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IEEE Standard for All-Dielectric Self-Supporting Fiber Optic Cable

IEEE Power Engineering Society

Sponsored by the
Power System Communications Committee

IEEE

3 Park Avenue, New York, NY 10016-5997, USA

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IEEE Std 1222™-2003

IEEE Standard for All-Dielectric Self-Supporting Fiber Optic Cable

Sponsor

Power System Communications Committee
of the
IEEE Power Engineering Society

Approved 31 March 2004

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IEEE-SA Standards Board

Abstract: Construction, mechanical, electrical, and optical performance, installation guidelines, acceptance criteria, test requirements, environmental considerations, and accessories for an all-dielectric, nonmetallic, self-supporting fiber optic (ADSS) cable are covered in this standard. The ADSS cable is designed to be located primarily on overhead utility facilities. This standard provides both construction and performance requirements that ensure within the guidelines of the standard that the dielectric capabilities of the cable components and maintenance of optical fiber integrity and optical transmissions are proper. This standard may involve hazardous materials, operations, and equipment. It does not purport to address all of the safety issues associated with its use, and it is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.
Keywords: aeolian vibration, aerial cables, all-dielectric self-supporting (ADSS), buffer, cable reels, cable safety, cable thermal aging, dielectric, distribution lines, electric fields, electrical stress, fiber optic cable, galloping, grounding, hardware, high voltage, optical ground wire (OPGW), plastic cable, sag and tension, self-supporting, sheave test, span length, string procedures, temperature cycle test, tracking, transmission lines, ultraviolet (UV) deterioration

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Introduction

(This introduction is not a part of IEEE Std 1222-2003, IEEE Standard for All-Dielectric Self-Supporting Fiber Optic Cable.)

All-dielectric self-supporting (ADSS) fiber optic cables are being installed throughout the power utility industry. Because of the unique service environment and design of these cables, many new requirements are necessary to ensure proper design and application of these cables. In order to develop an industry-wide set of requirements and tests, the Fiber Optic Standards Working Group, under the direction of the Fiber Optic Subcommittee of the Communications Committee, brought together the expertise of key representatives from throughout the industry. These key people are from each manufacturer of ADSS cables and a cross section of the end users. All manufacturers and all known users were invited to participate in preparing this standard.

The preparation of this standard occurred over a period of several years, and participation changed throughout that time as companies and individuals changed interests and positions. Effort was always made to include key individuals from each and every manufacturing concern, major user groups, and consulting firms. Membership and participation was open to everyone who had an interest in the standard, and all involvement was encouraged. This worldwide representation helps to ensure that this standard reflects the entire industry.

As ADSS fiber optic cables are a new and changing technology, the working group is continuing to work on new revisions to this standard as the need arises.

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IEEE Standard for All-Dielectric Self-Supporting Fiber Optic Cable

1. Overview

1.1 Scope

This standard covers the construction, mechanical, electrical, and optical performance, installation guidelines, acceptance criteria, test requirements, environmental considerations, and accessories for an all-dielectric, nonmetallic, self-supporting fiber optic (ADSS) cable. The ADSS cable is designed to be located primarily on overhead utility facilities.

The standard provides both construction and performance requirements that ensure within the guidelines of the standard that the dielectric capabilities of the cable components and maintenance of optical fiber integrity and optical transmissions are proper.

This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety issues associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2. ADSS cable and components

2.1 Description

The ADSS cable shall consist of coated glass optical fibers contained in a protective dielectric fiber optic unit surrounded by or attached to suitable dielectric strength members and jackets. The cable shall not contain metallic components. The cable shall be designed to meet the design requirements of the optical cable under all installation conditions, operating temperatures, and environmental loading.

2.2 Support systems

a) ADSS cable shall contain support systems that are integral to the cable. The purpose of the support system is to ensure that the cable meets the optical requirements under all specified installation conditions, operating temperatures, and environmental loading for its design life. This standard excludes any “lashed” type of cables.

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b) The basic annular construction may have aramid or other dielectric strands or a channeled dielectric rod as a support structure. In addition, other cable elements, such as central members, may be load bearing.

c) Figure-8 constructions may have a dielectric messenger and a fiber optic unit, both of which share a common outer jacket. In addition, other cable elements, such as central members, may be load bearing.

d) Helically stranded cable systems may consist of a dielectric optical cable prestranded around a dielectric messenger.

e) The design load of the cable shall be specified so that support hardware can be manufactured to perform under all environmental loading conditions. For zero fiber strain cable designs, the design load is defined as the load at which the optical fibers begin to elongate. For other cable designs, the design load is defined as the load at which the measured fiber strain reaches a predetermined level.

f) Other designs previously not described are not excluded from this specification.

2.3 Fiber optic cable core

The fiber optic cable core shall be made up of coated glass optical fibers housed to protect the fibers from mechanical, environmental, and electrical stresses. Materials used within the core shall be compatible with one another, shall not degrade under the electrical stresses to which they may be exposed, and shall not evolve hydrogen sufficient to degrade optical performance of fibers within the cable.

2.3.1 Fiber strain allowance

The cable core shall be designed such that fiber strain does not exceed the limit allowed by the cable manufacturer under the operational design limits of the cable. Maximum allowable fiber strain will generally be a function of the proof test level and strength and fatigue parameters of the coated glass fiber.

2.3.2 Central structural element

If a central structural element is necessary, it shall be of reinforced plastic, epoxiglass, or other dielectric material. If required, this element shall provide the necessary tensile strength to limit axial stress on the fibers and minimize fiber buckling due to cable contraction at low temperatures.

2.3.3 Buffer tube filling compound

Loose buffer tubes shall be filled with a suitable compound compatible with the tubing material, fiber coating, and coloring to protect the optical fibers and prevent moisture ingress.

2.3.4 Cable core filling/flooding compound

The design of the cable may include a suitable filling/flooding compound in the interstices to prohibit water migration along the fiber optic cable core. The filling compound shall be compatible with all components with which it may come in contact.

2.3.5 Binder/tape

A binder yarn(s) and/or a layer(s) of overlapping nonhygroscopic tape(s) may be used to hold the cable core elements in place during application of the jacket.

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2.3.6 Inner jacket

A protective inner jacket or jackets of a suitable material may be applied over the fiber optic cable core, isolating the cable core from any external strength elements and the cable outer jacket.

2.4 Optical fibers

Single-mode fibers, dispersion-unshifted, dispersion-shifted, or nonzero dispersion-shifted, and multimode fibers with 50/125 mm or 62.5/125 mm core/clad diameters are considered in this standard. The core and the cladding shall consist of glass that is predominantly silica (SiO2). The coating, usually made from one or more plastic materials or compositions, shall be provided to protect the fiber during manufacture, handling, and use.

2.5 Buffer construction

The individually coated optical fiber(s) or fiber ribbon(s) may be surrounded by a buffer for protection from physical damage during fabrication, installation, and performance of the ADSS. Loose buffer or tight buffer construction are two types of protection that may be used to isolate the fibers. The fiber coating and buffer shall be strippable for splicing and termination.

2.5.1 Loose buffer

Loose buffer construction shall consist of a tube or channel that surrounds each fiber or fiber group. The inside of the tube or channel shall be filled with a filling compound.

2.5.2 Tight buffer construction

Tight buffer construction shall consist of a suitable material that comes in contact with the coated fiber.

2.6 Color coding

Color coding is essential for identifying individual optical fibers and groups of optical fibers. The colors shall be in accordance with TIA/EIA 598-A-1995 [B43].[1]

2.6.1 Color performance

The original color coding system shall be discernible and permanent, in accordance with EIA 359-A-1985 [B3], throughout the design life of the cable, when cleaned and prepared per manufacturer's recommendations.

2.7 Jackets

The outer jacket shall be designed to house and protect the inner elements of the cable from damage due to moisture, sunlight, environmental, thermal, mechanical, and electrical stresses.

a) The jacket material shall be dielectric, non-nutrient to fungus, and meet the requirements of 3.1.1.13. The jacket material may consist of a polyethylene that shall contain carbon black and an antioxidant.

b) The jacket shall be extruded over the underlying element and shall be of uniform diameter to properly fit support hardware. The extruded surface shall be smooth for minimal ice buildup.

[1]The numbers in brackets correspond to those of the bibliography in Annex G.

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c) The cable jacket shall be suitable for application in electrical fields as defined in this clause and demonstrated in 3.1.1.3.

Class A: Where the level of electrical stress on the jacket does not exceed 12 kV space potential.

Class B: Where the level of electrical stress on the jacket may exceed 12 kV space potential.

NOTE—See 7.9 for additional deployment details.[2]

3. Test requirements

Each requirement in this clause is complementary to the corresponding paragraph in Clause 4 that describes a performance verification or test procedure.

3.1 Cable tests

3.1.1 Design tests

An ADSS cable shall successfully pass the following design tests. However, design tests may be waived at the option of the user if an ADSS cable of identical design has been previously tested to demonstrate the capability of the manufacturer to furnish cable with the desired performance characteristics.

3.1.1.1 Water blocking test

A water block test for cable shall be performed in accordance with 4.1.1.1. No water shall leak through the open end of the 1 m sample. If the first sample fails, one additional 1 m sample, taken from a section of cable adjacent to the first sample, may be tested for acceptance.

3.1.1.2 Seepage of filling/flooding compound

For filled/flooded fiber optic cable, a seepage of filling/flooding compound test shall be performed in accordance with 4.1.1.2. The filling and flooding compound shall not flow (drip or leak) at 65 ^{o}C.

3.1.1.3 Electrical tests

Electrical tests shall be performed for Class B cables in accordance with 4.1.1.3. Tracking on the outside of the sheath resulting in erosion at any point that exceeds more than 50% of the wall thickness shall constitute a failure.

3.1.1.4 Aeolian vibration test

An aeolian vibration test shall be carried out in accordance with 4.1.1.4. Any damage that will affect the mechanical performance of the cable or causes permanent or temporary increase in optical attenuation greater than 1.0 dB/km of the tested fibers at 1550 nm for single-mode fibers and at 1300 nm for multimode fibers shall constitute failure.

[2]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

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3.1.1.5 Galloping test

A galloping test shall be carried out in accordance with 4.1.1.5. Any damage that will affect the mechanical performance of the cable or causes permanent or temporary increase in optical attenuation greater than 1.0 dB/km of the tested fibers at 1550 nm for single-mode fibers and at 1300 nm for multimode fibers shall constitute failure.

3.1.1.6 Sheave test

A sheave test shall be carried out in accordance with 4.1.1.6. Any significant damage to the ADSS cable shall constitute failure. A permanent increase in optical attenuation greater than 1.0 dB/km of the tested fibers at 1550 nm for single-mode fibers and at 1300 nm for multimode fibers shall constitute failure.

Or successful completion of the following three tests may be a substitute for the sheave test:

a) *Tensile strength of a cable:* The maximum increase in attenuation shall not be greater than 0.10 dB for single-mode and 0.20 dB for multimode fibers when the cable is subjected to the maximum cable rated tensile load.

b) *Cable twist:* The cable shall be capable of withstanding mechanical twisting without experiencing an average increase in attenuation greater than 0.10 dB for single-mode and 0.20 dB for multimode fibers.

c) *Cable cyclic flexing:* The cable sample shall be capable of withstanding mechanical flexing without experiencing an average increase in attenuation greater than 0.10 dB for single-mode and 0.20 dB for multimode fibers.

3.1.1.7 Crush test and impact test

3.1.1.7.1 Crush test

A crush test shall be performed in accordance with 4.1.1.7.1. A permanent or temporary increase in optical attenuation value greater than 0.2 dB change in sample at 1550 nm for single-mode fibers and 0.4 dB at 1300 nm for multimode fibers shall constitute failure.

3.1.1.7.2 Impact test

An impact test shall be performed in accordance with 4.1.1.7.2. A permanent increase in optical attenuation value greater than 0.2 dB change in sample at 1550 nm for single-mode and 0.4 dB at 1300 nm for multi-mode fibers shall constitute failure.

3.1.1.8 Creep test

A creep test shall be carried out in accordance with 4.1.1.8. Values shall correspond with the manufacturer’s recommendations.

3.1.1.9 Stress/strain test

A stress/strain test shall be carried out in accordance with 4.1.1.9. The maximum rated cable load (MRCL), maximum rated cable strain (MRCS), and maximum axial fiber strain specified by the manufacturer for their cable design shall be verified. Any visual damage to the cable or permanent or temporary increase in optical attenuation greater than 0.10 dB at 1550 nm for single-mode fiber and 0.20 dB at 1300 nm for multimode fibers shall constitute failure.

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3.1.1.10 Cable cutoff wavelength (single-mode fiber)

The cutoff wavelength of the cabled fiber, λ_{cc}, shall be less than 1260 nm.

3.1.1.11 Temperature cycle test

Optical cables shall maintain mechanical and optical integrity when exposed to the following temperature extremes: –40 ^{o}C to +65 ^{o}C.

The change in attenuation at extreme operational temperatures for single-mode fibers shall not be greater than 0.20 dB/km, with 80% of the measured values no greater than 0.10 dB/km. For single-mode fibers, the attenuation change measurements shall be made at 1550 nm.

For multimode fibers, the change shall not be greater than 0.50 dB/km, with 80% of the measured values no greater than 0.25 dB/km. The multimode fiber measurements shall be made at 1300 nm unless otherwise specified.

A temperature cycle test shall be performed in accordance with 4.1.1.11.

3.1.1.12 Cable aging test

The cable aging test shall be a continuation of the temperature cycle test.

The change in attenuation from the original values observed before the start of the temperature cycle test shall not be greater than 0.40 dB/km, with 80% of the measured values no greater than 0.20 dB/km for single-mode fibers.

For multimode fibers, the change in attenuation shall not be greater than 1.00 dB/km, with 80% of the measured values no greater than 0.50 dB/km.

There shall be no discernible difference between the jacket identification and length marking colors of the aged sample relative to those of an unaged sample of the same cable. The fiber coating color(s) and unit/bundle identifier color(s) shall be in accordance with TIA/EIA 598-A-1992 [B43].

A cable aging test shall be performed in accordance with 4.1.1.12.

3.1.1.13 Ultraviolet (UV) resistance test

The cable and jacket system is expected to perform satisfactorily in the user-specified environment into which the cable is being placed into service. Because of the numerous possible environmental locations available, it is the user's and supplier's joint responsibility to provide the particular performance requirements of each installation location. These performance criteria are for nonsevere environments. The IEC 60068-2-1 [B12] performance standards should be used to define particular environmental testing requirements for each unique location.

The cable jacket shall meet the following requirements:

Where carbon black is used as a UV damage inhibitor, the cable shall have a minimum absorption coefficient of 0.32 per meter.

Where the other cable UV blocking systems are being employed, the cable shall

a) Meet the equivalent UV performance of carbon black at 0.32 per meter
b) Meet the performance requirements as stated in 4.1.1.13 for IEC 60068-2-1 [B12] testing

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3.1.1.14 Complete ADSS

Tests for rated strength of the completed ADSS cable are not required, but they may be made if agreed on by the manufacturer and the purchaser at the time of order placement. If tested, the breaking strength of the completed ADSS cable shall not be less than its specified rating breaking strength unless the failure occurs in the laboratory gripping device. If the failure occurs in the laboratory grip, the test value must not be less than 95% of the specified rated breaking strength of the cable.

3.1.2 Routine tests

Except where noted, routine tests shall be performed on a sampling basis such that each reel will meet 3.1.2 criteria.

3.1.2.1 Fiber optic cable dimensions

3.1.2.1.1 Jacket thickness

The minimal thickness of the outer jacket at any cross section may not be less than 70% of the nominal thickness.

3.1.2.1.2 Cable O.D.

The maximum deviation of the cable outside diameter shall be ±0.25 mm for cables 13 mm and smaller and ±0.5 mm for cables larger than 13 mm.

3.1.2.2 Optical acceptance tests

a) These tests shall be performed on each reel in accordance with 4.1.2.2.

b) Attenuation loss values exceeding those specified shall constitute failure.

3.2 Fiber tests

3.2.1 Design tests

3.2.1.1 Attenuation variation with wavelength

For dispersion unshifted single-mode fibers, the attenuation coefficient for wavelengths between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.1 dB/km. For multi-mode fibers, the window requirements should be mutually agreed to among the component suppliers and the user.

3.2.1.2 Attenuation at the water peak

For unshifted single-mode fibers, the attenuation coefficient at the water peak found within 1383 ± 3 nm shall not exceed 3 dB/km.

For multimode fibers, the attenuation coefficient at 1380 nm shall not exceed the attenuation coefficient at the 1300 nm wavelength by more than 3 dB/km.

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3.2.1.3 Attenuation with blending

For multimode fibers, the attenuation per 100 turns on a 75 mm diameter mandrel shall not exceed 0.5 dB at 850 nm and 1300 nm, including the intrinsic attenuation of the 23.6 m of fiber. For single-mode fibers, the attenuation per 100 turns shall not exceed 0.5 dB at 1550 nm. Also, the additional attenuation introduced when a single turn of a single-mode fiber is wound around a 32 ± 0.5 mm diameter mandrel shall not exceed 0.5 dB at 1550 nm.

NOTE—A 32 mm diameter bend in a fiber is only recommended for making short-term bend attenuation measurements. For considerations of long-term mechanical survivability, the recommendations of the manufacturer relative to minimum bend diameter should be followed.

3.2.1.4 Environmental requirements

3.2.1.4.1 Temperature cycling

Optical fibers shall maintain mechanical and optical integrity when exposed to the following operational temperature extremes: –55 ^{o}C to +85 ^{o}C.

The change in attenuation at extreme operational temperatures for single-mode fibers shall not be greater than 0.05 dB/km. For unshifted single-mode fibers, the attenuation change measurements shall be made at 1310 nm and 1550 nm. For dispersion-shifted single-mode fibers, the measurements shall be at 1550 nm. For multimode fibers, the change shall not be greater than 0.2 dB/km. The multimode fiber measurements shall be made at 850 nm and 1300 nm.

3.2.2 Routine tests

3.2.2.1 Optical requirements

3.2.2.1.1 Attenuation coefficient

The multimode fiber attenuation coefficient shall be specified at 850 nm and/or 1300 nm (unless otherwise required by the user). The attenuation coefficient shall be specified on the basis of the maximum individual fiber attenuation coefficient in the cable.

The attenuation coefficient for unshifted single-mode fiber shall be specified at 1310 nm and at 1550 nm unless otherwise required by the user. The dispersion-shifted attenuation coefficient shall be specified at 1550 nm. The attenuation coefficient shall be specified on the basis of the maximum individual fiber attenuation coefficient in the cable.

3.2.2.1.2 Attenuation uniformity

The attenuation of the fiber shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.1 dB for single-mode fiber and 0.2 dB for multimode fiber at any design wavelength. If factory splicing is permitted by the user, the spliced fiber shall meet all optical, geometrical, and environmental requirements as stated in this standard.

3.2.2.1.3 Chromatic dispersion (single-mode fiber)

For dispersion-unshifted single-mode fibers, the zero-dispersion wavelength, λ_o, shall be between 1295 nm and 1322 nm. The nominal zero-dispersion wavelength should be 1310 nm. In the context of this objective, the nominal zero-dispersion wavelength is defined as the median of the measured distribution of λ_o. In addition, the maximum value of the dispersion slope at λ_o, S_{omax}, shall be no greater than 0.095 ps/(km × nm^2).

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For dispersion-unshifted single-mode fibers, D_{max}, the maximum absolute value of the dispersion coefficient over a window, λ_{min} to λ_{max}, can be found as the larger of the absolute value of

$$\frac{\{S_{omax}\lambda_{min}\}}{4}\left[1-\frac{\lambda_{omax}4}{\lambda_{min}4}\right]$$

or

$$\frac{\{S_{omax}\lambda_{max}\}}{4}\left[1-\frac{\lambda_{omin}4}{\lambda_{max}4}\right]$$

For dispersion-shifted single-mode fibers, the nominal zero-dispersion wavelength should be 1550 nm. In the context of this objective, the nominal zero-dispersion wavelength is defined as the median of the measured distribution of λ_o. The required maximum tolerance on the zero dispersion wavelength, $\Delta\lambda_{omax}$ (i.e., 1550 nm ± $\Delta\lambda_{omax}$), is dependent on the specified maximum dispersion slope, S_{omax}:

If $S_{omax} < 0.06$ ps/(km × nm^2), then

$\Delta\lambda_{omax} < 25$ nm

If $S_{omax} < 0.085$ ps/(km × nm^2), then

$\Delta\lambda_{omax} < 15$ nm

Fibers with values of low S_{omax} and wide $\Delta\lambda_{omax}$ have different potential upgrade possibilities than the fibers with values of high S_{omax} and narrow $\Delta\lambda_{omax}$. Therefore, the two different dispersion-shifted fiber designs cannot be considered totally interchangeable.

3.2.2.1.4 Multimode bandwidth

The minimum bandwidth(s) shall be specified at the wavelength(s) of intended use by either the end-to-end bandwidth requirement of the cable span or by an individual reel bandwidth requirement.

3.2.2.1.5 Mofe field diameter (single-mode fiber)

The nominal mode field diameter (MFD) for dispersion-unshifted single-mode fibers at 1310 nm shall be no less than 8.3 microns and no greater than 10 microns. For dispersion-shifted single-mode fiber at 1550 nm, the nominal should be between 7 and 8.7 microns. A range about the specified nominal shall be less than ±8% for both the dispersion-unshifted and the dispersion-shifted single-mode fibers.

3.2.2.2 Geometric requirements

3.2.2.2.1 Multimode optical fibers

a) *Core diameter:* The fiber shall have a core diameter of either 50.0 microns or 62.5 microns, as appropriate. The permissible deviation from the nominal value for all designs shall be less than or equal to 3 microns.
b) *Core noncircularity:* Core noncircularity error shall be <6%.
c) *Concentricity error:* The concentricity error shall be <6%.

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d) *Numerical aperture (NA):* The nominal value of NA shall be as follows:

1) 50/125—The nominal NA shall be between 0.20 and 0.23.

2) 62.5/125—The nominal NA shall be between 0.27 and 0.29.

For a given design, the permissible deviation from the nominal value of NA shall be less than or equal to ±0.02.

The requirements on cladding diameter and cladding noncircularity shall conform to the dimensions for single-mode fiber specified in 3.2.2.2.2 and 3.2.2.2.3.

3.2.2.2.2 Single-mode optical fibers

Concentricity error: The offset between the center of the core and the center of the cladding shall be <1.0 microns.

3.2.2.2.3 Parameters common to both multimode and single-mode fibers

Cladding diameter: The cladding outside diameter shall be 125.0 microns ± 1.0 microns.

Cladding noncircularity: The cladding noncircularity shall be <1%.

Coating diameter: The nominal coating diameters should be 250 microns for standard protective coating. For use in tight buffered cable designs, an additional buffering with a nominal diameter of 400, 500, 700, or 900 microns may be used.

3.2.2.3 Mechanical requirements

Fiber tensile proof test: All single-mode fibers shall be subjected to a minimum proof stress of 0.69 GN/m^2 for 1 second equivalent by the fiber manufacturer (100% testing). All multimode fibers shall be subjected to a minimum proof stress of 0.35 GN/m^2 for 1 s equivalent by the fiber manufacturer (100% testing).

4. Test methods

Each procedure in this clause is complementary to Clause 3 that describes the specific requirement. For all test procedures described in this clause, the test temperature is 25 ± 5 ^oC unless otherwise stated. All measured and computed values shall be rounded to the number of decimal places given in the corresponding requirement using the procedures of ASTM E29-2002 [B2].

4.1 Cable tests

4.1.1 Design tests

4.1.1.1 Water blocking test

A water blocking test for cable shall be conducted in accordance with the requirements for TIA 455-82-B-1991 [B23], except that the retest length, if used, is 1 m rather than 3 m. This test may optionally be performed on the cable core assembly.

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4.1.1.2 Seepage of filling/flooding compound

A 0.3 m sample of cable shall be tested in accordance with EIA/TIA 455-81-A-1992 [B9]. The optional pre-conditioning cycle as described in EIA/TIA 455-81-A-1992 [B9] may be used. The unprepared cable end may be sealed.

4.1.1.3 Electrical tests

The electrical tests shall be performed on a sample cable in accordance with Annex A.

4.1.1.4 Aeolian vibration test

The aeolian vibration test shall be performed on a sample cable in accordance with Annex B.

4.1.1.5 Galloping test

The galloping test shall be performed on a sample cable in accordance with Annex C.

4.1.1.6 Sheave test

4.1.1.6.1 Sheave test

The sheave test shall be performed on a sample cable in accordance with Annex D.

4.1.1.6.2 Tensile strength of cable

The tensile strength of a cable shall be conducted in accordance with TIA 455-33-A-1988 [B17].

4.1.1.6.3 Cable twist

The cable twist test shall be conducted in accordance with TIA 455-85-A-1999 [B24]. The cable length subjected to the test shall be a maximum of 4 m.

4.1.1.6.4 Cable cyclic flexing

The cable cyclic flexing test shall be conducted in accordance with TIA/EIA 455-104-A-1993 [B37]. The sheave diameter shall be a maximum of 20 times the cable outside diameter. The cable shall be flexed at 30 ± 1 cycles/minute for 25 cycles. (For some cable designs, the sheave diameter must be greater than 20 times the cable outside diameter. For those designs, the sheave diameter shall be specified by the cable manufacturer and be stated to the customer prior to purchase.)

4.1.1.7 Crush test and impact test

4.1.1.7.1 Crush test

The crush test shall be carried out on a sample of cable according to the method provided by TIA/EIA 455-41-A-1993 [B30]. The cable shall withstand a compressive load of 220 N/cm for 10 minutes.

4.1.1.7.2 Impact test

The impact test shall be carried out on a sample of cable according to the method provided by EIA/TIA 455-25-A-1989 [B8].

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4.1.1.8 Creep test

A creep test shall be performed on an ADSS sample approximately 10 m long. The cable shall be terminated at each end, and a tension of at least 50% of the maximum rated cable loads shall be applied and sustained for a duration of at least 1000 h. The elongation of the cable versus time shall be measured at suitable intervals and recorded.

4.1.1.9 Stress/strain test

A static tensile test shall be conducted in accordance with TIA 455-33-A-1988 [B17] with the following exceptions. The use of sheaves is not mandatory. A sample of cable shall be placed in a tensile testing apparatus, such that a minimum of 25 m of cable within the middle of the test length can be subjected to tensile loading. The test sample shall be terminated at both ends prior to strain, in a manner such that the optical fiber ends cannot move relative to the cable ends.

The tensile test shall first be used to obtain a stress/strain curve. Load the cable stepwise to the manufacturer's maximum rated cable load (MRCL). Record

a) The load and strain on the cable

b) The maximum fiber attenuation increase in decibels

c) Maximum *added* fiber strain

A cyclic loading test shall be performed subsequent to the initial tensile test to gauge the cables dynamic performance. Cycle the cable from 0% (+10%) to 100% (±10%) of the MRCL for 50 cycles at approximately one to three cycles per minute. Take measurements at the high and low loading extremes for the first two cycles and last two cycles. Record

a) The load and strain on the cable

b) The maximum fiber attenuation increase in decibels

c) Maximum *added* fiber strain

The MRCL, MRCS, and the maximum added fiber strain shall be specified by the manufacturer and verified through this test. MRCS/MRCL (%/load) is the effective modulus for the cable design for the purpose of sag and tension calculations.

The overall change in length of the ADSS may be measured by suitable displacement transducers. Fiber strain measurements shall be performed using phase shift or time-of-flight techniques. The accuracy is limited by index of refraction changes under strain.

4.1.1.10 Cable cutoff wavelength (single-mode fiber)

The cutoff wavelength of cabled fiber, λ_{cc}, shall be measured according to EIA/TIA 455-170-1989 [B10]. The cable sample shall be 20 m long with additional 1 m fiber ends, each having one 76 mm loop to simulate the splice organizer. (The total fiber length is 22 m including the two 1 m ends.)

Alternatively, the test may also be applied to uncabled fiber by replacing the 20 m cable with 20 m of uncabled fiber coiled in a loop with a minimum diameter of 280 mm to simulate the effect of the cable. (The total fiber length is 22 m, including the two 1 m ends.)

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Rather than routinely making the cabled fiber cutoff wavelength measurement, a supplier can routinely measure the uncabled fiber cutoff wavelength, lcf, obtained via EIA 455-80-1988 [B6]. The supplier shall establish an empirical mapping function to translate the cabled fiber cutoff wavelength requirements into uncabled fiber cutoff wavelength requirements specific to the supplier with a 99% confidence interval. This mapping shall be initially based on and annually verified by direct fiber and cable cutoff measurements as previously outlined for all fiber types in all cable design families.

4.1.1.11 Temperature cycle test

The temperature cycle test shall be performed on a sample cable in accordance with Annex E.

4.1.1.12 Cable aging test

The cable aging test shall be performed on a sample cable in accordance with Annex F.

4.1.1.13 UV resistance testing

Carbon black UV resistance shall be tested in accordance with individual national performance standards such as average testing per ASTM D3349-1993 [B1] or equivalent user supplier standard.

IEC 60068-2-1 [B12] testing shall be specified per the particular IEC blank specification requirements as agreed to by both user and supplier with the following guidelines:

For Solar radiation, use IEC 60068-2-5 [B14]:

a) Method C for 56 days.

b) Support method fixed at either end with no heat sink available.

c) Temperature not to exceed 80 ^{o}C for low- and medium-density polyethylenes, 85 ^{o}C for high-density or altered polyethylenes, or 90 ^{o}C for cross-linked polyethylenes. Temperature not to fall below 50 ^{o}C.

d) Maximum air velocity shall be no more than that to maintain temperature requirements stated in Item c) above.

e) Humidity shall be cycled per IEC 60068-2-38 [B13] test Z/AD minus the cold cycles, or per humidity cycling that more closely reflects the proposed installation locations.

f) The test box and cable samples shall be preconditioned to full test conditions prior to the start of the 56-day cycle testing period.

4.1.2 Routine tests

4.1.2.1 Fiber optic cable dimensions

Dimensions will be continuously monitored during production, and results can be made available upon request.

4.1.2.2 Optical acceptance test

Attenuation test shall be performed on each fiber of each individual reel in accordance with 4.2.2.1.1. Certified test reports shall be supplied by the manufacturer.

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4.2 Fiber tests

4.2.1 Design tests

4.2.1.1 Attentuation with wavelength

The measurement shall be made in accordance with TIA/EIA 455-78-A-1990 [B36] or with TIA/EIA 455-46-A-1990 [B31] for multimode fibers. The spectral width of the source shall be less than 10 nm.

4.2.1.2 Water peak requirements

The measurement shall be made using the same procedures described in the previous clause.

4.2.1.3 Attenuation with bending

The two attenuation with bending requirements are measured by winding 100 turns of fiber on a collapsible reel or removable mandrel of 75 mm ± 2 mm diameter and by wrapping a single turn of fiber around a 32 ± 0.5 mm diameter mandrel. Attenuation with bending measurements shall be made in accordance with EIA/TIA 455-62-A-1992 [B22]. For multimode fiber, the launch conditions are critically important, and should sufficiently underfill the fiber mode volume so that modal transients are suppressed. The launch apparatus shall be in accordance with EIA 455-50-A-1987 [B4]. The spectral width of the source used to measure attenuation shall be less than 10 nm.

4.2.1.4 Environmental requirements

4.2.1.4.1 Temperature cycling

Temperature cycling measurements shall be made in accordance with TIA 455-3-A-1989 [B16], using test condition A, –55 ^{o}C to +85 ^{o}C, two cycles.

4.2.2 Routine tests

4.2.2.1 Optical requirements

4.2.2.1.1 Attenuation coefficient

Single-mode fiber attenuation measurements shall be made in accordance with TIA/EIA 455-78-A-1990 [B36] or with EIA/TIA 455-61-A-2000 [B21]. If OTDRs are used, measurements shall be made from both directions and the results shall be averaged. Multimode fiber attenuation measurements shall be made in accordance with either TIA/EIA 455-46-A-1990 [B31] or TIA/EIA 455-53-A-1990 [B34]. For multimode fiber, the launch conditions are critically important, and they should sufficiently underfill the fiber mode volume so that modal transients are suppressed. The launch apparatus shall be in accordance with EIA 455-50-A-1987 [B4]. The spectral width of the source used to measure attenuation shall be less than 10 nm.

Because multimode attenuation measurement accuracy becomes questionable when measured on short cable lengths and test procedures for short cable have not been written by the EIA, multimode attenuation measurements should be made on characterization cable lengths. If the shipping length of the cable is less than 1 km, the attenuation values measured on longer lengths of cable (characterization lengths of cable) before cutting to the shipping lengths of cable may be applied to the shipping lengths. For multimode fiber, the measurements made on the characterization lengths of cable can be applied to the shipping lengths of the cable only if characterization lengths are less than 3 km.

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4.2.2.1.2 Attenuation uniformity

Attenuation uniformity is measured in accordance with TIA 455-59-A-2000 [B20]. Measurements shall be made bidirectionally, and the results shall be averaged.

4.2.2.1.3 Chromatic dispersion (single-mode fiber)

Dispersion measurements shall be made in accordance with TIA/EIA 455-168-A-1992 [B40], TIA/EIA 455-169-A-1992 [B41], or TIA 455-175-A-1992 [B25].

4.2.2.1.4 Multimode fiber bandwidth

Multimode fiber bandwidth measurements shall be made in accordance with TIA/EIA 455-30-B-1991 [B28] or TIA/EIA 455-51-A-1991 [B33]. Launch conditions shall conform to EIA 455-54-A-1990 [B5].

4.2.2.1.5 Mode field diameter (single-mode fiber)

Any one of three MFD measurement techniques may be used. The techniques are in accordance with TIA/EIA 455-164-A-1991 [B38], TIA/EIA 455-167-A-1992 [B39], and EIA 455-174-1988 [B7]. The measurement wavelength shall be 1310 ± 20 nm for dispersion-unshifted single-mode fibers and 1550 ± 20 nm for dispersion-shifted single-mode fibers.

4.2.2.2 Geometric requirements

If a vidicon-based alternative procedure such as that referenced in TIA 455-176-1993 [B26] is used in the test procedures of this clause that reference TIA 455-45-B-1992 [B18], the measurement accuracy and repeatability should be equivalent to procedures described in TIA 455-45-B-1992 [B18].

4.2.2.2.1 Multimode optical fibers

Core diameter: The core diameter measurements shall be in accordance with TIA 455-58-B-2001 [B19].

Core noncircularity: Core noncircularity measurements shall be in accordance with TIA 455-45-B-1992 [B18] or TIA 455-176-1993 [B26]. The calculated core ovality multiplied by 100% expresses the core circularity in percent. The core noncircularity is expressed as 100% minus the core circularity.

Concentricity error: Core-to-clad concentricity error measurements shall be made in accordance with TIA 455-45-B-1992 [B18] or TIA 455-176-1993 [B26].

Numerical aperture: The numerical aperture measurements shall be made in accordance with TIA 455-177A-1992 [B27].

4.2.2.2.2 Single-mode optical fibers

Concentricity error: Core-to-clad concentricity error measurements shall be made in accordance with TIA 455-45-B-1992 [B18] or TIA 455-176-1993 [B26].

4.2.2.2.3 Parameters common to both multimode single-mode fibers

Cladding diameter: For quality conformance inspection, the cladding diameter measurement shall be made in accordance with TIA 455-45-B-1992 [B18] or TIA 455-176-1993 [B26]. Online process control measurements shall be made in accordance with TIA/EIA 455-48-B-1992 [B32].

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Cladding noncircularity: Cladding non-circularity measurements shall be made in accordance with TIA 455-45-B-1992 [B18] or TIA 455-176-1993 [B26].

Coating diameter: Coating diameter measurements shall be made in accordance with TIA/EIA 455-55-B-1990 [B35] or TIA/EIA 455-173-1990 [B42]. For tight buffer fibers, the manufacturer shall specify a method as long as the measurement accuracy and repeatability is equivalent to procedures described in TIA/EIA 455-55-B-1990 [B35] or TIA/EIA 455-173-1990 [B42].

4.2.2.3 Mechanical requirements

4.2.2.3.1 Fiber tensile proof test

Individual fibers shall be proof tested in accordance with TIA/EIA 455-31-B-1990 [B29] at each end of the test sample that has not been subjected to full proof test loading shall be discarded.

5. Sag and tension list

The following are recommended as minimum controls to be used in preparing sag and tension charts for ADSS cable:

a) ADSS cable sags should be such that the tensions do not exceed the rated MRCL.

b) Sag and tension recommendations regarding vibration protection should be obtained from the ADSS cable manufacturer or from other sources knowledgeable in the field of vibration protection of overhead cables.

c) It is recommended that tension limits for a specific application be chosen through a coordinated study that should include the requirements of the user, recommendations from the cable manufacturer, and recommendations from the manufacturer of all supporting hardware.

6. Field acceptance testing

Upon receipt of the ADSS cable from the manufacturer, the purchaser may elect to perform several acceptance tests in order to verify that the optical characteristics of the fiber meet the customer's requirements and to determine if the optical fibers have been damaged during shipment. The results of these tests and the manufacturer's certified quality control information, which is attached to each reel, should be compared with the fiber requirements specified in the purchase order.

These tests may be performed by either of two methods. The first method is to use an optical time domain reflectometer (OTDR), and the second is to use a light source and a power meter. Access to only one end of the cable is required using the OTDR, but both ends of the cable must be accessible when using the light source and power meter. This means the protective wood lagging does not need to be removed when using the OTDR, whereas it is necessary to remove at least a portion of the lagging to use the light source and power meter. A 1 km length of fiber may be spliced between the OTDR and the cable to improve resolution near the cable end. However, it should be noted that when using the OTDR, that breaks or damage within 10 m of either end of the fiber from where the OTDR is connected may not be detectable. If a reel fails using the single-end OTDR method, then before rejection of the reel, the fiber(s) in question should be tested from the opposite end and the results averaged for the fiber(s). Mechanical splices have been used successfully to conduct these tests.

The end of the cable should be sealed after completion of these tests in order to prevent entry of moisture into the cable. A visual inspection should be made of each reel, and if any indication is found of physical damage to either the reel or lagging, then the following test should be made.

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6.1 Fiber continuity

A continuity check of each fiber may be made to determine if any fiber is broken or any attenuation irregularities exist. Attenuation uniformity shall meet the requirements of 3.2.2.1.2 and 4.2.2.1.2.

6.2 Attenuation

Total attenuation for the entire reel length and attenuation per kilometer should be measured on each fiber.

6.3 Fiber length

The fiber length may be measured using the OTDR. The effective group index of refraction factor to be used in this measurement should be furnished by the fiber manufacturer. A check should be made to verify that the received reel numbers and lengths correspond to ordered quantities.

7. Installation recommendations

7.1 Installation procedure for ADSS

The installation techniques and equipment for ADSS cable correspond to those normally used for overhead lines. It is recommended that the manufacturer's recommended installation procedures be used for the installation of ADSS cable. Refer to IEEE Std 524™-1980 [B15] for additional details on installation techniques.

7.2 Electric field strength

The strength of the electric field where ADSS cable is installed will have an effect on the performance of the cable. Electrical stress will contribute to the aging of the outer jacket. ADSS cable may be installed in locations with varying electric field strengths. Therefore, the electric field strengths must be taken into consideration when determining the type of cable jacket which will be required. See 2.7 to determine the appropriate jacket based on electric field strength. Where possible, ADSS cable should be located in areas of minimum electric field strengths. ADSS cables are designed with different type jackets for use in the varying electric fields, and the proper jacket must be used in order for the cable to provide the expected service life.

7.3 Span lengths

Span lengths are generally defined as follows:

a) Short span: less than approximately 100 m

b) Medium span: approximately 100 m to 300 m

c) Long span: greater than approximately 300 m

ADSS cable design will vary depending on maximum span lengths and meteorological loading conditions. The manufacturer should be consulted for particular span length applications.

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7.4 Sag and tension

Sag and tension requirements will be dependent on the type cable being installed, clearance requirements, and meteorological loading requirements. Various ADSS cable designs are available to accommodate different sag and tension requirements. The ADSS cable manufacturer should be able to provide sag and tension information for specific situations and conditions. Some manufacturers have the capability to custom design ADSS for specific sag limitations.

7.5 Stringing sheaves

When installing ADSS cable, the diameter of the stringing sheaves must be taken into consideration, especially when passing around line angles.

The ADSS cable manufacturer should be consulted for the minimum diameter stringing sheaves to be used. When the proper stringing sheaves are used, multiple line angles may be included in one pull without damage to the cable. Due to the light weight of the ADSS cable and the relative low stringing tensions, the stringing sheaves may need to be supported to some degree to help prevent the cable from riding out of the sheave during installation.

7.6 Maximum stringing tension

Care should be taken during the stringing operation to not exceed the maximum allowable stringing tension. The ADSS cable manufacturer should be consulted as to the maximum stringing tension. This will vary depending on the cable design.

7.7 Handling

Care should be taken when coiling or bending ADSS cable. The ADSS cable manufacturer should be consulted to determine the minimum cable bend diameter. Care must be taken to not kink the cable, which may cause damage to the optical properties of the fibers.

7.8 Hardware and accessories

Suspension and dead-end hardware, some types of vibration damper hardware, and other clamps for ADSS cable are usually designed for a specific size. Hardware is generally not designed to accommodate a range of sizes of ADSS cables.

Excessive contact pressure under hardware can exceed the designed crushing limits of the ADSS cable. It is, therefore, recommended that hardware and other accessories connected to the ADSS cable be suitable for the specific cable being used.

7.9 Electrical stress

The design of an ADSS system (as defined as the combination of cable and hardware) located near high-voltage power lines should consider electrical stress effects on the cable jacket. This evaluation may be conducted by the cable manufacturer and/or the owner/operator of the system. Distance from the conductor (s), line voltage, conductor size(s), static wire location(s), and installation environment (e.g., pollution, local climate) are important considerations for the evaluation.

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8. Cable marking and packaging requirements

8.1 Reels

a) All cables shall be shipped and stored on returnable or nonreturnable wooden reels or steel reels. Each reel shall be sufficient in strength to prevent damage to the cable in transit, storage, and installation. Wooden reels shall be made of seasoned lumber or dried to a moisture content less than 18% and shall be free of dry rot.

b) Each length of cable shall be wound tightly and in uniform layers and shipped on a separate reel.

c) The diameter of the reel drum shall be a minimum of 30 times the outside diameter of the cable.

d) The minimum arbor hole diameter shall be 68 mm (2-11/16 in) with a maximum diameter of 108 mm (4.25 in). The arbor hole shall be centered on the flanges.

e) Each reel shall be covered with a thermal wrap to limit the solar heating of the cable to a maximum of 10 ^{o}C above ambient temperatures and wood lagging (or equivalent) to prevent damage to the cable during shipping, handling, and storage.

f) Each reel shall be permanently marked with the manufacturer's name and reel number in a very visible manner.

g) Each reel shall be marked to indicate the direction the reel should be rolled to prevent loosening of the cable.

h) The outside end location of the cable (running end) shall be clearly identified on the reel.

i) Protection to the cable test ends shall be provided during shipping and handling.

8.2 Cable end requirements

a) Each cable shall have both ends available for testing. The "test tail" (bottom/inside end) shall be approximately 3 m in length.

b) Each end of the cable shall have end caps to prevent moisture ingress into the cable.

c) Each end of the cable shall be securely fastened to the reel to prevent the cable from becoming loose in transit or during placing operations.

8.3 Cable length tolerance

Cable ordered to standard factory lengths shall have an actual length within –0% and +5% of the length ordered unless otherwise specified by the customer.

8.4 Certified test data

a) Each cable shall have certified test data securely fastened to the outside of the reel in a waterproof wrapping.

b) The certified test data sheet shall contain the following information:

Manufacturer's name

Customer's name

Manufacturer's factory order number

Cable serial number

Length of cable

Number and type of fibers

Fiber transmission data

Other information when requested by customer

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8.5 Reel tag

a) Each cable shall have a weatherproof reel tag securely fastened to the reel.

b) The reel tag shall include the following information:

Manufacturer's name

Customer's name

Cable description

Manufacturer's factory order number

Cable serial number

Length of cable

Beginning and ending sequential length markings

Gross weight

Net weight

Other information when requested by customer

8.6 Cable marking

Cable marking shall conform to the following except where installations of ADSS cable within certain electrical classifications/zone may necessitate printing limitations on the cable. Consult with the cable manufacturer for proper application.

a) Cable markings shall consist of identification marking, the standard optical cable code (SOCC) as defined in 8.9, and length marking.

b) Cable markings shall be imprinted with white characters on the outer jacket.

c) The markings shall be permanent, insoluble in water, and legible for the duration of the cable life.

d) The character height and spacing shall be in accordance with standard commercial practice.

e) An occasional illegible marking is permitted if there is a legible marking on either side of it.

f) The markings shall be imprinted on the jacket of the cable at intervals of not more than 1 m.

8.7 Cable remarking

If the initial cable marking (white characters) fails to meet the marking requirements, the cable shall be remarked. The remarking shall be imprinted with yellow characters on a different portion of the cable sheath, and it shall have a numbering scheme differing by a minimum of 1000 from the original number. Any cable that contains two sets of cable markings shall be labeled on the reel tag or cable identification package to indicate the color of the marking to be used.

8.8 Identification marking

Each length of cable shall be permanently imprinted on the cable jacket with the following information:

a) Name of manufacturer

b) Year of manufacture

c) Labeled "OPTICAL CABLE" or its appropriate trade name

d) The SOCC as defined in 8.9

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8.8.1 Length markings

All cables shall conform to the following:

a) All cables shall have sequentially numbered length markings imprinted on the jacket. This length marking shall not be reset to 0 along the cable length.

b) The actual length of the cable shall be within +5, –0% of the indicated length provided by the length marking.

c) Cable length shall be verified routinely by the actual measurement of a 3 m or longer length of cable between length marks. The measurement shall be taken with a calibrated measuring device.

8.9 SOCC

The SOCC is a descriptive code that offers a relatively complete mechanical and optical definition in a minimum number of characters.

The SOCC characters as outlined shall be imprinted on the cable jacket.

The code has three fields as shown:

a) The first field, M1 M2, is a manufacturer code defined by either the manufacturer or the user.

b) The middle field, S1 S2 S3 S4 S5 S6, is a structural description where each alphanumeric character carries information about the cable structure.

S1 defines the type of fiber

S2 defines the cable unit type

S3 defines the cable structure unit by identifying the number of working fibers per unit

S4 describes the mechanical configuration

S5 defines the maximum rated cable load (MRCL)

S6 defines the cable jacket suitable for application in electrical fields

1) The structural character S1, as listed in Table 1, defines the type of fiber:

Table 1—Fiber type code

Fiber type	Code
Conventional single mode	1
Dispersion shifted	2
50/125 multimode	3
62.5/125 multimode	4
85/125 multimode	5
Composite	6
Non-dispersion shifted	7
Nonzero, dispersion shifted	8
Other	0

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2) The structural character S2, as listed in Table 2, defines the type of cable unit:

Table 2—Unit type code

Type of units	Character
Fiber bundle	B
Hybrid tube in slot	H
Loose tube	L
Ribbon	R
Slotted core	S
Tight buffer	T
Other	O

3) The structural character S3, as listed in Table 3, identifies the number of working fibers per cable structure unit:

Table 3—Fibers per unit code

Fibers per unit	Character
1	1
2	2
4	4
6	6
8	8
12	T
16	S
18	E
Other	O

4) The structural character S4, as listed in Table 4, describes the mechanical configuration of the cable:

Table 4—ADSS mechanical design code

ADSS design	Character
Concentric	C
Prestranded messenger	P
Figure-8	F
Slotted rod	S
Other	O

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5) The structural character S5 describes the MRCL. Numbers 1 to 9 will be 1–500 to 4001–5000 kg, and letters A to Y will be 4501–5000 to 16 501–17 000 kg in 500 kg increments. MRCLs above 17 000 kg will be letter Z.

6) The structural character S6, as listed in Table 5, signifies the space potential rating class of the cable jacket:

Table 5—Space potential code

Space potential	Character
≤12 kV	A
>12 kV	B

c) The last field NNN, indicates the number of working fibers in the cable. Nonworking fibers are not counted.

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Annex A

(informative)

Electrical test

The objective of this test is to demonstrate the resistance of the cable sheath to erosion and tracking under combined electrical and mechanical stresses.

A.1 Test arrangements

A length of cable shall be taken from a production run and sealed at each end against moisture ingress before being supported horizontally in a salt fog chamber between two anchor points. This will enable it to be tensioned mechanically to a level that represents the value of initial sag conditions for the cable. The earth termination shall be identical to that proposed by the supplier for use in service adjacent to a support tower and may consist, for example, of spiral-wrap gripping wires together with any suitable mechanical or electrical stress-relieving accessories. This design of the high-voltage termination shall be at the discretion of the supplier.

The gauge length between terminations must be great enough to avoid flashovers from taking place during the salt fog test, and a length of 25 mm/kV is usually adequate. The cable should be tensioned by a spring so that any creep of the cable material during the test does not result in a major reduction in tension. At suitable intervals during the test, say every 100 hours, the tension should be checked, and if it has changed more than 10% of the initial value, it should be adjusted to fall within range again.

A conduction fog shall be produced within the chamber by the use of a suitable number of atomizing nozzles to the design shown in Figure 8 of IEC 60060-1 [B11]. A useful guide is to have one nozzle for each 2.5 m^3 of chamber volume. The salt water to the nozzle shall be prepared from NaCl and distilled and de-ionized water, and the droplet size should be in the range of 5 to 20 microns. This generally requires an air pressure of 3.3 bars to the nozzles. The nozzles shall be distributed evenly around the chamber to give a homogeneous fog density, and no jet should point directly at the cable. An aperture of no more than 80 cm^2 should be provided for the natural exhaust of air.

A power frequency test transformer shall be used with a minimum continuous rating of 250 mA rms and a trip level set at 1 A rms. There shall be a clearance of at least 300 mm to earth in the vicinity of the cable.

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A.2 Test procedure

After tensioning the cable, it shall be wiped with a cloth or paper towel soaked in water and then subjected to the salt fog. The test conditions shall be as in Table A.1:

Table A.1—Salt fog test conditions

Duration	1000 hours
Salt water flow rate	0.4 ± 0.1 L/hour for each cubic meter of chamber volume
Droplet size	5–20 microns
Temperature	15–25 °C
NaCl content of water	10 ± 0.5 kg/m^3
Test voltage and frequency	As agreed with customer

The salt water may not be recirculated. Several interruptions of the test for inspection purposes are permissible, each not exceeding 15 minutes. Interruption periods, which typically occur at 100 hour intervals, do not count toward test duration.

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Annex B

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Aeolian vibration test

The objective of this test is to assess the fatigue performance of ADSS cable and the optical characteristics of the fibers under typical aeolian vibrations.

B.1 Test setup

The general arrangement to be used for the aeolian vibration tests and the support details are shown in Figure B.1. The end abutments are used to load and maintain tension in the fiber optic cable. The test section is contained between the two intermediate abutments. End and intermediate abutments need not be separate units if the combined unit affords sufficient space for the apparatus specified in Figure B.1. The fiber optic cable to be tested should be cut a sufficient length beyond the intermediate abutments to allow removal of the cable coverings and to allow access to the optical fibers. Suitable dead-end assemblies or end abutments are installed on the fiber optic cable to fit between the intermediate abutments. The test sample shall be terminated at both ends prior to tensioning in a manner such that the optical fibers cannot move relative to the cable. A dynamometer, load cell, calibrated beam, or other device should be used to measure cable tension. Some means should be provided to maintain constant tension to allow for temperature fluctuations during the testing. The cable should be tensioned to 100% of the rated maximum installation tension.

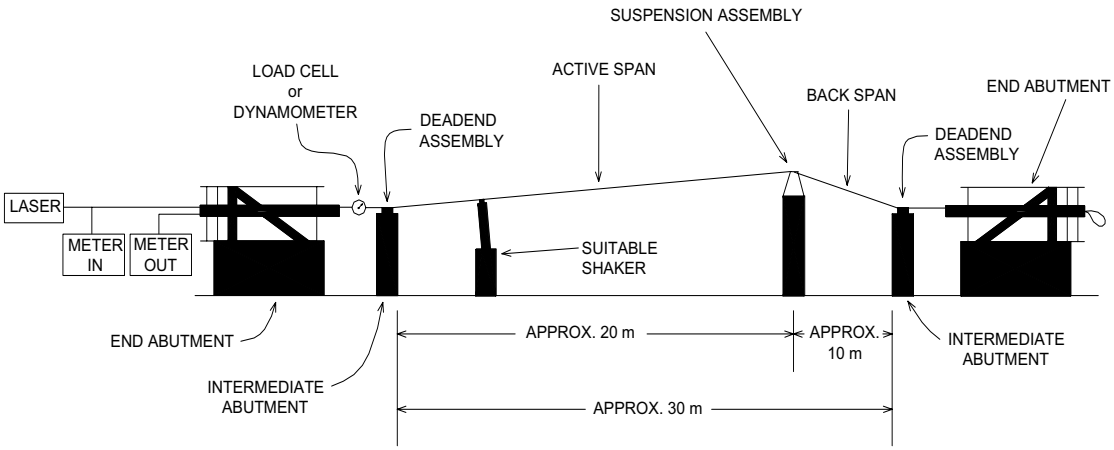


Figure B.1—Aeolian vibration test setup for ADSS fiber optic cable

In order to achieve repeatability of test results, the active span should be approximately 20 m or more, with a suitable suspension assembly located approximately two-thirds of the distance between the two dead-end assemblies. Longer active and/or back spans may be used. See Figure B.1. The suspension assembly shall be supported at a height such that the static sag angle of the cable to horizontal is 1-3/4 degrees ± 3/4 degree in the active span.

Means shall be provided for measuring and monitoring the mid-loop (antinode) vibration amplitude at a free loop, not a support loop.

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An electronically controlled shaker shall be used to excite the cable in the vertical plane. The shaker armature shall be securely fastened to the cable so that it is perpendicular to the cable in the vertical plane. The shaker should be located in the span to allow for a minimum of six vibration loops between the suspension assembly and the shaker.

The test length (i.e., between dead-end assemblies) of the optical fiber shall be a minimum of 100 m. To achieve this length, several fibers may be spliced together. At least one fiber shall be tested from each buffer tube or fiber bundle. Splices should be made so the optical equipment can be located at the same end. Optical measurements shall be made using a light source with a nominal wavelength of 1550 nm for single-mode fibers and a nominal wavelength of 1300 nm for multimode fibers.

The source shall be split into two signals. One signal shall be connected to an optical power meter and shall act as a reference. The other signal shall be connected to a free end of the test fiber. The returning signal shall be connected to a second optical power meter. All optical connections and splices shall remain intact through the entire test duration.

An initial optical measurement shall be taken when the span is pretensioned to approximately 10% of maximum installation tension prior to final tensioning to maximum installation tension. The difference between the two signals for the initial measurement provides a reference level. The change in this difference during the test will indicate the change in attenuation of the test fiber. The signals may be output on a strip chart recorder for a continuous hardcopy record.

B.2 Test procedure

The cable shall be subjected to a minimum of 100 million vibration cycles. The frequency of the test span shall be equal to and maintained at the nearest resonant frequency produced by a 16.1 km/hr wind (i.e., frequency = 82.92, diameter of cable in centimeters). The free loop peak-to-peak antinode amplitude shall be maintained at a level equal to one-half the diameter of the cable.

In the initial stages, the test span requires continuous attention and recordings shall be taken approximately every 15 minutes until the test span has stabilized. After the span has stabilized, readings shall be taken a minimum of two times per day, typically at the start and end of the working day.

A final optical measurement shall be taken at least two hours after the completion of the vibration test. A section of the cable from the location of the hardware support shall be loaded to the MRCL. The attenuation must comply with 3.1.1.4.

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Annex C

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Galloping test

The objective of this test is to assess the fatigue performance of ADSS cable and the optical characteristics of the fibers under typical galloping motions.

C.1 Test setup

The general arrangement to be used for the galloping test is shown in Figure C.1. The overall span between dead-end assemblies should be a minimum of 35 m. The end abutments are used to load and maintain tension in the fiber optic cable. The test section is contained between the two intermediate abutments. End and intermediate abutments need not be separate units if the combined unit affords sufficient space for the apparatus specified in Figure C.1. The fiber optic cable to be tested should be a sufficient length beyond the intermediate abutments to allow removal of the cable outer coverings and to allow access to the optical fibers. The test sample shall be terminated at both ends prior to tensioning in a manner such that the optical fibers cannot move relative to the cable. A dynamometer, load cell, calibrated beam, or other device should be used to measure cable tension. Some means should be provided to maintain constant tension to allow for temperature fluctuations during the testing. However, some tension fluctuations are expected from the galloping activity itself. The cable should be tensioned to a minimum of 50% of the maximum installation tension or a maximum of 500 kg. (For some cable designs, the test tension must be lowered to 250 kg in order to induce galloping. For these designs, the 250 kg test tension is acceptable.)

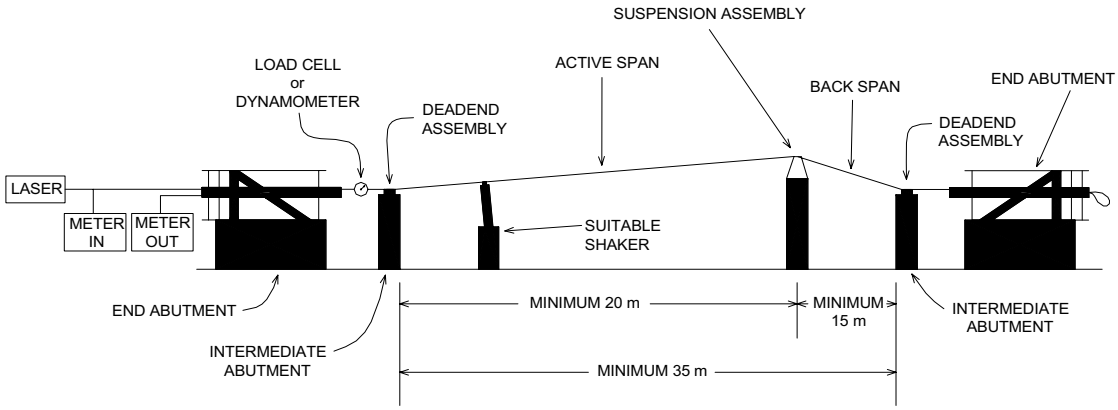


Figure C.1—Galloping test setup for ADSS fiber optic cable

A suitable suspension assembly shall be located approximately midway between the two dead-end assemblies. It shall be supported at a height such that the static sag angle of the cable to horizontal not exceed 1 degree.

Means shall be provided for measuring and monitoring the mid-loop (antinode), single-loop galloping amplitude.

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A suitable shaker shall be used to excite the cable in the vertical plane. The shaker armature shall be securely fastened to the cable in the vertical plane.

The test length (i.e., between dead-end assemblies) of the optical fiber shall be a minimum of 100 m. To achieve this length, several fibers may be spliced together. At least one fiber shall be tested from each buffer tube or fiber bundle. Splices should be made so the optical equipment can be located at the same end. Optical measurements shall be made using a light source with a nominal wavelength of 1550 nm for single-mode fibers and a nominal wavelength of 1300 nm for multimode fibers. The source shall be split into two signals. One signal shall be connected to an optical power meter and shall act as a reference. The other signal shall be connected to a free end of the test fiber. The returning signal shall be connected to a second optical power meter. All optical connections and splices shall remain intact through the entire test duration.

An initial optical measurement shall be taken when the span is pretensioned to approximately 5% of maximum installation tension prior to final tensioning to maximum installation tension. The difference between the two signals for the initial measurement provides a reference level. The change in this difference during the test shall indicate the change in attenuation of the test fiber. The signals may be output on a strip chart recorder for a continuous hardcopy record.

C.2 Test procedures

The cable shall be subjected to a minimum of 100 000 galloping cycles. The test frequency shall be the single-loop resonant frequency. The minimum peak-to-peak antinode amplitude/loop length ratio shall be maintained at a value of 1/25, as measured in the active span.

Mechanical and optical data shall be read and recorded approximately every 2000 cycles.

The optical power meters shall be continuously monitored beginning at least one hour before the test and ending at least two hours after the test.

The final optical measurement shall be taken at least two hours after the completion of the vibration test. A section of cable from the location of the hardware support shall be loaded to the MRCL, and the attenuation must comply with 3.1.1.5.

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Annex D

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Sheave test (ADSS)

The objective of this test is to verify that stringing of the ADSS cable with the recommended sheave size and procedures will not damage or degrade the quality of the optical fibers.

D.1 Test setup

The general arrangement for the sheave test is shown in Figure D.1. A sheave test shall be performed on a sample cable a minimum of 9 m long. Dead-end fittings shall be clamped a minimum of 3 m apart. The optical fibers shall be connected to each other by means of fusion or equally reliable splices. The test length of optical fiber shall be a minimum of 100 m long. A light source shall be connected to one end of the test fiber. At the other end, an optical power meter shall be used to monitor the relative light power level. The power meter shall be connected to a strip chart recorder that shall run continuously during the test.

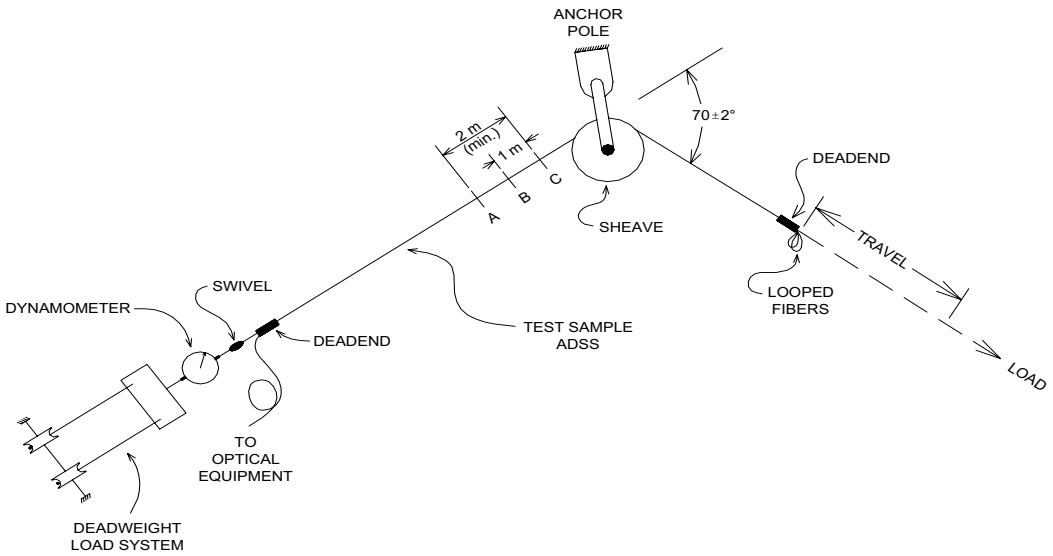


Figure D.1—Sheave test for ADSS

Depending on the size of the line angle, various diameter stringing sheaves will be recommended by the ADSS cable manufacturer. Therefore, this test shall be performed using various sheave diameters corresponding to the line angle being tested as listed in Table D.1. The cable shall be pulled at one dead-end at the maximum stringing tension specified by the ADSS cable manufacturer. The method of attachment, although not rigid, shall limit the amount of twist that could occur at the lead end. A dynamometer and a swivel shall be installed between the yoke and the other dead-end.

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D.2 Test procedures

A 2 m minimum length of the ADSS test sample shall be pulled 120 times forward and backward through the sheave (60 times in each direction). The 120 passes shall be distributed as shown in Table D.1:

Table D.1—Angle of pull

Angle of pull (degrees)	Number of passes
70	120

The diameter of the sheave for the angle of pull will be determined by the ADSS cable manufacturer. Before the first pull, the beginning, midpoint, and end of this length shall be marked. Micrometer readings of the diameter shall be taken and recorded before the first pass through the sheave and thereafter every tenth cycle. The output of the optical power meter shall be monitored continuously during the test. After the test is completed, the ADSS cable shall be removed in the test section and the cable shall be visually examined for any surface damage. The ADSS cable may be dissected to observe for any signs of damage to the inner structure.

The wavelength of the light source shall be nominally 1550 nm for single-mode fibers and nominally 1300 nm for multimode fibers.

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Annex E

(informative)

Temperature cycle test

At least 500 m of cable shall be taken from a representative sample of the cable. The cable shall be wound onto a reel and placed in an environmental chamber. The reel shall be supported in such a manner as to facilitate handling and free movement of air through it when it is in the conditioning chamber. Each end extending outside the chamber shall be as short as practical.

At least 10 fibers, or 100% of the fibers if less than 10 fibers, of the test cable shall be measured for optical attenuation or attenuation change. The fibers shall be selected, such that one fiber from each of a minimum of 10 different units in the cable is tested. Optical attenuation measurements shall be normalized and expressed as an attenuation coefficient at wavelengths of interest. The change in attenuation is measured with respect to the baseline attenuation values measured at room temperature before temperature cycling.

For both non-dispersion-shifted and dispersion-shifted single-mode fibers, the measurements shall be made at 1240 ± 2 nm and 1550 ± 20 nm. For multimode fibers, the measurements shall be made at 1300 nm. The 1240 nm baseline measurement is needed only for the cable aging continuation of the temperature cycling test.

The cable samples shall be tested in accordance with TIA 455-3-A-1989 [B16]. Test condition B-1 shall apply:

1) The sample shall be preconditioned for 24 hours at 23 °C ± 5 °C. The baseline attenuation measurements shall be made at the end of this period.
2) Decrease the temperature to the minimum operating temperature of –40 °C ± 2 °C. Maintain this temperature for 24 hours. No attenuation measurement are required.
3) Raise the temperature to the maximum temperature of 65 °C ± 2 °C. Maintain this temperature for 24 hours. No attenuation measurements are required.
4) Decrease the temperature to the minimum operating temperature of –40 °C ± 2 °C. Maintain this temperature for 24 hours. Attenuation measurements shall be performed at the end of this period.
5) Raise the temperature to the maximum temperature of 65 °C ± 2 °C. Maintain this temperature for 24 hours. Attenuation measurements shall be performed at the end of this period.

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Annex F

(informative)

Cable thermal aging test

The cable aging test shall be conducted as a continuation of the temperature cycling test. At the completion of the temperature cycling test, the test cable shall be exposed to 85 °C ± 2 °C (185 °F ± 3.6 °F) for a minimum of 120 hours. No optical measurement is required during this phase. After aging, the test cable shall be subjected to the test cycle described in Annex E except that step 1) may be omitted. The changes in attenuation at both 1240 ± 2 nm and 1550 ± 20 nm shall be measured with respect to the baseline attenuation values measured at room temperature before temperature cycling in the preceding test.

A 1 m section of the 500 m cable sample used in the temperature cycling and cable aging tests shall be observed and opened, and the fibers shall be removed for examination.

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