



Live-Line Procedures Manual

Live-Line Hot Stick Work Methods

Introductory Material



Live-Line Procedures Manual

Part 1:

Live-Line Rigging

Introductory Material

Contents

Foreword	v
Scope	v
References	v
1. Introduction	1
1.1. How Live-Line Tools Are Manufactured	2
1.2. Care of Live-Line Tools	3
1.3. Daily Inspection and Cleaning of Live-Line Tools	4
1.4. Care of Cover-Up	5
2. Definitions	6
3. General Requirements	8
4. Work Zones	10
Zone 1	11
Zone 2	11
Zone 3	11
5. Work Positioning	12

Introductory Material



Live-Line Procedures Manual

Foreword

This manual has been prepared as a guide for Live-Line work on PG&E's transmission system. It is not the object of this manual to provide detailed instructions covering the procedure of every hot-line tool Live-Line maintenance job. This would be impossible due to the great variety of jobs and types of line construction and special conditions. Every pole is unique. This manual is intended to be used as a guide to general concepts and methods employed in the most fundamental operations of Live-Line maintenance work with hot sticks and a hydraulic power arm.

Scope

This Live-Line hot-stick work methods manual covers the replacement of insulators, cross arms, or a total structure replacement of PG&E's overhead transmission infrastructure. The complexity of PG&E's transmission system requires that these procedures be performed in a uniform and highly disciplined manner. Anyone working on PG&E's transmission system shall follow all procedures detailed in this manual. These procedures have been developed in accordance with Cal/OSHA Title 8, Subchapter 5, Group 2, Article 36, 2941 "Work Procedures and Operating Procedures."

References

Cal/OSHA Title 8, Subchapter 5, Group 2, Article 36, 2941

"Work Procedures and Operating Procedures"

PG&E Switching and Clearance Procedures

IEEE 516—2009 Guide for Maintenance Methods of Energized Power Lines

ASTM F478-09 Standard Specification for In-Service Care
of Insulating Line Hose and Covers

ASTM F479-06 (2011) Standard Specification for In-Service Care of Insulating
Blankets

Introductory Material



Live-Line Procedures Manual

1. Introduction

Live-Line maintenance has been made possible by the development of special tools and procedures for the work. The demand for performing maintenance operations using Live-Line methods is constantly increasing due to an ever increasing distribution and transmission network and the necessity of maintaining continuous electric service. Continuity of service is very important to the customers of PG&E. Continuous service is possible through the use of Live-Line maintenance.

The maintenance of energized or “hot” high-voltage lines may appear to be hazardous, especially when compared to working on “dead” or de-energized and properly grounded lines. Actually, the work is completed safely when the lineman is continually conscious of the fact that the lines are “hot” and the need to be careful to follow correct procedures. There is no possibility of the line being “hot” when it was thought to be dead, as there is when working on de-energized lines. Also, there is no possibility of confusion with live duplicate circuits, in Live-Line work methods, every conductor is worked “hot” and every operation is planned and worked accordingly.

The most common of these Live-Line operations are:

- Replacing insulators
- Replacing cross arms
- Replacing poles
- Tapping an energized line
- Cutting in or removing conductor slack
- Splicing conductors
- Installing armor rods
- Installing vibration dampers



1.1. How Live-Line Tools Are Manufactured

Live-Line tools made of Epoxiglas are superior to wood and laminated wood tools. They are stronger both mechanically and dielectrically and are more resistant to impacts and abrasion. Moisture does not materially affect the insulating quality of epoxiglas tools.

Epoxiglas tools are produced by a patented process which positions epoxy resin-impregnated electrical grade fiberglass strands parallel to and around a polyurethane foam core. The epoxy resin is then cured by heat and pressure.

The rigid polyurethane foam core performs three functions. It serves as a precise diameter mandrel for the fiberglass strands of the outer shell. It increases the overall hot stick strength. It also permanently seals out moisture.

Thousands of small unconnected cells make up the core. Since each cell is closed, condensation cannot form. Moisture cannot travel from one cell to another. Moisture cannot migrate through the hot stick.

The high glass and low resin content of the stick shell develops maximum strength with minimum weight. The fiberglass strands are laid in spiral and longitudinal layers under tension on the core for the highest strength and surface uniformity. Maximum adhesion between strands and to the foam core is achieved by bathing the fiberglass strands in an epoxy resin before wrapping.

Avery tough fiberglass surface coating has greater resistance to impact and abrasion than other finishes. This helps to prevent fracture of the fiberglass fibers. The smooth high gloss finish resists solvents and is easy to keep clean.

Every inch of Epoxiglas pole is electronically monitored during the manufacturing process to assure dielectric consistency. The dielectric value of a new pole is 100 kV per foot. Each run of pole is also tested mechanically to ensure quality and consistency.

Epoxiglas Live-Line tools will retain indefinitely their dielectric and mechanical strength if given the proper care.



1.2. Care of Live-Line Tools

Extreme care is exercised in the manufacturing process of Live-Line tools. Care should be used to protect these tools. Proper care will result in not only longer tool life, but will contribute to the safety and confidence of the user.

Care of the tools begins with storage and transportation. The hot sticks should be stored and transported to the job site in a hot stick trailer. The hot sticks should be mounted on racks and securely strapped in place to avoid damage to the tool surface. These racks should be well padded.

The hot stick trailer is equipped with a heater so that it may serve as a drying cabinet when the tools are being stored between jobs. Saddles, lever lifts, clamps, hoists, rope blocks, hot rope and cover up equipment should be stored carefully in bins or containers in the tool trailer. Jack screws should be padded so that their threads are protected.

One of the most important factors in the care of Live-Line tools is to keep them clean and dry. They should never be laid on the ground. The hot sticks always should be placed on the tool racks or leaned against a truck. All conductor covers, hoists, rope blocks and Live-Line tool components should be placed on tarpaulins to keep them clean.

Care should be exercised when removing and storing tools in the tool trailer. A dirty tool should never be placed into the trailer. All hot sticks should be wiped down before returning them to their proper place in the trailer. If the tools are carelessly stored in the hot stick trailer, they can be damaged during transport.



1.3. Daily Inspection and Cleaning of Live-Line Tools

All Live-Line tools should be inspected and cleaned before and after each use. Field repair or modification of tools is not permitted. If after inspection, there is any doubt about the condition of a tool, it should not be used and be removed from service. The tool should be repaired and tested before being used on the job.

The hot sticks should be placed on tool racks and their surface inspected for dirt, creosote, grease or any other foreign contaminating material. If surface contamination is found, the stick must be cleaned with an approved hot stick cleaner and wiped down with a silicone cloth. If the hot stick has a clean glossy sheen clean and no surface contamination is found, the stick may be wiped down with a silicone cloth to remove dust.

- Inspect all hot stick attachment points for indications that the tool may have been overstressed. Check all metal parts for excessive wear and damage. Cracked, bent, broken or missing rivets or bolts indicate excessive strain or stress. Excessive strain will overstress the parts and weaken them, and weakened parts may cause the tool to fail.
- Inspect all saddles, lever lifts, clamps, etc., for bent or missing parts. Ensure that all rivets and bolts are in place, tight, and not damaged or deformed.
- Inspect all slings and rope for excessive wear. Look for small cuts or abrasions that can compromise the ultimate strength of the rigging equipment.
- Inspect rope blocks for damaged rope or sheaves. Sheaves can be cracked or missing parts.
- Inspect hoists for bent or missing parts. Inspect straps for contamination and small tears and abrasion.
- Inspect wire grips for proper alignment of the jaws and bent or missing parts. The grip should be clean and free of any residue of any kind.
- Inspect hot rope for abrasions and overall cleanliness. Hot rope should be stored in its own clean, dry container.
- Never lay any Live-Line tool directly on the ground. Always use tool racks and a clean plastic or vinyl tarpaulin to stage tools for use.

1.4. Care of Cover-Up

Thorough Visual Inspection. Visual inspection of each piece of cover just prior to use is required and important. Each cover should be inspected inside and out for cracks, deep gouges and contamination. Check to make sure that each grip-all adapter is secure and that all fasteners are in place. If there is any question that a cover is not suitable for use, it should be immediately be set aside for later cleaning, electrical testing, or discarding. Plastic cover cannot be repaired.

Careful Handling During Installation And Removal. Line workers should become acquainted with any unfamiliar cover-up equipment before actually using it up on a pole. The line worker needs to know how each piece of cover is installed, coupled, adjusted and removed. Rough handling can damage and shorten the life of hard plastic cover.

Cleaning. Proper and frequent cleaning of cover-up equipment is required. Dirt, creosote and conductor wire residue can be conductive and needs to be removed from the cover regularly. Covers are regularly slid along a conductor, cross arm or pole during installation and removal. This sliding action picks up contamination that can compromise the dielectric properties of the cover and cause scratches and gouges. Cover-up should be cleaned when it appears dirty. Mild soap and water are recommended for cleaning all cover-up materials. Strong household and industrial cleaners can cause permanent damage to some cover-up materials. Always follow manufacturer's recommended cleaning procedures.

Proper Use. Cover-up is designed and rated to provide safety protection for momentary incidental or brush contact only. Cover-up should never be intentionally used in continuous direct contact between line and ground voltage, or phase-to-phase voltage. MWD must always be maintained, even when using 69 kV line guard. Cover-up should not be left on conductors or structures for extended periods. Corona and UV damage may occur. Cover-up can be safely left up overnight if necessary.

Proper Storage. Store cover-up in a clean, dry location. The hot stick trailer is ideal for this. Prolonged exposure to sunlight is detrimental to cover-up. Cover-up equipment should always be stored in such a way that the original intended shape is preserved. Line guards are designed to have specific air gaps and flashover distances in order to achieve a specific electrical rating. Distortion can alter the electrical characteristics of the cover-up.



2. Definitions

Affected worker—An employee whose job duties require them to work in areas (Zone 1 & 2) during the operation, maintenance and construction of exposed energized conductors and equipment.

Energized—Electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of ground.

Exposed—Not isolated or guarded

NOTE: Rated insulated cover-up or insulated rubber gloves do not eliminate exposure. If energized conductors and equipment are exposed, a minimum of two qualified electrical workers shall be present at the work site.

Extended reach—The distance a worker can reach with a conductive object in an unprotected hand (screw driver, tape measure, armor rod, etc.)(See Figure 5.1).

NOTE: Unprotected hand is defined as a worker not wearing rated insulated gloves, or gloves and sleeves, and not using the rubber glove work method.

Insulated Cover-up—An insulating device rated for the voltage involved (line hose, plastic cover-up, blankets, etc.).

Inadvertent movement—An industry-accepted safety factor distance added to the MAID. If the worker was to accidentally enter this area with any part of their body, there would not be an arc flash. The inadvertent movement from 750V to 72.5 kV is two feet, and one foot from 72.5 kV and above.

Live-Line Hot-Stick Work Method—A work procedure which uses insulated Live-Line tools to install, move, remove and repair exposed energized conductors and equipment. Live-Line tools are often used as an extension of qualified electrical workers' arms, allowing them to position themselves where they will not reach into the MAD, and provide adequate insulating capability. Live-Line tools are typically constructed from fiberglass rods and, when in good condition, are rated for 100 kV per foot.

Mechanical equipment—Vehicles and equipment, including un-insulated manlifts, digger/derricks, boom trucks, cranes, directional boring equipment, trailers, and pulling and tensioning equipment used in stringing conductors, cable pulling, etc.



Minimum air insulation distance (MAID)—The shortest distance in air between an exposed energized conductor or equipment and a grounded surface (cross arm, pole, worker, pole ground, etc.), where the air's insulation will not allow an arc flash from the exposed energized conductor or equipment and the grounded surface. The MAID is dependent on humidity, altitude, air contaminants, smoke, impressed voltage, and transients.

Minimum approach distance (MAD)—The minimum air insulation distance (MAID) plus a factor for inadvertent movement.

Non-Reclose—The certification by the system operator that a specified conductor, cable, or equipment, controlled by the system operator, has had the automatic reclosing disabled, and a non-reclose tag has been placed next to a reclose control switch. A non-reclose order ensures the specified conductor, cable, or equipment will not be re-energized without approval from the clearance holder holding the non-reclose order.

Reach—The distance a worker can reach with hand and fingers fully extended.

System Operator—An authorized employee designated to operate PG&E's T&D system. The system operator has the authority and responsibility for all switching and clearances on distribution and transmission conductors, cables, stations, and equipment, operating at 600 volts and above, owned and operated by PG&E. The system operator issues orders to open and close switches, to place and remove tags, and to de-energize or clear conductors, cables, stations, and equipment on which personnel will work.

Qualified Electrical Worker—One who is knowledgeable in the operation, maintenance and construction of the electric power generation, transmission, and distribution equipment, along with the associated hazards. With proper training they may work in Zones 2 & 3.

Qualified Safety Watch—One whose has been assigned the task of observing the safe work practices of qualified electrical worker(s) performing Live-Line hot-stick work methods. They shall attend a minimum of five days training in Live-Line hot-stick work methods before performing this task. They shall be knowledgeable in the operation, maintenance and construction of the electric power generation, transmission, and distribution equipment involved, along with associated hazards.



3. General Requirements

- 3.1 A job briefing shall be held with all affected workers involved with Live-Line hot-stick work methods before the work begins. It shall include:
- A detailed discussion of the Live-Line work procedure to be used.
 - Identification of all exposed energized conductors and equipment, and the voltages involved at the work site.
 - Hazards involved in the planned work.
 - The minimum approach distance (MAD) for workers and mechanical equipment.
 - The required Personal Protective Equipment (PPE).
 - The required Live-Line tools, insulating rubber goods, and insulating cover-up equipment.
 - The proper set-up location of mechanical equipment.
- 3.2 All qualified electrical workers shall have a minimum of five days of Live-Line hot-stick work methods training before being allowed to perform Live-Line hot-stick work methods.
- 3.3 All anticipated conductor loading and weight, dead-end tension, conductor angles, and guying information shall be assembled. Calculations shall be performed to identify how much stress the structure and Live-Line tools must withstand during Live-Line work methods. All Live-Line tools, safety equipment, blocks, ropes, slings, and other associated tools shall be rated, including the proper safety factors, for the anticipated workloads.
- 3.4 Before beginning any Live-Line hot-stick work procedure, the condition of the structures on either side of the specific work location shall be inspected. The inspection shall include a visual assessment of the condition of the structures, arms, insulators, conductor, tie wires, and hardware. These structures must be capable of withstanding the stress and strain involved with the planned work. If either structure and/or its components are found to be in questionable condition, appropriate measures shall be taken to correct the identified weakness before the planned work begins.



- 3.5 All Live-Line tools required to perform the planned energized work shall be identified, inventoried, inspected, cleaned, and laid on tool racks or a tarpaulin before work begins. All energized Live-Line hot-stick work shall be performed using the proper length and load rated Live-Line tools and equipment. Any Live-Line tool found to be damaged shall be tagged and removed from service.
- 3.6 During the performance of Live-Line hot-stick work methods, a qualified safety watch shall be positioned where they can AT ALL TIMES:
- Observe the work and position of the qualified electrical worker(s) performing Live-Line hot-stick work methods;
 - Warn the qualified electrical workers if they are about to perform an unsafe act;
 - Provide rescue of the worker(s).

The qualified safety watch can be located on the ground if they can perform the duties listed above. However, the qualified safety watch cannot engage in any work or task that would take their total undivided attention away from the qualified electrical worker(s) performing line-line hot-stick work methods. They must position themselves in a location where they have a clear view of the Live-Line hot-stick work being performed. If the safety watch must leave their position, Live-Line hot-stick work methods shall stop until the qualified safety watch returns to the designated position.

- 3.7 Live-Line hot-stick work methods shall not be started during inclement weather, including rain, sleet, snow, smoke, fog, and/or heavy winds. If the weather changes after Live-Line hot-stick work methods have begun, the work should continue, if safe, until an appropriate stopping point is reached.
- 3.8 All Live-Line work methods shall be performed with reclosing disabled.
- 3.9 If exposed energized distribution conductors and equipment are located within the specific work location, the exposed energized distribution conductors, and equipment shall be covered with rated cover-up and/or relocated to extension arms, depending on the planned work. The energized distribution conductors and equipment must be covered or relocated to:
- Ensure workers can safely climb through the distribution space;
 - Allow for any planned rigging and Live-Line tool location set-up;
 - Allow the installation of a new structure, if applicable.

4. Work Zones

PG&E's transmission work areas have been broken into three zones (Zone 1, Zone 2 & Zone 3).

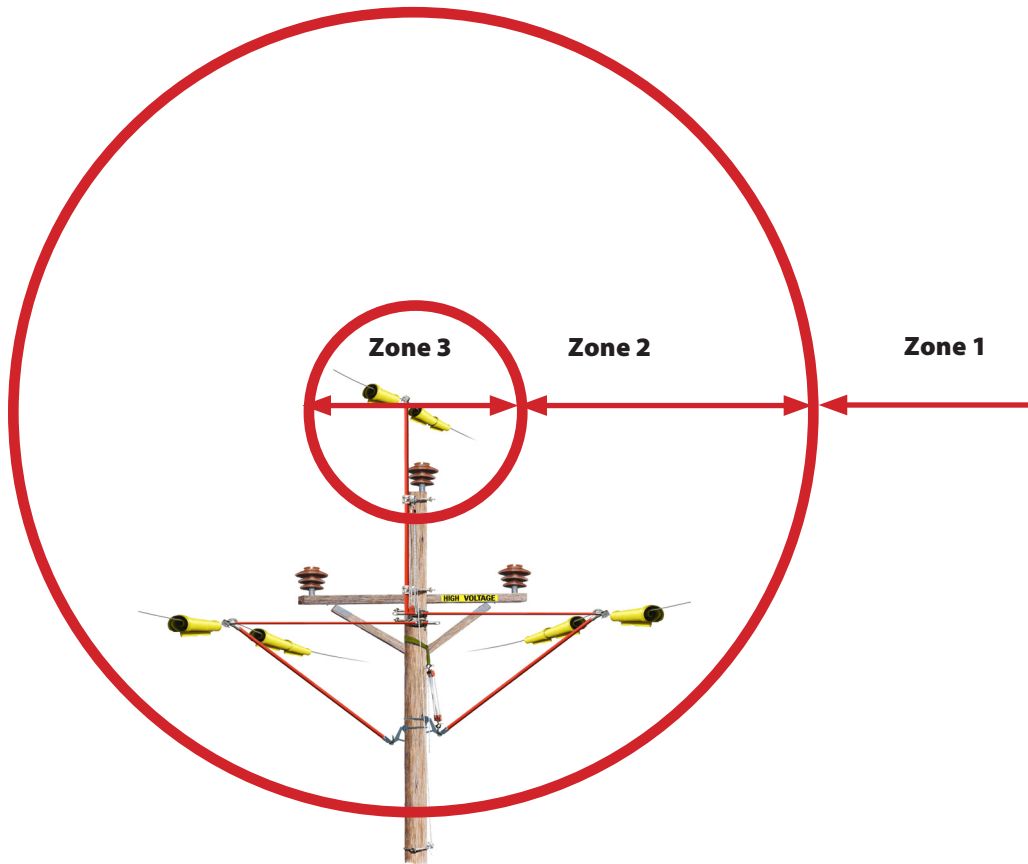


Figure 4.1.

Zone 1

The work area ten feet (10') or more from exposed energized conductors and equipment, energized up to 50 kV. For exposed energized conductors and equipment energized at more than 50 kV the ten foot distance is increased by 0.4 feet/kV (see Table 4.1). If work is to be performed in Zone 1, no workers, mechanical equipment or materials shall come within Zone 2 or Zone 3 without the required additional protection from exposed energized conductors and equipment (see Figure 4.1).

Table 4.1.

kV	Distance (feet)
60	10' 4"
69	10' 7.6"
115	12' 2"

Zone 2

The work area between Zone 1 (the ten foot distance, plus 0.4 feet/kV above 50 kV, and Zone 3, the minimum approach distance (MAD)). If work is to be performed in Zone 2, workers shall be considered qualified electrical workers, and mechanical equipment or materials shall not enter Zone 3 (the MAD) without additional specifications required for work within Zone 3, the MAD (see Figure 5.1).

Zone 3

The work area inside the MAD. If work is to be performed in Zone 3 the exposed energized conductors and equipment shall be covered with rated cover-up before workers enter the MAD. For voltages where rated cover-up is not available, no workers, mechanical equipment or materials shall enter Zone 3 (see Figure 5.1).

5. Work Positioning

While performing Live-Line hot stick work methods, workers shall position themselves where they cannot reach into the MAD, or where they will not extend their reach into the MAD. The term “reach” is defined by the distance a worker can reach with hand and fingers fully extended (see Table 5.1). The term “extended reach” is defined by the distance a worker can reach with a conductive object in their hand (screw driver, tape measure, armor rod, etc.) (see Figure 5.1).

Table 5.1

MAD and MAD + Reach		
Nominal Voltage (kV)	MAD Ø – GND with tools	MAD + Reach
46 – 72.5	3' 0"	6' 0"
72.5 – 121	3' 4"	6' 4"

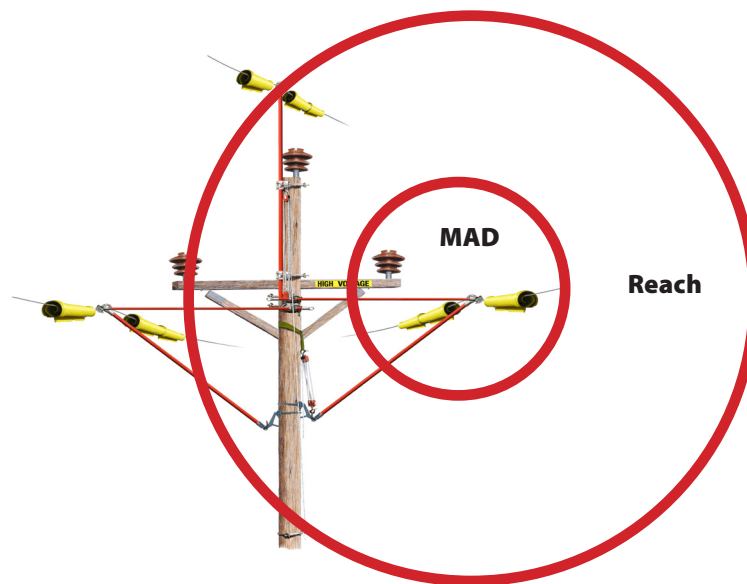


Figure 5.1.