Methods Utilized for the Prevention of Wood Structure Fires Caused by Leakage Currents

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***Abstract*--This paper discusses the past and present methods utilized for prevention of wood pole fires on transmission and distribution circuits due to leakage currents. We will consider these past and present methods concerning new construction, and existing construction. Economic concerns will be addressed. Utilities have struggled for years with various methods of shunting, bonding, or a combination of both, to prevent fires on wood poles. These fires typically occur after a long dry period, but also occur in contaminated environments. Usually these fires originate at the crossarm throughbolt area, but have also occurred at the crossarm brace bolts, the brace throughbolt, and where the system neutral is connected. With utilities entering a competitive, deregulated, environment pole fires represent a concern for reliability, safety, and economics of the electrical system.**

I. Introduction

The subject of fires occurring on wood poles has been studied in the past. Utilities have developed various methods to deter fires, with various methods working with good success. The history of these methods can be studied for recommended practices that will best suit the situation. For instance, if a utility has an existing 60 kV circuit that has been in service for greater than 40 years, and has been experiencing pole fires due to leakage currents, should the utility change out the insulators, bond the hardware, shunt the areas where the burning is occurring, or utilize a combination of these methods. There are other methods that can be applied also, washing or cleaning of the insulators, and/or applying silicone coatings to the insulators.

The method chosen for prevention may depend upon several variables. These variables include;

1. The importance of the circuit where fires are occurring.
2. Are there plans in the future to convert the circuit because of loading?
3. Is the circuit a radial feed with few customers?
4. Is it looped with switching capabilities?

There are existing wood poles in some areas that have had preventive methods applied years ago, only to find recently that pole fires have occurred or are occurring. These are only a few of the concerns that will need to be studied.

II. Field Conditions for Pole Fires

The occurrence of pole fires caused by leakage currents will increase after prolonged periods of dry weather. These prolonged periods cause the wood members to dry out, and coupled with contamination that accumulates on the insulator may lead to a fire. This phenomenon typically happens when moisture is introduced. This can be in the form of fog, a misty or light rain, or even snow. This moisture can initiate the flow of substantial amounts of insulator surface leakage currents that may cause a portion of the wood structure to smolder or possibly ignite into flames. When a pole is dry there is a high resistance series path to ground. Figure 1 illustrates the high resistance series schematically.

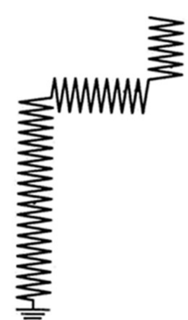

Fig. 1 Dry Pole - High Resistance (Schematic)

Figure 2 illustrates a pole, crossarm, brace, and throughbolt. When the pole becomes wet, the moisture will not be distributed across the whole surface of the structure. There are areas on the structure that are hidden from this moisture. These areas are referred to as "dry shadow areas".

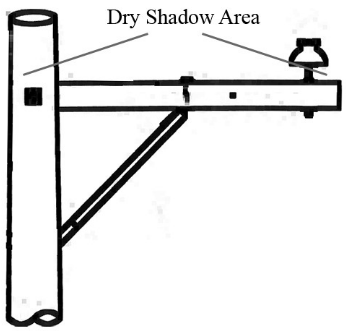

Fig. 2 Pole with Crossarm

One of these dry shadow areas will be at the crossarm throughbolt. This area of the structure is now dry. Therefore, there is a high resistance at the throughbolt area compared with the low resistance of the arm and pole. Figure 3 illustrates this schematically.


Fig.3 Wet low resistance pole
with dry high resistance area at throughbolt (Schematic)

Laboratory results have shown that the minimal amount of leakage current necessary for a "pocket fire" to develop is in the range of 5 to 10 milliamperes with intermittent surges for a few cycles as high as 200 milliamperes. When surface leakage currents are present, the flow of leakage current must through a series circuit consisting of small, dry, high resistance areas and large areas of wet low resistance. If these conditions continue the wood will become carbonized and possibly ignite.

III. Methods Utilized on Pre-existing, Pre-installed Deterrents

Typically, circuits energized in the 60 kV range are now bonded to prevent fires from occurring. In years past circuits may have had shunts installed. Various methods of shunting were utilized with good success for many years. Now that these circuits are getting older, the shunts are losing their effectiveness. The main cause for this is they're coming loose on the structure. The shunts are not making contact with the wood. Figures 4 through 7 illustrate shunting methods used in the past.

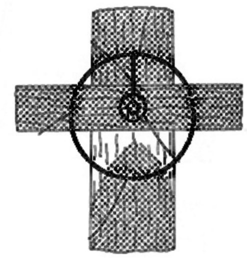
Fig.4 Shunt

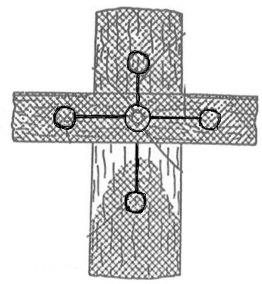
Fig.5 Shunt

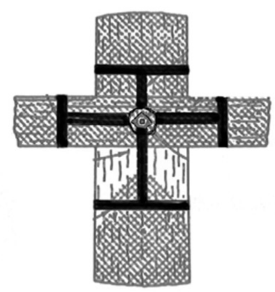
Fig.6 Shunt with Banding

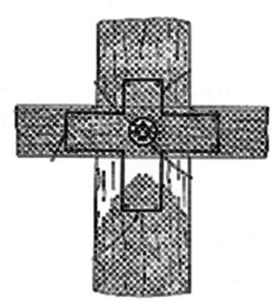
Fig.7 Shunt with Plates

The material used for shunts could have been copper wire, copper strapping, tin plates, or any other suitable material. In fact, the shunts coming loose can be contributing to the fires. Because the shunt is making contact with the wood at a point. This contact point is relatively small; therefore higher amounts of leakage current may collect at these points. The result may be burning at these points, or if the path of least resistance to ground is in series with the crossarm throughbolt area a fire may develop there. In other words, the shunt has lost its effectiveness at providing a path of least resistance.

One of three things may be employed to remedy the situation. The shunt can be repaired, replaced, or removed. If the shunt is going to be replaced the method used should be addressed. Improper design and application could cause increased burning at the collection points, as well as the point where leakage current exits. The potential should be spread over a larger area to prevent concentrated points.

IV. Methods Utilized for Existing Construction

Many utilities did not utilize shunts, or bond the hardware on transmission and distribution circuits. When a method is to be employed on an existing, energized circuit, many factors enter into the final decision. Some of these are;

1. The age of the circuit
2. The importance of the circuit
3. The condition of the insulators
4. The location of the circuit
5. The type and condition of the hardware
6. The length of the insulator pins
7. The thickness of the crossarms
8. Are there additional circuits on the structure that may have dry shadow areas also?
9. Is the circuit in question going to be converted to a different voltage?
10. Reconductored sometime in the future?

All these variables should be addressed prior to a commitment of resources. If an existing circuit is experiencing pole fires that are typical of leakage currents, then economics will usually determine the final decision. If a circuit is scheduled for a reconductor job then the insulators may or may not have to be changed out. This may be the time to look at bonding the circuit. If bonding is considered and changing out the insulators is not an option, then check to see if there are sufficient threads on the existing insulator pins for added hardware? Figures 8, 9 and 10 illustrate typical insulator pin, bonding arrangements. Figure 8 utilizes two round washers, a nut, and a half nut to secure, and #6 solid copper wire for the bond.

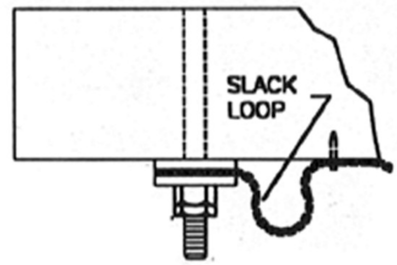

Fig.8 Bonding of Insulator Pin.

Figure 9 has a threaded lip washer, a round washer, a spring washer, a nut, and #6 Cu.

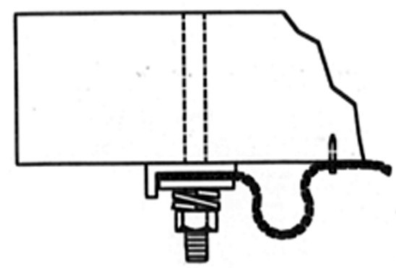

Fig.9 Insulator Pin.

Figure 10 uses the existing round washer and nut, then two round washers, a spring washer, a nut, and #6 Cu.

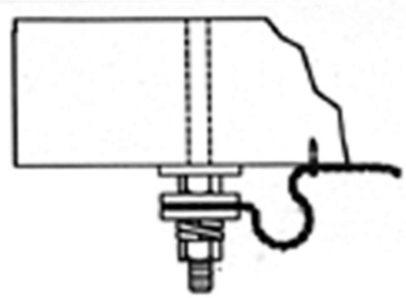

Fig.10 Bonding of Insulator Pin.

When a circuit that is experiencing pole fires is energized and cannot be taken out of service, two options exist. One, the conductors can be removed from the insulators, and a bond wire attached to the pin hardware, as in Figure 8, 9, or 10. Or two, the dry shadow area can be shunted without removing the conductors, provided there is sufficient working clearances. Option one is labor intensive, which will drive costs up. Option two, is not as labor intensive, and can be installed quickly.

Some utilities will ground their bond wire, others do not. For an existing circuit that does not have a deterrent installed the shunt can be a viable option. Figure 11,12,13, and 14 are an example of a shunt. In Figure 11 the wire extends down from the throughbolt area approximately 12 inches.

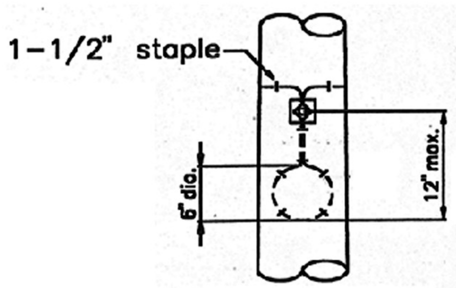

Fig.11 Shunt installed - back view.

In Figure 12 a loop is formed that is approximately 6 inches in diameter. The shunt is one continuous piece of wire. It makes contact around the pole and extends out on the top of the arm approximately 6 inches from the centerline of the pole.

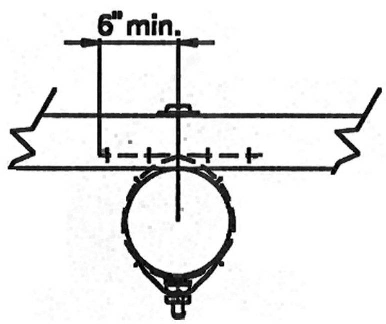

Fig.12 Shunt installed - Top View.

Figure 13 shows the schematic for the make-up at the throughbolt area.

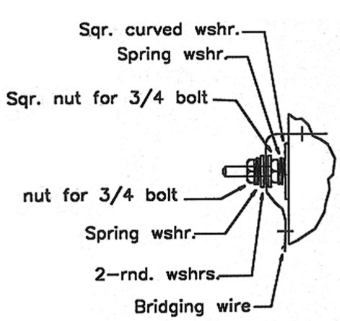

Fig.13 Side view of throughbolt hardware for shunt.

Figure 14 is a view of a distribution pole with the shunt installed. It should be noted that the shunt, when used in conjunction with a bond should not be connected together. Nor should they come in contact with each other. The method chosen will depend on economics, but in any event maintenance will be required to prevent pole fires.

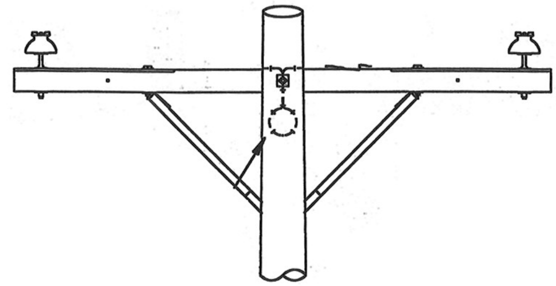

Fig.14 View of Pole with Shunt Installed.

V. Methods Utilized for New Construction

The magnitude of pole fires within a given service territory will dictate the method of prevention. There are different methodologies regarding bonding. If a service territory has a history of pole fires, then bonding in conjunction with shunting the crossarm throughbolt area will facilitate fire prevention. This method will work well even in areas with high contamination. Installation of the bond during new construction is relatively inexpensive, as compared to installation on a pre-existing circuit. Bond wires can be installed on crossarms prior to installation. Bond wires can be installed on single phase and three phase circuits. The bond wire should clear metal braces by a minimum of 1 1/2 inches. It should be placed on the underside of a crossarm, but is allowed on the face to clear unassociated hardware. In areas where pole fires occur and contamination is moderate, bonding the associated phase hardware is sufficient. In other service territory's where there is light contamination, most utilities do not bond or use a shunt. There are some utilities that have initiated insulator washing programs, but found that to be not sufficient by itself. In new construction as well as existing, a well-planned maintenance program will help. Hardware should be tightened periodically. If a shunt is installed it should be checked to make sure it's making good contact with the surface of the wood. Routine patrols and line inspections can identify problems. Inspectors from the ground can see evidence of tracking. Tree burning will be evident around the hardware. Pocket burning can sometimes be seen between the crossarm and pole.

VI. Conclusions

History has shown that shunting these dry shadow areas helps prevent pole fires. The problem is the need for periodic maintenance. Washing of insulators indeed helps, but in some locations washing alone is not sufficient for the prevention of wood pole fires. Other deterrents need to be employed in conjunction with washing. Bonding of the conductor related hardware on circuits from 4 kV up to 115 kV has also proven itself. With bonding as well as shunting it is important to keep the hardware tight, as well as having a good connection. Bonding works well when it's installed initially, cost is minimal. Installation of bonding after construction can be expensive. Shunting works well and the costs are minimal. Shunts can be installed initially or after construction.

VII. References

[1] 1. Paul M. Ross, "Burning of Wood Structures by Leakage Currents", AIEE Transactions, Volume 66, 1947

[2] 2. Chuck Frandrup, Pacific Gas & Electric," Pole Fires", 1993