1 Status

1.1 Update of existing policy, effective 06/03/11.

2 Purpose

2.1 To team members as they safely plan and execute work in or near energized electrical substations and switchyards.

3 Applicability

3.1 This policy applies to all subsidiary companies and departments of The Cianbro Companies.

3.2 All organizations are required to comply with the provisions of this policy and procedure. Any deviation, unless spelled out specifically in the policy, requires the permission of the Corporate Safety Officer or designee.

4 Definitions

4.1 Arc Flash: A short circuit through air. In an arc flash incident, an enormous amount of concentrated radiant energy explodes outward from electrical equipment, creating pressure waves that can damage a person’s hearing, a high-intensity flash that can damage a person’s eyesight and a superheated ball of gas that can severely burn a worker’s body and melt metal. The pressure waves can also send loose material like pieces of damaged equipment, tools, and other objects flying through the air.

4.2 Bond: The electrical interconnection of conductive parts to maintain a common electrical voltage.

4.3 Capacitor: Is two conductive objects separated by a dielectric (insulating) medium. It is an electrically conductive device characterized by its capacity to store an electric charge. When applied to substation safety, a capacitor is any object or conductor that has the potential to accumulate induced or direct voltage.

4.4 Clearance: A statement with documentation from the operations supervisor to an authorized individual declaring that the equipment to be worked on has been electrically isolated from all sources of primary energy.

4.5 Competent Person: A person who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to team members, and who has authorization to take prompt corrective measures to eliminate them.

4.6 Electrically Isolated: Removed from all primary sources of electrical energy by opening switches, disconnects, jumpers, taps, or other means of electrical supply. The line or equipment is isolated when all switches, disconnects, jumpers, taps, or other means through which known sources of electrical energy may be supplied to the particular lines and equipment have been opened on a de-energized electrical circuit or equipment.
4.7 Equipotential Work Zone: A work zone where all equipment is interconnected by jumpers, ground rods or grids that will provide acceptable potential differences between all parts of the zone under worst case conditions of energization.

4.8 Fault (Current): A current that flows from one conductor to ground or to another conductor because of an abnormal connection (including an arc) between the two.

4.9 Ground: A conducting connection, whether intentional or accidental, by which an electrical circuit or equipment is connected to earth, or to some conductive body of relatively large extent that serves in place of earth.

4.10 Induction (Coupling): The process of generating time varying voltages and / or currents in otherwise unenergized conductive objects or electric circuits by the influence of the time varying electric and / or magnetic fields.

4.11 Qualified Person: A person who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience has successfully demonstrated their ability to solve or resolve problems relating to the subject matter, the work, or the project. An team member who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a qualified person is considered to be a qualified person for the performance of those duties.

4.12 Step Voltage: The difference in surface potential experienced by a person bridging a distance of one meter with the feet without contacting any other grounded object. Step voltage will be greatest near the point where the fault current enters the earth and will reduce rapidly as one moves away from that point.

4.13 Touch Voltage: The difference in potential between a grounded structure or station and the surface potential at the point where a person is standing while at the same time having a hand in contact with the grounded structure or object.

4.14 Transferred Touch Voltage: A special case of touch voltage where a voltage is conducted toward or away from a grounded structure or station to a remote point. A transferred touch voltage (potential) can be contacted between the hands or hands and feet.

5 Policy

5.1 All Cianbro team members, subcontractors, and other personnel within our control shall comply with the requirements of this procedure in conjunction with other Owner, Federal, State, and Local requirements while working in or near energized substation and switchyards.

6 Responsibilities

6.1 The Corporate Safety Officer or designee is responsible for providing approval for any deviations from the requirements contained in this policy.

6.2 The top Cianbro manager on the job site is responsible for the implementation of this policy on the project.

6.3 The corporate safety department is responsible for maintaining this document.
7.1 Personal Protective Equipment & Tools

7.1.1 Working in Substations presents electrical Arc Flash hazards to all team members including but not limited to, electricians, operators, ironworkers, riggers, laborers and even supervisors monitoring work activities. Electrical Arc Flash hazards require certain personal protective equipment & tools be used to safely perform the work.

7.1.2 Minimum PPE Requirements:
- ANSI approved safety glasses with side shields.
- ANSI approved hard hats.
- F/R clothing while working in energized substation yards. Minimum level of protection shall be Level 2 or 8 cal/cm².
- E/H rated safety boots. No steel toe's showing on boots.
- PPE required to install personal protective grounds (Based on voltage and the NFPA flash protection charts. Refer to matrix in section 7.7.10).
- PPE required to work on battery installations. (Refer to section 7.10 Battery Safety)

7.1.3 Flame Resistant (FR) Clothing

A. The appropriate Flame Resistant clothing shall be worn while working on or near energized equipment where exposure to flash and other electrical hazards are present. This includes wearing FR clothing in any energized substation or switchyard. FR Clothing shall be in good condition, free from rips, tears and fraying.

B. Cianbro management shall determine on a case by case basis whether or not FR clothing is required for visitors and vendors entering an energized substation for purposes such as deliveries or attending meetings. Generally this would apply to people who are on site for a short period of time and are kept away from the work areas assuming it does not conflict with the Owner's policy.

C. Cianbro Reimbursement Policy

Team members who require FR clothing for their work assignment will be credited with an allowance twice per year to purchase the safety clothing. Refer to Cianbro’s current FR policy for the approved allowance amount. Personal accounts will be set up for each team member through an authorized FR clothing supplier where they may apply their allowance toward the purchase of approved FR clothing.

- On January and July of each year a Flame Resistant Clothing Allowance will be issued with the authorization of the team member’s Supervisor; if warranted by their job, i.e. Utility Line Workers, Electricians, and other personnel that work in energized substations.
- Each January and July it will be the responsibility of the Supervisor to make a list of authorized personnel requiring FR and submit it to the Cianbro Administrator for processing. A tracking log will also be maintained by the assigned Cianbro Administrator.
- It is the team member’s responsibility to use the allowance to purchase their own Flame Resistant clothing and to wear the necessary protective FR as required on job sites.
- Payment for any Flame Resistant clothing purchased over and above the allowance will be the sole responsibility of the team member.
Should a team member join the crew during either six month period they will be entitled to that period’s allowance once approved by their Supervisor.
FR coveralls will be furnished by Cianbro and loaned to team members working on relatively short term assignments where they may not have a selection of FR clothing or may not have received a clothing allowance previously. The coveralls shall be returned to Cianbro at the completion of the short term assignment.

7.1.4 Rubberized and Insulated PPE Application and Maintenance

A. Voltage rated rubber gloves with leather protectors shall be required for the following applications:
- When splicing ground wire to a substation ground grid in case of fault.
- While conducting work within reaching distances of un-grounded conductor or equipment that may have the possibility of becoming energized.
- During the installation or removal of ungrounded steel structures, such as lightening masts, which are relatively close to energized lines or equipment.
- When applying personal protective grounds to station equipment and lines.
- Voltage rated rubber gloves are not required when installing personal protective grounds to construction equipment unless this is a requirement of the Utility we are working for. Equipment grounds shall be installed immediately after the equipment is moved into position to avoid a static charge build up.
- The project supervisor has the authority to renounce the requirement of rubber gloves if he/she feels as though the gloves cause more of a safety hazard then without, such as work in live control cabinets with minimal work space.
- There are four classes of high voltage rubber gloves:
  - Class 1 7,500 Volts
  - Class 2 17,000 Volts
  - Class 3 26,500 Volts
  - Class 4 36,000 Volts
  The correct voltage rated gloves must be worn to safely protect workers while performing their work. In most substation applications, a Class 2 rubber glove is the required level of protection.

B. Rubberized/Insulated PPE Maintenance
- All electrical equipment shall be tested according to Cianbro safety policy, procedures and best practices.
- Rubber gloves shall never be worn without the leather protectors or worn inside out.
- Leather protectors shall not be worn without the rubber gloves.
- Gloves shall be exchanged whenever they are damaged or become questionably safe by the Cianbro team member to whom they are assigned.
- Rubber gloves are rated for specific electrical voltage hazards and shall not be used as regular work gloves.
- Team members shall not use another team member’s rubber gloves without consent.
- Prior to use, rubber gloves must be inspected for corona cracks, tears, punctures or any other type of visual damage. The roll up air test should be utilized to inspect for leaks.
- When rubber gloves are not in use, they must be kept in a canvas bag or another approved container that will protect the gloves from being punctured or damaged and protected from the effects of sunlight.
- Rubber gloves shall never be folded or placed with any other items when they are stored away.
- Inner liners may be worn if desired.
- Always store gloves with the cuff down in the bag in the event any sharp items collect in the bottom of the bag and to prevent items from falling into the gloves.
- Substation and Electrical crews shall have their gloves inspected and tested every six months (By approved testing agency).
Cianbro Management is responsible for maintaining the test record documentation and managing the glove and equipment inspection program.

7.1.5 Hot Sticks
A. Hot sticks shall be taken out of service and inspected and tested every twelve months checking for any problems that will prevent them from operating properly.
B. Before each use, hot sticks shall be inspected for the following conditions:
   • Moisture
   • Marred or cracked finish
   • Cracked, bent or broken parts
   • Excessive wear
   • Ease of action of all working parts
C. Hot sticks shall be cleaned, prior to use with a silicon cloth or liquid “moisture eater” material.
D. When not in use, hot sticks shall be stored in a dry location and in a protective sleeve so that the finish is not damaged.
E. Proper hot stick lengths must be identified and used when installing grounds or testing conductors to prevent encroachment of minimum qualified distances.
F. The minimum length for a hot stick shall be 6 feet.

7.1.6 Personal Protective Grounds
- All ground cables shall be identified and tracked with a numbered tag installed at one end of the ground cable assembly.
- Ground cables shall be inspected and tested a minimum of once per year. Ground cable assemblies will undergo visual inspections as well as conductivity and resistivity testing to insure that they will perform correctly in the field.
- After testing, a label shall be applied to the ground cable assembly identifying the date of the test.
- Refer to Sections 7.7.7 and 7.7.8 for fabrication and inspection practices of temporary protective grounds.
- Guidance for inspecting and testing safety grounds is provided in ASTM F 2249, Standard Specification for In-Service Test Methods for Temporary Grounding Jumper Assemblies Used on De-Energed Electric Power Lines and Equipment.
- During transportation, ground cables must be coiled and tied up to prevent accidental damage.
- When not in use, ground cables shall be coiled and stored out of elements.

7.2 Training Requirements

7.2.1 Minimum Training Requirements Based on Type of Work
A. General requirements for all types of work in Energized Substations:
   • Substation Access Awareness Training
   • Cianbro Electrical Awareness Training
   • Electrical Power Generation, Transmission, And Distribution OSHA 1910.269 (10 hour class).
   • Site specific orientation
   • Spotter Training as needed
B. Additional requirements for Electrical Construction workers:
   • Cianbro Policy Number 020 Electrical Safety And Flash Protection
   • CPR (2/3 of the crew must be trained)
   • First Aid
   • Equipotential Grounding Training
C. Additional requirements for Non-Electrical Construction workers:
   • Excavation Safety (As needed)
D. Subcontractor Training Requirements:
   • Same as general requirements above
   • Other specific training as required to perform work
7.2.2 Access Levels for Substation Entry

- **Escorted Access**: Entrants are required to be accompanied by an approved escort of their equivalent or higher skill/knowledge level.
- **Unescorted Access**: Entrants have completed job specific training and have been judged capable of entering a substation and performing work activities at their respective skill levels by themselves. Unescorted entrants are not automatically grated escort privileges.
- **Escort Privileges**: Are obtained when unescorted entrants have completed additional escort specific training, and have been granted escort privileges in their respective skill levels by their own supervision. Escorts are limited to escorting entrants of their own and/or lower skill levels. (For example, a Type II Escort may escort an Type I and II worker, but not a type III.)

7.2.3 Access Types

- **Type I Worker**: The skill set is limited to observations, inspections, and simple deliveries. The minimum safe working distance for type I worker is that of an unqualified person.
- **Type II Worker**: The skill set is limited to physical/civil type work. The minimum safe working distance for type I worker is that of an unqualified person.
- **Type III Worker**: The skill set is limited to electrical type work. The minimum safe working distance for type I worker is that of a qualified person.

7.2.4 Escort Policy and Delivery Protocol

- Prior to beginning projects, signage must be posted outside the yard for all delivery trucks and visitors identifying a phone number and contact they must call to gain escorted access in the event they are unable to contact any Cianbro personnel outside the gate limits.
- The Cianbro certified escort must be trained as a spotter if escorting trucks and shall hold an escort privileges level of access.
- All small packaged deliveries (FedEx, UPS) must be either received at the substation gate entrance, or escorted directly to the job trailer or unloading area.
- All delivery personnel must be escorted in and out of the substation.

7.3 Safe Work Clearances and Identification of Live Parts and Voltages

7.3.1 Qualified Worker

- Is trained and proficient in safety procedures
- Knows how to perform his or her job safely
- Knows the hazards associated with the job
- Is knowledgeable in the use of safety equipment, tools and PPE
- Can distinguish exposed live parts from other non-energized parts
- Can determine the voltage of live parts
- Has knowledge and understanding of the Minimum Approach Distances (MAD)
- Can identify and distinguish what a conductor is and what an insulator is
- Knows when it is necessary to apply grounds, where and how to ground

7.3.2 OSHA Unqualified Work Distances (Minimum Approach Distances – Unqualified)

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 50,000 volts</td>
<td>10’</td>
</tr>
<tr>
<td>69,000 volts</td>
<td>11’</td>
</tr>
<tr>
<td>115,000 / 138,000 volts</td>
<td>13’</td>
</tr>
<tr>
<td>230,000 volts</td>
<td>15’</td>
</tr>
<tr>
<td>345,000 volts</td>
<td>20’</td>
</tr>
</tbody>
</table>
7.3.3 OSHA Qualified Work Distances (Minimum Approach Distances – Qualified)

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Phase to Ground</th>
<th>Phase to Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 V to 600 V</td>
<td>Avoid Contact</td>
<td>Avoid Contact</td>
</tr>
<tr>
<td>1 kV to 15 kV</td>
<td>2’ 1”</td>
<td>2’ 2”</td>
</tr>
<tr>
<td>23 kV / 28kV</td>
<td>2’ 4”</td>
<td>2’ 7”</td>
</tr>
<tr>
<td>34.5 kV</td>
<td>2’ 4”</td>
<td>2’ 7”</td>
</tr>
<tr>
<td>69 kV</td>
<td>3’ 0”</td>
<td>3’ 6”</td>
</tr>
<tr>
<td>115 kV</td>
<td>3’ 2”</td>
<td>4’ 3”</td>
</tr>
<tr>
<td>345 kV</td>
<td>8’ 6”</td>
<td>12’ 6”</td>
</tr>
</tbody>
</table>

7.3.4 Identification of Voltage Levels and Live Equipment

A. It is necessary to understand the specific voltages that may surround any given work area in order to properly plan the work activity and consider the appropriate minimum approach distances. Some guidelines for identifying voltage values include:

- Look at the ratings and data stamped on equipment name plates.
- Review engineering drawings of the facility or system being worked on.
- Identify the differences in voltages on each side of any transformers in the yard (Primary and secondary voltage ratings).
- Look for incoming transmission lines or exiting distribution lines and their posted ratings.
- Ask questions. Seek answers and guidance from supervisors or facility owner representatives.

B. In addition to voltage identification, it is also critical when working in substations and switchyards to be able to distinguish between energized and de-energized parts. There are a variety of work situations that may include maintenance work in a fully commissioned substation or general construction work in a new or partially commissioned yard. Each work environment is unique and may involve varying degrees of complexity and electrical hazards. The following guidelines should be considered when pre-planning the work and becoming familiar with the surrounding work area:

- Identify conductors such as transmission lines, cables; flex taps, rigid bus, energized frames, etc. Distinguish these materials from insulating materials such as glass or polymer materials.
- Identify open switches and open breakers. Know which side of the open device is hot.
- Look for incomplete construction that may serve as breaks in continuity or separation of energized and de-energized areas.
- Look for attached personal protective grounds on de-energized systems (Remember, protective grounds must always be in place prior to work on any de-energized equipment).
- Identify locks and tags on systems and / or contact clearance holder for more information on the limits of a de-energized area or system.

7.3.5 Signage and Flagging

A. Barricades, flagging and signage play a significant role in identifying electrical hazards within a substation or switchyard. They provide visible reminders of the hazards and are effective in helping others plan their work and are necessary to keep unqualified personnel from entering restricted areas.

B. In addition to signage within the substation, signs posted at the entrance to the yard also play an important role.

C. Recommended temporary Cianbro signage posted at substation gate:

- Highest voltage that can be expected in substation
- 100 % F/R clothing (if required)
- ANSI approved safety glasses with side shields
- ANSI approved hard hats
- E/H safety toed boots
- OSHA unqualified work distance
- OSHA qualified work distances
7.4 Excavations in Energized Substation Yards

7.4.1 Just as in every sector of construction, planning is the most important step in risk management. Knowing where electrical lines are reduces the odds of an incident. Cianbro and subcontractor supervisors and their operators need to thoroughly plan their work with consideration given to the hazards of the work environment.

- Cianbro and subcontractor supervisors and operators must obtain and evaluate all documentation and drawings pertaining to the above and below ground utilities on site in addition to identifying other hazards and obstacles in the yard.
- Dig-Safe must be notified at least 72 hours (3 business days) in advance of any excavation work inside or outside the substation fence. Although the various utility companies representing Dig-Safe may not survey areas inside the substation fence on private property, they will be able to identify any buried utility that may be present just outside the perimeter fence and thus provide an indication as to whether or not any utilities may pass through the yard.
- The selection of all construction equipment utilized in energized substation yards must be approved by the Cianbro supervisor including equipment proposed for use by subcontractors. Consideration must be given to the size and type of equipment and its proximity to energized components. Other recommendations such as the use of toothless digging buckets shall be implemented when necessary.
- Prior to excavation, a survey of the area shall be conducted by a qualified person to help identify whether or not buried utilities exist. In addition to reviewing site drawings, as-built drawings and Dig-Safe markings, the qualified person shall utilize a cable detection tool designed to locate buried utilities for mapping out the work area.
- Barricades will be established to identify various hazards in the yard, such as energized vs. de-energized zones, open excavations, etc.
- A designated qualified spotter shall be assigned to the operator and must have completed Cianbro’s spotter training. The spotter’s sole purpose is to watch for hazards and to monitor safe clearances to exposed lines and equipment at all times when the equipment is operating and ensure that minimum approach distances are kept. Refer to additional Spotter requirements in section 7.10
- In addition to qualified operators and spotters, there must also always be a qualified electrical person assigned to the site when excavating in energized yards regardless of whether excavation work is performed by Cianbro or a subcontractor.
- Maintain safe slopes and appropriate barricades at all times. Refer to Cianbro safety policy and procedure for Excavation Safety.
- Cianbro supervision shall coordinate all changes in underground utility installations with the appropriate engineer to ensure accurate and complete as-built conditions are documented for future reference.
- Construction equipment shall be properly grounded at all times while working in energized yards or near other sources of high voltage energy.
- Safe minimum approach distances must be considered in the pre-planning when performing excavations in energized yards. It is the responsibility of the first line supervisor, spotter, and operator to ensure safe distances are maintained.
- Never move dump trucks unless their dump bodies are in the fully down position.
- It may be necessary in congested areas or when buried utilities are anticipated to implement hand digging in lieu of machine digging. Proper excavation methods shall be determined in the job hazard analysis.
- All construction equipment shall be inspected daily prior to use.

7.5 Current Flow and Effects on the Human Body

7.5.1 The human body is a natural conductor of electricity and since current always seeks ground and will take any and all paths to ground, a person’s body may become the path for current if placed in an electrically unsafe condition. The effect of current on the
body depends on the amount of current, the duration of current flow, and the specific path the current takes through the body. When current flow is through the heart, the chance of severe injury or death is the greatest. Cardiac arrest or fibrillation can occur when current above 50 ma passes through the heart. The most severe electrical burns occur when the current flow is over 200 ma. The heart is vulnerable since it is in the path of two common pathways through the body. Specifically, hand-to-hand and hand-to-foot contact pathways.

7.5.2 Individuals react differently to current values as a result of their makeup, size, and body resistance. Resistance can alter the effects of current flow through the body. Skin provides much more resistance to current flow than does muscle tissue. With dry skin, current is less likely to travel across the skin surface and more likely to flow through muscle tissue. Impurities in the moisture on skin however, can enhance the conductive nature of the skin.

Dalziel’s Research Data:

<table>
<thead>
<tr>
<th>Body Effect</th>
<th>Gender</th>
<th>60 HZ AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slight sensation at point(s) of contact</td>
<td>Men</td>
<td>0.4 mA</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>0.3 mA</td>
</tr>
<tr>
<td>Threshold of Bodily Perception</td>
<td>Men</td>
<td>1.1 mA</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>0.7 mA</td>
</tr>
<tr>
<td>Pain, with Voluntary Muscle Control</td>
<td>Men</td>
<td>9.0 mA</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>6.0 mA</td>
</tr>
<tr>
<td>Pain, with loss of Voluntary Muscle Control</td>
<td>Men</td>
<td>16.0 mA</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>10.5 mA</td>
</tr>
<tr>
<td>Severe Pain, Difficulty Breathing</td>
<td>Men</td>
<td>23 mA</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>15 mA</td>
</tr>
<tr>
<td>Possible Heart Fibrillation after 3 Seconds</td>
<td>Men</td>
<td>100 mA</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>100 mA</td>
</tr>
</tbody>
</table>

7.5.3 From Dalziel’s research data we know the fibrillation threshold is about 100 ma or 0.100 amps. Since the average human body has 500 to 1500 ohms of resistance Ohm’s Law will yield the following:

- \[ V = IR = (0.100\text{amps}) \times (500\text{ ohm}) = 50\text{ volts} \]

7.5.4 Under the right conditions and depending on the individual, this 50 volt threshold may cause ventricular fibrillation and can be life threatening. From Ohm’s Law Current and Resistance are inversely proportional. The higher the resistance the lower the current will be through any circuit. Thus, wearing the proper PPE to insulate including rubber gloves and boots increases the resistance factor through a worker and therefore further reduces the risk of unsafe current levels passing through the body.

7.6 Establishing an Electrically Safe Work Condition

7.6.1 Establishing a Safe Worksite

A. Prior to beginning any work activity a job hazard analysis must be conducted that will lead to the establishment of an electrically safe work area. The process of turning off the power, verifying that it is off and ensuring that it stays off while work is being performed is considered establishing an electrically safe work condition. There are six steps to consider in this process:

- Identify all power sources – Walk down the project site identifying sources of power. Review electrical drawings and current as-built information for immediate site as well as for any remote end sites affected by the switching orders. Work with facility manager for guidance.
• Disconnect all power sources – Open appropriate disconnect switches and circuit breakers.
• Verify that the power is off – Do a visual inspection to verify that circuit breakers and switch blades are in the open position for the work site and confirm with the Utility representative that any remote end switching devices have been confirmed open. Disconnecting devices may malfunction and fail to open all phase conductors when operated. After operating the handle of any enclosed disconnect, a qualified person should open the equipment door or cover to visually verify that there is a physical opening, air gap, in each blade.
• Lockout /Tagout systems – Apply lockout tags and locking devices to open equipment in accordance with an approved lockout policy for the work site. On some sites the lockout tags and locking devices may be applied by the Utility Representative on site according to that utility’s lockout policy. Under these circumstances, it may be necessary to work under their clearances and tagging methods. Refer to section 7.6.3 for additional information.
• Verify again that the power is off by testing – Use a voltage detector rated for the given voltage to test each phase conductor or circuit to verify a de-energized condition exists. Before and after each test, test the tester against a known energy source to verify it is operating properly (Refer to Section 7.7.9).
• Discharge stored electrical energy - Some substation components may have characteristics similar to capacitors where stored electrical energy or induced voltages exist. Install personal protective grounds as necessary before touching any such components (Refer to section 7.7 Personal Protective Grounding).

7.6.2 Dispatching and Clearances
• All oral communication about dispatching and clearances shall be recorded by the person receiving them and shall be read back to the person giving them. System clearances shall be documented.
• Under no circumstances shall clearances be granted or released on a predetermined time basis. (More for distribution work).
• If the person who received the clearance must leave the work site before it is completed, they shall so inform the dispatcher, giving the name of the person who will take his/her place. In such cases, the dispatcher shall communicate with both people, releasing the one who is leaving and accepting the other as authorized to report for him/her. Clear and precise entries of all such authorized changes shall be made on the dispatcher’s records and hold tags.
• When the work is completed, the grounds removed and all the workers and possible hazards are clear, the team member who received the clearance, or their properly authorized substitute, shall report to the person having jurisdiction that the line or apparatus is ready for service.

7.6.3 Lockout / Tagout and Work Area Isolation
• Most of our Utility Clients have their own procedures for addressing lockout / tagout, zero energy isolation, clearance holders and switching / tagging orders necessary to ensure a safe work zone for their people as well as any contractor working in their substation and switch yards. It is the responsibility of the Cianbro site supervisor to work closely with the Owners representative at the beginning of each project to understand and agree to a project specific process necessary to protect all personnel on site from all sources of energy. Refer to OSHA section 1910.269 for specific requirements. The following minimum standards must be met to achieve and secure a safe work area:

LOTO for Transmission & Distribution Lines and Substation Yard Work:
• Identify Owner and Contractor authorized responsible person.
• Identify Clearance Holder (Usually Owner Representative).
• Request a copy of the Owners Switching / Tagging Orders before commencing outage work or entering new work areas.
- Identify and document on system one line diagrams and/or other facility documents all sources of energy that must be isolated and all the necessary switches, breakers, and other equipment that must be opened to electrically isolate the work area. Verify this is consistent with Switching Orders.
- Identify and document locations for personal protective ground sets necessary to isolate the work area. Record information including the ground set number, location, date installed, date removed and the authorized responsible person. Verify that the grounds are in place on a daily basis.
- Implementation of a tagging system for isolation ground sets should be considered depending on the complexity of the project. Tags are not required for non-clearance / isolation grounds including construction equipment grounds.
- Develop project specific procedure with Owner Representative for application of locks and/or tags on switching devices and ground sets. Procedure shall address notification and concurrence of Owner and Contractor Authorized Responsible Persons prior to initiating any switching orders including closing switches or removing grounds prior to re-energization.
- Test for zero voltage prior to beginning work.
- Hold tailboard meeting with crews to review plan prior to beginning work.

7.7 Personal Protective Grounding

7.7.1 Purpose
- The purpose of this grounding procedure is to establish policy that will provide maximum protection against electrical shock to all personnel working on or near de-energized lines or substation equipment.

7.7.2 Establishing an Equipotential Work Zone
A. An “Equipotential Work Zone” is a work zone where all substation equipment is interconnected or bonded together by jumpers, ground rods and / or grids that will provide acceptable potential differences (close to equal) between all parts of the zone under worst case conditions of energization. In order to provide true equipotential protection for workers, all construction vehicles and equipment working near power lines must also be grounded. Therefore, an equipotential zone is an area where workers are protected from dangerous step and touch potentials under worst case conditions.
B. Grounding and bonding are necessary to ensure that all work is performed in an established Equipotential Zone in order to prevent accidental death or injury to workers from electrical shock. Proper grounding and bonding will reduce voltage differences across the worker to the lowest practical value in the event the line or equipment being worked on becomes charged. The basic difference between bonding and grounding is that bonding interconnects conductive parts to maintain a common voltage (Not necessarily zero) creating an equipotential zone between those parts whereas a ground actually connects to earth and gives voltage a place to go or discharge. People sometimes confuse grounded objects with bonded objects due to the fact that they both usually involve a copper conductor or jumper.
C. Temporary protective grounds shall be placed at such locations and arranged in such a manner as to prevent each team member from being exposed to hazardous differences in electrical potential.
High voltage lines and equipment shall be considered energized and appropriate minimum approach distances shall be adhered to until lines are tested and protective grounds are installed.

D. Personal protective grounds are installed to protect against:
   - Inadvertent or accidental energization of lines or equipment. Protective grounds limit the voltage rise in the work area to safe levels in the event the equipment being worked on is accidentally energized. They provide a low resistance / fast path for fault current to follow thus allowing upstream protective devices to trip.
   - Induced voltage from nearby energized lines or equipment and static charges as a result of wind and weather.

Inadvertent energization may be prevented through proper lock out and communication between all parties involved at the job site. Adherence to the principles identified in “Establishing an Electrically Safe Work Condition” above are also critical in preventing accidental energization. Inadvertent energization may also be caused by conditions beyond the control of the project including vehicle accidents, lightning strikes, unexpected back feed sources such as portable generators, and equipment malfunction.

Induced voltages from adjacent energized lines and equipment can be just as dangerous as accidental energization conditions and may perhaps be less obvious to recognize and predict due to variables such as weather, proximity, voltage levels, etc. Potential problems include Electrostatic Induction and Electromagnetic Induction.

E. Electrostatic induction occurs when an ungrounded open conductor acts like a capacitor and picks up a charge from wind blowing across large expanses of wire or from other sources. Electromagnetic induction occurs when an ungrounded open conductor picks up an induced voltage from an energized line running parallel to the ungrounded open conductor or from energized equipment nearby.

F. Proper placement of personal protective grounds is essential and they should be placed as close to the work location as possible to dissipate induced voltages. If substation equipment becomes energized, potentially hazardous voltage differences can result. Protective grounds will limit excessive voltage differences in the work area in conjunction with proper work procedures that will reduce exposure to step, touch, and transferred touch voltages on the ground. The most important rule in safe grounding is to ensure that the worker is never in series with a grounding system component. Specifically, if a worker touches an energized line or part that is not properly grounded, they may become part of the circuit as a human conductor, in series, as shown on the left side of Figure 1. Electrical shock hazards also exist when a person is placed in a parallel circuit arrangement as indicated on the right side of Figure 1.

**It is often stated that “Current will take the path of least resistance to ground”**. Actually, current will take all paths to ground.

G. Even though very low resistance ground cables may have been installed in your substation work area, by touching the same conductive part or bonded part that is grounded a worker becomes a parallel circuit to ground. In the event of a fault or induced current, the worker’s body resistance and the resistance of other circuits in parallel will determine just how much of the current will be conducted through each circuit including the one through the worker. With proper grounding, a low resistance ground cable will provide a quick path for a large surge of current to travel to ground causing upstream protective devices to trip thus reducing the amount of time a worker may be exposed to the current (Refer to section 7.5 for current flow effects on the human body).

H. When a worker is placed in series there is only one path to ground for the fault which is through the worker’s body. This series circuit condition can be very hazardous and may exist when ground cables are not installed in the work area.
Without a ground there is no unencumbered parallel path for the fault current to take. Depending on the overall resistance of the worker, their PPE and the platform they are standing on, a fault current may pass to ground that is too small to trip upstream devices but large enough to cause injury or death to the worker.

Figure 1 Current Path

![Figure 1: Current Path](image)

Figure 2 depicts the voltage rise curve used to demonstrate step and touch voltages. As the distance from the contact between the fault and the earth increases, the amount of resistive soil in between also increases.

![Figure 2: Voltage Rise Curve](image)

**NOTE:** The distance from the fault to points A and B depend on fault magnitude and soil resistivity.

Step, touch, and transferred touch voltages occur when there is a difference in potential between two points (Refer to figure 3). These voltages result from the energization of a grounded conductive object either by accidental energization or through continuous induced current.
A. Protection against step and touch voltages may be accomplished in three ways:

- **Equipotential** is obtained by keeping the person and reaching limits confined to an equipotential surface.
- **Insulation** is obtained by using insulated platforms, footwear, gloves, etc. insulated from the maximum anticipated fault or induced current at the worksite.
- **Isolation** is accomplished by limiting or restricting the approach distance to grounding systems with barricades or fencing. Barricading is the most efficient way to protect against step and touch voltages.
B. Thorough job preplanning is the key to establishing an equipotential zone or work site. Preplanning includes knowing the layout of the job site; the location of needed equipment, tools and materials; and where workers will need to be. Preplanning should also take into consideration the job site soil conditions and terrain, expected weather conditions, available fault current and characteristics, and any nearby energized lines. Using this information, a strategy should be developed to provide a safe worksite using grounding, insulation, isolation, or a combination of these methods.

7.7.3 Switchyard and Substation Protective Grounding Standards

The following grounding standards shall be followed when performing work on de-energized switchyard and substation equipment and lines:

- Cianbro crews shall install their own personal protective grounds as required to guard against accidental and/or induced voltages and shall not rely on the grounds that may be installed by other contractors or crews not directly involved with the specific work activity. In certain circumstances the Utility’s grounding rules may require that we deviate from these rules in order to comply with their rules. In these cases, Cianbro will follow the rules of the utility as long as they provide adequate protection for our Team Members.
- High voltage lines and equipment shall be considered energized and appropriate minimum approach distances adhered to until testing is complete and protective grounds are installed.
- Work on de-energized equipment and lines must be performed with protective grounds on each phase of the electrical system.
- Grounding cables should be visible from the work area.
- Grounding cables should be installed expeditiously after testing for no line potential.
- No switch or circuit breaker shall be used to maintain continuity between the protective grounds and the work area.
- Protective grounds should be installed as close to the work area as possible to minimize exposure voltage but, not so close that they may endanger the workers from whipping due to electromechanical separation forces in the event of a fault. In general, the grounds should be installed within reaching distance of a hot stick. Care must be taken to securely tie the cables to the structure to minimize cable movement under fault conditions.
- Do not coil grounding cables when installed.
- Shorter cable lengths reduce the electrical resistance and thus lessen the voltage drop across the grounding cables. Shorter cables are also lighter and easier to handle and reduce the chance of injury due to whipping during a fault.
- Verify the station ground connection you are attaching to is intact and grounded properly before connecting personal protective grounds.
- Size of ground cable should be adequate to handle maximum anticipated fault current. Copper cable sized 4/0 AWG is required for substation applications unless the customer utility has performed engineering studies and have standards that allow smaller sized grounds. Use of two ground cables per phase may be necessary where fault current-time energy values may exceed fusing current-time capability of a single ground assembly. Additionally, it is standard to use two ground cables for drops greater than 30-feet. When two ground cables are used they must be of equal length and be located as close to one another as possible to minimize any circulation of currents.
- Personal protective grounding shall be applied to de-energized lines or equipment with a nominal voltage rating over 600 volts. It is not necessary to ground equipment under 600 volts as this may create unnecessary hazards due to limited approach distances and close proximity between conductors and grounded parts. If circuits are not grounded, they shall be rendered safe through Job Hazard Analysis and the establishment of an electrically safe work area.
- Make sure there are no fuses, disconnects, recloser switches, breakers, and/or transformers between you and your trip ground.
• “Grounds may be removed temporarily during tests. During the test procedure, the employer shall ensure that each team member uses insulating equipment and is isolated from and hazards involved, and the employer shall institute and additional measures as may be necessary to protect each exposed team member in case the previously grounded lines and equipment become energized.” OSHA 1910.269(n)(9).

• If two bare conductors are to be spliced, the conductors shall be bonded and grounded before being spliced. An example where this is applicable is when a ground grid section is damaged or severed during excavation operations and requires a splice.

• When grounds are applied, team members on the ground must keep clear of any ground attachments or grounded equipment to avoid the risk of step potential hazards. Also, possible whipping action of the grounds caused by a fault could strike and cause injury to anyone within a close distance.

It is common to hear “If it’s not grounded it’s not dead”. Remember, installing a ground cable does not mean you have rendered the system dead. The system may still become energized from accidental faults or from continuous induced voltages. Installing ground cables only ensures a short-circuit path to ground.

7.7.4 Switchyard and Substation Equipment Grounding Guidelines
A. When determining the location and placement of personal protective grounds within a de-energized work site, it is important to consider all potential sources of voltage including faults from accidental re-energization of lines and induced voltages from adjacent parallel energized lines or equipment.

B. The following examples illustrate proper grounding methods for several work situations.
• Example 1: A substation crew is installing line taps at the top of the dead end structure between the 115kV line and line switch (Figure 1). The proper placement for personal protective grounds is PPG 1 and PPG2. In these locations the grounds positioned on each line phase will satisfy and protect against both accidental fault current through the transmission line and induced voltages from nearby energized lines and the grounds on the bus will give protection at the open blade of the line switch providing a work zone that does not break the listed unqualified work distances. Placing grounds at location PPG 2 alone would not protect the workers on both accounts since the workers would be in a dangerous position upstream of the grounds and the open line switch would not allow induced voltages to bleed off through ground PPG 2.

![Figure 1](image-url)
• Example 2: A substation crew is adjusting disconnect switch #2 (Figure 2). The proper placement of personal protective grounds is PPG 2. Although PPG 1 would protect the workers against accidental re-energization of the 115kV line upstream of them, PPG 1 would not be the best position to protect against induced voltages and it would violate the rule that we never depend on a breaker as part of our grounding protection plan. PPG 2 is the only choice since it is closer to the work area and is connected to the switch being worked on.

7.7.5 Preferred Grounding Points
A. New installations should include attachment points which accommodate the standard lengths of grounding cable. Welded grounded studs should be utilized when possible otherwise, grounding cables should be attached to the conductor, bus, or cable and the substation ground grid or, if necessary, a steel structure.

B. In the order of most effective to least effective, the following guideline should be utilized to ensure effective personal protective grounding.
   • Designed ground point or ground bus
   • Substation ground grid
   • Common Neutral
   • Multi-grounded system
   • Structure ground – Pole ground rod, footing ground, etc.
   • Grounded steel structure
   • Temporary driven ground rod

7.7.6 Procedure for Attaching Personal Protective Grounds
A. Prior to installation of any personal protective grounds the establishment of an electrically safe work area must be met (Refer to section 7.6).

B. The following identifies the general procedure for attaching personal protective grounds:
   • Inspect all ground assemblies.
   • Clean structural grounding stud or grounded attachment point to ensure good contact.
   • Wear appropriate PPE required for specific grounding task.
   • Test for no potential at exact locations where grounds are to be installed.
   • Tightly attach the ground clamp on the grounding cable.
   • Tighten the ground clamp locking bolt.
   • Clean equipment grounding stud, bus or cable terminal.
• Tightly attach the ground clamp to the equipment grounding stud, bus or cable terminal.

C. For Individual Phase Grounding where each phase is grounded separately to the ground terminal:
   • First, attach one end of each grounding cable to the ground source attachment point.
   • Second, attach the other end of each ground cable to the equipment grounding point for all three phases.
   • When removing grounds, first remove the equipment grounding connections. Second, remove the grounding terminal connections.

D. For Phase to Phase Grounding where grounding cables are connected in series across each phase:
   • First, attach one end of the cable to ground. Attach the other end to the nearest phase to be grounded.
   • Second, attach one end of a second cable to the first phase grounded. Attach the other end to the second phase to be grounded.
   • Third, attach one end of a third cable to the second phase grounded. Attach the other end to the third phase to be grounded.
   • When removing the phase to phase grounds, reverse the above procedure, always disconnecting the ungrounded end of each cable first and working from the last phase grounded back toward the grounding terminal end of the first grounding cable.

E. For vehicle and construction equipment grounding:
   • Parked vehicles that are involved in the substation work activities or in the general area shall be grounded to the station ground grid or mat.
   • Vehicle ground cables shall be completely removed from any reels or holders and laid to minimize inductive effects. Under no circumstances should a ground cable be coiled when in use.
   • When applying grounds, it is recommended that attachment be made to the vehicle or construction equipment ground point first, then to the substation ground grid to prevent arcing near the vehicle or equipment’s fuel source.
   • When working out of non-insulated aerial lift baskets, a ground cable should be attached to the frame of the lift equipment and it is recommended that a bond jumper be installed from the basket to the conductor(s) or device(s) being worked on prior to handling the conductor or device. This is to ensure workers in the basket are maintained at the same potential. The bond is recommended since there may be too many poor conducting connections through the aerial lift to the ground connection at the base of the lift. The bond may be established using a suitable personal protective ground installed directly between the conductors or devices and the platform as soon as possible after positioning and should remain in place as long as work is being performed. Bonding cables should be used in addition to any required grounding cables. Site supervisor shall evaluate when bond jumpers are required. Bond jumpers shall be a minimum size #6 AWG copper.
   • The correct T-Handle Flat Face grounding clamp or suitable equivalent must be used on all equipment that does not have a pre-fabricated grounding attachment.
   • Equipment grounds shall be installed immediately after the equipment is moved into position to avoid a static charge build up.

7.7.7 Ground Cable Assemblies
A. When fabricating temporary grounds, Cianbro will adhere to the following procedures:
   • Select appropriate ASTM approved ferrule for the type of clamp being used.
   • ASTM F 855 Grade 5 Copper Ground Cable size 4/0 AWG shall be used for all ground cable assemblies used in substations.
   • Cut 4/0 copper grounding cable to the desired length.
• Refer to the insert distance specified on the ferrule and strip 4/0 lead to that specified length. (Usually 2 ¼”, depending on ferrule type).
• Be sure that the open ferrule edge buts up against the edge of the cable insulation to verify that the bare copper lead is fully inserted.
B. Identify the manufacturer’s groove indicators located on the crimping end of the ferrule for placement of each crimp.
C. Crimp the ferrule to the 4/0 copper by following the groove indicators using a Burndy Y35 or equivalent hydraulic crimper.
D. Inspect the connection to ensure that the conductor cable is in place and secure.
E. Install a 5”-6” section of heat shrink tubing over the ferrule crimp barrel and cable and heat shrink into position.
F. Attach the corresponding clamp to the ferrule terminal in accordance to the manufacturer’s instructions. Be sure that the solid portion of the ferrule is placed directly between the saddle clamp and the conductor clamp.
G. Tighten the saddle clamp bolt (approximately 25 ft-lb torque).
H. Install stamped tag onto ground lead identifying the following information:
   • Cianbro Corp.
   • Size of Grounds (4/0 required for substations)
   • Testing Specifications
   • Date Fabricated
   • Date Tested
I. Test grounds using Cianbro’s protective-grounding-set tester manufactured by Chance Power Systems. Be sure to follow the manufacturer’s operating procedures and apply the correct voltage specified for that size ground cable (specified voltages are identified on the tester).
J. Prior to conducting the protective ground test, the person conducting the test must watch the manufacture’s instruction video on how to operate the tester. The Chance tester identifies the resistance of the ground lead, which is indicated on a digital display panel. The tester then compares the resistance (milliohms) to the preset threshold, which should always be set for 4/0 when testing substation temporary grounds. If the ground lead has less resistance than the preset amount, then the tester will flash a green “Pass” indicator. If the grounds have a higher resistance, then the tester will flash a red “Fail” indicator.
7.7.8 Field Maintenance & Inspections of Personal Protective Grounds

- Ensure that the cable and clamps are properly sized and rated for the specific application. 4/0 ground cable assemblies are required in substations.
- Make sure cables are properly terminated and compression connected in the ferrule.
- Ensure there are no broken, frayed, or discolored stranding and that there are no fused-ferrule terminations.
- Inspect cable for kinks, twists, scuffs, or cuts in the insulation or conductor before each use.
- Ensure that the serrated jaws, clamping jaw pins, and other clamping equipment is operating properly and is not excessively worn. Look for broken or loose fittings.
- Verify that the grounding cable connection to the grounding clamp is tight.
- Clean ground clamps and attachment points with wire brush prior to each use.
- Lubricate all moving clamp parts as needed.
- When ground leads are not in use, they shall be coiled and stored on hanging racks away from any equipment or tools that could possibly pinch or damage the ground clamps or cable.
- Immediately repair or replace any grounding cables that do not satisfy all of the inspection requirements.
- Always test any suspect or repaired temporary protective grounds using approved testing set. Test new ground cables after assembly and test used cables after repair.

*Ground assemblies are designed to save lives and should be respected and treated like any other life saving equipment!*
7.7.9 Voltage Detection Methods and Equipment

- Voltage detection is the process of sensing voltage on a line to determine whether or not line voltage is present and is used only for conformation of electrical isolation. The test is not a test for induced voltage. It should be noted that induced voltages may cause the tests to falsely indicate an energized circuit. A common method of voltage detection is:
  
  - Tic Tracers are not allowed to be used when identifying or testing energized conductors.
  - Voltage indicators may be used in lieu of noisy testers which offer an indication of the voltage levels present. Knowing the voltage level may help the operator determine if the source of the voltage is an induced voltage or an energized conductor.
  - If noisy tester indicates that a voltage is present, do not assume it is only an induced voltage / static charge.

- As with any tool or device, voltage detection tools are subject to failure or malfunction. It is therefore important to “Test the Tester” during the voltage detection procedure by holding it to a known source of power. Some common voltage detectors include:
  
  - Neon Indicator – Used on the end of a live line tool. It will produce a clear visual indication when in the vicinity of an energized circuit. The Neon Indicator is limited in its application and may light up because of induced voltage from a nearby line.
  - Hot Horn or Noisy Tester – The noisy tester voltage detector sounds an alarm to alert personnel that voltage is present. Many testers will give a signal despite the type of voltage on the circuit. Other types are equipped with two pitches to differentiate between circuit and electromagnetically induced voltages. These are battery operated devices.

- Voltage Detection Procedure
  
  - Prior to any work, the team member(s) must confirm that the line or bus has been de-energized and is tagged out.
  - The initial activity to take place is the inspection and length determination of the hot stick and noisy tester.
  - All proper PPE (reference 7.7.10) must then be applied and inspected.
  - The qualified team member must then confirm that the voltage detector is working properly by “testing the tester” to a known energized source. If the voltage detector activates and identifies the energized source as live, then the first confirmation is complete.
  - The qualified team member will then test the conductor at the location where they will be attaching their grounds. All phases require testing.
  - To confirm that the voltage detector has not malfunctioned during the process, the team member must then re-test the voltage detector by holding it next to the known energized source to confirm that the voltage detector is still performing accurately.
  - If the voltage detector does not pass either the first or final energized source test, then the team member must replace the malfunctioning voltage detector with a new one and must start the testing procedure over again from the beginning.
  - If both tests are accurate and conclusive, the team member may now apply their personal protective grounds.
## CIANBRO SUBSTATION PPE REQUIREMENT MATRIX

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Policy: 051 Electrical Substations
Rev. 06/03/2011
7.8 Work in Energized Cabinets and Panels

Refer to Cianbro Electrical Safety and Arc Flash Protection policy and procedure (Policy 020) for detailed safety requirements and procedures for working in energized cabinets and panels.

7.8.1 Written activity plans must be developed which address the specific work to be accomplished and all electrical hazards associated with it. Activity plans should be based on inspection of the work area and elimination, isolation, or control of identified hazards. A competent supervisor must be assigned to coordinate planning and monitor activities. Activity plans must be communicated with all persons associated with the work, prior to the commencement of the work. The flash protection policy should be followed as close as possible when working on energized panels & equipment, but may be altered if policy procedures create an increased possibility of incident or hazard.

7.8.2 Work on energized panels or equipment is prohibited, however necessary when working in substations and utility areas. Whenever possible, electrical equipment must be de-energized, tested, and positively locked-out in accordance with Cianbro’s Zero Energy State Policy and Procedure prior to conducting any work on or around it. Energized work will only be done, as an exception, when the work cannot be done with the equipment in an electrically safe working condition. For work on or near live electrical parts 50 volts or more, reference NFPA 70E Article 130.1 “Work Involving Electrical Hazards - Justification for Work”. This indicates that if live parts are not placed in electrically safe working condition, the work to be performed shall be considered energized electrical work and shall be performed by written permission only. A completed Cianbro Energized Work Permit is required.

7.8.3 Work on live circuits will require using specialized equipment and protective clothing following OSHA, NEC, and NFPA 70E guidelines. Client’s requirement shall also be considered.

7.8.4 Work on or adjacent to live circuits in confined spaces or enclosed areas with limited space will require the use of protective shields, barriers, or insulating materials to prevent team members from inadvertently touching electrical hazards. Ladders used for access to such areas must be non-conductive. Protective barriers must also be considered if team members are required to work with or handle conductive materials adjacent to the electrical hazards. Adequate lighting must always be provided in areas that contain live electrical parts.

7.8.5 There must be a minimum of two Cianbro team members, one being a qualified electrician, working at all times in an Electric Room when panels are open. No team member will ever be left alone.

7.8.6 All other work in an Electric Room will be evaluated for electrical hazards by a qualified electrician. If electrical hazards are not found to exist, work may proceed until change in conditions occurs. Should a change occur, work will be stopped and reevaluated by a qualified electrician.

7.8.7 When leaving the work area where energized parts are exposed, adequate barricades, guards, or temporary cover will be put in place as to prevent any unqualified team member or passer-by from possible contact with energized parts. If temporary covers are used, they must be of voltage rated non-flammable material. Signage shall be placed on all areas of entry explaining specific hazards and the voltage of each cabinet or panel.
7.9 DC Battery Safety and Handling

7.9.1 There are five major hazards associated with the handling and installation of industrial lead acid batteries.

- Hydrogen Gas
- Sulfuric Acid
- Electric Shock
- Weight of Batteries
- Lead Awareness

Hydrogen gas is the by-product of the batteries charging process and is one of the reasons why exhaust fans are required in control houses. Hydrogen gas is both flammable and explosive if concentrated. Sulfuric acid is a highly corrosive material that will burn both skin and eyes if contact is made. Electrical shock hazards are always present if the terminals are exposed, which they usually are in substation DC systems. Even disconnected terminals have the potential of electrical shock. Accidental shorting of battery terminals can cause severe electrical arcing to nearby personnel. Batteries can be very dense and heavy thus proper lifting techniques must be used to prevent back injury or strain. Battery posts may contain lead. Proper PPE and precautions must be addressed in the Job Hazard Analysis prior to terminal post cleaning operations.

7.9.2 Fire and Explosion Prevention

- Terminal shorts can occur when crossing terminals with a conductive object (tools, pipes, etc.), which can causes explosions. Consider waiting to install terminal connector bars until just prior to batteries being put into service to avoid exposure to a higher series voltage.
- Be sure that the battery bank area has proper ventilation prior to working on or near the batteries to prevent hydrogen gas build-up.
- Neutralize the static buildup prior to working on batteries by contacting the closest grounded surface.
- Tools and other metallic objects must be kept away from uncovered batteries.
- Prevent the possibility of having a spark or flame near the batteries.
- There must be an ABC dry chemical fire extinguisher in charging areas at all times.
- Covering battery banks with high voltage poly is acceptable to guard against inadvertent contact with the battery terminals provided adequate ventilation is maintained under the poly sheet. Otherwise, dangerous levels of hydrogen gas may build up.

7.9.3 Shock Prevention

- Never touch both battery terminals with your bare hands and/or at the same time.
- Be sure to remove all conducting objects from yourself before working near batteries, such as rings, watches, and other jewelry.
- Always wear rubber gloves and insulated tools when working on batteries.
- Always be sure that the battery charger is shut off and locked/tagged out before connecting or disconnecting a battery to prevent possible arcing.
- Barricade battery bank when not working directly on the batteries to prevent accidental contact.

7.9.4 Chemical Burn Prevention

- Proper PPE required for the installation and removal of batteries includes:
  - Chemical splash goggles
  - Rubber gloves
  - Face shield
  - Chemical apron or FR chemical rain suit
  - Rubber boots (never tuck pants into boots because spilled acid can pool in the bottom of your boots and burn your feet).
- There must be an acid neutralizing solution readily available at all times.
- To prevent accidental spills or drops, use appropriate and sufficient workers/equipment to load and unload batteries.
7.10 General Substation Safety

7.10.1 Typical hazards and considerations for work in substations

- PCBs (Polychlorinated Biphenyls) Contamination & Safety
  - PCBs are organic compounds that were often used in transformers, capacitors, and PVC wire coatings as a dielectric fluid. PCBs were banned in production due to their high toxicity in the 1970's. The compound can easily penetrate skin, PVC, and latex. Kerosene increases the rate that PCBs absorb through the skin. Studies have proven that high intake of PCBs can lead to multiple types of cancer including liver and biliary tract cancer.
  - Testing for PCBs should be conducted by an approved testing agency in existing substation yards where old equipment was once in service. Soils and concrete foundations are common sources of contamination.
  - PCB exposure symptoms include:
    - Chloracne and rashes
    - Fatigue
    - Headache
    - Cough
    - Unusual skin sores

- SF6 Gas in Breakers (Sulfur Hexafluoride)
  - The stability of the inert SF6 gas causes it to be a very effective electrical insulator and flash extinguisher. These characteristics are why it is used in high voltage circuit breakers. OSHA identifies SF6 gas as having no adverse effects when inhaled in the air at a Threshold Limit Value of 1,000 ppm. The gas is identified through the EPA as a greenhouse gas that can produce 23,900 times the global warming potential of an equal volume of Carbon Dioxide. SF6 is five times heavier than air and is both colorless and odorless. Due to its density, SF6 will displace air and can collect in cable trenches and other confined areas if not properly ventilated. Even though pure SF6 gas is non-toxic, its decomposed by-products, sulfur oxide and metal fluorides can be very poisonous. Both sulfur oxide and metal fluorides are the resulting by-products of electrical arcs within the breakers. The metal fluorides usually take the form of a fine gray powder and have an odor resembling rotten eggs. Removal and installation of SF6 gas from breakers should be performed by a qualified company certified to handle the gas.

- Proper Flagging and Barricades in Energized Yards
  - When identifying and barricading hazardous/energized areas in substations, the use of flagging instead of standard danger/caution tape is required. Flagging is a slightly heavier material than standard danger tape and has a lower probability of breaking and being carried by the wind into energized equipment or conductors. If open trenches and excavations are left over night, hard barricades must be fabricated and installed.
  - Open cable trenches shall be adequately barricaded.
• Working Overhead
  • High overhead work is a common activity in substation construction and can present extreme danger to ground workers who may be susceptible to falling debris and equipment. Team members on the ground must stay clear of all aerial lift work. Barriers shall be erected to prevent workers from accidentally passing through areas where overhead work is taking place.

• Carrying Materials in Energized Yards
  • Due to the prevalence of energized overhead lines and equipment in substations and switch yards, it is required that all material being hand carried through an energized yard must be at waist level or lower. Longer items such as rebar, conduit, and lumber create a greater risk of coming in contact with energized parts. It is suggested that materials be carried below waist level in de-energized substations as well, as this will reinforce proper handling practices in all substations.

• Crane and Hoisting Operations in Energized Yards
  • Due to frequent space restrictions as well as energized substation equipment, the implementation of Cianbro’s Crane Safety Policy (No. 028) and Safe Rigging Operations Policy (No. 008) is essential. Both Cianbro qualified riggers and crane/boom truck operators must meet the General, as well as the Non-Construction work requirements for substation access. Subcontracted crane companies must have established safety policies and plans, as well as meet the Subcontractor Training Requirements referenced in section 7.2.1. All cranes and boom trucks operating in energized substations must adhere to the grounding procedure as noted in section 7.7.6. Grounds must also be applied if the crane is located outside the fence boundary and is either in proximity to energized lines or has its boom within the limits of the energized substation or other energized power lines.

• Asbestos and Lead Paint in Existing Control Houses
  • A common threat that exists in many older control houses is Asbestos and Lead Paint. Asbestos is most frequently found in ceiling and floor tiles. The utility company should have signage within the control house identifying whether or not asbestos is present. In the case that asbestos is present the team members must follow Cianbro’s Asbestos Policy (No. 049). It is in the best interest of team member to minimize any contact or removal of ceiling and floor tiles, even if they are deemed asbestos free.
• Lead paint is another threat that must be foreseen in many aged substations. If the existence of lead paint is identified in an area Cianbro will be working, the team must refer and abide to Cianbro’s Workplace Protection Program for Lead and Other Heavy Metals Policy (No. 006).

• Protection of Gas Bottles and Containers
  • Gas bottles used during substation construction shall be either contained in a bottle cart/station while on site or tied off to a solid structure, such as structural steel. Also, all fuel containers must be stored in a fuel cabinet or double lined tank when not in use. With the amount of equipment traffic and welding required, it is imperative to keep gas and fuels from being struck and away from possible sparking.

• Demolition in Existing Yards
  • Demolition in existing yards must be treated in the same manner as construction; with adequate planning, grounding procedures, and the same work practices identified throughout Cianbro’s Substation Safety Policy. In the event that foundations are removed or chipped below ground, there is always the threat of PCBs and Silica Dust. Silica is a fine particulate dust from quartz rock that is known to cause a progressive lung injury over a long term. If any concrete demo is required, team members must refer to and follow Cianbro’s Concrete Demolition Safety Bulletin and Workplace Crystalline Silica Protection Program.

• Fall Hazards and Tie-off Rules
  • Since most mechanical work is completed in the air, either on a fiberglass step ladder or grounded aerial lift, fall hazards are always present. All team members are required to apply Cianbro’s Fall Protection Program (No. 011) when either working in the air or near excavations. Occupants of a lift whose basket is not in contact with or resting upon the ground shall be in compliance with 100% tie off rules at all times. When in an aerial lift, all team members must tie off to the manufacturer’s tie-off point or mid to lower rail if a tie-off point does not exist.
  • There are minimal, if any, approved tie-off points on top of a transformer. When it is necessary to work atop a transformer, a manufacturers supplied “may pole” should be utilized or, if possible, fall blocks should be positioned directly above the transformer attached to an adequate anchorage point.
  • Team members using a ladder over 6’ must be 100% tied off unless they are climbing or descending facing the ladder with both hands free to securely grip the ladder rungs. During winter months, it is necessary to position your step ladder in an area that is free of ice or is well sanded. Also, it is essential to confirm that the ladder steps are clear of ice or snow to prevent any slipping.

• Insulated Tools and Non-Metallic Tape Measures
  • To fully comply with OSHA 1910.333 (c)(2) and NFPA 70E 2004, insulated hand tools must be used when conducting work in live cabinets and panels, as well as battery installations. All hand tools must comply with IEC 900 and ASTM F 1505-01 Standards for Insulated Hand Tools. With the amount of field measuring done in live substations, non-metallic tape measures shall be required in any location where safe working distances might be compromised with a fully extended steel tape measure.

• Broken Insulator Glass
  • When broken insulator glass must be disposed of, all team members must wear Kevlar or cut resistant gloves while handling. All glass must be placed in a glass specific waste container.

• Equipment Spotters
  • Equipment spotters should be used to assist operators in congested substations or when the following conditions exist:
  • When operators can not see 360 degree around equipment.
• When excavating around buried electrical lines.
• When excavating around buried gas lines and utilities.
• When operator is working within the qualified and non-qualified approach distances to live substation parts and the equipment is in motion.

• A spotter is responsible for meeting the following requirements:
  - Must wear a bright orange or lime vest or jacket if working near moving vehicles or heavy equipment. (Wear reflectorized clothing at night and use a flashlight.)
  - A spotter has authority to stop work if any unsafe condition arises.
  - When assigned as a spotter that is your only responsibility until the assigned task is complete.
  - Always maintain visual contact with the equipment operator to be sure you are seen.
  - Operator and spotter shall conduct an area walk around to identify possible hazards prior to beginning the task.
  - Establish eye contact with the equipment operator before backing them up. Keep operator in sight at all times while backing. If you lose sight of the operator, STOP so they can determine your location.
  - Agree on clear, standard signals, easily understood by both spotter and operator. (Radio communication, audio communication air horn, or hand signals.)
  - If a clear signal is not given, understood, and acknowledged nothing should move.
  - Stay alert at all times.
  - Keep a safe distance.
  - Keep off the equipment unless authorized.
  - Watch out for shifting or unstable loads.
  - Watch out for other equipment in the work area.
  - If spotter needs to leave area, equipment operator must stop operation until they return.

• Utility and Pocket Knife Safety
  - Utility and Pocket Knives are useful and safe tools in substation construction when utilized properly. Therefore, when proper planning, training, and documentation through daily activity plans are implemented for the direct use of utility knives, team members may have the option of using a utility/pocket knife for specific functions. These functions include; stripping/prepping cables; opening packages; and scoring/marking for measurement. The following items need to be addressed prior to and during the use of utility knives:
    - Is the knife blade appropriate for the job?
    - Is the handle large enough to provide a secure grip?
    - Always cut in a motion away from the body, and away from other people and hazards.
    - Keep other hand, fingers, and thumbs out of the way when cutting.
    - Wear cut resistant gloves and cut resistant sleeves when stripping cable or performing other repetitive tasks.
    - Utility and pocket knives shall not be used to cut plastic tie wraps, tie wire, or other similar materials. The correct tool for the job shall be selected including side cutters or metal snips.
    - Only extend out the minimum amount of blade necessary for the task.
    - Knives shall be folded / retracted and stowed after each cut / use. Do not set the tool down without first retracting all exposed sharp edges or blades.
• Cable Stripping Safety
  • Before selecting a utility knife for stripping cable, consider all available stripping tools designed specifically for the task.
  • The best method for stripping back cable sheathing is to use the string installed inside the cable by the manufacture.
  • Have the supervisor review and approve your method of stripping.

• Working on Substation Equipment and Pressure Vessels
  • It is standard practice not to drill, weld, cut or otherwise alter any manufactured equipment particularly, pressurized or vacuum filled equipment, without specific approval from Owner, Owners Engineer, or Equipment Manufacturer. If authorization is granted, specific instruction shall be provided detailing the nature of the alteration and the work shall be addressed in the daily activity plan. When possible other less invasive methods of attaching conduits and accessories to equipment shall be considered such as welded studs, epoxy adhesives, edge clamps, beam clamps, and other types of fasteners.

8 Budget / Approval Process

  8.1 It is the responsibility of each jobsite to procure and provide all materials and PPE required and provide necessary training.

9 Related Documents

  9.2 OSHA 1910.269 Regulations for Electric Power Generation, Transmission, and Distribution