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***Standard for Optical Fiber
Outside Plant Communications Cable***

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Foreword

(This Foreword is not part of this Standard.)

This Standard provides information on specifying optical fiber cables for outdoor use in telecommunications applications.

The first edition of this Standard was approved by ICEA on March 4, 1992, and the second edition on September 15, 1999. A third edition was approved by ICEA on June 8, 2005; it was published by ICEA but was not published as an ANSI-approved Standard. Edition 4 of this Standard, approved by ICEA on September 13, 2006, was a republication of edition 3. It was approved by The American National Standards Institute (ANSI) on December 8, 2006, and adopted by the Telecommunications Industry Association (TIA) as TIA-472D000-B in April 2007. The fifth edition was approved by ICEA on June 7, 2011, and by ANSI on January 17, 2012. The 6th edition was approved by ICEA on December 8, 2015, and by ANSI on August 25, 2016. The members of the ICEA Communications Cable Division Working Group who participated in the seventh edition of this standard were:

Paul Baird, Chairman and Editor

G. Dorna	D. Parke	M. Stover
D. Fausz	J. Pavlicek	R. Stevens
N. Hatch	J. Quinn	H. Toland
M. Kinard	J. Lichtenwalner	J. Register
T. Schmalzigaug	R. Stanko	J. Morrow
D. Kozischek	P. Baird	

This issue replaces the previous issue of ANSI/ICEA S-87-640-2016, *Standard for Optical Fiber Outside Plant Communications Cable*. Major changes in this revision include the following:

- Addition of new fiber types
- Added 200 μm fiber coating option for ribbon cable
- Updated the ribbon dimensions
- Updated length accuracy requirement
- Changed impact requirement to one impact per location
- Updated water penetration requirement to reflect the updated FOTP
- Updated the multimode attenuation and bandwidth requirements.
- Updated jacket requirements to allow reduced carbon black option with customer approval for section 5.4.2 & 7.39.

This Standard contains eight annexes. Annexes C, D, and F are normative and are considered part of this Standard. Annex E is normative and considered part of this Standard when required by the customer. Annexes A, B, G, and H are informative and are not considered part of this Standard.

ICEA Standards are adopted in the public interest and are designed to eliminate misunderstanding between the manufacturer and user and to assist the user in selecting and obtaining proper products for a particular need. The existence of an ICEA Standard does not in any respect preclude the manufacture or use of products not conforming to this Standard.

The user of this Standard is cautioned to observe any applicable health or safety regulations and rules relative to the manufacture and use of cable made in conformity with this Standard. This Standard hereafter assumes that only properly trained personnel using suitable equipment will manufacture, test, install, and/or perform maintenance on cables defined by this Standard.

Requests for interpretation of this ICEA Standard must be submitted in writing (hard copy or email) to the Secretary of the Insulated Cable Engineers Association. The mailing address of ICEA Headquarters and a *Contact* link are shown on the ICEA web site - www.icea.net. An official written interpretation will be provided.

Section 1 Introduction

1.1 Scope

1.1.1 Products

This Standard covers optical fiber communications cable intended for outdoor use and normally installed aerially, directly buried, or placed in underground ducts. Additional requirements are included in Annex D for “figure-8” aerial self-supporting cables and in Annex F for all-dielectric self-support cables, as appropriate. Materials, constructions, and performance requirements are included in the Standard, together with applicable test procedures. Refer to other published ICEA cable product standards for information on optical fiber cable requirements for other applications:

- S-83-596: Indoor optical fiber cable
- S-104-696: Indoor-outdoor optical fiber cable
- S-110-717: Standard for optical fiber drop cable
- S-112-718: Optical fiber cable for placement in sewer environments)
- S-115-730: Optical fiber cables intended for Multiple Dwelling Unit (MDU) applications
- S-119-741: Fiber to the antenna (FTTA) optical fiber cable.
- S-120-742: Hybrid optical fiber cables intended for use in limited power circuits.
- S-121-744: Optical fiber outside plant microduct cables.

1.1.2 Applications Space

Products covered by this Standard are intended for operation only under conditions normally found in communications systems. These products normally convey communications signals (voice, video, and data) from point-to-point or point-to-multi-point, external to buildings. Products covered by this Standard may be factory terminated with connectors or splicing modules.

When a hybrid cable is required, the applicable metallic conductor requirements shall be as established by agreement between the end user and the cable manufacturer. The requirements of ANSI/ICEA S-84-608 should be considered when determining appropriate requirements.

1.1.3 Temperature Ranges

The normal temperature ranges for cables covered by this Standard are given in Table 1.1

For the purposes of this standard, very-low temperature applications are defined as -50 °C (-58 °F) per 1.4.1.6 and are addressed in Annex C), which contains requirements for lower operating and storage temperatures than listed in Table 1.1.

Table 1.1 - Cable normal temperature ranges

	°C	(°F)
Operation	-40 to +70	(-40 to +158)
Storage and Shipping	-40 to +70	(-40 to +158)
Installation	-30 to +60	(-22 to +140)

1.1.4 Tensile Rating

The standard installation tensile rating for cables covered by this Standard is 2670 N (600 lbf). Higher tensile ratings are also acceptable. For applications where a lower tensile rating is appropriate, the standard lower tensile rating is 1330 N (300 lbf). In all cases, the residual load is defined as a load equal to 30 % of the installation tensile rating.

For self-supporting aerial applications there are additional considerations that need to be addressed to ensure that the cable design is appropriate for the self-supporting distance and environmental loading conditions. See 7.30 and Annex D for information on figure-8 self-supporting aerial cable requirements and considerations. Also, see Annex F for information on all-dielectric self-supporting cable requirements and considerations.

For aerial applications in which the optical cable is lashed to a separate messenger wire, the use of a cable designed for a standard tensile rating for installation by direct burial, trenching, or pulling into duct may be adequate.

1.1.5 Minimum Bend Diameter

The standard minimum bend diameters for cables covered by this Standard are:

Residual (Installed): 20 x Cable OD or 30 x Cable OD
for ribbon cables greater than or
equal to 216 fibers

Loaded Condition (During Installation): 40 x Cable OD

For very small cables (e.g., such as those installed in microducts), manufacturers may specify a fixed cable minimum bend diameter (e.g., 300 mm) that is independent of the cable outer diameter (OD).

For cables not having a circular cross-section, bend diameter requirements are to be determined using the thickness (minor axis) as the cable diameter and bending in the direction of the preferential bend.

1.2 GENERAL

This Standard is so arranged that cables may be selected from numerous constructions covering a broad range of installation and service conditions. Sections 2 to 5 cover the major components and assembly of the cables:

Sections 2 and 3 designate the materials, material characteristics, dimensions, and tests applicable to the particular component.

Section 4 covers assembly, cabling, and identification of the individual optical fibers and conductors.

Section 5 describes coverings, such as binders, wraps, metallic coverings, and jacketing of the optical cable.

Section 6 provides other pertinent requirements not otherwise addressed by Sections 1 through 5 or by Section 7 of this Standard.

Section 7 contains the test methods and requirements applicable to completed cables and component parts. If there is a conflict between Sections 1 through 6 and Section 7, the provisions of Section 7 apply.

Section 8 contains routinely specified optical performance, requirements, and test methods for finished cables.

Section 9 contains cross-references to other standards and publications.

Annex A (Informative) contains information for users on ordering the types of cable products covered by this Standard.

Annex B (Informative) contains information on metallic shield and tape materials used in some outside plant cable constructions.

Annex C (Normative) contains information and requirements for cables used in “very low temperature” applications (-50 °C).

Annex D (Normative) contains additional information and requirements on aerial self-supporting figure-8 cable designs with integrated metallic messenger wire.

Annex E (Normative) contains requirements for 1625 nm performance requirements for outside plant cables when required by the customer.

Annex F (Normative) contains requirements for all-dielectric self-support requirements.

Annex G (Informative) contains general considerations for installation of outside plant cable.

Annex H (Informative) contains information on other ICEA Standards.

1.3 Units

In this Standard, metric (SI) units are used. Their approximate U.S. customary units are included where appropriate. Where approximate equivalents in alternate systems are included, they are provided for information only and in most cases are rounded off for measurement convenience. Unless otherwise specified, the Rounding Method of ASTM E 29 shall be used. ICEA P-57-653 is a useful guide for metric units used in this publication.

1.4 Definitions

For the purposes of this Standard, the following definitions apply.

1.4.1 Cable Classifications

1.4.1.1 Composite Cables¹

Cables containing more than one type of optical fiber.

1.4.1.2 Dielectric Cables

Cables which contain no metallic members or other electrically conductive materials.

¹ ICEA Standards prior to 2012 use definitions for *composite* and *hybrid* which are the exact opposite of those shown here. The change in definitions was made in the interest of harmonization with International documents and other National Standards. It must be noted that the definition of *composite* in the National Electrical Code, 2011 and earlier, are consistent with the older ICEA definition. Due to this change, users may see the terms used interchangeably. Regarding the definition for *hybrid*, as altered above: IEC uses a definition which encompasses metallic conductors used for all purposes – not just communication.

1.4.1.3 Figure-8 Cables

A specific type of aerial self-supporting cable design in which the outermost jacket is co-extruded over the cable core and an integral messenger wire, with the core and messenger separated by a thin webbing of the jacket material. The resulting characteristic “figure-8” shape gives these cables their name.

1.4.1.4 Hybrid Cables¹

Cables having both optical fibers and metallic conductors that are intended for communications use or powering.

1.4.1.5 Metallic Cables

Cables that contain conductive members including those not normally intended to transmit information (voice, video, or data), such as metallic strength members, sheaths, shields, or armors. This also includes elements intended for toning/locating.

1.4.1.6 Very Low Temperature Cables

Cables designed, specified, and qualified for use in applications where the low-end temperature extremes may reach -50 °C. Refer to Annex C which contains information and requirements for cables specified for use in very low temperature applications.

1.4.2 Jackets and Sheaths

In this Standard, the term “jacket” refers to a continuous non-metallic covering while “sheath” refers to the protective elements covering the cable core, which may include a combination of metallic coverings, jackets, strength members, and the like.

1.4.3 Optical Fiber and Electric/Electronic Terms

Refer to TIA-440 and IEEE-812 for definitions of other optical fiber terms. Refer to ANSI/IEEE 100 for definitions of other electrical and electronic terms.

1.4.4 Detail Specification

The term “Detail Specification” shall be used to refer to any requirement or set of requirements that are specific to the user’s purchase. In case of conflict between a requirement called out in a Detail Specification and this Standard, the requirements of this Standard may be modified by agreement between the manufacturer and user.

1.5 References

All documents referenced herein are listed in Section 9.

1.6 Information To Be Supplied by The User

When requesting proposals from cable manufacturers, the prospective user should describe the cable by referencing the pertinent paragraphs of this Standard. To help avoid misunderstandings and possible misapplication of cable, the user should also provide pertinent information concerning the intended application. Recommended ordering information is summarized in Annex A.

1.7 Modification of this Standard

Any part of this Standard may be modified by agreement between the manufacturer and user, but such modifications shall be clearly denoted as exceptions to the Standard. In this Standard, requirements which are recognized to have various options, but for which preferred values are given, have been introduced by phrases such as, "unless otherwise specified," "as mutually agreed upon," or "unless otherwise modified by manufacturer and user." Requirements which must be determined in each case are introduced by phrases such as, "...as agreed upon between manufacturer and user," or "...as mutually agreed upon."

1.8 Quality Assurance

It is the responsibility of the manufacturer to establish a quality assurance system consistent with TL 9000®, or an alternative system acceptable to the user, which will assure conformance with the requirements of this Standard. When the user wishes to require a specific quality assurance program or special testing procedures, agreement between the user and the manufacturer should be reached before the order is placed.

1.9 Safety Considerations

Materials in the cable shall present no dermal or environmental hazards as defined by current industry standards or applicable federal, state or local laws and regulations.

The manufacturer and user of cables made in accordance with this Standard are cautioned to observe any applicable health or safety rules and regulations relative to their manufacture and use. This Standard hereafter assumes that manufacture, testing, installation and maintenance of cables defined herein will be performed only by properly trained personnel using suitable equipment and employing appropriate safety precautions.

Use of certain potentially hazardous substances above allowed limits in electrical and electronic materials has been banned in the European Union by the Restriction on Hazardous Substances (RoHS2) Directive 2011/65/EU superseding the original RoHS Directive 2002/95/EC which was officially repealed January 3, 2013. RoHS 2 is applicable to all equipment that has at least one intended function dependent on electrical or electromagnetic fields.

Although use of these substances has not been banned throughout the United States at the time this document has been issued, other jurisdictions and nations

including the state of California, have adopted similar legislation banning use of these substances above allowed limits in electrical and electronic materials.

Cable materials shall comply with the requirements of the European Union Restriction on Hazardous Substances RoHS 2 directive as it applies to the cable constituent materials.

The materials restricted by the latest RoHS 2 Directive are listed below:

- Cadmium
- Hexavalent Chromium
- Lead
- Mercury
- Polybrominated Biphenyls
- Polybrominated Diphenyl Ethers

In 2015, a new Directive (EU) 2015/863 was published to add the following 4 phthalates to the list of restricted substances in [the RoHS 2 Directive](#).

- Bis(2-Ethylhexyl) phthalate (DEHP)
- Benzyl butyl phthalate (BBP)
- Dibutyl phthalate (DBP)
- Diisobutyl phthalate (DIBP)

The EU Frequently Asked Questions document on RoHS 2 explicitly notes that optical cables are exempt from RoHS 2 (refer to section Q7.2 of http://ec.europa.eu/environment/waste/rohs_eee/pdf/faq.pdf). Although the restrictions of RoHS 2 are not applicable to optical cable, it is best practice to avoid use of these potentially hazardous materials, therefore it is required in this Standard.

In addition, compliance may be required with Article 33 of the European REACH Directive 2006/1907/EC (Registration, Evaluation, Authorization and Restriction of Chemicals), which obligates manufacturers to notify customers in the EU of the presence of cable materials or components that are classified as substances of very high concern (SVHC). A list of current and candidate SVHC can be viewed on the European Chemical Agency (ECHA) website to help determine compliance with the REACH Directive (refer to <https://echa.europa.eu/candidate-list-table>).

Section 2 Optical Fibers

2.1 General

The optical fiber used in the cable shall comply with the requirements set forth in the IEC standards listed in Table 2.1 for multimode and Table 2.2 for single-mode glass core, glass cladding optical fibers.

2.2 Optical Fiber Classes

Optical fibers used shall be one of those listed in Tables 2.1 for multimode and Table 2.2 for single-mode fibers. Other types of fibers may be used as agreed between manufacturer and customer. Such fibers may include fibers of new design offering performance optimized for particular applications.

2.3 Optical Fiber Requirements

- 2.3.1 Unless otherwise specified, optical fibers shall conform to the requirements of IEC 60793-2-10 or IEC 60793-2-50 as listed in Table 2.1 and Table 2.2.

Note: Fibers are commonly specified by reference to the IEC fiber specifications. Fibers are commonly designated using the terminology of the parallel ISO/IEC 11801 specifications for cabled multimode fiber and ITU-T G.650 series recommendations for cabled single-mode fiber. TIA-4920000 series are commonly specified in North America; however, these standards often lag their IEC and ITU-T counterparts.

- 2.3.2 Each optical fiber shall be continuous throughout its length such that the requirements of Sections 7 and 8 of this Standard are met.

- 2.3.3 No spliced fibers are allowed.

2.4 Optical Fiber Coating and Requirements

- 2.4.1 Optical fiber (glass core and glass cladding) shall be coated with a suitable material to preserve the intrinsic strength of the glass. Such coated fibers are termed "Primary Coated Fibers."

- 2.4.2 The thickness of the primary coating(s) shall be such that the applicable requirements of this Standard are met. The coating diameter for standard 250 μm colored fiber is 235 to 265 μm and 235 to 255 μm for uncolored fiber per IEC 60793-2-50 for single mode fibers and IEC 60793-2-10 for multimode fibers. The coating diameter for 200 μm colored fiber is 190 to 215 μm and 180 to 210 μm for uncolored fiber per IEC 60793-2-50. Other coating diameters are acceptable as agreed between manufacturer and user, provided all applicable requirements of this

standard are met. Dimensions shall be measured according to the methods of 7.13.

- 2.4.3 The diameter over the coating is defined as the diameter of the fiber as used in the cable; that is, the diameter includes any coloring thickness if the fiber is colored, and is the uncolored coating diameter if the fiber is not colored.
- 2.4.4 Coating materials used shall meet the requirements of Sections 7 and 8 of this Standard or as otherwise permitted by the user.
- 2.4.5 The coating(s) shall be uniform and concentric with the glass. Coating(s) shall be removable by mechanical means without damage to the fiber(s) by using manufacturer's recommended procedures. The strip force of the optical fiber's protective coating shall be measured according to FOTP-178. The force required to remove 30 ± 3 mm of the fiber's protective coating shall be between 1.0 N and 8.9 N. This requirement does not apply to removal of the material applied to tight buffered or semi-tight buffered (loosely bound buffer) fiber.

Table 2.1
Multimode Fiber Specification
(Informational Cross Reference)

Fiber Type	ISO/IEC 11801-1 ⁽¹⁾	IEC Detail Specification	TIA Detail Specification
62.5/125 μ m MM fiber	OM1 ⁽²⁾	60793-2-10, A1-OM1 (Formerly A1b)	492AAAF, A1-OM-1 (Formerly 492AAAA)
50/125 μ m MM fiber	OM2 ⁽²⁾	60793-2-10, A1-OM2 (Formerly A1a.1)	492AAAF, A1-OM2 (Formerly 492AAAB)
50/125 μ m Laser Optimized MM fiber ⁽³⁾	OM3 ⁽⁴⁾	60793-2-10, A1-OM3 (Formerly A1a.2)	492AAAF, A1-OM3 (Formerly 492AAAC)
50/125 μ m Laser Optimized MM fiber ⁽³⁾	OM4 ⁽⁴⁾	60793-2-10, A1-OM4 (Formerly A1a.3)	492AAAF, A1-OM4 (Formerly 492AAAD)
50/125 μ m Laser Optimized MM fiber ⁽³⁾	OM5 ⁽⁴⁾	60793-2-10, A1-OM5 (Formerly A1a.4)	492AAAF, A1-OM5 (Formerly 492AAAE)

Notes:

- ISO/IEC 11801 series is analogous to TIA 568 series (Customer Premises Telecommunications Cabling Standard). ISO/IEC 11801-1 categories define fiber performance when cabled.
- OM1 and OM2 are no longer supported as normative in ISO/IEC 11801-1. They remain as informative, grandfathered for historical references.
- IEC 60793-2-10, edition 7, defines the A1 fiber bandwidth grades, A1-OM2, A1-OM3, A1-OM4, and A1-OM5, with two levels of macrobend loss performance. The "a" suffix, e.g., A1-OM3a, etc., will denote traditional macrobend loss performance levels, and those with the "b" suffix, e.g., A1-OM3b, etc., will define enhanced macrobend loss levels. Therefore, the "b" fibers will define bend insensitive multimode fibers.
- 50/125 μ m Laser Optimized MM fiber (OM3, OM4, or OM5) is designed for 850 nm laser-based operations but supports legacy LED data rates at 850 nm and 1300 nm. Mixing OM2, OM3, and OM4/OM5 fibers in links can disproportionately degrade performance and should be generally avoided.

Table 2.2
Single-Mode Fiber Specification ⁽¹⁾
(Informational Cross Reference)

Common Commercial Reference	ITU-T Recommendation	IEC Detail Specification	TIA Detail Specification
Dispersion-Unshifted SMF, with Low Water Peak	G.652. D	60793-2-50, B-652.D (Formerly B1.3)	492CAAC, B-652.D (Formerly 492CAAB)
Cut-off shifted SM Fiber	G.654	60793-2-50, B-654.B&C (Formerly B1.2)	492CAAC, B-654B&C
Non-Zero Dispersion-Shifted (NZDS)	G.655.D	60793-2-50, B-655.D (Formerly B4_d)	492CAAC, B-655.D (Formerly 492EA00)
	G.655.E	60793-2-50, B-655.E (Formerly B4_e)	492CAAC, B-655.E (Formerly 492EA00)
Non-Zero Dispersion-Shifted SM Fiber (NZDS) for Wideband Transport	G.656	60793-2-50, B-656 (Formerly B5)	492CAAC, B-656
Bend Optimized SMF	G.657.A1	60793-2-50, B-657.A1 ⁽²⁾ (Formerly B6_a1)	492CAAC, B-657.A1 ⁽³⁾
	G.657.A2	60793-2-50, B-657.A2 ⁽²⁾ (Formerly B6_a2)	492CAAC, B-657.A2 ⁽³⁾
	G.657.B2	60793-2-50, B-657.B2 ⁽²⁾ (Formerly B6_b2)	492CAAC, B-657.B2 ⁽³⁾
	G.657.B3	60793-2-50, B-657.B3 ⁽²⁾ (Formerly B6_b3)	492CAAC, B-657.B3 ⁽³⁾

Notes:

- Older fiber types not listed in Table 2-2 are typically suitable for use.
- The IEC fibre designations shown in parentheses are those used in IEC 60793-2-50, Ed 6, and earlier.
- Bend Optimized SM fiber (ITU-T G 657.A) is compliant with Dispersion-Unshifted SMF with Low Water Peak (ITU-T G.652.D). Note that G.657.B fiber may or may not be compliant with G.652.D. The bending characteristics of G.657 fibers are further explained in Table 2-3.
- At time of this publication, no TIA standard was published for Bend Optimized SM fiber.

Table 2-3
Fiber Bend Characteristics of G.657 Single-Mode Fiber
(Informative)

Minimum design radius ¹	G.652D Compliant ²	G.652D Compatible ³
10 mm	G.657.A1	
7.5 mm	G.657.A2	G.657.B2
5.0 mm		G.657.B3

Notes:

1. The minimum design radii are used to categorize the fibers and are based on the 1-turn specification in the applicable ITU-T Recommendation and IEC fiber specifications.
2. Compliant – Fully meets the standard specified.
3. Compatible – Can be used with fibers meeting the specification but does not necessarily meet the specification. These G.657 fibers do not necessarily meet the G.652.D specification but may be used with fibers that do.

General notes:

Two classes, which come from the systems considerations, are long distance (G.652.D compliant) and short reach applications. The short reach applications do not need to specify CD and PMD as the fiber segments are short enough that these properties do not impact system performance.

Three subcategories come from the cable specifications considerations where minimum design radius is the parameter of importance.

Bend insensitive fibers may also require use of alternative fusion splicer programs.

Section 3 Optical Fiber Core Units

3.1 General

This part defines specific types of units that may be used in cables designed for installation in the outside plant, such as: buffer tubes, optical fiber bundles, optical fiber ribbons, and tight and semi-tight buffered fibers. Fiber units are not limited to these types. Other types of units may be used provided that they meet the intent of Sections 3 and 4.

3.2 Buffer Tubes

Buffer tubes, sometimes referred to as loose tubes, consist of optical fiber(s) or optical fiber ribbon(s) inside a tube that isolates the fibers from outside stress. The inside dimension is greater than the maximum dimension of the combined optical elements surrounded by the tube. The space between the optical elements and the inside of the tube contains a suitable water blocking material. Loose tubes are typically employed as single central units, or in stranded configurations in multiple unit designs.

3.2.1 Buffer Tube Dimensions

Buffer tube dimensions are set by the manufacturer to ensure that the applicable performance requirements of this Standard are met. Dimensions shall be measured according to the methods of 7.13.

3.2.2 Buffer Tube Requirements

3.2.2.1 The buffer tubes shall be constructed such that the buffer tube and finished cable meet all applicable performance requirements specified in Section 7.

3.2.2.2 The buffer tubes shall be uniform and concentric such that they meet the cable performance requirements in Section 7. The buffer tubes shall meet the kink test requirements of 7.37. Buffer tubes must be removable, without damage to the fibers, using the manufacturer's recommended procedures.

3.2.2.3 Each buffer tube, in multi-tube cable designs, shall be uniquely identifiable. Methods shall conform to 4.3. For cables having a single (i.e. central) buffer tube, no specific identification method is required.

3.2.2.4 Aging requirements are addressed in 7.19.

3.3 Optical Fiber Bundles

Bundles are arrays of color-coded optical fibers, held together and identified by a color-coded binder, that reside in a buffer tube(s).

The binder color code shall conform to 4.3.

3.4 Optical Fiber Ribbons

Ribbon structures are typically designated as edge-bonded, encapsulated or partially-bonded.

Edge-bonded and encapsulated structures are differentiated by the amount of buffering afforded to the fibers by the bonding agent.

The partially-bonded ribbon can be of either structure but with the matrix applied periodically.

3.4.1 Ribbon Identification

Each ribbon shall be uniquely identifiable. Methods shall conform to 4.3. Generally, ribbons comprise one unit. However, ribbons may contain more than one unit, in which case separate units shall be appropriately identified.

3.4.2 Fiber Identification in Ribbons

Each fiber within a ribbon shall be uniquely identifiable. Methods shall conform to 4.2 and 4.3, as applicable.

3.4.3 Ribbon Fiber Counts

Common fiber counts for optical fiber ribbons are: 4, 6, 8, 12, 16, 24, 32, and 36. Fiber counts in ribbons shall be established by agreement between manufacturer and user.

3.4.4 Ribbon Requirements

Ribbons shall be constructed so that the finished cable meets all applicable performance requirements specified in Section 7. The following additional requirements pertain specifically to ribbons:

3.4.4.1 Ribbon Dimensions

Certain ribbon dimensions may be important in cable design, in splice apparatus, or for successful splicing of one ribbon to another. All measurements shall be referenced from either the cladding edge or the center of the core. Fiber coatings shall not be used for reference. Important dimensions are shown in Figure 7.1 and listed in Table 7.2. Measure the attributes as agreed between manufacturer and user, and as directed by 7.14.

3.4.4.2 Ribbon Twist Test: Test ribbons for robustness per 7.15.

3.4.4.3 Ribbon Residual Twist Test: Test for ribbon residual twist per 7.16.

3.4.4.4 Ribbon Separability Test: Measure ribbon separability per 7.17.

3.4.4.5 Fiber Crossovers in Ribbons: The fibers shall be parallel and not cross over throughout the length of the ribbon.

3.4.4.6 Ribbon Strippability

At least 25 mm (1.0 in) of the ribbon matrix and the fibers' protective coatings shall be removable with commercially available stripping tools from aged and unaged ribbons with no fiber breakage. Any remaining coating residue shall be readily removable using isopropyl alcohol wipes. Aging requirements are addressed in 7.19 (See 7.19.2.1).

3.4.5 Ribbon Construction

The fibers in the ribbon planar array may be surrounded by one or more layers of resin or other bonding materials. The resin may be edge-bonded, encapsulated or unitized (continuous), or have intermittent attachments (partially bonded) between fibers to aid in the flexibility of the ribbon.

3.4.5.1 Edge-Bonded/Encapsulated Ribbon

Ribbons shall meet the full mechanical and environmental requirements as an intact unit but may be dissected into individual units.

3.4.5.2 Partially-Bonded Ribbon

Partially bonded ribbons are a structure in which neighboring fibers are fixed together periodically in the longitudinal direction. Ribbons shall meet the full mechanical and environmental requirements as an intact unit with exceptions as stated in individual requirements.

3.4.5.3 Unitized Ribbon

Ribbons designed to be divided into pre-designed individual subunits i.e. 4, 6, 8, or 12 fiber units. Subunits of the unitized ribbon must meet the mechanical and environmental requirements of traditional non-unitized ribbon.

3.5 Buffered Fiber

A tight buffer consists of one or more layers of buffer material applied around the individual optical fiber, so that it is in intimate contact with the coating of the fiber. The buffers may be tight buffer or semi-tight buffer.

3.5.1 Tight Buffered Fiber

A tight buffer consists of one or more layers of buffer material applied around the individual optical fiber, so that it is in intimate contact with the primary coating of the fiber. The coating of the tight buffered fiber is generally adhered to the primary coating of the fiber such that all coatings are removed during stripping, leaving only the bare glass.

3.5.2 Semi-Tight (Loosely Bound Buffer) Buffered Fiber

A semi-tight buffer (also called loosely bound buffer) is substantially the same in function and construction as a tight buffer, but is not in such intimate contact with the primary fiber coating. The semi-tight buffer is capable of being removed without affecting the fiber primary coating.

Semi-tight buffers may also be defined as easily strippable semi-tight buffer. This allows longer lengths to be stripped at the specified strip force.

3.5.3 Buffered Dimensions (Both Types)

Buffer dimensions are established by the manufacturer to ensure that the applicable performance requirements of this Standard are met. Dimensions shall be measured according to the methods of 7.13.

The standard nominal buffer outer diameter is 900 μm . Common alternatives are 500 μm and 600 μm . In all cases, the tolerance about the nominal outer diameter is $\pm 50 \mu\text{m}$.

3.6 Slotted Core

A slotted core typically consists of a rigid central member covered with a slotted polymer. The ribbons, tubes, or fibers lay loosely in the slots.

3.6.1 Buffered Fiber Requirements (Both Types)

3.6.1.1 The buffered fiber shall be constructed so that the finished cable meets all applicable performance requirements specified in Section 7.

3.6.1.2 Each buffer shall be uniform and concentric with the optical fiber.

3.6.1.3 Each buffer shall be uniquely identifiable in accordance with 4.2.

3.6.1.4 The buffered fiber shall be strippable in accordance with 7.20.

Section 4

Cable and Component Assembly and Identification

4.1 Cabling of Multi-Fiber and Composite Optical Cables

Optical fiber communications cables shall be assembled in accordance with this part.

4.2 Identification of Fibers Within a Unit

- 4.2.1 In units with multiple fibers, each fiber in the unit shall be readily identifiable. Identification shall be provided by means of color coding or by other means as mutually agreed upon.
- 4.2.2 For color coding, the color order and color definitions designated for identification of individual fibers shall be in accordance with TIA-598, *Optical Fiber Cable Color Coding*. The order for 12 fiber units or subgroups is listed for convenience in Table 4.1.

4.3 Identification of Units Within a Cable

- 4.3.1 In cables with multiple units, each unit shall be readily identifiable. Identification shall be provided by means of color coding, printed legends, bar codes, positional configuration, tapes, threads, or by other means as mutually agreed upon.
- 4.3.2 For color coding, the color order and color definitions designated for identification of individual units within a cable shall be in accordance with TIA-598. The order is listed for convenience in Table 4.1.

4.4 Identification of Conductors in Hybrid Cable

Electrical conductors in hybrid cables may be used for communications or for power or both, depending on the specific hybrid cable design. Insulated paired electrical conductors employed in hybrid cables shall be identified by the color code required by appropriate copper standards. If non-paired electrical conductors are used, colors shall be as agreed upon by the manufacturer and user.

Table 4.1 - Individual fiber, unit, and group identification

Position number	Base color and tracer	Abbreviation/print legend
1	Blue	1 or BL or 1-BL
2	Orange	2 or OR or 2-OR
3	Green	3 or GR or 3-GR
4	Brown	4 or BR or 4-BR
5	Slate	5 or SL or 5-SL
6	White	6 or WH or 6-WH
7	Red	7 or RD or 7-RD
8	Black	8 or BK or 8-BK
9	Yellow	9 or YL or 9-YL
10	Violet	10 or VI or 10-VI
11	Rose	11 or RS or 11-RS
12	Aqua	12 or AQ or 12-AQ
13	Blue with Black Tracer	13 or D/BL or 13-D/BL ⁽¹⁾
14	Orange with Black Tracer	14 or D/OR or 14-D/OR
15	Green with Black Tracer	15 or D/GR or 15-D/GR
16	Brown with Black Tracer	16 or D/BR or 16-D/BR
17	Slate with Black Tracer	17 or D/SL or 17-D/SL
18	White with Black Tracer	18 or D/WH or 18-D/WH
19	Red with Black Tracer	19 or D/RD or 19-D/RD
20	Black with White Tracer	20 or D/BK or 20-D/BK ⁽²⁾
21	Yellow with Black Tracer	21 or D/YL or 21-D/YL
22	Violet with Black Tracer	22 or D/VI or 22-D/VI
23	Rose with Black Tracer	23 or D/RS or 23-D/RS
24	Aqua with Black Tracer	24 or D/AQ or 24-D/AQ
25	Blue with Double Black Tracer	25 or DD/BL or 25-DD/BL ^(3,4)
26	Orange with Double Black Tracer	26 or DD/OR or 26-DD/OR
27	Green with Double Black Tracer	27 or DD/GR or 27-DD/GR
28	Brown with Double Black Tracer	28 or DD/BR or 28-DD/BR
29	Slate with Double Black Tracer	29 or DD/SL or 29-DD/SL
30	White with Double Black Tracer	30 or DD/WH or 30-DD/WH
31	Red with Double Black Tracer	31 or DD/RD or 31-DD/RD
32	Black with Double White Tracer	32 or DD/BK or 32-DD/BK ⁽²⁾
33	Yellow with Double Black Tracer	33 or DD/YL or 33-DD/YL
34	Violet with Double Black Tracer	34 or DD/VI or 34-DD/VI
35	Rose with Double Black Tracer	35 or DD/RS or 35-DD/RS
36	Aqua with Double Black Tracer	36 or DD/AQ or 36-DD/AQ

Notes:

- 1) "D/" denotes a dashed mark or tracer. That is, D/BL is Dash/Blue, meaning Blue with a tracer.
- 2) Pertaining to positions 20 and 32, yellow tracers are also allowed. Other discernible tracer methods or colors may be used as agreed to by the manufacturer and the user.
- 3) "DD/" denotes a double dashed mark or tracer. That is, DD/BL is Double Dash/Blue, meaning Blue with a double tracer.
Other alternate marking schemes are allowed for fiber and unit identification for units 25-36 if agreed to by manufacture and end-user. Note that a red stripe is common in the industry. For red groupings a yellow or other contrasting tracer color may be used.
- 4) Other discernible tracer methods or colors may be used as agreed to by the manufacturer and the user.
- 5) TIA-598 states that an alternative to the above fiber and unit identification for fibers 13 through 16 may be Olive, Magenta, Tan, and Lime in this order.

4.5 Strength Members

Central or non-central strength members, or both, may be included in the cable design. These members may be metallic, non-metallic, or a combination of both. Strength members shall provide sufficient tensile strength for installation and residual loads to meet the applicable performance requirements of Section 7.

The messenger wires used for figure-8 aerial self-supporting applications shall meet the requirements of Annex D. The strength members used for all-dielectric self-supporting cables shall be capable of meeting the requirements of Annex F.

4.6 Assembly of Cables

- 4.6.1 The required number of optical fibers and metallic conductors shall be assembled into layers as in a concentric design, or into units as in a unit-type construction, or into other suitable constructions such as flat ribbon or slotted core configurations.
- 4.6.2 When tapes or threads are used as unit identifiers, their colors shall conform to the requirements of TIA-598. The lay length of identifiers, when used, is not specified, but the length shall assure adequate segregation and identification of the cable components enclosed.
- 4.6.3 Other components may be used as appropriate for specialized needs. For example, cable fillers may be used to occupy the interstitial spaces between cable elements. An inner jacket may be applied for protection or other purposes.

4.7 Filling and Flooding Material

- 4.7.1 Filling material may be used in the buffer tube to block the ingress and axial migration of water through the cable core. Tapes, threads, or other materials may be used which meet the intent of this paragraph and the requirements of Section 7.

- 4.7.2 Flooding material may be used in the cable core or sheath interface(s) for the purpose of preventing the ingress and migration of water. Tapes or other materials may be used which meet the intent of this paragraph and the requirements of Section 7.
- 4.7.3 The filling and flooding materials shall be compatible with all components of the cable that they contact. The elements typically in contact with the filling material are optical fibers, buffered fibers, optical fiber ribbons, and buffer tubes. The elements typically in contact with the flooding compound are buffer tubes, strength members, metal tapes, and jackets. Refer to 7.19 for methods to test material compatibility.
- 4.7.4 The filling compound shall conform to the oxidation induction time (OIT) requirements of 7.36.

Section 5 Coverings

5.1 Binders

If required for manufacturing reasons, a binder may be applied over the core, core wrap, metallic shield(s), or armor(s). Binders may also be used for unit or multi-unit identifiers as specified in 4.6.2.

5.2 Core Wrap

Cable cores may be covered by one or more layers of core wrap material.

5.3 Shielding, Armoring, or Other Metallic Coverings

5.3.1 General

If shielding, armoring, or other metallic covering is required for a specific construction, requirements shall be established by agreement between manufacturer and user. A shielding or armoring system may consist of single-tape or dual-tape constructions.

For the purpose of this Standard, in dual-tape constructions the term “shielding-tape” shall refer to a tape containing a highly conductive metal, such as copper or aluminum, which is present in the cable primarily for its electrical properties. In addition to tape, shielding may also consist of a serving, wrap, or braid of wires of various metals and gauges. The term “armoring tape” shall refer to a tape containing lower conductivity metal, such as steel or stainless steel, which is present in the cable primarily for mechanical protection of the cable core. Care should be used when putting dissimilar metals into electrical contact with each other. Coatings, claddings, or other methods of protection may be necessary to prevent galvanic interaction.

Shielding may be applied to a cable for any of several reasons including, but not limited to: lightning protection, bonding and grounding considerations, and electrical shielding.

Armoring may be applied to a cable for any of several reasons including, but not limited to: rodent resistance, termite resistance, environmental protection, and general mechanical protection.

5.3.1.1 Rodent Resistance

Cables not protected by conduits or trays may require the use of a rodent resistant outer sheath. Prospective users are advised to contact the cable manufacturer for information relating to the test methodology and rodent resistance of their cable product. Armoring tapes listed in Annex B, Section 2,