NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

ELECTRICAL SAFETY

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1. PURPOSE

The purpose of this suborder is to establish the requirements and associated roles and responsibilities to protect NIST staff from exposure to electrical hazards while working on or around electrical, electronic, and electro-mechanical equipment and circuits. This suborder supersedes NIST N 7101.64: *Electrical Safety* upon its effective date.

2. BACKGROUND

NIST workspaces vary from research laboratories to office environments to industrial-like settings. In addition, the type of work performed in these spaces varies greatly which yields the full spectrum of electrical safety hazards ranging from a mild electrical shock or burn to arc flash or electrocution. While some electrical safety requirements to ensure a safe workspace are straightforward, e.g., see Section 6.a, the complexity of some electrical safety hazards observed at NIST presents a challenge to communicating the necessary requirements effectively and efficiently. For those cases, this suborder provides a formal approach to identifying general safe work practices related to the characteristics of the electrical hazards NIST staff may encounter as they perform their official duties. To facilitate this effort, NIST adopted a best practice developed by the Department of Energy (DOE)[2] of using various parameters to make an electrical hazard assessment for the work to be performed:

- Electrical hazard categories – Five broad categories based on dissimilar electrical sources;
- Electrical hazard classes – Four classes derived from possible injury mechanisms that could occur when workers encounter varying levels of energy from different sources; and
- Modes of electrical work – Four different modes focused on the type of work to be performed.

These parameters are discussed in detail in Appendix B. Using this information collectively throughout Section 6 allows NIST staff to correctly identify the minimum applicable requirements such as control measures, type of personal protective equipment (PPE), and training qualifications requirements for a given scenario.

The requirements of this suborder do not supersede the requirements for conducting a hazard assessment per NIST S 7101.20 Hazard Review.

[2] DOE Handbook 1092.

3. APPLICABILITY

a. The requirements of this suborder apply to NIST employees and covered associates who may be exposed to electrical hazards while performing work on electrical, electronic, and electro-mechanical equipment or circuits at NIST worksites.

NOTE: Some requirements may not be applicable at worksites not under NIST jurisdiction. For questions or concerns, please contact the NIST Authority Having Jurisdiction (AHJ) regarding applicability of a requirement.

b. The requirements of this suborder apply to NIST non-R&D contractors who may be exposed to electrical hazards while performing work on electrical, electronic, and electro-mechanical equipment or circuits at NIST worksites.

(1) The non-R&D contractor is required to exchange their electrical safety program with NIST if they will be engaged in work covered by this suborder.

(2) The NIST Contracting Officer's Representative (COR) shall ensure NIST identifies requirements that are applicable to the non-R&D contractor and ensure the non-R&D contractor follows the NIST requirements.

c. The requirements in this document apply to the development, operation, and maintenance of electrical, electronic, and electro-mechanical equipment and circuits including design of future systems and equipment. Research that includes the development and use of specialized electrical, electronic, and electro-mechanical equipment for specific projects or in support of those projects shall comply with the requirements of this suborder to the extent feasible. In cases where it is not feasible to comply with one or more of these requirements, a request for variance[3] shall be submitted for review and approval to the AHJ.

d. This suborder does not specify the requirements for the control of hazardous energy (lockout/tagout - LOTO). All lockout/tagout operations, including lockout/tagout of live electrical conductors, must comply with the requirements of NIST S 7101.56. In general, workers should assume that all electrical conductors and circuit parts are energized until they have been de-energized, verified to have zero volts, locked, and tagged in accordance with the approved LOTO process. However, where required, additional requirements of this suborder must be met during all electrical work, including electrical lockout/tagout (*i.e.*, Mode 1 electrical work as discussed in Appendix B) and verification of zero voltage.

[3] Please see NIST PR 7101.00: *Procedure for Requesting Safety-Related Variances and Waivers* for details regarding the variance process.

4. REFERENCES

a. ANSI Z87.1, Practice for Occupational and Educational Eye and Face Protection, latest edition.

b. ANSI Z89.1, Requirements for Protective Headwear for Industrial Workers, latest edition.

c. ASTM D120, Standard Specification for Rubber Insulating Gloves, latest edition.

d. ASTM D178; Standard Specification for Rubber Insulating Matting, latest edition.

e. ASTM D1048 Standard Specification for Rubber Insulating Blankets, latest edition.

f. ASTM D1049; Standard Specification for Rubber Insulating Covers, latest edition.

g. ASTM D1050; Standard Specification for Rubber Insulating Line Hose, latest edition.

h. ASTM D1051; Standard Specification for Rubber Insulating Sleeves, latest edition.

i. ASTM F696, Standard Specification for Leather Protectors for Rubber Insulating Gloves and Mittens, latest edition.

j. ASTM F711, Standard Specification for Fiberglass-Reinforced Plastic (FRP) Rod and Tube Used in Live Line Tools, latest edition.

k. ASTM F1505, Standard Specification for Insulated and Insulating Hand Tools, latest edition.

l. ASTM F1506, Standard Performance Specification for Flame Resistant and Arc Rated Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards, latest edition.

m. ASTM F2413, Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear.

n. ASTM F2178 Standard Specification for Arc Rated Eye or Face Protective Products.

o. Department of Energy Handbook 1092, “Handbook for Electrical Safety” (DOE-HDBK-1092). https://www.standards.doe.gov/standards-documents/1000/1092-BHdbk-2013/@@images/file.

p. OSHA 29 CFR 1926.957 Subpart V, Electric Power Transmission and Distribution

q. OSHA 29 CFR 1910.301 Subpart S, Electrical

r. OSHA 29 CFR 1926.400 Subpart K, Electrical

s. National Fire Protection Association (NFPA) 70, National Electric Code, latest edition.

t. NFPA 70B, Standard for Electrical Equipment Maintenance, latest edition

u. NFPA 70E, Electrical Safety in the Workplace, latest edition

v. NFPA 79, Electrical Standard for Industrial Machinery, latest edition.

w. NFPA 790 Standard for Competency of Third-Party Field Evaluation Bodies, latest edition

x. NFPA 791, Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation, latest edition

y. Underwriters Laboratory (UL) 508, Industrial Control Equipment, latest edition.

z. UL 508A, Industrial Control Panels; latest edition.

aa. UL 60950-1, Standard for Safety, Information Technology Equipment – Safety; Part 1: General requirements; latest edition.

bb. UL 61010-1, Standard for Safety, Electrical Equipment for Measurement, latest edition. Control, and Laboratory Use; Part 1: General Requirements, latest edition.

5. APPLICABLE NIST DIRECTIVES

a. NIST S 7101.20: *Work and Worker Authorization Based on Hazard Reviews*

b. NIST S 7101.21: *Personal Protective Equipment (PPE)*

c. NIST S 7101.23: *Safety Education and Training*

d. NIST S 7101.24: *Incident Reporting and Investigation*

e. NIST S 7101.28: *Non-R&D Contractor Safety Program* (under development)

f. NIST S 7101.55: *Hearing Protection*

g. NIST S 7101.56: *Control of Hazardous Energy (Lockout/Tagout)*

h. NIST S 7101.57: *Permit-Required Confined Spaces*

i. NIST S 7101.73: *Out of Service*

j. NIST PR 7101.00: *Procedure for Requesting Safety-Related Variances and Waivers (Internal link only)*

6. REQUIREMENTS

a. General Electrical Safety Requirements for Any Workspace or Work Activity

(1) Electrical Cord Plugs of Any Kind

(a) When in use, an electrical cord plug of any kind (*e.g.*, on an extension cord or associated with a power cord to a computer or piece of lab equipment) shall be fully inserted into an electrical outlet such that the plug's metal prongs are not exposed.

(b) A damaged plug (*e.g.*, broken, cracked, or missing prongs or ground pins) of any kind shall be removed from service immediately.

i. If the cord or equipment the plug is connected to can be discarded, it shall be discarded immediately.

ii. If the cord or equipment the plug is connected to is to be repaired, it shall be immediately tagged out of service in accordance with the requirements of NIST S 7101.73 until the repair is complete.

(c) Three-prong to two-prong plug adapters shall not be used in lieu of proper circuit grounding.

i. During the course of a work activity, when it is required for the purpose of ground loop isolation, a "break-out" box or other type of isolation device shall be developed that will provide ground loop isolation with a visible indication that the ground has been inhibited.

(2) Electrical Cords of Any Kind

(a) When plugged into outlets, the tension on an electrical cord of any kind (*e.g.*, an extension cord or power cord to a computer or piece of lab equipment) shall be minimized to the extent possible and not exceed manufacturers recommendations for tension.

(b) An electrical cord of any kind shall be protected from damage.

i. An electrical cord of any kind shall not be pinched, bent, or similarly deformed such that the insulation or conductors are compromised. This does not apply to compression connections.

ii. A cord guard shall be used to protect an electrical cord of any kind positioned across a walkway from wear and tear caused by foot and other traffic.

(i) The cord guard shall be secured to prevent tripping.

(ii) An electrical cord of any kind shall not be taped (*e.g.*, gaffer tape) to the floor in any location where there is foot or other traffic. The electrical cord may be taped down in locations where there will not be foot or other traffic (*e.g.*, under tables or on the floor directly adjacent to a wall).

(c) An electrical cord of any kind shall not be securely fastened to building surfaces as permanent installations.

(d) A damaged cord of any kind (*e.g.*, a cord that is pinched, is missing insulation, has exposed conductors) shall be removed from service immediately.

i. If the cord or equipment the cord is connected to can be discarded, it shall be immediately discarded.

ii. If the cord or equipment the cord is connected to is to be repaired, it shall be immediately tagged out of service in accordance with the requirements of NIST S 7101.73 until the repair is complete.

(3) Supplemental Power Devices

(a) Supplemental power devices shall be labeled and listed by a Nationally Recognized Testing Laboratory (NRTL)[4], *e.g.*, Underwriters Laboratories. Examples of supplemental power devices are relocatable power taps (RPTs), surge suppressors, power strips, uninterruptible power supplies (UPS), power distribution units (PDUs) and extension cords.

i. An unlisted supplemental power device may be used in a laboratory or R&D workspace provided it is first evaluated per NFPA 791, as discussed in Section 6.j.

ii. An acceptable RPT shall meet the following requirements[5]:

(i) Is listed for commercial or industrial applications;

(ii) Has a master circuit breaker; and

(iii) Has a master power switch.

(b) Only a supplemental power device that is grounded shall be used. Please see Section 6.a(1)(c).

(c) When not in use, a supplemental power device shall be stored according to the manufacturer's safety instructions.

(d) A supplemental power device shall be used according to the manufacturer's safety instructions.

(e) A supplemental power device shall be connected directly to a permanently installed electrical outlet, *i.e.*, "daisy chaining" or "piggybacking" to other supplemental power devices is not permitted.

(f) The cord of a supplemental power device shall not be routed through walls, floors, windows, doorways, or ceilings.

[4] https://www.osha.gov/nationally-recognized-testing-laboratory-program/current-list-of-nrtls
[5] In general, acceptable RPTs shall be NRTL listed for the application and used in accordance with the NRTL listing.

(g) A supplemental power device may be secured in place in accordance with the requirements of their NRTL listing.

(h) A supplemental power device shall not be modified in any manner including for the purpose of mounting except as specified by the manufacturer using manufacturer supplied or recommended parts.

(i) A supplemental power device shall not be opened unless the operator's manual provided by the manufacturer allows and includes instructions for doing so.

(j) Extension cords shall not be used as a substitute for permanent wiring and shall be unplugged and properly stored after temporary use.

i. Temporary use is defined by NFPA 70 as no longer than 90 days.

ii. An extension cord may be used in a laboratory or R&D workspace for the duration of the experiment or research effort.

iii. An extension cord may be used for the duration of construction, remodeling, maintenance, repair, or demolition of building structures, components, or similar activities, please see Section 6.b(1).

(k) A damaged supplemental power device shall be removed from service immediately.

i. If the supplemental power device can be discarded, it shall be immediately discarded.

ii. If the supplemental power device is to be repaired, it shall be immediately tagged out of service in accordance with the requirements of NIST S 7101.73 until the repair is complete.

(4) Appliances

(a) An appliance shall be labeled and listed by an NRTL and used in accordance with listing instructions.

i. Unlisted appliances may be approved for used in a laboratory or R&D workspace provided it is first evaluated per NFPA 791, as discussed in Section 6.j.

(b) Manufacturer's safety instructions shall be followed for appliance use.

(c) An electrical appliance that has a current load greater than 12 amperes (power loads greater than 1440 Watts), *e.g.*, space heater, refrigerator, microwave oven, shall be plugged directly into:

i. A permanently installed electrical outlet (*i.e.*, wall receptacle); or

ii. A relocatable power tap (RPT) meeting the requirements in Section 6.a(3)(a)ii.

(d) An electrical appliance with a heating element, *e.g.*, portable electric space heater, coffee pot, toaster, toaster oven, shall be plugged directly into:

i. A permanently installed electrical outlet (*i.e.*, wall receptacle); or

ii. A RPT meeting the requirements in Section 6.a(3)(a)ii.

(e) Manufacturer's clearance requirements shall be maintained around an electrical appliance with a heating element, *e.g.*, coffee pot, toaster, toaster oven.

(f) When in use, a toaster, toaster oven, or other cooking appliances (*e.g.*, microwave) shall be attended, *i.e.*, the individual using the appliance shall remain in the space where the appliance is located while it is in use.

(g) Ground fault circuit interruption (GFCI) protection shall be used (as per NFPA 70) when cord-and-plug connected equipment and tools are used in wet or damp locations and supplied by a 125V 15A or 20A circuit.

NOTE: NFPA 70 requires GFCI protection when an outlet is within 6 feet of a water source. If the outlet is not GFCI protected, a GFCI plug is required to be used with the appliance. Wet or Damp locations are defined in NFPA 70.

(5) Electrical Equipment and Tools

(a) Electrical equipment and tools shall be labeled and listed by an NRTL and used in accordance with listing instructions.

i. Unlisted electric equipment and tools may be approved for use in a laboratory or R&D workspace provided they are first evaluated per NFPA 791, as discussed in Section 6.j.

(b) Electrical equipment and tools that have current loads greater than 12 amperes (power loads greater than 1440 Watts) shall be plugged directly into:

i. A permanently installed electrical outlet (*i.e.*, wall receptacle); or

ii. A RPT meeting the requirements in Section 6.a(3)(a)ii.

(c) Ground fault circuit interruption (GFCI) protection shall be used when cord-and-plug connected equipment and tools are used in wet or damp locations and supplied by a 125V 15A or a 20A circuit.

NOTE: NFPA 70 requires GFCI protection when an outlet is within 6 feet of a water source. If the outlet is not GFCI protected, a GFCI plug is required to be used with the electrical equipment or tool.

(6) Permanently Installed Electrical Outlets (*i.e.*, Wall Receptacles and Pendant Power Outlets)

(a) The load on permanently installed electrical 120V outlets shall not exceed:

i. 12 amperes (1440Watts) for a 15-amp circuit; or

ii. 16 amperes (1920 Watts) for a 20-amp circuit.

NOTE: Most circuits in offices and office-like spaces at NIST are 20-ampere circuits, but some are 15-ampere circuits. If you wish to attach more than a 12-ampere (1440 W) load and you are not sure if the circuit is 20-ampere circuit, contact the OFPM Service Desk:

- Boulder: 303-497-3191
- Gaithersburg: 301-975-6928

(b) Electrical outlets with broken, missing, and/or cracked cover plates shall be:

i. Marked out of service in accordance with the requirements of NIST S 7101.73 until the repair is complete; and

ii. Submitted in an M-slip, or reported as soon as possible to the OFPM Service Desk for repair or replacement at the following numbers:

- Boulder: 303-497-3191
- Gaithersburg: 301-975-6928

(c) Per the requirements of Section 6.k(1), permanently installed electrical outlets located in wet or damp locations, and specifically within 6 feet of a water source[6], shall have GFCI protection.

(7) Electrical Panels

(a) The working space around electrical panels[7] shall be kept clear as outlined in NFPA 70, Article 110.

i. Electrical panels supplied by 150 volts or less shall have a minimum of 36 inches (0.91 m) of clearance in the direction of the panel.

ii. Electrical panels supplied by greater than 150 volts shall have a minimum of 42 inches (1.07 m) of clearance in the direction of the panel.

(b) Moveable objects (*e.g.*, furniture, equipment, materials) shall not be placed in front of electrical panels.

(c) The working space shall permit at least a 90-degree opening of hinged panels.

i. Only OFPM or OFPM Director-authorized individuals shall operate breakers inside of electrical panels.

b. Provision of Temporary Electrical Power

(1) Means of providing temporary electrical power (*e.g.*, use of extension cords) shall only be permitted for the following types of work:

(a) Renovation;

(b) Construction;

[6] Emergency eyewashes and safety showers are not considered water sources.
[7] It is presumed that electrical panels in NIST offices and office-like spaces are supplied by 150 volts or less.

(c) Maintenance;

(d) Repair;

(e) Testing; and

(f) In laboratory and R&D workspaces, please see Section 6.a.(3)(j)ii.

(2) When used in wet or damp locations and on construction sites, the method to provide temporary electrical power shall have ground fault circuit interrupter protection (GFCI).

c. Work on Electrical, Electronic, and Electro-Mechanical Equipment and Circuits

NOTES:

- Prior to reviewing Section 6.c, the reader must have an understanding of the content contained in Appendix B.
- The requirements found in Section 6.c must be incorporated into the appropriate risk assessment (*e.g.*, hazard review or job hazard analysis) in accordance with the requirements of NIST S 7101.20.
- Those conducting the risk assessment must be qualified, per the appropriate table in Section 6.c, and have a thorough understanding of the work planned to appropriately analyze for hazards and identify subsequent control measures. If they do not, a subject matter expert with the appropriate knowledge, skills, and abilities must be consulted, in accordance with NIST S 7101.20.
- As part of the risk assessment process, electrical hazards should be categorized based upon the energy source, type, and other characteristics. Section 6.c is laid out as follows:
  - Section 6.c(1): General work requirements regardless of hazard category or hazard class.

  The remaining sub-sections of Section 6.c provide general control measures, worker qualifications, and PPE type corresponding to specific hazard category, hazard class, and mode of electrical work.
  - Section 6.c(2): Alternating current (AC) sources, equipment, or systems that use 50-60 Hz;
  - Section 6.c(3): Direct current (DC) power sources;
  - Section 6.c(4): Capacitors;
  - Section 6.c(5): Batteries; and
  - Section 6.c(6): Radiofrequency.
- Special care must be taken during the risk assessment process to ensure all electrical hazards are identified as more than one may be present in performance

of the work. Example – a single piece of equipment may have multiple energy sources and the combination of hazards associated with those sources must be addressed by the appropriate controls in total.

- The requirements for the control measures identified in Sections 6.c(2) through 6.c(6) are found in subsequent sections:
  - Section 6.d: Establishment of an electrically safe working condition;
  - Section 6.e: Provision of an energized electrical work permit;
  - Section 6.f: Additional requirements for energized electrical work greater than 600 V (High-Voltage)
  - Section 6.g: Establishment of boundaries using barricades;
  - Section 6.h: Employment of a two-person work rule; and
  - Section 6.i: PPE and other protective equipment.

(1) General Requirements for Any Hazard Category or Hazard Class

(a) Work on electrical, electronic, and electro-mechanical equipment and circuits shall be planned and authorized in accordance with the requirements of NIST S 7101.20.

(b) Work on electrical, electronic, and electro-mechanical equipment and circuits ***should*** be performed under electrically safe working conditions, *i.e.*, de-energized state or Mode 0. Section 6.d provides requirements for establishing this condition.

(c) Work ***may*** be performed on electrical, electronic, and electro-mechanical equipment and circuits in an energized state, *i.e.*, energized electrical work.

i. Energized electrical work may be performed provided one of the following conditions are met:

(i) Energized electrical conductors and circuit parts to which workers could be exposed operate at less than 50 V AC or 100V DC and no other electrical hazards[8], *e.g.*, potential for electrical burns or explosion, exist;

(ii) It can be demonstrated to the responsible organizational unit (OU) line management that de-energizing would introduce additional hazards, would introduce increased risk, or could cause significant property damage or loss of critical data;

[8] Per DOE Handbook, Table E-1

(iii) It can be demonstrated to the responsible OU line management that performing the work in a de-energized state is infeasible (not just inconvenient) due to equipment design or operational limitations; or

(iv) The equipment is being operated as intended, *e.g.*, breakers, service disconnects, and the equipment, circuits, and upstream protective devices are known to be properly installed and maintained[9].

NOTE: Where it cannot be determined that the upstream protective devices are properly installed and maintained, they should only be operated with caution using appropriate PPE as determined by the hazard review process.

ii. Energized electrical work may be performed ***with*** and ***without*** an energized electrical work permit (EEWP) depending on the criteria noted in 6.c(1)(c) iii and iv below.

iii. Energized Electrical Work ***Not Requiring*** an EEWP

(i) The following energized electrical work may be performed ***without*** an EEWP:

- Performing diagnostics, testing, troubleshooting, or voltage measuring (*e.g.*, taking readings or measurements of electrical equipment with approved test equipment that do not require making any physical changes to the equipment);
- Performing thermography and visual inspections if the restricted approach boundary is not crossed;
- Performing tasks involving access to and egress from an area with energized electrical equipment or circuits if no energized electrical work is performed and the restricted approach boundary is not crossed; or
- Performing general housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed and all automatic/remotely activated controls are inhibited.

[9] "Properly installed and maintained" is defined by requirements found in NFPA 70E, NFPA 70B.

(ii) Staff performing energized electrical work ***without*** an EEWP shall:

- Be a qualified individual;
- Be trained on the appropriate safe work practices associated with the task(s); and
- Use the appropriate PPE as determined by the method used to authorize the work, please see Section 6.c(1)(a).

iv. Energized Electrical Work **Requiring** an EEWP

(i) In addition to the types of work identified in Tables 6.1 through 6.5 below, activities requiring a qualified person to work within the restricted approach boundary shall be conducted in accordance with the requirements of an authorized EEWP, please see Section 6.e.

(d) NIST staff members performing work on electrical, electronic, and electro-mechanical equipment or circuits shall:

i. Make a concerted effort to eliminate all unsafe conditions, behaviors, or attitudes in their own work and that of others they are working with;

ii. Consider participating in a pre-job briefing to understand thoroughly the work to be performed, including each worker's part in the work, hazards associated with the job, required control measures, and any other special precautions;

NOTE: Performing EEW using an EEWP requires a pre-job briefing.

iii. Be trained in and use all applicable control measures including required protective devices;

iv. Never distract the attention of another individual while they are performing electrical work;

v. Report all incidents and injuries to their supervisor; and

vi. Have their condition evaluated immediately by a medical professional if they receive an electrical shock or are exposed to an arc flash.

(e) When a new NIST staff member performs electrical work, or an existing NIST staff member performs work not previously performed, they shall work under the supervision of an experienced NIST staff member who will explain in detail the specific hazards of the work to be performed and the safety rules and procedures necessary to ensure their safety;

i. The new NIST staff member performing electrical work or the existing NIST staff member performing work not previously performed shall remain supervised until the experienced NIST staff member believes they have the knowledge, skills, and abilities to perform the work without supervision.

NOTE: Per NIST S 7101.20, authorization of a staff member to perform work is the responsibility of the supervisor. The supervisor may rely on others to assist in determining if the staff member is authorized to perform work, *e.g.*, the "experienced NIST staff member".

(2) Work Involving Hazard Category A: *AC Sources, Equipment, or Systems that Use 50-60 Hz*

Table 6.1 provides the minimum control measures, PPE, and training qualifications required when staff will be performing tasks involving Hazard Category A sources given different hazard classes and modes of electrical work. This information shall be incorporated into the appropriate hazard review or job hazard analysis.

NOTES:

- Most small appliances, hand tools, and portable laboratory equipment running from 120V wall supply falls under Hazard Category A, Hazard Class 2.a.
- UPSs fall under Hazard Category A, Hazard Class 2.a, but must be evaluated for Hazard Category B and D as well.
- Larger facility and laboratory equipment may use up to 480 V (Hazard Category A, Hazard Class 3.a and 3.b). Often, if it is a large switchgear, or has significant available fault current, it may be Hazard Class 4.

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Table 6.1: Minimum requirements for work involving Hazard Category A

Hazard Class	Hazard Sub-Class	Electrical Work Mode	Two-person work rule	Qualifications	Control Measures [1]	PPE[2]
1	Hazard Class 1.a <15 V	All	Alone	Limited-Scope Qualified	None	No specific ES PPE
	Hazard Class 1.b 15–50 V	All	Alone	Limited-Scope Qualified	None	No specific ES PPE
2	Hazard Class 2.a 50-250V Single Phase	0	Alone	Limited-Scope Qualified	LOTO and ZVV	Minimum ES PPE
		1	Alone		LOTO and ZVV	Shock PPE
		2	Alone		Barricade	
		3	Alone		EEWP	
	Hazard Class 2.b 208-300V Single Phase without arc flash hazard	0	Alone	Limited-Scope Qualified	LOTO and ZVV	Minimum ES PPE
		1	Alone		LOTO and ZVV	Shock PPE
		2	Alone		Barricade	
		3	Alone		EEWP	
3	Hazard Class 3.a 3-phase 208-300V with arc flash hazard	0	Alone	Comprehensive Qualified	LOTO and ZVV	Minimum ES PPE
		1	Alone		LOTO and ZVV	Shock PPE; Arc Flash PPE
		2	Alone		Barricade	
		3	Alone		EEWP	
	Hazard class 3.b 3-phase 301-750V	0	Alone	Comprehensive Qualified	LOTO and ZVV	Minimum ES PPE
		1	Standby Person		LOTO and ZVV	Shock PPE; Arc Flash PPE
		2	Safety Watch		Barricade	
		3	Safety Watch		EEWP	
4	Hazard class 4 3-phase >750V	0	Alone	High-Voltage Qualified	LOTO and ZVV	Minimum ES PPE
		1	Safety Watch		LOTO and ZVV	Shock PPE; Arc Flash PPE
		2	Safety Watch		Barricade	
		3	Safety Watch		EEWP	

Table notes:

1. Control Measures:
   a. These control measures are in addition to those determined during the risk assessment conducted in accordance with the requirement of NIST S 7101.20.
   b. LOTO and ZVV: Lockout/Tagout and Zero Voltage Verification. Please see Section 6.d for requirements to establish this electrically safe working condition.
   c. EEWP: Please see Section 6.c.
   d. Barricade: Please see Section 6.g.
   e. Hazard Class 3 and 4 assume potential arc flash hazard exists.
   f. The two-person work rule requirements for Standby Person or Safety Watch noted in the table above only apply per OSHA 1910.269 or when direct incident energy exposure is > 40 cal/cm^2. Otherwise, Standby Person or Safety Watch is not required, although it is recommended as a good practice. Exceptions to OSHA 1910.269 are provided in 1910.269(l)(2)(ii).

2. PPE
   a. "No specific ES PPE" means no specific electrical safety PPE is required, but the worker is required to wear other PPE as determined by the risk assessment.
   b. "Minimum ES PPE" means the worker is required to wear (1) a long sleeve shirt and pants that are **NOT** made from a flammable synthetic material, *e.g.*, acetate, nylon, polyester, polypropylene, or spandex either alone or in blends; (2) safety glasses; and (3) hearing protection per the requirements of NIST S 7101.55.
   c. "Shock PPE" means PPE is determined by performing a shock risk assessment using methods covered in Article 130 of NFPA 70E.
   d. "Arc Flash PPE" means PPE is determined by performing an arc flash risk assessment as discussed in NFPA 70E.

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(3) Work Involving Hazard Category B: *DC Power*

Table 6.2 provides the minimum control measures, PPE, and training qualifications required when staff will be performing tasks involving Hazard Category B sources given different hazard classes and modes of electrical work. This information shall be incorporated into the appropriate hazard review or job hazard analysis.

NOTES:

- DC power supplies need to be evaluated for both DC (Hazard Category B) and Capacitance (Hazard Category C).

663 **Table 6.2:** Minimum requirements for work involving Hazard Category B

Hazard Class	Hazard Sub-Class	Electrical Work Mode	Two-person work rule	Qualifications	Control Measures[1]	PPE[2]
1	Hazard Class 1.a <15 V, < 100 W	All	Alone	Limited-Scope Qualified	None	No specific ES PPE
	Hazard Class 1.b < 100V, ≤1KW; or >100V, ≤40mA	All	Alone	Limited-Scope Qualified	None	No specific ES PPE
2	Hazard Class 2.a ≤ 15V, >1KW	0	Alone	Limited-Scope Qualified	None	No specific ES PPE
		1	Alone			
		2	Alone			
		3	Alone			
	Hazard Class 2.b 15-100V, >1KW	0	Alone	Limited-Scope Qualified	None	No specific ES PPE
		1	Alone			
		2	Alone			
		3	Alone			
	Hazard Class 2.c ≥100-400V, 40 mA-500 A	0	Alone	Comprehensive Qualified	LOTO and ZVV	Minimum ES PPE
		1	Alone		LOTO and ZVV	Shock PPE
		2	Alone		Barricade	
		3	Alone		EEWP	
	Hazard Class 2.d >400V, 40-200 mA	0	Alone	Comprehensive Qualified	LOTO and ZVV	Minimum ES PPE
		1	Alone		LOTO and ZVV	Shock PPE
		2	Alone		Barricade	
		3	Alone		EEWP	
3	Hazard Class 3.a 100-400V, >500 A	0	Alone	Comprehensive Qualified	LOTO and ZVV	Minimum ES PPE
		1	Alone		LOTO and ZVV	Shock PPE; Arc Flash PPE
		2	Alone		Barricade	
		3	Alone		EEWP	
	Hazard Class 3.b ≥400v, 200 mA- 500 A	0	Alone	Comprehensive Qualified	LOTO and ZVV	Minimum ES PPE
		1	Standby Person		LOTO and ZVV	Shock PPE; Arc Flash PPE
		2	Safety Watch		Barricade	
		3	Safety Watch		EEWP	
4	Hazard Class 4 >400 V, >500 A	0	Alone	Comprehensive Qualified	LOTO and ZVV	Minimum ES PPE
		1	Standby Person		LOTO and ZVV	Shock PPE; Arc Flash PPE
		2	Safety Watch		Barricade	
		3	Safety Watch		EEWP	

Table notes:

1. Control Measures:
   a. These control measures are in addition to those determined during the risk assessment conducted in accordance with the requirement of NIST S 7101.20.
   b. LOTO and ZVV: Lockout/Tagout and Zero Voltage Verification. Please see Section 6.d for requirements to establish this electrically safe working condition.
   c. EEWP: Please see Section 6.c.
   d. Barricade: Please see Section 6.g.
   e. The two-person work rule requirements for Standby Person or Safety Watch noted in the table above only apply per OSHA 1910.269 or when direct incident energy exposure is > 40 cal/cm^2. Otherwise, Standby Person or Safety Watch is not required, although it is recommended as a good practice. Exceptions to OSHA 1910.269 are provided in 1910.269(l)(2)(ii).

2. PPE
   a. "No specific ES PPE" means no specific electrical safety PPE is required, but the worker is required to wear other PPE as determined by the risk assessment.

b. "Minimum ES PPE" means the worker is required to wear (1) a long sleeve shirt and pants that are **NOT** made from a flammable synthetic material, *e.g.*, acetate, nylon, polyester, polypropylene, or spandex either alone or in blends; (2) safety glasses; and (3) hearing protection per the requirements of NIST S 7101.55.
c. "Shock PPE" means PPE is determined by performing a shock risk assessment using methods covered in Article 130 of NFPA 70E.
d. "Arc Flash PPE" means PPE is determined by performing an arc flash risk assessment as discussed in NFPA 70E.

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(4) Work Involving Hazard Category C: *Capacitors*

Tables 6.3a and 6.3b provides the minimum control measures, PPE, and training qualifications required when staff will be performing tasks involving Hazard Category C sources given different hazard classes and modes of electrical work. This information shall be incorporated into the appropriate hazard review or job hazard analysis.

672 **Table 6.3a:** Minimum requirements for work involving Hazard Category C - Capacitors < 400 V

Hazard Class	Hazard Sub-Class	Electrical Work Mode	Two-person work rule	Qualifications	Control Measures[1]	PPE[2]	Stored Energy Removal[3]
1	Hazard Class 1.b 100-399 V, < 10 J	All	Alone	Limited-Scope Qualified	None	No specific ES PPE	None
2	Hazard Class 2.a <100 V, 100 J – 999 J	0	Alone	Limited-Scope Qualified; Capacitor Safety Qualified	LOTO and ZVV	Safety Glasses	None
		1					Hard Ground Hook
		2					Hard Ground Hook
		3					Hard Ground Hook
	Hazard Class 2.b 100-399 V, 10 J – 99 J	0	Alone	Comprehensive Qualified; Capacitor Safety Qualified	LOTO and ZVV	Minimum ES PPE	None
		1	Alone		LOTO and ZVV	Shock PPE	Hard Ground Hook
		2	Alone		Barricade	Shock PPE	Hard Ground Hook
		3	Alone		EEWP	Shock PPE	Hard Ground Hook
3	Hazard Class 3.a < 100V, 1 kJ – 9.9 kJ	0	Alone	Comprehensive Qualified; Capacitor Safety Qualified	LOTO and ZVV	Minimum ES PPE	None
		1	Alone		LOTO and ZVV	Shock PPE	Soft ground hook > 1 kJ
		2	Alone		Barricade	Shock PPE	Soft ground hook > 1 kJ
		3	Alone		EEWP	Shock PPE	Soft ground hook > 1 kJ
	Hazard class 3.b 100-399 V, 100 J – 9.9 kJ	0	Alone	Comprehensive Qualified; Capacitor Safety Qualified	LOTO and ZVV	Minimum ES PPE	None
		1	Alone		LOTO and ZVV	Shock PPE	Soft ground hook > 1 kJ
		2	Alone		Barricade	Shock PPE	Soft ground hook > 1 kJ
		3	Alone		EEWP	Shock PPE	Soft ground hook > 1 kJ
4	Hazard class 4.a < 100 V, ≥ 10 kJ	0	Alone	Comprehensive Qualified; Capacitor Safety Qualified	LOTO and ZVV	Minimum ES PPE	None
		1	Standby Person		LOTO and ZVV	Shock PPE	Remote soft ground
		2	Safety Watch		Barricade	Shock PPE	Remote testing
		3	Safety Watch		EEWP	Shock PPE	Remote testing
	Hazard class 4.b 100-399V, ≥ 10kJ	0	Alone	Comprehensive Qualified; Capacitor Safety Qualified	LOTO and ZVV	Minimum ES PPE	None
		1	Standby Person		LOTO and ZVV	Shock PPE; Arc Flash PPE	Remote soft ground
		2	Safety Watch		Barricade	Shock PPE; Arc Flash PPE	Remote testing
		3	Safety Watch		EEWP	Shock PPE; Arc Flash PPE	Remote testing

Table notes:
1. Control Measures:
   a. These control measures are in addition to those determined during the risk assessment conducted in accordance with the requirement of NIST S 7101.20.
   b. LOTO and ZVV: Lockout/Tagout and Zero Voltage Verification. Please see Section 6.d for requirements to establish this electrically safe working condition.
   c. EEWP: Please see Section 6.c.
   d. Barricade: Please see Section 6.g.
   e. The two-person work rule requirements for Standby Person or Safety Watch noted in the table above only apply per OSHA 1910.269 or when direct incident energy exposure is > 40 cal/cm^2. Otherwise, Standby Person or Safety Watch is not required, although it is recommended as a good practice. Exceptions to OSHA 1910.269 are provided in 1910.269(l)(2)(ii).

NOTE: For Hazard Class 4, Modes 2 and 3, work should be avoided or performed remotely.

2. PPE
   a. "No specific ES PPE" means no specific electrical safety PPE is required, but the worker is required to wear other PPE as determined by the risk assessment.
   b. "Minimum ES PPE" means the worker is required to wear (1) a long sleeve shirt and pants that are **NOT** made from a flammable synthetic material, *e.g.*, acetate, nylon, polyester, polypropylene, or spandex either alone or in blends; (2) safety glasses; and (3) hearing protection per the requirements of NIST S 7101.55.
   c. "Shock PPE" means PPE is determined by performing a shock risk assessment using methods covered in Article 130 of NFPA 70E.
   d. "Arc Flash PPE" means PPE is determined by performing an arc flash risk assessment as discussed in NFPA 70E.

3. Stored Energy Removal - a method used to discharge lower-energy capacitors or apply a safety ground on higher-energy capacitors.
   a. "Remote soft ground" means using engineering methods to discharge and verify the capacitors without worker exposure (*e.g.*, a capacitor remote dump or discharge system). Refer NFPA 70E (latest version) Annex R for additional information.
   b. "Remote testing" means using sensors and instruments that are placed during a Mode 0 condition, then observed from a safe location during Mode 2 work.
   c. Ratings for ground hooks should exceed maximum stored energy values.

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674 **Table 6.3b:** Minimum requirements for work involving Hazard Category C – Capacitors ≥ 400 V

Hazard Class	Hazard Sub-Class	Electrical Work Mode	Two-person work rule	Qualifications	Control Measures[1]	PPE[2]	Stored Energy Removal[3]
1	Electro-static Discharge (ESD)	All	Alone	Limited-Scope Qualified	None	No specific ES PPE	None
	Hazard Class 1 ≥ 400 V, < 10 J	All	Alone	Limited-Scope Qualified	None	No specific ES PPE	Hard ground
2	Hazard Class 2 ≥ 400 V, 10 J – 49 J	0	Alone	Comprehensive Qualified; Capacitor Safety Qualified	LOTO and ZVV	Minimum ES PPE	
		1	Alone		LOTO and ZVV	Shock PPE	Hard ground
		2	Standby		Barricade	Shock PPE	
		3	Safety Watch		EEWP	Shock PPE	
3	Hazard Class 3.a ≥ 400 V, 50 J – 999 J	0	Alone	Comprehensive Qualified; Capacitor Safety Qualified	LOTO and ZVV	Minimum ES PPE	
		1	Standby Person		LOTO and ZVV	Shock PPE	Hard ground
		2	Safety Watch		Barricade	Shock PPE	
		3	**Do not proceed with this mode of work**				
	Hazard Class 3.b ≥ 400 V, 1 kJ – 9.9 kJ	0	Alone	High-Voltage Qualified; Capacitor Safety Qualified	LOTO and ZVV	Minimum ES PPE	
		1	Standby Person		LOTO and ZVV	Shock PPE	Soft ground hook rated appropriately
		2	Safety Watch		Barricade	Shock PPE	
		3	**Do not proceed with this mode of work**				
4	Hazard Class 4 ≥ 400 V, > 10 kJ	0	Alone	High-Voltage Qualified; Capacitor Safety Qualified	LOTO and ZVV	Minimum ES PPE	
		1	Alone		LOTO and ZVV	Shock PPE; Arc Flash PPE; Hearing protection	Soft ground hook rated appropriately
		2	Standby Person		Barricade	Shock PPE; Arc Flash PPE; Hearing protection	Remote testing
		3	**Do not proceed with this mode of work**				

Table notes:

1. Control Measures:
   a. These control measures are in addition to those determined during the risk assessment conducted in accordance with the requirement of NIST S 7101.20.
   b. LOTO and ZVV: Lockout/Tagout and Zero Voltage Verification. Please see Section 6.d for requirements to establish this electrically safe working condition.
   c. EEWP: Please see Section 6.c.
   d. Barricade: Please see Section 6.g.
   e. The two-person work rule requirements for Standby Person or Safety Watch noted in the table above only apply per OSHA 1910.269 or when direct incident energy exposure is > 40 cal/cm^2; otherwise, Standby Person or Safety Watch is not required, although it is recommended as a good practice. Exceptions to OSHA 1910.269 are provided in 1910.269(l)(2)(ii).
2. PPE
   a. "No specific ES PPE" means no specific electrical safety PPE is required, but the worker is required to wear other PPE as determined by the risk assessment.
   b. "Minimum ES PPE" means the worker is required to wear (1) a long sleeve shirt and pants that are **NOT** made from a flammable synthetic material, *e.g.*, acetate, nylon, polyester, polypropylene, or spandex either alone or in blends; (2) safety glasses; and (3) hearing protection per the requirements of NIST S 7101.55.
   c. "Shock PPE" means PPE is determined by performing a shock risk assessment using methods covered in Article 130 of NFPA 70E.
   d. "Arc Flash PPE" means PPE is determined by performing an arc flash risk assessment as discussed in NFPA 70E.

3. Stored Energy Removal - a method used to discharge lower-energy capacitors or apply a safety ground on higher-energy capacitors.
   a. "Hard ground" means the practice of shorting a capacitor from terminal to terminal and then directly to ground. See NFPA 70E Annex R for further information.
   b. "Remote testing" means using sensors and instruments that are placed during a Mode 0 condition, then observed from a safe location during Mode 2 work.
   c. Ratings for ground hooks should exceed maximum stored energy values.

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(5) Work Involving Hazard Category D: *Batteries*

Tables 6.4a and 6.4b provides the minimum control measures, PPE, and training qualifications required when staff will be performing tasks involving Hazard Category D sources given different hazard classes and modes of electrical work. This information shall be incorporated into the appropriate hazard review or job hazard analysis.

NOTES:

- For greater than 100 VDC, use Hazard Class 2 to categorize the shock hazard.
- For battery banks greater than 100 VDC, break up bank for energized work, when possible. Review NFPA 70E for additional information.

689 **Table 6.4a:** Minimum requirements for work involving Hazard Category D, Lead Acid < 100 V DC

Hazard Class	Hazard Sub-Class	Electrical Work Mode	Two-person work rule	Qualifications	Control Measures[1]	PPE[2]
1	Hazard Class 1.a <100W	All	Alone	Limited-Scope Qualified	None	No specific ES PPE; Eye Protection; No jewelry; Special Battery Tools
	Hazard Class 1.b 100W-1000W	All	Alone	Limited-Scope Qualified	None	No specific ES PPE; Eye Protection; No jewelry; Special Battery Tools
2	Hazard Class 2 1-30 kW	2	Alone	Limited-Scope Qualified	None	No specific ES PPE; Eye Protection; No jewelry; Special Battery Tools
			Alone			
		3	Alone			
			Alone			
3	Hazard Class 3 >30KW	2	Alone	Limited-Scope Qualified	None	No specific ES PPE; Eye Protection; No jewelry; Special Battery Tools
			Alone			
		3	Alone			
			Alone			

Table notes:
1. Control Measures:
   a. These control measures are in addition to those determined during the risk assessment conducted in accordance with the requirement of NIST S 7101.20.

2. PPE
   a. "No specific ES PPE" means no specific electrical safety PPE is required, but the worker is required to wear other PPE as determined by the risk assessment.

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691 **Table 6.4b:** Minimum requirements for work involving Hazard Category D, Lithium Ion < 100 V DC

Types of Cells	Electrical Work Mode	Two-person work rule	Qualifications	Control Measures[1]	PPE[2]
Commercial	All modes	Alone	Limited-Scope Qualified	Charge per manufacturer's instructions using supplied charger	No specific ES PPE; Eye Protection; No jewelry; Special Battery Tools
Single Cell	All modes	Alone	Limited-Scope Qualified	Charge per manufacturer's instructions using supplied charger	No specific ES PPE; Eye Protection; No jewelry; Special Battery Tools
Multiple Cell	All modes	Alone	Limited-Scope Qualified	Charge per manufacturer's instructions using supplied charger; Containment; Monitor temperature using thermocouples	No specific ES PPE; Eye Protection; No jewelry; Special Battery Tools

Table notes:
1. Control Measures:
   a. These control measures are in addition to those determined during the risk assessment conducted in accordance with the requirement of NIST S 7101.20.

2. PPE
   a. "No specific ES PPE" means no specific electrical safety PPE is required, but the worker is required to wear other PPE as determined by the risk assessment.

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693 (6) Work Involving Hazard Category E: *Radio Frequency*
694 Table 6.5 provides the minimum control measures, PPE, and training qualifications
695 required when staff will be performing tasks involving Hazard Category E sources given
696 different hazard classes and modes of electrical work. This information shall be
697 incorporated into the appropriate hazard review or job hazard analysis.
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700 **Table 6.5:** Minimum requirements for work involving Hazard Category E, RF Circuits

Hazard Class	Hazard Sub-Class	Electrical Work Mode	Two-person work rule.	Qualifications	Control Measures[1]	PPE[2]
1	Hazard Class 1 ≤50 V, ≤1 kW or >50 V, ≤5 mA	All	Alone	Limited-Scope Qualified	None	No specific ES PPE
2	Hazard Class 2.a ≤50 V, >1 kW	All	Alone	Limited-Scope Qualified	None	No specific ES PPE
	Hazard Class 2.b 50-250V, > 5 mA	0	Alone	Comprehensive Qualified	LOTO and ZVV	Minimum ES PPE
		1	Alone		LOTO and ZVV	Shock PPE
		2	Alone		Barricade	
		3	Alone		EEWP	
	Hazard Class 2.c >250V, 5 mA – 75 mA	0	Alone	Comprehensive Qualified	LOTO and ZVV	Minimum ES PPE
		1	Alone		LOTO and ZVV	Shock PPE
		2	Alone		Barricade	
		3	Alone		EEWP	
3	Hazard Class 3 >250 V, 75 mA – 500 mA	0	Alone	Comprehensive Qualified	LOTO and ZVV	Minimum ES PPE
		1	Alone		LOTO and ZVV	Shock PPE; Arc Flash PPE
		2	Alone		Barricade	
		3	Alone		EEWP	
4	Hazard Class 4 >250 V, >500 A	0	Alone	Comprehensive Qualified.	LOTO and ZVV	Minimum ES PPE
		1	Standby Person		LOTO and ZVV	Shock PPE; Arc Flash PPE
		2	Safety Watch		Barricade	
		3	Safety Watch		EEWP	

Table notes:

1. Control Measures:
   a. These control measures are in addition to those determined during the risk assessment conducted in accordance with the requirement of NIST S 7101.20.
   b. LOTO and ZVV: Lockout/Tagout and Zero Voltage Verification. Please see Section 6.d for requirements to establish this electrically safe working condition.
   c. EEWP: Please see Section 6.c.
   d. Barricade: Please see Section 6.g.
   e. The two-person work rule requirements for Standby Person or Safety Watch noted in the table above only apply per OSHA 1910.269 or when direct incident energy exposure is > 40 cal/cm^2. Otherwise, Standby Person or Safety Watch is not required, although it is recommended as a good practice. Exceptions to OSHA 1910.269 are provided in 1910.269(l)(2)(ii).

2. PPE
   a. "No specific ES PPE" means no specific electrical safety PPE is required, but the worker is required to wear other PPE as determined by the risk assessment.
   b. "Minimum ES PPE" means the worker is required to wear (1) a long sleeve shirt and pants that are **NOT** made from a flammable synthetic material, *e.g.*, acetate, nylon, polyester, polypropylene, or spandex either alone or in blends; (2) safety glasses; and (3) hearing protection per the requirements of NIST S 7101.55.
   c. "Shock PPE" means PPE is determined by performing a shock risk assessment using methods covered in Article 130 of NFPA 70E.
   d. "Arc Flash PPE" means PPE is determined by performing an arc flash risk assessment as discussed in NFPA 70E.

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d. Establishment of an Electrically Safe Working Condition, *i.e.*, achieving Mode 0
The preferred approach for working on electrical, electronic, and electro-mechanical equipment and circuits should always be to avoid electrical hazards altogether by creating an electrically safe work condition, *i.e.*, de-energized. This is a state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged, tested to ensure the absence of voltage, and grounded if determined necessary.

NOTE: De-energizing an electrical conductor or circuit part is a potentially hazardous task.

(1) The procedure to de-energize electrical, electronic, and electro-mechanical equipment and circuits shall require:

(a) A risk assessment conducted in accordance with NIST S 7101.20.

(b) Electrical LOTO.

i. Electrical LOTO shall be conducted in accordance with the requirements of NIST S 7101.56;

ii. Electrical LOTO shall be performed only by an individual with the appropriate qualifications for the work to be performed.

iii. When applicable, OUs shall establish energy-control procedures (including required worker training and PPE) prior to conducting servicing or maintenance on equipment where the unexpected energizing, startup, or release of stored energy could occur and cause injury.

(c) Zero Voltage Verification
The following requirements for verifying the de-energized condition shall be met before any equipment can be considered and worked on as de-energized:

i. An individual qualified appropriately per this suborder shall use adequately rated portable test equipment (*e.g.*, multimeter, voltmeter) to verify that electrical parts of equipment and circuit elements to which employees and/or associates will be exposed are de-energized.

ii. An individual qualified appropriately per this suborder shall use adequately rated portable test equipment (*e.g.*, multimeter, voltmeter) to determine if any energized condition exists because of inadvertently induced voltage or

unrelated voltage back-feed even though specific parts of the circuit have been de-energized and presumed to be safe.

iii. An adequately rated voltmeter or multimeter on the appropriate range/scale shall be used to verify zero volts phase-to-phase and phase-to-ground for all source phases. Testing shall be as follows:

(i) Test the meter on a known source of the same voltage as that being verified for zero electrical volts;

(ii) Test for zero electrical volts; and

(iii) Test the meter again on a known source of the same voltage as that being verified for zero electrical volts.

iv. Proximity testers or "tic tracers" shall **not** be used to verify zero volts in the performance of electrical LOTO except for voltages over 1000 volts.

(i) For voltages at or below 1000 volts, proximity testers or "tic tracers" may be used to perform "prechecks" for zero voltage verification prior to using an appropriately rated measurement device or instrument to perform zero voltage verification.

(2) A Safety Watch shall be required to establish an electrically safe working condition, *i.e.*, de-energized, for a system greater than 600 VAC. Please see Section 6.h(2) for Safety Watch requirements.

(3) Work on cord-and-plug-connected electrical equipment is exempt from the requirements of Section 6.d provided all the following conditions are met:

(a) The equipment has a single energy source;

(b) All hazardous energy to which workers could be exposed can be controlled by unplugging the equipment; and

(c) The plug is under exclusive control of the worker servicing or maintaining the equipment.

e. Provision of an Energized Electrical Work Permit

If working on electrical, electronic, and electro-mechanical equipment and circuits cannot be done in a de-energized state, the approach is to create an environment that eliminates or minimizes the potential for exposure, including but not limited to guarding, clearances, and use of PPE. The required controls shall be determined through completion, approval, and implementation of the NIST Form 380 – *Energized Electrical Work Permit* (please see Appendix C).

NOTE: Section 6.c(1)(c)iii describes energized electrical work which may be performed without an EEWP.

(1) Required Information on NIST Form 380 – *Energized Electrical Work Permit*.

(a) Part A. Work Order or Contract Details

i. The work order or contract number (if applicable);

ii. Location of the work to be performed;

iii. Date of Request

iv. Description of the electrical equipment and/or circuit; and

v. Description of the task including task steps outlined as necessary.

(b) Part B. Justification for Energized Work

Applicable sections shall be completed.

i. Description of why de-energizing the equipment or circuit introduces additional hazards, introduces increased risk, or could cause significant property damage or loss of critical data; or

ii. Description of why de-energizing the equipment or circuit is infeasible (not just inconvenient) due to equipment design or operational limitations; or

iii. Indication of why an outage cannot be performed and the name of the individual who denied the outage request.

(c) Part C. Requestor

i. Indicate the person requesting the EEWP.

(d) Part D. Qualified Person

i. Indicate the Qualified Person(s) who will perform the work.

(e) Part E. Supervisor of Qualified Person or Contractor Officer's Representative

i. Indicate the supervisor of the Qualified Person(s) who will perform the work. If work is to be performed by a non-R&D contractor, provide the name of the Contractor Officer's Representative (COR).

(f) Part F. Hazard Analysis

i. Indicate relevant information pertaining to the hazard analysis of the work to be performed (*e.g.*, energized exposure hazard, shock hazard analysis, flash hazard analysis, PPE requirements, individual who performed the hazard analysis).

NOTE: Individual must have fluent knowledge of NFPA 70, NFPA 70E, 29 CFR 1910 (Subpart S), and 29 CFR 1926 (Subpart K).

(g) Part G. Safety Review and Approval

i. Indicate the individual who reviewed the hazard analysis and the result of the review (*i.e.*, approved or disapproved and any comments).

(i) The NIST AHJ may delegate this responsibility to a NIST staff member provided the staff member:

- Has fluent knowledge of NFPA 70, NFPA 70E, 29 CFR 1910 (Subpart S), and 29 CFR 1926 (Subpart K);
- Was not involved with the development of the Hazard Analysis (Part F): and
- Is not performing the work.

(h) Part H. Energized Electric Work Permit Authorization

i. Indicate the individual who authorizes the work. If work is to be performed by a non-R&D contractor, this shall be the OFPM Director.

(i) Part I. Attachments (Optional)

i. Indicate any attachments that were used as part of the hazard analysis or in authorizing the work.

(j) Part J. Notes (Optional)

i. Provide any notes related to the work either before or after completion.

(k) Part K. Pre-Work Briefing Attendees

i. Indicate all individuals who attended the pre-work briefing.

(2) Just prior to beginning the authorized energized electrical work, a pre-work meeting shall be held by the first-level supervisor or designee with all personnel participating in the work present.

(a) The following shall be reviewed:

i. The contents of the authorized NIST-380 form;

ii. Work steps;

iii. Job/worksite specific hazards; and

iv. Any other relevant safety documents or precautions.

(b) All those in attendance shall sign the NIST 380 indicating they attended the pre-work briefing (Part K).

(3) The authorized NIST-380 form shall be located at the work site for the duration of the work.

(4) Any general comments or issues encountered during the energized electrical work shall be noted on the authorized NIST-380 form (Part J) so that appropriate revisions to planning and implementation of future energized electrical work can be made.

(5) Hard or electronic copies of authorized NIST-380 forms shall be kept by the OUs for a minimum of 1 year from the completion of the work.

(6) Insulated Tool Requirements for Energized Electrical Work

(a) Insulated tools used for energized electrical work shall meet the requirements of ASTM F 1505.

(b) The appropriate insulated tools shall be identified and documented in the hazard analysis.

(c) Insulated tools shall be inspected prior to use each day.

(d) Insulated tools found to be damaged shall be taken out of service in accordance with the requirements of NIST S 7101.73 Out of Service.

i. If the tool cannot be repaired, it shall be disposed of appropriately.

ii. If the tool is to be repaired, it shall be immediately tagged out of service in accordance with the requirements of NIST S 7101.73 Out of Service until the repair is complete.

f. Additional Requirements for Energized Electrical Work Greater than 600 V (High-Voltage)
In addition to meeting the requirements established in Section 6.e (e.g., requirements for EEWP), the following requirements shall also be met for energized electrical work greater than 600 V.

(1) General Precautions

(a) Only a High-Voltage Qualified individual (by training) shall be assigned to work on high-voltage equipment.

i. Non-qualified individuals in training may be allowed to work on energized equipment only under the direct supervision of a High-Voltage Qualified individual as part of on-the-job training.

(b) All operation or maintenance activities involving potential exposure or contact with energized utility equipment shall require two High-Voltage Qualified individuals at the work site, *i.e.*, a Safety Watch is required (please see Section 6.h(2) for requirements).

(c) Keep all gates and doors to enclosures containing high-voltage equipment closed and if practicable, locked at all times when they are not occupied by one or more High-Voltage Qualified individuals.

(d) Prior to entering any open electrical cabinet or metal clad switchgear, personnel wearing the appropriate PPE in accordance with the EEWP shall test all components within the cabinet to determine the energized status of those components.

(2) Switchyards and Substations

(a) Only High-Voltage Qualified individuals shall enter switchyards or substations unless escorted by a High-Voltage Qualified individual.

(b) Unqualified personnel entering switchyards or substations shall:

i. Be escorted by a High-Voltage Qualified individual;

ii. Be briefed on the hazards associated with the switchyard or substation prior to entry; and

iii. Comply with all instructions given by the High-Voltage Qualified individual.

(c) Substations and switchyards shall not be used for storage of combustible material.

(d) Materials and tools of any sort shall not be carried on the shoulder when inside the fence of a substation or switchyard.

i. Long material, including lumber and ladders, shall be carried in a horizontal position.

(3) Switchgear

(a) All ungrounded metal parts and devices on switchboards shall be handled as if they were operating at the highest voltage.

(b) Switchgear circuits shall be de-energized for cleaning and dusting of the switchgear.

(c) The secondary circuits of a current transformer shall not be opened or left open while the primary circuit is energized. Grounding via shorting blocks is required for current transformers.

(4) Cables rated from 600 volts to 69 kV

(a) The outer insulation of cables rated from 600 volts to 69 kV shall be considered an exposed energized source until the cable is deenergized and verified to be deenergized.

(5) Manhole and Cable Vaults

(a) Entry into electrical manholes and cable vaults containing cables rated from 600 volts to 69 kV, *e.g.*, energized feeder, shall require a confined space permit in accordance with NIST S 7101.57.

(b) Entry into electrical manholes and cable vaults having at least one energized feeder shall require an EEWP and the following:

i. PPE in accordance with the permit requirements;

ii. Constant ventilation;

iii. All energized feeder splices shall be protected with an arc flash blanket, as necessary with a minimum kA rating per the EEWP; and

iv. All areas of energized cables rated from 600 volts to 69 kV where workers could come into contact shall be protected by use of shock protection blankets as necessary.

(c) Prior to entry into electrical manholes, a documented pre-work briefing shall be held on-site with all participants per the EEWP.

(6) Work Performed Outdoors

(a) All operating equipment shall be kept a minimum distance of 3.7 m (12 ft) from overhead power lines or other exposed high-voltage equipment.

i. Exception – High-Voltage Qualified individuals working from an insulated bucket truck rated for the voltage to be encountered are not required to be 12 ft from overhead lines.

(7) High-Voltage Equipment and Tool Maintenance

(a) Grounding and Bonding Equipment

NOTE**:** The effectiveness of these devices depends on the integrity of the electrical contact surfaces, the cable stranding, and the clamping mechanism.

i. Care shall be taken to prevent damage to the cable and the clamping mechanism. These devices shall be stored separately to avoid kinking the cable.

ii. Contact surfaces and threads shall always be kept clean per manufacturers recommendations. Heavily oxidized or tarnished contact surfaces can present excessive contact resistance. Poor contact surfaces can compromise safety in the event of a line fault.

iii. These devices shall be inspected for strand breakage especially around the areas where the ferrule is crimped to the cable, for tightness of the cable terminal to the clamp body, and for condition of the threads for smooth operation and clean surfaces.

iv. Grounding and bonding equipment shall be tested by a certified testing company if the insulation properties are suspect.

(b) Live-Line Tools

i. Rods and tubes shall meet the requirements of ASTM F 711.

ii. Weather conditions materially affect the safety of hot line work. For this reason, live-line tools shall be kept in proper containers for transporting them to and from job locations.

iii. Hot sticks shall be inspected visually before use. If any defects are noted, the sticks shall be tagged as out of service in accordance with NIST S 7101.73 and returned to the OFPM electric shop for repair and testing.

iv. Hot sticks shall be tested by a certified testing company as per OSHA 1926.957.

v. The outer surfaces of hot sticks shall be cleaned before and after use and whenever they appear dirty.

vi. When not in use, insulating tools should be stored where they will remain dry and clean and they are not subjected to abuse or direct sunlight.

vii. Wood insulating tools are prohibited.

viii. Insulating tools used for energized-line maintenance should be placed on clean, dry tarpaulins, moisture proof blankets, or tool racks. They may also be leaned against dry supports. The tools should not be laid on the ground because of possible contamination, damage, or wetting.

ix. When transporting insulating tools, ventilated containers should be provided to prevent damage to the surfaces of the individual tools, or the tools should be mounted on racks in trucks or trailers. These racks should be well padded and constructed so that the tools are held firmly in place.

x. Live-line tools used for primary worker protection shall follow the requirements of OSHA 1926.957.

g. Establishment of Boundaries using Barricades.

(1) Barricades such as tape and signage, shall be:

(a) Used where it is necessary to prevent or limit access to work areas when exposure to non-insulated energized conductors or circuit parts is possible; and

(b) Installed no closer than the limited approach boundary or the arc flash boundary, whichever is greater.

(2) While the barricade is being installed:

(a) The restricted approach boundary distance shall be maintained;

(b) The energized conductors or circuit parts shall be placed in an electrically safe work condition; or

(c) Appropriate PPE shall be worn to install barricade.

h. Employment of a Two-Person Work Rule

(1) A Standby Person shall be required as determined in the tables in Section 6.c.

(a) The Standby Person:

i. ***Should*** have the same qualifications required for the electrical worker performing the work;

ii. Shall have no other duties that preclude them from continually observing the work being performed;

iii. Shall remain in visual and audible contact with the qualified worker performing the task; and

iv. Shall know the location of the nearest phone and how to alert emergency response personnel.

(b) If the Standby Person does not have the same qualifications required for the electrical worker performing the work, they shall remain outside of the limited approach boundary or arc flash boundary.

(2) A Safety Watch shall be required as determined by the tables in Section 6.c.

(a) The individual performing the Safety Watch shall:

i. Have the same qualifications required for the electrical work;

ii. Ensure boundaries are properly barricaded and controlled, *i.e.*, only qualified workers shall enter the boundary;

iii. Have no other duties that preclude continually observing, coaching, and closely monitoring the progress of the work;

iv. Wear PPE appropriate to the hazard and the distance from the work in progress;

v. Be trained on how to de-energize equipment being worked on; and

vi. Know the location of the nearest phone and how to alert emergency response personnel.

NOTE: While not a requirement, it would be a best practice to have staff trained in CPR.

(b) Employment of the two-person rule shall not be required when the working environment is free from all electrical hazards and establishment of an electrically safe working condition has been achieved.

i. Personal Protective Equipment (PPE) and Other Protective Equipment

(1) PPE and other protective equipment (*e.g.*, insulating blankets, matting, and covers) shall be:

(a) Determined as part of the hazard analysis associated with the risk assessment for the work being conducted (*i.e.*, specified in the hazard review, job hazard analysis, and where applicable the EEWP); and

(b) Comply with the requirements of NFPA 70E.

(2) All PPE and other protective equipment shall be used, maintained, and stored in accordance with the manufacturer's instructions.

(3) All PPE and other protective equipment shall be inspected for damage or defects before each day's use and immediately following any incident that could have caused damage.

(a) PPE and other protective equipment found to be damaged or defective shall be taken out of service immediately in accordance with the requirements of NIST 7191-73.

i. If the PPE or other protective equipment cannot be repaired, it shall be disposed of appropriately.

ii. If the PPE or other protective equipment is to be repaired, it shall be immediately tagged out of service until the repair is complete.

(4) Head Protection

(a) Nonconductive head protection shall be worn whenever there is danger of head injury from electric shock or burn due to contact with exposed energized parts .

(b) The hard hat shall meet the requirements of ANSI Z89.1.

(c) The appropriate class of hard hat (Class E or G) shall be determined as part of the hazard analysis associated with the risk assessment for the work being performed.

(5) Face Protection

(a) Face shields shall be required whenever there is danger of injury to the face from electric arcs or flashes or from flying objects resulting from electrical explosion.

(b) The face shield shall meet the requirements of ASTM F2178.

(c) The face shield shall have an arc rating suitable for the arc-flash exposure. Where the back of the head is inside the arc flash boundary, a balaclava or arc flash hood shall be required for full head and neck protection.

(6) Eye Protection

(a) Safety glasses shall be required at all times while electrical work is being performed inside the limited approach boundary, restricted approach boundary, or arc flash boundary.

i. Safety glasses shall be required even if a face shield is worn.

(b) Safety eyeglasses shall have side shields and non-conductive frames that are compliant with ANSI Z87.1.

(7) Hearing Protection

(a) Hearing protection shall be worn when performing tasks within any arc flash boundary.

(8) Clothing

(a) When performing energized electrical work, clothing made from flammable synthetic materials that melt at temperatures below 315°C (600°F), *e.g.*, acetate, nylon, polyester, polypropylene, or spandex either alone or in blends, shall not be worn.

(b) When performing high-voltage work, all clothing worn above the waist shall be selected in accordance with NFPA 70E and be a minimum of PPE Category 1.

(c) Arc Rated (AR) clothing shall meet ASTM F1506.

(d) Clothing contaminated with grease, oil, or flammable liquids or combustible materials shall not be worn to perform electrical work.

(9) Hand Protection

(a) Insulated gloves shall meet the requirements of ASTM D120.

i. Staff shall visually examine and air test their gloves (*i.e.*, fill them with air and hold against the cheek to feel for and hear releasing air) prior to each use.

(b) Leather protectors shall meet the requirements of ASTM F696.

(10) Footwear

(a) When performing electrical work when the incident energy at the working distance is >4 cal/cm^2, staff shall wear electrical-hazard-rated (EH) footwear that meets ASTM F2413.

(b) Steel toe safety footwear shall not have the steel exposed.

(c) The soles of electrical-hazard-rated footwear must be kept clean and free of materials that could compromise the non-conductive rating for the shoes.

(11) Rubber insulating protective equipment shall meet the requirements of the following standards, as applicable:

(a) ASTM D120;

(b) ASTM D178;

(c) ASTM D1048;

(d) ASTM D1049;

(e) ASTM D1050; and

(f) ASTM D1051.

Rubber insulating protective equipment shall be tested and/or inspected per the manufacturer's instructions.

j. Listed or Labeled Electrical and Electronic Equipment

(1) All procured electrical or electronic equipment should be listed or labeled by an NRTL.

(a) Listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling provisions.

(2) For electrical or electronic equipment which is not listed or labeled by an NRTL (including custom-built, procured non-NRTL, and modified NRTL electrical or electronic equipment), the electrical or electronic equipment shall require acceptance and certification by the NIST AHJ prior to use through approval of the NIST Form TBD – *Unlisted/Unlabeled Electrical or Electronic Equipment Acceptance* (please see Section 6.j(3) and Appendix D).

(a) Following review for acceptance and certification, one of the following tags shall be affixed to the equipment:

i. A green tag with NIST NRTL Acceptance Number indicating acceptance and certifying compliance;

ii. A blue tag with NIST NRTL Conditional Acceptance Number indicating conditional acceptance. A description of operation conditions and/or limitations shall also be provided; or

iii. A red tag with NIST NRTL Reference Number indicating failure of acceptance. A description of why the form was not approved shall also be provided.

(3) Required Information on NIST Form TBD – *Unlisted/Unlabeled Electrical or Electronic Equipment Acceptance.*

(a) Part A. Submitter Information

i. Name of the submitter;

ii. Organizational code of the submitter; and

iii. Date of equipment submittal.

(b) Part B. Equipment Description

i. Name of the equipment;

ii. Type of equipment, and if not custom-built, any specific information related to its manufacture;

iii. Location where equipment will be used;

iv. Operating environment;

v. Documentation for general description of equipment, *e.g.*, how is it intended to be used, relevant operating procedure(s), safety features; and

vi. Diagram/drawing illustrating equipment design and any markings on the equipment.

(c) Part C. External Inspection

Affirmative inspection of the following is required unless the criterion does not apply.

i. Enclosure;

ii. Power source – cords and plugs;

iii. Power source – hardwired configurations;

iv. Grounding;

v. Foreign power supplies and equipment; and

vi. Marking requirements

(d) Part D. Internal Inspection
Affirmative inspection of the following is required unless the criterion does not apply.

i. Internal wiring; and

ii. Test performed.

(e) Part E. Other Design Requirements
A description of how any additional design requirements would apply from the following (as applicable).

i. NFPA 70, National Electrical Code;

ii. NFPA 79, Electrical Standard for Industrial Machinery;

iii. NFPA 790, Standard for Competency of Third-Party Field Evaluation Bodies;

iv. NFPA 791, Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation;

v. UL 508, Industrial Control Equipment;

vi. UL 508A, Industrial Control Panels;

vii. UL 60950-1, Standard for Safety, Information Technology Equipment – Safety; Part 1: General Requirements; and

viii. UL 61010-1, Standard for Safety, Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements.

(f) Part F. Testing
A list of the tests performed to verify the functionality of the safety-related aspects of the equipment and the results.

(g) Part G. AHJ or Delegate Review

i. Name of the reviewer;

ii. Date of the review;

iii. General comments (if provided) regarding the review; and

iv. Decision regarding approval.

(4) Any modification to the equipment subsequent to acceptance and certification shall require the equipment to be re-certified per the requirements of Section 6.j(2).

Records for certified unlisted or unlabeled electrical or electronic equipment, including supporting design documentation, shall be retained for the life of the equipment by the OU or owner of the equipment. Records may be stored electronically or in hard copy by the OU. NOTE: Inspections follow the requirements of NFPA 791 *Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation*. While NFPA 791 generally tells the inspector what parts of the equipment to check, specific design or performance criteria are found in a number of supporting standards. The individual performing the review for acceptance and certification must determine, based on the type of equipment being inspected, which primary standard is most applicable to be used in conjunction with NFPA 791. Additional criteria may be applied at the discretion of the individual performing the review for acceptance and certification. These primary standards include:

- NFPA 70, National Electrical Code;
- NFPA 79, Electrical Standard for Industrial Machinery;
- UL 508, Industrial Control Equipment;
- UL 508A, Industrial Control Panels;
- UL 60950-1, Standard for Safety, Information Technology Equipment – Safety; Part 1: General requirements; and
- UL 61010-1, Standard for Safety, Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements.

k. Electrical Distribution Systems

NOTE: The requirements of this section are applicable to design, installation, testing, and maintenance performed by both NIST employees and non-R&D contractors. Where work is performed by non-R&D contractors, it is the responsibility of the NIST employee responsible for generating the work requirements, *i.e.*, the

Contracting Official's Representative with assistance from their technical point of contact, to ensure the requirements of this section are included in the scope of work.

NOTE: Currently installed equipment is grandfathered from these requirements.

(1) Design Practices to Minimize Risk and Hazards Associated with Electrical Distribution Systems

(a) Electrical distribution system designs shall comply with the applicable requirements of the following:

i. ANSI/NECA (please see specific requirements identified in Section 4);

ii. NFPA (please see specific requirements identified in Section 4);

iii. OSHA (please see specific requirements identified in Section 4); and

iv. Relevant industry standards.

(b) Safeguarding of personnel shall be given prime consideration in electrical distribution system design, to the extent possible. To that end, electrical system designs shall incorporate the following features, as applicable, to reduce electrical hazards:

i. 24-V control (as practicable);

ii. Current-limiting or fast-acting overcurrent devices;

iii. Electronic trip circuit breakers with instantaneous trip capability;

iv. Circuit breakers and protective relays with "maintenance mode" feature;

v. Arc-resistant switchgear, including Motor Control Centers (MCC's);

vi. Resistance-grounded systems;

vii. Ground-fault circuit interrupter (GFCI) protection for 120-volt convenience receptacles in all locations where shock hazards exist;

viii. Finger-Safe or Touch-Safe terminals and lugs;

ix. Multiple small transformers in lieu of one large facility transformer (as practicable);

x. Remote-racking functionality for circuit breakers and MCC equipment; and

xi. Windows for infrared scanning and visual verification of knife-blade position.

(c) Location of electrical equipment associated with electrical distribution systems (*e.g.*, electrical panels, switchgear, overcurrent protection devices) should not be in hazardous locations, damp/wet locations, or in areas where they may be subjected to deteriorating agents (*e.g.*, corrosive gases, fumes, vapors, liquids).

i. With approval of NIST AHJ, and use of protection techniques to eliminate or reduce the objectionable conditions[10], electrical equipment to be installed in hazardous locations, damp/wet locations, or in areas where they may be subjected to deteriorating agents shall be:

(i) Identified and labeled on electrical drawings; and

(ii) Listed or labeled as suitable for that environment.

ii. Electrical equipment associated with electrical distribution systems that have exposed live parts shall be:

(i) Located in permanently dry locations; and

(ii) Accessible to qualified persons only.

(d) Rooms or areas dedicated for containing electrical equipment associated with electrical distribution systems (*e.g.*, enclosures for electrical installations, electric vaults, dedicated equipment space) shall:

i. Have entrances complying with NFPA 70, as practicable; and

ii. Not be used for storage of any kind.

(e) Electrical or electronic equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the available fault current.

[10] Acceptable protection techniques are listed in the NFPA 70 Article 500.

(f) Electrical or electronic equipment and their overcurrent devices shall be selected and coordinated to avoid extensive damage during fault conditions and to provide selective coordination with upstream and downstream devices.

(g) Clearances of Open Conductors above Ground and Structures or Buildings shall meet requirements issued by the following:

i. ANSI/NECA (please see specific requirements identified in Section 4);

ii. NFPA (please see specific requirements identified in Section 4);

iii. OSHA (please see specific requirements identified in Section 4); and

iv. Other relevant industry standards.

(2) Installation of Electrical Distribution Systems

(a) Electrical equipment shall be installed in accordance with the requirements of following, as practicable:

i. NFPA 70, National Electric Code;

ii. NFPA 70B, Standard for Electrical Equipment Maintenance;

iii. Manufacturer's recommendations; and

iv. Specific guidelines detailed in Section 6.k(1).

(b) Unused openings in cabinets, boxes, and fixtures shall also be effectively closed.

(c) All pull boxes, junction boxes, and fittings shall be provided with covers approved for the purpose.

i. Where used, metal covers shall be grounded.

ii. In completed installations, each outlet box shall have a cover, faceplate, or fixture canopy.

iii. Pull boxes and junction boxes for systems over 600 V, nominal, shall:

(i) Have complete enclosures;

(ii) Be closed by suitable covers securely fastened in place; and

(iii) Be permanently marked "High-Voltage".

(d) Abandoned cables and associated equipment should be removed back to the power source.

NOTE: Cost should not be a contributing factor in the decision to remove cables.

(e) Cables designated for reuse shall be properly terminated at both ends and labeled.

(3) Safety Labeling of Electrical Equipment

(a) Equipment Identification

i. All labels and markings shall be durable enough to withstand the environment to which they may be exposed.

ii. All disconnecting devices shall be labeled indicating:

(i) Load; and

(ii) Location.

iii. Each disconnecting means (*e.g.*, switch or device used to disconnect the circuit from the power source) shall be clearly labeled to indicate the circuit's function unless it is located and arranged so the purpose is evident.

iv. Switch panels shall have a panel schedule affixed to the inside of the outer door.

(i) The panel schedule shall be updated any time loads are added or changed.

v. All switchboards, panelboards, motor control centers, industrial control panels, and utilization equipment shall be labeled identifying:

(i) The power source; and

(ii) The power source location.

vi. Each service disconnect shall be permanently marked to identify:

(i) It as a service disconnect; and

(ii) The upstream isolating device.

vii. Where a building is supplied by more than one service, a permanent plaque or directory shall be installed at each service disconnect location denoting all other services.

(b) Electrical Safety/Arc Flash Labeling

i. Switchboards, panelboards, industrial control panels, and motor control centers, 3-phase service disconnects, and similar equipment likely to require examination, adjustment, servicing, or maintenance while energized shall be labeled to warn of potential arc-flash hazards.

ii. The labels shall at a minimum provide the following information in the format detailed in Appendix E:

(i) Nominal system voltage;

(ii) Arc flash boundary.

(iii) Minimum PPE level.

(iv) Limited approach boundary; and

(v) Restricted approach boundary.

iii. Electrical safety/arc flash labels shall be affixed to new or modified equipment before any power is applied, even for the purpose of testing.

(4) Testing of Electrical Distribution Systems

(a) The following shall be performed by the organization responsible for performing the work before any new or modified installation is energized (even for the purpose of testing):

i. Insulation resistance tests;

ii. Continuity tests;

iii. Ground tests;

iv. Polarity tests of all outlets;

v. Measurement Phase Rotation for 3-phase power (CCW or CW) – phase rotation shall be matched to existing phase rotation of equipment;

vi. Coordination study (see Section 7.k); and

vii. Arc-flash hazard calculation study to include:

(i) Incident energy calculations;

(ii) PPE requirements;

(iii) Arc-flash protection boundary(s); and

(iv) Shock protection boundaries.

(5) Maintenance of Electrical Distribution Systems

(a) Electrical equipment associated with electrical distribution systems shall be maintained in accordance the requirements of following, as practicable:

i. NFPA 70, National Electric Code;

ii. NFPA 70B, Standard for Electrical Equipment Maintenance;

iii. Manufacturer's recommendations; and

iv. Specific guidelines detailed in Section 6.c(1).

l. Training

(1) Training shall be documented and recorded in accordance with the requirements of NIST S 7101.23.

(2) Workers shall be qualified to perform work on electrical, electronic, and electro-mechanical equipment and circuits by completing the appropriate NIST-level training:

(a) Limited-Scope Qualified, completion of the course titled:

i. NIST S 7101.64: *Safe Electrical Work Practices – Limited-Scope Course*.

(b) Comprehensive Qualified, completion of the course titled:

i. NIST S 7101.64: *Safe Electrical Work Practices – Comprehensive Course*.

(c) High-Voltage Qualified, completion of the courses titled:

i. NIST S 7101.64: *Safe Electrical Work Practices – Comprehensive Course*; and

ii. NIST S 7101.64: *High-Voltage Electrical Safety*

(d) Capacitor Safety Qualified, completion of the course titled:

i. NIST S 7101.64: *Electrical Safety for Capacitors*.

(3) Workers shall complete the OU-provided activity-specific training on the tasks they are to perform.

(4) Workers performing the duties of a Safety Watch shall:

(a) Meet the same training qualifications necessary for the work to be performed;

(b) Be trained on how to de-energizing the equipment being worked on; and

(c) Be trained on safety release of persons.

NOTE: Best practice is the Safety Watch should train on safety release of a person just prior to the work being performed.

(5) Workers performing the duties of a Stand By should meet the same training qualifications necessary for the work to be performed.

(6) Workers submitting a piece of equipment which is not listed or labeled for AHJ acceptance shall complete the following course:

(a) NIST S 7101.64: *Requirements for Submitting a Piece of Electrical Equipment for Acceptance and Certification*

(7) Retraining

(a) Retraining of workers shall be completed:

i. At intervals not to exceed three (3) years; or

ii. When any of the following conditions exist:

(i) An individual is not complying with safety work practices.

(ii) New technology, equipment, or practices require training related to safe work practices;

(iii) An individual is assigned a task that is not normally performed during their normal work assignments; or

(iv) After a near miss or incident such that inadequate understanding of hazards was determined to be root cause. .

(b) Retraining shall include retraining on safety-related work practices and applicable changes in NFPA standards, as applicable.

m. Electrical Incidents and Investigations

(1) In accordance with the requirements of NIST S 7101.24, the OSHE Electrical Safety Engineer or designee shall participate in near miss and incident investigations involving:

(a) Electric shocks;

(b) Arc flashes; and

(c) Electrical fires.

n. Annual Audits

(1) Documents associated with hazard reviews and job hazard analyses shall be reviewed to ensure they are compliant with the requirements of this program.

(a) At least 25% of the OU hazard reviews or job hazard analyses with work pertaining to this suborder shall be audited annually.

NOTE: If a hazard review or job hazard analysis is not regularly performed (*i.e.*, more than once per year), the hazard review or job hazard analysis shall be reviewed prior to the work commencing and observation of the work shall occur.

(b) If the audit determines there are deficiencies in the hazard review or job hazard analysis, corrective actions (*e.g.*, revision of documents and re-training of staff) shall be taken prior to allowing the work to be performed again.

(2) Observation of the work performed under the hazard review or job hazard analysis being audited in Section 6.n(1) shall also be performed.

(a) The observation shall cover:

i. The worker's understanding of the hazard review or job hazard analysis; and

ii. The worker's ability to follow the procedures contained in the hazard review or job hazard analysis.

(b) If the observation determines there are deficiencies in the hazard review or job hazard analysis or the worker is not following the procedures, corrective actions (*e.g.*, revision of documents and re-training of staff) shall be taken prior to allowing the work to be performed again.

o. Records Required by this Suborder

(1) Hard or electronic copies of authorized NIST-380 forms shall be kept by the OU for a minimum of 1 year from the completion of the work.

(2) Testing records of high-voltage equipment and tools performed by an external company shall be kept by the OU for the life of the equipment or tool.

(3) Records for certified unlisted or unlabeled electrical or electronic equipment, including supporting design documentation, shall be retained by the OU for the life of the equipment.

(4) Records associated with the annual audit shall be kept by the OU for a minimum of 5 years from completion of the audit.

1. DEFINITIONS

a. Appliance – Equipment, generally other than industrial, that is normally built in standardized sizes or types and is installed or connected as a unit to perform one or more functions such as making hot drinks or warming food.

b. Arc Flash – A flashover of electric current through the air from one conductor to another, or to ground.

c. Arc Flash Boundary – An approach limit at a distance from exposed live parts at which a person could receive a second degree burn if an electrical arc flash were to occur. The boundary is established at the point away from a potential arc source where the incident energy would be reduced to 1.2 cal/cm^2. Personnel inside this boundary are required to don the required PPE based on the incident energy level at the distance the face and chest are located from the potential arc source.

d. Arc Flash Hazard – A dangerous condition associated with the possible release of energy caused by an electric arc. An arc flash hazard may exist when energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc. Under normal operating conditions, undisturbed, enclosed, energized equipment that has been properly installed and maintained is not likely to pose an arc flash hazard.

e. Arc-Rating – The maximum incident energy resistance demonstrated by a material, or a layered system of materials, prior to break open or at the onset of a second-degree skin burn. Arc rating is normally expressed in cal/cm^2.

f. Authority Having Jurisdiction (AHJ) – A Fire Protection Engineer in OSHE designated by the Chief Safety Officer to enforce the NIST-adopted codes and standards relevant to fire, electrical, and life safety on NIST-owned and operated sites. Please see NIST O 7401.00

g. Barricade – A physical obstruction such as tapes, cones, or A-frame-type wood or metal structures intended to provide a warning and limit access to electrical hazards.

h. Capacitor – A device used to store an electric charge, consisting of one or more pairs of conductors separated by an insulator.

i. Capacitor Safety Qualified Individual – A person whose electrical work tasks allows them to work on capacitors, subsequent to completion of training specified in this suborder and authorization of their supervisor.

j. Comprehensive Qualified Individual – A person whose electrical work tasks are limited to voltages 600 V or less unless they are also High-Voltage qualified, subsequent to completion of training specified in this suborder and authorization of their supervisor.

k. Coordination Study – A study to determine the proper settings of protective devices to ensure reliability of a power distribution system. Typically, there is a balance between protection and overprotection causing nuisance tripping of protective devices and impacting system reliability. The study determines the best settings of the protective devices so that the protective device closest and upstream to a fault trips thereby limiting impacting other parts of the distribution system.

l. De-Energized – Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential difference from the earth.

m. Diagnostics – Taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment.

n. Disconnecting Means – A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

o. Electrical Hazard – A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn, or blast. The limited and restricted approach boundaries (for shock) and the arc flash boundary are the boundaries within which potential electrical hazards to workers exist.

p. Electrically Safe Working Condition – The state or condition absent of any electrical hazard.

q. Energized – Electrically connected to, or is, a source of voltage.

r. Energized Electrical Work – Work conducted by an employee or associate on electrical, electronic, or electro-mechanical equipment or circuits where:

(1) The equipment or circuit is either known to be energized or not known to have been de-energized in accordance with the requirements of this suborder; and

(2) The employee or associate is within the restricted-approach boundary or interacts with the equipment or circuit within the arc-flash boundary.

s. Energized Electrical Work Permit – A document (NIST Form 380) that details the information identified in Section 6.e required to perform energized electrical work.

t. Energy-Isolating Device – A mechanical device that physically prevents the transmission or release of energy, including but not limited to the following: a manually operated electrical-circuit breaker; a disconnect switch; a manually-operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors and, in addition, no pole can be operated independently; a line valve; a block; and any similar device used to block or isolate energy. Push buttons, selector switches, and other control-circuit-type devices are not energy-isolating devices.

u. Equipment – A general term, including circuits, components, devices, and the like, used as a part of, or in connection with, an electrical installation.

v. Exclusive Control – A condition in which a worker has taken actions or is continuously in a position to prevent (exclude) other individuals from re-energizing or starting equipment while it is being serviced or maintained.

w. 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.

x. Flame-Resistant – The property of a material whereby combustion is prevented, terminated, or inhibited following the application of a source of ignition. Note: Arc-rated clothing is flame-resistant, but not all flame-resistant clothing is arc-rated.

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

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

aa. Ground-Fault Circuit Interrupter (GFCI) – A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established

period of time when a current to ground exceeds the values established for a Class A device.

bb. Grounding Conductor, Equipment – The conductor used to connect the non-current-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system.

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

dd. Hazardous Energy – Energy capable of causing personal harm or property damage if it is not controlled. Types of hazardous energy include, but are not limited to, electrical, mechanical, rotational, gravitational, chemical, radioactive, hydraulic, pneumatic, and thermal.

ee. Hazardous-Energy Control – The process of systematically implementing engineering and administrative means to prevent hazardous energy from flowing to a person.

ff. Hazardous-Energy Source – Equipment, machine, apparatus, process piping, and so on, which is a source of hazardous energy.

gg. High-Voltage – As defined by OSHA and for the purpose of this suborder regarding qualifications, voltages above 600 V, as both OSHA and NFPA 70E has additional requirements at 600 V and above.

hh. High-Voltage Qualified Individual – A person who can perform work on all hazard classes of equipment, subsequent to completion of training specified in this suborder and authorization of their supervisor.

ii. Incident – A work-related event in which any of the following, individually or in combination, occurred: an injury or illness; an unauthorized spill or release of hazardous or regulated material to the environment; property damage; exposure; or contamination by radioactive material.

jj. Incident Energy – The amount of energy impressed on a surface, a certain distance from a source, generated during an electrical arc event. The incident energy level is expressed in calories per centimeter-squared (cal/cm2) and is a measure of the heat created by the electrical arc.

kk. Interrupting Rating – The highest current at rated voltage that a device is intended to interrupt under standard test conditions.

ll. Job Briefing – A job specific discussion to make all affected employees aware of the job specific hazards, work procedures, special precautions, energy source controls and PPE.

mm. Labeled – Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the AHJ and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

nn. Laboratory – A building, space, room, or group of rooms intended to serve activities involving procedures for investigation, diagnostics, product testing, or use of custom or special electrical components, systems, or equipment.

oo. Limited Approach Boundary – A shock protection boundary. An approach limit at a distance from an exposed energized electrical conductor or part within which a shock hazard exists. This shock protection boundary is to be crossed only by qualified employees. If an unqualified person is to cross this boundary, they must be continuously escorted by a qualified person.

pp. Limited-Scope Qualified Individual – A person whose electrical work tasks are limited to the following, subsequent to completion of training specified in this suborder and authorization of their supervisor:

(1) Working on or operating equipment with energized and exposed circuits, components or parts supplied by a single cord and plug at 240V AC, single phase, or less and 25 kA short circuit current or less;

(2) Working on or operating equipment with voltages 100V DC or less and short circuit currents less than 4 kA; or

(3) Operating service disconnects.

qq. Listed – Equipment, materials, or services included in a list published by an organization that is acceptable to the AHJ and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that the equipment, material, or services

either meets appropriate designated standards or has been tested and found suitable for a specified purpose.

rr. Live Parts – Energized conductive components.

ss. Load – Non-transient electrical loads.

tt. Lockout – The placement of a lockout device on an energy-isolating device, in accordance with an established procedure, to ensure the energy-isolating device and the equipment being controlled cannot be operated until the lockout device is removed.

uu. Lockout Device – Any device that uses a positive means such as a lock, blank flanges, and bolted slip blinds to hold an energy-isolating device in a safe position to prevent equipment from unexpectedly energizing.

vv. Non-R&D Contractor – An individual who performs non-R&D work at a NIST workplace in accordance with the safety requirements of a contract or other legal arrangement, such as a Memorandum of Understanding, with NIST. Non-R&D contractors include, but are not limited to, construction contractors; facilities contractors; equipment installation, service, and maintenance contractors; Health Unit contractors; contract cafeteria workers; and janitorial contractors.

ww. Overcurrent – Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.

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

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

zz. Permanent – An object that is intended to remain in place for more than 180 days in any consecutive 12-month period.

aaa. Permanently Installed – Securely fastened so that tools must be used for removal.

bbb. Properly Installed – Equipment or circuit that has been installed in accordance with applicable industry codes and standards and the manufacturer's recommendations.

ccc. Properly Maintained – Equipment or circuit that has been maintained in accordance with applicable industry codes and standards and the manufacturer's recommendations.

ddd. Qualified Individual – One who has demonstrated knowledge, skills, and abilities related to the construction, installation, and operation of specific electrical equipment or circuits and has received safety training to identify and avoid the hazards involved.

eee. Repair – Any physical alteration of electrical equipment, e.g., making or tightening connections, removing or replacing components.

fff. Research and Development (R&D) – An activity in an installation specifically designated for research or development conducted with custom or special electrical equipment.

ggg. 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. This area is reserved only for qualified persons. Shock protection techniques and safety equipment are required.

hhh. Serviceable – As pertains to electrical equipment, requiring servicing, maintenance or operation.

iii. Servicing and/or Maintenance – Workplace activities such as constructing, installing, setting up, adjusting, inspecting, and modifying equipment that could expose workers to the unexpected release of hazardous energy. Maintenance activities may also include lubrication, cleaning, or unjamming equipment, and making adjustments or tool changes.

jjj. Supplemental Power Device – A supplemental power device refers to any device of system designed to provide additional electric power beyond what is available from the primary power source to provide backup power often to portable electronics or to extend operating time of devices when access to conventional power sources is limited. Examples include relocatable power taps (RPTs), surge suppressors, uninterruptible power supplies (UPSs), and extension cords.

kkk. Storage Battery – A battery consisting of one or more rechargeable cells of the lead-acid, nickel-cadmium, or other rechargeable electrochemical types.

lll. Stored Energy – Energy located within any device after equipment is shut down. This includes, but is not limited to, capacitors, tanks, pipes, springs, and flywheels.

mmm. Switchboard – A large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets.

nnn. Tagout – The placement of a tagout device on an energy-isolating device, in accordance with an established procedure, to indicate that the energy-isolating device and the equipment being controlled shall not be operated until the tagout device is removed.

ooo. Testing – See definition of "Diagnostics".

ppp. Wet Location - Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as vehicle-washing areas, and locations unprotected and exposed to weather.

qqq. Work – See definition of "Working On".

rrr. Working – See definition of "Working On".

sss. Working Near (live parts) – Any activity performed inside a Limited Approach Boundary.

ttt. Working On (Energized Electrical Conductors or Circuit Parts) – Intentionally coming in contact with electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the PPE a person is wearing. There are two categories of "working on": "Diagnostics" ("Testing") and "Repair" (see definitions).

uuu. Working Space – Space around electrical equipment to allow for safe servicing, maintenance or operation of the equipment.

vvv. Zero Voltage Verification – The process by which an individual verifies the electrical, electronic, and electro-mechanical equipment or circuit is in an electrically safe work condition, *i.e.*, de-energized.

7. ACRONYMS

a. AC – Alternating Current

b. AHJ – Authority Having Jurisdiction.

c. COR – Contracting Officer's Representative

d. DC – Direct Current

e. EEWP – Energized Electrical Work Permit

f. LOTO – Lockout/Tagout

g. NRTL – Nationally Recognized Testing Laboratory

h. NFPA – National Fire Protection Association

i. OU – Organizational Unit

j. OSHA – Occupational Safety and Health Administration

k. OSHE – Office of Safety, Health, and Environment

l. PPE – Personal Protective Equipment

m. R&D – Research and Development

n. RPT – Relocatable Power Tap

o. UL – Underwriters Laboratory

p. ZVV – Zero Voltage Verification

8. RESPONSIBILITIES

For responsibilities applicable to all NIST OSH Suborders, see the "Responsibilities" section of NIST O 7101.00.

a. OU Directors are responsible for:

(1) Ensuring the requirements of this suborder are met within their OU; and

(2) Authorizing EEWPs originating from within their OU for work to be conducted by their staff and their non-R&D contractors.

b. Director, Office of Facilities and Property Management is responsible for:

(1) Ensuring the requirements for electrical distribution systems (Section 6.k) are met at NIST-owned worksites; and

(2) Approving individuals to be OFPM Director-authorized to operate breakers inside of electrical panels.

c. Division Chiefs (or equivalent) are responsible for implementing the requirements of this program as it applies to activities involving their personnel in accordance with any applicable OU-established policies and procedures.

d. First-level Supervisors are responsible for:

(1) Ensuring the appropriate control measures, including an approved EEWP when necessary, are in place and effective prior to staff performing work on or around electrical, electronic, and electro-mechanical equipment and circuits;

(2) Ensuring staff who may be exposed to electrical hazards while working on or around electrical, electronic, and electro-mechanical equipment and circuits:

(a) Have the appropriate training per the requirements of this program;

(b) Wear the appropriate PPE for the work to be performed; and

(c) Implement all engineering and administrative control measures, including LOTO and ZVV procedures and the Two-Person Work Rule, as identified in the risk assessment documents (hazard review and EEWP); and

(3) Ensuring annual audits per Section 6.n are performed and documented.

e. Contracting Officer's Representatives/Project Managers are responsible for:

(1) Ensuring their non-R&D contractor is aware of the requirements of this suborder; and

(2) Coordinating with their non-R&D contractor to ensure the process to perform energized electrical work, if necessary, is followed.

f. All NIST Staff are responsible for:

(1) Ensuring all electrical, electronic, and electro-mechanical equipment they are using are labeled and listed by an NRTL; and

(2) Only performing work on or around electrical, electronic, and electro-mechanical equipment and circuits for which they are authorized.

g. NIST staff desiring to use electrical or electronic equipment which is not listed or labeled by an NRTL are responsible for:

(1) Completing the training necessary to submit a piece of equipment which is not listed or labeled for acceptance by the NIST AHJ – please see Section 6.l(5); and

(2) Following the requirement to submit a piece of equipment which is not listed or labeled for NIST AHJ acceptance – please see Section 6.j.

h. NIST Staff whose duties requires them to perform work on or around electrical, electronic, and electro-mechanical equipment and circuits are responsible for:

(1) Completing the appropriate training per the requirements of this program;

(2) Wearing the appropriate PPE for the work to be performed; and

(3) Implementing all engineering and administrative control measures, including LOTO and ZVV procedures and the Two-Person Work Rule, as identified in the risk assessment.

i. The NIST AHJ is responsible for:

(1) Interpreting applicable electrical codes and standards;

(2) Reviewing and approving variances to electrical codes and standards;

(3) Reviewing and approving EEWPs; and

(4) Approving and certifying unlisted/unlabeled equipment.

9. AUTHORITIES

a. Authorities common to all NIST OSH suborders can be found in the "Authorities" section of NIST O 7101.00. Authorities specific to this suborder are:

(1) The NIST AHJ to delegate to other NIST staff members, as appropriate and based upon meeting requirements and/or qualifications specific to the delegated task, the authority to carry out the AHJ responsibilities listed above.

(2) OU Directors to delegate to OU Deputy Directors and Division Chiefs (or equivalent) the authority to authorize EEWPs on their behalf.

10. DIRECTIVE OWNER

Chief Safety Officer

11. APPENDICES

A. Revision History

B. Electrical Safety Parameters and Electrical Hazard Assessment

C. NIST Form 380 – Energized Electrical Work Permit

D. Unlisted/Unlabeled Electrical or Electronic Equipment Acceptance

E. Electrical Safety/Arc Flash Labeling

Appendix A: Revision History

Version #	Approval Date	Effective Date	Brief Description of Change
1	09/19/2024	TBD	• Initial document
1a	1/3/25	TBD	• Fixed typo in document number (7301 to 7101) on pages 1-70 of footer.

Appendix B: Electrical Safety Parameters and Electrical Hazard Assessment

NIST has adopted a process which closely follows the DOE Electrical Safety Handbook to facilitate electrical risk assessment (*e.g.*, hazard review or job hazard analysis) commensurate with the intent of NIST S 7101.20: *Work and Worker Authorization Based on Hazard Reviews*. By using the following parameters collectively, as seen in multiple headings in Section 6, NIST staff can correctly identify the minimum applicable requirements such as methods of work control, type of PPE, and training qualifications requirements for a given scenario. When performing the risk assessment, individuals with the appropriate knowledge, skills, and abilities must be on the team to ensure all the electrical hazards are identified and sufficiently controlled.

It should be noted that applicable electrical safety requirements contained in OSHA and NFPA 70E are not superseded by this process. Rather, this process is intended to serve as a supplementary resource for NIST staff to quickly identify the minimum applicable requirements for scenarios and hazards they may encounter. General electrical safety requirements provided throughout the various headings in Section 6 would apply and each should be reviewed for applicability for the work to be performed.

1. Electrical Hazard Categories

The electrical hazard categories used in the electrical hazard assessment cover five broad types of energy sources and should account for most of the scenarios NIST staff would encounter.

Table B.1: Electrical Hazard Categories

Hazard Category	Source/Description
A	AC sources, equipment, or systems that use 60 Hz
B	DC power sources
C	Capacitors
D	Batteries
E	Radio frequency (RF)

2271 **2. Electrical Hazards Classes.**
2272 Within each electrical hazard category, one of four electric hazard classes can be assigned
2273 and are based on the severity of possible injury and mechanism of injury (*e.g.*, shock, burn,
2274 arc flash).
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2276 Table B.2: Electrical Hazard Classes

Hazard Class	Description
Class 1	• Indicates little to no hazards associated with the work (*i.e.*, lowest level of risk). • No electrical-related injuries are expected. • Few or no engineering or administrative controls are required.
Class 2	• Indicates hazards may be significant while performing the work. • Injury or death could occur by ***close*** proximity (*e.g.*, directly next to equipment) or contact; Often the hazard is shock or contact burn. • Engineering controls are necessary for operation (*e.g.*, listing or equipment approval); Administrative controls are necessary for electrical work.
Class 3	• Indicates hazards are likely to be significant while performing the work. • Injury or death could occur by proximity (*i.e.*, at further distances than Class 2) or contact; Often the hazard is shock, contact burn, or arc flash burn. • Engineering controls are necessary for operation (*e.g.*, listing or equipment approval); Administrative controls are necessary for electrical work.
Class 4	• Indicates hazards are significant while performing the work (*i.e.*, highest level of risk); • Injury or death could occur by proximity or contact (*i.e.*, at further distances than class 3) • Significant engineering and administrative controls are necessary to manage the hazard in this class.

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3. Modes of Electrical Work

When engineering controls are not yet in place, not approved, or removed for diagnostics, maintenance, or repair, work on electrical equipment is classified as electrical work and falls into one of the following modes. These modes are primarily used as shorthand terminology for cataloging types of electrical work:

Table B.3: Modes of Electrical Work

Mode of Electrical Work	Description and Example
Mode 0	• An electrically safe work condition has been established. • Example – A state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with NIST S 7101.56 (LOTO program), and tested by a qualified worker to ensure the absence of voltage, and grounded if necessary
Mode 1	• Establishing electrically safe work condition. • Example – Work is considered energized electrical work, but exempt from the requirements for an energized electrical work permit (please see Section 6.d); Complex lockout tagout involving more than one electrical source, disconnecting wires, *etc.*
Mode 2	• Diagnostics and testing performed while equipment is energized. • Example – Testing or measuring voltage, current, or other parameters on energized circuit parts, performing diagnostics on energized circuits, or parts, *etc.* **NOTE**: Measurements, diagnostics, testing, and visual inspection of equipment functions are conducted with the equipment energized and with some, or all, of the normal protective barriers removed and interlocks bypassed. Mode 2 should be covered by hazard review.
Mode 3	• Energized electrical repair or maintenance work requiring an energized electrical work permit (please see Section 6.e) • Example – Racking low voltage power circuit breaker in 480v switchgear.

Appendix C: NIST Form 380 – Energized Electrical Work Permit

NIST-380
(9-2015)
NFPA 70E Article 130.2(B)

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

ENERGIZED ELECTRICAL WORK PERMIT

A. WORK ORDER OR CONTRACT DETAILS

Work Order/Contract #	Building Number	Building/Area	Date of Request

Electrical Equipment and/or Circuit Description

Task Description:

B. JUSTIFICATION FOR ENERGIZED WORK

☐ De-energizing the equipment or circuit introduces additional hazards; introduces increased risk, or could cause significant property damage or loss of critical data

Explain:

☐ De-energizing the equipment or circuit is infeasible (not just inconvenient) due to equipment design or operational limitations

Explain:

☐ An outage was requested and denied

Explain:

C. REQUESTOR

Name & Title (Print)	(Signature)

D. QUALIFIED PERSON

Name & Title (Print)	(Signature)

E. REQUESTOR SUPERVISOR/MANAGER OR CONTRACTOR OFFICER REPRESENTATIVE

Name & Title (Print)	(Signature)

NIST-380 (9-2015)

Total Number of Pages _____

ENERGIZED ELECTRICAL WORK PERMIT

F. HAZARD ANALYSIS (SECTION REQUIRED FOR BOTH ON OR NEAR EXPOSED ENERGIZED PARTS)

1. Maximum exposure in Volts _____ Maximum Amperage kA _____ Fault Clear Time _____ (cycles)

2. Energized Exposure Hazard:
Working on or near:

- ☐ Bare Bus
- ☐ Bare conductor
- ☐ Open circuit(s)
- ☐ Open Terminals
- ☐ Panel boards
- ☐ Switch boards
- ☐ NEMA E2 Motor Starters
- ☐ Metal Clad Switch gear
- ☐ Confined Space
- ☐ Energized Feeders

List: _____

Other *(List)*:

3. Method of analysis: NFPA 70E Tables ☐ Calculations ☐

4. Shock Hazard Analysis:

Limited Approach Boundary _____ft_____ in Restricted Approach Boundary _____ft _____in

5. Flash Hazard Analysis:

Flash Protection Boundary _____ft_____ in Incident Energy Value _____ cal/cm² at _____ ft _____in Working Distance

6. PPE Category: 1 ☐ 2 ☐ 3 ☐ 4 ☐

7. PPE Minimum FR Rating: _____ cal/cm²

8. Required PPE & Tools:

- ☐ V Rated Gloves
- ☐ V Rated Tools
- ☐ Face Shield
- ☐ Leather Shoes
- ☐ FR Shirt
- ☐ FR Pants
- ☐ Leather Gloves
- ☐ Flash Suit
- ☐ Hard Hat
- ☐ Hearing Protection (Ear Plugs, Muffs or Both)
- ☐ Coveralls
- ☐ Flash Hood

9. Is work required to be performed in area classified as a "Confined Space"? Yes ☐ No ☐

10. If manhole work, can the work be performed at least 18" from energized cables or splices? Yes ☐ No ☐

11. Engineering/Administrative Controls Planned to Reduce/Eliminate Exposure to Energized Equipment:

Put Protective Relays in Maintenance Settings ☐

- Insulating Blankets ☐ If checked, provide details below or on an attached diagram (required)
- Arc Suppression Blankets ☐ If checked, provide details below or on an attached diagram (required)
- Other Controls ☐ If checked, provide details below or on an attached diagram (required)

12. Additional controls/comments/means to restrict access

13. Engineering Hazard Analysis completed by:

PRINTED NAME _____ SIGNATURE _____ DATE _____

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ENERGIZED ELECTRICAL WORK PERMIT

G. SAFETY REVIEW AND APPROVAL (NIST AUTHORITY HAVING JURISDICTION OR DELEGATE)

☐ Approved ☐ Disapproved

Name & Title (Print)	(Signature)	Date

Comments:

H. ENERGIZED ELECTRICAL WORK PERMIT AUTHORIZATION

☐ Approved ☐ Disapproved

OU DIRECTOR or DESIGNATED REPRESENTATIVE / TITLE *(Print)*	*(Signature)*	Date

Comments:

I. ATTACHMENTS

Number	Pages	Attachment Title

J. NOTES

K. PRE-WORK BRIEFING ATTENDEES

Printed Name	SIGNATURE	Printed Name	SIGNATURE

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Appendix D: Unlisted/Unlabeled Electrical or Electronic Equipment Acceptance

Part A. Submitter Information	
1. Name of Requestor	
2. Org code of Requestor	
3. Date of equipment submittal	

Part B. Equipment Description	
1. Name of Equipment	
2. Type of Equipment (select one)	
☐ Custom-built	
Previously reviewed by NIST	☐ Yes, NIST UL Acceptance #:_____ ☐ No
☐ Procured Non-NRTL	
Manufacturer	
Model Number	
Serial Number	
Voltage	
Frequency	
Amps	
Short Circuit Current Rating	
☐ Modified NRTL	
Manufacturer	
Model Number	
Serial Number	
Voltage	
Frequency	
Amps	
Short Circuit Current Rating	
3. Location where equipment will be used	☐ Building: Room: ☐ Other (please attach separate documentation)
4. Operating Environment	☐ Indoor/dry ☐ Outdoor/wet/damp ☐ Hazardous Locations (Flammable/Explosive)
5. Documentation attached for general description of equipment	☐ Yes (please attach documentation) ☐ No (please attach documentation indicating why)
6. Diagram/drawing attached illustrating equipment design and any markings on the equipment	☐ Yes (please attach documentation) ☐ No (please attach documentation indicating why)

Part C. External Inspection			
1. Enclosure			
a. No evidence of hazard to operator	Yes	No	NA
b. Not damaged	Yes	No	NA
c. Appropriate material	Yes	No	NA
d. Protects contents from operating environment	Yes	No	NA
2. Power Source – cords and plugs:			
a. Proper voltage and current rating for plug and cord	Yes	No	NA
b. Grounding conductor included when required	Yes	No	NA
c. Cord is not frayed or damaged	Yes	No	NA
d. Proper wiring of plug (Visual inspection required on field installed plugs.)	Yes	No	NA
e. Strain relief on cord	Yes	No	NA
f. Conductor is in full contact with terminal	Yes	No	NA
g. Terminals are torqued to manufacturer's specifications	Yes	No	NA
h. Plugs are listed by an NRTL	Yes	No	NA
3. Power Source – direct wired into facility covered			
a. Proper voltage and current rating for wiring method	Yes	No	NA
b. Suitable for permanent installation by a qualified person	Yes	No	NA
c. Proper loading and overcurrent protection in branch circuit	Yes	No	NA
4. Grounding			
a. Is an equipment grounding conductor included in the circuit	Yes	No	NA
b. Is the equipment grounding conductor properly terminated and has it been tested for continuity	Yes	No	NA
c. Are all non-current carrying exposed metal surfaces properly bonded	Yes	No	NA
5. Foreign Power Supplies and Equipment			
a. The connection to facility power is made with appropriate adapters	Yes	No	NA
b. Correct wire ampacity for use in the United States	Yes	No	NA
c. Is the voltage, frequency, and phasing correct for application	Yes	No	NA
6. Marking Requirements			
a. Is equipment marked with potential hazards (stored energy, open buss, *etc.*)	Yes	No	NA
b. Is the voltage, current, and frequency properly marked on equipment	Yes	No	NA
c. Is the make, model, and drawing number included	Yes	No	NA
d. Is supporting documentation adequate	Yes	No	NA

Part D. Internal Inspection			
1. Internal Wiring			
a. Is the polarity correct	Yes	No	NA
b. Is the phasing correct	Yes	No	NA
c. Is the equipment grounding conductor properly attached	Yes	No	NA
d. If different voltages are being used, is the separation adequate	Yes	No	NA
e. Are the wiring terminals the correct size for the conductors	Yes	No	NA
f. Is the wire sized adequately for the load	Yes	No	NA
g. Clearance/Creepage distances for High-Voltage equipment adequate	Yes	No	NA
h. Are all conductors being used listed by an NRTL	Yes	No	NA
i. Are all cables installed in neat workmanlike manner	Yes	No	NA
j. Are all conductors protected from any sharp edges	Yes	No	NA
k. If equipment generates heat, does it have sufficient room for air circulation and/or cooling	Yes	No	NA
l. Does equipment have an automatic discharge for any stored energy (capacitor)	Yes	No	NA

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Part E. Other Design Requirements			
If additional design requirements are applicable, please indicate which of the following are applicable and attach documentation with a description.			
1. NFPA 70, National Electrical Code	Yes	No	NA
2. NFPA 79, Electrical Standard for Industrial Machinery	Yes	No	NA
3. NFPA 790, Standard for Competency of Third-Party Field Evaluation Bodies	Yes	No	NA
4. NFPA 791, Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation	Yes	No	NA
5. UL 508, Industrial Control Equipment	Yes	No	NA
6. UL 508A, Industrial Control Panels	Yes	No	NA
7. UL 60950-1, Standard for Safety, Information Technology Equipment – Safety; Part 1: General Requirements	Yes	No	NA
8. UL 61010-1, Standard for Safety, Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements	Yes	No	NA

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Part F. Testing	
If testing was performed to verify the functionality of the safety-related aspects of the equipment (*e.g.,* leakage current on cord and plug-connected equipment, ground continuity, dielectric withstand, emergency stop), please indicate what testing was performed and the results.	
1. Testing performed to verify the functionality of the safety-related aspects of equipment.	☐ Yes (please attach documentation) ☐ No (please attach documentation indicating why it was unnecessary)

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Part G. AHJ or Delegate Review	
1. Reviewer	
2. Date of review	
3. General Comments	☐ Provided, please see attached ☐ Not provided
4. Decision	
☐ Approved	This equipment is approved for installation and use at NIST. **NOTE:** If this equipment is modified, damaged, or utilized for other than the intended use stated above, this approval is void pending re-evaluation of the equipment.
	NIST UL Acceptance #: (green tag)
☐ Conditionally Approved	This equipment is conditionally approved for installation and use at NIST per the conditional requirements. **NOTE:** If this equipment is modified, damaged, or utilized for other than the intended use stated above and in accordance with the conditional requirements, this conditional approval is void pending re-evaluation of the equipment.
	Please see attached for conditional requirements
	NIST UL Conditional Acceptance #: (blue tag)
☐ Reject	Please see attached for reasoning
	NIST UL Reference #: (red tag)

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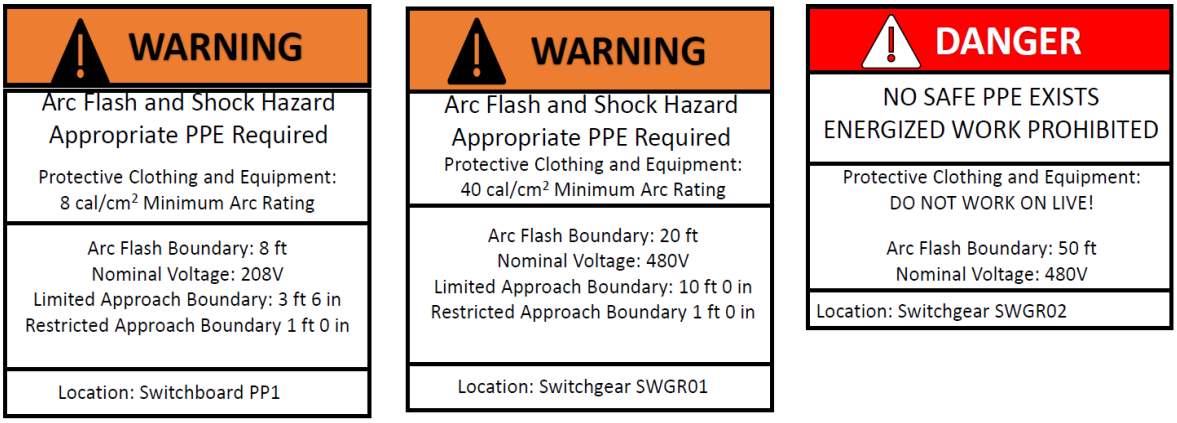
Appendix E: Electrical Safety/Arc Flash Labeling



NIST Standard AF Labels Examples
4" x 6"