

**CALIFORNIA STATE UNIVERSITY,
LOS ANGELES**

ELECTRICAL SAFETY PROGRAM

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PROGRAM APPROVAL AND AUTHORIZATION

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1.0. PURPOSE:

- 1.1. California State University, Los Angeles (Cal State LA) has adopted a policy to protect employees and the campus community from electrical hazards. It focuses on staff performing electrical work or who may encounter electrical hazards during their work routine. Risk Management & Environmental Health and Safety (RM/EHS) will proactively coordinate training, investigative and corrective measures with specific departments. This program addresses safe work practices, training, and protective equipment. It does not, however, cover all requirements especially related to installation methods and procedures specifically learned through an electrician apprenticeship program.

This program applies to all Qualified and Non-Qualified Personnel working on or near energized electrical equipment or systems (50 volts or more), their supervisors and managers, Planning and Construction, RM/EHS, and Facilities Services due to their involvement in electrical safety. This program is not intended to address all of the regulatory requirements or applicable guidelines, which can be found in CCR, Title 8, Electrical Safety Orders.

2.0. ORGANIZATIONS AFFECTED:

- 2.1. The following departments are affected by these procedures:

2.1.1. Facilities Services.

1. Building Service Engineers
2. Plumbers
3. Mechanics
4. Auto Shop
5. Refrigeration
6. Electrical Shop

2.1.2. Facilities Planning and Construction.

2.1.3. Independent Contractors

2.1.4. Engineering & Technology Maintenance

2.1.5. Theater Maintenance Personnel

2.1.6. Housing Maintenance

3.0. REFERENCES:

- 3.1. California Code of Regulations (CCR), Title 8, §2299 – 2974
- 3.2. Code of Federal Regulations (CRC), Title 29, §1910 and §1926
- 3.3. National Fire Protection Association (NFPA), 70E Standard for Electrical Safety in the Workplace, 2015 Edition

4.0. DEFINITIONS:

- 4.1. **Arc Flash Hazard** – a dangerous condition associated with the possible release of energy caused by an electric arc.

- 4.2. **Arc Flash Hazard Analysis** – a study investigating a worker’s potential exposure to arc flash energy, conducted for the purpose of injury prevention and the determination of safe work practices, arc flash protection boundary, and the appropriate levels of PPE.
- 4.3. **Arc Flash Suit** – a complete FR clothing and equipment system that covers the entire body, except for the hands and feet. This includes pants and jacket, and beekeeper-type hood fitted with a face-shield.
- 4.4. **Arc Rating** – the value attributed to materials describing their protective performance when exposed to an electrical arc discharge (in cal/cm²). Arc flash protection ratings are specified by ASTM F1959F/F1959M.
- 4.5. **Barricade** – a physical obstruction such as tapes, cones, or A-frame-type wood or metal structures intended to provide a warning and to limit access.
- 4.6. **Boundaries**
- 4.6.1. **Arc Flash Boundary** – The farthest established boundary from the energy source. If an arc flash occurred, this boundary is where an unprotected person would be exposed to no more than a curable second degree burn (based solely on the arc’s heat generation).
- 4.6.2. **Limited Approach Boundary** – An approach limit at a distance from an exposed live part within which a shock hazard exists.
- 4.6.3. **Restricted Approach Boundary** – An approach limit to exposed live parts in which there is an increased likelihood of electric shock due to electrical arc-over combined with inadvertent movement, for personnel working in close proximity energized parts.
- (Prohibited Approach Boundary concept obsolete in 2015)
- 4.7. **De-energized** – Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth
- 4.8. **Electrical Equipment or Systems** – Equipment or systems operating at 50 volts or more
- 4.9. **Electrical Hazard** – A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn, or blast
- 4.10. **Energized Parts** – Electrically connected to or having a source of voltage
- 4.11. **FR Rating** – The property of material to resist combustion expressed in cal/cm². Note that FR ratings have been superseded as less protective against arc flash. Arc rated materials are used in NFPA 70E – 2015.
- 4.12. **High Voltage Electrical Work** – Work on associated electrical conductors and equipment operating at or intended to operate at a sustained voltage of more than 600 volts between conductors.
- 4.13. **Live Parts** – Exposed energized electrical conductor or circuit part.
- 4.14. **Personal Protective Equipment (PPE)** – Includes, but is not limited to electrically rated or FR head protection, eye and face protection, gloves, sleeves, leather protectors, footwear, work clothing, raingear, hot sticks with fittings, personal safety grounds, barriers, mats, insulated blankets, insulated tools, and face protective products

4.15. **Qualifications**

- 4.15.1. **Qualified Electrical Worker** – A Qualified Person with a minimum of two years of training and experience with high-voltage circuits and equipment under the supervision of another qualified electrical worker and who has demonstrated by performance familiarity with the work to be performed and the hazards involved. Additionally, they must be able to distinguish exposed live parts from other parts of electric equipment, determine their nominal voltage, maintain approach distances, properly use energy isolation procedures and special precautionary techniques, and properly use PPE, insulating and shielding materials, insulated tools, grounding devices, and test equipment.
- 4.15.2. **Qualified Person** – One who has demonstrated skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training. Qualified Persons shall at a minimum be trained and familiar with the following:
1. Skills and knowledge necessary to distinguish exposed live parts from other parts of electric equipment;
 2. Skills and techniques necessary to determine nominal voltage of exposed parts; and,
 3. The clearance distances specified in 1910.333(C) and the corresponding voltages to which the qualified person will be exposed.
- 4.15.3. **Non-Qualified Person** – A person who may be exposed to electrical hazards or work within limited approach boundaries but who is not authorized as a Qualified Person or Qualified Electrical Worker.

5.0. RESPONSIBILITIES:

5.1. RM/EHS shall:

- 5.1.1. Develop and implement a written electrical safety program with Facilities Services consultation.
- 5.1.2. Implement a permit program for all work on live parts (other than testing, troubleshooting and voltage measuring by Qualified Personnel) with Facilities Services.
- 5.1.3. Develop baseline training for Non-Qualified Personnel with Facilities Services.
- 5.1.4. Ensure that the program elements are incorporated into contractor safety requirements in consultation with Facilities Services and Planning & Construction.

5.2. Facilities Services shall:

- 5.2.1. Identify Qualified Personnel, Qualified Electrical Workers, and Non-Qualified Personnel.
- 5.2.2. Complete a written electrical safety program with RM/EHS.
- 5.2.3. Implement a permit program for work on live parts 50 volts or more (other than testing, troubleshooting, and voltage measuring by qualified personnel) with RM/EHS.
- 5.2.4. Provide baseline training for Qualified Personnel, Qualified Electrical Workers, and Non-Qualified Personnel with RM/EHS.
- 5.2.5. Identify and provide appropriate personal protective equipment (PPE) for Qualified Personnel and Qualified Electrical Workers, and require its use.
- 5.2.6. Provide for and monitor the use of PPE and other protective safety devices.

- 5.2.7. Complete an arc flash hazard analysis and update as the system requires.
- 5.2.8. Ensure that Program elements are incorporated into the contractor safety requirements, in consultation with RM/EHS.
- 5.2.9. Label all equipment and components on campus.
- 5.2.10. Identify the following flash/approach boundaries:
 - 1. Arc flash boundary;
 - 2. Limited approach boundary; and,
 - 3. Restricted approach boundary.
- 5.2.11. Ensure that consultants provide training on arc flash hazard analysis to all electrical workers.
- 5.2.12. Determine the frequency for reassessing electrical equipment and components.
- 5.2.13. Provide surveillance of the Program elements including training, hazard assessment and labeling on an ongoing basis.
- 5.3. Qualified Personnel and Qualified Electrical Workers shall:
 - 5.3.1. Ensure that Qualified Electrical Workers are the only employees who may perform high voltage work (50 volts or more) that involves potential exposure to shock or arc flash hazard.
 - 5.3.2. Ensure that two Qualified Electrical Workers are present during work with 300 volts or more.
 - 5.3.3. Determine the following shock protection boundaries.
 - 1. Limited Approach
 - 2. Restricted Approach
 - 5.3.4. Determine the arc flash boundary.
 - 5.3.5. Establish a barricade at the limited approach or arc flash boundary, whichever is further from the electrical hazard.
 - 5.3.6. When working on live electrical equipment that is 50 volts or more fill out the Energized Electrical Work Permit (Appendix C).
- 5.4. Non-Qualified Personnel shall:
 - 5.4.1. Avoid barricade marking the arc flash and/or limited approach boundary unless directly supervised by Qualified Personnel or a Qualified Electrical Worker. When inside these boundaries, wear the appropriate arc flash and shock protective clothing/PPE. Non-Qualified personnel crossing the restricted approach boundary is not allowed under any circumstances.
- 5.5. Project Managers (Planning & Construction and Facility Services) shall:
 - 5.5.1. Instruct contract employers of known hazards covered by Cal/OSHA and NFPA 70E related to their work on campus and that their employees might not recognize.

- 5.5.2. Provide contract employers with information on Cal State LA electrical installations so they can adequately assess Cal/OSHA and NFPA safety requirements [Complete Appendix A--High Voltage Switching Procedures].
 - 5.5.3. Report contract employee safety violations to the contract employer.
 - 5.5.4. Ensure contract employers doing electrical work have electrical safety programs addressing high voltage work, lockout/tag-out, and performing live work on/near energized parts.
 - 5.5.5. Require a subcontractor pre-qualification. Examine Injury and Illness Prevention Programs, insurance loss runs, and three-year history of Cal OSHA citations.
 - 5.5.6. Provide a copy of the High Voltage Switching Procedures & Acknowledgement of Receipt [See Appendix "A"] to the contractor for agreements and retain a signed copy in Facilities Services records.
 - 5.5.7. Contractors will return/submit updated changes to any and all drawing(s) at completion of the job.
 - 5.5.8. Require at the completion of the job that all impacted panels will be recalibrated and panel markings revised to reflect changes. Notification to Facilities Services of any changes should occur.
- 5.6. Contract Employer shall:
- 5.6.1. Instruct their employees of hazards reported by Cal State LA.
 - 5.6.2. Enforce safe work practice requirements, as required by regulation and by Cal State LA program guidelines.
 - 5.6.3. Advise the Cal State LA Project Manager of:
 - 5.6.3.1. Unique hazards presented by contract employer's work.
 - 5.6.3.2. Unanticipated hazards found during the contract employer's work.
 - 5.6.3.3. Corrective actions taken to correct safety violations.

6.0. TRAINING:

Training represents one of the most important aspects of any safety program. Electrical safety training should occur as either classroom or on-the-job training. However, the specialized nature of the field requires that an electrician or someone working in the electrical field conduct a large portion of the training. RM/EHS can assist in coordinating the training with the specialist and can cover many non-specialty training elements, such as: regulatory requirements, injury potential, emergency procedures, Non-Qualified Personnel training, and basic elements of training for Qualified Personnel and Qualified Electrical Workers. Any organizations conducting this training must document all employees' training and maintain those records throughout their employment.

6.1. Non-Qualified Personnel Training Elements.

- Limited approach boundaries; See table (#1).
- Arc flash approach boundaries
- Lockout/tagout recognition
- Types of electrical injuries.
- Recognition of electrical hazards.

6.2. Qualified Personnel Training Elements.

- Completion of all training elements for Non-Qualified Personnel.
- Specific hazards associated with electrical energy and how they relate to injury potential and injury types.
- Safety-related work practices.
- Procedural requirements to determine voltage of exposed live parts and to differentiate them from other parts.
- Selection of appropriate voltage detectors, demonstration of their use to verify the absence of voltage, and information on their limitations.
- Barricade requirements.
- Boundaries requirements: arc flash, limited approach, and restricted approach.
- Lockout/Tagout procedures.
- Emergency procedures.
- Methods to release victims from contact with exposed energized electrical conductors or circuit parts.
- Recognizing signs and symptoms of electric shock, heart fibrillation, electric burns, and proper first aid protocols for these conditions.
- CPR training.
- Task specific hazards, precautions, and arc flash potential. Tasks performed less than once per year require re-training prior to performing the task. Refer to Job Safety Analysis (JSA) for specific task.
- Use of PPE, insulating and shielding materials, and insulated tools and test equipment based on the hazard.

6.3. Qualified Electrical Worker Training Elements.

- Completion of all training elements for Qualified Personnel.
- Minimum of two years of training and experience with high-voltage circuits and equipment.
- Demonstration by performance familiarity with the work to be performed and the hazards involved. Tasks performed less than once per year require re-training prior to performing the task.

6.4. Retrain employees on any required element when:

- They are not complying with safety-related work practices.
- Changing work conditions require safety-related work practices different than those that are normally used.
- The employee must use safety-related work practices not normally used during regular job duties.

7.0. PROGRAM ELEMENTS:

7.1. Hazard/Risk Evaluation – Employees shall identify the hazards through a risk evaluation process before they work within Limited Approach Boundaries or with any electrical hazards. In addition to specific hazards, the evaluation should consider the following:

1. Improper installation
2. Improper maintenance
3. Absence of properly secured doors/covers
4. Evidence of an impending failure

7.2. Electrical Safety Auditing – Management shall audit all elements of the electrical safety program at a risk-based frequency to ensure that the principles and procedures are being followed. Management shall make the appropriate program revisions based on those observations and/or conclusions.

7.3. Operation Verification

- 7.3.1. Test Equipment Selection. Ensure test equipment either meet or exceed both the voltage and Category rating. Do not assume that meeting only the voltage rating is a guarantee the equipment will be safe to use in transient conditions.
- 7.3.2. Employees performing work to verify absence of voltage must verify operation of the test instrument immediately before and after the test instrument is used. Verify using the same voltage type (AC or DC) as the test part. This verification applies to tests on electrical conductors or circuit parts operating at 50 volts or more.

7.4. Lockout/Tagout (LOTO) - Hazardous energy appears in the workplace in the form electrical, mechanical, pneumatic, hydraulic and thermal energy and includes chemical, water, steam and gaseous energy systems. LOTO procedures prevent the unexpected energizing, start up or release of stored energy that could cause injury to employees working on the equipment. The University has established a LOTO Program to safeguard employees from hazardous energy while they are performing service or maintenance on machines and equipment. The purpose of this program is to identify the practices and procedures necessary to shut down and LOTO machines and equipment. It requires that employees receive training in the LOTO program and requires that periodic inspections be conducted to maintain and enhance the program.

7.5. Personal Protective Equipment (PPE)

7.5.1. Qualified Personnel's normal work clothing shall include:

- Arc-rated long-sleeve shirt (minimum arc rating of 4) worn over an untreated cotton T-shirt with Arc-rated pants (minimum arc rating of 8);
- or, Arc-rated coveralls (minimum arc rating of 4) worn over untreated cotton T-shirt (or an untreated natural fiber long sleeve-shirt) with untreated natural fiber pants.

7.5.2. Qualified Personnel and Qualified Electrical Workers shall not wear **non- arc-rated** clothing that will ignite or melt when exposed to an arc flash. Clothing that pass ASTM F1959 and ASTM F1506 has been tested for both flame impingement and arc flash environments. FR rated materials exist that have not been arc rated and should not be used in place of arc-rated materials. Untreated cotton underwear is permissible. A synthetic waistband is also permissible so long as it is fully covered by untreated cotton.

7.5.3 If PPE is required, select the PPE category using Table 2ac or Table 2dc. If PPE requirements cannot be determined from Tables 1, 2ac, or 2dc then an incident energy analysis shall form the basis of PPE selection. (Note: *It is not intended that the two methods be compared when choosing the level of protection.*)

7.6. Approach Boundaries to Live Parts (NFPA 70E, 130.2)

7.6.1. A properly trained employee shall not approach or take any conductive object closer to exposed live parts (operating at 50 volts or more) than the Restricted Approach Boundary listed in Table 1 (below) unless ANY of the following apply:

- The properly trained employee is insulated or guarded from live parts using proper PPE, insulated tools and has a signed energized electrical work permit (Appendix C) authorizing the work, or
- The live part operating at 50 volts or more is insulated from the employee and there is no likelihood of arc flash caused by work disturbances in the area.

7.6.2. Approach by unqualified persons: When an unqualified person has need to cross the Limited Approach Boundary, a qualified electrician shall advise the unqualified person

of the electrical hazards, provide continuous escort, and under no circumstances allow the unqualified person to cross the Restricted Approach Boundary.

7.7. Arc Flash Boundaries

7.7.1. When an arc flash hazard exists, an arc flash boundary must be determined where unprotected personnel might receive a maximum of 1.2 cal/cm². The larger of the two boundaries distances, limited approach and arc flash, is used to barricade and inform all unauthorized and unprotected personnel away from the hazardous work location.

7.7.2. The arc flash boundary distance may be determined by any of the following:

- Table 2 (for the specific circuit breaker type),
- Table 3b (must include all parts of the equipment description), or
- Incident energy calculations (distance at 1.2 cal/cm²).

Note: It is not intended that incident energy calculations be compared with results from tables to choose the more advantageous result.

7.7.3. Determine which PPE will be sufficient to protect the worker within the arc flash boundary using Table 4 or Appendix B.1.

7.7.4. Barricades indicating the outer boundary determined in 8.7.1 must use an alerting means. Use of "Caution" or similarly worded barricade tape is permitted, placed no closer than the 8.7.1 distance. The interior area shall never be left unattended while the energized electrical system is accessible.

7.7.5. Workers may use the simplified two category PPE approach of Appendix B.1 when the arc flash category is known. If the incident energy has been determined, workers may use Appendix B.2 for required PPE combinations.

8.0. TABLES:

TABLE 1 Approach Boundaries to Live Parts for Shock Protection

Nominal System Voltage	<u>Limited Approach Boundary</u>		<u>Restricted Approach Boundary</u>
	<i>Exposed Movable Conductor</i>	<i>Exposed Fixed Circuit Part</i>	<i>Includes Inadvertent Movement Adder</i>
AC Range, Phase to Phase			
<50 V	Not specified	Not specified	Not specified
51 – 150 V	10 ft. 0 in.	3 ft. 6 in.	Avoid contact
151 – 751 V	10 ft. 0 in.	3 ft. 6 in.	1 ft. 0 in.
751 – 15k V	10 ft. 0 in.	5 ft. 0 in.	2 ft. 2 in.
DC Nominal Potential Difference			
<100 V	Not specified	Not specified	Not specified
101 – 300 V	10 ft. 0 in.	3 ft. 6 in.	Avoid contact

[Information in this table includes information from NFPA 70E Table 130.4(D) (a & b)]

TABLE 2 Incident Energy and Arc Flash Boundary by Circuit Breaker Type

Use this formula to determine the arc flash boundary for the breaker type at a known bolted current fault. The arc flash boundary is 1.2 cal/cm².

Rating (A)	Breaker Type	Trip Unit Type	480 V or Lower		575 V –600 V	
			Incident Energy (J/cm ²)	Arc Flash Boundary (mm)	Incident Energy (J/cm ²)	Arc Flash Boundary (mm)
100–400	MCCB	TM or M	0.189 <i>I</i> _{bf} + 0.548	9.16/ <i>I</i> _{BF} + 194	0.271/ <i>I</i> _{BF} + 0.180	11.8/ <i>I</i> _{BF} + 196
600–1200	MCCB	TM or M	0.223/ <i>I</i> _{BF} + 1.590	8.45/ <i>I</i> _{BF} + 364	0.335/ <i>I</i> _{BF} + 0.380	11.4/ <i>I</i> _{BF} + 369
600–1200	MCCB	E or M	0.337/ <i>I</i> _{BF} + 1.360	12.5/ <i>I</i> _{BF} + 428	0.468/ <i>I</i> _{BF} + 4.600	14.3/ <i>I</i> _{BF} + 568
1600–6000	MCCB or ICCB	TM or E, LI	0.448/ <i>I</i> _{BF} + 3.000	11.1/ <i>I</i> _{BF} + 696	0.686/ <i>I</i> _{BF} + 0.165	16.7/ <i>I</i> _{BF} + 606
800–6300	LVPCB	E, LI	0.636/ <i>I</i> _{BF} + 3.670	14.5/ <i>I</i> _{BF} + 786	0.958/ <i>I</i> _{BF} + 0.292	19.1/ <i>I</i> _{BF} + 864
800–6300	LVPCB	E, LS ^b	4.560/ <i>I</i> _{BF} + 27.23	47.2/ <i>I</i> _{BF} + 2660	6.86/ <i>I</i> _{BF} + 2.170	62.4/ <i>I</i> _{BF} + 2930

*I*_{bf} in kiloAmperes with working distance 455 mm.

(*I*_{bf} refers to a symetrically loaded bolted fault)

MCCB=molded case circuit breaker

TM= thermal-magnetic trip units

M=magnetic trip (instantaneous only) units

E=electronic (long, short or instantaneous

ICCB=Isulated-case circuit breaker

LVPCB=low-voltage power circuit breaker

^b Short-time delay is set at maximum

(Note: Information in this table duplicates NFPA 70E Annex D, Table D.4.7)

TABLE 3a Arc-Flash Hazard Identification for AC and DC systems

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 the following: The equipment is properly installed The equipment is properly maintained All equipment doors are 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 All equipment doors are open or not secured All equipment covers are off or not secured There is evidence of impending failure	Yes
For ac systems: Work on energized electrical conductors and circuit parts, including voltage testing	Any	Yes
For dc systems: Work on energized electrical conductors and circuit 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 All equipment doors are 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 All equipment doors are open or not secured All equipment covers are off or not secured There is evidence of impending failure	Yes
Work on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panelboard or motor control center	Any	Yes
Insertion and removal of revenue meters (kW-hour, at primary voltage and current)	Any	Yes
For dc systems, insertion or removal of individual battery cells or individual multi-cell units of a battery system in an enclosure	Any	Yes

TABLE 3a (continued)

Task	Equipment Condition	Arc Flash PPE Required
For dc systems, insertion or removal of individual battery cells or individual multi-cell units of a battery system in an open rack.	Any	No
For dc systems, maintenance on a single cell of a battery or multi-cell units in an open rack.	Any	No
For dc systems, work on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source	Any	Yes
Arc-resistant switchgear Type 1 or Type 2 (for clearing times of <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, tested in accordance with IEEE C37.20.7: <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 	All of the following: The equipment is properly installed The equipment is properly maintained All equipment doors are 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 All equipment doors are open or not secured All equipment covers are off or not secured There is evidence of impending failure	
Opening voltage transformer or control power transformer compartments	Any	Yes
Outdoor disconnect switch operation (hookstick operated) at 1 kV thru 15 kV	Any	Yes
Outdoor disconnect switch operation (hookstick operated) at 1 kV thru 15 kV	Any	Yes
Note – Phrases used in this table: Properly installed , means that the equipment is installed in accordance with applicable industry codes and standards and the manufacturer’s instructions. Properly maintained , means that the equipment has been maintained in accordance with the manufacturer’s recommendations and applicable industry codes and standards. Evidence of failure , means that there is evidence of arcing, overheating, loose or bound equipment parts, visible damage, deterioration, or other damage. Note: Information in this table follows NFPA 70E Table 130.7(C) (15)(A)(a).		

TABLE 3b Arc-Flash Hazard PPE Categories for Alternating Current (ac) Systems.

<i>Equipment</i>	<i>Arc Flash PPE Category</i>	<i>Arc-Flash Boundary</i>
Panelboards rated 240 V and below Parameters: Max of 25kA short-circuit current available; max of 0.03 sec (2 cycles) fault clearing time; working distance 18 inches	1	19 in.
Panelboards rated >240 V and up to 600V Parameters: Max of 25kA short-circuit current available; max of 0.03 sec (2 cycles) fault clearing time; working distance 18 inches	2	3 ft.
600-V class motor control centers (MCCs) Parameters: Max of 42kA short-circuit current available; max of 0.03 sec (2 cycles) fault clearing time; working distance 18 inches	2	5 ft.
600-V class motor control centers (MCCs) Parameters: Max of 35kA short-circuit current available; max of 0.33 sec (20 cycles) fault clearing time; working distance 18 inches	4	14 ft.
600-V class switchgear(with power circuit breakers or fused switches) and 600 V class switchboards Parameters: Max of 35kA short-circuit current available; max of 0.5 sec (30 cycles) fault clearing time; working distance 18 inches	4	20 ft.
Other 600-V class (277 V through 600 V, nominal) equipment Parameters: Max of 65kA short-circuit current available; max of 0.03 sec (2 cycles) fault clearing time; working distance 18 inches	2	5 ft.
NEMA E2 (fused contactor) motor starters, 2.3 kV thru 7.2 kV Parameters: Max of 35kA short-circuit current available; max of 0.24 sec (15 cycles) fault clearing time; working distance 36 inches	4	40 ft.
Metal-clad switchgear, 1 kV through 15 kV Parameters: Max of 35kA short-circuit current available; max of 0.24 sec (15 cycles) fault clearing time; working distance 36 inches	4	40 ft.
Arc-resistant switchgear Type 1 or 2 (for clearing times of <0.5 sec (30 cycles) with a perspective 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, tested in accordance with IEEE C37.20.7, 1 kV through 15 kV	N/A (doors closed)	N/A (doors closed)
Parameters: Max of 35kA short-circuit current available; max of 0.24 sec(15 cycles) fault clearing time; working distance 36 inches	4 (doors open)	40 ft.
Other equipment 1 kV through 15 kV Parameters: Max of 65kA short-circuit current available; max of 0.24 sec (15 cycles) fault clearing time; working distance 36 inches	4	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 amps or less, the arc flash PPE category can be reduced by one number but not below arc flash PPE category 1.</p> <p>Note: Information in this table follows NFPA 70E Table 130.7(C)(15)(A)(b).</p>		

TABLE 3b Arc-Flash Hazard PPE Categories for Direct Current (dc) Systems.

<i>Equipment</i>	<i>Arc Flash PPE Category</i>	<i>Arc-Flash Boundary</i>
Storage batteries, dc switchboards, and other dc supply sources 100 V > Voltage < 250 V Parameters: Voltage 250 V Max arc duration and working distance: 2 sec @ 18 inches		
Short- circuit current < 4 kA	1	3 ft.
4 kA ≤ short- circuit current < 7 kA	2	4 ft.
7 kA ≤ short- circuit current < 15 kA	3	6 ft.
Storage batteries, dc switchboards, and other dc supply sources 250 V ≤ Voltage ≤ 250 V Parameters: Voltage 600 V Max arc duration and working distance: 2 sec @ 18 inches		
Short- circuit current < 1.5 kA	1	3 ft.
1.5 kA ≤ short- circuit current < 3 kA	2	4 ft.
3 kA ≤ short- circuit current < 7 kA	3	6 ft.
7 kA ≤ short- circuit current < 10 kA	4	8 ft.

Table Notes:

- (a) Apparel that can be expected to be exposed to electrolyte must meet ASTM F11296 and ASTM F1891.
- (b) “Short circuit current” used in this table is determined from dc power system maximum short circuit including the effects of cables and other impedances in the circuit. Battery system short-circuit current can be obtained from the battery manufacturer.
- (c) The values in this table represent open-air incident energy calculations since most battery systems are in open air. If the batteries are in an enclosure, additional PPE protection should be considered.

Note: Information in this table follows NFPA 70E Table 130.7(C)(15)(B).

TABLE 4 Personal Protective Equipment

PPE Category	PPE
1	<p>Arc-Rated Clothing, Minimum Arc Rating 4 cal/cm² (see Note 1) Arc-rated long sleeve shirt and pant or arc-rated coverall Arc-rated face shield (see Note 2) or arc flash suit hood Arc-rated jacket, parka, rainwear, or hard hat liner (AN)</p> <p>Protective Equipment Hard hat Safety Glasses or safety goggles (SR) Hearing protection (ear canal inserts) Heavy duty leather gloves (see Note 3) Leather footwear (AN)</p>
2	<p>Arc-Rated Clothing, Minimum Arc Rating 8 cal/cm² (see Note 1) Arc-rated long sleeve shirt and pant or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield (Note 2) and arc-rated balaclava Arc-rated jacket, parka, rainwear, or hard hat liner (AN)</p> <p>Protective Equipment Hard hat Safety Glasses or safety goggles (SR) Hearing protection (ear canal inserts) Heavy duty leather gloves (see Note 3) Leather footwear</p>
3	<p>Arc-Rated Clothing Selected so that the System Arc Rating Meets the Required Minimum Arc Rating of 25 /cm² (see Note 1) Arc-rated long sleeve shirt (AR) Arc-rated pants (AR) Arc-rated coverall (AR) Arc-rated arc suit jacket (AR) Arc-rated arc flash suit hood Arc-rated gloves (see Note 1)</p> <p>Protective Equipment Hard hat Safety Glasses or safety goggles (SR) Hearing protection (ear canal inserts) Leather footwear</p>
4	<p>Arc-Rated Clothing Selected so that the System Arc Rating Meets the Required Minimum 40/cm² (see Note 1) Arc-rated long sleeve shirt (AR) Arc-rated pants (AR) Arc-rated coverall (AR) Arc-rated arc suit jacket (AR) Arc-rated arc flash suit pants (AR) Arc-rated arc flash suit hood Arc-rated gloves (see Note 1)</p> <p>Protective Equipment Hard hat Safety Glasses or safety goggles (SR) Hearing protection (ear canal inserts) Leather footwear</p>

AN: as needed (optional). AR: as required. SR: selection required

Table 4 Notes:

- (1) *Arc rating* is a materials performance exposed to an electric arc discharge in units of cal/cm².
- (2) *Face shields* are to have wrap-around guarding to protect not only the face but also the forehead, ears, and neck, or alternatively, an arc rated flash suit hood.
- (3) If rubber insulating gloves with leather protectors are used, additional leather or arc-rated gloves are not required. The combination of rubber insulating gloves with leather protectors satisfies the arc-flash protection requirement.
- (4) Information in this table follows NFPA 70E Table 130.7(C)(16).

TABLE 5

Electric Shop Tasks with Potential Electrical Hazards

- Replacing a 15 or 20 amp 110V receptacle or switch
- Disconnecting/reconnecting utilization equipment, 0-240V
- Disconnecting/reconnecting utilization equipment, rated at 240 V to 600V.
- Voltage testing at utilization equipment rated less than 240V.

Using NFPA 70E Table 130.7(C)(9)(a) Hazard/risk Category Classification the following guide lines will be maintained:

1. 110V (25 kA max, 0.03 sec. clearing) – Hazard Level 1; work on energized parts including voltage testing requires “V” rated gloves and tools.
2. 240V (25 kA max short, 0.03 sec. clearing) – Hazard Level 2; work on energized parts including voltage testing requires “V” rated gloves and tools.
3. 277V (25 kA max, 0.03 sec. clearing) – Hazard Level 2; work on energized parts including voltage testing requires “V” rated gloves, tools and double layer switching hood and hearing protection.
4. 480V - Hazard Level 2; work on energized parts including voltage testing requires “V” rated gloves, tools and double layer switching hood and hearing protection.
5. 12kv – Hazard Level 4; Insulated cable examination in manhole – Do Not enter or work in manholes unless feeder is verified de-energized and locked out.

In addition to the above mentioned PPE and other PPE required for the associated hazard levels are:

- Insulating Blanket – for work on energized equipment in wet areas.
- Personal voltage meter (training in proper care and use) to verify equipment is de-energized.
- LOTO kit – to lock out equipment once it is verified de-energized
- GFIs – for working with corded equipment/power tools in wet conditions.
- Flash blanket/panel board cover – with “high voltage” warning label on it.

TABLE 6

Plumbing Shop Tasks with Potential Electrical Hazards

- Manhole entry in proximity of high voltage (up to 12kv)
- 110v, 240v and 440v operation of circuit breakers with panel/cover compromised
- 110, 240 and 480v pump maintenance
- 110, 277 and 480v water heater or heat exchange maintenance
- 110 v solenoid valve maintenance
- Core drilling and corded equipment in wet areas
- Use of snake in sump pits (possible entanglement in pump electrical lines)
- Pipe fuse sealing equipment – around energized wires at 110v or above
- Extension cords in wet areas

TABLE 7

HVAC Shop Tasks with Potential Electrical Hazards

- Manhole entry in proximity of high voltage (9kv up to 12kv)
- 110v, 240v and 440v operation of circuit breakers with panel/cover compromised
- 110v, 240v and 440v motor maintenance
- 110v, 277v and 480v MCC maintenance
- 110v, 240v and 480v refrigeration unit maintenance
- 110v solenoid valve maintenance
- 440v refrigeration compressor maintenance
- Use of extension cords and corded equipment in wet areas

TABLE 8

Typical Arc Flash AC Electrical PPE (as interpreted from NFPA 70E)

Opening hinged access doors of electrical panels:

For panel equipment in good repair, panel is assembled, conductors unexposed: Operation of circuit breakers/contactors/starters is okay without PPE.

If equipment in panel is damaged or has a maintenance problem, use FR rated protection to operate.

Opening panels accessing exposed conductors: Use FR rated protection to remove covers.

Panel conductors are exposed and being tested for absence of voltage: Use FR rated protection.

High Voltage Switching Procedures & Acknowledgement

Purpose:

To establish a procedure for switching high voltage lines (> 600 volts) to alternate feeders.

SCOPE:

Facilities Services Electrical Shop and electrical contractors work >600 volts.

PROCEDURES:

1. Notify Facilities Services of conditions requiring switching.
2. If working with a contractor, the contractor shall be in charge of the job, including compliance with California Occupational Health & Safety Laws. This fact shall be noted in the documentation of the scope of work meeting described herein. University employees shall follow the directions of the contractor provided the directions do not unduly jeopardize their safety and do not diminish the level of safety provided by this procedure.
3. Review the campus high voltage single-line drawings to determine how to completely isolate the circuit and possible backfeed conditions prior to switching building(s) to alternate feeders. If working with a contractor, the contractor shall be provided with all single-line drawings, and a copy of the University's Lockout Tagout program (<http://www.calstatela.edu/ehs>). The contractor shall review this information with campus personnel.
4. When working with outside contractors, the complete isolation of the circuit and/or equipment, the determination of possible backfeed conditions and review of the lockout tagout procedures shall be performed together as a team.
5. Prior to switching or working on high voltage, all parties involved shall participate in a safety meeting to identify all hazards and possible hazards; and to review the line diagrams, locking out and tagging out all sources of electrical power, required personnel protective equipment (see Article 130.7 NFPA 70E 2015 edition), this procedure, and the work to be performed. This safety meeting shall be documented in writing, and shall include the printed names and signatures of all attendees.
6. At all times prior to switching, personnel working on equipment and personnel performing switching shall communicate their plan to each other. Each communication shall be confirmed.
7. At all times immediately prior to switching, an "All-Clear" command shall be made and confirmed by all parties. "All-Clear" means the all tools, mechanical constraints and electrical jumpers, shorts and grounds have been removed so that the circuits and equipment are in a condition to be safely energized.
8. All personnel planning to close switches and all personnel in close proximity shall put on the appropriate personnel protective equipment prior to closing the switch.
9. Following an "All-Clear" command and before continuing work, personnel shall re-verify that all circuits are de-energized, utilizing appropriate testing equipment.
10. Prior to working on any electrical equipment, the equipment will be locked-out and tagged-out de-energized, and tested to verify that it is de-energized. This will include all pre-identified and known potential sources.

APPENDIX A

- 11. At all times, personnel shall confirm power has been de-energized by using the appropriate meter. This shall be communicated and confirmed by all parties. Work shall not proceed unless all parties are sure that circuits and equipment have been isolated and all switches that could be closed to provide electricity have been locked-out.
- 12. All de-energized equipment to be worked on shall be grounded.
- 13. No one is to close any switch if they have any doubts or do not know what will energize.

MANAGEMENT RECORDS:

A copy of this procedure shall be kept in the procedures Manual maintained by Facilities Services Director.

ACKNOWLEDGMENT OF RECIEPT:

I hereby acknowledge receipt of these procedures, and that I have read and understand it.

Signature _____ Date _____

Name (please print) _____

Facilities Services Work order number: _____

Name/Description of Project: _____

Electrical Contractor:

Name of Company _____ Date _____

Print Name _____ Signature _____

Facilities Services Management:

Print Name _____ Signature _____ Date _____

Print Name _____ Signature _____ Date _____

Print Name _____ Signature _____ Date _____

DISTRIBUTION OF SIGNED DOCUMENT:

- Original – Facilities Services
- Copy – Electrical Contractor
- Copy – EH&S

SIMPLIFIED, TWO-CATEGORY, ARC-RATED CLOTHING SYSTEM
(NFPA 70E ANNEX H.2)

Table B.1 can be used as a simplified approach to assure adequate PPE for electrical workers on campus. The clothing listed in Table B.1 fulfills the minimum FR clothing requirements of Table 3 and Table 4. The clothing systems listed in this table should be used with the other PPE appropriate for the Hazard / Risk Category (see Table 4).

Table B.1 Simplified, Two-Category, Arc-Rated Clothing System

CLOTHING*	APPLICABLE TASK
Everyday Work Clothing	
Arc-rated long-sleeve shirt with arc-rated pants (both with minimum arc-rating of 8)	All Arc Flash PPE Category 1 and 2 tasks listed in Table 3a for alternating current and Table 3b for direct current.
<i>or</i>	
Arc rated coveralls (minimum arc rating of 8)	All Arc Flash PPE Category 3 and 4 tasks listed in Table 3a for alternating current and Table 3b for direct current.
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 each with a minimum arc rating of 40).	All Hazard / Risk Category 3 and 4 tasks listed in Table 3.

* **Note:** Other PPE required for the specific tasks listed in Table 2 and Table 3, which include arc-rated face shields or flash suit hoods, FR hardhat liners, safety glasses or safety goggles, hard hat, hearing protection, leather gloves, voltage-rated gloves, and voltage-rated tools. For tasks not listed in Table 3 or having longer clearing times or greater short circuit capacity an arc flash incident energy analysis must be performed.

Also, note the under garments are no longer considered part of the arc rating as a layered system. However, undergarments that are worn must be made of untreated natural fibers.

Tailgate Safety Meeting Documentation: Briefing & Planning Checklist

Identify

Who is in charge: _____	How many people are needed to do the job: _____
Hazards: _____	Shock protection boundaries: _____
Voltage levels involved: _____	Available incident energy: _____
Skills required: _____	Potential for arc flash (Conduct a flash-hazard analysis): _____ Yes _____ No
Foreign (secondary source) voltage source(s): _____	Flash protection boundaries: _____
_____	_____
Unusual work conditions: _____	_____
_____	_____

Ask

Can equipment be de-energized? _____ Yes _____ No	Is a "standby person" required? _____ Yes _____ No
Are feedbacks possible? _____ Yes _____ No	

If "Yes" follow Lock-out/Tag-out procedures to prevent backfeed.

Check

Job plans: _____ Yes _____ No	Safety procedures: _____ Yes _____ No
Single-line diagrams/prints: _____ Yes _____ No	All individuals are familiar with _____ Yes _____ No the facility?
Status Board: _____ Yes _____ No	
Information on resources is up-to-date: _____ Yes _____ No	

Know

- | | |
|--|--|
| <ul style="list-style-type: none"> • What the job is. • Who else need to know – communicate! | <ul style="list-style-type: none"> • Who is in charge |
|--|--|

Think

- | | |
|--|--|
| <ul style="list-style-type: none"> • About the unexpected event...What if? • Lock—Tag—Test—Try • Test for voltage—FIRST | <ul style="list-style-type: none"> • Install and remove grounds • Install barriers and barricades • What else...? |
|--|--|

Prepare for an emergency

CPR trained standby person: _____	Exact work location: _____
Location of required emergency equipment: _____	_____
_____	How is the equipment shut off in an emergency: _____
Location of nearest telephone: _____	_____
Confined space rescue available: _____ Yes _____ No	Location of fire extinguisher: _____
_____	Radio communications: _____
_____	_____

INCIDENT ENERGY CALCULATIONS (found in NFPA 70E 2015, Annex D)

MANY DIFFERENT WAYS OF LOOKING AT POWER AND CALCULATING EXPOSURE. The tables below are found in NFPA 70E 2015 Annex D. They have brought together several assumptions and ways of modeling exposure.

In order to calculate incident energy (E) in cal/cm² the following data need to be assembled:

- Bolted fault short circuit current, in kilo-Amperes (F)
- System phase to phase voltage, in kilo-Volts (V)
- Arc duration, in seconds (t_a)
- Distance from the arc source, in inches (D)
- Configuration of the structure around the arc source

Calculate incident energy without consideration of energy focusing or direction:

$$E = \frac{793 \times F \times V \times t_a}{D^2}$$

Additionally, if configuration (an arc in open air or arc in a box) is considered, the following formulae may be used:

- Arc in open air

$$E = 5271 D^{-1.9593} \times t_a \times (0.0016 F^2 - 0.0076 F + 0.8938)$$

- Arc directed from a cubic box, such as an equipment enclosure

$$E = 1038.7 D^{-1.4738} \times t_a \times (0.0093 F^2 - 0.3453 F + 5.9675)$$

For use in typical 3 Phase Systems, 208 V to 15 kV, 700 to 106,000 Amperes use:

D.4.3 (assumes arc duration 0.2 sec and typical working distance of Table D.4.3)

$$E = 4.184 C_f E_n (t / 0.2) (610^x / D_x)$$

Where:

E = incident energy, J/cm²

C_f = calculation factor 1.0 for voltage > 1 kV, 1.5 for voltage ≤ 1 kV

E_n = incident energy normalized

t = arcing time, sec

x = distance exponent, see Table D.4.2 below

D = typical working distance, mm see Table D.4.3 below

Equipment factors (Table D.4.2)

System Voltage kV	Type of Equipment	Typical Conductor Gap (mm)	Distance Exp. Factor x
0.208 – 1	Open air	10 – 40	2.000
	Switchgear	32	1.473
	MCCs & panels	25	1.641
	Cables	13	2.000
>1 – 5	Open air	102	2.000
	Switchgear	13 – 102	0.973
	Cables	13	2.000
>5 – 15	Open air	13 – 102	2.000
	Switchgear	153	1.973
	Cables	13	2.000

Typical Working Distance (Table D.4.3)

15 kV switchgear	910
5 kV switchgear	910
Low-voltage switchgear	610
Low-voltage MCCs & Panelboards	455
Cables	455
Other	determine in the field

D.4.5 Arc Flash Boundary calculations

$$D_B = (4.184 C_f E_n t 610^x / 0.2 E_B)^{1/x} \quad (\text{empirical})$$

$$D_B = (2.142 \times 10^6 V I_{bf} t / E_B)^{1/2} \quad (\text{theoretical})$$

Where:

D_B = distance (mm) of the arc flash boundary from arcing point

C_f = calculation factor: 1.0 for voltage > 1 kV, 1.5 for voltage ≤ 1 kV

E_n = incident energy normalized

t = time, sec.

x = distance exponent factor from Table D.4.2

E_B = incident energy in J/cm² at the arc flash boundary

V = system voltage, kV

I_{bf} = bolted three phase available short-circuit current

Note: Either empirical or theoretical equations above might be used to determine PPE for thermal protection at the specified distance.

D.4.7 Low voltage circuit breaker calculations and adjustment factors are further explained in Annex D section D.4.7 of the Handbook. **Table 2** (above) is the result of those calculations.

For Direct Current Systems,

D.5 Maximum Power Calculations Method

$$I_{\text{arc}} = 0.5 I_{\text{bf}}$$

$$IE_{\text{m}} = 0.01 V_{\text{sys}} I_{\text{arc}} t_{\text{arc}} / D^2$$

Where:

I_{arc} = arcing current in Amperes

I_{bf} = system bolted fault current Amperes

IE_{m} = estimated dc arc flash incident energy, at maximum power cal/cm²

V_{sys} = system voltage in Volts

t_{arc} = arcing time in seconds

D = working distance in centimeters