



Fire Performance Standard

At present, in cable industry, Fire Retardant, Low Smoke Halogen Free (LSZH), Low Smoke Fume (LSF) and Fire Resistant cables are all described as Fire survival Cables.

- **Fire retardant cables** are designed for use in fire situations where the spread of flames along a cable route needs to be retarded. Due to relative low cost, fire retardant cables are widely used as fire survival cables. No matter the cables are installed in single wire or in bundles, during a fire, the flame spread will be retarded and the fire will be confined to a small area, thus reducing the fire hazard due to fire propagation.
- **Low Smoke & Halogen Free & Fire Retardant (LSZH)** LSZH cables are not only characterized by the fire retardant performance but also by the halogen free properties, thus offering low corrosivity and toxicity. During a fire the LSZH cables will emit less smoke and acid gases which may damage the human being and expensive equipment. Compared with normal PVC cables, LSZH cables outperform by their fire retardancy, low corrosivity and low smoke emission properties, however, normal PVC cables have better mechanical and electrical properties.
- **Low Smoke Fume (LSF)** The low halogen content and low corrosivity of low smoke fume cables lies somewhat in between that of fire retardant cables and LSZH cables. LSF cables also contain halogen but the content is much less than that of PVC

cables. LSF cables are designed to reduce the spread of fire toxic gases and smoke during fire. The LSF cables are usually manufactured from flameretardant PVC blended with HCL additive and smoke absorbent. These materials help improve the fire performance of the LSF cables.

- **Fire Resistant (FR)** Fire resistant cables are designed to maintain circuit integrity of those vital emergency services during the fire. The individual conductors are wrapped with a layer of fire resisting mica/glass tape which prevents phase to phase and phase to earth contact even after the insulation has been burnt away. The fire resistant cables exhibit same performance even under fire with water spray or mechanical shock situation.
- **Fire Performance Class** The main concerns for the cables in their fire survival properties are their flame spread, smoke characterization and gas toxicity. In American fire standard, the concern lies more on the first two and it differs from the European standard which concerns all these aspects. In USA, it is believed that the fire hazard is mainly due to CO toxic gas emitted and the heat release during the conversion of CO to CO₂ during the fire. Therefore, to control the heat release is the most important concern for reducing the fire hazard. However, in European countries, halogen content, the corrosivity of the gases, the smoke density and the toxicity of the gas are equally important factors affecting the safety and survival of human during a fire.



IEC Standard for Flame Retardancy

The European Electrical Committee categorizes the fire performance of the cables into three classes, namely IEC 60332-1, IEC 60332-2, IEC 60332-3, IEC 60332-1 and IEC 60332-2 are used to assess the flame propagation characteristics of a single wire. IEC 60332-3 is used to assess the flame propagation characteristics of bundled cables. Comparatively speaking, IEC 60332-3 for bundled cables is more demanding than IEC 60332-1 for single wires.

- **IEC 60332-1/BS 4066-1 (Flame Test On Single Vertical Insulated Wires/Cables)**

This test details a method of test for the assessment of the flame propagation characteristics of a single wire or cable. In this test, a 60cm cable sample is fixed vertically inside a metallic box and a 175mm long flame is applied at 45°C from a gas burner placed at 450mm from the top at the upper portion.

The specimen is deemed to have passed this test, if after burning has ceased, the charred or affected position does not reach within 50mm of the lower edge of the top clamp which is equivalent to 425mm above the point of flame application. The test method is not suitable for the testing of some small wires due to the melting of the conductors during the time of application of the flame.

- **IEC 60332-3/BS 4066-3 (Flame Test On Bunched Wires/Cables)**

IEC60332-3C describes a method of type approval testing to define the ability of bunched cables to resist fire propagation. In this test, a cable specimen, consisting of number of 3.5m length of cables are fixed to a vertical ladder tray where they are applied with a flame from a gas burner for a specified times under controlled air flow. Four categories (A, B, C & D) are defined and distinguished by test duration and the volume of non metallic material of the sample under test. The cable specimen is deemed to have met the requirements of the standard if, after burning has ceased, the extent of charred or affected portion does not reach a height exceeding 2.5m above the bottom edge of the burner.



UL Standard for Fire Retardancy

If a cable can pass a specified UL fire standard, an UL performance verification mark can be applied onto the cable jacket illustrating both the UL class and the number. There are five primary fire testing standards as follows.

- **CMP (Plenum Flame Test/ Steiner Tunnel Test)**

Plenum rated cables meet the NFPA -262 standard (formerly known as UL910) which provides the most stringent requirement of all the tests. Cable samples on a horizontal tray in a tunnel type of chamber are burned at 87.9KW (300,000 BTU/Hr) for 20 minutes. To qualify for a plenum rating the cable specimen must have the fame spread of less than 5 feet or 1.5 meters with a smoke density during the test of (a) 0.5 peak and 0.15 maximum average. The CMP cables are usually installed in air ventilation ducts and air returns widely used in Canada and USA. The fire retardant properties of CMP cables are much better than that of normal LSZH cables complying with IEC 60332-1 and IEC 60332-3.

- **CMR (Riser Flame Test)**

Riser rated cables meets UL1666. Cable samples on a vertical shaft are burned at 154.5KW (527,500 BTU/Hr) for 30 minutes. To qualify for a riser rating, cable specimen must have the fame spread of less than 12 feet beyond the ignition point. This test does not look at the smoke density or toxicity. Riser rated cables are suitable for vertical shafts not defined as an environmental air plenum.

- **CM (Vertical Tray Flame Test)**

General purpose cables meet UL 1581. Cable samples on a 8 feet vertical tray are burned at 20KW (70,000 BTU/Hr) for 20

minutes. The cable specimen is deemed to pass the test if the fame spread will not extend to the upper portion and extinguish by itself. UL 1581 is similar to IEC 60332-3C except for that the number of testing samples is different. This test does not look at the smoke density or toxicity. The CMG cables are usually used in runs penetrating single floor. These cables cannot be installed in vertical pathways.

- **CMG (Vertical Tray Flame Test)**

These general purpose cable also meet UL1581. CM and CMG are similar and both are recognized in Canada and USA. This test does not look at the smoke density or toxicity. The CMX cables are usually used in runs penetrating single floor. The cables cannot be installed in vertical pathways.

- **CMX (Vertical Wire Flame Test)**

The restricted cables meet UL1581 Limited-use. The test consists of 25 feet long ventilated tunnel. The cable specimen is placed on a ladder inside the tunnel and the fame of 30,000 BTU/Hr is applied to the cable 15 seconds on and 15 seconds off five times for a total exposure to the fame of 1 minute and 15 seconds. To qualify for this test, after the test fame is removed the cable specimen can fame for not more than 60 seconds and the charred portion will not exceed by 25%. UL 1581 VW-1 is similar to IEC 60332-1 except for the difference in the time for fame applied. This test does not look at the smoke density or toxicity. The CMG cables are suitable for use in dwellings and for use in raceway. These cables cannot be installed in bundles and must be protected in metal conduit. This type of cable is chosen as the minimum requirement for commercial installations.



Standard for Fire Resistance

Fire resistant cables are designed for maintaining circuit integrity during a fire. The IEC and the BS adopted two different standards, namely the IEC 60331 and BS 6387. Comparatively speaking, the fire performance requirement for BS 6387 is more demanding.

- **IEC60331 Fire Resistance Test**

A cable sample is placed over a gas burner and connected to an electrical supply at its rated voltage. Fire is applied for a period of 3 hours. The temperature on the cable is between 750 °C and 800 °C. After 3 hours, the fire and the power is switched off. 12 hours later, the cable sample is reenergized and must maintain its circuit integrity.

- **BS6387 Fire Resistance Test**

BS6387 specifies the performance requirements for cables required to maintain circuit integrity under fire conditions. It details the following methods to categorize the cables according to cable withstand capacities. Resistance to fire alone - the cables is tested by gas burner fame while passing a current at its rate voltage. Four survival categories are defined Cat A (3

hours at 650°C), Cat B (3 hours at 750°C), Cat C (3 hours at 950°C), and Cat S (20 minutes at 950°C). Resistance to fire with water spray - a new sample of cable is exposed to fame at 650°C for 15 minutes while passing a current at its rated voltage and then the spray is turned on to give exposure to both fire and water for a further 15 minutes. A single survival category W is defined if the cables surpassed the testing requirement. Resistance to fire with mechanical shock - the final requirement is mechanical shock damage. A fresh sample is mounted on a backing panel in an S bend and is exposed to fames while the backing panel is stuck with a steel bar with the same diameter as the cables under test every 30 seconds for 15 minutes. The cables will be tested under the following temperatures: X (650°C/15min), Y(750°C/15min) and Z (950°C/15min). The highest standard for BS 6387 is CWZ.



Standard for Halogen & Smoke Emission, Corrosivity & Toxicity

• IEC 60754-1/BS6425-1 (Emission of Halogen)

This specifies a test for determination of the amount of halogen acid gas other than the hydrofluoric acid evolved during combustion of compound based on halogenated polymers and compounds containing halogenated additives taken from cable constructions. Halogen includes Fluorine, Chlorine, Bromine, Iodine and Astatine.

All these elements are toxic by their nature. In this test, when the burner is heated to 800°C, 1g sample is placed inside and the HCL is absorbed into water inside the chamber fed with air flow. The water is then tested with its acidity. If the hydrochloric acid yield is less than 5 mg/g, the cable specimen is categorized as LSZH. If the hydrochloric acid yield lies between 5mg/g to 15mg/g, the cable specimen is categorized as LSF. IEC60754-1 cannot be used for measuring the exact HCL yield if the yield is less than 5mg/g. This test cannot determine if the cable is 100% halogen free or not. To determine if the cable specimen is 100% halogen free or not, IEC60754-2 has to be employed.

• IEC 60754-2 (Corrosivity)

This test specifies a method for the determination of degree of acidity of gases evolved during combustion of the cable specimen by measuring its pH and conductivity.

The specimen is deemed to pass this test if the pH value is not less than 4.3 when related to 1 litre of water and conductivity is less than 10µs/min.

When the HCL yield lies between 2mg/g and 5mg/g, a cable specimen can pass IEC 60754-1 but its pH value will likely be less than 4.3 and therefore cannot pass the IEC 60754-2 test.

• IEC 61034-1/ASTM E662 (Emission of Smoke)

This specifies a test for determination of smoke density. The 3 metre cube test measures the generation of smoke from electric cables during fire. A light beam emitted from a window is projected across the enclosure to a photo cell connected to a recorder at the opposite window.

The recorder is adjusted to register from 0% for complete obscuration to 100% luminous transmissions. A 1 metre cable sample is placed in the centre of the enclosure and is applied with a fire. The minimum light transmission is recorded. The result is expressed as percentage of light transmitted. The specimen is deemed to pass this test (IEC61034-1 & 2) if the value is greater than 60%. The higher the light transmittance, the less smoke emitted during a fire.

• ISO4589-2/BS2863 (Oxygen Index LOI)

This is a test for assessing the oxygen index of the material in accordance with the test method specified in ASTM D2863-95 (Measuring the minimum oxygen concentration to support candle-like combustion of plastics). At room temperature when

the oxygen content in the air exceeds the oxygen index, the material will burn by itself automatically.

The higher the oxygen index, the more retardant the cable will be.

For example, if the oxygen index of a material is 21%, it means that the material will burn by itself even at room temperature because at room temperature the normal oxygen content is 21%. In general, the oxygen index of a LSZH cables ranges from 33% to 42%.

• ISO4589-3/BS2782.1 (Temperature Index TI)

This is a test for assessing the performance of a material when it is tested in accordance with BS2782 Part 1 Method 143A and 143B. The oxygen index of a material will drop when the temperature rises.

When the temperature rises and the oxygen index drops to 21%, the material will burn automatically. This temperature is defined as temperature index. For example, the temperature index of coal is 50%. When the temperature climbs to 150°C, its oxygen index drop to 21% and the coal will burn by itself automatically.

The temperature index of the coal will then be defined as 150.

In general, the temperature index of LSZH cables ranges from 250°C to 300.

• ES713 (Toxicity Index)

This is a test defined by Naval Engineering Standard which is a directed at the analysis of a specified set of gaseous species which are commonly present in the combustion products of materials used in military application and which may cause lethality at the time of a fire. In this test, a 1g cable specimen is completely burnt inside a sealed chambers of volume 0.7-1m³ using a burner fed with air and gas to give a non-luminous fame. The resulting chamber atmosphere is quantitatively analysed for a specified set of gases. For each gas, the measured concentration (Ci) is scaled up for 100g and the concentration is recalculated as though the combustion products is diffused into a volume of exactly 1m³.

The resulting concentration (C8) is expressed as the ratio of critical factor (Cf) which is equal to the concentration of this gas considered fatal to human for 30 minutes exposure. The ratio C8/Cf is summed for all gases detected to give the toxicity index. The higher the toxicity index, the more toxic the cable materials is. In general, the toxicity index of LSZH materials are less than 5. LSZH cable will also emit toxic CO and if the cable materials contains P, N and S, the toxic gases generated will even be greater. Thus LSZH cables cannot be categorized as toxic free. CM, CMR and CMP cables in general contains halogen elements which are essential for passing the strict fire retardancy testing. For example, CMP cables are made from FEP which contains Fluorine and are much toxic than normal LSZH cables. be defined as 150°C. In general, the temperature index of LSZH cables ranges from 250°C to 300°C.