NFPA 70E SYNOPSIS

ARC FLASH WHITE PAPER

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A. Introduction

NFPA 70E Standard for Electrical Safety in the Workplace, 2009 Edition further copies electrical safety procedures. The document clearly defines electrical Arc Flash conditions of concern and personnel safety requirements. This white paper provides a synopsis of the document and begins with an Executive Summary highlighting the major topics covered by NFPA 70E.

B. Executive Summary

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C. Detailed Synopsis

Article 90 - Covered:

- Public & Private premises.
- Yards, lots, parking lots, carnivals, and industrial substations.
- Installation of conductors and equipments (Electrical).
- Installations used by the electrical utility, such as office building, warehouse, garage, machine shops.

Not Covered:

- Ships, watercraft, railway rolling stock, aircraft, automobile.
- Mine, mining machinery.
- Railway generation, transformation, transmission and distribution.
- Communications equipment.
- Installations under the exclusive control of an electrical utility
    - Public service commission, utility commission, or other regulatory agencies.
    - Property owned or leased by the electric utility for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy.

Article 110 - Responsibilities with Contractors:

1. Host Employer Responsibilities:
    a. Inform contract employers for known hazards
    b. Report observed contract employer related violations.
2. Contract Employer Responsibilities:
    a. Ensure that each of his employees is instructed in the hazards. This instruction is in addition to the basic training required.
    b. Ensure that each of his employees follows the safety procedures.
    c. Advise the host employer of
        i. Any unique hazards
        ii. Any unanticipated hazards found during work.
        iii. The measures the contractor took to correct any violations and to prevent such violations from recurring in the future.

Training Requirements:

- Safety Training – Employee shall be trained to identify and understand the hazards.
- Type of training – Classroom or on the job, or a combination of the two.
- Emergency procedure
- Employee Training
    - Qualified person
    - Unqualified person
- Retraining
- Training Document

Electrical Safety Program:

- Awareness and Self-Discipline
- Electrical Safety Program Principles
- Electrical Safety Program Controls

- Electrical Safety Program Procedures
- Hazard/Risk Evaluation Procedure
- Job Briefing
- Electrical Safety Auditing

Working while exposed to electrical hazards:

- Energized Electrical Conductors and Circuit Parts – Safe Work Condition
- Energized Electrical Conductors and Circuit Parts – Unsafe Work Condition

Working within the limited approach boundary of exposed electrical conductors or circuit parts that are or might become energized:

- 50 volt or more – lockout/tagout
- Electrical Hazard analysis
- Shock hazard analysis – boundary requirement, PPE
- Arc flash hazard analysis – Arc flash protection boundary, PPE
- Energize electrical work permit – written permit
- Unqualified person – not permitted
- Safety interlock – only qualified person

Test Instruments and Equipments:

- Rating
- Design
- Visual Inspection – before each use
- Operation verification

Portable electric equipment:

- Handling
- Grounding type equipment
- Visual inspection of portable cord-and-plug connected equipment and flexible cord sets – before each use, defective equipment, proper mating
- Conductive work location – ground fault circuit interrupter
- Connecting attachment plug – hands dry, locking type connectors

GFCI protection devices: shall be tested per manufacturer's instructions

Overcurrent protection modification – shall not be modified, even on a temporary basis

Article 120 - Process of achieving an electrically safe work condition:

- Determine all possible source, check up-to-date drawing, diagrams and identification tags.
- Open disconnecting device

- Visually verify disconnecting device's blades
- Lockout/tagout
- Adequately rated voltage detector to test each conductors
- Possibility of induced voltage – ground the phase conductors before touching.

Deenergized electrical conductors or circuit parts that have lockout/tagout devices applied:

- All electrical circuit conductors and circuit parts shall be considered energized.
- Electrical conductors and circuit parts that have been disconnected, but not under lockout/tagout tested and grounded shall not be considered electrically safe work condition
- Principles of lockout/tagout execution
    - Employee involvement – each exposed employee shall be involved
    - Training - each exposed employee shall be trained
    - Plan
    - Control of energy
    - Identification – unique
    - Voltage
    - Coordination
- Responsibility
    - Employer shall establish lockout/tagout procedures, providing training, equipment, audit
    - Audit procedure – audit shall be conducted at least annually by a qualified person and shall cover at least one lockout/tagout procedure details
- Hazardous electrical energy control procedure
    - Individual qualified employee control procedure
    - Simple lockout/tagout procedure
    - Complex lockout/tagout procedure
    - Coordination
    - Training and retraining
- Equipment
    - Lock application – electrical isolation device installed after 1990, shall be capable of accepting lockout/tagout device
    - Lockout/tagout device – employer shall supply and employee shall use
    - Electrical circuit interlocks – up-to-date diagram shall be consulted to ensure that no electric circuit interlock operation can result in reenergizing the circuit.
    - Control devices – locks/tags shall be installed only on circuit disconnecting means. Control devices, such as push buttons or selector switches, shall not be used as the primary isolation device.
- Procedures – maintain a copy of the procedure and available to all employee
    - Planning
        - Locating sources – up-to-date single-line diagram
        - Exposed person – identify person and PPE

        - Person in charge
        - Individual qualified employee
        - Simple lockout/tagout
        - Complex lockout/tagout
    - Elements of control
        - Deenergizing equipment – establish the person who performs the switching and where and how to deenergize the load
        - Stored energy – all capacitors shall be discharged and high capacitance elements shall also be short circuited and grounded. Springs shall be released or physical restraint shall be applied.
        - Disconnecting means
        - Responsibility – person
        - Verification – verify that equipment cannot be restarted
        - Testing – what voltage detector, PPE, who will verify
            - To define the boundary of the work area
            - Test before touching the exposed conductors within the defined boundary work area
            - Requirement for retest when circuit conditions changed or when job location has been left unattended
            - If no accessible exposed point to take voltage measurements, planning considerations shall include methods of verification
        - Grounding
        - Shift change – transfer responsibility for lockout/tagout to another person
        - Coordination
        - Accountability for personnel
        - Lockout/tagout application
        - Removal of Lockout/tagout devices
        - Temporary release for testing/positioning

Temporary protective grounding equipment:

- Placement
- Capacity
- Equipment approval
- Impedance

Article 130 - WORK INVOLVING ELECTRICAL HAZARDS

Article 130.1 - Justification for work:

(A) General – energized electrical conductors and circuit parts

- Greater hazard – energized work shall be permitted where deenergizing introduces additional or increased hazards

- Infeasibility –energized work shall be permitted where the work is infeasible in a deenergized state
- Less than 50 volts

(B) Energized Electrical Work Permit

- Where required – performed by written permit only
- Elements of work permit
    - Description of circuit and equipment
    - Justification for energized work
    - Description of safe work practices
    - Results of the shock hazard analysis
    - Determination of shock protection boundary
    - Results of the arc flash hazard analysis
    - The arc flash protection boundary
    - Necessary PPE
    - Means employed to restrict the access of unqualified persons
    - Evidence of completion of a job briefing
    - Energized work approval
- Exemptions to work permit – if the purpose of crossing the limited approach boundary is only for visual inspection and the restricted approach boundary will not be crossed, than an energized electrical work permit shall not be required

Article 130.2 - Approach Boundaries to Energized Electrical Conductors or Circuit Parts

- Shock Hazard Analysis – shock hazard analysis determine the voltage to which personal will be exposed, boundary requirements, and PPE
- Shock protection boundaries – limited, restricted and prohibited approach boundaries
- Approach to exposed energized electrical conductors or circuit parts operating at 50 volts or more – No qualified person shall approach or take any conductive object closer to exposed energized electrical conductors or circuit parts operating at 50 volts or more than the restricted approach boundary unless any of the following apply
    - Qualified person is insulated
    - The energized electrical conductors or circuit part are insulated
    - Qualified person is insulated from any other conductive object
- Approach by unqualified person - shall not be permitted to enter space that are required to be accessible to qualified employee only
    - Working at or close to the limited approach boundary – designated person in charge shall advise the unqualified person of the electrical hazard and warn him to stay outside of the limited approach boundary
    - Entering the limited approach boundary – if there is a need an unqualified person to cross the limited approach boundary, a qualified person shall advise him the possible

hazards and continuously escort the unqualified person. Under no circumstance shall the unqualified person be permitted to cross the restricted approach boundary.

Article 130.3 - Arc Flash Hazard Analysis – An arc flash hazard analysis shall determine the arc flash protection boundary and the personal protective equipment that within the arc flash protection boundary shall use. The arc flash hazard analysis shall be updated when a major modification or renovation takes place. It shall be reviewed periodically, not to exceed five years, to account for changes in the electrical distribution system that could affect the results of the arc flash hazard analysis. Arc flash hazard analysis shall take into consideration the design of the overcurrent protective device and its opening time, including its condition of maintenance.

Arc flash hazard analysis shall not be required where

- The circuit is rated 240 volts or less
- The circuit is supplied by one transformer
- Transformer supplying the circuit is rated less than 125 KVA

Arc Flash Protection Boundary:

- Voltage level between 50 Volts and 600 Volts – in case where detail arc flash hazard analysis are not performed, the arc flash protection boundary shall be 4.0 ft. When product of clearing times and cycle exceeds 100KA cycles, the arc flash protection boundary shall be calculated.
- Voltage level above 600 volts – the arc flash protection boundary shall be the distance at which the incident energy equals 5 J/cm^2 (1.2 cal/cm^2). When full clearing time is equal to or less than 0.1 sec, arc flash protection boundary shall be the distance at which the incident energy equals 6.24 J/cm^2 (1.5 cal/cm^2).

Protective clothing and other personal protective equipment for application with an arc flash hazard analysis:

- Incident energy analysis
- Hazard/risk categories

Equipment labeling – equipment shall be field marked with a label containing the available incident energy or required label of PPE.

Article 130.4 - Test Instruments and Equipment Use – Only qualified persons shall perform testing work within the limited approach boundary of energized electrical conductors or circuit parts operating at 50 volts or more.

Article 130.5 - Work within the limited approach boundary of uninsulated overhead lines

- Uninsulated and energized – precautions shall be taken. If contact is possible, the line shall be deenergized and visibly grounded at a point of work, or suitably guarded.

- Deenergizing or guarding – if the lines are to be deenergized, arrangement shall be made with the person or organization that operates or control the lines. If arrangements are made to use protective measures, such as guarding, isolating, or insulation, these precautions shall prevent each employee from contacting such lines directly or indirectly.
- Employer and employee responsibility – the employer and employee shall be responsible for ensuring that guards or protective measures are satisfactory for the condition. Employee shall comply with established work method and use PPE.
- Approach distance for unqualified persons – the distance are in Table 130.2(C), Column 2.
- Vehicular and mechanical equipment
    - Elevated equipment – Table 130.2(C), column 2.
        - If vehicle is in transit, the limited approach boundary to overhead line shall be permitted to 6 ft. If insulated barriers, rated for the voltage involved, are installed the clearance shall be permitted to reduce to the design working dimension.
        - If the equipment is an aerial lift insulated for the voltage involved, and the work is performed by a qualified person, the clearance shall be permitted to be reduced to the restricted approach boundary. Table 130.2(C), Column 4.
    - Equipment contact – employees standing on the ground shall not contact the vehicle/mechanical equipment unless either of the following conditions applied
        - Using PPE rated for the voltage
        - Equipment distance from line is at least that shown in Table 130.2(C), column 2.
    - Equipment Grounding – if the vehicle is intentionally grounded, employees working on the ground shall not stand near the ground point. Additional precautions such as barricades, electric overshoe footwear or insulation.

Article 130.6 - Other precautions for personal activities

- Alertness
    - When hazardous – alert at all time when working at 50 volts or more
    - When impaired – shall not be permitted within limited approach boundary
    - Changes in scope – employee shall be instructed
- Blind reaching – not to reach blindly into areas that might contain exposed energized electrical conductors.
- Illumination
    - Shall not enter spaces when not enough light
    - Obstructed view of work area – employee shall not perform any task within the limited approach boundary
- Conductive articles being worn – jewelry and conductive clothing shall not be worn when they present an electrical hazard with exposed energized electrical conductors.
- Conductive materials, tools, and equipment being handled
    - Shall be handled in a manner that prevents accidental contact with energized electrical conductors

    - Approach to energized electrical conductors and circuit parts – no closer than table 130.2.
- Confined or enclosed work spaces – employer shall provide and employee shall use protective shields, protective barriers, and insulating materials. Doors, hinged panels and the like shall be secured to prevent their swinging into an employee.
- Housekeeping duties – employees shall not perform housekeeping duties inside the limited approach boundary unless adequate safeguards are provided. Electrically conductive cleaning materials shall not be used inside limited approach boundary.
- Occasional use of flammable materials – where flammable materials are present occasionally, electric equipment capable of igniting them may not be used, unless measures are taken to prevent hazardous conditions from developing.
- Anticipating failure – when there is evidence that electric equipment could fail, the electric equipment shall be deenergized.
- Routine operating and closing of circuits – load rated switches, circuit breakers, or other devices shall be used.
- Reclosing circuits after protective device operation – after a circuit is deenergized by a circuit protective device, the circuit shall not be manually reenergized until it has been determined that equipment and circuit can be safely energized. If automatic operation of the device was caused by an overload rather than faulty condition, examination of the circuit shall not be required before the circuit is reenergized.

Article 130.7 - Personal and other protective equipment

- Where electrical hazards are present, employee shall use PPE.
- Care of equipment – PPE shall be maintained in a safe, reliable condition. PPE shall be visually inspected before each use. It shall be stored in a safe manner.
- Personal Protective Equipment – when an employee is working within the arc flash protection boundary, he shall wear PPE.
    - Movement and visibility – when flame-resistant clothing is worn, it shall cover all ignitable clothing and shall allow for movement and visibility.
    - Head, Face, Neck, and Chin Protection – Employee shall wear non conductive head protection. Employee shall wear nonconductive protective equipment for the face, neck and chin.
    - Eye protection – employee shall wear PPE for the eyes whenever there is danger of injury from electric arc, flashes or from flying objects resulting from electric explosion.
    - Body protection – employee shall wear fire rated clothing whenever there is a possibility of arc flash above the incident energy of 5 J/cm^2.
    - Hand and arm protection – hand and arm protection shall be provided
        - Shock protection – employee shall wear rubber insulating gloves with leather protectors and rubber insulating sleeves.
        - Arc flash protection – hand and arm protection shall be worn when there is possible exposure to arc flash burn.

        - Maintenance and use – shall be maintained in a safe, reliable condition. Shall be inspected for damage before each days use and immediately following an incident. Insulating gloves shall be given an air test, along with inspection. Electrical protective equipment shall be subjected to periodic electrical test.
    - Foot protection – for step and touch potential, dielectric overshoes shall be required. Insulated shoes shall not be used as primary electrical protection.
- Standards for Personal protective equipment – PPE shall conform to the standards given in Table 130.7(C)(8)
- Selection of Personal Protective Equipment when required for various tasks – use Table 130.7(C)(8). For tasks not listed, or for power systems with greater than the assumed maximum short-circuit current capacity or with longer than the assumed maximum fault clearing times, an arc flash hazard analysis shall be required.
- Protective clothing and personal equipment matrix – once the hazard/risk category has been identified from Table 130.7(C)(9) and the requirements of 130.7(C)(9), Table 130.7(C)(10) shall be used to determine the required PPE for the task.
- Protective Clothing Characteristics - Table 130.7(C)(11).
- Factors in Selection of Protective Clothing – clothing and equipment required for the degree of exposure shall be permitted to be worn alone or integrated with flammable, non-melting apparel. If FR clothing is required, it shall cover associated parts of the body as well as all flammable apparel while allowing movement and visibility. All PPE shall be maintained in a sanitary and functionally effective condition.
    - Layering – nonmelting flammable fiber garments shall be permitted to be used as underlayers in conjunction with FR garments. The system arc rating shall be sufficient to prevent breakopen of the innermost FR layer.
    - Outer layers – garments worn as outer layers over FR clothing, such as jackets or rainwear shall be made from FR material.
    - Underlayers – meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted.
    - Coverage – clothing shall cover potentially exposed areas as completely as possible.
    - Fit – Tight fitting shall be avoided. FR apparel shall fit properly such that it does not interfere with the work task.
    - Interference – the garment selected shall result in the least interference with the task but still provide the necessary protection.
- Arc Flash Protective Equipment -
    - Arc flash suits – design shall permit easy and rapid removal by the wearer. When exterior air is supplied into the hood, the air hoses and pump housing shall be either covered by FR materials or constructed of nonmelting and nonflammable materials.
    - Face protection – face shields shall have an arc rating suitable for the arc flash exposure. Eye protection shall always be worn under face shields or hoods.

    - Hand protection – leather or FR gloves shall be worn where required. Where insulated rubber gloves are used for shock protection, leather protectors shall be worn over the rubber gloves.
    - Foot protection – heavy duty leather work shoes provide some arc protection to the feet and shall be used in all tasks in hazard/risk category 2 and higher.
- Clothing material characteristics – clothing made from flammable synthetic materials that melt at temperature below 600˚F, such as acetate, acrylic, nylon, polyester, polyethylene, polypropylene, and spandex, either alone or in blends shall not be used.
- Clothing and other apparel not permitted – clothing made from materials that do not meet the requirements shall not be permitted to be worn.
- Care and maintenance of FR clothing and FR arc flash suits
    - Inspection – FR apparel shall be inspected before each use. Any damaged suits shall not be used. Contaminated with grease, oil or flammable liquids or combustible materials shall not be used.
    - Manufacturer's instruction – for care and maintenance.
    - Storage – FR apparel shall be stored in a manner that prevents physical damage.
    - Cleaning – manufacturer's instructions shall be followed.
- Other protective equipment
    - Insulated tools and equipment - employees shall use insulated tools and handling equipment when working inside the limited approach boundary where tools might make accidental contact. Insulated tools shall be rated for the voltage. It shall be inspected prior to use. Fiberglass reinforced plastic rod and tube used for live line tools shall meet the requirements. Ropes and handling shall be nonconductive. Portable ladder shall have nonconductive side rails. Protective shields, protective barriers or insulating materials shall be used to protect employee from shock, burn or other electrically related injuries while working in limited approach boundary. When normally enclosed energized conductors or circuit parts are exposed for maintenance or repair, they shall be guarded to protect unqualified persons from contact with energized conductors or circuits. Rubber insulating equipment shall meet the ASTM standards listed in Table 130.7(F). Voltage rated plastic guard equipment shall meet the ASTM standards listed in Table 130.7(F). Physical or mechanical barriers shall be installed no closer than the restricted approach boundary.
    - Alerting Techniques – safety sign and symbols shall be used. Series of safety signs and tags given in 130.7(F). Barricades shall be used in conjunction with safety signs. Conductive barricades shall not be used where it may cause an electrical hazard. Barricades shall be placed no closer than the limited approach boundary. Table 130.2(C). Attendants – If signs and barricades do not provide sufficient warning and protection, an attendant shall be stationed. An attendant shall remain in the area as long as there is a potential for employees to be exposed. Look-Alike equipment – where work performed on equipment that is deenergized and placed in an electrically safe condition exists in a work area with other energized equipment that is similar in size, shape and

construction, one of the alternating methods shall be employed to prevent the employee from entering look alike equipment.

Chapter 2 Safety Related Maintenance Requirements

- Substations, Switchgear Assemblies, Switchboards, Panelboards, Motor Control Centers, and Disconnect Switch – enclosures shall be kept free of materials that would create hazard. Fences, physical protection, enclosures, attendant or other protective means to guard the energized equipment shall be maintained. Current carrying conductor shall be maintained to conduct rated current without overheating, withstand available fault current. Insulating integrity shall be maintained to support the voltage. Protective device shall be maintained to withstand or interrupt available fault current.
- Premises wiring – covers for wiring system components shall be in place with all associated hardware and there shall be no unprotected openings. Open wiring protection, raceway and cable trays shall be maintained.
- Controller equipment – protection and control circuitry used to guard against accidental contact with energized conductors shall be maintained.
- Fuses and circuit breakers – fuseholders for circuit limiting fuses shall not be modified to allow the insertion of fuses that are not current limiting. Molded-Case Circuit breakers shall be maintained free of cracks in cases or broken operating handles. Circuit breakers that interrupt faults approaching their interrupting ratings shall be inspected and tested in accordance with manufacturer's instructions.
- Rotating equipment – terminal chambers, enclosures, and boxes shall be maintained to guard against accidental contact with energized conductors. Guards, barriers and access plates shall be maintained to prevent employees from contacting moving or energized parts.
- Hazardous locations – no energized parts are exposed. Exception: Intrinsically safe and nonincendive circuits. No breaks in conduit, fittings or enclosures. All bonding jumpers are securely fastened and intact. Fittings, boxes and enclosures with bolted covers have all bolts installed and bolted tight. All threaded conduit shall be wrenchtight and enclosure cover shall be tightened. No open entries into fittings, boxes and enclosures. All close-up plugs, breathers, seals and drains are securely in place. Marking of luminaries for maximum lamp wattage and temperature rating is legible and not exceeded. Required markings are secure and legible.
- Batteries and battery rooms – ventilation systems, forced or natural, shall be maintained. The maintenance shall include a functional test of any associated detection and alarm systems. Eye and body wash apparatus shall be maintained. Battery cell ventilation openings shall be unobstructed and cell flame arrestors shall be maintained.
- Portable electric tools and equipment – attachment plugs, receptacles, cover plates and cord connection shall be maintained. No breaks, damage, or cracks exposing energized conductors. No missing cover plates. Terminations have no loose terminals. No missing, loose, altered, or damaged blades, pins, or contacts. Polarity is correct.
- Personal safety and protective equipment – shall be maintained in safe working condition
    - Grounding equipment

    - Hot sticks
    - Rubber gloves, sleeves, and leather protectors
    - Voltage test indicators
    - Blanket, insulating mats and similar insulating equipment
    - Protective barriers
    - External circuit breaker rack-out devices
    - Portable lighting equipment
    - Dielectric footwear, protective clothing
    - Bypass jumpers
    - Insulated and insulating hand tools
- Inspection and testing of protective equipment and protective tools – visually inspected for damage and defects before initial use and intervals thereafter, but no case shall the interval exceed 1 year, unless specified otherwise by ASTM standards. Appropriate test before initial use and at intervals thereafter, but no case shall the interval exceed 3 years, unless specified otherwise by ASTM standards.
- Safety grounding equipment – ground cable sets shall be inspected for cuts in the protective sheath and damage to the conductors. Clamps and connector strain relief devices shall be checked for tightness. Inspection shall be made at intervals but no more than 1 year. Safety grounds that have been modified or repaired shall be tested prior to being returned to service. Guidance: ASTM F2249. Grounding and testing devices shall be stored in a clean and dry area. Grounding and testing devices shall be properly inspected and tested before each use. Guidance: IEEE C37.20.6-1997.

Chapter 3 Safety requirements for Special Equipment

Employer shall provide safety related work practices and employee training. The employee shall follow those work practices.

- Safety related work practices for electrolytic cells
    - Employee training:
        - Qualified person – shall be trained in the operation of cell line working zone equipment and specific work methods. Training shall include the following:
            - The skills and techniques to avoid dangerous contact with hazardous voltage. Skills and techniques might include temporarily insulating or guarding parts to permit the employee to work on energized parts.
            - The method of determining the cell line working zone area boundaries.
        - Qualified persons shall be permitted to work within the cell line working zone.
        - Unqualified person – unqualified persons shall be trained to recognize the electrical hazards to which they may be exposed and the proper methods of avoiding the hazards. When there is a need for an unqualified person to enter the cell line working zone to perform a specific task, that person shall be advised by the designated person in charge of the possible hazards.

- Safeguarding of employees in the cell line working zone – may require contact by employees with exposed energized surfaces. Hazardous battery effect voltages shall be dissipated to consider a cell line deenergized. Permanent signs shall clearly designate electrolytic cell areas.
    - Arc Flash Hazard Analysis – each task performed in the electrolytic cell line working zone shall be analyzed for the risk of arc flash hazard injury. For arc flash hazard use PPE, later work procedure to eliminate the possibility of arc flash, schedule the task so that work can be performed when the cell line is deenergized. Arc flash hazard risk analysis shall be done for all routine/non-routine tasks performed in the cell line work zone. This result shall be used in training employees. If possibility of an arc flash hazard exists for either routine or non-routine tasks, employee shall use appropriate safeguard.
    - Safeguards – safeguards shall include one or combination of the following means.
        - Insulation – glass, porcelain, epoxy coating, rubber, fiberglass, plastic, and when dry, such materials as concrete, tile, brick, and wood. Insulation shall be permitted to be applied to energized or grounded surface.
        - PPE – shoes, boots, or overshoes for wet/dry service, gloves/sleeves for wet/dry service, electrically insulated head protection, protective clothing, eye protection with nonconductive frames, faceshield.
        - Barriers
        - Voltage equalization – voltage equalization shall be permitted by bonding a conductive surface, to an electrically energized surface, either directly or through a resistance, so that there is insufficient voltage to create an electrical hazard.
        - Isolation
        - Safe work practices – employees shall be trained and shall comply with established safe work practices and the safe use of protective equipment.
            - Attitude awareness – safe work practice training shall include attitude awareness instructions.
            - Bypassing of safety equipment – safe work practice training shall include techniques to prevent bypassing the protection of safe equipment. Clothing, trouser legs, shirt sleeves, jewelry.
        - Tools – tools and other devices used in the energized cell line work zone shall be selected to prevent bridging between surfaces at hazardous potential difference. Tools and other devices of magnetic material could be difficult to handle in energized cells' areas due to their strong dc magnetic fields.

- Portable cutout type switches - Portable cell cutout type switches that are connected shall be considered as energized and as an extension of the cell line work zone. Appropriate procedures shall be used to ensure proper cutout switch connection and operation.
- Cranes and hoists – shall meet the requirements of 668.32 of NFPA 70, National Electrical Code. Insulation required for safeguarding employees, such as insulated crane hooks, shall be periodically tested.
- Attachments – attachments that extend the cell line electrical hazards beyond the cell line working zone shall utilize one or more of the following:
    - Temporary or permanent extension of the work zone
    - Barriers
    - Insulating brakes
    - Isolation
- Pacemakers or metallic implants – employee with implanted pacemakers, ferromagnetic medical devices, or other electronic devices vital to life shall not be permitted in cell areas unless written permission from employee's physician.

▪ Portable tools and equipment –

- Portable electrical equipment –Portable electrical equipment shall meet the requirements of 668.20 of NFPA 70, NEC. Power supplies for portable electrical equipment shall meet the requirements of 668.21 of NFPA 70, NEC.
- Auxiliary nonelectric connections – auxiliary nonelectric connections such as air, water, and gas hoses shall meet the requirements of 668.31 of NFPA 70, NEC. Pneumatic-powered tools shall be supplied with nonconductive air hoses in the cell line working zone.
- Welding machines – welding machine frames shall be considered at cell potential when within the cell line working zone. Cell line not be grounded through the welding machine or its power supply. Welding machines located outside the cell line working zone shall be barricaded to prevent employees from touching.
- Portable test equipment – test equipment shall be suitable for use in areas of large magnetic fields and orientation.

Article 320 - Safety requirements related to batteries and battery rooms

This article shall apply for installations of stationary storage batteries and battery rooms with a storage capacity exceeding 1kWH or a nominal voltage that exceeds 50 volts but does not exceed 650 volts.

- Battery connections

- Method of connection – cells of unequal capacity should not be connected in series. Parallel connections of batteries are not recommended for constant current charging applications.
- Battery short circuit current – manufacturer shall be consulted regarding the sizing of the battery short circuit protection.
- Connection between battery and dc switching equipment – shall be rated to withstand the prospective short-circuit current. Outside busbars and cables should be both of the following: insulated from the battery terminals to a height of 12'4" or the battery room ceiling, whichever is lower, clearly identified and segregated from any other supply circuits.
    - Cables shall be effectively clamped and sufficient support shall be provided.
    - Busbars should be insulated throughout their length by an insulating material not affected by the acid fumes. The steelwork supporting the busbar system should be insulated.
    - Busways should be fully enclosed and able to withstand high level of fault current without danger.
- Terminals and connections – intercell and battery terminal connections shall be constructed of materials, resistant to corrosion or suitably protected by surface finish against corrosion. The joining of materials that are incapable in a corrosive atmosphere shall be avoided.
    - To prevent mechanical stress on the battery terminal posts, connection between the battery and any busbar system should be by insulated flexible cable.
    - The takeoff battery terminals and busbar connections should be protected by physical barriers to prevent accidental contact.
- DC systems grounding and ground fault detection – one of the four shall be used.
    - The ungrounded DC system in which neither pole of the battery is connected to ground. An ungrounded DC system should be equipped with an alarm to indicate the presence of a ground fault.
    - Solidly grounded system.
    - The resistance grounded DC system
    - A tapped solid ground, either at the center point or at another point to suit the load system.
- Protection of DC circuit – follow NEC.
- Alarms
    - Abnormal battery condition
        - For vented batteries – overvoltage, undervoltage, overcurrent, ground fault.
        - For VRLA batteries - overvoltage, undervoltage, overcurrent, ground fault, overtemperature as measured at the pilot cell.

        - Warning signal – alarm system shall provide an audible alarm and visual indication at the battery location, and where applicable, at remote manned control point.
- Installations of batteries –
    - Location – installed one of the following:
        - dedicated battery room
        - an area only accessible to authorized personnel
        - Enclosure with lockable doors or a suitable housing that shall require a key or tool to gain access.
    - Arrangement of Cells
        - Cells shall be readily accessible for inspection and maintenance.
        - The space between adjacent containers shall be no less that manufacturer's recommendation. If not available, use ½".
        - Each cell shall be readily accessible without having to reach over another cell.
    - Ventilation for Batteries of the Vented Type
        - Installation – shall be located in rooms or enclosures with outside vent or well vented rooms.
        - Ventilation shall be provided so as to prevent liberated hydrogen gas from exceeding 1% concentration.
            - Room ventilation shall be adequate to assure that pockets or trapped hydrogen gas do not occur.
            - Exhaust air shall not pass over electrical equipment
            - Inlets shall be no higher than the top of the battery cells and outlets at the highest level in the room.
        - Mechanical ventilation – where mechanical ventilation is installed the following shall be required.
            - Airflow sensors shall be installed. Alarm for no air flow.
            - Control equipment for the exhaust fan shall be located more than 6' from the battery and a minimum of 4" below the lowest point of the highest ventilation opening.
            - All exhaust shall be discharged outside the building.
            - Fans used to remove air from the battery room shall not be located in the duct unless the fan is listed for the use.
    - Ventilation for VRLA Type
        - Ventilation – same
        - Mechanical ventilation - same
        - Temperature requirement – thermal management shall be provided to maintain battery design temperature to prevent thermal runaway that can cause cell meltdown, leading to a fire or explosion.
- Battery room requirements
    - Shall be accessible only to authorized personnel.

        - Door – doors shall open outward. The doors shall be equipped with quick release, quick opening hardware.
        - Foreign piping that is not protected against corrosion shall not pass through the battery room.
        - Passageways shall be of sufficient width to allow the replacement of all battery room equipment.
        - Emergency exit shall be provided.
    - Battery enclosures – all cells shall be readily accessible for inspection, cleaning, maintenance and removal.
    - Floor loading shall take into account the seismic activity.
    - Battery systems containing free flowing liquid electrolyte shall be provided with spill containment systems in accordance with the fire code.
    - Battery layout – shall be so designed that unless there is a physical barrier, voltage over 120V shall be separated by a distance not less than 3’.
    - Floor area –
        - The minimum isle width shall be 3’.
        - Single row batteries - Minimum clearance of 1” between cells and any wall or structure. Battery shelf has a free air space for no less than 90% of its length.
        - Double row batteries – minimum isle width shall be maintained on one end and both sides of the battery. The remaining end shall have a minimum clearance of 4”.
        - Tiered batteries shall meet requirements of the above. There shall be a minimum clearance of 12” between the highest point of the battery located on the bottom tire and the lowest point of the underside of the upper runner bearer.
        - Where a charger or other electrical equipment, is located in a battery room, the isle width between any battery and any part of the battery charging equipment (including door) shall be at least 3’.
    - Takeoff battery terminals
        - Outgoing busbars and cables shall meet the following
            - Be installed from the battery terminals to a height of 12’4” or the battery room ceiling, whichever is lower.
            - Be clearly identifier from any other supply circuit.
            - Prevent mechanical stress on the battery post.
            - Be protected by physical barrier to prevent accidental contact.
            - Be shrouded.
        - Interior and interrow connections – be shrouded, be protected by insulating barrier.
        - Barriers
            - Double row batteries – insulating barriers between double row batteries shall be installed for the entire length of the battery extending 4” past

the end terminals. The barrier shall extend vertically a minimum of 16" above the exposed portion of the intercell connections and a minimum of 1" below the top of the battery container.

- Battery above 120V – barriers shall extend a minimum of 2" out from the exposed side of the battery and a minimum of 16" above the top of the container.

- Illumination
  - Battery room lighting – minimum 300 lux.
  - Emergency lighting – shall be provided.
- Location of luminaries and switches – shall not be installed directly over cells or exposed energized conductors. Switches shall be readily accessible.
- Power – general purpose outlets shall be installed.
- Location of general purpose outlets – 6' from the battery and a minimum of 4" below the lowest point of the highest ventilation opening.

- Enclosure requirements –
  - Separate compartments shall be provided for battery, battery charger, and other equipment.
  - Ventilation openings for the battery compartments shall prevent the exchange of air within compartments containing electrical equipment; prevent accumulation of flammable gas in pockets exceeding 1%.
  - Battery compartment circuits – only circuits associated with the battery shall be installed within a battery compartment of the enclosure.
- Protection
  - When battery capacity exceeds 100 Amp-hours or where nominal voltage is over 50 Volts, suitable warning notice shall be provided.
  - Each output conductor shall be individually protected by a fuse or circuit breaker.
  - Protective equipment shall not be located in the battery compartment of the enclosure.
  - Switching and control equipment shall comply with NFPA 70, NEC.
  - Ground fault protection – for ungrounded battery of nominal voltage in excess of 120 volts, a ground fault detector shall be provided to initiate a ground fault alarm.
  - The battery installation shall have an isolation switch installed as close as practicable to the main terminals of the battery. Where busbar system is installed, the isolation switch may be incorporated into the end of the busway.
  - Section isolating equipment – where the battery section exceeds 250 volts, the installation shall include an isolating switch, plugs, or links, as required.
  - The following signs shall be posted in appropriate locations:
    - Electrical hazard warning signs indicating the shock hazard, arc hazard.

- Chemical hazard warning signs indicating the danger of hydrogen explosion from open flame and smoking and the danger of chemical burns from the electrolyte.
- Notice for personnel to wear PPE.
- Notice prohibiting access to unauthorized personnel.

- PPE – goggle and face shields, chemical resistant gloves, protective aprons, protective overshoes, portable or stationary water facilities for rinsing eyes and skin in case of electrolyte spillage.
- Tools and equipment shall comply with the following:
  - Be of non-sparking type
  - Be equipped with handle listed as insulated for the maximum working voltage.

Article 330 – Safety related work practices for use of Lasers

Article shall apply to the use of lasers in the laboratory and the workshop.

- Personnel to be trained – all operator and maintenance personnel.
- Scope of training
  - Familiarization with laser principles of operation, laser types, and laser emissions.
  - Laser safety –
    1. System operating procedures
    2. Hazard control procedures
    3. The need for personnel protection
    4. Accident reporting procedures
    5. Biological effects of the laser upon the eye and the skin.
    6. Electrical and other hazards
       a. High voltages and stored energy in the capacitors
       b. Circuit components, such as electron tubes, with anode voltage greater than 5 kV emitting X-rays.
       c. Capacitor bank explosions
       d. Production of ionizing radiation
       e. Poisoning from the solvent or dye switching liquids or laser media
       f. High sound intensity levels from pulsed lasers.
- Proof of qualifications – shall be available and in possession of the operator at all times.
- Safeguarding of employee in the laser operating area
  - Eye protection
  - Warning signs
  - Master control – high power laser equipment shall include a key operated master control.

        - High power laser equipment shall include a failsafe laser radiation emission audible and visible warning.
        - Beam shutters or cap shall be utilized, or the laser switched off when the transmission is not required.
        - Laser beams shall not be aimed at employees.
        - PPE for users and operators
    - Employee responsibility
        - Obtain authorization for laser use
        - Obtain authorization for being in a laser operating area
        - Observe safety rules
        - Reporting laser equipment failures and accidents to the employer

Article 340 – Safety related work practices: Power Electronic Equipment

Applied for the following:

- Electric arc welding equipment
- High power radio, radar, and television transmitting tower and antenna
- Industrial electronic and RF induction heaters
- Shortwave or RF diathermy devices
- Process equipment that includes rectifier and inverters
    - Motor drives
    - Uninterruptible power supply systems
    - Lighting controllers
- Hazardous effects of electricity on the human body
    - Results of power frequency current
        - At 5 mA, shock is perceptible.
        - At 10 mA, a person may not be able to voluntarily let go to the hazard.
        - At about 40 mA, the shock, if lasting for 1 second or longer, may be fetal due to ventricular fibrillation.
        - Further increasing current leads to burn and cardiac arrest.
    - Results of direct current
        - 2 mA is perceptible
        - 10 mA is considered the threshold of the let go current.
    - Results of voltage – 30 VAC or 60 VDC is considered safe except when the skin is broken.
    - Results of short contact –
        - Less than 0.1 sec and current greater than 0.5 A, ventricular fibrillation may occur only if the shock is in a vulnerable part of the cardiac cycle.
        - Greater than 0.8 sec and current greater than 0.5 A, cardiac arrest may occur.
        - Greater than 0.8 sec and with currents of several amps, burn and death are possible.

    - When the threshold of perception increases from 10 kHz to 100 kHz, the threshold of let go current increases from 10 mA to 100 mA.
    - Effects of waveshape – contact with voltages from phase controls usually causes effects between those of ac and dc sources.
    - Effects of capacitive discharge
        - 1µF having a 10kV capacitor charge may cause ventricular fibrillation.
        - 20 µF having a 10kV capacitor charge may be dangerous and probably cause ventricular fibrillation.
- Hazards associates with power electronic equipment
    - High voltages within the power supplies
    - Radio frequency energy – induced high voltages
    - Effects of RF fields in the vicinity of antenna and antenna transmission lines, which can introduce electrical shock and burns.
    - Ionizing hazards from magnetrons, klystrons, thyratrons, cathode ray tubes, and similar devices.
    - Non-ionizing RF radiation hazards
        - Radar equipment
        - Radio communication equipment, including broadcast transmitters
        - Satellite-earth transmitters
        - Industrial scientific and medical equipment
        - RF induction heaters and dielectric heaters
        - Industrial microwave heaters and diathermy radiators
- Specific measures for personnel safety
    - Employer responsibility –
        - Training
        - Properly installed equipment
        - Proper access to the equipment
        - Availability of correct tools
        - Proper identification and guarding of dangerous equipment
        - Provision of complete and accurate circuit diagram and other published information
        - Maintenance of clear and clean work area
        - Provision of adequate and proper illumination
    - Employee responsibility
        - Being continuously alert and aware of possible hazards
        - Using the proper tools and procedures
        - Informing the employer of manufacturing protective measures, such as faulty or inoperable enclosures and locking schemes
        - Examining all documents provided by the employer
        - Maintaining good housekeeping
        - Reporting any hazardous incident

General categories of electrical hazards

There are three general categories of electrical hazards: electrical shock, arc-flash, and arc-blast.

Electric shock: approximately 30,000 nonfatal electrical shock accidents per year. 1000 fatalities/year are due to electrocution. More than half of them while servicing energized systems of less than 600 Volts. Electrocution is the fourth leading cause of industrial fatalities, after traffic, homicide, and construction accidents.

Arc-Flash: temperature can reach 35.000˚F. 2000 people/year are admitted to burn centers due to arc-flash burn. Arc-flashes can and do kill at distances of 10 ft.

Arc-Blast: copper expands by a factor of 67.000 times when it turns from a solid to a vapor. Danger – high pressure, sound, shrapnel. High pressure can easily exceed hundreds or even thousands of pounds per square foot. Sounds can exceed 160 dB. Material and molten metal is expelled away from the arc at speeds exceeding 700 mph, fast enough for shrapnel to completely penetrate the human body.

TABLES

It is necessary to refer to numerous tables contained in the document to fully appreciate the significance of the hazards involved and necessary precautions. Following is a summary of the tables contained in NFPA 70E.

- 130.2(C) Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Shock Protection
- 130.7(C)(6)(c) Rubber Insulating Equipment, Maximum Test Intervals
- 130.7(C)(8) Standards on Protective Equipment
- 130.7(C)(9) Hazard/Risk Category Classifications and Use of Rubber Insulating Gloves and Insulated and Insulating Hand Tools
- 130.7(C)(10) Protective Clothing and Personal Protective Equipment (PPE)
- 130.7(C)(11) Protective Clothing Characteristics

Protective Clothing Characteristics:

- **Hazard/Risk Category: 0**
    - Nonmelting, flammable materials i.e., untreated cotton, wool, rayon, or silk, or blends of these materials with a fabric weight at least 4.5 oz/yd^2. Minimum Arc rating of PPE – N/A.
- **Hazard/Risk Category: 1**
    - Arc-rated FR shirt and pants or FR coverall. Minimum Arc rating of PPE – 4 cal/cm^2.
- **Hazard/Risk Category: 2**
    - Arc-rated FR shirt and pants or FR coverall. Minimum Arc rating of PPE – 8 cal/cm^2.
- **Hazard/Risk Category: 3**

    - Arc-rated FR shirt and pants or FR coverall, arc flash suit. Minimum Arc rating of PPE – 25 cal/cm^2.
- **Hazard/Risk Category: 4**
    - Arc-rated FR shirt and pants or FR coverall, arc flash suit. Minimum Arc rating of PPE – 40 cal/cm^2.

Protective Clothing and Personal Protective Equipment

- **Hazard/Risk Category: 0**
    - Long sleeve shirt, long pants, safety glasses or safety goggles (selection required), ear canal inserts hearing protection, leather gloves (as needed).
- **Hazard/Risk Category: 1**
    - Arc-rated: Long sleeve shirt, long pants, coverall, face shield or suit hood, jacket, parka or rainwear (as needed).
    - FR protective equipment – hard hat, safety glasses or safety goggles (selection required), ear canal inserts hearing protection, leather gloves, leather work shoes (as needed).
- **Hazard/Risk Category: 2**
    - Arc-rated: Long sleeve shirt, long pants, coverall, face shield or suit hood, jacket, parka or rainwear (as needed).
    - FR protective equipment – hard hat, safety glasses or safety goggles (selection required), ear canal inserts hearing protection, leather gloves, leather work shoes.
- **Hazard/Risk Category: 3**
    - Arc-rated: Long sleeve shirt, long pants, coverall, arc flash suit jacket, arc flash suit pants, arc flash suit hood, jacket, parka or rainwear (as needed).
    - FR protective equipment – hard hat, FR hard hat liner, safety glasses or safety goggles (selection required), ear canal inserts hearing protection, leather gloves, leather work shoes.
- **Hazard/Risk Category: 4**
    - Arc-rated: Long sleeve shirt, long pants, coverall, arc flash suit jacket, arc flash suit pants, arc flash suit hood, jacket, parka or rainwear (as needed).
    - FR protective equipment – hard hat, FR hard hat liner, safety glasses or safety goggles (selection required), ear canal inserts hearing protection, leather gloves, leather work shoes.

Rubber Insulating Equipment – Maximum test intervals

- Blankets – Before first use and every 12 months thereafter.
- Covers – if insulating value is suspect.
- Gloves – before first use and every 6 months thereafter.
- Line hose – if insulating value is suspect.
- Sleeves – before first use and every 12 months thereafter.

Use of rubber insulating gloves and insulated and insulating hand tools:

- Perform infrared thermography and other non-contact inspections outside the restricted approach boundary: no rubber insulating gloves and hand tools are required for the following categories
    - 240V and below, note -1; Panelboards and Switchboards rated 240V through 600V (with molded case or insulated case circuit breakers, note -1; 600V MCC, note – 2; 600V class switchgear (with power circuit breakers or fused switches), note – 4; NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV; Metal Clad Switchgear, 1kV through 38kV.
- Circuit breaker (CB) or fused switch or starter operation with covers on or enclosure doors closed: no rubber insulating gloves and hand tools are required for the following categories
    - 240V and below, note -1; Panelboards and Switchboards rated 240V through 600V (with molded case or insulated case circuit breakers, note -1; 600V MCC, note – 2; 600V class switchgear (with power circuit breakers or fused switches), note – 4; Metal Clad Switchgear, 1kV through 38kV; Arc-Resistant Switchgear Type 1 or 2 (clearing time <0.5 sec).
- CB or fused switch operation with covers off or enclosure door open: no rubber insulating gloves and hand tools are required for the following categories
    - 240V and below, note -1; 600V MCC, note – 2; 600V class switchgear (with power circuit breakers or fused switches), note – 4; Metal Clad Switchgear, 1kV through 38kV.
- CB or fused switch operation with covers off or enclosure door open: no rubber insulating hand tools are required for the following categories
    - Panelboards and Switchboards rated 240V through 600V (with molded case or insulated case circuit breakers, note -1
- CB or fused switch operation with covers off or enclosure door open: rubber insulating gloves are required for the following categories
    - Panelboards and Switchboards rated 240V through 600V (with molded case or insulated case circuit breakers, note -1;
- Work on energized electrical conductors and circuit parts, including voltage testing: rubber insulating gloves and hand tools are required for the following categories
    - 240V and below, note -1; Panelboards and Switchboards rated 240V through 600V (with molded case or insulated case circuit breakers, note -1; 600V MCC, note – 2; 600V class switchgear (with power circuit breakers or fused switches), note – 4; Other 600V class equipment, note -2; NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV; Metal Clad Switchgear, 1kV through 38kV.
- Remove/install CBs or fused switches: rubber insulating gloves and hand tools are required for the following categories
    - 240V and below, note -1.
- Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard or switchboard or MCC: rubber insulating gloves and hand tools are required for the following categories

    - 240V and below, note -1; Panelboards and Switchboards rated 240V through 600V (with molded case or insulated case circuit breakers, note -1; 600V MCC, note – 2.
- Reading a panel meter while operating a meter switch: no rubber insulating gloves and hand tools are required for the following categories
    - 600V MCC, note – 2; 600V class switchgear (with power circuit breakers or fused switches), note – 4; NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV; Metal Clad Switchgear, 1kV through 38kV.
- Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed: rubber insulating gloves and hand tools are required for the following categories
    - 600V MCC, note – 2; 600V class switchgear (with power circuit breakers or fused switches), note – 4; NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV; Metal Clad Switchgear, 1kV through 38kV; Arc-Resistant Switchgear Type 1 or 2 (clearing time <0.5 sec).
- Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed: rubber insulating gloves and hand tools are required for the following categories
    - 600V MCC, note – 2; 600V class switchgear (with power circuit breakers or fused switches), note – 4; NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV; Metal Clad Switchgear, 1kV through 38kV.
- Insertion or removal of individual starter “buckets” from MCC: rubber insulating gloves are required for the following categories
    - 600V MCC, Note - 3.
- Insertion or removal of individual starter “buckets” from MCC: no rubber insulating hand tools are required for the following categories
    - 600V MCC, Note - 3.
- Application of safety grounds, after voltage test: rubber insulating gloves are required for the following categories
    - 600V MCC, note – 2; 600V class switchgear (with power circuit breakers or fused switches), note – 4; Other 600V class equipment, note -2; NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV; Metal Clad Switchgear, 1kV through 38kV.
- Application of safety grounds, after voltage test: no rubber insulating hand tools are required for the following categories
    - 600V MCC, note – 2; 600V class switchgear (with power circuit breakers or fused switches), note – 4; Other 600V class equipment, note -2; NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV; Metal Clad Switchgear, 1kV through 38kV.
- Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts): no rubber insulating gloves and hand tools are required for the following categories
    - 240V and below, note -1; 600V MCC, Note - 3; 600V class switchgear (with power circuit breakers or fused switches), note – 4; Other 600V class equipment, note -2; NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV; Metal Clad Switchgear, 1kV through 38kV.

- Opening hinged covers (to expose bare, energized electrical conductors and circuit parts): no rubber insulating gloves and hand tools are required for the following categories
    - 240V and below, note -1; 600V MCC, Note - 3; 600V class switchgear (with power circuit breakers or fused switches), note – 4; Other 600V class equipment, note -2; NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV; Metal Clad Switchgear, 1kV through 38kV.
- Insertion or removal (racking) of CBs or starters from cubicles, doors open or closed: no rubber insulating gloves and hand tools are required for the following categories
    - 600V class switchgear (with power circuit breakers or fused switches), note – 4; NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV; Metal Clad Switchgear, 1kV through 38kV; Arc-Resistant Switchgear Type 1 or 2 (clearing time <0.5 sec).
- Revenue meters (kW-hour, at primary voltage and current) Insertion or removal: rubber insulating gloves are required for the following categories
    - Other 600V class equipment, note -2.
- Revenue meters (kW-hour, at primary voltage and current) Insertion or removal: no rubber insulating hand tools are required for the following categories
    - Other 600V class equipment, note -2.
- Cable trough or tray cover removal or installation: no rubber insulating gloves and hand tools are required for the following categories
    - Other 600V class equipment, note -2.
- Miscellaneous equipment cover removal or installation: no rubber insulating gloves and hand tools are required for the following categories
    - Other 600V class equipment, note -2.
- Insertion or removal of plug-in devices into or from busways: rubber insulating gloves are required for the following categories
    - Other 600V class equipment, note -2.
- Insertion or removal of plug-in devices into or from busways: no rubber insulating hand tools are required for the following categories
    - Other 600V class equipment, note -2.
- Contactor operation with enclosure doors open or closed: no rubber insulating gloves and hand tools are required for the following categories
    - NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV.
- Insertion or removal (racking) of starters from cubicles of arc-resistant construction, tested in accordance with IEEE C37.20.7, doors closed only: no rubber insulating gloves and hand tools are required for the following categories
    - NEMA E2 (fused contactor) Motor Starters, 2.3kV through 7.2kV.
- Opening voltage transformer or control power transformer compartments: no rubber insulating gloves and hand tools are required for the following categories
    - Metal Clad Switchgear, 1kV through 38kV.
- Insertion or removal (racking) of ground and test device with door closed: no rubber insulating gloves and hand tools are required for the following categories

    - Arc-Resistant Switchgear Type 1 or 2 (clearing time <0.5 sec.
- Insertion or removal (racking) of voltage transformers on or off the bus door closed: no rubber insulating gloves and hand tools are required for the following categories
    - Arc-Resistant Switchgear Type 1 or 2 (clearing time <0.5 sec.
- Metal-enclosed interrupter switchgear, fused or unfused - Switch operation of arc-resistant-type construction, tested in accordance with IEEE C37.20.7, doors closed only: no rubber insulating gloves and hand tools are required for the following categories
    - Other Equipment 1kV through 38kV.
- Metal-enclosed interrupter switchgear, fused or unfused - Switch operation, doors closed: no rubber insulating gloves and hand tools are required for the following categories
    - Other Equipment 1kV through 38kV.
- Metal-enclosed interrupter switchgear, fused or unfused - Work on energized electrical conductors and circuit parts, including voltage testing: rubber insulating gloves and hand tools are required for the following categories
    - Other Equipment 1kV through 38kV.
- Metal-enclosed interrupter switchgear, fused or unfused - Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts): no rubber insulating gloves and hand tools are required for the following categories
    - Other Equipment 1kV through 38kV.
- Metal-enclosed interrupter switchgear, fused or unfused - Opening hinged covers (to expose bare, energized electrical conductors and circuit parts): no rubber insulating gloves and hand tools are required for the following categories
    - Other Equipment 1kV through 38kV.
- Outdoor disconnect switch operation (hookstick operated): rubber insulating gloves and hand tools are required for the following categories
    - Other Equipment 1kV through 38kV.
- Outdoor disconnect switch operation (gang-operated, from grade): rubber insulating gloves are required for the following categories
    - Other Equipment 1kV through 38kV.
- Outdoor disconnect switch operation (gang-operated, from grade): no rubber insulating hand tools are required for the following categories
    - Other Equipment 1kV through 38kV.
- Insulated cable examination, in manhole or other confined space: rubber insulating gloves are required for the following categories
    - Other Equipment 1kV through 38kV.
- Insulated cable examination, in manhole or other confined space: no rubber insulating hand tools are required for the following categories
    - Other Equipment 1kV through 38kV.
- Insulated cable examination, in open area: rubber insulating gloves are required for the following categories
    - Other Equipment 1kV through 38kV.

- Insulated cable examination, in open area: no rubber insulating hand tools are required for the following categories
    - Other Equipment 1kV through 38kV.

Notes:

1. Maximum of 25 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time.

2. Maximum of 65 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time.

3. Maximum of 42 kA short circuit current available; maximum of 0.33 sec (20 cycle) fault clearing time.

4. Maximum of 35 kA short circuit current available; maximum of up to 0.5 sec (30 cycle) fault clearing time.