

**TENNESSEE VALLEY AUTHORITY
EMPLOYEE TECHNICAL TRAINING & OE
INDUSTRIAL SAFETY TRAINING**

Industrial Safety Training

TRAINING PROGRAM

Arc Flash Hazard Calculation and Required Protection

00059114

COURSE TITLE

COURSE NO.

LESSON TITLE

PREPARED BY L. Denayer	----- Signature / Date
TRAINING MATERIAL REVIEW Dallas Lucas, Review Coordinator	----- Signature / Date
COO Safety Ken McVay, Senior Manager	----- Signature / Date
	----- Signature / Date

**SAFETY TRAINING
REVISION/USAGE LOG**

Rev.	Description of Change	Date	Pages Affected	Reviewed by
0	Initial issue.		All	



I. **PROGRAM**: Industrial Safety Training

II. **COURSE**: Arc Flash Hazard Calculation and Required Protection

III. **LESSON TITLE**:

IV. **LENGTH OF LESSON/COURSE**: 1 hour

V. **PREREQUISITES**: None

VI. TRAINING OBJECTIVES

A. Terminal Objective

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

B. Enabling Objectives

1. 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.
2. Define common terms associated with TVA procedure number 1022, Arc Flash Hazard Calculation and Required Protection, without error.
3. State the basic requirements for any employee to perform the activities listed in TSP 1022, Table 3, in accordance with TVA policy.
4. Describe the PPE required for any employee to perform the activities listed in TSP 1022, Table 3, in accordance with TVA policy.
5. Establish approach boundaries without error.
6. List the requirements for maintaining flame-resistant clothing (FR clothing) without error.



VI. TRAINING AIDS:

- A. Computer with projector for Power Point Presentation
- B. Whiteboards and markers

VII. TRAINING MATERIALS (include props):

Lesson Plan 59114, handout one copy of lesson plan, appendices and attachments.

VIII. REFERENCES

- A. 29 CFR 1910.269 - Power Generation, Transmission, and Distribution.
- B. NFPA 70E - Standard for Electrical Safety Requirements for Employee Workplaces, 2004 Edition.
- C. IEEE Standard 1584, IEEE Guide for Performing Arc Flash Hazard Calculations.
- D. TVA Safety Procedure, TSP 1022, Arc Flash Hazard Calculation and Required Protection.

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TVA Training

Electric Arc Flash Protection

00059114



Introduction Purpose Definitions Basic Requirements
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X. Welcome & Introduction

Welcome to the Tennessee Valley Authority Arc Flash Hazard Calculation and Required Protection safety course. This course is designed to provide you with an understanding of the safety requirements when performing work that exposes you to a potential arc-flash hazard.

Instructor Notes

Project slide 5 on to screen while students are entering classroom and during introduction.

Course Title – 00059114

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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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Instructor Notes

Introduction

Course 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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TVA Training



What's in it for me?

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Instructor Notes

Introduction (cont)

What's in it for me?

This safety training will provide you with the knowledge necessary to limit the extent of your burn injuries due to being subjected to an arc flash from an electrical accident.

Note that the standard protects against third-degree burns. An arc-flash victim may experience first-degree and some second-degree burns.

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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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XI. Lesson Body

Instructor Notes

Introduction (cont)

Benefits to you

By knowing and understanding the requirements, you will be ensuring your safety and the safety of those who work with you. You will also be meeting a TVA requirement to provide safety training to employees who are exposed to the hazards of electric arcs.

Training Requirements ETT & OE
TVA Training

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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Instructor Notes

Introduction (cont)

Training requirements

The following are the requirements for TVA employees regarding safety training.

Each employee who is exposed to the hazards of electric arcs shall be trained in the hazards involved.

Employees performing work within the arc flash boundaries defined in this course shall complete the "Electrical Safety per OSHA" training course 00059115.



References ETT & OE
TVA Training



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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Instructor Notes

Introduction (cont)

The following references were used in developing this course:

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

In addition, electrical protective clothing and equipment may be selected from the TVA Master List of Standardized Products — for selection of flame-resistant (FR) clothing and arc-flash personal protective equipment.

Learning Objectives

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TVA Training

- ✓ **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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Instructor Notes

Introduction (cont)

Learning objectives:

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



Learning Objectives ETT & OE
TVA Training

- ✓ 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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Instructor Notes

Introduction (cont)
Learning objectives:
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



ETT & OE
TVA Training

Purpose

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Instructor Notes

Purpose

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Learning Objectives ETT & OE
TVA Training

- ✓ **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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Instructor Notes

Purpose (cont)
Learning objectives:
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.



TVA Safety Procedures ETT & OE
TVA Training



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

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Instructor Notes

Purpose (cont)

TVA safety procedures

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.

Until the analyses of circuits operating at 480 V to 60 kV are complete and warning signs posted, flame-resistant FR clothing, flame-resistant or 100% natural-fabric undergarments (except for a T-shirt, which must be FR if worn), hard hats, arc rated face shields, safety glasses, substantial type work shoes, and leather gloves or voltage-rated gloves are the minimum PPE to be worn within 10 feet (interim arc flash boundary) when performing any of the work listed in [Table 3](#), “Work Requiring Arc Flash Protection,” of the procedure.

TVA Safety Procedures ETT & OE
TVA Training



- ✓ **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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Instructor Notes

Purpose (cont)

TVA safety procedures (continued)

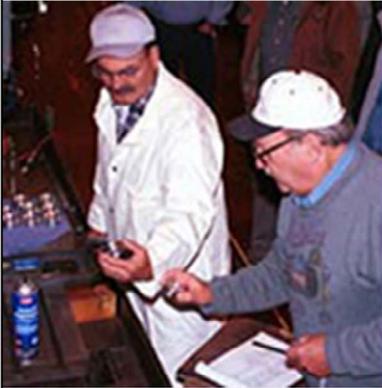
Electrical circuits operating at 60 kV and above will not be analyzed because there is no accepted method for performing the calculations.

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.”

The required protection within the arc flash boundary for circuits and components operating at 60 kV and above 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 work shoes, and leather gloves.

Click on the link on this slide to view table 3. Refer students to pages 94 - 95 in the lesson plan.

TVA Safety Procedures ETT & OE
TVA Training



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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Instructor Notes

Purpose (cont)

TVA safety procedures (continued)

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

Applicability ETT & OE
TVA Training



- ✓ **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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Instructor Notes

Purpose (cont)

Applicability

The guidance provided in the Arc Flash Hazard Calculation and Required Protection procedure is applicable for:

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.

Applicability ETT & OE
TVA Training

✓ **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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Instructor Notes

Purpose (cont)

The Arc Flash Hazard Calculation and Required Protection procedure applies to work involving electrical power circuits that have the potential to produce arcs with very high currents.

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

(This area is reserved for instructor notes.)

Electrical Safety

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TVA Training

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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Instructor Notes

Purpose (cont)

The Arc Flash Hazard Calculation and Required Protection procedure applies to work involving electrical power circuits that have the potential to produce arcs with very high currents.

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

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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Instructor Notes

Purpose (cont)

Review Question

Section Review ETT & OE
TVA Training

- ✓ **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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Instructor Notes

Purpose (cont)

Section Review

The Arc Flash Hazard Calculation and Required Protection procedure establishes requirements for the use of PPE during the performance of the work listed in Table 3, “Work Requiring Arc Flash Protection,” of the procedure.

These requirements apply to the work in Table 3, “Work Requiring Arc Flash Protection,” until the equipment, lines, and/or circuits are de-energized in accordance with paragraph 11.3.3 of the procedure.

The guidance provided in the TVA Safety Procedure 1022 is applicable to electrical power circuits operating at 480 V through 500 kV.



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TVA Training

Definitions

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Instructor Notes

Definitions

Learning Objectives				ETT & OE TVA Training	
Upon completion of this section, you will be able to state the definition of the following terms with no error:					
<ul style="list-style-type: none">✓ Contact distance✓ Exposed energized conductors and parts✓ Flash protection boundary✓ Metal clad switchgear✓ Motor control center✓ Natural fibers					
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Instructor Notes

Definitions (cont)

Learning objectives:

This section will define key terms relating to the Arc Flash Hazard Calculation and Required Protection Procedure.

Objectives

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

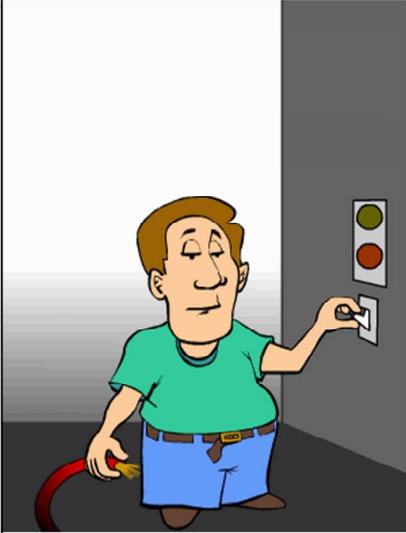
Flash protection boundary

Metal clad switchgear

Motor control center, and

Natural fibers

Contact Distance ETT & OE
TVA Training



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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Instructor Notes

Definitions: (cont)

Contact distance

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.

Exposed Energized Conductors & Parts

ETT & OE
TVA Training



- ✓ 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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Instructor Notes

Definitions: (cont)

Exposed energized conductors and parts

Exposed energized conductors and parts defines any point where an exposed electrical potential may be present.

Although the Electric Arc Flash Hazard Calculation and Required Protection Procedure concentrates on electrical systems and components that have the potential to produce arcs that pass very high currents, the definition of exposed energized conductors and parts applies to any such energized component.

Flash Protection Boundary

ETT & OE
TVA Training

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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Instructor Notes

Definitions: (cont)

Flash protection boundary

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.”

Metal Clad Switchgear

ETT & OE
TVA Training

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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Instructor Notes

Definitions: (cont)

Metal clad switchgear is an assembly of components 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. It is equipped with self-aligning and self-coupling primary and secondary devices.

The interrupting devices, buses, voltage transformers and control power transformers are completely enclosed by grounded metal barriers, which have no intentional openings between compartments. 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.

Metal Clad Switchgear ETT & OE
TVA Training



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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Instructor Notes

Definitions: (cont)

Metal clad switchgear (cont)

All live parts are enclosed within grounded metal barriers and separated into individual compartments by voltage level. Instruments, meters, relays, secondary control devices, and their wiring are isolated from all primary circuit elements by grounded metal barriers.

Primary bus conductors and connections are covered with tract-resistant insulation.

Mechanical interlocks are provided to ensure proper and safe operation. The circuit breaker cannot be racked to or from the connected position with its contacts closed, nor can it be removed from the enclosure with the stored energy mechanism charged.

Metal Clad Switchgear ETT & OE
TVA Training



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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Instructor Notes

Definitions: (cont)

Metal clad switchgear (cont)

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, in that MCCs typically consists of molded case breakers and often use starters, also known as contactors, to energize and de-energize loads.

Motor Control Center ETT & OE
TVA Training



- ✓ 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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Instructor Notes

Definitions: (cont)

Motor Control Center

A motor control center, or MCC, is defined as 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, nor do they include control system engineering.

MCCs differ from metal clad switchgear in that they cannot control loads via a breaker.

Natural Fibers ETT & OE
TVA Training

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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Instructor Notes

Definitions: (cont)

Natural fibers

Natural fibers as described in the Arc Flash Hazard Calculation and Required Protection Procedure are 100% cotton, 100% silk, or 100% wool.

Empty area for Instructor Notes.

Section Review ETT & OE
TVA Training

- ✓ **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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Instructor Notes

Definitions (cont)

Section Review

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.



Section Review ETT & OE
TVA Training

- ✓ **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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Instructor Notes

Definitions (cont)

Section Review

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.



ETT & OE
TVA Training

Basic Requirements

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Instructor Notes

Basic Requirements

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Learning Objectives				ETT & OE TVA Training	
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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Instructor Notes

Basic Requirements (cont)

Learning objectives:

This section will provide you with the basic requirements of the Arc Flash Hazard Calculation and Required Protection procedure.

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.

Purpose ETT & OE
TVA Training



✓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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Instructor Notes

Basic Requirements (cont)

Purpose

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.

Click on the link on this slide to review and Industry Event on this subject. Refer students to page 93 in the lesson plan.

Clothing ETT & OE
TVA Training



- ✓ 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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Instructor Notes

Basic Requirements (cont)

Clothing

Each employee who is exposed to the hazards of flames or electric arcs shall not wear clothing that, when exposed to flames or electric arcs, could increase the extent of injury that would be sustained by the employee.

An example of this would be clothing that melts when exposed to high heat.

Remember that, until the incident energy levels are determined and warning signs are posted on circuits and equipment operating at 480 V through 60 kV, the interim protection consists of FR clothing with an Arc Thermal Performance Value (ATPV) at least 4.2 cal/cm², hard hat, arc-rated face shield, safety glasses, substantial industrial type shoes meeting requirements of TSP 307, “Foot Protection,” and dry leather gloves or voltage-rated gloves.

Clothing ETT & OE
TVA Training

- ✓ 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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Basic Requirements (cont)

Clothing (cont)

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.

Clothing ETT & OE
TVA Training

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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Instructor Notes

Basic Requirements (cont)

Clothing (cont)

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

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.

Introduction	Purpose	Definitions	Basic Requirements
	PPE	Approach Boundaries	FR Clothing

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Instructor Notes

Basic Requirements (cont)

Review Question

Section Review ETT & OE
TVA Training

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

Introduction	Purpose	Definitions	Basic Requirements
PPE	Approach Boundaries	FR Clothing	▲

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Instructor Notes

Basic Requirements (cont)

Section Review

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.



ETT & OE
TVA Training

Personal Protective Equipment

Introduction Purpose Definitions Basic Requirements
PPE Approach Boundaries FR Clothing

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Instructor Notes

Personal protective equipment (PPE)

--

Learning Objectives		ETT & OE TVA Training	
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			
Introduction	Purpose	Definitions	Basic Requirements
PPE		Approach Boundaries	FR Clothing
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Instructor Notes

Personal protective equipment (cont)

Objectives:

This section will explain how to determine the PPE required for a given task. 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.

Learning Objectives (cont) ETT & OE
TVA Training

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**

Introduction	Purpose	Definitions	Basic Requirements
PPE	Approach Boundaries	FR Clothing	

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Instructor Notes

Personal protective equipment (cont)

Objectives:

This section will explain how to determine the PPE required for a given task. Upon completion of this section, you will be able to:

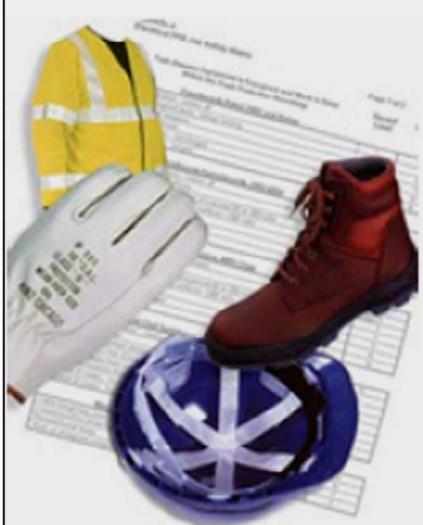
- Identify the incident energy level above which you must use TVA Procedure Number 1022 to select required FR clothing and PPE.

- 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.



Arc Flash Incident Energy Analysis ETT & OE
TVA Training



- ✓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

Introduction	Purpose	Definitions	Basic Requirements
PPE	Approach Boundaries	FR Clothing	

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XI. Lesson Body

Instructor Notes

Personal protective equipment (cont)

Arc flash incident energy analysis

TVA organizations are required to analyze electrical circuits and/or equipment operating at 480 volts and above to determine incident energy levels for selection of appropriate flame-resistant clothing and other personal protective equipment, or PPE.

The analysis is also used to establish arc-flash boundaries.

Flash Protection Boundary ETT & OE
TVA Training

- ✓ 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

Introduction	Purpose	Definitions	Basic Requirements
	PPE	Approach Boundaries	FR Clothing

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XI. Lesson Body

Instructor Notes

Personal protective equipment (cont)

Flash Protection Boundaries

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.

Note: Until the analyses are complete and warning signs posted, flame-resistant FR clothing, flame-resistant or 100% natural-fabric undergarments, hard hats, arc-rated face shields, safety glasses, substantial type shoes, and leather gloves or voltage-rated gloves are the minimum PPE to be worn within 10 feet (interim arc flash boundary) when performing any of the work listed in Table 3, “Work Requiring Arc Flash Protection,” of the procedure.



ETT & OE
TVA Training

Flash Protection Boundary (cont)

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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Instructor Notes

Personal protective equipment (cont)

Flash Protection Boundaries (cont)

Electrical circuits operating at 60 kV and above will not be analyzed because there is no accepted method of 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,” of the procedure.

The 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

Daily Wear FR Clothing

ETT & OE
TVA Training

- ✓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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Instructor Notes

Personal protective equipment (cont)

Daily-wear FR clothing

TVA purchases and provides daily-wear FR clothing to identified employees who routinely work on circuits and equipment operating at 480 volts and above.

These employees come to work wearing their daily-wear FR clothing unless their job assignment clearly excludes potential exposure to arc flash hazards, for instance, when in classroom training.

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).

Daily Wear FR Clothing (cont)

ETT & OE
TVA Training

- ✓ **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
	PPE	Approach Boundaries	FR Clothing

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Instructor Notes

Personal protective equipment (cont)

Daily-wear FR clothing (cont)

All organizations must maintain a list of employees who are provided daily-wear FR clothing.

TVA's transmission organization has a daily-wear clothing program in effect since 1994. A large percent of this clothing has an ATPV of 4.5 cal/cm².

These garments may continue to be worn unless arc flash hazard calculations show the energy incident rate at the point of exposure is above 4.5 cal/cm². In this case, the ATPV of clothing worn must meet or exceed the calculated exposure value.

Safety Procedure 1022 ETT & OE
TVA Training

- ✓ **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

Introduction	Purpose	Definitions	Basic Requirements
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Instructor Notes

Personal protective equipment (cont)

Arc Flash Hazard Calculation and Required Protection (Procedure Number 1022)

Appendix A in the Arc Flash Hazard Calculation and Required Protection Procedure Number 1022 provides tables used to identify the PPE requirements based on the arc flash incident energy calculated in the arc flash hazard analysis.

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.

Click on the link on this slide to view table A. Refer students to lesson plan pages 96 – 97 in the lesson plan.

Layering of FR Clothing ETT & OE
TVA Training

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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PPE Approach Boundaries FR Clothing 54

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Instructor Notes

Personal protective equipment (cont)

Appendix A

Required FR clothing and PPE

Layering of FR clothing/PPE

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.

Note: The organization's safety staff approves any layering system to be used.

Removal of PPE ETT & OE
TVA Training

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**

Introduction	Purpose	Definitions	Basic Requirements
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Instructor Notes

Personal protective equipment (cont)

Removal of PPE

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.

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.



Removal of PPE (cont) ETT & OE
TVA Training

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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Instructor Notes

Personal protective equipment (cont)

Removal of PPE (cont)

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.

Removal of PPE (cont) ETT & OE
TVA Training



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

Introduction	Purpose	Definitions	Basic Requirements
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XI. Lesson Body

Instructor Notes

Personal protective equipment (cont)

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/covers latched or screwed closed unless an arc flash boundary has been established and/or work listed in Table 3 is being performed. This is a revision to TSP 1022 effective July 2006.

These employees may be in the area taking readings, operating switches, or performing other non-electrical work. Or, they may just be walking through the area.

The required PPE includes a hard hat, safety glasses, leather gloves, and substantial industrial type shoes.

Allowable Clothing ETT & OE
TVA Training

- ✓ **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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Instructor Notes

Personal protective equipment (cont)

Allowable clothing

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.

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.

Face ShieldsETT & OE
TVA Training

- ✓ **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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Instructor Notes

Personal protective equipment (cont)

Face shields

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.

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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XI. Lesson Body

Instructor Notes

Personal protective equipment (cont)

Review Question

Section Review ETT & OE
TVA Training

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**

Introduction	Purpose	Definitions	Basic Requirements
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XI. Lesson Body

Instructor Notes

Personal protective equipment (cont)

Section Review

Appendix A of TVA Procedure Number 1022 is used to identify required flame-resistant clothing and PPE based on the calculated incident energy levels of the potential arc.

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 provided through the transmission organization's program may continue to be worn unless arc flash hazard calculations show the energy incident rate at the point of exposure is above 4.5 cal/cm². In this case, they must add protection to increase the ATPV of clothing worn to meet or exceed the calculated exposure value.



Section Review ETT & OE
TVA Training

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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Instructor Notes

Personal protective equipment (cont)

Section Review (cont)

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.



Section Review ETT & OE
TVA Training

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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PPE Approach Boundaries FR Clothing 63

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Instructor Notes

Personal protective equipment (cont)

Section Review (cont)

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.

Section Review ETT & OE
TVA Training

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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Instructor Notes

Personal protective equipment (cont)

Section Review (cont)

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.

ETT & OE
TVA Training

Approach Boundaries

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XI. Lesson Body

Instructor Notes

Approach boundaries

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Learning Objectives			ETT & OE TVA Training	
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				
Introduction	Purpose	Definitions	Basic Requirements	
	PPE	Approach Boundaries	FR Clothing	66

XI. Lesson Body

Instructor Notes

Approach boundaries (cont)

Objectives

This section will present the requirements for setting boundaries for electrical work.

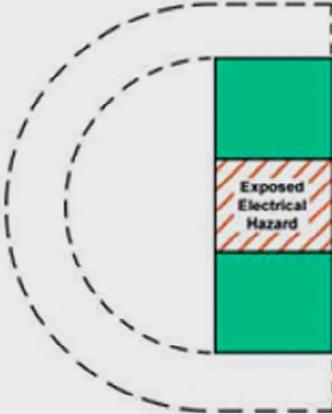
Upon completion of this section, you will be able to:

- 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.

Arc Flash Protection Boundary ETT & OE
TVA Training

PPE Boundaries

- ✓ 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



The diagram illustrates the Arc Flash Protection Boundary. It shows a dashed semi-circular line representing the boundary. To the right of this boundary is a vertical rectangular area representing an electrical hazard. This area is divided into three horizontal sections: a top green section, a middle section with red diagonal hatching labeled 'Exposed Electrical Hazard', and a bottom green section. The dashed boundary is positioned to the left of the hazard, indicating the safe distance for workers.

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PPE Approach Boundaries FR Clothing 67

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Instructor Notes

Approach boundaries (cont)

Arc flash protection boundary

What is an arc flash protection boundary?

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.

Interim Arc Flash Boundary ETT & OE
TVA Training

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



Introduction	Purpose	Definitions	Basic Requirements
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Instructor Notes

Approach boundaries (cont)

Interim arc flash boundary

TVA organizations must analyze electrical circuits and/or equipment operating at 480 volts to 60 kV to determine incident energy levels, select appropriate FR clothing and other PPE, and establish arc flash boundaries.

Until the analyses are complete and warning signs posted, the following are the minimum to be worn within 10 feet (interim arc flash boundary) when performing any of the work listed in Table 3, “Work Requiring Arc Flash Protection”:

- FR clothing (either checkout or daily-wear)
- FR or 100% natural-fabric undergarments (except for a T-shirt, which must be FR if worn)
- Hard hat
- Safety glasses
- Substantial industrial type work shoes
- Leather gloves and/or voltage-rated gloves
- Arc-rated face shield

Interim Arc Flash Boundary (cont)

ETT & OE
TVA Training

✓ 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



Introduction	Purpose	Definitions	Basic Requirements
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Approach boundaries (cont)

Interim arc flash boundary (cont)

For circuits above 60 kV, the arc flash boundary is 10 feet for any of the work listed in Table 3, "Work Requiring Arc Flash Protection."

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, and leather gloves.

Instructor Notes

Note:

Electrical circuits operating above 60 kV will not be analyzed because there is no accepted method of performing the calculations

Arc Flash Boundary Calculations

ETT & OE
TVA Training

- ✓ **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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Instructor Notes

Approach boundaries (cont)

Arc flash boundary calculation

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.



Arc Flash Boundary Calculations

ETT & OE
TVA Training

- ✓ 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

Introduction

Purpose

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Instructor Notes

Approach boundaries (cont)

Arc flash boundary calculation (cont)

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.

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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Instructor Notes

Approach boundaries (cont)

Review Question

Reviewing Analysis Results ETT & OE
TVA Training

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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Instructor Notes

Approach boundaries (cont)

Reviewing analysis results

The results of the TVA 1584 Calculator and the ARCPRO Software are essentially the same. Each method calculates the boundaries differently. The 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.



Reviewing Analysis Results ETT & OE
TVA Training

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**



Introduction	Purpose	Definitions	Basic Requirements
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Instructor Notes

Approach boundaries (cont)

Reviewing analysis results (cont)

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 category specified in Appendix A, Table A-1 of TVA Procedure 1022.

Arc Flash Energy Reduction ETT & OE
TVA Training

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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XI. Lesson Body

Instructor Notes

Approach boundaries (cont)

Arc flash energy reduction

Once the analysis calculations are complete, the engineering department is responsible for reviewing the calculated incident energies for opportunities to reduce the higher values through electrical engineering changes to the circuits.

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.



Prohibition on Work ETT & OE
TVA Training



- ✓ 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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Instructor Notes

Approach boundaries (cont)

Prohibition on work

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.

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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Instructor Notes

Approach boundaries (cont)

Review Question

Section Review ETT & OE
TVA Training

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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Instructor Notes

Approach boundaries (cont)

Section 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 operating at 480 V to 60 kV, an interim arc flash boundary is established.

Empty area for Instructor Notes.



Section Review

ETT & OE
TVA Training

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



Introduction	Purpose	Definitions	Basic Requirements
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Instructor Notes

Approach boundaries (cont)

Section review (cont)

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 (except for a T-shirt, which must be FR if worn).
- Hard hat.
- Safety glasses.
- Substantial industrial type work shoes.
- Leather gloves or voltage-rated gloves.
- Arc-rated face shield.

Section Review ETT & OE
TVA Training

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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Instructor Notes

Approach boundaries (cont)

Section review (cont)

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

Section Review

ETT & OE
TVA Training

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**

Introduction	Purpose	Definitions	Basic Requirements
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Instructor Notes

Approach boundaries (cont)

Section review (cont)

There are two methods used for performing the arc flash hazard analysis: TVA 1584 Calculator, used for voltages from 480 V to 15 kV, and ARCPRO Software, used for circuits between 15 kV and 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.



ETT & OE
TVA Training

Flame Resistant Clothing

Introduction	Purpose	Definitions	Basic Requirements
	PPE	Approach Boundaries	FR Clothing

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Instructor Notes

FR Clothing

Learning Objectives

ETT & OE
TVA Training

- 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
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Instructor Notes

FR Clothing (cont)

This section will describe the requirements for maintaining flame-resistant clothing used as personal protective equipment.

Objectives

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

- Describe the inspection requirements for flame-resistant clothing in accordance with the Arc Flash Hazard Calculation and Required Protection procedure.
- List the requirements for washing and drying flame-resistant clothing, including the restrictions.
- State the types of repairs that can be made on flame-resistant clothing in accordance with the Arc Flash Hazard Calculation and Required Protection procedure.
- Identify the type of clothing that can be worn underneath flame-resistant clothing, and the reason why the OSHA standard exists.



Inspection ETT & OE
TVA Training



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

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Instructor Notes

FR Clothing (cont)

Inspecting flame-resistant 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.

Washing/Drying Guidelines ETT & OE
TVA Training

✓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

[View Guidelines](#)



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FR Clothing (cont)

Washing/drying guidelines

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

Instructor Notes

Click on the link shown on this slide to view the washing and drying guidelines for FR clothing used at TVA. Refer students to pages 98 – 101 in the lesson plan.

Washing/Drying Requirements ETT & OE
TVA Training

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



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Instructor Notes

FR Clothing (cont)

Washing/drying requirements

Here are some basic guidelines for washing and drying FR clothing:

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

Do not:

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

Repairs ETT & OE
TVA Training



- ✓ 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

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Instructor Notes

FR Clothing (cont)

Repairing flame-resistant 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.

Undergarments

ETT & OE
TVA Training

- ✓ 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

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Instructor Notes

FR Clothing (cont)

Undergarments

Clothing worn under flame-resistant clothing shall be made of FR or 100% natural fibers (except for T-shirts, which must be FR) such as cotton, wool, or silk.

The OSHA standard does not allow synthetic or polyester blends because in a flash situation, the intensity of the heat can melt the fabric even when it is worn under flame-resistant clothing, and increase the extent of injury. The polyester must be removed from the body before healing of the burn can take place.

It is each worker's responsibility to comply with this requirement.

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

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Instructor Notes

FR Clothing (cont)

Review Question

Section Review ETT & OE
TVA Training

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**

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Instructor Notes

FR Clothing (cont)

Section 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.



XII. Summary

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. This procedure establishes requirements for the use of PPE during the performance of the work to protect employees who work inside arc flash boundaries. Therefore, 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.

Appendix A

Industry Event

On March 26, 2002, with Browns Ferry Unit 3 in cold shutdown for a refueling outage, an electrical flash injured four experienced electricians while they were placing a grounding cable inside a 4-kV unit board. The electrical transient also resulted in a loss of the operating residual heat removal (RHR) pump. RHR was restored within fifteen minutes. The four individuals involved included three Browns Ferry electricians and a contractor electrician.

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.

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. 600 V 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 circuits 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 enclosure. 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> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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 <u>not</u> to be pulled (tripped) under load.</p>	

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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.

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- 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.

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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.

