

Electric Arc Flash Protection

00059114

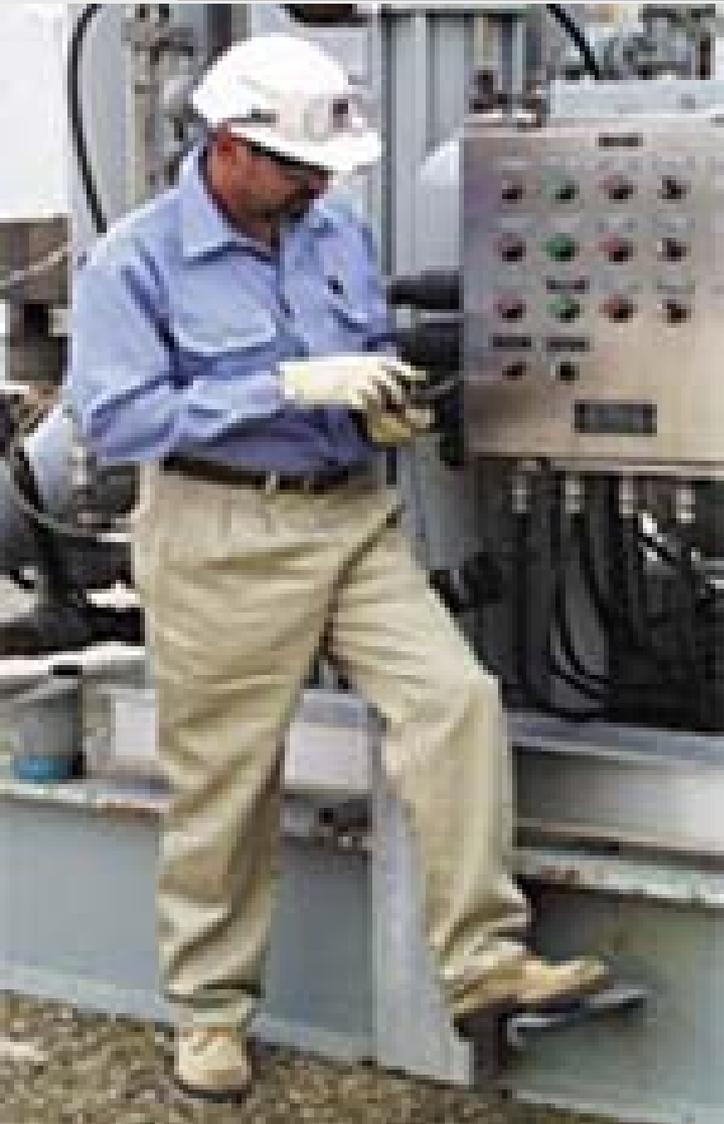


Introduction	Purpose	Definitions	Basic Requirements
▲ PPE	Approach Boundaries	FR Clothing	

Terminal Objective

Upon completion of this course, you will demonstrate your knowledge of arc flash requirements as presented in the course material. Successful completion requires a score of 100% on a written examination

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What's in it for me?

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Benefits to you

- ✓ Know and understanding the arc flash
- ✓ Safety training to employees who are exposed to the hazards of electric arcs

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This course will take about 1 hour to complete.

To receive credit for this course, you must pass the assessment with a score of 100. This is the standard for personal safety.

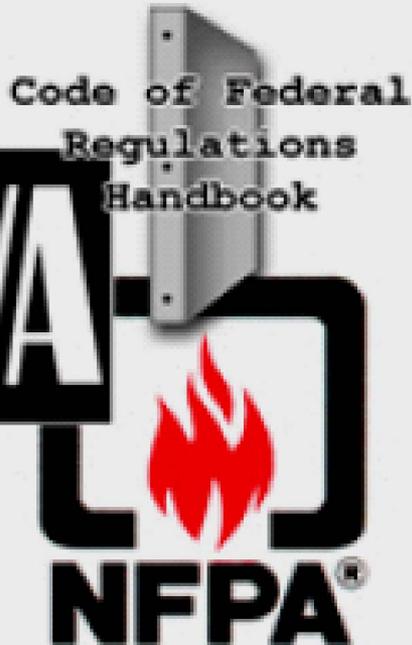
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Training requirements

- ✓ The following are the requirements for TVA employees regarding safety training
- ✓ Each employee who is exposed to the hazards of electric arcs must be trained in the hazards involved.
- ✓ Employees performing work within the arc flash boundaries defined in this course must also complete the "Electrical Safety per OSHA" training course 00059115

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29 CFR 1910.269 - Power Generation, Transmission, and Distribution



NFPA 70E - Standard for Electrical Safety Requirements for Employee Workplaces, 2004 Edition

IEEE Standard 1584, IEEE Guide for Performing Arc Flash Hazard Calculations

TVA Safety Procedure, TSP 1022, Arc Flash Hazard Calculation and Required Protection

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- ✓ **State the conditions under which the use of personal protective equipment (PPE) is required during the performance of work activities listed in TSP 1022, Table 3 in accordance with TVA policy**
- ✓ **Define common terms associated with TVA procedure number 1022, Arc Flash Hazard Calculation and Required Protection, without error**
- ✓ **State the basic requirements for any employee to perform the activities listed in TSP 1022, Table 3, in accordance with TVA policy**

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- ✓ Describe the PPE required for any employee to perform the activities listed in TSP 1022, Table 3, in accordance with TVA policy
- ✓ Establish approach boundaries without error
- ✓ List the requirements for maintaining flame-resistant clothing (FR clothing) without error

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Purpose

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- ✓ **State the requirements established by the TVA Safety Procedure for Arc Flash Hazard Calculation and Required Protection.**
- ✓ **List the applicability of the Arc Flash Hazard Calculation and Required Protection procedure in terms of equipment voltage ranges and personnel.**

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The Arc Flash Hazard Calculation and Required Protection procedure establishes requirements for analyzing electrical circuits operating at 480V and above to determine incident energy levels, and to select appropriate flame-resistant clothing and PPE

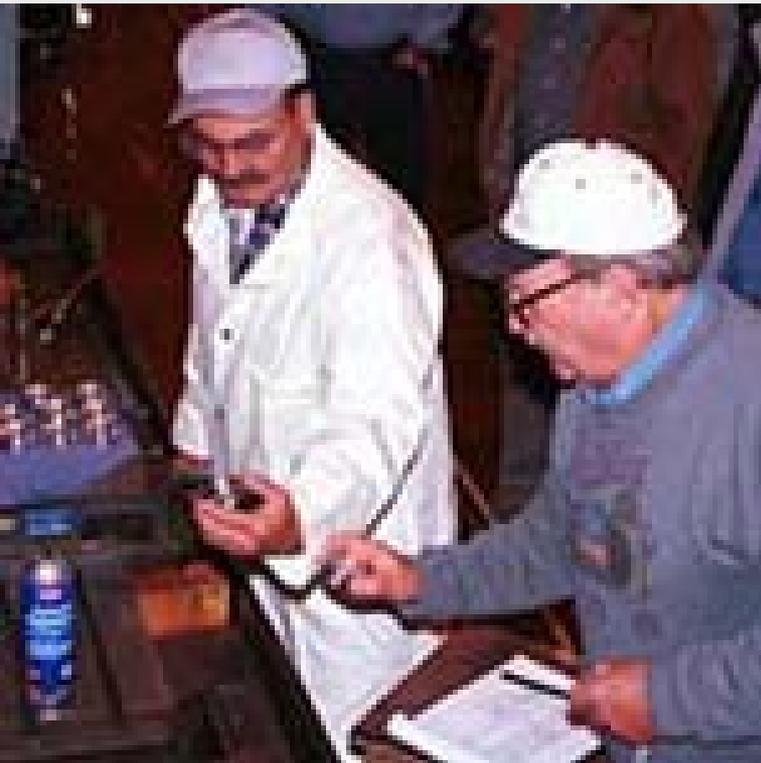
Introduction	Purpose	Definitions	Basic Requirements
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- ✓ **Electrical circuits operating at 60 kV and above will not be analyzed because there is no accepted method for performing the calculations**
- ✓ **Therefore, for circuits at and above 60 kV, the arc flash boundary is 10 feet for any of the work listed in Table 3, “Work Requiring Arc Flash Protection”**

View Table 3

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Deviation from procedure

- ✓ Note that any deviation from the requirements of a safety procedure must be addressed by revising the existing standard and going through the Safety Process Ownership Team, or Safety POST, and/or Designated Agency Safety and Health Officer, or DASHO, for approval

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- ✓ **Work near or involving exposed voltages including all operating voltages above 480 volts**
- ✓ **The procedure applies to all individuals who perform any of the work listed in Table 3, “Work Requiring Arc Flash Protection,” of the procedure**
- ✓ **“Near” in regard to arc flash protection is defined as any body part within the arc flash protection boundary**

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- ✓ **Some electronic components operate at voltages that are the same or greater than those listed in the procedure, but due to their low current capacity, they do not have the capability of creating an arc or flash that will cause bodily harm**

They include:

- ✓ **Radiation detectors**
- ✓ **Rack mounted converters**
- ✓ **Inverters & Instruments**
- ✓ **Sensors**
- ✓ **Low energy power supplies**



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Although the requirements of the Arc Flash Hazard Calculation and Required Protection procedure may not apply to low-amperage components, this does not alleviate the need to follow sound electrical work practices and the use of insulated tools, blankets, or gloves when working on energized components



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Review Question

Which of the following statements best describes the applicability of the TVA Arc Flash Hazard Calculation and Protection procedure?

Select the correct answer:

- A. The procedure is applicable for work near or involving exposed conductors or parts including all operating voltages **below 500 V**.
- B. The procedure is applicable for work near or involving exposed conductors or parts including all operating voltages **above 22,500 V**.
- C. The procedure is applicable for work near or involving exposed conductors or parts including all operating voltages **below 600 V**.
- D. The procedure is applicable for work near or involving exposed conductors or parts including all operating voltages **at or above 480 V**.

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- ✓ The Arc Flash Hazard procedure establishes requirements for the use of PPE during the performance of the work listed in Table 3
- ✓ These requirements apply until the equipment, lines, and/or circuits are de-energized
- ✓ Applies to electrical power circuits operating at 480 V through 500 kV

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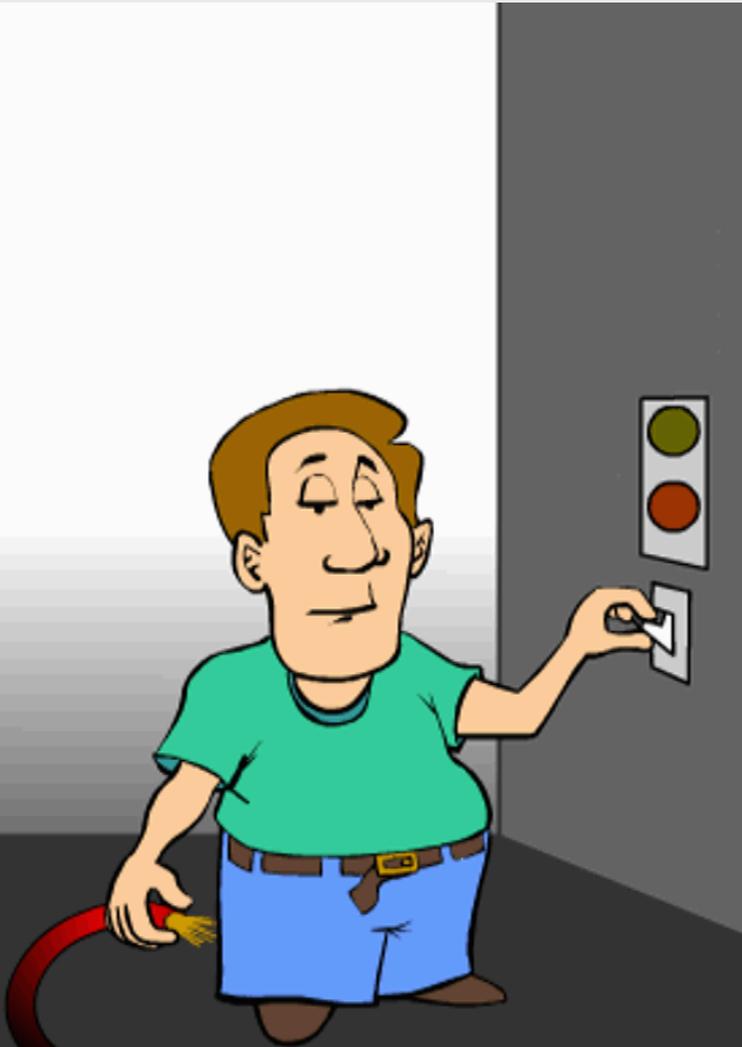
Definitions

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Upon completion of this section, you will be able to state the definition of the following terms with no error:

- ✓ **Contact distance**
- ✓ **Exposed energized conductors and parts**
- ✓ **Flash protection boundary**
- ✓ **Metal clad switchgear**
- ✓ **Motor control center**
- ✓ **Natural fibers**

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Contact distance defines the condition where you are:

- ✓ **Within the minimum approach distance to exposed electrical conductors or parts**
- ✓ **When within this boundary, insulated tools or protective equipment such as voltage-rated gloves must be used or worn**

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Exposed Energized Conductors & Parts



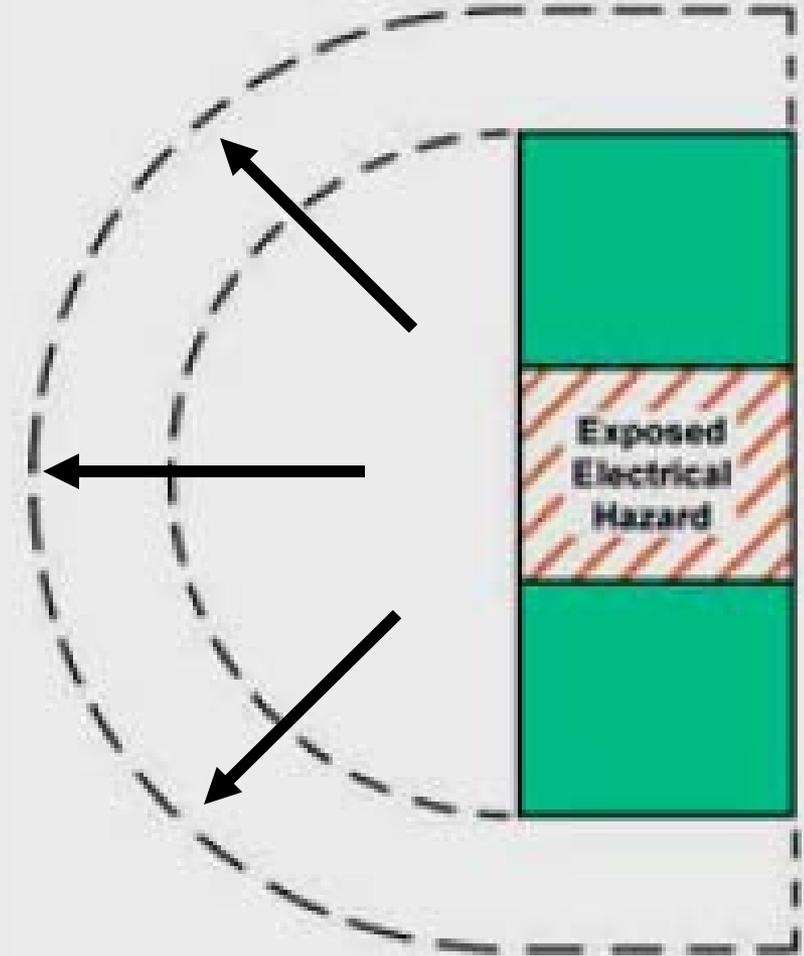
- ✓ **Exposed energized conductors and parts defines any point where an exposed electrical potential may be present**
- ✓ **This definition applies to any such energized component**

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Flash Protection Boundary

PPE Boundaries

A flash protection boundary defines the limits of the area established as potentially subject to second- and third-degree burns from electrical flash exposure due to performing any of the work listed in Table 3, “Work Requiring Arc Flash Protection.”



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Characterized by the following features:

- ✓ The main circuit interrupting device is removable and is arranged with a mechanism for moving it between the connected and disconnected positions
- ✓ Energized parts are completely enclosed by grounded metal barriers. A metal barrier in front of the interrupting device ensures that no live parts are exposed by the opening of a door, when in a connected position.
- ✓ Automatic shutters cover the primary disconnects when the removable element is removed or in the test or disconnected positions

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Characterized by the following features:

- ✓ All live parts are enclosed within grounded metal barriers and separated into individual compartments by voltage level
- ✓ Primary bus conductors and connections are covered with tract-resistant insulation
- ✓ Mechanical interlocks are provided to ensure proper and safe operation

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Additionally, the metal clad switchgear category includes other loads controlled with circuit breakers, such as:

- ✓ **Recirculation MG set field breakers**
- ✓ **Main generator field breakers**
- ✓ **Nuclear plant electrical distribution equipment**

Metal clad switchgear differs from a Motor Control Center or MCC

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- ✓ A mechanical grouping or combinations of motor control units, feeder tap units, other units, and electrical devices arranged in a convenient assembly
- ✓ MCCs do not include inter-wiring or inter-locking between units or to remotely mounted devices
- ✓ MCCs differ from metal clad switchgear in that they cannot control loads via a breaker

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Natural fibers as described in the Arc Flash Hazard Calculation and Required Protection Procedure are:

- ✓ **100% cotton**
- ✓ **100% silk**
- ✓ **100% wool**



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- ✓ **Contact distance – within close proximity where inadvertent contact could reasonably be anticipated**
- ✓ **Exposed energized conductors and parts – any point where an exposed electrical potential is present**
- ✓ **Flash protection boundary - limits of the area established as potentially subject to second-degree and third-degree burns from electrical flash exposure due to work on or around exposed energized conductors and parts**

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- ✓ **Metal clad switchgear - electrical distribution equipment that uses circuit breakers only to energize/de-energize circuits**
- ✓ **Motor Control Center - electrical distribution equipment that uses molded case circuit breakers and often a motor starter or contactor to energize/de-energize a load**
- ✓ **Natural fibers – 100% cotton, 100% silk, or 100% wool**

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Basic Requirements

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Upon completion of this section, you will be able to:

- ✓ **Define the purpose of the Arc Flash Hazard Calculation and Required Protection procedure**
- ✓ **Describe the requirements regarding clothing worn according to the Arc Flash Hazard Calculation and Required Protection procedure**

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- ✓ The intent of the Arc Flash Hazard Calculation and Required Protection procedure is to limit the extent of injury to employees subject to arc-flash burns from incident energy flash



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- ✓ Each employee who is exposed to the hazards of flames or electric arcs must not wear clothing that, when exposed to flames or electric arcs, could increase the extent of injury
- ✓ An example of this would be clothing that melts when exposed to high heat

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- ✓ For electrical circuits and equipment operating at greater than 60 kV, arc flash protection consists of FR clothing with an ATPV at least 4.2 cal/cm², hard hat, safety glasses, substantial industrial type shoes meeting the requirements of TSP 307, “Foot Protection,” and leather gloves.
- ✓ The arc flash protection boundary is 10 feet from exposed energized parts operating at 60 kV and above.

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Clothing made from the following fabrics, either alone or in blends, is prohibited unless it can be demonstrated that the fabric has been treated to withstand the conditions that may be encountered, which means the fabric is rated to withstand an electric arc:

- ✓ **Acetate**
- ✓ **Nylon**
- ✓ **Polyester**
- ✓ **Rayon**

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Review Question

The requirements of the Arc Flash Hazard Calculation and Required Protection Procedure are intended to limit the extent of injury to employees subject to which of the following?

Select the correct answer:

- A. Burns from clothing that melts.
- B. Arc-flash burns from incident energy flash.
- C. Wearing clothing made from polyester blends.
- D. All of the above.

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Let's Review:

- ✓ **The intent of the Arc Flash Hazard Calculation and Required Protection Procedure is to limit the extent of injury to employees subject to arc-flash burns from incident energy flash**

- ✓ **Each employee who is exposed to the hazards of flames or electric arcs shall wear clothing that is flame-resistant, and such other PPE that is designed to prevent second- and third-degree burns**

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Personal Protective Equipment

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Upon completion of this section, you will be able to:

- ✓ **Use the correct section of TVA Procedure Number 1022 to identify required flame-resistant clothing and PPE based on the calculated incident energy levels of the potential arc**
- ✓ **Describe daily-wear FR clothing in terms of who is required to use them, and what their protection rating must be**

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PPE		Approach Boundaries	FR Clothing

Upon completion of this section, you will be able to:

- ✓ **Identify the incident energy level above which you must use TVA Procedure Number 1022 to select required FR clothing and PPE**
- ✓ **State the requirements for removal of additional FR clothing and PPE**
- ✓ **List the requirements for allowable clothing within the arc flash protection boundary, including the requirements for face shields**

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- ✓ TVA organizations are required to analyze electrical circuits and/or equipment operating at 480 volts and above to determine incident energy levels
- ✓ The analysis is also used to select PPE & establish arc-flash boundaries

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- ✓ Once the incident energy analyses are complete, flash protection boundaries can be established when performing an activity listed in Table 3, “Work Requiring Arc Flash Protection,” of the procedure
- ✓ The flash protection boundary must be clearly established to keep non-electrical workers without proper FR clothing/PPE from entering the area where electrical work is being performed

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10 Feet

For circuits at and above 60 kV, the arc flash boundary is 10 feet for any of the work listed in Table 3, “Work Requiring Arc Flash Protection,” of the procedure

Required protection within the arc flash boundary is:

- ✓ Flame-resistant clothing
- ✓ Flame-resistant or 100% natural-fabric undergarments
- ✓ Hard hat
- ✓ Safety glasses
- ✓ Substantial type shoes
- ✓ Leather gloves



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Daily Wear FR Clothing

- ✓ TVA provides daily-wear FR clothing to employees who routinely work on equipment operating at 480 volts and above
- ✓ Employees come to work wearing their daily-wear FR clothing
- ✓ Daily-wear FR clothing must have a minimum Arc Thermal Performance Value (ATPV) of 4.2 cal/cm² (some organizations require 8 cal/cm² or greater ATPV)



Introduction	Purpose	Definitions	Basic Requirements
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- ✓ All organizations must maintain a list of employees provided daily-wear FR clothing
- ✓ TVA's transmission organization has a daily-wear clothing program in effect since 1994
- ✓ Daily Wear FR clothing worn must meet or exceed the calculated exposure value at all times



Introduction	Purpose	Definitions	Basic Requirements
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Review Question

Which set of statements shown describes the purpose of Arc Flash Incident Energy Analyses?

Select the correct answer:

- A. - Required to be performed on electrical circuits/equipment operating at 480 V and above.
 - Used to establish arc flash protection boundaries.
 - Results are used for selection of appropriate FR clothing and PPE.
- B. - Identifies employees who use daily-wear FR clothing.
 - Results are used for selection of appropriate FR clothing and PPE.
- C. - Used to establish arc flash protection boundaries.
 - Allows use of FR clothing rated at 4.5 cal/cm².
- D. - Identifies employees who use daily-wear FR clothing.
 - Allows use of FR clothing rated at 4.5 cal/cm².
 - Used to establish arc flash protection boundaries

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- ✓ Appendix A in the Arc Flash Hazard Calculation and Required Protection Procedure Number 1022 provides tables used to identify the PPE requirements
- ✓ Signs stating the specific arc flash protection level – from one to seven will be posted on equipment. All employees should understand the protection levels and wear the appropriate clothing and/or PPE for that level.

View Table A

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If layering of FR clothing is being considered, the ATPV of the layered garments is determined by one of the following:

- ✓ Add the arc-rating values of the FR clothing garment and the arc rating of the garment to be worn over the FR clothing to determine their combined ATPV, which gives a minimum ATPV of the layered garments
- ✓ Obtain manufacturer's layered test data for the actual ATPV of the layered garments

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Procedure Number 1022 defines an “Electrically Safe Condition” as a state in which:

- ✓ The conductor or circuit part to be worked on or near has been disconnected from energized sources
- ✓ Tagged, or locked out in accordance with the established clearance procedure
- ✓ Verified that the conductor or part under clearance is correct for the work
- ✓ Tested to ensure absence of voltage

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Also:

- ✓ Install temporary protective grounds, if required
- ✓ Install orange barrier tape, if required
- ✓ Perform an assessment to ensure that the work area is not intersected by adjacent flash protection boundaries
- ✓ Once an electrically safe condition is established, employees may remove the additional PPE being worn

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Removal of PPE (cont)



Employees are not required to wear FR clothing or PPE when performing other work within or traveling through an area of equipment operating at 480 V and above with doors and covers latched or screwed closed

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- ✓ **Synthetic or blends of synthetic fabric are prohibited within the arc flash protection boundary**
- ✓ **If rainwear or cold-weather garments are needed to perform a task within a flash boundary, the rainwear or cold-weather garment must be arc rated**

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- ✓ Only face shields that are designed for arc flash hazard protection should be used within a flash boundary
- ✓ These face shields are generally green in color, and have an ATPV of 8 to 15 cal/cm²
- ✓ Do Not use a polycarbonate face shield, which is primarily designed for protection against projectile impact, and is not capable of providing arc flash hazard protection



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Review Question

When must you use Appendix A of TVA Procedure Number 1022 to select required FR clothing and PPE?

Select the correct answer:

- A. When the possibility of exposure to incident energy greater than 4.5 cal/cm² exists.
- B. When there is no arc flash warning sign posted that shows the required protection.
- C. When using a polycarbonate face shield to provide arc flash hazard protection.
- D. When an electrically safe condition is established in the work area.

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Let's Review:

- ✓ Appendix A of TVA Procedure Number 1022 is used to identify required flame-resistant clothing and PPE
- ✓ Daily-wear FR clothing is provided to TVA employees who are identified by management as routinely working on circuits and equipment operating at 480 V and above
- ✓ Daily Wear FR clothing worn must meet or exceed the calculated exposure value at all times

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Let's Review:

- ✓ When the possibility of exposure to incident energy greater than that of the FR clothing being worn exists, you must use Appendix A in TVA Procedure Number 1022 to select required FR clothing and PPE
- ✓ Once an electrically safe condition is established in the work area, employees may remove the additional FR protection being worn over their daily-wear FR clothing

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Let's Review:

- ✓ Clothing made of synthetic or blends of synthetic fabric are prohibited within the arc flash protection boundary
- ✓ All employees working within the flash protection boundary must wear FR clothing rated for the calculated exposure
- ✓ The protection level determined in the analysis is used to select additional PPE as needed

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Let's Review:

- ✓ If rainwear or cold-weather garments are needed to perform a task within a flash boundary, the rainwear or cold-weather garment must be arc-rated
- ✓ Only face shields that are designed for arc flash hazard protection should be used within a flash boundary. They normally have an ATPV of 8 to 15 cal/cm²

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Approach Boundaries

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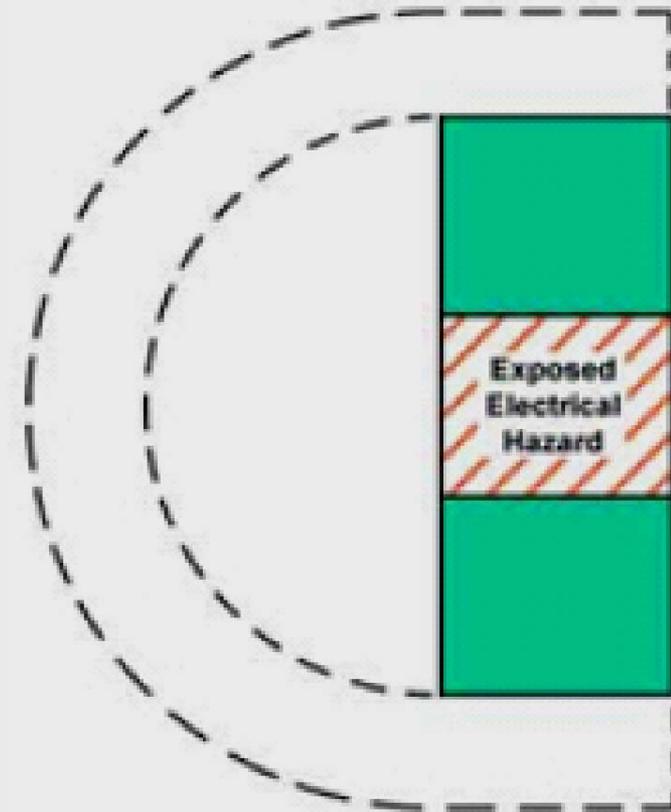
Upon completion of this section, you will be able to:

- ✓ **Define Arc Flash Protection Boundary**
- ✓ **State the interim arc flash boundary FR clothing and PPE requirement**
- ✓ **State the incident energy exposure level above which work is not performed, and what actions must be taken**

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- ✓ An arc flash protection boundary is the distance from an arc at which the incident energy level is equal to 1.2 cal/cm²
- ✓ This is the incident energy level necessary for the onset of second-degree burns to the skin

PPE Boundaries



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Until the analyses are complete and warning signs posted, the following are the minimum to be worn within 10 feet of interim arc flash boundary:

- ✓ FR clothing (either checkout or daily-wear)
- ✓ FR or 100% natural-fabric undergarments
- ✓ Hard hat
- ✓ Safety glasses
- ✓ Substantial industrial type work shoes
- ✓ Leather gloves and/or voltage-rated gloves
- ✓ Arc-rated face shield



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- ✓ For circuits above 60 kV, the arc flash boundary is 10 feet

The required protection within the arc flash boundary of above 60 kV circuits is:

- ✓ Flame-resistant clothing
- ✓ Flame-resistant or 100% natural-fabric undergarments
- ✓ Hard hat
- ✓ Safety glasses
- ✓ Substantial type shoes
- ✓ Leather gloves



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- ✓ Two methods are used for performing the arc flash hazard analysis
- ✓ One method involves a TVA method based on the Institute of Electrical and Electronics Engineers 1584 Guide for determining arc flash boundaries. This method is used for electrical circuits at voltages between 480 volts and 15 kilovolts.
- ✓ The TVA 1584 Calculator may be downloaded from the TVA Safety home page

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- ✓ For electrical circuits at voltages between 15 kilovolts and 60 kilovolts, the ARCPRO (Arc Pro) software is used to analyze potential arc flash hazards
- ✓ Both methods for performing arc flash hazard analysis are based on the assumption that the primary circuit protective devices will operate as designed

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Review Question

When an interim arc flash boundary is established, you are required to wear which of the items shown?

Select the correct answer:

- A. Safety glasses and hard hat.
- B. Substantial industrial type work shoes and leather gloves/voltage-rated gloves.
- C. FR clothing either checkout or daily-wear and FR or 100% natural-fabric undergarments (except for a T-shirt, which must be FR if worn).
- D. All of the above.

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TVA 1584 Calculator determines the following:

- ✓ The incident energy at the worker's position for each arcing point exposure entered on the calculator's data sheets
- ✓ The distance from the arcing point to the arc flash protection boundary
- ✓ The required PPE category at the working distance from the arcing point, which is specified in Appendix A, Table A-1 of TVA Procedure 1022

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The ARCPRO software determines the following:

- ✓ The incident energy at various points from the arc to the limit distance entered in order to establish an arc flash protection boundary
- ✓ The incident energy at the worker's exposure position to be used in selecting the appropriate PPE



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Once the analysis calculations are complete, the responsible engineering staffs should investigate all possibilities to reduce the incident energy exposures through methods such as:

- ✓ - Modifying breaker trip settings
- ✓ - Current-limiting fuses
- ✓ - Remote operation
- ✓ - Robotics
- ✓ - Remote voltage tests

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- ✓ Work is not permitted on electrical circuits with incident energy exposure at the worker's position of more than 100 cal/cm²
- ✓ Incident energy exposures of this magnitude are reduced to 100 cal/cm² or less by instituting engineering or administrative controls

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Review Question

Work is not permitted on electrical circuits with incident energy exposure at the worker's position of:

Select the correct answer:

- A. Less than 100 cal/cm².
- B. 8 cal/cm².
- C. 100 cal/cm².
- D. More than 100 cal/cm².

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Lets Review:

- ✓ An arc flash protection boundary is the distance from an arc at which the incident energy level is equal to the onset of second-degree burns (1.2 cal/cm²)
- ✓ Until an analysis is complete and warning signs posted for circuits 480 V to 60 kV, an interim arc flash boundary is established

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The minimum worn within 10 feet of exposed energized parts for an interim arc flash boundary is:

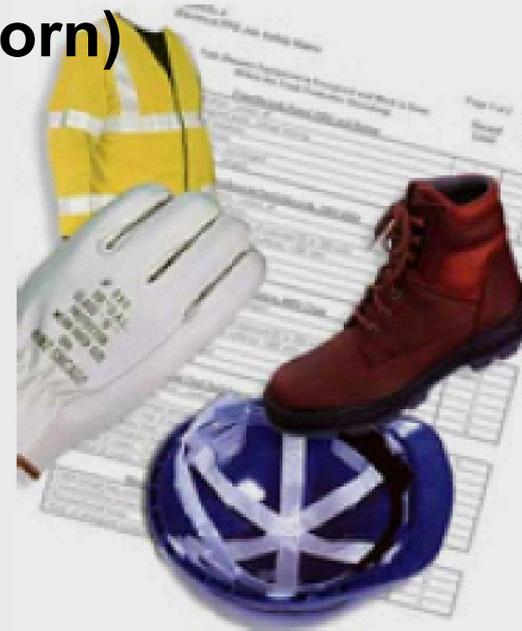
- ✓ FR clothing either checkout or daily-wear
- ✓ FR or 100% natural-fabric undergarments
- ✓ Hard hat
- ✓ Safety glasses
- ✓ Substantial industrial type work shoes
- ✓ Leather gloves or voltage-rated gloves
- ✓ Arc-rated face shield



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The required protection within the arc flash boundary of above 60 kV circuits is:

- ✓ Flame-resistant clothing
- ✓ Flame-resistant or 100% natural-fabric undergarments (except for a T-shirt, which must be FR if worn)
- ✓ Hard hat
- ✓ Safety glasses
- ✓ Substantial type shoes
- ✓ Leather gloves



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There are two methods used for performing the arc flash hazard analysis:

- **TVA 1584 Calculator, used for voltages from 480 V to 15 kV**
- **ARCPRO Software, used for voltages from 15 kV to 60 kV**

- ✓ **Work is not permitted on electrical circuits with incident energy exposure at the worker's position of greater than 100 cal/cm²**

- ✓ **Incident energy exposures of this magnitude are reduced to 100 cal/cm² or less by instituting engineering or administrative controls**

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Flame Resistant Clothing

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Upon completion of this section, you will be able to:

- ✓ Describe the inspection requirements for flame-resistant clothing
- ✓ List the requirements for washing and drying flame-resistant clothing, including restrictions
- ✓ State the types of repairs that can be made on flame-resistant clothing
- ✓ Identify the type of clothing that can be worn underneath flame-resistant clothing, and the reason why the OSHA standard exists

Introduction	Purpose	Definitions	Basic Requirements
PPE		Approach Boundaries	FR Clothing



Flame-resistant clothing should be inspected at least weekly for cleanliness and defects. This will ensure the effectiveness of the clothing to provide protection

Introduction	Purpose	Definitions	Basic Requirements
	PPE	Approach Boundaries	FR Clothing

- ✓ The TVA Flame-Resistant Garment Program consists of a number of different types of body fabrics and linings
- ✓ The cleaning and maintenance of these garments is **YOUR** responsibility

Four categories of fabrics are used:

- ✓ Indura/Indura Ultra Soft/Excel FR/Excel FR ComforTouch
- ✓ Nomex
- ✓ Firewear
- ✓ PBI

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Introduction	Purpose	Definitions	Basic Requirements
	PPE	Approach Boundaries	FR Clothing

Always follow the manufacturer's instructions, normally located on the garment tag

Do Not:

- ✓ **Wash at temperatures greater than 140 degrees F**
- ✓ **Use tallow soaps that may contain animal fats**
- ✓ **Use bleach**
- ✓ **Over dry the garment**
- ✓ **Line dry in direct sunlight**
- ✓ **Use fabric softeners**



Introduction	Purpose	Definitions	Basic Requirements
	PPE	Approach Boundaries	FR Clothing



- ✓ Minor repairs can be performed on flame-resistant garments as long as the repairs do not affect the integrity of the clothing
- ✓ These repairs can be made by sewing on patches of the same material
- ✓ Other repairs to flame-resistant clothing must be performed with special materials by the manufacturer

Introduction	Purpose	Definitions	Basic Requirements
	PPE	Approach Boundaries	FR Clothing

- ✓ Clothing worn under flame-resistant clothing must be made of FR or 100% natural fibers
- ✓ The OSHA standard does not allow synthetic or polyester blends
- ✓ It is each worker's responsibility to comply with this requirement



Introduction	Purpose	Definitions	Basic Requirements
	PPE	Approach Boundaries	FR Clothing

Review Question

From the groupings shown, select one that includes all requirements for maintaining flame-resistant clothing.

Select the correct answer:

- A. Wash at less than 140 degrees F - Use fabric softeners - Line dry in direct sunlight
- B. Inspect at least weekly - Always use bleach - Use fabric softeners
- C. Line dry in direct sunlight - Use fabric softeners - Inspect at least weekly
- D. Inspect at least weekly - Wash at less than 140 degrees F - Do not use bleach

Introduction	Purpose	Definitions	Basic Requirements
PPE		Approach Boundaries	FR Clothing

Lets Review:

- ✓ Flame-resistant clothing should be inspected at least weekly for cleanliness and defects
- ✓ Flame-resistant clothing should be washed at temperatures not to exceed 140 degrees Fahrenheit
- ✓ Do not use bleach or soaps that may contain animal fats
- ✓ Tumble dry flame-resistant clothing on the permanent press cycle

Introduction	Purpose	Definitions	Basic Requirements
PPE		Approach Boundaries	FR Clothing

Lets Review:

- ✓ Do not line dry in direct sunlight, or use fabric softeners
- ✓ Minor repairs can be performed on flame-resistant garments as long as the repairs do not affect the integrity of the clothing
- ✓ Clothing worn under flame-resistant clothing must be made of 100% natural fibers except for T-shirts, which must be FR

Introduction	Purpose	Definitions	Basic Requirements
PPE		Approach Boundaries	FR Clothing

- ✓ **The Arc Flash Hazard Calculation and Required Protection Procedure establishes requirements for the use of PPE during the performance of work to protect employees who work inside arc flash boundaries**
- ✓ **Each employee who is exposed to the hazards of flames or electric arcs is responsible to wear flame resistant clothing, and such other PPE that is designed to protect them**
- ✓ **Remember, always consult the TVA Safety Manual, and your supervisor for the proper PPE and safe work rules to follow when working near arc flash hazards**

Introduction	Purpose	Definitions	Basic Requirements
	PPE	Approach Boundaries	FR Clothing

Industry Event - Summary

Electricians were installing grounding cables as part of a clearance to isolate the main generator and the station service transformers. They were placing grounding cables in five circuit breaker cubicles. Each of these circuit breakers was the supply breaker for an electrical bus. The electricians had completed grounding four of five cubicles. The remaining breaker was the normal supply breaker for the 3B 4-kV unit board. The 3B unit board was energized from its alternate power source.

The associated breaker was racked out of its cubicle. The cubicle has a shutter that is designed to prevent access to the source and load connection stabs of the panel when the breaker is removed. Two electricians, one on each side of the cubicle, held the shutter open, exposing both the source and load connection stabs. The upper row of stabs was energized and the lower row, about 10 inches below, was not. The electricians had attached one end of each of the three grounding cables to a station grounding plate on the floor of the cubicle. The other end of the grounding cable was attached to a connecting rod that could be mated to a stab in the cubicle.

The third electrician was squatting in front of the cubicle and used a voltage detector to confirm the bottom stabs were de-energized. He did this by placing the detector in the vicinity of an energized stab (upper row) to check its operation, next verifying that the bottom stabs were de-energized, and then rechecking operation of the voltage detector using an energized stab. He then placed the voltage detector outside the cubicle, picked up the grounding cable connecting rod, and started to place it inappropriately on one of the energized stabs. One of the electricians holding the shutter saw this and shouted while the other attempted to close the shutter. An electrical flash occurred and all three individuals, as well as a fourth electrician watching the activity a few feet back, received burns, primarily to their faces and arms.



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TABLE 3 Work Requiring Arc Flash Protection ^{Note 1} (Equipment is energized and the work is performed within the flash boundary)	
Work Activity	Applicable Equipment
1. Working on or near exposed energized parts of circuits and equipment.	a. All 480 V and above equipment.
2. Applying or removing temporary protective safety grounds.	a. All 480 V and above equipment.
3. Locally operating a disconnect switch, motor starter, fused contactor, or any circuit breaker, e.g., molded case, insulated case, power breaker. (See Note 1, <u>d</u> and <u>e</u> for exceptions).	a. 600V Class (includes 480 V nominal) panelboards and disconnects. b. 600 V Class (includes 480 V nominal) motor control centers. c. 600 V Class (includes 480 V nominal) switchgear with power circuit breakers or fused switches. d. NEMA E2 (fused contactor) motor starters 2.3 kV through 7.2 kV. e. 1 kV and above metal-clad switchgear. f. 1 kV and above metal-clad load interrupter switches, fused or unfused.
4. Installing or removing (racking) circuit breaker or grounding device with door closed or open.	a. 600 V Class (includes 480 V nominal) switchgear with power circuit breakers. b. NEMA E2 (fused contactor) motor starter 2.3 kV and 7.2 kV. c. 1 kV and above metal-clad switchgear.
5. Operating outdoor disconnect switch, 1 kV and above (located outside such as in a switchyard). See activity 3 for operating other type disconnect switches, 1 kV and above.	a. Outdoor disconnect switches, hookstick operated. b. Outdoor disconnect switches, gang operated from grade.
6. Removing and installing starter bucket.	a. 600 V Class (includes 480 V nominal) motor control centers.

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TABLE 3 Work Requiring Arc Flash Protection ^{Note 1} (Equipment is energized and the work is performed within the flash boundary)	
Work Activity	Applicable Equipment
7. Opening hinged or bolted door/cover to expose bare, energized parts.	a. 480 V – 600 V NEMA enclosures. b. 600 V Class (includes 480 V nominal) motor control centers. c. 600 V Class (includes 480 V nominal) switchgear with power circuit breakers or fused switches. d. NEMA E2 (fused contactor) motor starters 2.3 kV through 7.2 kV. e. 1 kV and above metal-clad switchgear. f. 1 kV and above metal-clad load interrupter switches, fused or unfused.
<p>Note 1: Situations where FR clothing and PPE are not required based on Table 3 are as follows:</p> <ul style="list-style-type: none"> a. If exposed open-air buses (4160 V through 500 kV) in a transformer or switch yard are positioned at a height that prevents inadvertent contact by the employee, then employees and/or contractors who normally wear checkout FR clothing are <u>not</u> required to don FR clothing while walking through or performing non-electrical work within the arc flash boundary. Employees not in daily-wear FR clothing program are provided "checkout" FR clothing when they are within the arc flash boundary of exposed open-air buses (4160 V through 500 kV) in a transformer or switch yard and work listed in Table 3 is in progress. b. If the walkway to the crane operator's booth is guarded to prevent inadvertent contact with the exposed, open-air, energized, 480 V buses located on the crane's power rails, employees/contractors who normally wear checkout FR clothing are <u>not</u> required to don FR clothing while walking through the arc flash boundary. Employees not in daily-wear FR clothing program are provided "checkout" FR clothing when they are within the arc flash boundary of the exposed, open-air, energized, 480 V buses located on the crane's power rails and work listed in Table 3 is in progress. c. If electrical boards that are front vented have their doors/covers securely closed, employees/contractors who normally wear checkout FR clothing are <u>not</u> required to don FR clothing while walking through or performing non-electrical work within the arc flash boundary of this equipment. Employees not in daily-wear FR clothing program are provided "checkout" FR clothing when the doors/covers are open and/or work listed in Table 3 is in progress. d. Molded Case Circuit Breakers mounted in low energy (8 cal/cm² and below) panelboards can be operated without arc flash protection if the enclosure is properly closed. This exception is for panels that are properly trimmed-out and no exposed energized parts. e. Low energy (8 cal/cm² and below) safety disconnects for motor controllers, motors, electrically driven machinery (shop machines), air-conditioning equipment, and refrigeration equipment can be operated without arc flash protection if the enclosure is properly closed and the equipment's main power switch is in the "off" position. Safety disconnects are not to be pulled (tripped) under load. 	

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Table A-1 Arc Flash Personal Protective Equipment (PPE)

This table applies to arc flash exposures from circuits with a nominal voltage between 480 V and 60 kV

Flash Protection Level	Calculated incident energy (cal/cm ²)	FR Clothing Protective Requirements ^{1,2}	PPE Requirements
I	0 – 4	FR shirt/pant or coveralls with an ATPV of 4 cal/cm ² or greater	Safety glasses ³ , 8 cal/cm ² or greater face shield (a face shield is not required for incident energies less than 1.2 cal/cm ²), hard hat, substantial industrial type shoes meeting requirements of TSP 307, "Foot Protection," dry leather gloves or voltage rated gloves/protectors
II	>4 – 8	FR shirt/pants or coveralls with an ATPV of 8 or greater	Safety glasses ³ , hard hat, 8 cal/cm ² or greater face shield, substantial industrial type shoes meeting requirements of TSP 307, "Foot Protection," dry leather gloves or voltage rated gloves/protectors
III	>8 – 30	FR flash suit with an ATPV of 30 or greater, or a Level-I or II FR garments plus another FR garment layer which gives a combined total rating of 30 cal/cm ² or greater ⁴	Safety glasses ³ , hard hat, hearing protection, 30 cal/cm ² or greater hood ⁵ , substantial industrial type shoes meeting requirements of TSP 307, "Foot Protection," dry leather gloves or voltage rated gloves with protectors

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Flash Protection Level	Calculated incident energy (cal/cm ²)	FR Clothing Protective Requirements ^{1,2}	PPE Requirements
IV	>30 – 50	FR flash suit with an ATPV of 50 or greater, or a Level-I or greater FR garment plus another FR garment layer which gives a combined total rating of 50 cal/cm ² or greater ATPV ⁴ .	Safety glasses ³ , hard hat, hearing protection, substantial industrial type shoes meeting requirements of TSP 307, "Foot Protection," 50 cal/cm ² rated hood ⁵ , 50 cal/cm ² gloves or voltage rated gloves with protectors
V	>50 – 75	FR flash suit with an ATPV of 75 cal/cm ² or greater.	Safety glasses ³ , hard hat, hearing protection, substantial industrial type shoes meeting requirements of TSP 307, "Foot Protection," 75 cal/cm ² rated hood ⁵ , gloves rated for 75 cal/cm ² or rated voltage gloves with protectors
VI	>75 – 100	FR flash suit with an ATPV of 100 cal/cm ² or greater.	Safety glasses ³ , hard hat, hearing protection, substantial industrial type shoes meeting requirements of TSP 307, "Foot Protection," 100 cal/cm ² rated hood ⁵ , gloves rated for 100 cal/cm ² (rated voltage gloves with protectors are not acceptable at this ATPV)
VII	> 100	None: This level of exposure requires a Job Safety Analysis and special protection procedures to limit the exposure to 100 cal/cm ² or less.	None: This level of exposure requires a Job Safety Analysis and special protection procedures to limit the exposure to 100 cal/cm ² or less.

¹ Tee-shirts worn under FR clothing must be constructed of FR material.

² Undergarments (except FR tee-shirts) must be made of 100 percent natural fiber material such as cotton, wool, and/or silk. Non-FR undergarments are not items of daily-wear FR clothing provided by TVA.

³ The term safety glasses include safety side shields on the glasses.

⁴ Where the primary FR garment(s) does not meet the ATPV required, a second FR garment may be worn over the primary garment if the combined ATPV of the two garments meets the exposure incident energy level. Otherwise, select a flash suit that is rated for the level of incident energy exposure.

⁵ Arc flash hoods must have an ambient air system provided or recommended by the manufacturer.

⁶ Wearing a FR lab coat over 100 percent natural fiber clothing does not meet the requirements for FR clothing within an arc flash boundary.

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FR CLOTHING WASHING GUIDELINES

Because employees are responsible for the cleaning and maintenance of these garments, the expectation is that they will be washed at home. There is little that can be done in laundering to damage either the flame resistance of the material or the garments themselves. Of course overloading washing machines will cause abrasion and color loss, and over-drying the garments can lead to excessive shrinkage, but only the continued use of chlorine bleach can cause serious problems.

Chlorine bleach will destroy the flame retardant in flame resistant treated cotton fabrics and weaken NOMEX fabric resulting in shorter than expected service life. Chlorine will also damage FireWear and PBI. Chlorine bleach should never be used when laundering flame resistant garments.

The following are laundry recommendations for each category of material:

INDURA and INDURA Ultra Soft/Tuf Stuff: 100% cotton INDURA and 88% cotton/12% high tenacity nylon Ultra Soft/Tuf Stuff fabrics.

- A. Wash with like colors on Normal or Cotton cycle at any water temperature. Hotter water generally causes greater shrinkage, but may be required to remove oily soils. Turning the garments inside out the first time or two they are washed and dried will help reduce streaking from abrasion.
- B. Use any typical laundry detergent. **Do not use soap** (tallow soap containing animal fats). Home wash products are clearly labeled. For example, *Tide* detergent, or *Dial* soap.
- C. Starch, fabric softener, and other laundry additives should not be used as they can coat the fiber and mask flame resistance.
- D. **Do not use chlorine bleach.** Oxygen bleaches such as found in *Tide with Bleach* can affect the color of navy garments and should not be used.
- E. Tumble dry on Cotton or Sturdy setting, remove promptly. Do not over-dry.
- F. If desired, iron on Cotton/Normal setting.
- G. Either perchloroethylene or petroleum solvent can be used in dry cleaning. Jeans should not be dry cleaned because the indigo dye will bleed into the solvent and fade the material.

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Excel FR / Excel FR ComforTouch: 100% cotton Excel FR and 88% cotton/12% high tenacity nylon Excel FR ComforTouch fabrics.

- A. Use any typical home laundry detergent. Home wash detergents that contain sodium perborate and other “color safe” bleach alternatives, both liquid and powder, will not affect the flame resistance of the garments. However, they should not be used to launder Navy dyed garments as this will cause garments to fade to a purple cast.
- B. **Do not use chlorine bleach, liquid non-chlorine bleach or detergents that contain hydrogen peroxide.** These include but are not limited to liquid Tide with Bleach, liquid Clorox II, and liquid Vivid.
- C. It is important that all potentially flammable soils and other contaminants are completely removed from garments during the wash process. This may require the use of stain removal products, such as Shout, Spray 'n Wash, or Zout; or presoaking garments prior to washing. The use of hot water can often make detergents more effective in the removal of soils. If all contaminants cannot be removed in home care, you should obtain professional help in getting your FR garments clean.
- D. The use of conditioned or soft water can help improve removal of contaminants from garments. Hard water precipitates soaps and can result in the build-up of calcium and magnesium salts. These can serve as fuel in the event they are exposed to a source of ignition.
- E. Starch and other laundry additives are not recommended because they can coat fibers and mask FR performance, or serve as fuel in case of garment ignition. If desired, one softener sheet may be used in the clothes dryer. Liquid softeners should not be used.

- F. Do not over-dry garments. If desired, you may press with an iron on the normal cotton setting.
- G. It is recommended that you turn the garments inside out to help reduce streaking that can occur due to abrasion in the washer.

NOMEX and Cool Touch: NOMEX fabrics and shirts made from 65% NOMEX / 35% Lenzing FR fabric:

- A. Wash with like colors on Permanent Press cycle at water temperatures up to 140°F.
- B. Use any typical laundry detergent. Any commercial stain treatment may be used such as *Whisk*, or *Shout*.
- B. Starch, fabric softener, and other laundry additives should not be used. NOMEX has a static dissipative fiber in the blend to reduce nuisance static. A build-up of fabric softener on the fabric decreases wick ability that reduces comfort.
- C. **Do not use chlorine bleach.** Chlorine bleach can weaken the fabric and accelerates color loss. If necessary, oxygen bleaches such as found in *Tide with Bleach* may be used.
- D. Tumble dry on Permanent Press setting with proper cool down, remove promptly. Do not over-dry. Do not line dry in direct sun.
- E. If desired, use warm iron on Permanent Press setting.
- F. Either perchloroethylene or petroleum solvent can be used in dry cleaning.

FireWear: 55% cotton/45% FFR fiber Fire Wear:

- A. Wash with like colors on Permanent Press cycle at water temperatures up to 120°F. Turning garments inside out can result in longer lasting, brighter colors and longer garment life.
- B. Use any typical laundry detergent. Any commercial stain treatment may be used such as *Whisk*, or *Shout*.
- C. Starch, fabric softener, and other laundry additives should not be used.
- D. **Do not use chlorine bleach.** Chlorine bleach accelerates color loss. If necessary, oxygen bleaches such as found in *Tide with Bleach* may be used.
- E. Tumble dry on the lowest possible setting with proper cool down, remove promptly. Do not over-dry. **Do not line dry in direct sun.**
- F. If desired, use cool iron on lowest possible setting.
- G. Either perchloroethylene or petroleum solvent can be used in dry cleaning.

PBI: (shirts, pants, coveralls, and a lab coats are made from 60% Kevlar Aramid / 40% polybenzimidazole)

- A. Wash with like colors on Permanent Press cycle at water temperatures up to 140°F. Turning garments inside out can result in longer lasting, brighter colors and longer garment life.
- B. Use any typical laundry detergent. Any commercial stain treatment may be used such as *Whisk*, or *Shout*.
- C. Do not starch.
- D. **Do not use chlorine bleach.**
- E. Tumble dry on the Permanent Press setting with proper cool down, remove promptly. Do not over-dry. **Do not line dry in direct sun.**
- F. If desired, use warm iron on Permanent Press setting.
- G. Either perchloroethylene or petroleum solvent can be used in dry cleaning.

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Unlabeled or damaged garments and those showing abnormal or excessive wear do not satisfy the requirements of TVA's protective clothing program shall not be worn.