Nuclear Power Plant LSZH Cable Overview

While still dominant, wire and cable usage of halogenated compounds in wire and cable, particularly PVC, has decreased over the past several years. Low-smoke, zero halogen (LSZH) compounds, which are polyolefin based with a loading with inorganic hydrated minerals, emit cleaner smoke when burned. The wire and cable industry has developed new LSZH compounds that perform the same or better than common halogenated compounds.

History

The wire and cable industry began using low-smoke, low-halogen materials in the 1970's. The objective was to create a flame retardant wire and cable jacketing material that during a fire did not generate dense, obscuring smoke and toxic or corrosive gases. Several large fires over the years increased the awareness of the role that wire and cable materials play in a fire and contributed to a greater adoption of LSZH cables. Industry groups, such the IEEE Power Engineering Society's Insulated Conductors Committee, began to develop tests methods to evaluate smoke, corrosion and toxicity.

With an increase in the amount of cable found in residential, commercial and industrial applications in recent years, there is a greater fuel load in the event of a fire. Wire and cable manufacturers responded by developing materials that had a high resistance to fire while maintaining performance. Low-smoke, zero-halogen compounds proved to be a key materials group that delivered enhanced fire protection performance.

Low smoke and zero halogen have different meanings and cannot be used interchangeably. A cable can be low smoke without being halogen free or vice versa. Halogen-free materials typically produce clearer, whiter smoke while chlorinated polymers tend to produce, in part due to their flame resistance, thicker, dark smoke when burned.

Low Smoke Cables

When burned, a low-smoke cable (also known as limited-smoke cable) emits a less optically dense smoke that releases at a lower rate. During a fire, a low-smoke cable is desirable because it reduces the amount and density of the smoke, which makes exiting a space easier for occupants as well as increases the safety of firefighting operations.

Several standards describe the processes used for measuring smoke output during combustion. During these tests, a technician burns a cable and measures the optical density of the smoke given off. There are various means of measuring optical density: peak smoke release rate, total smoke released, and smoke density at various points and durations during the test. Results must be below a certain value and the cable must pass the burn test in order for the material to be labeled as low smoke.

According to UL standards, a low-smoke designation (abbreviated as "-LS") can be added to certain types of UL Listed cables if they pass the UL 1685 test. To pass the test, a cable must have a total smoke release of less

13721 Jetport Commerce Parkway • Suite 6 • Fort Myers, FL 33913 • Tel: 800-840-6655 • Fax: 509-695-4287
www.cablelannuclear.com

than 95 m^2 and a peak smoke release rate under 0.25 m^2/s. UL also defines a ST1 (smoke test one) rating that measures peak and total smoke emission for some wire types

The National Electrical Code (NEC) only requires that cable used in plenum spaces be rated as low smoke; this requirement first appeared in the 1975 code. A major concern is that toxic or corrosive products from a localized fire can spread through the plenum spaces to other areas of the building. The National Fire Protection Association (NFPA) maintains the standard used to qualify cables for plenum air spaces, NFPA 262 (formerly UL 910). This test is regarded as one of the more difficult industry fire tests to pass. Unfortunately, most polyolefin-based LSZH cables sold in the U.S. cannot pass the NFPA 262 test.

Zero Halogen Cables

"Low halogen" is not as well defined as "low smoke". UL does not define an equivalent to the "-LS" rating for halogen-free products, and many materials that are often defined as zero halogen still contain trace amounts of halogen. For example, the military standard MIL-DTL-24643 dictates a halogen content of less than 0.2 percent by weight. However, in the US halogen levels of <0.02 % by weight are generally considered to be "zero halogen"

In comparison, the halogen content in halogenated cables may range as high 17% of the cable weight.

Halogens have come under scrutiny for the toxicity and corrosivity of their combustion byproducts. Their reactive nature that makes them effective flame retardants can also present a danger to building occupants by giving off toxic gases when burning and by risking damage to electronic equipment and metallic structures. Standards for corrosivity and toxicity testing exist as well and may be more appropriate indicators of a cables suitability for a certain application than the halogen content.

Despite the concerns related to halogenated materials, the majority of today's plenum cables contain significant levels of halogens. There is now concern that if this material burns, it can represent a significant safety risk. The opposing viewpoint is that while halogenated products of combustion may be dangerous, the flame retardant halogenated materials are less likely to burn and, therefore, safer overall.

Flame Testing

It is important to separate the fire performance of wire and cable from the LSZH label. Almost all modern cables are required to pass some type of flame test. Commonly UL 1666, UL1202, NFPA 262 and others. Nuclear power plants almost universally specify IEEE 1202, as cited in recent versions of IEEE 383 and IEEE 1682. Particularly in Ethernet electrical cables, and in fiber optic cables, LSZH cables meets the IEEE 1202, and the more severe UL 1666 riser and Canadian FT-4 requirements.

A typical LSZH flame test measures five criteria in order to predict how a cable will behave in the event of a fire:

1. How easily the cable ignites
2. How fast and far fire will propagate along the cable

13721 Jetport Commerce Parkway • Suite 6 • Fort Myers, FL 33913 • Tel: 800-840-6655 • Fax: 509-695-4287
www.cablelannuclear.com

3. How much smoke is generated by the cable when it combusts
4. The toxicity of the products of combustion
5. The byproducts' corrosivity

Industry tests exist in the U.S. and abroad to measure each of these factors, but there is continuing debate around how best to measure and test wire and cable for fire performance. Developing LSZH compounds and cables that maintain costs and processing characteristics has been a constant challenge for the industry. There is also ongoing research into correlating small-scale, also called bench tests (e.g., UL 94 or cone calorimeter tests) to large-scale fire tests.

Flame Retardant Mechanisms

Products containing halogenated polymers (such as polyvinylchloride [PVC] and fluorinated ethylene propylene [FEP]) are inherently flame resistant. When burned, the materials generate free radicals that slow down the combustion process by reacting with the high-energy free radicals. One of the products of this process is a halogen acid gas such as hydrochloric acid (HCl).

For non-halogenated materials, flame retardancy is achieved by using additives. In the case of flame retardant polyethylene (XLPE) and ethylene propylene rubber (EPR), these additives are typically halogens like chlorine and bromine.

Adding inorganic hydrates to the base polymer, such as aluminum trihydrate or magnesium hydroxide will provide flame retardation. In the event of a fire, as both of these materials undergo an endothermic chemical reaction (one that absorbs heat energy) and releases steam when the compound reaches a certain temperature. In other words, no halogenated or other acid gases!

The steam disrupts combustion and a char layer develops that protects the remaining material and traps particulates. Because these materials replace the base polymer, the total amount of fuel available for combustion is also reduced. In plain English, less BTU's per foot as compared with halogenated materials.

The main challenge with mineral-based fillers is the high loading levels required to pass industry flame tests. This loading can have a negative effect on the cable's physical properties, which typically results in a lower elongation, elongation at break and tensile strengths. Processing can also be more difficult, but many methods of improving the processing exist. Manufacturers use a variety of compound blends as different polymers process and perform better with some additives than others.

Finally, other materials exploited for flame retardation include intumescents, which are materials that undergo an endothermic reaction and swell when exposed to heat to provide a protective layer. Nanocomposite fillers, which are typically a type of clay, are used at lower loadings [4] as a synergistic additive with other flame retardants to improve the processing and flame performance. Synthetic clays further enhance performance, and in the future-carbon nanotubes or other carbon-based nanostructures may be available for commercial use.

13721 Jetport Commerce Parkway • Suite 6 • Fort Myers, FL 33913 • Tel: 800-840-6655 • Fax: 509-695-4287
www.cablelannuclear.com

Thermoset or Thermoplastic LSZH?

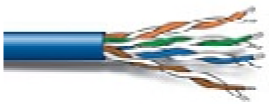
Thermoset wire and cable typically offers better performance than thermoplastic wire and cable. A thermoset is a material that assumes its final form after processing. A thermoplastic can be melted and given a new form after processing. Chlorinated thermoset jackets, notably CSPE, are common in industrial applications due to their desirable physical features and ability to pass the most rigorous flame tests.

However, recent advances in compounding technology have produced thermoset LSZH cables that pass many of the same tests as chlorinated thermosets, such as the IEEE 1202 and UL VW-1 flame tests. A past problem had been the water absorption tests required in by many cable standards. The new compounds and processing techniques have overcome this problem.

So the user now has a choice of thermoplastic or thermoset LSZH cables. Thermoset cable is more expensive than thermoplastic designs, and this is a consideration beyond the environmental conditions in selecting the right cable for each application.

Applications

The clearest uses for LSZH are confined spaces with large amounts of cables in close proximity to humans or sensitive electronic equipment. Submarines and ships are classic examples, which is why the military was one of the first adopters of LSZH standards. Additionally, mass transit and central office facilities are common applications for LSZH, and many telecommunication standards require LSZH cables.



Installation at lower temperatures can also be affected. Reduced flexibility due to the high additive loading in the materials can prevent cables from being installed in cold environments. The high mineral content can also result in fractures of the material if the installation is not done carefully. Research of the cracking behavior of LSZH has been done with the goal of improving performance. Generally, today's LSZH cables have conquered the early cracking problem.

One advantage of LSZH is that it typically has a lower coefficient of friction, although lubricant suppliers recommend a special pulling lubricant for low-smoke, zero-halogen jackets. Though there has been a trend toward jackets that do not require lubrication, some installations will still require lube to help with difficult pulls.

Another consideration is the environment in which the cable will be installed. If a fire occurs in an open area in which smoke concentration is not sufficient to obscure escape routes, using a LSZH cable may not be beneficial. There is also the question of the fuel load in a building other than cabling. The smoke being given off by other materials burning can vastly outweigh the contribution of the wire and cable. Of course, this is highly dependent on the installation and the relative amounts of cable present as well as the building's function and contents.

In industrial facilities, the relative fuel load of cables will not be at the same level. Other materials burning may also contribute greater amounts of dangerous gases that outweigh the effect of the cables. There have

13721 Jetport Commerce Parkway • Suite 6 • Fort Myers, FL 33913 • Tel: 800-840-6655 • Fax: 509-695-4287
www.cablelannuclear.com

been notable fires where cables burning contributed to corrosion (the Hinsdale Central Office fire is a famous example), but in some instances, better fire response techniques could have prevented this damage. However, there is no question that the amount of cable installed in buildings has increased as data communication has proliferated. Central office telecommunication facilities were some of the first places that LSZH cables became common due to the large relative fuel load represented by wire and cable.

The nuclear industry is another area where LSZH cables have been and will be used in the future. Major cable manufacturers have been producing LSZH cables for nuclear facilities since the early 1990s. The expected construction of new nuclear plants around the world is using large volumes of LSZH cables, particularly for Category 5e, 6 and 6A electrical cables and in fiber optic cables are being installed in both safety and non-safety related applications.

As with all cables, particularly those in nuclear power plants, not all cables are equal. CableLAN supplies LSZH Etherrnet and fiber optic cables that have met the requirements specific to the nuclear industry, and are made under applicable QA standards,

Conclusion

Low-smoke and zero-halogen cable technology has advanced significantly. The nuclear industry, and several others with unique requirements, will continue to see increased adoption of LSZH standards and specifications.

13721 Jetport Commerce Parkway • Suite 6 • Fort Myers, FL 33913 • Tel: 800-840-6655 • Fax: 509-695-4287
www.cablelannuclear.com