Electrical Safety - Construction
Electrical Safety

References

- EM 385-1-1 Section 11
- 29 CFR 1926.400 ; Subpart K
- 29 CFR 1910.300 ; Subpart S
- UFGS 01 39 26
- National Electrical Code/ ANSI / NFPA
- Accident Abstracts
Potential Contractor Mishap Outcomes

- Shocks and Electrocutions
- Arc Blast and Burns
- Falls
- Explosions
- Fires

Leading to property damage, injury, death

An average of one worker is electrocuted on the job every day.
Direct Causes of Electrical Mishaps

- Drilling and cutting through cables
- Defective tools, cables and equipment
- Failure to maintain clearance distances
- Failure to follow standard Lockout/Tagout/Groundout procedures
- Failure to guard live parts
- Failure to use proper electrical PPE
- Unqualified personnel
- Improper installation/use of temporary electrical systems and equipment
- By-passing electrical protective devices
Indirect Causes of Electrical Mishaps

- Lack of training
- No SOP for operation
- Lack of supervision
- Failure to apply AHA by site superintendent
- Inadequate site-specific safety training prior to phase of work
- Approved safety plan not implemented
- Proper tools, materials & PPE not provided
- Regular site safety inspections not performed
- Lack of management leadership
Electrical Terminology

- **Current** – the movement of electrical charge
- **Resistance** – opposition to current flow
- **Voltage** – a measure of electrical force
- **Conductors** – substances, such as metals, that have little resistance to electricity
- **Insulators** – substances, such as wood, rubber, glass, and bakelite, that have high resistance to electricity
- **Grounding** – a conductive connection to the earth which acts as a protective measure
Electricity - The Dangers

- About 5 workers are electrocuted every week
- Causes 12% of young worker workplace deaths
- Takes very little electricity to cause harm
- Significant risk of causing fires
Electrical Circuits

- Electrical source
- Electrical user
- Wires
Electricity - How it Works

- Electricity is the flow of energy from one place to another
- Requires a source of power: usually a generating station
- A flow of electrons (current) travels through a conductor
- Travels in a closed circuit
Rules of Electricity

- Electricity travels in a completed circuit
- Electricity always travels in the path of least resistance
- Electricity tries to travel to ground
Electricity and People

- A person usually offers less resistance for the electricity.
- A person forms a completed circuit when the person is touching the ground.
- Electricity always tries to travel to ground.
Shocks Occur in Three Ways

- Contact with both wires
- Contact with one energized wire and ground
- Contact with “hot” metal part and ground
Electrical Shock

- Received when current passes through the body
- Severity of the shock depends on:
  - Path of current through the body
  - Amount of current flowing through the body
  - Length of time the body is in the circuit
- LOW VOLTAGE DOES NOT MEAN LOW HAZARD
Dangers of Electrical Shock

- Currents greater than 75 mA* can cause ventricular fibrillation (rapid, ineffective heartbeat)
- Will cause death in a few minutes unless a defibrillator is used
- 75 mA is not much current - a small power drill uses 30 times as much

---

* mA = milliampere = 1/1,000 of an ampere
Falls

- Electric shock can also cause indirect or secondary injuries
- Workers in elevated locations who experience a shock can fall, resulting in serious injury or death
Electrical Burns

- Most common shock-related, nonfatal injury
- Occurs when you touch electrical wiring or equipment that is improperly used or maintained
- Typically occurs on the hands
- Very serious injury that needs immediate attention
Electrical mishaps and how to control them

Electrical accidents are caused by a combination of three factors:

- Unsafe equipment and/or installation,
- Workplaces made unsafe by the environment, and
- Unsafe work practices.
Controlling Electrical Hazards

- Contractors must use various methods to protect their workers from the hazards associated with electricity. These controls include:
  - Isolating
  - Guarding
  - Grounding
  - Circuit Protection Devices
  - Safe Work Practices.
Qualified Personnel

11.A.01 “Qualified Personnel, Electrical” -

- c. Electrical work shall be performed by Qualified Personnel with verifiable credentials who are familiar with applicable code requirements. Verifiable credentials consist of State, National and/or Local Licenses or Certifications that a Master or Journeyman Electrician may hold, depending on work being performed, and should be identified in the appropriate AHA.

- (2) For all work, Journeyman/ Apprentice ratio shall be in accordance with State, Local and Host Nation requirements applicable to where work is being performed.
Isolation

- Before work is begun, the person in charge shall ascertain by inquiry, by direct observation, or by instruments, whether any part of an electric power circuit (exposed or concealed) is located such that the performance of work could bring any person, tool, or machine into physical or electrical contact with it.

11.A.02.a
Isolating Circuits

- Live parts of wiring or equipment shall be guarded to protect all persons or objects from harm.
Hazard – Exposed Electrical Parts

Cover removed from wiring or box

(11.A.02.d)
Energized work may never be performed without prior authorization. If it is determined that equipment must be worked in an energized condition, an energized work permit shall be submitted to GDA for acceptance.

11.A.02.c
Flexible Cords and Cables

- For construction sites, all flexible cords shall be inspected by the user of the cord at least daily. **11.A.03.a.**
- Flexible cord sets used on construction sites or in damp locations shall contain the number of conductors required for the service plus an equipment ground wire. **11.A.03.b.**
Flexible Cords and Cables

- What’s wrong with these cords???
Electrical cable not protected from vehicular traffic
Flexible Cords
Section 11.A.03.d

- Flexible cord shall be used only in continuous lengths without splice or tap. The repair of hard-service cord 14 AWG and larger shall be permitted if conductors are spliced in accordance with NEC (the splices are made by a qualified electrician, the insulation is equal to the cable being spliced, and wire connections are soldered).
Number of Workers

- The Qualified Person is responsible for determining the number of workers required to perform the job safely and shall identify work hazards and controls in corresponding AHA. Work must be performed with a sufficient number of workers to provide a safe working environment.

11.A.05
An AHA and written work procedures must be prepared for unusual or complicated work activities or any activity identified by the Qualified Person.
11.B ARC FLASH

- Whenever it is necessary to work on energized parts greater than 50 volts to ground, a risk/hazard analysis/arc flash hazard analysis will be conducted in accordance with NFPA 70E. Either Appendices or Tables may be used to conduct analysis. The flash protection boundary, approach distances, hazard/risk category and PPE requirements shall all be identified. This AHA is separate, distinct and in addition to the AHA required in Section 01.
Arc Flash PPE

- PPE that provides appropriate arc flash protection is required for all personnel working on or near exposed energized electrical equipment operating at 50 volts or more.
Over current protection devices must be readily accessible, clearly labeled, not exposed to physical damage, not placed in the vicinity of easily ignitable materials, and located or shielded such that their operation will not expose employees to injury due to arching or the sudden movement of parts.
• Enclosures containing over current protective devices shall be provided with lockable, close-fitting doors. At least 36 in (91.4 cm) of clearance must be maintained around all sides of the enclosure.
Switches, fuses, and automatic circuit breakers shall be marked, labeled, or arranged for ready identification of the circuits or equipment that they supply.

11.C.04
Grounding

- All electrical circuits, equipment and enclosures shall be grounded in accordance with the NEC and the NESC to provide a permanent, continuous and effective path to ground unless otherwise noted in this manual.

11.D.01
Portable Generators

- The frame of a portable generator is not required to be grounded and may serve as the grounding electrode for a system supplied by the generator....

11.D.01.b
Vehicle-Mounted Generators

- The frame of a vehicle need not be grounded and may serve as the grounding electrode for a system supplied by a generator located on the vehicle under the following conditions:
  
  1. The frame of the generator is bonded to the vehicle frame;
  2. The generator supplies only equipment located on the vehicle or cord-and-plug-connected equipment through receptacles mounted on the vehicle;
  3. The non-concurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame; and
  4. The system complies with provisions of Section 11.D.01

11.D.01.c
Grounding rod and pipe electrodes

- A. Electrodes of rod or pipe shall be free from non-conducting coatings and, if practicable, shall be embedded below permanent moisture levels.

- b. Grounding rod and pipe electrodes shall be in unbroken 8-ft (2.4-m) lengths and driven to full depth. Where rock bottom is encountered, the electrode shall be driven at an angle not to exceed 45° from the vertical or shall be buried in a trench that is at least 2.5 ft (0.7 m) deep.
All receptacle outlets that provide temporary electrical power during construction, remodeling, maintenance, repair, or demolition shall have ground-fault circuit-interrupter (GFCI) protection for personnel.
GFCI’s

- GFCIs may be sensitive to some equipment (such as concrete vibrators), or unavailable for the voltage and current rating. In these instances, an AEGCP in accordance with Appendix D is acceptable in lieu of GFCIs if the exception is documented on an AHA and contains the following:
  
  (1) The conditions, or need, for the exception; and
  
  (2) Implementation of the requirements of the AEGCP;

  (3) The request for the exception, the AHA, and the AEGCP must be submitted and accepted by the GDA prior to implementing the program.
An assured equipment grounding conductor program (AEGCP) is a method of protection for personnel against ground-fault current flow through the body. The basic concept of the AEGCP is that conductive surfaces which may become energized due to line-to-ground faults and with which personnel may come in contact be properly grounded. Thus if properly grounded and a line-to-ground fault occurs, the low impedance path would allow resulting current flow to be large enough to be detected and removed by the circuit protective device. This would then de-energize the conductive surface subject to contact by personnel, removing the shock hazard.
GFCl’s

- If the current flowing in the **black** (ungrounded) wire is within 5 milliamperes of the current flowing in the **white** (grounded) all the current will flow in the normal path.

- If the current flow differs by more than 5mA, the GFCl will quickly open the circuit.
Testing GFCI’s

- Before first use
- Before used after repairs
- Before used after any likely damage
- Every 3 months
- Comply with above or do not use!

- EM 385-1-1 Sec 11.E.02.a – GFCI shall be tested monthly
TEMPORARY WIRING AND LIGHTING

- A sketch of proposed temporary power distribution systems shall be submitted to the GDA and accepted for use before temporary power is installed. The sketch shall indicate the location, voltages, and means of protection of all circuits, including receptacles, disconnecting means, grounding, GFCIs, and lighting circuits.

11.E.01
Testing

a. Temporary electrical distribution systems and devices shall be checked and found acceptable for polarity, ground continuity, and ground resistance before initial use and before use after modification.

11.E.02

- Reversed polarity is a condition when the grounded conductor (neutral) is incorrectly connected to the ungrounded (hot) terminal of a plug, receptacle, or other type of conductor.
Temporary Wiring

- Temporary Distribution Panel Box
Vertical Clearances of Temporary Wiring

- Clearance from ground:
  - 10 feet above finished grade, sidewalks
  - 12 feet over vehicular traffic
  - 15 feet over areas other than those specified above
  - 18 feet over public streets, alleys, roadways
Temporary Lighting

- Bulbs attached to temporary lighting strings and extension cords shall be protected by guards unless the bulbs are deeply recessed in a reflector.
b. Unless designed for suspension, temporary lights shall not be suspended by their electric wire.

c. Exposed empty light sockets and broken bulbs shall be replaced immediately.
OPERATIONS ADJACENT TO OVERHEAD LINES

- Any overhead wire shall be considered energized unless the person owning such line or operating officials of the electrical utility supplying the line certifies that it is not energized and it has been visibly grounded and tested.
BATTERIES

- Storage batteries shall be stored in enclosures with outside vents or in well-ventilated rooms and be so arranged as to prevent the escape of fumes, gases, or electrolyte spray into other areas.
Battery storage and handling

- Racks and trays shall be substantial and shall be treated to make them resistant to the electrolyte.

11.G.03.a.
Battery PPE

- The following shall be available and used for the safe handling of the battery and protection of personnel
  - a. Safety glasses with side shields and face shields or goggles;
  - b. Acid-resistant rubber gloves;
  - c. Protective rubber aprons and safety shoes;
  - d. Lifting devices of adequate capacity, when required.

11.G.06
HAZARDOUS (CLASSIFIED) LOCATIONS

- Hazardous Locations
  - Class I - gas or vapor
  - Class II - dust
  - Class III - fibers and flying debris

11.H
Before starting work, existing conditions shall be evaluated and determined.

11.I.02
Clearance Requirements

- No employee shall be permitted to approach or take any conductive object without an approved insulating handle closer to exposed energized parts than shown in Table 11-3 (phase to ground) unless:

  (1) The employee is insulated or guarded from the energized part (gloves or gloves with sleeves rated for the voltage involved shall be considered insulation of the employee from the energized part)

11.I.03.a
The aerial device manufacturer shall state in the operator’s manual and on the instruction plate whether the aerial device is insulating or non-insulating.
UNDERGROUND ELECTRICAL INSTALLATIONS

Warning signs and rigid barricades shall be promptly placed when covers of manholes, handholes, or vaults are removed.

11.J.01.a
ENERGIZED SUBSTATIONS

- Only qualified employees shall perform work on or adjacent to energized control panels.

11.K.04
Fatal Accident

While exiting from a substation, boom truck driver failed to lower boom, boom contacted 34.5KV energized line.
Summary

- Electricity is a silent killer
- Personnel must be trained and qualified
- Electrical safety systems must not be by-passed.
- AHA/ORM must be followed.
- Equipment must be properly maintained.
- Lockout and Tagout procedures must be applied.
- Live electrical energy sources must be guarded to prevent accidental contact.