Protecting Cables From Damage

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Of all the chemical exposures that can affect the life and performance of electrical cables, oil is one of the most damaging. Used as a coolant and lubricant in many industrial and infrastructure settings, oil can inflict molecular damage on the polymers used for cable insulation and jacketing.

If ignored, oil damage to cables can be severe. It will ultimately result in cable failure, downtime, and replacement costs.

Awareness of oil damage has been on the upswing in recent years, thanks to regulatory changes and the increased performance characteristics in renewable energy, automotive assembly, and other advanced production facilities.

Fortunately, there are cables that have been designed from the ground up to resist the effects of cooling and lubricating oils. Here’s a closer look at how oil degrades cables, how to diagnose oil exposure problems, and how to select cables that can stand up to oils over the long haul:

Degradation Mechanism

Why does oil cause such excessive damage on some types of insulations and jackets, while others are more resistant? The main reason is that not all polymer compounds offer equivalent performance even if they have the same family name. This is true for many physical properties, including oil resistance.

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Cracking – Caused during exposure of the PVC to oil or other chemicals due the complete removal of plasticizers, resulting in hardening and eventual cracking of the insulation and jacket.For example, some PVC compounds have a higher degree of flame resistance, while others have better oil resistance. Still others demonstrate improved flexibility characteristics. PVC formulations vary greatly, depending on the desired properties and applications. These properties can be achieved by adjusting the formulations of a particular PVC compound. The modification or addition of flame-retardants (iodine), stabilizers, and fillers allow the compound to exhibit these types of enhanced characteristics. However, when certain PVC characteristics are improved, the enhancement sometimes comes at a cost, the cost being that other performance traits are affected or completely lost.

Melting – Caused during exposure of the PVC to oil or other chemicals due to the absorption and combination with the plasticizer, resulting in softening and the high elasticity noted in the compound.With oil resistance in particular, all wire and cable insulations are not created equal. Electrical, environmental, mechanical, and chemical attributes will vary depending upon the individual compound formulations. Insulating compounds contain a specific amount of plasticizers in their individual formulations, which help promote flexibility and resistance to fatigue. When compounds are exposed to lubricating and coolant processing oils the material either absorbs the oil or the plasticizer will diffuse from the compound.

Swelling – Caused during exposure of the PVC to oil or other chemicals due to migration of the oils into the plasticizer, resulting in noticeable increases in insulation and jacket diameter.When oil is absorbed, it causes severe swelling and softening of the compound resulting in degradation of tensile properties. When the oil causes diffusion of the compound plasticizer, hardening will result and all flexibility and elongation properties are lost.

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Discoloring – Caused during the exposure of the PVC to oil or other chemicals due to the diffusion of the plasticizers along with colorant from the insulation and jacket.In short, oil attacks the insulating compound, where it will become virtually ineffective in its primary role as an effective insulator. This action can create a possibly very hazardous situation, not only to human life, but also to the overall function of the industrial machinery to which it is connected. This results in very expensive downtime, costly repair and in the worst-case scenario, entire replacement of the machine.

Application Conditions Matter Too

The specific application will determine if oil is used as a lubricant, coolant or both. Acting as a lubricant, oil might be applied to a gear system driven by motors to prevent premature wear down and insure smooth operation. Acting as a coolant, oil might be applied during the machine lathing process to keep metal from becoming too hot.

And oil exposures don’t just happen in factories but also in infrastructure applications. In wind turbines, for example, cables high up in the nacelle can potentially see constant exposure to lubricating and cooling oils for very long periods of time.

Temperature extremes and other chemical exposures can exacerbate the damage caused by oils. Wind turbines applications, for example, subject cables not just to oils but also to temperature extremes.

Oil rarely makes up the sole threat to cables. Instead, it works in concert with other degradation mechanisms, including temperature. In general, the greater the intensity of the oil exposure and ambient temperatures, the faster oil will start the deterioration process.

Avoiding Oil Damage

Once it gets underway, oil damage is not reversible. But it can be prevented by selecting cables with inherent oil resistance. Without a deep knowledge of the specific polymer compounds used in the cable you’re considering, it can be difficult to know which products can stand up to oils.

And that’s why testing is so important. To avoid oil resistance problems, engineers should pay close attention to UL tests, which help determine how a cable will react in the industrial oil environment.

These tests are more commonly referred to as the Oil Res I and Oil Res II tests, which involve continuous immersion of the cable samples in IRM 902 Oil at elevated temperatures for a specified period of time. Passing results are determined by the evaluation of mechanical properties and observations of physical damage caused by the oil exposure. In 2000, Lapp approached UL about creating tougher standards which resulted in the creation of AWM style 21098, which takes oil resistance to a new level.

The oil resistance of cables has now become a critical performance parameter when electrical contractors, engineers, and installers specify cables. As time moves forward, superior oil resistant cables will become standard, rather than the exception.

Sidebar: Regulatory and Cable Changes

Tensile and Elongation Test Methods

Let us assume, for example, that the cable jacket of your product is going to be tested for compliance to UL Oil Res II. Tensile and Elongation tests must be performed both on the original (unaged) and oil immersed (aged) test samples and must be prepared as defined under UL Standard 2556. Die cut dumbbell specimens are taken from the jacket and are then tested for tensile strength and elongation.

As for sample preparation, two marks are applied approximately 1.3 inches apart from each other and equidistant from the center of the dumbbell sample. (See diagram below). These marks are applied at right angles to the direction of the pull in the testing apparatus. The sample is then clamped on the tester with one-inch marks outside of and between the grips. The grips are then separated at the rate of 20 inches per minute until the sample breaks. Results are then recorded for elongation and pound force breakage; tensile strength is calculated by dividing the pound force by the cross sectional area of the specimen.

Die-Cut Specimen

Untested die cut samples are aged under the UL Oil Res II requirement of 75°C for 60 days. After 60 days, the samples are removed from the oil for a minimum of 16 hours. They are then tested for tensile and elongation, which must retain 65 percent of the unaged values. The following is an example for an Oil Res II test results:

Oil Res II Test Requirement:

65 percent of the original tensile and elongation values
65 percent (3698 Psi) = 2404 Psi, min.
65 percent (167 percent) = 109 percent, min.

Unaged Tensile Strength:	3698 Psi
Aged Tensile Strength:	3625 Psi
Percent Retention:	3625 Psi x 100 = 98 percent 3698 Psi
Unaged Elongation:	167 percent
Aged Elongation:	129 percent
Percent Retention:	129 percent x 100 = 77 percent 167 percent

Regulatory and Code Changes

With the changes to the National Electrical Code (NEC) in the past 10 years, protective conduit or raceway is no longer required when running an exposed run (-ER) cable from the tray to the equipment or device. Previously, when the cable was extended from tray to machine, conduit or raceway was used primarily as a protection mechanism in helping to prevent cable damage. Originally TC-ER cable (previously printed “open wiring”) had a length limitation of 50 ft. from the tray to the equipment. The 50 Ft. allowances resolved a large “grey” area in the industrial environment and was initially a well-received solution by the industry.

Due to the overwhelming acceptance of the 50 ft. length allowance, the NEC committee enacted further changes shortly thereafter, permitting unlimited length of TC-ER under Article 336. With the advent of unlimited length, Article 336 also brought other issues, like a greater area of cable exposure and susceptibility to the surrounding industrial environment. Under the typical conditions of operation, consideration for factors such as ambient temperature, a cables mechanical strength, unintended movement and constant exposure to industrial lubricating and coolant oils must be taken into account.

When exposed to these conditions, the cable inevitably will begin to deteriorate; the overall jacket may swell and/or crack, creating a potentially hazardous condition, along with machine and production down time. These possible problems are undesirable and necessitate the need to implement cable protection measures.

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