Department of the Air Force
HQ AEDC (AFMC)
Arnold AFB, TN 37389

Safety, Health, and Environmental Standard

Title: **Low-Voltage Electrical Safety-Related Work Practices**

Standard No.: B6

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Releasability: There are no releasability restrictions on this publication.

The provisions and requirements of this standard are mandatory for use by all AEDC personnel engaged in work tasks necessary to fulfill the AEDC mission. Please contact your safety, industrial health and/or environmental representative for clarification or questions regarding this standard.

Approved:

Contractor /ATA Director
Safety, Health, and Environmental

Air Force Functional Chief

Record of Review/Revision

Date/POC	Description
03/11/15 Northcott; Tate	Updated to align with NFPA 70 2015 edition.
07/16/14 Tate; Northcott	Administrative update to incorporate current arc flash labels.
02/06/13 R. Tate T. Northcott	Three-year review: Clarified a number of sections and restructured to align with SHE Standard B4 High Voltage Electrical Work where appropriate. Eliminated Annex "Guidelines for Work around 480 VAC or Greater Electrical Equipment" and renumbered subsequent annexes. Added direct current approach distances, added nomenclature to Annex C, modified EEWP approval block (Annex A). Added several definitions. Added NFAC supplement. *[03/11/2013: Incorporated NFAC Supplement. Added Base Operating Contractor Process Council administrative changes; 03/21/2013: Incorporated Base Operating Contractor Executive Management Steering Committee Changes.]*
08/11/11 Eichel	Revised examples of ARC Flash labels and updated tables to current NFPA 70E and AEDC standard. Removed all references to Hazard Class 1 and 3. No change to current process.
08/10/09 - 03/10/10 S. Bryan and the Electrical Systems Subcommittee	Major revision. Read entire standard. Revision made to clarify definitions and bring standard in line with current PPE and energized work requirements per NFPA 70E and AFI 32-1064 which require a written Energized Electrical Work Permit for work on energized electrical equipment operating at 50 volts or more. Moved training requirements to a separate section and re-numbered subsequent sections. Re-aligned annex references to follow proper alphabetical sequence.
11/28/07 and 01/28/08 S. Bryan	Revised to allow non-qualified persons to reset certain low-voltage circuit breakers when faults or overloads can be safely identified and removed. Revised Annexes as follows: PPE Requirements – added section for panelboards rated 240v and below, also added Notes 1 and 2; – added Hazard Risk Class -1 and revised typical clothing description for HRC 0; Annex C – replaced **WARNING** and **DANGER** labels.
03/23/07 Tom Lavelle	Annual review; no change required.
01/15/06 Tom Lavelle	Major revision; read entire standard.
01/15/05 M. Lindstrom/ R. Jones	Reorganization and incorporation of site comments.
02/27/04 G. Neal	Initial release.

Safety, Health, and Environmental Standard

LOW-VOLTAGE ELECTRICAL SAFETY-RELATED WORK PRACTICES

1.0 INTRODUCTION/SCOPE/APPLICABILITY

1.1 Introduction – This Safety, Health, and Environmental (SHE) standard outlines the hazards involved, safety equipment required, safety precautions to be observed, and operating procedure requirements when working with low-voltage electricity, i.e. less than or equal to 600 volts.

1.2 Scope – This standard applies in all situations where exposure to energized or potentially energized electrical equipment is possible due to the nature of the work to be performed. Following this standard will help ensure that electrical work is performed under the safest conditions possible.

This standard addresses safety of workers whose job responsibilities entail interaction with electrical equipment and systems with potential exposure to energized electrical equipment and circuit parts. Concepts in this standard are often adapted to other workers whose exposure to electrical hazards is unintentional or not recognized as part of their job responsibilities. The highest risk for injury from electrical hazards for other workers involve unintentional contact with overhead power lines and electric shock from machines, tools, and appliances.

1.3 Applicability – This standard applies to all employees and subcontractors engaged in operations, maintenance, or construction at AEDC.

2.0 BASIC HAZARDS

2.1 Shock Hazard – A dangerous condition associated with the possible release of energy caused by contact or approach to energized electrical conductors or circuit parts. Electric shock is the most common hazard to be encountered in electrical operations. This is caused when a person comes in contact with an energized part, and electrical current travels through the body. Minor shock may cause tingling or discomfort. A serious shock may cause extreme pain, burns, and/or death. Although the shock may not be severe enough to stop breathing, it may cause a fall or other accident. If a worker sustains a severe shock that does stop the heart and/or breathing, cardio-pulmonary resuscitation (CPR) should be administered by a properly trained individual immediately and medical aid should be summoned.

CAUTION: Workers shall exercise extreme caution to avoid contact with a "hot" line or bus bar.

2.2 Arc Flash Hazard – A dangerous condition associated with the release of energy caused by an electric arc. This flash can damage a person's eyes, cause burns up to 3rd degree, and/or death. This hazard exists when energized electrical conductors or circuit parts are exposed or within guarded or enclosed equipment, provided a person is interacting with the equipment in such a manner that could cause an electric arc.

Arcing can also cause overheating to the extent molten metal may be expelled which may result in the worker being burned. Vaporized metal and ionized gases, as well as metallic fragments, may be violently thrust into the zone occupied by the worker, necessitating use of arc-rated (AR) personal protective equipment (PPE).

2.3 Arc blast – An explosive force caused by the rapid expansion of super-heated air and metal vaporized during an electric arc. Arc blasts can damage a person's hearing or cause other internal injuries. Shrapnel from the blast may pierce the skin. Blasts from higher energies may cause death.

2.4 Fire – Improper wiring, circuit overloading, and defective tools or equipment can cause sparking, or overheat wires. This could cause a fire and damage property, or injure personnel.

3.0 DEFINITIONS

Automated External Defibrillator (AED) – A device used to administer an electric shock through the chest wall to treat ventricular fibrillation.

Arc Flash Protection Boundary – When an arc flash hazard 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.

Barrier – Physical obstruction which is intended to prevent contact with energized lines or equipment or to prevent unauthorized access to a work area.

Base Operating Contractor – A long-term contractor directly accountable to the Air Force for the AEDC mission; term used to identify the AEDC Operation, Maintenance, Information Management and Support Contractor.

Cable – A conductor with insulation (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).

Cardiopulmonary Resuscitation (CPR) – An emergency medical procedure, which includes opening and maintaining an airway, providing ventilation through rescue breathing, and providing artificial circulation through the use of external cardiac compression.

Circuit – A conductor or system of conductors through which an electric current is intended to flow.

Clearance (between objects) – Clear distance between two objects measured surface to surface.

Conductor – A material, usually in the form of a wire, cable, or bus bar, used for carrying an electric current.

Current-Carrying Part – A conducting part intended to be connected in an electric circuit to a source of voltage. Non-current-carrying parts are those parts which are not intended to be so connected.

De-energized – Free from any electrical connection to a source of potential difference and from electrical charge: not having a potential different from earth. De-energized alone does not constitute an electrically safe work condition.

Diagnostic Work – A category of work that involves the taking readings or measurements of electrical equipment, with approved test equipment which does not require making any physical change to the equipment. In most cases, diagnostic work requires shock PPE and/or arc flash PPE along with other required industrial PPE.

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

Electrical Equipment – Wiring, circuits, switches, switchgear, fuses, breakers, distribution systems, and any other equipment or systems capable of containing electrical energy.

Electrically Safe Work Condition – A state in which the conductors, circuits, and equipment to be worked on have been disconnected or isolated from energized parts, locked/tagged in accordance with established lockout/tagout practices [as detailed in AEDC SHE Standard B2, Lockout/Tagout (LOTO)], tested to ensure the absence of voltage. (Flowcharts for achieving electrical safe work conditions for Electrical Maintenance and Electrical Operations are provided in Attachments 1 and 2.)

Energized – Electrically connected to, or is, a source of voltage. Any electrical circuit or circuit parts where all voltage sources have not been LOTO and absence of voltage has not been positively verified shall be considered energized.

Energized Electrical Work Permit (EEWP) – A permit approved by supervision or management which authorizes energized repair work on electrical equipment operating at 50 volts or more. The purpose of the permit is to ensure that the increased risks posed by this work receive adequate consideration before the work is performed (Permit Form Annex A of this document).

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.

Exposure – Where hazards are present or could be created that might result in harm to personnel, equipment or the environment if not properly controlled.

Flash Hazard Boundary - A burn protection boundary surrounding a potentially energized system which, when crossed, requires the use of Flame Resistant (FR) Clothing and other Personal Protective Equipment (PPE) by the person crossing the boundary.

Ground – A conducting connection, whether intentional or accidental, between an electric circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Guarded – Covered, fenced, enclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, mats, or platforms, designed to minimize the possibility, under normal conditions, of dangerous approach or accidental contact by persons or objects.

NOTE: Wires which are insulated, but not otherwise protected, are not considered to be guarded.

Incident Energy - The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. One of the units to measure is calories per centimeter squared (cal/cm^2).

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

Insulation – That which is relied upon to insulate the conductor from other conductors or conducting parts or from ground.

Job Safety Analysis (JSA) – (Also known as a safe plan of action or similar name.) A document prepared to help workers and management review hazards and safety precautions required for each job. (AEDC uses Form GC-1707 Job Safety Analysis; see SHE Standard A10, Job Safety Analysis for details.)

Job Safety Review (JSR) – A streamlined safety analysis technique for routine jobs meeting the following criteria:

1. The job is routine (At least one assigned person has experience on the job)
2. The job must be able to be completed in three days or less, and a new JSR must be initiated each day.
3. Three persons or less are assigned to the job.

(AEDC uses Form GC-1862 Job Safety Review; see SHE Standard A10, Job Safety Analysis for details.)

Limited Approach Boundary – An approach limit at a distance from an exposed live part within which a shock hazard exists. Non-electrically qualified personnel may not cross this boundary unless escorted by a qualified electrical person.

Minimum Approach Distance – The closest distance a qualified employee is permitted to approach either an energized or a grounded object, as applicable for the work method being used.

Outside Contractor/Subcontractor - An organization employed by a contractor or the Air Force to do construction, maintenance, repair or other work at AEDC. There is no employment relationship, control or supervision of the subcontractor's employees by AEDC contractors. Also referred to as the construction contractor.

Personal Protective Equipment (PPE) – Equipment such as voltage-rated rubber gloves, hardhats, face shields, protective arc-flash clothing, hoods, flame resistant (FR) clothing, etc., used to protect the worker from electrical shock and arc-flash hazards. (See SHE Standard F2 for additional information.)

Potentially Energized – Electrical equipment or circuits capable of containing electrical energy that has not been locked out, tagged out, and verified as de-energized by proper testing methods.

Prohibited Approach Boundary – An approach limit or a distance from an exposed live part within which work is considered the same as making contact with the live part. An EEWP is required to cross this boundary; see 4.1.1.3.4 for exceptions.

Qualified Electrical Person – Persons who, by training and demonstration, possess the skills and knowledge to (1) distinguish exposed live parts from other parts of electrical equipment, (2) determine the nominal voltage of exposed live parts, (3) maintain minimum clearance distances corresponding to the voltages to which that person will be exposed, and (4) have the training required to identify and avoid the hazards involved. A qualified electrical person may be an electrician, electrical technician, electrical engineer, or others, depending on their function and training, and may only be qualified with respect to certain aspects of electrical work. (See Section 5.)

Qualified Industrial Person – Employees trained in basic industrial safety including but not limited to:

- Lockout/Tagout
- Confined Space
- Job Safety Analysis
- Personal Protective Equipment
- Electrical Safety
- Fall Protection
- Master Work Permit

Reasonable Effort to De-Energize – This is a subjective judgment by supervision, the worker, and electrical/plant operations, which produces a risk assessment that considers personnel safety, impact of switching effort hazards, mortality risk of equipment, and the impact of the outage.

Repair Work- A category of work that involves any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, etc.).

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. An EEWP is required to cross this boundary; see 4.1.1.3.4 for exceptions.

Switch – A device for opening and closing or for changing the connection of a circuit. In this standard, a switch is understood to be manually operable, unless otherwise stated.

Task Qualified Electrical Person – Persons who have been trained to safely perform only specific electrical task(s) for which they have received the appropriate level of electrical training, safety training, and have appropriate PPE available.

Voltage – The potential difference between any two conductors or between a conductor and ground/earth.

Voltage, Nominal – A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (240/120, 208/120, 480/277, 600, etc.). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Working on Energized Equipment – Intentionally coming in contact with energized conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective

equipment a person is wearing. This includes diagnostic and repair activities while the equipment is energized. (See *energized* definition.)

4.0 REQUIREMENTS/RESPONSIBILITIES

4.1 REQUIREMENTS

4.1.1 Electrical Safe Work Practices

4.1.1.1 Systems Less than 50 Volts: Energized parts less than 50 volts shall not be required to be de-energized if there is no increased exposure to electrical burns or explosion due to electric arcs.

4.1.1.2 Systems 50 Volts or More: All systems of 50 volts or more shall be considered energized until an electrically safe work condition is established using appropriately rated test equipment and the correct types and level of PPE. Proper PPE, including arc flash protection, shall be used in accordance with equipment labeling (e.g., Annex B). If no label is present refer to Annex C and Annex D while equipment is considered energized.

4.1.1.2.1 Every reasonable effort shall be made to de-energize and control electrical equipment operating at 50 volts and above per the SHE B2 LOTO Standard prior to performing any repair/non-diagnostic work on them. Energized work shall be permitted only where it can be demonstrated that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations.

4.1.1.2.2 Equipment with Arc Flash Incident Energies above 40 cal/cm^2 shall be de-energized before any work or local alteration (e. g. breaker operation or racking) may be performed.

4.1.1.2.3 Energized electrical equipment with Arc Flash Incident Energies of 40 cal/cm² or less can be worked/ operated only when approval is granted with proper documentation (JSA and EEWP, when required) and all required PPE is worn.

4.1.1.2.4 The correct types and level of PPE is mandatory when performing either repair-type or diagnostic-type work on energized electrical equipment or locally altering the configuration/position of energized electrical equipment, e.g. operating breakers, switches, disconnects; racking breakers, etc. If equipment is not labeled in accordance with Annex B, refer to Annex C and Annex D or NFPA 70E 2015 Edition.

4.1.1.2.5 Energized conductors/components may be covered and or guarded by blankets, mats, etc., to protect from accidental contact by the qualified worker when within the Limited Approach Boundary. If the covered/guarded conductors/components can no longer be inadvertently contacted, then the shock hazard and arc flash hazard associated with those conductors/components no longer exist.

4.1.1.3 **Energized Electrical Work Permit (EEWP):** The EEWP is required when working within the restricted approach boundary or the arc flash boundary of exposed energized electrical conductors or circuit parts that are not placed in an electrically safe work condition.

NOTE: The purpose of the EEWP is to ensure that the increased risks posed by this work receive adequate consideration to ensure that it is infeasible to perform the task with the circuit de-energized (Permit Form Annex A of this document).

4.1.1.3.1 Manager or Supervisor approval shall be required before repair-type work is performed within the Restricted Approach Boundary of energized electrical equipment operating at 50 volts or greater (Alternating Current [AC] or Direct Current [DC] systems). Documentation is required on the EEWP.

4.1.1.3.2 Manager or Supervisor approval shall be required before repair-type work is performed inside the Prohibited Approach Boundary of energized electrical equipment operating at 50 volts up to and including 150V (AC or DC) nominal. Documentation is required on the EEWP.

4.1.1.3.3 Additionally, Department Director or Deputy Director Approval shall be required before any repair-type work is performed within the prohibited approach boundary of energized electrical equipment operating at greater than 150V (AC or DC) nominal. Documentation is required on the EEWP.

4.1.1.3.4 The EEWP shall not be approved when the Arc Flash Incident is greater than 40 cal/cm².

4.1.1.3.5 The routine operations below do not require an approved EEWP, but do require Manager or Supervisor approval, which is indicated by signing the JSA/JSR; craft and working foremen cannot provide this approval:

4.1.1.3.5.1 Diagnostic testing, de-energizing or re-energizing an electrical system.

4.1.1.3.5.2 Switching, operating disconnects, racking breakers.

4.1.1.3.5.3 Operating electrical circuit testing or diagnostic equipment.

4.1.1.3.5.4 Re-lamping by personnel other than a qualified electrical person, no approval is required for a qualified electrical person.

4.1.1.3.5.5 Removal/insertion of a DC Fuse Block rated less than 151VDC nominal.

4.1.1.4 Working on a system rated less than 50V nominal, a digital system, or instrumentation circuitry while outside of any shock or arc flash boundary does not require an EEWP but does require a JSA/JSR.

4.1.1.5 Qualified Electrical Person: Only qualified electrical persons shall be permitted to work on energized electrical equipment.

4.1.1.5.1 Only a qualified electrical person shall energize or de-energize any disconnect over 50 volts where the operation could directly or potentially expose personnel to energized electrical circuits. Personnel may be task qualified to safely operate electrical equipment rated over 50 volts provided they are equipped with the required Arc Flash PPE and trained to identify and avoid the hazards involved with the task.

4.1.1.5.2 A minimum of two qualified electrical persons shall be assigned to any work where potential exists for direct contact with energized circuits greater than 300 volts nominal or when there is an elevated potential for an arc flash such as racking a breaker off of an energized bus. As a minimum, the second qualified electrical person shall be dressed in the same required PPE as the qualified electrical person performing the task.

4.1.1.6 A JSA/JSR shall be completed for all electrical work, energized or de-energized

4.1.1.7 Circuits automatically tripped by a circuit protective device shall not be reenergized until a qualified electrical person has determined the equipment and circuit can be safely energized. If the fault or overload can be identified and removed on 120/240/208/277 voltages of 30 amps or less, the resetting of a circuit breaker is permitted by non-qualified persons without a JSA/JSR or Arc Flash PPE only when the covers are in place and properly closed. Repetitive manual reclosing of circuit breakers or reenergizing circuits through replaced fuses is prohibited.

4.1.1.8 Approach Boundaries: The approach boundaries to live (energized) parts for shock protection are tabulated below. Qualified electrical persons shall provide boundaries to prevent unqualified personnel from getting any closer to exposed energized parts than the limit approach distance shown or the arc flash boundary, whichever is greater.

Approach Boundaries for Alternating Current Systems

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

Approach Boundaries for Direct Current Systems

Nominal Potential Difference System Voltage	Limited Approach Boundary		Restricted Approach Boundary	Prohibited Approach Boundary
	Exposed Movable Conductor	Exposed Fixed Circuit Part		
Less than 100	Not specified	Not specified	Not specified	Not specified
100 to 300	10 ft. 0 in.	3 ft. 6 in.	Avoid contact	Avoid Contact
301 to 1kV	10 ft. 0 in.	3 ft. 6 in.	1 ft. 0 in.	0 ft. 1 in.
1.1 to 5kV	10 ft. 0 in.	5 ft. 0 in.	1 ft. 5 in.	0 ft. 4 in.
5 kV to 15 kV	10 ft. 0 in.	5 ft. 0 in.	2 ft. 2 in.	0 ft. 7 in.
15.1 kV to 45 kV	10 ft. 0 in.	8 ft. 0 in.	2 ft. 9 in.	1 ft. 5 in.
45.1 kV to 75 kV	10 ft. 0 in.	8 ft. 0 in.	3 ft. 2 in.	2 ft. 1 in.
75.1 kV to 150 kV	10 ft. 8 in.	10 ft. 0 in.	4 ft. 0 in.	3 ft. 2 in.
150.1 kV to 250 kV	11 ft. 8 in.	11 ft. 8 in	5 ft. 3 in.	5 ft. 0 in.
250.1 kV to 500 kV	20 ft 0 in.	20 ft 0 in.	11 ft. 6 in.	10 ft. 10 in.
500.1 kV to 800 kV	26 ft. 0 in. .	26 ft. 0 in.	16 ft. 5 in.	16 ft. 5 in.

NOTE: "*Exposed movable conductor"* describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

4.1.1.8.1 To cross the prohibited approach boundary (shock hazard), the qualified person shall:

(a) Have specified training to work on exposed live parts.

(b) Have a completed/approved JSA/JSR and EEWP when required.

(c) Use PPE suitable for working near exposed live parts and rated for the voltage and energy level involved as described in Section 4.1.2.

(d) Employees shall use insulated tools or handling equipment, or both, when working inside the prohibited approach boundary of exposed energized electrical conductors or circuit parts. Annex C provides further information for tasks that require insulated and insulating hand tools.

4.1.1.8.2 To cross the restricted approach boundary (possible shock from arc over), the qualified person shall:

(a) Have a completed and approved JSA/JSR and EEWP when required.

(b) Use PPE suitable for working near exposed live parts and rated for the voltage and energy level involved as described in Section 4.1.2.

(c) Be certain that no part of the body enters the prohibited space.

(d) Minimize the risk from unintended movement, by keeping as much of the body as possible out of the restricted space; body parts in the restricted space must be protected.

(e) Employees shall use insulated tools or handling equipment, or both, when working inside the restricted approach boundary of exposed energized electrical conductors or circuit parts. Annex C provides further information for tasks that require insulated and insulating hand tools.

4.1.1.8.3 Limited Approach Boundary:

(a) Boundary is to be set up by the qualified electrical person. The type of boundary used will depend on the area. In high traffic areas, physical barriers, like stanchions or red danger tape may be used. For remote areas, visually monitoring the area may be appropriate. The distance of the barrier from the exposed conductor will be the equal to or greater than the limited approach boundary or the arc flash hazard boundary, whichever is greater. For more information, please see AEDC SHE Standard B3, Control of Hazardous Areas.

(b) Have a completed/approved JSA/JSR.

(c) May only be crossed by non-electrical personnel when escorted by a qualified electrical person familiar with the current work.

(d) Walls or other physical barriers within the boundary, which provide sufficient protection, will suffice for the barrier, provided entrance is limited.

4.1.1.8.4 Arc Flash Protection Boundary: The distance for the flash hazard boundary will be found on the equipment's arc flash warning decal (see Annex B). For low-voltage equipment without a decal, the arc flash protection boundary shall be in accordance with the value found in Annex C according to the appropriate equipment type and task. When any part of a person's body is within the arc/flash hazard boundary, the person must:

4.1.1.8.4.1 Use appropriate PPE and protective equipment in accordance with the Arc Flash Label attached to the equipment or as specified in Annex D of this standard.

4.1.1.8.4.2 Ensure that all PPE is in good condition, is locally inspected prior to use, and has been externally inspected as required.

4.1.1.8.4.3 Have a completed/approved JSA/JSR and EEWP when required

4.1.1.9 Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, metallized aprons, cloth with conductive thread, metal headgear, or metal framed glasses) shall not be worn when working within the Restricted Approach Boundary of energized or potentially energized circuits or equipment. Qualified Electrical Persons requiring prescription glasses through the company furnished PPE plan shall get plastic frame prescription safety glasses.

4.1.1.10 No current-carrying conductors shall be opened without the use of a properly rated switch in the circuit. Do not cut cables or open connections without first verifying that there is no current flowing. This applies to both maintenance and demolition work.

4.1.1.11 When performing demolition work, qualified electrical persons shall positively verify that the cables and circuits are de-energized before cutting conduits, cable trays, supports, and associated wiring for removal.

4.1.1.12 No person shall authorize, perform, nor permit alterations or modifications to equipment, circuits, or protective device settings without written authorization from the system engineer. This includes, but is not limited to, switchgear modifications, removal or bypass of device contacts from control circuits, and the installation of temporary back feeds.

4.1.1.12.1 Any setting changes on breakers or protective relays on 480V or greater systems shall be coordinated and approved by the Power Control Power System Analysis Systems Engineer and/or the Power Control Arc Flash Systems Engineer. Changing settings on a protective device will alter the arc flash ratings of the downstream equipment and could put personnel at risk if the required level of PPE is not appropriately documented on the equipment.

4.1.1.13 Employees shall use insulated tools and/or handling equipment when working inside the restricted approach boundary of live parts. Insulated tools shall be protected from damage to the insulating material. Insulated tools shall be rated for the voltages on which they are used. Insulated tools shall be designed and constructed for the environment to which they will be exposed and the manner in which they are used.

4.1.1.14 Fuse-handling equipment, insulated for the circuit voltage, shall be used to remove or install a fuse if the fuse terminals are not in an electrically safe work condition.

4.1.1.15 Protective shields, protective barriers, or insulating materials should be used to protect each employee from shock, burns, or other electrically related injuries while that employee is working near live parts, which might be accidentally contacted or where dangerous electric heating or arcing might occur.

4.1.1.16 Test instruments, equipment and their accessories shall be rated for the circuits and equipment to which they will be connected.

4.1.1.17 Absence of voltage shall be verified utilizing the live/dead/live test method; i.e. Test the voltage meter on a known energized source (preferably the same voltage class), test the circuit/part to be worked on, and then test the known energized source again to verify functionality of the meter.

4.1.1.18 Test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors shall be visually inspected for external defects and damage before 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 removed from service, and no employee shall use it until repairs and tests necessary to render the equipment safe have been made.

4.1.1.19 Design and installation of electrical circuits and utilization systems and equipment shall be in accordance with the latest edition of National Fire Protection Association (NFPA) 70, The National Electrical Code (NEC). Annex E provides the AEDC Recorded Low-Voltage Wire Color Chart. This document will meet the requirements of Articles 210.5 and 215.12 per the 2014 NEC.

4.1.1.20 Safe work practices shall be in compliance with the direction and intent of NFPA 70E, The Standard for Electrical Safety Requirements for Employee Workplaces.

4.1.1.21 Underground Electrical Lines and Equipment: Before excavation starts a dig permit must be approved to identify and mark the location of the electrical lines or equipment. When it has been determined that a reasonable possibility of contacting energized electrical lines or equipment exists, appropriate safe work practices and PPE shall be used during the excavation.

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

4.1.1.22.1 Identify and mark the location of conductors, cables, raceways, or equipment by obtaining an approved dig permit prior to cutting or drilling.

4.1.1.22.2 Create an electrically safe work condition

4.1.1.22.3 Identify safe work practices and PPE to be used

4.1.2 Personal Protective Equipment (PPE)

4.1.2.1 Employees working in areas where there are potential electrical hazards shall be provided with, and shall use, electrical protective equipment that is appropriate for the specific parts of the body to be protected and

for the work to be performed. Some equipment will be posted with the PPE requirements in accordance with Annex B. The table in Annex C provides the hazard risk to be followed when PPE requirements are not posted on a piece of equipment. Should any tasks not be covered in Annex C, consult NFPA 70E, Table 130.7(C)(9). Annex D identifies typical PPE requirements.

4.1.2.2 Protective equipment shall be maintained in a safe, reliable condition and shall be periodically inspected or tested in accordance with the requirements specified in Para 4.1.2.5..

4.1.2.3 All PPE shall be thoroughly inspected prior to use.

4.1.2.4 Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burn due to contact with exposed energized parts.

4.1.2.5 Employees shall wear rubber insulating gloves with leather protectors when crossing the Restricted Approach Boundary with their hands, tools, probes, or test. Employees shall wear rubber insulating gloves with leather protectors and rubber insulating sleeves where there is a danger of hand and arm injury from electric shock due to contact with energized electrical conductors or circuit parts. Rubber insulating gloves shall be rated for the voltage for which the gloves will be exposed.

EXCEPTION: From ASTM F496 8.7.4 – Protector gloves may be omitted for Class 0 gloves, under limited use conditions, where small equipment and parts manipulation require unusually good finger dexterity. Under the same conditions, Class 00 gloves may be used without protectors, but only at voltages up to and including 250 VAC. Other classes of gloves may be used without protector gloves for similar conditions only where the possibility of physical damage to the gloves is unlikely and provided the voltage class of the glove used is one class above the voltage exposure. Rubber insulating gloves that have been used without protectors shall not be used with protectors until given an inspection and electrical retest.

4.1.2.5.1 Rubber Insulating Gloves must be placed into service (i.e. removed from the plastic bag) within 12 months of their most recent dielectric test and then retested no longer than six months after the date they are placed into service. If they are not placed into service within 12 months of their dielectric test, they shall not be used until they have been retested.

4.1.2.5.2 Rubber Insulating Gloves must be air tested and visually inspected prior to each use.

4.1.2.6 Temporary protective grounding equipment shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to a shock hazard (hazardous differences in electrical potential). The location, sizing, and application of temporary protective grounding equipment shall be identified as part of the job planning and documented on the JSA/JSR and/or Work Instruction Documents.

4.1.3 Electrical Equipment

4.1.3.1 Electrical System/Equipment Maintenance

4.1.3.1.1 Electrical systems and equipment shall be maintained, in accordance with manufacturers' instructions/ recommendations and accepted maintenance practices.

4.1.3.1.2 Defective electrical equipment shall be removed from service, then discarded, abandoned, or repaired to operational condition before being returned into service.

4.1.3.2 Labeling of Equipment to Warn of Arc/Flash Hazards

New equipment such as switchboards, panel boards, industrial control panels, and motor control centers 480v and greater that are likely to require examination, adjustment, servicing, or maintenance while energized shall be field marked to warn qualified persons of potential electric arc flash hazards. The marking shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

4.1.3.3 480 VAC Electrical Safety Requirements

For all installations requiring 480 VAC receptacle and connectors, material shall meet the guidelines set up in Annex F; 480 VAC extension cord requirements shall meet the guidelines set up in Annex G.

4.2 Responsibilities

4.2.1 Supervisors shall

4.2.1.1 Assume ownership and responsibility for the implementation of this standard.

4.2.1.2 Know and implement applicable safety procedures and take action as required to ensure the safety of the personnel and operations they supervise. This responsibility shall include taking positive action to

determine and reduce the hazards associated with their operations, allowing only qualified persons to perform electrical work, and ensuring that employees perform their work safely.

4.2.1.3 Be familiar with the locations where their assigned crews are required to work.

4.2.1.4 Review and sign all JSAs and EEWPs, when required, for work on energized electrical equipment, whether scheduled or emergency, prior to starting work for operations under their supervision.

4.2.1.5 Ensure assigned electrical persons receive refresher training as required.

4.2.1.6 Annually assess the knowledge and abilities of electrical craft personnel under their supervision to determine where training (retraining) is needed to prevent injuries. A mandatory assessment of training adequacy shall be performed when a qualified electrical person or qualified industrial person has been involved in a mishap or a near miss, or has been observed performing an unsafe act.

4.2.1.7 Ensure that each new or transferred employee is instructed in the safe practices pertaining to his or her work, and schedule employees to receive training in work permits and JSAs, lockout/tagout, and confined space procedures as warranted by the employee's duties.

4.3 Investment Projects, Code Compliant Electrical Installations

4.3.1 All electrical equipment shall be installed in compliance with the most recent adopted version of the National Electric Code/NFPA 70, the AEDC SHE Standard D3 and this AEDC SHE Standard B6.

4.3.2 Code compliance should be confirmed and approved by an assessment of the installed equipment during the installation and before completion or energizing the equipment by the assessor.

4.3.3 Assessments shall be done prior to covering or the completion of the electrical work.

4.3.4 Installations or deficiencies that are not approved shall be resolved or corrected prior to the job progressing.

4.3.5. The assessor will be a qualified electrical person selected by the Project Manager to perform this task.

5.0 TRAINING AND QUALIFICATIONS

5.1 Qualified Electrical Person Training

Training Requirements for Low-Voltage Qualified Electrical Persons

Job Function	CPR	First Aid	Low Voltage Safety-Related Work Practices	Lockout/ Tagout
LV Electrician	X	X	X	X
Electrical Test Technician	X	X	X	X
Lineman	X	X	X	X
Power Systems Dispatcher			~~X~~	X
Power Switchboard Operator	X	X	X	X
Electrical Engineer	X	X	X	X
Electrical Standby Person	X	X	X	X
Competent Person	X	X	X	X
Refresher Training Frequency	2 years	2 years	3 year	Initial
NOTE: Training requirements listed in this standard are necessary to meet safety aspects of the electrical worker's job function. Other aspects of the worker's qualifications are obtained by vocational training, apprenticeship, on-the-job training, and special training given within the worker's department or by others**.**				

5.1.1 Qualified electrical persons shall have satisfactorily demonstrated the skills and techniques necessary to distinguish exposed live parts from other parts of electrical equipment, to safely determine the nominal voltage of exposed live parts, and to determine the safe minimum approach distances corresponding to the voltages to which they are exposed.

5.1.2 Qualified electrical persons shall be trained in the performance of special precautionary techniques, in proper lockout/tagout procedures, and in the proper use and care of PPE, insulating and shielding materials, and insulated tools for working on or near exposed energized parts of electrical equipment related to the task(s) they are to perform.

5.1.3 Qualified electrical persons shall be trained in other aspects of their craft, including, but not limited to, basic electrical formulas, proper installation, support, and termination of power and control wiring, and troubleshooting of electrical circuits and controls. Qualified electrical persons shall be trained to read

electrical drawings, including, but not limited to single-line drawings, three-line drawings, control schematics, and wiring diagrams.

5.1.4 Qualified electrical persons shall be trained in rescue techniques for electric shock victims including proper methods of removing personnel from energized circuits in an emergency situation.

5.1.5. Prior to using an automated external defibrillator (AED), personnel shall be trained in its proper use.

5.1.6 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 direct supervision of a qualified person shall be considered to be a qualified person for the performance of those duties.

5.1.7 A task qualified electrical person shall be trained on safety-related work practices associated with the specific task(s) they are qualified to perform. This shall include, as a minimum, the proper methods for performing the specific task(s) for which they are qualified, the recognition of potential electrical hazards associated with the specific task(s), the PPE requirements associated with performing the task(s) for which they are qualified, and the limitations of their qualification.

5.1.8 Retraining: Retraining in safety-related work practices and applicable changes in this standard shall be performed at intervals not to exceed three years. An employee shall receive additional training (or retraining) if any of the following conditions exists:

5.1.8.1 The supervision or annual inspections indicate that the employee is not complying with the safety-related work practices.

5.1.8.2 New technology, new types of equipment, or changes in procedures necessitate the use of safety-related work practices that are different from those that the employee would normally use.

5.1.8.3 The employee must employ safety-related work practices that are not normally used during his or her regular job duties.

5.2 Qualified Industrial Person Training

5.2.1 Employees who will be working in the industrial environment performing limited electrical operations not involving direct exposure to energized electrical circuits (i.e., operating switches, circuit breakers and/or disconnects to control plant equipment, plugging cord and plug type tools and equipment into approved receptacles, etc.) but who are not qualified electrical persons, shall receive training in lockout/tagout and basic electrical safe work practices required for their assigned task(s).

5.2.2 Supervisors and leads over qualified electrical persons shall be trained in low-voltage safety-related work practices.

5.3 Job Briefings

5.3.1 The employee in charge shall conduct a job briefing with the employees involved before the start of each job. The job briefing will cover the following subjects: contents of the JSA/JSR, hazards associated with the job, work instructions involved, special precautions, energy source controls, and PPE requirements.

5.3.2 If the work or operations to be performed during the work day are repetitive and similar, one job briefing shall be conducted before the start of the first job of each day or shift.

5.3.3 Additional briefings shall be held if there are significant changes which might affect employee safety.

NOTE: A brief discussion is satisfactory if the work involved is routine and if the employee, by virtue of training and experience, can reasonably be expected to recognize and avoid the hazards involved in the job. A more extensive discussion shall be conducted if the work is complicated or extremely hazardous.

5.3.4 **An employee working alone** need not conduct a job briefing. However, the employee shall ensure that the tasks to be performed are planned as if a briefing were required to have been made.

6.0 INSPECTION/AUDITS

Base Operating Contractor Safety, Health, and Environmental may conduct inspections of work activities as directed by Base Operating Contractor management.

7.0 REFERENCES

AEDC Safety, Health, and Environmental Standard A10 – Job Safety Analysis
AEDC Safety, Health, and Environmental Standard B1 – Master Work Permit
AEDC Safety, Health, and Environmental Standard B2 – Lockout/Tagout - LOTO
AEDC Safety, Health, and Environmental Standard B3 – Control of Hazard Areas
AEDC Safety, Health, and Environmental Standard B4 – High Voltage Electrical Work
AEDC Safety, Health, and Environmental Standard B5 – Confined Spaces
AEDC Safety, Health, and Environmental Standard F2 – Personal Protective Equipment

Air Force Instruction (AFI) 32-1064 Electrical Safe Practices

ANSI C2 – National Electrical Safety Code (latest revision)

IEEE Standard 1584 – IEEE Guide for Performing Arc-Flash Hazard Calculations

NFPA 70 – National Electrical Code
NFPA 70E – Standard for Electrical Safety in the Workplaces

OSHA 29CFR1910.137 – Electrical Protective Devices
OSHA 29CFR1910.146 – The Control of Hazardous Energy (lockout/tagout)
OSHA 29CFR1910.331 – Scope
OSHA 29CFR1910.332 – Training-Electrical
OSHA 29CFR1910.333 – Selection and Use of Work Practices-Electrical
OSHA 29CFR1910.334 – Use of Equipment
OSHA 29CFR1910.335 – Safeguards for Personnel Protection

8.0 ATTACHMENTS

1 Electrical Maintenance Flowchart
2 Electrical Operations Flowchart

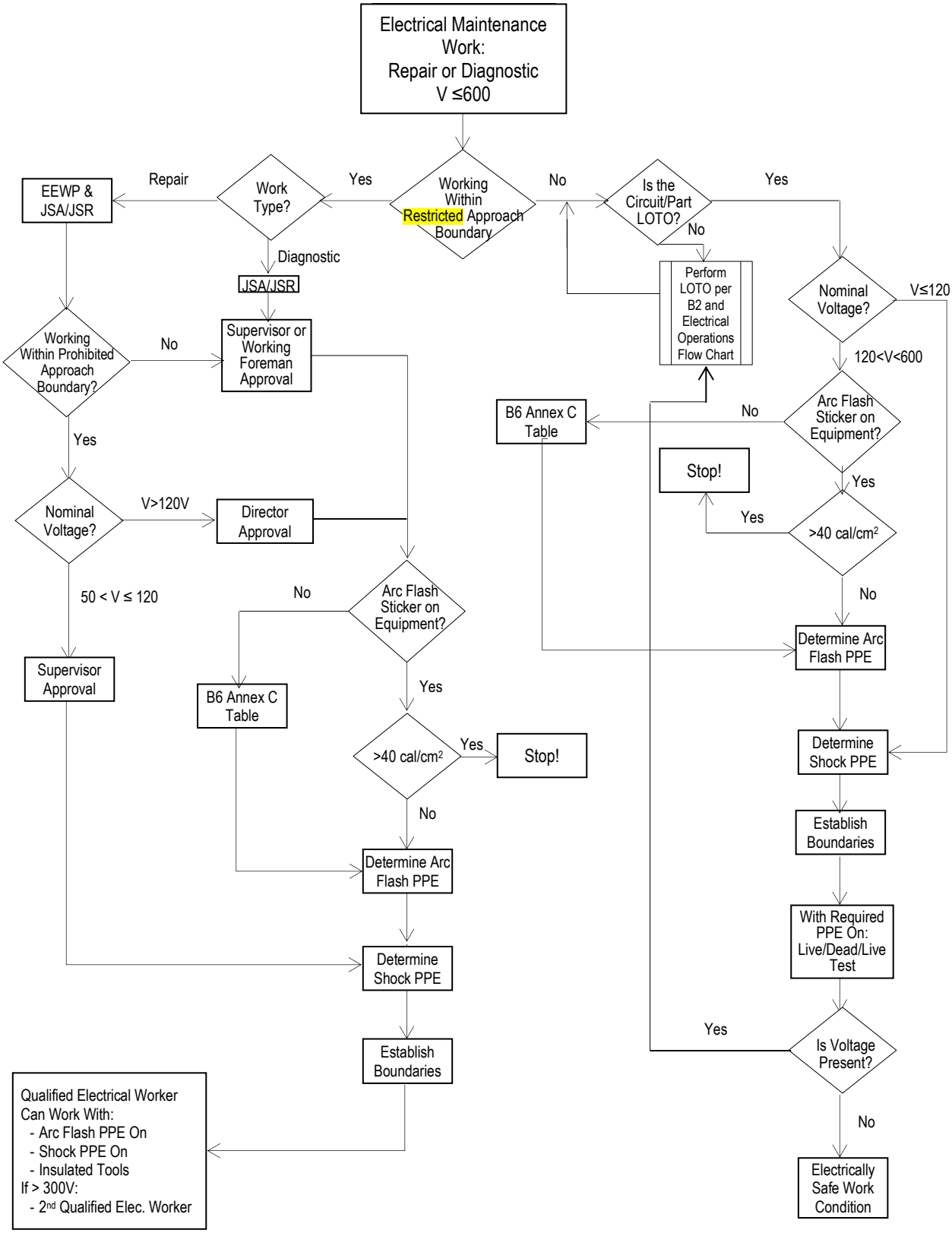
9.0 ANNEXES

A. Energized Electrical Work Permit
B. Example Labeling of Electrical Equipment to Warn of Possible Arc/Flash Hazards
C. PPE Requirements for Common Low-Voltage Tasks
D. Protective Clothing and Personal Protective Equipment (PPE) Matrix
E. New Installation- Color Codes for Electrical Systems (<600 V)
F. 480 VAC Receptacles and Connectors
G. 480 VAC Extension Cords

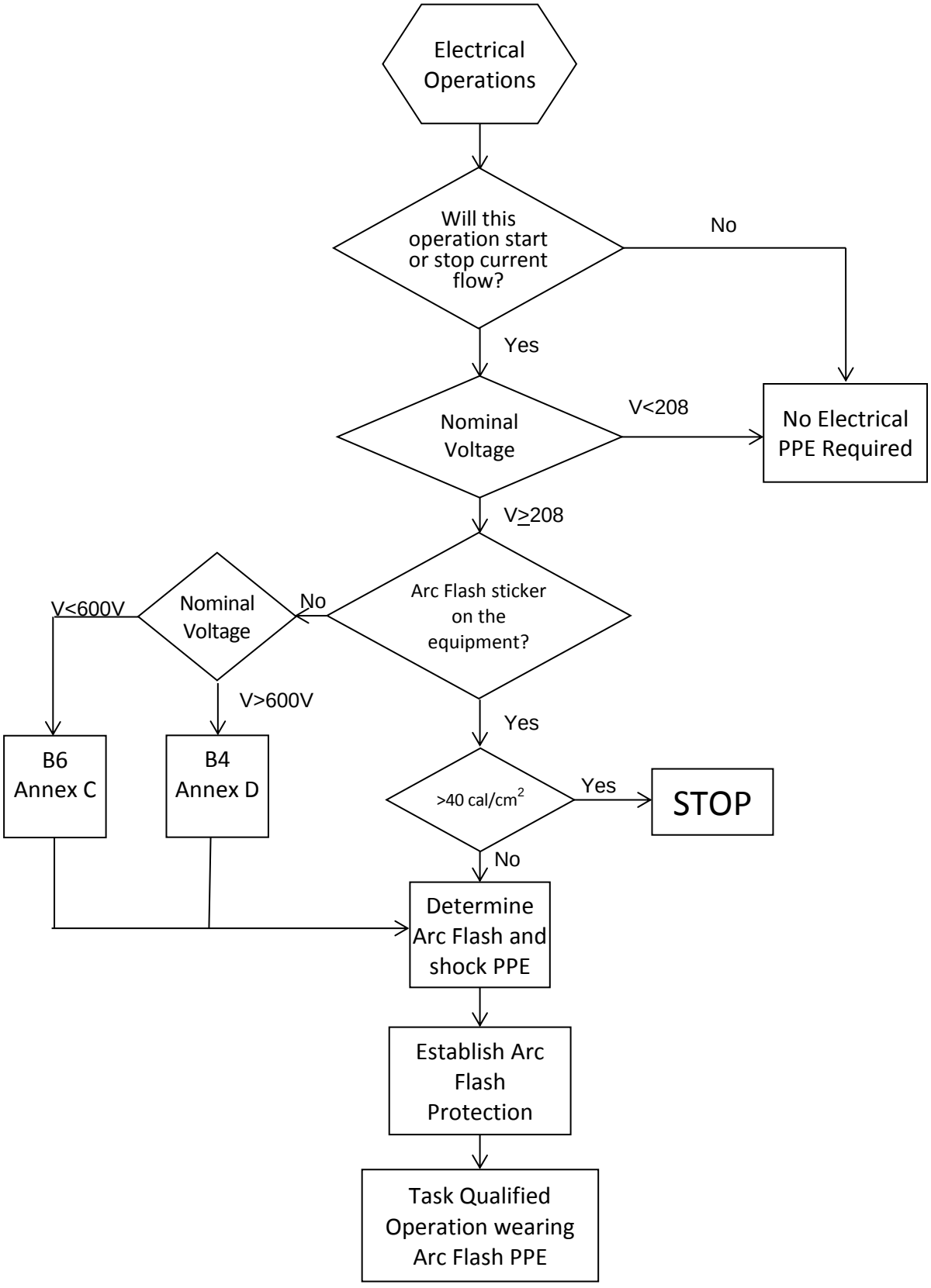
10.0 SUPPLEMENT

NFAC A321-0801-XSP B6 Low-Voltage Electrical Safety Related Work Practices

ATTACHMENT 1
ELECTRICAL MAINTENANCE FLOW CHART



ATTACHMENT 2
ELECTRICAL OPERATIONS FLOW CHART



ANNEX A

AEDC ENERGIZED ELECTRICAL WORK PERMIT

Job/Work Order Number_____

1. Location of work to be performed: Include the Building, Panel Name/Number, Equipment being worked, etc.

   _____

2. Justification why the work **must** be performed while energized. _____

   _____

3. Detailed description of work to be performed. _____

   _____

4. Arc Flash Incident Energy from Arc Flash Label or Hazard Risk Class from Annex _____

5. PPE Requirements (Taken from Arc Flash Label or Annex C.) (Check all that apply.)

☐ Safety Glasses or Goggles	☐ Arc-Rated Shirt and Pants or Coveralls, (8 cal minimum)
☐ Hearing Protection (ear canal inserts)	☐ Arc-Rated Face Shield and Balaclava or Arc-Rated Flash Suit Hood
☐ Hard Hat	☐ Arc-Rated Foul Weather Gear (jacket, parka, coveralls, rainwear, etc.)
☐ Heavy Duty Leather Gloves	☐ Arc-Rated Gloves
☐ Leather Shoes	☐ Arc Flash Suit (40 cal minimum)
☐ Voltage Rated Gloves Class _____	

6. Shock Hazard Boundary Determination (AC and/or DC):
   Nominal voltage(s) of exposed conductor(s) _____
   Limited Approach Boundary _____ Restricted Approach Boundary _____ Prohibited Approach Boundary _____

7. Arc Flash Protection Boundary Distance (Taken from Arc Flash Label or if there is no label, reference Annex C) _____

8. Method to restrict the access of unqualified persons from the work area (e.g. Barrier Set with Danger Tape etc.). _____

   _____

9. A Job Briefing including discussion of any job-related hazards and emergency egress plan has been completed by:

   _____ _____
   Qualified Electrical Person Date

10. By signing below, you agree that it is infeasible to perform the work described above de-energized and it can be done safely:

_____	_____	_____	_____
(1 of 2 Required) Qualified Electrical Person	Date	(2 of 2 Required) Qualified Electrical Person	Date

11. Approval of Work:
Inside the Restricted Approach Boundary but outside the Prohibited Approach Boundary:

_____ _____
Manager or Supervisor Date

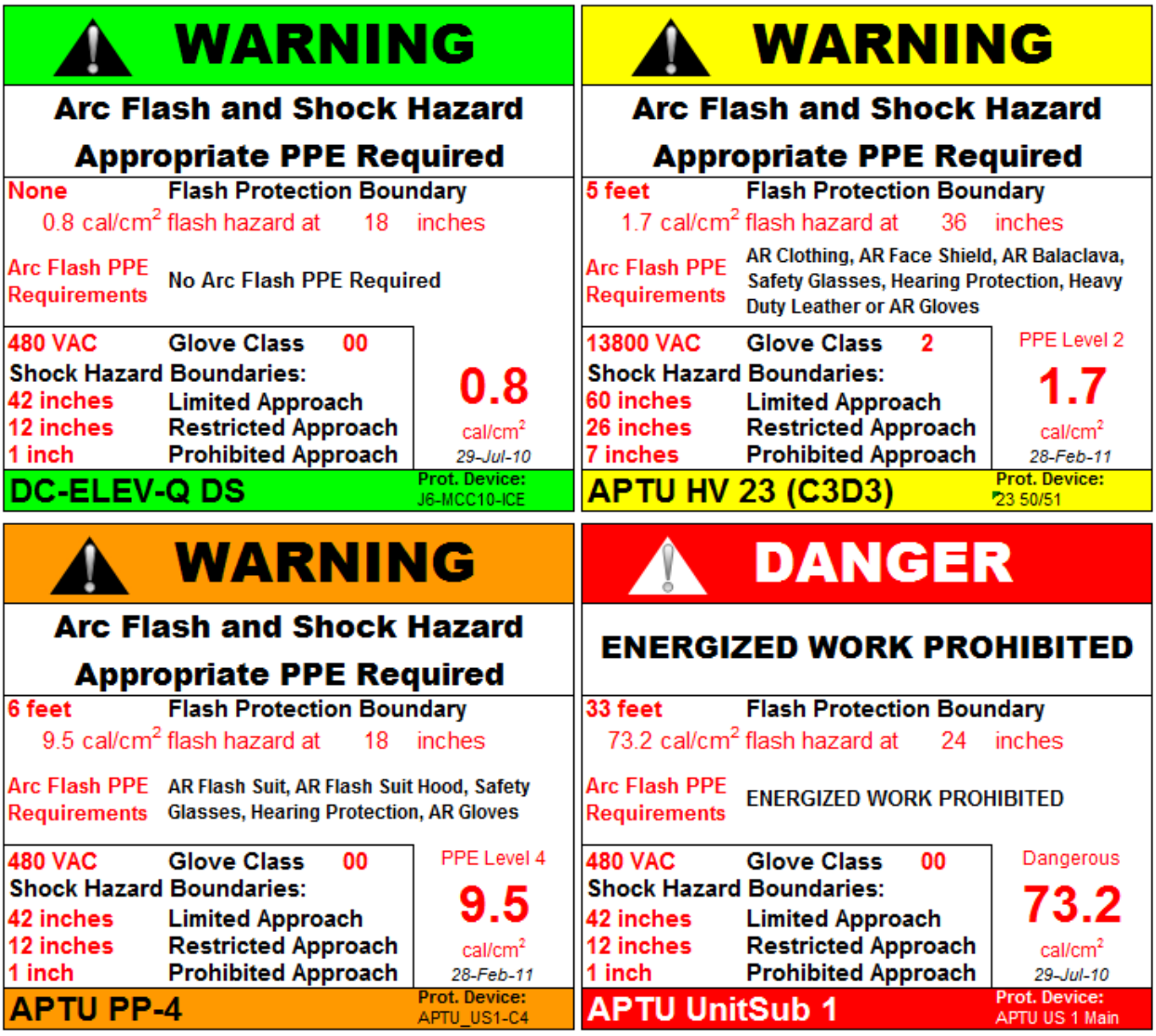
Or
Inside the Prohibited Approach Boundary; 50V to 150V: _____ _____
Manager or Supervisor Date

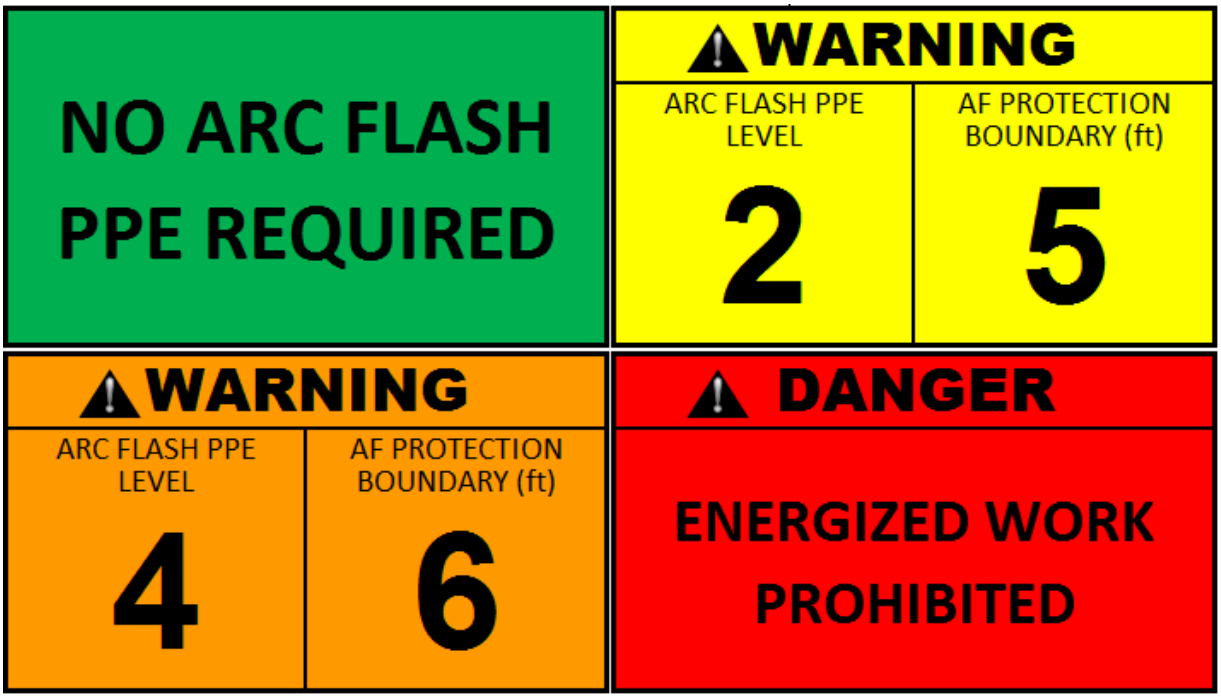
Or
Inside the Prohibited Approach Boundary; 151V and above: _____ _____
Director or Deputy Director Date

*Reference SHE Standard B04 or B06 for additional information

ANNEX B

EXAMPLE LABELING OF ELECTRICAL EQUIPMENT TO WARN OF POSSIBLE ARC/FLASH HAZARDS





Categories:

- **No Arc Flash PPE Required**
  - <1.2 cal/cm^2 calculated arc flash hazard
  - Color: Green
  - No Arc Flash PPE Required - No Arc Flash Boundary requirement
- **Level 2**
  - 1.2 through 8 cal/cm^2 calculated arc flash hazard
  - Color: Yellow
  - Minimum Arc Flash PPE Requirements:
    - Arc-rated (AR) long-sleeve shirt with Arc-rated pants (≥ 8 cal/cm^2 rating) or Arc-rated coveralls (≥ 8 cal/cm^2 rating)
    - Arc-rated face shield (≥ 8 cal/cm^2 rating) and AR Balaclava (≥ 8 cal/cm^2 rating) or arc flash suit hood
    - Any optional clothing worn with AR PPE must be non-melting
    - Hard hat, Safety glasses/goggles, hearing protection, heavy duty leather or AR gloves, leather work shoes
- **Level 4**
  - >8 cal/cm^2 up to 40 cal/cm^2 calculated arc flash hazard
  - Color: Orange
  - Minimum Arc Flash PPE Requirements:
    - Arc-rated arc flash suit jacket, arc flash suit pants, and arc flash suit hood (≥ 40 cal/cm^2 rating)
    - Any optional clothing worn with AR PPE must be non-melting
    - Hard hat, Safety glasses/goggles, hearing protection, rubber insulated gloves with AR Gloves, leather work shoes

NOTE: Non-AR clothing shall not be worn over AR clothing.

- **Energized Work Prohibited**
  - >40 cal/cm^2
  - Color: Red
  - No PPE can protect against the non-thermal hazards for energies above 40 cal/cm^2

ANNEX C
PPE REQUIREMENTS FOR COMMON LOW-VOLTAGE TASKS WHEN NO ARC FLASH LABEL IS POSTED ON THE EQUIPMENT

Task (Assumes equipment is energized and work is done within the arc flash boundary)	**Equipment Condition**	**Arc Flash PPE Req'd**
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 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 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 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 installation 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 circuit parts	All of the following: The equipment is properly installed The equipment is properly maintained 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 There is evidence of impending failure	Yes
Removal of bolted covers (to expose bare energized electrical conductors and circuit parts). For dc systems, this includes bolted covers, such as battery terminal covers.	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

Task (Assumes equipment is energized and work is done within the arc flash boundary)	Equipment Condition	Arc Flash PPE Req'd
Opening hinged door(s) or cover(s) (to expose bare energized electrical conductors and circuit parts)	Any	Yes
Perform infrared thermography and other noncontact inspection outside the restricted approach boundary. This activity does not include opening of doors or covers.	Any	No
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 (racking) 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 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 cells or multi-cell 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 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 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: •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 Equipment doors are open or not secured Equipment covers are off or not secured There is evidence of impending failure	Yes
Opening voltage transformer or control power transformer compartments	Any	Yes
Outdoor disconnect switch operation (hookstick operated) at 1 kV through 15 kV	Any	Yes
Outdoor disconnect switch operation (gang-operated, from grade) at 1 kV through 15 kV	Any	Yes

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 indicates that arc flash PPE is not required, an arc flash is not likely to occur.

*The phrase properly installed, 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 properly maintained, 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 evidence of impending failure, as used in this table, means that there is evidence of arcing, overheating, loose or bound equipment parts, visible damage, deterioration, or other damage.

Arc Flash Hazard PPE Categories for Alternating Current (ac) Systems:

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 V and below Parameters: Maximum of 25 kA short-circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)	1	19 in.
Panelboards or other equipment rated >240 V and up to 600 V Parameters: Maximum of 25 kA short-circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 455 mm (18 in.)	2	3 ft
600-V class motor control centers (MCCs) 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.)	2	5 ft
600-V class motor control centers (MCCs) Parameters: Maximum of 42 kA short-circuit current available; maximum of 0.33 sec (20 cycles) fault clearing time; working distance 455 mm (18 in.)	4	14 ft
600-V class switchgear (with power circuit breakers or fused switches) and 600 V class switchboards Parameters: 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.)	4	20 ft
Other 600-V class (277 V through 600 V, nominal) equipment 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.)	2	5 ft
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV 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.)	4	40 ft
Metal-clad switchgear, 1 kV through 15 kV 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.)	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 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.)	N/A (doors closed) 4 (doors open)	N/A (doors closed) 40 ft
Other equipment 1 kV through 15 kV 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.)	4	40 ft
Note: For equipment rated 600 volts and below, and protected by upstream current-limiting fuses or current-limiting circuit breakers sized at 200 amperes or less, the arc flash PPE category can be reduced by one number but not below arc flash PPE category 1.		

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	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 ≤ 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	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
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, Standard Guide for Evaluating Chemical Protective Clothing (2) Be arc-rated in accordance with ASTM F1891, Standard Specification for Arc Rated and Flame Resistant Rainwear, or equivalent		

ANNEX D

PROTECTIVE CLOTHING AND PERSONAL PROTECTIVE EQUIPMENT (PPE) MATRIX

PPE requirements in SHE Standard F2 must be complied with in addition to the requirements below

PPE Level	Protective Clothing and PPE
PPE Level 0	
Arc-rated Clothing, Minimum Arc Rating of ≥8cal/cm^2 (Note 1)	Arc-rated long-sleeved shirt
Protective Equipment	Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Heavy Duty Leather gloves (Note 2) Leather work shoes
PPE Level 2	
Arc-rated Clothing, Minimum Arc Rating of 8 (Note 1)	Arc-rated long-sleeved shirt Arc-rated pants Arc-rated coverall (Note 3) Arc-rated arc flash suit hood (Note 4) Arc-rated jacket, parka, or rainwear (AN)
Protective Equipment	Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Heavy Duty Leather gloves (Note 2) Leather work shoes
PPE Level 4	
Arc-rated Clothing, Minimum Arc Rating of 40 (Note 1)	Arc-rated arc flash suit jacket AR Arc-rated flash suit pants AR Arc-rated arc flash suit hood Arc-rated jacket, parka, or rainwear (AN)
Protective Equipment	Hard hat Arc-rated hard hat liner (AR) Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Arc-rated gloves (Note 2) Leather work shoes

AN = As needed (Optional)
AR = As required
SR = Selection required

Notes:

1. See NFPA 70E Table 130.7(C)(16). Arc rating for a garment or system is expressed in cal/cm^2.
2. If rubber insulating gloves with leather protectors are required, additional leather or arc-rated gloves are not required. The combination of rubber insulating gloves with leather protectors satisfies the arc flash protection requirement.
3. Alternate is to use FR coveralls (minimum arc rating of 8) instead of FR shirt and FR pants.
4. Alternate is to use face shield with a minimum arc rating of 8 and a balaclava (sock hood) with a minimum arc rating of 8 which covers the face, head, and neck except for the eye and nose areas.

Additional Arc Flash PPE Required

	Hazard Risk Class		
	0	**2**	**4**
Safety Glasses or Goggles	X	X	X
Hard Hat	X	X	X
FR Hard Hat Liner	-	-	X
Hearing Protection	X	X	X
Leather Gloves	X	X	
Arc-Rated Gloves			X-Note
Leather Shoes	X	X	X
Arc-Rated Face Shield	-	X	
Balaclava	-	X	
Flash Suit Hood	-	Alternative to FS & Balaclava	X

AN- As Needed

NOTE: If voltage-rated gloves are required per Annex B or Annex C additional leather or arc-rated gloves are not required. The combination of voltage and leather gloves satisfies the arc flash protection requirement.

Glove/Class#/ Color of Identification Label	Maximum Usage Voltage AC	Test Voltage
00 / Beige	500	2,500 V
0 / Red	1,000	5,000 V
1 / White	7,500	10,000 V
2 / Yellow	17000	20,000 V
3 / Green	26,500	30,000 V
4 / Orange	36,000	40,000 V

ANNEX E

NEW INSTALLATIONS - COLOR CODES FOR ELECTRICAL SYSTEMS (<600 V)

Voltage (AC) 3-Phase	**Phase 1**	**Phase 2**	**Phase 3**	**Ground (Safety or Power)**
480 VAC	Brown	Orange	Yellow	Green or Bare
208 VAC	Black	Red	Blue	Green or Bare
Voltage (AC) Single-Phase	**Hot**	**Neutral**		
120 VAC	Black	White		Green or Bare
120 VAC, multi-wire	Black, Red or Blue	White		Green or Bare
277 VAC	Brown, Orange, or Yellow	Gray		Green or Bare
Voltage (DC)	**Positive (+)**	**Negative (-)**		**Ground (Safety or Power)**
24 VDC Power Feeders	Blue	Gray or White/Blue[1]		Green or Bare (if required)
24 VDC System[2]	Red	Black		
125 VDC Feeder	Red	Black		
125 VDC System	Red	Black		
5 VDC	Red	Black		
+/-15VDC	+15V Red	-15V White		Black
Instrumentation Ground, Signal Reference Ground, and Isolated Ground[3]				Green/Yellow[1]
All Uninterruptible Power Supply (UPS) receptacle and panel covers should be painted yellow.				

NOTES:

1. Color 1/Color 2 denotes that the primary color of the insulation is Color 1 and there is a tracer of Color 2.
2. This color code is a change for designing 24 VDC systems in ETF.
3. 120VAC Isolated Ground receptacles are signified with an orange marking.
4. NFPA70/NEC, Articles 200.6 and 250.118 shall be observed and followed.
5. Identification shall be the correct colored insulation, marking tape, or other approved means.

This chart satisfies the requirement of documentation that is readily available and removes the requirement to post each panel board. Colors designated in this chart are the basic industry standards. Most of these colors have been and are currently being used throughout the facility.

NOTE: (NFPA 70/NEC 2014: Articles 210.5 and 215.12 presently requires all branch circuits and feeders to be properly identified where a premises is supplied by more than one voltage system. The identification scheme shall be documented in a manner that is readily available or shall be posted at each panelboard or at the distribution equipment.)

ANNEX F

480 VAC RECEPTACLES AND CONNECTORS

1. All 480 VAC receptacle/disconnects shall be installed by qualified electrical persons.
2. Receptacles shall be of the interlocking disconnecting type.
   The disconnect enclosure cannot be opened unless the disconnect is “OFF”.
   Plugs cannot be inserted or removed unless the disconnect is “OFF”.
   The disconnect shall have provisions to lock in the “OFF” position for lockout/tagout requirements.
3. Receptacles and disconnects shall be rated for the intended load (30, 60 or 100 amp).
4. Receptacles and disconnects may be of the fused or non-fused type.
   If fused, the rating of the fuses shall be for the intended load.
   NFPA-70 requirements shall be met.
5. Receptacles shall be approved for the location to be installed:
   - Indoor (Industrial, general purpose, etc.)
   - Weatherproof
   - Hazard location
   - Etc.
6. Receptacles shall be able to accept Crouse-Hinds Arktite® compatible designed plugs;
   e.g. Appleton Powertite®, Hubbell Insulgrip®.

ANNEX G

480 VAC EXTENSION CORDS

1. Extension Cords are only allowed under the following conditions:
   - The need is temporary, and
   - The equipment requiring 480 VAC is too far away from the permanently installed receptacle to properly insert the equipment plug.
2. 480 VAC extension cords shall be rated for the intended load and shall follow manufacturer recommendations for wire size and insulation type.
3. 480 VAC extension cords shall be part of the "Assured Equipment Grounding Conductor Program" and shall be inspected by qualified industrial persons at intervals not exceeding 3 months. (NFPA-70 2014, Article 590.6, B (2)

A321-0801-XSP B6 Low-Voltage Electrical Safety-Related Work Practices Supplement

Review: This supplement will be reviewed and updated using the same cycle as AEDC Safety, Health, and Environmental (SHE) Standard B6 Low-Voltage Electrical Safety Related Work Practices.

References: AEDC SHE Standard B6 Low-Voltage Electrical Safety Related Work Practices

NFAC Procedural Requirements APR 1700.1 Chapter 11 Electrical Safety

Scope:

This supplement outlines the hazards involved, safety equipment required, safety precautions to be observed, and operating procedure requirements when working with low-voltage electricity, i.e. less than or equal to 600 volts.

This supplement applies in all situations where exposure to energized or potentially energized electrical equipment is possible due to the nature of the work to be performed. Following this standard will help ensure that electrical work is performed under the safest conditions possible.

This supplement applies to all personnel conducting operations, maintenance, testing and support at NFAC, NASA AMES.

NFAC Worksite Application:

NFAC will follow Ames Procedural Requirements APR 1700.1 Chapter 11 Electrical Safety.

Requirements/Responsibilities:

I. NFAC Site Management shall

1. Ensure this supplement is followed.
2. All personnel, customers, and vendors utilize SOPs and Lockout Tagout working with low voltage

II. NFAC Supervisors and Test Directors shall

1. Ensure this supplement is followed.
2. Ensure staff, customers, and vendors follow the supplement.
3. NFAC Electrical Supervisor will issue “Electrical Safety Checklist for Hot Work” A321-0801-XSF-18 form for any live circuit work ≥50 volts.

III. NFAC Safety Engineer/Management Designee shall maintain records on electrical training (annual) and Lockout Tagout (2 years).

IV. NFAC Staff shall

1. Follow this supplement.
2. Follow all SOPs, safety protocols, PPE, and Lockout Tagout as required.
3. Obtain signed off “Electrical Safety Checklist for Hot Work” A321-0801-XSF-18 for any live circuit work ≥50 volts.
4. Restrict access to areas during maintenance/trouble shooting operations of low voltage work.
5. Remain current on Lockout Tagout training.