



**STANDARD FOR
OPTICAL FIBER CABLE
FOR PLACEMENT IN SEWER ENVIRONMENTS**

**Approved by
AMERICAN NATIONAL STANDARDS INSTITUTE
April 8, 2008**

Publication # ANSI/ICEA S-112-718-2008

**©2008 by
INSULATED CABLE ENGINEERS ASSOCIATION, Inc.**

STANDARD FOR
OPTICAL FIBER CABLE
FOR PLACEMENT IN SEWER ENVIRONMENTS

Publication S-112-718

First Edition – April 2008

Published By
Insulated Cable Engineers Association, Inc. (ICEA)
P. O. Box 1568
Carrollton, Georgia 30112, USA

Approved June 2007 by
INSULATED CABLE ENGINEERS ASSOCIATION, Inc.

Approved April 8, 2008, by
The 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 from:

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 blank.]

FOREWORD

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.

The Secretary can only accept questions of interpretation of ICEA Standards in writing at Headquarters at the address below, 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, U.S.A
United States of America

This Standard was approved by ICEA on June 12, 2007. This Standard was approved by The American National Standards Institute (ANSI) on April 8, 2008. ICEA intends to present this Standard to TIA for adoption into the TIA-472-series of cable standards. The members of the ICEA Communications Cable Division, Working Group 718 who participated in this project were:

Ray Lovie, Chairman

Ken Chauvin and Mike Kinard, Editors

D. K. Baker	G. L. Doma	K. Dunn	D. Hessong
N. Jones	J. Struhar	J. Rosko	J. Shinoski
O. Storaasli	D. Taylor	P. VanVickle	

vi

[This page blank.]

CONTENTS

<u>PARAGRAPH</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	6
1.6 Information to Be Supplied by the User	6
1.7 Modification of this Standard	6
1.8 Quality Assurance	6
1.9 Fire Resistance Codes	7
1.10 Safety Considerations	7
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 ASSEMBLY, FILLERS, STRENGTH MEMBERS, AND FIBER AND UNIT IDENTIFICATION	15
4.1 Cabling of Multi-Fiber Optical Fiber Cables	15
4.2 Identification of Fibers within a Unit	15
4.3 Identification of Units within a Cable	15
4.4 Strength Members	15
4.5 Assembly of Cables	17
4.6 Filling and Flooding Materials	17

PARAGRAPH	PAGE
Part 5: COVERINGS	18
5.1 Binders.....	18
5.2 Shielding, Armoring, or Other Metallic Coverings	18
5.3 Jackets.....	20
5.4 Other Coverings.....	21
5.5 Jacket Repairs	21
5.6 Ripcords	21
Part 6: OTHER REQUIREMENTS	22
6.1 Identification and Date Marking	22
6.2 Optical Cable Identification and Other Markings.....	22
6.3 Length Marking	23
6.4 Cable Remarking.....	24
6.5 Packaging and Marking	24
Part 7: TESTING AND TEST METHODS	26
7.1 Testing	26
7.2 Extent of Testing.....	26
7.3 Standard Test Conditions	26
7.4 Testing of Conductive Wires in Composite Optical Cables.....	27
7.5 Verification of Physical Construction, Color Code, and Identification	27
7.6 Environmental Stress Cracking Resistance Test	28
7.7 Jacket Shrinkage Test	28
7.8 Cable Chemical Resistance Test	29
7.9 Gas-Blocked Cable Test.....	31
7.10 Weathering Test	32
7.11 Verification of Cable Length and Marking Accuracy.....	32
7.12 Cable and Component Dimensions.....	33
7.13 Ribbon Dimensions.....	33
7.14 Ribbon Separability Test.....	34
7.15 Ribbon Twist Test	36
7.16 Ribbon Residual Twist Test.....	36
7.17 Tight Buffer Strippability Test.....	37
7.18 Ripcord Functional Test.....	37
7.19 Material Compatibility and Cable Aging Test	38
7.20 Cable Low and High Temperature Bend Test.....	39
7.21 Cable External Freezing Test.....	39
7.22 Cable Compound Flow (Drip) Test.....	40
7.23 Cable Temperature Cycling Test.....	40

PARAGRAPH**PAGE****Part 7: TESTING AND TEST METHODS (continued)**

7.24	Cable Cyclic Flexing Test	41
7.25	Cable Impact Test.....	41
7.26	Cable Cold Impact Test	42
7.27	Cable Tensile Loading, Bending, and Fiber Strain Test.....	43
7.28	Cable Compressive Loading Test	44
7.29	Cable Twist Test	45
7.30	Cable Sheath Adherence Test	46
7.31	Cable Water Penetration Test	46
7.32	Cable Fire Resistance	47

Part 8: FINISHED CABLE OPTICAL PERFORMANCE REQUIREMENTS 48

8.1	Optical Performance	48
8.2	Attenuation Coefficient.....	49
8.3	Multimode Optical Bandwidth	50
8.4	Measurements of Optical Point Discontinuities	50
8.5	Cable Cutoff Wavelength Measurement (Single-Mode Fibers)	51

PART 9 REFERENCES 52**ANNEX A ORDERING INFORMATION 56****ANNEX B SEWER CABLE CONSIDERATIONS 57****ANNEX C ICEA TELECOMMUNICATIONS CABLE STANDARDS 68****TABLES**

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	16
Table 6-1	Year of Manufacture Marker Threads	23
Table 7-1	Fluid Immersion Test Criteria	30
Table 7-2	Maximum Dimensions of Optical Fiber Ribbons	34
Table 8-1	Attenuation Coefficient Performance Requirements	48
Table 8-2	Multimode Bandwidth Coefficient Performance Requirements.....	48
Table 8-3	Point Discontinuity Acceptance Criteria	49
Table 8-4	Optical Attenuation Measurement Methods	49
Table 8-5	Multimode Optical Bandwidth Measurement Methods.....	50

FIGURES

Figure 7-1	Ribbon Dimensional Parameters.....	34
Figure 7-2	Ribbon Preparation.....	35
Figure 7-3	Ribbon Separation.....	35

**ICEA STANDARD
FOR
OPTICAL FIBER CABLE FOR PLACEMENT IN SEWER ENVIRONMENTS**

PART 1

INTRODUCTION

1.1 SCOPE

1.1.1 General Overview

This Standard covers optical fiber communications cables intended for installation in underground sewers, specifically storm and sanitary sewers. Materials, construction, and performance requirements are included in this Standard, together with applicable test procedures. Additional applications-based considerations are discussed as well.

Refer to ICEA S-87-640 for optical fiber communications cables intended for general outside plant use, ICEA S-110-717 for optical fiber cables intended for aerial, duct, and buried outdoor and indoor/outdoor drop applications, and ICEA S-104-696 for optical fiber communications cables intended for indoor/outdoor use.

1.1.2 Applications Space

Products covered by this Standard are intended for use in metropolitan, urban, and suburban communications networks via use of underground infrastructures, in the last portion of all-optical networks, such as storm and sanitary sewers. These products convey communications signals (voice, video, and data) in metropolitan network rings and serve as point-to-point connections to the subscriber's premises via sewer laterals, in the last portion of the optical network.

These products are intended for use in sewer lines, using man-entry and non-man entry techniques. Such installations are intended to have no adverse effect on the efficiency of the sewer system. These cables are generally placed manually in pre-installed trays or conduits or may be secured to the sewer pipe wall by means of hooks, adhesive beds, sewer pipe liners, or may be tensioned intermittently, in order to maintain the cable and/or conduit out of the flow of the effluent.

The successful application of optical fiber cables in sewer systems requires that all identified maintenance to or rehabilitation of the sewer pipes be conducted

prior to cable installation, in accordance with procedures under development by ASTM¹.

1.1.3 Temperature Ranges

The normal temperature ranges for cables covered by this Standard are given in Table 1-1

Table 1-1

Cable Normal Temperature Ranges⁽¹⁾

	°C	(°F)
Operation	-20 to +70	(-4 to +158)
Storage and Shipping	-40 to +70	(-40 to +158)
Installation	-20 to +60	(-4 to +140)
Note:		
1) See section 1.4.1.6 for information on sewer-only cables.		

1.1.4 Tensile Rating

For the purposes of this document, the standard tensile rating represents the maximum allowable installation load for the cable. The standard tensile ratings for products covered by this Standard are as follows:

- 1335 N (300 lbf) for cables designed for installation by pulling into ducts.
- 440 N (100 lbf) for cables designed for installation into ducts with the assistance of compressed gases or for installation under low tension using man-entry (i.e., hand-installation), or non-man entry (e.g., robotics), techniques.

For some sewer applications additional considerations for tensile performance may be appropriate to ensure that the cable design is appropriate for the installation. One example is when tensioning a cable designed to stay at the top of a sewer pipe without the use of hooks. Some applications may require higher installation tensile ratings [e.g., 2670 N (600 lbf)] to support pulling of longer span distances or applications requiring larger diameter cables. See Annex B for information on additional sewer cable plant requirements and considerations.

The residual load is defined as a load equivalent to 30% of the standard tensile rating.

¹ Systems-level work on sewer-based communications applications is the prerogative of ASTM Technical Committee F36 on Technology and Underground Utilities.

1.1.5 Minimum Bend Diameter

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

<u>Condition</u>	<u>Bend Diameter</u>
Residual (Installed):	20 x Cable OD*
Loaded (During Installation):	40 x Cable OD

*OD = outer diameter

For very small cables, such as those installed in miniature ducts, manufacturers may specify fixed cable minimum bend diameters (e.g., 300 mm) that are independent of the cable OD.

For cables having a non-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.

1.1.6 Fire-Resistance

For purposes of this document, fire resistance listings are not required for cables designed for placement in sewers. However, fire resistance performance may be required for specific applications, such as installations with a transition from outdoors to indoors.

Users of this document are encouraged to consult pertinent Building and Fire Codes, such as those described in 1.9, to ensure product compliance to the requirements for a particular installation. Users are cautioned that the choice of materials needed to achieve adequate fire-resistance may impact the ability of such cables to be installed at the low temperatures of Table 1-1.

1.2 GENERAL

This publication is arranged such that cables may be selected from numerous constructions covering a broad range of installation and service conditions.

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.

Part 5 includes cable coverings.

Part 6 provides other pertinent requirements not otherwise addressed by Parts 1 through 5 or by Parts 7 and 8 of this Standard.

Part 7 describes the test methods and performance requirements applicable to the component materials, in addition to Parts 2 and 3, and completed cables manufactured under this Standard. 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, test methods, and requirements 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 considerations for sewer cable installations.

Annex C (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

See Annex B for additional definitions for sewer cable applications.

1.4.1 Cable Classification

In this Standard, communications cables are classified as one of the following types:

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 Gas-Blockable Cable

Cable that is not designed to be gas-blocked, but which can be modified in the field to prevent the escape of gases through the cable ends.

1.4.1.4 Gas-Blocked Cable

Cable designed and manufactured to prevent the axial migration of gases through the cable.

1.4.1.5 Hybrid Cables

Cables which contain more than one type of optical fiber.

1.4.1.6 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.

1.4.1.7 Sewer-only Cable

Cable designed for use only within the protected confines of a sewer plant. Such cables may not have the requisite performance to withstand the conditions that might be encountered in the unprotected environment of the outside plant, such as extended exposure to solar radiation or temperature extremes. They may also have limitations on their use in indoor applications where fire-resistance is a concern.

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/EIA-440 and to IEEE-812 for definitions of other optical fiber terms. Refer to ANSI/IEEE Standard 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 Tables 2-1 and 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 requirement of this Standard may be modified by agreement between the manufacturer and user, but such modifications shall be clearly denoted as exceptions to this 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," or "Unless otherwise modified by manufacturer and user." Requirements not specified in this Standard, and which therefore must be determined in each case, are introduced by phrases such as "...established by agreement 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 ANSI/ASQ Q9000, ISO 9000, TL 9000®, or an alternate 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 FIRE RESISTANCE CODES

The fire resistance requirements of optical fiber cable are addressed by the following Codes and are dependent upon the application for which it is being used and local jurisdictional requirements. Users are encouraged to contact the Local Authority Having Jurisdiction in order to determine the minimum fire-resistance requirements for a particular application, prior to placing an order.

United States Fire Resistance Codes:

1. NFPA 70, National Electrical Code (NEC)
2. Local Codes

Canada Fire Resistance Codes:

1. C22.2 No. 232, Canadian Standards Association (CSA)
2. Local Codes

Mexico Fire Resistance Codes:

1. Telecommunications - Cables - Optical Fiber Cables for Premises Applications (NMX-I-237-NYCE-2001)
2. Local Codes

1.10 SAFETY CONSIDERATIONS

Materials in the cable shall present no dermal or environmental hazards as defined by current industry Standards or applicable federal or state 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 the manufacture, testing, installation, and maintenance of cables, defined herein, will be performed only by properly trained personnel, using suitable equipment, employing appropriate safety precautions, and working in accordance with applicable local, state, and national safety requirements.

PART 2

OPTICAL FIBERS

2.1 GENERAL

The optical fiber used in the cable shall comply with the requirements per the latest issue of TIA-4920000, *Generic Specification for Optical Waveguide Fibers*, in accordance with 2.2 through 2.4.

2.2 OPTICAL FIBER CLASSES

Optical fibers used shall be of a type as listed in Table 2-1 for multimode fibers, and Table 2-2 for single-mode fibers.

2.3 OPTICAL FIBER REQUIREMENTS

2.3.1 Unless otherwise specified, optical fibers shall conform to the requirements of the Specifications listed in Table 2-1 for multimode fibers and Table 2-2 for single-mode fibers. The fiber attributes of Tables 2-1 and 2-2 are included for information, only. Refer to the fiber Specifications for normative values.

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, splices made in optical fibers during the fiber or cable manufacturing process shall conform to the requirements of the latest issue of TIA-4920000.

2.3.4 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.

2.4 OPTICAL FIBER COATING AND REQUIREMENTS

2.4.1 Optical fibers (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 coating(s) shall be such that the applicable requirements of this Standard are met.

- 2.4.3** The diameter of the fiber 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. This diameter shall be in the range of 235 to 265 μm ; other diameters are acceptable provided that all other applicable requirements are met. Dimensions shall be measured according to the methods of 7.12.
- 2.4.4** Coating materials used shall meet the requirements of Part 7 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-178². The force required to remove 30 $\pm$ 3 mm of the fiber's protective coating shall be between 1.0 N and 9.0 N. For tight buffers, refer to subclause 7.17.

Table 2-1 – Multimode Optical Fiber Specification Requirements ⁽¹⁾

Fiber Type	TIA/EIA Specification Reference		
	Sectional	Blank Detail	Detail
50 μm	492A000	492AA00	492AAAB
50 μm ⁽²⁾	492A000	492AA00	492AAAC
62.5 μm	492A000	492AA00	492AAAA
Fiber Attributes (Informative) ⁽³⁾			
Fiber Class and Subclass	Diameters (μm)		Numerical Aperture
	Core	Cladding	
1a	50 $\pm$ 3.0	125.0 $\pm$ 2.0	0.200 $\pm$ 0.015
	62.5 $\pm$ 3.0	125.0 $\pm$ 2.0	0.275 $\pm$ 0.015
Notes: 1) Fiber specifications listed herein are provided for convenience, but are dynamic and subject to change. Users should refer to the relevant TIA-492 fiber Detail Specification for current requirements. 2) 850 nm laser-optimized 50 μm fiber 3) These attributes are defined by the Specifications called out above. The values are subject to change, and are included here for information, only. Refer to the latest fiber Specifications for current normative values.			

² FOTPs, Fiber Optic Test Procedures, comprise the TIA-455-series of documents. They are referenced, herein, by their short-form number, e.g. FOTP-178, rather than TIA/EIA-455-178A.

Table 2-2 – Single-mode Optical Fiber Specification Requirements ^(1,2)

Fiber Class		TIA/EIA Specification Reference ⁽³⁾				
		Fiber Type	Sectional	Blank Detail	Detail	
IVa		Dispersion Unshifted	492C000	492CA00	492CAAA	
IVa		Dispersion Unshifted Low Water Peak	492C000	492CA00	492CAAB	
IVb		Dispersion Shifted	—	492BB00	—	
IVd		Non-zero Dispersion	492E000	492EA00	—	
Fiber Attributes (Informative) ⁽⁴⁾						
Fiber Class	Diameter (μm)			Chromatic Dispersion		
	Mode Field Diameter (Nominal)	Mode Field Diameter Tolerance	Cladding	Zero Dispersion Wavelength (nm)	Zero Dispersion Wavelength Slope Maximum ps/(nm ² -km)	Dispersion Coefficient (ps/nm-km)
IVa	8.8-9.3 @ 1310 nm	± 0.5	125.0 ± 1.0	1300 – 1324	0.093	Not Applicable
IVb ⁽⁵⁾	7.8-8.5 @ 1550 nm	± 0.7	125.0 ± 1.0	1535 – 1565	0.085	≤ 2.7
IVd	7.2-11.0 @ 1550 nm	± 0.7	125.0 ± 1.0	Not Applicable	Not Applicable	(6)
Notes:						
1) Fiber specifications listed herein are provided for convenience, but are dynamic and subject to change. Users should refer to the relevant TIA-492 fiber Detail Specification for current requirements.						
2) Missing references, including blank spaces in Table 2-2, indicate that no fiber Specification is available.						
3) When no Detail Specification is available, fiber requirements shall be at the discretion of the cable manufacturer, unless otherwise agreed upon between manufacturer and user.						
4) These attributes are defined by the Specifications called out above. The values are subject to change, and are included here for information only. Refer to the latest fiber Specifications for current normative values.						
5) Fiber class IVb is provided for historical reference.						
6) For class IVd dispersion coefficient: The absolute value of the dispersion coefficient D(λ) shall satisfy 0.1 ≤ D _{min} ≤ D ≤ D _{max} ≤ 8.0 ps/nm-km for the wavelength range 1530 nm ≤ λ _{min} ≤ λ ≤ λ _{max} ≤ 1565 nm.						

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 sewers, 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 providing 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 7.12.

3.2.2 Loose Buffer Tube Requirements

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

3.2.2.2 The loose buffer tubes shall be uniform and concentric. 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.

3.3 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).

Binders shall comply with 4.3 and 4.5.2.

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

The following are common fiber counts of optical fiber ribbons that may be used in the applications covered by this Standard: 2, 4, 6, 8, 12, and 24. 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, except the outer matrix dimensions, 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 are listed in Table 7-2. Measure the attributes as established by agreement between manufacturer and user, and as directed by 7.13.

3.4.4.2 Ribbon Separability Test

Measure the ribbon separability per 7.14.

3.4.4.3 Ribbon Twist Test

Test ribbons for robustness per 7.15.

3.4.4.4 Ribbon Residual Twist Test

Test for ribbon residual twist according to 7.16.

3.4.4.5 Fiber Crossovers in Ribbons

The fibers shall be parallel and shall not cross over throughout the length of the ribbon.

3.4.4.6 Ribbon Strippability

At least 25 mm (1.0 in) of the matrix and the fibers' protective coatings shall be removable with commercially available stripping tools from aged and unaged ribbons. There shall be 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 TIGHT BUFFERS

A tight buffer consists of one or more layers of buffer material applied around the individual optical fiber, so that it is in contact with the coating of the fiber.

3.5.1 Tight Buffer Dimensions

Buffer dimensions are established by the cable manufacturer to ensure that the applicable performance requirements of this Standard are met. Dimensions shall be measured according to the methods of 7.12.

3.5.2 Tight Buffer Requirements

3.5.2.1 The tight buffer shall be constructed so that the finished cable meets all applicable performance requirements specified in Part 7.

3.5.2.2 The tight buffer shall be uniform and concentric. It must be removable, without damage to the fibers, using the manufacturer's recommended procedures.

3.5.2.3 Each tight buffered fiber shall be uniquely identifiable. Methods shall conform to 4.2.