



Environmental, Health and Safety

Electrical Safety in the Workplace Program

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1.1 Purpose

The purpose of this program is to define the electrical safety requirements that are necessary for the practical safeguarding of employees in their workplaces and is divided into five major divisions as follows:

1. Design safety standards for electrical systems – these contain design safety standards for electric utilization systems. Included in this category are all electric equipment and installations used to provide electrical power and light for employee workplaces.
2. Safety related work practices.
3. Safety related maintenance requirements.
4. Safety requirements for special equipment.
5. Definitions.

2.1 Scope

The scope of this program is to establish safety precautions for individuals working on or near electrical circuits of 50 to 600 volts that are not building electrical service entrance panels.

The safety-related work practices covered include persons working on, near, or with the following Davidson College installations:

1. Premises wiring: Installations of electric conductors and equipment within or on buildings or other structures, and on other premises such as yards, parking and other lots, and electrical substations.
2. Wiring for connection to supply: Installations of conductors that connect to the supply of electricity.
3. Other wiring: Installations of other outside conductors on the premises;
4. Optical fiber cable: Installations of optical fiber cable where such are made along with electric conductors.

This procedure complies with OSHA Part 1910 Subpart S – Electrical, and NFPA 70E (2015) – *Standard for Electrical Safety in the Workplace*.

3.1 Definitions

Arc – the passage of substantial electric current through ionized air.

Arc Flash – the expanding arc or fireball emanating from the source of the arc. It may be from a fraction of an inch to ten feet or more in size. It involves extremely intense heat and may ignite anything combustible in its path. The duration is usually a fraction of a second. An arc flash can reach temperatures of 35,000 degrees and can produce a concussive force of expanding gases and metal plasma.

Arc Flash Boundary – When an arc flash exists, an approach limit at a distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur.

Arc Rating - the maximum incident energy resistance demonstrated by a material (or a layered system of materials) prior to breakopen or at the onset of a second-degree skin burn. Arc rating is normally expressed in cal/cm².

(NFPA fine print note): Breakopen is a material response evidenced by the formation of one or more holes in the innermost layer of flame-resistant material that would allow flame to pass through the material.

Arc Thermal Performance Value (ATPV) – the rating of a protective garment or shield. Refers to the maximum amount of energy that the garment or shield can withstand without breaking open or transmitting heat that would cause more than a second-degree burn.

Bonding- refers to deliberately connecting (electrically) all metal parts in a system that does not carry current. Therefore all these parts have the same electrical potential, and differences in current do not exist, reducing the electrical danger.

Certified – equipment is “certified” if it bears a label, tag, or other record of certification that the equipment:

- Has been tested and found by a national recognized testing laboratory to meet nationally recognized standards or to be safety for use in a specified manner; or
- Is of a kind whose production is periodically inspected by a nationally recognized testing laboratory and is accepted by the laboratory as safe for its intended use.

Circuit breaker - a device designed to open and close a circuit by non-automatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

Conductor – the physical elements that allow electricity to flow along a path, there are three types:

- (1) Bare. A conductor having no covering or electrical insulation whatsoever.
- (2) Covered. A conductor encased within material of composition or thickness that is not recognized by Subpart S of the OSHA standard.
- (3) Insulated. A conductor encased within material of composition and thickness that is recognized by Subpart S of the OSHA standard.

Contractor – service provider that performs facility-related work including equipment service/maintenance or construction type activities. Contractors are typically hired to install new equipment, perform service, maintain or modify an existing facility or related equipment. Contractors may be called upon to perform a wide variety of work including but not limited to construction activities, demolition, crane/rigging services, electrical contracting, mechanical contracting, painting, landscaping/lawn care, janitorial services, etc.

Curable Burn – An electrical burn that is second degree or less.

Current – is the volume of electricity (number of electrons) moving past a point in a one second. Current is best described as the flow of electrons through an electrical circuit. On an electrical schematic or drawing or in calculations, current is represented by the letter I.

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

Energized Electrical Work – Work performed on or near energized electrical systems or equipment with exposed components operating at 50 volts or greater and as defined by Restricted Approach Boundary and Limited Approach Boundary terminology.

Equipment – A general term including material, fittings, devices, appliances, luminaires (fixtures), apparatus, and the like used as a part of, or in connection with, an electrical installation.

Exposed - (as applied to live parts) - 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, or insulated.

Flame Resistant (FR) - The property of a material whereby combustion is prevented, terminated, or inhibited following the application of a flaming or non-flaming source of ignition, with or without subsequent removal of the ignition source.

(NFPA fine print note): Flame resistance can be an inherent property of a material, or it can be imparted by a specific treatment applied to the material.

Flash Hazard Analysis – A study investigating a worker’s potential exposure to arc-flash energy, conducted for the purpose of injury prevention and determination of safe work practices and the appropriate levels of PPE.

Flash Protection Boundary – An approach limit at a distance from exposed live parts within which a person could receive a second degree burn if an electrical arc flash were to occur **(see illustration 1A, page 11)**.

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 to a point of danger or contact by persons or objects.

Ground Fault Circuit Interrupter (GFCI) – A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device.

(NFPA Fine Print Note): Class A ground-fault circuit-interrupter trips when the current to ground has a value in the range of 4 mA to 6 mA. For further information, see UL 943, Standard for Ground-Fault Circuit Interrupters.

Incident Energy – The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. Incident energy is typically expressed in calories per square centimeter (cal/cm²).

Incident Energy Analysis – A component of an arc flash risk assessment used to predict the incident energy of an arc flash for a specified set of conditions.

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

Insulated Tools – Tools tested and approved by the manufacturer for the rated voltage or tools that are covered, surrounded or separated with a nonconductive material in order to prevent or reduce the transfer of electricity. Insulated tools are rated to a specific voltage.

Live Parts – energized conductive components.

Load- is any device that converts electrical energy to motion, light, heat, or sound.

Limited Approach Boundary – An approach limit at a distance from an exposed live part within which a shock hazard exists (**see illustration 1A, page 10**).

May – Indicates permission is granted.

Motor Control Center – An assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

Panelboard – a single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front.

Power – is the rate of doing work or using energy and is represented by the letter P. Power can be best described as the rate at which electrical energy is transferred by an electrical circuit. It is measured in watts or kilowatts.

Qualified Person – A Qualified Person shall be trained and knowledgeable of the construction and operation of equipment or a specific work method and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method.

- (a) Such persons shall also be familiar with the proper use of the special precautionary techniques, personal protective equipment, including arc-flash, insulating and shielding materials, insulated tools and

test equipment. A person can be considered qualified with respect to certain equipment and methods but still are an unqualified for others.

- (b) An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a qualified person shall be considered to be a qualified person for the performance of those duties.
- (c) Such persons permitted to work within the Limited Approach Boundary of exposed live parts operating at 50 volts or more shall, at a minimum, be additionally trained in all of the following:
 - (1) The skills and techniques necessary to distinguish exposed energized parts from other parts of electrical equipment.
 - (2) The skills and techniques necessary to determine the nominal voltage of exposed live parts.
 - (3) The approach distances specified in Approach Boundaries Table and the corresponding voltages to which the qualified person will be exposed.
 - (4) The decision-making process necessary to determine the degree and extent of the hazard and the personal protective equipment and job planning necessary to perform the task safely.

Resistance – the opposition to the flow of electrons and is measured in ohms. On an electrical schematic or drawing, or in calculations, resistance is represented by the letter R.

Restricted Approach Boundary –an approach limit at a distance from an exposed live part within which there is an increased risk of shock, due to electrical arc over combined with inadvertent movement, for personnel working in close proximity to the live part (**see illustration 1A, page 10**).

Service Equipment – the necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply.

Single-Phase Power - single phase power refers to two wire Alternating Current (AC) power circuits, typically with one power (leg) conductor and one neutral conductor. In the US, 120VAC is the standard single phase voltage with one 120V power (leg) conductor and one neutral conductor.

Switchboard – a large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments.

Three-Phase Power - in a three-phase power supply system, three conductors each carry an alternating current (of the same frequency) but the phase of the voltage on each conductor is displaced from each of the other conductors by 120 degrees.

Transformer – uses the principle of electromagnetic induction to raise or lower voltage levels as needed. Transformers can step down (reduce) voltages to desired levels, and can be single-phased, or three-phased.

Voltage – is the electromotive force (EMF) or “push” that moves electrons along a conductor. It is the amount of electrical pressure in a circuit and can be either direct current (DC) or alternating current (AC). On an electrical schematic or drawing, or in calculations, voltage is represented by the letter E.

4.1 Responsibilities

Technicians – Technicians performing work on energized equipment shall follow the requirements of this procedure, wear appropriate PPE, and bring forward any electrically hazardous or unsafe condition to the attention of their Supervisor.

Supervisors – Supervisors will ensure that their Technicians have been trained in the details of this procedure. When hazardous or unsafe conditions are brought forward by Technicians, the Supervisor will address these deficiencies to the appropriate individuals to correct them.

Through supervisory inspections (conducted at least annually) on each applicable employee, Supervisors shall verify that each employee is complying with these safety related work practices. Supervisors must ensure that each employee understand what specific tasks the employee is qualified to perform.

Supervisors are also responsible for completing the Davidson College - Energized Electrical Work Permit, if work is performed on exposed electrical parts. (**See Appendix A**). The supervisors should retain a copy of the permit on file for a period of one year.

Qualified Persons – When electrical equipment is open and energized parts are exposed, only qualified persons with the proper PPE are allowed to cross the Arc Flash Protection Boundary and the Limited Approach Boundary. It is the responsibility of the qualified person to prevent any unqualified or qualified person without proper PPE from entering the work area.

Management/Department Leadership – Management personnel are responsible for full implementation and compliance of this procedure. They will ensure that

Supervisors/Technicians have the necessary skills, training and protective equipment to perform work on energized equipment in accordance with this procedure.

Contractors- contractors must comply with the Contractor Safety Program and determine any site specific information from their designated Project Manager.

Environmental Health and Safety Office

- Periodically audit the program to ensure the procedures are being followed;
- Provide technical assistance as needed for the development of non-standard procedures;
- Ensure all electrical safety policies are reviewed at least annually;
- Periodically audit and review employee's work practices to ensure safety related requirements are being followed;
- Collect and review electrical safety permits when applicable;
- Coordinate Electrical Safety Training.

5.1 Requirements

Work Procedures – If live exposed electrical parts are not placed in an electrically safe work condition (i.e., for the reasons of increased or additional hazards or infeasibility), work to be performed under this procedure shall be considered energized electrical work and shall be performed by a Qualified Person. The Qualified Person shall complete the **Davidson College – Energized Electrical Work Permit (See Appendix A). This permit must be completed by the qualified employee and authorized by their supervisor.**

In addition, safe work practices and PPE shall be used to protect employees who might be exposed to the electrical hazards. Such work practices and PPE shall protect employees from arc flash and from direct contact with live body parts, or indirectly through some other conductive object. The work practices used shall be suitable for the conditions under which the work is to be performed and for the voltage level of the live parts.

Note: *Tasks such as troubleshooting and measuring voltage, may be completed without an energized work permit, provided appropriate safe work practices and PPE are used.*

Electrical Service Equipment - shall not be worked on while energized because of the large fault currents available and the potentially long clearing times. This restriction includes all panels and equipment where electricity enters each building or structure.

Lockout/Tagout – Every attempt must be made to de-energize electrical equipment prior to work. Equipment shall be rendered electrically safe by reviewing the

College Lockout /Tagout program and following the applicable hazardous energy control procedures. The hazardous energy control procedures shall identify the type and magnitude of the hazardous energy, the means and methods that will be used to protect employees during servicing, replacement, or installation of equipment. These procedures include adherence to safe work practices and PPE requirements.

Arc Flash Protection Boundaries - Flash protection boundaries must be calculated by a professionally certified electrical engineer.

Approach Boundaries - Employees considered Qualified Persons shall not approach or take any conductive object closer to live parts than the restricted approach boundary given in Table 1, unless:

- (a) The Qualified Person is insulated or guarded from the live parts (Insulating gloves compliant with Table 2), arc-face shield and protective clothing are considered insulation only with regard to the energized parts upon which work is being performed), OR
- (b) The live part is insulated from the employee and from any other conductive object at a different potential.

Table 1 – Approach Boundaries

All dimensions are distance from live part to associate

Nominal System Voltage Range Phase to Phase Voltage	Limited Approach Boundary		Restricted Approach Boundary
	Exposable Movable Conductor	Exposed Fixed Circuit Part	
Less than 50	Not Specified	Not Specified	Not Specified
50 V to 150 V	10 ft., 0 in	3 ft., 6 in	Avoid Contact
151 V to 750 V	10 ft., 0 in	3 ft., 6 in	1 ft., 0 in
751 V to 15 kV	10 ft., 0 in	5 ft., 0 in	2 ft., 2 in
15.1 kV- 36 kV	10 ft., 0 in	6 ft., 0in	2 ft., 7 in

Illustration 1A -- Approach Boundaries

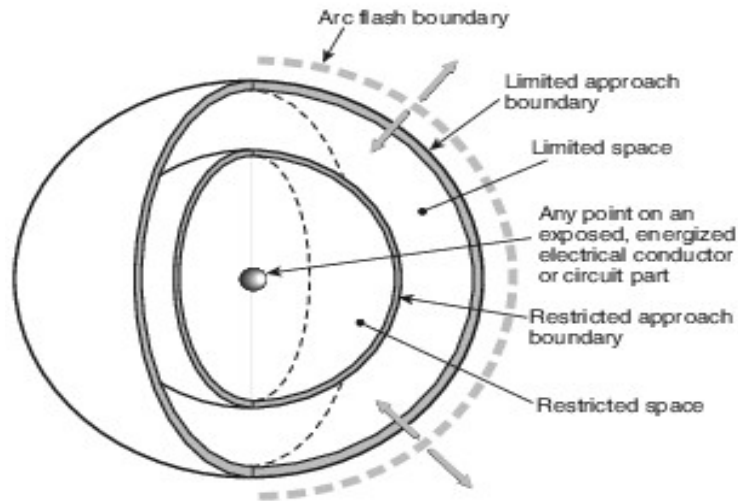


Table 2 – Glove Classifications – Shock Protection by Voltage Maximum

Approach Boundaries – Shock Prevention	
Maximum Voltages per Glove Class	
Glove Class	Maximum AC Voltage Allowed
00	500 V
0	1 kV
1	7.5 kV
2	17 kV
3	26.5 kV
4	36 kV

Overhead Lines – if work is to be performed near overhead lines, the lines shall be de-energized and grounded, or other protective measures shall be provided before work commences. If the lines are to be de-energized, arrangements shall be made with the person or organization that operates or controls the electric circuits involved to de-energize and ground them. If protective measures, such as guarding, isolating, or insulating are provided, these precautions shall prevent employees from contacting such lines directly with any part of their body or indirectly through conductive materials, tools, or equipment.

Illumination – Employees may not enter spaces containing exposed energized parts, unless illumination is provided that enables the employees to work safely. Where lack of illumination or an obstruction precludes work, employees may not perform tasks near exposed energized parts. Employees may not reach blindly into areas which contain energized parts.

Enclosed Work Spaces – When an employee works in an enclosed space doors and hinged panels, they should be secured to prevent swinging into an employee and initiating contact with exposed, energized parts.

Conductive Materials, and Equipment – Conductive materials, and equipment that are in contact with any part of an employee's body shall be handled in a manner that will prevent them from contacting exposed energized conductors or circuit parts. If an employee must handle long dimensional conductive objects (such as ducts and pipes) in areas with exposed live parts, the employer shall institute work practices (such as the use of insulation, guarding, and material handling techniques) which will minimize the hazard.

Portable Ladders – Portable ladders shall have nonconductive side rails if they are used where the employee or the ladder could contact exposed energized parts.

Conductive Apparel - Articles of jewelry and clothing (such as earrings, bracelets, rings, necklaces, belt buckles and metal buttons) may not be worn if they risk contact exposed energized parts.

Housekeeping Duties – Employees may not perform housekeeping duties at such close distances to the parts that there is a possibility of contact, unless adequate safeguards (such as insulating equipment or barriers) are provided. Electricity conductive cleaning materials (including conductive solids such as steel wool, metalized cloth, and silicon carbide, as well as conductive liquid solutions) may not be used in proximity to energized parts unless procedures are followed which will prevent electrical contact.

Safety Interlocks – Only employees considered “Qualified Persons” meeting the requirements for working on or near exposed energized parts may defeat an electrical safety interlock, and then only temporarily while he or she is working on the equipment. The safety interlock system shall be returned to its operable condition when work is completed.

Portable Electric Equipment – Applies to cord and plug-connected equipment which should be handled in a manner that will not cause damage. Flexible electric cords connected to equipment may not be used for raising or lowering equipment. Fastening with staples will damage insulation. Equipment should be visually inspected before use. These devices shall contain an equipment grounding

conductor (ground pin) and should not be used in areas in work locations with water or other conductive liquids.

Insulated Tools and Equipment – Employees shall use insulated tools and equipment when working inside the limited approach boundary. The insulated tools shall be protected from damage and inspected prior to use. Fuse or fuse holder handling equipment, insulated for the circuit voltage, shall be used to remove or install a fuse if either of the fuse terminals are energized.

Test Instruments and Equipment – Only “Qualified Persons” may perform testing work on electric circuits or equipment. Electrical circuit testing instruments like voltage testers (multimeters), ammeters, megohmmeters, etc. are designed for use on energized equipment, however, care must be taken to use them on circuits for which the equipment is rated. Misapplication of the equipment can result in equipment failure, flashover and severe burns. Instruments must be used in accordance with manufacturers’ recommendations.

Test instruments/equipment and all associated test leads, cables, power cords, probes and connectors shall be visually inspected for external defects and damage before each time the equipment is used. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be **immediately** removed from service, and no employee may use it until repairs and tests necessary to render the equipment safe have been made.

Test instruments/equipment and their accessories shall be rated for the circuits and equipment to which they will be connected and shall be designed for the environment in which they will be used.

Use of Flammable/Ignitable Materials – Where flammable materials are present, electric equipment capable of igniting them shall not be used, unless measures are taken to prevent hazardous conditions from developing. Such materials include, but are not limited to: flammable gases, vapors, or liquids; combustible dust; and ignitable fibers.

Ground Fault Circuit Interrupters (GFCIs)

- (1) Approved GFCI protection shall be provided and used for all 125 volt (nominal) single phase 15, 20 and 30 amp receptacle outlets that are not part of the permanent wiring of the building or structure. GFCIs shall be used whenever employees are working on a construction project, working with temporary wiring or working in wet areas. Extension cords used for construction or used in wet applications shall be equipped with Ground Fault Circuit Interrupters (GFCI) protection, unless a breaker, receptacle, or portable GFCI unit provides GFCI protection.

- (2) Portable and permanent GFCIs shall be tested prior to each use. GFCIs have a built-in test circuit, which imposes an artificial ground fault on the load circuit to assure that the ground-fault protection is still functioning. GFCI units shall be tested by pressing the “test” button and the “reset” with a load on the circuit to verify the GFCI cuts power to the load. A trained and qualified electrical worker should also test permanent GFCIs monthly. This testing shall be documented and records retained for the life of the unit.

6.1 Personal Protective Equipment

Employees working in areas where energized exposed live parts and/or equipment are within the Limited Approach Boundary shall wear protective clothing and other personal protective equipment in accordance with this procedure and as indicated by PPE Categories in Table 3. The PPE and clothing requirements may be determined by conducting a Flash Hazard Analysis or by using the requirements presented in the following table:

Table 3- Personal Protective Equipment Categories

Table 130.7 (C)(15)(A)(a) Arc Flash Hazard Identification for Alternating Current (ac) and Direct Current (dc) System		
Task	Equipment Condition*	Arc Flash PPE Required
Reading a panel meter while operating a meter switch.	Any	No
Normal operation of a circuit breaker (CB), switch, contactor or starter.	All of following: The equipment is properly installed. The equipment is properly maintained. All equipment doors arc closed and secured. All equipment covers are in place and secured. There is no evidence of impending failure.	No
	One or more of the following: The equipment is not properly installed. The equipment is not properly maintained. Equipment doors are open or not secured. Equipment covers are off or not secured. There is evidence of impending failure.	Yes
For ac systems: Work on energized	Any	Yes

electrical conductors and circuit parts including voltage testing.		
For dc systems: Work on energized electrical conductors and circuits parts of series-connected battery cells, including voltage testing.	Any	Yes
Voltage testing on individual battery cells or individual multi-cell units.	All of the following: The equipment is properly installed. The equipment is properly maintained. Covers for all other equipment are in place and secured. There is no evidence of impending failure.	No
	One or more of the following: The equipment is not properly installed. The equipment is not properly maintained. Equipment doors are open or not secured. Equipment covers are off or not secured. There is evidence of impending failure.	Yes
Removal or installations of CBs or switches.	Any	Yes
Removal or installation of covers for equipment such as wireways, junction boxes and cable trays that does not expose bare energized electrical conductors and circuits parts.	All of the following: The equipment is properly installed. The equipment is properly maintained. There is no evidence of impending failure.	No
	All of the following: The equipment is not properly installed. The equipment is not properly maintained. There is evidence of impending failure.	Yes
Removal of bolted covers (to expose bare energized electrical conductors and circuit parts). For dc system, this includes bolted covers, such as battery terminal covers.	Any	Yes
Removal of battery intercell connector covers.	All of the following: The equipment is properly installed. The equipment is properly maintained. Covers for all other equipment are in place and secured. There is no evidence of impending failure.	No
	One or more of the following: The equipment is not properly installed. The equipment is not properly maintained. Equipment doors are open or not secured. Equipment covers are off or not secured. There is evidence of impending failure.	Yes
Opening hinged door(s) or cover(s) (to expose bare energized electrical conductors and circuit parts)	Any	Yes
Perform infrared thermography and	Any	No

other noncontact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers.		
Application of temporary protective grounding equipment after voltage test.	Any	Yes
Work on control circuits with exposed energized electrical conductors and circuit parts 120 volts or below without any other exposed energized equipment over 120 V including opening of hinged covers to gain access.	Any	No
Work on control circuits with exposed energized electrical conductors and circuit parts, greater than 120 V.	Any	Yes
Insertion or removal of individual starter buckets from motor control center (MCC).	Any	Yes
Insertion or removal (tracking) of CBs or starters from cubicles, doors open or closed.	Any	Yes
Insertion or removal of plug-in devices into or from busways.	Any	Yes
Insulated cable examination with no manipulation of cable.	Any	No
Insulated cable examination with manipulation of cable.	Any	Yes
Work on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panel board or motor control center.	Any	Yes
Insertion and removal of revenue meters (k-W-hour, at primary voltage and current).	Any	Yes
For dc systems, insertion or removal of individual cells or multi-cells units of a battery system in an enclosure.	Any	Yes
For dc systems, insertion or removal of individual cells or multi-cell units of a battery system in an open rack.	Any	No
For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack.	Any	No
For dc system, work on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source.	Any	Yes

Table 130.7 (c)(15)(A)(a) Continued

Task	Equipment Condition*	Arc Flash PPE Required
<p>Arc-resistant switchgear Type 1 or 2 (for clearing times of <0.5 see with a prospective fault current not to exceed the arc-resistance of the equipment) and metal enclosed interrupter switchgear, fused or unfused of arc resistant type construction, tested in accordance with IEEE C37.20.7:</p> <ul style="list-style-type: none"> • Insertion or removal (racking) of CBs from cubicles • Insertion or removal (racking) of ground and test device. • Insertion or removal (racking) of voltage transformers on or off the bus. 	<p>All of the following:</p> <p>The equipment is properly installed. The equipment is properly maintained. All equipment doors are closed and secured. All equipment covers are in place secured. There is no evidence of impending failure.</p> <p>One or more of the following:</p> <p>The equipment is not properly installed. The equipment is not properly maintained. Equipment doors are open or not secured. Equipment covers are off or not secured. There is evidence of impending failure.</p>	<p>No</p> <p>Yes</p>
<p>Opening voltage transformer or control power transformer compartments.</p>	<p>Any</p>	<p>Yes</p>
<p>Outdoor disconnect switch operation (hookstick operated) at 1 kV through 15 kV.</p>	<p>Any</p>	<p>Yes</p>
<p>Outdoor disconnect switch operation (gang-operated, from grade) at 1 kV through 15 kV.</p>	<p>Any</p>	<p>Yes</p>
<p>Note: Hazard identification is one component of risk assessment. Risk assessment involves a determination of the likelihood of occurrence of an incident, resulting from a hazard that could cause injury or damage to health. The assessment of the likelihood of occurrence contained in this table does not cover every possible condition or situation. Where this table indicated that arc flash PPE is not required, an arc flash is not likely to occur.</p>		
<p>*The phrase <i>properly installed</i>, as used in this table, means that the equipment is installed in accordance with applicable industry codes and standards and the manufacturer’s recommendations. The phrase <i>properly maintained</i>, as used in this table, means that the equipment has been maintained in accordance with the manufacturer’s recommendations and applicable industry codes and standards. The phrase <i>evidence of impending failure</i>, as used in this table, means that there is evidence of arcing, overheating, loose or bound equipment parts, visible damage, deterioration, or other damage.</p>		

Table 130.7 (C)(15) (A)(b) Arc-Flash Hazard PPE Categories for Alternating Current (ac) Systems

Equipment	Arc Flash PPE Category	Arc-Flash Boundary
<p>Panelboards or other equipment rated 240 V and below</p> <p>Parameter: Maximum of 25 kA short circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)</p>	1	485 mm (19 in)
<p>Panelboards or other equipment rated >240 V and up to 600 V.</p> <p>Parameter: Maximum of 25 kA short circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)</p>	2	900 mm (3 ft.)
<p>600-V class motor control centers (MCC's)</p> <p>Parameter: Maximum of 65 kA short circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)</p>	2	1.5 m (5 ft.)
<p>600-V class motor control centers (MCC's)</p> <p>Parameter: Maximum of 42 kA short circuit current available; maximum of 0.03 sec (20 cycles) fault clearing time; working distance 455 mm (18 in.)</p>	4	5.1 m (14 ft)
<p>600-V switchgear (with power circuit breakers or fused switches) and 600 V class switchboards</p> <p>Parameter: Maximum of 35 kA short circuit current available; maximum of up to 0.5 sec (30 cycles) fault clearing time; working distance 455 mm (18 in.)</p>	4	6m (20 ft.)
<p>Other 600-V class (277 V through 600 V, nominal) equipment.</p>	2	1.5 m (5 ft.)

<p>Parameters: Maximum of 65 kA short circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)</p>		
<p>NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV.</p> <p>Parameters: Maximum of 35 kA short circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 910 mm (36 in.)</p>	4	12 m (40 ft)
<p>Metal-clad switchgear, 1 kV through 15 kV.</p> <p>Parameters: Maximum of 35 kA short circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 910 mm (36 in.)</p>	4	12m (40 ft)
<p>Arc-resistance switchgear Type 1 or 2 (for clearing times of <0.5 sec (30 cycles) with a prospective fault current not to exceed the arc-resistant of the equipment) and metal-enclosed interrupter switchgear, fused or unfused of arc-resistant type construction, tested in accordance with IEEE C37.20.7, 1 kV through 15 kV</p> <p>Parameters: Maximum of 35 kA short circuit current available; maximum of up to 0.24 sec (15 cycles) fault clearing time; working distance 910 mm (36 in.).</p>	N/A (doors closed)	N/A (doors closed)
	4 (doors open)	12 m (40 ft)
<p>Other equipment 1 kV through 15 kV</p> <p>Parameters: Maximum of 35 kA short circuit current available; maximum of up to .24 sec (15 cycles) fault clearing time; working distance 910 mm (36 in)</p>	4	12 m (40 ft)
<p>Note: For equipment rated 600 volts and below, and protected by upstream current limiting fuses or current limiting circuit breakers sized at 200 amperes, the arc flash PPE category can be reduced by one number but not below arc flash PPE category 1.</p>		

Table 130.7 (C)(15) (B) Arc-Flash Hazard PPE Categories for Direct Current (dc) Systems

Equipment	Arc Flash PPE Category	Arc-Flash Boundary
Storage batteries, dc switchboards, and other dc supply sources 100 V > Voltage < 250 V Parameters: Voltage: 250 V Maximum arc duration and working distance: 2 sec @ 455 mm (18 in)		
Short circuit current < 4 kA	1	900 mm (3 ft.)
4 kA ≤ short-circuit current < 7kA	2	1.2 m (4 ft.)
7 kA ≤ short circuit current <15 kA	3	1.8 m (6 ft.)
Storage batteries, dc switchboards, and other dc supply sources 250V ≤ Voltage ≤ 600 V Parameters: Voltage: 600 V Maximum arc duration and working distance: 2 sec @ 455 mm (18 in)		
Short circuit current 1.5 kA	1	900 mm (3 ft.)
1.5 kA ≤ short circuit < 3 kA	2	1.2 m (40 ft.)
3 kA ≤ short circuit current < 7kA	3	1.8 m (40 ft.)
7kA ≤ short circuit current < 10kA	4	2.5 m (8 ft.)
Note: Apparel that can be expected to be exposed to electrolyte must meet both of the following conditions: (1) Be evaluated for electrolyte protection in accordance with ASTM F1296, <i>Standard Guide for Evaluating Chemical Protective Clothing</i> (2) Be arc-rated accordance with ASTM F1891, <i>Standard Specification for Arc Rated and Flame Resistant, Rainwear, Or equivalent.</i>		

Examples of PPE - Some examples of PPE include:

- Hard Hats - Class G or Class E (depending of working voltage)
- Insulating gloves rated for the voltage being worked
- Leather protectors for insulating gloves
- Flame resistant and/or cotton underwear, shirt, pants, and coveralls

Flame resistant switching hood
Safety glasses (no metal frames) or goggles
Face shield
Hearing protection (Must be worn when working near an approach boundary)
Leather boots (EH rated)

Using Flame Resistant Clothing - Where it has been determined that work will be performed in areas where there are electrical hazards, Flame Resistant (FR) clothing and PPE, shall be used by employees working within the Arc Flash Protection Boundary. Clothing made from synthetic materials such as acetate, nylon, polyester, rayon, or cotton blends containing these materials are prohibited. Logos and labels shall not be affixed to clothing.

Inspecting and Maintaining Equipment (PPE) – Personal safety and protective equipment shall be maintained in a safe, reliable condition and shall be inspected before each use and as otherwise recommended by the manufacturer. Safety and protective equipment and tools shall be visually inspected for damage and defects before initial use and at intervals thereafter as service conditions require, but in no case shall the interval exceed one year.

NOTE: *The PPE requirements contained in this section are designed to protect an employee from arc-flash and shock hazards. Electrical PPE will limit a burn to the skin to a curable burn (second degree or less). Because of the explosive nature of some catastrophic electric failures, physical trauma may occur. The potential for physical trauma injuries should be considered prior to the start of the project. Objects that could cause injury in an explosive arc flash should be removed or padded.*

Protective Shields – Protective shields, barriers, or insulating materials shall be used to protect employees from shock, burns, or other electrically related injuries due to accidental contact with energized parts within the restricted approach boundary that the employee is not working on. This provision applies to situations where uninsulated parts of the employee's body (such as the back, shoulders, arms) come in close with energized parts that the employee is not working on.

Alerting Techniques - 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:

1. **Safety Signs and Tags** – safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards which may endanger them.
2. **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 circuits.

Conductive barricades may not be used where they might cause an electrical contact hazard.

3. **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.

7.1 Training

General Requirements - Safety training shall be provided to employees who face a risk of electrical shock that is not reduced to a safe level by the electrical installation requirements of OSHA 1910.303 thru 1910.308. Employees shall be trained in and familiar with the safety related work practices and procedures as needed to provide them protection from the electrical hazards associated with their respective job tasks.

This training should include the identification of electrical hazards, potential injuries and special precautionary measures that should be taken in order to minimize the possibility for injury. Training shall consist of classroom training, on the job training, or a combination of both. The degree of training shall be determined by the risk to the employee and the job task assigned. Retraining shall be provided anytime there is a change in the process and when an audit or incident investigation indicates a need. Retraining shall be performed at intervals not to exceed three years. All training shall be documented and retained for the duration of employment.

Qualified Person Training - A “Qualified Person” shall be trained and knowledgeable of the construction and operation of equipment or a specific work method, and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Employees who are “Qualified Persons” shall also be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating/shielding materials, insulated tools and test equipment. A person can be considered “Qualified” with respect to certain equipment and methods but “Unqualified” for others.

Such persons permitted to work within limited approach of exposed energized conductors and circuit parts shall, at a minimum, be additionally trained in all of the following:

- (1) The skills and techniques necessary to distinguish exposed energized parts from other parts of electric equipment;
- (2) The skills and techniques necessary to determine the nominal voltage of exposed energized parts;
- (3) The approach boundaries specified in Table 1 and the corresponding voltages to which the qualified person will be exposed; and

- (4) The decision-making process necessary to determine the degree/extent of the hazard, the personal protective equipment and job planning necessary to perform the task safely.

Qualified persons working on or near exposed energized parts shall be trained in emergency actions (i.e. removing victim from live circuits), first aid, and the use of cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED).

Unqualified Person Training - Unqualified persons shall be trained in and familiar with any of the electrical safety related practices that are necessary for their safety, including, but not limited to the general training requirements listed above.

8.1 Labeling

Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be field-marked with a label containing all of the following information:

1. Nominal system voltage.
2. Arc-flash boundary.
3. At least one of the following:
 - a. Available incident energy and the corresponding working distance.
 - b. Minimum arc rating of clothing.
 - c. Site-specific level of PPE.
 - d. PPE category.

9.0 Storage

Working space in front of electrical equipment shall be free from storage. The space should be kept clear to permit safe operation and maintenance of electrical equipment.

Appendix A - Energized Electrical Work Permit

Appendix A		DAVIDSON COLLEGE -- ENERGIZED ELECTRICAL WORK PERMIT	
Extended Duration		One-time Use Only <input type="checkbox"/>	
Department:	Building:	Room/Area:	
Job Supervisor/Responsible Engineer:		Date Start:	Expiration Date:
Description of work to be done:			
Description of Circuit/Equipment:			
Justification for why equipment cannot be de-energized:			
TO BE COMPLETED BY THE ELECTRICALLY QUALIFIED PERSONS DOING THEWORK:			
<input type="checkbox"/> Ensure Shock Protection Boundary of at least 10 feet unless specified on electrical equipment.			
<input type="checkbox"/> Ensure Arc Flash Protection Boundary of at least 4 feet unless specified on electrical equipment.			
<input type="checkbox"/> All Natural Fiber Outerwear is being worn			
<input type="checkbox"/> Fire Retardant Clothing is being worn			
<input type="checkbox"/> Required Additional PPE:			
<input type="checkbox"/> All measuring / testing tools (Voltmeter, Multi-meter, Ampere meter, etc.) are rated to be safely used on the equipment to be worked on.			
<input type="checkbox"/> Safety watch is required. This person must be trained in CPR/AED, qualified to do the work, and be able to cut off all power sources, and have immediate access to a telephone or radio to call 911 in case of emergency.			
<input type="checkbox"/> Insulated tools and equipment required:			
<input type="checkbox"/> Remove all jewelry and metal apparel.			
<input type="checkbox"/> YES <input type="checkbox"/> NO Do you agree the work can be completed safely?			
AUTHORIZED WORKERS that understand and agree to the above:			
Printed or typed name(s):	Signature(s) & Date(s):	Printed or typed name(s):	Signature(s) & Date(s):
APPROVAL(S) TO PERFORM THE WORK WHILE ELECTRICALLY ENERGIZED:			
Departmental Supervisor:		Date:	
Departmental Manager:		Date:	
Forward a completed copy of this form to the EH&S Office.			