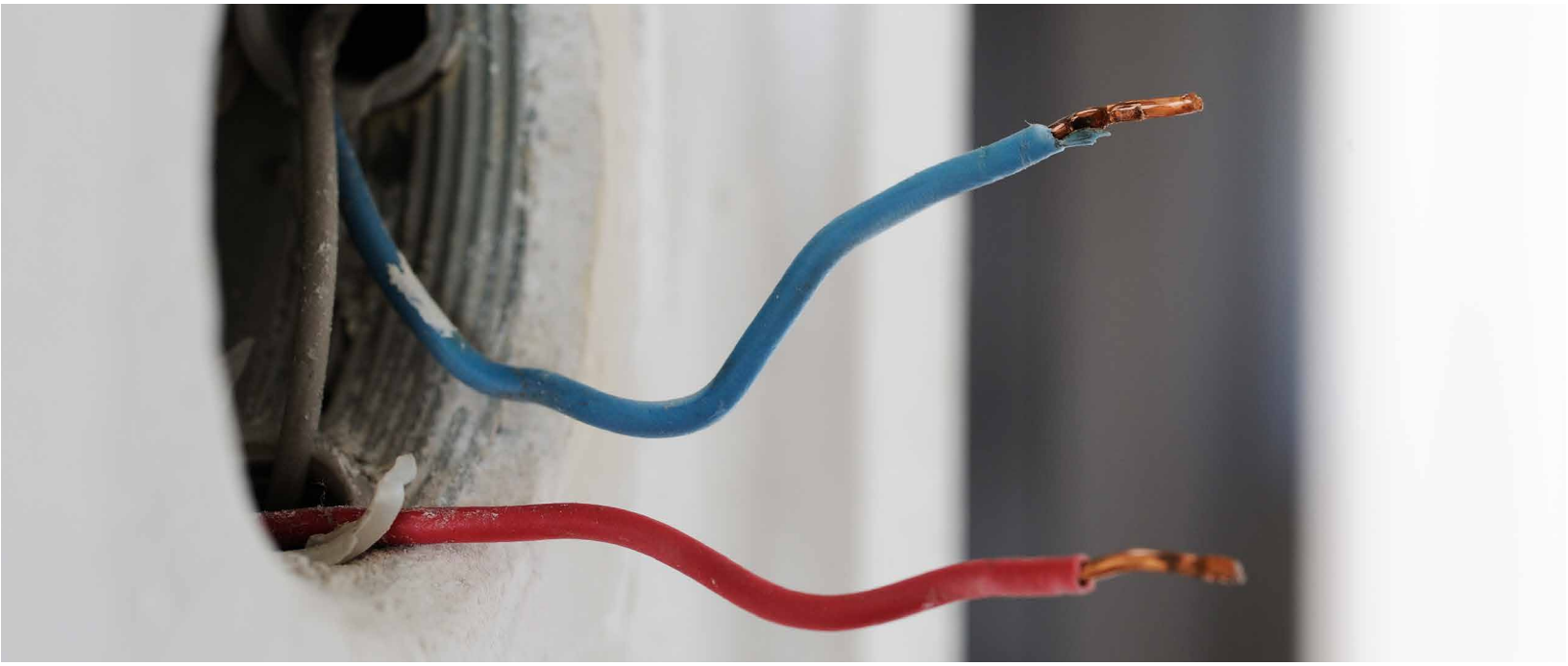
CLEARING MISCONCEPTIONS ABOUT LOW-SMOKE, HALOGEN-FREE CABLES

EXECUTIVE SUMMARY



The use of low-smoke, halogen-free (LSHF) cables in commercial and residential building projects can help reduce equipment damage and reduce smoke toxicity. However, there remains much confusion among manufacturers, product specifiers and contractors about exactly what the LSFH designation means, and the extensive, standards-based testing that is required to ensure that a cable fully complies with LSFH requirements. The confusion is further compounded by increased instances of cable products bearing counterfeit labels and safety marks without having undergone rigorous safety, smoke density and halogen content testing.

In this UL white paper, we'll discuss the benefits of using LSHF-rated cables in key construction applications, as well as the type of testing that is required to verify that a cable is truly low-smoke and halogen-free. We'll also discuss the specifics of UL's Material Recognition Program, and cable surface mark program for LSHF cables and materials, and the benefits of certification in accordance with the requirements of UL 2885, "Outline of Investigation for Acid Gas, Acidity and Conductivity of Combusted Materials and Assessment of Halogens."

CABLE STRUCTURE AND MATERIALS

Wire and cable products are an essential component behind the functionality of infrastructure projects, industrial and commercial buildings and residences. Wire and cable products of all types are used to power and control systems, equipment and electrically-operated devices, as well as in data and telecommunications applications to support audio, video and data transmission capabilities. Even with the increased availability of advanced wireless connection technologies, wire and cable products offer reliable electrical and data connections at reasonable costs.

In general, cable products consist of copper conductors or optical fiber surrounded by a protective outer sheath. In some instances, additional layers are added below the outer sheath to shield or insulate the cable's core. The composition of the outer sheath typically depends on the cable's intended use or its anticipated exposure to environmental elements or conditions, e.g., outdoors, underground, etc. But most cables manufactured today use some combination of polymeric materials that provide strength, durability and flexibility to the finished cable product.

For decades, polymeric-based cable compounds have incorporated resins, additives, flame retardants and color concentrates that contain halogen compounds and other halogenated ingredients. In the case of cable insulation and sheathing materials, halogenated ingredients, such as brominated compounds, are often added to improve a material's fire retardant properties. Other polymeric materials used in cable insulation and sheathing, including polyvinyl chloride (PVC), fluorinated ethylene propylene and chlorinated polyethylene, can be additional potential sources of halogen.

THE POTENTIAL HARM FROM HALOGENATED CABLE MATERIALS

While cable insulation and sheathing materials incorporating halogenated ingredients may to be more flame retardant, they also emit a smoke when exposed to fire that can become toxic and corrosive under fire conditions. Specifically, halogens released from exposure to fire react with normally-occurring hydrogen to form hydrogen halide. When mixed with water (for example, the water used to fight a fire), hydrogen halides form hydrochloric acid, hydrofluoric acid or hydrobromic acid. These acids can damage or destroy critical structures, components and equipment, and increase toxicity. Cables containing halogenated materials also produce significantly higher levels of carbon monoxide (CO) gas during combustion, further escalating their potential danger.

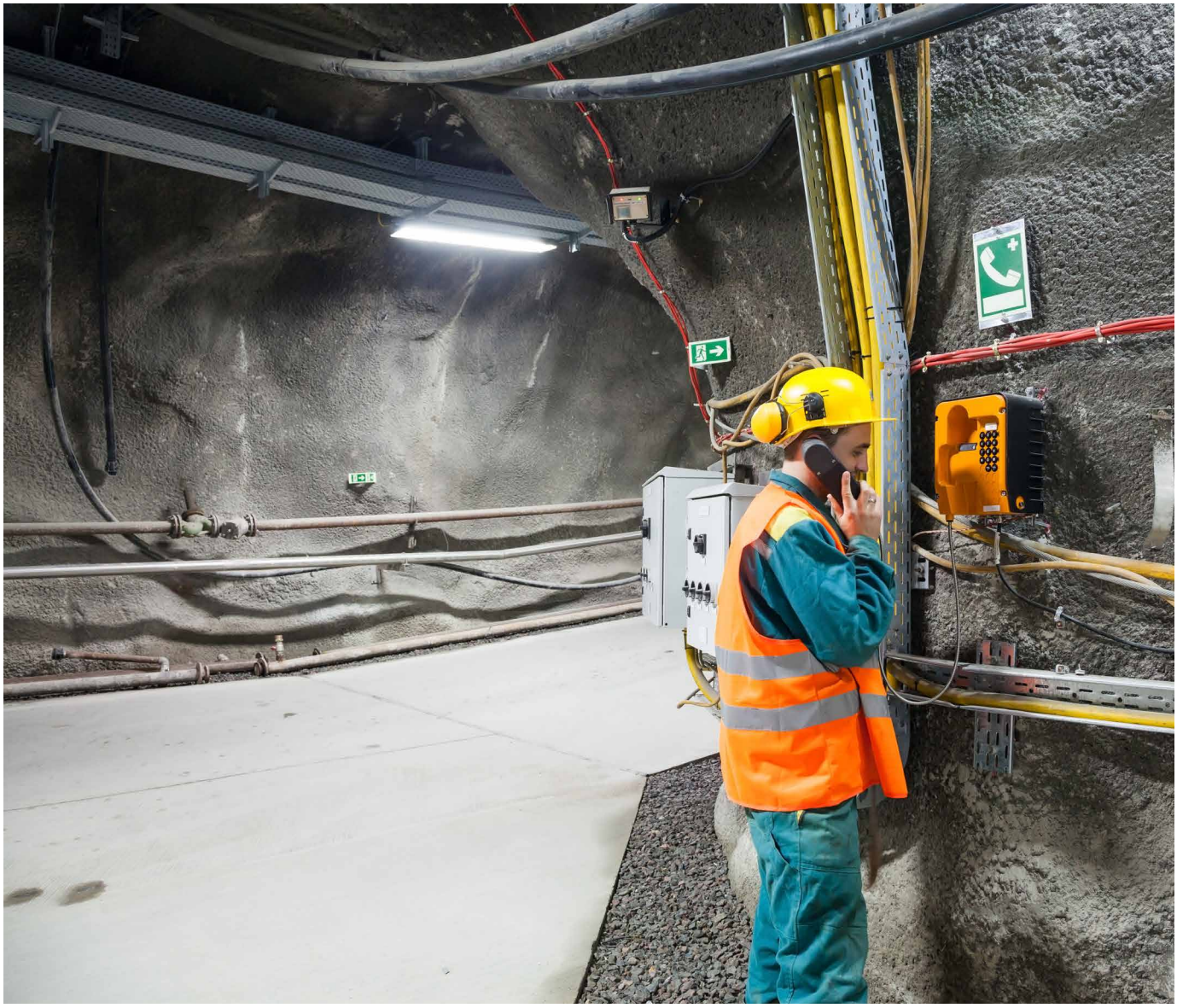
Over the years, a number of high-profile fires have provided clear evidence of the potential dangers of cables shielded with materials containing halogenated ingredients. To cite just one example, an electrical short-circuit in a Washington, D.C. Metro subway tunnel in 2015 resulted in the burning of legacy power cables that emitted noxious smoke and gases, leading to the death of one woman and sickening dozens of other passengers. The tragedy reportedly led Metro maintenance officials to speed up the long-planned replacement of older power cables with low-halogen or halogen-free alternatives[1].

THE DEMAND FOR LSHF CABLES

First introduced in the 1970s, cables with LSHF properties were initially intended for installation in small, confined spaces where the risk of corrosion and toxicity from smoke generated in a fire by legacy cables would be particularly problematic. However, the potential risks from cables incorporating halogenated materials have resulted in an increased interest in the use of LSHF cables in a wider variety of environments.

Rather than being deployed exclusively in confined space applications, such as tunnels, mines and ships, LSHF cables are now being used in any environment where critical operations require the continuous operation of equipment and systems, such as data centers, emergency call centers and telecommunications switching stations. LSHF cables are also being used in settings where the prompt and efficient evacuation of people is not always possible, such as hospitals, critical care centers and nursing homes.

The safety profile of LSHF cable products has also resulted in their expanded use beyond the power and control cable categories. Today, LSHF alternatives are available for data and telecom cables, fiber optic cables and appliance wires and cables. And the absence of halogenated materials makes LSHF cables a logical choice for new construction projects where environmental and sustainability considerations are involved since the use of LSHF cables may qualify for project credit under the U.S. Green Building Counsel's LEED Green Building Initiative.



THE CONFUSION ABOUT STANDARDS FOR LSHF CABLES

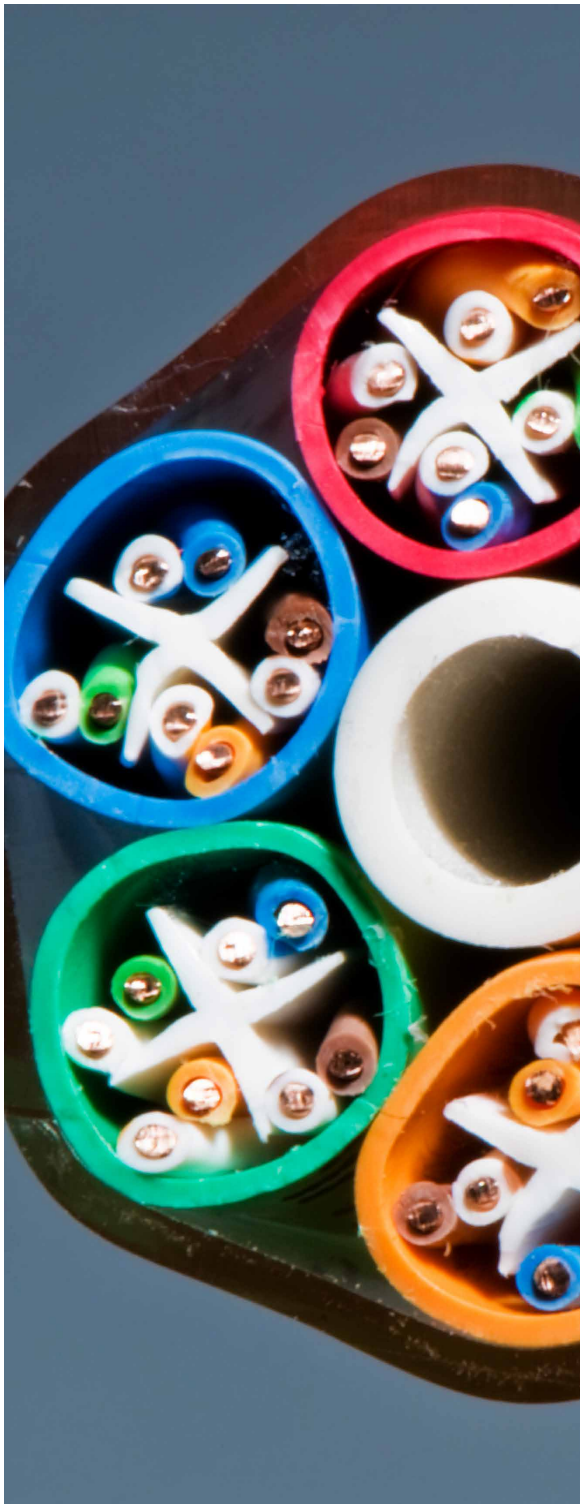
While the previously mentioned factors have resulted in an increased demand for LSHF cables, there is also increased confusion among both cable manufacturers and cable buyers regarding not only the terminology around these products, but also which standards can be used to satisfactorily evaluate and test those cable products and cable components purporting to be low-smoke and halogen free.

At the present time, there is no standardized approach regarding the terminology applicable to cables that generate low levels of smoke, or that are free of halogenated materials, or that are fire-resistant. For example, some manufacturers offer cables that are "low-smoke, halogen-free", while others offer comparable products that are "low-smoke, zero-halogen" (LSZH). Other companies offer "halogen-free, fire-resistant" (HFFR) cables, while still others market cables that are "low-smoke and fume" (LSF).

In many cases, the confusing array of acronyms also highlights the subjective nature of the terminology itself. Just what exactly characterizes a "low-smoke" cable? Does "zero-halogen" simply mean free of halogenated materials or does it refer to halogen emissions released under fire conditions?

An important factor contributing to this confusion about cables designated as LSHF are the very standards that have traditionally been used to evaluate their halogen content. The two most-frequently used standards include IEC 60754-1, "Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content," and IEC 60754-2, "Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity." Other standards commonly used in cable assessment are MIL-DTL-24643 C, which covers requirements for cables used in Navy shipboard applications, and IEC 61249-2.

However, neither IEC 60754-1 nor IEC 60754-2 test for or reference content levels of essential elements of halogen, namely, chlorine, bromine, fluorine, astatine or iodine. Instead, each standard defines methods to test halogen acid gas created as a result of the combustion of testing materials (by titration under IEC 60754-1, and by pH and conductivity under IEC 60754-2) and infer that the halogen acid gas created is from one of the five halogen elements described above. No actual halogen content level in terms of percent and or part per million (PPM) are provided in these standards. Further under IEC 60754-2, minimum pH values and maximum conductivity limits are defined as "recommended" performance requirements, rather than stated as "normative" requirements.



In addition, **these and other standards used in connection with the evaluation of cable characteristics often state seemingly different requirements regarding permissible levels of halides in cable products or materials.** MIL-DTL-24643C, for example, specifies that all cable materials shall have "no more than 0.2% halogen content," while an industry standard, ICEA T-33-655 (from the Insulated Cable Engineers Association, ICEA) states that cable materials must have "less than 0.2% weight of any halogen."

BRINGING CLARITY TO LSHF CABLE CLASSIFICATION AND TESTING

The term "low-smoke, halogen-free" consists of two separate and distinct aspects of performance that must be considered in a cable evaluation. "Low-smoke" refers to the amount of smoke that a complete cable construction produces upon combustion. "Halogen-free" refers to the amount of individual halogen elements that are present in each combustible cable component. To be accurately considered LSHF, a cable must be evaluated for its performance against each of these criteria.

Fortunately, a recently-introduced series of internationally accepted standards goes a long way toward clarifying and harmonizing requirements for both low-smoke and halogen-free characteristics in cable products and materials. Published in 2015, the IEC 62821 series of standards, "Electric cables – Halogen-free, low smoke, thermoplastic insulated and sheathed cables of rated voltages up to and including 450/750 V," consists of three parts. Part 1 addresses general requirements, Part 2 covers testing methods, and Part 3 details additional considerations for flexible cables and cords. Taken together, the IEC 62821 series is one of the first to provide halogen-free and low-smoke requirements for both complete cable assemblies and for cable material components.

In addition to the IEC 62821 series, there are several standards currently under development intended to specifically address LSHF cables, cable materials and advanced test methods. These include the following:

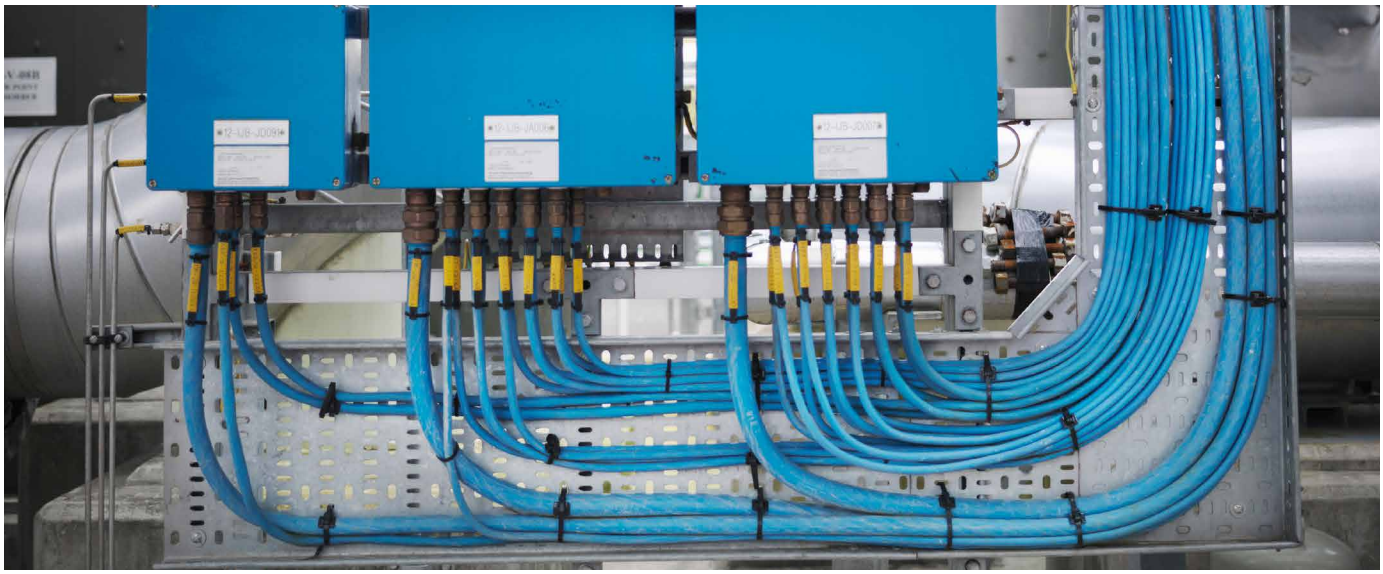
1. IEC 63010-1, "Electrical cables – Halogen-free thermoplastics insulated and sheathed flexible cables of rated voltages up to and including 300/300V – Part 1: General requirements"
(Expected publication in March 2018)

2. IEC 63010-2, "Electrical cables – Halogen-free thermoplastics insulated and sheathed flexible cables of rated voltages up to and including 300/300V – Part 2: Test methods"
(Expected publication in March 2018)

3. IEC 60754-3, "Test on gases evolved during combustion of materials from cables – Part 3: Detection of low level of halogen content by ion chromatography"
(Expected publication in June 2018)

4. IEC 62321-3-2, "Determination of certain substances in electrotechnical products – Part 3-2: Screening of fluorine, bromine and chlorine in polymer and electronics by Combustion – Ion Chromatography"
(Expected publication in December 2018)

Based on current science and cable material technology, these standards will help to further clarify both requirements and testing criteria for smoke-free, non-halogenated cables and cable materials.



2885 AND UL'S CERTIFICATION OF LSHF CABLES

To help facilitate the continued development and adoption of HF and LSHF cables, UL offers a series of certification programs that can be used to validate the characteristics of halogen-free and low-smoke, halogen-free wire and cable constructions. The certification programs can be used in connection with wire and cable products in all UL categories.

Under these voluntary certification programs, the evaluation of the halogen characteristics of cable materials follows the protocol outlined in UL 2885, "Outline of Investigation for Acid Gas, Acidity and Conductivity of Combusted Material and Assessment of Halogens." Based extensively on the IEC 62821 series of standards, testing under UL 2885 assesses the halogen content of cable insulation and jacket compounds, as well as cable components including fillers, tapes and wraps, through the application of the following four-stage testing protocol:

- **STAGE 0**
  Sodium fusion (per IEC 62821-1/-2)
- **STAGE 1**
  pH and conductivity (per IEC 60754-2)
- **STAGE 2**
  Bromine and chlorine as HCl (per IEC 60754-1)
- **STAGE 3**
  Fluorine content (per IEC 62821-1/-2)

Cable materials that meet the halogen content requirements of UL 2885 are eligible for HF material Recognition designation under the standard. Using compounds and components that have earned HF Recognition can also expedite the evaluation process of complete cable constructions for those cable manufacturers seeking to apply the optional HF cable surface mark to their products.

Complete cable constructions can also be evaluated and certified for their low-smoke characteristics. For the UL LSHF designation, cable constructions are evaluated according to the requirements of IEC 62821-3, which specifies the testing method detailed in IEC 61034-2, "Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements." Cable constructions that meet these additional requirements can apply the LSHF cable surface mark to their products.

It is important to note that UL-listed cables that have also received either the HF or LSHF marks have been evaluated for compliance with all generally-applicable certification requirements. Further, complete cable constructions that use the HF or LSHF marks are subject to periodic review under UL's Follow-Up Service (FUS) program which monitors and tests UL-certified products on an ongoing basis to help ensure that product production continues to meet the original certification requirements.

THE BENEFITS OF UL'S LSHF PROGRAMS

UL's HF and LSHF certification programs for cable materials and complete cable assemblies, respectively, offers manufacturers and buyers several potentially important benefits, as follows:

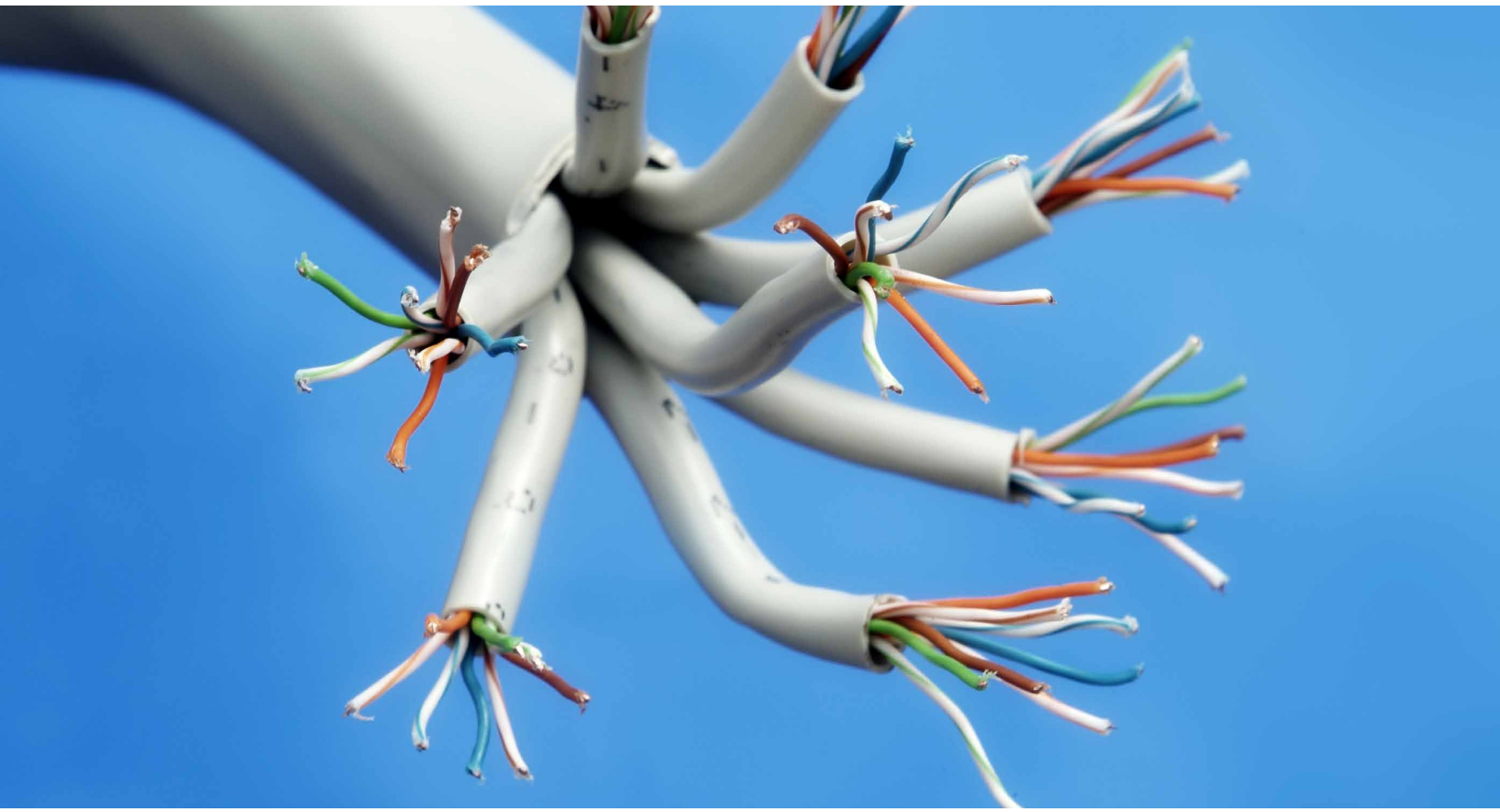
BASED ON INTERNATIONALLY-RECOGNIZED AND ACCEPTED STANDARDS AND TEST METHODS—UL's HF and LSHF certification programs are based on the IEC 62821 series of standards which details requirements and testing methods for cables and cable materials.

HELPS ELIMINATE CONFUSION ABOUT LSHF CABLE PRODUCTS AND COMPONENTS—UL's comprehensive approach to the evaluation and testing of smoke and halogen-related characteristics of cables and cable materials can provide clarity and ease product comparisons for buyers seeking LSHF products.

UL'S ONLINE CERTIFICATION DIRECTORY EASES PRODUCT SPECIFICATION AND HELPS DETECT COUNTERFEIT PRODUCTS—Information on UL-Recognized cables and components is easily accessible through our Online Certification Directory, available at www.UL.com. Access to this information enables buyers to validate product certification claims and identify potentially counterfeit claims regarding HF and LSHF certification.

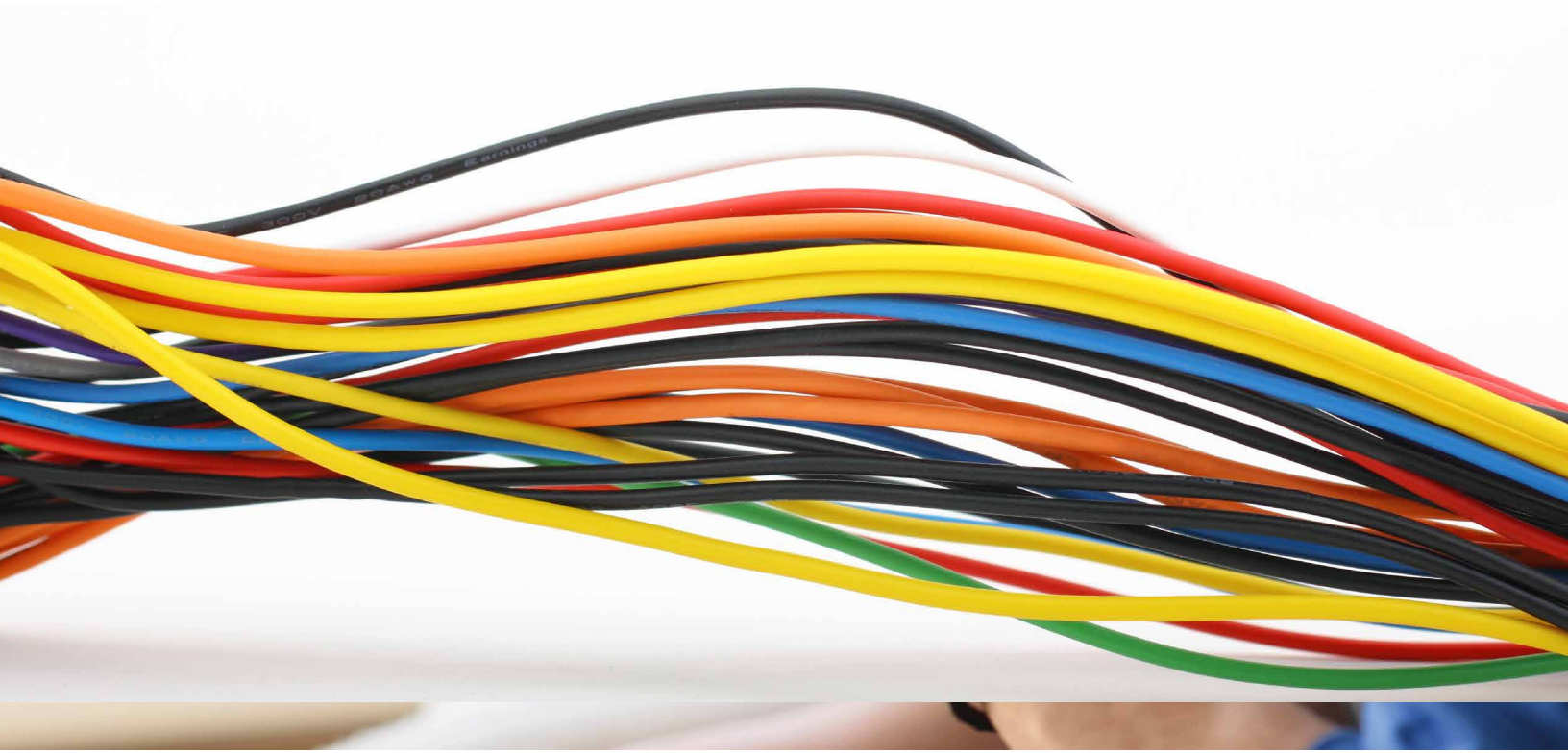
CAN STREAMLINE PRODUCT ACCEPTANCE IN JURISDICTIONS OUTSIDE THE U.S.—By earning Recognition under UL's standards-based LSHF cable certification programs, cable designers can develop new products and materials that will be readily accepted by buyers and regulatory authorities in most jurisdictions around the world.

FACILITATES BROADER INDUSTRY ACCEPTANCE—UL HF and LSHF certifications can earn LEED Green Building points by the U.S Green Building Counsel, support compliance with Proposition 65 requirements for installations in California, and help to keep cables and cable assemblies off the International Living Future Institute's Red List of compound materials.



SUMMARY + CONCLUSION

The potential benefits associated with reduced corrosivity and toxicity associated with the use of wire and cable products that incorporate halogen-free materials is driving an increased demand for HF and LSHF cables and cable components. However, there is confusion among both manufacturers and buyers of cables about the meaning of these terms, as well as the validity of self-certified claims about cable smoke and halogen-related characteristics. UL's HF and LSHF certification programs have been designed to provide objective, comprehensive and up-to-date requirements and testing methodologies for the evaluation of cable materials and complete cable assemblies.



For additional information about UL's certification programs for LS and LSHF cables and cable materials, contact **ROBERT BELLASSAI** at **ROBERT.W.BELLASSAI@UL.COM** or visit **UL.com**

END NOTES

1. "Metro rushes to install more 'low-smoke' power cables after L'Enfant Plaza incident," Washington Post, January 31, 2015. Web. 3 August 2017. https://www.washingtonpost.com/local/trafficandcommuting/metro-rushes-to-install-low-smoke-power-cables-after-lenfant-plaza-incident/2015/01/31/89979118-a85b-11e4-a06b-9df2002b86a0_story.html?tid=a_inl&utm_term=.c31b7080366a.