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John C. Stennis Space Center
Electrical Safety Program

Approval/Concurrence

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Gary Benton, Director
Safety and Mission Assurance Directorate

Date

Document History Log

Status/Change/ Revision	Change Date	Originator/Phone	Description
Basic	May 19, 2009	Amy Rice 8-2972	Removed from SSP 8715-0001 Safety and Health Handbook and revised to include the guidance for electrical safety
Revision A	November 2, 2009	Amy Rice 8-2972	Added reference for Hazardous Classification SCWI
Revision B	January 18, 2011	Amy Rice 8-2972	Added Reference for Lock Out Tag Out SCWI, updated audit form number
Revision C	May 11, 2012	Amy Rice 8-2972	Updated 5.4 to reference NFPA 70E requirement. Updated extension cord section 6.1;
Revision D	August 2, 2012	Amy Rice 8-2972	Added reference for small appliance permits, updated forms section with the proper form numbers. Section 12.0.
Revision E	December 2, 2013	Delton Rodriguez 8-2499	Complete Revision
Revision F	June 24, 2014	Delton Rodriguez 8-2499	Clarifications to sections 5.0 and 6.0. Revised section 7.1.

Revision G	April 15, 2015	Delton Rodriguez 8-2499	Revised Section 4.1 to read NASA and SSC Employees, removed Section 4.4 the Safety and Mission Assurance Office of the Onsite Prime contractors shall from title, deleted section 5.5 e., revised Training Requirements for Qualified Persons 9.1 and Training Requirements for Unqualified Persons 9.2 to include New Employee Safety and Heath Orientation for NASA and Onsite Prime contractors and referenced SCWI-8715-0008 Construction Safety and Health Program for construction contractor training requirements.
Revision H	2/3/2017	Delton Rodriguez 8-2499	Administrative changes throughout. Updated references and acronyms. 4.3-a: Added "NFPA 70E". 4.3-l: Deleted "per System Operations and Maintenance Responsibility Database". 4.4: Added "or SMA Support Contractor". 4.4: Deleted sections e and f in their entirety. 5.1: Changed "Refer to Section 9.0" to "Refer to Sections 9.1". 5.2: Changed "NFPA 70E and OSHA" to "OSHA 1910.269 and NPR 8715.3C Section 3.6.2". 5.7.1-o: Deleted "and identified storage areas". 5.7.2-h: Deleted "Location of flash suits shall be identified for documentation." 5.7.6-b: Deleted "Exception" in its entirety. 5.10: Replaced section c and items 1-5 with sections c and d, and item 1. 5.10-e: Deleted "When de-energizing, follow the procedures described in Section 00." 6.1: Deleted "A Hazard/Risk Category 0 for PPE shall be used for the inspection

			of dead front panel board schedules. Hearing protection shall be used whenever inspecting or auditing electrical dead front panel boards." Added "In an effort to maintain electrical configuration of panel boards and schedules all electrical circuit breakers marked spare shall be kept in the off position." 6.2: Deleted previous section b in its entirety. 6.2-l: Deleted "All NASA Onsite Prime Contractors and Construction Contractors shall follow the Assured Equipment Grounding Conductor Program or use Ground Fault Circuit Interrupter Protection as outlined in Section 7.1." 6.3: Added sections a and b. 6.3-d: Added "transformer". 6.7: Added section f. 7.3: Added section a. 8.0: Deleted "using SSC Form 869, Electrical Safety Audit Form".
Revision I	6/29/2017	Delton Rodriguez 8-2499	6.1: Added "it is recommended all electrical circuit breakers marked "spare" shall be kept in the off position." 7.1b: Added "The following requirements apply to temporary wiring installations that are used during construction-life activities, including certain maintenance, remodeling, or repair activities, involving buildings, structures or equipment." 7.1-c Added "Receptacles other than 125 volt, single-phase, 15-, 20-, and 30-ampere receptacles that are not part of the permanent wiring of the building or structure and that are in use by personnel shave have ground-fault circuit-interrupter protection for personnel." 7.1-d: Added "Where the ground-fault circuit-interrupter protection is not available for receptacles other than 125-

			volt, single-phase, 15-, 20-, and 30-ampere, the contractor shall establish and implement an assured equipment grounding conductor program covering cord sets, receptacles that are not a part of the building or structure, and equipment connected by cord and plug that are available for use or used by employees on those receptacles." 9.1-c: Deleted "blood borne pathogen requirement."
Revision J	October 31, 2022	Amanda Loyd 8-1422	Complete Revision for compliance with 2021 NFPA 70E/2020 NFPA 70 2.0: Extended applicability to tenants, resident agencies, and document agreement parties. 3.0: Added references to IEEE 1814 and SSTD-8070-0138. 4.3-e: Added requirements for establishing Electrically Safe-Related Work Practices. 4.3-f: Added requirement for conformance with IEEE 1814. 4.3-i: Added risk assessment procedure and performance requirements. 4.3-o: Added risk assessment record keeping requirement. 4.5-c: Added conformance requirement to SSTD-8070-0183. 4.5-d: Added requirement for arc flash labeling. 4.6: Added cognizant organizational representative approval for Energized Electrical Work Permits. 5.3: Created new section for General Safety Requirements. 5.4: Created new section for Risk Assessment requirements. 5.5: Added approval requirements for Energized Electrical Work Permit. 5.5-e: Added reference to NFPA for safe work practices.

			5.5-f: Added reference to NFPA for shock risk assessment. 5.5-h: Added reference to NFPA for means to restrict access of unqualified workers. 5.5-i: Added reference to NFPA for Job Safety Planning. 5.5: Added exemptions to EEWP. 5.6.b-1: Added requirements for unqualified personnel to cross limited approach boundary. 5.6.c: Added requirements for qualified personnel to cross restricted approach boundary. 5.7.1-a: Added arc flash PPE selection methods. 5.7.1-e: Added guidance for selecting protective footwear for arc flash and electrical hazard exposure. 5.7.1-f: Added guidance for ANSI conformant face shields. 5.7.1-o: Added PPE assessment requirements for contractors. 5.7.2: Added requirements for using Arc Rated Apparel. 5.7.3: Added testing requirements for rubber insulting equipment. 5.7.4: Added requirements for insulted tools and equipment. 5.7.5: Added requirements for access limiting equipment. 5.8.1: Updated table references for working space about electrical equipment. 5.8.3-a: Added requirements for safety grounding equipment. 5.8.4: Updated table references for elevated equipment requirements. 5.8.6: Updated grounding requirements for equipment elevated within the limited approach boundary. 5.8.8: Created new section for Cutting, Removing or Rerouting of Conductors.

			5.9: Created new section Establishing an Electrically Safe Working Condition. 5.9.e: Added LOTO procedural requirements. 5.9.f: Added NFPA reference for the process for establishing an electrically safe work condition. 6.2.a: Added NFPA uses permitted and not permitted for flexible cords and cables. 6.2.d: Added NFPA requirements for job-made extension cords. 6.2.u: Added requirement for using flexible cords and cables in wet or damp locations according to manufacturer's instructions. 6.3.k: Added requirement for using temporary wiring according to manufacturer's instructions. 6.6.a: Added NFPA requirements for portable lighting equipment. 7.1.f: Added requirements for using GFCI Protection Devices according to manufacturer's instructions. 7.1.2: Added testing requirements for GFCI Protection Devices. 7.2.c: Added ground system inspection requirements for explosive storage facilities. 7.2.g: Listed new NPD 8710.3D standard for ESD measures/controls for Hydrogen. 7.2.h: Added requirements for ESD measures/controls for LNG. 7.3: Created new section Working with Capacitors. 7.4: Created new section Safety Requirements Related to Batteries and Battery Rooms. 7.5.i: Updated arc flash label requirements to conform with SSTD-8070-0138 and 2021 NFPA 70E revision. 7.5.j: Updated arc flash label images to comply with 2021 NFPA 70E revision requirements.

			8.0: Added NFPA 70E audit requirements for electrical safety program and field work. 9.1.a: Updated NFPA 70 articles to correct numbers per 2020 revision. 9.1.c: Added NFPA 70E training requirements for qualified employees. 9.1.d: Added NFPA 70E training requirements for qualified persons responding to electrical shock and injury. 9.2.c: Added NFPA 70E training requirements for unqualified employees. 9.2.g: Updated training information for construction workers. 10.0: Added SSTD-8070-0138 to listed electrical procedures. 11.0: Added SSC405 to listed forms. Appendix B: Added definitions for arc blast hazard, battery, bare conductor, capacitors, equipment, simple equipment/systems, and storage battery. Updated definition of electrically safe-work condition, qualified person/employee, and working on (energized electrical conductors or circuit parts).
Revision J-1	October 31, 2023	Jasper Cook 8-1511	5.8.1: Added new NFPA 70 110.26(A)(6) reference to existing workspace requirements

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TABLES

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1.0 PURPOSE

This Stennis Common Work Instruction (SCWI) establishes minimum standards to prevent personnel from hazardous electrical exposures and to ensure compliance with regulatory requirements applicable to electrical systems. This SCWI is designed to help ensure that energized electrical work at John C. Stennis Space Center (SSC) is performed safely by qualified electrical workers who are trained and provided with the appropriate safe work procedures, protective equipment, and other controls. This SCWI is also intended to educate all employees about electrical shock, burns, and other potential electrical safety hazards.

2.0 APPLICABILITY

This procedure is applicable to office activities, industrial activities/operations, test operations, maintenance processes, and construction projects at SSC in which personnel may be exposed to electrical hazards. This procedure applies to all National Aeronautics and Space Administration (NASA) personnel, NASA on-site prime contractor personnel, construction contractors, resident agencies, NASA/SSC tenants, and host tenant support parties as directed by Space Act Agreements and other applicable space utilization agreement documents.

3.0 REFERENCES

All references are assumed to be the latest version unless otherwise indicated.

a. 29 Code of Federal Regulations (CFR) 1910, Occupational Safety and Health Standards
b. 29 CFR 1926, Safety and Health Regulations for Construction
c. American National Standards Institute (ANSI)/American Institute of Aeronautics and Astronautics (AIAA) G-095A, Guide to Safety of Hydrogen and Hydrogen Systems
d. ANSI Z535, Safety Alerting Standards
e. American Society for Testing and Materials (ASTM) F496-06, Standard Specifications for In-Service Care of Insulating Gloves and Sleeves
f. ASTM F855, Standard Specification for Temporary Protective Grounds to be used on De-energized Electric Power Lines and Equipment
g. ASTM MNL 36, Safe Use of Oxygen and Oxygen Systems
h. ASTM 1506-19a, Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs
i. ASTM F1959, Standard Test Method for Determining the Arc Rating of Materials for Clothing
j. Institute of Electrical and Electronics Engineers (IEEE) 1814 Recommended Practices for Electrical System Design Techniques to Improve Electrical Safety
k. NASA Technical Standard (NASA-STD)-8719.17, Requirements for Ground-Based Pressure Vessels, and Pressurized Systems
l. NASA-STD-8719.12, Safety Standard for Explosives, Propellants, and Pyrotechnics
m. National Fire Protection Association (NFPA) 70, National Electrical Code (NEC)

n. NFPA 70B, Recommended Practice for Electrical Equipment Maintenance
o. NFPA 70E, Standard for Electrical Safety in the Workplace®
p. NFPA 780, Standard for the Installation of Lightning Protection Systems
q. NASA Policy Requirement (NPR) 8715.3D, NASA General Safety Program Requirements
r. SCWI-3410-0003, Training/Certification Plan and Schedule Report
s. SCWI-8715-0001, SSC Lightning Warning System
t. SCWI-8715-0008, Construction Safety and Health Program
u. SCWI-8715-0012, Work in Hazard Classification Areas
v. SCWI-8715-0013, SSC Control of Hazardous Energy Lockout/Tagout (LO/TO) and Non-Service/Maintenance Hazardous Energy Isolation
w. Stennis Plan (SPLN)-8838-0001, SSC Fire Protection Prevention Plan
x. Stennis Procedural Requirement (SPR) 8715.1, Safety and Health Program Requirements
y. SPR 8730.4, SSC Metrology and Calibration Control Program
z. Stennis Safety Procedure (SSP)-1740-0018, Use of Small Electrical Appliances
aa. Stennis Standard (SSTD)-8070-0081-ELEC, SSC Facility Electrical Standard
bb. SSTD-8070-0083-ELEC, SSC Standard for 13.8kV Distribution System
cc. SSTD-8070-0138-ELEC, *SSC Arc Flash Standard*
dd. Underwriters' Laboratory (UL) 96, Standard for Lightning Protection Components
bb. UL 96A, Standard for Safety Installation Requirements for Lightning Protection Systems

4.0 RESPONSIBILITY

4.1 NASA and SSC Employees

All NASA and SSC employees shall:

a. Not work on or near energized electrical equipment above fifty (50) Volts (V) if not qualified to do so.
b. Maintain a safe workspace, free of all electrical hazards and in compliance with all regulatory requirements.
c. Follow all applicable safe work practices listed in this SCWI.
d. Report unsafe electrical work conditions immediately to their supervisor or cognizant safety representative.

4.2 NASA SSC Directorates and Offices

NASA SSC directorates and offices shall:

a. Ensure all personnel are trained to recognize electrical hazards and understand the basic Occupational Safety and Health Administration (OSHA), NFPA 70, NEC, and NFPA 70E Electrical Safety Standards applicable to their work task and assignments.
b. Maintain a work environment free of all electrical safety hazards.

4.3 NASA Onsite Contractors and Construction Contractors

NASA contractors and construction contractors shall:

a. Ensure personnel are trained to recognize electrical hazards and understand the basic OSHA, NEC, and NFPA 70E electrical safety standards applicable to their work tasks.
b. Develop detailed electrical safety procedures for their employees to address all work conducted in both high and low voltage areas.
c. Ensure employees are trained in the proper use, wear, inspection, cleaning, and storage of personnel protection equipment (PPE) for electrical work.
d. Develop and utilize electrical safety programs that meet or exceed all applicable guidelines of this SCWI and directs activity appropriate to the risks associated with electrical hazards, voltage, energy levels, and circuit conditions.
e. Electrical safety program shall include Electrically Safety-Related Work Practices and establishes an electrically safe work condition compliant with NFPA 70E Sections 110 and 120.
f. Utilize Standard IEEE 1814 – Recommended Practices for Electrical System Design Techniques to Improve Electrical Safety for electrical design work.
g. Review electrical safety procedures of their subcontractors when the task of the subcontractors involves electrical work prior to the start of work.
h. Maintain electrical safety practices and procedures as part of their overall safety plan. The procedures shall be made specific to SSC.
i. Perform risk assessment (procedures) and comply with NFPA 70E 110.5(H)(1) through 110.5(H)(3), *Risk Assessment Procedure*.
j. Audit the electrical safety program and employee training to verify the principles and procedures of the electrical safety program are in compliance with OSHA, NEC, and NFPA 70E.
k. Conduct fieldwork and document audits of employees, subcontractors, and construction contractors to verify the requirements contained in the procedures of the electrical safety program and federal regulations are being followed. When the auditing determines that the principles and procedures of the electrical safety program are not being followed, the appropriate revisions to the training program or revisions to the procedures shall be made.
l. Utilize Energized Electrical Work Permit (EEWP) process for **approved work only** per Section 5.5. Energized electrical work is only allowed where de-energizing introduces an increased hazard or is not feasible and requires an EEWP to be completed.
m. Recognize equipment adjustments in high voltage or any other highly hazardous locations as being “SAFETY CRITICAL”. The responsible organization safety representative shall approve “SAFETY CRITICAL” operations. All work above 600V is classified as “SAFETY CRITICAL”.
n. Work in energized manholes or on energized manholes shall not be allowed unless approved by the NASA Operations and Maintenance cognizant organizational representative and the NASA SMA Electrical Subject Matter Expert (SME).

o. Maintain recordkeeping associated with the SCWI (e.g., documentation on electrical PPE, preventive maintenance, EEWPs, arc flash analysis, risk assessments, and coordination reports and project arc flash analysis software files).

4.4 Safety and Mission Assurance

The Safety and Mission Assurance Directorate (SMA) of NASA SSC or SMA Support Contractor shall:

a. Be the Office of Primary Responsibility (OPR) for an electrical safety program work instruction that is up to date and meets NASA, SSC, NFPA, and OSHA requirements.
b. Review all electrical safety plans for applicable content submitted by NASA direct construction contractors performing work at SSC. These plans shall be submitted as part of the construction contractor's health and safety plan.
c. Conduct field audits of employees, subcontractors, and construction contractors' electrical safety work to ensure compliance with federal regulations and compliance with this SCWI.
d. Evaluate electrical work being performed and determine compliance with this SCWI.

4.5 NASA Prime Contractors

The contractors shall perform the following to the extent specified in their respective contracts.

a. Perform electrical work as directed in their contract.
b. Correct electrical deficiencies reported through the Facility Manager Database in a timely manner.
c. Comply with requirements of SSTD-8070-0183, *SSC Arc Flash Standard.*
d. Produce and install field arc flash stickers that are compliant with requirements outlined in Section 6.1 of SSTD-8070-0183, *SSC Arc Flash Standard*. The method of calculating and data to support the information for the label shall be documented in an easily accessible central location for future system modifications and audits. Refer to Section 7.5 Equipment Labeling requirements.
e. Maintain electrical equipment in accordance with manufacturers' instructions or industry consensus standards to reduce the risk of failure and the subsequent exposure of employees to electrical hazards. Maintenance, tests, and inspections shall be documented.
f. Verify that newly installed or modified electrical equipment or systems have been inspected to comply with applicable installation codes and standards prior to being placed into service.

4.6 NASA Center Operations Directorate

NASA Center Operations Directorate (COD) shall:

a. Assure that a safe workplace is maintained through active coordination with and support to the designated facility managers and support organizations.
b. Provide cognizant organizational representative approval for Energized Work Permits.
c. The status of corrective actions shall be verified every thirty (30) days.

5.0 SAFETY REQUIREMENTS AND QUALIFIED PERSONS

5.1 Qualified and Unqualified Personnel

Only qualified personnel will conduct any electrical related work. Qualified personnel include employees (and their supervisors) working on or near exposed electrical circuits or unlisted equipment posing a shock or arc flash hazard who have received work specific training. A qualified person is one who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.

a. A qualified person shall be competent in the following:
    (1) Familiar with the proper use of the special precautionary techniques, applicable electrical policies and procedures, PPE, insulating and shielding materials, and insulated tools and test equipment for working on or near energized parts.
    (2) A person can be considered qualified with respect to certain equipment and tasks but still be unqualified for others.
    (3) Such persons permitted to work within the limited approach boundary shall, at a minimum, be additionally trained in all the following:
        i. Skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment.
        ii. Skills and techniques necessary to determine the nominal voltage of exposed live parts.
        iii. Calculation of the approach distances specified in NFPA 70E Table 130.4(E)(a), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating Current (AC) Systems* and NFPA 70E Table 130.4(E)(b), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Direct Current (DC) Systems* and the corresponding voltages to which the qualified person will be exposed.
        iv. Decision-making process necessary to be able to do the following:
            1. Perform the job safety planning
            2. Identify electrical hazards
            3. Assess the associated risk
            4. Select the appropriate risk control methods from the hierarchy of controls identified in NFPA 70E 110.1(H)(3), *Risk Assessment Procedure, Hierarchy of Risk Control Methods* including PPE

Unqualified personnel are those personnel who have not received the full training specified in Section 9.1 and/or do not possess or have not proven the knowledge and proficiency necessary to complete the associated electrical work safely and successfully. Unqualified persons shall be trained in, and be familiar with, any electrical safety-related practices necessary for their safety. Refer to Sections 9.1 and 9.2 for Training Requirements for Qualified and Unqualified Persons.

5.2 Required Personnel

At a minimum, two (2) qualified persons must be always in the immediate area when work is being performed on exposed, energized electrical conductors, or circuit parts carrying 50V or more. Each qualified person must be able to see and hear the other. This ensures that the qualified person will be available to assist the other in case of an accident and that one qualified person may act as a safety watch. Each qualified person will know the location of, have unobstructed access to, and know how to operate the power cutoff for the work area and how to contact emergency personnel. When hazard levels are significant, a safety watch is required. Refer to OSHA 1910.269 and NPR 8715.1B, Section 13.6.2 and 13.6.3 for specific requirements.

5.3 General Safety Requirements

General safety related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from electrical conductors or circuit parts that are or can become energized.

When energized electrical conductors and circuit parts operating at voltages equal to or greater than 50V are not put into an electrically safe work condition, and work is performed as permitting in accordance with NFPA 70E 110.4, all the following requirements shall apply:

a. Only qualified persons shall be permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition.
b. An energized work permit shall be completed as required by NFPA 70E 130.2. Refer to Section 5.5 for additional guidance on SSC requirements.
c. A shock risk assessment shall be performed as required by NFPA 70E 130.4.
d. An arc flash risk assessment shall be performed as required by NFPA 70E 130.5.

Note: All requirements of NFPA 70E Article 130 shall apply whether an incident energy analysis is completed or if Table 130.7(C)(15)(a), Table 130.7(C)(15)(b), and Table 130.7(C)(15)(c) are used in lieu of an incident energy analysis.

5.4 Risk Assessment

A risk assessment shall be conducted by a qualified electrical supervisor/engineer where electrical work is conducted on facility electrical distribution systems or electrical equipment or devices of exposed, energized electrical conductors or circuit parts, in accordance with NFPA 70E.

A risk assessment is an overall process that identifies hazards, estimates the likelihood of the occurrence of the injury or damage to health, estimates the potential severity of injury or damage to health, and determines if protective measures are required.

The electrical safety program shall include a risk assessment procedure with steps to include shock, arc flash, and battery type risk assessments and shall comply with the following:

a. **Elements of a Risk Assessment Procedure.** The risk assessment procedure shall address employee exposure to electrical hazards and shall identify the process to be used by the employee before work is started to carry out the following:
   (1) Identify hazards
   (2) Assess risks
   (3) Implement risk control according to the hierarchy of risk control methods
b. **Human Error.** The risk assessment procedure shall address the potential for human error and its negative consequences on people, processes, the work environment, and equipment relative to the electrical hazards in the workplace.
   Note: The potential for human error varies with factors such as tasks and the work environment. See Informative Annex Q in NFPA 70E.
c. **Hierarchy of Risk Control Methods.** The risk assessment procedure shall require that preventive and protective risk control methods be implemented in accordance with the following hierarchy methods outlined in NFPA 70E Annex F:
   (1) Elimination
   (2) Substitution
   (3) Engineering controls
   (4) Awareness
   (5) Administrative controls
   (6) PPE
d. **Job Safety Planning and Job Safety Briefing (Activity Hazard Analysis (AHA) or Safe Plan of Action (SPA))** whenever work involves exposure to electrical hazards, the qualified person in charge shall complete an AHA and conduct a job safety briefing with the personnel involved with the work. The job safety planning and briefing will address, at a minimum, the requirements per NFPA 70E Annex I:
   (1) A description of the work and procedures involved in the work.
   (2) Identification of hazards associated with each task.
   (3) Shock risk assessment in accordance with NFPA 70E 130.4, *Shock Risk Assessment.*
   (4) Arc flash risk assessment in accordance with NFPA 70E 130.5, *Arc Flash Risk Assessment* for tasks involving an arc flash hazard.
   (5) Battery risk assessment prior to any work on a battery system to identify the chemical, electric shock, and arc flash hazards and assess the risks associated with the type of tasks to be performed.
   (6) Work procedures involved, special precautions, and energy control sources.
   (7) PPE required for the work by determining which method shall be used for the selection using NFPA 70E 130.5(G), *Arc Flash Risk Assessment, Incident Energy*

Analysis Method and 130.7(C)(15), *Personal and Other Protective Equipment*, *Arc Flash PPE Category Method* & 130.7(C)(15)(c), *Arc Flash PPE Category Method, Protective Clothing and PPE.*

The job briefing shall cover the job safety plan (AHA or SPA) and the information on the EEWP if a permit is required.

e. **Change in Scope** requires additional job safety planning and job briefings shall be held if changes occur during the course of the work that might affect the safety of employees.

5.5 Energized Electrical Work Permit (EEWP)

Work on energized electrical equipment is generally not allowed at SSC. Working on equipment in a de-energized state is **required** unless de-energizing the equipment introduces an increased hazard or is not feasible. If live parts 50V or more are not placed in an electrically safe condition, the work to be performed shall be considered energized electrical work and shall be performed by **written permit only.** The NASA Prime Contractor's EEWP, S3-3100-F276, EEWP requires the approval of the Facility/Equipment Owner, Electrical Supervisor, Operations and Maintenance Manager (Prime Contractor), SMA Manager, and General Manager, and the electricians that perform the work. Any NASA Direct EEWP requires approval of facility service contractor or their designee/subcontractor, the SMA Support Contractor Safety, NASA Operations and Maintenance cognizant organizational representative, and NASA SMA Electrical Safety POC. The EEWP shall include, but not be limited to, the following items:

a. The permit shall be originated from a qualified supervisor or electrical system engineer.
b. Description of the circuit and equipment to be worked on and their location.
c. Description of the work to be performed.
d. Justification for why the work must be performed in an energized condition.
e. Description of the safe work practices to be employed – See NFPA 70E 130.1.
f. Results of the shock risk assessment – See NFPA 70E 130.4(A)
   (1) Voltage to which personnel will be exposed.
   (2) Limited approach boundary – See NFPA 70E Table 130.4(E)(a), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for AC Systems* and NFPA 70E Table 130.4(E)(b), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for DC Systems.*
   (3) Restricted approach boundary - See NFPA 70E Table 130.4(E)(a), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for AC Systems* and NFPA 70E Table 130.4(E)(b), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for DC Systems.*
   (4) Personal and other protective equipment required by this standard to safely perform the assigned task and to protect against the shock hazard.
g. Results of the arc flash risk assessment
   (1) Available incident energy at the working distance or arc flash PPE category. See Section 5.3.

(2) Personal and other protective equipment required by this standard to protect against the arc flash hazard. See NFPA 70E Table 130.7(C)(15)(c), *PPE.*
(3) Arc flash boundary. See Section 5.3 and see NFPA 70E 130.5(E), *Arc Flash Risk Assessment, Arc Flash Boundary.*

h. Means employed to restrict the access of unqualified persons from the work area [see NFPA 70E 130.2(B)(7), *EEWP, Elements of a Work Permit*].
i. Evidence of completion of a job briefing, including a discussion of any job-specific hazards [see NFPA 70E 110.5(I), *Electrical Safety Program*, *Job Safety Planning and Job Briefing*].
j. Energized work approval (authorizing or responsible management, safety officer, or owner, etc.) signature(s) informational.
k. The permit shall be posted in an appropriate location where the energized work is taking place for the duration of the task.
l. EEWP shall be maintained for a period of one (1) year.
m. EEWP shall be submitted to the appropriate work crew supervisor. In test areas, follow the proper protocols for obtaining access to the area by checking in with NASA/Synergy Achieving Consolidated Operations and Maintenance (SACOM) test stand operations personnel.
n. A cognizant responsible organization representative must obtain additional signature authorizations on the EEWP for electrical work over 600V which is considered Safety Critical Work. These signatures include facility service contractor or their designee/subcontractor, the SMA Support Contractor Safety, NASA Operations and Maintenance cognizant organizational representative, and NASA SMA Electrical Safety POC.

Note: An example of an EEWP can be found in Annex J of NFPA 70E. The intent of this permit is to ensure that all appropriate safety precautions are taken prior to starting energized electrical work.

Electrical work shall be permitted without an EEWP if a qualified person is provided with and uses appropriate safe work practices and PPE in accordance with Section 5.6 as well as properly verifies circuit elements and equipment are de-energized following the proper LO/TO protocols outlined in SCWI-8715-0013, *SSC Control of Hazardous Energy LO/TO.* Exemptions to EEWP include the following:

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

Note: Only a qualified person shall perform tasks such as testing, troubleshooting, and voltage measuring on equipment where electrical hazards exist.

5.6 Approach Distances

NFPA 70E defines two (2) approach distances for shock hazards and one (1) for arc flash. The approach boundaries specify minimum safe distances from exposed energized electrical circuits or circuit parts posing a shock hazard (limited, and restricted approach) or an arc flash hazard (arc flash boundary).

a. Approach boundaries to energized electrical or circuit parts for shock prevention are defined in NFPA 70E Table 130.4(E)(a), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for AC Systems*; and NFPA 70E Table 130.4(E)(b), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for DC Systems*.
b. The limited approach is a boundary to protect unqualified personnel (not performing work on exposed energized electric circuits above 50V and untrained in such work) from a shock hazard.

    (1) Unqualified personnel may not approach energized exposed electrical parts or bring conductive objects within ten (10) ft. (3 m) or the distance as dictated by following NFPA 70E Table 130.4(E)(a), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for AC Systems*. If there is a need for an unqualified person(s) to cross the limited approach boundary, a qualified person shall advise the unqualified person(s) of the possible hazards and continuously escort the unqualified person(s) while inside the limited approach boundary. Under no circumstance shall the unqualified person(s) be permitted to cross the restricted boundary.
    (2) Warning signs or temporary barriers will be installed in areas where energized electrical parts are exposed. A qualified person within this area will escort unqualified persons.
    (3) In certain instances, the arc flash boundary might be a greater distance from the energized electrical conductors or circuit parts than the limited approach boundary. The shock protection boundaries and the arc flash boundary are independent of each other. Placement of barriers and use of applicable PPE should be adjusted to the greater hazard.
    (4) Hearing protection shall be used whenever working within the arc flash boundary.

c. The **restricted approach boundary** is the closest distance to exposed live parts a qualified person can approach when using the applicable PPE. Due to its proximity to a shock hazard, the use of shock protection techniques and equipment are required. Inside this boundary, accidental movement can put a part of the body or conductive tools in contact with live parts. To cross the restricted approach boundary, the qualified person must:

(1) Have performed a Risk Assessment per Section 5.4 and an EEWP per Section 5.5 that is approved by the responsible qualified supervisor.
(2) Be insulated or guarded from energized electrical conductors or circuit parts operating at 50V or more. Insulating gloves and sleeves are considered insulation only regarding the energized parts upon which work is performed.
(3) Be working where the energized electrical conductors or circuit parts are insulated from the qualified person and from any other conductive object at a different potential.
(4) Minimize the risk from unintended movement by keeping as much of the body as possible out of the restricted space; body parts in the restricted space should be protected.
(5) Utilize hearing protection whenever working within the restricted approach boundary.

5.7 Personal Protective Equipment

5.7.1 General Requirements

a. Employees working in areas where there are potential electrical hazards must be provided with and use PPE that is appropriate for the specific work to be performed as required by NFPA 70E. The electrical tools and protective equipment must be specifically approved, rated, and tested for the levels of voltage to which an employee may be exposed.
   (1) Arc flash PPE will be selected using one of the following methods as part of an Arc Flash Risk Assessment for which requirements can be found in Section 5.3:
      i. The incident energy analysis method in accordance with NFPA 70E 130.5(G)
      ii. The arc flash PPE category method in accordance with NFPA 70E 130.7(C)(15)
b. Employees shall wear nonconductive head protection whenever there is a danger of head injury from electric shock or burns due to contact with live parts or from flying objects resulting from an electrical explosion.
c. Employees shall wear protective eye equipment whenever there is a danger of injury from electric arcs, flashes, or flying objects resulting from an electrical explosion.
d. Employees shall wear rubber-insulating gloves where there is a danger of hand or arm contact with live parts or possible exposure to arc flash burn. The employer shall certify that each pair of gloves is tested in accordance with American Society for Testing and Material (ASTM) F496-06 and industry standards. The certification shall identify that the gloves have passed the test and the date of the test. The employer shall have a system of documentation for tracking each pair of gloves with serial numbers, test results, and test dates, which correspond to the issued gloves.
e. Where insulated footwear is needed for protection against step and touch potential, employees shall wear leather or dielectric overshoes or both to provide some arc flash protection to the feet and shall be used in all exposures greater than 4cal/cm2 (16.75 J/cm2). Footwear other than leather or dielectric shall be permitted to be used provided it has been tested to demonstrate no ignition, melting, or dripping at the estimated incident

energy exposure or the minimum arc rating for the respective arc flash PPE category. Insulated soles shall not be used as primary electrical protection.

f. Face shields compliant with ANSI/International Safety Equipment Association (ISEA) Z87.1 without arc rating shall not be used for electrical work. Safety glasses or goggles must always be worn underneath face shields. Face shields are to be worn as secondary protection with primary eye protection worn underneath.
g. Additional illumination may be needed when using tinted face shields as protection during electrical work.
h. Electrical protective equipment must be selected to meet the criteria established by the ASTM and by the ANSI.
i. PPE must be maintained in a safe, reliable condition and be inspected for damage before each day's use and immediately following any incident.
j. Employees must use insulated tools and handling equipment that are rated for the voltages where a likelihood of contacting energized electrical lines or parts exists. Tools and handling equipment should be replaced if the insulating capability is decreased due to damage. Protective gloves must be used when employees are working with exposed electrical parts above fifty (50) volts.
k. Fiberglass reinforced plastic rod and tube used for live-line tools shall meet the requirements of applicable portions of electrical codes and standards dealing with electrical installation requirements.
l. Fuse handling equipment (insulated for circuit voltage) must be used to remove or install fuses when the fuse terminals are energized. Ropes and hand-lines used near exposed energized parts shall be nonconductive.
m. Protective shields, barriers, or insulating materials must be used to protect each employee from shock, burns, or other electrical injuries while that person is working near exposed energized parts that might be accidentally contacted or where dangerous electric heating or arcing might occur.
n. Documentation of electrical PPE testing shall be maintained and made available for audit and review.
o. Prime contractor and contractors shall conform NFPA 70E Annex H – Conformity Assessment of PPE. NFPA 70E Informative Annex H.4 offers a system of conformity assessment that can augment an employer’s PPE approval process. ANSI/SEA 125, American National Standard for Conformity Assessment of Safety and PPE is the standard for the conformity assessment methodology, and it provides three levels of conformity assessment.

5.7.2 Arc Rated Apparel and Under-Layers

a. When using Arc Rated (AR) Apparel, NPFA 70E Table 130.7(C)(14), *Informational Note: Standards for PPE* shall be followed.
b. AR apparel shall be visually inspected before each use. AR apparel that is contaminated or damaged shall not be used. Protective items that become contaminated with grease, oil, flammable liquids, or combustible liquids shall not be used.

c. The garment manufacturer's instructions for care and maintenance of AR apparel shall be followed. AR apparel shall be stored in a manner that prevents physical damage; damage from moisture, dust, or other deteriorating agents; or contamination from flammable or combustible materials. When AR clothing is cleaned, manufacturer's instructions shall be followed to avoid loss of protection.
d. When AR apparel is worn to protect an employee, it shall cover all ignitable clothing and allow for movement and visibility.
e. AR apparel must cover potentially exposed areas as completely as possible. AR shirt sleeves must be fastened, and AR shirts/jackets must be closed at the neck.
f. Non-melting, flammable garments (i.e., cotton, wool, rayon, silk, or blends of these materials) may be used as under-layers beneath AR apparel.
g. Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric under-layers next to skin. (An incidental amount of elastic used on non-melting fabric underwear or socks shall be permitted.)
h. AR garments worn as outer layers over AR apparel (i.e., jackets or rainwear) must also be made from AR material.
i. Arc Flash suits must permit easy and rapid removal by the user.

5.7.3 Rubber Insulating Equipment

a. Rubber insulating equipment includes protective devices such as gloves, sleeves, blankets, and matting.
b. Rubber insulating equipment shall be subject to periodic electrical tests in accordance with applicable state, federal, or local codes and standards. The maximum test interval shall not exceed that specified in NFPA 70E Table 130.7(C)(7)(b).
c. Maximum use voltages for rubber gloves shall not exceed that specified in NFPA 70E Table 130.7(C)(7)(a). The top of the cuff of the protector glove shall be shorter than the rolled top of the cuff of the insulting glove by the distance specified in Table NFPA 70E Table 130.7(C)(7)(a).
d. Matting will be required when the type of work performed requires the qualified person to contact the floor in a kneeling or prone position.
e. Insulating equipment must be inspected for damage before each day's use and immediately following any incident that could have caused damage.
f. An air test must be performed on rubber insulating gloves before each use.
g. Insulating equipment found to have defects that might affect its insulating properties must be removed from service until testing indicates that it is acceptable for continued use.
h. Where the insulating capability of protective equipment is subject to damage during use, the insulating material shall be protected by an outer covering of leather or other appropriate materials.
i. Rubber insulating equipment must be stored in an area protected from light, temperature extremes, excessive humidity, ozone, and other substances and conditions that may cause damage.
j. Repairs to rubber insulating equipment are prohibited.

5.7.4 Insulated Tools and Equipment

a. Tools and handling equipment used within the Restricted Approach Boundary shall be insulated. Insulated tools shall be protected from damage to the insulating material.
b. Only tools with a defined voltage rating are considered insulated.
c. Tools with unmarked rubber grips and plastic handles shall not be used in lieu of properly rated tools.
d. Requirements for insulated tools. The following requirements shall apply to insulated tools can be found in NFPA 70E 130.7(D).

5.7.5 Access Limiting Equipment

a. Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas containing energized conductors or circuit parts in accordance with 130.7(D)(2)(a) and 130.7(D)(2)(c). Conductive barricades shall not be used where it might increase the likelihood of exposure to an electrical hazard. Barricades shall be placed no closer than the limited approach boundary given in Table 130.4(E)(a) and Table 130.4(E)(b). Where the arc flash boundary is greater than the limited approach boundary, barricades shall not be placed closer than the arc flash boundary.
b. If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees. The primary duty and responsibility of an attendant providing manual signaling and alerting shall be to keep unqualified employees outside a work area where the unqualified employee might be exposed to electrical hazards. An attendant shall remain in the area if there is a potential for employees to be exposed to the electrical hazards.

5.8 Working Space about Electrical Equipment

5.8.1 Spaces around Electrical Equipment

Access and working space shall be provided and maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment in compliance with NFPA 70 110.26, *Spaces About Electrical Equipment*.

a. **Sufficient Access –** Sufficient access shall be provided and maintained around all electric equipment to permit ready and safe operating and maintenance of such equipment. Floor mark areas per SSTD-8070-0081-ELEC, Section 6.14 l.
b. **Working Space –** Working space for equipment operating at 1000V, nominal, or less to ground and likely to require examination, adjustment, services, or maintenance while energized shall comply with the dimensions of NFPA 70 110.26(A)(1), (A)(2), (A)(3), v(A)(4), and (A)(6) or as required or permitted elsewhere in NFPA 70.
c. **Depth of Working Space –** The depth of the working space in the direction of live parts shall be not less than that indicated in NFPA 70 Table 110.26(A)(1), *Working Spaces*

unless the requirements of NFPA 70 110.26(A)(1)(a), (A)(1)(b), or (A)(1)(c) are met. Distances shall be measured from the exposed live parts or from the enclosure or opening if the live parts are enclosed.

d. **Dead-front Assemblies –** Working space shall not be required in the back or sides of assemblies, such as dead-front switchboards or motor control centers (MCCs), where all connections and all renewable or adjustable parts, such as fuses or switches, are accessible from locations other than the back or sides. Where rear access is required to work on non-electrical parts on the back of enclosed equipment, a minimum horizontal working space of 762 mm (30 in.) shall be provided.
e. **Low Voltage –** Smaller working spaces can be permitted where all uninsulated parts operate at not greater than 30 Vrms, 42V peak, or 60V DC.
f. **Existing Buildings –** In existing buildings where electric equipment is being replaced, Condition 2 working clearance shall be permitted between dead-front switch boards, panel boards, or MCCs located across the aisle from each other where conditions of maintenance and supervision ensure that written procedures have been adopted to prohibit equipment on both sides of the aisle from being open at the same time. Qualified electrical workers who are authorized will service the installation.
g. **Width of Working Space –** The width of the working space in front of the electrical equipment shall be the width of the equipment or 762 mm (30 in.), whichever is greater. In all cases, the workspace shall permit at least a 90-degree opening of equipment doors or hinged panels.
h. **Height of Working Space –** The workspace shall be clear and extend from the grade, floor, or platform to the height of 2.0(m) (6 ft - 6 in.) or the height of the equipment, whichever is greater per NFPA 70 110.26(A)(3). Within the height requirements of this section, other equipment, or support structures, such as concrete pads, associated with the electrical installation and located above or below the electrical equipment shall be permitted to extend not more than 150 mm (6 in.) beyond the front of the electrical equipment.
i. **Clear Spaces –** Working space required by NFPA 70 110.26(B) shall not be used for storage. When normally enclosed live parts operating at 50V or more are exposed for inspection or service, the working space, if in a passageway or a general open space, shall be suitably guarded.
j. **Storage** – Storage of any materials is prohibited in mechanical and electrical rooms.

5.8.2 Other Working Space Requirements

Entrance to and egress from working spaces, area illumination, headroom, dedicated equipment space, and locked electrical equipment rooms or enclosures shall be maintained in accordance with NFPA 70 110.26**.**

5.8.3 Vehicular or Mechanical Equipment

a. When work must be performed near overhead lines, the lines shall be de-energized and grounded, or other protective measures shall be provided before work is started. Safety

grounding equipment including personal protective ground cable sets shall be visually inspected, tested prior to being returned to service (placing equipment in state of operation before it was taken out of service) for temporary protective grounding equipment, and stored in a clean and dry area per guidelines outlined in NFPA 70E 250.3, *Safety Grounding Equipment*.

b. If the lines are to be de-energized, arrangements shall be made with the person or organization that operates or controls the electric circuits involved to de-energize and ground the lines.
c. If protective measures, such as guarding, isolating, or insulating are provided, these precautions shall prevent employees from contacting such lines directly with any parts of their bodies or indirectly through conductive materials, tools, or equipment.

5.8.4 Elevated Equipment

Where any vehicle or mechanical equipment structure will be elevated near energized overhead lines, they shall be operated to maintain the Limited Approach Boundary distance indicated in NFPA 70E Table 130.4(E)(a), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for AC Systems,* Column 2 and NFPA 70E Table 130.4(E)(b), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for DC Systems,* Column 2 is maintained. However, under any of the following conditions, the clearances shall be permitted to be reduced:

a. If the vehicle is in transit with its structure lowered, the limited approach boundary to overhead lines as indicated in NFPA 70E Table 130.4(E)(a), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for AC Systems,* Column 2 and NFPA 70E Table 130.4(E)(b), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for DC Systems*, Column 2 shall be permitted to be reduced by 1.83 m (6 ft). If insulated barriers, rated for the voltages involved, are installed and they are not part of an attachment to the vehicle, the clearance shall be permitted to be reduced to the design working dimensions of the insulating barrier.
b. If the equipment is an aerial lift insulated for the voltage involved, and if the work is performed by a qualified person, the clearance (between the uninsulated portion of the aerial lift and the power line) shall be permitted as indicated in NFPA 70E Table 130.4(E)(a), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for AC Systems,* Column 4 and NFPA 70E Table 130.4(E)(b), *Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for DC Systems,* Column 4.

5.8.5 Equipment Contact

Employees standing on the ground shall not contact the vehicle or mechanical equipment or any of its attachments unless either of the following conditions applies:

a. The employee is using protective equipment rated for the voltage.
b. The equipment is located so that no non-insulated part of the structure (that portion of the structure that provides a conductive path to employees on the ground) can come closer to the line than permitted in NFPA 70E 130.9 (F)(1), *Work Within the Limited Approach Boundary or Arc Flash Boundary of Overlines, Vehicular and Mechanical Equipment, Elevated Equipment.*

5.8.6 Equipment Grounding

a. If any vehicle or mechanical equipment can have portions of its structure elevated within the limited approach boundary of exposed movable conductors of energized overhead lines and is intentionally grounded, employees working on the ground near the point of grounding shall not stand at the grounding location whenever there is a possibility of overhead line contact.
b. Additional precautions, such as the use of barricades or insulation, shall be taken to protect employees from hazardous ground potentials (step and touch potential) that can develop within a few feet or more outward from the ground point.

5.8.7 Cutting or Drilling

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

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

5.8.8 Cutting, Removing or Rerouting of Conductors

Where conductors are de-energized to cut, remove, or reroute them and the conductor terminations are not within sight from the point of work, such as where the conductors are remote from the source of supply in a junction or pull box, additional steps to verify absence of voltage or identify the conductors shall be taken prior to cutting, removing, or rerouting the conductors.

5.9 Establishing an Electrically Safe Working Condition

a. Personnel shall comply with NFPA 70E Section 120 requirements for establishing an Electrically Safe Work Condition for the period which the state is maintained.
b. The most important principle of electrical safety is to assume all electric circuits are energized unless each involved worker ensures they are not per NFPA 70E 120.1 Section 120.5 requirements. Every circuit and conductor must be tested every time work is done. Proper PPE must be selected in accordance with Section 5.6.
c. PPE shall always be worn until the equipment is proven to be de-energized.

d. Perform LO/TO in accordance with SCWI-8715-0013, SSC Control of Hazardous Energy LO/TO and Non-Service/Maintenance Hazardous Energy F to ensure the system is blocked and/or relieved any stored non-electrical stored energy in devices to the extent the circuits parts cannot be unintentionally energized and in a safe state where no hazardous energy is present.
e. A LO/TO procedure shall be developed based on the existing electrical equipment and system and shall use suitable documentation including up-to-date drawings and diagrams. The procedure shall meet the requirements of applicable codes, standards, and regulations for lockout and tagging of electrical sources.
f. The process for establishing and verifying an Electrically Safe Work Condition shall include all the steps listed in NFPA 70E Sections 120.5(1)-120.5(8).
g. The process of de-energizing is "live" work and can result in an arc flash due to equipment failure.

6.0 GENERAL ELECTRICAL SAFETY REQUIREMENTS

This section applies to all employees regardless of qualification.

6.1 Inspections and Audits of Panel Boards

Only qualified personnel will open or close electrical panels, box doors, or touch any circuit breaker (CB) for inspections or audits of electrically protected dead front panel boards. Inspectors and auditors are required to take the SACOM Electrical Utilization Class prior to performing inspections or audits of electrical dead front panel boards. To maintain electrical configuration of panel boards and schedules, all electrical CBs marked “spare” shall be kept in the off position.

6.2 Flexible Cords, Cables, and Extension Cords

a. NFPA 70 Sections 400.10 and 400.12, *Flexible Cords and Cables*, *Uses Permitted and Uses Not Permitted* and 590, *Temporary Installations*, do not permit flexible cords and cables to be used as a substitute for permanent building wiring. Uses permitted include the following:
   (1) Pendants
   (2) Wiring of luminaires
   (3) Connection of portable luminaires, portable and mobile signs, or appliances
   (4) Elevator cables
   (5) Wiring of cranes and hoists

   Uses not permitted include the following:
   (1) As a substitute for the fixed wiring of a structure
   (2) Where run through holes in walls, structural ceilings, suspended ceilings, dropped ceilings, or floors
   (3) Where run through doorways, windows, or similar openings
   (4) Where attached to building surfaces

Exception to (4): Flexible cord and flexible cable shall be permitted to be attached to building surfaces in accordance with NFPA 70 Section 368.56(B).

(5) Where concealed by walls, floors, or ceilings or located above suspended or dropped ceilings
Exception to (5): Flexible cord and flexible cable shall be permitted if contained within an enclosure for use in other spaces used for Environmental Air as permitted by NFPA 70 Section 300.22(C)(3).

(6) Where installed in raceways, except as otherwise permitted in this Code

(7) Where subject to physical damage

b. Use of extension cords and re-locatable multiple-outlet power strips are to be used in a manner compatible with their Nationally Recognized Testing Laboratory (NRTL), e.g., Underwriters Laboratories Inc. (UL), rating and listing. They shall not be used as a substitute for the installation of permanent building branch circuits.

c. Extension cords intended for hazardous locations shall comply with SCWI-8715-0012*, Work in Hazard Classification Locations.*

d. Job-made extension cords shall comply with the following:
(1) Shall comply with NFPA 70E 110.9.
(2) Be constructed using Nationally Recognized Testing Laboratory (NRTL) approved parts.
(3) Be assembled by a qualified electrician knowledgeable in wiring methods as required by the NFPA 70 for electrical equipment.
(4) Maintain a documented log of the personnel performing the wiring.
(5) Be constructed with cable conductor sized appropriately for the voltage and amperage rating required for the intended use.
(6) Be tested and verified for correct phasing of the cord, hot-to-hot, neutral-to-neutral, and ground-to-ground, by the qualified electrical personnel constructing the extension cord during assembly.

e. Damaged extension cord ends may be replaced as needed (no jacket repairs or splicing are authorized). The damaged portion of the extension cord may be removed and be replaced with a cord connector or attachment plug. Shrink-wrapping of cords only applies to hard service cords (types S, SO, ST, and STO) as designated on the cord by the manufacturer.

f. Extension cords and multiple-outlet power strips shall not be connected in series (daisy-chained) and are to be plugged directly into a wall receptacle for general use. Cords may be connected in series for construction work as long as the power source has a Ground-Fault Circuit Interrupters (GFCI).

g. Extension cords and multiple-outlet power strips may be used as needed to support office-type equipment in an office environment when used in a manner compatible with their NRTL rating and listing.

h. Extension cords and multiple-outlet power strips shall not exceed fifteen (15) feet in length when used in the office environment.

i. Extension cords and multiple-outlet power strips shall have conductors correctly sized and rated, have an outer jacket rated for their intended use, and be used according to the manufacturer's recommended instructions.

j. Extension cords and multiple-outlet power strips are to be inspected before use for defects such as exposed wiring, loose connections, cracked insulation, and loose strain reliefs.

Pre-Use: Portable cord-and-plug-connected equipment and extension cords must be visually inspected before each use for external defects such as loose parts, deformed and missing pins, or damage to outer jacket or insulation, and for possible internal damage such as pinched or crushed outer jacket. Any defective cord or cord-and-plug-connected equipment must be removed from service, and no person may use it until it is repaired and tested to ensure its safety in accordance with Section 6.7.

k. Extension cords or power strips must be kept clear of walkways where they can become a tripping hazard or be damaged. Protect cords by placing them along a perimeter wall or under protective covers.

l. Extension cords shall be protected from damage. Sharp corners shall be avoided. Flexible cords shall not be run through windows or doors unless protected from damage and precautions have been taken to protect personnel, and then only on a temporary basis. Flexible cords shall not be run above ceilings, inside or through walls, ceilings, and floors. Cords may not be fastened with staples or otherwise hung in such a fashion as would damage the outer jacket or insulation.

m. Attachment plugs and receptacles may not be connected or altered in any way that would interrupt the continuity of the equipment grounding conductor. Additionally, these devices may not be altered to allow the grounding pole to be inserted into current connector slots.

n. Clipping the grounding prong from an electrical plug or using an electrical cord with the ground prong missing is prohibited.

o. In general, all equipment and tools connected by cord and plug must be grounded. Listed or labeled double-insulated tools and appliances need not be grounded.

p. Extension cords must be of the three (3) wire type. Extension cords and flexible cords must be designed for hard or extra-hard usage (e.g., types S, ST, and SO). The rating or approval must be visible.

q. Because of the nature of SSC environment, GFCI shall be used with all extension cords when work is performed outdoors and indoors when there is the potential for damp or wet environments. Portable type GFCIs shall be tested each time before use with the test and reset buttons.

r. Portable equipment must be handled in a manner that will not cause damage. Flexible electric cords connected to equipment may not be used for raising or lowering the equipment.

s. Work in **wet** or **damp locations** (i.e., areas surrounded or near water or other liquids) should not be performed unless it is critical. Electrical work should be postponed until the liquid can be cleaned up.

t. If working in wet or damp locations cannot be avoided, the following special precautions must be incorporated:
   (1) All portable electric equipment and flexible cords used in highly conductive work locations must be approved for those locations.
   (2) Only electrical cords equipped with or connected to a GFCI shall be used.

(3) All GFCIs shall be plugged in at the power source, not at the working end of the cord. Cord-connected portable tools likely to be used in wet and conductive locations shall be protected by UL approved weatherproof GFCI. The GFCI shall be rated for the load of the equipment being used.
(4) A dry barrier shall be placed over any wet or damp work surface.
(5) All electrical cords shall be kept away from standing water.
(6) Equipment shall be used in accordance with manufacturer's instructions and safety warnings.

u. Employees' hands must be dry when plugging and unplugging flexible cords and cord-and-plug connected equipment if energized equipment is involved.
v. If the connection could provide a conducting path to employees' hands (e.g., if a cord connector is wet from being immersed in water), the energized plug and receptacle connections must be handled only with insulating protective equipment.
w. Locking-type connectors must be properly locked into the connector.

6.3 Temporary Wiring

This section applies to temporary wiring typically found in a construction environment where voltages are less than 600V.

a. Temporary installations shall be approved by NASA SMA Electrical SME.
b. A submission of a sketch for temporary wiring and power installation shall be required during the 90% design review for approval by the SMA Electrical SME.
c. NASA SMA Electrical SME shall approve temporary electrical installations and time duration.
d. Temporary installation shall be designed and installed per NFPA 70 Section 590, *Temporary Installations* requirements.
e. Feeders must originate in an approved distribution center, such as a panel board, that is rated for the voltages and currents the system is expected to carry. Over current protection and cables (type) shall comply with NFPA 70 Section 590.4(B), *Temporary Installations, Feeders*.
f. All branch circuits shall originate in an approved power outlet, transformer, switchgear, switchboard or panel board, MCC, or fused switch enclosure.
g. Neither bare conductors nor earth returns may be used for the wiring of any temporary circuit.
h. Receptacles must be of the grounding type. Unless installed in a complete metallic raceway, each branch circuit must contain a separate equipment-grounding conductor and all receptacles must be electrically connected to the grounding conductor.
i. Flexible cords and cables must be of an approved type and suitable for the location and intended use. They may be used only for pendants, wiring of fixtures, and connection of portable lamps or appliances, elevators, hoists, connection of stationary equipment where frequently interchanged, prevention of transmission of noise or vibration, data processing cables, or where needed to permit maintenance or repair.

j. Suitable disconnecting switches or plug connects shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.
k. Equipment and devices shall be used in accordance with manufacturer's instructions and any UL listings.

6.4 Small Appliance Permit for Personal Use

a. All appliances for personal use in the workplace such as coffee pots, heaters, microwaves, and toasters will be listed and shall exhibit the label of an NRTL.
b. Form SSC222, *Permit for Use of Small Appliance*, is issued only by the SSC Fire Department and shall accompany small electric appliances per SSP-1740-0018.
c. The permit shall be obtained prior to initial usage of the appliances at NASA SSC.
d. Electric heaters for office use shall not be permitted without written authorization from the Authority Having Jurisdiction for fire safety as required by SPLN-8838-0001 Section 5.7.1, *SSC Fire Protection/Prevention Plan*. Electric heaters must have automatic shut-off tip over feature.

6.5 Portable Electric Tools and Electrical Apparatus

a. Area Supervisors shall ensure that periodic inspections are performed of portable electric tools and apparatus, and that employees using such tools have been properly trained.
b. Prior to use, employees shall inspect portable electric tools, hand lamps, and extension cords to ensure proper configuration, safe operation, and tag out of defective tools/equipment for return to the tool crib for repair/replacement.
c. Electric tools, hand lamps, extension cords, and similar hand-held electric equipment shall be approved by an NRTL for its intended purpose.
d. Pneumatic tools, portable electrical tools, intrinsically safe instruments, or approved equipment shall meet the standards/requirements for use in any area that meets a NFPA Class I/Division I and Class I/Division II classification per SCWI-8715-0012, *Work in Hazard Classification Areas*.
e. All portable electric tools shall be equipped with a ground wire unless they are double insulated. Portable electric tools equipped with the double-insulation system are normally identified by a two-conductor cord and plug attached to the portable electric tool.
f. Low-voltage transformers, insulating platforms, rubber mats, or rubber gloves are to be used when using tools in damp locations.
g. Low-voltage transformers shall be used whenever electrical work is performed in wet locations.
h. The operating control on handheld power tools shall have a switch that requires constant pressure to operate and be located as to minimize the possibility of inadvertent actuation.
i. Handheld powered drills, horizontal/vertical/angle grinders with wheels greater than two (2) inches in diameter, disc sanders with discs greater than two (2) inches in diameter, belt sanders, and reciprocating/saber/scroll/jig saws with blade shanks greater than a nominal 0.25 in. (+0.05 in.) shall be equipped with a switch that requires constant pressure to operate (dead man switch).

6.6 Portable Hand Lamps/Temporary Lighting

a. Portable lighting equipment shall comply with NFPA 70 501.130(A)(1), *Luminaires, Class I, Division I* or Section 501.130(B), *Luminaires, Class I, Division 2*.
b. Lamps shall be equipped with polarized/grounded attachment plugs, a handle made of molded composition or other insulating material, and include a guard attached to the handle/lamp holder. Metal shell and paper-lined lamp holders are not permitted for use.
c. Bulbs of all overhead/temporary lighting shall be enclosed by guards to prevent damage to bulbs and injury to personnel by electric shock or broken glass.
d. Lamps for general illumination must be protected from breakage, and metal shell sockets must be grounded.
e. Temporary lights must not be suspended by their cords unless they have been designed for this purpose.
f. Portable lighting used in wet or conductive locations, such as tanks or boilers, must be operated at no more than 12V or must be protected by GFCIs.

6.7 Test Instruments and Equipment

a. Only qualified persons shall perform tasks such as testing, troubleshooting, and voltage measuring within the limited approach boundary of energized electrical conductors or circuit parts operating at 50V or more or where an electrical hazard exists.
b. Test instruments, equipment, and their accessories shall be rated for circuits and equipment to which they will be connected.
c. Test instruments, equipment, and their accessories shall be designed for the environment to which they will be exposed and for the manner in which they will be used.
d. Test instruments, equipment, and all associated test leads, cables, power cords, probes, and connectors shall be visually inspected for external defects and damage before each use. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service, and no employee shall use it until repairs and tests necessary to render the equipment safe have been made. All damaged or unusable equipment shall be tagged out of service and turned in for repair or replacement.
e. When test instruments are used for verifying the absence of voltage on conductors or circuit parts operating at 50V or more, the operation of the test instrument shall be verified before and after an absence of voltage test is performed.
f. Only calibrated test equipment shall be used for safety critical functions such as LO/TO and verification of zero electrical energy.

6.8 Emergency Lighting

a. All windowless buildings shall be provided with emergency lighting.
b. Emergency lighting shall be provided for all occupied facilities per SSTD-8070-0081-ELEC, *Facility Electrical Standard*.

7.0 SPECIAL REQUIREMENTS FOR ELECTRICAL SAFETY

7.1 Assured Equipment Grounding Conductor Program (AEGCP) and GFCI Protection

a. Employees who are exposed to electrical hazards at the work location shall use either GFCI Protection or an AEGCP.
b. The AEGCP and the GFCI Protection applies to NASA onsite prime contractors and construction contractors. The following requirements apply to temporary wiring installations that are used during construction-like activities, including certain maintenance, remodeling, or repair activities, involving buildings, structures or equipment.
c. Receptacles other than 125V, single-phase, 15-, 20-, and 30- ampere receptacles that are not part of the permanent wiring of the building or structure and that are in use by personnel shall have ground-fault circuit-interrupter protection for personnel.
d. Where the ground fault circuit-interrupter protection is not available for receptacles other than125V, single-phase, 15-, 20- and 30- ampere, the contractor shall establish and implement an assured equipment grounding conductor program covering cord sets, and receptacles that are not a part of the building or structure, and equipment connected by cord and plug that are available for use or used by employees on those receptacles.
e. Equipment shall be used in accordance with manufacturer’s recommendations.

7.1.1 AEGCP

a. The AEGCP includes a scheduled system for testing construction site electrical tools and extension cords to assure their proper grounding, polarity, and resistance.
b. The AEGCP shall cover all cord sets and receptacles not part of the permanent wiring of a structure, and equipment connected by a cord and plug on all maintenance and construction sites.
c. A written description of the program shall be maintained, which outlines the implementation and required procedures, equipment inspections, tests, and test schedule for inspection and copying by OSHA and any affected employee upon demand.
d. The contractor shall designate one (1) or more competent persons (as defined in OSHA 1926.32(f)) to implement the program.
e. Daily Visual Inspections (Pre-Use) – Each cord set, attachment cap, plug, and receptacle of cord sets, and any equipment connected by cord and plug, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as deformed or missing pins or insulation damage, and for indications of possible internal damage such as pinched or crushed outer jacket. Any defective cord or cord-and-plug connected equipment shall be removed from service. Cords/Equipment found damaged or defective shall not be used until repaired.
f. Removing Cords/Equipment – All cords or cord-and-plug connected equipment found damaged or defective, or which fails any of the prescribed inspections or tests, may not

be used until repaired or replaced. All defective or failed equipment must be tagged with a Red Tag "Do Not Operate" until repaired and tested or rendered unusable and discarded. Equipment that has not been tested within three (3) months shall not be used.

g. The following tests shall be performed on all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and cord-and plug-connected equipment required to be grounded:
   (1) All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.
   (2) Each receptacle and attachment cap or plug shall be tested for correct attachment of the equipment grounding conductor.
   (3) The equipment grounding conductor shall be connected to its proper terminal.

h. All required tests shall be performed as follows:
   (1) Before first use on site.
   (2) Before equipment is returned to service (placing equipment in state of operation before it was taken out of service) following any repairs.
   (3) Before equipment is used after any incident in which it was reasonable to suspect it became damaged. (For example, a cord set is run over.)
   (4) At intervals not exceeding three (3) months, except for cord sets and receptacles which are fixed and not exposed to damage, which should be tested at intervals not to exceed six (6) months.
   (5) The tests required in items 1) – 4) shall be recorded,
   (6) Tester shall use either a continuity tester, ohmmeter, and/or a receptacle tester for testing continuity and equipment grounding conductor/terminals.

i. The NASA onsite prime contractors and construction contractors shall maintain a written record of the required tests, identifying all equipment that passed the test and the last date it was tested (or the testing interval). This record shall be kept by means of logs and color coding (see **Table 1**), or other effective means and shall be maintained until replaced by a more current record. These records will be available for audit or inspection by NASA SMA or their designees, OSHA and any affected personnel upon demand.

Table 1. Assured Equipment Grounding Conductor Program – Color Coding Scheme

Quarter	Month	Monthly Color
1st	January	White
1st	February	White
1st	March	White
2nd	April	Red
2nd	May	Red
2nd	June	Red
3rd	July	Green

3rd	August	Green
3rd	September	Green
4th	October	Blue
4th	November	Blue
4th	December	Blue
	Repair Color	Brown

Note: Ensure that the prior quarter's color tape is removed before the current quarter's tape is applied.

7.1.2 GFCI Protection

a. Testing of GFCI Protection Devices shall be tested in accordance with manufacturer's recommendations.
b. GFCI protection shall be provided when an employee is outdoors and operating or using cord-and plug-connected equipment supplied by 125V, 15-, 20-, or 30-ampere circuits. For additional GFCI protection requirements, refer to Section 6.2
b. Portable electrical devices used inside/on conductive surfaces shall be equipped with a GFCI. Due to the complexity of a GFCI, it is necessary to test the device on a regular basis. Refer to NFPA 70 110.3(B) and CFR 1910.303 (b) (2) for requirements.
c. All electrical equipment using over 24V in a confined space shall be protected by a GFCI.
d. A GFCI line cord must be connected on the line side of the extension cord. Refer to Figure 1.

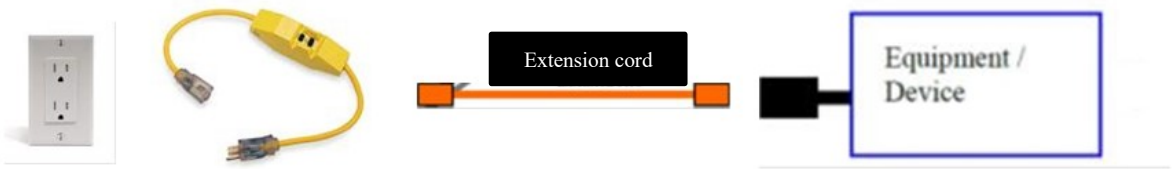

Figure 1. Example of a Line Cord GFCI

e. Temporary protective grounding equipment shall be placed at such locations (overhead lines, switchgear, busbar) and arranged in such a manner as to prevent each employee from being exposed to hazardous differences in electrical potential.
f. Temporary protective grounding equipment shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.

g. Temporary protective grounding equipment shall meet the requirements of ASTM F 855, *Standard Specification for Temporary Protective Grounds to be used on De-energized Electric Power Lines and Equipment.*

7.2 Fundamental Safety Rules and Procedures - Electrostatic Discharge Control

This instruction provides the general safety requirements for the development of appropriate control measures to provide protection against personal injury, property damage, and/or mission degradation due to the Electrostatic Discharge (ESD) and subsequent initiation of solid propellants, igniter components, explosives, or flammable/combustible materials. These instructions establish mandatory ESD control requirements for NASA and for NASA contractors at SSC who engage in the receiving, distributing, assembling, disassembling, handling, testing, repairing, or storing of explosive ordinance, flammable/combustible materials, or propellants. ESD control general requirements are listed below.

a. **Grounding Systems:** Grounding systems shall be tested and retested for electrical resistance and continuity in the following conditions:
   (1) When initial installation is completed to establish a baseline.
   (2) Before equipment is returned to service (placing equipment in state of operation before it was taken out of service) following any repairs.
   (3) Before equipment is used after an incident that is suspected to have caused damage to power (electrical) systems in the equipment or system.
   (4) Explosive operations/facilities shall be visually inspected semiannually and shall be tested once each year for electrical continuity and adequacy of grounding.
b. **Ground Tests:** Ground tests will be recorded, identifying the item/system, the date of test, the test equipment used, and the test equipment's calibration date.
c. **Ground System Inspection:** The ground system shall be visually inspected, and grounds shall be tested by maintenance prior to activation and reactivation of the system if the equipment has been inactive for more than one (1) year. For explosive operations, the ground system shall be visually inspected by maintenance prior to activation and reactivation of the system if the equipment has been inactive for more than one (1) month. If the system has been inactive for more than six (6) months, it shall be visually inspected by maintenance and tested prior to activation and reactivation. Recurring visual and measured grounding inspections of explosive storage facilities shall be performed at the rate specified in NASA-STD-8719.12.
d. **Maximum Resistance to Ground:** The maximum resistance to ground permitted for different types of equipment/systems for hazardous locations and non-hazardous locations shall be designed and tested per SSTD-8070-0081-ELEC, *SSC Facility Electrical Standard*, and per NASA-STD-8719.12, *Safety Standard for Explosives, Propellants, and Pyrotechnics*.
e. **Electrostatic Charging Control:** Controls required for preventing electrostatic charging are dependent on many factors, including the materials being processed, contacting materials, the process or operation being performed, hardware and equipment design, and materials of construction. The control measures may include the use of anti-static spray to

minimize charge build-up, static dissipation, and conductive plastics, metals, electrical bonding and grounding; process delays permitting charge relaxation from materials of low conductivity, and the use of leg or wrist-straps by operating personnel. The specific measures must be defined for each operation or process determined to be a significant electrostatic charge generator. Control measures shall be specified in individual operating procedures.

f. **Process Procedures:** Material electrical properties are primary contributors to the magnitude of the electrostatic charge build-up and rate dissipation. Process procedures shall define the materials to be permitted to contact live propellants, energetic materials, and loaded solid rocket motors. Nonconductive materials are not to be used unless specified within a procedure.

g. **ESD Measures for Combustibles:** ESD measures/controls for working with flammable/combustible liquids:
   (1) Paint Spraying – Paint spray gun nozzles and pressure feed pots shall be grounded. Care must be taken to ensure ground connections remain free of paint coatings.

h. **ESD Measures for Hydrogen:** ESD measures/controls for working with liquid/gaseous hydrogen shall follow: NASA Policy Directive (NPD) 8710.3D, *NASA General Safety Program Requirements*; NASA-STD-8719.17, *NASA Requirements for Ground-Based Pressure Vessels and Pressurized Systems*; appropriate OSHA; NFPA; ASTM (ASTM MNL 36, *Safe Use of Oxygen and Oxygen Systems*), and ANSI (ANSI/AIAA G-095-2004, *Guide to Safety of Hydrogen and Hydrogen Systems*).

i. **ESD Measures for Liquefied Natural Gas (LNG):** ESD measures/controls for working with LNG shall follow: NFPA 59A, *Standard for the Production, Storage, Handling of LNG*.

7.3 Working with Capacitors

Electrical safety-related requirements for the practical safeguarding of employees while working with capacitors that present an electrical hazard can be found in NFPA 70E Section 360. A process for performing a capacitor risk assessment can be found in NFPA 70E Section 360.4(B). NFPA 70E Informative Annex R provides detailed information on capacitor hazards and controls. Qualified personnel must have documented training before working with capacitors.

7.4 Safety Requirements Related to Batteries and Battery Rooms

7.4.1 General Safety Requirements

Responsible personnel should follow best practices for storage, transportation, handling, procurement, and disposal of batteries by referencing relevant standards including ANSI/AIAA S-136-201X, Safety Standard for Space Lithium Batteries, NFPA 70E Section 320, *Safety Requirements Related to Batteries and Battery Rooms,* NFPA 70 Section 480, *Storage Batteries* and NPR 8715.3, Section 3.6. Test criteria can be found in UL 1642, Standard for Lithium Batteries.

7.4.2 Storage

Stored batteries should be labeled and segregated as new, used, or damaged and stored away from combustible materials. Batteries should be stored in controlled environments per manufacturer instructions. Refer to manufacturer instructions for routine cell voltage checks and long-term storage requirements. Battery rooms and enclosures shall only be accessible to authorized personnel.

7.4.3 Transportation

While transporting batteries, comply with CFR Title 49: Part 174.185. Transport batteries in dustproof, moisture-resistant cartons with appropriate labels.

7.4.4 Handling

Perform a Battery Risk Assessment with required Arc Flash Incident Energy Analysis per Section 5.3 and NFPA 70E Section 320. An example is found in NFPA 70E Informational Annex F and Figure F.7. Hazard identification and risk assessment should consider the unique characteristics of DC systems and shall follow NFPA 70E Section 310.5(C), *Direct-Current Incident Energy Calculations*. If it is determined that an electrical hazard does exist, only those persons considered as qualified are permitted to perform tasks such as testing, troubleshooting, voltage measuring, or similar diagnostic work. Post warning signs or labels that adhere to NFPA 70E Section 320.3 (A)(6) based on results of the risk assessment and corresponding arc flash analysis. Include warning signs or labels to address shock and arc flash as well as chemical and thermal hazards. Consider labeling all positive and negative terminals. Use PPE that is appropriate for the conditions as determined by risk assessment. Follow NFPA 70E Section 310.5(D) for safeguards to prevent contact with energized or grounded surfaces that could present an electrical hazard.

7.4.5 Procurement/Operation

Procure only UL-certified batteries by verifying that proper testing and certification documentation are included with purchase. Ensure that batteries are operated, used, and maintained in accord with manufacturer’s specifications and cut sheets. Use approved procedures during the testing, operating, and handling of batteries. Avoid any repair or modification to battery hardware.

7.4.6 Disposal

Follow appropriate protocols for disposing of hazardous waste include guidance provided in ANSI/AIAA S-136-201X, Safety Standard for Space Lithium Batteries. Consider covering exposed battery cell terminals with electrical tape to prevent accident short-circuit discharges.

7.5 Equipment Labeling

a. Mechanical and electrical rooms shall have signage stating authorized personnel only and shall be locked to prevent access by unauthorized persons.
b. NFPA 70 Section 110.16, *Arc Flash Warning Hazard* and NFPA 70E Section 130.5(H) requires switchboards, switchgear, panel boards, industrial control panels, meter socket enclosures and MCCs that are likely to require examination adjustment, servicing or maintenance while energized to be field marked to warn workers of potential electric arc flash hazards.
c. The term, Industrial Control Panel, covers every enclosure that may contain exposed energized conductors or components.
d. Marking is intended to reduce the occurrence of serious injury or death due to arcing faults to employees working on or near energized electrical equipment.
e. Markings (labels) shall be located so they are visible to the personnel before examination, adjustment, servicing, or maintenance of the equipment, and markings shall meet NFPA 70 110.21(B), *Field Applied Equipment Markings* requirements.
f. Labels shall be either of the two (2) designs shown in Figure 2.
g. In Figure 2, The "Danger" header identifies those situations of extreme danger. The red "Danger" header shall be used when the voltage is over 600V or when the incident energy is over 40cal/cm². If the incident energy is less than that of the threshold, an orange "Warning" header shall be used. It is imperative that consistency shall be maintained on all labels throughout the facility.
   Note: When the incident energy exceeds 40cal/cm², the electrical equipment shall be de-energized and follow SCWI-8715-0013 LO/TO procedures.
h. If a "Danger" arc flash label is present on a piece of equipment, no work shall be allowed unless the equipment is deenergized per LO/TO procedures and grounded as necessary.
i. The Danger and Warning Label with listings required by SSTD-8070-0138-ELEC, *SSC Arc Flash Standard* shown in Figure 2 shall be used.
j. When arc flash and shock data are available for industrial control panels, labels shall include information on flash hazard boundary, the hazard category, required PPE, minimum arc rating, limited approach distances and restricted approach distances.

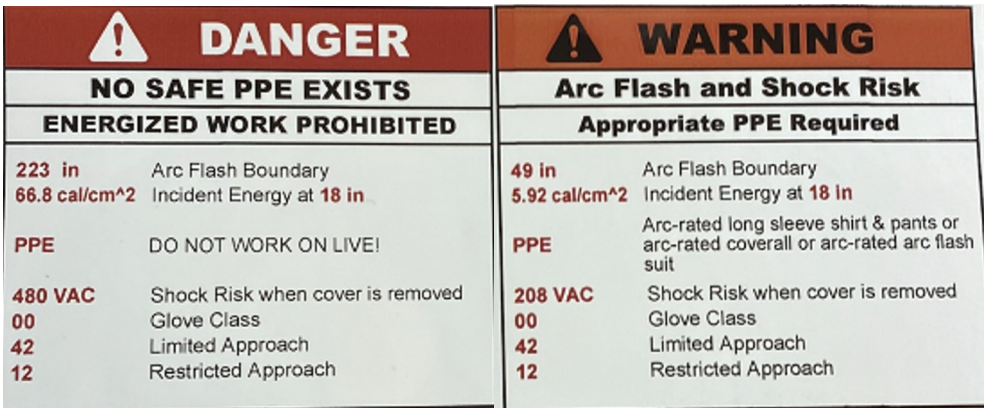

Figure 2. Electric Arc Flash Hazard - Danger and Warning Labels

k. The "Danger" and "Warning" headers in Figure 2 are an example of labels to be affixed to industrial control panels after arc flash hazard analysis has been completed.

Note: The labels, design and formatting shall conform to ANSI Z535 and Series of Standards for Safety Signs and Tags. All Arc Flash Labels shall withstand their usage and shall be UV rated. The print shall not fade, and the adhesive shall be aggressive enough to avoid peeling. When necessary, a protective laminate should be applied to the print surface to protect from harsh chemicals and exposure to sunlight.

8.0 AUDIT PROCESS

An Electrical Safety Program Audit and a Field Work Audit shall be performed to comply with NFPA 70E audit requirements. The electrical safety program shall be audited to verify that the principles and the procedures of the electrical safety program are in compliance with this document. Audits shall be performed at intervals not to exceed 3 years using Form SSC869, Electrical Safety Audit Checklist or another similar form approved by SMA. Field work shall be audited to verify that requirements contained in the procedures of electrical safety are being followed. Audits shall be performed at intervals not to exceed a year using Form SSC852, Construction Safety and Health Job Site Audit. Annual Facility Safety Inspections will also review electrical installations and distribution systems and will utilize the SSC405 Form.

9.0 TRAINING REQUIREMENTS

9.1 Training Requirements for Qualified Persons

a. The employees shall receive training in accordance with NFPA 70E Section 110.6, *Training Requirements* and Section 110.7, *Host and Contract Employers' Responsibilities* and with 29 CFR 1910.331 and 335.
b. A qualified person shall be trained and knowledgeable in the construction and operation of equipment or a specific work method and be trained to identify and avoid the electrical hazards that might be present with respect to that equipment or work method.
c. A qualified employee shall satisfactorily perform on-the-job training with a qualified electrical worker and complete the Electrical Utilization Training class with a passing grade on the written exam.
d. Qualified employee training shall comply with NFPA 70E Sections 110.6(A)(1)-(5) requirements.
e. Qualified Persons must also be trained in recognizing signs and symptoms of electric shock, heart fibrillation, electric burns, and proper first aid protocols for these conditions as required in NFPA 70E Sections 110.6(C)(1)-(4). They must have the following training:
   (1) Contact Release

(2) Basic Cardiopulmonary Resuscitation
(3) Automatic External Defibrillator
(4) Contacting emergency personnel and basic first aid

f. Training shall be documented in the accordance with the following:
(1) Be made when the employee demonstrates proficiency in the work practices involved.
(2) Be retained for the duration of the employee's employment.
(3) Contain the content of the training, each employee's name, and dates of training.

g. Training for NASA employees shall be conducted by qualified and competent SACOM or third-party personnel.

h. All qualified electrical personnel shall take SSC-EG601FOS Electrical Utilization System training.

i. Training and refresher training will be performed in accordance with the frequency described in SCWI-3410-0003*, Training Certification and Schedule Report*.

j. NASA and onsite prime contractor employees shall receive initial training through the New Employee Safety and Health Orientation (NESHO) program. The employer shall determine, through regular supervision or through inspections conducted on at least an annual basis that each employee is complying with the safety-related work practices required by this standard.

9.2 Training Requirements for Unqualified Persons

a. The training requirements in this section of the SCWI apply to personnel who are considered unqualified persons.

b. Unqualified persons shall be trained in and be familiar with any electrical safety-related practices necessary for their safety.

c. Unqualified employee training shall comply with NFPA 70E Section 110.6(A)(1)-(5) requirements.

d. Training shall be documented in the accordance with the following:
(1) Be made when the employee demonstrates proficiency in the work practices involved.
(2) Be retained for the duration of the employee's employment.
(3) Contain the content of the training, each employee's name, and dates of training.

e. Training for NASA employees shall be conducted by trained and competent SACOM persons.

f. NASA and onsite prime contractor employees shall receive initial training through the NESHO program.

g. Construction project managers, superintendents, supervisors (i.e., foremen, crew chiefs), safety and health professionals, and construction employees, qualified or unqualified, shall complete the "SSC Construction Contractor Safety Orientation" training posted to the Construction Safety Site at (http://constructionsafety.ssc.nasa.gov/), in accordance with paragraph 5.3.1 of SCWI-8715-0008, *Construction Safety and Health Program*.

10.0 OTHER ELECTRICAL PROCEDURES

SSTD-8070-0081-ELEC, *Facility Electrical Standard*, contains the basic engineering guidance, policy, criteria, and standards for the design and construction of electrical systems at SSC.
SSTD-8070-0083-ELEC, *Standard for the 13.8kV Distribution System,* contains the basic engineering guidance, policy, criteria, and standards for the design and construction of 13.8kV Distribution Systems at SSC.
SSTD-8070-0138, *Arc Flash Standard,* contains the basic engineering guidance, policy, criteria, and standards for Arc Flash Analysis used during the design, construction and renovation of low voltage and high voltage distribution systems at SSC.

11.0 RECORDS AND FORMS

All records and forms are assumed to be the latest version unless otherwise indicated. Quality Records are identified in the SSC Master Records Index.

a. NASA form SSC222, *Permit for Use of Small Appliance*
b. NASA form SSC405, *Safety, Health, and Housekeeping Inspection Report*
c. NASA form SSC869, *Electrical Safety Audit*
d. NASA Form SSC852, *Construction Safety and Health Job Site Audit*
e. *EEWP*

APPENDIX A: ACRONYMS

A	Ampere
AC	Alternating Current
AEGCP	Assured Equipment Grounding Conductor Program
AHA	Activity Hazard Analysis
AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standard Institute
AR	Arc Rated
ASTM	American Society for Testing and Material
CB	Circuit Breaker
CFR	Code of Federal Regulations
COD	Center Operations Directorate
DC	Direct Current
EEWP	Energized Electrical Work Permit
ESD	Electrostatic Discharge
GFCI	Ground-Fault Circuit Interrupter
IEEE	Institute of Electrical and Electronics Engineers
ISEA	International Safety Equipment Association
LNG	Liquified Natural Gas
LO/TO	Lockout/Tagout
MCC	Motor Control Center
MNL	Manual
NASA	National Aeronautics and Space Administration
NESHO	New Employee Safety and Health Orientation
NEC	National Electrical Code
NFPA	National Fire Protection Association
NPD	NASA Policy Directive
NPR	NASA Procedural Requirement
NRTL	Nationally Recognized Testing Laboratory
OPR	Office of Primary Responsibility
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
SACOM	Synergy Achieving Consolidated Operations and Maintenance
SCWI	Stennis Common Work Instruction
SMA	Safety and Mission Assurance Directorate
SME	Subject Matter Expert
SPA	Safe Plan of Action
SPLN	Stennis Plan
SPR	Stennis Procedural Requirement
SSC	John C. Stennis Space Center
SSP	Stennis Safety Procedure
SSTD	Stennis Standard
UL	Underwriters Laboratories

V Volts

APPENDIX B: DEFINITIONS

Arc Blast – A pressure wave resulting from arcing.

Arc Flash – An electrical short circuit through air when insulation or isolation between electrified conductors are breached or can no longer withstand the applied voltage. Temperatures can reach up to 35,000 ºF.

Arc Flash Boundary - When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm2 (5 J/cm2).

Arc Blast Hazard – A source of possible injury or damage to health from the energy deposited into acoustical shockwave and high-velocity shrapnel.

Arc Flash Hazard - A source of possible injury or damage to health associated with the release of energy caused by an electric arc.

Authorized Employee – A trained and qualified employee who locks out and tags the equipment or system to perform service or maintenance on the equipment or system.

Battery – A system consisting of two or more electrochemical cells connected in series or parallel and capable of storing electrical energy received and that can give it back by reconversion.

Bare Conductor – A conductor having no covering or electrical insulation whatsoever.

Buddy System – While one (1) person works on the equipment, another person that is trained and able to recognize electrical hazards serves as an attendant. The attendant watches the movements of the person performing the work and warns or alerts the person if he/she gets dangerously close to exposed electrical hazards or live conductors or performs an unsafe act. The attendant also assists the employee in the event of an accident.

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

Cardiopulmonary Resuscitation – A procedure designed to restore normal breathing after cardiac arrest that includes the clearance of air passages to the lungs and heart massage by the exertion of pressure on the chest.

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

Complex Equipment/Systems – Equipment/systems that operate at more than 120V, have a hazard category rating of two (2) or higher, have more than one (1) source of energy that are

required to be de-energized to place the equipment in a safe-working condition, or have a specific sequence of steps required to safely shut-down or start-up.

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

De-energized (as related to current-carrying parts) – Free from any electrical connection to a source of potential difference and from electric charge; not having a potential difference from that of the Earth.

Effectively Grounded – Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the buildup of voltages that may result in undue hazards to connected equipment or to persons.

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

Electrical Hazard – A dangerous condition where contact with energized parts or equipment/systems failure can result in electric shock, arc-flash burn, thermal burn, or arc blast injury.

Electrical Safety - Identifying hazards associated with the use of electrical energy and taking precautions to reduce the risk associated with those hazards.

Electrical Safety Program - A documented system consisting of electrical safety principles, policies, procedures, and processes that directs activities appropriate for the risk associated with electrical hazards.

Electrically Safe-Work Condition – A state in which the conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards (29 CFR 1910.147, The Control of Hazardous Energy (Lockout/Tagout)), tested to verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection. An electrically safe work condition is not a procedure, it is a state wherein all hazardous electrical conductors or circuit parts to which the worker might be exposed are maintained in a de-energized state for the purpose of temporarily eliminating electrical hazards for the period for which the state in maintained. See NFPA 70E Article 120 for requirement to establish an electrically safe work condition for the period which the state is maintained. See Information Annex F for information regarding the hierarchy of risk control and hazard elimination.

Electrical Shock – Occurs when current passes through the human body.

Enclosed - Surrounded by a case, housing, fence, or wall(s) that prevents persons from unintentionally contacting energized parts.

Enclosure - The case or housing of apparatus — or the fence or walls surrounding an installation to prevent personnel from unintentionally contacting energized electrical conductors or circuit parts or to protect the equipment from physical damage.

Energized – Connected to an energy source or containing residual or stored energy.

Energy Isolation – The complete de-energizing of equipment that has the potential to receive or transfer electrical, mechanical, chemical, gravitational, and/or physical energy. Energy isolation or de-energization can occur through blockage, separation, or elimination of the sources of energy.

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

Exposed (as applied to energized electrical conductors or circuit parts) - Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated, or insulated.

Exposed (as applied to wiring methods) – On or attached to the surface, or behind panels designed to allow access.

Fault Current - The amount of current delivered at a point on the system during a short-circuit condition.

Fault Current, Available. The largest amount of current capable of being delivered at a point on the system during a short-circuit condition.

Ground - The earth.

Grounded – Connected (connecting) to ground or to a conductive body that extends the ground connection.

Grounded Conductor - A system or circuit conductor that is intentionally grounded.

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.

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

Hazard - A source of possible injury or damage to health.

High Voltage – Any electrical equipment (lines, wires, switches, relays, transformers, buses, capacitors, rectifiers, etc.) that has the potential to carry or contain voltage equal to or greater than 600V. High Voltage work is considered Safety Critical and requires approval of the cognizant safety representative in addition to the cognizant engineer per SPR 8715.1 Safety and Health Program Requirements.

Hazardous - Involving exposure to at least one hazard.

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

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

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

Isolated (as applied to location) - Not readily accessible to persons unless special means for access are used.

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

Limited Approach Boundary - An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.

Listed - Equipment, materials, or services included in a list published by an organization that is acceptable to the Authority Having Jurisdiction 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 either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Lineman – Workers who will perform work on energized or potentially energized electrical equipment (voltage up to and including 13,800V AC).

Live Parts (as applied to electricity) – Energized-conductive components.

LO/TO – The placement of a lockout and/or tagout device to an energy-isolation device in accordance with established energy-control procedures to obtain a zero-energy state safe working condition by ensuring the energy-isolating device and equipment being controlled cannot be operated until the lockout and/or tagout device is removed.

Low Voltage – Any electrical equipment (lines, wires, switches, relays, transformers, buses, capacitors, rectifiers, etc.) that has the potential to carry or contain voltage up to 600V.

Maintenance (condition of) - The state of the electrical equipment considering the manufacturers' instructions, manufacturers' recommendations, and applicable industry codes, standards, and recommended practices.

Mission Critical Equipment/Systems – Equipment/systems that form an integral part of a system supporting the Space Station, Shuttle mission, or other NASA-required system.

Nationally Recognized Testing Laboratory (NRTL) – A program in OSHA's Directorate of Science, Technology, and Medicine. It recognizes private sector organizations as NRTLs, and this recognition signifies that an organization has met the necessary qualifications specified in the regulations for the program. The NRTL determines that specific equipment and materials ("products") meet consensus-based standards of safety to provide the assurance (required by OSHA) that these products are safe for use in the United States workplace.

Overcurrent - Any current more than the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.

Overload - Operation of equipment more than 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.

Organization Point of Contact – An individual within the organization requesting that work be performed and who is to be contacted prior to beginning the work.

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.

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

Qualified Person/Employee – A person who has received training per 29 CFR 1910.332 and Section 9, Training Requirements, of this SCWI; One who has demonstrated the skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to identify the hazards involved and reduce the associated risks. Such persons shall be capable of establishing electrical safe work condition and work safely performing energized work. and shall be familiar with the proper use of special precautionary techniques, PPE, barriers, barricades, insulating and shielding materials, and insulated tools.

Raceway. An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this standard.

Receptacle. A receptacle is a contact device installed at the outlet for the connection of an attachment plug, or for the direct connection of electrical utilization equipment designed to mate with the corresponding contact device. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke.

Requestor Organization – The organization requesting the work to be performed.

Responsible Organization – The organization having the primary responsibility for the equipment/systems and making the determination whether the equipment/systems cannot be de-energized to perform the work.

Restricted Approach Boundary – An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

Risk – A combination of the likelihood of occurrence of injury or damage to health and the severity of injury or damage to health that results from a hazard.

Risk Assessments – An overall process that identifies hazards, estimates the likelihood of the occurrence of the injury or damage to health, estimates the potential severity of injury or damage to health, and determine if protective measures are required. Note, as used in this SCWI, arc flash assessment, shock assessment, battery risk assessment are types of risk assessments.

Safe-Work Practices – Techniques used by the worker to ensure safety of the worker and the equipment/systems. This can include the use of such items as PPE, barriers, insulated tools, and on-the-job training.

Shock Hazard – A source of possible injury or damage to health associated with current through the body caused by contact or approach to exposed energized electrical conductors or circuit parts.

Shock Risk Assessment – A shock risk assessment shall determine the voltage of the circuits and equipment to which personnel will be exposed, the boundary requirements (limited and restricted) and the required personal and other protective equipment required to safely perform the assigned task and to protect against the shock hazard.

Short-Circuit Current Rating – The prospective symmetrical fault current at a nominal voltage to which an apparatus or system can be connected without sustaining damage exceeding defined acceptance criteria.

Simple Equipment/Systems – Equipment/system that operates from 120V or less, have a hazard category rating of one (1) or less, and have a single energy source that, when de-energized, places it in a safe working condition where there is no possibility to accumulate stored energy.

Storage Battery - A single or group of rechargeable cells connected electrically in series, in parallel, or in combination of both, and comprised of lead-acid, nickel-cadmium, or other rechargeable electrochemical types.

Touch Potential – A ground potential gradient difference that can cause current flow from hand to hand, hand to foot, or another path, other than foot to foot, through the body.

Ungrounded – Not connected to ground or to a conductive body that extends the ground connection.

Unqualified Person/Employee – A person not having the training (or knowledge and skills) related to the construction and operation of the electrical equipment/systems, installations, and hazards involved. Any employee who is not a qualified person is an unqualified person.

Working Distance – The distance between a person's face and chest area and a prospective arc source.

Working On (energized electrical conductors or circuit parts) – Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment (PPE) a person is wearing. There are two categories of "working on": Diagnostic (testing) is taking readings or measurements of electrical equipment, conductors, or circuit parts with approved test equipment that does not require making any physical change to the electrical equipment, conductors, or circuit parts. Repair is any physical alteration of electrical equipment, conductors, or circuit parts (such as making or tightening connections, removing, or replacing components, etc.).