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IEEE Standard for Testing and Performance of Hardware for All-Dielectric Self-Supporting (ADSS) Fiber Optic Cable

IEEE Power and Energy Society

Sponsored by the
Power System Communications Committee

IEEE
3 Park Avenue
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USA

IEEE Std 1591.2™-2017

IEEE Standard for Testing and Performance of Hardware for All-Dielectric Self-Supporting (ADSS) Fiber Optic Cable

Sponsor

Power System Communications Committee
of the
IEEE Power and Energy Society

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Abstract: Hardware performance, test requirements, procedures, and acceptance criteria for an all-dielectric self-supporting overhead cable with optical fibers are covered in this standard. Functional requirements, such as electrical, mechanical, optical fiber, environmental and test requirements related to design, installation, in-service, and maintenance, including routine tests, are covered.

Keywords: ADSS, all-dielectric self-supporting fiber optic cable, fiber optic cable, IEEE 1591.2™, laboratory tests, maximum installation tension, maximum rated cable load, maximum rated design tension

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Introduction

This introduction is not part of IEEE Std 1591.2-2017, IEEE Standard for Testing and Performance of Hardware for All-Dielectric Self-Supporting (ADSS) Fiber Optic Cable.

IEEE Std 1591.2 is the hardware test standard for all-dielectric self-supporting (ADSS) fiber optic cable applications. Hardware for ADSS is identified as hardware in direct contact with the ADSS cable in an ADSS cable and hardware system. This test standard provides standardization of terminology, performance, and test requirements for ADSS hardware. This hardware standard compliments IEEE Std 1222™[1] for ADSS cable, as many of the terms and tests requirements are common for consistency and testing efficiency.

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[1]Information on references can be found in Clause 2.

Contents

IEEE Standard for Testing and Performance of Hardware for All-Dielectric Self-Supporting (ADSS) Fiber Optic Cable

1. Overview

1.1 Scope

This standard covers the construction, mechanical and electrical performance, test requirements, environmental considerations, and acceptance criteria for qualifying hardware for use with all-dielectric self-supporting (ADSS) fiber optic cable.

1.2 Purpose

The purpose of this standard is to establish performance and testing specifications for hardware used on ADSS systems in order to standardize testing, simplify procurement specifications, and assure product quality.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they shall be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ASTM A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.[2]

ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.

AWS D1.1/D1.1M, Structural Welding Code—Steel.

IEC 61897, Overhead Lines—Requirements and Tests for Stockbridge Type Aeolian Vibration Dampers.[3]

IEEE Std 664™, IEEE Guide for Laboratory Measurement of the Power Dissipation Characteristics of Aeolian Vibration Dampers for Single Conductors.[4,5]

[2]ASTM publications are available from the American Society for Testing and Materials (http://www.astm.org/).
[3]IEC publications are available from the International Electrotechnical Commission (http://www.iec.ch) and the American National Standards Institute (http://www.ansi.org/).
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IEEE Std 1222™, IEEE Standard for Testing and Performance for All-Dielectric Self-Supporting (ADSS) Fiber Optic Cable for Use on Electric Utility Power Lines.

ISO 1461, Hot dip galvanized coatings on fabricated iron and steel articles—Specifications and test methods.[6]

ISO 4892, Plastics—Methods of exposure to laboratory light sources.

ISO 9227, Corrosion tests in artificial atmospheres—Salt spray tests.

3. Definitions, acronyms, and abbreviations

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[7]

3.1 ADSS cable and hardware system definitions

breaking strength: The calculated maximum tensile load that the cable is estimated to reach upon mechanical failure. Mechanical failure is primarily associated with the cable strength member however other cable components may contribute to the overall strength. The maximum rated cable load is typically less than 60% of the breaking strength. *Syn:* **breaking tension**.

every day tension (EDT): The final tension with no ice and no wind at the average annual mean temperature throughout the year. This temperature is assumed as 16 °C (60 °F). This number is often used in specifying motion control devices such as vibration dampers.

hardware: Attachments or fittings that are in direct contact with the cable.

maximum hardware safety tension (MHST): This is the maximum hardware tension rating for dead-end hardware to hold all-dielectric self-supporting cable that can exceed the cable maximum rated cable load (MRCL) rating. Maximum hardware safety tension is greater than the maximum loaded tension (MLT) or MRCL and may approach the cable estimated breaking strength. If the hardware tension rating is less than or equal to the cable MRCL then the MLT terminology is used.

maximum installation tension (MIT): This is the initial tension at which the cable is pulled during the sagging portion of the installation process. This tension is used to achieve the appropriate installation sag defined by the manufacturer relative to conductors, other cables, and the ground. *Syn:* **sagging tension**.

NOTE—This is the same as the everyday tension when specified at 16 °C (60 °F).[8]

maximum loaded tension (MLT): The system tension that represents the tension above maximum installation tension (MIT) caused by environmental load conditions such as wind and ice. This tension shall not exceed the cable MRCL or the maximum tension allowed by the hardware (whichever is less). The load is greater than MIT but less than or equal to maximum rated cable load (MRCL). It is also referred to as maximum operating tension or short-term load. It may also be referred to as the National Electric Safety Code® (NESC®) (Accredited Standards Committee C2-2012 [B1]) loaded tension, which corresponds with local regions across the United States that are referenced in the NESC.

NOTE—For example, the MLT may be used in a case where the MRCL is higher than the expected loading on the cable (i.e., a stronger cable used than needed) and lower strength hardware is suitable.

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[6]ISO publications are available from the International Organization for Standardization (http://www.iso.org/) and the American National Standards Institute (http://www.ansi.org/).
[7]*IEEE Standards Dictionary Online* is available at http://dictionary.ieee.org.
[8]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

maximum rated cable load (MRCL): This is the maximum tensile load the cable is designed to withstand during its lifetime without reducing the performance of the optical fibers. This tension rating is determined by the cable manufacturer and is sometimes referred to as maximum rated design tension by the IEEE or the maximum allowed tension by the IEC. MRCL may be expressed in terms of tension or as a percentage of breaking strength. MRCL is typically the load the cable is designed to withstand when the cable is installed in its maximum specified span length while experiencing the maximum specified weather load. The weather load or environmental load factors in local wind and ice load.

NOTE—See Figure 1.

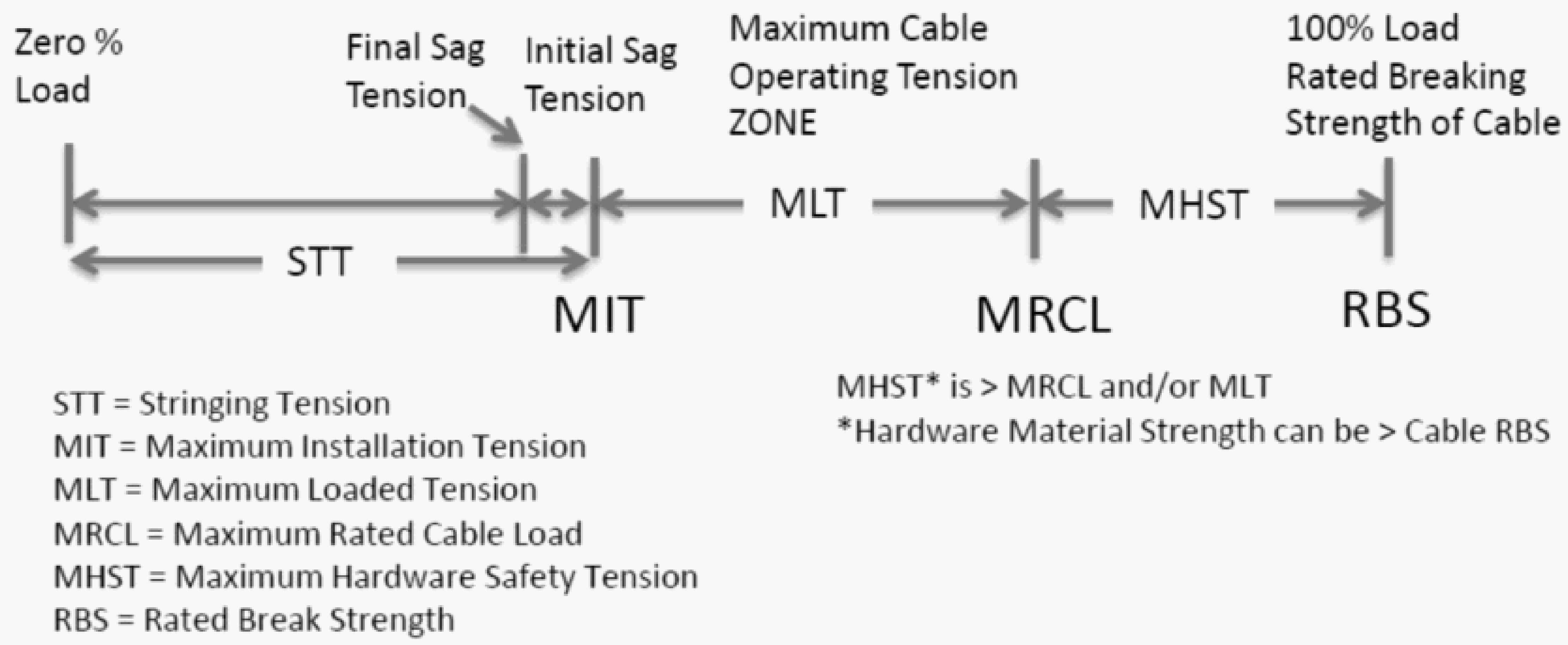

Figure 1—Line graphic of ADSS cable and hardware tension parameters

optical time domain reflectometer (OTDR): Used to determine the degree and location of attenuation in optical fibers by transmitting a light source and measuring time of flight and strength of reflected optical signal.

sagging tension (SAT): *See:* **maximum installation tension**.

standard jacket: The outer plastic layer or protective sheath of an ADSS cable that is designed for applications in lower voltage environments. Cables with standard jackets are identified as Class A and are typically installed in electrical distribution systems.

NOTE—Further information covering the effects on Class A cable from electrical field, space potential, corona, and pollution can be found in the annexes of IEEE Std 1222-2011.[9]

stringing tension (STT): The stringing tension, also known as the pulling tension, is defined as the tension used to pull the cable through sheaves during the stringing portion of the installation process. This should never be greater than the sagging tension or maximum installation tension.

system: The cable and hardware described in this standard function as an integrated unit.

track resistant jacket: The outer plastic layer or protective sheath of an all-dielectric self-supporting cable that is designed for applications in higher voltage environments. Cables with track-resistant jackets are identified as Class B and are typically installed in electrical transmission systems.

NOTE—Further information covering the effects on Class B cable from electrical field stress, space potential, corona, and pollution can be found in the annexes of IEEE Std 1222-2011.

[9]Information on references can be found in Clause 2.

3.2 Electrical definitions

corona: Electrical discharge brought on by the ionization of the air near and around any conductive element caused by the electrical field strength. Corona is pertinent to the standard since it can be generated from the edges of hardware elements attached to the cable.

dry band arcing: When wet pollution on all-dielectric self-supporting cable jacket dries, high resistance dry bands form. Induced voltage of sufficient magnitude across dry bands will produce an arc that can potentially damage the jacket.

electric field: The change in space potential over a change in distance. The basic concept is $\mathbf{E} \cong \mathbf{dV/ds}$ and **E** is a vector that has magnitude and direction. Magnitude is described in units of volts/meter (common abbreviations are V/m, kV/m, and kV/cm). Direction may be in the form of components such as Ex, Ey, and Ez or given by unit direction vectors (Ux, Uy, Uz).

induced voltage (Voc): In this document, Voc refers to the induced voltage across a formed dry band in the absence of an arc, often called "voltage open circuit."

NOTE—For further information, consult Annex D and Annex E of IEEE Std 1222-2011.

pollution index: This is the exponent of the wet pollution linear resistance in ohms/meter. *Example*: An index of 5.7 indicates a resistance of $10^{5.7}$ or 501 kΩ/m.

NOTE—For further information, consult Annex D and Annex E of IEEE Std 1222-2011.

pollution resistance: The wet pollution resistance on the all-dielectric self-supporting (ADSS) jacket surface in ohms/meter. This parameter is used to determine currents in the wet pollution layer as well as for computing dry band arc voltage. These currents and voltages form the basis of the test described in IEEE Std 1222.

NOTE—ADSS cable wet pollution is normally very conductive compared to dry pollution. In general, 108 Ω/m or less is considered conductive. For further information, consult Annex D and Annex E of IEEE Std 1222-2011.

space potential: A level of voltage in space between energized as well as grounded objects (e.g., conductors of a high voltage transmission line and tower members). The magnitude is described in units of volts. Mathematically this is a scalar value. *See:* **electric field**.

surface gradient: Defined as the electric field on a surface. Levels near 20 kV/cm are high enough to breakdown air resulting in corona. *See also:* **electric field**.

3.3 Acronyms and abbreviations

ADSS	all-dielectric self-supporting
MHST	maximum hardware safety tension
MIT	maximum installation tension
MLT	maximum loaded tension
MRCL	maximum rated cable load
RBS	rated break strength
SAT	sagging tension
STT	stringing tension

4. Requirements for ADSS hardware

4.1 General

All ADSS hardware is to be of proper manufacture, unused, and free of defects that could be detrimental to its application.

System testing is typically conducted to demonstrate hardware and ADSS cable compatibility. This standard describes the type of test, performance requirements, and acceptance criteria for respective hardware in Clause 5.

Guidelines for optical measurements are established in 5.2. This subclause is referenced in hardware tests that require optical results as a measure of acceptance.

This standard covers requirements for hardware specifically designed for and in direct contact with ADSS cable such as dead-ends and suspensions. Conventional hardware fittings that do not come in direct contact with the cable such as Y-clevis, extension links, yoke plates, etc., are not covered by this standard.[10]

ADSS hardware design dimension tolerances shall ensure that the product components and interface areas meet their specified mechanical and electrical requirements.

4.2 Functional requirements

4.2.1 ADSS cable diameter and hardware range/interface

Suspension and dead-end hardware, some types of vibration damper hardware, and downlead clamps for ADSS cable are usually designed for a specific (narrow range) size and/or (specific) type of ADSS cable. Hardware is generally not designed to accommodate a large range of sizes or classes/types of ADSS cable.

Factors that can influence the interaction of the hardware to the ADSS cable interface are as follows:

a) Excessive contact pressure imposed by the hardware can impair the optical signal or cause localized mechanical damage or stress risers to the ADSS cable.

b) High voltage environments can induce electrical potential differences causing problems such as tracking or corona. Proper design or application of hardware can mitigate electrically induced damage.

c) Contact between dissimilar materials may cause excessive corrosion in some environments.

d) Hardware surfaces may require coatings or shaping to avoid scoring or cuts into the cable sheath that may lead to exposure of the underlying aramid strength member.

It is therefore recommended that hardware and other accessories connected electrically and mechanically to the ADSS cable be compatible with the ADSS cable being used.

4.2.2 Functions specific to hardware types

4.2.2.1 Dead-ends

The functions specific to dead-end hardware types are as follows:

— Dead-ends are required to hold cable tension as follows:
  — At maximum installation tension (MIT) at maximum elevated temperatures
  — At maximum loaded tension (MLT) of the system if MLT less than or equal to maximum rated cable load (MRCL) at low temperatures that reflect local operating conditions

[10]IEC 61284 [B10] can be used as a reference for conventional fittings.

The user may specify higher hardware or holding strength beyond the parameters above for a factor of safety. This is defined as maximum hardware safety tension (MHST).

— Dead-ends have a provision to transfer cable load to the structure and allow ample distance for cable minimum bend radius.

— Dead-ends may have a provision for strain relief to protect against long-term fatigue.

— Dead-ends may have a method of mechanical protection to prevent crushing at the cable interface.

— Dead-ends may have a provision for ground connection. (See Annex C for further information.)

— Dead-ends shall be specified for the appropriate ADSS cable jacket application (i.e., standard jacket, track resistant jacket, or both).

4.2.2.2 Tangent hardware (suspension, support, and trunnion)

The functions specific to tangent hardware types are as follows:

— Tangent hardware supports or suspends cable from a structure as follows:

  — Suspension hardware typically allows at least two degrees of freedom or cable movement relative to the structure.

  — Support hardware is typically fixed against the structure, not allowing cable movement.

  — Trunnion hardware typically allows one degree of freedom or cable movement. The hardware pivots about an axis perpendicular to the cable axis.

— Tangent hardware is required to support or suspend maximum vertical loads due to environmental conditions on the system.

— Tangent hardware may be required to hold longitudinal tensile loads to meet unbalanced load conditions—load level requirements can vary with span length and cable size or application. Applications may be identified as drop cable, distribution cable, and transmission cable applications.

— Tangent hardware has a provision to transfer cable load to the structure.

— Tangent hardware may have provisions for strain relief to protect against long-term fatigue and excess stress due to turning angles and sag angles.

— Tangent hardware may have a method of mechanical protection to prevent crushing at the cable interface such as armor rods, etc.

— Tangent hardware may have a provision for ground connection. (See Annex C for further information).

4.2.2.3 Damper

The functions specific to damper hardware types are as follows:

— Dampers are required to damp aeolian vibration—a high frequency, low amplitude cable vibration induced by laminar wind flow. This type of motion can be detrimental to the life of the system due to fatigue damage of the cable and/or hardware.

— Methods of mechanical protection may be necessary at the interface to prevent crushing.

— Stockbridge type dampers shall be designed to meet the general requirements of IEC 61897. Stockbridge damper designs typically include damper weights mounted to messenger wire (stranded cable) that is secured to a clamp. The damper clamp provides a method of attaching the damper to the ADSS.

— Impact type dampers (also known as spiral type) made from non-metallic materials shall be designed to survive ultraviolet light exposure and high voltage field conditions. Mitigating the effects of high electrical field strength can be accomplished with proper damper location (see Annex B). The damper shall function without causing damage to the ADSS surface. A provision to secure the damper to the ADSS without damage is required.

4.2.2.4 Come-along or sagging tension device

The functions specific to come-along hardware types or sagging tension devices are as follows:

— Come-alongs are required to hold cable sagging tension.

— Come-alongs have a provision to transfer cable load to the structure or pulling equipment.

4.2.2.5 Corona suppression device

The functions specific to corona suppression devices are as follows:

— In high voltage environments, corona suppression devices are applied to cable attachment hardware in areas susceptible to high electrical stress such as small protrusions or sharp corners. Corona suppression devices reduce electrical stress to help prevent damage from corona on the ADSS cable.

— Corona suppression devices provide a method of attachment to the cable attachment hardware without introducing stress risers and/or damage to the cable jacket.

4.2.2.6 Downlead clamp

The functions specific to downlead clamp hardware types are as follows:

— Downlead clamps train and secure the ADSS along the structure—typically to or from a splice enclosure.

— Downlead clamps shall be made from a material compatible with ADSS plastic jackets.

— Downlead clamps have provisions to mount to various structures.

4.3 Material requirements

4.3.1 Design selection

The material used in the fabrication of the ADSS hardware shall be selected to provide required durability, ductility, and compatibility with ADSS cable material for the system's service life requirements.

In the case of non-metallic material, selection shall be made to withstand degradation due to aging, ultraviolet radiation, and pollution for the expected range of service temperatures. The materials shall not induce corrosion in contact with the attachment hardware or cable.

4.3.2 Finish/workmanship

Material requirements for the finish/workmanship of ADSS hardware are as follows:

— Castings, forgings, and extrusions shall be uniform, without sharp edges or corners, free of cracks, and shall not contain defects to the extent that the strength or suitability is affected.

— Holes shall be cylindrical and clean-cut. Holes in plates or terminal pads may be sub-punched and reamed, drilled, or cast in place. The periphery of the hole shall be free from burrs.

— The finish of all bearing surfaces shall be smooth and contoured and the outer edges and corners shall be rounded as required. The ADSS hardware shall be free of metal particles, dirt, and oils.

— Aluminum oxide grit used to enhance mechanical holding for certain formed wire hardware is not considered a contaminant.

— Marking shall provide manufacturing lot traceability for the product.

4.3.3 Metallic welds

Welding shall be in accordance with AWS D1.1 or an equivalent that meets or exceeds this standard. All welds shall be smooth, uniform, and without overlaps or excessive undercutting. Rough surfaces, scale, slag, and/or splatter shall be removed by grinding, sanding, or other acceptable practices. Distortions and stresses, if occurring due to welding, shall be properly corrected. Welders and welding operators shall be qualified in accordance with AWS D1.1 or an equivalent that meets or exceeds this standard. Proper stress relief methods shall be employed where necessary.

4.3.4 Corrosion resistance protection

Adequate corrosion resistant treatment per 4.4 shall be applied to all ferrous materials as agreed upon by the customer and manufacturer. Special requirements are necessary for threaded fasteners. If no other specifications are referenced, ferrous materials shall be hot-dip galvanized in accordance with ASTM A153 or ISO 1461, or equivalent.

4.4 Environmental corrosion

The hardware shall be able to withstand the natural elements that exist at its installation location. The corrosive nature of installation sites can vary vastly from location to location. Therefore, some hardware designs are more suitable for certain locations than other designs. High corrosion sites such as high-moisture zones, salt water zones, industrial corrosion zones, volcanic sulfur zones, or combinations of zones require special protection from corrosion for the hardware.

4.4.1 Low-corrosion installation sites

These areas are defined as installation locations that have low or very low levels of corrosive materials such as moisture, salts, industrial pollution, volcanic pollution, naturally occurring atmospheric/animal corrosive pollutants, or any combinations of these materials. Care shall still be taken when considering hardware that may be affected by other corrosive or damaging elements such as wind-blown sand.

In general, most types of ADSS hardware defined in this standard can be installed in low-corrosion installation sites. These include, but are not limited to, designs of similar and dissimilar materials such as aluminum, galvanized steel, stainless steel, brass, or copper.

4.4.2 High-corrosion installation sites

These areas are defined as installation locations that contain high or very high levels of corrosive materials such as moisture, salts, industrial pollution, volcanic pollution, naturally occurring atmospheric/animal corrosive pollutants, or any combinations of these or other non-listed corrosive materials. Care shall be taken when considering hardware that may be affected by additional corrosive or damaging products such as agricultural aerial spraying, wind-blown salt and sand, and burning carbons from petrochemical activities, burning agricultural crop fields, forest fires, etc.

Corrosion resistant hardware (CR-hardware) shall pass the qualification tests as described for respective hardware in 5.5.2.3.5, 5.5.3.3.7, 5.5.4.3.3, and 5.5.6.3.2.

Not all types of hardware defined in this standard can be installed in high corrosion installation sites. Only designs that have passed the appropriate CR-hardware corrosion qualification tests can be installed in these locations. This generally includes, but is not limited to, designs that are made of complete or nearly complete similar noble materials as shown in the chemical electromotive series, such as all aluminum, some stainless steels, coated galvanized steel, brass, or copper. Unless they pass the appropriate corrosion qualification test, designs of dissimilar materials as shown in the chemical electromotive series are in general not allowed. Galvanized steels are not normally acceptable in high-corrosion zones; hence the user and manufacturer shall be clear on the limitations of galvanized hardware being supplied for use in high-corrosion zones. New or novel designs can be acceptable if they allow the hardware to pass the appropriate corrosion qualification test.

4.5 Installation

Suppliers shall provide documented procedures and supporting illustrations with the product for proper installation.

5. Tests

The tests described in this standard for ADSS hardware are based on the intended overhead installation of the system. Overhead installations encounter physical phenomena that affect the operation and performance of any line hardware included in the ADSS system.

Testing to this standard is based on design, manufacture, installation, and application variables that may affect the performance of hardware for use on ADSS. As a result, tests were selected to provide some assurance to the user that the hardware is suitable for the expected lifetime of the application.

ADSS hardware shall successfully pass a number of mandatory tests in order to be qualified per this standard. Any test(s) may be waived if an ADSS cable and hardware of sufficiently similar design has been previously tested to demonstrate the hardware and cable compatibility and performance. The definition of "similar design" shall be agreed upon between the supplier and the user.

5.1 Classification of tests

The terms listed in Table 1 are used to classify each test.

Table 1—Classification of tests

Classification of test	Description
Hardware characteristics tests	Determine the characteristics of the ADSS hardware to assist in the design of the line.
Installation tests	Relate to conditions that the hardware may experience under installation conditions.
In-service tests	Relate to conditions that the hardware may experience under in-service conditions.
Electrical tests	Relate to electrical conditions imposed on the hardware.
Mechanical tests	Relate to mechanical conditions imposed on the hardware.
Environmental tests	Relate to environmental conditions imposed on the hardware.
Mandatory tests	Are required in order for hardware to comply with IEEE Std 1591.2.
Conditional tests	May or may not be applicable depending on the hardware/ADSS design, location of installation, etc. A conditional test is not required for the hardware to comply with this standard unless agreed upon by supplier and user.

5.2 General guidelines for optical measurements

A procedure for optical measurements and fiber preparation is described in this subclause for reference throughout this standard. The summary of qualification tests in Table 3 reference this subclause for optical testing in accordance with this paragraph.

An assumption for the tests for this standard is that the cables include the most bend-sensitive fiber for the application. The optical performance of bend-insensitive fiber can mask improper compatibility between cable and hardware. If bend-insensitive fiber is used, this shall be declared to the end user, and special attention shall be paid to mechanical deformities of the optical buffer units.

5.2.1 Procedure for optical measurements and fiber preparation

The parameters specified in this standard may be affected by measurement uncertainty arising from measurement error or calibration error from the lack of suitable standards. Acceptance criteria shall consider this uncertainty. For the purpose of this standard, the total uncertainty shall be considered to be $\leq$0.05 dB for attenuation or $\leq$0.05 dB/km for attenuation coefficient. Any measurement within this range is considered "no change" in attenuation.

Optical fiber performance can generally be performed by the following two methods:

a) Monitor individual fibers for attenuation change: This method can determine the maximum change of any individual fiber tested. When the change for all individually tested fibers is averaged, the "average change" for all fibers can be determined. The minimum number of fibers to be monitored is provided in Table 2.

b) Loop-back measurements: This method splices the fibers under test to each other so that they are concatenated or loop-backed with each other in a continuous length. The attenuation change is determined by dividing the attenuation change across all loop-back fibers under test by the number of loop-backed fibers. This provides an attenuation change per fiber. This result is actually the average attenuation change across all the loop-back fibers. The minimum number of fibers to be monitored is provided in Table 2.

Table 2—Minimum fibers for tests

Cable fiber count	Minimum number of fibers to be spliced and monitored [a]
1–10	All
11–104	10
105–300	10% of cable fiber count
>300	30

[a]An equal number of fibers shall be selected from each optical unit and/or buffer tubes within the optical unit

In the testing standard for ADSS cable (IEEE Std 1222), tests such as crush, low/high temperature bend, twist, cyclic flex, impact, and mid-span buffer tube storage do not specify loop-back testing and instead require the monitoring of individual fibers. Laboratories equipped to monitor fibers individually may find it convenient to measure signal change for each fiber without concatenation for ADSS hardware tests such as suspension unbalanced load, turning angle, or damper clamp bolt tightening test.

Under dynamic test conditions such as Aeolian vibration, loop-back measurements can provide continuous optical monitoring to capture events during the test (whereas monitoring fibers individually may utilize optical switching to intermittently check each fiber during the test). Under less dynamic or point loss tests, the concatenated method may be used with the understanding that the total end-to-end spliced fiber attenuation change shall be less than the maximum individual attenuation fiber specification. If the loop-back measurements exceed the maximum individual attenuation fiber specification, additional testing to isolate individual fibers is necessary to determine if the individual fibers are within the acceptance criteria. For further illustration of loop-back compliance, the following note includes an example:

NOTE—Loop-back testing may determine compliance to a maximum specification if the "total end-to-end loop-back attenuation change" is less than the "maximum individual attenuation fiber specification"; however, if "total end-end-loop-back" measurement is greater than the "maximum individual fiber" specification, it cannot be used to determine a failure to the specification.

For example:

- If the specified maximum individual fiber criteria is equal to 0.10 dB and the average = 0.05 dB.
- Measured end-end attenuation across 10 loop-backed fibers = 0.15 dB = 0.015 dB/fiber. This complies with the 0.05 dB average specification.
- Because 0.15 dB exceeds 0.10 dB maximum individual fiber specification, one cannot determine if this complies with the maximum individual fiber specification. If the end-end attenuation loop-back fiber measurement was 0.09 dB, this could be used to show compliance.

When individual fiber monitoring is performed to determine conformance to the "maximum change" criteria, the average criteria is determined by averaging the individual fiber readings.

When specified by a test method, hardware manufacturers shall determine compliance to both conditions as follows:

- The maximum change from individual fibers that are individually monitored—this requires that individual fibers be monitored during testing.
- The average change across all monitored fibers—the manufacturer is allowed to test by using either of the two test methods: monitoring individual fibers or monitoring loop-back fibers.

Independent third-party test labs may monitor fibers individually or may monitor fibers using the loop-back method. If the loop-back method is used, only the "average" criteria shall be used if it is specified. For tests that do not specify an "average" criterion, the maximum criteria shall be used and compared to the measured per fiber value. Any number of fibers may be tested as long as they meet the minimum number specified in Table 2.

When testing optical fiber, optical measurements shall be made using a light source of the longest nominal operating wavelength of the fiber type (i.e., 1300 nm for multimode and 1550 nm for single mode). Test wavelengths may be measured at other longer wavelengths, with the agreement of the end user and the manufacturer. Longer wavelengths are typically more bend sensitive, and may warrant different acceptance criteria.

When measuring with a power meter, a laser source with the appropriate wavelength is injected into an optical splitter. The splitter divides the source signal into at least two signals. During the test, the optical measuring system (source, splitter, and receiver) shall maintain a certain level of stability in accordance with the test. One of the split signals is sent directly to an optical power meter and serves as the reference signal. The other split signal is used to measure the test fibers. When individual fibers are monitored, it is acceptable to use a switching system. During the tests, the readings from both optical power meters are monitored periodically in a suitable manner for future analysis. Any changes in the difference between the reference and test signals indicate a change in the attenuation in the test fiber. A net increase in attenuation means a loss in the optical signal, and a net decrease in attenuation indicates a gain in the signal.

The following criteria shall be applied when considering the placement of fibers to be tested:

a) Cable type

   Stranded tube designs: For single layer cables, a minimum of two active units should be positioned diametrically opposite each other. For two-layer cables, four units (two in each layer) should be positioned at 90° intervals within a cable. For multi-layer cables, similar reasoning for unit positioning may apply.

   Ribbon designs: The active units should be located in the first, last, and middle positions. At a minimum, active fibers shall be positioned in the edge positions within these ribbons. For cables with multi-stacks, units should be selected from stacks diametrically opposite each other.

b) Core units (i.e., tubes) shall contain a full complement of fibers; however, dummy fibers may be allowed. The working fibers shall be disbursed in the working units. Filler rods may be allowed in place of buffer tubes. The manufacturer shall position the working units within a cable so that these units will be subjected to the full force of the testing stresses. The manufacturer shall demonstrate theoretically or through testing that the positioning of the test fibers is representative of the performance of all the fibers within the cable.

For tests where the ADSS is subjected to tension, the samples are terminated in a manner such that the optical fibers at both ends of the sample cannot move relative to the ADSS cable. Although other arrangements may be used, an example of an arrangement for preparing loops between the test sample and the fiber splice tray is shown in Figure 2. Three loops of cable with a diameter of 1 m are formed and secured as close as possible to the dead-end tension clamps. Another three loops of the fiber optic unit only are formed just in front of the splice tray. This configuration will help ensure that all non-metallic and fiber components are prevented from relative movement during the test.

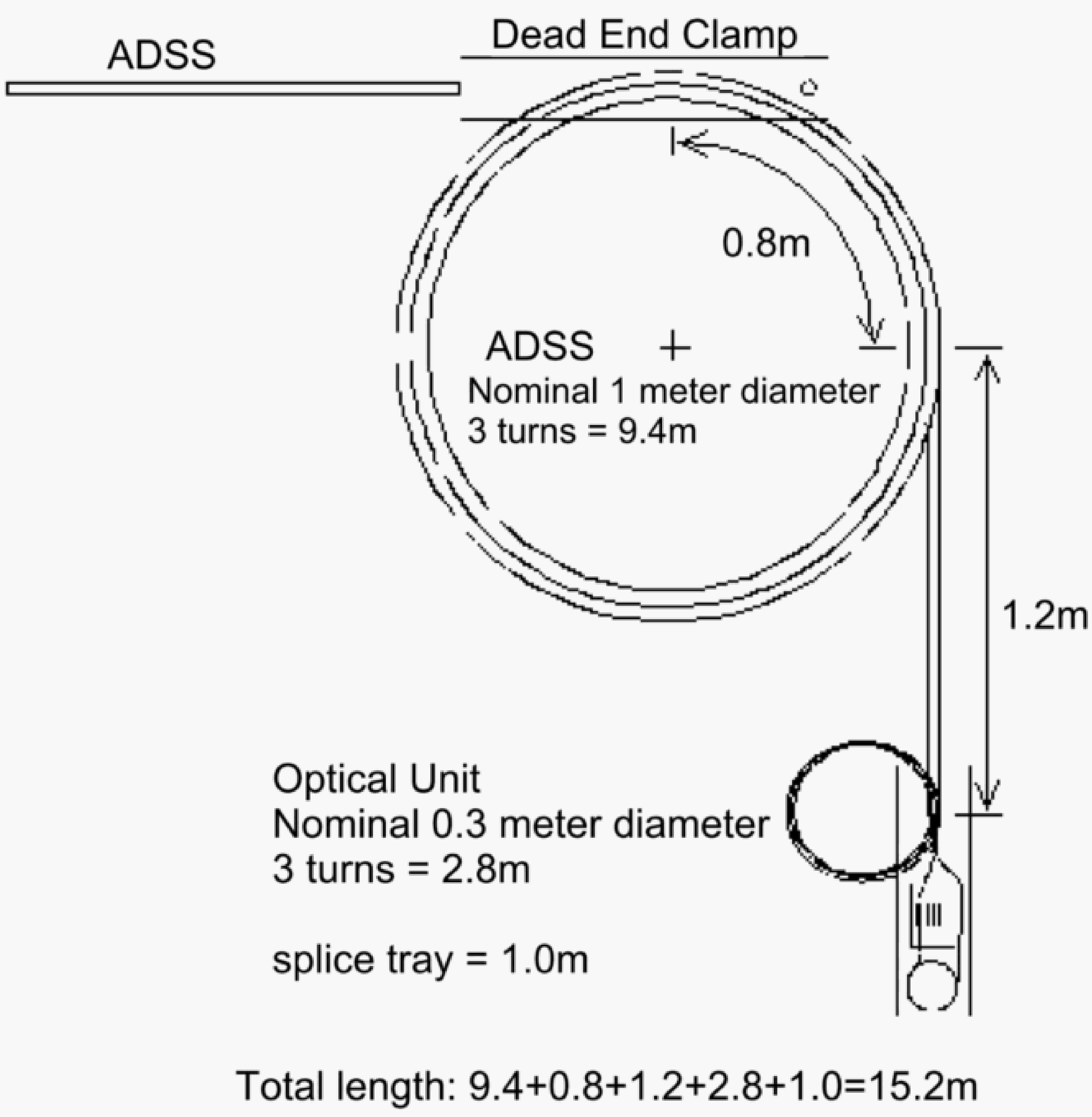

Figure 2—Test sample termination arrangement

5.2.2 Acceptance criteria

Unless otherwise stated, a permanent or temporary increase in optical attenuation greater than 0.1 dB/km within the cable and hardware test sample under test at nominally 1550 nm for concatenated single mode fibers shall constitute failure. When measuring fibers not concatenated, the maximum individual fiber attenuation shall not exceed 0.1 dB at 1550 nm for single mode fiber and the average increase of all fibers under test shall not exceed 0.05 dB per fiber, unless otherwise stated.

As mentioned in 5.2.1, for tests that apply static load with potential point losses (such as suspension unbalanced load, turning angle, or damper clamp bolt tightening), laboratories may elect to measure fibers individually without concatenation and use the decibel loss criteria in the previous paragraph. If, however, they choose the concatenated method, the same criteria applies with the exception that if the concatenated fiber exceeds 0.1 dB, further evaluation by separating the concatenated fiber may be necessary to measure the fibers individually and assure they are within the individual fiber criteria.

5.3 Retesting

In the event of a failure, a review of the product and test set-up is recommended. If an anomaly is discovered, the test may be repeated if mutually agreed upon by the purchaser and the supplier.

5.4 Sample selection for hardware characteristics tests

A hardware product line (hardware type for given application/strength/span length range that is developed for multiple ADSS cable sizes) of three sizes or less intended to be used on a line of ADSS (an ADSS cable design with multiple sizes) may be qualified to this standard by testing the largest and smallest hardware sizes within the hardware line. Testing the intermediate size is optional.

Hardware product lines with four or more distinct sizes for use on a line of ADSS shall have the largest, smallest, and one intermediate size tested per this standard.

Range taking hardware (single hardware size for use on multiple ADSS cable sizes) shall meet the requirements throughout the range specified. Availability of cable designs may limit testing within the range specified, however it is preferred to test the maximum and minimum of the range for verification.

Minimum sample quantities to be used for each size and each range are provided in Table 3 and within the associated test method subclause of this standard.

A line of hardware tested with one type of ADSS may be considered qualified for other types of ADSS product lines after review. The review can include the following considerations for ADSS comparison:

— ADSS specifications including cable diameter, jacket construction, cable core construction, mechanical characteristics, dry band arcing resistance. Round ADSS cable is shown in Figure 3.

— ADSS conformance to IEEE Std 1222.

— Quality control of materials and processes.

— History of proposed ADSS design or similarities to an existing design in the industry.

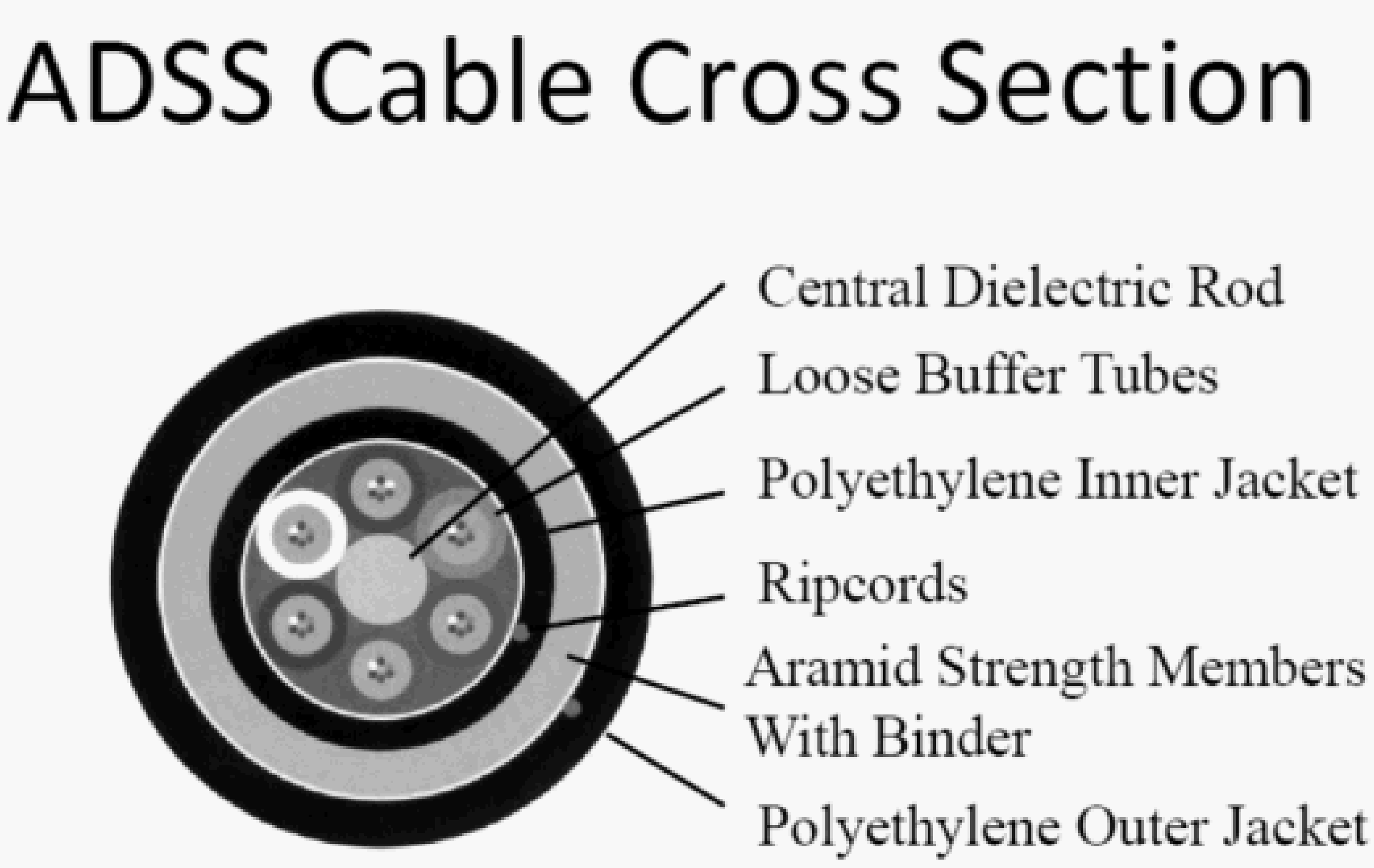

Figure 3—Elements of ADSS cable construction

5.5 Qualification tests

5.5.1 Qualification test summary

The listing of the tests to be performed for the specific types of hardware is given in Table 3. Tests can be performed on isolated hardware (I) or as a system (S) (hardware and cable) when appropriate, as shown in Table 3 and described in the identified test subclause. The minimum number of samples for each test are listed as well. More than one test sample may be required to demonstrate repeatability of results.

Table 3—Qualification test sequence and sample quantities

Hardware type	Test	Subclause	Optical evaluation required	System (S) or isolated (I) test	Minimum quantity of samples per test[a]
Dead-end	Tensile test (A) Tension to MLT/MRCL (B) Tension to MHST/Ultimate	5.5.2.1.1	Test (A) Yes—subclause 5.2 and acceptance criteria (a), Test (B) optional—subclause 5.2 and acceptance criteria (g)	S	1
	Aeolian vibration	5.5.2.3.2	Yes—subclause 5.2 and acceptance criteria (b)	S	1
	Galloping (conditional)	5.5.2.3.3	Yes—subclause 5.2 and acceptance criteria (b)	S	1
	Corona mitigation (conditional)	5.5.2.3.4.	No	S or I	1
	Corrosion (conditional) (material compatibility)	5.5.2.3.5	No	S or I	1
Tangent hardware (suspensions, supports, and trunnions)	Vertical load	5.5.3.1.1	No	I	2
	Turning angle	5.5.3.1.2	Yes—subclause 5.2 and acceptance criteria (a)	S	1
	Unbalanced load	5.5.3.3.3	Yes—subclause 5.2 and acceptance criteria (a)	S	3
	Aeolian vibration	5.5.3.3.4	Yes—subclause 5.2 and acceptance criteria (b)	S	1
	Galloping (conditional)	5.5.3.3.5	Yes—subclause 5.2 and acceptance criteria (b)	S	1
	Corona mitigation (conditional)	5.5.3.3.6	No	S or I	1
	Corrosion (conditional)	5.5.3.3.7	No	S or I	1
	Stringing (conditional)	5.5.3.3.8	Yes—subclause 5.2 and acceptance criteria (a)	S	1

Table continues

Table 3—Qualification test sequence and sample quantities *(continued)*

Hardware type	Test	Subclause	Optical evaluation required	System (S) or isolated (I) test	Minimum quantity of samples per test[a]
Dampers: stockbridge type	Clamp slip test	5.5.4	Yes—subclause 5.2 and Table 5—acceptance criteria (1)	S	Per IEC 61897
	Breakaway bolt test		No	I	
	Clamp bolt tightening test		Yes—subclause 5.2 and Table 5—acceptance criteria (1)	S	
	Corona and RIV tests		No	S	
	Damper performance test		No	S	
	Damper fatigue test		No	S or I	
	Corrosion	5.5.4.3.3	No	S	
Dampers: impact type	Power dissipation	5.5.4.1.1	No	S	3
	UVA exposure	5.5.4.1.2	No	S	3
	Crush	5.5.4.2.1	Yes—subclause 5.2 and acceptance criteria (b)	S	1
	Corrosion (conditional)	5.5.4.3.3	No	S or I	1
Come-along	Crush	5.5.5.2.1	Yes—subclause 5.2 and acceptance criteria (b)	S	1
	Tensile	5.5.5.3.1	No	S	1
Corona suppression device	Corona mitigation	Annex A	No	S or I	1
Download clamps	Crush	5.5.6.2.1	No	S	1
	Slip test	5.5.6.3.1	No	S	2
	Corrosion (optional)	5.5.6.3.2	No	S or I	1

[a]These are the minimum quantity of hardware samples of each design size and ADSS combination being tested. Sample guidelines for product lines and ranges can be found in 5.4.

Table 4 classifies the qualification tests for each hardware type. The key classifications drawn from 5.1 include hardware characteristics, installation tests, and in-service tests. Beginning with 5.5.2, qualification tests are organized according to the key classifications for each hardware type within this document.

Table 4—Classification of tests for hardware type

Hardware type (subclause)	Test classification and test clause		
	Hardware characteristics	**Installation tests**	**In-service**
Dead-end (5.5.2)	Tensile test A (MIT, MRCL) and B (MHST, breaking strength) 5.5.2.1.1	Tensile test A (MIT) 5.5.2.2.1	Tensile test (MIT, MRCL, MHST, breaking strength) 5.5.2.3.1
			Aeolian vibration 5.5.2.3.2
			Galloping 5.5.2.3.3
			Corona mitigation 5.5.2.3.4 (Annex A)
			Corrosion 5.5.2.3.5
Tangent hardware (suspensions, supports, and trunions) (5.5.3)	Vertical load 5.5.3.1.1		Vertical load 5.5.3.3.1
	Turning angle 5.5.3.1.2	Turning angle 5.5.3.2.1	Turning angle 5.5.3.3.2
			Unbalanced load 5.5.3.3.3
			Aeolian vibration 5.5.3.3.4
			Galloping 5.5.3.3.5
			Corona mitigation 5.5.3.3.6 (Annex A)
			Corrosion 5.5.3.3.7
			Stringing 5.5.3.3.8
Dampers: stockbridge type (5.5.4)	See Table 5	See Table 5	See Table 5
Dampers: impact type (5.5.4)	Power dissipation 5.5.4.1.1		Power dissipation 5.5.4.3.1
	UVA exposure 5.5.4.1.2		UVA exposure 5.5.4.3.2
			Corrosion 5.5.4.3.3
		Crush 5.5.4.2.1	Electrical Effects—Ref. (Annex B)
Come-along (5.5.5)			Tensile test 5.5.5.3.1
		Crush 5.5.5.2.1	
Corona suppression device (Annex A)	Corona mitigation (Annex A)		Corona mitigation (Annex A)
Downlead clamps (5.5.6)			Slip test 5.5.6.3.1
			Corrosion 5.5.6.3.2
		Crush 5.5.6.2.1	

5.5.2 Dead-ends

Dead-ends are designed to hold cable MIT at elevated temperatures and MLT at temperatures expected under local environmental conditions without introducing unacceptable levels of optical attenuation. The user may specify MHST that by definition exceeds the cable MRCL and possibly approach the cable breaking strength. Tension above MRCL can permanently reduce optical performance or fiber lifetime, thus only mechanical performance is verified. The dead-end shall terminate the tensioned span of cable, and allow proper grounding (where applicable) of the ADSS cable. Some of the tests for qualifying dead-ends may be performed individually or, when suitable, as a system (specified in Table 3). Tests for dead-ends (as well as all hardware covered in this standard) are summarized in Table 4.

5.5.2.1 Hardware characteristics tests

5.5.2.1.1 Tensile (dead-end)

5.5.2.1.1.1 General

Classification

Hardware characteristics/Installation tests/In-service test/Mechanical/Environmental/Mandatory

Intent

The tensile test is a mechanical and optical test designed to simulate performance under various tensile load conditions, and to demonstrate the ability of the system to reach its MRCL or MLT rating without introducing unacceptable signal attenuation while maintaining its mechanical integrity. This test, by its nature, also tests in service crush forces of the dead-end during load conditions.

Tensile loading in overhead applications is a function of installation tension as well as tension due to environmental and seasonal factors. Testing at MIT and elevated temperatures is necessary to demonstrate hardware performance on softening plastic jacket material. Testing at higher loads approaching MRCL is necessary to demonstrate hardware performance under loads produced by wind and/or ice loading. Cycling the tensile load is included to demonstrate the effects of environmental and seasonal conditions that can cause load fluctuation. Testing above MRCL to an MHST may be required to determine the rated holding strength of the dead-end to verify mechanical performance. Optical monitoring above MRCL is not required as the optical fibers are not expected to function properly; however, monitoring can demonstrate reaction to hardware at the excess load condition.

Objective

The tensile test subjects the sample dead-end hardware to various tensile loads to help ensure the following:

a) Hardware and ADSS cable reach MIT and MLT (or MRCL) at respective temperature conditions.

b) The optical signal integrity is not adversely affected beyond acceptable limits under tensile loading up to MLT (or MRCL).

c) The hardware is mechanically sound for overhead loading applications up to MLT (or MRCL) and above if specified.

d) The ADSS is not damaged by the hardware beyond acceptable limits.

Set-up

Measure the diameter of the cable in an area designated for dead-end placement. These measurements shall be performed and marked at three locations on the cable that will be under pressure within the length of the dead-end; one near each end and one near the middle. Each measurement shall include the maximum and minimum for each location. The dead-ends shall then be installed per the manufacturer's standard practice. For optical attenuation measurements, the ADSS cable shall be prepared according to Table 3 with the adequate cable length extended beyond the exterior edge of each dead-end.

The terminated ADSS test sample shall be installed in a suitable tensile test machine and heat chamber. The heat chamber encloses one dead-end completely, whereas the other dead-end remains at room temperature outside the chamber. The length of the cable between the inner edges of the dead-ends shall be a minimum of 10 m (Figure 4) for samples that are optically tested. Mechanical tensile tests without fiber optic monitoring require 3 m minimum length between the dead-ends and 3 m beyond each cable termination coiled in a loop similar to that shown in Figure 1. The test sample shall be preloaded to 5% of MRCL. Place thermocouples to monitor the cable jacket, dead-end near the cable surface, and ambient temperature within the chamber. Place reference marks on the ADSS cable at the inner and outer edges of each dead-end and measure the cable outer diameter near each end of the dead-end—recording the minimum and maximum for each location. The markings help to visually monitor relative movement and the measurements are used to compare before and after results. A suitable transducer such as a load cell or dynamometer shall be used to measure the tension in the test sample.

NOTE—The intent of the optical test is to have 100 m of fiber under strain. If test bed does not allow 10 m between dead-ends, shorter length and additional numbers of fibers under strain may be concatenated. The minimum length between dead-ends is 3 m.

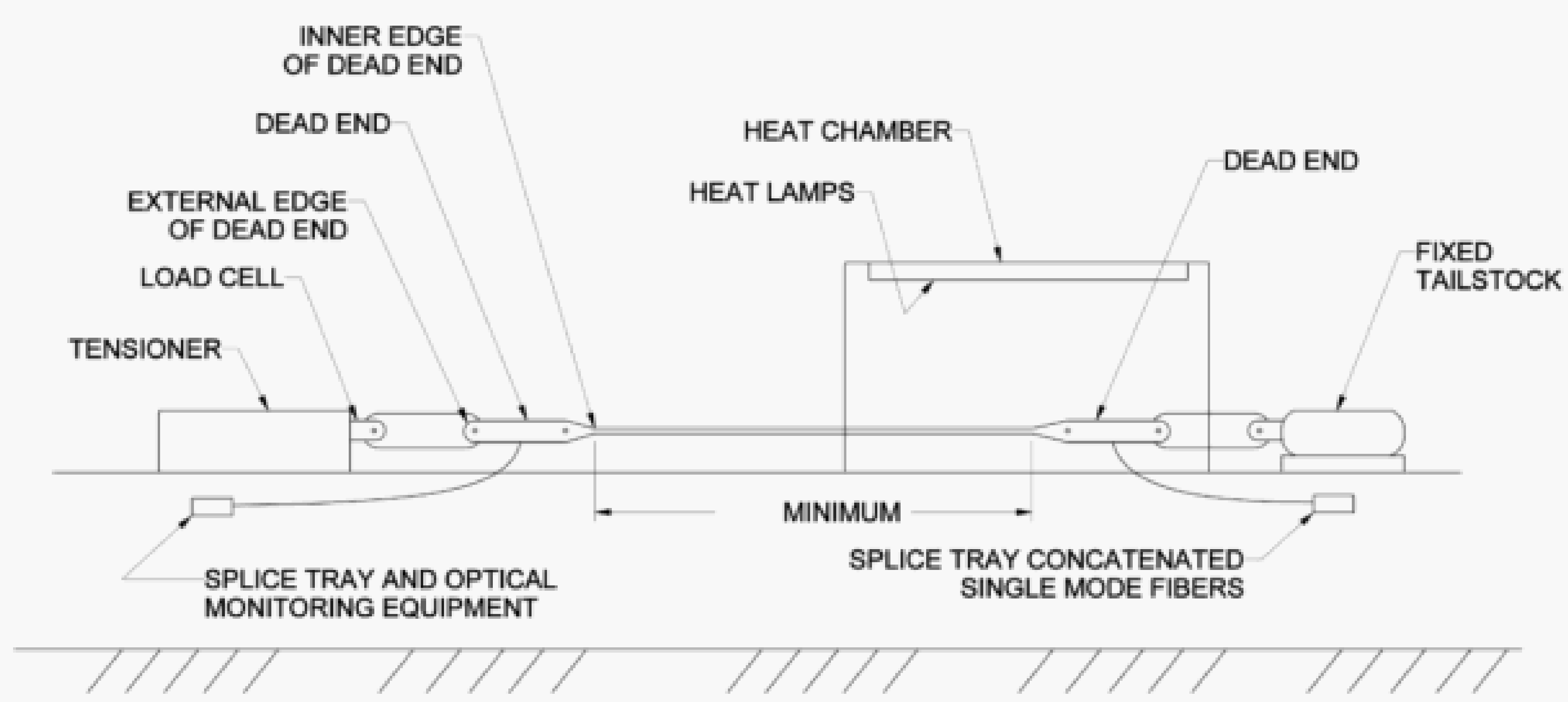

Figure 4—General arrangement for tensile test with optical monitoring

5.5.2.1.1.2 Procedure

5.5.2.1.1.2.1 General

Test A is conducted for standard tension requirements to MLT not to exceed MRCL. Test B is conducted to verify customer specified load of MHST above MRCL that may conform to customer's hardware strength and/or holding standards. In addition, test B is run to determine ultimate tensile load of the dead-end and cable system, and the failure mode.

5.5.2.1.1.2.2 Tensile test A—Tension to MLT or MRCL

Test samples for tensile test A shall be tensioned at a rate of 20% MRCL per minute and optically monitored during the following test sequence:

a) Preload to 5.0% MRCL and measure the optical signal.

b) Increase load to MIT and hold for 24 h at 60 °C ± 3 °C jacket temperature. Record optical signal at the beginning and end of hold.

c) Reduce load to 5% MRCL and allow to cool for 4 h minimum at room temperature (23 °C ± 5 °C). Record optical signal before proceeding to the next step.

d) Increase to the MLT (not to exceed MRCL) and sustain load for 1 h at room temperature. Record optical signal at end of hold.

e) Reduce load to MIT for 5 min at room temperature. Record optical signal at end of hold.

f) Repeat step d).

g) Repeat step e).

h) Repeat step d).

i) Repeat step e).

j) Upon completion of step i), reduce load to near zero and measure the cable diameter as before at the ends of the dead-end. Remove the dead-ends to expose the premarked locations and repeat cable diameter measurements. Record visual observations of the cable jacket condition. This step shall be completed within 0.5 h of the last step.

k) If attenuation exceeded acceptance level during the test, upon completion of step j), begin dissecting the cable by carefully removing the cable jacket, but transfer all five premarked locations for the test dead-end to the underlying buffer tubes. The locations represent three that were under the dead-end and two that were just beyond the ends of the dead-end (not covered by the dead-end). Note any distinguishing characteristics of the dead-end relative to the orientation of the buffer tubes and record observations. Unwrap the buffer tubes to record observations at each of the five previously designated locations. This step shall be completed within 0.5 h of the last step.

In the example shown in Figure 5, MIT is 20% of MRCL and MLT is 90% of MRCL. MIT and MLT shall be specified by the user.

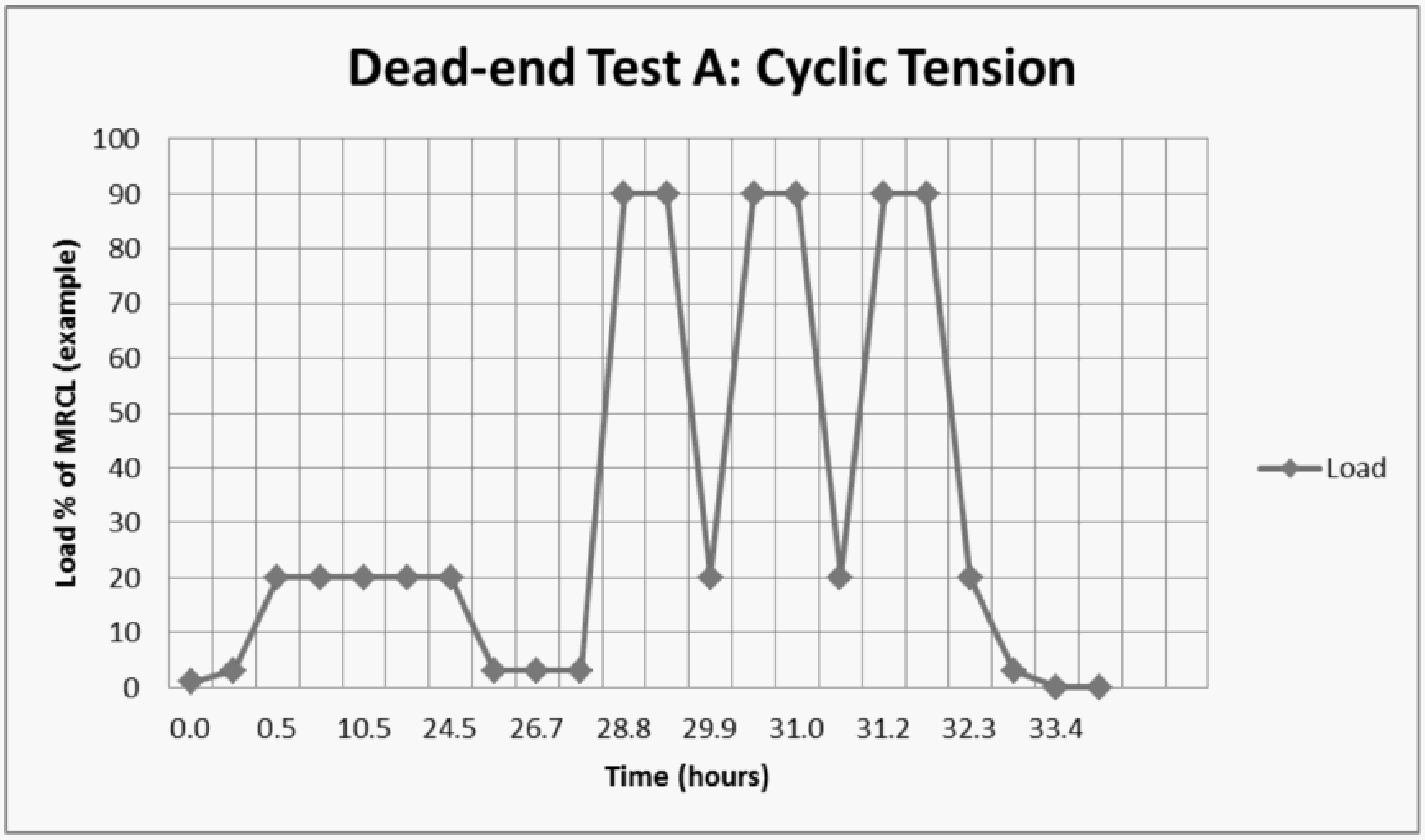

Figure 5—Example of graphical representation of dead-end test A

5.5.2.1.1.2.3 Tensile test B—Tension to MHST and/or ultimate tension

Test samples for tensile test B shall be tensioned at a rate of 20% MRCL per minute. Optical monitoring is optional.

a) Preload to 5.0% MRCL. Record optical signal if monitoring optics.

b) Increase load to MLT (not to exceed MRCL) and hold for 1 h at room temperature (23 °C ± 5 °C). Record optical signal at the end of hold if monitoring optics. If only mechanical results without optical data are required, proceed to step h).

c) Reduce load to MIT at room temperature. Record optical signal before proceeding to the next step.

d) Increase to the MLT (not to exceed MRCL) and sustain load for 0.5 h at room temperature. Record optical signal at end of hold.

e) Reduce load to MIT for 5 min at room temperature. Record optical signal at end of hold.

f) Repeat step d).

g) Repeat step e).

h) If a higher load is specified (MHST), increase at a rate of 20% MRCL strength per minute and hold tension for 1 h at room temperature. Monitoring optics above MRCL is optional for informational purposes. If a higher load is not specified, proceed to step i).

i) Increase load at a rate of 20% MRCL strength/minute minimum until mechanical failure occurs. Record the maximum load and elongation at failure and visual observations. Dissection and monitoring optics above MRCL is optional for informational purposes.

5.5.2.1.1.3 Acceptance criteria

The acceptance criteria are as follows:

a) The test sample shall show no permanent increase in optical attenuation greater than 0.05 dB/fiber from preload to MIT after heat soak cycle. The test sample shall show no permanent increase in optical attenuation greater than 0.10 dB/ fiber from preload to the MLT of the cable at 1550 nm ± 20 nm for single-mode fibers and at 1300 nm for multimode fibers. The minimum length of 100 m shall be measured for each case.

b) The tested samples shall survive the mechanical loading with no more than 50 mm at MRCL of relative movement in relation to the pre-marked ADSS cable at the internal and external edge of the dead-end, and shall exhibit no signs of damage such as breaking or cracking of the dead-end or cable at any time during the tensile load testing up to MLT not to exceed MRCL.

   NOTE—Certain style designs may exhibit "seating" characteristics during this test where the cable moves initially with respect to the dead-end components. In these cases, the allowable movement of the cable relative to the components shall not exceed the manufacturer's stated maximum value.

c) The cable and hardware shall pass test A.

d) In test B, for specified higher load (MHST) the tested samples shall not exhibit signs of slipping (beyond 75 mm), cracking, breaking, or jacket damage at any time during the tensile load testing up to MHST.

e) In test B, without a specified MHST the ultimate tensile load shall exceed the system requirements of MLT and/or MRCL as specified by the user.

f) In test B, if optical monitoring is performed, acceptance criteria "a" applies for tensile load up to MLT, not to exceed MRCL. Reaction of the optical signal monitored above MRCL may be recorded for informational purposes.

5.5.2.2 Installation tests

5.5.2.2.1 Tensile (dead-end)

Tension to MIT test A covered in 5.5.2.1.1.

5.5.2.3 In-service tests

5.5.2.3.1 Tensile (dead-end)

Same as test in 5.5.2.1.1.

5.5.2.3.2 Aeolian vibration (dead-end)

5.5.2.3.2.1 General

The Aeolian vibration test can be run for dead-ends and suspensions simultaneously.

Classification

In-service test/Mechanical/Environmental/Mandatory

Intent

The intent of the Aeolian vibration test is to subject the ADSS cable and hardware to Aeolian vibrations. This type of vibration is caused by laminar wind flow as it passes over bare cable and is a common occurrence in the field. Aeolian vibration motion can fatigue components of the cable and/or hardware at attachment locations. Aeolian vibration may adversely affect the optical signals of the cable as well. It is the intent that this test method is the same as in IEEE Std 1222.

Objective

Sample hardware is subjected to the effects of vibration to verify the following:

a) The hardware is mechanically sound to withstand a referenced level of vibration cycling associated with overhead applications.

b) The mechanical performance of the ADSS is not damaged by the hardware when subjected to the specified vibration conditions.

c) The optical performance of the ADSS is not adversely affected by the hardware when subjected to the specified vibration conditions.

Set-up

The general arrangement to be used for the Aeolian vibration tests and support details are shown in Figure 6. Figure 6 depicts the industry accepted practice of testing dead-ends and suspensions simultaneously.

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 the next paragraph and in Figure 6. 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. For most of the test, the cable is tensioned to 100% of the rated MIT. A thermocouple shall be used to measure the air temperature.

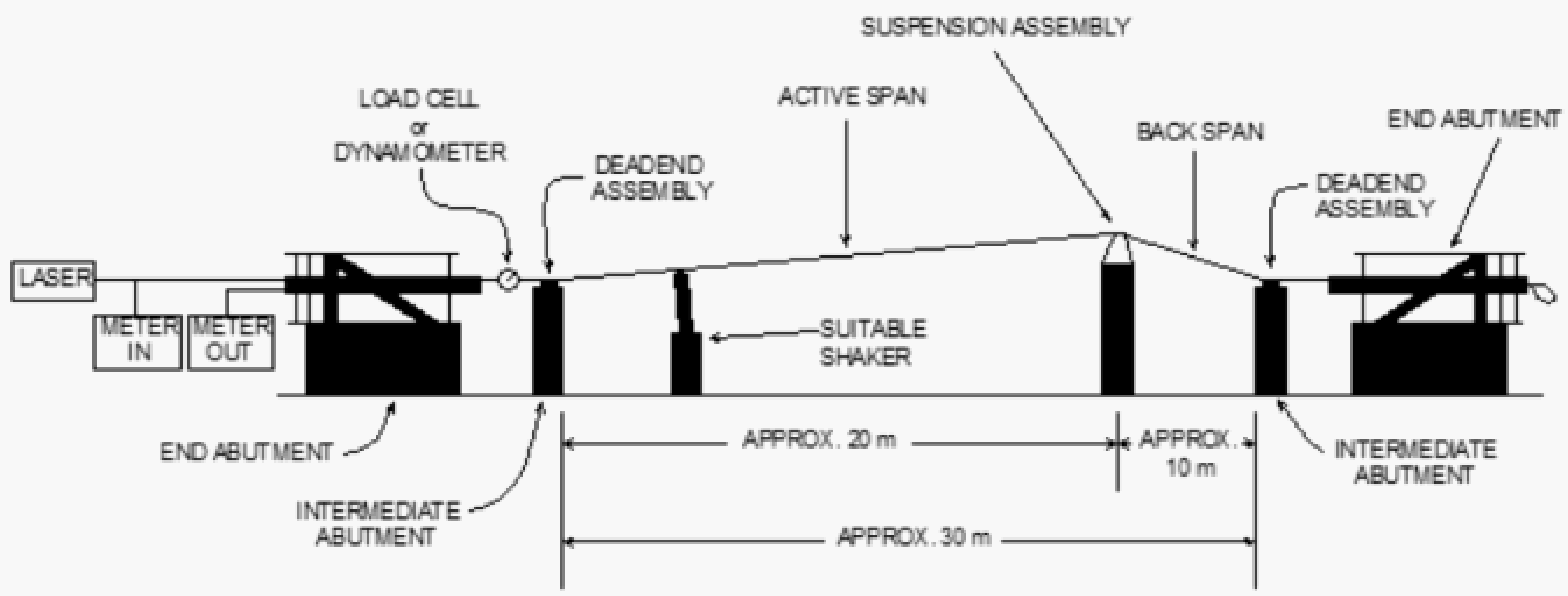

Figure 6—General arrangement for Aeolian vibration test

In order to achieve repeatability of test results, the active span should be approximately 20 m or more, with a suitable suspension (tangent) 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 6.) The vibration amplitude in the back-span shall be significantly less than the activity of the active span (e.g., less than 15%). The suspension assembly shall be supported at a height such that the static sag angle of the cable to horizontal is 1.75° ± 0.75° in the active span.

A laser micrometer or other suitable means shall be provided for measuring and monitoring the mid-loop (anti-node) vibration amplitude at a free loop, not a support loop.

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 in accordance with Table 3. 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 1300 nm nominal for multimode fiber. Test wavelengths may be measured at other nominal wavelengths with the agreement of end users and the manufacturer.

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 pre-tensioned to approximately 10% of MIT prior to final tensioning to MIT. 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 optical power signals, peak-to-peak free loop amplitude, vibration frequency, number of cycles, cable tension, and air temperature shall be recorded at periodic intervals by a suitable data logging system.

5.5.2.3.2.2 Procedure

The ADSS shall be tensioned to the MIT ±5% and the exit angles of the cable from the suspension clamp measured.

The cable shall be subjected to a minimum of one hundred 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/h wind (i.e., frequency = 82.92 ÷ diameter of cable in centimeters). The free loop peak-to-peak anti-node 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 min 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 15 min after the completion of the vibration test. Note that IEEE Std 1222 requires 2 h (it is expected to be reduced in the next update). After completion of the Aeolian vibration test, a section of cable from the location of the hardware dead-end in the active span shall be loaded to the MRCL to verify mechanical integrity. The section of cable having tangent hardware may also be included in the section to verify mechanical integrity of the cable for both areas.

5.5.2.3.2.3 Acceptance criteria

The acceptance criteria are as follows:

a) Any cracking or breaking of any component of the ADSS cable or the hardware shall constitute failure. This assessment is made with the naked eye. Each hardware sample shall be removed to do a complete visual inspection.

b) A permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at nominal wavelength 1550 nm for single-mode fiber and 1300 nm for multimode fiber shall constitute failure.

5.5.2.3.3 Galloping (dead-end)

5.5.2.3.3.1 General

The galloping test requirements are optional for qualifying dead-ends to this standard. In general, ADSS is not specifically designed to withstand the rigors of galloping. In the event the effects of galloping need to be investigated, the following tests and criteria apply.

Classification

In-service test/Mechanical/Conditional

Intent

The intent of the galloping test is to subject the ADSS cable and support hardware to galloping motions. This type of conductor motion is caused by the wind as it passes over round profile cables that have been iced or cables with oblong shapes (e.g., as flat or figure eight). Fatigue or other damage can occur on the components of the cable, hardware, and/or to the structure. The optical signals may also be adversely affected by galloping. It is the intent that this test method is the same as in IEEE Std 1222.

The galloping test is an optical and mechanical test conducted to simulate the effects of low frequency, high-amplitude motion on ADSS hardware.

Objective

The galloping test subjects the sample dead-ends to high amplitude vibration loads to help ensure the following:

a) The optical signal integrity is not adversely affected beyond acceptable limits as a result of mechanical degradation due to hardware induced stress.

b) The hardware is mechanically sound to withstand high amplitude vibration cycling associated with overhead applications.

c) The ADSS cable is not damaged by the hardware beyond acceptable limits.

Set-up

The general arrangement to be used for the galloping test is shown in Figure 7.

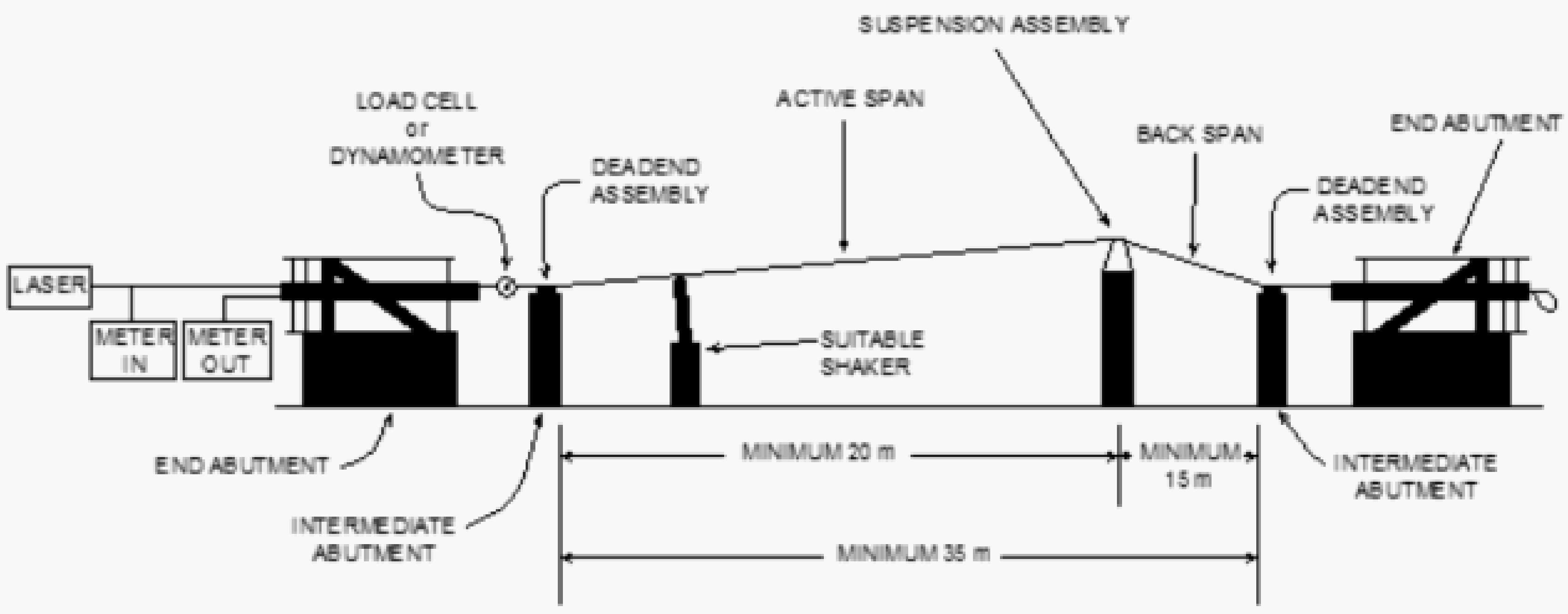

Figure 7—General arrangement for galloping test

The overall span between dead-end assemblies should be a minimum of 35 m. For free tangent hardware with higher degrees of freedom (such as suspensions), the length of the active span and back span are typically equal to achieve consistent galloping motion. Certain fixed tangents such as supports can prevent the galloping motion from passing through to the back span thus the back span may be shortened. 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 the next paragraph and in Figure 7. 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 MIT (also called maximum sagging tension) or a maximum of 500 kg. (For some cable designs, the test tension may need to be lowered to 250 kg in order to induce galloping. For these designs, the 250 kg test tension is acceptable.)

A suitable suspension (tangent) 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 shall not exceed one degree.

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

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 cable shall be prepared for optical attenuation measurements as described in Table 3. 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 1300 nm nominal for multimode fiber. Test wavelengths may be measured at other nominal wavelengths with the agreement of the end users and the manufacturer. 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 pre-tensioned to approximately 5% of MIT prior to final tensioning to MIT. 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 free loop peak-to-peak antinode amplitude, galloping frequency, optical power signals, tension, and number of cycles shall be recorded at periodic intervals. They may be recorded manually or with a data logging system.

5.5.2.3.3.2 Procedure

The cable shall be subjected to a minimum of one hundred thousand galloping cycles. The test frequency shall be the single loop resonant frequency. The minimum peak-to-peak anti-node 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 monitored beginning at least 1 h before the test.

A final optical measurement shall be taken at least 15 min after the completion of the galloping test. Note that IEEE Std 1222 requires 2 h (it is expected to be reduced in the next update). After completion of the galloping test, a section of cable from the location of the hardware dead-end in the active span shall be loaded to the MRCL to verify mechanical integrity. The cable section having tangent hardware may also be included in the section to verify mechanical integrity of the cable for both areas.

5.5.2.3.3.3 Acceptance criteria

The acceptance criteria are as follows:

a) At the completion of all vibration cycling and optical test requirements, the hardware shall be removed and the ADSS cable shall be visually inspected for damage at the hardware location(s). Any cracking or breaking of any component of the ADSS cable or supporting hardware shall constitute failure. Any damage to the hardware samples tested that is not a function of installation or removal shall also constitute a failure. This assessment is made with the naked eye.

b) A permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at nominal wavelength 1550 nm for single mode fiber and 1300 nm for multimode fiber shall constitute failure.

5.5.2.3.4 Corona mitigation (dead-end [see Annex A])

Testing for corona mitigation

5.5.2.3.5 Corrosion (dead-end)

5.5.2.3.5.1 General

The test described in this subclause focuses on hardware corrosion. A similar approach may be used to test the hardware and ADSS cable system to determine compatibility.

Classification

In-service/ Environmental/Conditional

Intent

To subject the hardware to an accelerated salt fog corrosion test that may be experienced in the field.

Objective

The objective of this test is to determine the effects of a controlled salt atmosphere on the hardware sample.

Set-up

This test is a 1000 h saltbox spray test. The hardware samples shall be placed uniformly into the box for testing. In the event that hardware samples exceed the length of the test chamber, the samples may be cut to fit. The cut ends shall be protected (sealed) from exposure within 76 mm from the cut end. The final configuration of the sample shall be agreed upon between the user and supplier.

5.5.2.3.5.2 Procedure

The procedure is as follows:

a) The hardware test samples are to be placed into a standard salt spray-testing box as defined by ASTM B117 and ISO 9227. The hardware samples are to be placed horizontally in the test chamber to simulate a standard horizontally suspended hardware position. The test is to run continuously for 1000 h of salt spray testing.

g) For system testing, install hardware onto a short piece of ADSS and perform the same test. The ADSS cut cable ends shall be protected or drawn outside the chamber to avoid salt fog exposure.

5.5.2.3.5.3 Acceptance criteria

At the end of the test, the hardware is to be removed and dissected for corrosion damage. The hardware passes the test if the following criteria are met:

a) For coated samples (galvanized steel, aluminum coated steel, copper coated steel, etc.), there shall be no locations where the samples have been pitted so as to expose the underlying strength member in any way.

b) There are no locations where solid aluminum, stainless steel, brass or copper, hardware that have been point pitted beyond a depth of 10% of the total hardware thickness cross-section of the hardware at the point of the pit.

c) There shall be no damage to the hardware and cable and hardware system such that it may affect the operation of the cable.

d) In the case of "other hardware designs that are new or novel," there can be no removal of the coating or material thicknesses in any way. The functionality of the hardware and its usability to perform its intended application cannot be altered or changed in any manner.

5.5.3 Tangent hardware: Suspensions, supports, and trunnions

5.5.3.1 Hardware characteristics tests

5.5.3.1.1 Vertical load (tangent hardware)

5.5.3.1.1.1 General

Tangent hardware is designed to support vertical loads resulting from system cable weight and environmental load conditions. Hardware vertical load demand can increase significantly in areas with extreme ice and wind loading conditions.

Classification

Hardware Characteristics/In-service/Mechanical/Environmental/Mandatory

Intent

The intent of the vertical load test is to verify the manufacturer's strength rating of the hardware. Vertical load testing can simulate potential field conditions of extreme ice and wind loading. The angle Θ in Figure 7 is defined as the maximum turning angle specified by the manufacturer. This angle is used when testing with flexible members that simulate cable—another option is to test with a rigid bar (in place of the flexible member) to reach the maximum vertical load rating. This test is purely a mechanical test that loads the hardware to destruction. It is up to the user to verify that the rating meets or exceeds the requirements of their ADSS cable system.

Objective

The objectives are as follows:

a) To verify the manufacturer's published mechanical strength of the tangent hardware when subjected to extreme vertical loading

b) To identify failure mode and record the test results

Set-up

The tangent hardware shall be mounted in the test apparatus to reflect field load applications. Figure 8 depicts the general arrangement and orientation for a tangent suspension. Tangent supports and tangent trunnions are to be mounted and loaded according to respective field attachments as provided in the manufacturer's installation procedures. To reach high mechanical loads, a wire rope cable may be used within the ADSS tangent hardware for this test. Install the terminated wire rope in a test fixture and apply the tangent hardware. The maximum turning angle Θ is specified by the manufacturer. As an option, the test may be performed using a rigid bar in place of the flexible member. In this case, the turning angle Θ essentially remains zero throughout the test. The tangent hardware can be confined to components necessary to demonstrate the vertical load connection to the structure. Use a load cell to monitor tension.

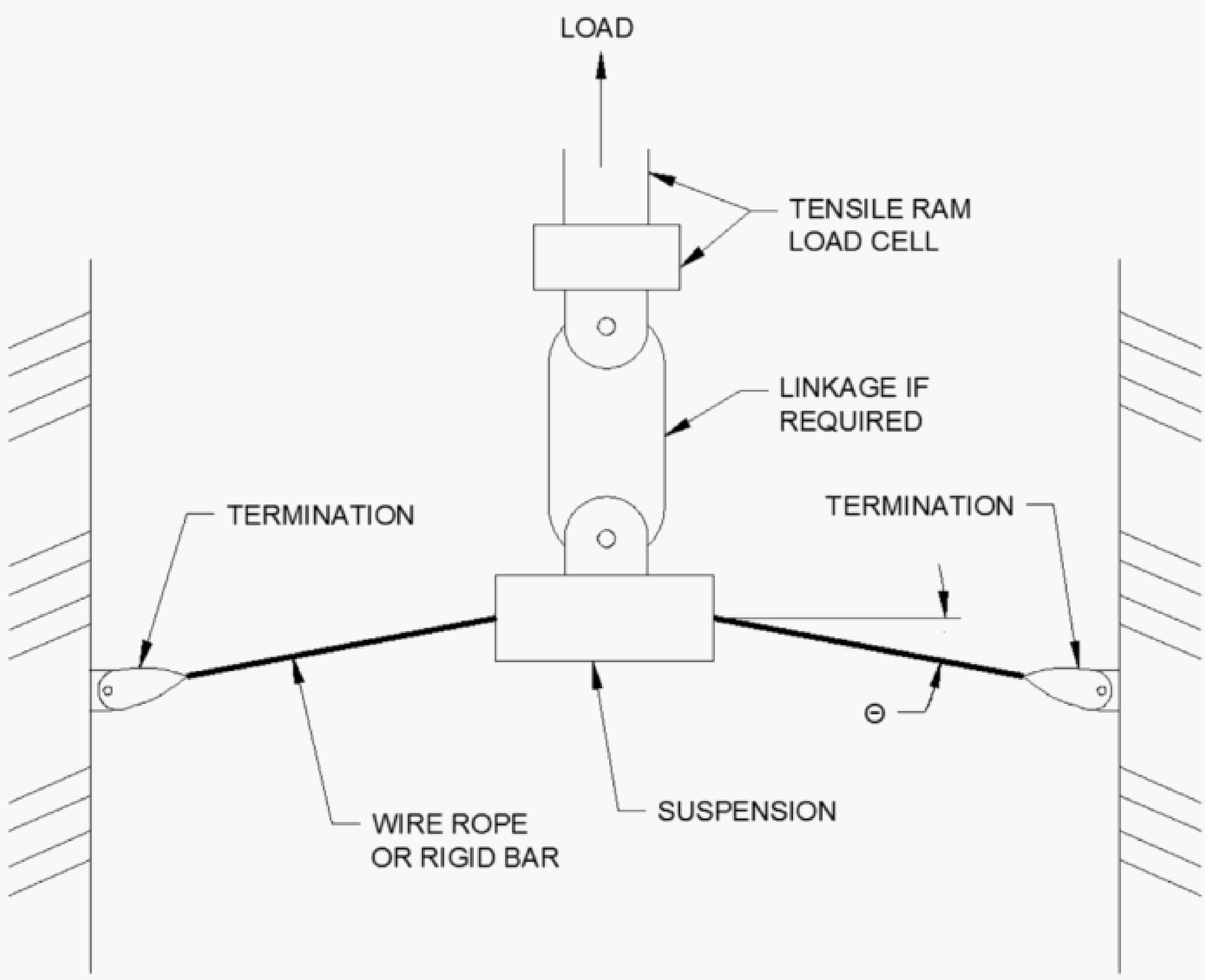

Figure 8—General arrangement for vertical load test

5.5.3.1.1.2 Procedure

Load the tangent hardware perpendicular to the axis of flexible cable or rigid bar until failure occurs. For flexible cable, maintain the maximum turning angle for the simulated cable set-up. For rigid bar set-up, the maximum turning angle is zero. A suggested load rate is 50% of the hardware rating per minute. Record the load rate, maximum load, and failure mode.

5.5.3.1.1.3 Acceptance criteria

The hardware passes the test if the maximum vertical load meets or exceeds the manufacturer's published rating without fracture of any component.

5.5.3.1.2 Turning angle (tangent hardware)

5.5.3.1.2.1 General

Single attachment ADSS tangent hardware has maximum turning angle ratings that allow for horizontal and vertical changes in direction. Figure 8 shows the set-up for turning angle testing with a maximum rated turning angle that shall be specified by the manufacturer. For field applications that exceed the turning angle rating of single attachment tangent hardware, double attachment tangent hardware may be appropriate, or the use of two dead-ends can be implemented. Consequently, the larger the turning angle rating for single attachment tangent hardware, the less need there may be to install double attachment tangent hardware or two dead-ends.

With more degrees of freedom, single attachment tangent suspension hardware is commonly rated for greater turning angles. Single attachment tangent suspensions are designed for both distribution and transmission environments. Supports and trunnions are typically designed for distribution applications.

In-service or operating conditions include initial installation and maximum environmental loads as found in sag and tension calculations. Everyday load conditions by definition are at or below MIT and periodically the system may approach MLT that is less than or equal to MRCL. At excess loads above MRCL the system is not expected to perform optically, however the system mechanical strength may exceed MRCL.

Classification

Hardware characteristics/Installation/In-service/Mechanical/Environmental/Mandatory

Intent

The turning angle test is a mechanical and optical test that simulates application conditions ADSS hardware may be subjected to in-service. The turning angle test simulates line angle changes that commonly occur in overhead aerial application due to horizontal directional changes and/or elevation changes.

Objective

The turning angle test subjects the tangent hardware to increasing tensile loads at the maximum recommended line angle of the tangent hardware to help ensure the following:

a) The optical signal is not adversely affected beyond acceptable limits as a result of either a severe bend at the hardware or inappropriate force applied to the ADSS by the tangent hardware.

b) The hardware is mechanically sound to withstand the forces applied by turning angles.

c) The ADSS is not damaged by the hardware beyond acceptable limits.

Set-up

The tangent hardware shall be mounted in the test apparatus to reflect field load applications. Figure 9 depicts the general arrangement and orientation for a tangent suspension. Tangent supports and tangent trunnions are to be mounted and loaded according to respective field attachments as provided in the manufacturer's installation procedures. For optical measurements, the test sample shall be prepared according to Table 3. The length of the ADSS cable between the inner edges of the dead-end terminations shall be approximately 8 m. Note that the intent of establishing some distance is to allow for the length of mechanical elements in the set-up and achieve at least 100 m of fiber under strain. If test bed does not allow 8 m between dead-ends, shorter length and additional numbers of fibers under strain may be concatenated. The minimum length between dead-end and tangent is 1 m. Install the tangent hardware at the center of the ADSS test sample length and hoist to develop the maximum recommended turning angle (±2 degrees) of the tangent hardware under test. The method of attachment, while not required to be rigid, shall limit the twisting of the cable occurring near the terminations. The roller shown in Figure 8 is used to keep the test turning angle constant as load is applied by the tensile ram. A torque balanced wire rope link may be used to connect the test sample termination to the tensile ram and avoid potential test sample attenuation induced by traveling through the roller.

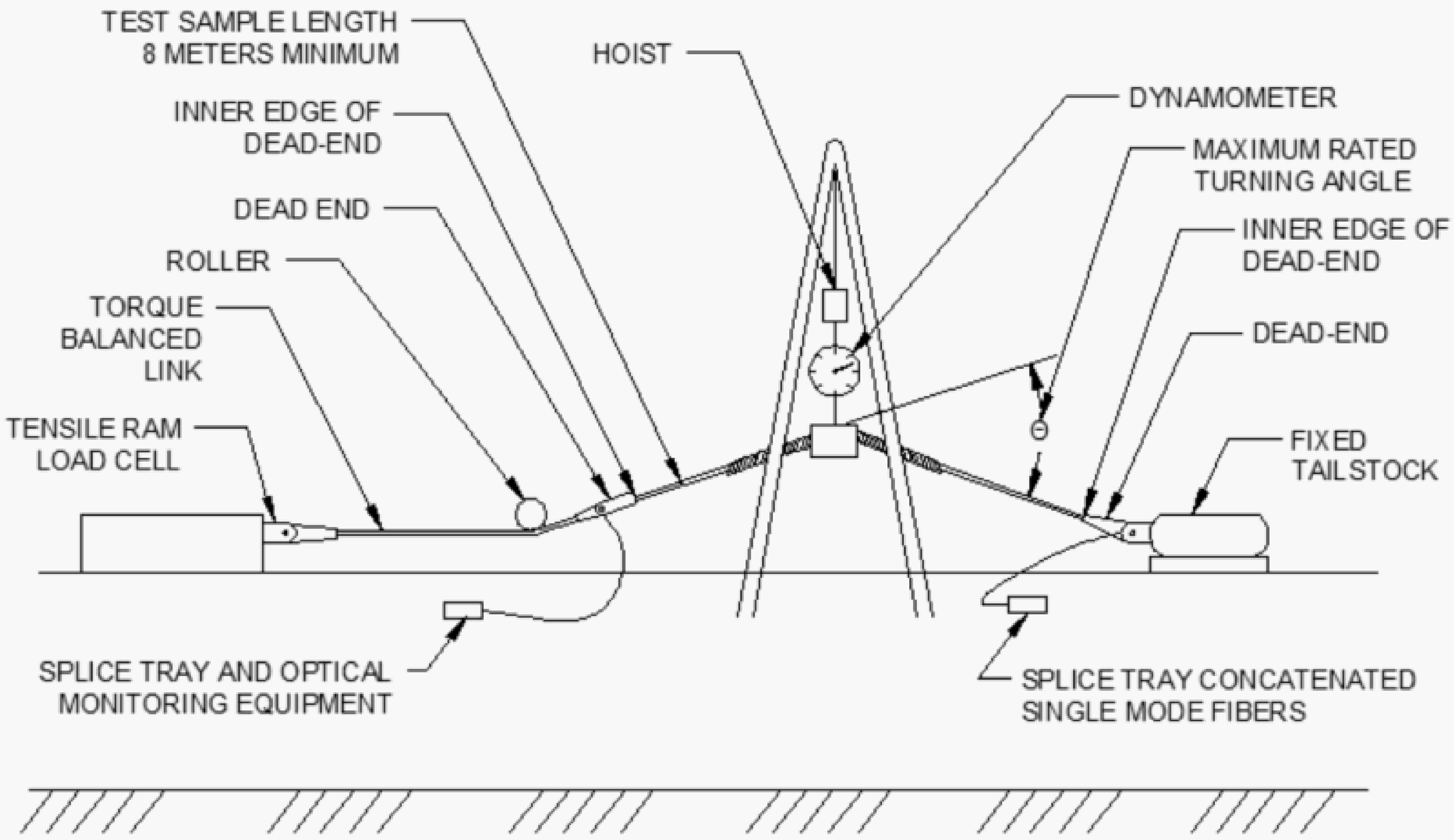

Figure 9—General arrangement for turning angle test

5.5.3.1.2.2 Procedure

The ADSS shall be axially loaded and monitored in the following sequence (reference Table 3 for optical measurement methodology):

a) Load to 10% MLT and record optical signal.

b) Load to 20% MLT and hold for 5 min.– Record optical signal at end of hold.

c) Load to 40% MLT and hold for 5 min.– Record optical signal at end of hold.

d) Load to 60% MLT and hold for 5 min.– Record optical signal at end of hold.

e) Load to 80% MLT and hold for 5 min.– Record optical signal at end of hold.

f) Load to 100% MLT and hold for 5 min.– Record optical signal at end of hold.

g) Unload to 10% MLT and record optical signal.

An additional step may be added during the load sequence [step a) through step g)] to include an entry at MIT. Record optical signal at end of 5 min hold.

MRCL may be used in place of MLT if agreed to by the purchaser and the manufacturer.

5.5.3.1.2.3 Acceptance criteria

The acceptance criteria are as follows:

a) For 80% MLT or less, there shall be no increase in optical attenuation greater than 0.1 dB/fiber at nominal wavelength of 1550 nm for single-mode fiber and 1300 nm for multimode fiber. The average increase of all fibers under test shall not exceed 0.05 dB per fiber. For greater than 80% MLT up to MLT, there shall be no permanent increase in optical attenuation greater than 0.2dB/fiber at nominal wavelength of 1550 nm for single mode fiber and 1300 nm for multimode fiber. The average increase of all fiber under test shall not exceed 0.1 dB per fiber. For systems tested to MRCL, replace MLT with MRCL for the aforementioned acceptance criteria.

b) The tested samples shall exhibit no signs of detrimental damage such as breaking or cracking at any time during the axial loading.

c) The tangent hardware shall be removed from the ADSS, and the ADSS shall be visually inspected for damage at the hardware location. Any jacket perforation or tear shall constitute a failure.

5.5.3.2 Installation tests

5.5.3.2.1 Turning angle (tangent hardware)

Same as test in 5.5.3.1.2.

5.5.3.3 In-service tests

5.5.3.3.1 Vertical load (tangent hardware)

Same as test in 5.5.3.1.1.

5.5.3.3.2 Turning angle (tangent hardware)

Same as test in 5.5.3.1.2.

5.5.3.3.3 Unbalanced load (tangent hardware)

5.5.3.3.3.1 General

ADSS cable designs meet various fiber counts, jacket types, and strength requirements using a mixture of non-metallic component materials. As a result, it is possible to have ADSS cables with a common size that vary significantly in strength, surface friction, and resistance to compression. Unlike dead-ends, tangent hardware is not required to hold maximum loaded tension MLT of the cable. Allowing slip under excessive load conditions through the tangent hardware can reduce the risk of damaging the ADSS or supporting structure. Hardware manufacturers supply the minimum unbalance load rating for the respective tangent hardware design.

Classification

In-service test/Mechanical/Mandatory

Intent

The unbalanced load test is a mechanical and optical test that simulates application conditions ADSS hardware is subjected to during in-service conditions. The unbalanced load test simulates load imbalances to ADSS that can occur in overhead aerial application as caused by tree limb impacts, ice loading and unloading, wind-induced motion, and other similar phenomena.

Objective

The unbalanced load test creates an imbalance in tensile loading on the tangent hardware to help ensure the following:

a) The optical signal is not adversely affected beyond acceptable limits as a result of unbalanced loading.

b) The hardware is mechanically sound to withstand the forces applied by unbalanced loads.

c) The ADSS is not damaged by the hardware beyond acceptable limits.

5.5.3.3.3.2 Set-up and procedure

The general arrangement for the unbalanced load test is shown in Figure 10. For optical measurements, the test sample shall be prepared according to Table 3. The hardware under test is mounted on a suitable fixed support frame and the test sample length from the tangent hardware to the dead-end is 10 m. Note that the intent of establishing a distance is to allow for length of mechanical elements in the set-up and achieve at least 100 m of fiber under strain. If test bed does not allow 10 m between dead-ends, shorter length and additional numbers of fibers under strain may be concatenated. The minimum length between dead-end and tangent hardware is 3 m. Mark the ADSS cable at the suspension edge and between hardware components to visually monitor relative movement.

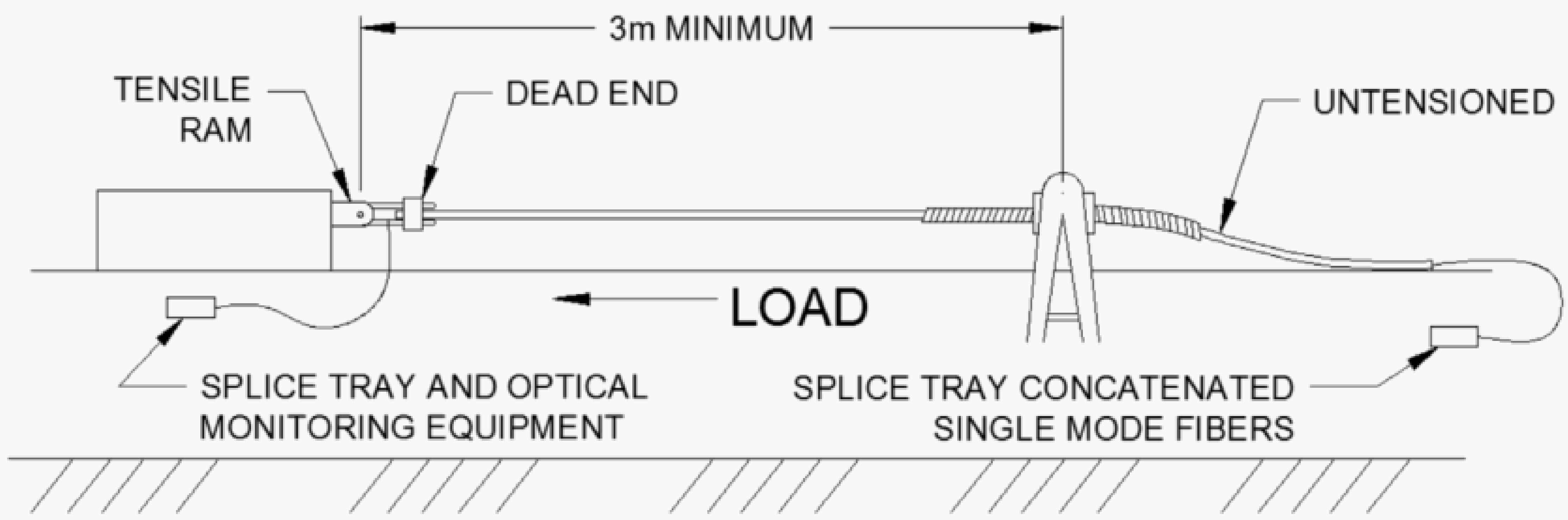

Figure 10—General arrangement for unbalanced load test

The ADSS on one side of the tangent hardware is un-tensioned to permit tension imbalance. On the other side of the tangent hardware, the ADSS shall be loaded according to the following sequence (reference Table 3 for optical measurement methodology):

a) Load to eliminate cable slack and hold for 1 min. Record optical signal at end of hold.

b) Continue loading to manufacturer's minimum unbalance load rating and hold for 1 min. Record optical signal at end of hold. (Increase load at a suggested rate of 50% of unbalance load rating per minute.)

c) Continue loading until relative movement between the cable and hardware is detected. Record the load and optical signal immediately before reducing load to slack load (no slipping).

d) Reduce to slack load and record optical signal.

If the cable moves relative to the tangent hardware prior to the manufacturer's rating, record the load and optical signal. Note any damage to the hardware or cable.

5.5.3.3.3.3 Acceptance criteria

The acceptance criteria are as follows:

a) There shall be no permanent increase in optical attenuation greater than 0.1 dB/fiber at nominal wavelength of 1550 nm for single-mode fiber and 1300 nm for multimode fiber. The average increase of all fibers under test shall not exceed 0.05 dB per fiber.

b) The tested samples shall exhibit no signs of detrimental damage such as breaking or cracking at any time during the unbalanced loading.

c) The tangent hardware shall be removed from the ADSS, and the ADSS shall be visually inspected for damage at the hardware location. Any jacket perforation or tear shall constitute a failure. Dissection of cable to inspect buffer tube compression is optional. Measure the buffer tubes in the areas within the hardware length at the ends of the hardware and hardware center. Use acceptance criteria found in tensile test subclause (5.5.2.1.1). This can be compared to buffer tubes in areas of the cable that were not exposed to the tension and vibration (beyond the termination ends). Note that dissection inspection should begin within 0.5 h of unloading the tested sample.

d) Slipping at a load below the manufacturer's minimum rating shall constitute a failure.

5.5.3.3.4 Aeolian vibration (tangent hardware)

Same as the test in 5.5.2.3.2 except the tangent hardware becomes the primary subject and the dead-end is secondary.

NOTE—The general arrangement in Figure 6 lists a suspension assembly but represents the location and placement for any type of tangent hardware. It is important to mount the respective hardware in accordance with standard field installations to demonstrate proper performance.

5.5.3.3.5 Galloping (tangent hardware)

Same as the test in 5.5.2.3.3.

NOTE—The general arrangement in Figure 7 lists a suspension assembly but represents the location and placement for any type of tangent hardware. It is important to mount the respective hardware in accordance with standard field installations to demonstrate proper performance.

5.5.3.3.6 Corona mitigation (tangent hardware [see Annex A])

5.5.3.3.7 Corrosion (tangent hardware)

Same as the test in 5.5.2.3.5.

5.5.3.3.8 Stringing (tangent hardware)

5.5.3.3.8.1 General

Stringing blocks are temporarily used at structures to safely support and guide the cable through aerial line installation as the cable is being pulled in. Stringing blocks can vary in size depending on the direction change of the pull. Sharp turning angles can require large stringing blocks based on the diameter of the cable in order to properly support the cable under stringing tension (STT). Tangent support and trunnion hardware may be designed to string cable at structures with relatively small turning angles. Hardware manufacturers supply maximum turning angle ratings for hardware. Tangent hardware is commonly used for stringing in distribution systems as it can save time and labor by eliminating the need to install and remove conventional stringing blocks at every structure.

Classification

Installation/Mechanical/Conditional

Intent

The stringing test is a mechanical and optical test that simulates installation conditions ADSS hardware is subjected to during cable stringing. ADSS cable is cycled through the tangent to simulate exposure to several structure locations in a cable route. Stringing operations are normally carried out during calm conditions for safety reasons and to reduce the possibility of cable damage.

Objective

The stringing test cycles cable through tangent hardware to help ensure the following:

a) The optical signal is not adversely affected beyond acceptable limits as a result of pulling cable through the tangent hardware at the manufacturer's maximum turning angle rating.

b) The hardware is mechanically sound to withstand the forces applied by stringing loads and turning angles.

c) The ADSS is not affected by the hardware beyond acceptable limits.

5.5.3.3.8.2 Set-up and procedure

The general arrangement for the stringing test is shown in Figure 11. For optical measurements, the test sample shall be prepared according to Table 3. A swivel shall be placed in line with the cable test sample to simulate common practice during field installations. The hardware under test shall be mounted on a structure midspan to establish a turning angle at the hardware manufacturer's rating plus 30% minus zero. The minimum test sample length between dead-ends is 10 m. The test length of the optical fiber shall be a minimum of 100 m. Mark the ADSS cable at the tangent edge and between hardware components to visually monitor relative movement for informational purposes. Tension the cable to the STT and maintain the load throughout the test. Mark a 1.5 m ± 0.2 m section of cable to represent the test section exposed to stringing through the tangents. Measure and record the maximum and minimum diameter of the cable near the center of the test section before the first cycle. Pass this section over the tangent 120 times (60 times in each direction) at a rate of 2 s to 3 s per pass. Measure and record the maximum and minimum diameter of the cable near the center of the test section after test cycling. Record the average of the maximum and minimum to compare before and after measurements. Record optical measurements and any notable wear or damage during the test.

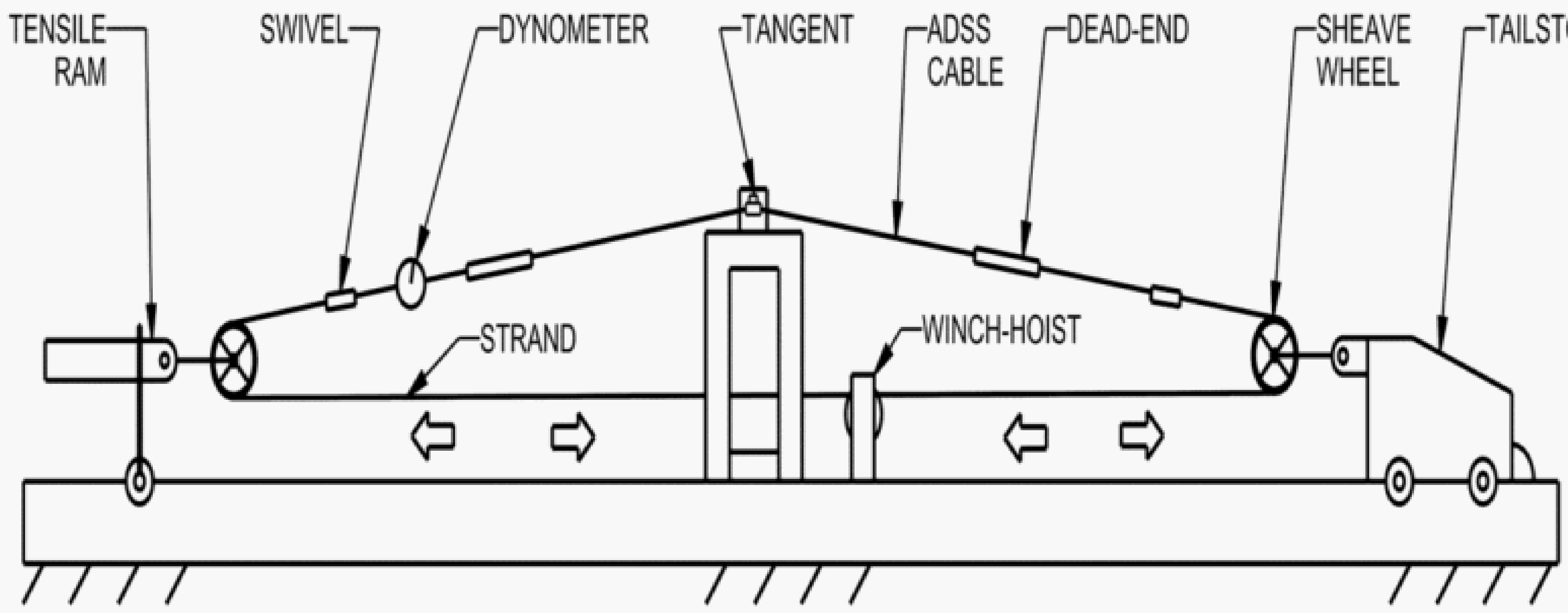

Figure 11—General arrangement for stringing test

5.5.3.3.8.3 Acceptance criteria

The acceptance criteria are as follows:

a) There shall be no permanent increase in optical attenuation greater than 0.1 dB/fiber at nominal wavelengths of 1550 nm for single mode fibers and 1300 nm for multimode fibers. The average increase of all fibers under test shall not exceed 0.05 dB per fiber.

b) The cable sample test length shall exhibit no signs of detrimental damage such as excess wear as agreed upon by the user and manufacturer. Jacket perforation or tearing during the stringing test shall constitute failure.

c) The tangent hardware shall be visually inspected for damage or excess wear upon completion of the test. Any cracking or breaking shall constitute failure. Percentage change of the average cable diameter greater than 15% shall constitute failure.

5.5.4 Dampers

Historically, dampers have been used to protect shield wire and conductor lines from Aeolian vibration by limiting the level of vibration. It has been demonstrated that dampers can reduce Aeolian vibration to a strain level that the line can endure nearly indefinitely.

Two types of dampers are addressed in this standard and they can be referred to as 1) Stockbridge type and 2) impact type (as referenced in 4.2.2.3). Stockbridge dampers are characterized as having flexible messenger wire with weights that respond to motion in the line without direct contact. Impact dampers can be characterized as a device that disrupts the line motion by interacting directly with the line.

Test standards have been established primarily for the Stockbridge type to measure damper performance and requirements, and these standards are referenced where applicable. In some cases, the same test standards established for Stockbridge-type dampers are applicable to impact dampers with further explanation covered in this standard.

Except for damper performance testing, the tests covered in IEC 61897 and listed in Table 5 shall apply for Stockbridge dampers. For damper performance testing, either IEC 61897 or IEEE Std 664 may be used.

Table 5—Stockbridge damper tests per IEC 61897

IEC 61897 tests on Stockbridge dampers	Applicable classification under IEEE Std 1591.2		
	Hardware characteristics	Installation tests	In-service test
Clamp slip tests[a]	X		X
Breakaway bolt test	X	X	
Clamp bolt tightening test[a]	X	X	
Corona and radio interference voltage (RIV) tests[b]	X		X
Damper performance tests			
— Damper characteristics test	X		
— Damper effectiveness evaluation	X		X
Damper fatigue test	X		X
NOTE—With the exception of fiber optic testing for the clamp slip test[a] and clamp bolt tightening test,[a] test set-up, procedures, and acceptance criteria for the above tests are found in Test Methods, Clause 7 of IEC 61897. The tests listed in this table represent the minimum technical details to be agreed upon by the purchaser and supplier as per IEC 61897, Annex A. Additional tests from IEC 61897 including visual examination, verification of dimensions/materials/mass, corrosion protection tests, attachment of weights to messenger, and attachment of clamp to messenger cable may be added if agreed upon by the purchaser and supplier.			

[a]For application of damper clamps on ADSS optical, attenuation shall be measured and the ADSS cable shall be prepared according to Table 3. Conventional metallic damper clamps designed for metallic cables cannot be directly applied to ADSS and require application over an intermediate protection such as armor rods or hardware rods. Assure that adequate ADSS extends beyond the exterior edge of each damper assembly to measure optical results.
Acceptance criteria is as follows:

a) A permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at nominally 1550 nm for single mode fibers shall constitute failure.

b) The tested samples shall exhibit no signs of detrimental damage such as breaking or cracking at any time during the axial loading.

[b]Induced voltage on ADSS stockbridge hardware may approach levels such that corona is created. In cases where corona is a consideration, refer to applicable IEC standards for corona tests. See "Corona considerations for ADSS hardware" in Annex A for further information.

5.5.4.1 Hardware characteristics tests

5.5.4.1.1 Power Dissipation (impact dampers)

5.5.4.1.1.1 General

Four basic laboratory test methods of determining damper dissipation characteristics covered in IEEE Std 664 include: 1) decay, 2) inverse standing wave ratio, 3) power, and 4) forced response. (Note that IEC 61897 references IEEE Std 664 as well.) In each of these methods, pure sinusoidal vibration is introduced to the sample and the sample response is measured to determine dissipation characteristics. Unlike the Stockbridge damper, the active nature of the impact damper introduces in essence another component to the conductor motion during vibration—as is, only the decay method can be used to compare decay rates between dampers. In order to calculate power dissipation, a practical approach to the power method may be used through the use of electronic filters and is described in this subclause.

Classification

Hardware characteristics/In-service/Mechanical/Mandatory

Intent

The intent of the power dissipation test is to measure damper performance and determine suitability for protection against Aeolian vibration on ADSS lines.

Objective

To verify the manufacturer's published damper characteristics

5.5.4.1.1.2 Set-up and procedure

The laboratory test set-up has the same general configuration described in IEEE Std 664 and shown in Figure 12.

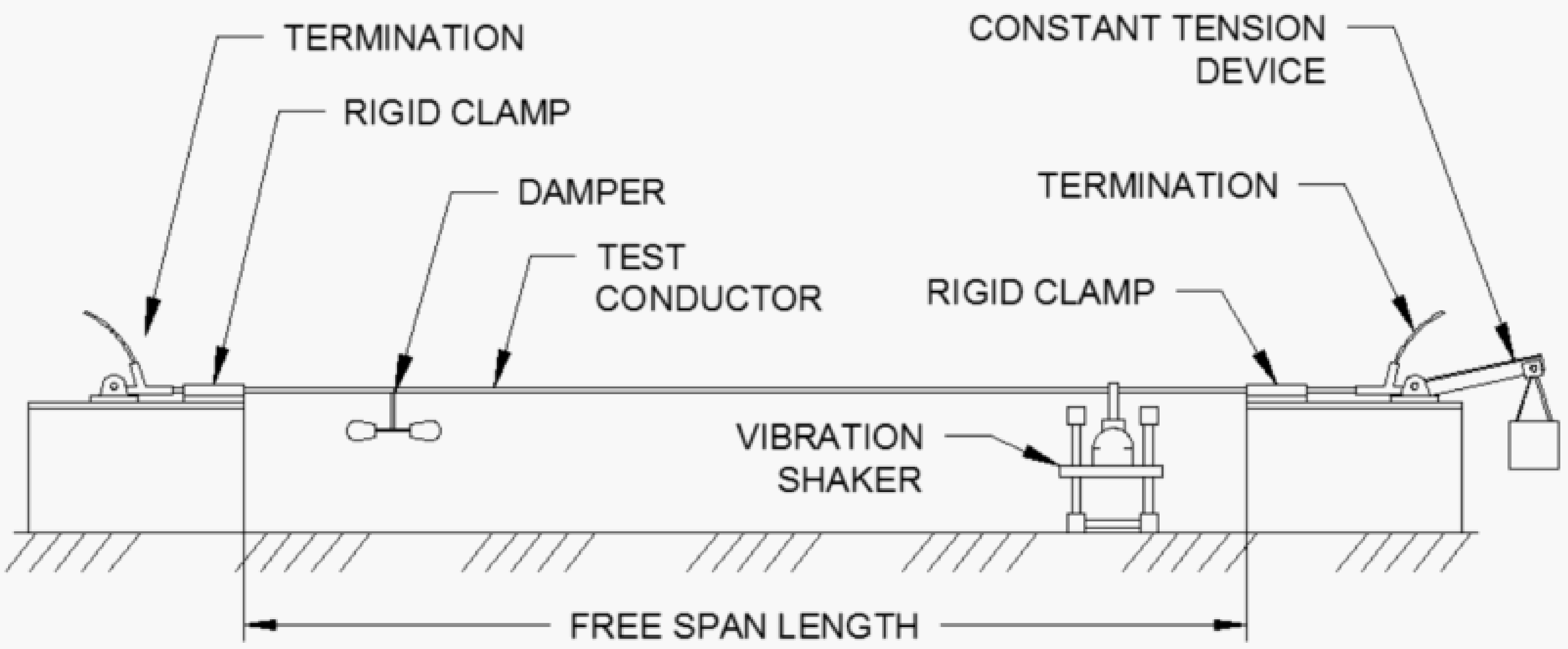

Figure 12—General arrangement for power dissipation test

The minimum free span length shall be 30 m. Install transducers to measure the force and velocity or acceleration imparted to the ADSS cable at the shaker. The force and velocity/acceleration signals are filtered by an electronic filter or FFT analyzer, which displays the frequency spectrum of each signal and the phase angle between the two signals, to remove signals other than the driving frequency. The force and velocity signals should be averaged independently to reduce the signal distortion caused by random impacts. Guidance on the measurements of power dissipation of Aeolian vibration dampers is given in IEEE Std 664. Detailed procedures for setting up and controlling tests can be found in these procedures.

Measurements are executed to determine the dissipated power at frequencies for which resonance occurs within the range $0.18/d$ to $1.4/d$, where d is the conductor diameter in meters, unless a narrower frequency range is agreed upon by the purchaser and the supplier.

Suggested methods of controlling amplitudes include strain gage methods as described in IEC 61897 and constant velocity methods as described in IEEE Std 664.

Per IEC 61897 controlling amplitude via strain gage method is described as follows: Conductor bending strain shall be monitored adjacent to the rigid clamp at the span end with the damper. Depending on the impact damper attachment design, discretion may be used for the need to monitor conductor strain at the impact damper attachment area. Attach two strain gages at the uppermost strands of the ADSS at each designated location within 2 mm from the rigid clamp edge and "if needed" 5 mm from the damper clamp edge. Signals from the strain gage amplifiers are electronically filtered and averaged in a manner similar to the force and velocity signals referenced above.

Per IEEE Std 664, testing shall be performed at a constant loop velocity of 200 mm/s at each tunable harmonic frequency. This velocity corresponds approximately to an antinodal amplitude (mm) of 67/*f* where *f* is the frequency of vibration. Additional testing at other loop velocities (100 mm/s, 300 mm/s, etc.) can be used to provide a good spectrum of results for the end user's evaluation. The input antinodal velocity should be maintained within ± 2% of the calculated value at each test frequency. The measurement of nodal and antinodal amplitudes (when required) should be made within ± 5%. The measurement of input force and velocity signals at the vibration shaker should be made within ± 5% of the measured value. The measurement of the phase angle between the input force and velocity signals should be made with sufficient accuracy to ensure that the cosine of the phase angle is within ± 1% of the measured value.

At each tunable frequency, adjust the shaker input to achieve the desired amplitude based on the method chosen (strain gage method corresponding to 150 microstrain or constant velocity method at 200 mm/s).

The antinode amplitude shall be measured at the first free vibration loop from the damper. A non-contact measuring instrument is preferred, but a low mass transducer or accelerometer can be installed on the conductor. The signal should be filtered and averaged as described above. The velocity of the antinode amplitude may then be calculated.

The dissipated power is then calculated from the force, acceleration, and phase angle between the respective signals. Dissipated Power is calculated from the following equation:

$$P = \frac{1}{2}(FV_s)\cos\theta_v$$

If an accelerometer is used for data acquisition, the power dissipated by the damper can be calculated from the following equation:

$$P = \frac{1}{4\pi f} FA_s \sin\theta_a$$

where

P is power dissipated by the damper (W)
F is force measured at the vibration shaker (N)
V_s is velocity measured at the vibration shaker (m/sec)
θ_v is phase angle difference between the measured force and velocity signals
A_s is acceleration measured at the vibration shaker (m/sec^2)
θ_a is phase angle difference between the measured force and accelerations signals measured

The wind power input is calculated from:

$$P = D^4 \times f^3 \times \text{fnc}(Y/D) \times L$$

where

P is power (W)
F is the measured force at the shaker (N)

A is the measured acceleration at the shaker (m/sec^2)
θ is the phase angle between the force and acceleration signals
f is the frequency of vibration (Hz)
D is the conductor diameter (m)
L is the span length (m). Calculations can be made for designated span length
Y is the antinode amplitude (m single peak)
fnc(*Y* / *D*) is a function of conductor antinode amplitude expressed in terms of conductor diameter and given from established data

5.5.4.1.1.3 Acceptance criteria

At each tunable resonant frequency, the dissipated power shall be greater than the wind power input for the designated span.

5.5.4.1.2 UVA exposure—Impact dampers

5.5.4.1.2.1 General

Impact dampers fabricated from non-metallic materials can be damaged from the ultraviolet content of sunlight. The sunlight spectrum includes visible light that measures above 400 nm wavelength and UV below 400 nm wavelength. UV wavelengths are categorized into three regions: UVA (400 nm to 315 nm), UVB (315 nm to 280 nm), and UVC (280 nm to 100 nm). In the case of overhead line hardware, UVA can cause polymer damage and represents the applicable UV test level. Industry accepted plastic dampers made from PVC have been used since the 1970s—although other materials may be considered. This test standard bases testing parameters and acceptance criteria on that established with the PVC material. General guidance for test equipment and methods of UVA exposure can be found in ISO 4892.

Classification

Hardware characteristics test/In-service/Mechanical/Mandatory

Intent

The intent of this test is to determine the comparative performance of non-metallic impact dampers exposed to ultraviolet light waves that can be experienced in sunlight. Sunlight is defined as global noon midsummer sunlight, also known as “solar maximum.”

Objective

To determine the ability of the damper to resist damage from UVA after soaking it for 3000 h at solar maximum.

5.5.4.1.2.2 Set-up and procedure

Place test sample(s) approximately 305 mm long in a UV exposure test chamber with controlled irradiance and controlled temperature. Provisions shall be made to assure exposure uniformity for each sample. Set equipment to maintain temperature at 60 °C and UVA wavelength emission. UVA type florescent lamps can be used that closely simulate sunlight in the critical short wave UV region from 365 nm down to the solar cutoff of 295 nm—the peak emission is at 340 nm (irradiance approximately 0.7 Wm^2/nm). Soak for 3000 hours. Check samples a minimum of once per week to record observations.

5.5.4.1.2.3 Acceptance criteria

Any cracking, discoloration, or deterioration shall constitute failure.

5.5.4.2 Installation tests

5.5.4.2.1 Crush (dampers)

5.5.4.2.1.1 General

Classification

Installation/Mechanical/Conditional

Stockbridge dampers

Refer to Table 5—the clamp bolt tightening test shall apply. Use the manufacturer's installation recommendations for installation torque and applications over hardware rods.

Impact dampers

Intent

Hardware is required to protect ADSS cable from excess wind-induced motion without introducing excess strain, stress risers, or fiber attenuation. Excess stress coupled with wind-induced motion can greatly reduce the life of the cable system. The intent of this test is to apply the hardware to an ADSS cable and verify that installation alone does not distort or damage the ADSS cable.

Objective

To verify that the ADSS cable is not exposed to excess damage from crush upon initial installation of hardware

Set-up

The ADSS sample length shall allow for a minimum of three hardware installations and 1 m beyond each end of the hardware trial application. Identify and mark the three proposed areas of hardware installation along the length of ADSS cable sample. The load on the test cable shall be sufficient enough to keep the cable taut during installation and not exceed 5% of the breaking strength.

5.5.4.2.1.2 Procedure

Install hardware per manufacturer's instructions at one of the designated areas. Mark the final position of the hardware at both ends of the ADSS cable under test.

Remove the hardware per manufacturer's instructions. Visually inspect the cable within the reference marks and compare to the adjacent open areas of the cable. If there is no visible damage to the cable, optical testing is not required.

Repeat the procedure twice at untested areas of the cable.

5.5.4.2.1.3 Acceptance criteria

The acceptance criteria are as follows:

a) There shall be no cracking, splitting, or similar damage to exterior cable. Cable exterior deformation shall not be considered as damage. This assessment is made with the naked eye.

b) For optical measurements there shall be no permanent increase in optical attenuation greater than 0.1 dB at nominally 1550 nm for single-mode fibers. The average increase of all fibers under test shall not exceed 0.05 dB.

For direct application of impact dampers on ADSS that may potentially create significant clamping force, optical attenuation shall be measured and the ADSS cable shall be prepared according to Table 3, with the adequate ADSS extended beyond the exterior edge of each damper clamp, and the test length of optical fiber shall be a minimum of 100 m long.

5.5.4.3 In-service tests

5.5.4.3.1 Power dissipation—Impact dampers

Same as the test in 5.5.4.1.1.

5.5.4.3.2 UVA exposure—Impact dampers

Same as the test in 5.5.4.1.2.

5.5.4.3.3 Corrosion (dampers)

For Stockbridge dampers testing shall be in accordance with IEC 61897.

For impact dampers, see 5.5.2.3.5.

5.5.4.3.4 Electrical effects (dampers)

See Annex B.

5.5.5 Come-alongs

Come-alongs or temporary tensioning grips are designed to maintain the cable tension during the sagging process and installation of dead-ends. It may also be used for general line work and maintenance. This section applies to tools specifically designed for sagging. Formed wire dead-ends that are used to dead-end the system are commonly used temporarily for sagging. In this case, the formed wire dead-end is used once for sagging and then permanently installed in the next dead-ended location. This method is referenced in IEEE Std 524™ and is acceptable with an adequately formed wired dead-end that meets sagging load requirements. The come-alongs shall not cause damage to the cable in any way.

5.5.5.1 Hardware characteristics tests

There are no hardware characteristics tests for come-alongs.

5.5.5.2 Installation tests

5.5.5.2.1 Crush (come-alongs)

Classification

Installation/Mechanical/Conditional

Intent

Hardware is required to secure ADSS cable without introducing excess strain and stress risers, which may reduce the life of the system and cause fiber attenuation. The intent of this test is to apply the hardware to an ADSS cable and verify that installation alone does not distort or damage the ADSS cable.

The objective, set-up, procedure, and acceptance criteria are the same as those in 5.5.4.2.1 (impact dampers).

5.5.5.3 In-service tests

5.5.5.3.1 Tensile (come-alongs)

5.5.5.3.1.1 General

Classification

In-service/Mechanical/Mandatory

Intent

The tensile test is a mechanical test to simulate performance under sagging tensile load conditions and to demonstrate the ability of the system to reach sagging tensions (SAT) without damage to the cable.

Objective

The tensile test subjects the sample come-along to various tensile loads to help ensure the following:

a) The come-along holds the manufacturer-specified tensile load.

b) The ADSS is not damaged by the hardware beyond acceptable limits.

Set-up

The come-along shall be installed per the manufacturer's standard practice on one end of a length of ADSS cable of minimum 5 m length. The other end of the cable shall be connected to a tensile machine using a suitable clamp or other means. The position of the ADSS shall be pre-marked at one end of the come-along under test.

5.5.5.3.1.2 Procedure

Come-alongs shall be loaded at a rate of no greater than 10% breaking strength per minute. The optical signal need not be monitored during this test. The come-along samples shall be loaded to 125% of the come-along rating, and held for 15 min at that tension.

5.5.5.3.1.3 Acceptance criteria

The tested samples shall successfully hold the cable to 125% of the come-along tension rating with no more than 50 mm of relative movement in relation to the pre-marked cable, and shall exhibit no signs of detriment on the cable.

5.5.6 Downlead clamps

Downlead clamps are typically used to secure cable leading from the dead-end to the splice case for fiber optic splices. Securing the cable helps maintain minimum bend radius of the cable and avoid abrasion from excess motion.

5.5.6.1 Hardware characteristics tests

There are no hardware characteristics tests for downlead clamps.

5.5.6.2 Installation tests

5.5.6.2.1 Crush (downlead clamps)

Same as the test in 5.5.5.2.1.

5.5.6.3 In-service tests

5.5.6.3.1 Slip (downlead clamps)

5.5.6.3.1.1 General

Classification

In-service/Mechanical/Mandatory

Intent

Downlead clamps experience loading from the ADSS cable weight and environmental conditions such as wind and ice. To adequately train and secure the ADSS cable to the structure, hardware instructions cover recommended tightening and spacing distance between downlead clamps. The intent of this test is to verify that the downlead clamp adequately secures ADSS before slip occurs.

Objective

Tensile load the ADSS cable secured in the downlead clamp to help ensure the following:

a) The downlead holds the manufacturer-specified slip load.

b) The hardware does not damage the ADSS beyond acceptable limits.

5.5.6.3.1.2 Set-up and procedure

The unbalanced load test (Figure 9) shows a similar set-up except load is applied to two cables secured with a downlead clamp. Mount the downlead clamp in a suitable tensile machine and follow the manufacturer's instructions to install two ADSS cables within the clamp—the terminated end of the ADSS cables shall be connected to the load cell in a manner that equalizes the load between each cable as tension is applied to the sample. The overall sample length shall be a minimum of 2 m from the end of the cable termination to the downlead clamp. Premark the ADSS cable at the end of the downlead clamp and dead-end to observe relative movement. Procedures are as follows:

a) Preload the cable to 67 N/leg and set load rate to 222 N/min.

b) Continue loading to the manufacturer's minimum slip withstand rating and hold for 1 min.

c) Continue loading until 5 mm of relative movement between the cable and downlead is detected. Pause loading, measure and record slip distance and load.

d) Increase load until slip is continuous and record load.

If the cable moves relative to the downlead prior to the manufacturer's rating, record the load. Note any damage to the hardware or cable.

5.5.6.3.1.3 Acceptance criteria

The acceptance criteria are as follows:

a) The tested samples shall exhibit no signs of detrimental damage such as breaking or cracking at any time during the loading.

b) Slipping at a load below the manufacturer's minimum rating shall constitute a failure.

5.5.6.3.2 Corrosion (downlead clamps)

Same as the test in 5.5.2.3.5.

Annex A

(informative)

Corona considerations for ADSS hardware

A.1 General

It is possible for corona to exist on ADSS and related hardware due to proximity and arrangement of adjacent energized conductors. Corona is the result of surface electric fields (i.e., surface gradients), which exceed the threshold level of approximately 20 kV/cm; the exact level will vary with atmospheric conditions as well as the nature (particularly roughness) of ADSS/hardware surfaces. General geometric shape also affects the level of the surface fields. Corona is corrosive and can be a source of radio and TV interference. Experience indicates that hardware corona should be investigated on transmission lines of 345kVand higher, with caution that there may be situations at lower voltages. Depending on the conditions (voltage level, conductor proximity, line configuration), line voltages as low as 115 kV and possibly less may develop enough electrical stress for corona to occur.

Because the highvoltage environment is identical in nature for both ADSS and ADSS hardware, IEEE Std 1222 for ADSS is suggested as a source of information for this topic.

As noted in IEEE Std 1222, three-dimensional electric field analysis techniques can indicate areas in and around hardware where corona may exist. Mitigation is possible by application of shielding devices or careful design of the hardware itself.

NOTE 1—A design level of 14 kV/cm is suggested for surface gradients.

Laboratory testing is always advisable, provided electric field conditions in the test arrangement match the "real world" as closely as possible. However, at this date, an IEEE standard for corona testing is still undergoing development. Until that document is finalized and available, the following methodology is suggested.

NOTE 2—Some utilities may already have established corona testing procedures.

A.2 Suggested method for corona testing of ADSS hardware: Matching the laboratory to the "real world" via electric fields

The approach is to match the electric fields in a laboratory test setup to a "real world" installation. To demonstrate this, Figure A.1 shows a hypothetical laboratory arrangement model and a "real world" high voltage tower model. Both models contain the ADSS hardware assembly to be checked for corona.

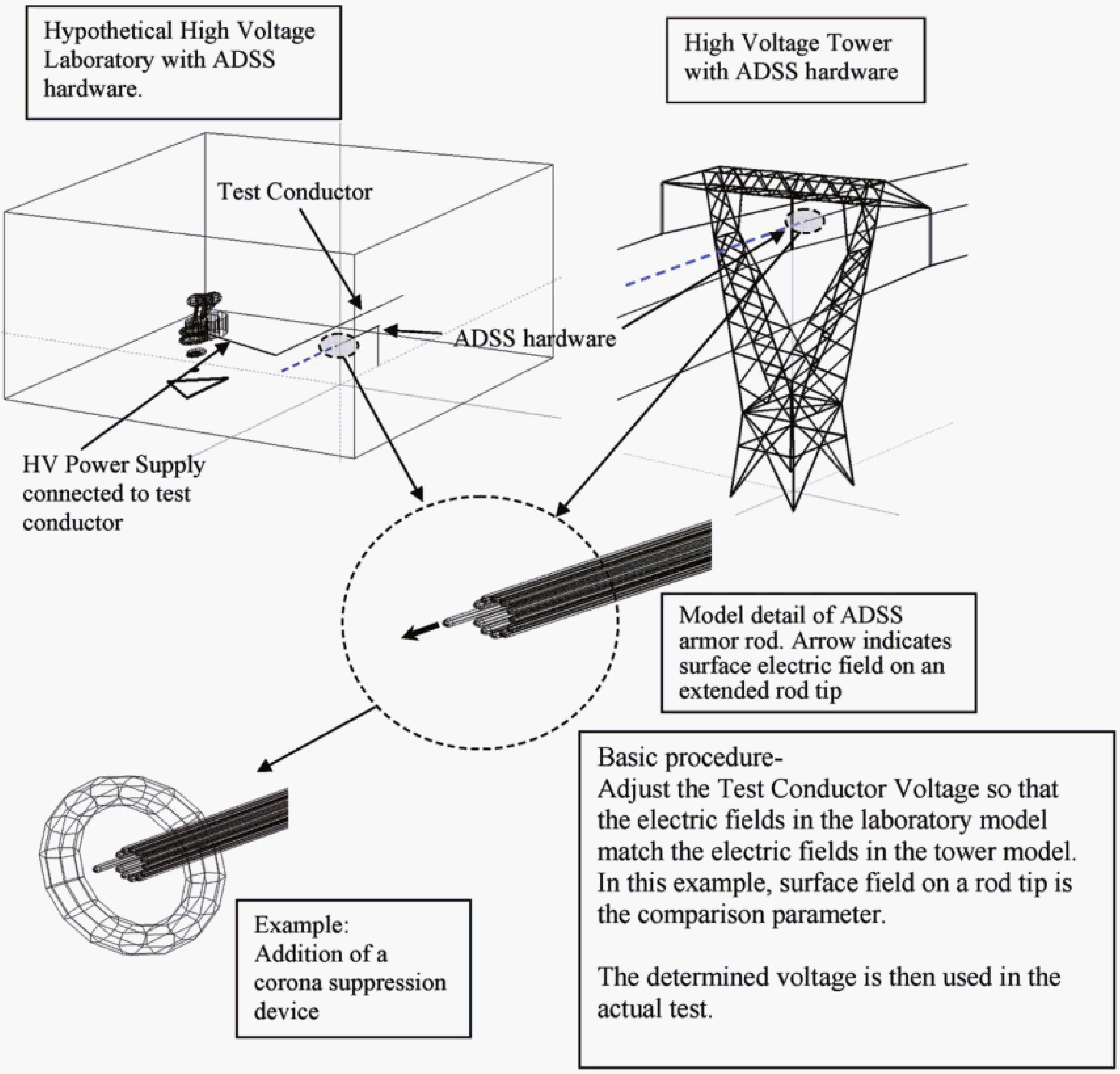

Figure A.1—Models comparing laboratory test to "real world" installation

Annex B

(informative)

Location of impact dampers

High electric fields (changes of space potential) exist near the end of ADSS armor rod assemblies. In these high fields, impact dampers (also referred to as spiral vibration dampers) are subject to arcing between the damper material and ADSS jacket, which can be worsened by pollution. There have been known failures due to this phenomenon.

Mitigation is accomplished by maintaining sufficient distance between the damper and the end of the armor rod. This locates the damper in lower electric fields. Figure B.1 is a general illustration of damper and ADSS hardware on a high-voltage tower.

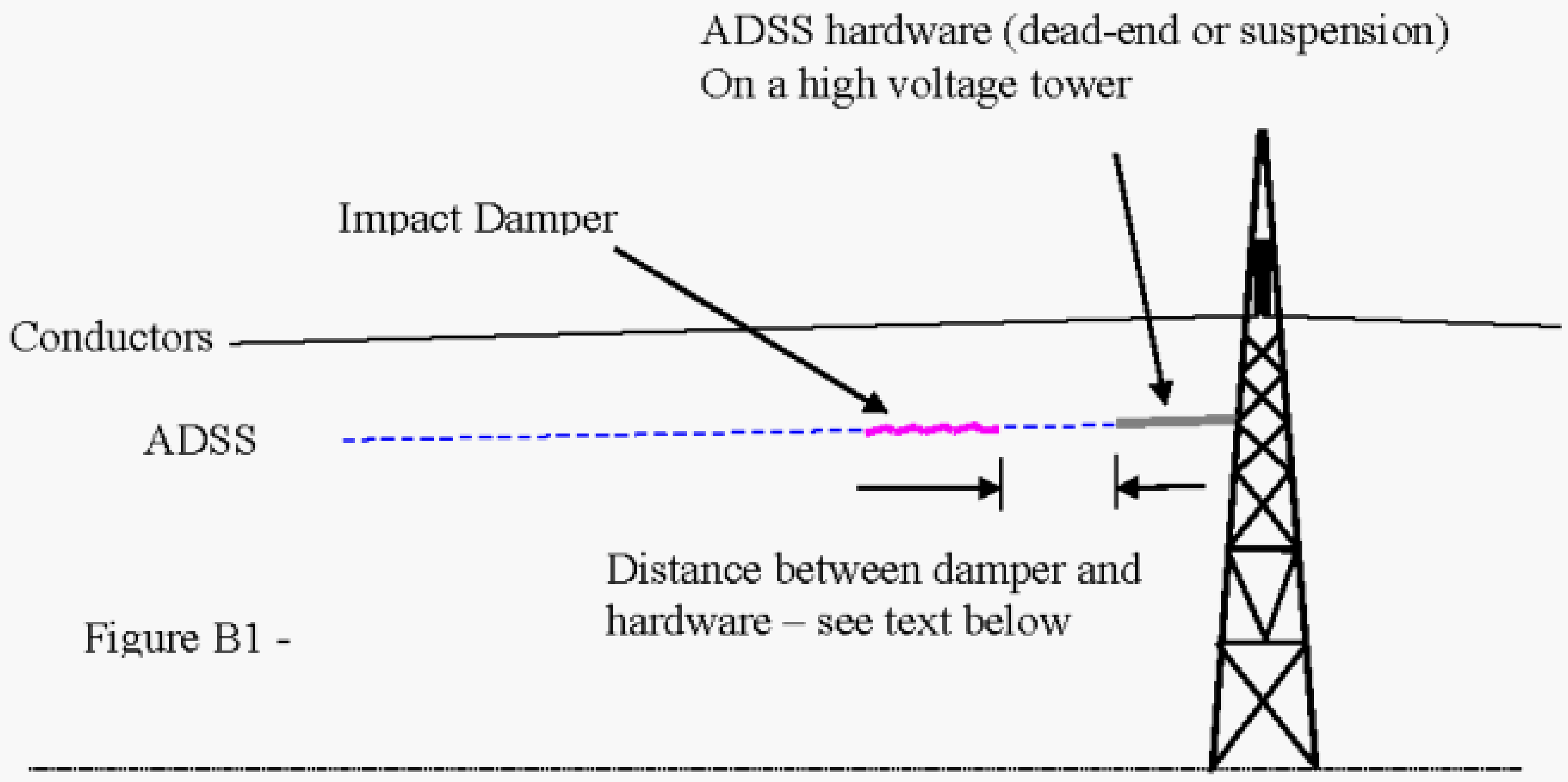

Figure B.1—Damper and ADSS hardware on a high-voltage tower

There are no known laboratory studies establishing a sufficient distance. However, in the case of one failure on a double circuit 345 kV line—where the initial distance was only several centimeters—failures were eliminated by moving the damper 4.6 m (15 ft) from the armor rod. A North American utility company with low pollution has illustrated use of 3 m (10 ft) in presentations concerning ADSS and dampers on 500 kV towers.

Further studies and tests may show less and thus more convenient separation distances; until such knowledge is established, it is recommended to use a distance of 3 m (10 ft) for low accumulation areas and 4.6 m (15 ft) for high accumulation areas.

NOTE—Moving the damper further into the span reduces space potential to approximately 2 kV or less end to end (across the damper).

Annex C

(informative)

Hardware ground connection

In most cases, hardware and connecting fittings made from conductive metals such as steel and aluminum are usually adequate to provide a conductive path to the metallic structure for the low current levels expected in an ADSS cable system. Metallic fittings, such as clevises, extension links, eye-nuts, and Y-clevises, connected in series can be joined to the nearest grounded object. Examples of the object can be a double arming bolt that is clipped to the wood pole structure ground or a vang on a grounded lattice tower.

If necessary, a grounding wire connection may be required to shunt capacitively induced currents that could cause eventual damage to hardware connecting fittings. Direct connections from the main cable hardware to the structure ground can be accomplished via separate bonding attachments or integral to the cable hardware.

Ungrounded hardware attached to wood poles will be subject to a space potential that may be sufficient to create currents in the wood pole and eventually lead to dry band arcing. Wood pole fires have occurred in this case. Connecting the hardware to the nearest grounded object is suggested. This object could be a downlead connecting static wires and earth ground, or other hardware such as cross arms, clamps, etc., which are grounded.

In electrical distribution environments, there is less need for grounding ADSS hardware. However, installers should follow local user's standard procedure that may require grounding in their system.

Metallic hardware components that are insulated or isolated by non-metallic (non-conductive) components require a means to connect to a ground or metallic component that is eventually joined to ground.

Annex D

(informative)

Tensile test dissection and ovality

Construction of ADSS cables vary and the protection of fibers within plastic buffer tubes vary as well, depending on the loading the cable is expected to experience. Since ADSS was introduced in the 1980s, many tensile tests have been performed for the industry to verify cable and dead-end compatibility. This document provides an attempt to standardize the test method without the requirement of measuring the buffer tubes that house the fibers in 5.5.2.1.1. Industry manufacturers and users were able to agree on the test procedure but found it difficult to agree on acceptance criteria for buffer tube deformation. Consequently, it was decided not to include the acceptance criteria for buffer tube deformation until more data is collected.

In order to collect data in a consistent manner, the following guidelines have been established for buffer tube deformation and measurements:

a) Upon completion of step j) of test A in 5.5.2.1.1, begin dissecting the cable by carefully removing the cable jacket but transfer all five premarked locations for the test dead-end to the underlying buffer tubes. The locations represent three that were under the dead-end and two that were just beyond the ends of the dead-end (not covered by the dead-end). Note any distinguishing characteristics of the dead-end relative to the orientation of the buffer tubes and record observations. Unwrap the buffer tubes to record observations and measurements at each of the five previously designated locations. This step shall be completed within 0.5 h of the last step.

b) Upon completion of (a) above, measure the buffer tubes in an area that were not exposed to tension approximately 1 m beyond the end of the dead-end. Record dimensions for comparison. This step shall be completed within 1 h of the last step.

Acceptance criteria for buffer tube deformation may ultimately be included in 5.5.2.1.1 after item b) of the acceptance criteria.

The acceptance criteria can read as follows:

c) In test A, the buffer tubes shall exhibit no more than X% compression compared to a section of test sample not exposed to tensile load. Excess compression constitutes failure. The percent compression is calculated using the following equation for "ovality."

$$\text{Ovality} = ((\text{dmax} - \text{dmin}) / (\text{dmax} + \text{dmin})) \times 100\%$$

where

dmax	is the maximum diameter of buffer tube
dmin	is the minimum diameter of buffer tube

Annex E

(informative)

Bibliography

Bibliographical references are resources that provide additional or helpful material but do not need to be understood or used to implement this standard. Reference to these resources is made for informational use only.

[B1] Accredited Standards Committee C2-2012, National Electrical Safety Code® (NESC®).[11]

[B2] ANSI/EIA 35, Standard Colors for Identification and Coding.[12]

[B3] ASTM B416, Standard Specification for Concentric-Lay-Stranded Aluminum-Clad Steel Conductors.[13]

[B4] ASTM B549, Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Aluminum-Clad Steel Reinforced (ACSR/AW).

[B5] ASTM E29, Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications.

[B6] EIA/TIA-455-170, Cable Cutoff Wavelength of Single-Mode Fiber by Transmitted Power.

[B7] IEC 60793-2-10, Optical fibres—Part 2-10: Product specifications—Sectional specification for category A1 multimode fibres.[14]

[B8] IEC 60793-2-50, Optical fibres—Part 2-50: Product specifications—Sectional specification for class B single-mode fibres.

[B9] IEC 61089-am1, Amendment 1—Round Wire Concentric Lay Overhead Electrical Stranded Conductors.

[B10] IEC 61284, Overhead lines—Requirements and Tests for Fittings.

[B11] IEC 61284:1998, Overhead lines—Requirements and tests for fittings.

[B12] IEEE Std 1138™-2009, IEEE Standard for Testing and Performance for Optical Ground Wire (OGPW) for Use on Electric Utility Power Lines.[15,16]

[B13] ITU-T G.650.1, Definitions and Test Methods for Linear, Deterministic Attributes of Single-Mode Fibre and Cable.[17]

[B14] ITU-T G.650.2, Definitions and Test Methods for Statistical and Non-Linear Related Attributes of Single-Mode Fibre and Cable.

[11]The NESC is available from the Institute of Electrical and Electronics Engineers, Inc. (http://standards.ieee.org/).
[12]ANSI publications are available from the American National Standards Institute (http://www.ansi.org/).
[13]ASTM publications are available from the American Society for Testing and Materials (http://www.astm.org/).
[14]IEC publications are available from the International Electrotechnical Commission (http://www.iec.ch/) and the American National Standards Institute(http://www.ansi.org/).
[15]The IEEE standards or products referred to in Clause 2 are trademarks owned by the Institute of Electrical and Electronics Engineers, Incorporated.
[16]IEEE publications are available from the Institute of Electrical and Electronics Engineers (http://standards.ieee.org/).
[17]ITU-T publications are available from the International Telecommunications Union (http://www.itu.int/).

[B15] ITU-T G.651, Characteristics of a 50/125 μm Multimode Graded Index Optical Fibre Cable.

[B16] ITU-T G.652, Characteristics of a Single-Mode Optical Fibre and Cable.

[B17] ITU-T G.653, Characteristics of a Dispersion-Shifted Single-Mode Optical Fibre and Cable.

[B18] ITU-T G.655, Characteristics of a Non-Zero Dispersion-Shifted Single-Mode Optical Fibre and Cable.

[B19] TIA-455-78-B, IEC 60793-1-40, Optical Fibres—Part 1-40: Measurement Methods and Test Procedures—Attenuation.[18]

[B20] TIA-455-80-C, IEC 60793-1-44, Optical Fibres—Part 1-44: Measurement Methods and Test Procedures—Cut-off Wavelength.

[B21] TIA/EIA-455-25-C, Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies.[19]

[B22] TIA/EIA-455-46-A, Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers.

[B23] TIA/EIA-455-50-B, Light Launch Conditions for Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements.

[B24] TIA/EIA-455-53-A, Attenuation by Substitution Measurement for Multimode Graded-Index Optical Fiber or Fiber Assemblies Used in Long Length Communications Systems.

[B25] TIA/EIA-455-54-A, Mode Scrambler Requirements for Overfilled Launching Conditions to Multimode Fibers.

[B26] TIA/EIA-455-59, Measurement of Fiber Point Defect Using an OTDR.

[B27] TIA/EIA-455-61, Measurement of Fiber or Cable Attenuation Using an OTDR.

[B28] TIA/EIA-455-62-A, Measurement of Optical Fiber Macrobend Attenuation.

[B29] TIA/EIA-455-78-A, Spectral Attenuation Cutback Measurement for Single-Mode Optical Fibers.

[18]TIA publications are available from the Telecommunications Industry Association (http://tiaonline.org/).
[19]TIA/EIA publications are available from the Telecommunications Industry Association (http://tiaonline.org/).

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