



Brian McCauley  
December 2017

# ELECTRICAL SAFETY COMPLIANCE & NFPA 70E 2018

**Honeywell**  
SALISBURY

# Agenda

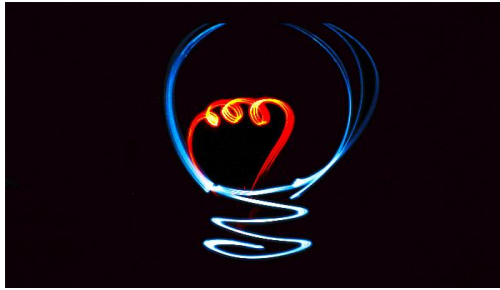
- Introduction
- Electrical Safety Basics
- Electrical Safety Statistics
- NFPA 70E 2018 Updates
- PPE
- Questions



# A Little bit of History....

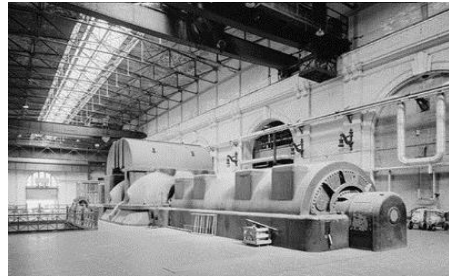


1747: First experiments with Electricity (do not try this!!!)



1880: Light bulb is patented by T.A. Edison

Early 1900's Samuel Insull  
developed modern power grid



Today, 16% of total population live with no  
electricity





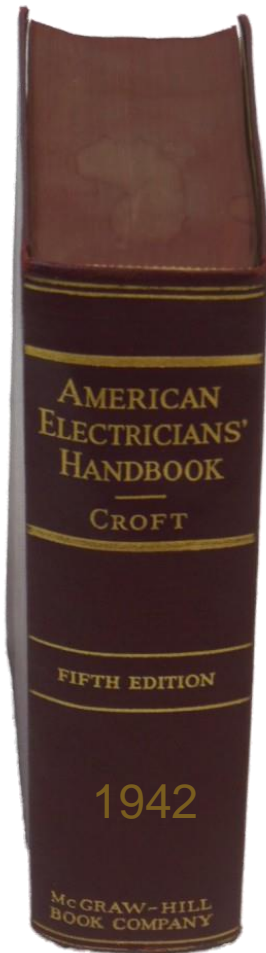
# Salisbury History

- **History**

- **Started business in 1855.**
- **In early 1900's, Salisbury was approached by ComEd—the local electrical utility in Chicago.**
  - Linehose was born.
- **Salisbury has been working closely with electrical workers ever since!**
  - Insulated Rubber Gloves, Insulated Blankets Grounding Products all came next.
  - The Arc Flash line was developed in 2001.



# Changing Profession, Changing Attitudes



38 AMERICAN ELECTRICIANS' HANDBOOK [Sect. 1

## MEASURING, TESTING AND INSTRUMENTS

90. Electricians often test circuits for the presence of voltage by touching the conductors with the fingers. This method is safe where the voltage does not exceed 250 and is often very convenient for locating a blown-out fuse or for ascertaining whether or not a circuit is alive. Some men can endure the electric shock that results without discomfort whereas others cannot. Therefore, the method is not feasible in some cases. Which are the outside wires and which is the neutral wire of a 110-220 volt, three-wire system can be determined in this way by noting the intensity of the shock that results by touching different pairs of wires with the fingers. Use the method with caution and be certain that the voltage of the circuit does not exceed 250 before touching the conductors. (This and the several paragraphs that follow are taken from *Electrical Engineering*.)

91. The presence of low voltages can be determined by "tasting." The method is feasible only where the pressure is but a few volts and hence is used only in bell and signal work. Where the voltage is very low, the bared ends of the conductors constituting the two sides of the circuit are held a short distance apart on the tongue. If voltage is present a peculiar mildly burning sensation results which will never be forgotten after one has experienced it. The "taste" is due to the electrolytic decomposition of the liquids on the tongue which produces a salt having a taste. With relatively high voltages, possibly 4 or 5 volts, due to as many cells of battery,

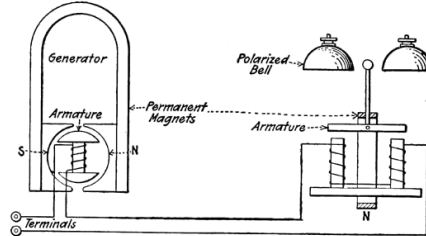


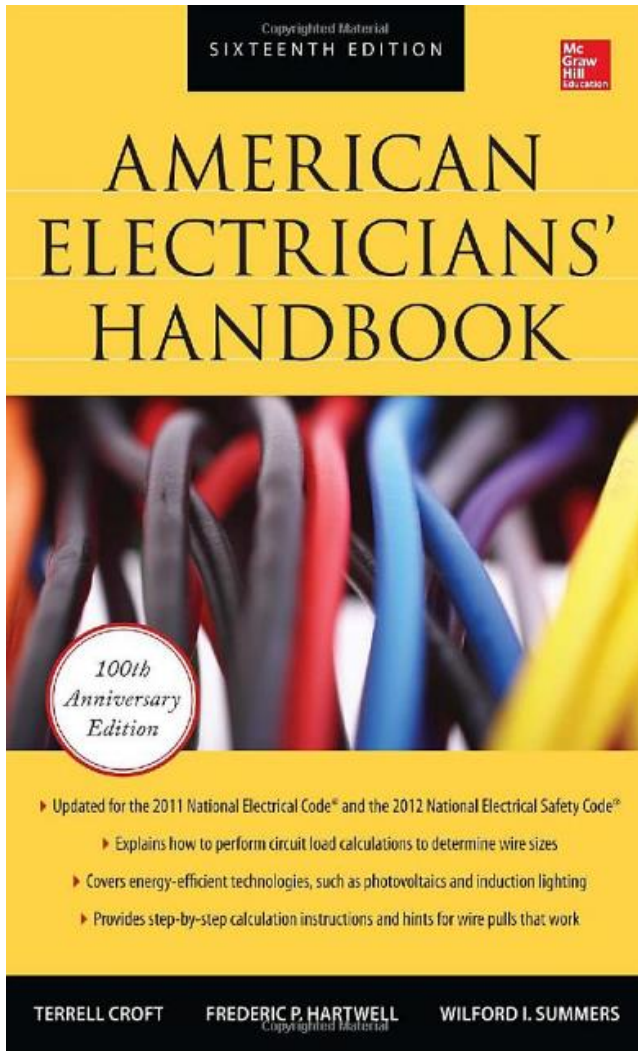
FIG. 44.—Circuits of testing magneto.

it is best to first test for the presence of voltage by holding one of the bared conductors in the hand and touching the other to the tongue. Where a terminal of the battery is grounded, often a taste can be detected by standing on moist ground and touching a conductor from the other battery terminal to the tongue. Care should be exercised to prevent the two conductor ends from touching each other at the tongue, for if they do a spark can result that may burn.

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# Safer Practices Today





# What are the Electrical Hazards?

- **Electrical Shock** – When electrical current enters and exits the body creating a path.
- **Arc Flash** – A dangerous condition associated with the release of energy caused by an electric arc. Note that this explosive condition includes a broad spectrum of electromagnetic energy, plasma, fragments and a spray of molten materials.
- **Arc Blast** – Pressure wave caused by the expansion of gases and conducting materials with flying molten materials.



# Arc Blast

- **Electrical Arc-Flash can create blast in excess of 2,000 lbs/ft<sup>2</sup>.**
- **Arc-Blast can cause collateral damage and extreme personal damage.**
  - Exploding switchgear
  - Send molten metal at extreme high velocities.





# What Causes an Arc Flash?

- Electricity will go through the path of least resistance. When the path of electricity is suddenly interrupted, the electricity will create a new pathway.

The arc can be generated by:

- Mechanical breakdown/failure
- Current overload

- **Accidental contact**



# Arc Flash Impacts

- **As much as 80% of all electrical injuries are burns resulting from an arc-flash and ignition of flammable clothing.**
- **1.2 cal/cm<sup>2</sup> equates a 2<sup>nd</sup> degree burn on human skin**
- **Arc temperature can reach 35,000°F - this is four times hotter than the surface of the sun. Fatal burns can occur at distances over 10 ft.**
- **Over 2000 people are admitted into burn centers each year with severe electrical burns (\$10k/day)**



# Why Important?

- **Arc Flash Statistics**

- A recent study from the National Institute for Occupational Safety and Health (NIOSH) found that 17,101 injuries were caused by electric arc flash burns between 1992 and 2002. <sup>1</sup>
- 97% of electricians have been shocked or injured on the job.
- Every 30 minutes during the work day, a worker suffers an electrically induced injury that requires time off the job for recovery. <sup>2</sup>
- Over the last ten years, more than 46,000 workers have been injured from on-the-job electrical hazards. <sup>2</sup>
- Medical costs for severe electrical burns can exceed \$4M per person. <sup>3</sup>
- Work-related injuries can cost businesses well over \$30M in fines, medical costs, litigation, lost business and equipment costs. <sup>3</sup>

(1) "Arc Flash Protection Should be Job No. 1," IEEE/NFPA Collaboration on Arc Flash Phenomena, in <http://www.powermag.com>, Feb. 2007.

(2) Electrical Safety Foundation International

(3) National Safety Council



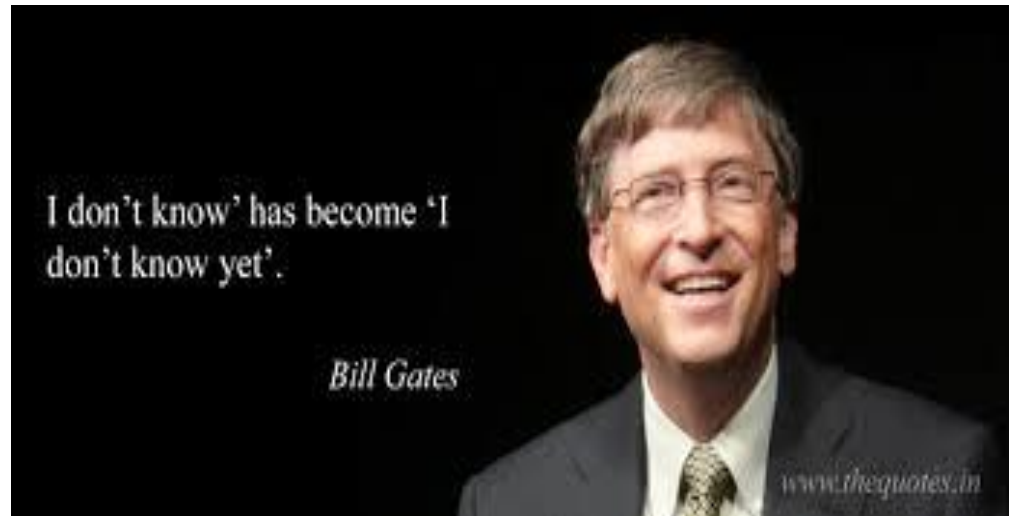
# Are you in Compliance? Are your Workers Safe?

- Industry standards and regulations:
  - OSHA 29 CFR 1910 Subpart S
  - NEC
  - NFPA 70E-2015 Edition
    - ***2018 Edition takes effect in November.***
  - Various ASTM Requirements



# NFPA 70E Schedule

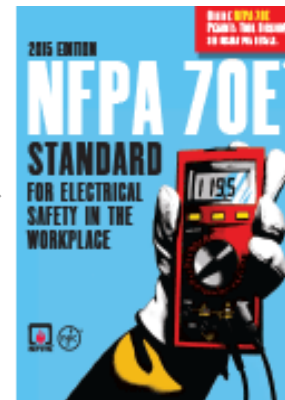
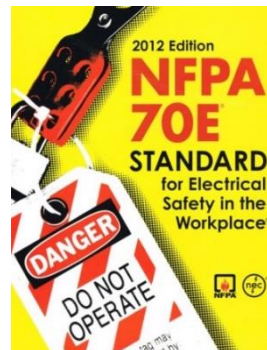
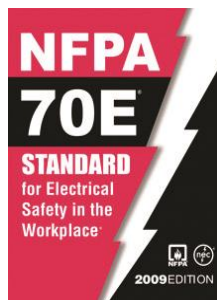
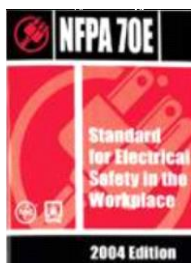
- Delayed Publication
  - PDF – Available! (September)
  - Book – Available! (October)
  - E-Book – Available 11/27/17



# NFPA 70E

- History

- Prior to 1982, it was assumed that electric shock was the major risk associated with live electrical work. This was incorrect. According to studies a high percentage of electrical injuries resulted from arc flash rather than from shock.
- In 1990, the threat of arc flash was well-established, and OSHA updated [29 CFR-1910 Subpart S](#) to recognize the need for arc-flash safety. A few years later, [NFPA 70E](#) was revised to include the calculations necessary to establish arc flash protection boundaries.



11<sup>th</sup> Revision Since 1979



# NFPA 70E Updates

- Changes to Terms

- Accident has been replaced with incident
- Accidental and accidentally have been replaced with unintentional and unintentionally
- Qualified Person (2015 change) – changed from one who has skills and knowledge to one who has demonstrated the skills and knowledge
  - 2018 Change – Reduce the risk rather than avoid the hazards after identifying the hazards
- “Dangerous condition” was replaced with “as source of possible injury or damage to health” for an arc flash hazard
- “Short circuit current” was replaced with “available fault current”
- “Recognizing” was changed to “Identifying”
- “At a Distance” was changed to “Approach Limit”
- “Second Degree Burn” was changed to “At point which incident energy equals  $1.2 \text{ cal/cm}^2$ ”

# NFPA 70E Updates

- New Terms

- Electrical Safety Program – documented system consisting of electrical safety principles, policies, procedures, and processes that directs activities appropriate for the risk associated with electrical hazards
- Working Distance – measurement is between face, chest and arc source
- Available Fault Current – The amount of current delivered at a point on the system during a short-circuit condition.
- Fault Current – The largest amount of current capable of being delivered at a point on the system during a short-circuit condition.
- Risk Assessment Procedure
  - You must address the potential for human error. To assist, Annex Q – Human Performance & Workplace Electrical Safety has been added.

# NFPA 70E Updates

- Article 105 (Application of Safety Related Work Practices and Procedures)
  - 105.3 Responsibility: This section was revised and subdivided into “**Employer Responsibility**” and “**Employee Responsibility.**”
  - 105.3(A) Employer Responsibility: This new text requires that **safety-related work practices and procedures required by this standard shall be established, documented and implemented by the employer.** In addition, the **employer shall provide training** in safety-related work practices and procedures for employees.
  - 105.3(B) Employee Responsibility: This new text requires the **employee to comply with the safety-related work practices and procedures** provided by the employer.
  - 105.4 Priority: This new **addition emphasizes that hazard elimination shall be the first priority** in the implementation of safety-related work practices.

***\*Hazard elimination must be the first priority with any implementation of safety-work related practices.***



# NFPA 70E Updates

- Article 120
  - This article was reorganized to provide a more logical sequence for the overall process. It is now organized into the following sections:
  - 120.1 Lockout/Tagout Program
  - 120.2 Lockout/Tagout Principles
  - 120.3 Lockout/Tagout Equipment
    - Covers the requirements of lock application, LOTO devices, etc...
  - 120.4 Lockout/Tagout Procedures
  - 120.5 Process for Establishing and Verifying an Electrically Safe Work Condition
    - For 120.5 there were also 2 additional steps added on releasing or blocking stored mechanical energy as well as releasing stored electricity

# NFPA 70E Updates

- Article 120 .1
  - **120.1(A) General:** This section states that “Each employer shall establish, document and implement a lockout/tagout program.” The LOTO program and procedures shall also incorporate the following:
    - (1) Be applicable to the experience and training of the workers and conditions in the workplace
    - (2) Meet the requirements of Article 120
    - (3) Apply to fixed, permanently installed equipment, temporarily installed equipment and portable equipment
  - **120.1(B) Employer Responsibilities:** As part of the LOTO program, Section 120.1(B) states the employer shall be responsible for the following:
    - (1) Providing the equipment necessary to execute the lockout/tagout procedures
    - (2) Providing LOTO training to workers in accordance with 110.2
    - (3) Auditing the LOTO program in accordance with 110.1
    - (4) Auditing execution of the LOTO program in accordance with 110.1

# NFPA 70E Updates

- Article 120 .2
  - **120.2(A) General:** This states the requirements of Article 120 must be met in order to have an electrically safe work condition.
  - **120.2(B) Employee Involvement:** This requires that “each person” who could be exposed directly or indirectly to a source of electrical energy shall be involved in the lockout/tagout process.
  - **120.2(C) Lockout/Tagout Procedure:** Previously named “Plan,” this language was relocated from 120.2(B)(5). The language “A lockout/tagout procedure” shall be developed and “suitable documentation including” up-to-date drawings and diagrams was added.



# NFPA 70E Updates

- Article 120.3, 120.4, and 120.5
  - **120.3 Lockout/Tagout Equipment:** This is based on relocating 120.2(E) and covers the requirements of lock application, LOTO device, lockout device and tagout device.
  - **120.4 Lockout/Tagout Procedures:** This section is derived from relocating other sections.
  - **120.5 Process for Establishing and Verifying an Electrically Safe Work Condition:** This was previously 120.1. It was relocated and the title was revised. Two additional steps were added to the process. They include:
    - **(4) Release stored electrical energy**
    - **(5) Release or block stored mechanical energy**

*\*Use an adequately rated portable test instrument to test each phase conductor or circuit part to verify it is de-energized. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on any known voltage source.*

*Two Additional Steps in 2018*

# NFPA 70E Updates

- Table 130.5 (G)
  - This table used to be in the annex, but a lot of people were incorrectly using the PPE categories. So the table has been moved to the mandatory text to assist with PPE selection.
- Two Choices to Conduct an Arc Flash Risk Assessment
  - Calculation Procedures
    - This is a much more precise method as workers are placed in exact PPE requirements. i.e., if tables are used an Arc Flash PPE Category Level 3 requires a minimum of 25 cal/cm<sup>2</sup> VS incident energy calculation of 8 cal/cm<sup>2</sup> where an 8 cal arc flash suit can be worn.
  - NFPA 70E Tables
    - Should only be used under electrical engineering supervision.
  - Example: 8 cal/cm<sup>2</sup> **VS** Arc Flash PPE Category 3 or 4



# NFPA 70E Updates

- Table 130.7 (C)(7) – Insulating Rubber Gloves
  - There shall be no activity performed that risks cutting or damaging the glove
  - The rubber insulating gloves shall be electrically retested **before reuse**
  - The voltage rating of the rubber insulating gloves shall be reduced by 50% for class 00 and by one whole class for classes 0 through 4.



# NFPA 70E Updates

- Arc Flash Personal Protective Equipment
  - 3<sup>rd</sup> Party Testing – NFPA 70E considered this to be introduced into 2018, but it was not passed.
    - 3<sup>rd</sup> party certification is critical—especially with standards requirements moved to non-mandatory annex.
  - 2015 – PPE must meet the standards listed in Table 130.7 (C)(14).
    - 2018 states that your PPE must conform to applicable state, federal, or local codes or standards.
  - Recommendation: Be sure to always request ASTM or IEC testing.
  - In EU and other countries, CE certification is required.

# NFPA 70E Updates

- Arc Flash Boundaries
  - The revision utilizes “approach limit” rather than “at a distance”
  - “Second degree burn” has been removed and replaced with “at which incident energy equals  $1.2 \text{ cal/cm}^2$ ”

Eliminated in  
2015 version

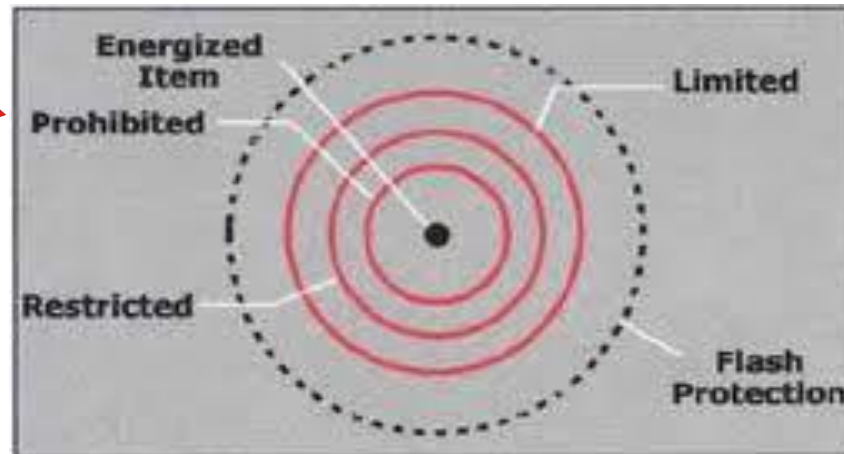


Figure 1 - NFPA 70E Approach Boundaries

- Restricted Approach Boundary
  - May only be crossed by qualified workers with appropriate PPE. In addition, a work permit is needed
- Limited Approach Boundary
  - Unqualified workers must be in PPE and accompanied by qualified worker to cross



# NFPA 70E Updates

- 130.7 (A)
  - In the 2015 edition, there was a note stating that when the incident energy exceeded 40 cal/cm<sup>2</sup> that greater emphasis was needed for de-energizing.
  - This has been deleted as NFPA 70E 2018 really states that a strong emphasis should be put on de-energizing at all times. This should not only apply to 40 cal/cm<sup>2</sup> and above.

*\*A 40 cal/cm<sup>2</sup> occurrence with very few cycles will be pretty explosive (uncommon) but a 40 cal/cm<sup>2</sup> with 60-90 cycles is likely not going to be very explosive and this would be much more common.*

# NFPA 70E Arc Flash Labels

# WARNING

**Bus: Boiler CP Prot: PP1-1**

## **Appropriate PPE Required Arc Flash and Shock Hazard**

### **FLASH PROTECTION**

Flash Hazard at 18 in

Min. Arc Rating: 0.40 cal/cm<sup>2</sup>

Flash Protection Boundary: 9 in

### **PPE Required**

- PPE
- Safety Glasses or Goggles
  - Hearing Protection
  - Leather Gloves and Shoes
  - Non-Melting Shirt and Pants

### **SHOCK PROTECTION**

Exposed Voltage 480 VAC

Glove Class: 0

Limited Approach 42 in

Restricted Approach 12 in

Prohibited Approach 1 in

Salisbury Assessment Solutions

101 E. Crossroads Pkwy Suite A

Bolingbrook, IL 60440

1-888-429-0389

1-877-406-4501

Sep 04, 2013

# 10004

# NFPA 70E Arc Flash Labels

# DANGER

**Bus: Collector Bus (Seconadry Collector bus in Vault) Prot: SG-3**

**ENERGIZED WORK PROHIBITED**

**NO SAFE PPE EXISTS**

## FLASH PROTECTION

Flash Hazard at 18 inches

Min. Arc Rating: 90 cal/cm<sup>2</sup>

Flash Protection Boundary: 156 inches

Clothing Category: Dangerous!

PPE ■ No FR Category Found  
■ Do not work on LIVE!

## SHOCK PROTECTION

Exposed Voltage 240 VAC

Glove Class: 00

Limited Approach 42 inches

Restricted Approach Avoid Contact

Prohibited Approach Avoid Contact

Salisbury Assessment Solutions

101 E. Crossroads Pkwy Suite A

Bolingbrook, IL 60440

513-827-9559

877-318-5054

Feb 03, 2011

# Electrical Compliance

- What is Needed for Full Electrical Compliance
  - Written Electrical Safety Program
    - Policies and Procedures
  - Electrical Safety Training Program
  - Arc Flash Assessment
    - A site needs to clearly identify the electrical hazards
  - Proper Electrical Personal Protective Equipment



# Why so Important?





# **!!!!WARNING!!!!**

## **The following slides are very graphic.**

# Arc Flash Burn



# Electrical Shock





# Electrical Flash Burn



**Electrocution caused by  
grasping a high power cable.**





High voltage electrical burn, immediately after (left) and 8 days after (right).

# Why Invest in Electrical Safety?

- **ABC Manufacturing – Boston Facility**

- 210,000 square feet, heavy manufacturing
- Written Electrical Safety Program in place & Electrical assessment/training has been conducted per NFPA 70E.

- Annual Spend (over 5 year period) = \$17,500/year

– Electrical Assessment	\$43,800
– Electrical Training	\$28,700
– Electrical PPE	\$11,400
– Model Updates/Engineering Support/Mitigation	<u>\$3,600</u>
5 Year Total Spend	<b>\$87,500</b>

- **Based on electrical safety commitment, no electrical safety recordables over 5 year span.**

# Why Invest in Electrical Safety?

- **XYZ Manufacturing – Miami Facility**

- 195,000 square feet, heavy manufacturing
- No updated written electrical safety program in place, some electrical training has been provided, but no electrical assessment has been conducted.
  - 2012 – Maintenance worker was assisting with an electrical application and was standing inside the electrical boundary without wearing the proper PPE.
    - Without an electrical assessment performed, this individual would have no idea what to wear or how close they could stand
  - Inadvertent contact was made with the electrical equipment and an arc flash took place. The maintenance worker was wearing a 65/35 polyester/cotton blend and clothing caught on fire from head to toe.
- 2012 – 2014
  - Extensive surgeries, skin grafts, and therapy were performed on worker.
- 2016 Update
  - The worker has still not been able to return to work.
- **Total Cost to XYZ Manufacturing over 5 years - \$5.8M, or \$1.16M/year**
  - **This overall cost includes surgeries, therapy, loss of work wages, loss of productivity for business, fines, equipment costs and unfortunately litigation.**

# Arc Flash Assessment Deliverables

## It is Critical to Have the Right Partner

### —Deliverables

- Fault Current Study (needed to perform the arc flash study)
- Equipment Evaluation – NEC requires that OC devices be rated to withstand available fault currents. **Must be done per NEC.**
- Impedance Report – catalog of all electrical equipment, devices, cables, etc... **Valuable for maintenance** in the event of replacements.
- Coordination Study – **Verifies settings to reduce or eliminate tripping.**
- Updated one lines for each site (AutoCAD and PDF)
- All deliverables in both paper and electronic formats
- Ongoing support to maintain model, drawings and studies

# What's Next?

- Arc Flash Labels
  - Once your electrical assessment is complete and arc flash labels are installed, your entire site is aware of any and all arc flash hazards within your site.
- Next step – Electrical PPE Selection





# How Do I Protect Against Shock?

- **Insulating Rubber Gloves**  
**OSHA 1910.333(a)(1)**

**Rubber Insulating Gloves are among the most important articles of personal protective equipment for electrical workers. They are the first line of defense for contact with any energized components or lines.**



# Testing Rubber Insulating Goods

- The interval between electrical retest for issued Rubber Gloves shall not exceed six months and twelve months for sleeves
- Gloves and sleeves that have been electrically tested but not issued shall not be placed into service unless they have been electrically tested within previous twelve months

(ASTM F 496 Section 7.1)



# Leather Protectors

**Rubber gloves should never be used without protector gloves over them**

**The use of protector gloves will provide the mechanical protection necessary to make sure the rubber gloves will adequately perform**



# Arc Flash Face Shields

- Must Meet ASTM F2178-17
- Must Meet ANSI Z87.1
- Meet Same Criteria for ATPV Rating Given to Garments Based on ASTM F1959
- Clean With Mild Soap and Warm Water



# PPE Category 2



# PPE Category 3





# PPE Category 4



# New Innovative Lift Front Hood

- **40 cal/cm<sup>2</sup> Lift Front Hood**
  - Increased Visibility
    - Contoured lens allows for better peripheral vision and light
    - Clear chin cup allows for additional vertical view
    - Task lights allow for better light in dark places
    - No fabric impeding on lens
  - Comfort
    - Less fabric than a standard hood makes it lighter and more comfortable
      - Reduces neck strain and fatigue
    - Weight balanced shield assembly provides stability when stowed
  - Ventilation
    - Innovative design creates natural ventilation system beneath the brim of the hard hat
    - Ventilation allows for CO<sub>2</sub> and heat to escape bringing in increased oxygen levels
    - Ventilation reduces fogging of the lens
    - Feature allows access to fresh air without hood removal



# New Innovative Premium Light Weight

## 40 cal/cm<sup>2</sup> Premium Light Weight Arc Flash Suit

- Weight
  - Under 6.5 pounds versus standard 40 cal suit weighing over 9.0 pounds.
- Heat Retention
  - Significantly reduces!
- Movement
  - Thinner fabric, easier movement!
- Inherently FR
- \*Available with Premium Light Weight version of the Lift Front Hood



# PrismShield Overall Benefits

- **Full Color recognition**

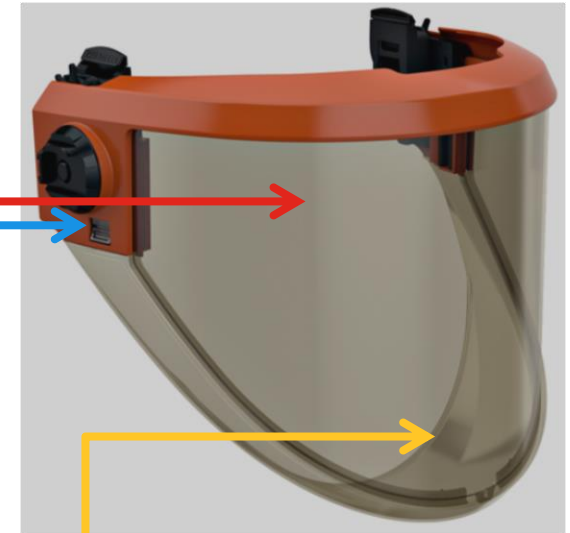
- See colors just as well as without the shield
- Easily set wires and other objects apart at all times
- No need to remove lens to see clearly

- **Weight Balancing frame**

- Wear the leans for longer with less neck-strain
- A balanced shield improves natural head movement
- Easily flip open the shield when needed and have it stay in place

- **Specialty Anti-fog and Anti-scratch coating**

- Keep focused on the task without a decrease in visibility
- Less nicks and scratches that decreases visibility
- Shield is usable in a wider range of climates



# Compliance Support

## Electrical Assessments

- ***Required every 5 years by NFPA 70E.***
- Key Deliverables:
  - Fault Current Study
  - Short Circuit Study
  - One Line Diagrams
  - Arc flash labeling
  - Equipment Evaluation
  - Coordination of overcurrent devices
  - Ongoing support

## Electrical Training

- ***Required every 3 years by NFPA 70E, recommended refreshers every year.***
- Classroom 2,4, 8 and 16 hour courses for general and qualified workers
- E-Learning Courses
- Webinars Available

## Other

- Thermography
- Design
- Preventative Maintenance
- WESP's
- Mitigation
- Modeling
- Consulting
- And, much, much more!

- **Based on the electrical assessment process Salisbury provides electrical PPE solution recommendations on product to mitigate the hazards**







**THANK  
YOU!**

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**(847) 687-7586**

**For more information or to  
receive a free quote visit the SAS  
website at:**

**[www.arcsafety.com](http://www.arcsafety.com)**

**[www.SalisburybyHoneywell.com](http://www.SalisburybyHoneywell.com)**