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Interaction of Cable Pulling Lubricants with Semi-conducting Polymer Materials

The stability of semi-conducting polymer shields and jackets is critical to the performance of power cable. Volume resistivity, usually expressed as ohm-cm or ohm-m, is a measure of such polymers' limited conductivity. Limits and measurement methods for volume resistivity appear in a number of power cable standards.

Modern semi-conducting polymers are quite stable (to heat, light, etc.). However, they are susceptible to migrating ingredients from other materials that contact them. Any migrating ingredients disrupt carbon particle-to-particle contact, and raise the resistivity of the polymer. Even small amounts of a migrating material can cause several orders of magnitude increase in volume resistivity. This electrical effect occurs long before any physical strength changes (tensile, elongation) become measurable.

Numerous materials can come into contact with semi-conducting cable components as the cable is installed. Duct blocks, sealants, foams, cleaners, and pulling compounds are all examples. It's important that these installation materials do not affect volume resistivity.

Recent American Polywater testing shows some interesting dependence of volume resistivity on aging time and temperature. Details are presented below

Background and Test Method

These tests were run to determine the effect of a hydrocarbon grease, normally used to pull lead-jacketed cable, on the exposed semi-conducting polymers in an XLPE-insulated power cable. The grease was compared with POLYWATER® J, POLYWATER® SG, and a wax emulsion pulling lubricant.

The measurement electrodes circled the cable (insulation shield), and the lubricating compound (or no compound for the control) was applied *completely around* the cable, covering one-third of the length between the electrodes.

Resistance was measured over time, and the volume resistivity of the semi-con shield was calculated. Aging was done at various temperatures. All samples were cooled to room temperature for resistance measurements.

The results are plotted as volume resistivity (ohm-cm) versus time. The volume resistivity is shown on a logarithmic scale, since changes of several orders of magnitude can and do occur.

Lubricant Effects

The data in Figure 1 show several different lubricants on the XLPE insulation shield at a 90° C aging temperature. This temperature is used in several power cable standards.

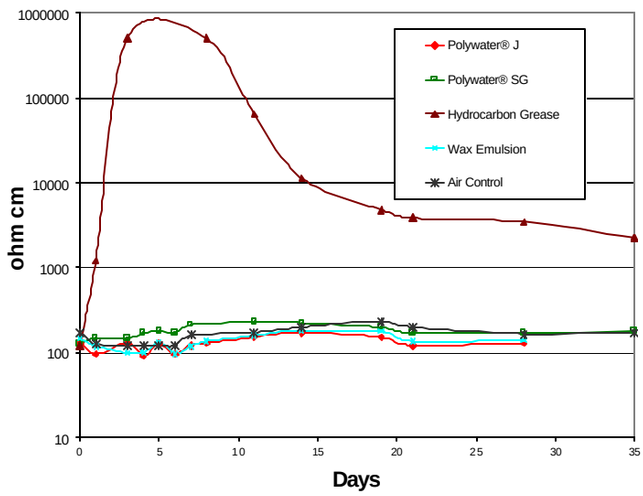

Figure 1. Volume Resistivity (90° C Aging)

The "air control" is the same cable with no lubricant aged in 90° C air. For this particular semi-con, the initial readings are 100 to 200 ohm-cm, and the material is stable enough at 90° C that the control stays in this range.

The grease has a significant effect, and raises volume resistivity to 1,000,000 ohm-cm in under three days. This grease should not be used on semi-con materials. This is no surprise; greases are generally not considered acceptable pulling lubricants based on their interaction with various plastics and rubbers.

Interestingly, the grease effect is partially reversed over time on this semi-con. The volume resistivity has decrease from over a million ohm-cm to approximately 2,200 ohm-cm after 35-days. This probably indicates that some volatiles that initially migrate into the shield eventually evaporate and dissipate at the 90◦ C aging temperature.

POLYWATER® J and SG show no significant effect on the semi-con compared with the control. The POLYWATER® Lubricants are compatible with the XLPE semi-con material.

The performance of the wax-emulsion lube is a surprise. Historically, wax emulsion lubricants have not proven suitable for use on power cable semi-cons. However, we see no effect from the wax emulsion during the 90◦ C aging. This is clarified in the next set of tests, where the harmful effects of wax lubes on semi-con materials are again documented.

Hydrocarbon Grease Vs. Aging Temperature

Figure 2 shows the effect of the grease on the semi-con when aging at three different temperatures [23◦ C (room temperature), 50◦ C, and 90◦ C.

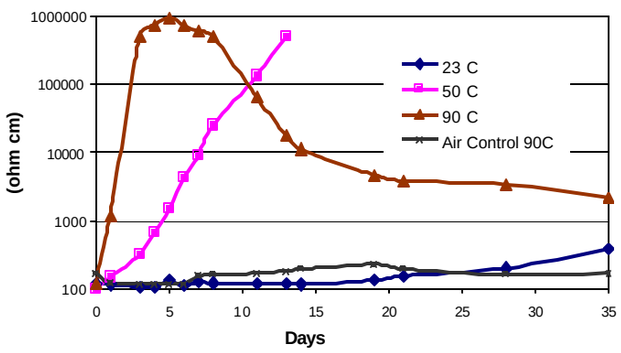

Figure 2. Volume Resistivity (Grease)

We see that the aging temperature affects both rate of change and the duration of elevated resistivity. The 50◦ C samples rose at about one-third the rate of the 90◦ C sample, but are still above 1,000,000 ohm-cm after 35 days. The room temperature (23◦ C) sample seems to be rising slowly, but more aging (beyond 35 days) is needed to determine an effect.

Wax Emulsion vs. Aging Temperature

The same 23◦ C, 50◦ C and 90◦ C data is plotted below for the wax emulsion lubricant.

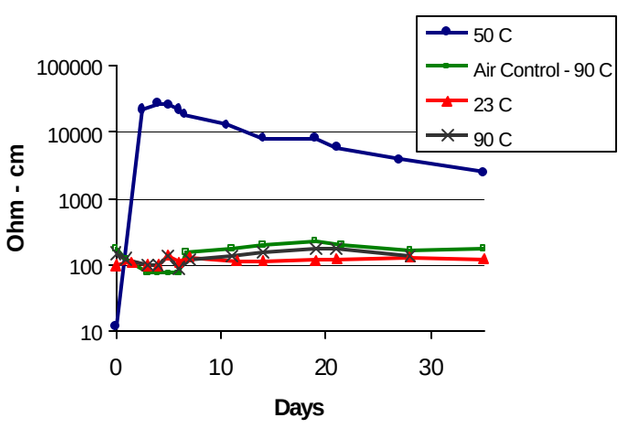

Figure 3. Volume Resistivity (Wax Emulsion)

This data helps clarify the high temperature wax performance from Figure 2. The migrating materials in the wax lubricant are fairly volatile, i.e., they evaporate quickly at high temperature, and thus cannot be detected in the 90◦ C daily test readings. At 50◦ C, we do see a resistivity effect from the wax. This increase in resistivity is not acceptable from a cable performance point of view, and this lubricant should not be applied on semi-con materials. If there is a slower effect from the wax at *room temperature*, it is not detectable in the 35-day aging in this test.

POLYWATER® J Vs. Aging Temperature

The same study using POLYWATER® J as the lubricant is plotted in Figure 4 below.

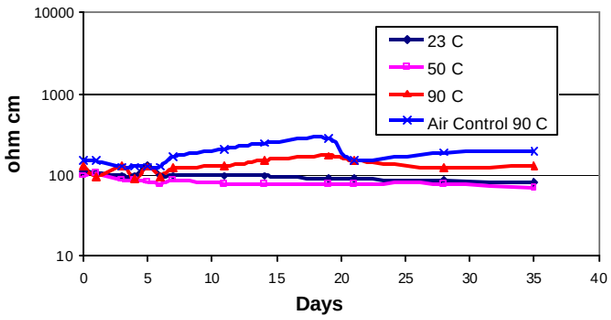

Figure 4. Volume Resistivity (POLYWATER® J)

There is no effect on the semi-con from POLYWATER® J at any of the temperatures. POLYWATER® J is fully compatible with this semi-con polymer.

Summary

These studies demonstrate several important points about the interaction of lubricants with semi-conducting polymer materials.

1) Today's heat-stable semi-cons can be negatively affected by poor lubricant choice.

2) When the ingredients that affect the semi-con are volatile, too high an aging temperature may mask the volume resistivity effect.

3) POLYWATER® Lubricants continue to prove compatible with semi-conductor polymers.

Comments, questions, or editorial requests, please contact:

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