



WORKPLACE SAFETY

A W A R E N E S S C O U N C I L

Personal Protective Equipment For Electrical Hazards

Introduction



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This material was produced by the Workplace Safety Awareness Council, a 501(c)(3) not-for-profit organization dedicated to safety in the workplace. For further information about the council or upcoming safety related training, please visit our website at www.wpsac.org or call us at (863) 537-4053.

Hierarchy of Control

1910 Subpart I Appendix B



Engineering Solutions:

- Guards
- Barriers
- Design Features

Administrative Solutions:

- Employee Training
- Standard Operating Procedures
- Hot Work Permit

Personal Protective Equipment:

- FR Clothing
- Hard Hat
- Safety Glasses



Remember – PPE is a last line of defense!

Alerting Techniques

1910.335(b)(1)-(3)

Other examples to protect employees from electrical hazards:

- Safety signs and tags
- Barricades
- Attendants



PPE Requirements

1910.335(a)(1)(i)



Employers


- Must determine what is needed (JHA)
- Must train employees on proper use
- Must enforce use of PPE
- May be required to pay for the PPE

Employees must use the PPE!

Why is FR Needed?

- Most severe burn energies and fatalities are caused by non-flame resistant clothing igniting and continuing to burn
- Flame resistant clothing will self-extinguish, thus limiting the injury
- Body area under non-FR clothing is often burned more severely than exposed skin





NON-FR

EQUIPMENT

200 Amp Disconnect

TEST PARAMETERS

Voltage = 480
Amperage = 12.5 kA
Cycles = 10
Distance = 12"
"Arc in a Box"

CALCULATED ENERGY
Per IEEE 1584

8.4 cal/cm²

MAIN MENU

[Top 10 Video Clips](#)
[No Manikin Clips](#)
[NON-FR Clips](#)
[INDURA® Ultra Soft Clips](#)

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WESTEX INC.
A WORLD LEADER IN FLAME RESISTANT FABRICS
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Explosions created by 70E Solutions at KEMA Powertest

QUIT

CLOTHING ON MANIKIN
Pant = 100% Cotton
Shirt = 100% Cotton

Top 10 - Clip 7



NON-FR

EQUIPMENT

200 Amp Disconnect

TEST PARAMETERS

Voltage = 480
Amperage = 16.5 kA
Cycles = 13
Distance = 12"
"Arc in a Box"

CALCULATED ENERGY

Per IEEE 1584

7.6 cal/cm²

MAIN MENU

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NON-FR Clips

INDURA[®] Ultra Soft[®] Clips

QUIT

CLOTHING ON MANIKIN

Pant = 65/35 Poly/Cotton

Shirt = 65/35 Poly/Cotton

Top 10 - Clip 2

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CLOTHING ON MANIKIN

Pant = INDURA® Ultra Soft® Style 451 9oz
Shirt = INDURA® Ultra Soft® Style 301 7oz

Top 10 - Clip 4

EQUIPMENT

200 Amp Disconnect

**TEST
PARAMETERS**

Voltage = 480
Amperage = 16 kA
Cycles = 7
Distance = 12"
"Arc in a Box"

**CALCULATED
ENERGY**

Per IEEE 1584

7.4 cal/cm²

MAIN MENU

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QUIT



NON-FR

EQUIPMENT

100 Amp Disconnect

TEST PARAMETERS

Voltage = 480
Amperage = 13.4 kA
Cycles = 9
Distance = 12"
"Arc in a Box"

CALCULATED ENERGY
Per IEEE 1584

8.0 cal/cm²

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QUIT

CLOTHING ON MANIKIN
Pant = 65/35 Poly/Cotton
Shirt = 65/35 Poly/Cotton

Top 10 - Clip 10

INDURA
Ultra Soft
Flame Resistant Fabrics

CLOTHING ON MANIKIN

**INDURA® Ultra Soft® Style 801 13oz over Style 341
5.5oz - 50 Cal (HRC 4) Arc Flash Suit**

Top 10 - Clip 6

EQUIPMENT

Motor Control Center

**TEST
PARAMETERS**

Voltage = 480
Amperage = 38.4 kA
Cycles = 15
Distance = 12"
"Arc in a Box"

**CALCULATED
ENERGY**

Per IEEE 1584

35.4 cal/cm²

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**Return to Top 10
Index**

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QUIT

Arc Energy vs Distance



Energy goes up dramatically as distance from arc drops:

EXAMPLE: 22,000A, 480V, 6 cycles:

24"	18"	15"	12"	10"
2.7 cal.	3.2 cal.	7.5 cal.	12.2 cal.	18 cal.

How close are **you** to the arc?

What PPE Do I Have to Wear



NFPA uses a three-step process:

Step 1: Determine the Hazard / Risk Category

Classification based on NFPA 70E Table 130.7(C)(9)(a)

Task	Hazard / Risk Category	V-Rated Gloves	V-Rated Tools
Panelboards & Switchboards >240V and up to 600V			
CB or Fuse Switch Operation With covers ON	0	No	No
CB or Fuse Switch Operation With covers OFF	1	No	No
Work on energized parts, including voltage testing	2*	Yes	Yes

These tables are used for demonstration purposes only.
Always refer to NFPA 70E for actual requirements

NFPA Hazard Risk Categories



Step 2: Select Protective Clothing and PPE based on NFPA 70E Table 130.7(C)(10).

Personal Protective Clothing	Hazard / Risk Category Number					
	-1	0	1	2	3	4
FR Clothing:						
Long-sleeved Shirt			X	X	X	X
Pants			X	X	X	X
Coverall			(Note 5)	(Note 7)	X (Note 9)	(Note 5)
Jacket, Parka, Rainwear			AN	AN	AN	AN

These tables are used for demonstration purposes only.
Always refer to NFPA 70E for actual requirements

NFPA Hazard Risk Categories



NFPA 70E Table 130.7(C)(10) – Continued. . .

Personal Protective Equipment	Hazard / Risk Category Number					
	-1	0	1	2	3	4
FR Protective Equipment:						
Hard Hat			X	X	X	X
Safety Glasses	X	X	X			
Flash Suit Hood					X	X
Hearing Protection				X (note 8)	X	X

These tables are used for demonstration purposes only.
Always refer to NFPA 70E for actual requirements

NFPA Hazard Risk Categories



Step 3: Identify Minimum ATPV and System based on HRC From Table 130.7(C)(II)

Typical Protective Clothing Systems		
Hazard Risk Category	Clothing Description (number of layers in parenthesis)	Minimum ATPV
0	Non Melting Flammable Materials (1)	N/A
1	FR Shirt and FR Pant or FR Coverall (1)	4
2	Cotton Underwear PLUS FR Shirt and FR Pant or FR Coverall (1-2)	8
3	Cotton Underwear PLUS FR Shirt and FR Pant or FR Coverall (2-3)	25
4	Cotton Underwear PLUS FR Shirt and FR Pant PLUS Double Layer Switching Coat and Pants (3 or more)	40

These tables are used for demonstration purposes only.
Always refer to NFPA 70E for actual requirements

Arc Thermal Protection Value (ATPV) is
defined by ASTM F 1959-00 as:

“the incident energy on a fabric or material that results in sufficient heat transfer through the fabric or material to cause the onset of a second degree burn based on the Stoll Curve”

Confused by the selection process?

National trend is single layer HRC 2 daily wear
and HRC 4 flash gear

Don't let confusion delay your PPE selection!

What is Flame Resistant Clothing?

- Clothing made from fabrics that self-extinguish
- Fabrics may be natural or synthetic
- Designed to limit (not eliminate) burn injury
- Survival, extent of injury, recovery time and quality of life are all dependent on FRC performance



- Natural fibers
- Synthetic fibers
- Natural / synthetic blends

NOTE: Flame resistance must be durable to launderings, wear, the environment, etc. for the service life of the garment

Look for proven products!

- FRC used to be perceived as ugly, uncomfortable, expensive, scratchy, hot and not breathable
- Major shift last 3-5 years to lighter, softer more breathable fabrics and to styles virtually identical to “street clothing”
- Examples include Nomex/Rayon blends, Indura UltraSoft®, knits, fleeces, denims.

Proper Use

- FRC should be appropriate to hazard
- Always the outermost layer
- Worn correctly; zipped, buttoned, etc
- All natural, non-melting undergarments
- Clean, no flammable contaminants
- Repaired correctly and removed from service when needed



Insulating gloves come in two “type’s”:

Type I

Pro: Greater flexibility and “feel”

Con: Not ozone-resistant, will crack if exposed to ozone or UV over time.







Type II

Pro: Ozone-resistant.

Con: Not as comfortable to wear (less flexible)



Insulating Gloves: Class

Voltage Classifications for Rubber Gloves				
Tag Color	Class	Proof Test Voltage AC / DC	Max. Usage Voltage AC / DC	Glove Tag
Beige	00	2,500 / 10,000	500 / 750	
Red	0	5,000 / 20,000	1,000 / 1,500	
White	1	10,000 / 40,000	7,500 / 11,250	
Yellow	2	20,000 / 50,000	17,000 / 25,500	
Green	3	30,000 / 60,000	26,500 / 39,750	
Orange	4	40,000 / 70,000	36,000 / 54,000	

FAST FACT: Remember, it's not the color of the glove that's important – it's the color of the tag!

Glove Markings

1910.137(a)(1)(iv)

Class & Type designations are found on the cuff portion of the glove.



Protector Gloves

1910.137(b)(2)(vii)(A)



Protector gloves must be worn over insulating gloves, except for Class 0 gloves, under limited-use conditions, where small equipment and parts manipulation necessitate unusually high finger dexterity.



FAST FACT: Do not use leather protectors alone for protection against electric shock. Serious injury or death could result. Always use proper rubber insulating gloves.

Glove

1910.335(a)(1)(ii)

1910.335(a)(1)(ii) Protective equipment shall be maintained in a safe, reliable condition and shall be periodically inspected or tested, as required by 1910.137.

1910.335(a)(1)(iii) If the insulating capability of protective equipment may be subject to damage during use, the insulating material shall be protected. (For example, an outer covering of leather is sometimes used for the protection of rubber insulating material.)



Glove Testing

1910.335(a)(1)(ii)



Protective Equipment Testing Schedule	
Equipment	When to Test
Gloves	Before first issue and every six months after that.*
Blankets / Sleeves	Before first issue and every 12 months after that.
Line Hose / Covers	Upon indication that insulating value is devalued.

* If the protective equipment has been electrically tested, but not issued for use it may not be placed in service unless it has been electrically tested within the previous 12 months.

Eye Protection

1910.335(a)(1)(v)



Eye protection is required whenever there is danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion.



Remember: If using face shield for arc flash protection be sure to check the Minimum ATPV rating (in cal/cm²)

Eye Protection Markings

1910.133(a)(4) & (b)(1) - (2)



PPE for eye and face protection purchased after July 5, 1994 shall comply with ANSI Z87.1-1989 or shall be demonstrated by the employer to be equally effective.

PPE for eye and face purchased before July 5, 1994 shall comply with the ANSI "USA standard for Occupational and Educational Eye and Face Protection," Z87.1-1968 or shall be demonstrated by the employer to be equally effective.

Eye and face PPE shall be distinctly marked to identify the manufacturer.

Head Protection

1910.335(a)(1)(iv) & 1910.135(b)(1)



Protective helmets purchased after July 5, 1994 shall comply with ANSI Z89.1-1986



FAST FACT: ANSI has revised its Z89.1 standard a few times since 1986 and its most current standard is ANSI Z89.1-2003. OSHA however, still references the 1986 standard. As a practical matter if you comply with any of the ANSI Z89.1 standards from 1986 onward, you are compliant with OSHA.

Helmet Type (Pre-1987)

ANSI Z89.1-1986 separates protective helmets into two different types and three different classes.

Type 1 helmets incorporate a full brim (brim fully encircles the dome of the hat)

Type 2 helmets have no encircling brim, but may include a short bill on the front



Helmet Class (Pre-1987)



Regarding electrical performance, ANSI Z89.1-1986 recognizes three classes:

Class A Helmets reduce the force of impact of falling objects and also reduce the danger of contact with exposed low-voltage electrical conductors. Helmet shells are proof-tested at 2,200 volts of electrical charge.

Class B Helmets reduce the force of impact of falling objects and also reduce the danger of contact with exposed high-voltage electrical conductors. Helmet shells are proof-tested at 20,000 volts.

Class C Helmets reduce the force of impact of falling objects, but offer no electrical protection.

Helmet Type (After 1986)



ANSI Z89.1-2003 no longer uses Type 1 and Type 2 to describe the brim characteristics of a protective helmet. The new Type designation is as follows:

Type I helmets offer protection from blows to the top of the head

Type II helmets offer protection from blows to both the top and sides of the head

Helmet Class (After 1986)



Class G (General) Helmets - This is equivalent to the old Class A. Class G helmets are proof tested at 2,200 volts.

Class E (Electrical) Helmets - This is equivalent to the old Class B. Class E helmets are proof tested at 20,000 volts.

Class C (Conductive) Helmets - This class provides no electrical insulation; the class designation did not change from the old standard.

The following information must be marked inside the helmet

- Manufacturer's name
- The “ANSI Z89.1-1997” designation
- Class designation (G, E or C)
- Date of manufacture



Protective Footwear

1910.136(a)



Employees must use protective footwear when

- falling or rolling objects,
- objects piercing the sole,
- employee's feet are exposed to electrical hazards.



ANSI Markings – Footwear

1910.136(b)(1)-(2)



Protective footwear purchased after July 5, 1994 shall comply with ANSI Z41-1991

Protective footwear purchased before July 5, 1994 shall comply with the ANSI Z41.1-1967



ANSI Markings – Footwear

1910.136(b)(1)



Indicates ANSI standard met
PT indicates “protective toe”
portion of standard

Indicates Male or Female
Impact resistance
Compression resistance

(Cd) conductive properties
(EH) electrical hazard
(Mt) metatarsal resistance rating,
(PR) puncture resistance
(SD) static dissipative properties.

Electrical shock resistant (EH) footwear is manufactured with non-conductive electrical shock resistant soles and heels.

It must be capable of withstanding the application of 14,000 volts at 60 hertz for one minute with no current flow or leakage current in excess of 3.0 milliamperes, under dry conditions.



ASTM Designations

After March 2005



On March 2005, ANSI Z41 was replaced by two new American Society of Testing Material (ASTM) International Standards. The new ASTM standards are:

- F2412-05 Standard Test Methods for Foot Protection
- F2413-05 Standard Specification for Performance Requirements for Foot Protection.



ASTM Designations

After March 2005



ASTM F2413-05

M I/75/C/75/Mt75

PR

CS

Indicates ASTM standard met

Indicates Male or Female

Impact resistance

Compression resistance

(Mt) metatarsal resistance rating

(Cd) conductive properties

(CS) chain saw cut resistance

(DI) dielectric insulation

(EH) electrical hazard

(PR) puncture resistance

(SD) static dissipative properties

Insulating Blankets

1910.137(a) - 1910.137(a)(1)(ii)(G)

Insulating blankets, matting, covers, line hose, gloves, and sleeves made of rubber shall meet the following requirements:

- Manufacture and marking
- Blankets, gloves, and sleeves shall be produced by a seamless process.
- Each item shall be marked with its classification (i.e. Class 0 – Class 4)



REMEMBER: Non-ozone-resistant will be marked “Type I”
Ozone-resistant will be marked “Type II”

Employee Owned PPE

1910.132(b)



If an employee provides their own protective equipment, the employer shall be responsible to assure its adequacy, including proper maintenance, and sanitation of such equipment.



Insulated Tools

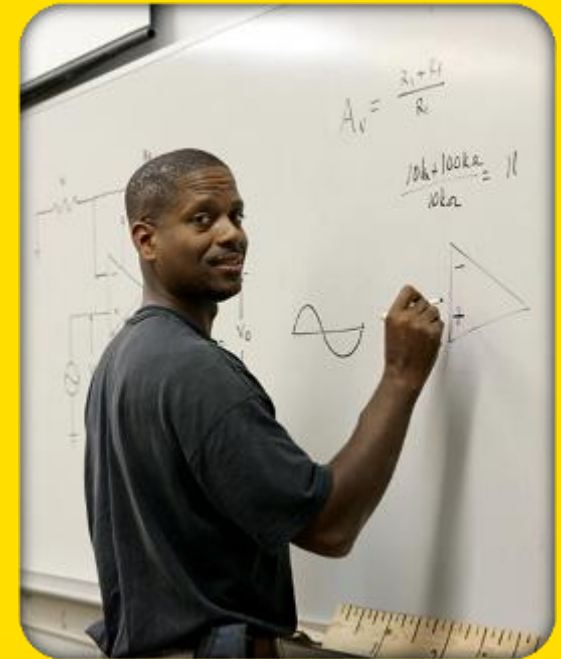
1910.335(a)(2)(i)

When working near exposed conductors the employee must use insulated tools or handling equipment



When PPE is required, the employer must cover the following areas:

- When PPE is necessary;
- What PPE is necessary;
- How to properly don and doff PPE
- How to adjust and wear PPE;
- The limitations of the PPE; and,
- The proper care, maintenance, useful life and disposal of the PPE.



Training Documentation

1910.132(f)(4)



The employer must issue a written “training certificate” which must include:

- the name of each employee trained,
- the date(s) of training, and
- Identity of the subject covered

Certificate of Completion	
This is to certify that	
<u>John Doe</u>	
Has successfully completed training in the	
Electrical Safety including Arc Flash In accordance with 1910.300-399	
Joe Trainer <small>Trainer</small>	3/01/2008 <small>Date of Training</small>

Electrical Safety Training Session
Attendance List

Trainer: _____ Date of Session: _____

Employee Name (please print)	Date	Job Title	Employee Signature

By signing this form, I agree that I have attended this training class in its entirety. The information was presented in a language I understand and I had the opportunity to ask questions of the trainer.