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Electrical Safety & Lighting

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The Event Safety Working Group, which authored this standard, consists of a cross section of entertainment industry professionals representing a diversity of interests. ESTA is committed to developing consensus-based standards and recommended practices in an open setting.

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Voting members:**Observer (non-voting) members:****Interest category codes:**

DE = designer	DR = Equipment dealer or rental company
EQP = Equipment provider	EVP = Event producer
EW = Event worker	G = general interest
INS = Insurance company	P = Performing Artist

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Foreword

The Event Safety Guide was first published by the Event Safety Alliance in 2014, as a guideline for discourse regarding the many aspects of special event safety. It originated in the UK Health and Safety Executive's HSG195 "The event safety guide (Second edition) A guide to health, safety and welfare at music and similar events." where its purple cover subsequently led to its reference as, simply, "The Purple Guide". In 2016 the Event Safety Working Group was established within ESTA's Technical Standards Program for the purpose of converting the Event Safety Guide chapters into formally recognized, consensus-based standards that could be universally referenced across special events organizers, producers, enforcement agencies and user-groups. This document is one of many such chapters, intended to be used in conjunction with each other, as a collection of standards, which are used to establish minimum standards for care and public safety for special events. Because event technology and requirements constantly evolve, so too will this collection of standards change and evolve to accommodate industry needs.

The execution of any design provision in this standard should be entrusted to appropriately qualified and experienced people, and any fabrication and use provision is carried out by competent, suitably experienced people and organizations.

Compliance with this Standard does not of itself confer immunity from legal obligations.

Introduction

The amount of electrical power and equipment (even on smaller events), mean that electrical risks can blend into the background. The fact that it is used in some form by every department can create complacency when working alongside electrical hazards. This complacency encourages an over reliance on the engineering controls built into the system. This may be coupled with a lack of understanding of the limits of those engineering controls to protect human beings. Factor in the speed of the production process and the risks are compounded.

The way that we utilize and distribute electricity is unique, so much so, that much of it often exists in a regulatory grey area being neither permanent nor temporary. When we factor in the broad range of environmental conditions in which we operate it is clear we need to address safer ways to manage the inherent risks of using electricity at events.

1 Scope, purpose and application

The standard shall apply to the application, assessment & documentation of safe electrical working practices during the installation, show and dismantling of event electrical systems and equipment. The event industry includes, but is not limited to, musical productions, festivals, concerts, theatre and film production, video productions, corporate events, trade shows, sporting events, broadcast production, and events related to them.

This shall include the identification and assessment of specific event electrical hazards and the potential impacts of unsafe electrical working practices.

1.1 Purpose

The purpose of this document is to describe and address selected steps necessary to minimize the potential electrical hazards created during the installation, show and dismantling of an event.

1.2 Intent

This document is intended for use by both users and enforcement officials to help establish and maintain minimum standards for care and public safety for live events.

1.3 Equivalency

The provisions of this standard are not intended to prevent the use of any materials or to prohibit any design, method of fabrication, or services not specifically prescribed by this standard, provided that any such alternative materials, design, method of fabrication, or services that complies with the intent of the provisions of this standard. The quality, strength and effectiveness of all materials, methods of work and services shall be at least equivalent to those prescribed in this standard.

This standard is not intended to replace or supersede any applicable local rules or laws, but should supplement them in an abundance of caution with the goal of improving safety.

1.4 Application

This document is one part of a larger collection of standards relating to special event safety. The requirements of the complete collection shall be considered in relation to the application of this standard, where necessary to coordinate and correlate all related requirements into the scope of the event.

1.5 Normative references

The following documents contain requirements relating to the scope of this standard. They are provided for guidance only, unless otherwise referenced specifically elsewhere within this standard. Where a specific version is not given, the version applicable to the event jurisdiction shall be used.

ANSI E1.19-2021, Recommended Practice for the Use of Class A Ground-Fault Circuit Interrupters (GFCIs) Intended for Personnel Protection in the Entertainment Industry
ANSI E1.58, Electrical Safety Standard for Portable Stage and Studio Equipment Used Outdoors
NFPA 70, National Electrical Code
NFPA 70E, Standard for Electrical Safety in the Workplace
NFPA 101, Life Safety Code
NFPA 790, Standard for Competency of Third-Party Field Evaluation Bodies
NFPA 791, Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation
IES Online Lighting Library
ANSI E1.6-2 2020 Design, Inspection and Maintenance of Electric Chain Hoists for the Entertainment industry
ANSI E1.6-4 2013 Portable Control of Fixed Speed Electric Chain Hoists
ANSI E1.36-2007 (R2017) Lamps In Trade Show Booths
ANSI E1.53-2016 Overhead Mounting of Luminaires
ANSI E1.55-2016 Standard for Makeup Mirrors
29 CFR 1910
29 CFR 1926
Americans with Disabilities Act (ADA)
ASME B30.16 Manufacturing standard for powered hoists

In the United States the NEC (National Electrical Code) contains Articles with specific requirements or exceptions that pertain to various uses, among which are:

Article 518 Assembly Occupancies
Article 520 Theatres, Audience Areas, Performance Areas and Similar Locations
Article 522 Control Systems for Permanent Amusement Attractions
Article 525 Carnivals, Circuses and Fairs and Similar Events
Article 530 Motion Picture and Television Studios and Similar Locations

However, there are numerous other articles that pertain to spaces that might not normally host an event but would be applicable if the space became an event space. Examples of these spaces are agricultural buildings, marinas and boatyards, recreational parks and vehicles, hospitals, etc. In such cases these additional articles of the NEC would become applicable and should be consulted.

2 Definitions

2.1 Affected event personnel: Event personnel at risk from a hazard due to their proximity to or potential interaction with the potential hazard.

2.2 Authority Having Jurisdiction (AHJ): An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

2.3 Bonding (electrical): The practice of intentionally electrically connecting all exposed metal items not designed to carry electricity as protection from electric shock. This provides a low impedance pathway to the Earth in the event of an electrical fault.

2.4 Cable (electrical): An assembly of one or more insulated conductors running side by side or bundled, which is used to carry electric current.

2.5 Cable ramp: Modular interlocking non-conductive devices with preformed internal cable channels, or grooves, beveled edges and flat lids (often hinged). The ramp is intended to reduce trip hazards and protect the cable within from damage. A ramp itself may create a trip hazard and may provide limited protection to the cable within.

2.6 Circuit breaker: A device designed to open and close a circuit by non-automatic means and to open the circuit automatically on a predetermined over-current without damage to itself when properly applied within its rating.

2.7 Competent person: One who is qualified and capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, volunteers, patrons, or the public; and who has authorization to take prompt corrective measures to eliminate them.

2.8 Conductors (electrical): A suitable material that has a low impedance and allows electricity to flow freely (e.g., copper or aluminum wire).

2.9 Control measure: Any action that can be taken to reduce or eliminate exposure to the hazard.

2.10 Earth(ing) (See also Ground): The process of transferring the immediate discharge of the electrical energy directly to the earth by the help of the low resistance wire is known as the electrical earthing. The electrical earthing is done by connecting the non-current carrying part of the equipment or neutral of supply system to the ground.

2.11 Event: Any assembly, public or private, indoor or outdoor, including the planning for, preparation for and dismantling of (load in, load out) the event. See also Live Event.

2.12 Event electrical safety plan: The plan for the event to effectively mitigate reasonably foreseeable risks caused by reasonably foreseeable electrical hazards at the event.

2.13 Event emergency lighting systems: Lighting systems designed to provide lighting during an emergency at the event. Systems will often have an independent or back up power supply and be visually distinct from the event lighting, to avoid any confusion.

2.14 Event emergency power systems: Power systems (e.g., generators, batteries etc.) designed to provide redundant or back-up power during an emergency, electrical failure or to power critical event emergency systems.

2.15 Event organizer: The individual, group, or organization (or their authorized representatives) that originates, organizes, promotes, and manages an event.

2.16 Event personnel: Anyone working the event, including the production team, vendors, contractors, subcontractors, laborers, volunteers, etc. See also event staff.

2.17 Event site: The physical or virtual location where the event occurs, regardless of the original use or designation of the location (includes venues).

2.18 Field certification: A procedure used at the event site by qualified event personnel to formally designate a repaired piece of event equipment safe and fit for its intended use.

2.19 Field repair: Repair to event equipment that is conducted at the event site.

2.20 Flexible Cord or Cable: Flexible Cable - A stranded wire cable manufactured with the ability to bend and coil repeatedly. Flexible cords and cables may be vulnerable to environmental damage and wear.

2.21 Frequency: Electrical frequency is the measure of the rate of change of polarity in an alternating current and is measured in the number of changes per second – also called hertz (Hz).

2.22 Ground (see also Earth): In electrical engineering, ground or earth is the reference point in an electrical circuit from which voltages are measured, a common return path for electric current, or a direct physical connection to the earth.

2.23 Grounded: A piece of equipment that intentionally has an uninterrupted low impedance path to the ground/earth to act as a return path.

2.24 Grounding: The act of mechanically connecting a piece of equipment (usually an electrical device) to the grounding path and/or inserting an electrode into the Earth to provide a path to safely dissipate fault currents, lightning, and static electricity. (Also see Earthing).

2.25 GFCI (Ground Fault Circuit Interrupter): A device that is designed to quickly shut-off electric power in the event of a ground-fault to protect people from the risk of an electric shock.

2.26 Hazard: Any source of potential damage, harm or adverse health effects on something or someone.

2.27 Health and Safety: Regulations, Laws, rules, principles, guidelines, policies and procedures that are intended to keep people safe from injury or disease at work or in public places. Sometimes referred to as Occupational Safety and Health or Life Safety.

2.28 Hot/Live: A wire that conducts electricity from the source to the point of use (e.g., motor, tool, light, etc.).

2.29 Live Event: See also “event”.

2.30 Lock Out /Tag Out (LOTO): For the purposes of this document “Lockout/Tagout” refers to specific practices and procedures to safeguard employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy.

2.31 Main power switch: The switch that disconnects all of the electrical power to a venue, area, or event’s departmental electrical distribution equipment (e.g., lighting, audio, rigging, etc.).

2.32 Metered: The process of measuring the voltage, continuity, frequency and amperage at an outlet, source and intermediate locations on the electrical path using an approved measuring device (e.g., multimeter, oscilloscope, voltmeter, amp meter, ohm meter) with UL listing, CE (or other nationally recognized testing laboratory approval).

2.33 Must: Denotes a mandatory action; equivalent to the term “shall”.

2.34 Neutral conductor: A color coded conductor (white in the U.S. blue in Europe & the UK) that acts as the return electrical pathway for an AC electrical circuit. The neutral conductor may also be referred to as a grounded conductor as it is bonded to the grounding system by means of a bonded bus bar in the main electrical panel.

2.35 Occupational Safety and Health: See also “Health and Safety”

2.36 OSHA (Occupational Safety and Health Administration): A government body in the U.S. responsible for setting minimum regulatory requirements at the federal (national) level that employers shall follow to protect the safety and health of their employees. These minimum requirements are adopted and additional requirements are implemented at the State (Regional) level.

2.37 Overcurrent protection device: A piece of equipment used in electrical systems to protect against an overcurrent due to overloads, short circuits, or ground faults.

2.38 Personal protective equipment (PPE): Personal protective equipment is the safety equipment worn by a user to prevent bodily harm. It is only to be used to mitigate the remaining risk of injury after all technical and organizational means have been implemented. (E.g., safety shoes or boots, hi visibility vests, hard hats and safety (fall arrest) harnesses).

2.39 Portable event electrical equipment: The equipment used as part of portable event electrical systems to distribute, protect, or perform work for the event (e.g. cable, electrical distribution, safety equipment, lighting, sound, video, rigging or other event equipment that is powered by electricity).

2.40 Portable event electrical systems: A system including power supply, equipment, procedures, and documentation specific to systems required for the event.

2.41 Qualified person: A person who by profession or recognized degree or certificate of professional standing, who by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve and resolve problems relating to the subject matter and work.

2.42 Risk assessment: See Event Electrical Risk Assessment

2.43 Shall: denotes a mandatory requirement.

2.44 Should: denotes a recommendation.

2.45 Tying In or Tie In: The process of connecting the cables feeding the portable event electrical equipment to the event power supply (e.g., connecting, C-Form, Feeder, Camlock etc. the original meaning of tying in was often only used to identify various methods of connecting bare end cables directly into an electrical box containing a power source).

2.46 Un-grounded (Equipment): A piece of equipment that has no uninterrupted low impedance path to ground/earth to as a return path.

2.47 Venue: See Event Site.

3 General

3.1 Every event shall be constructed, designed, equipped, maintained and operated in accordance with this standard and all national, regional and local regulation to provide a reasonable level of life safety, property protection, from actual and potential hazards created by portable electrical installations for live events.

3.2 Codes: Every portable electrical installation for the event shall comply with NFPA 101, NFPA 1, NFPA 70, National Electrical Code (NEC), NFPA 70E, CFR 1910 Subpart S, OSHA regulation, 29 CFR 1910.14 where applicable.

3.3 Causing short circuits or disabling protective devices, deliberately or due to negligence shall be in violation of this standard.

3.4 All equipment, devices & materials shall be used in accordance with the manufacturer's instructions and where required display all necessary labels and limitations.

3.5 All documentation required by applicable regulation, this standard and the AHJ shall be maintained onsite throughout the duration of the event. The documents should be easily identifiable and readily accessible.

3.6 Portable event electrical systems required for egress, used for evacuation, or for delivery of emergency management services shall have a redundant electrical that can be energized promptly if the supply used for the normal operation of the event is interrupted.

E3.6 Examples may include lighting, emergency announcements, radio communications etc. Specific requirements for emergency lighting can be found in section 20 of this standard.

3.7 All portable event electrical systems shall not create electrical hazard(s) for permanent electrical systems or people working on or near said systems.

E3.7 All reasonably practicable measures shall be taken to minimize or prevent such hazards (e.g., “back feeding” from a generator, defeating electrical protection devices, using improperly rated equipment for the intended use and electrical load, proximity to high-voltage systems, improper grounding etc.).

3.8 All portable event electrical systems shall be installed, maintained and operated by competent persons who have been authorized by the event Organizer.

E3.8 In the United States, Europe and the U.K., all distribution system equipment shall be “Acceptable” to the AHJ which usually means Listed by a Nationally Recognized Testing Laboratory for the purpose for which it is being used.

4 Planning: Evaluation

4.1 The following factors shall be evaluated when planning the installation of portable event electrical systems include:

- The location of any existing overhead power lines, buried cables and other buried utilities.
- Positioning of portable overhead or underground cables.
- The total power requirements for the event site.
- The use and location of event generators and transformers.
- The main service disconnects controlling the electrical supplies to all event departments.
- Proper system grounding and bonding.
- The location of all standard voltage event services & electrical equipment.
- The location of all non-standard voltage event services & electrical equipment for geographical location in which you are operating.
- The location of the stages.
- The location of mixer positions, delay towers, video towers, etc.
- Power supplies required for hoists, portable tools, etc.
- The electrical requirements for event emergency power, emergency lighting, and exit signs.
- High amperage areas (e.g., catering equipment, coffee pots, clothes dryers, hair dryers, etc.).
- Power supplies for first-aid points, event control room, CCTV cameras, etc.
- Power supplies for heating or air conditioning.

4.2 All reasonable foreseeable event electrical hazards, should be annotated on a plan or diagram of the event and be accessible & available for review to all affected event personnel.

5 Electrical Risk Assessment

The electrical risk assessment for the event is a subset of the overall event risk assessment. It is a key tool for mitigating risks at the event.

The following paragraphs provide more detail on key considerations for foreseeable electrical risks at an event.

5.1 Method

Any method or model should contain the following as a minimum standard:

- A physical examination of the event site or space & event production elements to determine the risks present.
- Identification of potential impacts of any risk or hazard.
- Steps should be taken to reduce the risks likelihood and severity
- The control measure should reduce the likelihood & severity to an acceptable level in the given circumstances.

- It should be written document and relevant sections shall be made freely available to all affected event personnel.
- It should be revised as necessary throughout the production process

5.2 Risk Factors

5.2.1 It is recommended that the following topic headings should be used to establish a consistent approach to assessing risks for an event. Each of the topic headings can & should contain several sub-headings (some have been included as examples).

Risk factors specific to electrical hazards at the event:

5.2.2 Location & Date

- Weather
 - Lightning
 - High winds & storms
 - Precipitation
 - Damaged power lines
- Topography
 - Terrain features & slopes
 - Water features
 - Access roads
 - Surface textures and substrates
 - Seismic activity (earthquake)
- Voltage & frequency for local area

5.2.3 Audience

- Unauthorized access to electrical equipment
- Human proximity to electrical equipment
- Unauthorized unplugging of electrical equipment
- Fluids in proximity of electrical equipment
- Physical damage to electrical equipment
- Electric Shock
- Electrocutation

5.2.4 Site and Venue

- Building(s) age, construction & wiring
- Capacity & suitability of electrical service (if present)
- Supplement power (such as generators if required)
- Cable Routes and protection
 - Impact on entry & exit requirements for the site
 - Hazards related to the distribution, location of electrical system(s)
- Water or fluid hazards
- Electrical system suitability, grounding & bonding
- Methods & locations for energizing and de-energizing electrical systems
- Evacuation routes
 - Emergency egress illumination
 - Emergency sign illumination
- Rally and assembly points

5.2.5 Major Incidents

- Electrical risks associated with potential major incident hazards associated with the event
- structure collapse
- civil unrest
 - protests

- civil disorder
- crushing
- explosion
 - fire
 - chemical release
- Special considerations
 - Overhead power lines
 - Buried utilities
 - Generator use

5.2.6 AHJ

- Identify AHJ requirements for electrical installation
- Determine applicable regulation
- National (e.g., USA-Federal)
- Regional (e.g., USA-State)
- Local (e.g., USA-Municipal)
- Documentation requirements
- Inspection & compliance verification

5.2.7 EMS

- EMS response for electrical injury
- EMS response times
- EMS response capacity & capability in relation to electrical hazard rescue
- EMS Access to patients
 - vehicular access
 - foot patrols & or bike teams

5.2.8 Event Content

- Proximity of pyrotechnic & special effects to electrical system
- Proximity of heat sources (e.g., lighting equipment) to combustible materials (e.g., scenic items & fabrics)
- Performers and artists and proximity to electrical systems
- Electrical services & systems for departments
 - Video
 - Lighting
 - Audio
 - Scenic
 - Rigging
- Liquids/moisture & proximity to electrical hazards

5.2.9 Design & Production

- Occupancy load related to cabling and production locations
- Clear egress free of obstructions caused by cable routing
- Evacuation communication (electrical redundancy)
- Power for emergency signs & lighting
- Catering, wardrobe, promotional etc. (equipment & electrical requirements)
- Site induction for electrical safety
 - Clear backstage egress free of cable routing electrical distribution obstructions
- Availability of hospitality and other social services
- Maps and plans-showing main power and cutoffs
- Required communication with local utilities

5.2.10 Staffing

- Competency & training requirements
 - Base level electrical safety training
 - Specialist qualification and training
 - Permit or licensed workers
 - Working at height (incl. live electrical systems)
 - Generators
 - Heavy equipment
- Assignments & roles
- Work hours & staffing levels

5.2.11 Electrical Injury Planning

- Electrical injury rescue plan
- Roles & responsibilities in the case of an electrical injury
- Working & rescue at height around live electrical systems

5.2.12 Logistics

- Vehicles
- Heavy equipment & proximity to electrical hazards
- Electrical hazards & working at height and fall protection
- Manual handling of electrical equipment
- Fuel storage & handling

5.2.13 Communication

- Communication breakdown
 - Avoidance of breakdown & building resilient systems
 - Mitigation and response during breakdown
- Communicating around electrical equipment in high noise environments
- Limited visibility
- Confusion
- Delayed evacuation
- Failing sensors
- Protocols for switching electrical systems on & off

5.2.14 Equipment

- Electrical safety of all electrical components within the electrical system
- Equipment Inspection
- Damaged equipment and removal from service
- Hazards associated with the field repair of equipment
- Unauthorized access and tampering
- Lock out/Tag out procedures
- Grounding, bonding, surge protection and isolation
- Phasing, nominal voltage(s) and electrical frequency
- Equipment storage
- Servicing protocols
- Documentation

5.2.15 ADA (Assistive Services) & Vulnerable attendees

- Cabling & cable Ramps
 - Trip hazards considering restricted mobility
 - ADA cable ramps vs goal posts
 - 6ft minimum separation between ADA cable ramps for ease wheelchair access
- illumination
- Cable protection sufficient for assistive devices (e.g., battery-operated wheel chairs)
- Electrical failure of ADA evacuation equipment that slows or prevents egress

- Charging for assistive devices
- Oxygen cylinders and proximity to electrical equipment

5.2.16 Special Circumstances and Risks

- Electrical failure for automated staging, scenery & rigging
 - Rapid deceleration or stopping of equipment
 - Release of stored potentially hazardous energy
 - Blackout (reduced visibility)
- Electrical isolation for electrical systems used for the detonation or operation of pyrotechnics and special effects
- Battery storage and charging

6 Event Electrical Safety Plan

Every event shall have an electrical safety plan.

6.1 Plan contents

The event plan shall conform to the following:

- The plan shall be a written plan.
- The plan shall contain reasonable documentation, including checklists and inspection reports
- Training for affected event personnel
- The relevant parts of the plan shall be communicated to all affected event personnel.
- Written copies of the plan shall be available in a designated location easily accessible to event personnel.
- Written copies shall be made available to affected parties upon request.
- The plan shall contain information on the electrical risks at the event.
- The plan shall contain procedures to mitigate the risk of electric shock to event personnel & attendees.
- The plan shall identify and mitigate the reasonable ways that event personnel can be exposed to an electric shock while working at the height.
- The plan shall specifically mitigate the additional hazards of working at height and experiencing an electric shock, (e.g. falls etc.)
- The plan shall contain information on emergency shut down procedures including the location of electrical system disconnect(s).
- A list of the competent event personnel (including their current contact information) who will perform an emergency shut down or a partial shut-down of the event electrical system if required.
- Required safety equipment (e.g., GFCI's and appropriate PPE)
- The implementation of an AEGCP when required by applicable regulation or the reasonably foreseeable hazards.

E6.1 An AEGCP (Assured Equipment Grounding Conductor Program) is a set of procedures written by the employer that requires periodic testing of all equipment-grounding conductors of cord sets and connected to receptacles to ensure no faults will occur. The goal of an AEGCP is to mitigate the risks to humans of ground faults when GFCI's are not or cannot be used. The program requires a competent person be designated to continuously enforce the AEGCP at the site. The program is meant to offer the same level of protection and mitigation as that offered using GFCI's).

6.1.2 Events shall use the electrical risk assessment as the basis for the development of the event electrical safety plan. (See section 6)

6.1.3 The event electrical safety plan shall contain details specific to risks present at the event; including how to respond promptly and safely to event personnel who are exposed to an electric shock at any stage of the event.

6.2 Roles & Responsibilities

6.2.1 The plan shall as a minimum contain timings, roles and responsibilities, protocols & communication procedures for the following situations including their potential impact on other event operations:

- Normal "powering on" of the event electrical system
- Normal "operation" of the event electrical system

- Normal “powering down” of the event electrical system
- Emergency shut down or startup of (or parts of) the portable event electrical system.
- System redundancies (if required)
- Total or Partial event electrical system failure
- Electrical short, fire or other fault(s)
- Safe Restoration of power after a total or partial power failure.

6.3 Electric Shock Response

6.3 Every event shall have measures in place to respond promptly to an electric shock in addition to calling the emergency services. A prompt response shall include:

- Designating competent event personnel trained and able to assess the risks present and implement a response plan.
- Safe disconnection of the power source prior to any response or rescue, in a manner that does not expose responding personnel to risk of an electric shock themselves or other reasonable risks.
- The administration of Basic Life Support (CPR, AED etc.) and basic first aid by designated and appropriately trained event personnel.
- The rescue of any event personnel who have experienced an electric shock at height and are unable to safely self-rescue.
- The methods and criteria for contacting of local emergency services, (e.g. radio, phone etc.)
- The assessment of all personnel that have experienced an electric shock, at the event by medical personnel with the appropriate training, experience, and proper diagnostic equipment to evaluate said personnel. This may be done at the event site, or a local medical facility equipped for such an evaluation.
- Anyone at the event who has experienced an electric shock shall be properly evaluated no matter how unaffected they appear to be prior to returning to the event.
- The steps that will be taken to investigate, identify and mitigate the hazard that caused the electric shock prior to energizing any equipment involved and returning it to service.

E6.3 Understanding the Risks

Mitigating the risks from an electric shock requires some basic understanding of electricity.

“Amps” (short for Amperes) describe the size of the electrical current. Most standard electrical outlets around the world deliver a maximum of between 10 and 20 amps. The hazards to humans are due to the amps disrupting electrical signals of the heart, electrical burns and involuntary muscle contraction. An electric shock as small as 10mA to 60mA can easily cause serious injury or death.

“Volts” (short for Voltage) describe the motive force or “pushing power”, driving the amps around a circuit and overcoming any resistance present in the system. The higher the voltage the more likely it is to overcome the resistance of materials used in the system, the air (e.g., sparks between two objects) and human skin increasing the risk of an injury due to an electrical shock.

“Ohms” describes a unit of electrical resistance. A reduction in resistance can be a significant hazard to humans. The contact resistance (touching) to electricity of dry skin can be as high as 100,000 ohms. The resistance of moist skin can be a little as 1000 ohms. The skin does not need to be “wet”, sweat, or high humidity can be enough to dramatically lower the resistance of skin and increase the risk of an electric shock.

Many jurisdictions around the world require certain electrical services to be labeled with amperage and voltage clearly displayed. Identifying and understanding the potential exposure to amps and voltage is a critical first step to mitigating the risk of electrical shock.

For more details and ideas on responding to an incident involving an electric shock please see section A1.0 of the annex. Please note your plan may require additional steps based upon the circumstances at the event. For additional information on the risk factors associated with electrical shock and working at height please see section A2.0 of the annex.

7 Documentation

7.1 Purpose

7.1.1 All event electrical documentation shall communicate information in a clear, simple, and legible fashion. Pictographs and illustrations should be used to supplement written language where possible.

7.1.2 Where abbreviations, colloquialisms, graphical elements, or technical language is used a key shall be provided with meanings translated into plain language of the user. The key shall be part of the document it refers to.

7.2 Accessibility

All event electrical documentation shall be provided to all affected event personnel that require access to it as part of their roles and responsibilities at the event.

7.3 Required information

As a minimum the following electrical information should be documented:

- The event electrical risk assessment
- The location, identification, and operation of all main electrical disconnects.
- The location, identification, and operation of any back up or emergency systems.
- The location, identification, and operation of general and emergency lighting.
- The identification, location, and operation of portable event electrical system distribution and branch circuits.
- Emergency policies and procedures, including roles and responsibilities.
- Warnings of any hazards present due to type, operation or location of electrical equipment or supply (e.g., automatic switch gear for back-up generator sets, etc.)
- Required permits

8 Materials and Equipment

8.1 Protection & Environment

8.1.1 All portable event electrical power distribution equipment shall be protected from impact, physical contact, sharp edges, bends, abrasion and other sources of damage.

8.1.2 All portable event electrical equipment shall be rated for the environment in which it will be used.

8.3.3 All portable event electrical power distribution shall be sized correctly to limit voltage drop along the entire distribution system to allowable levels, (including all applicable horizontal and vertical distances, and cable length) or additional measures to mitigate the associated hazards shall be taken.

8.2 Weather & Outdoor Use

8.2.1 All event electrical equipment that is not rated for outdoor use, shall be protected by means suitable for the environment it is being (potentially) exposed to and accordance with applicable regulation.

8.2.2 Protective methods used to comply with 8.2.1 shall not create additional hazards.

E8.2.2 Many means of protection may be used but, any means of protection shall not circumvent or prevent the normal operation of protective materials or safety devices. (e.g. GFCI, thermal cut-offs etc.).

8.3 Other standards

Any use of electrical equipment or materials, which is within the scope of ANSI/ESTA E1.58 electrical safety standard for portable stage and studio equipment used outdoors, shall comply with that standard.

8.4 Overcurrent Protection Devices

8.4.1 Overcurrent protection devices on circuits with life safety equipment shall be protected from accidental de-energization.

8.4.2 The creation of any additional hazards by the requirements in 8.8 shall be evaluated, identified, and mitigated.

8.4.3 Overcurrent protection devices shall not be bypassed, tampered with or defeated.

8.4.4 Overcurrent protection devices shall be sized to protect against reasonable hazards, higher capacity protection devices shall not be used as a method of circumventing the hazards they are designed to protect against.

8.5 Ground-Fault Circuit Interrupter (GFCI)

8.5.1 GFCIs used in portable event electrical power systems shall comply with ANSI/ESTA E1.19 “Recommended Practice for the use of Class A Ground-Fault Circuit Interrupters (GFCIs) Intended for Personnel Protection and in the Entertainment Industry” and the requirements in both 29 CFR 1910 Subpart S and 29 CFR 1926 Subpart K or the applicable national, regional, local equivalent.

E 8.5.1 It should be noted that the use of the term RCD is more common in other jurisdictions (e.g. Europe, U.K. etc.) There are several different types of RCD, RCCB, RCBO, SRCD, PRCD. High current RCD’s serve a role similar to that of circuit breakers in the USA, meaning their primary role is equipment and fire protection, not protection against electric shock.

The lettering denotes its function (e.g., RCBO “Residual Current Operated Circuit Breaker with Integrated Overcurrent Protection”). While it is possible to get RCD devices that function similar to a GFCI, it is increasingly common to find overcurrent protection and ground fault protection built into the same device, much like the GFCI circuit breaker is now required as part of NFPA 70E in certain circumstances. Another difference is that most GFCI devices will “trip” when they experience 5mA of fault current, whereas RCD’s, depending on type, “trip” at 30mA to provide shock protection while avoiding “nuisance trips”.

8.6 Testing

8.6.1 GFCI’s without an automatic or self-diagnosing test function shall be manually tested by use of the test and reset button prior to the first use of the equipment they are intended to protect each shift or day.

8.6.2 Manual GFCI’s shall be retested if any part of the equipment is subject to damage, even if the equipment once evaluated is deemed fit for service.

8.7 Batteries

8.7.1 Batteries for the event shall be transported, stored, charged, and used in accordance with all applicable regulation and the manufacturer’s instructions.

8.7.2 Different battery types and chemistries present different hazardous material hazards, fire & electrical hazards. All affected event personnel shall be trained and properly equipped to mitigate the unique hazards of the batteries they will be exposed to.

8.7.3 Batteries shall be disconnected prior to the exposure of internal working parts, components or when changing attachments, tools or being exposed to the potential hazards of external moving parts.

Where disconnection or isolation is not possible other mitigation measures shall be used to provide an equal level of protection.

8.8 Cable Ramps/Cable Protection

8.8.1 Cable ramps should not be used in pathways and other areas where people are likely to walk.

E8.8.1 Cable ramps often fail to mitigate the hazards of cable running on a walking or working surface and in many circumstances may create additional hazards. Other methods of mitigation (e.g., redesigning the cable path or running the cable overhead) provide superior mitigation. Cable ramps can increase trip hazards, risks of physical damage, or may mask said damage.

8.8.2 Cable ramps should not be used in areas where there is a risk of physical damage from things like vehicles and heavy equipment and material handling.

8.8.3 Cable ramps should not be used in areas where event personnel are exposed to risk of injury while handling materials and equipment due to the presence of the ramps themselves, especially when such equipment has to be manually manipulated over said cable ramps.

8.8.4 Cable ramps shall completely close flat and shall not be forced to close using tape or other methods that cause the lid to bow, bulge or bend.

8.8.5 Cable ramps shall be sufficiently illuminated so that are easily visible to people that shall cross them, even in “show lighting” conditions

8.8.6 Cable ramps shall be colored or marked in a way that provides visual contrast for the edges, slope, and flat surfaces of the ramp.

8.8.7 Where cable ramps are used in pathways, and they may become invisible to people moving along the pathway (due to the volume of people) signage situated above 7ft (3m) shall be used indicating the presence of the potential trip hazard (ramp).

8.8.8 Multiple runs of cable ramps shall never be used in pathways unless separated by a minimum distance between runs of 10ft (3m). The risks to and ease of use for people with limited mobility shall be evaluated and mitigated.

9 Signage, Labeling, Marking, and Traceability

9.1 Markings, labels, and other forms of communication relating to event power distribution shall be:

- Present where and when required by this standard, applicable codes and regulations.
- Clearly legible.
- Durable for the period of use of the equipment.
- In sufficient languages and forms to be easily understood by all personnel who may be reasonably expected to interact with the equipment.

9.2 Labeling Circuits & Devices

9.2.1 Overcurrent protection devices which would, if de-energized, create a life safety hazard shall be clearly identified as such.

9.2.2 Overcurrent protection devices shall be labeled to clearly identify connected branch circuits, sub panels, locations, or other relevant divisions of the portable event electrical distribution system.

9.2.3 As far as reasonably practicable, overcurrent protection devices should be labeled with specific information about the connected equipment and its use.

9.3 Compliance

9.3.1 Signs warning of the hazards that comply in terms of size, style, content and color with all applicable local, regional and national regulation should be displayed around all main electrical supplies.

9.4 Minimum Standards

9.3.1 Absent of applicable regulation signs shall at a minimum contain the following:

- The words “Danger”, “Warning” or “Caution” depending on the level and type of the potential hazard.
- Indicate the type and severity of the hazard.
- Use pictograms that clearly communicate the hazard regardless of the reader’s primary language.
- Indicate the applicable electrical characteristics of the hazard (e.g., Voltage and Amperage).

- Clearly identify the means of safe disconnection.
- Contain the words authorized access only.

10 Grounding and Bonding

10.1 The use of equipment or methods that defeat or circumvent the safety (“grounding”) wire of any device or circuit is prohibited. This is known to increase the risk of severe electric shock and, injury.

10.1.1 All portable event electrical equipment shall be properly bonded and grounded to protect everyone from a ground fault or short circuit in the electrical system.

10.1.2 All exposed metal parts of the event (scenery, staging, rigging, etc.) in proximity to the portable event electrical system shall be properly bonded to the system to provide protection against electric shock from a ground fault or short circuit.

E10.1.2 It is useful to address some basic misconceptions around grounding and bonding. “Ground” refers to the actual Earth and making a physical electrical connection to it typically with a grounding rod of a specified gauge and depth to achieve a proper connection with earth materials of different compositions and moisture content.

In electrical circuits there are three relationships to the Ground:

1. The “Hot” or “Live” wire supplies electrical current to a circuit. Voltage is the measurement of the potential of this circuit above the reference ground potential. The NEC refers to this as the “Ungrounded” conductor. Wire insulation can be any color except white or green regardless of voltage. In Euro zone, this wire insulation is typically brown. Common colors used in the USA for 3phase systems are Red, Black and Blue. In Europe & the UK the live conductors for a 3phase system are required to have Brown, Black and Grey insulation.
2. The “Neutral” wire provides a return path for current in a circuit. This is tied to a ground buss bar in the load panel. The NEC refers to this as the intentionally “Grounded” conductor. This wire must be white or natural in the US, in the Euro zone & UK it is typically blue.
3. The “Ground” wire is a 3rd wire that provides a low impedance, redundant, safety path back to the load panel where it is also tied to the ground buss bar. The NEC refers to this as the “Grounding” wire that is not supposed to be part of the normal electrical circuit path. It only comes into play when there is an unintentional contact between a “Hot” wire and a conductive surface (outer case) to which the grounding wire is attached. The result should be a short circuit that trips the overcurrent protective device and prevents damage to the equipment or wiring or injury to persons. In the US this wire must be green, in the Euro zone & the U.K. it is typically a green/yellow striped wire. (Some devices that are double insulated may not require a 3rd grounding wire.)

“Bonding” is the physical process of ensuring that the Grounding path is unbroken and at a low impedance between all conductive surfaces and the ground point.

10.2 Additional Protection Requirements

Where the portable event electrical supply cannot be protected by devices such as GFCI or then additional measures shall be taken to mitigate the electrical hazards of fire and electric shock or electrocution.

E10.2 More useful information can be about the use of GFCI devices can be found in ANSI-E1.19, Recommended Practice for the Use of Class A Ground-Fault Circuit Interrupters in the Entertainment Industry, and ANSI E1.58, Electrical Safety Standard for Portable Stage and Studio Equipment Used Outdoors (current edition).

11 Installation, De-Installation, and Operation

E11 Upstream & Downstream

The purpose of using the terms upstream and downstream in this section is as a tool for hazard mitigation as event electrical systems are often very complex.

It is a crucial safety measure to understand the extent & type of the electrical hazard upstream or downstream of your position when working on or around the system. Often, (though not always) the hazard increases as you move upstream in the system towards the main power source(s). It is critical to accurately describe which parts of the system(s) are energized and deenergized relative to the main power source(s).

11.1 Tie-in

The tie in(s) for the event shall only be performed by authorized, competent and qualified event personnel.

11.2 Metering

Prior to the tie-in the supply shall be metered for proper voltage; all safety mechanisms and contacts that will be accessed shall be inspected to ensure proper operation and that there is no visible damage.

11.3 Lock-out/Tag-out (LOTO)

During the tie-in the main power switch(es) shall be in the off position, isolated and locked-out and tagged-out using the procedures outlined in section 15 of this document and in accordance with local regulation.

11.4 Verification

11.4.1 The portable event electrical service(s) at the point of tie-in shall be metered to verify that it is in fact de-energized.

11.4.2 The electrical service(s) at the point of tie-in shall be metered to verify:

- Continuity between ground and neutral on the incoming service supply (upstream) connections.
- That there is no continuity from the ground, to the hot or neutral on the load side (downstream) connections.

11.5 System

Prior to the tie-in the event electrical system(s) should be as complete as possible and downstream overcurrent protection devices should be open (in the off position).

11.6 Order

The conductors used for the tie in shall be connected in the following order. grounded conductor first, neutral conductor second and then any of the hot or live conductors.

11.7 Live Tie-in

11.7.1 No event personnel shall perform a "live tie-in" except as a method of last resort and where de-energizing the electrical service would create a greater safety hazard.

11.7.2 A live tie-in shall only be performed by event personnel that are licensed as a qualified electrician within the jurisdiction where the live tie-in is being performed, using all the necessary safety protocols, tools and equipment.

11.8 Disconnect

11.8.1 When disconnecting the tie-in, the downstream overcurrent protection devices shall be open, the main electrical service(s) shall be in the off position, isolated and locked-out and tagged-out using the procedures outlined in section 15 of this document and in accordance with local regulation.

11.9 Metering

The electrical service(s) at the point of tie-in shall be metered (preferably) using test points (when available) to verify:

- That there is no voltage between ground and neutral on the incoming service supply (upstream) connections where there is a risk of being exposed to a live electrical service.
- That there is no voltage between the ground, hot or neutral on the load side (downstream) connections.

11.10 Order

The conductors shall be disconnected in the following order. Hot or live conductor(s) first, neutral conductor second and then the grounded conductor last.

11.11 Energization and De-Energization

11.11.1 Energization and de-energization of event electrical equipment shall be performed only by competent and authorized event personnel.

11.11.2 Energization and de-energization of event electrical equipment shall be performed in accordance with the electrical safety plan.

11.11.3 Affected event personnel shall be protected from the risks and informed prior to energization or de-energization taking place.

11.12 Methods

11.12.1 Energization of portable event electrical equipment should be performed in small, controlled increments applying electrical power to a minimal number of branches, sub-systems, or connected electrical load devices at a time.

11.12.2 Energization of event electrical equipment should be performed sequentially from “upstream” (nearer to the electrical supply, e.g. main breaker) to “downstream” (further from the electrical supply, e.g. branch circuits) rather than simultaneously.

11.12.3 The functionality and safety of such equipment and systems shall be verified by competent person periodically.

11.12.3 Connections vulnerable to damage or disconnection should be rechecked before energization of the portable event electrical system if the system has been left unattended for more than 8 hours.

11.13 Additions and Changes

11.13.1 Portable event electrical equipment shall be de-energized while any device is being installed, removed, repaired, and if internal electrical components are exposed and their covers removed.

11.13.2 Where reasonably practicable the circuit in question shall be isolated by turning it off at the breaker and lock out tag out procedures shall be used to protect event personnel downstream.

11.13.3 If the circuit is only “turned off” by means of a control channel on a lighting board or cannot be de-energized then additional steps shall be taken to mitigate the risks including appropriate training and notification of the affected event personnel.

11.14 Show Control

11.14.1 11.12 shall not apply to the energization of circuits by any kind of “show control” (e.g., console) necessary for the function of the event during focus, systems check, rehearsal or the event. Event personnel shall still be trained and informed about the hazards they may be exposed to under these circumstances.

11.14.2 Event personnel shall be protected from hazards present during the operation of the event.

E.11.14.2 It is essential that personnel can safely identify when equipment is energized or de-energized.

11.15 Unattended Equipment

Portable event power distribution equipment should be de-energized when it is left unattended for a period of 4 hours or more except where de-energization would create an unavoidable life safety hazard.

11.16 Ergonomics

11.16.1 Material handling equipment (e.g., carts, hoists, mechanical aides) shall be used whenever the size, shape or weight of the electrical equipment could pose a reasonably foreseeable risk of injury to event personnel. Additional risks created using material handling equipment shall be evaluated and mitigated.

11.16.2 Additional mitigation shall be evaluated to allow reasonable accommodation for differing physical abilities, and anatomical differences.

E11.16 It is reasonable that 25ft (7.6 m) 6 circuit Multi circuit cable could be safely hand carried, uncoiled, and coiled by a single person of average stature and fitness. There is a reasonably foreseeable high risk of injury if the same person is required to perform similar tasks with a similar cable that was 150ft (45.5 M) long.

11.16.3 The additional ergonomic risks of injury shall be evaluated and mitigated.

E11.16.1 Sources of additional ergonomic risk of injury may include but are not limited to kneeling, bending, twisting, lifting, and carrying.

11.17 PPE

The use of personal protective equipment (PPE) to mitigate identified ergonomic hazards shall be evaluated and appropriate PPE shall be provided to, and utilized by, event personnel.

11.18 Working at Height

11.18.1 Event personnel shall not work at height without other event personnel being present who have been trained to assist or respond in an emergency. A fall rescue plan shall be in place with authorized event personnel equipped and able to supply prompt rescue as necessary.

11.18.2 Event personnel working at height shall secure all tools, equipment, and personal items to prevent accidental drops.

11.18.3 Means and methods of securing tools, equipment, or personal items shall not create additional hazards (e.g., attachment of heavy objects to the body).

11.18.4 Secure areas or containers (e.g., lockers) should be provided for the storage of personal items and unnecessary items while event personnel are working at height.

11.19 Lighting

11.19.1 Striking & maintenance of arc-source lamps (gas discharge lamp) shall be performed only by competent event personnel. competent event personnel shall wear the appropriate PPE while striking and maintaining arc-source lamps.

E11.19.1 A Xenon arc lamp (short arc) is an example of an arc-source lamp commonly found in theatrical Followspots and high output digital projectors and in legacy analogue (film projectors). The bright white light that closely facsimiles sunlight or daylight is produced by passing electricity (a spark or arc) through high pressure xenon gas.

The main hazards of Xenon arc lamps are:

- The production of significant amounts of UV radiation
- The Source will produce Ozone unless specially coated (sold as Ozone free)
- The Xenon gas is contained at high pressures (up to 30 atmospheres (441psi))
- Mercury metal from Xenon-Mercury Lamps
- Potential exposures to high voltages

The power supply for a Xenon arc lamp “starts” the lamp by means of a high voltage pulse 20-50kv. They then operate at a low voltage high-current (DC). As an example, a 450W lamp operates normally at 18 volts and 25 amps once started.

11.19.2 Arc-Lamp source equipment (e.g., lamp, power supply, fire control measures etc.) shall be inspected prior to powering on and striking.

11.19.3 The area directly in front of the aperture of an arc-source lamp shall be cleared of all personnel to a distance of 20 feet (6 meters) before striking and shall remain clear for 300 seconds (5 minutes) after striking.

11.19.4 Striking of arc-source lamps shall be announced and communicated to all affected event personnel.

11.32 Arc-source lamps shall be replaced by competent event personnel, wearing the appropriate PPE to protect against the potential hazards listed in E11.29

11.19.5 Lamps containing any Mercury metals or compounds shall be disposed of in accordance with local safety and environmental regulation. The lamps shall only be handled by competent event personnel, wearing the proper PPE to protect against potential exposure.

11.19.6 Fire prevention and control measures shall be implemented to protect against the increased fire risks created using arc-source lamps.

11.20 Equipment Inspection and Testing

11.20.1 Inspection and testing shall verify that all event electrical equipment and systems meet all applicable safety requirements & regulations

11.20.2 Visual inspection should be continuously undertaken whenever event personnel interact with event electrical equipment.

11.20.3 Upon completion of the electrical installation and prior to use for the event, event power system(s) shall be inspected and tested according to applicable regulations.

11.20.4 Periodic inspections should be undertaken for electrical systems in place for longer than 7 days or when changes in the system or environmental conditions would increase the likelihood of a hazard.

11.20.5 All multiphase event electrical services shall be metered under load (normal event operating conditions) to verify the load applied to the phases is balanced.

11.20.6 A written record of compliance and testing shall be kept by the event organizer or their designated representatives.

12 Removal from Service and Repair

12.1 Removal from service

12.1.1 Event electrical equipment awaiting repair, removal from service, or disposal shall be obviously tagged or marked to prevent accidental use, return to service, or return to inventory.

12.1.2 Tags or markings shall be present in sufficient forms and languages to be understood by all event personnel who may be reasonably expected to interact with the equipment.

12.1.3 Tags or markings should include the name of the person applying the tag or marking, when the tag or marking was applied, and the reason the tag or marking was applied.

12.1.4 Event electrical equipment which is to be removed from service shall be de-energized before de-installation.

12.1.5 When Event electrical equipment is de-energized for de-installation the Lock out/Tag out requirements of section 15 shall be followed.

12.2 Repair

12.2.1 Repair of event electrical equipment shall only be performed by qualified and authorized personnel.

12.2.2 Repair of event electrical equipment shall be performed using only parts and materials which are suitably rated and approved for the environment and application in which they will be used.

12.2.3 Repair of event electrical equipment should be performed using only parts and materials approved by the original equipment manufacturer (OEM).

12.3 Field Repair

12.3.1 Field repair is an inherently high-risk activity. Field repair of electrical equipment should not be undertaken if replacement, substitution, or non-field repair is possible.

12.3.2 Field repair of electrical equipment shall only be performed by qualified and authorized personnel.

12.3.4 Field repaired equipment shall be inspected and tested as necessary to assure safe operation of the equipment before being returned to service.

12.3.5 Field repaired equipment shall be re-inspected and re-tested by qualified personnel for proper function before being returned to regular service or inventory.

12.4 Inspection & Testing

Repaired equipment shall be fully and thoroughly inspected and tested to verify it performs to the specifications of its original listing before being returned to service or inventory.

12.5 Repair Records

12.5.1 A record should be created for any repair action undertaken on event electrical equipment.

12.5.2 Repair records should include, at minimum, the following information where applicable: manufacturer, model, serial number, date, identity of person(s) performing the repair, testing, and notes on the required repairs and procedures used.

12.5.3 Repair records should be kept and made accessible to affected personnel for the lifetime of the equipment.

13 Personal Protective Equipment (PPE)

13.1 General

13.1.1 PPE shall be considered a measure of last resort when addressing hazards. Hazards which can reasonably be mitigated by elimination, substitution, engineering controls, or administrative controls shall be used instead of or in conjunction with those methods.

13.1.2 Provision of PPE, and enforcement of its use, is the responsibility of the event organizer or their representative.

13.1.3 The use of PPE should be actively verified and enforced by designated personnel at the event site.

13.2 Clothing

13.2.1 Event personnel working with event electrical equipment should wear clothing that complies with US 29 CFR 1910.269 (l)(8)(iii) or its applicable equivalent.

E13.2.1 In the event of arc flash, arc blast, or fire synthetic materials may melt quickly and cause additional injury. In the US 29 CFR 1910.269(l)(8)(iii) requires that "The employer shall ensure that each employee who is exposed to hazards from flames or electric arcs does not wear clothing that could melt onto his or her skin or that could ignite and continue to burn when exposed to flames or the heat energy estimated under paragraph (l)(8)(ii) of this section."

13.2.3 Event personnel working with electrical equipment should wear flame retardant (FR) clothing.

13.2.4 Flame retardant (FR) clothing shall be appropriately rated to meet or exceed the calculated potential heat energy exposure.

13.3 Footwear

Event personnel working with electrical equipment should wear electrical hazard (EH) rated safety footwear that comply with ANSI Z41-1 and 29 CFR 1910.136.

13.4 Gloves

13.4.1 Event personnel should at a minimum wear dry leather gloves when working with live electrical equipment.

E13.4.1 Leather gloves help to increase electrical resistance and reduce the possibility and severity of electric shock.

13.4.2 Event personnel working on, or in proximity to, energized and exposed electrical components or conductors shall wear class 00 or better electrical insulating gloves as defined in 29 CFR 1910.137 & 29 CFR 1926.97 for potential exposures of less than 500v AC or the national, regional, or local equivalent.

13.4.3 Use, inspection, and testing of electrical insulating gloves shall comply with the requirements of 29 CFR 1910.137/29 CFR 1926.97 or a national, regional or local equivalent.

14 Tools

14.1 Insulated Tools

Tools used on, or in proximity to, energized and exposed electrical components or conductors shall be insulated sufficiently for the potential electrical exposure.

E14.1 It is recommended that properly electrically insulated tools be used on all electrical equipment whether live or not, to encourage safer working practices.

14.2 Metering & Testing Equipment

14.2.1 Electrical metering and testing equipment used on event electrical equipment shall be be rated for the equipment they will be metering and testing (e.g., Category III or Category IV).

14.2.2 Electrical metering and testing equipment used on generators or connections to utility power shall for the generators and services they will be metering and testing (e.g., category IV).

14.2.3 Electrical metering and testing equipment used on event electrical equipment shall be of the true root mean square type (also known as true-RMS or TRMS).

E14.2.3 Electrical metering and testing equipment which is not true root mean square type (e.g., average responding meters) will display inaccurate readings for systems with non-linear loads. Non-linear loads are common in event electrical systems.

15 Lock out Tag out

E15 Underestimated Risks

It is often easy at live events to underestimate the risks present due to potentially hazardous energy sources. Due to the control measures being present in most equipment, injury due to the discharge of potentially hazardous energy may seem rare. It should be noted that many engineering controls are designed for permanent installations, whereas portable event power is more accessible, subject to more physical abuse and often dynamic in terms of it set up and use.

Unfortunately, accidents and injuries are often under reported. Many event personnel do not currently have the training to understand the level of risk they are being exposed to.

In event electrical systems, (even on smaller events) the main supply for the lighting alone can easily be 200amp or 400amp 3 phase. At 200amp 3 phase that is more electricity present than used to power an entire average sized home.

15.1 Evaluation

The following list of sources of potentially hazardous energy should be evaluated at the event to determine when and how Lock out/Tag out procedures should be used to protect event personnel. Other sources of potentially hazardous energy may be present.

- Automation
- Electrical services
- Acoustic energy
- Main or "Company Switches"
- Power drops or tie ins
- Distribution panels
- Generators
- Rigging control
- Rigging hoists or motors
- Arbor or counterweight rigging systems
- Winches
- Over-head rigging
- SFX (Special Effects) controls, materials, equipment and firing systems
- Fuel storage, flammable liquids & dispensing systems
- Lithium-Ion battery charging & battery powered effects
- Compressed gases
- Compressed fluid
- Heat sources (e.g., steamers, irons, soldering iron, ovens, space heaters etc.)

15.2 Compliance

The event & event organizer shall comply with all applicable national, regional and local LOTO regulations. (e.g., in the USA 29 CFR 1910.147, Subpart J, and 29 CFR 1926.417, Subpart K).

E15.2 The standards for LOTO detailed below are intended to exceed the minimum requirements for LOTO under OSHA standards and fill any gaps due to the unique nature of electrical work in the event and entertainment industry. Many systems can have more than one source of potentially hazardous energy, each source should be included in the LOTO plan. (e.g., a lift may have an electrical hazard and a hydraulic hazard).

They specifically address potentially hazardous energy sources present in the event environment during assembly, show and disassembly and how to mitigate them using LOTO procedures.

15.3 Assessment

The following minimum criteria shall be used to assess the need for controlling potential hazardous energy at the event:

- Are there any energy sources where the unexpected release could cause a potential hazard to the event personnel and attendees present?
- What are the type(s) of potentially hazardous energy?
- Is it possible to energize a device or system without event personnel being aware of its' change to an energized state?
- Are energy sources placed in locations where the control of access is difficult to achieve?
- Can unauthorized people access and activate the potential sources of hazardous energy?

15.4 Controlling Hazards

15.4.1 If there is a source of potentially hazardous energy at the event, then measures to control and mitigate the potential hazard(s) shall be taken.

15.4.2 If the potential source of hazardous energy can be feasibly eliminated or substituted it should be. If it cannot be eliminated or substituted, then access to the potential hazards shall be controlled, and they shall be isolated.

15.5 Locking Devices & Tags

15.5.1 In addition, the potentially hazardous energy source shall be mechanically isolated with a locking device that prevents operation by any unauthorized persons. (e.g., Locked room, padlock with key or combination, locked cover etc.)

15.5.2 To comply with this standard any control measure shall use one or more of the following methods to isolate the energy source.

Each potential hazardous energy source shall have an appropriate sufficiently rated control to change the source of potentially hazardous energy between a (safe) de-energized state and an energized state and isolate the potentially hazardous energy, (e.g., using a manually operated (valve), electronic (solid state), electro-mechanical (RCD) or mechanical (circuit breaker), etc.)

15.5.3 The locking device shall be able to prevent unauthorized use of the device by people without tools. (e.g., 150kg (300lbs) of force).

15.5.4 Each potentially hazardous source of energy shall be tagged out of service when not energized or not operating for normal event operations.

15.5.5 In circumstances where the unauthorized de-energization of an energy source will cause a hazard, then that energy source shall be locked and or tagged.

15.5.6 The lock or tag shall not interfere with the safe operation of any other safety devices, (e.g. overload devices, emergency stops etc.).

15.6 Identification

15.6.1 The potential hazards from unauthorized de-energization shall be clearly identified communicated and appropriate training given.

15.6.2 Tags shall be easily visible and use contrasting colors. The tags shall clearly identify what the device controls and the type of energy hazard. The tag shall not be easily removed and shall resist at least 25kg (50lbs) of force. The tag shall also identify the person who tagged the device and their contact information.

15.7 Personnel, Roles & Responsibilities

15.7.1 Only competent event personnel shall operate the control to energize or de-energize a potential hazardous energy source.

15.7.2 Only a competent event personnel trained in LOTO procedures shall add, or remove tags or locking devices.

15.7.3 Authorized LOTO event personnel shall be clearly identified, and their roles and responsibilities defined.

15.7.4 A Competent and qualified LOTO supervisor shall be designated.

15.7.5 Authorized LOTO event personnel shall inform the LOTO supervisor prior to the removal of any tag or lock out device and both shall verify it is safe to remove the tag or locking device and that affected event personnel are informed and clear of the hazard(s).

15.7.6 In group LOTO where multiple tags and/or locking devices have been applied to one energy source only the LOTO supervisor shall be authorized to remove the final tag and locking device and energize the affected system(s).

15.7.6 Prior to removal the LOTO the supervisor shall verify that it is safe to remove the tag and/or locking device and that all affected personnel are informed and clear of the hazard(s).

15.7.7 Authorized LOTO event personnel shall verify that any potential hazardous energy sources they are responsible for locking and/or tagging-out have been safely isolated, tagged and/or locked out and that any potentially hazardous energy has been safely dissipated and cannot re-accumulate.

15.8 Duty to Inform

In every circumstance affected event personnel shall be informed every time the state of a potentially hazardous source of energy is changed, except under the following circumstances.

- The change is part of the normal operations of the event and the hazards caused by the changes are understood by all affected event personnel
- (e.g., A lighting Cue, Rigging Cue, Show, rehearsal etc.)
- The source and any associated control devices are specifically engineered to mitigate or eliminate the hazard and be safely operated by un-trained persons (e.g., A light switch) if that device is installed and used in compliance with all applicable local regulation.
- Where authorized event personnel have been trained in safe work operations for the specific potentially hazardous energy they are being exposed to.

E15.8 However, where practicable informing affected event personnel during the circumstances detailed in 15.19 is considered reasonable practice.

15.9 Removal

15.9.1 Each locking device and tag shall be removed by the person that applied it. In the event of a change of personnel, a new tag and locking device shall be substituted with both authorized and qualified event personnel being present.

15.9.2 When the person who originally installed the tag and locking device is no longer present at the event site then every reasonable effort shall be made to contact them and verify the purpose of the tag and locking device. Only after consulting the original person and in extreme circumstances may the original tag and locking device be removed by another authorized, competent and qualified person.

15.9.3 Before removal and changing the energized state a new risk assessment shall be conducted. All affected event personnel at risk shall be cleared from the area of the hazard and informed of the change prior to any change taking place.

15.9.4 If the original event personnel cannot be contacted then the tag and locking device shall only be removed as a measure of last resort. If removed they shall only be removed by another authorized, competent and qualified person.

15.9.5 Prior to removal and a change in energy state the original risk assessment shall be consulted, and a new risk assessment conducted.

15.9.6 All affected event personnel & attendees at risk shall be cleared from the area of hazard and informed of the change prior to any change taking place.

16 Cabling & Electrical Distribution

16.1 Cables

16.1.1 All cables selected for the event shall be well maintained, rated and suitable for their purpose and application in portable event power systems and comply with all applicable codes & regulations.

16.1.2 Portable overhead cables, regardless of type, purpose, or voltage shall be installed according to all applicable codes & regulation.

16.2 Flexible Cord and Cable

16.2.1 Flexible cord and cable shall be used in accordance with applicable standards, codes, and regulations.

16.2.2 Where no stricter requirement exists, flexible cord and cable shall be used in accordance with ANSI/NFPA 70 National Electrical Code

16.2.3 Welding cable & connectors shall not be used for electrical distribution.

16.2.4 “Trico” style connectors shall not be used for portable event electrical distribution or “tie in”.

E16.2.4 Below is a picture of a Trico connector they are designed to “clamp” onto electrical terminals and are subject to slippage, failure and often require that the live parts in the cabinet remain exposed.



16.2.5 Flexible cords shall not be placed in locations where they can easily be subject to damage (e.g., through doorways etc.).

16.3 Overhead Support & Clearances

16.3.1 The supporting structure for portable overhead cables shall be, bonded & grounded, sufficient for the anticipated loads, types of cable and prevailing conditions at the event site.

16.3.2 The minimum height above the ground (final grade) shall be evaluated for proper clearance (including a sufficient safety factor to address any sag) from vehicles, structures, event personnel, attendees and any other obstacles or objects that could pose a risk.

16.4 Signage

Advisory notices and signage should be clearly displayed and effectively warn of the location of the overhead cables and information on the hazards present.

16.5 Barriers

Wherever possible fences or barriers should be used to separate roadways, attendees and pedestrian pathways from overhead cables running parallel to the roadway to prevent inadvertent contact.

16.6 Burial

16.6.1 All reasonable efforts should be made to avoid direct burial of any portable event power cable not specifically rated for direct burial, using elimination, substitution, or engineering control measures to mitigate the hazards that would require the burial of Portable Event Power cable

16.6.2 If it is necessary to bury portable cables, the event shall follow all applicable codes & regulations. Where such codes & regulations do not apply. At a minimum, steps shall be taken to avoid:

- Crushing by vehicles
- Machinery, equipment, or tools
- Other mechanical damage
- Damage to buried cables, gas lines, water lines or any other buried utilities by the driving of grounding-rods, trenching, or other activity.
- Where the cable or connectors create a hazard due to not being suitable for burial or the prevailing ground conditions.

- Where cables or connectors are potentially exposed to moisture, and they are not rated for that exposure or protected against that exposure. (N.B. Wrapping connectors in plastic bags and/or cling wrap is dangerous as it does not protect the connector from moisture and adds the additional hazard of heat build-up.)
- Creating any safety hazard due to an electrical fault.

16.7 Cable Protection

Portable event power cables run on the surface shall be protected against damages for things such as, environmental conditions, sharp edges or crushing by heavy loads. Devices such as cable ramps should be avoided if possible as they provide limited means of protection and can create tripping hazards. If cable ramps are used, they shall be conspicuously marked to mitigate the tripping hazards they create and avoided when transporting heavy loads or sharp-edged objects.

16.8 Cable Routes

16.8.1 The use of “ADA” (Disabled Access) compliant cable ramps shall be used in any areas where foot traffic will cross cable runs,(except emergency exit routes where no obstructions of any kind are allowed).

16.8.2 Where no alternative exists and cannot be avoided, Cable Ramps designed for use with wheelchairs and people with limited mobility shall be used in any area where foot traffic is reasonably foreseeable.

16.8.3 Cables crossing pathways on the floor should be a method of last resort, there are many other safer solutions such as flown truss, goal posts or re-routing the cable so that it no longer crosses a pathway.

E16.8 It should be noted that OSHA 1910.37 (a)(3) states “Exit routes shall be free and unobstructed. No materials or equipment may be placed, either permanently or temporarily, within the exit route” and this should be factored into your emergency egress plan.

16.9 Switching

16.9.1 All electrical distribution for the event departments (e.g., audio, lighting, rigging etc.) shall be controlled by switches, such that if power is disconnected for one department it will not disconnect any other department.

16.9.2 Authorized Access to these switches shall be restricted by engineering or administrative controls to the event personnel designated as authorized to operate the switch for their own department and the switch shall be easily accessible to them.

16.9.3 Switches and/or panels should be clearly labeled as to their specific use and authorized event personnel should be familiar with the physical location, panels, disconnects and labeling.

16.9.4 Portable event power distribution for departments should be of sufficient capacity to meet the identified needs and each system should be properly electrically protected for its assigned capacity.

16.9.5 Any switches or distribution powering any systems crucial to safety shall be clearly labeled and shall require additional authorization prior to shut down.

16.9.6 All event personnel should be clearly informed of their roles and responsibilities related event power systems and what tasks or actions they are or are not authorized to perform.

16.10 Emergencies

In the event of accidental energization of an event structure (e.g., due to a fault or a structural collapse), procedures shall be in place to minimize the hazards caused by the potential energization of any structure due to damaged cables or equipment.

Examples of procedures may include but are not limited to:

- Emergency shut down
- Precautionary shut down
- Partial Shut down
- Safely assessing continued operations

- Incapacitated authorized/competent persons
- Crowd management
- Stage activities
- Medical care/response
- Audio/Video systems
- Safety systems
- Critical event operations
- Communications
- Emergency Action Planning (e.g., adverse weather, security, fire etc.)

16.11 Emergency Response

The event shall have, competent event personnel present during potential emergencies to assess electrical hazards and take preventative or corrective action when necessary. This should include pre-planned procedures for the event's related power systems during reasonably foreseeable emergencies.

E16.11 An emergency action plan (EAP) is a written document, required by regulation (e.g. OSHA in the USA, HSA in Canada), for an event, which describes the actions event organizers or their representatives should take to ensure the safety of everyone onsite during emergency situations.

16.12 Environmental Conditions

16.12.1 All portable event power distribution cable that is not protected by a permanent method of enclosure shall have an external sheathing that has an abrasion resistance that is rated for hard, extra hard usage or the local equivalent designation. The abrasion resistance required will depend on the location and intended use of the cable and any potential damage it might reasonably be anticipated.

16.12.2 All portable event portable power distribution cable shall have a temperature rating sufficient for a combination of the amperage draw, and prevailing environmental conditions.

16.12.3 Where the conditions (e.g., heat/ambient temperature, spacing of conductors etc.) combined with the electrical load could exceed the temperature rating of the cable, sufficient ventilation, a cable with a higher temperature rating or electrical capacity shall be used.

16.12.4 Where this is not possible the circuit shall be derated, by reducing the working ampacity of the cable, so that the combination of heat generated by the movement of electricity and the environmental heat do not exceed the maximum safe operating temperature of the electrical insulation protecting the cable.

E16.12.4 When black event portable power cable is used outdoors in direct sunlight it can add a significant additional heat load to the insulation on the cable. When the ambient temperature is above 90F (32 C) It may be necessary to reduce the power draw on that cable by as much as 50%.

16.13 Confined Spaces

16.13.1 Routing of portable event power cable through confined spaces, chases, mouse holes or other restrictions shall be done in compliance with applicable codes, standards, and regulations.

16.13.2 When running portable event power cable through confined spaces, chases, mouse holes or other restrictions, the number of conductors, spacing, levels of ventilation and their electrical load shall be evaluated to ensure that the working temperature rating for individual conductors is never exceeded.

17 Utility Safety

Working around overhead power lines & other utilities carries significant risk of life changing injury or death and shall be considered a high hazard. The event organizer or their representative shall evaluate reasonably foreseeable hazards from utilities and use signage, training and other control measure to mitigate any of the utility hazards present.

17.1 Overhead

17.1.1 Overhead or underground electrical supply cables belonging to an electrical supply company may cross the site, or its access roads. If so, precautions shall be taken to avoid danger from these cables.

17.1.2 The event organizer shall ensure minimum separation distances between people, structures, equipment, and power lines are maintained.

E17.1.2 Specific training is required by many national & local AHJ's (e.g., OSHA) for working with cranes, scaffolding & MEWP's (Mobile Elevated Work Platforms (e.g. Boom & Scissor lifts etc.) in proximity to overhead power lines 29 CFR 1926.1408

17.2 Buried Utilities

The event organizer or their representative should locate & mark all buried utility and power lines prior to any digging or activity where the grade is penetrated on any event site where their presence or proximity to the work would present a reasonably foreseeable hazard.

E17.2 Examples of places where you can find information on buried utility and power lines are 811 in the USA, 811 in Canada, <https://www.linesearchbeforeudig.co.uk>, <https://www.ukpowernetworks.co.uk/>, hse.gov.uk in the UK, many other jurisdictions will offer similar access to this type of information.

18 Generators

18.1 Access

The event generator its associated electrical distribution, and its fuel source shall be protected from unauthorized access and may require fencing, warning signs and other methods to restrict access.

18.2 Exhaust

18.2.1 Event generators should be located to reduce the risk of exposure of event personnel & attendees from exhaust fumes and noise due to their operation. Local wind direction should be evaluated. It may be necessary to increase the stack (exhaust) height where proximity to event personnel & attendees cannot be avoided.

18.2.2 The location of food & beverage provision, event control and rest areas should be specifically evaluated to mitigate any hazards caused by exhaust fumes, fire hazards or noise.

18.3 Selection

18.3.1 Event generators should be appropriate for their intended use at the event and the events and entertainment industry.

E18.3.1 Examples of generator selection considerations:

- Size for load (including power factor),
- Ambient temperature,
- Fuel capacity,
- Size for transport and location,
- Suitability for emergency and life safety power (if applicable),
- Methods of starting & stopping (e.g., auto start, fail over, emergency shutdown etc.)
- Computer controlled synchronization for paralleled generators,
- Remote monitoring capability
- Noise (sound attenuation),
- Air quality (regional restrictions)
- Fuel storage regulations
- Type of fuel and fuel availability
- Climate
- Availability of dedicated testing points/ports,
- Available connections (e.g., camlock).

18.3.2 Selection of event generators shall be performed only by qualified event personnel.

18.4 Fire Risk

18.4.1 The increased risk of fire from the use of event generators shall be evaluated and mitigated including but not limited to, evacuation planning, evacuation routes, fire protection measures & signage.

E18.4.1 It is also important to evaluate the additional fire risks & other hazards from small event generators such as those used by food trucks and catering tents, and these should be factored into your electrical risk assessment.

18.4.2 The location, type, use and response for using fire extinguishers associated with generator operations shall be evaluated by a competent person and be included in the event electrical safety plan.

18.5 Bonding & Grounding

18.5.1 All event generator installation shall follow the requirements for grounding and bonding of portable generators in NFPA 70E or equivalent acceptable to the AHJ. Additional evaluation and mitigation shall be undertaken to protect event electrical systems that contain both generator & utility power sources and any affected event personnel and attendees.

18.5.2 AHJ approval: of any deviation from the applicable regulation shall be documented as part of the event electrical safety plan.

18.6 Location Evaluation

The location and placement of any generator for the event shall be evaluated by a competent person for suitability and to mitigate potential hazards.

E18.6 Evaluation examples may include:

- Proximity to water
- Proximity to traffic
- Proximity to attendees and event personnel
- Levelling
- Safe exhausting
- Overhead electrical hazards
- Underground hazards
- Load bearing capacity of the surface
- The weight of the generator
- Fueling operations and hazardous chemicals safety
- Safe fueling access
- Containment requirements for environmental protection
- Spill response
- Noise requirements and allowable hours of operation
- Fire prevention & control
- Fire suppression equipment
- Proximity of flammable vegetation & waste
- Heat

18.7 Prohibited Use

Event generators shall never be used indoors or in any other enclosed or partially enclosed space.

18.8 Unintended Movement

18.8.1 Event generators shall be secured against accidental movement.

18.8.2 Event generators on wheels, trailers, or vehicles, shall have the wheels chocked and have the brakes engaged whenever the generator is not being transported.

18.9 Start Up

18.9.1 All event generators shall be inspected according to the manufacturer's instructions prior to each use.

E18.9.1 The purpose of the walk around inspection is to identify damage or possible hazards (e.g. leaks, physical damage, missing equipment etc.).

18.9.2 Circuit breakers and disconnects connecting the generator to other electrical equipment shall be open (i.e., in the off position) during generator start up and adjustment of voltage or frequency.

18.9.3 Voltage and frequency (e.g., 50 Hz, 60 Hz) shall be measured after the event generator has been started and allowed to come up to normal operating speed and all affected personnel informed before the energization of connected electrical equipment.

18.9.4 Appropriate PPE, equipment and safe work practices shall be used while metering operating event generators.

18.9.5 Energization of generator connected electrical equipment shall comply with this standard.

18.10 Operation

18.10.1 Event generators shall only be operated by competent event personnel.

18.10.2 All event personnel should be informed of generator emergency shutdown procedures prior to operation.

18.10.3 The voltage configuration of event generators with selectable voltage configuration (e.g., 120/208v, 120/240v, 277/480v) shall not be changed while the generator is operating.

18.11 Carbon Monoxide

Event personnel & attendees shall be protected from potential carbon monoxide poisoning caused by the operation event generators.

E18.11 There are many ways that the risk from carbon monoxide poisoning can be mitigated. Methods may include:

- The location of the generator
- The height of the exhaust stack
- Atmospheric monitoring

18.12 Grid Tied Systems

Event generators with connections to conductors that are also fed by power from the local electric grid/supply or connected to conductors fed by other generators, shall follow all local regulation with to prevent “back feeding” etc. and electrically isolate said generators.

E18.12 In many jurisdictions transfer switches are required for generators that supply electrical power to equipment in the event of a grid power failure. These switches isolate the system from the grid so that power is not being “back fed” onto the grid putting utility workers who may be working on the grid at potential risk. In an event electrical system fed by multiple generators this risk of “back feeding” is also present to measure including the use of equipment such as devices that electrically isolate a generator are necessary to mitigate the risk to event personnel.

18.13 Shut Down

18.13.1 Except for emergency shut down circuit breakers and disconnects connecting the generator to other electrical equipment shall be open (i.e., in the off position) and all affected event personnel informed prior to event generator shut down.

18.13.2 Attended event generators shall be allowed to cool to safe temperatures before being left unattended. The event organizer shall take reasonable measures to prevent unauthorized access to unattended event generators.

18.14 Fueling

18.14.1 The event organizer shall evaluate their location and accessibility for safe refueling. Allow for proper fuel storage (as required by the AHJ and/or NFPA 30 (flammable and combustible liquids) where no other required minimums apply).

18.14.2 Any event personnel involved in the use or handling of fuels shall be trained for the hazards they may be exposed to and the methods of mitigating and protecting against those hazards including appropriate clothing and PPE.

18.14.3 Before fueling, fuel type (e.g., gasoline, diesel, propane, natural gas, etc.) shall be confirmed appropriate for the event generator to be fueled.

18.14.4 Event generators shall be off and cool before fueling.

18.14.5 Before fueling, the area around the event generator and fueling equipment should be cleared of unauthorized event personnel.

18.14.6 Fueling of event generators should only be undertaken by competent event personnel.

18.14.7 Appropriate spill containment and cleanup equipment and measures shall be in place when event generators are being fueled.

18.14.8 Contaminated spill containment and cleanup equipment shall be properly stored. Used equipment or materials shall be properly cleaned or disposed of.

18.14.9 Fueling equipment shall not be left unattended while generators are being fueled.

18.14.10 After fueling, a visual walk around inspection of the area and equipment shall be performed to identify spills, leaks, and other hazards or damage.

18.15 Fuel Storage

Fuel shall be stored in accordance with 29 CFR 1926.152 or all applicable national, regional and local regulation.

E18.15 Examples of improper storage include but are not limited to:

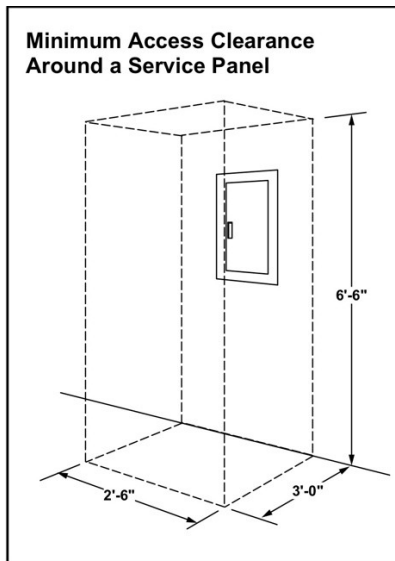
- Storing fuel in improper containers.
- Storing too much fuel in a location.
- Storing fuel in poorly ventilated spaces.
- Storing fuel along exit and egress paths.
- Storing fuel with other incompatible and/or flammable chemicals.
- Storing fuel near ignition sources.
- Lack of easily accessible fire-fighting equipment appropriate for the type of fuel used.

19 Access to Electrical Equipment

19.1 Clearances

19.1.1 Appropriate minimum clear working space shall be established and maintained around electrical equipment to allow access for operation, maintenance, and emergency access. Where no other more stringent local, regional, or national regulation applies the distance around main/primary electrical distribution equipment shall be no less than 3'-3" (1m) from the faces or sides of said equipment. The clearance of 3'3" (1m) shall be maintained vertically from the floor to a minimum of 6'6" (2m) above the floor or 3'3" (1m) above the equipment (whichever is greater).

19.1.2 Clearances should be evaluated for portable event electrical distribution equipment that is larger than 30" (77cm) wide or where the risks from the inductive load (e.g., transformers, motors, generators) requires additional space around the equipment.



19.1.3 Other equipment should also be evaluated for minimum safe clearances, including but is not limited to:

- Control switches and equipment.
- Amplification equipment.
- Special effects equipment.
- Follow spots.
- Dimmers.
- Ballasts and high-voltage discharge lighting.
- Incandescent light sources.
- Overhead power lines.
- Generators and fuel storage.

19.2 Access

19.2.1 event electrical equipment shall not prevent or impede access to the event site by emergency vehicles or services.

19.2.2 The event electrical service, supply and associated electrical distribution equipment shall be protected from unauthorized access (including unauthorized event personnel and attendees) and may require fencing, warning signs and/ or other methods to restrict access.

19.2.3 Event personnel responsible for the emergency energization or de-energization of electrical equipment shall have unimpeded access to said equipment. This includes door keys, key cards, electrical panel keys, access credentials, and other means of access as may be necessary. Note: For emergency purposes, more than one person should have the means & authorization for emergency access.

19.2.4 When placing or designing the location of portable event electrical equipment, sufficient access for emergency personnel & vehicles shall be maintained in accordance with national & local laws and regulations.

19.2.5 The event's main electrical supply source(s) and disconnect(s) should be located where they are accessible for normal operations and emergencies but segregated from public areas of the venue and protected from unauthorized access.

19.2.6 As far as is practicable, all electrical equipment should be located so that it cannot be touched by attendees or unauthorized event personnel.

19.2.7 Where there is a potential for contact by unauthorized event personnel then they shall be briefed and trained; to mitigate the hazard of the potential contact.

19.3 Signage

Where there is a potential for contact by attendees and unauthorized event personnel signs warning of the type and nature of the hazard shall be displayed.

19.4 Egress Paths

19.4.1 Exit and egress paths shall be kept clear of event electrical equipment for the full width of the exit and egress paths and to a height of not less than 7ft (2.1m).

E19.4.2 Even when such cable is taped, matted, or “protected” by standard cable ramps as it presents a clear trip hazard and as such a clear threat to Health & Safety.

19.4.3 Overhead cables and cable supports shall be secured to prevent tipping due to a high center of gravity, cable sag, or impacts to the support bases.

20 Emergency Power & Lighting Systems

20.1 Emergency Power

20.1.1 The event shall comply with all applicable regulation governing the installation and operation of emergency power and lighting systems. It is the responsibility of the event organizer or their representatives to understand and implement the relevant local requirements.

E 20.1.1 In the United States, (e.g., the most recent editions of Article 700 of NFPA 70 and the Life Safety Code NFPA 101 etc.) establish requirements for emergency electrical systems including lighting. Emergency lighting systems are legally required, are classified as emergency systems, and shall be marked as such. In the U.K. BS 5266-1 deals with emergency lighting along with The Regulatory Reform (Fire Safety) Order 2005

20.1.2 Event emergency power and lighting systems shall be tested to verify they function as intended prior to every event where attendees or event personnel are present once the system is installed or at least once a week. The testing should be conducted according to applicable manufacturer specifications and local, regional and national regulatory requirements. Testing shall be documented.

20.1.3 Requirements for power & emergency lighting should be determined by a risk assessment which may identify risks that require mitigation beyond the applicable regulation.

E20.1.4 The assessments should cover all reasonable hazards associated with the venue, including but not limited to emergency evacuation routes for attendees and event personnel, unique hazards such as scenery, masking, pits, holes, trenches, ditches, etc.

20.1.5 The provision of redundant emergency lighting within generator enclosures and the main electrical service(s) shall be evaluated.

20.1.6 Requirements for event emergency power systems:

- Shall be exclusive
- Shall operate when event or venue power is no longer operating
- Shall provide power to essential emergency show systems (e.g., audio, communication etc.)

20.2 Emergency Lighting Systems

When an emergency requires the attention of the attendees and event personnel the lighting should:

- Clearly distinguish between the visual look of the lighting for the event and the emergency (e.g., normal event colors and bright white lighting)
- Contain no movement or special effects.
- Not solely rely on lighting colors to communicate emergency information. (e.g., risk to those with color blindness & visual impairment should be evaluated)
- Illuminate at a level necessary for responding to the emergency including providing sufficient contrast ratio (see NFPA 101), this may require higher levels of illumination in areas than those required by applicable regulation. (e.g., lighting of egress paths, exits, and exit signs)

- Not require an operator to remain at the console during the emergency.

E 20.2 NFPA 101(2021) requires that “In order to provide sufficient contrast and subsequent visual acuity, the maximum to minimum illumination uniformity ratio shall be no greater than 40:1”.

20.3 Additional Requirements

20.3.1 There can be many types of events where existing regulation for emergency lighting systems do not apply or is insufficient to meet the reasonably foreseeable hazards at the event, (e.g., Outdoor festivals, Temporary Venues etc.). In these circumstances emergency lighting systems for the event should meet the following requirements:

- The event emergency lighting system and its control system should use a redundant power source, of sufficient power and duration for the risks at the event. The system should be separate from the main event lighting power system.
- Lighting for critical safety systems: (e.g. illuminated exits signs etc.) should have a battery backup or other back up power supply.
- Shall be at a level for safe egress including during the operational portion of the event.
- Shall comply with the access control requirements listed in section 19 of this standard.
- Shall be protected from accidental and unauthorized disconnection.

20.3.2 Where general lighting can be switched off due to show requirements, provisions shall be made to turn general lighting on in case the failing of show lighting leaves the audience in total darkness.

20.3.3 Indoor emergency lighting shall be operational and automatically switched on should general lighting fail due to power outage.

20.3.4 It shall only be reset by manual means once mains power has been restored.

21 Lighting levels for means of egress during events

21.1 Egress

21.1.1 During the event all public areas of the venue shall be provided with operational and emergency lighting capable of giving sufficient illumination for people to exit safely. This shall be determined using a risk assessment. Both normal and emergency lighting shall eliminate shadows that increase the risk of slips, trips or falls and enhance visual identification of edges and transitions. These shall be evaluated during or by simulating the conditions of the operational portion of the event.

21.1.2 If lighting levels are reduced in the areas occupied by attendees and event personnel during the event then safe egress lighting levels shall be maintained on all aisles, stairways, and other walking surfaces. Safe egress lighting shall reduce or eliminate shadows that create potential hazards and aid in providing contrast to edges and surface transitions.

E21.1.2 Lighting for stairways, gangways, corridors, exit doorways, gates, emergency lighting, etc., should be installed, operated and maintained in accordance with local, regional and national regulation.

Note: NFPA 101 specifies minimum-to-maximum contrast and illumination levels between contiguous walking surfaces. In some situations, the safety and comfort of venue occupants will be enhanced with higher lighting levels. Consideration should be given to the age of the people in the space, to lighting glare, and to the changes of light levels from one space to another.

21.2 Age

Lighting levels for egress at an event shall be sufficient to accommodate people of any age regardless of the anticipated demographic. The risks from the level of illumination, glare and contrast shall be evaluated and mitigated.

E21.2 Age: In general, older people need more light to see clearly than younger people. The recommended illumination levels for various tasks in the IES's Online Lighting Library are twice as high for people from 25 to 65

years of age as they are for people younger than 25. The recommended levels for people over 65 are twice the levels recommended for those 25 to 65, (four times higher than the levels for people younger than 25).

21.3 Visual Acuity

The needs of people with visual disabilities should be evaluated.

E21.3 Glare: Glare is a problem for everyone, but becomes more of a problem as people age. That is, light shining directly into a person's eyes makes it harder to see dimly lit objects in the visual field. Light meant to illuminate a floor should light the floor, and not shine into people's eyes (e.g., lighting from a steeper angle is less likely to produce glare). Glare can be partially compensated by increasing the illumination on the floor.

Contrast: It takes time for a person's eyes to adjust from a very bright environment to a darker one.. Work to reduce high variations in illumination level where they could create visual perception problems.

22 Electrical Equipment Approval

22.1 Approvals

All electrical equipment used at the event shall be approved according to local, regional and national regulation. This requirement applies equipment as designed and assembled for the end user and not simply the parts it is assembled from.

E22.1 Most electrical inspectors and other AHJ's will look for approval on all electrical equipment, including equipment not used by event personnel.

22.2 Field certification

22.2.1 Electrical devices that don't have a listing mark from a NRTL shall be inspected and certified as acceptable in the field according to local, regional, or national regulation.

22.2.2 However, the equipment is certified in accordance with the AHJ's requirements, safety information for assembly, operation, disassembly, and storage shall be provided to the end user.

E22.2 Prior to installation you should contact your AHJ for input.

Some AHJs will insist that in order for equipment to be field certified it "shall" be inspected. There are usually two ways this can be done.

A NRTL can send compliance technicians to evaluate the equipment and issue a certification if it is okay. This is expensive, but it sometimes is necessary.

An inspector representing a regional, municipal, or other local authority can evaluate the equipment and certify it if it is acceptable for the proposed application and use. NFPA 791, "Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation", offers guidance on this, or it may be found in the requirements of the local regulation.

ANNEX

A1.0 Responding to an Electrical Shock

Examples of how to respond to an electrical shock can be found at these websites:

<https://electricalsafety.lbl.gov/electrical-safety/emergency-response/>

<https://www.mayoclinic.org/first-aid/first-aid-electrical-shock/basics/art-20056695>

A2.0 Additional Hazards of Electrical Shock when working at height

The risk of Injury or Death from the electricity itself is compounded at height by four main factors:

1. How personnel may be exposed to electrical hazards that otherwise would be out of reach.
2. The risk of additional injuries from a fall due to minor electric shocks (e.g., Static discharge) which under most circumstances is insufficient to cause a direct injury but may startle personnel sufficiently to cause them to fall and be injured because of the fall.
3. The rescue and potential delay in treatment of personnel at height who have been injured directly or indirectly by and electric shock.
4. Risks to personnel below someone working at height who is injured by an electric shock.

Electrical Hazards

There are several ways event personnel can be exposed to additional hazards when working at height.

What is often underappreciated is that the risks to event personnel when working at height can be increased when they are electrically isolated from the ground. Electrical isolation can increase the risk of falling due to a shock. Often it is not the shock that kills but the fall as the result of the shock.

In specific circumstances being electrically isolated from the ground (sometimes referred to as working in an equipotential zone) can help protect personnel from the risks of electric shock.

To be effective this requires specific procedures and a higher level of training to ensure that any potential paths to ground those personnel may encounter have been eliminated or insulated against and that those personnel know how to work safely around energized equipment.

It also requires that additional PPE be worn that is specifically designed to protect personnel when potentially exposed to electrical energy.

It is crucial to understand whether event personnel are intentionally or inadvertently electrically isolated when working at height. The dangers of inadvertently isolating event personnel can create potential conditions that are immediately dangerous to life or health (IDLH).

Common examples of things that can cause event personnel to be electrically isolated when working at height can include:

- The rubber or plastic wheels on access equipment, (e.g., lifts and rolling scaffolds).
- The rubber feet on ladders or the materials they are constructed from (e.g., wood & fiberglass).
- The surfaces upon which their access equipment or ladder are being used (e.g., protective plastic coverings, laminate and wooden materials).
- Electrically conductive structures and equipment not being properly bonded to the grounding system (e.g., pipe battens, truss etc.).

Being electrically isolated becomes a significant hazard when exposed to electrical energy and the path of least resistance to ground is through the human being.

Examples of ways that event personnel working at height can become the path of least resistance to ground:

- Touching two or more conductive materials at height one of which has an electrical fault and is energized but isolated and one of which is connected physically or electrically to the ground (e.g., an energized lighting pipe and a ground supported truss with a gap between them that can be physically grasped by the personnel in question).
- An electrical fault with the access equipment which is electrically isolated (due to its wheels or materials it is operating on) and then contacts conductive materials that are bonded to the grounding system or touching the ground.

Lifts can have convenience outlets that are supplied from the ground and this wiring can become damaged and metal parts of the lift can become energized and personnel can when touching properly rigged and bonded equipment become the conduit to ground for that energy; please note if you think this sounds far-fetched that this actually happened to one of the authors of this standard and when they metered the railing of the lift is measured a consistent 120volts.

- a) Damaged access equipment that is not electrically isolated and event personnel are working on live equipment or live exposed parts at height. (e.g., at focus when focusing live lighting instruments or trouble shooting instruments that are not working).
- b) Contact between bonded conductive materials and electrically isolated energized equipment where the metal frame of the access equipment becomes the connecting electrical pathway to ground

The bottom line is that electrical isolation is like spandex in that it can be used for both good and evil. When used properly in conjunction with other procedures and proper training it can protect personnel from potential injury, often in the context of event personnel electrical isolation often masks potential electrical hazards.

Measures that can reduce the risk of electric shock when working at height:

- Proper inspection, risk assessment, evaluation and maintenance of systems and equipment.
- Appropriate safety procedures and training.
- Eliminating work on or around energized equipment.
- Mitigating Environmental conditions (e.g., noise, moisture, weather, potential for static build up etc.).
- Sufficient time & supervision.
- Appropriate hazard communications.
- Descend to access additional materials or when moving locations.
- Never work alone.
- The National Electrical Code is generally considered an electrical installation document, which protects employees under normal circumstances. NFPA 70E is intended to provide guidance with respect to electrical safe work practices.

Approval of electrical equipment

In the US there are three ways something can be approved.

“(1) If it is accepted, or certified, or listed, or labeled, or otherwise determined to be safe by a nationally recognized testing laboratory recognized pursuant to § 29 CFR Sub Part A 1910.7 “Definition and requirements for a nationally recognized testing laboratory”; or

“(2) With respect to an installation or equipment of a kind that no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, if it is inspected or tested by another Federal agency, or by a State, municipal, or other local authority responsible for enforcing occupational safety provisions of the National Electrical Code, and found in compliance with the provisions of the National Electrical Code or local equivalent as applied in this subpart; or

“(3) With respect to custom-made equipment or related installations that are designed, fabricated for, and intended for use by a particular customer, if it is determined to be safe for its intended use by its manufacturer on the basis of test data which the employer keeps and makes available for inspection to the Assistant Secretary and his authorized representatives.”