December 2008

Low-Smoke Zero-Halogen Wire and Cable

Since the 1970s, fire-retardant, low-smoke zero-halogen (LSZH) wire and cable has been commercially available for shipboard applications, offshore marine platforms, rapid transit and similar applications where people are present in confined areas. When combined with other fire prevention and suppression practices, fire-retardant LSZH cables can help minimize fire-related deaths and property damage. However, gases produced by all burning materials—whether LSZH or not—are extremely toxic. Several key advantages and disadvantages of LSZH cables are shown in Table 1.

Table 1 — LSZH Wire and Cable

Advantages	Disadvantages
• LSZH wire and cable produces less smoke when burned, which permits people to exit a burning building more quickly and results in less soot damage to electronic equipment located near the fire.	• Because LSZH is more susceptible to jacket cracking caused by pulling lubricants or cable bending, special lubricants[1] have been developed to minimize cable damage during installation.
• Because LSZH releases little or no halogen gas when burned, it reduces the damage to the human respiratory system if inhaled and contributes to less corrosion damage to equipment near the fire.	• LSZH jacket compounds usually have very high filler content (approx. 50%) to provide the required flame and smoke performance. As a result, most have poorer mechanical, chemical resistance, water absorption and electrical properties than non-LSZH compounds.
• LSZH jackets have a lower coefficient of friction than some non-LSZH jackets, which can make installation easier.	• The current generation of LSZH cables has not yet established a proven history of long-term performance.

What are Halogens?

Although everyone is familiar with smoke, halogens are not as well understood. When present in a fire, halogens are a class of chemical elements that can form hazardous gasses. For the wire and cable industry, chlorine, fluorine and bromine halogens pose the most concern. Certain polymers contain halogens as part of their basic chemical structure, for example chlorine in PVC and fluorine in FEP. Ironically, halogens are excellent low-cost fire-retardants, so halogenated fire-retardants are sometimes added to non-halogenated wire and cable polymers to decrease their flammability—resulting in halogenated cables! Fortunately, halogen-free fire retardants are available, but they are not universally used because of their generally higher cost. The typical halogen

Table 2 — Typical Halogen Content of Common Wire and Cable Polymers

Polymer	Halogen Content (% by weight)
XLP (cross-linked polyethylene)	<0.02
FR-XLP (flame-retardant XLP) with halogen-free flame retardants	<0.02
EPR (ethylene propylene rubber)	<0.02
PU (polyurethane)	<0.02
PE (polyethylene)	<0.02
FR-PE (flame-retardant PE) with halogen-free flame retardants	<0.02
FR-XLP with halogenated flame retardants	7–17
FR-EPR with halogenated flame retardants	9–14
CSPE (chlorosulfonated polyethylene)	13–26
CPE (chlorinated polyethylene)	14–28
PVC (polyvinyl chloride)	22–29
FEP (fluorinated ethylene propylene)	62–78

[1]For example, Polywater® LZ, American Polywater Corporation, www.polywater.com.

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content of some common cable polymers are shown in Table 2.

Industry Standards

Various abbreviations are used to refer to low-smoke zero-halogen cables around the world. In addition to LSZH, other common names include LSF (low smoke and fume), LSHF (low smoke halogen free) and LS0H (low smoke zero halogen). These names have no official definition, but numerous test methods have been developed and published by industry organizations to define specific levels of performance. A few terms that do have official definitions are described below.

Plenum Rated: In the United States, a cable must pass the smoke emission and fire propagation requirements contained in NFPA 262[2] to be plenum rated. This industry standard specifies maximum permissible values for flame spread and optical density of evolved smoke, but it does not specify halogen content. The NEC[3] requires plenum-rated cables such as types CMP and CL2P in certain applications, including ducts, plenums and other spaces used for environmental air handling, such as those above suspended ceilings.

LS Rated: UL standards define LS-rated wire and cable differently, depending on the type of product. For single-conductor wire types that must meet the requirements of UL 44[3] or UL 83[4] such as XHHW, RHW, RHW-2, THW and THWN, an LS-rated wire must meet specific values for flame spread, smoke emission and halogen acid gas. However, for other cable types such as TC, AC, ITC, MC, CMR, OFN and CM, an LS-rated cable must comply with only the flame spread and smoke-emission values contained in UL 1685[5]—a halogen requirement is not specified. In either case, a wire or cable that meets all applicable requirements can be printed LS to indicate compliance—for example RHW-LS, TC-LS or CM-LS. The NEC permits, but does not require, the use of LS-rated wire or cable.

ST1 Rated: Industry standards define a ST1-rated cable as a cable that passes the ST1 smoke requirements contained in standards such as UL 44 and UL 83. These standards specify maximum total and peak smoke-emission values, but do not specify halogen content. A wire or cable that meets these requirements can be printed ST1 to indicate compliance. As with LS-rated wires, the NEC permits the installation of ST1-rated wires but does not require their use.

One term that is not yet well standardized in the industry is zero-halogen (or halogen-free). A few existing standards define a zero-halogen polymer as one containing less than 0.2 percent (2,000 ppm) halogen content by weight. However, other standards have significant variations in test methods and in pass/fail criteria. Some typical standards used for evaluating the halogen content of wire and cable are listed in Table 3.

Table 3 — Typical Halogen Test Standards

ASTM D5424	Combustion Gas Analysis (USA)
BSI BS EN 50267-2-1	Gases Evolved During Combustion of Electric Cables (United Kingdom)
CSA C22.2 No. 0.3	Acid Gas Evolution (Canada)
DIN VG 95218-60	Halogen Free Wire & Cable (Germany)
ICEA T-33-655	Low-Smoke, Halogen-Free Polymeric Cable Jackets (North America)
IEC 60754-1	Gases Evolved During Combustion of Materials from Cables (International)
MIL-DTL-24643	Acid Gas Evolution (USA)
MIL-DTL-24643	Halogen Content (USA)
UL 44, Clause 5.14.8.4	Halogen Acid Gas Emission (USA)

[2] NFPA 262, "Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces", www.nfpa.org.
[3] UL 44, "Thermoset-Insulated Wires and Cables", www.ul.com.
[4] UL 83, "Thermoplastic-Insulated Wires and Cables", www.ul.com.
[5] UL 1685, “Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables”, www.ul.com.