Technical Information Paper

Conductor Shields for Overhead Cables

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When a bare conductor in air is energized, we all recognize that the electric field lines emanate from the conductor surface and terminate at ground. If the conductor is round and smooth and the distance to the ground plane is proportionately large, the electrical stresses at the conductor surface are quite evenly distributed (Fig. 1). However, if there is a sharp burr or defect on the conductor surface, electrical stress- es will be concentrated at the burr, and the insulating air will be more highly stressed in this area (Fig. 2). As the voltage on the conductor is increased, there will be a level at which the air can no longer endure the increasing electrical stress and it will break down at that point. This breakdown causes the air in the immediate vicinity of the conductor to ionize and appear as a "glow" of light around the conductor. This condition is called CORONA.

Since the air is free to move, the breakdown is normally confined to the immediate vicinity of the burr. This will remain a static condition as long as the ground plane or adjacent conductors are distant and the voltage is not increased to extremely high levels. No breakdown to the ground plane will occur.

Stranded conductors automatically present an irregular surface with high and low points which will concentrate the electrical stresses. While these stress concentrations will generally not be as bad as a sharp burr, they are certainly worse than a smooth round conductor surface (Fig. 3).

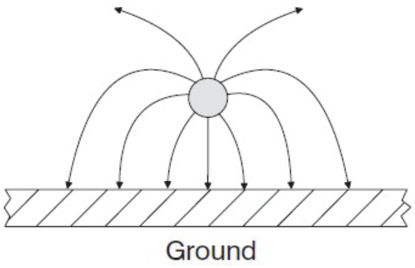

Fig. 1

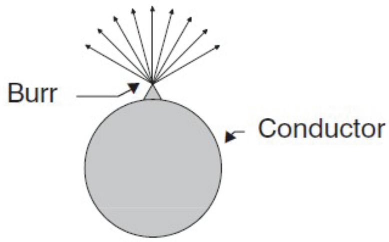

Fig. 2

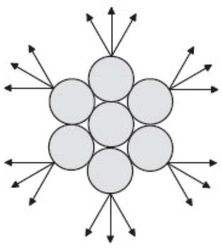
Fig. 3

continued

When the insulating air surrounding the conductor is replaced with a better insulating material such as the polyethylene covering on a spacer cable or tree wire, the concentration of electrical stresses and corona become much more important. Unlike the air, solid materials, such as polyethylene, are not free to move and regenerate. Thus, any breakdown of material at the conductor surface will probably progress through the entire wall, potentially causing a flashover to ground and burn down of the conductor. If an insulating material is extruded directly over the stranded conductor, there is the possibility that the small air voids between the conductor interstices and the insulating material can ionize and result in corona as described above. This is all of little concern as long as the ground plain or adjacent conductors are distant (except at higher voltages).

Since the voltage stress is from conductor to ground, the stress in volts/inch or volts/mil becomes greater and greater as the ground plane is brought closer to the energized conductor. If the resulting stress is further concentrated by a burr or high point on the conductor surface, the probability of exceeding the voltage strength of the covering becomes greater (Fig. 4).

In the case of underground cables, they are designed to have the ground plane quite close to the con- ductor. In order to reduce the possibility of insulation breakdown, a conductor shield is commonly used on cables operating at 2kV and above. In fact, above 5kV, these cables also incorporate an insulation shield on the outside of the insulation to avoid stress concentration and tracking on the insulation surface due to intermittent contacts with a ground or other objects, but that is the subject of another TIP.

The materials normally used to form the conductor shield consist of a polymer to which a sufficient amount of carbon black has been added to change the polymer from insulating to semi-conducting. When this material is extruded over the conductor, it electrically re-shapes the conductor to hide or fill any rough spots, burrs, strand high points and air voids between the strand interstices, thereby leaving a smooth, round conductor with "ideally" no sites to concentrate the electrical stress (Fig. 5).

Without Conductor Shield

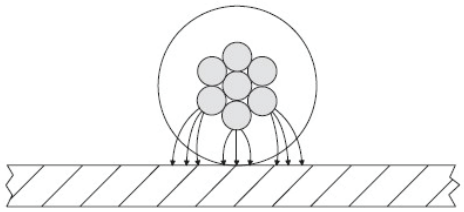

Fig. 4

With Conductor Shield

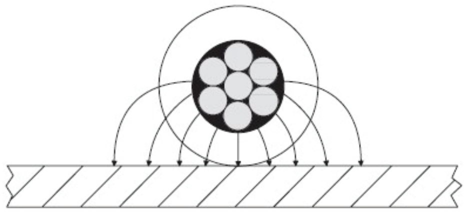

Fig. 5

continued

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Why is all of this important to a covered overhead conductor? Well, the truth is, when we use a covered conductor, such as a spacer cable or tree wire, we may be imposing even harsher conditions than those experienced by an underground cable. You see, in the case of the overhead covered conductor, we are designing a cable that will be subjected to ice, snow, wet branches, limbs, large birds (and whatever else you can imagine) shorting the cable to an adjacent conductor or ground and will also continue to operate for as long as possible. Yes, we fully expect these cables to operate for extended periods of time with those "intermittent contacts" that we so carefully avoid with underground cables by providing a continu- ous insulation shield. It also needs to be recognized that there will be some charging current flow on the outer surface of the cable covering (known as tracking, which is the subject of yet another TIP). This current flow can cause erosion of the cable covering. The problem is compounded if the cable design also allows for stress concentrations at the conductor as would be the case if there is no conductor shield.

One of the best indicators of the benefit of a conductor shield is to apply alternating current voltage to a cable having a conductor shield and raise the voltage until breakdown occurs and compare the results with an identical cable which does not have a conductor shield. To make this comparison, Hendrix produced two 1/0 AWG aluminum conductor cables with .080" of black high density polyethylene cover- ing (same blend, same production line, same date), one with a conductor shield and one without. Five 50' samples of both constructions were placed in a water tank and subjected to AC voltage which was raised at five minute intervals until the samples broke down. The results of these tests showed that the average breakdown for the samples with a conductor shield was 41% higher than the average for the samples without a conductor shield. In addition, the variation between the highest and lowest breakdown for the samples with conductor shield was less than half the variation for the samples without the con- ductor shield, indicating a much more consistent cable design.

No wonder Hendrix strongly recommends the use of conductor shields for covered conductors operating on overhead systems rated 15kV and above.