NC Central University
Environmental Health and Safety

Electrical Safety Plan

Version #1.1

Contents

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Kristin Long-Witter

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I. Applicable Regulations

North Carolina Central University (NCCU) Electrical Safety Program has been developed to comply with the Occupational Safety and Health Administration (OSHA), 29CFR 1910.1200 Subparts S and R and 1910.137. In addition, this plan complies with guidelines set forth by the National Fire Protection Association NFPA 70 National Electrical Code, 70E Standard for Electrical Safety in the Workplace and 70B Preventative Electrical Maintenance.

II. Purpose

This program provides information about electrical hazards, electrical safety procedures, equipment design, development and installation for all electrical work, equipment and systems at NCCU. All faculty, staff, students, visitors and contractors must comply with the requirements of this program as it ensures their safety by:

- Defining safe work practices and use requirements for people who work with electrically energized equipment as part of their job/research duties
- Define qualified electrical worker (QEW) and training requirements
- Establishing a process for evaluating hazards and for determining appropriate hazard controls
- Establishing a formal process controlling energized electrical work through assessment and documentation using the Energized Work Permit form and process

III. Responsibilities

NCCU EHS is responsible for implementation and management of this Plan, providing employee safety training, conducting electrical safety inspections, providing required corrections to users when non-compliance is noted and ensuring new electrical equipment and components comply with codes and regulations.

Employees are responsible for the immediate reporting of electrical safety hazards, for not working on electrical equipment without proper training and authorization, and for inspecting equipment prior to using it.

Position	Applicability	Responsibility
Research / Experimental Design and	Manage equipment that generates or in some way uses or stores electricity either AC or DC	• Contact EHS for guidance

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Development		• Complete Electrical Safety Awareness Training for Non-Electrical Workers
Qualified Electrical Workers (QEW)	If you work with electricity, or equipment that uses electricity as a source of energy for operation, or equipment that generates electrical current during the course of your work; **ONLY QEW may install, fabricate, repair, test, calibrate, or modify electrical or electronics wiring, devices, systems, or equipment at NCCU**	• Demonstrate skill and knowledge related to the construction and operation of electrical equipment and installations • Complete required Electrical Safety Training • Complete training in methods of safe release and special precautionary techniques • Demonstrate the ability to use a test instrument to verify the absence of voltage
Electrical Contractors	Contractors hired to do electrical work either on facilities and/or equipment owned/controlled by NCCU as well as processes and safe work practices to be followed for working and interfacing with the NCCU electrical system	• Must have completed qualified worker; training according to NFPA 70E 110.2
Facilities Management	Persons who oversee the design, development, construction of new or refurbished facilities or who arrange for work involving current electrical equipment or supply	• Respond to all reports of electrical hazards on campus in a timely manner • Ensure personnel are properly trained • Supply appropriate PPE • Hire electrical contractors who have completed qualified person training according to NFPA 70 E 110.2

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		• Include arc flash study specifications as part of the RFP/Bid process and contracts
Faculty, Staff and Students		• Uses extension cords & power strips appropriately • Identify electrical hazards • Review Electrical Safety Fact Sheet • Review Guidelines for Space Heater Use • Report all electrical safety concerns using a School Dude work order. or the EHS Hazard and Incident Report Form • Review Guidelines for Space Heater Use • Report all electrical safety concerns using a School Dude work order. or the EHS Hazard and Incident Report Form

IV. Definitions and Acronyms

Accessible (equipment) - Admitting close approach; not guarded by locked doors, elevation, or other effective isolation means.

Accessible (readily) - Location or equipment capable of being reached quickly for actuation or inspection without requiring personnel to climb over or remove obstacles or to resort to portable ladders, etc.

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Arc Blast - An explosive release of molten material and shock-wave from equipment caused by high-amperage arcs / plasma.

Arc Rating - A value of the energy necessary to pass through any given fabric to cause with 50% probability a second or third degree burn. This value is measured in calories/cm^2. The necessary Arc Rating for an article of clothing is determined by a Hazard/Risk Assessment and the resulting HRC. Usually measured in terms of ATPV or EBT.

Arc Thermal Performance Value (ATPV) - A reported value from electric arc testing describing how much heat can be exposed to a flame resistant garment before a second degree burn injury is expected to occur.

ANSI: American National Standards Institute

AWG: American Wire Gauge

Calorie/cm^2 – Measurement of the value of the energy necessary to pass through any given fabric to cause with 50% probability a second or third degree burn.

Conductive - Able to carry electric current.

De-energized - Free from any electrical connection to a source of potential difference and from electrical charge. This condition is otherwise known as "not having an electrical potential different from that of the earth or ground".

Electrically Safe Work Condition - When the conductor or circuit part to be worked on has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded if determined necessary.

Energized - Electrically connected to or having a source of voltage.

Energized Work – Physically working on or nearby electrically energized equipment and parts without barriers, guards or physical safe-guards in place.

Exposed - Capable of being inadvertently touched or approached nearer than a safe distance by a

person. It is applied to parts that are not suitably guarded, isolated, insulated, or enclosed.

Flame-Resistant (FR) - The property of a material The characteristic of a fabric to resist ignition and to self-extinguish if ignited.

Flame retardant - chemical substance used to impart flame resistance – not part of the basic fibers so treatments can diminish overtime or with use.

Flash Hazard - A dangerous condition associated with the release of energy caused by an electric arc.

Ground fault circuit interrupter (GFCI) - detect a difference in current between black and white circuit wires caused by current leakage which is known as a ground fault and can shut off electricity flow in 1/40 of a second. The following are required to have GFCI protection: 125-volt receptacles installed in bathrooms or on rooftops must have GFCI protection, and temporary wiring installations 125-volt, single phase, 15-20 ampere, used for maintenance, remodeling, demolition, or construction activities.

Grounded - Connected to earth or to some conducting body that serves in place of the earth.

Guarded - Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger.

Hazard Risk Assessment (HRA) - By OSHA standards it is up to an employer to conduct a Hazard Risk Assessment and determine the required level of protection for tasks workers are required to perform. The electrical equipment being tested is assessed for the potential of an explosion or ARC flash, which is also measured in Cal/cm^2.

HRC (Hazard Risk Category) – As specified in NFPA 70E, determines the necessary arc rating of a garment worn during a given job task. The system is based on classification of a task according to the type of hazard(s) present during the task. Zero represents minimal risk, four represents the greatest risk. HRC 0 allows for 100% untreated cotton while HRC 4 requires flame resistant clothing with a minimum arc rating of 40.

Insulated - Separated from other conducting surfaces by a dielectric material (including air space) offering a high resistance to the passage of electric current.

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Isolated Equipment - Equipment that has been de-energized and locked-out

J: Joules (watt-seconds)

JHA: Job Hazard Analysis

Labeled - Equipment or materials to which has been attached a label, symbol, or other identifying mark of a listing organization (such as an NRTL) following third-party product evaluation and periodic inspections of production of labeled equipment or materials, and by such labeling the manufacturer indicates compliance with appropriate standards of equipment performance and safety in a specified manner.

Limited Approach Boundary - A distance from an exposed live part within which an electrical shock hazard exists for unqualified personnel, unless escorted by a qualified worker. The Limited Approach Boundary determines the minimum safe distance for the placement of barricades for shock protection. An unqualified worker may not enter the limited approach boundary without escort by a qualified worker.

Listed - Equipment, materials, or services included in a list published by a NRTL that is concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that the equipment, material or services either meets appropriate designated standards or has been tested and found suitable for a specific purpose.

Lockout/Tagout (LOTO) - The standard provides criteria for establishing an effective program for locking out or tagging out energy isolating devices and requires training for authorized and affected employees.

mA: Milliamperes

Nationally Recognized Testing Laboratory (NRTL) - Private sector organizations recognized by OSHA as an NRTL. That recognition signifies that the organization has met the necessary qualifications specified in the OSHA NRTL program. The NRTL determines that specific equipment and materials (products) meet consensus-based standards of safety to provide assurance that these products are safe for use in the U.S. workplace (e.g. Underwriters Laboratory (UL) is an NRTL).

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NESC: National Electrical Safety Code

NFPA: National Fire Protection Association

NFPA 70: National Electrical Code also known as the NEC.

NFPA 70E: Standard for Electrical Safety in the Workplace

NRTL: Nationally Recognized Testing Laboratory

Overload - Operation of equipment in excess of normal, full-load rating or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload.

Qualified Electrical Worker – Person authorized to install, fabricate, repair, test, calibrate, or modify electrical or electronics wiring, devices, systems, or equipment at NCCU. They must demonstrate skill and knowledge related to the construction and operation of electrical equipment and installations and receiving safety training to identify and avoid the hazards involved including methods of safe release and special precautionary techniques. Must be able to demonstrate the ability to use a test instrument to verify the absence of voltage

PPE: Personal Protective Equipment

Supervisor - This is a general term used throughout this program that is defined as a person who oversees electrical work, and persons doing electrical work, and who have the primary responsibility of ensuring a safe working environment.

Shock Hazard - A dangerous condition associated with the possible release of energy caused by contact or approach to live parts.

Unqualified Electrical Worker - An employee who may work around or with electrical equipment but may NOT perform any work for which a Qualified Worker is required.

Voltage (V)- This is the greatest root-mean-square (rms) difference of electrical potential between any two conductors of a circuit.

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Voltage to Ground - For grounded circuits, this is the voltage between the given conductor and the part of the equipment / circuit that is grounded. For ungrounded circuits, this is the greatest voltage between the given conductor and any other conductor of the circuit.

W: Watts

Working Near energized/live parts - Any activity inside a Limited Approach Boundary.

Working On energized/live parts– Conducting Energized Work using insulated tools, probes, or test equipment to physically contact energized equipment / circuits.

V. General Electrical Safety Rules

- Work on or near equipment operating within electrical hazard conditions is performed in an electrically safe state (verified de-energized) or is formally approved and documented through the Hazard Assessment for Energized Electrical Work and Energized Work Permit (Appendix A)
- Always consider electrical equipment energized until positively proven otherwise
- All electrical work must be done by a QEW
- Energized parts that operate at less than 50 volts and less than 1000 watts are not required to be de-energized if there will be no exposure to electrical burns or to explosion blast due to electric arcs.
- When work on energized electrical circuits or components operating at voltages greater than 50 volts to ground and capable of an electrical current greater than 5 mA is justified and approved, engineering controls (guards, covers, shields, insulated tools, fused probes, remote methods, etc.) and personal protective equipment is used to reduce the potential for contact with energized components.
- All research or test devices operating at a voltage greater than 50 volts or storing more than 1000 watt/seconds (joules) are protected by an enclosure with secured or interlocked covers, or isolated in a manner that will prevent inadvertent contact with exposed live parts.
- All electrically energized equipment is used in a safe manner as intended by the manufacturer and within the equipment's NRTL listing.
- Use suitably rated electrical tools and devices only as intended.
- Know how to isolate all energy sources to equipment in an emergency.

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- Tripped circuit breakers should be reset by a QEW who has the skills and knowledge to trouble-shoot, understand the cause, and safely re-energize the circuit. Report all tripped circuit breakers to Facilities Operations, regardless of cause or circumstances.
- Maintain the protection of covers, barriers and shielding of all electrical equipment.
- Be aware of hidden raceways and other utilities that may be concealed behind walls and/or concealed below or in concrete walls and slabs.
- Never penetrate premises wiring conduit or enclosed wire ways.
- Workers are instructed to be alert at all times where electrical hazards might exist.
- Workers are not permitted to work where electrical hazards exist while recognizably impaired due to illness, fatigue, or other reasons.
- Workers are instructed to be alert for changes in the job or task that could lead the person outside of the electrically safe work condition or expose the person to additional hazards that were not part of the original plan.
- Never reach blindly into areas that might contain exposed energized electrical conductors or circuit parts where an electrical hazard exists.
- Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, or metal frame glasses) shall not be worn within the restricted approach boundary or where they present an electrical contact hazard with exposed energized electrical conductors or circuit parts.

VI. Identifying Electrical Hazards

The human body is a good conductor of electricity. As a result, electrical current can easily travel through it. There are three main types of electrical hazards: electric shock, electrical burns, and the effects of arc blast. Understanding the basics of these hazards is critical in enforcing electrical safety in the workplace.

A. Electric Shock

Electric shock occurs when a body becomes part of an electrical current. Examples of electric shock include. Electrical current is measured in amps depending upon how much available current is present - the higher the current the higher the number of amps available to produce a shock

- A person may come in contact with both conductors in a circuit.
- Touching a live wire and an electrical ground.
- A person may provide a path between an ungrounded conductor and the ground.

- A person may provide a path between the ground and a conducting material that is in contact with an ungrounded conductor.

The severity of electric shock is related to four elements. If the combination of these four elements is just right, the shock can be severe or lead to death by electrocution.

- Amount of current
- Length of time current is present
- Path of current through the body
- Frequency of the current (Hz)

Table 1. Reaction of the human body to electrical current flows from one of their hands to a foot for 1 second

Effect of AC current (95% of Young Adults Average weight 115-150 lbs)	
Perception Threshold - tingling sensation	0.7-1 mA
Slight Shock (not painful) - no loss of muscle control	1.2-1.8 mA
Shock (painful) - no loss of muscle control	6-9 mA
Shock (severe) - muscle control loss, breathing difficulty, onset of *let go* threshold	15-23 mA
Possible ventricular fibrillation - 3 send shock	0.1 A
Possible ventricular fibrillation - 1 send shock	0.2 A
Heart muscle activity ceases	0.5 A
Tissue and organ burn	1.5 A

Source: Electrical Safety in the Workplace, Jones, et. al.

B. Electrical Burns

Burns suffered in electrical accidents can be of three types:

- **Electrical -** result of the electric current flowing in the tissues. These burns may be skin deep or may affect deeper layers such as muscle and bones.
- **Arc -** result of high temperatures produced by electric arcs or by explosions close to the body.
- **Thermal -** burns normally experienced from the skin-contacting hot surfaces of overheated electrical conductors, conduits, or other energized equipment.

Tissue damage is caused by heat generated by the current through the body and is often immediately classified as a third-degree burn. If the energy delivered by the electric shock is high, the body cannot dissipate the heat, and the tissue is burned. Typically, such electrical burns heal slowly.

C. Electric Arc Blasts

If the current is strong enough, the blast effect that can result from arcing can cause injuries and start files. The power arc is a discharge of electricity through a combination of ionized air and vaporized conductor material. The conductive material is vaporized by temperatures in an arc which can be as high as 35,000°F.

- Low-energy arcs can cause violent explosions or blasts in atmospheres containing explosive gases, vapors, or combustible dusts.
- High-energy arcs can also damage equipment causing metal to fly in all directions.

Burns caused by arc flash are typically severe, 2nd-degree (partial thickness) or 3rd-degree (full thickness) burns. Clothing may catch on fire, and this will contribute to the area of the burn, further increasing the already high risk of mortality.

VII. Protections Against Electrical Hazards

A. Insulation

Insulators such as glass, mica, rubber, or plastic used to coat metals and other conductors help stop or reduce the flow of electrical current. This helps prevent shock, fires, and short circuits.

B. Guarding

Inspect and enclose electric equipment to ensure that workers do not come in contact with any exposed electrical parts. OSHA requires that all high voltage tools and equipment is placed in an enclosed location, out of reach of other employees. Signs must alert about the electrical danger and forbid entry to unauthorized personnel.

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C. Grounding

Grounding a tool, a piece of equipment, or a specific part of an electrical system means intentionally creating a low-resistance path that connects to the earth to prevent the buildup of voltages, including a static charge. Grounding is often a permanent part of any functioning electrical circuit. Grounding may also be added temporarily to electrical circuits or equipment by maintenance or research personnel to ensure safety and that the equipment they are working on cannot build-up an electrical charge greater than ground.

D. Electrical Protective Devices

Circuit protection devices, such as breakers and circuit breakers, automatically stop the flow of an electric current if a short circuit occurs. Fuses and circuit breakers protect the equipment by opening or breaking the circuit when too much current flows through them. OSHA requires construction sites and high-risk areas to use ground fault circuit interrupters.

After a circuit is de-energized by the automatic operation of a circuit protective device, the circuit shall not be manually re-energized until it has been determined that the equipment and circuit can be safely energized. When it is determined from the design of the circuit and the overcurrent devices involved that the automatic operation of a device was caused by an overload rather than a fault condition, examination of the circuit or connected equipment shall not be required before the circuit is re-energized. However, repetitive manual reclosing of circuit breakers or re-energizing circuits through replaced fuses is prohibited.

E. Safe Work Practices

Employees can prevent electrical accidents by following OSHA safety instructions applicable to their workplaces. These may include de-energizing equipment before inspection or repair, keeping electrical tools in good working condition with timely maintenance, exercising caution when working near electrical lines, and always using appropriate protective equipment.

VIII. Qualified Electrical and Unqualified Electrical Workers

The Electrical Safety Program requires that only qualified electrical workers (QEW) install, fabricate, repair, test, calibrate, or modify electrical or electronics wiring, devices, systems, or equipment on NCCU facilities or property.

A QEW is a worker formally recognized as:

- One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk

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- Having completed required classroom training
- Having sufficient understanding of a device, system, piece of equipment, or facility to be able to recognize and positively control any hazards it may present
- Having completed site, area, facility, equipment and apparatus specific training, and having the work experience and formal training necessary to execute the work according to recognized and accepted technical standards
- Having qualifications and demonstrated skill and knowledge documented by their Supervisor and/or Manager.

A. General Guidelines for QEW

Qualification for electrical or electronics work is determined by the employee's Supervisor or Manager. It is based upon a risk review of hazards in the workplace versus the known technical knowledge and safe-work expertise of the qualified worker.

A worker is deemed a QEW when they can demonstrate adequate knowledge to work safely with electricity through a combination of formal electrical trade recognition, military, college or other training, work experience, and on-the-job training (including required periodic retraining).

Formal training can be the completion of apprenticeship, journeyman or comparable training. Experience may include formal technical related education courses and hands-on field or classroom lab work that may or may not result in licenses or certifications.

B. Specific Criteria for QEW Designation

Supervisors and Managers use the following guidelines to determine whether an individual is eligible to become a QEW. At a minimum, the documentation of an employee's qualifications considers:

- Ability to identify all possible hazards associated with a job task
- Ability to locate and read the appropriate engineering documents for the equipment or facility.
- Knowledge of how to check calibration, condition, and operation of equipment or a facility,
- Knowledge of how to shut down, isolate, and verify all sources of hazardous energy.
- Awareness of requirements of the NCCU LOTO and Electrical Safety Programs
- Ability to identify, interpret and implement all applicable codes and standards pertaining to a job task.
- Experience and training to independently distinguish correct construction techniques from incorrect techniques.

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- Experience and training to select the correct materials and components, and to use them in a manner consistent with their manufacture and/or listing.
- Ability to distinguish between appropriate and inappropriate equipment-grounding techniques.
- Experience, training and ability to predict all likely failure modes of a particular construction, and to properly mitigate the effects of such failures.
- Familiarity with the proper use of the special precautionary techniques, personal protective equipment, including arc-flash, insulating and shielding materials, and insulated tools and test equipment.

If the person will be permitted to work within the Limited Approach Boundary of exposed energized parts operating at 50V or more, the QEW must be knowledgeable of the requirement to follow the Hazard Assessment for Energized Electrical Work and Energized Work Permit process (Appendix A).

C. Unqualified Employees

Employees not qualified to perform work on electrical equipment and components will be trained in general electrical safety precautions for the purpose of hazard awareness.

The following electrical safety rules also apply to unqualified employees:

- Unqualified persons shall be trained in, and be familiar with, any electrical safety-related practices necessary for their safety
- Do not conduct any electrical repairs
- Report all electrical hazards to their supervisor
- Do not operate equipment if there is an electrical hazard
- Do not allow electrical equipment or components to contact water
- Remember that even low-voltage electricity can be physically harmful
- Do not use cords or plugs that are missing the 'ground' prong
- Do not overload electrical receptacles
- Only trained, authorized employees may repair or service electrical equipment
- Contractors must be licensed to perform electrical work
- Physical barriers must be used to prevent unauthorized persons from entering areas where new installation or repair of electrical components or equipment is being performed
- Only authorized employees may enter electrical distribution rooms

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- All electrical control devices must be labeled properly

IX. Arc Flash Boundaries

The arc flash boundary is the minimum "safe" distance from exposed energized conductors or circuit parts that has the potential for an arc flash. NFPA recommends defining three boundaries to minimize risk of electrical injuries: Arc Flash, Limited and Restricted. NFPA 70E describes what each boundary is and how to determine where to place it such that the closer to the exposed and live equipment a worker is qualified to work, the more training and higher levels of personal protective equipment (PPE) they require.

Take the proper steps to ensure your safety before taking any measurements, especially on energized equipment. Know where the arc flash boundaries are and keep these top safety measures in mind. It is important to remember that no prescribed distance measurement is given – boundaries are always set individually for each piece of equipment.

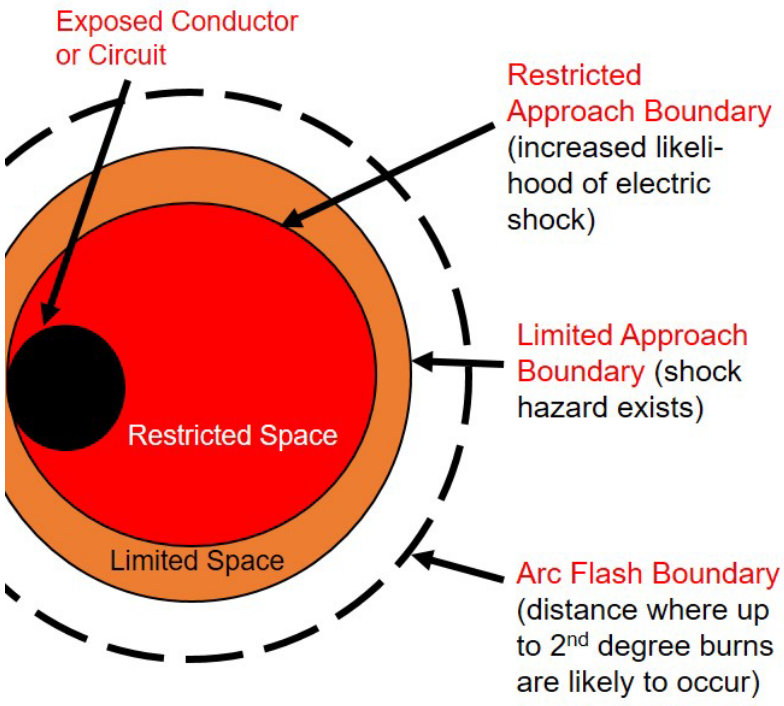

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Figure 1. Descriptions of NFPA Arc Flash Boundary

Table 2. Arc Flash Boundary Descriptions	
Boundary	**Meaning**
Arc Flash	• Outer boundary of the flash protection zone. • Workers passing it must wear flash protective equipment.
Limited Approach	• Only QEW allowed to cross line unescorted • Workers must wear flash protective equipment
Restricted Approach	• Only QEW may cross this boundary • Must have Energized Electrical Work Permit approved • Must use PPE appropriate for working near energized parts • No body part may cross the prohibited line and keep minimize body in restricted space if possible
Prohibited Approach (area nearest exposed conductor or circuit)	• Crossing this line is the same as having contact with the live part • Only QEW may cross this line • Must have specific training to work on energized parts • Must have Energized Electrical Work Permit approved • Must wear PPE appropriate for working on live parts

X. Environmental Considerations

Only workers trained in Confined Space Entry may work in a designated confined or enclosed space (such as a manhole or vault) where an electrical hazard exists in compliance with the NCCU Confined Space Program.

Doors, hinged panels, and other similar items must be secured to prevent their swinging into a worker and causing the employee to contact exposed energized electrical conductors or circuit parts where an electrical hazard exists if movement of the door, hinged panel, and the like is likely to create a hazard.

The area surrounding electrical panels, etc. must remain clear and never used for storage to allow for safe operation and maintenance of electrical equipment.

Where flammable materials are present even only occasionally, electric equipment capable of igniting them

shall not be permitted to be used, unless measures are taken to prevent hazardous conditions from developing. Such materials shall include, but are not limited to, flammable gases, vapors, or liquids, combustible dust, and ignitible fibers or flyings.

XI. Engineering Controls

Engineering controls are designed to separate or shield persons from a hazard and are the primary control measure used to reduce the potential for direct contact with exposed and energized electrical components.

- Energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts shall be put into an electrically safe work condition before an employee performs work if any of the following conditions exist:
  - The worker is within the limited approach boundary.
  - The worker interacts with equipment where conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.
- The NCCU LOTO Program details protocols for de-energizing and locking out all sources of energy prior to working on electrical equipment
- GFCIs
- Rated insulated barrier mats, floor coverings or gratings to isolate the worker from conductive ground paths while working on exposed and energized electrical components
- All electrical distribution panels, breakers, disconnects, switches and junction boxes must be completely enclosed.
- Water-tight enclosures must be used if any of these components could possibly be exposed to moisture; Structural barriers must be used to prevent accidental damage to electrical components.
- Conduits must be supported for their entire length, and non-electrical attachments to conduits are prohibited; non-rigid electrical cords must have strain relief wherever necessary.

XII. Administrative Controls

Administrative controls emphasize improving safety through the implementation of policies, practices, and procedures that govern worker behavior.

- Only QEW may install, fabricate, repair, test, calibrate, or modify electrical or electronics wiring, devices, systems, or equipment at NCCU.

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- Regular inspections of all electrical equipment for hazards are required using these criteria
  - Suitability for the intended use.
  - Proper insulation.
  - Heating effects under conditions of use.
  - Arcing effects.
- Classification by type, size, voltage, current capacity and intended use.
- Safety signs, safety symbols, and accident prevention tags warn employees about electrical hazards
- Energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts shall be put into an electrically safe work condition before an employee performs work if any of the following conditions exist:
  - The worker is within the limited approach boundary.
  - The worker interacts with equipment where conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.

XIII. Protective Equipment and Tools

- When working near exposed energized conductors or circuit parts, workers must use insulated tools or handling equipment if the tools or handling equipment might make contact with such conductors or parts. If the insulating capability of insulated tools or handling equipment is subject to damage, the insulating material shall be protected.
- Fuse handling equipment, insulated for the circuit voltage, shall be used to remove or install fuses when the fuse terminals are energized.
- Ropes and hand lines used near exposed energized parts shall be nonconductive.
- Protective shields, protective barriers, or insulating materials shall be used to protect each employee from shock, burns, or other electrically related injuries while that employee is working near exposed energized parts which might be accidentally contacted or where dangerous electric heating or arcing might occur. When normally enclosed live parts are exposed for maintenance or repair, they shall be guarded to protect unqualified persons from contact with the live parts.
- Alerting techniques. The following alerting techniques shall be used to warn and protect employees from hazards which could cause injury due to electric shock, burns, or failure of electric equipment parts:

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- **Barricades** - Used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas exposing employees to uninsulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard.
- **Attendants -** If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees.

XIV. Labeling

According to NFPA 70E, labeling is required for any piece of electrical equipment that may need examination, adjustment, service or maintenance while energized. These labels communicate the electrical hazards an employee may be exposed to, including the potential for an arc flash incident. Examples include the following:

- Switchboards
- Panel boards
- Industrial control panels
- Motor control centers transformers
- Disconnect switches

Required label information includes the following:

- Nominal system voltage
- Arc flash boundary
- At least one of the following:
  - Available incident energy and the corresponding working distance
  - Site-specific level of PPE

Safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards which may endanger them, as required by 1910.145.

XV. Electrical Equipment Inspections

All electrical equipment must be inspected for hazards that could cause injury or death. Consider the following factors when determining the safety of the equipment:

- Suitability for the intended use.

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- Proper insulation.
- Heating effects under conditions of use.
- Arcing effects.
- Classification by type, size, voltage, current capacity and intended use.

XVI. Electrical Equipment Failure

Electrical equipment frequently offers indications when failure is imminent, and employees should be trained to recognize these indications. Indications of impending failure include hot enclosures, unusual noises or sounds, warning lights, and unfamiliar smells. If any of these indications is observed, normal operation of the equipment should not be permitted or attempted.

The equipment in failure mode must be isolated using barricades or similar protective measures to protect employees from accidental contact with the equipment. After the equipment has been isolated, it should be de-energized from a remote location. The disconnecting means located in the equipment should not be operated unless the person operating it is protected from the effects of equipment failure.

XVII. Arc Flash Analysis

Arc flash hazard analysis is the process of studying a facility's electrical equipment to determine the incident energy levels at any given part of the electrical system. This assessment helps determine whether employees who come into contact with certain parts of an electrical system will be safe during an arc flash event. The goal of arc flash hazard analysis is to identify and document:

1. The flash protection boundary
2. Proper personal protective equipment (PPE)
3. Appropriate safety related work practices

There are two acceptable methods defined by NFPA 70E: 1) Incident Energy Analysis Method and 2) Arc Flash PPE Category Method.

A. Incident Energy Analysis Method

Use of the incident energy analysis method is defined by NFPA 70E and Institute of Electrical and Electronics Engineers (IEEE) 1584. While most often this is performed by an electrical professional, incident energy and arc flash boundary can be calculated using an online flash calculator or modeling software using the parameters in the table below:

Parameter	Description
Nominal voltage	The nominal operating voltage. For example, 400 V, 600 V or 15 kV.
Working distances	Determine onsite or use the typical working distances in NFPA 70E.
Short circuit current	Maximum prospective bolted short circuit current taken from an existing short-circuit study. If one is not available, the short-circuit currents will have to be calculated as part of the arc flash study.
Protection settings	Combined clearing time of the protection relay, and the circuit breaker or the fuse clearing time.
Conductor spacing	Determine the gaps between conductors, where the arc is likely to occur using design documentation or measure it. If information is not available, use the typical information from IEEE 1584.
Enclosure sizing	Determine the enclosure size, where the arc is likely to occur from design documentation or measuring it. If information not available, use the typical information from IEEE 1584.
Electrode configuration	IEEE 1584 defines 5 different types: • VCB: Vertical conductors inside a metal enclosure. • VCBB: Vertical conductors terminated in an insulating barrier inside a metal enclosure. • HCB: Horizontal conductors inside a metal enclosure. • VOA: Vertical conductors in open air. • HOA: Horizontal conductors in open air.

1. PPE Selection Using Incident Energy Method

For the Incident Energy Analysis Method, PPE is divided into the following two levels.

1. Incident energy exposures equal to 1.2 cal/cm2 up to 12 cal/cm2
2. Incident energy exposures greater than 12 cal/cm2

There are no categories, and the arc rating specified on the PPE must be higher than the calculated energy, which must be shown on the label. See Table 130.5G (Appendix B).

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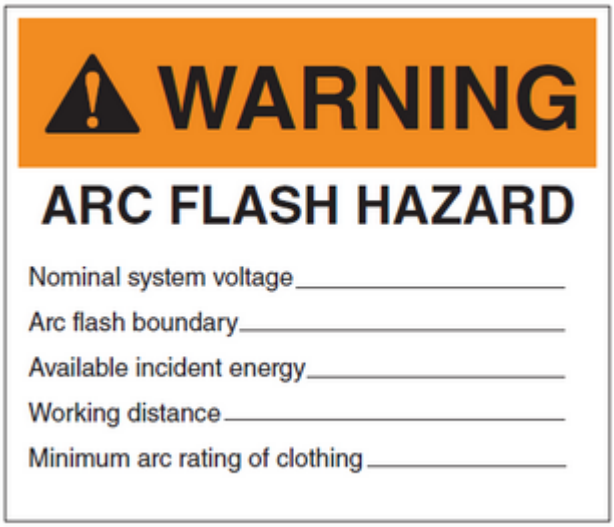
2. Arc Flash Label for Incident Energy Method

When the Incident Energy Analysis Method is used, the label must include the following:



B. Arc Flash PPE Category Method

There may be occasions when electrical work must begin before the Flash Hazard and Shock Hazard Analyses are complete. In these instances, the workers must still wear PPE. NFPA has provided tables to help determine which PPE is required when the calculations have not been done.

The arc flash PPE Category Method as defined by NFPA 70E is a two-step process:

1. Determine the likelihood of an arc flash
2. Select the PPE Category and the Arc Flash Boundary.

Table 130.5C (Appendix C) is used to determine the likelihood of an arc flash occurring considering the task and equipment condition. If the likelihood is yes, additional protective measures must be implemented including PPE.

1. PPE Selection Using the PPE Category Method

Parameters in the table below are necessary to use the PPE Category Method.

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Table 3. Parameters for Use of he PPE Category Method of Arc Flash Analysis	
Parameter	**Description**
Nominal voltage	The nominal operating voltage. For example, 400 V, 600 V or 15 kV.
Working distances	Must use the pre-defined working distances in NFPA 70E
Short circuit current	Maximum prospective bolted short circuit current taken from an existing short-circuit study. If one is not available, the short-circuit currents will have to be calculated as part of the arc flash study.
Fault clearing time	Combined clearing time of the protection relay, and the circuit breaker or the fuse clearing time. It is permissible to work this out from the bolted-fault currents and the protection settings.
Type of equipment	e.g. – switchgear, battery
Condition of equipment	Normal or Abnormal. Normal means: 1. The equipment is properly installed. 2. The equipment is properly maintained. 3. The equipment is used according to the manufacturer's instructions. 4. Equipment doors are closed and secured. 5. Equipment covers are in place and secured. 6. There is no evidence of impending failure.

Using these parameters, select PPE category and arc flash boundary from Table 130.7(C)(15)(a) (Appendix D) or (b) (Appendix E) as appropriate. Appendix F is guidance that can be used with tables 130.7(15)(a-b).

2. Arc Flash Label for PPE Category Method

The label for the arc flash PPE categories method must include the following:

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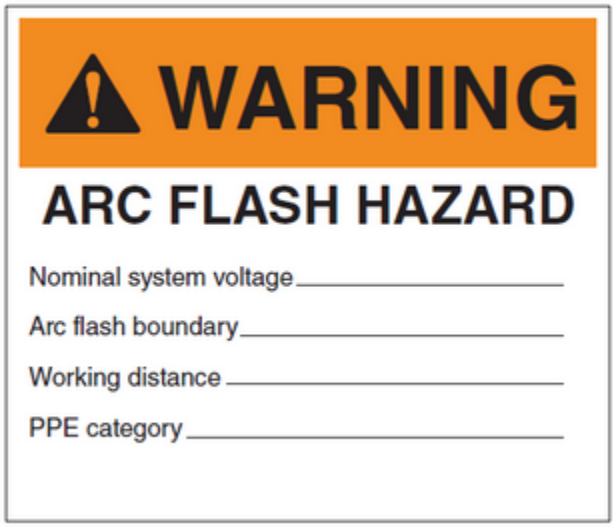

XVIII. Shock Hazard Analysis

A Shock Hazard Analysis determines the voltage to which personnel will be exposed, boundary requirements, and the PPE necessary to minimize the possibility of electric shock. To determine shock hazard, a licensed electrical engineer will perform either a calculation or use Tables 130.4(E)(a-b) of NFPA 70E. A shock risk assessment shall be performed to:

- Identify shock hazards
- Estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health
- Determine if additional protective measures are required, including the use of PPE

If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk control methods.

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Table F.3 The Hierarchy of Risk Control Methods	
Risk Control Method	**Examples**
(1) Elimination	Conductors and circuit parts in an electrically safe working condition
(2) Substitution	Reduce energy by replacing 120 V control circuitry with 24 Vac or Vdc control circuitry
(3) Engineering controls	Guard energized electrical conductors and circuit parts to reduce the likelihood of electrical contact or arcing faults
(4) Awareness	Signs alerting of the potential presence of hazards
(5) Administrative controls	Procedures and job planning tools
(6) PPE	Shock and arc flash PPE

Shock protection boundaries identified as limited approach boundary and restricted approach boundary are applicable where personnel are approaching exposed energized electrical conductors or circuit parts. Table 130.4(D)(a) shall be used for the distances associated with various ac system voltages. Table 130.4(D)(b) shall be used for the distances associated with various dc system voltages.

No QEW shall approach or take any conductive object closer to exposed energized electrical conductors or circuit parts than the restricted approach boundary unless the QEW is insulated or guarded from energized electrical conductors or circuit parts operating at 50 volts or more. Insulating gloves and sleeves are considered insulation only with regard to the energized parts upon which work is performed. Further, the energized electrical conductors or circuit parts are insulated from the qualified person and from any other conductive object at a different potential.

No unqualified person shall be permitted to approach nearer than the limited approach boundary of energized conductors and circuit parts unless a QEW advises unqualified person(s) of the possible hazards and continuously escorts the unqualified person within the limited approach boundary. Under no circumstance shall unqualified person(s) be permitted to cross the restricted approach boundary.

XIX. Evaluating Fall Hazards

If electrical work requires working at height (roof or ceiling work, tree trimming), it is important to evaluate the potential hazards that could cause a fall in the event of an electrical incident. Use the Fall Hazard Checklist (Appendix G) for proper evaluation prior to the job/project.

XX. Energized Electrical Work Permit

Energized work shall be permitted where the employer can demonstrate that de-energizing introduces additional hazards or increased risk. When work is performed without establishing an electrically safe

work condition, an Energized Electrical Work Permit (Appendix A) shall be required under the any of following conditions:

- When work is performed within the restricted approach boundary
- When the employee interacts with the equipment when conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists

Electrical work shall be permitted without an energized electrical work permit if a QEW is provided with and uses appropriate safe work practices and PPE under any of the following conditions:

- Testing, troubleshooting, or voltage measuring
- Thermography, ultrasound, or visual inspections if the restricted approach boundary is not crossed
- Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed
- General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed

XXI. Underground Electrical Lines and Equipment

Before excavation starts where there exists a reasonable possibility of contacting electrical lines or equipment, the employer shall take the necessary steps to contact the appropriate owners or authorities to identify and mark the location of the electrical lines or equipment. When it has been determined that a reasonable possibility of contacting electrical lines or equipment exists, appropriate safe work practices and PPE shall be used during the excavation.

All underground utilities, including gas, electricity, telephone, and cable TV companies, are members of 811. The call center notifies utility companies of excavation work near their underground installations and directs them to mark the approximate location of underground lines, pipes, and cables. There is a legal obligation in NC for a contact 811 prior to any excavation work.

Call 811 or use the web-based ticket system. North Carolina 811 member facility operators have three full working days, starting the day after a notice is received, in which to mark their facilities.

XXII. Cutting or Drilling

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Before cutting or drilling into equipment, floors, walls, or structural elements where a likelihood of contacting energized electrical lines or parts exists, the employer shall perform a risk assessment to:

1. Identify and mark the location of conductors, cables, raceways, or equipment
2. Create an electrically safe work condition
3. Identify safe work practices and PPE to be used

XXIII. Cutting, Removing, or Rerouting of Conductors

Where conductors are de-energized in order to cut, remove, or reroute them and the conductor terminations are not within sight from the point of work, additional steps to verify absence of voltage or identify the conductors shall be taken prior to cutting, removing, or rerouting the conductors. Additional steps to be taken where conductors are de-energized in order to cut, remove, or reroute them include, but are not limited to:

- Remotely spiking the conductors
- Pulling conductors to visually verify movement
- Remotely cutting the conductors

Non-shielded conductors could be additionally verified with a non-contact test instrument, and shielded conductors could be verified with devices that identify the conductors.

XXIV. Training

OSHA 1910 Subpart S mandates that any employee who might come into contact with an electrical hazard must receive electrical safety training. Employees must be retrained in safe work practices and in any changes to the NFPA 70E standard at least once every three years. Training is also required when new equipment is added, after a change in job duties, or after deficiencies are found during annual audits or routine supervision.

Training is required for all QEW personnel as well as any unqualified workers such as maintenance or janitorial staff who work near a hazard.

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XXV. Appendix A Hazard Assessment & Energized Work Permit

Supervisor Name: Department:

Names of Qualified Electrical Workers

Names of Unqualified Workers:

Job Location/Circuit/Equipment:

Description of work to be performed:

1. **Will this job or task require exposure to energized electrical conductors or circuit parts and/or work within an arc flash boundary (this includes testing and troubleshooting)?**

2. **Shock Hazard Analysis**

   Voltage (V) Level Phase to Phase

   ≤ 50V OR ≥ 50V and ≤ 5 mA available OR ≤ 20kV available fault currents less than 5 Ma

   50 – 250 V AC/DC and > 5 mA

   250 - 600V AC/DC OR DC ≤ 50V and ≤ 10,000 A

   > 600V AC/DC OR DC ≤ 50V and ≥10,000 A

   Approach Boundaries (provide in inches)

   Limited: Restricted: Prohibited:

3. **Arc Flash Hazard**
   Has an arc flash analysis been performed on this equipment? Yes No
   What method of arc flash analysis was used?
   Incident Energy PPE Category

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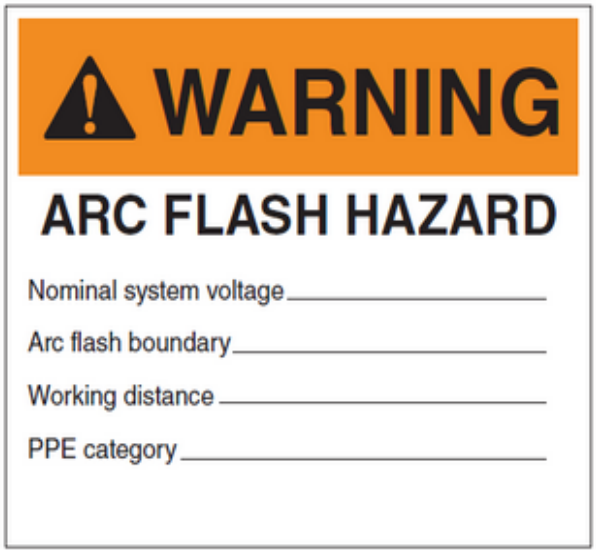
Complete appropriate label below with all information for method used

Incident Energy Method

PPE Category Method



4. **Can equipment be de-energized, locked and tagged out prior to task (other than testing/ trouble-shooting)?** Yes No

   If no, complete the Energized Electrical Work Permit

5. **Non Electrical Hazards**

Falls	Chemical Exposure	Traffic in Public Areas
Falling Objects	Biological Exposure	Obstructed Egress
Lack of Lighting	Heavy or Repetitive Motion	Wet or Damp Area
Confined Space	Noise	
Other:		

6. **What personal protective equipment (PPE) and safety measures will be used (check all that apply)**

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Body	Arc-rated or Cotton, long sleeve shirt & long pants or coveralls Arc-rated or Rainwear or jacket Arc-rated flash suit jacket & pants Arc-rated fall protection harness
Eyes, Face, Head	Safety Glasses Safety goggles Arc-rated face shield Arc-rated hardhat Arc-rated balaclava Hardhat liner Arc-rated flash hood Hearing protection
Hands & Arms	Heavy duty leather gloves Rubber insulating gloves only Rubber insulating gloves with leather protectors Rubber sleeves
Foot	Closed toe shoes Leather work shoes
Respiratory	Dust mask Air filtering respirator
Tools	Insulated tools Meter Rubber blankets
Safety Measures	Barricades with signage Attendant
Other (describe)	

7. Additional Hazard Requirements
   Fall Hazard Checklist
   Lockout/Tagout
   Confined Space
   Hearing Protection

Employee Name:
Employee Signature:
Date:

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Energized Electrical Work Permit

Part I: TO BE COMPLETED BY THE REQUESTER

Description of Circuit/Equipment/Job Location:

Description of work to be done:

Justification why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage:

Requester Name:

Requestor Title:

Date: Requestor Signature:

Part II: MUST BE COMPLETED BY QEW PERFORMING WORK

Check when complete

Detailed description of the job procedures to be used performing work above

Description of the safe work practices to be employed

Results of shock risk assessment

Results of arc flash assessment

Means employed to restrict access of unqualified persons from work area

Completion of a job briefing including discussion of any job-related hazards

Do you agree the work can be done safely? Yes No

QEW Name:

Date: QEW Signature:

Part III: APPROVAL TO PERFORM WORK ELECTRICALLY ENERGIZED

Supervisor Name:

Date: Supervisor Signature:

Once work is completed, forward copy to EHS for review and retention.

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XXVI. Appendix B NFPA Table 130.5(G) Selection of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method Is Used

Incident energy exposures equal to 1.2 cal/cm² up to 12 cal/cm²
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Long-sleeve shirt and pants or coverall or arc flash suit (SR)
Arc-rated face shield and arc-rated balaclava or arc flash suit hood (SR)[b]
Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)
Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[c]
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear
Incident energy exposures greater than 12 cal/cm²

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Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Long-sleeve shirt and pants or coverall or arc flash suit (SR)
Arc-rated arc flash suit hood
Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)
Arc-rated gloves or rubber insulating gloves with leather protectors (SR)[c]
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear

SR: Selection of one in group is required
AN: As needed
[a]Arc ratings can be for a single layer, such as an arc-rated shirt and pants or a coverall, or for an arc flash suit or a multi-layer system if tested as a combination consisting of an arc-rated shirt and pants, coverall, and arc flash suit.
[b]Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area are required by 130.7(C)(10)(c). Where the back of the head is inside the arc flash boundary, a balaclava or an arc flash hood shall be required for full head and neck protection.
[c]Rubber insulating gloves with leather protectors provide arc flash protection in addition to shock protection. Higher class rubber insulating gloves with leather protectors, due to their increased material thickness, provide increased arc flash protection.

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XXVII. Appendix C Table 130.5(C) Estimate of the Likelihood of Occurrence of an Arc Flash Incident for ac and dc Systems

Task	Equipment Condition	Likelihood of Occurrence*
Reading a panel meter while operating a meter switch.	Any	No
Performing infrared thermography and other non-contact inspections outside the restricted approach boundary. Not opening of doors or covers.		
Working on control circuits with exposed energized electrical conductors and circuit parts, nominal 125 volts ac or dc, or below without any other exposed energized equipment over nominal 125 volts ac or dc, including opening of hinged covers to gain access.		
Examination of insulated cable with no manipulation of cable.		
For dc systems, insertion or removal of individual cells or multi-cell units of a battery system in an open rack.		
For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack.		
For ac systems, work on energized electrical conductors and circuit parts, including voltage testing.	Any	Yes
For dc systems, working on energized electrical conductors and circuit parts of series-connected battery cells, including voltage testing.		
Removal or installation of CBs or switches.		
Opening hinged door(s) or cover(s) or removal of bolted covers (to expose bare, energized electrical conductors and circuit parts). For dc systems, this includes bolted covers, such as battery terminal covers.		
Application of temporary protective grounding equipment, after voltage test.		
Working on control circuits with exposed energized electrical conductors and circuit parts, greater than 120 volts.		
Insertion or removal of individual starter buckets from motor control center (MCC).		
Insertion or removal (racking) of circuit breakers (CBs) or starters from cubicles, doors open or closed.		
Insertion or removal of plug-in devices into or from busways.		
Examination of insulated cable with manipulation of cable.		
Working on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panelboard or motor control center.		

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Task	Equipment Condition	Likelihood of Occurrence*
Insertion or removal of revenue meters (kW-hour, at primary voltage and current).		
Removal of battery conductive intercell connector covers.	Any	Yes
For dc systems, working on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source.		
Opening voltage transformer or control power transformer compartments.		
Operation of outdoor disconnect switch (hookstick operated) at 1 kV through 15 kV.		
Operation of outdoor disconnect switch (gang-operated, from grade) at 1 kV through 15 kV.		
Operation of a CB, switch, contactor, or starter.	Normal[a]	No
Voltage testing on individual battery cells or individual multi-cell units.		
Removal or installation of covers for equipment such as wireways, junction boxes, and cable trays that does not expose bare, energized electrical conductors and circuit parts.		
Opening a panelboard hinged door or cover to access dead front overcurrent devices.		
Removal of battery nonconductive intercell connector covers.		
Maintenance and testing on individual battery cells or individual multi-cell units in an open rack	Abnormal	Yes
Insertion or removal of individual cells or multi-cell units of a battery system in an open rack.		
Arc-resistant switchgear Type 1 or 2 (for clearing times of less than 0.5 sec with a prospective fault current not to exceed the arc-resistant rating of the equipment) and metal enclosed interrupter switchgear, fused or unfused of arc resistant type construction, 1 kV through 15 kV.		
Insertion or removal (racking) of CBs from cubicles;		
Insertion or removal (racking) of ground and test device; or		
Insertion or removal (racking) of voltage transformers on or off the bus.		

[a] Equipment condition is considered to be "normal" if all of the following apply:

- Equipment is properly installed and maintained in accordance with the manufacturer's recommendations and applicable industry codes and standards.
- Equipment is used in accordance with instructions included in the listing and labeling and in accordance with manufacturer's instructions.
- Equipment doors are closed and secured.

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- Equipment covers are in place and secured.
- No evidence of impending failure such as arcing, overheating, loose or bound equipment parts, visible damage, or deterioration."

XXVIII. Appendix D Table 130.7(C)(15)(a) Arc-Flash PPE Categories for Alternating Current (ac) Systems

Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Panelboards or other equipment rated 240 volts and below Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	1	485 mm (19 in.)
Panelboards or other equipment rated greater than 240 volts and up to 600 volts Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	900 mm (3 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 42 kA available fault current; maximum of 0.33 sec (20 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	4.3 m (14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Maximum of 35 kA available fault current; maximum of up to 0.5 sec (30 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	6 m (20 ft)
Other 600-volt class (277 volts through 600 volts, nominal) equipment Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)

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NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Equipment	**Arc-Flash PPE Category**	**Arc-Flash Boundary**
Metal-clad switchgear, 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m
Arc-resistant switchgear 1 kV through 15 kV [for clearing times of less than 0.5 sec (30 cycles) with an available fault current not to exceed the arc-resistant rating of the equipment], and metal-enclosed interrupter switchgear, fused or unfused of arc-resistant-type construction, 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	N/A (doors closed) 4 (doors open)	N/A (doors closed) 12 m (40 ft)
Other equipment 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)

Note: For equipment rated 600 volts and below and protected by upstream current-limiting fuses or current-limiting circuit breakers sized at 200 amperes or less, the arc flash PPE category can be reduced by one number but not below arc flash PPE category 1.

The following are typical fault clearing times of overcurrent protective devices:
(1) 0.5 cycle fault clearing time is typical for current limiting fuses when the fault current is within the current limiting range.
(2) 1.5 cycle fault clearing time is typical for molded case circuit breakers rated less than 1000 volts with an instantaneous integral trip.
(3) 3.0 cycle fault clearing time is typical for insulated case circuit breakers rated less than 1000 volts with an instantaneous integral trip or relay operated trip.
(4) 5.0 cycle fault clearing time is typical for relay operated circuit breakers rated 1 kV to 35 kV when the relay operates in the instantaneous range (i.e., "no intentional delay").

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(5) 20 cycle fault clearing time is typical for low-voltage power and insulated case circuit breakers with a short time fault clearing delay for motor inrush.
(6) 30 cycle fault clearing time is typical for low-voltage power and insulated case circuit breakers with a short time fault clearing delay without instantaneous trip.

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XXIX. Appendix E Table 130.7(C)(15)(b) Arc-Flash PPE Categories for Direct Current (dc) Systems

Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Storage batteries, dc switchboards, and other dc supply sources Parameters: Greater than or equal to 100 V and less than or equal to 250 V		
Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.)		
Available fault current less than 4 kA	2	900 mm (3 ft)
Available fault current greater than or equal to 4 kA and less than 7 kA	2	1.2 m (4 ft)
Available fault current greater than or equal to 7 kA and less than 15 kA	3	1.8 m (6 ft)
Storage batteries, dc switchboards, and other dc supply sources Parameters: Greater than 250 V and less than or equal to 600 V		
Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.)		
Available fault current less than 1.5 kA	2	900 mm (3 ft)
Available fault current greater than or equal to 1.5 kA and less than 3 kA	2	1.2 m (4 ft)
Available fault current greater than or equal to 3 kA and less than 7 kA	3	1.8 m (6 ft)
Available fault current greater than or equal to 7 kA and less than 10 kA	4	2.5 m (8 ft)

Apparel that can be expected to be exposed to electrolyte must be evaluated for electrolyte protection and be arc-rate.

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XXX. Appendix F NFPA Annex H Simplified Two-Category Approach for PPE Selection

Table H.2 Simplified Two-Category, Arc-Rated Clothing System

Clothing[a]	Applicable Situations
Everyday Work Clothing Arc-rated long-sleeve shirt with arc-rated pants (minimum arc rating of 8)*or* Arc-rated coveralls (minimum arc rating of 8)	Situations where a risk assessment indicates that PPE is required and where Table 130.7(C)(15)(a) and Table 130.7(C)(15)(b) specify arc flash PPE category 1 or 2[b]
Arc Flash Suit A total clothing system consisting of arc-rated shirt and pants and/or arc-rated coveralls and/or arc flash coat and pants (clothing system minimum arc rating of 40)	Situations where a risk assessment indicates that PPE is required and where Table 130.7(C)(15)(a) and Table 130.7(C)(15)(b) specify arc flash PPE category 3 or 4[b]

[a]Note that other PPE listed in Table 130.7(C)(15)(c), which include arc-rated face shields or arc flash suit hoods, arc-rated hard hat liners, safety glasses or safety goggles, hard hats, hearing protection, heavy-duty leather gloves, rubber insulating gloves, and leather protectors, could be required. The arc rating for a garment is expressed in cal/cm^2.

[b]The estimated available fault current capacities and fault clearing times or arcing durations are listed in the text of Table 130.7(C)(15)(a) and Table 130.7(C)(15)(b). For power systems with greater than the estimated available fault current capacity or with longer than the assumed fault clearing times, Table H.2 cannot be used and arc flash PPE must be determined and selected by means of an incident energy analysis in accordance with 130.5(G).

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XXXI. Appendix G Fall Hazard Checklist

Item to Evaluate	Yes	No
Is there a proper scaffold or work platform?		
Is the scaffold or work platform of a non-conductive material?		
Does the work platform have proper guard railing (top edge height between 39 and 45 inches)?		
Does scaffold or work platform have screens or mesh to protect tools from falling into or near the electrical system?		
If a ladder is used, is it of non-conductive material?		
Does scaffold have toe boards to prevent tools and other loose equipment from falling?		
On a suspension or scissor scaffold, are electrical wires properly insulated and free of damage?		
Is there adequate clearance between the scaffold or ladder and power lines?		
Is the scaffold free of dust and debris?		
Are fall arrest systems used?		
Is the scaffold or ladder free of moisture, snow and ice?		

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