# IEC TR 63484

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# TECHNICAL REPORT

colour inside

## Guidance on fungus resistance of optical fibre cables



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The text of this Technical Report is based on the following documents:

| Draft | Report on voting |
|---|---|
| 86A/2485/DTR | 86A/2489/RVDTR |

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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- revised.

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# GUIDANCE ON FUNGUS RESISTANCE OF OPTICAL FIBRE CABLES

## 1 Scope

This document provides information about fungal growth on the outer sheath of optical fibre cables and on the inner components of the cable. It also provides guidance for specifying fungus resistance performance of optical cable outer sheath and internal cable components, including recommendations for fungus resistance test method as well as evaluation after test.

This document applies to optical fibre cables for use with telecommunication equipment and devices employing similar techniques, and to hybrid telecommunication cables having a combination of both optical fibres and electrical conductors.

Since conditions suitable for fungal growth include high relative humidity and a warm atmosphere, the document is applicable to optical cables intended for transportation, storage and use under such environment over certain period, for instance, some days at least.

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

## 4 Mechanisms of fungal infection and growth

### 4.1 Mechanisms of fungal infection

Fungi grow in or on many types of common materials. They propagate by producing spores. These spores are very small (1 µm to 10 µm) and easily carried in moving air. They also adhere to dust particles and various surfaces.

Thus, the cable surface and the cable end into which air penetrates can be infected with spores. The infection can also occur during handling, for example, spores can be transferred by touch.

### 4.2 Environmental conditions for fungal growth

There are various factors which affect the germination and growth of spores. But the key factors are shown as follows:

a) **Moisture**

Adequate moisture is necessary for spore growth and propagation. 65 % humidity is the threshold for fungal growth, whereas explosive growth occurs in excess of 90 %.

Fungal spores can survive for an extended period of time in a state of hibernation when humidity levels are below 65 %. Once adequate moisture becomes available, these spores will activate and start growing.

Water-absorption products on cable surfaces will accelerate fungal spore growth. These materials will absorb water from the atmosphere and fungi can access that water for metabolic use.

b) **Temperature**

Most fungi require temperatures between 10 °C to 35 °C, with some exceptions based on fungal species. Within this range, the closer to 35 °C, more growth will occur. Almost no fungi types grow below 0 °C or above 40 °C.

Fungal spores do not die when exposed to extreme temperatures, rather they go into a hibernation state. Once temperatures return to a suitable level, they will activate and start growing again.

c) **Nutrient**

Fungi require certain essential nutrients for growth including nitrogen, potassium, phosphorus, and sulphur, amongst others from a nutrient base for energy. Generally, nutrients can include inorganic salts and a carbon source. Basic plastic resins do not typically serve as carbon sources for fungal growth, but other components such as plasticizers, stabilizers, colorants, lubricants, and cellulosics can be responsible for fungal attack.

d) **Airflow**

Airflow also has an effect on the rate of fungal growth. High airflow can limit the growth and propagation of fungi. Stagnant air spaces and lack of ventilation can encourage fungal growth. In vacuum conditions, fungi cannot grow.

In addition, pH value, sunlight, surface roughness, interaction of organisms, exposure time and so on can affect fungal growth as well.

## 5 Effects of fungal growth on optical cable

### 5.1 General

Organic materials are commonly used in optical cable production, such as the sheath, buffer, filling/flooding compound, strength member, conductor insulation and fibre coating.

Fungi can live on most organic materials. They decompose certain organic materials as a normal metabolic process, thus degrading them and causing porosity and loss of structural integrity, even to function failure.

Fungal growth normally occurs only on surfaces exposed to the air. Surfaces which adsorb moisture, will generally be more susceptible to attack from fungal spores. The cable sheath, the cable components at cable ends and mid-span points, which can be exposed in the air, face high potential risk of fungal growth.

### 5.2 Main effects on optical cable

The detrimental effects of fungi on optical cables can either directly impact performance or have indirect causes to poor performance. A direct impact would be the fungal consumption and metabolization of cable components. An indirect influence can be attributed to the waste by-products of fungal growth, which are enzymes and organic acids that can break down cable components. The main effects are as follows:

a) Surface discoloration, leaving traces after cleaning the fungal growth area;
b) Sheath performance degradation, such as cracking, corrosion, modulus increase, weight and dimension change, embrittlement;
c) Hardening of cable filling/flooding compounds;
d) Mycelial growth into cable ends that are exposed to moisture or water. Mycelium can cause microbends where they touch the optical fibres;
e) Decrease in conductor insulation resistance.

## 6 Prevention of fungal growth

### 6.1 General

If optical cable is properly deployed, the cable sheath will be the most probable component which is subject to fungal attack. Usually, fungal growth occurs only on the sheath of optical cable. However, there are situations where cable internal components are exposed to the air with a risk of fungal growth. These situations include, but are not limited to:

a) Accidental sheath damage, by mechanical force, rodent bite;
b) Sheath cracking by environmental stress or ageing;
c) Optical cable closure is damaged or not tightly sealed after operation;
d) Improper installation or termination of optical cable;
e) Severe shrinkage of cable components after termination.

### 6.2 Cable sheath

Usually, there are physical methods and chemical methods for the prevention of fungal growth.

#### 6.2.1 Physical methods

As to the cable sheath, physical methods for the prevention of fungal growth are listed below:

a) When possible, install cable in an environment that is not conducive to fungal growth (i.e. low temperature, low humidity, and adequate ventilation).
b) The cable surface can be smooth to which dust is not easy to adhere.
c) Avoid fungal nutrients attached to the sheath surface.
d) For easy-to-maintain optical cables, for example, data centre cables, remove the existing fungi from the cable in time to prevent its further propagation.

#### 6.2.2 Chemical methods

It is also common to prevent fungal growth by chemical means:

a) The preferred method is to select materials which do not promote fungal growth.
b) When selected jacket material is inadequate to repel fungal growth, a mildew inhibitor can be added to the base resin during or prior to extrusion. Non-polar mildew inhibitors are recommended for polyolefin materials, as cracking can occur in the jacket when polar inhibitors are used.
c) Spray suitable fungicides directly on the cable surface to prevent fungal growth.

### 6.3 Cable internal components

Typically, fungal growth on internal cable components is not as common as that on the outer surface of the cable jacket. Prevention of fungal growth on internal components is usually done by physical methods, which are more economical, though chemical prevention is used when necessary. Suggested methods are as follows:

a) Ensure cable jacket is without tears, punctures, extrusion pinholes, or other miscellaneous defects that would allow access to internal components.
b) Proper installation and use of cables, enclosures, and related products. Avoid any unnecessary exposure of internal cable components.
c) Ensure cable ends are kept dry and clean after handling.
d) Anti-fungus materials are suggested to be used for conductor insulation.
e) If necessary, internal plastic cable materials, such as buffer, filling/flooding materials, fibre coating, can also be fungus-resistant.

### 6.4 Cable drum

The optical cable drum is often made of wood, which is highly susceptible to fungal attack. During the rainy seasons, fungi grow even faster on wood material. The fungi can spread and pollute the surface of optical cable during cable storage and transport. Therefore, it is recommended to either treat cable drums with fungicide (to protect against fungal attack) or with heat or gas (to eliminate dangerous pests), or both, before use.

## 7 Sheath material selection and cable design principles

### 7.1 Common sheath material

In addition to commonly used outdoor, indoor and indoor/outdoor optical cables, there are also many optical cables for special application scenarios. Therefore, various kinds of cable sheath materials are employed, including polyethylene, polyvinyl chloride, low-smoke zero-halogen polyolefin, thermoplastic polyurethanes etc.

**a) Polyethylene (PE)**

Polyethylene is the most widely used cable sheath material. PE material for cable sheath almost includes no inorganic salt fillers and is inherently non-nutritive to fungi. Generally, no specific criterion of fungus resistance is required.

However, recycled polyethylene has many inorganic impurities and organic additives. If recycled PE is used in optical cable, take consideration with respect to the cable fungus resistance.

**b) Polyvinyl chloride (PVC)**

Polyvinyl chloride is widely used in optical cables, particularly flame-retardant cables, and has inherent fungus-resistant properties similar to PE. However, widely used PVC additives such as plasticizers, lubricants, antioxidants, etc. are rich in nutrients for fungal growth. An example is shown in Figure 1.

A suitable mildew inhibitor can be added to the PVC material to prevent fungal growth.


**Figure 1 – Fungal growth on optical cable with PVC sheath**

c) **Low-smoke zero-halogen polyolefin (LSZH)**

Low-smoke zero-halogen polyolefin compounds are commonly used as optical cable sheath materials, particularly for indoor cables, due to their flame-retardant properties, and harmless nature when ignited. LSZH compounds are highly filled with hydroxides and organic additives and are susceptible to fungal attack. An example is shown in Figure 2.

Adding a mildew inhibitor to the LSZH jacket compound prior to, or during extrusion is a feasible solution for preventing fungi. If the cables are temporarily used indoors, spraying suitable fungicides directly onto the cable surface is also an economical choice.

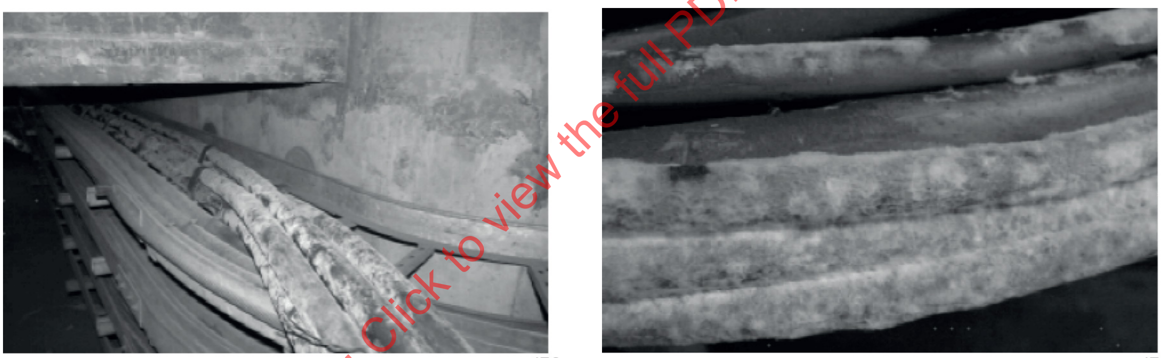


**Figure 2 – Fungal growth on optical cable with LSZH sheath**

d) **Thermoplastic polyurethane (TPU)**

Thermoplastic polyurethane has excellent abrasion resistance, high strength, good elasticity and strong weatherability. It is used as optical cable sheath material in specific scenarios. Similar to PVC, its resin has strong fungus resistance. However, due to the introduction of various additives, its fungus resistance deteriorates a lot and shows the possibility for fungal growth. Figure 3 illustrates the phenomenon of fungal growth on TPU cables.


**Figure 3 – Fungal growth on optical cable with TPU sheath**

### 7.2 Cable design principles

Based on above analysis, several principles are summarized to improve fungus resistance during the cable design:

a) Select suitable anti-fungus materials, especially for sheath material.

b) Cable sheath is required to be intact and smooth where dust will not adhere to the outer surface.

c) Selecting sheath material that has adequate tensile and elongation properties, resistant to post-shrinkage and environmental extremes is critical to prevent exposure of internal cable components.

d) Excellent water-blocking performance is also required to prevent wet mycelium penetration into the cable from cable end.

## 8 Fungus resistance test method

### 8.1 General consideration

In principle, fungus resistance test is only applicable to optical cables intended for transportation, storage, or use in an appropriate environment for fungal growth.

For cable manufacturers, most of the required information about fungus resistance can be acquired from raw material suppliers. The fungus resistance test is used to verify specific product designs or for materials that have not been tested. If cable materials or components have passed the fungus resistance test, it is unnecessary to retest such materials or components by cable samples.

According to the growth law of fungal spores, 28 days is the shortest duration during which a fungus can grow and decompose a carbon-containing molecule. The 28-day test can reflect the anti-fungal properties of a material but is not sufficient to reveal structural damage and performance changes within a cable. If the effects of fungal growth on product structure and performance requires evaluation, the test period is extended to 56 days.

### 8.2 Objective

The objective of this test method is to evaluate the adequacy of optical fibre cables and their components to retain their structural integrity and performance level under environmental conditions suitable for fungal growth.

The test methods in IEC 60068-2-10 can be used. The testing procedures in this document are equivalent of those set out in ISO 846 Method A (fungal-growth test).

For some applications, optical cable can, when buried in natural soil that has a water holding capacity, exhibit degradation in structural characteristics. The evaluation of such conditions is not included in this document. However, if the evaluation is required, ISO 846 method D (soil-burial test) is suggested. Similarly, if it is necessary to evaluate a sample's resistance to biological growth, ISO 846 method C (resistance to bacteria) is suggested.

## 8.3 Sample

### 8.3.1 General

Test sample can be optical fibre, optical cable or plastic material.

The required sample number can follow the requirement in TIA-455-56-C:2009, 4.1 and IEC 60068-2-10:2018, 11.1.1.

If other tests except visual inspection are specified, the number of specimens can be specified according to the corresponding tests. And two groups of specimens can be involved:

Group 1 Test specimen(s) inoculated with the spore suspension and incubated.

Group 2 Negative control specimen(s) sprayed, painted with, dipped in sterilized distilled water in accordance with the inoculation method used for group 1 and stored at the same temperature and relative humidity as prescribed for incubation but in a sterile environment.

### 8.3.2 Fibre samples

Fibre samples can be prepared according to TIA-455-56-C:2009, 4.2.

### 8.3.3 Cable samples

Cable samples can be prepared according to TIA-455-56-C:2009, 4.3.

### 8.3.4 Material samples

For solid material, the simplest specimens can be flat squares 50 mm on a side; flat circles 50 mm in diameter; or rods or tubing 75 mm in length.

For liquid material, such as filling compound or flooding material, the specimens can be placed in glass dishes or pans with minimum 50 mm in diameter.

### 8.3.5 Biocide/Fungicide efficacy samples

If the test specimens (fibre, cable or material) contain biocides/fungicides and the test is intended to show the biocidal efficacy of an active substance intended to protect the material from biodeterioration, then for test Group 1, two sets of test specimens have to be tested: one without a biocide and one with the biocide. This test set-up would allow the demonstration of the basic preservative efficacy for an active substance.

## 8.4 Apparatus

The apparatus to be used is described in IEC 60068-2-10, as applicable.

In addition to the fungi exposure chamber and specimen container, a stereoscopic microscope with a nominal magnification of approximately 50 x is necessary in visual inspection. If other tests except visual inspection are specified, the test apparatus in corresponding tests can be used.

### 8.5 Procedure

#### 8.5.1 General

The test variant 1 indicated in IEC 60068-2-10:2018 can be followed. Prior to conditioning, 10.1 (Cleaning) and 10.2 (Damp heat storage) in IEC 60068-2-10:2018 will be performed.

#### 8.5.2 Conditioning

The inoculation of the test specimen(s) and control strips with the spore suspension as well as the conditioning process procedure indicated in IEC 60068-2-10:2018, Clause 11, can be followed with the following exceptions:

If only visual inspection is necessary，the duration of incubation is 28 days.

If other tests except visual inspection after exposure to fungi are specified, the duration of incubation is minimum 56 days. Negative control specimens can be used. They can be sprayed in sterilized distilled water in same inoculation method used for test specimens and stored at the same temperature and relative humidity as prescribed for incubation but in a sterile environment.

#### 8.5.3 Test fungi

The following fungi are suggested to be used for performing the test (see Table 1). Other species can be used according to the actual conditions of the area where the cable will be deployed. State the test fungi used in the test report.

**Table 1 – Test fungi**

| Name | Strain |
|---|---|
| Aspergillus niger | ATCC 6275 |
| Aspergillus terreus | ATCC 10690 |
| Chaetomium globosum | ATCC 6205 |
| Hormoconis resinae | DSM 1203 |
| Paecilomyces variotii | ATCC 18502 |
| Penicillium funiculosum | ATCC 36839 |
| Scopulariopsis brevicaulis | ATCC 36840 |
| Trichoderma virens | ATCC 9645 |



### 8.6 Assessment

#### 8.6.1 Visual inspection

After conditioning, remove the specimens from the incubator. The specimens can be inspected first by the naked eye and then if necessary, with a stereoscopic microscope with a nominal magnification of approximately 50x and then rate them according to IEC 60068-2-10:2018, 12.3.

Check for evidence of cracking, swelling, discoloration, blistering, and other signs of deterioration in the test sample.

#### 8.6.2 Evaluation of other properties

Wash the specimens free of growth, immerse in an aqueous solution of mercuric chloride (0,1 %) for 5 min, rinse in tap water, air dry overnight at room temperature, and recondition at the standard laboratory conditions, and measure the properties (see Table 2) of the exposed specimens and the control specimens.

**Table 2 – Suggested test items (other than visual inspection) after exposure**

| Sample | Test item | Test standards |
|---|---|---|
| Optical fibre | Fibre strippability | IEC 60793-1-32 |
| | Tensile strength | IEC 60793-1-31 |
| | Colour identification | - |
| Cable sheath/sheath material | Tensile strength and elongation | IEC 60811-501 |
| | Change in mass | - |
| Buffer tube | Buffer tube kink | IEC 60794-1-23 method G7 |
| | Buffer tube bend | IEC 60794-1-23 method G1 |
| Conductor insulation | Insulation resistance | IEC 61196-1-102 |
| Optical cable | All the tests above (except change in mass of sheath) | - |

## 8.7 Requirements

The requirements can be specified in the relevant specification. A recommended rating for visual inspection is 2 b minimum according to IEC 60068-2-10. Other physical properties after exposure and the change of these properties can meet the relevant specification.

## 8.8 Details to be specified

The relevant specification can include the following:

a) Test fungi (if deviating from the test standard).

b) Initial, intermediate and final examinations (detailed).

c) Conditions of incubation (if deviating from the test standard).

d) Requirements of visible inspection (permissible grade of fungi growth if prescribed).

e) If necessary, evaluation of other properties (physical, optical, or electrical performance).