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SHIELDING EFFECTIVENESS OF COAXIAL DROP CABLE

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Abstract

The electrical property that enables RF signals to propagate through coaxial cable unaffected by outside interference is shielding. The effectiveness of a shield is completely dependent on the outer conductor. In drop cables this consists of a multi-layered conductive tape in conjunction with a metallic wire braid. Most of the high frequency shielding is achieved as a result of the conductive tape.

Over time, stresses induced by flexure cause this tape to develop radial cracks that decrease the shielding effectiveness of the cable. Because of this simulation in the laboratory is necessary to predict, thus anticipate this change. The device used to simulate flexure must be severe and apply equal stress to the entire perimeter of the cable. When considering shielding effectiveness values, data taken after flexing should be evaluated.

Introduction

Many changes are in store for the telecommun-ications industry. From interactive video services to telephony, the information highway is under construction. Full service networks using digital compression are already being evaluated in test trials. Along with these new services come additional concerns for system performance. Digital transmissions are very tolerant of noise, but if effected, the result can be catastrophic signal loss. This is in contrast to analog signals where noise causes distortion but the signal is not lost. The original function for coaxial drop cable was to carry television video and audio. While interrupted service was not welcome, it was not life threatening. At most it was a nuisance. Now that many new system designs are planning to offer full service, including telephony with 911 service, system reliability will be paramount.

The final link of most all proposed broadband multimedia network architectures is the drop cable. This cable must be flexible, durable, yet maintain the desired electrical performance over time. In the field cables experience an environment of wide temperature variations, wind and ice loading, and stress inducing movements caused by the wind. When properly installed the drop cable will maintain all of the electrical characteristics, with the exception of shielding effectiveness. Field studies have shown that shielding effectiveness degrades over time on cables that have been installed aerially. (1)

The field samples used for this report were messenger and non-messengered cables that were installed aerially. Installing non-messenger cable serially is not a recommended practice but one that occurs regularly. In terms of shielding effectiveness a non-messengered cable installed aerially may represent the worst-case scenario. A field study was completed to obtain a basic view of shielding effectiveness in aged cables. A more detailed characterization of shielding effectiveness degradation that examines the many variables present in aerial drop cable spans is necessary.

Several techniques for accelerating fatigue by mechanical flexure have been used in the cable industry. This paper focuses on the rotary flexer as it has been shown to produce shielding effectiveness degradation similar to that observed in the field. A direct correlation of shielding effectiveness degradation induced by simulated aging to actual field aging is not practical without more data. It is, however, a very useful tool for cable to cable comparisons and for material and process variations.

Drop Cable Design

Coaxial drop cables are manufactured in various standardized sizes, each size having several construction variations. They range in size from approximately 0.240 inches (6.096 mm) to 0.405 inches (10.287 mm) in outside diameter. The major advantage gained with increased size is lower attenuation values.

The general construction of coaxial drop cable is a center conductor, usually surrounded by a foamed polyethylene dielectric. The center conductor is usually coated with a precoat material to aid in corrosion prevention and to insure complete and easy removal of the dielectric material when preparing the cable for a connector. The foamed dielectric is then surrounded by a laminated shielding tape. This tape is generally comprised of two layers of aluminum foil laminated to a strength member. This first shield is usually bonded to the dielectric to better withstand the fatigue of the foil tape associated with flexing. This is followed by a conductive braid, generally made of aluminum, to aid in electrical shielding and to add structural support. The braided core is then covered with a PVC or PE jacket for protection. All of these variations are also available with steel messenger wires for aerial applications.

The major variations within cable sizes are found in the shielding configuration. Standard shielded cables have one layer of laminated tape and one layer of braided wire. Still within the realm of standard cable construction, the braiding variations are typically available from 60% to 95% coverage. The advantages of larger braid coverages are electrical shielding, mechanical strength, and lower DC resistance. Tri- and quad-shield variations are also available with various braid coverages. Tri-shield cables have a second laminated shielding tape over the braid, and the quad-shield cables have a second layer of braid over the second tape.

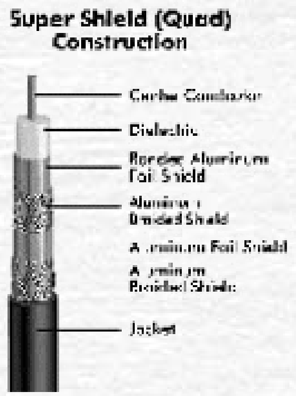
The various construction differences offer a tradeoff between flexibility, cost and electrical performance. The end result is to produce a cable that is flexible and durable, yet possesses and maintains the desired electrical performance.

Aerial Installation

Aerial drops are typically messenger cables installed by attaching the messenger wire at the pole and at the house using various types of hardware designed for this purpose. In this case, the weight and tension of the cable are largely supported by the messenger wire. Although aerial installation without a messenger is not recommended, many drops have been installed in this manner. There are several clamping devices that are designed to support non-messenger cables. In these instances the stress from some types of these cable clamps have been noticed to cause deformations in the dielectric and the outer conductor that result in impedance discontinuities. Drop cable spans generally vary in length from 50 to 150 feet. Variables like tension, span length, climate, exposure to wind, installation practices and other environmental factors make it impractical to predict with any certainty shielding degradation over time.

Effects of Environment

It can be shown that under certain conditions as in NESC (National Electrical Safety Code) heavy loading districts, drop cables can experience strain from 0.25 to 0.50 percent. (2) Most of this strain is from the effects of ice and wind loading. These forces were derived under static conditions, however, it can also be shown that aerial drop cables are not static but will sway and flex in the wind. Samples of drop cable collected from aerial installations in the field exhibited small radial cracks in the aluminum shielding tape. The decrease in shielding effectiveness of the aged samples can be linked to these small radial cracks. The cracks can terminate current densities and scatter electromagnetic energy.



Shielding Effectiveness Study

A field study was conducted. Several samples of F59 with 67% braid coverage drop cable were obtained from a system in North Carolina. The age of the samples was approximately 10 years old. The messengered samples were F6 and F59 and were obtained from a system in Florida. The age of the messengered samples were approximated at 5 to 10 years old. The shielding effectiveness of the samples was determined using a triaxial transfer impedance chamber.

Methods of measuring transfer impedance have been adequately treated in several papers, thus a simple generalization will be offered here. (3) The triaxial transfer impedance method is a technique that measures longitudinal currents on the outer surface of the shield induced by currents on the inside surface of the shield. This method produces a dB value that represents the difference between the energy propagating inside the cable and the energy received by a probe positioned on the outside of the cable's outer shield. This value is a direct result of the outer shield's ability to contain electromagnetic energy.

A wide range of shielding effectiveness was noticed in the non-messengered field samples. They ranged from 100 to 60.7 dB in shielding effectiveness. This is understandable when one considers the many variables involved with cables installed in the field. Some of the variables are as follows: The triaxial chamber used to measure the shielding effectiveness is only one meter in length. The section cable being measured may have been from the center of the span or near the hangers and experienced much less movement. Many other variables exist from span to span including length, temperature, orientation to prevalent wind direction, tension and other factors. The shielding effectiveness of the messenger samples is listed in Table 1 below.

Shielding Effectiveness of Messenger Samples

Description	Braid Coverage	Average dB
F59 Messenger	67%	80.5
F6 Messenger	60%	79.6
F6 Messenger	60%	82.1

Table 1

Shielding effectiveness measurements of various typical drop cable shield configurations were made using the triaxial transfer impedance method and are listed in Table 2. The flex fatigue was achieved using the rotary method described in Figure 2.

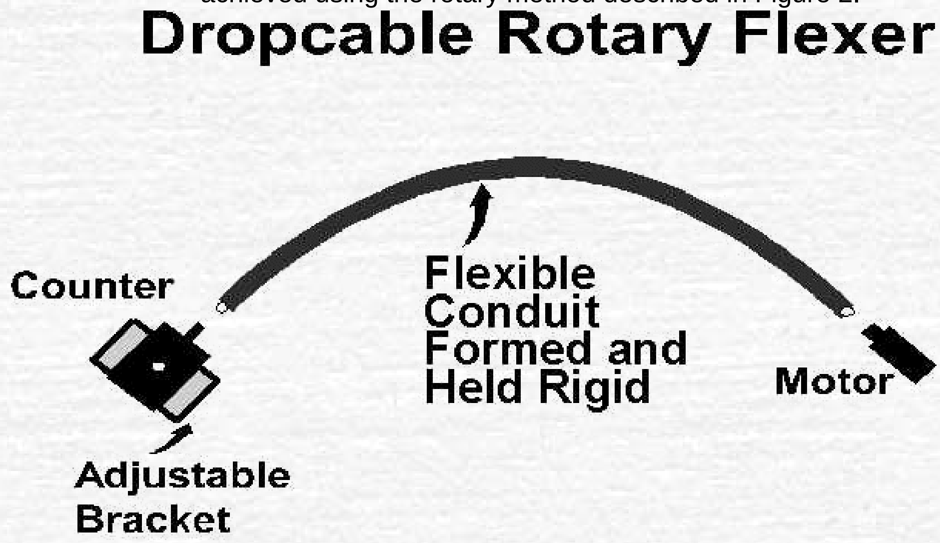


Figure : 2

Simulated Fatigue Flexing

Several flexing techniques were considered to simulate the cyclic stress created by the environment. The simulator had to severely stress cables. It was also deemed necessary to subject the entire perimeter of the cable to flexure equally. The simulator also had to induce shielding effectiveness degradation similar to that observed in the field. One way to achieve these objectives was to bend a piece of conduit, as if over a mandrel, hold it steady, then rotate a cable that was inserted into the conduit. See Figure 2.

With this method the sample undergoes expansion and compression around the entire circumference. In order to evaluate all samples equally regardless of the construction, flexure had to be equal around the entire perimeter of the cable. This is necessary since the shielding tape is a flat tape longitudinally wrapped around the cable. This creates an overlap in the foil. This overlap section makes the tape two layers thick for the overlapped portion of the cable perimeter.

In the field aerial cables can be shown to sway back and forth about an arc. The motion of the rotary flexer was designed to continue that arc through 360 degrees of rotation. This insures that the sample will be flexed around the entire perimeter.

Flexing cables has not been shown to seriously degrade the structure of the braid. The damage is mostly confined to the laminated shielding tape. Small radial cracks have been observed in the foil laminate tape in aerial samples taken from the field. These cracks are similar in appearance to the cracks visible on the samples that underwent accelerated flexure fatigue using the rotary flex method. Other flexers considered, subjected samples to flexing in only one plane, similar to the back and forth motion of a reverse bend test. Since various cable designs have different bonding and overlap characteristics of the laminated shielding tape, this type of flexer was considered inadequate. For instance, if a sample had a weak bond at the overlap but was positioned so the overlap was 90 degrees to the direction of the motion, the overlap will not receive the full punishment of compression and stress. See Figure 3.

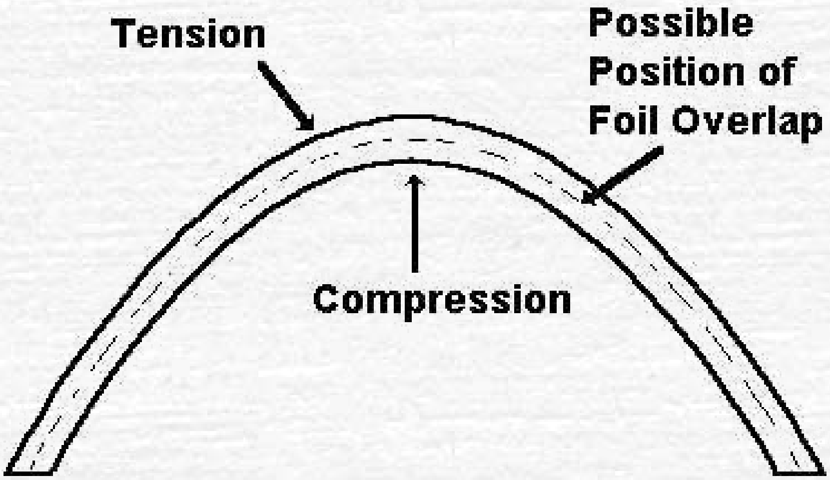


Figure : 3

Conclusion

A necessary characteristic of coaxial drop cable is flexibility. To achieve this flexibility, the basic outer conductor designs consist of a laminated foil shielding tape in conjunction with a flexible conductive wire braid. While this design offers flexibility along with a high degree of shielding effectiveness, there is a tradeoff, flexibility for shielding effectiveness.

When comparing coaxial drop cables for shielding configurations it is important to use the values obtained after flexure. It has been shown that the shielding effectiveness of new drop cables will in many cases degrade with time when installed aerially.

Drop cables installed aerially are subjected to stress from several sources. The major sources are wind and ice loading and constant flexure from movements caused by the wind. It has been shown that the shielding effectiveness in samples from the field can degrade. At high frequencies this degradation is most likely due in part from small radial cracks induced in the laminated shielding tape.

Accelerated flex fatigue using the rotary type flexer induces small radial cracks that are similar in appearance to the cracks observed in the field samples. The decline in shielding effectiveness noticed in the field study was consistent with the results achieved using the rotary flexer to accelerate the fatigue of laboratory samples. A more detailed characterization of shielding effectiveness degradation that examines the many variables present in aerial drop cable spans is necessary.

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