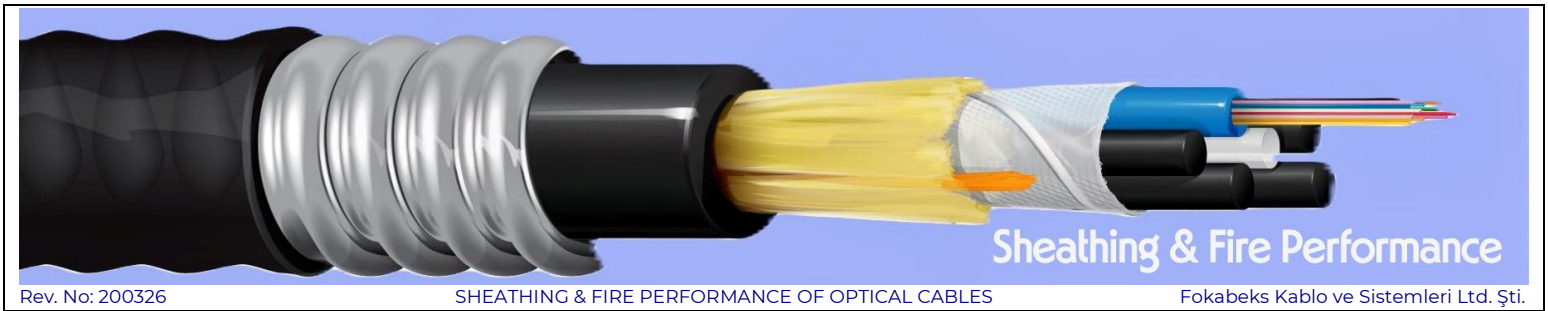


FOCABEX

'where **fiber optic** happens'

SHEATHING OF OPTICAL FIBER CABLES

Below features show a general approach to plastic materials used for fiber optic Cable sheathing and jacketing in the world market.

But, these do not cover all materials used for fiber optic cables jacketing and there are other plastic materials in addition to these below indicated ones .

Depending on the innovations and developments as a result of technological improvements etc., more materials are started to use in related field.

This below table is a type of simple guidance acc. to the best of our today's knowledge and it is based on typical values.

Given information is limited with characteristics of FOC jacketing materials but properties/ resistivity of cables can not be derived from it

Material	Polyolefine flame retardant	Polyvinyl Chloride	Polyetylene		Polyurethane flame retardant	Polyurethane	Polyamide
Abbreviation	**LSZH / LSOH**	**PVC**	**LD PE**	**MD/ HD PE**	**PUR / TPU**	**PUR / TPU**	**PA**
DIN VDE Code	H	Y	2Y	2Y	11Y	11Y	4Y

Combustion Properties

Halogen free	yes	no	yes	yes	yes	yes
Flame retardant	yes	yes	no	yes	no	no
Smoke emission	low	strong	medium	medium	strong	strong
Corrosive fumes	low	high	no	low	low	no

Mechanical Properties

Abrasion Resist.	low	medium	medium	good	good	good	good
Flexibility	high	high	medium	low	high	high	low
Hardness	medium	soft	medium	high	soft	soft	hard

Environmental Resistance

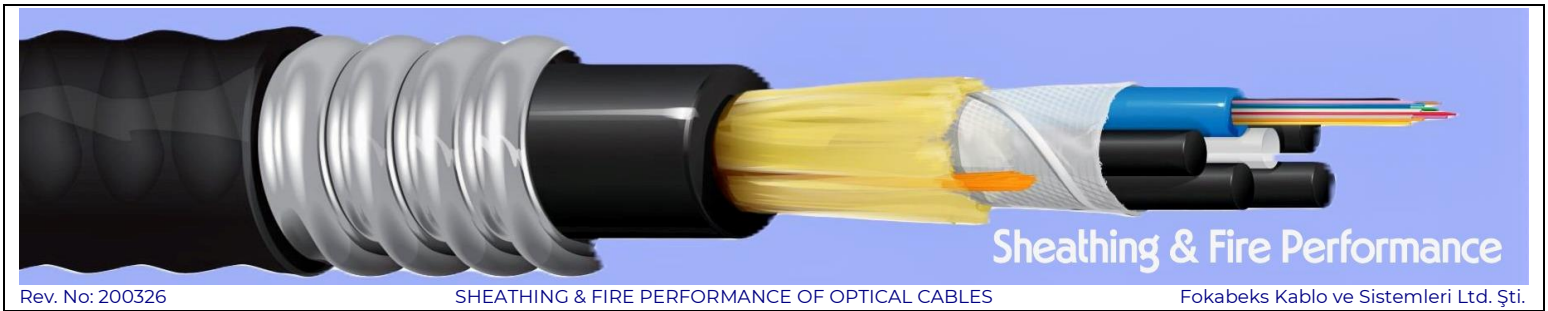
Oil / fuel*	good / satisfactory**	satisfactory	good / satisfactory	satisfactory	good	good
Water	good / satisfactory**	good	very good	satisfactory	good	satisfactory
Weathering ***	good	good	very good	good	very good	good

* Resistivity of various types of jacketing plastics has to be verified against specific types of oils and fuels

** Based on requested cable structure, various types of LSZH materials are used for FOC sheathing having different properties than each other

*** Black color for all types of plastic jacketing materials offers the best UV resistance but UV resistivity does not depend on solely color of plastic material used as UV resistive additives are used also for plastic jacketing materials independently color of the jacket etc.

All rights reserved 2026 Subject to improve, enhance, modify & update without prior notice www.focabex.com



FOCABEX

'where **fiber optic** happens'

SHEATHING MATERIALS

MDPE, BLACK

This is the Standard sheathing material for cables for outdoor use. The material is UV stabilised with using 2.5 ± 0.5 % carbon black.
It has excellent weathering resistance.

The MDPE has very good physical properties such as: good abrasion resistance, high hardness, low dielectric constant and outstanding oxidation resistance.

Compared with HDPE, the MDPE has better resistance to stress cracking.Compared to LDPE the MDPE has a higher strength.

The MDPE meets the requirements of various international standards:

- ISO 1872-PE, KGC, 40-G200, C
- ASTM D1248-84: Type II, Class C, Cat 5
- BS 6234 3C
- The MDPE fullfills the requirements of IEC 708-1 (test according to IEC 811)

LDPE, BLACK

This is the alternative PE material for cables for outdoor use. The material is UV stabilised using 2.5 ± 0.5 % carbon black and have very good weathering resistance.

The LDPE meets the requirements of various international standards:

- ISO 1872-PE, KCHL, 18-D003
- ANSI C 8.35
- ASTM D1248-84: Type I, Class C, Cat 5, grade J3, E5
- BS 6234 03C, TS1
- DIN VDE 0207 type 2YM2
- NF C 32-060
- The LDPE fullfills the requirements of IEC 708-1 (test according to IEC 811)

MDPE, COLOURED

The coloured MDFE is used for outdoor cables where the end user requires a cable sheath of other colours than black.

The material is UV stabilised for good weathering stability.

Standard sheath colours are: Black, orange, red, green, blue and aqua .Other colours according to IEC 304 or sample are possible.

The natural base material meets the requirements of various international standards:

- ISO 1872-PE, KNH, 27-D003
- ASTM D 1248 Type II, Class A, Cat 5 Grade E4,E5
- DIN VDE 0207 2YI1, 2YI3.
- NF C 32-060
- BS 6234: type 03

STANDARD MULTIPURPOSE LSZH

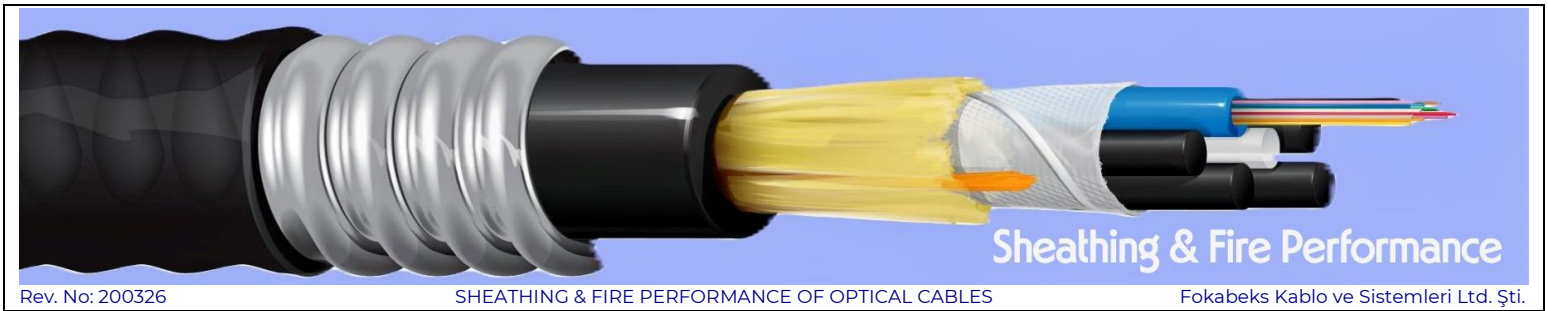
Standard LSZH (Low Smoke Zero Halogen) material is produced from polyolefin's and is filled with flame-retardants in the form of aluminium or magnesium hydroxide.

This sheathing compound is used for indoor as well as multipurpose cables. They are commonly used for tight coating of fibers to produce tight buffered optical fiber cables which are mainly used for indoor riser and plenum applications.

Standard sheath colours are: Black, orange, red, green, blue and aqua .Other colours according to IEC 304 or sample are possible.

The LSZH material meets the requirements of various international standards as described in the following pages

All rights reserved 2026 Subject to improve, enhance, modify & update without prior notice www.focabex.com



FOCABEX

'where **fiber optic** happens'

Cables made with LSOH IEC 60332-1 complied materials for sheathing

Low Smoke Zero Halogen material is produced from PE- copolymers and silicon elastomer with chalk as fire retardant filler.

This sheathing compound is used for cables that are installed as indoor/outdoor cables, due to its very low water absorption.

The cables made with this compound can be used outdoor installation in ducts (also flooded with water) as well as for direct burial.

Sheathing material is UV stabilized using a selected type of hindered amine light stabilizer (HALS). Thus a long lifetime even in the open air is assured.

Cables made with this material is selfextinguishing and fullfills IEC 60332-1.

The material fullfills the requirements of:

- EN 50290-2-27:2002
- VDE0207 Teil 24(HM5)

Cables made with LSOH IEC 60332-3C complied material for sheathing

Sheathing material is a high performance state-of-the-art LSZH (Low Smoke Zero Halogen) material.

Primarily is used where a very high resistance towards fire is needed.

While this material implement improvements well known multi purpose concept regarding performance in case of fire,the resistance towards the outdoor environment is retained: Material is UV resistant, and water resistant.

The UV resistance is achieved using a selected type of hindered amine light stabilizer (HALS). Thus a long lifetime even in open air is assured.

Material is non- toxic, non-corrosive and do not contain any halogens that could cause damage to equipment or the environments.

Further in case of fire it generates only extremely low amount of smoke.

Material fullfills all relevant international and national standards for this class of sheathing material, among them:

- EN 50290-2-27:2002
- VDE 0207 part 24, type HM2
- BS 7655 6.1 type LTS1 and LTS2

Cables made with this sheathing material is selfextinguishing and generally fullfills IEC 60332-3C.

PA (Polyamide) 12

A PA12 outer jacket is used optionally on top of a black MDPE sheath. This jacket gives the cable a hard, smooth surface.

The hardness is >71 (Shore D according to DIN 53505 and ISO R868).

The PA12 jacket adds a number of features to the cable: The cable gets improved rodent protection properties. The friction between cable and a PE duct is reduced with approximately 50%.

The PA12 jacket has a good chemical resistance towards certain chemicals:

At moderate temperatures the material is resistant without appreciable swelling to water, dilute and concentrated alkalis, ediple, lubricating and diesel oils, aliphatic hydrocarbons, esters, ketones and ethers.

At room temperature, the material is resistant to dilute organic acids and to very dilute mineral acids. Standard colour for the PA12 jacket is orange and black.

All rights reserved 2026 Subject to improve, enhance, modify & update without prior notice www.focabex.com

FOCABEX

'where
fiber optic happens'

PP (Polypropylene)

A PP outer jacket is used optionally on top of a black MDPE sheath. This jacket gives the cable a hard surface.

The PP jacket adds a number of features to the cable: The cable gets improved rodent protection properties. The friction between cable and a PE duct is somewhat reduced. The outer PP jacket is 0,5 mm thick. Standard colour for the PP jacket is orange.

ALUMINIUM TAPE AS MOISTURE BARRIER

Aluminium moisture barrier in the form of a folded tape is mainly used for telecom trunk lines. The aluminium tape is adhesively bonded to the outer jacket, which is made of LDPE or MDPE. This type of jacket is often called a 'LAP' sheath '.

The aluminium moisture barrier fullfills the requirements of:

- IEC 708-1
- IEC 794-3
- EN 187 100
- DIN/VDE 888-3 (DIN/VDE 816-1) (together with a black LDPE jacket.)

The nominal thickness of the aluminium tape is 0.20 mm. There is a polymer film on both sides of the aluminium tape.

The nominal thickness of the polymer film is 0.05 mm. The adhesion between aluminium tape and the polyethylene sheath is fullfilling the requirements of IEC 708-1.

The tape is folded with an overlap. As Standard the aluminium tape is surrounded by a LDPE or a MDPE jacket.

ARAMID YARNS FOR REINFORCEMENT

Aramid yarns are used as strength member for cables with tight buffered fibres, some cables with semi tight fibres and for UNI loose tube cables.

Aramid yarns are also used in loose tube cables with central strength member as additional tensile reinforcement.

There are no international or national standards for Aramid yarns. The most common trade names for Aramid yarns are Twaron™ and Kevlar™.

The tensile strength requirement for the cable determines the amount of Aramid yarn to be used.

They are not so effectively used for protection against rodents but wowen rowings are used sometimes for ballistic protection and against rodent attacks.

Water swellable alternatives are possible to achieve water resistivity in fiber optic dry core cables if requested .

GLASS YARNS FOR REINFORCEMENT AND RODENT PROTECTION

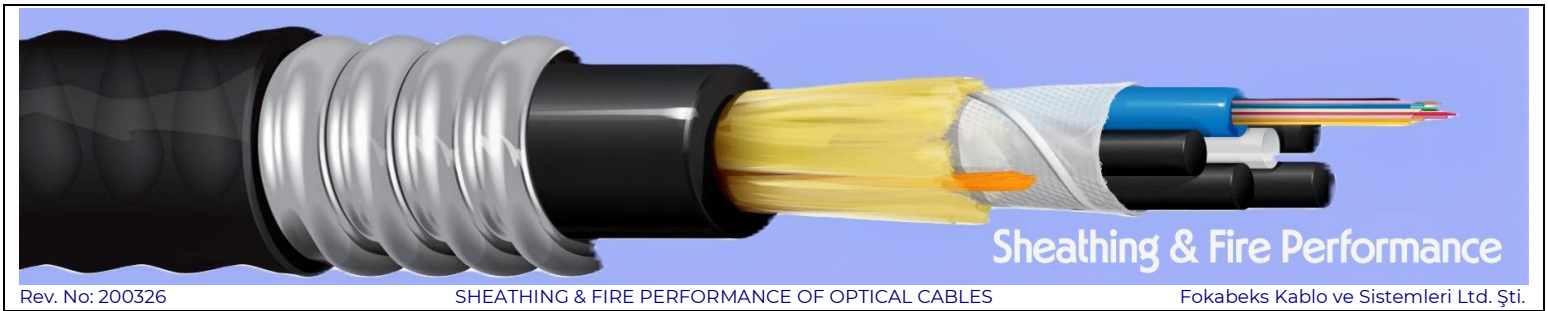
Glass yarns in the form of rovings are used as alternative strength member for UNI tube cables. Glass yarns are also used in loose tube cables with central strength member as additional tensile reinforcement.

Thick layers of glaziers have appeared to be a good rodent protection scheme, however not as effective as steel armouring.

Water swellable ones are also possible to achieve water resistivity in the Cable core if preferred.

They provide strenght to the Cable to achieve high crush and impact test values. But, due to their structure ,they increase the Cable outer diameter

All rights reserved 2026 Subject to improve, enhance, modify & update without prior notice www.focabex.com



FOCABEX

'where **fiber optic** happens'

FIRE PERFORMANCE OF OPTICAL FIBER CABLES

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.

• Flame Retardant (FR)

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 flame retardant 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 toearth 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 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 toxis 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 STANDARDS 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 60332-3C

IEC 60332-1 and IEC 60332-2 are used to assess the flame propagation characteristics of a single wire.

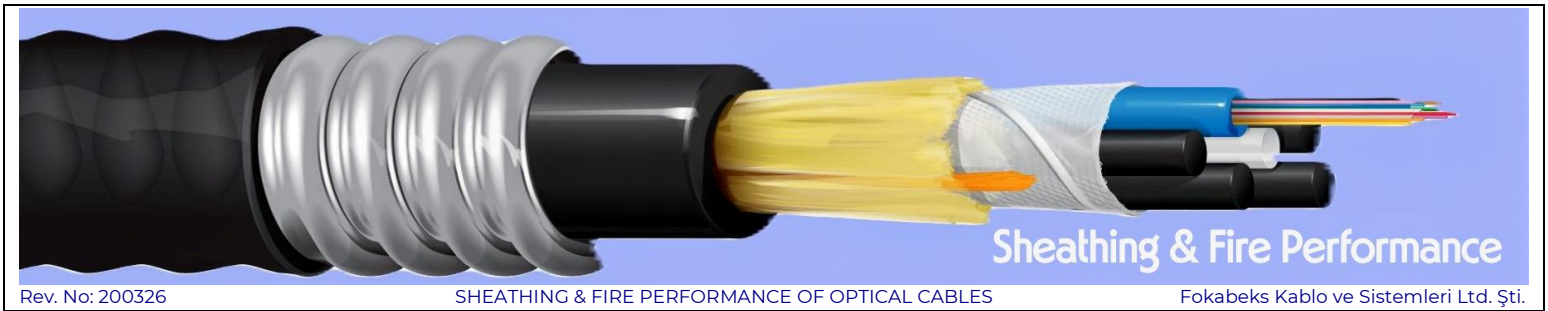
IEC 60332-3C is used to assess the flame propagation characteristics of bundled cables.

• IEC 60332-1 / 2 (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 17,5 (It is 12,5cm for IEC 60332-2) cm long flame is applied at 45 °C from a gas burner placed at 10cm above of the lower part of the sample for a duration dependent of the weight of the specimen whereas in case of IEC 60332-2 duration is max. 20 sec.

The specimen is deemed to have passed this test, if after burning has ceased, the charred of affected position does not reach to upper end of the sample . 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.

All rights reserved 2026 Subject to improve, enhance, modify & update without prior notice www.focabex.com



FOCABEX

'where **fiber optic** happens'

• IEC 60332-3 (Flame Test On Bunched Wires / Cables)

IEC 60332-3C 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 in 90° angle 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 exeeding 2.5m above the bottom edge of the burner.

STANDARDS FOR FIRE RESISTANCE

• IEC 60331-25 Fire Resistance Test for single Cable specimen

A cable sample is placed over a gas burner in horizontal direction and 60 cm in distance 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.

STANDARDS FOR HALOGEN & SMOKE EMISSION, CORROSIVITY AND TOXICITY

• IEC 60754-1 (Emission of Halogen)

This specifies a test for determination of the 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 Florine, 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 is 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 5 mg/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 10us/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 (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 (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%. İn general, the oxygen index of a LSZH cables ranges from 33% to 42%.

All rights reserved 2026 Subject to improve, enhance, modify & update without prior notice www.focabex.com