Spacer Cable Reduces Tree Caused Customer Interruptions

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***Abstract*-- A specific type of compact overhead distribution construction is presented, utilizing insulated conductors supported on a high-strength messenger by insulated spacers. The benefit of using this type of construction to reduce tree related customer interruptions is noted. Also identified are the specific material requirements of a successful installation that will provide many years of reliable service.**

***Index Terms*-- distribution, spacer cable, tree trimming,**

I. Introduction

THROUGHOUT a major portion of the United States, trees contacting power lines are a significant cause of customer interruptions, both momentary and sustained. Despite spending tens of millions of dollars each year on trimming branches away from their wires, or removing hazardous trees and dead limbs entirely, trees continue to be a problem for many utilities. Droughts cause trees to shed limbs and shrink supporting root systems, while excessive rains cause rapid branch growth and loosens soil around the root system, allowing trees to fall over more easily. Storms, no matter the average weather in an area, break limbs and blow trees over.

A solution has existed for over 40 years that nearly eliminates tree caused customer interruptions, reduces the amount of O&M dollars spent on tree trimming and hazard tree removal, and improves customer satisfaction, spacer cable. Shunned by those utilities that emphasized lowest first cost construction, due to its 20 - 30% higher material cost over an open bare wire configuration, it has proven to be a long term benefit to many smaller municipal electric utilities in New England, where some of them have used this construction almost universally. Its ability to resist most outage causes, and remain energized even after the supports are severely damaged, has caused it to be chosen for such diverse, and critical, applications as the Trident submarine base in the State of Washington, the Alaskan oil pipeline, and at McMurdo Bay Experimental Station in Antarctica.

This paper describes the physical construction of spacer cable, presents some variations on the materials used and their effect on reliability, and discusses some anecdotal situations from the author’s experience.

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II. Basic Configuration, Materials and Costs

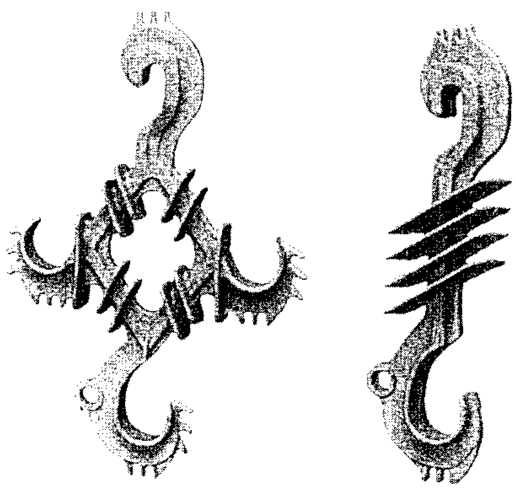
Overhead spacer cable construction consists of non-shielded, non-tensioned, insulated conductors, supported in a close triangular configuration by insulating spacers from a high strength messenger/neutral.

The conductors are insulated, most commonly with polyethylene, but must be treated as if they were not, since they have no exterior semi-conductive layer nor concentric neutral/drain wires. A commonly used brand uses a 150 mil thickness on 15 kV cable, consisting of 75 mils of natural polyethylene covered by 75 mils of track resistant high density polyethylene. Higher voltages obviously use thicker insulation levels, with 25 kV using 250 mils, 34.5 kV using 300 mils, and 46 kV using 400 mils.

The messenger/neutral, providing the full support of the non-tensioned phase conductors, is a high-strength aluma-weld/aluminum (AWAC) conductor. Since it is also acting as the system neutral, for a system of non-shielded, insulated conductors, it is required to be well grounded at a more frequent interval than that required for open wire overhead construction by the National Electrical Safety Code. It is suggested that every pole be grounded, but, definitely not more than every 500 feet.

The spacers used to hold the phase conductors to the messenger are also made of polyethylene, the same material as the insulation on the phase conductors. There are both three phase and single phase configurations of these spacers, see Fig. 1. Since the phase conductors are not shielded, the charge build-up is not drained from their surface. If materials of a dissimilar dielectric constant are used in parallel, the charge will not divide evenly, the charge densities will differ, and a charge current flow will occur across the material interface eventually breaking down the insulation completely. While flexible polyethylene “jar rubbers” have been the most commonly used method of holding the conductors to the spacers, spacers can now be obtained with integral locking clamps.

The use of non-shielded conductors also requires that trees still be trimmed, since their contact with the insulation will create a charge density differential, and cause a charge current flow. Some utilities have specified that a 15 mil semi-conducting strand shield be added to minimize the damaging effects of an increased electric field at a tree contact point, thereby extending the life of the conductor even if tree contact is made.



. Fig. 1. Three Phase and Single Phase Spacer

Some utilities have tried to use materials of differing dielectric constants in the construction of spacer cable systems. Spacers made of various types of plastics, conductor ties made of various rubber compounds and even metals, and porcelain insulators where the cables need to be spread out on a crossarm, have all been utilized. In every case known, these experiments to reduce the overall cost of spacer cable systems have ended in reduced life of the components and increased outages due to material failure. Unfortunately, these types of incidents become well known, without the underlying problems identified.

The cost of spacer cable will be higher than open bare-wire construction, due to the insulation on the conductors, the spacers, the more frequent grounding required and the more specialized hardware. Estimates have been seen between 20 to 40% higher, with much depending upon how experienced the installation crews are with the methods used for spacer cable. Once the supporting structures are dressed out for this construction, crews have been known to install 3 miles of spacer cable a day, with an additional day required to tie it all in place and remove the installation hardware. A Midwest utility estimated an additional 25% cost over an equivalent bare-wire system [1].

O&M costs can be reduced significantly. The trim envelope around spacer cable can be much smaller than around bare-wire construction. For one, the 8 foot spacing common on 15 kV bare-wire construction is reduced to less than 18 inches with spacer cable. Not only that, but the frequency of the trim cycle can be reduced since incidental contact of growing branches will not cause fault current to flow from the insulated phase wires. It must be mentioned, however, that long term contact will cause charge current flow to a degree where the insulation can be damaged. Therefore, a regular trim cycle, even if extended, is required.

One additional O&M reduction, often overlooked, is the reduction in labor and material costs due to the elimination of outage events. When spacer cable is utilized in remote, heavily treed, rural areas far removed from the utility's local operations facility, this savings can be substantial.

III. Trees and Reliability

The most common power-line construction throughout most of the country is bare wire on crossarms. While proven to be adequately safe and reasonably reliable over the past one hundred and twenty-five years, this configuration is susceptible to outages caused by tree contact. Throughout much of the country, tree contact is the single major cause of customer interruptions, both momentary and sustained. Untrimmed verdant branch growth, high winds and rain, and ice and heavy wet snow all contribute to the tree caused interruption problem. At some utilities in the Northeast, tree contacts contribute to more than 25% of all customer interruptions.

Trimming trees, by removing branches over, under and around the electric delivery system conductors, has been the typical way utilities have tried to improve their reliability results. Usually, this trimming was scheduled to be done on a multi-year cycle, with times ranging from 3 to 8 years, depending on growth rates of the trees, extensiveness of the trim work done on the previous cycle, and impact of the tree caused interruptions on any penalties assessed. Increasingly, utilities are adding hazard branch, and even whole tree, removal.

While this type of maintenance program has proven to be effective, when followed each and every year, utility operations budget constraints often look to tree trimming programs as a first solution. Also, if tree trimming is not done in accordance with proven practices, lateral branch growth can be accelerated, requiring ever shortened trim cycle times and exacerbating any budget constraints. In addition, the general public is becoming more vociferous in their opposition to any removal of trees, or their branches. Local ordinances requiring coordination with and approval from municipal tree wardens, or even worse, signed approval from the abutting residents, have made the efforts to reduce tree contact customer interruptions much more difficult and costly.

IV. Spacer Cable and Reliability

Spacer cable has been effectively used to significantly reduce the occurrence of tree caused customer interruptions, the space required to be trimmed around the conductors, the frequency of the trim cycle, and therefore, the utility's O&M requirements.

Utilizing data from one utility, spacer cable reduced tree caused customer interruptions by 90%, compared to bare open-wire construction [2]. Not only will the insulation on the conductors keep the tree contacts from establishing fault currents, the high-strength messenger protects the compact bundle of conductors below it from falling branches and bent trees due to heavy wet snow or ice.

Some municipal utilities in Massachusetts, Groton and Sterling are good examples, have nearly changed their whole overhead construction to spacer cable. Employees of these utilities openly tout the fact that their customers are seldom left in the dark while other nearby areas scramble to repair blown fuses and downed lines.

One benefit often overlooked in the use of spacer cable is that the high strength messenger, along with the spacers located every 30 feet, supporting the insulated phase conductors, allows severe damage to the structure holding the cable system in the air without any loss of service to the customer. Spacer cables have been known to remain energized, without even experiencing a momentary interruption after automobile accidents or falling trees completely breaking the poles that supported them. One incident in the present service territory of National Grid saw a pole hit with such force that the upper ten feet of the pole did a complete somersault, twisting the spacer cable circuit upon itself. No service interruption occurred, even during the repairs to the pole and untwisting of the spacer cable.

V. Summary

For those utilities trying to improve their reliability results, reduce their O&M costs, improve customer satisfaction, reduce customer animosity for their vegetation management program, and are experiencing a large number of tree caused interruptions, spacer cable construction is a viable option. Acceptance of higher construction costs, the need for a fully integrated insulation system, and much more frequent grounding will provide the utility with a most reliable, lower total cost system than open, bare-wire construction.

VI. References and Suggested Readings

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VII. Biography

James D. Bouford P.E. (SM'01) received a B. Sc. (1968) in Electrical Engineering from University of Maine in Orono, ME and an M. Mgt. (1980) from Thomas College in Waterville, ME. Mr. Bouford worked for Central Maine Power from 1968 – 1999 where he held numerous positions. Today, he is the V.P, of Distribution Engineering for National Grid., based in Northborough, MA 01532. Mr. Bouford is the recipient of two EPRI Innovator Awards (1992 and 1993). He also chaired the EPRI Task Force on Custom Power Distribution (1993) and the EPRI Task Force on Distribution (1991-1993). He is an active member of the IEEE where he formerly chaired the Task Force on Reliable Distribution Design, is the vice-chair of the Working Group on Stray Voltage, and is a member of the WG on System Design.