

Chapter 8.1

Electrical safety

This could be you . . .

During a late-night shift when no electrical technician was available, a mechanical technician was instructed to work on a live electrical panel in a test area. He was shocked by 480 volts, but received only minor burns to the thumb.

A worker suffered flash burns when his scraper was vaporized by high-voltage electricity while scraping a louvered duct for painting. The duct contained a power buss, and the scraper entered a louver and shorted the buss to the duct.

1. Applicability of this chapter

You are required to follow the requirements in this chapter if you design, install, maintain, or work on electrical equipment or if your work exposes you to the hazards of electricity.

2. What this chapter covers

This chapter covers the minimum requirements for work on power generation, transmission, and distribution systems, motors, transformers, rectifiers, voltage regulators, batteries, battery chargers, and associated components. There are additional requirements for working with batteries in Chapter 6.1, “Battery safety,” of this handbook.

Working on electrical equipment safely

3. Electrical safety program

The following describes JSC’s electrical safety program:

- a. **Electrical safety program principles.** JSC workers and organizations shall:
 1. Follow NFPA 70E, to include arc flash requirements.
 2. Inspect and evaluate the electrical equipment. This includes testing test equipment used after each test.
 3. Maintain the electrical equipment’s insulation and enclosure integrity.
 4. Classify circuits operating at or above 600 volts nominal or 600 root mean square as SAFETY CRITICAL. An electrical crew supervisor or contractor safety officer shall approve your written procedures, and your supervisor shall be present during operations.

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- b. **Electrical hazard controls.** As an electrical worker, you shall follow the general principles of hazard control in chapter 3.2 of this handbook and these specific electrical hazard controls:
 - 1. Consider every electrical conductor or circuit part to be energized until proven otherwise.
 - 2. Make no bare-hand contact with exposed energized electrical conductors or circuit parts operating at 50 volts or more, unless the bare-hand method is properly used.
 - 3. De-energize, if possible. Live parts that operate at less than 50 volts to ground need not be de-energized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.
- c. **Procedures** as described in NFPA 70E, Article 110 and chapter 5.8, paragraph 13 of this handbook.
- d. **Hazard identification and risk assessment** as described in NFPA 70E, Article 110 and chapter 2.4 of this handbook.
- e. **Job briefings** as described in NFPA 70E, paragraph 110.
- f. **Program audits** every three years and random field audits as described in NFPA 70E, Article 110.

4. Limitations for working on electrical equipment

You shall follow the limitations listed below:

<i>When you are . . .</i>	<i>You shall . . .</i>
Maintaining electrical equipment	<ul style="list-style-type: none">• Work only on de-energized equipment. (See lockout/tagout (LO/TO) in Chapter 8.2 of this handbook.)• Get an exception to this limitation from the appropriate authority by performing and documenting an investigation. Your company or directorate shall have policies for working on energized equipment that clearly define the “appropriate authority.” Only designated “qualified electricians” or “electronic technicians” may work on energized equipment. (See National Fire Protection Association Standard 70E, Article 130.)• Verify that equipment cannot be re-energized by attempting a restart using the normal operating controls (where possible) to make sure the equipment or system will not operate. You may need to request a remote restart. (See LO/TO in Chapter 8.2 of this handbook.)• Make sure that all covers, barriers, housings, and containment

	devices are in place.
Doing maintenance, repair, or construction on overhead line or in a substation, where the wiring is congested and you are exposed to or must handle energized equipment	<ul style="list-style-type: none"> • Have at least one additional employee who watches the other workers and warns them if they get near live conductors or helps them if there is an accident. • Have at least two CPR-qualified employees on site. • Assign enough qualified workers to perform the work safely if you are a supervisor.
Doing potentially hazardous operations	<ul style="list-style-type: none"> • Limit access to the work area to authorized personnel only.

5. Controls for working more safely on electrical equipment

You shall implement the following controls:

<i>If you are . . .</i>	<i>Then you shall. . .</i>
Doing an inspection or maintaining equipment	<ul style="list-style-type: none"> • Be qualified to inspect and maintain the electrical equipment. • Inspect the equipment at predetermined intervals.
Adjusting equipment	<ul style="list-style-type: none"> • Never adjust any part of electrical or electronics equipment if there is a risk that you can contact unprotected energized equipment. • Get approval from the electrical supervisor and the Safety and Test Operations Division if you must work on circuits at or over 50 Vac.
Working around energized electrical circuits	<ul style="list-style-type: none"> • Never wear rings, watches, neck chains, or other metallic objects that are electrical conductors. • Wear the proper PPE. • Work on energized equipment ONLY if you are a designated “qualified electrician” or “electronic technician.” (See National Fire Protection Association Standard 70E, Article 130.)

<i>If you are . . .</i>	<i>Then you shall. . .</i>
Repairing or testing electronic equipment on a work bench	<ul style="list-style-type: none"> • Keep work benches clean at all times. • Ground all metal work benches.
Working on poles	<ul style="list-style-type: none"> • Follow the requirements in 29 CFR 1910.268, “Telecommunications,” 29 CFR 1910.269, “Electric Power Generation, Transmission, and Distribution,” and 29CFR 1926.950–960, “Power Transmission and Distribution.” • Inspect all poles before climbing them to do line work, and pike or support them before climbing if they are rotten or weak. • Use proper PPE, tools, and barriers to protect workers from energized circuits. • As a pole climber (lineman), firmly set your spurs and fasten your safety belt before working on pole-mounted electrical lines or equipment. • As the first of two linemen working on the same pole, be in the working position (safety belt fastened) before the second lineman climbs the pole. • Complete all work on one line or phase before working on another, never work on two lines or phases simultaneously when on a pole.

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<i>If you are . . .</i>	<i>Then you shall. . .</i>
	<ul style="list-style-type: none"> • Never intentionally drop anything from a pole to the ground or allow anything to be tossed up to you. • Turn your head away to diminish the risk of injury from an arc blast when opening primary disconnects or cutouts. • Use certified connect/disconnect extension poles when possible.
Working on micro-wave equipment	<ul style="list-style-type: none"> • Know about radiation hazards before working on microwave equipment to avoid possible tissue injury, particularly to the eyes. • Never examine or adjust radiators, waveguide openings, or horns during transmission. • Post warning signs that follow 29 CFR 1910.97 if someone may inadvertently enter the path of a microwave beam greater than 10 mw/cm².
Grounding equipment	<ul style="list-style-type: none"> • Ground non-current-carrying metal parts exposed to contact by personnel with a continuous conductor from the device to a known good ground point. • See National Fire Protection Association Standard 70, “National Electric Code,” Article 250, “Grounding,” and OSHA 29 CFR 1910.302–308, Subpart S, “Electrical,” for requirements. • Ensure that semi-portable equipment such as generators, electric hand tools, and floodlights are properly grounded. • Maintain the protective ground on the metal enclosures during movement, unless the supply circuits are de-energized.
Cleaning electronic equipment	<ul style="list-style-type: none"> • Use only approved and authorized solvents to clean electronic equipment. • Provide adequate ventilation and PPE as directed in the MSDS for the solvent (see Part 9 of this handbook for details on hazardous materials).
Working on high-voltage systems	<ul style="list-style-type: none"> • Have at least two persons trained in CPR per work crew.
Locking or tagging equipment	<ul style="list-style-type: none"> • Follow the requirements of OSHA 29 CFR 1910.147, “The Control of Hazardous Energy (Lockout/Tagout).” (See LO/TO in Chapter 8.2 of this handbook.)

6. Requirements, besides this chapter, to follow for working safely with electrical equipment

You shall follow the regulations listed below:

<i>If you are . . .</i>	<i>Follow . . .</i>
Locking or tagging out an electrical energy source	Chapter 8.2 of this handbook, which implements OSHA 29 CFR 1910.147
Working on communications equipment	OSHA 29 CFR 1910.268
Working on high voltage transmission and distribution equipment	OSHA 29 CFR 1910.269
Working on common facility wiring and equipment	<ul style="list-style-type: none"> • OSHA 29 CFR 1910, Subpart S (all), “Electrical” • National Fire Protection Association Standards 70 and

Designing and installing electrical equipment

7. Safety design requirements for JSC electrical equipment

You shall design permanent JSC electrical equipment to meet the following requirements:

a. Electrical equipment shall have the following safety features:

<i>For . . .</i>	<i>You shall use equipment that . . .</i>
Equipment in ordinary occupancies	<ul style="list-style-type: none"> • Is listed by UL, FM) or other recognized testing laboratories. • Meets the design requirements of the project specification and of National Fire Protection Association Standard 70.
Equipment in hazardous locations	Meets the design requirements in National Fire Protection Association Standard 70, "National Electrical Code," especially Chapter 5, "Special Occupancies," and OSHA 29 CFR 1910.307, "Hazardous Locations."
Safety mechanisms	Meets the requirements listed in paragraph 6 above to ensure personnel and equipment safety.
Minimizing accidental contact	<ul style="list-style-type: none"> • Is designed to locate or guard control boards, switches, transformers, and other hazardous equipment operating at 50 volts or more with grounded railings, barriers, or enclosures. • Has all sharp edges removed and/or isolated from electrical conductors. • Has sufficient room for wiring and maintenance. • Does not apply undue forces on electrical terminations.

- b. The equipment design documents shall show voltage, frequency, number of phases, type of raceways, type, number, and size of conductors, and all data pertinent to personnel and equipment safety.
- c. The Safety and Test Operations Division shall review electrical systems design.
- d. Permanently tag wires, terminals, and equipment with identification numbers that agree with the associated wiring diagrams and schematics.

8. Grounding JSC electrical equipment

Permanent JSC electrical equipment shall meet the following safety requirements for grounding:

- a. Follow National Fire Protection Association Standard 70, National Electric Code Article 250, and OSHA 29 CFR 1910.302–308.

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- b. Show grounding points and grounding details on project drawings and diagrams.
- c. Protect the grounds from physical damage.
- d. Test newly installed grounding systems and document the tests.
- e. Provide an effective separate ground for non-current-carrying metal parts in:
 1. Generators, switches, or motor controller enclosures.
 2. Fuse boxes, distribution cabinets, frames, tracks, and motors of electrically operated equipment.

9. Electrical safety requirements for temporary JSC equipment

JSC temporary equipment shall meet the following requirements:

<i>For . . .</i>	<i>You shall . . .</i>
Temporary lines	<ul style="list-style-type: none">• Limit service to 90 days unless approved by the Safety and Test Operations Division.• Guard or elevate open wiring with 600 volts or less 10 feet above walkways to prevent accidental contact by workers who may be carrying construction materials or tools.
Cords and connections	<ul style="list-style-type: none">• Use portable power tool cords that have an identified grounding conductor connected to the frame or are double-insulated with a UL label.• Use cords that are connected to the grounding contact of an approved plug and UL-listed for the intended use.• Use an appropriately sized GFCI near the power source on temporary circuits that power tools.• Ensure that the extension cords are large enough for the load and are sized to minimize the voltage drop.
Temporary wiring in tanks or confined spaces	<ul style="list-style-type: none">• Provide a properly identified FM- or UL-listed switch, which is rated for the environment, at or near the entrance to allow for Emergency Power Shut-Down.• Protect all circuits with GFCIs.

10. Installing and servicing transformers

To install or service transformers, you shall:

- a. Control access to ground-level outdoor transformers by:
 1. Completely enclosing them with grounded chain-link fences or nonconductive barriers.
 2. Locking entrances not under constant observation.
 3. Posting warning signs for high voltage that prohibit unauthorized entry.
 4. Maintaining an access list of personnel qualified to enter.
- b. Provide for the safe removal of oil spilled during routine maintenance around all outdoor transformers.

- c. Make sure that transformers do not contain any traceable amounts of polychlorinated biphenyls (PCBs).
- d. Test for PCBs. If you suspect them, take all precautions as if they were present (see Chapter 9.1, “Hazardous materials safety and health,” of this handbook). Contact the Safety and Test Operations Division or the Occupational Health Officer for additional information and instructions.
- e. Never place liquid-filled transformers indoors without permission from the Center Operations Directorate.

11. Requirements for installing lighting systems

You shall install systems that meet National Fire Protection Association Standard 70.

12. Features to include when designing an emergency lighting or power system

You shall follow National Fire Protection Association Standard 101, National Electric Code Article 700, and the requirements listed below when you design emergency lighting systems:

- a. Provide an independent source of energy to light work areas, corridors, tunnels, exits, and stairways during a power failure.
- b. Provide a visual alarm system to warn of improper operation.
- c. Never use circuits or outlets that power emergency lighting chargers for other lights or appliances.
- d. Make sure that emergency lights automatically activate when the primary lighting system fails or during a power failure. A failure of any one component in the emergency system shall never leave any critical space in total darkness.
- e. Make sure that emergency power circuits have an emergency supply source to which the load will be switched automatically when the primary source fails.
- f. Provide a switch for testing the emergency lighting system. The test switch shall be clearly marked and accessible from the normal working level.
- g. Make sure that generators used to supply emergency power are started, brought up to speed and frequency, and put on line as soon as emergency switching operations can be done safely.

13. Requirements for operating emergency power and lighting systems

You shall follow NASA-STD-8719.11 and the requirements listed below:

- a. Put multipurpose dry chemical or CO₂ extinguishers next to generators.
- b. Store generator fuels in approved containers in a protected location if you shall store reserve fuel for a mobile power source.

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- c. Refuel generators using approved containers and fuel dispensers.
- d. As the immediate supervisor, you shall make sure that:
 - 1. Servicing, operating, or maintaining of emergency power equipment is performed by qualified and certified personnel.
 - 2. The maintenance crew is proficient in administering CPR, familiar with pertinent safety regulations, and supplied with appropriate safety equipment.
- e. Use approved plans to do maintenance on emergency lighting and power systems.
- f. Have the Electrical Operations Branch, Plant Engineering Division, approve repairs on or modifications to emergency lighting and power systems.
- g. Ground portable generators per NPFA 70 Article 250 and manufacturer's instructions.

Requirements for tags and stickers

14. Defective electrical equipment

Remove power from defective electrical equipment immediately. If the equipment could cause personal injury and cannot be repaired immediately, you shall attach WARNING - *DO NOT OPERATE* tags, JSC Form 19A (Appendix 8A). (**Note:** JSC Form 19A is different than JSC Form 1291, the "Danger, Lockout/Tagout (Tag).") Electrical equipment with these defects requires tags for:

- a. Poor ground impedance.
- b. Energized ground wires.
- c. Exposed wiring.
- d. Loose receptacle housings.
- e. Broken receptacles.
- f. Reversed polarity in shop areas.
- g. Failure to function unless the cause is known to be nonhazardous.

15. Removing a *DANGER*, *CAUTION*, and *WARNING* tag or sticker

Normally, only the installer is allowed to remove a danger, caution, or warning tag. However, when defective electrical outlets are repaired, the repair electrician may remove the tag or sticker and **shall notify the person who attached it and the facility manager.**

Requirements for controlling static electricity

16. Preventing hazardous static discharges

You shall bond and ground all systems designed to transfer, store, or handle flammable gases or liquids.

17. Specific design and installation requirements for bonding and grounding these systems

You shall follow the requirements listed below to bond and ground systems mentioned in paragraph 16:

Note: These installations shall be individually engineered to meet the codes for the various products and environmental conditions.

<i>If you are working with . . .</i>	<i>Then you shall . . .</i>
Flammable gases or liquids	<ul style="list-style-type: none"> • Follow the engineering specifications, and all local and national codes. • Use a correctly sized bond or ground wire with adequate strength, corrosion resistance, and flexibility for the service intended. You may use insulated or non-insulated wire. • Follow National Fire Protection Association Standard 77, "Static Electricity," for the design of ground systems unless the NASA design standards are more restrictive.
Storage tanks, equipment, and piping	<ul style="list-style-type: none"> • Follow the engineering specifications, and all local and national codes. • Ground per the engineering design drawings, which will take into consideration the stored material. • Make sure the resistance of the tank, piping, or equipment to ground meets the design specifications. • Install provisions for grounding all components, including the tank car or tank truck. The system may have to be the alarming type. Check the engineering specifications.
Submerged filling lines	<ul style="list-style-type: none"> • Follow the engineering specifications, and all local and national codes.
Grounding or bonding connections	<ul style="list-style-type: none"> • Follow the engineering specifications, and all local and national codes.

18. Specific operational requirements for bonding and grounding temporary storage vessels

You shall ground transport vessels, portable containers, and other types of temporary storage vessels while transferring flammable liquids or gases. Visually check the grounding and bonding system before each transfer operation to make sure that all connections are good and that there is a continuous path to ground. Periodically check the grounding system with the appropriate test equipment.

19. Hazards of static discharges

You could be seriously injured if exposed to the following hazards:

- a. An explosion could occur in a flammable atmosphere caused by a spark from a charged object near a ground line or another charged object.
- b. A large enough static discharge could set off igniter circuits.
- c. Although static electricity is not lethal, your reaction to a shock may be enough to cause you injury or cause you to damage equipment.

Other electrical safety requirements

20. Precautions for reconnecting or restarting critical equipment after an electrical maintenance or a power outage

Check to verify that voltage, phase, polarity, and current-limiting devices (including motor overloads) are correct. Contact Facility Management and the Operations Office for help.

21. Training for working on electrical equipment

You, as an electrician, shall be trained and certified as follows:

- a. As described in NFPA 70E, Article 110.
- b. To install, maintain, and operate electrical equipment and power lines.
- c. Shall also have LO/TO training described in Chapter 8.2 of this handbook.
- d. To maintain electrical equipment or work with exposed energized circuits. You shall be fully trained in electrical safe work practices, emergency procedures, first aid, and CPR. This includes periodic refresher training.
- e. To work on energized equipment.
- f. To work on high-voltage systems. You shall be trained and certified and have a Hazardous Operations Permit.

Note: See Chapters 4.1, “Program description” (for safety and health training), and 5.8, “Hazardous operations: safe practice and certification,” of this handbook for more requirements on training and certification.

22. PPE for electrical work

You shall follow these requirements for PPE and use any other PPE identified in a Job Hazard Analysis. See Chapter 5.6, “Personal protective equipment,” of this handbook for more requirements on PPE:

<i>For . . .</i>	<i>You shall . . .</i>
All PPE	<ul style="list-style-type: none"> • Inspect PPE before each use to make sure the insulating qualities provide adequate protection.
Electrically insulating rubber equipment	<ul style="list-style-type: none"> • Use equipment that is classified and marked Class 0-4, and that meets the design requirements of OSHA 29 CFR 1910.137(a), “Electrical Protective Devices.” • Inspect and test equipment to meet the requirements of OSHA 29 CFR 1910.137(b).
Safety gloves	<ul style="list-style-type: none"> • Use gloves designed for electrical work and inspect them for cuts, punctures, or signs of wear before beginning work. • Never use gloves with an insulation rating less than the working voltage. • Wear leather gloves over safety gloves to avoid cutting or tearing them. • Make sure that the gloves have been inspected and tested at least every 6 months as described in OSHA 29 CFR 1910.137(b).
Lineman's spurs	<ul style="list-style-type: none"> • Use spurs that are at least 1¼-inch long. • Make sure that they have safety covers to cover the gaffs when not in use.
Safety belts	<ul style="list-style-type: none"> • Use belts for climbing over 4 feet above the ground (see Chapter 5.6 for specific requirements).
Ladders	<ul style="list-style-type: none"> • Use nonconductive ladders that meet OSHA 29 CFR 1910.25, “Portable Wood Ladders,” OSHA 29 CFR 1910.268(H), OSHA 29 CFR 1910.269-1(H), and ANSI standards if doing maintenance on or near electrical equipment (see Chapter 5.7, “Ladders, scaffolds, and elevated platforms: how to work with them safely,” of this handbook for specific requirements).
Working on energized systems.	Refer to National Fire Protection Association Standard 70E, Article 130 for the requirements.

23. Electrical emergencies

You shall take the following actions for these emergency situations:

a. For *electrical shock* you shall:

1. **Call for help, using the emergency phone numbers or using a two-way radio.**
2. Switch the power off.
3. **Administer first aid and, if necessary, CPR.**
4. **Do not attempt to separate the energized circuit from the victim.**

b. For a *fire* you shall:

1. Evacuate the area.
2. **Call for help, using the emergency phone numbers or using a two-way radio.**

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3. Use a CO₂ or multipurpose dry chemical extinguisher to fight **only the incipient** fire, and only if you are trained to use an extinguisher properly. See Chapter 3.8, “Emergency preparedness,” of this handbook.

Remember your emergency number: x33333 at JSC, Sonny Carter Training Facility, and Ellington Field, 911 at any off-site location, and x5911 at WSTF. **Cell phone number: 281-483-3333.**

24. Responsibilities

- a. As an *electrical supervisor*, you are responsible for making sure that:
 1. An LO/TO program is in place and **is being used correctly**.
 2. All electrically powered tools are in good working condition.
 3. All safety devices are available, maintained, and properly used.
 4. All assigned personnel follow safety requirements.
 5. **Electrical work is done by employees trained and certified for the task or the employees are** under the direct supervision of a **trained and certified** person.
- b. The *Safety and Test Operations Division* is responsible for auditing JSC’s electrical safety program as described in subparagraph 3.f of this chapter.