ZVEI:
Die Elektroindustrie

White Paper

Low fire-hazard cables improve safety

Cables as preventive fire protection according to the European Construction Products Regulation

German Cable Makers' Association

Content

Fire – A global concern

Fire in buildings takes a heavy toll on human life. In 2013, 415 people died in Germany alone from smoke, fire and flames. Out of these, 242 died in buildings[1]. The majority of deaths in a fire is due to inhaling dangerous toxic gases or smoke causing about 92 percent of all victims in buildings[2].

For centuries man has known that fire is a life-threatening danger. This is why for a long time flame-retardant material is being used in buildings. Recent studies on the effect of smoke and gas toxicity, as well as on the fire situation, as a process give insight into a new perspective on preventive fire protection in buildings.

The German cable makers' industry has developed a range of low fire-hazard cables which in the event of a fire show very low emission of smoke and low release of dangerous gases. These cables help provide more time to escape and a less hazardous environment for rescue teams.

In order to improve fire safety in buildings, the European Union created uniform classification criteria throughout Europe within the framework of the Construction Products Regulation of 2011 (CPR). The regulation became effective on July 1st 2013 and since is mandatory for all EU Member States. On July 10th 2015, the European Commission published the harmonized standard hEN 50575 for power, control and communication cables which makes these cables subject to the Construction Products Regulation.

The CPR goes hand in hand with an extensive certification system which ensures that only approved products can be used in buildings. Now, cables are also covered by this regulation if they are permanently installed in buildings-, and for which harmonized, European standards on the basis of the Construction Products Regulation exist.

This paper aims to bring closer the state-of-the-art technical standards and regulations referring to low fire-hazard cables to all groups affected like planners, installers and users of buildings. Further, planning approaches are explained which possibly make the building as a system safer with regard to fire safety.

Fire in buildings and its impact

About one third of fire originate within buildings. Often, people escaping have only a few minutes to leave a building safely before the development of smoke makes orientation increasingly difficult. This makes identifying escape and rescue routes impossible. Furthermore, those escaping need to go through a dense cloud of toxic fumes that limits their visual radius.

Fire growth modelling in buildings

A fire is usually triggered by the combustion of a local ignition source which further ignites surrounding material. During this phase, the temperature rises until the ignition temperature of the surrounding material is reached (>300 °C). Thereby, plastics in the room are ignited in a chain reaction at about 450°C. The strong heat release further sets nearby furniture and equipment on fire. Within the ignition and growth phase the temperature continually increases while a huge amount of burning pyrolysis gas and carbon monoxide is being released. The term **flashover** refers to the moment when infiltrating air in the room causes burning of the pyrolysis gases beneath the ceiling. Due to high temperatures, all flammable material will instantly be ignited without contact with any ignition flame at all. At temperatures above 1000°C, the fully

[1] Statistisches Bundesamt, Tabelle Gestorbene: Deutschland, Jahre, Todesursachen: Exposition gegenüber Rauch, Feuer und Flammen, X00-X09, Stand 02.03.2015 und Statistisches Bundesamt, Tabelle Gestorbene: Deutschland, Jahre, Todesursachen: Exposition gegenüber Rauch, Feuer und Flammen, X00+X02, Stand 02.03.2015

[2] Statistisches Bundesamt, Tabelle Gestorbene: Deutschland, Jahre, Todesursachen: Exposition gegenüber Rauch, Feuer und Flammen, X00-X09 gekreuzt mit T58 und T59, Stand 02.03.2015

developed phase forms the last phase of the sustained burning. At that point, all combustible materials have been consumed and there is no more energy being released[3].

In a report on the prevention of fire the Swedish Rescue Services Agency[4] (SRSA) emphasizes: it may take only a few seconds from the ignition of a fire to its flashover[5]. Today, already after 3 minutes extremely dangerous conditions can ensue. With the increase of plastics in our homes in recent years the time between ignition and flashover becomes shorter and shorter.

Effect of smoke and gas release

A particular danger in the event of a fire is caused by the type of flammable material that is burning. Hence, in order to provide more time to escape and a less hazardous environment for rescue teams the production of smoke and effluent gases needs to be reduced to a minimum.

Cables as well need to be looked at as products that are inflammable and, therefore, smoke producers. The parameters acidity and smoke density have been used by the cable industry for many years. By determining acidity, the corrosive potential of gases evolving from cables can be identified. This parameter is a good indicator for the irritant effect of gases. The acidity of low fire-hazard cables to be used in buildings is close to zero. Furthermore, an important parameter is the amount of smoke released and its density during combustion. Low fire-hazard cables are characterized by a low smoke density and, thus, they considerably contribute to the successful evacuation of people.

ZVEI draws attention to possible solutions

Within the German Electrical and Electronic Manufacturers' Association (ZVEI), spokesperson and platform of the German Electrical industry, innovative fire protection solutions are being discussed and brought to public attention. As an example, the cable industry in Germany developed a range of low fire-hazard cables which in the event of fire show a very low emission of smoke and a considerably lower amount of dangerous gases.

ZVEI: Manufacturer´s Association of Germany´s Most Innovative Industry

The 'ZVEI - German Electrical and Electronic Manufacturers' Association' promotes the industry's joint economic, technological and environmental policy interests on a national, European, and global level. The ZVEI represents more than 1,600 companies, mostly SMEs.

The sector has 844,000 employees in Germany plus 692,000 employees all over the world. In 2014, the turnover was approximately Euro 171 billion.

The electrical and electronics industry is the most innovative and the second largest industry sector in Germany. Every third innovation in Germany´s manufacturing sector stems on solutions of this sector. 20 percent of all industrial R+D spending comes from this industry.

Of the ZVEI's current 22 divisions, four coorporative members and four Working Groups, it is the German Cable Makers' Association's that represents the manufacturers of power and communication cables as well as of a wide range of products in the field of winding wires and accessories.

The German Cable Makers' Association provides the necessary platform to develop system solutions regarding technical and political issues.

[3] Dougal Drysdale (2011): An introduction to fire dynamics, Hoboken, NJ [u.a.] Wiley
[4] SRSA (Swedish Rescue Services Agency): Schwedische Agentur zur Gefahrenabwehr und zum Katastrophenschutz
[5] Lars-Göran Bengtsson and the Swedish Rescue Services Agency (2001): Enclosure Fires

Cables under fire conditions

In the event of a fire, cables can support the start of a fire and it's propagation from one room to adjacent rooms. According to statistics of the German Institute for Damage Prevention and Research (IFS) about 33 percent[6] of all fires examined can be attributed to electricity. The percentage of this increased within the last years according to the fire cause statistics. Defective devices, aged connectors or improper electrical installation or connections quickly lead to smoldering fire. Such a fire is often discovered very late. Still, smoldering fire may lead to the release of toxic substances.

Cables can also transfer a fire from one room to adjacent rooms. Thus, cables potentially contribute to fire propagation.

Low fire-hazard cables improve safety

Cables usually consist of a metallic (or optical fibre) conductor and organic insulation and sheathing materials. These organic materials vary in their flammability and cause a different smoke density each.

As cables potentially contribute to fire propagation due to their laying in buildings, this danger has been considered in multiple national regulations for many years. The reaction to fire performance of cables can be influenced by cable design in terms of using compounds made of "self-extinguishing" or "flame-retardant" materials. Performance is determined not only regarding a single cable but also regarding a vertically installed bunch of cables as this type of installation highly demands the reduction of fire propagation by using flame-retardant materials. The parameters and fundamental decision criteria for choosing materials, which reduce the release of toxic gases in the event of a fire, are smoke density and acidity of arising gases.

It is of key significance to keep the development of opaque smoke and dangerous gases to an absolute minimum during a fire. These criteria are fulfilled by flame-retardant and halogen-free cables.

It is vital to reduce the exposure time of people to these gases by facilitating safe evacuation with the best possible visibility.

Longer escape times are essential

The University of Lund in Sweden conducted a study using computer programs especially designed for simulating the propagation of smoke and gases that evolve during combustion in a building and people's behaviour in case of a fire alarm[7]. The study examined different cabling types in a building in relation to the evacuation in the event of a fire. The study's result was that with conventional cabling only human beings evacuated within 53 seconds were able to exit the building on fire in time. This clearly shows how important a certain retardation effect with the help of fire prevention methods can be. On the basis of data obtained from measurements of combustion products according to the fire scenario described in EN 50399, the University of Lund conducted a study on the simulation of critical evacuation conditions for fire scenarios involving different cables. This study confirmed that the use of low fire-hazard cables can substantially reduce the danger in the event of a fire. By using materials with a low level of opacity of smoke produced, visibility and, hence, chances to escape were significantly improved.

[6] Fire cause statistics of IFS: "IFS-Brandursachenstatistik 2013", status 01/04/2014

[7] van Hees, Patrick and Nillson, Daniel (2009): Simulation of Critical Evacuation Conditions for Fire Scenarios Involving Cables and Comparison of Different Cables, Department of fire safety engineering and safety systems, Lund University, Sweden

Cables as a construction product

Considering fire safety of construction products

Fire safety is usually ascribed to structural elements or construction materials – other construction products, which are not directly structural elements or construction materials, were traditionally not focused on. Since the Düsseldorf airport fire in 1996, it became apparent that in many further product groups fire safety issues are being discussed.

The European Union recognized that different national regulations with regard to fire performance characteristics of construction products in Europe need to be aligned in a single uniform evaluation system. With the Construction Products Regulation (CPR), that came into force in July 2013 and is mandatory for all EU member states, the EU created a clear legal framework for relevant construction products. According to the European Construction Products Regulation, "a 'construction product' means any product or kit which is produced and placed on the market for incorporation in a permanent manner in construction works or parts thereof and the performance of which has an effect on the performance of the construction works with respect to the basic requirements for construction works". Per definition, cables are construction products if created for incorporation in a permanent manner in construction works.[8] 'Permanent' has to be seen as contrary to an intentionally temporary installation.

Consequently, cables that are incorporated in construction works comply with the definition – even if plastered or laid in shafts. Flexible cables, which are installed for a building's energy supply as single cables or a system in a permanent manner, are also within the scope of the CPR. On the contrary, cables that connect a device with the building via a connector are not within the scope. Included here are inter alia power cords connecting appliances which, for instance, connect lamps or machines with the power grid. Data cables, which are not installed in a permanent manner, as e.g., in data centres but are detachable as patch cables and can be used flexibly, are not covered by this definition. However, such data cables that are not installed temporarily but permanently, fall within the scope of the Construction Products Regulation.

Accordingly, cables that are permanently incorporated in a building and for which harmonized standards on the basis of the Construction Products Regulation exist (power, control and communication cables) are subject to this regulation. Thereby, Europe created new fire protection categories for cables demanding a reassessment of fire safety in buildings.

European classification for the construction product 'cable'

The European standardization bodies CEN and CENELEC were explicitly given a mandate by the European Commission to establish a harmonized standard for power, control and communication cables for permanent installation in construction works. Cables are categorized in different classes with regard to their reaction to fire performance which is tested according to the testing standards developed under the mandate.

The following Chart 1 shows the different reaction to fire classes whereby class A_{ca} is categorized as "non-flammable" and class F_{ca} is categorized as "not fulfilling class E_{ca}".

[8] EU-Construction Products Regulation, Article 2, 1

Chart 1: Reaction to fire classes for cables[9]

	Class	Test methods	Classification criteria	Additional classification
non-flammable	A_{ca}	EN ISO 1716	PCS ≤ 2,0 MJ/kg	
	$B1_{ca}$	EN 50399 (30 kW burner) *and*	FS ≤ 1,75 m and THR_{1200s} ≤ 10 MJ and Peak HRR ≤ 20 kW and FIGRA ≤ 120 Ws^{-1}	smoke production and flaming droplets/particles and acidity
		EN 60332-1-2	H ≤ 425 mm	
	$B2_{ca}$	EN 50399 (20,5 kW Burner) *and*	FS ≤ 1,5 m; and THR_{1200s} ≤ 15 MJ; and Peak HRR ≤ 30 kW; and FIGRA ≤ 150 Ws^{-1}	smoke production and flaming droplets/particles and acidity
		EN 60332-1-2	H ≤ 425 mm	
	C_{ca}	EN 50399 (20,5 kW Burner) *and*	FS ≤ 2,0 m; and THR_{1200s} ≤ 30 MJ; and Peak HRR ≤ 60 kW and FIGRA ≤ 300 Ws^{-1}	smoke production and flaming droplets/particles and acidity
		EN 60332-1-2	H ≤ 425 mm	
easily flammable	D_{ca}	EN 50399 (20,5 kW Burner) *and*	THR_{1200s} ≤ 70 MJ; and Peak HRR ≤ 400 kW; and FIGRA ≤ 1300 Ws^{-1}	smoke production and flaming droplets/particles and acidity
		EN 60332-1-2	H ≤ 425 mm	
	E_{ca}	EN 60332-1-2	H ≤ 425 mm	
	F_{ca}	does not fulfil class E_{ca}		

Product certification

Within the terms of the EU-product certification, the certification of reliable products, i.e. from class E_{ca} onwards, is carried out by notified bodies. These are testing institutes which are independent from manufacturers. Notified bodies are designated by one single defined body that has been entitled by each Member State and that already has been subjected to an authorization procedure.

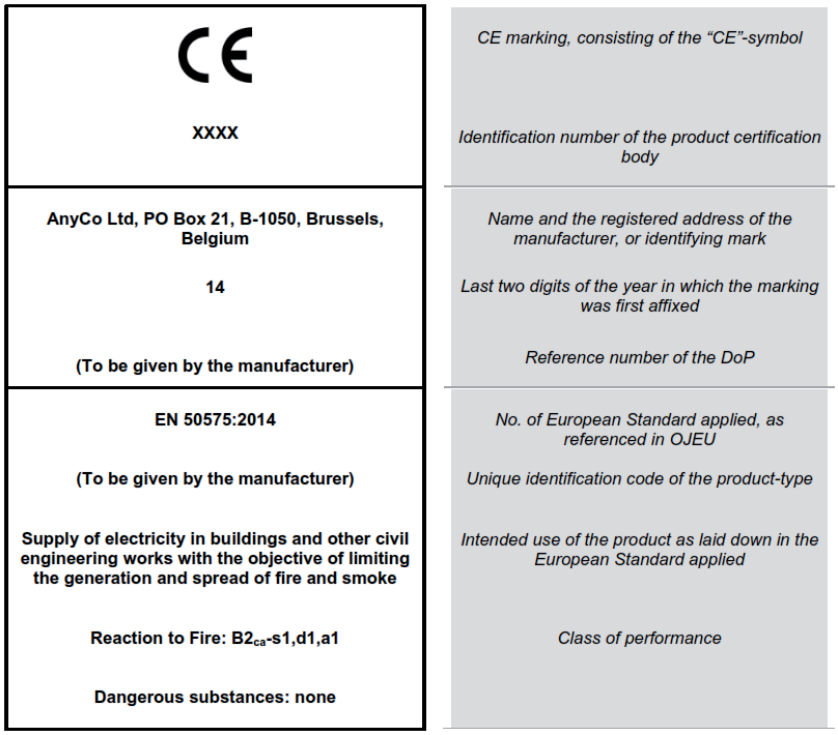
It depends on the reaction to fire class to which degree a notified body is involved in the certification of products. The system for cable certification of conformity complies with the allocation represented in Chart 2.

Chart 2: System for cable certification of conformity[10]

Reaction to fire class	Assessment and verification of constancy of performance (AVCP) system for cable certification of conformity	Duties of notified body
A_{ca}, $B1_{ca}$, $B2_{ca}$, C_{ca}	1+	• type testing • regular plant auditing • regular sampling from ongoing production
D_{ca}, E_{ca}	3	• type testing
F_{ca}	4	• none

[9] prEN 13501-6:2011-11 : Fire classification of construction products and building elements - Part 6: Classification using data from reaction to fire tests on electric cables; German version prEN 13501-6:2011

[10] hEN 50575:2014: Power, control and communications cables – Cables for general applications in construction works subject to reaction to fire requirements



Example of CE marking information on the product label for products subject to AVCP system 1+[11]

Whereas a class F_{ca} product is declared as such by the manufacturer, a class D_{ca} product or a class E_{ca}product needs to run through a notified testing laboratory's type testing. A product falling into classes A_{ca}, $B1_{ca}$, $B2_{ca}$or C_{ca}, which are critical for fire safety, will be continually surveyed in production in accordance with the conformity procedure 1+ by a notified product certification body.

A successfully completed conformity procedure is a prerequisite for labelling a product with CE marking.

The assignment to the respective class is documented by the CE marking. Hence, the user can be sure that required fire safety criteria are met and that the class can be easily identified.

Recommendation of the German cable makers' industry

With new applications arising, e.g. with the trend to intelligent control in buildings or innovative solutions for broadband access, cables tend to contribute more and more to fire risk. The development of low fire-hazard cables of the German cable makers' industry – in close cooperation with the European cable makers' industry – embraces this issue by focusing on the cables' low flame spread and heat release with very low emission of smoke and dangerous gases. Smoke reduction of materials and the cables' property of being halogen-free in particular facilitate a faster evacuation and, therefore, save human lives.

Cables, which are intended for being installed in construction works, need to be tested for their reaction to fire. As a result of the fire testing, cables are categorized into the respective classes as shown in Chart 1. The classes serve as better orientation and classification of construction products and their reaction to fire classes. The CPR is to be seen as a legal framework for all construction products that are safety relevant.

Higher safety level with low fire-hazard cables

In order to lift an entire buildings' fire safety level, the cable makers' industry recommends the use of low fire-hazard cables. Thus, it is highly recommended to use class $B2_{ca}$cables in buildings with very high safety requirements (e.g. in hospitals, nurseries) as well as in escape routes, and class C_{ca}cables in buildings with high safety requirements (e.g. in administration and office buildings). Chart 3 below shows a proposal for classes to be used for low fire-hazard cables by which additional classes are in descending order, i.e. s1 is superior to s2, a1 is superior to a2, and d1 is superior to d2.

[11] hEN 50575:2014: Power, control and communications cables – Cables for general applications in construction works subject to reaction to fire requirements

Chart 3: Proposal for classes to be used for low fire-hazard cables

Reaction to fire classes Flame propagation/ heat development	Additional classes Smoke production/ density	 Flaming droplets/ particles	 Acidity development/ corrosivity	Security requirements in a building
A_{ca}				very high
$B1_{ca}$				very high
$B2_{ca}$	s1	d1	a1	very high
C_{ca}	s1	d1	a1	high
D_{ca}	s2	d2	a1	medium
E_{ca}				low
F_{ca}				none

This assignment goes along with further recommendations on how to use these cable classes in different building classes. As different as buildings might be, as different are their safety requirements with regard to their intended use. Therefore, it is useful to design a cables' fire safety level depending on the type of building. For this purpose, planners and users can refer to the building typification included in the German model building regulation (German: Musterbauordnung) which has existed for more than ten years now.

There is more than one escape route available in a detached house for a single family. Hence, the use of high-quality low fire-hazard cables does not substantially contribute to the rescuing of human beings here.

This is significantly different from the situation in high-rise buildings or in buildings with a high density of people like in sales outlets, event locations or administration halls with a high amount of public traffic. All efforts need to be made here to allow more time for evacuating people in the event of a fire and to enable escape.

Consequently, the highest safety level has to be considered for buildings with people who, for instance due to their age or illness, are not able to escape independently.

With the recommended fire classes the entire building's safety level increases so that low fire-hazard cables can be installed in escape routes, corridors and supply shafts.

Accordingly, the cable makers' industry recommends the adaptation of the German 'Musterleitungsanlagenrichtlinie' (MLAR – regulation on model conduit installation) to the state-of-the-art.

A summary of these recommendations is shown in the following Chart 4.

Chart 4: Proposal of the German cable makers' industry for correlating building types and cable classes

Building classes according to the German model building regulation (Musterbauordnung)				Fire classes	
Class	Description			Minimum requirements	
				Building (except for escape routes)	Escape routes
1	detached buildings or detached buildings for agricultural or forestry-related use	up to 7 m	not exceeding a total of 400 m²	E_{ca}	
2	buildings	up to 7 m	not exceeding a total of 400 m²	E_{ca}	
3	other buildings	up to 7 m		E_{ca}	$B2_{ca}$ s1 d1 a1
4	other buildings	up to 13 m	up to nx400 m²	E_{ca}	$B2_{ca}$ s1 d1 a1
5	other buildings including underground buildings			C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
Special-purpose constructions					
S1	high-rise buildings	exceeding 22 m		C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S2	construction works	exceeding 30 m		C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S3	buildings	with the largest floorspace of 1600 m², except for residential buildings and garages		C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S4	sales outlets	exceeding 800 m²		C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S5	office/administration	rooms exceeding 400 m²		C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S6	buildings with single rooms	single rooms can be used with more than 100 persons		C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S7	places of assembly	more than 200 persons		C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S8	restaurants/hotels	for more than 40 guests in buildings, more than 12 beds, casinos more than 150 m²		C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S9	buildings with functional units provided for care or assistance dependent people	more than 6 persons, need for intensive care		$B2_{ca}$ s1 d1 a1	$B2_{ca}$ s1 d1 a1
S10	hospitals			$B2_{ca}$ s1 d1 a1	$B2_{ca}$ s1 d1 a1
S11	other facilities for accommodating people like residences			C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S12	day-care facilities for children, disabled people and elderly			$B2_{ca}$ s1 d1 a1	$B2_{ca}$ s1 d1 a1
S13	schools, universities or similar facilities			C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S14	penal institution and construction works for psychiatric hospital treatments			C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S16	leisure/ amusement parks			C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
S18	warehouse shelves with top of the load higher exceeding 7,5 m			E_{ca}	$B2_{ca}$ s1 d1 a1
S19	construction works for storage of substances with increased fire hazard			$B2_{ca}$ s1 d1 a1	$B2_{ca}$ s1 d1 a1
Further classification recommended by the German cable makers' industry					
	industry			C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1
	server rooms			$B2_{ca}$ s1 d1 a1	$B2_{ca}$ s1 d1 a1
	road tunnels			$B2_{ca}$ s1 d1 a1	$B2_{ca}$ s1 d1 a1
	rail tunnels			$B2_{ca}$ s1 d1 a1	$B2_{ca}$ s1 d1 a1
	underground parking			C_{ca} s1 d2 a1	$B2_{ca}$ s1 d1 a1

The above recommendations by the German cable makers' industry are currently included in the revised version of national construction regulations of communications- and energy installations (DIN EN 50174 part 1-3, VDE 0100-520 and VDE 0100-420).

Conclusion

The backbone of an intelligent building is formed by its information technology and electrical infrastructure which consists of cable systems. Such buildings can be office buildings, data centres or production plants. The increasing degree of interconnection with flammable cable material and the concomitant fire risk in high-rise buildings demands a new reflection upon the issue. Cables not only have to function during normal operation, but they also have to ensure safety during fire. The risk resulting from cable systems in the event of a fire can be minimized by using low fire-hazard cables. Thus, the risk of fire propagation can be reduced.

With the introduction of pan-European reaction-to-fire classes for cables, architects, planners and operators have a clear framework for using cables with improved reaction-to-fire properties. Competition all over Europe ensures that products are constantly available. Furthermore, the products' quality is being evidenced by a neutral certificate of conformity.

In order to reach a higher fire safety level, the cable makers' industry recommends:

- upgrading the fire safety level in the entire building by using low fire-hazard cables.
- the use of class $B2_{ca}$ in special-purpose constructions with very high safety needs (e. g. hospitals, nurseries).
- the use of class C_{ca} in buildings with high safety needs (e.g. administration or office buildings).

Implementing safety standards in buildings with high safety needs and adapting current national regulations is incumbent on all construction ministries of the single federal states. The ZVEI-German Cable Makers' Association looks forward to supporting the national implementation with its technical expertise and is prepared for a constructive dialogue with stakeholders.

The advantages of low fire-hazard cables won't be noticeable in daily life – similar to airbags in vehicles – however, in the event of an accident or a fire you wish to rely on them. Therefore, a significant contribution to preventive fire protection is made by using low fire-hazard cables according to the above recommendations.

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