

# OSHA & NFPA 70E Personal Protective Equipment



Presented by:  
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# Insulating Equipment

12-2018

SLIDE-2

- OSHA requires that insulating equipment used for the protection of employees be capable of withstanding, without failure, the voltages that may be imposed upon it.
- Insulating equipment shall be:
  - Clearly marked
  - Cleaned as needed to remove foreign substances.
  - Stored in such a location and in such a manner as to protect it from light, temperature extremes, excessive humidity, ozone, and other damaging substances and conditions.
  - Inspected for damage before each day's use and immediately following any incident that can reasonably be suspected of causing damage.
  - Electrical protective equipment shall be maintained in a safe, reliable condition.



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# Insulating Equipment

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- Insulating equipment with any of the following defects may not be used:
  - A hole, tear, puncture, or cut;
  - Ozone cutting or ozone checking (that is, a series of interlacing cracks produced by ozone on rubber under mechanical stress);
  - An embedded foreign object;
  - Any of the following texture changes: swelling, softening, hardening, or becoming sticky or inelastic.
  - Any other defect that damages the insulating properties.
- Insulating equipment found to have other defects that might affect its insulating properties shall be removed from service and returned for testing.



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# Insulating Equipment

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- Rubber insulating equipment meeting the following national consensus standards is deemed to be in compliance with OSHA:
  - American Society for Testing and Materials (ASTM) D120-09, *Standard Specification for Rubber Insulating Gloves.*
  - ASTM D178-01 (2010), *Standard Specification for Rubber Insulating Matting.*
  - ASTM D1048-12, *Standard Specification for Rubber Insulating Blankets.*
  - ASTM D1049-98 (2010), *Standard Specification for Rubber Insulating Covers.*
  - ASTM D1050-05 (2011), *Standard Specification for Rubber Insulating Line Hose.*
  - ASTM D1051-08, *Standard Specification for Rubber Insulating Sleeves.*



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# Insulating Equipment

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- Rubber insulating equipment must be tested and certified periodically according to strict guidelines.
- If the insulating equipment have been electrically tested but not issued for service, the insulating equipment may not be placed into service unless it has been electrically tested within the previous 12 months.

Table 130.7(C)(7)(c) Rubber Insulating Equipment, Maximum Test Intervals

Rubber Insulating Equipment	When to Test	Governing Standard for Test Voltage*
Blankets	Before first issue; every 12 months thereafter <sup>†</sup>	ASTM F479
Covers	If insulating value is suspect	ASTM F478
Gloves	Before first issue; every 6 months thereafter <sup>†</sup>	ASTM F496
Line hose	If insulating value is suspect	ASTM F478
Sleeves	Before first issue; every 12 months thereafter <sup>†</sup>	ASTM F496

\*ASTM F478, *Standard Specification for In-Service Care of Insulating Line Hose and Covers*; ASTM F479, *Standard Specification for In-Service Care of Insulating Blankets*; ASTM F496, *Standard Specification for In-Service Care of Insulating Gloves and Sleeves*.

<sup>†</sup>If the insulating equipment has been electrically tested but not issued for service, it is not permitted to be placed into service unless it has been electrically tested within the previous 12 months.

# PPE

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SLIDE-6

- NFPA 70 E requires the use of Personal Protective Equipment (PPE) to prevent contact with live electrical equipment and to protect workers in case of an arc flash.



# Shock PPE

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SLIDE-7

- Employees working in areas where electrical hazards are present shall be provided with, and shall use, PPE that is designed and constructed for the specific part of the body to be protected and for the work to be performed.
  - Employees shall wear rubber insulating gloves with leather protectors and rubber insulating sleeves where there is a danger of hand and or arm injury from electric shock due to contact with energized electrical conductors.
  - Rubber insulating gloves shall be rated for the voltage for which the gloves will be exposed.



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# Shock PPE

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- Where insulating rubber gloves are used for shock protection, leather protectors shall be worn over the rubber gloves.
  - The leather protectors worn over rubber insulating gloves provide additional arc flash protection.
  - Do not use leather protectors alone for protection against electric shock.
    - Serious injury or death could result.
    - Always use proper rubber insulating gloves.







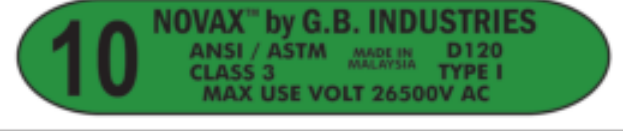



# Shock PPE

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SLIDE-9

- Electrical gloves are assigned class and color code based on rating.

CLASS	TEST AC VOLTS	USE AC VOLTS	USE DC VOLTS	LABEL COLOR	LABEL IMAGE
00	2,500	500	750	Beige	
0	5,000	1,000	1,500	Red	
1	10,000	7,500	11,250	White	
2	20,000	17,000	25,500	Yellow	
3	30,000	26,500	39,750	Green	
4	40,000	36,000	54,000	Orange	

# Shock PPE

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SLIDE-10

- ASTM requires the following cuff to bead distances.

Minimum Distance from Protector and Rubber Glove	Glove Class	Leather Protector Cuff
		----- Cuff Line -----
	00, 0	1/2" from cuff
	1	1" from cuff
	2	2" from cuff
	3	3" from cuff
	4	4" from cuff



# Shock PPE

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SLIDE-11

- Insulating electrical gloves shall be inspected for damage before each day's use and immediately following any incident that can reasonably be suspected of causing damage.
  - The pre use inspection includes a visual inspection and an air test prior to use.



# Glove Inspection

Manual Inflation: per ASTM F 1236



**1. Grasp glove**



**2. Stretch to seal closed**



**3. Press and roll tightly**



**4. Twirl glove, rotating on rolled ends**



**5. Entrap air by holding in one hand**



**6. Hold close to ear, squeeze to add pressure, listen and feel for pinhole leaks**



**7. Turn glove inside out**



**Repeat process**

# Glove Inspection

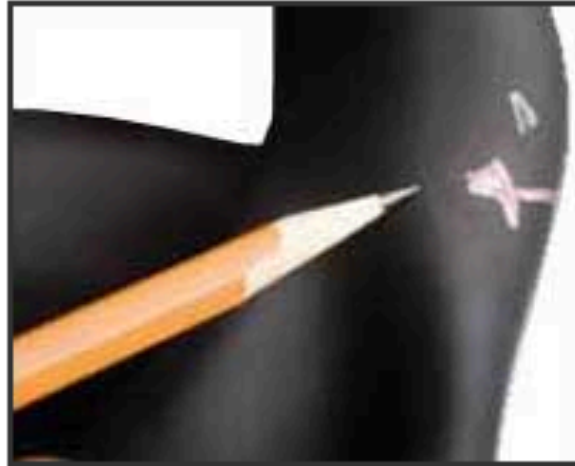
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SLIDE-13

**Examine closely to spot damaged, faulty gloves.**



**Checking for cracks due to UV or ozone**



**Splits, cuts or holes from snags and punctures**



**Grooves worn due to rope burns or heat exposure**



**Weak creases resulting from being left inside out or folded too long**



**Palm fold pattern due to overflexing, rigorous duty**



**"Blooms" or "swells" from chemicals, oils**

# Glove Limited Use

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SLIDE-14

- Protector leather gloves need not be used with Class 0 gloves, under limited-use conditions, when small equipment and parts manipulation necessitate unusually high finger dexterity.
  - If the voltage does not exceed 250 volts, ac, or 375 volts, dc, protector gloves need not be used with Class 00 gloves, under limited-use conditions, when small equipment and parts manipulation necessitate unusually high finger dexterity.
  - Any other class of glove may be used without protector gloves, under limited-use conditions, when small equipment and parts manipulation necessitate unusually high finger dexterity but only if the employer can demonstrate that the possibility of physical damage to the gloves is small and if the class of glove is one class higher than that required for the voltage involved.



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# Glove Limited Use

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- Employees inspecting rubber insulating gloves used under limited use conditions need to take extra care in visually examining them.
- Employees using rubber insulating gloves under limited use conditions need to take extra care to avoid handling sharp objects.
- Insulating gloves that have been used without protector gloves may not be reused until they have been tested.



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# Glove Repair

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- Rubber insulating gloves and sleeves with minor physical defects, such as small cuts, tears, or punctures, may be repaired by the application of a compatible patch.
- Also, rubber insulating gloves and sleeves with minor surface blemishes may be repaired with a compatible liquid compound.
  - The repaired area shall have electrical and physical properties equal to those of the surrounding material.
  - Repairs to gloves are permitted only in the area between the wrist and the reinforced edge of the opening.



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# Glove Marking

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- Each electrical insulating glove shall be clearly marked.
  - Markings on gloves shall be confined to the cuff portion of the glove.
- Markings shall be non-conducting and shall be applied in such a manner as not to impair the insulating qualities of the equipment.
- Marking equipment with, and entering onto logs, the results of the tests and the dates of testing are two acceptable means of meeting the certification requirement.
- Non-ozone-resistant equipment shall be marked Type I.
- Ozone-resistant equipment shall be marked Type II.



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# Shock PPE

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- Where insulated footwear is used as protection against step and touch potential, dielectric overshoes shall be required.
  - Insulated soles shall not be used as primary electrical protection.
  - EH (Electrical Hazard) shoes meeting ASTM F 2413 can provide a secondary source of electric shock protection under dry conditions.



# Shock PPE

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SLIDE-19

- NFPA requires employees wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with energized electrical conductors or from flying objects resulting from electrical explosion.
- OSHA requires a hard hat be worn in areas where there is the risk of exposure to electrical conductors that can potentially contact the head.
- OSHA requires head protection to meet ANSI Z89.1 standard.



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# Shock PPE

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SLIDE-20

- ANSI hard hat electrical performance is divided into three categories:
  - Class E, Electrical;
  - Class G, General, and;
  - Class C, Conductive.
- **Class E (Electrical) Hard Hats** are designed to reduce exposure to high voltage conductors, and offer dielectric protection up to 20,000 volts (phase to ground).
  - This amount of voltage protection, however, is designated to the head only, and is not an indication of voltage protection allocated to the user as a whole.
- **Class G (General) Hard Hats** are designed to reduce exposure to low voltage conductors, and offer dielectric protection up to 2,200 volts.



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# Arc Flash PPE

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SLIDE-21

- Employees shall wear arc-rated clothing wherever there is possible exposure to an electric arc flash above the threshold incident energy level for a second degree burn of 1.2 calories per square centimeter (cal/cm<sup>2</sup>).
- All parts of the body that may be exposed to the arc flash need to be covered by the appropriate type and quality of PPE.
- When arc-rated clothing is worn to protect an employee, it shall cover all ignitable clothing and shall allow for movement and visibility.



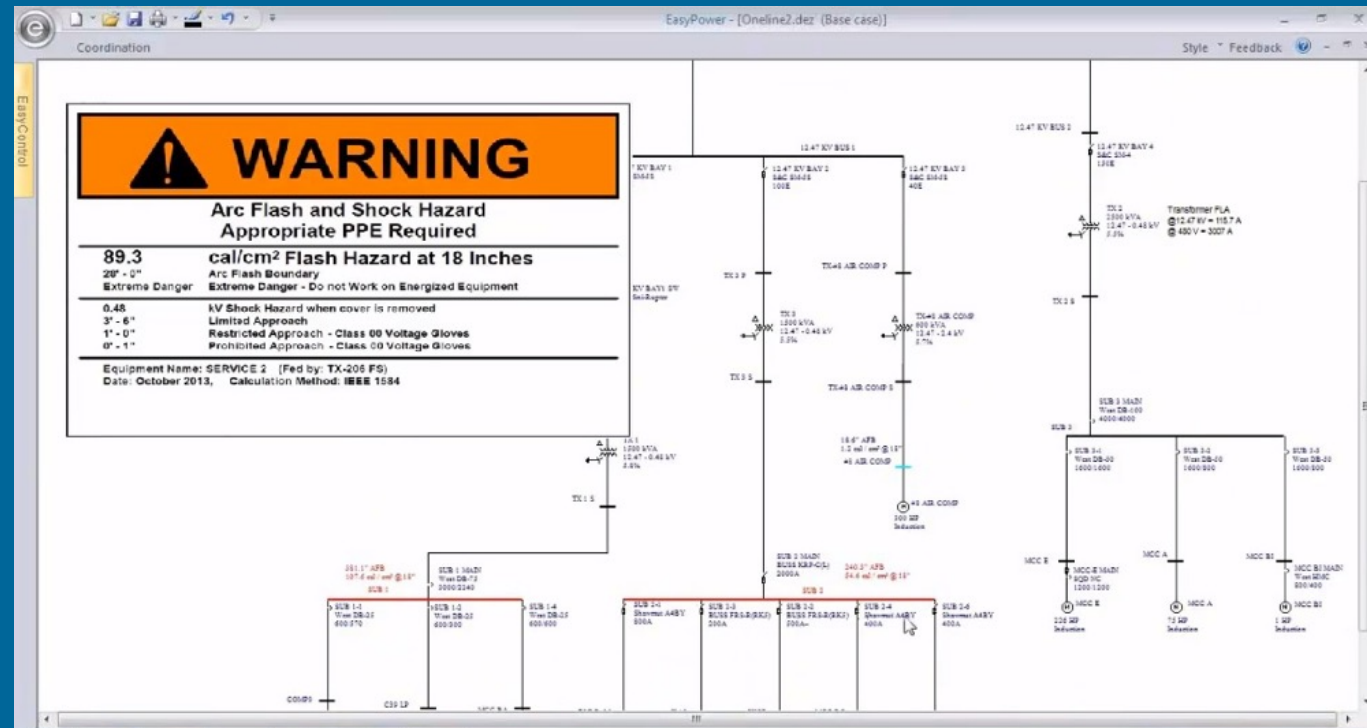
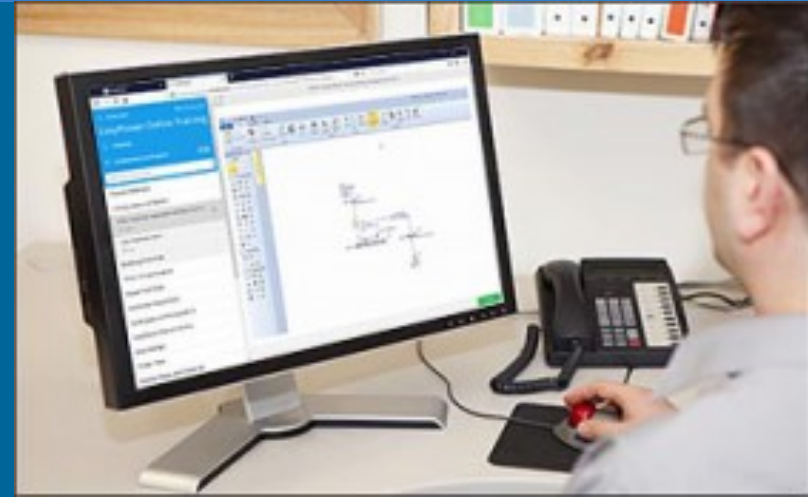
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# Arc Flash PPE

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- To determine incident energy and arc flash boundary there are several software programs that can be used.
- Once the incident energy is calculated the following table can be used to select PPE.



# Arc Flash PPE

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- If the incident energy is known and it is between 1.2 to 12 calories per centimeter squared (cal/cm<sup>2</sup>) the following PPE are required:
  - Arc rated clothing rated at or above the incident energy
  - Long sleeve shirt & pants or coverall or arc flash suit
  - Arc rated face shield and arc rated balaclava or
  - Arc rated suit hood
  - Arc rated outerwear (rainwear)
  - Heavy duty leather gloves, or
  - Arc rated gloves
  - Hard hat
  - Safety glasses
  - Hearing protection
  - Leather footwear



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# Arc Flash PPE

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- If the incident energy is greater than 12 cal/cm<sup>2</sup> the only modification is that a face shield is not allowed and an arc rated suit hood is required.

**Table 130.5(G) Selection of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method Is Used**

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**Incident energy exposures equal to 1.2 cal/cm<sup>2</sup> up to 12 cal/cm<sup>2</sup>**

Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy<sup>a</sup>

Long-sleeve shirt and pants or coverall or arc flash suit (SR)

Arc-rated face shield and arc-rated balaclava or arc flash suit hood (SR)<sup>b</sup>

Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)

Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)<sup>c</sup>

Hard hat

Safety glasses or safety goggles (SR)

Hearing protection

Leather footwear

**Incident energy exposures greater than 12 cal/cm<sup>2</sup>**

Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy<sup>a</sup>

Long-sleeve shirt and pants or coverall or arc flash suit (SR)

Arc-rated arc flash suit hood

Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)

Arc-rated gloves or rubber insulating gloves with leather protectors (SR)<sup>c</sup>

Hard hat

Safety glasses or safety goggles (SR)

Hearing protection

Leather footwear

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SR: Selection of one in group is required.

AN: As needed.

<sup>a</sup>Arc ratings can be for a single layer, such as an arc-rated shirt and pants or a coverall, or for an arc flash suit or a multi-layer system if tested as a combination consisting of an arc-rated shirt and pants, coverall, and arc flash suit.

<sup>b</sup>Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area are required by 130.7(C)(10)(c). Where the back of the head is inside the arc flash boundary, a balaclava or an arc flash hood shall be required for full head and neck protection.

<sup>c</sup>Rubber insulating gloves with leather protectors provide arc flash protection in addition to shock protection. Higher class rubber insulating gloves with leather protectors, due to their increased material thickness, provide increased arc flash protection.



# PPE Category 1

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SLIDE-25

- NFPA 70E PPE Category 1 requires a minimum arc rating of 4 calories per square centimeter (cal/cm<sup>2</sup>) for arc rated clothing:
  - Arc-rated long-sleeve shirt & pants or arc-rated coverall
  - Arc-rated face shield with wrap-around guarding to protect not only the face but also the forehead, ears, and neck, or, alternatively, an arc-rated arc flash suit hood.
  - Arc-rated jacket, parka, rainwear, or hard hat liner (As Needed = AN)
- Protective Equipment:
  - Safety glasses or safety goggles (Selection Required = SR)
  - Hearing protection (ear canal inserts)
  - Heavy duty leather gloves
  - Leather footwear (AN)
  - Voltage Rated Hard hat,



# PPE Category 2

12-2018

SLIDE-26

- NFPA 70E PPE Category 2 requires a minimum arc rating of 8 cal/cm<sup>2</sup> for arc rated clothing:
  - Arc-rated long-sleeve shirt & pants or arc-rated coverall
  - Arc-rated face shield with balaclava OR an arc-rated arc flash suit hood.
  - Arc-rated jacket, parka, rainwear, or hard hat liner (AN)
- Protective Equipment:
  - Safety glasses or safety goggles (SR)
  - Hearing protection (ear canal inserts)
  - Heavy duty leather gloves
  - Leather footwear (AN)
  - Voltage Rated Hard hat,



# PPE Category 3

12-2018

SLIDE-27

- NFPA 70E PPE Category 3 requires a minimum arc rating of 25 cal/cm<sup>2</sup> for arc rated clothing:
  - Arc-rated long-sleeve shirt (AR)
  - Arc-rated pants (AR)
  - Arc-rated coverall (AR)
  - Arc-rated arc flash suit jacket (AR)
  - Arc-rated arc flash suit pants (AR)
  - Arc-rated arc flash suit hood
  - Arc-rated gloves
  - Arc-rated jacket, parka, rainwear, or hard hat liner (AN)
- Protective Equipment:
  - Safety glasses or safety goggles (SR)
  - Hearing protection (ear canal inserts)
  - Leather footwear
  - Voltage Rated Hard hat.



# PPE Category 4

12-2018

SLIDE-28

- NFPA 70E PPE Category 4 requires a minimum arc rating of 40 cal/cm<sup>2</sup> for arc rated clothing:
  - Arc-rated long-sleeve shirt (AR)
  - Arc-rated pants (AR)
  - Arc-rated coverall (AR)
  - Arc-rated arc flash suit jacket (AR)
  - Arc-rated arc flash suit pants (AR)
  - Arc-rated arc flash suit hood
  - Arc-rated gloves
  - Arc-rated jacket, parka, rainwear, or hard hat liner (AN)
- Protective Equipment:
  - Safety glasses or safety goggles (SR)
  - Hearing protection (ear canal inserts)
  - Leather footwear
  - Voltage Rated Hard hat.



# Eye Protection

12-2018

SLIDE-29

- Employees shall wear protective equipment for the eyes whenever there is danger of injury from electric arcs, flashes, or from flying objects resulting from electrical explosion.
- Safety glasses alone reduce the energy but still allow about 40% of the incident energy to reach the eyes.
  - The rest of the face remains unprotected.
  - Use of safety glasses and a hard hat with a polycarbonate face shield provides more protection, allowing about 25% of the incident energy to reach the eyes and about 48% to reach the mouth.

# Head Protection

12-2018

SLIDE-30

- An arc-rated balaclava shall be used with an arc-rated face shield when the back of the head is within the arc flash boundary.
  - An arc-rated hood shall be permitted to be used instead of an arc-rated face shield and balaclava.
- An arc-rated hood shall be used when the anticipated incident energy exposure exceeds 12 cal/cm<sup>2</sup>.



# Hand Protection

12-2018

SLIDE-31

- Hand and arm protection shall be worn where there is possible exposure to arc flash burn.
- Heavy-duty leather gloves or arc-rated gloves shall be worn where required for arc flash protection.
  - Heavy-duty leather gloves are made entirely of leather with minimum thickness of 0.03", are unlined or lined with nonflammable, non-melting fabrics.
  - Heavy-duty leather gloves meeting this requirement have been shown to have ATPV values in excess of 10 cal/cm<sup>2</sup>.
  - Arc rated gloves normally do not provide shock protection.



# Foot Protection

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- Heavy-duty leather work shoes provide some arc flash protection to the feet and shall be used in all exposures greater than 4 cal/cm<sup>2</sup> .
  - Do not wear athletic shoes with plastic mesh.



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# Face Protection

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- Face shields shall have an arc rating suitable for the arc flash exposure.
  - Face shields with a wraparound guarding to protect the face, chin, forehead, ears, and neck area shall be used.
  - Face shields without an arc rating shall not be used.
  - Eye protection (safety glasses or goggles) shall always be worn under face shields or hoods.
- Most arc rated faceshields are tinted and can reduce visual acuity and color perception.
  - Additional illumination of the task area might be necessary when these types of arc protective face shields are used.



# Arc Flash PPE

12-2018

SLIDE-34

- Employees shall wear nonconductive protective equipment for the face, neck, and chin whenever there is a danger of injury from exposure to electric arcs or flashes or from flying objects resulting from electrical explosion.
- Employees shall wear hearing protection whenever working within the arc flash boundary.

# Arc Flash PPE

12-2018

SLIDE-35

- Protective clothing includes shirts, pants, coveralls, jackets, and parkas worn routinely by workers who, under normal working conditions, are exposed to momentary electric arc and related thermal hazards.
  - Arc-rated rainwear worn in inclement weather is included in this category of clothing.
- DEET can render your arc rated PPE flammable.
  - So, try another solution for keeping the mosquitos at bay—like a non-DEET spray that contains Permethrin—a nonflammable insecticide.



DEET is an FR don't



# Arc Flash PPE

12-2018

SLIDE-36

- Garments worn as outer layers over arc-rated clothing, such as jackets or rainwear, shall also be made from arc-rated material.
- Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric underlayers (underwear) next to the skin.
  - Exception: An incidental amount of elastic used on nonmelting fabric underwear or socks shall be permitted.
- Clothing shall cover potentially exposed areas as completely as possible.
- Shirt and coverall sleeves shall be fastened at the wrists, shirts shall be tucked into pants, and shirts, coveralls, and jackets shall be closed at the neck.

# Arc Flash PPE

12-2018

SLIDE-37

- Arc flash suit design shall permit easy and rapid removal by the wearer.
  - Tight-fitting clothing shall be avoided.
  - Loosefitting clothing provides additional thermal insulation because of air spaces.
- The entire arc flash suit, including the hood's face shield, shall have an arc rating that is suitable for the arc flash exposure.
  - When exterior air is supplied into the hood, the air hoses and pump housing shall be either covered by arc-rated materials or constructed of nonmelting and nonflammable materials.
- The letters "AR" stand for Arc Rated,
  - ALL AR clothing is Flame Resistant (FR), but not all FR clothing has been Arc Rated.

# Arc Flash PPE

12-2018

SLIDE-38

- Layering of arc-rated clothing is an effective approach to achieving the required arc rating.
  - The use of all arc rated clothing layers will result in achieving the required arc rating with the lowest number of layers and lowest clothing system weight.
  - Garments that are not arc rated shall not be used to increase the arc rating of a garment or of a clothing system.
- The total system of protective clothing can be selected to take credit for the protection provided by all the layers of clothing that are worn.
  - For example, to achieve an arc rating of 40 cal/cm<sup>2</sup> , an arc flash suit with an arc rating of 40 cal/cm<sup>2</sup> could be worn over a cotton shirt and cotton pants.

# Arc Flash PPE

12-2018

SLIDE-39

- Alternatively, an arc flash suit with a 25 cal/cm<sup>2</sup> arc rating could be worn over an arc-rated shirt and arc-rated pants with an arc rating of 8 cal/cm<sup>2</sup> to achieve a total system arc rating of 40 cal/cm<sup>2</sup>.
  - This latter approach provides the required arc rating at a lower weight and with fewer total layers of fabric and, consequently, would provide the required protection with a higher level of worker comfort.
- Under some exposure conditions, natural fiber under layers can ignite even when it is worn under arc rated clothing.

# Arc Flash PPE

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SLIDE-40

- “Inherent” arc rated refers to a fabric that has arc rated properties—defined by the fabric’s ability to self-extinguish when the ignition source is removed—by its very nature, as a core property.
  - In other words, a fabric is arc rated without any additional finishing.
  - “Treated” refers to a fabric that has been engineered with flame-retardant chemistry to have arc rated properties that were not present prior to the treatment.
- There are 3 levels at which FR properties can be achieved:
  - The Molecular Level – Synthetic derivatives are engineered at the molecular level to be FR (e.g., Nomex, Kermel, Twaron, Kevlar, etc.)
  - The Fiber Level – At this level, flame-retardant chemicals are added to the process prior to the fiber being extruded (e.g., FR Modacrylics, FR Rayons)
  - The Fabric Level – Arc rated properties are permanently imparted into flammable fabrics through a combination of chemical and mechanical processes (e.g., FR Cotton, 88/12)



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# Arc Flash PPE

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- Arc rated materials, such as flame-retardant-treated cotton, meta-aramid, para-aramid, and Poly Benzim Idazole (PBI) fibers, provide thermal protection.
  - These materials can ignite but will not continue to burn after the ignition source is removed.
  - Arc-rated fabrics reduce burn injuries during an arc flash exposure by providing a thermal barrier between the arc flash and the wearer.
- Non–arc-rated cotton, polyester cotton blends, nylon, nylon-cotton blends, silk, rayon, and wool fabrics are flammable.
  - Fabrics, zipper tapes, and findings made of these materials can ignite and continue to burn on the body, resulting in serious burn injuries.
  - Rayon is a cellulose-based (wood pulp) synthetic fiber that can burn but is non-melting.



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# Arc Flash PPE

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- Clothing consisting of fabrics made from synthetic materials such as acetate, acrylic, nylon, polyester, polyethylene, polypropylene, and spandex, either alone or in blends, shall not be used.
  - These materials melt as a result of arc flash exposure conditions, form intimate contact with the skin, and aggravate the burn injury.
  - Clothing and other apparel (such as hard hat liners and hair nets) made from materials that are not arc rated shall not be permitted to be worn.
  - Non melting undergarments are usually safe if the outer garment does not break open or stay on fire.



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# Arc Flash PPE

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- Where the work to be performed inside the arc flash boundary exposes the worker to multiple hazards, such as airborne contaminants, under special permission by the authority having jurisdiction and where it can be shown that the level of protection is adequate to address the arc flash hazard, non-arc-rated PPE shall be permitted.
- Arc-rated apparel shall be inspected before each use.
- Work clothing or arc flash suits that are contaminated, or damaged to the extent that their protective qualities are impaired, shall not be used.
  - Protective items that become contaminated with grease, oil, or flammable liquids or combustible materials shall not be used.
  - Visible stains may mean that the PPE is contaminated.
  - If PPE smells of solvent re-laundry or retire.



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# Arc Rating

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- Arc Rating is the value attributed to materials that describes their performance to exposure to an electrical arc discharge.
  - The arc rating is expressed in calories per centimeter squared (cal/cm<sup>2</sup>) and is derived from the determined value of the Arc Thermal Performance Value (ATPV) or Energy of Breakopen Threshold (EBT).
  - Arc rating is reported as either ATPV or EBT, whichever is the lower value.
- EBT is defined in ASTM F 1959-06 as the incident energy on a material that results in a 50 percent probability of breakopen.
  - Breakopen is a material response evidenced by the formation of one or more holes in the innermost layer of arc-rated material that would allow flame to pass through the material.
  - Breakopen is defined as a hole with an area of 0.5 in<sup>2</sup> or an opening of 1.0 inch in any dimension.



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# Arc Rating

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SLIDE-45

- ATPV is defined in ASTM F 1959-06 as the incident energy on a material that results in a 50 percent probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a second degree skin burn injury based on the Stoll curve, cal/cm<sup>2</sup>.
- Arc rating measures insulation of FR fabrics to arc flash.

# Arc Rated

12-2018

SLIDE-46

- A significant risk for death or serious injury occurs when the arc ignites the worker's clothing.
  - The primary purpose of arc rated clothing is to resist ignition (as tested by ASTM D-6413, also known as Vertical Flame Test).
  - If flammable clothing is ignited by an arc flash, flash fire, molten metal, etc, the hazard to the wearer instantly becomes much greater, because a clothing fire will last much longer than the initial hazard, will typically burn the victim over a much larger body surface area and more deeply, and is more likely to result in airway and lung damage.
  - By not continuing to burn after the initial hazard is over, arc rated clothing limits burn injury to, at most, only the body surface area directly impacted by the hazard (and it's this reduction of TBSA –Total Body Surface Area-burn that's most directly linked to survival).
  - Arc rated clothing will not support combustion after the heat source is removed.



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# Arc Rated

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SLIDE-47

- The second goal of arc rated clothing is to insulate the wearer from the thermal hazard, thus reducing or eliminating any 2nd or 3rd degree burn through the garments, even in areas directly impacted by the hazard.
  - On exposure to a flame, arc rated fabric hardens, starts to melt, discolors and chars, thereby forming a protective coating.
  - The char formation is beneficial because first, it inhibits the release of flammable gases and second, it forms an insulating barrier against thermal energy
- ASTM F1506 (2004) requires arc rated apparel to contain a label indicating that it meets the standard's performance specifications.
  - Apparel must be labeled with care instructions, fiber content and arc rating (APTV) or break open threshold.



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# Arc Rated

12-2018

SLIDE-48

- Myth: Cotton has flame resistance
  - Cotton has a 50% probability of ignition in the range of 0.8 to 1.2 cal/cm<sup>2</sup>.
  - Burns resulting from ignition of 100% cotton clothing produce deeper, more severe burns than those resulting from polyester-cotton blends.
- Finding the right fit for your FR clothing is extremely important.
  - A garment that's too loose could become entangled in machinery or other equipment, and
  - Clothing that's too tight could allow more heat energy to be transferred to your skin during a flash fire or arc flash.



# Maintenance

12-2018

SLIDE-49

- Keep track of how old your arc rated clothing is.
  - There are many different arc rated fabrics in use now, and each has a different lifespan.
  - The general rule of thumb is to own five sets of arc flash clothing, with each set being washed and worn once per work week.
  - Used according to these guidelines, treated 100 percent cotton (like Westex Indura®) lasts an average of 12 to 16 months, 88/12 cotton and nylon blends last for 18 to 30 months, and 93 percent Nomex® blends last anywhere from 2-1/2 to 4 years.
  - Chlorine bleach should not be used when washing arc rated fabrics because it significantly reduces the life of a garment and can break down the flame retardants in chemically treated garments, making them ineffective after several washes with bleach.
  - Still in doubt? Check the manufacturer's instructions.



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# Maintenance

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SLIDE-50

- Go easy when washing arc flash clothing.
  - When it comes to laundering arc flash PPE, gentler is better.
  - If you have the option between sending the clothing out to an industrial laundering service and just washing them at home, wash at home, because it inflicts less wear-and-tear, and helps arc rated clothes last longer.
  - Stick with mild detergent and warm (not hot) water, and then tumble dry on low.
  - Never use bleach or any other chlorine-based detergents, because in most cases, they'll just break down arc rated fabrics.

# Maintenance

12-2018

SLIDE-51

- Keep your arc rated clothing very clean.
  - Dirt, oil, chemicals and other contaminants can easily wear down the flame-fighting properties of arc flash pants, shirts, hoods, jackets and coveralls, so it's very important that arc rated clothing is washed as soon as possible after being soiled.
  - And never re-wear arc flash clothing without laundering it first - dirty PPE is less effective than clean, and can actually increase your risk of injury.



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# Inspection

12-2018

SLIDE-52

- Inspect PPE for damage.
  - Even small tears and cuts can greatly reduce the protective powers of FR clothing, so it's important to regularly inspect your arc flash apparel for signs of wear and damage.
  - In the event that damage is found, either repair it in accordance with the manufacturer's specifications (special flame-resistant fabric patches and/or thread may be required), or replace the damaged article of clothing immediately.
  - Never continue to wear damaged PPE, as it can greatly increase your risk of on-the-job injury.



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