



FIRE RESISTANCE IN EUROPE

Fire resistance on cables and systems

FIRE RESISTANCE AND SAFETY IN CASE OF FIRE

How rules and regulations apply in Europe on fire resistant cables and cables management systems.

ELAN SRL

Introduction

One minute after a fire ignites, it is generally said that only one water glass is needed to extinguish it. After two minutes, one pail of water is needed, and after three minutes, the fire is out of control. Only firefighters or well-trained people can act to contain the disaster. Bearing this in mind, it is crucial to have the possibility of escaping the building as quickly as possible. In this event, pre-planned fire-safety strategy is paramount. Flame, fire, smoke detectors can be installed in all areas to alert people and allow their escape during the first stage of a fire. But for a well-developed fire, smoke is released and can reduce visibility. To remedy this, EXIT signs are used to help people find their way out. In addition, blinding and choking smoke is extracted via smoke exhaust systems. In all cases, the devices will have to be connected to the electrical system. The usual way is to use fire-resistant cable to enable electrical continuity even in extreme fire conditions. This White Paper aims to show how fire-resistant cables work, as well as to explain how their reliability and robustness impact on safety.

Fire development

Generally speaking, the spread of fires in buildings follows four different stages of development, as showed here.

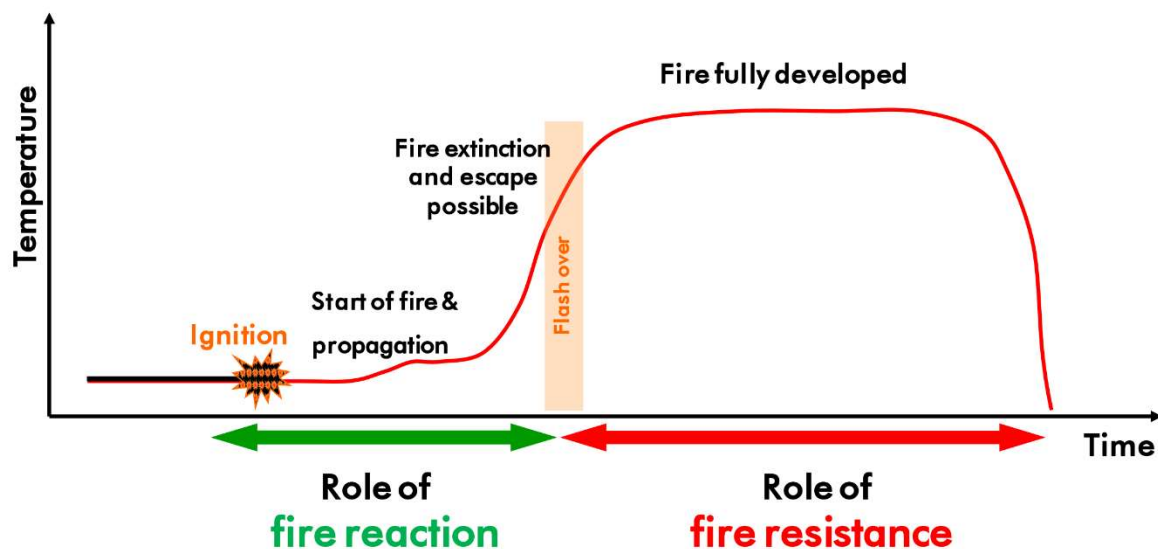


Figure 1: Fire development

Ignition

The fire triangle (see Figure 2) illustrates the fire principle. To start burning, three different elements are necessary at the same time, in just the right proportion. They are heat, fuel and an oxidizing agent, usually oxygen. However, in flats, offices, two of them are always present.

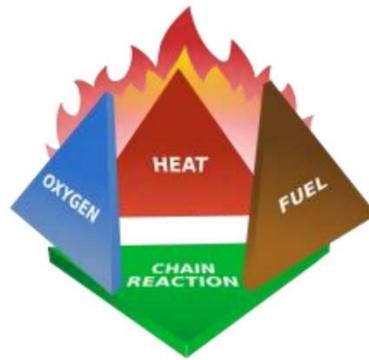


Figure 2: Fire triangle

The fuel consists of all of the materials: the furniture, computers, paper, combustible liquids, etc. Air brings the necessary oxygen into the room. In air, the oxygen content is 20.95%. Finally, only a simple spark or flame is missing to trigger the infernal process. This could occur because of a short circuit due to an electrical device malfunction or external events (fire in a garbage can, cigarette, etc.).

Growth or propagation

Finally, the fuel is heated to a temperature at which it starts to decompose and release gaseous products. They diffuse into the flame, and undergo combustion in the gas phase, liberating more heat. Under steady-state burning conditions, heat is transferred back to the fuel surface, producing more volatile polymer fragments to sustain the combustion cycle. The overall temperature in the room increases and the fire continues to grow. By convection, the hot gases or particles ignite other items in the room. The pressure increases, and gases try to escape via openings igniting other fire sources. Furthermore, depending on the building construction thermal conductivity, a significant amount of energy can be transferred from one room to another increasing the likelihood of fire propagation. The higher the thermal conductivity, the higher the risk.

Full development

In the case of a closed room, a flashover may occur if the overall temperature is high enough (500-600°C), with sufficient oxygen content. There is a sudden transition from a growth stage to a fully developed fire with a total surface involvement of all combustible materials. The internal pressure becomes huge in the enclosed space, leading to a possible explosion and aperture openings. At the same time, the heat released is at its maximum, and hot gases (as well as flames) can propagate far away from the starting point. Finally the fire spreads from one room to another following the same cycle, and conditions quickly threaten life and infrastructure.

Decay

When the combustible material and/or the oxygen contents are not high enough to sustain the fire cycle, the fire starts to decay. This is obviously a good sign that the fire will stop soon. Nevertheless, it may be a trap. Decay begins when the oxygen content is not high enough to sustain fire combustion. The heat released decreases, but the temperature can still increase for some time. Hot combustible particles and gases are still produced and can burst into flame again if fresh air arrives in the environment.

Fire Resistance and cable technologies

During the first stage of a fire, the basic idea is to stop or reduce as much as possible its propagation and make possible fire extinguishment. At the same time, it ensures that people can be evacuated under safe conditions. ELAN has developed various fire-retardant systems. When the fire is out of control, the situation becomes critical. It propagates quickly, releasing intense heat, opaque smoke and toxic substances, which drastically limit the possibility of escape. Here, special devices alert people to EXITs, and extract harmful substances, etc. Those safety elements must be connected to the power network. It is well known that standard smoke detectors are sometimes unreliable because people forget to test and change the batteries regularly. Also, fire-resistant cables are often used to provide power, or to make connections between emergency equipment. In this case, they function as “active” elements since they must maintain electrical continuity or transmit a signal for an adequate amount of time. Three main technologies are used to produce fire-resistant cables. Initial designs were based on copper conductors wrapped with mica tape(s) and cross-linked polyolefin. Conductors are usually insulated with PE or PPE (that is not responding to IEC 60331 or CEI 20-22 because very flammable) to ease the stripping operation. Here the core technology is the mica, and the cable performance is related to its quality, nature, suppliers, and taping. The second generation was based on silicone-rubber-insulated conductors. This material has the property of forming a ceramic shield when burning which maintains high electrical resistance. It is the most common solution for building applications, but often you can find cheap quality silicone leaving you with a lot of doubts regarding reliability in case of fire. ELAN developed a third system: **ELANFIRE**, the fire resistant cable with the mica technology **without** using **PE** or **PPE** for the insulation of the cores. **ELANFIRE** has insulated cores using a special LSZH (Low Smoke Zero Halogen) compound that comply with all the strict regulations about zero halogen emissions without compromising the easy stripping of cores.

Installation concept for safety circuits

Safety installations can be considered in two ways. The first one consists in placing fire resistant cables directly within cable management systems (trays, ladders, etc.), having at least equal performance in terms of integrity. This is done easily by standard assemblers. The second solution is more sophisticated and complex. The cables are drawn inside protective systems that are either pre-manufactured or built onsite. These have the advantage of ensuring fire resistance even for standard cables. The inside temperature is never higher than their failure point ($>100^{\circ}\text{C}$). This special property can be reached, for example, using specific additives releasing water when exposed to high temperatures. Unfortunately, they are extremely sensitive to external threats, such as mechanical shocks. A small fissure is enough to make them unreliable, since heat will penetrate inside. In terms of installation, they are also much more expensive, and time consuming. Furthermore, certain building spaces have to be pre-allocated by the architects since they are bulky, and once installed, system maintenance is difficult. Another point is seldom raised. They can easily promote fire propagation inside the building. In the case of short circuit, the standard cables start to burn and the fire quickly progresses along a route throughout the building that is almost impossible to detect. Instead of

providing protection, they become a threat. All things considered, it seems much more appropriate and far less expensive to install safety circuits using fire-resistant cables only, like **ELANFIRE**, that is



Figure 4: safety circuit installation concepts

able to grant the efficiency of the system for more than 120 minutes at 850 °C.

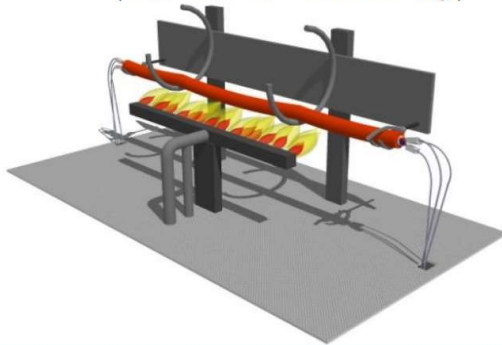
Cable fire-resistance assessment

As fire is of great concern, for many years, standardization bodies (IEC, CENELEC as well as national organizations) have been dealing with it. They have proposed various fire-resistant test protocols in order to assess cable reliability. The main differences consist in modifying the test duration, the fire/flame temperature, or adding mechanical stress and water sprays. Moreover, two different philosophies were used: either testing the intrinsic fire resistance of cables, or assessing the performance of cables with their associated management systems. The different testing protocols are

- International: IEC 60331 part 11 and associated part 21, 23 and 25

IEC 60331-11 & -21 & -23

(cable horizontal on metallic rings)



Sample characteristics

- Cable diameter : mm
- Minimum length : 1200 mm

Test characteristics

- Flame temperature 750°C
- Ring number :
 - cable dia $\leq 10 \Rightarrow 5$
 - cable dia $\leq 10 \Rightarrow 2$
- Voltage : cable nominal voltage
- Duration : 105 min
(90min with fire + 15 min under voltage)

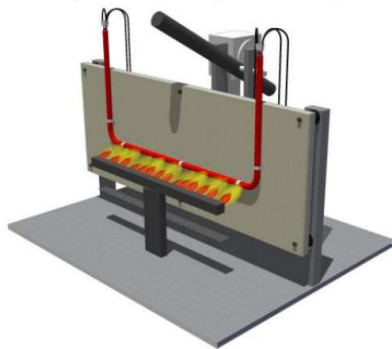
Requirement :

Function continuity ≥ 105 min

- European:
 - EN 50200

EN 50200 / IEC 60331-2

(« U » mounting on a fire proof frame)



Sample characteristics

- Cable diameter : ≤ 20 mm
- Minimum length : 1200 mm / test

Test characteristics

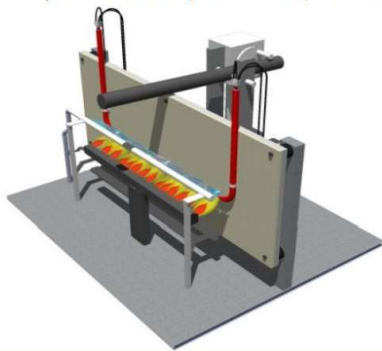
- Flame temperature : 850°C
- Mechanical shock : each 5 min
- Bending radius : cable manufacturer
- Voltage : cable nominal voltage
- Duration : 15 – 30 – 60 – 90 – 120 min

Requirement :

Function continuity $\geq 15 - 30 - 60 - 90 - 120$ min

- EN 50200 with water spray

EN 50200 Annex E & BS 8434-2
(« U » mounting on a fire proof frame)



Similar to EN 50200 with water spray

- Flame temperature : 850°C
- Duration : 30 min
(15 min fire & Shock + 15 min fire & shock & water)

BS 8434-2

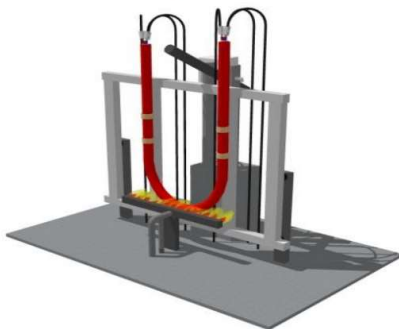
- Flame temperature : 950°C
- Duration : 120 min
(60 min fire & Shock + 60 min fire & shock & water)

Requirements :

- ⇒ Function continuity ≥ 30 min (Annex E)
- ⇒ Function continuity ≥ 120 min (BS test)

- EN 50362

EN 50362 / IEC 60331-1
(« U » mounting on a metallic ladder)



Sample characteristics

- Cable diameter : > 20 mm
- Minimum length : 1500 mm

Test characteristics

- Flame temperature 850°C
- Mechanical shock : each 5 min
- Bending radius : cable manufacturer
- Voltage : cable nominal voltage
- Duration : 15 - 30 - 60 - 90 - 120 min

Requirement :

- Function continuity ≥ 15 - 30 - 60 - 90 - 120 min

- France : NFC 32070 test n°3

NFC 32070 CR1

Cable horizontal place in a metallic tube if unarmoured



Sample characteristics

- Cable diameter : 0 - 40 mm
- Minimum length : 1200 mm

Test characteristics

- Temperature ramp : from 20 to 920°C then a plateau for minimum 15min
 $\Delta T = 345 \log (8t_{\min} + 1)$
- Mechanical shock : 1 each 30s on a tube or the cable if armoured
- Voltage : cable nominal voltage

Requirement :

- function continuity ≥ 65 min

- Germany: DIN VDE 0472 part 814

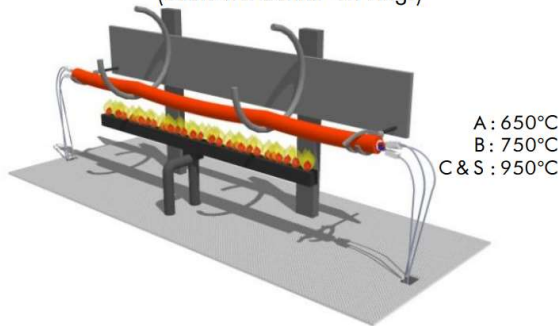
This test is similar to the IEC 60331-11 associated to part 21, except that the fire exposition is 3 hours at 400V plus 24 hours in voltage conditions without fire.

- UK

- BS 8434-2 (see EN50200 with water spray)
- BS 6387 A, B, C, S

BS 6387 cat A B C S

(cable horizontal on rings)



Sample characteristics

- Minimum length : 1200 mm

Test characteristics

- Flame temperature :
 - A : 650°C
 - B : 750°C
 - C & S : 950°C
- Burner position : vertical
- Voltage : cable nominal voltage
- Duration : 180 min or 20min for cat S

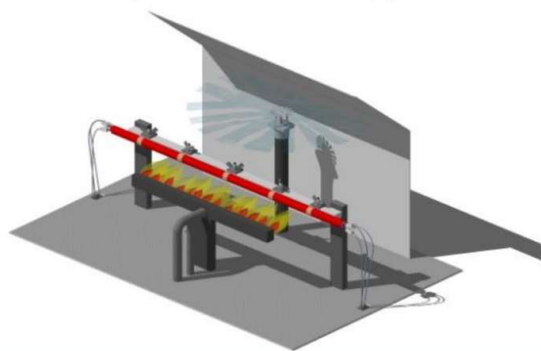
Requirement :

- Function continuity ≥ 180 min
- Function continuity ≥ 20 min for Cat S

○ BS 6387 W

BS 6387 cat W

(cable horizontal on rings)



Sample characteristics

- Minimum length : 1500 mm

Test characteristics

- Flame temperature : 650°C
- Water spray with sprinkler
- Voltage : cable nominal voltage
- Test duration : 30 min
(15 min fire + 15 min fire & water)

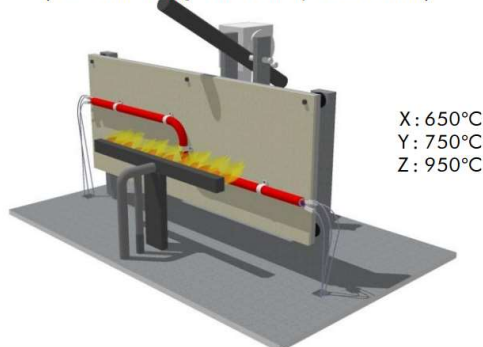
Requirement :

- Function continuity ≥ 30 min

○ BS 6387 X, Y, Z

BS 6387 cat X Y Z

(« Z » mounting on a fire proof frame)



Sample characteristics

- Cable diameter : 0 - 20 mm
- Minimum length : 1200 mm

Test characteristics

- Flame temperature : from 650 to 950°C
- mechanical shock : each 30s
- Bending radius : cable manufacturer
- Voltage : cable nominal voltage
- Test duration : 15 min

Requirement :

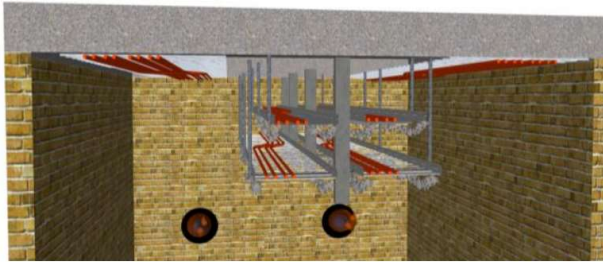
- Function continuity ≥ 15 min

5.2 Example of tests on systems

- Germany: DIN 4102-12

In this case the systems are tested at their nominal load (between 10 to 30kg/m). The cables are bent to form an "S" shape on the systems.

Test in Furnace (system test DIN 1402-12)



Sample characteristics

- Minimum length : 4 m

Test characteristics

- Fire temperature : from ambient to $> 1000^{\circ}\text{C}$ ($\Delta T = 345 \log [8t_{\min} + 1]$)
- Bending radius : cable manufacturer
- Voltage : 400V
- Duration : 30 - 60 - 90 min

Requirement :

Function continuity
 $\geq 30 - 60 - 90$ min

- Belgium: NBN 713020

Here there is no load on the system. The cables cross the wall and are sealed with concrete.

Test in Furnace NBN 713020



Sample characteristics

- Minimum length : 4 m

Test characteristics

- Fire temperature : from ambient to $> 1000^{\circ}\text{C}$ ($\Delta T = 345 \log [8t_{\min} + 1]$)
- Bending radius : cable manufacturer
- Voltage : 400V
- Duration : 60 - 90 min

Requirement :

Function continuity
 $\geq 60 - 90$ min

- Europe and Future Construction Product Regulation: EN50577

As for DIN4102-12, the systems with a load of 20kg/m and the system shall be of the same class as the cables. Furthermore, cables are bend to form a "U" or "S" shape on the systems.

Test in Furnace EN50577



Sample characteristics

- Minimum length : 4 m

Test characteristics

- Fire temperature : from ambient to $> 1000^{\circ}\text{C}$ ($\Delta T = 345 \log [8t_{\min} + 1]$)
- Bending radius : cable manufacturer
- Voltage : rated voltage
- Duration : 15 - 30 - 60 - 90 - 120 min

Requirement :

Function continuity
 $\geq 15 - 30 - 60 - 90 - 120$ min

Conclusion

In the case of fire, escape conditions drastically affect the possibilities for people to evacuate a building safely. The EXIT routes must be well identified. Visibility must be high enough to find their way out. People must be informed as soon as possible. And special devices, used to maintain the right

conditions for as long as possible, must continue to function flawlessly: exhaust fans, fire/flame or smoke detectors, etc. Various safety strategies can be used to maintain the electrical integrity of safety circuits.

It appears that fire-resistant cables and especially the **ELANFIRE** ranges installed on fire-resistant cable management systems are relevant, reliable and robust enough to ensure safety. They have demonstrated their intrinsic fire-resistance value and the ability to maintain electrical integrity when installed on cable management systems simulating real electrical installations. For architects and builders, this special solution is bound to be a preferred first choice in comparison to traditional protected systems.