults cleared within 10 cycles

# Incident Energy vs. Transformer Size

## Using IEEE 1584-2002

| Total Incident Energy (cal/cm²) 208Y/120V Transformer Secondary | | | | | |
|---|---|---|---|---|---|
| Transformer size (KVA) | Arc Flash Duration Cycles (1/60 second) | | | | |
| | 1 | 6 | 10 | 20 | 30 |
| **112.5** | 0.20 | 1.22 | 2.03 | 4.07 | 6.10 |
| **75** | 0.15 | 0.90 | 1.50 | 3.0 | 4.50 |
| **45** | 0.10 | 0.62 | 1.03 | 2.07 | 3.10 |
| **30** | 0.08 | 0.46 | 0.77 | 1.53 | 2.30 |

# Incident Energy vs. Transformer Size

## Using IEEE 1584-2018

| Total Incident Energy (cal/cm$^2$) 208Y/120V Transformer Secondary | | | | | |
|---|---|---|---|---|---|
| **Transformer size (KVA)** | **Arc Flash Duration Cycles (1/60 second)** | | | | |
| | 1 | 6 | 10 | 20 | 30 |
| **112.5** | 0.13 | 0.79 | 1.32 | 2.64 | 3.96 |
| **75** | 0.08 | 0.5 | 0.83 | 1.66 | 2.49 |
| **45** | 0.05 | 0.28 | 0.46 | 0.92 | 1.38 |
| **30** | 0.03 | 0.17 | 0.29 | 0.58 | 0.87 |

# Summary

- **Equipment arrangement more likely to sustain an arc at 208Y/120V or 240V is on equipment that:**
  - Maintain short arc length (arc gap < 0.5in.) **AND** confined equipment
- **Horizontal electrodes geometries considered not to be a factor**

# Conclusions

- The existing 208Y/120V and 240V systems should be evaluated by engineering to assess the factors that may be of concern and determine if additional arc analysis and/or hazard labeling is warranted.
- The engineer performing the analysis will need to exercise judgment for these conditions.

# References


- 1. “An Investigation of Low Voltage Arc Flash Exposure” IEEE Paper No. ESW2013-30
- 2. “Arc Flash Testing Update: Effect of Arc Electrode Geometry and Distance on Shirt Ignition” IEEE ESW 2014
- 3. “Low Voltage Arc Sustainability’ IEEE ESW M. L. Eblen and T. A. Short
- 4. “208V Arc Flash Testing: Network Protectors and Meters” 1022218 Technical Update, September 2010 EPRI
- 5. “Electrical Injuries and Fatalities: Facts, Myths, and Unknowns” IEEE Paper No. ESW2019-32

# Future Work

- **Provide support IEEE 1584.1 revision "Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation"**
  - Provide guidance for low voltage arc sustainability
  - Test equipment vs real equipment
- **Electrode configuration**
  - When to use HCB (Medium voltage only?)

FCOG
Electrical Safety Task Group

# Electric Utility

Don Lehman – INL
Scot Winningham – ORNL

# Electrical Utility Risk Assessment BP

**Brief Description of Best Practice: This best practice is developed to define and evaluate risk for working with medium and high voltage activities in the DOE complex.**

**Why the best practice was used: Electrical Utility tasks involve high hazard activities where the risk is often undefined. This best practice is developed to assess the risk of high hazard activities to assist DOE contractors in implementing controls to reduce risk. These controls follow the hierarchy of risk control method defined in ISM and NFPA 70E. Additionally, human performance indicators and tools are utilized to address the human element of risk.**

# Electrical Utility Risk Assessment BP

## Scope and Applicability

**The best practice applies to Electrical Utility Operations (EUO) at United States Department of Energy (DOE) sites. The risk assessment herein covers the scope of High Hazard electrical work not covered by NFPA 70E *Electrical Safety in the Workplace*.**

# Electrical Utility Risk Assessment BP

## What are the benefits of the best practice:

- EFCOG ESTG is an industry leading body that has a history of influencing several electrical standards and is currently adding more focus on the electrical utility applications to improve safety and effectiveness
- Works in conjunction with the previous best practice and what's to come next
- Proactive approach to quantify and rank risk levels of high hazard activities
- Provides a structured methodology to review specific electrical utility activities and identify consistent safe work methods
- Brings the Hierarchy of Risk Controls to life within the work planning process
- Be able to anticipate and justify personnel and equipment needs for safe execution of electrical utility tasks

**Table 1: Risk Assessment Matrix**

| Severity | Consequence | | | Probability – Increasing Likelihood | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 |
| | People | Equipment | Environment | Event never heard of in the industry | Event heard of in the industry | Event has occurred in similar company | Event happens several times per year | Event occurs several times per year in a specific location |
| 1 | No health effects or injury | No damage | No effect | 1 | 2 | 3 | 4 | 5 |
| 2 | Slight health effect of injury (first aid) | Minor damage | Minor effect | 2 | 4 | 6 | 8 | 10 |
| 3 | Minor health effect of injury (outpatient) | Localized damage | Contained effects | 3 | 6 | 9 | 12 | 15 |
| 4 | Major injury requiring surgery, hospitalization or extensive treatments | Major damage | Uncontained effects | 4 | 8 | 12 | 16 | 20 |
| 5 | Fatalities | Extensive damage | Extensive Geographic effects | 5 | 10 | 15 | 20 | 25 |
| Low 1 - 6 | | | Medium 7 - 12 | | | High 13 - 25 | | |

## Table 2: Oversight Matrix

| Level of Risk | Additional Worker** | Crew Chief / Lead Worker | Foreman, Supervisor | Safety | Engineer / Planner | Line Manager |
|---|---|---|---|---|---|---|
| LOW | * | * | A, B | * | * | |
| MEDIUM | A, C | A, C | A, B, C | A, * | A | |
| HI | A, C | A, C | A, D | A, C | A, C | * |

A: Involved in pre-job and/or package walk down

B: Periodic/random job involvement or oversight

C: On the job for the Risk element of the task

D: Full task oversight

* May be required per site requirements

** Additional worker to be a qualified worker for the equipment, task, and/or potential rescue.

## Table A1: Example Task Based Risk Assessment

| Task | | Status | Shock Analysis | | | | Arc Flash Analysis | | | Risk Matrix | | | Risk | Oversight Matrix | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Operational Situations: Other | Energized >50V | Shock Hazard <150Vac | Shock Hazard 151 to 750Vac | Shock Hazard 751 to 15kV | Shock Hazard >15kV | Arc Flash Hazard <1.2 cal/cm2 | Arc Flash Hazard 1.2 to 12 cal/cm2 | Arc Flash Hazard >12 cal/cm2 | Severity | Likelihood | Score | Risk Level | Additional Worker | Crew Chief / Lead Worker | Foreman / Supervisor | Safety | Engineer / Planner | Line Manager |
| 1 | Transformer Visual Inspection (not crossing MAD) | X | | | | | | | | 2 | 1 | 2 | Low | * | * | A, B | * | * | |
| 2 | Applying Grounds (15kV system) | X | | | X | | | X | | 3 | 4 | 12 | Medium | A, C | A, C | A, B, C | A, * | A | |
| 3 | Manually racking breaker | X | | | | | | | X | 4 | 4 | 16 | High | A, C | A, C | A, D | A, C | A, C | * |

| | |
|---|---|
| A | Involved in pre-job and/or package walk down |
| B | Periodic/random job involvement or oversight |
| C | On the job for the Risk element of the task |
| D | Full task oversight |

*May be required per site requirements

**Additional worker should be a qualfied worker for the equipment and task

# Immediate Future Focus Area

**Scope – Electrical Utility training and qualifications**

**Goals:**

1. **Identify core curriculum for EUO Linemen / high voltage electricians**
2. **Develop a list of skills or tasks that linemen must be capable of performing.**
3. **A process to validate they have the proficiency to perform the task.**
   - Exposed
   - Knowledgeable
   - Proficient

**Deliverable(s) – Best practice to assist EUO in evaluating and qualifying individuals for the tasks they perform. Develop a list of skills and tasks that require demonstration of proficiency.**

**Actions from this meeting – Update in Dropbox benchmarking materials**

# Additional Future Focus Areas

1. Further bridging the gap between the NESC and NFPA 70E
2. Crosswalk/Interfaces for LOTO and T&D Clearances
3. Field guide(s) for work processes
4. Justifications for and applications of new technology engineering controls to reduce risk (remote racking, absence of energy devices, etc.)
5. Clearing up the confusion of grounding and equipotential grounding.

EFCOG

Electrical Safety Task Group

# AU-11 Electrical Safety WebEx

# EFCOG Electrical Safety Task Group

## Chair: Dave Mertz, Fermilab

EFCOG promotes excellence in all aspects of the operation, management, and integration of DOE facilities in a safe, environmentally sound, efficient and cost-effective manner through the ongoing exchange of information on lessons learned.

## EFCOG ESTG scheduled activities:

- Monthly teleconferences on the third Wednesday of every month at 11:00 Eastern Time
- Spring meeting 2020: 2 March 2020, in coordination with the Institute of Electrical and Electronic Engineers (IEEE) Electrical Safety Workshop
- EFCOG Electrical Safety Workshop: 27 to 31 July 2020 at Brookhaven National Laboratory

**The EFCOG ESTG appreciates your time and attention today.**

# Opportunity for questions