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LIVE LINE MAINTENANCE IN POWER SECTOR

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ABSTRACT

In electrical engineering, live-line working is the maintenance of electrical equipment, often operating at high voltage, while the equipment is energized. The first techniques for live-line working were developed in the early years of the 20th century, and both equipment and work methods were later refined to deal with increasingly higher voltages. In the 1960s, methods were developed in the laboratory to enable field workers to come into direct contact with high voltage lines. Such methods can be applied to enable safe work at the highest transmission voltages.

KEYWORDS: Electrical Engineering, Transmission, High Voltage Lines.

INTRODUCTION

Why Live Line Maintenance

By using live line techniques to maintain transmission line infrastructure, circuits and transmission lines are able to remain in service while maintenance tasks are carried out. This is a major advantage to transmission asset owners because less redundancy is needed in the transmission network. Electricity consumers who are supplied by spur lines (single circuit supplies typically in rural areas) also benefit from live line work. They do not suffer the inconvenience of a cut in their electricity supply every time maintenance is carried out on their supply lines. Given the high cost of transmission lines and the impact that transmission lines have on the environment, there is a major advantage in being able to avoid duplication of assets purely for maintenance purposes.

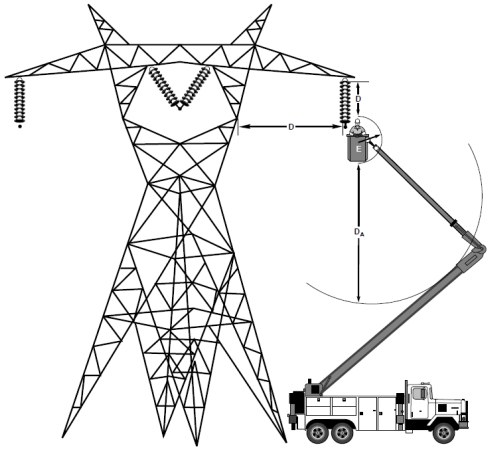

Fig 1: A Linemen in a Bucket Going for Live Line Maintenance.

Live Line Maintenance can be Resorted for

- Changing of insulators
- Replacement of damaged section of conductor
- Testing of insulators (on-line insulator tester)
- Changing of cross arm
- Changing of poles
- Transferring conductor to higher pole

Major Tools Used for Live Line Maintenance

1. **Wire tongs**: Normally used on pin type or suspension type construction for maneuvering and holding live conductors clear of the working area or for transferring to conductors to knee positions.
2. **Wire tongs saddle:** are used to secure wire tongs to a structure.
3. **Tie stick**: used for manipulation of the wires.
4. **Strain link sticks**: used principally for supporting heavy conductor loads either for assisting wire tongs or for supporting entire load when changing insulators on running corners and dead end structures.
5. **Roller link sticks**: used principally to hold conductors aside when relocating poles in mid span.
6. **Suspension link sticks:** principally designed for lifting the conductor to relieve the strain from suspension insulators on high voltage lines.
7. **Strain carrier**: used principally for relieving the strain on conductors when changing insulators on dead end structure.
8. **Auxiliary arms**: used principally for holding conductors while damaged conductors or cross arms are being changed on pole structure.
9. **Double string dead end insulator tool**: normally used to remove the strain from the one side of the double insulator strings.
10. **Gin poles**: Used for lifting heavy conductors, hoisting transformers switches and other heavy items around energized conductors and other objects.
11. **Cum-a-along-clamp**: normally used to grip the conductor when tension is applied to the clamps by rope blocks, link sticks etc.
12. **Safety equipment** like conductor guards, cross arm guards, insulator covers, hand gloves etc.

Techniques Used are

Hot line maintenance is usually done by using one of the following methods:

1. **Hot Stick Method Using Insulated Sticks**

   In this method the linemen is at the ground potential and is isolated from the energized conductor. This method is generally adopted for transmission lines up to 220 KV. The sticks

enable the linemen to carry out the work without infringing minimum clearance distances from live equipment. As experience with the techniques developed, the operating voltages at which the work was performed, increased. With the advent of fiberglass poles in the late 1950s, which neither split nor soaked up rainwater, utilities were prepared to carry out hot-stick working to their highest operating voltages, perhaps 765 kV. Tools, such as hooks or socket wrenches can be mounted at the end of the pole. More sophisticated poles can accept pneumatically or hydraulically driven power tools which allow, for example bolts to be unscrewed remotely. A rotary wire brush allows a terminal to be scoured clean before a connection is made. However, a worker's dexterity is naturally reduced when operating tools at the end of a pole that is several meters long.

2. **Bare Hand Technique**

   In this method linemen works either from the insulated bucket / truck or ladder and is bonded to the energized conductor and isolated from the ground. This method is generally employed for transmission lines above 220 kV. The first procedures for barehand working were developed in 1960 by Harold L. Rorden, a high-voltage engineer for American Electric Power. Techniques were further refined following field and laboratory tests.

There are a number of ways in which the worker can access the live parts:

- The worker can access from a specialist type of mobile elevating work platform (MEWP) termed an insulating aerial device (IAD) which has a boom of insulating material and which all conductive parts at the platform end are bonded together. There are other requirements for safe working such as gradient control devices, means of preventing a vacuum in the hydraulic lines.
- The worker can stand on a insulating ladder which is maneuvered to the line by means of non conductive rope.
- The worker is lowered from a helicopter and transfers himself to the line.
- He is brought alongside the wire in a hovering helicopter and works from that position.

As the lineman approaches the wire, an arc will form between them as his body is charged. Although this arc carries no more than a few micro amps, it is debilitating, and the worker must immediately bond himself electrically to the line to prevent further arcing. He may use a conducting wand during the approach to first make the connection. Once on the line, he is safe from shock as both the lineman and the wire are at the same electric potential and no current passes through his body. This is the same principle that allows birds to safely alight on power lines.

When the work is completed, the process is reversed to remove him safely from the wire. Barehand working provides the lineman with greater dexterity than the hot stick method, and may be the preferred option if conditions permit it. With this technique, insulator strings, conductor spacers and vibration dampers can be replaced, or lines spliced, without any loss of supply.

The strong electric field surrounding charged equipment is enough to drive a current of approximately 15 μA for each kV/m through a human body, to prevent this hot-hand workers are usually required to wear a Faraday suit. This is a set of overalls made from or woven throughout with conducting fibers. The suit is in effect a wearable Faraday cage, which equalises the potential over the body, and ensures there is no through-tissue current. Conducting gloves, even conducting socks, are also necessary leaving only the face uncovered.

There is little practical upper voltage limit for hot-hand working, and it has been successfully performed at some of the highest transmission operating voltages in the world, such as the Russian 1150 kV system.

Fig. 2: A Linemen Wearing a Conductive Suit is About to Change a Insulator String

Major Safety Precautions to be Observed During Live Line Working

1. A golden rule for hot line operation is "nothing is too safe when a life is at stake". Records prove that hot line work on high voltage lines is actually safer than maintenance work on "Cold" lines which could possibly become energized while the line is being worked. Linemen working with hot sticks are always conscious of the danger involved, and being aware of this danger they work more cautiously and keep a safe distance
2. While working it should be kept in mind that the person working invariably keeps a certain distance from the earth point. In addition to this he should also keep a certain safe distance from the other phases of the lines.
3. Use freely safety equipment like cross-arm guards, hand gloves, etc.
4. Never use a tool which is not tested and which is not familiar, never use a damp tool.
5. Do not exceed the manufacturer’s ratings in the use of hot line tools. Linemen must know the approximate weight of a conductor span and the line tensions which they are dealing with. When in doubt use a longer tool or two identical tools.
6. Check each tool regularly for indicating that the tool may have been overstressed.
7. When not in use, tools should be kept in the tool container and not on the ground.

8. All the hotline tools shall be inspected manually and electrical strength test shall be carried out as per design at site.
9. All the insulators in the string must be healthy except one or two depending on voltage class.
10. Altitude correction factor should be applied in the above electrical clearances.
11. Distance from inadvertent movement shall be considered depending on the work procedure and expertise of the lineman.
12. Permissible current in the energized tool is 1 micro amp per kV line to ground.
13. Difference in current of two adjacent tools should not be more than 20% of the small value.
14. If auto-recloser is installed the same should be in manual mode.
15. Always Remain Cool And Unruffled Under Any Circumstances While Working On A Hot Line.

Advancemnets and New Trends

1. By integrating maintenance aspects into the structure design at planning stage rather than as afterthoughts, safety and efficiency can increase. Clearances can be pre-established, and working ease can be assured through scaled layouts utilizing human factor considerations. This should encompass the structures, insulators, hardware and tools to be used and the approach interfaces of these with the line workers (accessibility, steps, hand holds, platforms, attachments, weight, visibility, etc.).
2. Nowadays there are several different telerobotics systems for live-line maintenance being developed around the world. Each of these systems is specially designed to fulfill a series of requirements for the application they are suited for. In order to fulfill these requirements the designers had to cope with different solutions and approaches, some specific of their application and others of general relevance for all the systems. The solutions taken define the practical and efficient use of the telerobotic system, and have to be taken with care, being fairly conservative but always looking what would be needed in the future.
3. The latest techniques also employ helicopters, useful where transmission lines traverse inaccessible terrain or where a bucket truck would damage crops.

CONCLUSIONS

This paper has thoroughly discussed the live line maintenance practices being adopted in different parts of the world. Considering the fact that system availability can be greatly increased keeping the revenue loss due to shutdowns and inconvenience to customers to a minimum, Live line maintenance has proved to be a must choice for Power utilities.

At the same time it must be kept in mind that electricity is hazardous and strict Regulations for live working and rigid adherence to protocols must be ensured.

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