The Fibreoptic Industry Association
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TECHNICAL SUPPORT GUIDE

FIA-TSD-2000-2-1

CABLE SELECTION GUIDE

This document has been re-issued (version 2.01) to reflect the change in FIA web-site details and to update the list of FIA Technical Support Documents (both published and in development). A future release (version 3) will be required to address the wider range of information being created by IEC SC86A and the product standards for optical fibre cables being developed both at IEC, CLC and UK level. If you need advance information about these specific changes please contact the FIA Secretariat or the FIA Technical Director.

Price: £75 (free to FIA members)

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The Fibreoptic Industry Association

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An introduction for the new millennium

The past decade has seen a vast increase in the use of optical fibre - primarily driven by the need to provide a quality, high-speed transmission media for digital trunk telephony services. The specifications for these systems have typically been produced by large national telecommunications service providers. This has resulted in clear standards and specifications exist to which all suppliers to the WAN telecommunications industry must adhere.

In parallel there has been a significant growth in optical fibre systems being installed in private data, entertainment and telecommunications networks which are separate from the national telephony and data carrier systems. This part of the industry is served by a large number of relatively small organizations supplying small, medium and large corporate customers with products and services. An organizational focus is required for both suppliers and users in this sector of the industry in order to ensure the quality and reliability of network design, installation practice and methods of training.

The **Fibreoptic Industry Association** provides such a focus as a Trade Association to which companies, organizations and individuals involved with, or planning an involvement with, fibre optics can subscribe. In addition, by means of seminars, publications, newsletters, press promotion and similar activities, the **Fibreoptic Industry Association** is dedicated to raising the profile of the industry and highlighting its many benefits in order to increase its growth and thus provide direct benefits for members.

Our overall aims can be summarised as follows:

- to promote an awareness of the benefits and applications of fibre optic technology as an adjunct to - or as a replacement for - conventional copper communications technology;
- to promote an awareness of the existence of a professional fibre optics industry fully capable of meeting the needs of users or, so benefiting both suppliers and their customers;
- to promote and adopt standards to which professional participants within the fibre optic industry should be expected to adhere;
- **t**o provide a central source for information on wide ranging aspects of the fibre optic industry;
- to provide a single voice to promote and represent the interests of the industry obtained by consensus and debate amongst FIA members;
- to develop and promote codes of practice within the industry - both operational and ethical - to which members will be expected to adhere and thus offer an assurance that the highest quality of service will be provided.

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FIA TECHNICAL SUPPORT GUIDES

This document is one a series of FIA Technical Support Guides. During the year 2000 all the existing FIA documents were re-written or re-published in the format used throughout this document.

More importantly, the way in which these Technical Support Guides is published has also changed.

These documents are now **free** to **FIA members** via downloads from the FIA web-site (**www.fia-online.co.uk**). Non-members are also able to purchase these documents either by contacting the Secretariat (address shown below) or by on-line purchase.

Members and non-members unable to benefit from this service may receive the documents in hard-copy or diskette/CD ROM by contacting the FIA Secretariat (contact details are shown at the bottom of each text page in this document). However, the rapidly changing nature of our technology means that web-based documents can be amended and revised easily and it is the responsibility of the reader to ensure that the latest issue of a document is used.

The FIA web-site will indicate the issue status of each document and will have links to previous issues in order that changes made will be clear to readers.

The complete list of FIA Technical Support Guides is shown in the Table below.

TOPIC	FIA-TSD-	TITLE
DESIGN	2000-1-1	OPTICAL FIBRE CABLING: LAN APPLICATION SUPPORT GUIDE
COMPONENT SELECTION	2000-2-1	OPTICAL FIBRE CABLING: CABLE SELECTION GUIDE
	2000-2-2	OPTICAL FIBRE CABLING: CONNECTING HARDWARE SELECTION GUIDE
OPERATION	2000-3-2-1	OPTICAL FIBRE CABLING: ADMINISTRATION: User Guides
	2000-3-2-2	OPTICAL FIBRE CABLING: ADMINISTRATION: Cords
	2000-3-3	OPTICAL FIBRE CABLING: POLARITY MAINTENANCE
INSTALLATION	2000-4-1-1	OPTICAL FIBRE CABLING: INSTALLATION PRACTICE: SPLICING
	2000-4-2-1	OPTICAL FIBRE CABLING: TESTING Installed cabling using LSPM equipment
	2000-4-2-2	OPTICAL FIBRE CABLING: TESTING Installed cabling using OTDR equipment
	2000-4-2-3	OPTICAL FIBRE CABLING: TESTING: Test cords
SAFETY	2000-5-1	OPTICAL POWER: SAFETY LEVELS
	2000-5-2	OPTICAL FIBRE: HANDLING OF PROCESSING CHEMICALS
	2000-5-3	OPTICAL FIBRE: DISPOSAL OF WASTE

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Whether or not they are members of the FIA, readers of these Technical Support Guides are warmly invited to contribute ideas for new publications by contacting the FIA Technical Director via the FIA Secretariat (address shown below).

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FOREWORD

Over the past few years manufacturers and suppliers of optical fibre cables have responded to the use of optical fibre in a ever-widening range of environments by producing an increasingly diverse designs of optical fibre cables.

The United Kingdom Fibreoptic Industry Association has combined its resources with those of several of the countries leading optical cable manufacturers and suppliers in order to produce this new and revised Technical Support Guide for the selection of optical fibre cables. It is hoped that this Technical Support Guide will offer the installer, consultant and end user a simple and clear route to optical fibre cable selection.

By Colin Snook, Cablenet Training

ACKNOWLEDGEMENTS

The FIA would like to thank the following companies for their assistance in the production of this document.

Alcatel Data Cable
Anixter (UK) Ltd
Brand Rex Ltd
Cablenet Training Ltd
Pinacl Communications Systems Ltd
Pirelli Cables Ltd

Errors and omissions

The contributors to, and editors of, the FIA Technical Support Guides are only human. If during your reading of this document you find any errors, editorial or technical, please do not hesitate to contact the FIA Technical Director via the FIA Secretariat (address shown below).

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1 INTRODUCTION

In order for an optical fibre infrastructure to function, the transmission performance of the installed cabling (channel) must meet the requirements of the application to be supported. The channel performance is founded upon the optical performance of both the optical fibre within the interconnecting cables and the connecting hardware used to create the channel.

However, the level of environmental protection afforded by the cable construction determines both the initial and long-term performance of an optical fibre. Failure to correctly identify the environmental requirements for storage, installation and operation of the cables can result in transmission problems.

In addition, the behaviour of optical fibre cables under extreme conditions, including those of fire, are becoming a focus of attention from certain groups of users and their insurers.

This Technical Support Guide provides a basis for selection of optical fibre cables and should be used in conjunction with:

- BS 7718: 1996, “A code of practice for the installation of fibre optic cabling”;
- BS EN 50174, “Information technology – Cabling installation”;
- FIA Application Support Guides and relevant application standards;
- manufacturers specifications and data sheets.

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2 DEFINITIONS

For the purposes of this Technical Support Guide, the following definitions apply.

Attenuation	A decrease of electromagnetic power between two points and the quantitative expression of power decrease which may be expressed by the ratio of the values at two points of a quality related to power in a well defined manner. NOTE 1: The loss of optical power through a fibre optic component is measured in dB units. NOTE 2: Attenuation is generally expressed in logarithmic units, such as the decibel (dB).
Attenuation coefficient	The limit of the quotient of attenuation between two points on the axis of a transmission line or waveguide by the distance between the points when this distance tends to zero. NOTE: Attenuation coefficient of an optical fibre is measured in dB/km.
Bandwidth	A measure of the capacity of an optical fibre to transmit high speed data AND That value numerically equal to the lowest modulation frequency at which the magnitude of the baseband transfer function of an optical fibre decreases to a specified fraction, generally to one half of the zero frequency value. The bandwidth is limited by several mechanisms: • in multimode optical fibres, mainly modal distortion and material dispersion; • in singlemode optical fibres, mainly material and waveguide dispersion.
Cladding	That dielectric material of an optical fibre surrounding the core.
Cladding diameter	The diameter of the circle defining the cladding centre.
Connecting hardware	A device or a combination of devices used to connect cables or cable elements
Connector	See optical fibre connector
Core	The central region of an optical fibre through which most of the optical power is transmitted.
Core diameter	The diameter of the circle defining the core centre.
Cut-off wavelength	For a given optical fibre, the wavelength below which singlemode transmission changes to multimode transmission.
Dispersion coefficient	The relevant bandwidth parameter for singlemode optical fibre (see “Bandwidth”)
Equipment cord	A cable assembly permanently assembled at both ends with connector components principally for connection to transmission equipment.
Fusion splice	A splice accomplished by the application of localized heat sufficient to fuse or melt the ends of two lengths of optical fibre, to produce a single continuous optical fibre.
Mechanical splice	A fibre splice accomplished by fixtures or materials rather than thermal fusion.
Modal bandwidth	The relevant bandwidth parameter for multimode optical fibre (see “Bandwidth”)
Multimode optical fibre	An optical fibre along the core of which the radiation of two or more bound modes can propagate at the wavelength of interest.
Numerical aperture (N.A.)	A measure of the capacity of the following: 1) an optical fibre to accept light. 2) an optical transmitter to inject light into an optical fibre; 3) an optical receiver to accept light from an optical fibre. AND The sine of the vertex half-angle of the largest cone of meridional rays that enter the core of an optical fibre multiplied by the refractive index of the medium in which the vertex of the core is located.
Optical fibre cable	An assembly comprising one or more optical fibres or fibre bundles inside a common covering designed to protect them against mechanical stresses and other environmental influences while retaining the transmission quality of the fibres. NOTE: It may also contain metallic conductors.
Optical fibre connector	An optical fibre component normally normally attached to a cable or piece of apparatus, for the purpose of providing optical interconnection/disconnection of optical cables.
Optical fibre	A filament shaped optical waveguide made of dielectric materials.

Optical fibre geometry	The physical dimensions of the optical fibre core and cladding e.g. 50/125, 62.5/125 etc.
Optical fibre pigtail	A short length of optical fibre usually attached to a component and intended to facilitate jointing between that component and another optical fibre or component.
Patchcord	A cable assembly permanently assembled at both ends with connector components principally for cross-connection within a patching facility.
Pigtail	See optical fibre pigtail
Primary buffer	A thin coating applied directly to the cladding to preserve the integrity of the cladding surface.
Primary coating	See “Primary buffer”
Tight buffer	Coating applied directly to the primary coating to reinforce the protection of the optical fibre during handling and cabling.
Secondary coating	See “Tight buffer”
Singlemode optical fibre	An optical fibre in which the radiation of only one bound mode can propagate at the wavelength of interest.

3 OPTICAL FIBRE PERFORMANCE

The transmission performance of an optical fibre cable is controlled by the quality of the optical fibre used within it. Table 1 and Table 2 show some of the options that are available in the market today for multimode and singlemode optical fibres respectively.

The use of optical fibre with a lower attenuation coefficient offers the opportunity to reduce the signal loss over the complete network and may allow extended distance of transmission. Similarly, for multimode optical fibre, the use of optical fibres with improved modal bandwidth performance may also increase supported distances for certain networks (see FIA-TSD-2000-1-1, LAN Application Support Guide, to be published in Q2, 2000, for further details). As a result, many manufacturers produce cables of a given construction while offering the user the option to choose the geometry and transmission performance of the optical fibres to suit particular applications.

In all cases care should be taken to ensuring that the optical performance specified is that of the cabled optical fibre rather then the optical fibre as manufactured. Manufacturers or suppliers should be consulted when the information provided is not sufficiently clear.

	Optical Performance					Dimensions		
Fibre geometry	**Attenuation coefficient (dBkm^{-1}) max.**		**Modal bandwidth (MHz.km) minimum**		**Numerical aperture (N.A.)**	**Nominal core OD**	**Nominal cladding OD**	**Primary buffer (primary coating) diameter**
	850nm	**1300nm**	**850nm**	**1300nm**				
50/125	2.6	0.6	400	800	0.2+/-0.015	50+/-3 μm	125+/-3 μm	250+/-15 μm
50/125	2.8	0.8	500	500	0.2+/-0.015	50+/-3 μm	125+/-3 μm	250+/-15 μm
62.5/125	3.2	0.8	200	500	0.275+/-0.015	62.5+/-3 μm	125+/-3 μm	250+/-15 μm
62.5/125	2.9	0.7	160	500	0.275+/-0.015	62.5+/-3 μm	125+/-3 μm	250+/-15 μm
NOTE: The above figures are examples only and may change from manufacturer to manufacturer								

Table 1: Multimode optical fibre specifications

	Optical Performance					Dimensions		
Fibre geometry	**Attenuation coefficient (dBkm^{-1}) max.**		**Dispersion coefficient (MHz.km) maximum**		**Cut off wavelength (nm)**	**Nominal mode field diameter**	**Nominal cladding OD**	**Primary buffer (primary coating) diameter**
	1310nm	**1550nm**	**1310nm**	**1550nm**				
9/125	0.4	0.3	3.5	18	1215+/-65	9.3+/-0.5 μm	125+/-1 μm	245+/-10 μm
NOTE: Single mode core diameters change and may fall within a range of between 8/125 - 10/125 NOTE: The above figures are examples only and may change from manufacturer to manufacturer								

Table 2: Singlemode optical fibre specifications

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4 CABLE SELECTION CRITERIA

4.1 Environmental criteria

Optical fibre cables may be stated as being compliant with one or more of the environments specified in the BS EN 60721-3-xx series of standards (see 8.2).

Suitability of any optical fibre cable for a particular installation will depend on its compatibility with the following three environments:

- storage (prior to installation);
- installation (cable installation and optical fibre termination);
- operation.

These three environments may be dramatically different and is important to ensure that the cable selected in appropriate for the most demanding environment. Alternatively, the environment (in particular, the storage environment) may be modified to suit the selected cable.

This Technical Support Guide reviews the possible cable designs and constructions in terms of the materials used (see clause 5), the installation environment, the installation route and the installation techniques to be employed (see clause 6).

Temperature ratings should be considered when selecting a cable, if in doubt the manufacturer should be contacted for advice.

It is recommended that reference be made to BS 7718: 1996 for additional information and requirements concerning environmental issues.

4.2 Termination of optical fibres

The proposed method of termination influences the selection of appropriate cable designs.

Optical fibre connector manufacturers generally do not recommend direct termination of 250µm (0.25mm) diameter primary buffered (primary coated) optical fibres due to the stress that can be placed on the optical fibres. It is recommended that optical fibre cables containing these optical fibres should be terminated using pre-terminated optical fibre pigtails which are fusion or mechanically spliced to the installed cable and housed in some form of closure.

If the optical fibres are to be directly terminated within some form of closure then an optical fibre cable containing 900µm (0.9mm) diameter tight buffered (secondary coated) optical fibres should be considered; this will give sufficient mechanical protection once the connector is terminated.

Cables to be terminated in free-standing connecting hardware without the need for closures shall feature appropriate strength members and jacket constructions (see 6.1.1 and 6.1.3).

It is suggested that reference be made to BS 7718: 1996 for additional information and requirements concerning termination and handling of optical fibre elements.

5 MATERIALS

5.1 General

The transmission performance of the optical fibre within a cable is vital for application support. However, the materials used in the construction of the cable are equally important in terms of:

- protection of the optical fibre during its installation and operation;
- environmental performance e.g. toxicity under fire conditions.

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5.2 Material types

5.2.1 PVC

PVC (polyvinyl chloride) has been used for many years within internal and armoured cables. This is now proving to be unacceptable as these cables may give off toxic fumes when burnt. Although they have a lower cost than the LSZH cables discussed in 5.2.2, the difference is now minimal, and LSZH cables should be considered in preference to PVC for new installations.

5.2.2 LSZH

LSZH (low smoke zero halogen) is the standards-based term for materials that have been specifically designed for use where, if a fire should break out and the cable burns, then certain criteria for emission of smoke, toxic and corrosive gases will be met.

NOTE: There are a wide variety of terms and words used by manufacturers to describe these materials including LSF, LS0H, LFH. FRNC, LSNC etc. This Technical Support Guide uses only the abbreviation LSZH or the words “low smoke zero halogen”.

The production of smoke when cable materials are burnt is undesirable due to the increased difficulty of both escape and fire-fighting.

Halogen gases that can be both colourless and odourless and which are produced by many materials when burnt (including PVC - the halogen in this case being chlorine) are toxic to personnel involved in the fire and can be corrosive to the building infrastructure and its assets. The combination of these two factors has been blamed for loss of life in a number of recent disasters in the UK (e.g. King Cross Underground) and overseas.

At the time of publication of this Technical Support Guide all cables claiming low smoke zero halogen performance when burnt should meet the following:

- IEC 61034 “Smoke Emissions” test, also known as the 3 metre smoke cube test.
- IEC 60754-1 (wet chemical test), BS6425-1:1990 and other national and international “acid gas” emission standards

Flame retardance should also be taken into consideration and should meet a minimum of the IEC 60332-1 (single cable test) and preferably the IEC 60332-3 (ladder burn test).

5.2.3 Pe

Pe (polyethene) is excellent when additional physical strength is required, has a good resistance to abrasion and a low coefficient of friction assisting the installation of cables in an external environment. Polyethylene is generally a good option where cables are to be submerged in water for any length of time.

However, there are different grades of polyethylene. At the most basic level these can be described as low density (LDPe) and high density (HDPe). The detailed performance of the particular materials used under extreme conditions, e.g. cables that are to be submerged for an extended period of time, should be determined from the cable manufacturer or supplier.

Polyethylene is a halogen-free material but it is not recommended for installation within a building. When burnt, polyethylene is not self-extinguishing and supports combustion. Standards such as BS 6701, BS EN 50174-2 (in preparation at the time of publication of this Technical Support Guide) and building regulations in the UK cover the usage of such materials and should always be consulted before installation.

5.2.4 Nylon

Nylon should be considered where:

- a non-metallic armour is required;
- as an alternative to a lead sheath for installation in areas where petro-chemicals are present.

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5.3 Comparison chart

Table 3 gives a general overview of the materials currently used in the production of optical fibre cables. This is designed as a guide only and should always be confirmed with a manufacturer for their exact recommendations for specific installation needs.

	Resistance To					
Material	Weather	Oil	Water	Chemicals+	Solvents+	Abrasion
LSZH	2	3	3	1	1	3
LDPe	3	3	4	2	2	2
HDPe	4	2	4	2	2	4
PVC	2	2	2	2	3	2
Nylon	2	4	2	4	4	4
* General guidance: always consult the manufacturer for specific cases.						
4 = Excellent, 3 = Fair, 2 = Good, 1 = Poor						

Table 3: Cable materials comparison chart

6 TYPICAL OPTICAL FIBRE CABLE CONSTRUCTIONS

This clause discusses cable construction options defined in terms of the type of infrastructure within which the cable is to be used.

6.1 Internal infrastructure

6.1.1 Patch and equipment cord cables

The construction of patch and equipment cord cables reflect their intended use and have low cross-sectional area, are lightweight and are flexible making them suitable for use in communication cabinets and equipment rooms. These cables are designed to be terminated in free-standing connecting hardware without the need for closures.

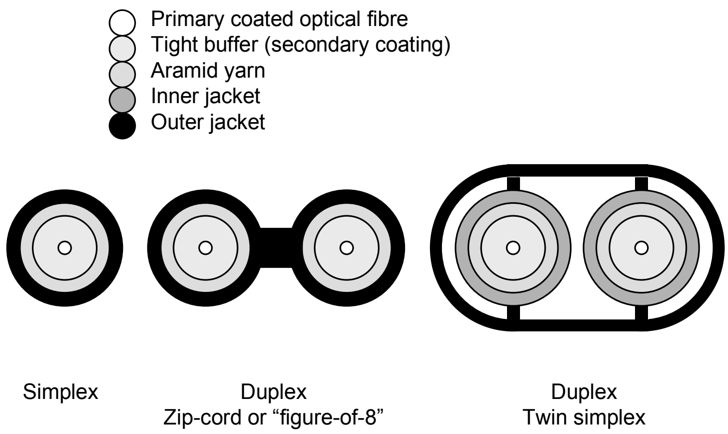

Figure 1: Patch and equipment cord cables

Typical designs are shown in Figure 1. A simplex cable comprises a single 900µm (0.9mm) diameter tight buffered (secondary coated) optical fibre, typically encircled with Aramid yarns for strength and then jacketed with a flexible material. More complex designs include “duplex” containing either two “simplex” optical fibre cables in the form of a “Zip-cord” (also known as a “figure-of-8” style) cable or two simplex cables with an overall jacket.

The jacket material is typically PVC or, more commonly, a LSZH material. The outer jacket of the material is typically marked with the optical fibre geometry, the jacket material and the manufacturers details.

6.1.2 Internal distribution cables

These cables are designed for sub-floor and riser installation within buildings and may be installed within trunking, conduit or on open tray. The terminations of these cables are normally protected in some form of closure.

The cables contain 900µm (0.9mm) diameter tight buffered (secondary coated) optical fibres. The optical fibres are generally colour-coded for ease of installation.

The detailed design is dependent upon the number of optical fibres (or “fibre count”) within the cable.

The “fibre count” is typically between two and forty-eight. For low “fibre count” cables the optical fibres are encircled with non-metallic strength members such as Aramid yarns over which the outer jacket is applied. For higher “fibre count” cables a non-metallic central strength member may be incorporated.

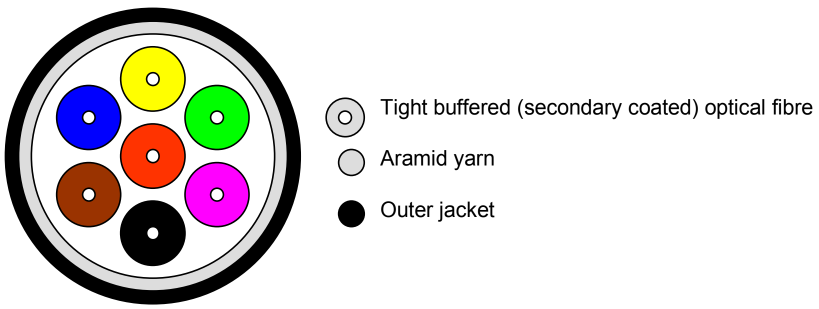

Figure 2: Internal distribution cables

The jacket material is typically PVC or, more commonly now, a LSZH material. The outer jacket of the material is typically marked with the optical fibre geometry, the jacket material and the manufacturers’ details.

6.1.3 Breakout cables

These cables are designed for sub-floor and riser installation within buildings and may be installed within trunking, conduit or on open tray. The cables are designed to be terminated in free-standing connecting hardware without the need for closures.

Breakout cables consist of two or more simplex jacketed optical fibre units, of the type described in 6.1, stranded together, within an overall outer sheath. Each unit is identified by either a colour or printed number and is designed to be compatible with most standard connectors.

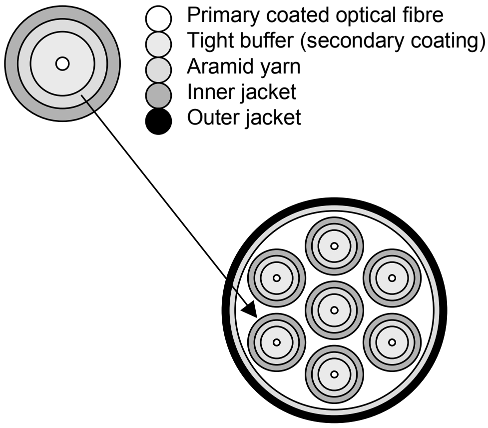

Figure 3: Breakout cables

6.2 External and combined external/internal infrastructures

6.2.1 Design considerations

A number of different constructions are available where installations require an optical fibre cable to connect two or more buildings. This clause provides information on the various design options. The options are introduced in terms of their installed environment.

6.2.2 Ingress of moisture

“Dry” ducts are defined as ducts/conduits that are either completely sealed to prevent ingress of water or are routed or designed in such a way as to ensure that any flooding that may occur is temporary. Where these conditions do not apply then the ducts must be considered to “wet”.

Most “dry duct” internal/external optical fibre cables produced currently have a LSZH sheath and have a reasonable resistance to water permeation. Some of these cables contain gel-fill compoounds which should be non-flammable. Other forms of moisture protection are available including aluminium tapes and non-metallic tapes that absorb water.

LSZH materials may not be the best choice for wet ducts that are permanently or semi-permanently flooded. For such environments a cable construction that will protect the optical fibres from the ingress of moisture via the jacket should be considered. The preferred sheath materials are HDPe or LDPe that have excellent or good moisture resistance properties respectively. Alternatively, or in addition, aluminium tape can be applied lengthways under the jacket to provide giving superior moisture resistance properties.

6.2.3 Dry ducts

6.2.3.1 Loose tube

Loose tube optical fibre cables are designed to be terminated via the mechanical or fusion splicing of pre-terminated optical fibre “pigtails” and are not recommended for direct termination (see 4.2).

These types of construction are not generally suitable for installation if a significant section of the route is vertical as there is a risk that the strain load applied to the optical fibres could create excessive attenuation or even break the optical fibres.

The design depends largely upon the "fibre count" and the environment into which the cable is to be installed. For low fibre count cables the construction may use only a single tube. The single tube typically holds between two and twenty-four, colour-coded, 250µm (0.25mm) diameter primary buffered (primary coated) optical fibres. The tube is then encased with non-metallic strength members and an outer jacket (LSZH material is typically used).

For higher fibre counts, multiple tubes are used. Multi-tube optical fibre cables are readily available for fibre counts of up to, and in excess of, ninety-six (even higher fibre count designs are available although these are typically manufactured to order). Multi-tube constructions consist of individual small tubes, containing the 250µm (0.25mm) diameter primary buffered (primary coated) optical fibres or fillers, which are then stranded around a central metallic or non-metallic strength member.

Where external routes are exposed it is recommended that non-metallic cables be used, wherever possible, to protect against the possibility of lightning strikes travelling along the cables. However, aluminium moisture barrier tapes may be included within the cable construction.

6.2.3.2 Tight buffered

If direct termination of the optical fibres is required or if a significant section of the route is to be installed vertically, then cables containing 900µm (0.9mm) diameter tight buffered (secondary coated) optical fibres should be considered. The construction of these cables is similar to the internal distribution cables described in 6.1.2.

Some manufacturers have tight buffered (secondary coated) optical fibres that prevent ingress of moisture by the use of improved buffering materials.

6.2.4 Wet ducts

Loose tube cable types are the most commonly used with colour-coded 250µm (0.25mm) diameter primary buffered (primary coated) optical fibres enclosed in single or multiple tubes. The constructions described in 6.2.3.1 are applicable but a change to the jacket material should be considered. In addition to the superior moisture resistance properties of HDPe or LDPe; both materials also offer robustness, low coefficient of friction and good flexibility.

6.2.5 Direct burial

These cables can be "direct-buried" or fixed directly to the surfaces in exposed conditions that are susceptible to possible mechanical damage. As with the dry and wet duct environment optical fibre cables there are many constructions that are available depending on the installation requirements,

6.2.5.1 SWA

SWA (Steel Wire Armour) cables typically take a duct style cable and use the sheath as a bedding for the armouring, this consists of a number of galvanised steel wires (dependant on the diameter) applied helically to the cable and then a further outer jacket over that. This outer jacket may be Pe, PVC, LSZH or Nylon dependent on installation requirements. Cables with this type of armour have been produced for many years and are both bulky (large cross-sectional area and bend radii) and are heavy. In addition, SWA offers little resistance to attack by rodents as they can gain a purchase on the individual wires and pull them apart to get to the inner material.

6.2.5.2 SPL

SPL (corrugated Steel Polymer Laminate tape) is an alternative to SWA. A Steel Polymer Laminated tape is applied longitudinally for mechanical protection. It can offer a high protection against rodents as they find it difficult to bite.

6.2.5.3 Non-metallic armour

Unlike the steel armoured cable types the non-metallic armour is applied to a multi-element construction. A Glass Reinforced Plastic (GRP) central strength member has the loose tubes or fillers stranded around it. Aramid or glass fibre yarn strength members are then stranded around the core for mechanical protection a final outer sheath is then applied. Rodent resistance is obtained by using glass yarn this breaks when gnawed and sticks into the mouth of the animal making it stop its attack.

6.3 Quick reference guide

Table 4 acts as a quick reference guide for the selection of cable types and their recommended installation environments.

	Environment					
Product	**Internal**	**Internal /external**	**Duct**	**Direct-buried**	**Standard duty[1]**	**Heavy duty[2]**
Patch/equipment cable	Y	N	N	N	Y	N
Breakout cable	Y	N	N	N	N	N
Internal distribution cable	Y	Y	N	N	Y	N
Internal/external tight buffer	Y	Y	Y	N	Y	N
Internal/external loose tube	S	Y	Y	N	Y	N
SWA Armour	N	O	Y	Y	Y	Y
SPL Armour	N	O	Y	Y	Y	Y
Non-metallic armour	N	O	Y	Y	Y	Y
Blown fibre tubing (see clause 7)	Y	O	N	N	Y	N

KEY:
Y = Recommended
N = Not Recommended
S = Suitable but Not Recommended
O = option with correct Jacket Material

NOTE 1:
Typically suitable for:
- hand pulled installation of no more than 500 metres with minimal bends in a single pull section;
- suitable for laying in trunking, conduit or on open tray;
- can also be fixed directly to walls after due consideration of the increased risk of damage due to impact or severe bend radii.

NOTE 2:
Typically suitable for:
- rope/hand pulled to lengths of 2000 metres including a number of changes in direction;
- suitable for laying in trunking, conduit or on open tray;
- can be fixed directly to walls
- direct burial in prepared ground (e.g. sand)
- direct burial without further protection in unprepared ground
- laying in cable trenches

Table 4: Quick reference chart

7 BLOWN FIBRE TUBING

As an option to cabled optical fibre, blown fibre technology is available in the local area network environment in both internal and external designs.

Miniature plastic ducting and accessories can be installed throughout the building at an early stage of design. The required multimode or singlemode optical fibres are then added using compressed air to “blow” optical fibres (with specially designed

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coatings) into the tubes. If it becomes necessary to replace the optical fibre then selected installed optical fibres can be removed from the tube by "blowing out". New optical fibres can then be "blown in" to the same tube.

8 SPECIFICATION REFERENCES

The following standards apply to the construction of optical fibre cables and define various tests that these cables are manufactured to:

8.1 Test standards

ALL CABLE TYPES	**STANDARD**	**TEST**
	BS EN 187000 501	Tensile strength
	BS EN 187000 504	Crush resistance
	BS EN 187000 513	Bend
	BS EN 187000 601	Temperature cycle
EXTERNAL CABLES	**STANDARD**	**TEST**
	BS EN 187000 605	Water penetration (fully filled)
	BS EN 187000 603	Sheath Integrity Test (metallic)
INTERNAL CABLES	**STANDARD**	**TEST**
	CENELEC HD 624.7(5)	Halogen gas emission
	IEC 60332-1	Flame propagation
	IEC 61034	Smoke emission
	IEC 60754	Corrosive gas

8.2 Useful references

STANDARD	**TITLE**
BS EN 188000:1994	Generic Specification for Optical Fibres
IEC 60793-1	Generic Specification for Optical Fibres
IEC 60794-1	Generic Specification for Optical Fibre Cables
IEC 60332-1	Tests on Electrical Cables under Fire Conditions
CENELEC HD 624.7	Requirements for Halogen Free Flame Retardant Thermoplastic Sheathing Compound
IEC 60754	Test on Gases Evolved During Combustion of Electric Cables
IEC 61034	Measurement of Smoke Density of Electric Cables Burning Under Defined Conditions
BS EN 60721-3-0:1993	BS EN 60721-3-0:1993 (IEC 60721-3-0:1984) Classification of environmental conditions. Classification of groups of environmental parameters and their severities - Introduction
BS EN 60721-3-1:1997	Classification of environmental conditions. Classification of groups of environmental parameters and their severities – Storage
BS EN 60721-3-3:1995	Classification of environmental conditions. Classification of groups of environmental parameters and their severities - Stationary use at "weather protected" locations
BS EN 60721-3-4:1995	Classification of environmental conditions. Classification of groups of environmental parameters and their severities - Stationary use at "non-weather protected" locations