Electrical Stress Mechanisms
Application Note AN-810

This application note addresses issues associated with installing an all-dielectric self-supporting (ADSS) cable in high voltage applications. OFS categorizes high voltage applications as tower configurations with conductor voltages greater than or equal to 69 kV. The outer sheaths of cables suspended in high voltage aerial networks have the potential of sheath break down due to stress derived from the electromagnetic fields surrounding the power conductors. The two most significant electrical stress mechanisms are dry band arcing and corona.

Space Potential and Surface Gradients

The space potential (kV) gives a relative measure of the possibility or likelihood of electrical stress mechanisms occurring on the jacketing material. The space potential is a measure of the voltage induced by the phase conductors viewed at the ADSS cable attachment point. Space potential is a 2-dimensional calculation involving the conductor voltages, proximity of ADSS to conductors, conductor size and phasing. This value can be used with application specific information to make a recommendation concerning the cable placement, appropriate jacketing materials, and the use of electrical stress reduction devices. See Application 203, "Space Potential Calculation" for determination of space potential for a specific application.

The determination of surface gradients requires a 3-dimension evaluation that includes tower type (steel, wood, etc), cable placement, armor rod profile and conductor voltages. Variability between poles, armor rod end alignment, elevation, and contamination cause differences in the calculation. In addition, the calculations are computationally intensive and require excessive processor time. Due the complexity of the 3 dimensional calculation and impact of small variations on the calculation, the space potential has been adopted as the standard value. The space potential can be performed quickly with minimal information.

Dry Band Arcing

Induced voltages can drive milliamp-sized, earth leakage currents along a polluted or wet cable sheath. Electrical breakdown can occur during drying which results in flashover and is termed dry band arcing.

Cable sheath damage may be caused by radiated and convected heat from the body of the arc. Temperatures may exceed 400 C on the surface of the jacketing material. These extreme temperatures may melt and deteriorate the jacketing material greatly reducing its life expectancy. The arcs may pit and provide a path for moisture to enter the cable core region, which may accelerate the conductive/arcing process. In addition, the mechanical performance of the cable may be compromised once the aramid yarn (i.e. Kevlar®) strength elements are exposed to ultraviolet light, moisture, and outside plant environments.

Step 1:
The surface of the ADSS cable jacket may become conductive, due to rain or pollutants, and a current will be present along its length. The induced earth leakage current may range from zero up to several hundred milliamps depending on the application.

Figure 2. Surface Films on the PowerGuide ADSS cable

Step 2:
A dry band may form on the cable surface as it dries or the pollutants are removed.

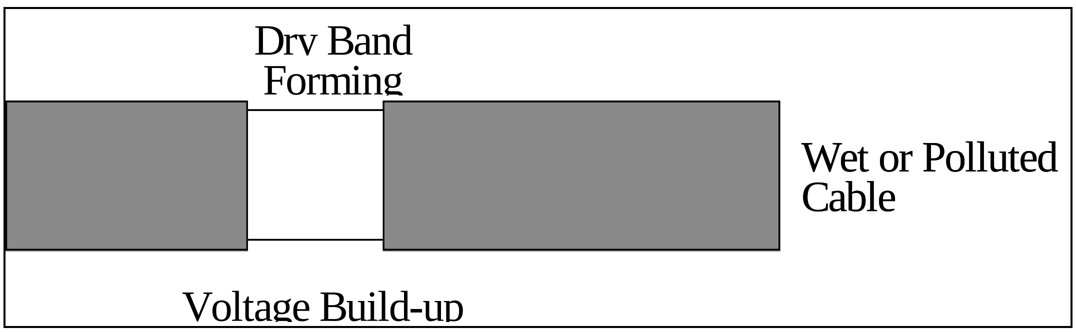

Figure 3. Dry Band Forming on the PowerGuide ADSS cable

Step 3:
If the resultant axial electric field in the dry band exceeds the breakdown strength of air, then flashover will occur and low-current arcing will take place.

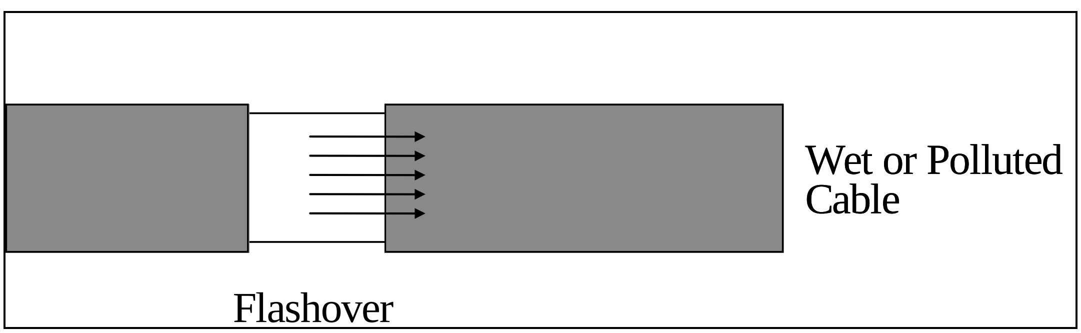

Figure 4. Flashover on the PowerGuide ADSS cable

The arcs may occur as a large-scale event easily visible or as a small-scale micro spark. The smaller arcs may occur between water droplets located on the underside of the cable. Current research is ongoing to better understand and characterize the types of arcs, earth leakage current values, hydrolytic stability of aged jacketing materials, contamination levels, and corona mitigation devices.

Corona

In an electrically charged environment, the air may become ionized and provide a conductive path. This commonly occurs on high voltage transmission systems and is referred to as corona. Corona occurs when the voltage gradient in the immediate vicinity between the armor rod tips and cable exceeds the breakdown strength of air. Once the air becomes ionized, the air becomes a conductor of electricity. Electrical discharge occurs between the surface of the cable and the armor rod tips. Corona is visible at night as a luminous glow and can be seen with special low light enhancing viewers. Multiple factors influence the onset and likelihood of corona they include:

- armor rod end tip alignment (a single rod with an 1" extension represent worst case)
- elevation (lower pressure yields lower onset gradients)
- contamination has a profound effect on the onset of corona
- roughness of armor tip

Applicable Standards & Jacket Selection

Per Section 3.7 of IEEE P1222 Draft September 1997, two classes of cable jacketing materials shall be established. "Class A" jacketing materials are suitable where electrical stresses on the jacket do not exceed 12 kV space potential and "Class B" are suitable where electrical stresses on the jacket may exceed 12 kV space potential and not to exceed 25 kV space potential. PowerGuide and PowerGuide®TR meet or exceed all applicable mechanical and environmental specifications as specified in the following standards:

- IEEE P1222, Draft, September 1997, draft - *IEEE Standard for All Dielectric Self-Supporting Fiber Optic Cable (ADSS) for Use on Overhead Utility Lines*
- Telecordia TR-NWT-1221 Issue 1, October 1991 - *Generic Requirements For Self-Supporting Optical Cable*
- Telecordia GR-20-CORE Issue 1, September 1994 - *Generic Requirements for Fiber Optic Cable*
- Appropriate EIA/TIA fiber optic test procedures (FOTP's)

Summary

Two electrical stress mechanisms may operate on a cable sheath installed parallel to high voltage conductors. These electrical stress mechanisms are categorized as corona and dry band arcing. The arcing and corona occur within one meter of the grounded metallic hardware. Coastal environments and heavily industrialized areas are applications at the greatest risk of dry band arcing due to elevated contamination levels.

The space potential gives a relative measure of the possibility of electrical stress mechanisms occurring on the outer jacket. As the space potential value approaches and exceeds 12 kV, the likelihood of electrical stresses occurring increases. For standard applications, lower space potential values yield sufficiently low leakage currents and typically do not have sufficient potential to cause flashover. Research conducted in the United Kingdom, indicated that jacket degradation is reduced or negated by configurations that yield resultant earth currents less than 1 mA.

Dry band arcs cause jacket degradation by exceeding the materials softening and melt temperatures. Thus, the jacket becomes soft and is easily perforated or pitted by the arcs. Corona causes a change in the sheaths chemical composition and may appear as jacket discoloration or whitening. Both mechanisms may excessively age the jacketing material and limit its life expectancy.

It is essential that cable manufacturers test, qualify and field trial a jacketing material that can withstand the thermal effects of arcing. In addition, the manufacturers should propose corona mitigation devices where necessary. See Application Note 811, "Recommendations for Electrical Stress Reduction", for specific OFS recommendations on placement of the PowerGuide®TR all dielectric self-supporting cable is high voltage environments.