An Approach for Reducing the Number of Pole Fires at Rocky Mountain Power

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Scope

This document proposes an approach for significantly reducing the number of pole fires at Rocky Mountain Power (RMP) in the long term. It is a summary document and assumes that the reader has some familiarity with the topic. Hence it covers the causes of pole fires only in the briefest terms and focuses instead on methods to prevent most pole fires from occurring.

Background and Causes

In February of 2007 the RMP system suffered from a rash of pole fires throughout its service territory shortly after a dry spell. Because there were so many fires with accompanying complaints, RMP increased its focus on causes and mitigation. This was repeated in January of 2012 after a similar winter dry spell resulting in two major event days.

While there are a few causes for pole fires, by far the most common is contamination of insulators during a long period of dry weather, followed by light moisture that causes significant leakage current to flow. This current flows (or "leaks") from the energized conductor over the contaminated insulator surface to the cross arm and pole. When this current flows on or through wood that is made slightly conductive by the contaminated moisture, then erosion, charring, and open flame can result. This happens most often where the leakage current is concentrated by sharp points in conductive hardware, locally exceeds 1-2 mA, and penetrates from wet wood to dry wood, usually near the vicinity of the through-bolt that holds the pole and cross arm together.

Investigations

While a rash of pole fires is rare—requiring a convergence of particular weather, pollution, and susceptible structures—individual pole fires can be quite common in a large utility if not properly addressed. These pole fires are nothing new to the industry and have been investigated by competent researchers. Two of the best publications are ref. [1] by Paul Ross in 1947 and ref. [2] by Ontario Hydro researchers in 1997. The Ross paper is the seminal paper in the field, and the Ontario Hydro paper is the most comprehensive.

Traditional Shunts

It seems that each time a utility grapples with a rash of pole fires the Ross paper is uncovered and another approach is considered. The Ross paper focuses on identifying the root cause of pole fires and preventing pole fires through applying conductive shunts that bypass the common trouble-prone areas and distribute the leakage currents in benign ways. We will call this the *traditional shunt* approach.

This traditional approach has spawned a great diversity of shunt designs, a few of which are proposed in [1]. A later traditional shunt design that seemed to work well in the Pacific Gas and Electric (PG&E) service territory, was tried on one structure in PacifiCorp's Green River, WY, power system with apparent success. This configuration consists of bare wire making contact with the pole and each leg of the cross arm, surrounding and bonding to (but not grounding) the through-bolt, and also bonded to the de-energized end of each insulator pin. It has the advantage of abundant contact with the wet wood surfaces and no sharp points into the wood. This allows it to widely distribute the leakage currents, thus preventing them from concentrating in a dry-wood area.

Gains

Another approach that has been discussed is to use metal *gains* (allows the flat cross arm to attach to the round pole without movement) in place of plastic gains as leakage current shunts. The idea here is to provide a more distributed path for the leakage current to bypass the problematic through-bolt as the current passes from the cross arm to the pole. The advantage of this approach is low cost and simplicity. There is concern, however, that the metal gain might merely introduce more sharp points through which concentrated leakage currents could flow into dry wood and start charring or burning. This approach is supported by the testimony of the area engineer at Flathead Electric in Montana, that wherever they have installed metal gains no pole fires have been experienced.

A Comprehensive Study

Fifty years after the Ross paper was published the work of Ontario Hydro was documented in [2]. They did this work in response to a very similar set of circumstances to what RMP experienced last January and in 2007—only theirs were worse with entire communities out of power in 1988.

Researchers used more modern measurement technologies and re-examined traditional shunts. (Their version used *gang-nailed bands* around the poles and cross arms at the points where metal braces were affixed—see pp. 70-72 of [2].) They found traditional shunts to be less effective because they (1) could work loose with time, (2) did not address the whole pole, including cracks and other trouble-prone areas experienced in Ontario, and (3) sometimes transferred currents into the pole in areas that could cause more problems later on. They also made no mention of using gains as shunts.

The Ontario Hydro researchers went way beyond shunts to examine different types and classes of insulators, insulator coatings, insulator washing, framing, pole species, pole treatments, detailed electrical modeling of pole leakage currents, critical flashover effects, and high-resistance (non-traditional) shunts. Of these areas they found that *over-insulating, applying certain insulator coatings, using polymeric insulators, using post insulators (especially non-vertical), and using high-impedance shunts were effective in reducing the likelihood of pole fires*. While describing each of these measures is beyond the scope of the present summary document, they are explained well in [2].

High-Z Shunting

In particular, Ontario researchers were innovative in proposing a new approach to reduce the likelihood of pole fires. This approach bonded the bottoms of insulator pins with insulated high-resistance wire (similar to automotive spark plug wire) and attaching this wire to a grounding wire. Two variations of this approach were tried: straight wire and longer coiled wire (added inductance). Such a solution has the advantages of (1) directing the leakage currents to bypass the *entire* wood structure, (2) largely maintaining the critical flashover distances, (3) being safe to work around, and (4) being low in cost. The only disadvantage of this approach, when it was proposed in 1997, was that it was new and lacking in field experience. As with any new approach it also lacked standardization with the procedural and cost efficiencies that standardization provides.

PacifiCorp engineers contacted a representative of Hydro One in an attempt to determine the success of this approach, but were not able to find anyone who knew anything about it. It was thought that program success would have been reported in trade publications or professional journals by 2007 when contact was attempted. Other than interest about the approach in general, concern was expressed about the survivability of the wire, both due to the carbon making up the semiconductor and the weathering of the jacket.

Recommendations

A field trial should be conducted in the Tooele area that was recently hardest hit by the pole fires. This trial should include four different configurations on lines of similar age and construction in the same pole fire prone area:

1. Metal gains with no insulator pin bonding
2. Pin bonding with no metal gains
3. Metal gains with pin bonding
4. No metal gains and no pin bonding

In the test area these four options should be interleaved on adjacent poles with a total of at least three instances of each configuration. That is, if the field trial were done on one line, the pole sequence of the above configuration should be 1-2-3-4-1-2-3-4-1-2-3-4, as opposed to 1-1-1-2-2-2-3-3-3-4-4-4. The former sequence would make a better scientific test for a physically local cause such as salt contamination in a local area followed by a local misting rain.

Recently PacifiCorp sought advice from and explored additional laboratory testing of different mitigations through the National Electric Energy Testing Research and Applications Center (NEETRAC). Such testing would be very expensive, and it is questionable whether it would add information beyond that resulting from the excellent laboratory and field work already documented in [1] & [2]. Therefore it is not recommended that further NEETRAC laboratory testing be pursued at this time.

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[1] Ross, Paul M. for Ohio Brass; *Burning of Wood Structures by Leakage Currents*; AIEE Transactions, Vol. 66, 1947, pp 279-284.

[2] Filter, Reinhard, and Mintz, David for Ontario Hydro Technologies; *The Prevention of Pole Fires—Final Report*; Report for the Canadian Electricity Association and Municipal Electric Association, CEA # 265 D 748, Jan 2007.