



STANDARD FOR

OPTICAL FIBER

OUTSIDE PLANT COMMUNICATIONS CABLE

Approved by

AMERICAN NATIONAL STANDARDS INSTITUTE

January 17, 2012

Publication # ANSI/ICEA S-87-640-2011

Fifth Edition

© 2011 by ICEA

INSULATED CABLE ENGINEERS ASSOCIATION, Inc.

ANSI/ICEA S-87-640-2011

STANDARD FOR OPTICAL FIBER

OUTSIDE PLANT COMMUNICATIONS CABLE

January 17, 2012

Fifth Edition

Published By

Insulated Cable Engineers Association, Inc. (ICEA)

P.O. Box 1568

Carrollton, Georgia 30112, USA

(770) 830-0369

Approved June 7, 2011, by
INSULATED CABLE ENGINEERS ASSOCIATION, Inc.

Approved January 17, 2012, by ANSI ASC C-8
AMERICAN NATIONAL STANDARDS INSTITUTE

Copyrighted by the ICEA

Contents may not be reproduced
in any form without permission of the
INSULATED CABLE ENGINEERS ASSOCIATION, INC.

Copies of this publication may be ordered online or by contacting:

IHS
15 Inverness Way East
Englewood, CO 80113-5776 USA
Telephone: (800) 854-7179
www.global.ihs.com

NOTICE AND DISCLAIMER

The information in this publication was considered technically sound by the consensus of persons engaged in the development and approval of the document at the time it was developed. Consensus does not necessarily mean that there is unanimous agreement among every person participating in the development of this document.

The Insulated Cable Engineers Association, Inc. (ICEA) standards and guideline publications, of which the document contained herein is one, are developed through a voluntary consensus standards development process. This process brings together persons who have an interest in the topic covered by this publication. While ICEA administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy or completeness of any information or the soundness of any judgments contained in its standards and guideline publications.

ICEA disclaims liability for personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, application, or reliance on this document. ICEA disclaims and makes no guaranty or warranty, expressed or implied, as to the accuracy or completeness of any information published herein, and disclaims and makes no warranty that the information in this document will fulfill any of your particular purposes or needs. ICEA does not undertake to guarantee the performance of any individual manufacturer or seller's products or services by virtue of this standard or guide.

In publishing and making this document available, ICEA is not undertaking to render professional or other services for or on behalf of any person or entity, nor is ICEA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. Information and other standards on the topic covered by this publication may be available from other sources, which the user may wish to consult for additional views or information not covered by this publication.

ICEA has no power, nor does it undertake to police or enforce compliance with the contents of this document. ICEA does not certify, test, or inspect products, designs, or installations for safety or health purposes. Any certification or other statement of compliance with any health or safety-related information in this document shall not be attributable to ICEA and is solely the responsibility of the certifier or maker of the statement.

[This page intentionally blank.]

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 revision on September 15, 1999. A third revision was approved by ICEA on June 8, 2005. It was published by ICEA, but was not published as an ANSI-approved Standard. Revision 4 of this Standard, approved by ICEA on September 13, 2006, was a republication of revision 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 members of the ICEA Communications Cable Division Working Group who participated in the fifth edition of this standard were:

Jim Ryan, Chairman and Editor

M. D. Kinard
P. Fraley
D. Taylor

D. Baker
J. Register
P. VanVickle

D. Hessong
J. Shinoski

This issue replaces the previous issue of ANSI/ICEA S-87-640-2006, *Standard for Optical Fiber Outside Plant Communications Cable*. Major changes in this revision include the following:

- Addition of new fiber types
- Addition of a mid-span buffer tube storage testing
- Addition of a buffer tube kink test
- Addition of all-dielectric self-support cable requirements
- Addition of an informative annex on General Outside Plant Optical Fiber Cable Installation Considerations

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.

Questions of interpretation of ICEA Standards can only be accepted in writing and the reply shall be provided in writing. Suggestions for improvements in this Standard are welcome. Questions and suggestions shall be sent to:

Secretary
Insulated Cable Engineers Association, Inc.
Post Office Box 1568
Carrollton, GA 30112
United States of America

Alternatively, you can contact ICEA by utilizing the *Contact* link in the ICEA web site:

www.icea.net

[This page intentionally blank.]

CONTENTS

<u>SECTION</u>	<u>PAGE</u>
PART 1 INTRODUCTION	1
1.1 Scope	1
1.2 General	3
1.3 Units	4
1.4 Definitions	4
1.5 References.....	5
1.6 Information to be Supplied by the User	5
1.7 Modification of this Standard	6
1.8 Quality Assurance.....	6
1.9 Safety Considerations.....	6
PART 2 OPTICAL FIBERS	8
2.1 General	8
2.2 Optical Fiber Classes.....	8
2.3 Optical Fiber Requirements	8
2.4 Optical Fiber Coating and Requirements	8
PART 3 OPTICAL FIBER CORE UNITS	11
3.1 General	11
3.2 Loose Buffer Tubes	11
3.3 Optical Fiber Bundles	12
3.4 Optical Fiber Ribbons	12
3.5 Tight Buffers.....	13
PART 4 CABLE AND COMPONENT ASSEMBLY AND IDENTIFICATION	14
4.1 Cabling of Multi-Fiber and Composite Optical Cables.....	14
4.2 Identification of Fibers within a Unit	14
4.3 Identification of Units within a Cable	14
4.4 Identification of Conductors in Composite Cable.....	14
4.5 Strength Members	16

CONTENTS (cont.)

<u>SECTION</u>	<u>PAGE</u>
Part 4: (Continued)	
4.6 Assembly of Cables	16
4.7 Filling and Flooding Material	16
PART 5 COVERINGS	17
5.1 Binders	17
5.2 Core Wrap	17
5.3 Shielding, Armoring, or Other Metallic Coverings	17
5.4 Jackets	19
5.5 Jacket Repairs	23
5.6 Other Coverings	23
5.7 Ripcords	23
PART 6 OTHER REQUIREMENTS	24
6.1 Identification and Date Markings	24
6.2 Optical Cable Identification and Other Markings	25
6.3 Length Marking	25
6.4 Cable Remarking	26
6.5 Packaging, Packing, and Package Marking	26
PART 7 TESTING, TEST METHODS, AND REQUIREMENTS	28
7.1 Testing	28
7.2 Extent of Testing	28
7.3 Standard Test Conditions	28
7.4 Electrical Testing of Conductive Materials	29
7.5 Construction, Color Code, and Identification	29
7.6 Jacket Thickness Measurements	30
7.7 Jacket Material Density Measurement	30
7.8 Jacket Tensile Strength, Yield Strength, and Ultimate Elongation Tests .	30
7.9 Jacket Material Absorption Coefficient Test	31

CONTENTS (cont.)

<u>SECTION</u>	<u>PAGE</u>
Part 7: (Continued)	
7.10 Environmental Stress Crack Resistance Test	31
7.11 Jacket Shrinkage Test	32
7.12 Verification of Cable Length and Marking Accuracy	33
7.13 Cable and Component Dimensions.....	33
7.14 Ribbon Dimensions.....	34
7.15 Ribbon Twist Test	34
7.16 Ribbon Residual Twist Test	35
7.17 Ribbon Separability Test.....	35
7.18 Ripcord Functional Test.....	36
7.19 Material Compatibility and Cable Aging Test.....	37
7.20 Tight Buffer Strippability Test.....	39
7.21 Cable Low and High Temperature Bend Test	39
7.22 Cable External Freezing Test	40
7.23 Compound Flow (Drip) Test for Filled Cable	40
7.24 Cable Temperature Cycling Test.....	41
7.25 Hydrogen Evolution in Cable	41
7.26 Cable Sheath Adherence Test	42
7.27 Cyclic Flexing Test.....	42
7.28 Water Penetration Test.....	43
7.29 Cable Impact Test.....	43
7.30 Cable Tensile Loading and Fiber Strain Test	44
7.31 Cable Compression Loading Test	46
7.32 Cable Twist Test	46
7.33 Cable Lightning Damage Susceptibility Test	47
7.34 Mid-Span Buffer Tube Storage	48
7.35 Central Tube Cable Coupling	48
7.36 Oxidative Induction Time, OIT	49
7.37 Buffer Tube Kink Test	49

CONTENTS (cont.)

<u>SECTION</u>	<u>PAGE</u>
PART 8 FINISHED CABLE OPTICAL PERFORMANCE REQUIREMENTS	51
8.1 Optical Performance	51
8.2 Attenuation Coefficient.....	52
8.3 Multimode Optical Bandwidth	53
8.4 Optical Point Discontinuities	53
8.5 Cable Cutoff Wavelength (Single-Mode Fibers Only)	54
8.6 Polarization Mode Dispersion (Single-Mode Fibers Only).....	54
PART 9 REFERENCES	56

ANNEXES

Annex A (Informative)	Suggested Information for a Purchase Document.....	62
Annex B (Informative)	Metallic Covering Materials	64
Annex C (Normative)	Requirements for Very-Low Temperature Applications ...	69
Annex D (Normative)	Self-supporting Figure-8 Cables Designs	71
Annex E (Normative)	1625 nm Cabled Fiber Performance Requirements	77
Annex F (Normative)	All-Dielectric Self-Supporting Cable (ADSS)	78
Annex G (Informative)	General Outside Plant Optical Fiber Cable Installation Considerations	79
Annex H (Informative)	ICEA Telecommunications Cable Standards	84

FIGURES

Figure 7.1	Ribbon dimensional parameters	34
Figure 7.2	Ribbon preparation	36
Figure 7.3	Ribbon separation.....	36
Figure D.1	Cable galloping test schematic	76

CONTENTS (cont.)

<u>TABLES</u>	<u>PAGE</u>
Table 1.1	Cable normal temperature ranges 2
Table 2.1	Multimode optical fiber specification requirements 9
Table 2.2	Single-mode optical fiber specification requirements 10
Table 4.1	Individual fiber, unit, and group identification..... 15
Table 5.1	Requirements for jackets removed from completed cable 21
Table 5.2	Jacket thickness requirements 22
Table 6.1	Year of manufacture marker threads..... 25
Table 7.1	Sample preparation and test set-up, jacket tensile properties 31
Table 7.2	Maximum dimensions of optical fiber ribbons..... 34
Table 8.1	Attenuation coefficient performance requirements 51
Table 8.2	Multimode bandwidth coefficient performance requirements 51
Table 8.3	Point discontinuity acceptance criteria..... 52
Table 8.4	Optical attenuation measurement methods..... 52
Table 8.5	Multimode optical bandwidth measurement methods 53
Table B.1	Thickness of aluminum alloy tapes..... 64
Table B.2	Thickness of copper, copper alloy, and bronze tapes 65
Table B.3	Thickness of copper-steel-copper laminate tapes 65
Table B.4	Stainless steel tape composition 66
Table B.5	Stainless steel tape physical performance 67
Table B.6	Thickness of stainless steel tapes 67
Table B.7	Thickness of steel tapes 67
Table B.8	Steel tape composition 68
Table D.1	Outer jacket thickness requirements for figure-8 messenger cables 72
Table D.2	Dimension requirements for messenger webs 72
Table E.1	Acceptance criteria for L-Band operation 77

[This page intentionally blank.]

PART 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 (TIA) cable product standards for information on optical fiber cable requirements for other applications:

- S-83-596: Standard for indoor optical fiber cable (TIA-472C000-C)
- S-104-696: Indoor-outdoor optical fiber cable (ANSI/TIA-472E000)
- S-110-717: Optical fiber drop cable (ANSI/TIA-472F000)
- S-112-718: Optical fiber cable for placement in sewer environments (TIA-472G000)

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 composite 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 (Normative), 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 percent 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.

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, such as those installed in miniature ducts, 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. Parts 2 to 5 cover the major components and assembly of the cables:

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

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

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

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

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

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

Part 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 Cables

Cables containing both optical fibers and metallic conductors that are intended for communications use.

1.4.1.2 Dielectric Cables

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

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 Cables

Cables which contain more than one type of optical fiber.

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 or powering.

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 (Normative) 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 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. This definition does not apply to the optical fiber Detail Specifications referenced in Table 2.1 and Table 2.2 of this Standard.

1.5 References

All documents referenced herein are listed in Part 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. Cable materials shall comply with the requirements of the European Union Restriction on Hazardous Substances (RoHS) directive, EU Directive 2002/95/EC.

Typically, the substances listed below should not be present in cable materials beyond specified maximum concentrations.

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

Use of these substances in electrical and electronic materials has been banned in the European Union by the Restriction on Hazardous Substances (RoHS) Directive (EU Directive 2002/95/EC) as amended by the Commission Decision of 18 August 2005 (2005/618/EC). Although use of these substances has not been

banned throughout the United States at the time this document has been issued, many other nations and jurisdictions have adopted similar legislation.

In addition it may also be required to comply with Article 33 of the European Directive REACH Directive 2006/1907/EC (Registration, Evaluation, Authorization and Restriction of Chemicals) which obligates the manufacture to notify the customers the presence of substances of very high concern (SVHC). A list can be viewed on the European Chemical Agency (ECHA) website for compliance to the REACH Directive (refer to http://echa.europa.eu/chem_data_en.asp).

PART 2

OPTICAL FIBERS

2.1 General

The optical fiber used in the cable shall comply with the requirements set forth in the 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 the IEC 60793-2-10 and IEC 60793-2-50 specifications 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. These mirror the IEC fiber specifications.

- 2.3.2 Each optical fiber shall be continuous throughout its length such that the requirements of Parts 7 and 8 of this Standard are met.
- 2.3.3 Unless otherwise specified, any section of an optical fiber and its coating, including any section containing a factory splice, shall meet the same dimensional, mechanical, optical, and environmental requirements as un-spliced fiber, and shall be capable of meeting the performance requirements of Parts 7 and 8. If spliced fibers are utilized in a cable, the customer shall be notified.

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. Nominal coating diameters for standard fibers are 235 to 265 μm ; other coating diameters are acceptable provided that all

other applicable requirements 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 Parts 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 9.0 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⁾	IEC Detail Specification	TIA Detail Specification
62.5/125 μ m MMF	OM-1	60793-2-10, A1b	492AAAA-B
50/125 μ m MMF	OM-2	60793-2-10, A1a.1	492AAAB-A
50/125 μ m Laser Optimized MMF	OM-3 ⁽²⁾	60793-2-10, A1a.2	492AAAC-B
50/125 μ m Laser Optimized MMF	OM-4 ⁽³⁾	60793-2-10, A1a.3 ⁽³⁾	492AAAD
Notes 1) ISO/IEC 11801 is analogous to TIA 568 series (Commercial Building Wiring Standards) 2) 50 μ m Laser Optimized MMF (OM-3) are commonly used for 10 Gbps Ethernet and Fibre Channel Systems. Mixing OM-2 fibers in OM-3 links can disproportionately degrade performance and should be generally avoided. 3) 60793-2-10: The new edition containing the OM4 specification information is not published as of this writing.			

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	G652.C & D	60793-2-50 B1.3	492CAAB
Cut-off shifted SM Fiber	G654	60793-2-50,B1.2	NA
Non-zero Dispersion-Shifted (NZDS)	G.655D	60793-2-50.B4_d	492EA00
	G655 E	60793-2-50.B4_e	492EA00
Non-zero Dispersion-Shifted SM Fiber (NZDS) for Wideband Transport	G.656	60793-2-50, B5	NA
Bend Optimized SMF ⁽³⁾	G.657.A1 G.657.A2	60793-2-50, B6_a1 ⁽⁴⁾ 60793-2-50, B6_a2 ⁽⁴⁾	NA ⁽²⁾
	G.657.B2 G.657.B3	60793-2-50, B6_b2 ⁽⁴⁾ 60793-2-50, B6_b3 ⁽⁴⁾	NA ⁽²⁾
Notes 1) Older fiber types not listed in Table 2-2 are typically suitable for use. 2) At time of this publication, no TIA standard was published for Bend Optimized SM fiber. 3) Bend Optimized SM fiber (ITU-T G 657.A) is compliant with Dispersion-Unshifted SMF with Low Water Peak (TIA 492CAAB) 4) These specifications will be 60793-2-50 ed4.			

PART 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: loose buffer tubes, optical fiber bundles, optical fiber ribbons, and 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 Parts 3 and 4.

3.2 Loose Buffer Tubes

Loose buffer 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 Loose 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 Loose Buffer Tube Requirements

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

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

3.2.2.3 Each loose 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

A ribbon is a planar array of optical fibers.

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, 24 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 Part 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).

3.5 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 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.

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 $\pm 50 \mu\text{m}$.

3.5.4 Buffered Fiber Requirements (Both Types)

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

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

3.5.4.3 Each buffer shall be uniquely identifiable in accordance with 4.2

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

PART 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 is listed for convenience in Table 4.1.

For reference testing using the Munsell color system, specimens shall be tested for compliance as viewed under North Sky Daylight in the Northern Hemisphere. The minimum intensity of illumination shall be 1076 lumens/square meter (100 foot-candles).

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 Composite Cable

Insulated paired electrical conductors employed in composite cables shall be identified by the color code required by ICEA S-84-608. 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⁾
26	Orange with Double Black Tracer	26 or DD/OR or 14-DD/OR
27	Green with Double Black Tracer	27 or DD/GR or 15-DD/GR
28	Brown with Double Black Tracer	28 or DD/BR or 16-DD/BR
29	Slate with Double Black Tracer	29 or DD/SL or 17-DD/SL
30	White with Double Black Tracer	30 or DD/WH or 18-DD/WH
31	Red with Double Black Tracer	31 or DD/RD or 19-DD/RD
32	Black with Double White Tracer	32 or DD/BK or 20-DD/BK ⁽²⁾
33	Yellow with Double Black Tracer	33 or DD/YL or 21-DD/YL
34	Violet with Double Black Tracer	34 or DD/VI or 22-DD/VI
35	Rose with Double Black Tracer	35 or DD/RS or 23-DD/RS
36	Aqua with Double Black Tracer	36 or DD/AQ or 24-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.
- 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.