Dryden Flight Research Center
Edwards, California 93523

DCP-S-063, Baseline-1
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Dryden Centerwide Procedure

Code S

Electrical Safety

This Procedure Contains Hazardous Operations.

Electronically approved by
Assistant Director for Management Systems

Contents

1.0 PURPOSE OF DOCUMENT

This document describes procedures and guidelines, delegates authority, and assigns responsibility for managing the Dryden Flight Research Center (DFRC) Electrical Safety Program. It defines the responsibilities of managers, designers, users, installers, and others who service or operate electrical power sources and equipment.

2.0 PROCEDURE SCOPE & APPLICABILITY

Scope: This procedure applies to operations involving programmatic electrical activities at DFRC.

Applicability: This procedure applies to all personnel in Codes who conduct electrical service or repairs to equipment at DFRC and to on-site support contractors, grant recipients, and other partners to the extent specified in their contracts or agreements.

3.0 PROCEDURE OBJECTIVES, TARGETS, METRICS, & TREND ANALYSIS

Objective: Ensure all electrical service personnel receive required training to safely perform electrical work.
Target: 100% of electrical service personnel received required electrical training
Metric: Percentage of electrical service personnel who have received training.

Trend analysis: Metrics will be analyzed to determine whether procedural objectives have been met. Code SH will track and review training records in SATERN and contractor records to determine which employees have and have not completed training.

4.0 WAIVER AUTHORITY

Requests for waivers and variances to DFRC Electrical Safety Program will be made to the Office of Safety and Mission Assurance (Code S) on form DFRC 117-1f. Requests for waivers and variances to NASA safety instructions are made to NASA HQ in accordance with instructions provided by NPR 8715.3, NASA General Safety Program Requirements, Para. 1.13, Safety Variance Process, and Para. 1.6, Risk Assessment and Risk Acceptance.

5.0 RESPONSIBILITIES

5.1 Directorates & Single Letter Offices

Ensure persons under their supervision receive appropriate electrical safety training and follow electrical safety procedures when working with electrical sources. Electrical power sources that require special handling and training at DFRC include equipment using or distributing 600V or greater, but may be less depending on the specific operation being conducted.

5.2 Chief, Safety, Health, & Environmental Office

A. Advise management on matters concerning electrical safety.

B. Ensure adequate local safety policies are written for the control of hazards from electrical sources.

C. Investigate accidents and incidents and report findings and recommendations to management and required agencies.

D. Revise this document as often as necessary to reflect changes and review annually.

5.3 Electrical Supervisors

A. Ensure that employees under his/her supervision are properly trained and qualified to perform the tasks assigned them.

B. Provide proper personal protective equipment (PPE) and ensure each employee is trained to use it.

C. Follow this document and other applicable regulations, codes, and instructions that impact the specific task being accomplished.

5.4 Electrical Personnel

A. Be trained and qualified as required, and only perform electrical work on equipment for which they are trained, qualified, and authorized by their employer.

B. Be able to recognize the hazards associated with a task and know how to minimize the risks by using proper procedures, tools, and PPE.

C. Follow regulations, guidelines, policies, and codes applicable to the work they are performing. If an employee has any questions regarding procedures or electrical safety, he or she will consult his or her supervisor or the DFRC Safety, Health, and Environmental Office before continuing.

D. Report any known or suspected electrical safety hazards to supervisor or the Safety, Health, and Environmental Office.

E. Be trained in lockout / tagout procedures.

F. Be trained in confined space entry procedures if the work will involve entry into such spaces as electrical vaults, tunnels, and manholes.

5.5 Line Supervisors

A. Inform workers of the location of electric sources or equipment that could pose a potential hazard within their work area.

B. Ensure employees are trained to recognize the potential electrical hazards in their work area and how to avoid such hazards.

6.0 CONFIGURATION CONTROL

6.1 Configuration Changes

Configuration change occurs when original electrical systems are altered. When major configurations are made, the Facility Design Electrical Engineer or qualified designee will review and sign off the proposed electrical design changes for correctness. For day-to-day operations and minor changes, the DFRC Facilities Maintenance Electrical Engineer will approve the changes. In either case, the electrical engineer will verify that required electrical codes are met.

6.2 Change Review

The Safety, Health, and Environmental Office will review and approve all configuration changes for completeness. Items to be reviewed will include, but are not limited to:

A. Drawings of the proposed changes are approved by the reviewing electrical engineer

B. New drawings are attached to the original drawings and made a part of the master file maintained by the Facilities Maintenance contractor.

C. The Facilities System Safety Engineer (Code SH) is satisfied with the changes.

D. Electrical equipment listed and labeled by a nationally recognized testing laboratory (NRTL), will be added to the appropriate employer's inventory listing as applicable, prior to first use. Any electrical equipment that is not listed and labeled by an NRTL and/or not built to nationally recognized standards will require approval for use by the DFRC electrical Authority Having Jurisdiction (AHJ).

7.0 ELECTRICAL SAFETY PROCEDURES

7.1 General Safety Rules

A. Qualifications – Only qualified and authorized individuals are permitted to perform electrical work on equipment at DFRC. A qualified person is one who has the required skills, training, and knowledge to perform electrical work safely. Such individuals must be aware of the hazards associated with electrical work and the methods for reducing the risk of accidents that can result from unsafe conditions or acts.

B. System Isolation – Electrical systems must be considered energized until verified to be de-energized and grounded or other appropriate actions are taken to ensure the system is de-energized. Verification that low voltage equipment is de-energized can be made by using an approved voltage test device. For the application of personal protective grounds, see 29 CFR 1910.269(n), and ASTM F855.

C. Appropriate arc-rated apparel and electrical PPE will be worn while performing electrical verifications and during the installation and removal of personal protective grounds in accordance with the current NFPA 70E requirement.

7.2 Electrical Equipment Switching Order

Before starting work on high voltage equipment of 600V or greater, the designated supervisor will develop a work plan and make it available to persons who will work on the equipment. The plan will include, as appropriate:

A. Diagram or drawing of the electrical system to be worked on.

B. Lockout / Tagout procedures to be used.

C. A high voltage switching order for isolation, grounding, and restoration of power. When high voltages are involved (above 600V), the Facilities Maintenance Electrical Engineer will approve the switching order for both isolation and restoration of power.

D. The identification of hazardous materials such as mercury, dust, vapors, polychlorinated biphenyls (PCB), and physical hazards.

E. Level of skill, training, and certification required to accomplish the task.

F. Tools and type of PPE required and certification to use them.

G. Other considerations, such as confined space, that could involve the safety of others.

7.3 Lockout / Tagout

A. Lockout / Tagout – Prior to work being done on electrical or electro-mechanical equipment, the electrical source must be de-energized, grounded, locked, or tagged out and verified in accordance DCP-S-009, Chapter 4, Lockout / Tagout procedures.

B. Qualification to Lockout / Tagout – Only qualified Facility Maintenance, Facility Maintenance Contractor, or authorized off-site electrical contractor personnel (under contract to DFRC) may lockout / tagout DFRC electrical systems.

C. Notification – In order to safeguard sensitive electrical equipment and enhance safety, the using organization must be notified in every possible situation when electrical power is to be shut off and the estimated duration. Notification of electrical shutdowns generally falls under the responsibility of the Facilities Maintenance Electrical Engineer for high voltages (600 volts and greater) and to the electrical maintenance supervisor for low voltages (less than 600 volts).

D. Work in Confined Space – Electrical maintenance conducted in confined spaces will adhere to the procedures defined in DCP-S-009, Chapter 10, Confined Space Safety Procedure.

7.4 Initial Energizing of Electrical Installations & Equipment

A. Pre-Energizing Checks – Protective relays and circuit breakers will be tested to their trip range. Wiring will be checked for conformity to design, fabrication, and load requirements. Motors, cables, and switching equipment will be tested to assure proper operations.

B. Initial Energizing – Initial energizing of electrical circuits and equipment will be accomplished by trained and qualified electrical technicians. PPE and switching orders will be required.

7.5 Electrical Drawings & Diagrams

Completing, maintaining, updating, distributing, and destroying outdated electrical drawings and diagrams of DFRC facilities are the responsibility of Facilities Engineering and Asset Management. Electrical drawings and diagrams are required for the following:

A. Building Diagrams – A plot of each building showing the partitions and physical locations of all panel boards, motor control centers, main distribution panels, and unit power substations will be maintained by Facilities Engineering and Asset Management. These drawings include the front view of load centers with identification numbers shown to correspond with those on the actual load centers.

B. Power Distribution Diagram – Shows a complete line power distribution diagram of power flow from the building substations to the building load

center buses and showing the circuit breakers controlling the identified loads.

C. Power Circuits – A schedule of the circuits powered by each breaker in each panel board must be shown. Every change to circuits will be shown on the panel board and updated on the appropriate diagram.

D. Power Distribution Centers – Shows manholes, underground vaults, and duct banks that contain electrical sources.

E. High Voltage Grid Diagrams – High voltage grids and switching diagrams (usually for system of 2300V and greater) will be on file at the Facilities Engineering and Asset Management Branch. These diagrams will be used by qualified and authorized electrical technicians to conduct maintenance on the DFRC grid.

7.6 Isolation

A. Energized Systems – Work on energized electrical systems is not authorized at DFRC except by trained and qualified technicians using approved procedures and certified test equipment, tools, and PPE, and in possession of a valid, approved, and released Energized Electrical Work Permit to:

1) Probe high or low voltage apparatus to verify circuit conditions.

2) Probe experimental equipment and systems operating at low voltages.

Exceptions:
Work by qualified persons on energized electrical conductors or circuits related to tasks such as testing, troubleshooting, voltage measuring, etc. within the Limited Approach Boundary is permitted without an energized electrical work permit, provided appropriate safe work practices and PPE are provided and used.

B. Testing Devices – Only devices designed for voltage testing and rated for the circuit being tested may be used The test equipment will be verified before and after the test by applying it to an energized circuit or an appropriate test unit.

C. High Voltage Lines – Work on or in close proximity to high voltage equipment or lines (over 600 volts) where a potential contact exists requires two open breaks (“two opens”) in series on all electrical phases between the work site and each energy source, including back feeds, and one open break (“one open”) between the work site and any transformers. An “open” may be a fuse or breaker, but not an oil switch. Visible personal protective safety grounds must be provided, either on both sides of the work site or at the actual work site. The grounds will be applied in an equipotential manner.

Exception: When work is performed by qualified personnel outside of the approach distance, but not on high voltage electrical cables and associated cable apparatus, and contact is not anticipated, de-energizing is not required if proper safety measures are taken. For such cases where cables or cable apparatus are de-energized for added safety purposes, one open is required, and safety grounds are optional. Serious consideration must be taken before using this exception, and will be approved by the appropriate electrical engineer. Should there be any possibility of contact with a high voltage line, the line will be de-energized before work is performed. For detailed instructions for safe distances from power sources, see 29 CFR 1910.333 (c), (i), (ii), (iii) and the National Electrical Safety Code.

D. Multiple Work Sites – When more than one work site exists on isolated high voltage source equipment or lines, such as overhead distribution lines, visible personal protective safety grounds must be provided at both ends of the lines and at the work site.

E. Oil Switches – Work will not be done on circuits or equipment disconnected from power source by oil switches only.

F. Low Voltage – A minimum of “one open” is required to isolate low voltage sources. Low voltage is 600 V or less. A lock and tag will be placed on each disconnecting means used to de-energize circuits and equipment on which work is to be performed, except as provided in paragraphs (b) (2) (iii)(c), (b) (2) (iii) (d), and (b)(2)(iii)(E) of 29 CFR 1910.333. The lock will be attached so as to prevent persons from operating the disconnecting means unless they resort to undue force or the use of tools.

7.7 High Voltage Switching

A. Opening and closing of high voltage electrical air break switches will be accomplished by trained and qualified electrical technicians.

B. The “buddy system” will be used with an electrical safety monitor (ESM) who will stand at a safe distance, watch for unsafe conditions or procedures, and be prepared to take appropriate action in the event of an emergency.

C. Disconnect poles (hot sticks) and proper PPE will be used when operating high voltage hook-stick-operated disconnect switches having open circuit voltages.

7.8 Research Modification to Electrical System

Project managers will include proposed modifications of electrical systems and equipment in their hazard analysis. Particular attention will be made to ensure normal and emergency sources are de-energized.

Communication and coordination with the Dryden Safety, Health, and Environmental Office will be required for all modifications to Center electrical systems.

7.9 Backup Electric Source Systems

Backup electric sources are those derived from generators, certain transformers, capacitors, converters, and batteries. In many cases, these power sources can back feed a line if not properly isolated and grounded and can present unusual safety considerations. Designs for these systems will be approved by the Facilities Design Electrical Engineer.

7.10 Battery Systems

Battery systems at DFRC include those in uninterrupted power systems (UPS), aircraft, vehicles, ground support equipment, switchgear and substations, emergency lighting and warning systems, radios, and experimental equipment. Over charging can cause vented batteries, regardless of electrolyte type, to vent excessively and cause spillage. When handling vented batteries, the following safety actions must be followed:

A. Use face shields, rubber gloves, and apron.

B. Ensure that an eye wash/shower station is located nearby.

C. Ensure that an ample amount of water will be available to flood spills in locations where batteries are recharged.

D. No smoking, open flames, or sparking devices are permitted in battery areas.

E. Make provisions for sufficient diffusion and ventilation of vented battery gasses to prevent accumulation.

F. UPS battery installation will be reviewed by the Facilities Maintenance Electrical Engineer.

G. A weak neutralizing agent suitable for the type of battery electrolyte will be kept near by in case of spills on clothing or skin.

H. Follow all manufacturers' technical documents, maintenance instructions, and Material Safety Data Sheets (MSDS).

NOTE: Battery electrolyte in the eyes is very dangerous. Flush eyes with copious amounts of water and seek medical help.

For additional information on battery safety, see NFPA 70E, Article 320; Storage Batteries.

7.11 Ladders

Only fiberglass ladders may be used near electrical sources. Metal ladders will have a stenciled warning sign on them reading: DO NOT USE NEAR ELECTRICAL EQUIPMENT.

7.12 Hazardous Classified Locations

A. A hazardous classified location is one where fire or explosion hazards may exist due to the presence of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings.

B. Areas that meets the definition of a hazardous location will be evaluated by the Safety, Health, and Environmental Office and given a hazard classification as listed in 29 CFR 1910.307. When given a classification, electrical system and equipment will meet the requirements for the assigned classification as specified in NFPA 70 (NEC), Chapter 5.

C. Organizations or experimenters using or storing materials in hazardous classified locations will follow storage procedures in accordance with the restrictions of the hazard classification. For further explanation of hazardous location classifications and restrictions, see NFPA 70 (NEC) Chapter 5, Special Occupancies.

7.13 Capacitors

Capacitors pose a special electrical hazard because certain ones (usually DC powered) can hold a high voltage for long periods and certain capacitors contain flammable liquids. Before work can be performed on electrical equipment containing or in line with a capacitor(s), the capacitor(s) must be discharged. For detailed requirements, see NFPA 70, (NEC), Article 460 - Capacitors and ANSI/IEEE 18, Shunt Power Capacitors.

7.14 Temporary Wiring

Temporary wiring for power and lighting is permitted during periods of construction, remodeling, maintenance, repair, or demolition of equipment or structures, and during emergencies. When using temporary wiring, the level of safety will remain the same as with permanent wiring. For information regarding the use of temporary wiring, see 29 CFR 1910.305(a) (2), 29 CFR 1926.405(a) (2), and NFPA-70, (NEC), Article 590.6 Ground Fault Protection for Personnel.

7.15 Flexible Power Cords & Cables

Flexible cords and cables will meet requirements of NFPA-70, (NEC), Article 400, and Table 400-4. Flexible cords and cables will be inspected by the user prior to use each day and will not be:

A. Used as a substitute for fixed wiring of a structure.

B. Attached to building surface.

C. Routed through holes in walls, ceilings, floors, doorways, windows, or other similar openings.

D. Concealed behind walls, ceilings, or floors.

E. Placed where they could present a trip or fall hazard.

F. Damaged, spliced, or have a missing grounding pin.

G. Installed in raceways where not permitted by NFPA-70, (NEC).

H. Allowed to remain after project is completed.

7.16 Ground Fault Circuit-Interrupters

A. 120V, single-phase, 15, 20, and 30 ampere receptacle outlets that are not a part of the permanent wiring of the building or structure and that may be used by personnel to operate electrical equipment will be protected by ground fault circuit-interrupter (CFCI) protection.

B. GFCI will be used at DFRC for circuits used in construction operations even if the power source is from permanent wiring. DFRC requires the same level of protection for employees as they would have in their homes. Install GFCIs to protect circuits in:

1) Bathrooms
2) Kitchens
3) Garages
4) Crawl spaces
5) Circuits installed at or below ground level
6) Unfurnished basements
7) Circuits located within 6 feet of a sink or water faucet

7.17 Extension Cords

Observe the following precautions when using extension cords with either single or multiple outlets, including surge protectors:

A. Use only three-wire cords that are designed to carry the current being used. Attachment plugs and receptacles may not be connected or

altered in a manner that would prevent proper continuity of the equipment grounding conductor at the point where plugs are attached to receptacles. Additionally, these devices may not be altered to allow the grounding pole of the plug to be inserted into the slots intended for the connection of the current-carrying conductors. Do not use extension cords for appliances. Appliances, for the purpose of this procedure, are defined as, but not limited to, space heaters, coffee makers, hotplates, microwaves, refrigerators, etc. These appliances must be connected to the permanent building wiring system.

B. Inspect cords for external defects (such as loose parts, deformed or missing pins, or damage to the outer jacket or insulation) (29 CFR 1910.334(a) (2) (i)) before putting them into use each day, and ensure they are approved by a Nationally Recognized Testing Laboratory, such as Underwriters Laboratory (UL).

C. Use only high-visibility orange or yellow cords outdoors.

D. Plug each extension cord into a wall receptacle. Do not connect multiple extension cords together (daisy-chained).

7.18 Entry into Electrical Substations

Entry into electrical substations by other than trained, qualified, and authorized electrical technicians will NOT be allowed at DFRC without the approval of the Facilities Maintenance Electrical Engineer and with an Electrical Safety Monitor present at entry. The Electrical Safety Monitor will remain with personnel throughout the duration of time in the electrical substations.

7.19 Designated Electrical Safety Monitor (ESM)

The ESM is designated by the Facilities Maintenance Contractor. The ESM, a trained and qualified electrician, is trained to recognize electrical hazards and delegated to watch the movements of other personnel working with electrical equipment to warn them if they get dangerously close to live conductors or perform unsafe acts and to assist (or respond by summoning emergency help) in the event of a mishap. Hazardous areas include electrical supply areas such as transformer vaults, power manholes, cable tunnels, substations, and other areas where exposed energized electrical sources are located. Confined space procedures may apply in these locations.

7.20 Construction Operations near High Voltage Sources

A. Construction equipment or vehicles working near high voltage lines and apparatus will be separated far enough from the electrical source that a failure of a line or cable will not result in the energized electrical

source being closer to the vehicle or equipment than the established minimum approach distance for unqualified personnel.

B. Construction equipment will be properly grounded when in transit or operated in close proximity to energized sources

C. A designated employee other than the equipment operator will observe the approach distance to exposed lines and equipment and give timely warnings before the minimum approach distance required is reached.

7.21 Warning Signs & Barriers

A. Warning signs of high voltage will be posted where untrained employees could come into contact with live parts.

B. Appropriate warning signs and/or barriers will be used to isolate entry into areas where electrical work is performed if such work would pose a hazard to untrained persons.

C. Electrical sources that pose a potential hazard to untrained persons will be secured by locks to prevent unauthorized entry.

7.22 Clearance & Working Spaces around Electrical Equipment

The clearances and working spaces around electrical equipment such as panel boards, switches, circuit breakers, controllers, facility equipment, and other equipment with energized exposed parts will be adequate to accomplish all maintenance required, for emergencies, and for rescue of injured persons.

Table 1
Working Spaces
600V or less, (NASA requirements)

Voltage to ground	Condition 1	Condition 2	Condition 3
0 to 150 volts	3 ft.	3 ft.	3 ft.
151 to 600 volts	3 ft.	3 1/2 ft.	4 ft.

- **Condition 1:** Exposed live parts on one side of the working space and no live or grounded parts on the other side of the working space, or exposed live parts on both sides of the working space that are effectively guarded by insulating materials.
- **Condition 2:** Exposed live parts on one side of the working space and grounded parts on the other side of the working space. Concrete, brick", or tile walls will be considered grounded.
- **Condition 3:** Exposed live parts on both sides of the working space.

See NFPA 70, (NEC) Article 110-26 for information concerning equipment access and working space for voltages less than 600 volts.

Table 2
Working Spaces
Over 600V

Voltage to ground	Condition 1	Condition 2	Condition 3
501 to 2500	3 ft.	4 ft.	5 ft.
2501 to 9000	4 ft.	5 ft.	6 ft.
9001 to 25,000	5 ft.	6 ft.	9 ft.
25,001 to 75Kv	6 ft.	8 ft.	10 ft.
75Kv and above	8 ft.	10 ft.	12 ft

Note: Where the conditions are as follows:

- **Condition 1:** Exposed live parts on one side of the working space and no live or grounded parts on the other side of the working space, or exposed live parts on both sides of the working space that are effectively guarded by insulating materials.
- **Condition 2:** Exposed live parts on one side of the working space and grounded parts on the other side of the working space. Concrete, brick, or tile walls will be considered grounded.
- **Condition 3:** Exposed live parts on both sides of the working space.

7.23 Grounding

Proper grounding of electrical sources is an extremely important part of any electrical safety plan. Proper grounding procedures will be strictly adhered to at DFRC. For details on requirement and procedures on grounding see NFPA 70 (NEC), Article 250, Grounding and 29 CFR 1910.304. DFRC grounding policies are:

A. AC circuits of less than 50 volts will be grounded if they are installed overhead or outside of building or if they are supplied by a transformer that is ungrounded or that exceeds 120 volts.

B. 120 Volt electrical AC circuits at DFRC will be grounded. Equipment operating on these circuits will use a 3-prong grounded connector unless the manufacture of the equipment certifies through a NRTL, such as Underwriters Laboratories, Inc. (UL), that the equipment is safe using a two-prong or ungrounded power supply. Extension cords will also be of the 3-prong grounded type.

C. The conductor used for grounding equipment, systems, and apparatus will:

1) Be permanent and continuous.
2) Facilitate operation of the circuit's protective devices.
3) Have sufficiently low impedance to limit the voltage to ground to a safe level at all frequencies and fault-current incidences anticipated.
4) Have the capacity with size and rating to safely conduct any fault current that may be imposed on it for the time required for protective device operation.

D. High voltage grounding such as occurs in substations, etc., must be performed with extreme caution. Feedback from other sources must be guarded. Protective grounding for electrical maintenance work will be accomplished after equipment or electrical sources are de-energized, verified (using appropriate PPE and metering), and tagged out and before any repair work is started. All conductors will be grounded, including neutral and static conductors. Protective grounds will not be removed until maintenance personnel are finished and clear of the circuit or equipment. When a station grounding system is available, the grounding cable will be attached to it first and then to each conductor. Proper clearance from all potentially live parts will be maintained until total grounding is completed. When removing grounding cables, remove them from the conductors, and then the grounding system. Personnel will stay clear of the grounding cables until they are removed from the conductors. Disconnect poles (hotsticks) will be used to apply and remove protective grounds. Appropriate arc-rated apparel and PPE will be worn as required in NFPA 70E.

E. High voltage grounding will be performed only when both the supervisor and the qualified employees agree on the procedures to be taken. The Facilities Maintenance Electrical Engineer will be contacted when any questions regarding grounding exist.

F. Transformers will be considered fully charged until they are de-energized, grounded, and voltage checked in accordance with the type of transformer being worked on. See NFPA 70 (NEC), Article 450; Transformers and Transformer Vaults and CFR 1926, Subpart V; Power Transmission & Distribution, for specifics in working with transformers.

G. Power capacitors must be grounded in an approved manner before working on the capacitors or on equipment where the capacitor provides an energy source.

7.24 Static Electricity

Static electricity or charge occurs when there is an imbalance of electrons on objects. Discharges can cause shocks (usually not serious), or be sufficient to ignite a flammable vapor or start a fire. Instructions for controlling static electricity are found in DCP-O-021, Electrostatic Discharge (ESD) Control Program.

A. Ground equipment where possible.

B. Use bonding to equalize potentials between adjacent noncurrent carrying metal parts.

C. Do not clean the face of video display terminal when the power is on.

D. Do not allow electrical equipment to get wet, and do not turn on wet equipment.

In certain working conditions, the operator may require grounding. This may occur when working with semiconductors, sensitive electronic equipment, or with potentially ignitable or explosive materials. (See DCP-O-021, Section 9.8 A & B)

7.25 Research & Development Experimental & Flight Level Electrical Equipment

DFRC conducts numerous research projects, both stationary and airborne, where electrical or electro-mechanic equipment is developed, tested, and used in a laboratory or project settings. The development, use, and frequent modifications of this equipment pose a special safety situation. The person who assumes the responsibility for the project, usually the project manager, will also accept the responsibility for safety for both personnel and equipment. Hazard assessment will be made periodically where experimental electrical equipment is in use in order to develop safe work practices, procedures, and the proper use of tools and PPE.

7.26 Personal Protective Equipment (PPE)

Personal protective equipment is essential when working on electrical supply sources or apparatus. The electrical service supervisor will ensure that workers have and use the required PPE, know its limitation, and are trained to use it properly. For questions regarding PPE, contact the Safety, Health, and Environmental Office.

7.27 Rubber Insulating Items

A. Rubber-insulating items such as blankets, line hose, gloves, and sleeves will be inspected for damage before each use and following usage if it is suspected that damage could have occurred. These

items will be tested in accordance with 29 CFR 1910.137(b) (2) (viii), Table I-5 and Table I-6 by a testing laboratory.

B. There are 6 classes of rubber insulating gloves. It is important that the correct class is used for the job undertaken. Rubber insulating gloves will be given an air test and visual inspection with each pre-use inspection and will be retested in accordance with 29 CFR 1910.137(b) (2) (viii), Table I-5 and Table I-6. Gloves will be maintained in accordance with ASTM F496, Standard Specifications for In-Service Care of Insulating Gloves and Sleeves. See 29 CFR 1910.137, Table I-5 and Table I-6, for Rubber Insulating Equipment Voltage Requirements for glove classes and voltage limits, and for Rubber Insulating Equipment Test Intervals.

   Leather protectors will be worn with rubber insulating gloves except as exempted in

   - 29 CFR 1910.137(b) (2) (vii) (A), which states “Protector gloves need not be used with Class 0 gloves, under limited-use conditions, where small equipment and parts manipulation necessitate unusually high finger dexterity.” Note: Extra care is needed in the visual examination of the glove and in the avoidance of handling sharp objects.
   - and (b) (2) (vii) (B), “Any other class of glove may be used for similar work without protector gloves if the employer can demonstrate that the possibility of physical damage to the gloves is small and if the class of glove is one class higher than that required for the voltage involved. Insulating gloves that have been used without protector gloves may not be used at a higher voltage until they have been electrically tested before the next use.”

C. Each certified switchman will have a personal pair of rubber insulating gloves with leather protectors and a glove bag. The Chief, Facilities Engineering and Asset Management Branch will determine if additional gloves and protectors need to be stored in high voltage substations for emergency use.

7.28 Hard Hats

Anyone entering a high voltage electric source station, cable tunnel, cable room, transformer vaults, manholes containing high voltage, or other areas containing high voltage sources will wear a Class-E hard hat.

7.29 Safety Shoes

Persons who enter high voltage source areas will wear safety shoes rated appropriately for the task. Where there is a step potential hazard, the

worker will wear properly rated and electrically tested insulated overshoes meeting the requirements of ASTM F1116 and 1117.

7.30 Arc Rated Fire Resistant (FR) Apparel

Employees will wear arc-rated FR apparel and other electrical PPE whenever there is possible exposure to an electric arc flash above the threshold incident-energy level for a second degree burn [5J/cm2 (1.2 cal/cm2)]. See NFPA 70E, 130.7 (5).

7.31 Eye & Face Protection

Employees will wear nonconductive head protection (Class E hard hat) wherever there is a danger of head injury from electric shock or burns due to contact with energized electrical conductors or circuit parts or from flying objects resulting from electrical explosion. Employees will wear arc-rated protective equipment for the face, neck, and chin whenever there is a danger of injury from exposure to electric arcs or flashes or from flying objects resulting from electrical explosion. If employees use hairnets and/or beard nets, these items must be arc-rated.

Employees will wear protective equipment for the eyes whenever there is danger of injury from electric arcs, flashes, or from flying objects resulting from electrical explosion.

7.32 Portable Electrical Equipment

Portable electrical equipment such as motor driven hand tools will use 3-prong grounding plugs and receptacles. Equipment supplied with 50 volts or more will have a ground except:

1) Those driven by self-contained batteries.
2) When the tool is classified and labeled as “Double Insulated”.
3) For equipment that is supplied by 120 volts or less where exceptions have been granted by the Safety, Health, and Environmental Office.

8.0 EMERGENCY PROCEDURES

The DFRC emergency 911 telephone system is the primary means for alerting the security command post and emergency response personnel. When using a cell phone, call 661-276-3256. Use these numbers to report:

A. A person(s) has been injured or there is a condition that jeopardizes persons or equipment.

B. The power supply to all or portions of the Center is in jeopardy.

C. An unscheduled outage occurs that affects major portions of the Center.

9.0 SCHEDULED ELECTRICAL OUTAGE

Scheduled outages will be during non-work periods when possible and will be announced on the Center paging and email systems to allow for the protection of sensitive electrical equipment.

10.0 TRAINING & CERTIFICATION

10.1 Training Requirements

Employees who perform electrical work will be trained to recognize the hazards associated with their work and how to mitigate the risks of accidents and injuries. The amount of training will be dictated by the risk associated with the employees' job requirements. Persons working on high voltages, by definition, will be qualified. Training will be by qualified instructors and include both classroom and on the job training. Universities and trade schools may also be a source of training. The responsibility for ensuring that employees are qualified to perform their jobs rests with management, supervisors, and the worker. As a minimum, DFRC electrical maintenance workers will be trained in and be familiar with the:

A. Skills and techniques necessary to distinguish exposed live parts from other parts of electrical equipment.

B. Skill and techniques necessary to determine the nominal voltage of exposed live parts.

C. Clearance distance specified in 29 CFR 1910.333 and the corresponding voltages to which the qualified person will be exposed.

D. Proper use, care, and limitations of PPE, to include fit tests where required.

E. Responsibilities of safety observers (buddy system and/or the ESM).

F. Practices, policies, and procedures necessary to safely accomplishing an assigned task.

Note: Unqualified persons will also be trained in and familiar with any electrically related safety practices that are necessary for their safety. All other personnel will be trained in electrical safety awareness.

10.2 Certification

NPR 8715.3C, NASA General Safety Program Requirements, requires those persons working with voltages of 600 Volts and greater (high voltage) to be certified. Recertification periods will not exceed four years.

10.3 CPR & First Aid Training

Both high and low voltages are capable of stopping the heart or causing arrhythmia (abnormal heart beat). In these situations, the victim may need assistance in regaining a normal heartbeat; therefore, it is mandatory that electrical service personnel who work on voltages at or above 50 Volts is trained in both cardiopulmonary resuscitation (CPR) and first aid. CPR and First Aid training is provided by the DFRC Health Clinic.

11.0 MANAGEMENT RECORDS & RECORD RETENTION

Training and certification records include:

A. Certification for work on high voltage systems

B. Formal electrical service training courses

C. On-the-job training

D. CPR and First Aid

Maintenance of training and certification records will be the responsibility of the employee's supervisor. These records may be kept by the supervisor or in a central location accessible to the supervisor, employee, and authorized inspectors. On-site contractors are responsible for the maintenance of their employee's records. The DFRC Health Unit will keep records of CPR and First Aid training and issue a certificate to trainees.

When an employee no longer requires the training, i.e., job change, retirement, etc., a disposition for the records will be made by the supervisor using NPD 1441.1, Records Retention Schedules, and DFRC records management procedures. Generally, technical training records are maintained for 5 years following the employee's need for the training.

Form DFRC 117-1f, Requests for Deviation or Waiver, will be retained in the DFRC Safety, Health, and Environmental office.

Destruction of any records, regardless of format, without an approved schedule is a violation of Federal law.

12.0 RELEVANT DOCUMENTS

12.1 Authority Documents

NPR 8715.3	Par. 3.6 Electrical Safety and Par. 3.3, Personal Protective Equipment
NASA General Safety Program Requirements	
National Electric Code, MIL-STD 454	Standard General Requirements for Electronic Equipment
29 CFR 1910	Subpart S; Electrical 1910.301 – 308 1910.331 – 335
29 CFR 1910	Subpart R: Special Industries 1910.269
29 CFR 1926	Subpart K; Electrical, and Subpart V; Power Transmission & Distribution
NFPA 70E (National Fire Protection Association)	Standard for Electrical Safety in the Workplace
National Electrical Safety Code	National Electrical Safety Code (NESC®)

12.2 Reference Documents

29 CFR 1910.137	Electrical protective devices
29 CFR 1910.269	Electric Power Generation, Transmission and Distribution – General Industry Standard
29 CFR 1910.304	Wiring design and protection
29 CFR 1910.307	Hazardous (classified) locations
29 CFR 1910.333	Selection and use of work practices
29 CFR 1910.334	Use of equipment
ANSI Z87.1	Eye and Face Protection
ANSI Z89.1	Industrial Workers Protective Headwear
ANSI/IEEE 516	Disconnect poles (Hot Sticks).
ASTM F1116	Standard Test Method for Determining Dielectric Strength of Dielectric Footwear
ASTM F1117	Standard Specification for Dielectric Footwear
ASTM F2412 and ASTM F2413	Protective Footwear
ASTM F496	Standard Specification for In-Service Care of Insulating Gloves and Sleeves
ASTM F855	Standard Specifications for Temporary Protective Grounds to Be Used on De-energized Electric

	Power Lines and Equipment
DCP-O-021	Electrostatic Discharge (ESD) Control Program
DCP-S-009, Chapter 10	Confined Space Safety
DCP-S-009, Chapter 4	Lockout/Tagout Procedure
IEEE 1048	Guide for Protective Grounding of Power Lines

12.3 Forms

DFRC 117-1f	Request for Deviation or Waiver

12.4 Associations

Associations that publish electrical safety guidelines for specific applications are

- National Electrical Manufactures Association (NEMA).
- American Society of Testing Materials (ASTM)
- IEEE Institute of Electrical and Electronic Engineers

13.0 ACRONYMS & DEFINITIONS

13.1 Acronyms

AC	Alternating Current
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute.
ASTM	American Society of Testing Materials
DC	Direct Current
EMS	Electrical Safety Monitor
ESD	Electrostatic Discharge
IEEE	Institute of Electrical and Electronic Engineers.
MSDS	Material Safety Data Sheet
NEMA	National Electrical Manufactures Association.
NFPA	National Fire Protection Association includes NFPA 70, National Electrical Code (NEC).
NRTL	National Recognized Testing Laboratory, such as Underwriters Laboratories, Inc. (UL).
PCB	Polychlorinated biphenyls
PPE	Personal Protective Equipment
UO	Underwriters Laboratories, Inc.

UPS Uninterrupted Power Supply

13.2 Definitions

Ampere	The unit for measuring the rate of flow of electricity.
Alternating Current (AC)	The type of current in which the electrons move to-and-fro in the conductor. The rate of the change of flow is measured in cycles per second, i.e., 60 Hz means the flow changes 60 times per second. AC can be transmitted over long distances and is, therefore, the type of current used commercially.
Conductor	A material through which an electrical current can travel. Most metals are conductors. Copper and aluminum are examples of very good conductors.
Direct Current (DC)	The type of electric current in which the movement of the electrons are in one direction through the conductor. DC is often associated with batteries. The electrical system in your car is mostly DC. DC cannot be transmitted economically over long distances.
Electric Current	The flow of electrons through a conductor.
Electrical Work	Coming in contact with electrical conductors or circuit parts with the hands, feet, or other body parts, or with tools, probes, or other test equipment, regardless of the personal protective equipment a person is wearing.
Hazardous Classified Location	An area that due to its function causes a hazard to exist if electrical sources are not properly used. Examples may include an aircraft hanger, facility where explosive dust is created, a fuel farm where explosive fumes and vapors could exist, etc.
High Voltage	Nationally, high voltage is above 600 volts. See NPR 8715.3C, NASA General Safety Program Requirements, Section 3.6.1.
Insulator	A material through which an electric current does not pass easily.
Low Voltage	Low voltage is considered less than 600 volts nationally.
OPEN	An open electrical circuit.
Resistance	The opposition to the flow of electrons. Resistance is measured in ohms (Ω).
Volt	The unit for measuring the force that drives current through a conductor.

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Admin Change	Baseline-1	11-17-10		Updated footer to show that the document may be distributed outside of Dryden.