



IEEE Standard for Testing and Performance for Optical Ground Wire (OPGW) for Use on Electric Utility Power Lines

IEEE Power & Energy Society

Sponsored by the
Power System Communications Committee

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IEEE Standard for Testing and Performance for Optical Ground Wire (OPGW) for Use on Electric Utility Power Lines

Sponsor

Power System Communications Committee
of the
IEEE Power & Energy Society

Approved 11 September 2009

IEEE-SA Standards Board

Abstract: The performance, test requirements, procedures, and acceptance criteria for a transmission line overhead ground wire (a.k.a. shield wire, static wire, earth wire, skywire) with optical fibers commonly known as optical ground wire (OPGW) are covered. Functional requirements, such as electrical, mechanical, optical fiber, environmental, and packaging, and test requirements related to design, installation, in-service, and maintenance, including routine tests, are covered.

Keywords: fiber optic ground wire, laboratory tests, OPGW, optical ground wire, type tests

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Introduction

This introduction is not part of IEEE Std 1138-2009, IEEE Standard for Testing and Performance for Optical Ground Wire (OPGW) for Use on Electric Utility Power Lines.

IEEE Std 1138-1994 [B39] for optical ground wire (OPGW) was first published in 1994 and since then has been used worldwide to purchase and specify the performance of OPGW cables.^a The original purpose of the standard was to fill a need for standardization of terminology, performance, and test requirements for OPGW cables. The original title was: IEEE Standard Construction of Composite Fiber Optic Overhead Ground Wire (OPGW) for Use on Electric Utility Power Lines. Over the years, the document has been used primarily as a test standard. To better reflect how the standard is presently used, the title has been changed to: IEEE Standard for Testing and Performance for Optical Ground Wire (OPGW) for Use on Electric Utility Power Lines.

This revised standard documents the collective experience gained by the industry since the original publication. Changes have been made in the following areas:

- a) Organization of contents
- b) Functional requirements
- c) Test requirements
- d) Installation recommendations
- e) Hardware
- f) Packaging requirements
- g) Updating of all references and annexes

Representatives of the following IEEE subcommittees have reviewed this document:

- Fiber Optics Subcommittee—Power Systems Communications Committee, PES
- Towers, Poles, and Conductors Subcommittee—Transmission and Distribution Committee, PES
- ESMOL Subcommittee—Transmission and Distribution Committee, PES
- Lightning and Insulator Subcommittee—Transmission and Distribution Committee, PES

^a The numbers in brackets correspond to those of the bibliography in Annex A.

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IEEE Standard ~~Construction of Composite Fiber Optic Overhead~~ for Testing and Performance for Optical Ground Wire (OPGW) for Use on Electric Utility Power Lines

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1. Overview

1.1 Scope

This standard covers the performance, test requirements, procedures, and acceptance criteria for a transmission line overhead ground wire (a.k.a. shield wire, static wire, earth wire, skywire) with optical fibers commonly known as optical ground wire (OPGW). An OPGW cable has the dual performance functions of a ground wire with telecommunications capabilities.

This standard includes functional requirements, such as electrical, mechanical, optical fiber, environmental and packaging, and test requirements related to design, installation, in-service, and maintenance, including routine tests.

This standard is not intended to supersede any established safety rules, codes, regulations, or practices associated with the use of OPGW cables. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

~~This standard provides both construction and performance requirements that ensure within the guidelines of this standard that the ground wire function and maintenance of optical fiber integrity and optical transmissions are proper~~

1.2 Purpose

This standard covers the construction, mechanical and electrical performance, acceptance criteria, and test requirements for overhead ground wire (OPGW) designed to be located primarily on overhead power utility facilities. The standard provides performance and testing requirements that insure within the guidelines of this standard that the mechanical and electrical capabilities of the cable and cable components properly maintain mechanical integrity, optical fiber integrity, and optical transmission.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must 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. ~~This standard should be used in conjunction with the latest editions of the following standards:~~

ANSI/AA 53, ~~1981~~, Packaging Standards for Aluminum Conductor and ACSR.¹

ASTM B 230/B 230M, Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes.²

~~ANSI/EIA-359-A-1984, Standard Colors for Identification and Coding.~~

ASTM B 398/B 398M, Standard Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes.

ASTM B 415, Standard Specification for Hard-Drawn Aluminum clad Steel Wire.

ASTM B 498, Standard Specification for Zinc-Coated (Galvanized) Steel Core Wire for Aluminum IEC 61232, Aluminum-Clad Steel Wires for Electrical Purposes.

IEC 61395, Overhead Electrical Conductors—Creep Test Procedures for Stranded Conductors, TIA/EIA-455-3, FOTP-3A, Procedures to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components.⁷

TIA/EIA-455-81-B, FOTP-81A, Compound Flow (Drip) Test for Filled Fiber Optic Cable.

IEEE Std 524™, IEEE Guide to the Installation of Overhead Transmission Line Conductors

¹ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

²ASTM publications are available from the Customer Service Department, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, USA.

~~EIA/TIA 455-3A-1989, Procedures to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components.~~³

~~EIA/TIA 455-25A-1989, Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies.~~

~~EIA/TIA 455-30B-1991, Frequency Domain Measurement of Multimode Optical Fiber Information Transmission Capacity.~~

~~EIA/TIA 455-31B-1990, Fiber Tensile Proof Test Method.~~

~~EIA 455-41-1985, Compressive Loading Resistance of Fiber Optic Cables.~~

~~EIA/TIA 455-45B-1992, Microscopic Method for Measuring Fiber Geometry of Optical Waveguide Fibers. EIA/TIA 455-46A-1990, Spectral Attenuation Measurement for Long Length, Graded-Index Optical Fibers. EIA/TIA 455-48B-1990, Measurement of Optical Fiber Cladding Diameter Using Laser-Based Instruments.~~

~~EIA 455-50A-1987, Light Launch Conditions for Long Length, Graded-Index Optical Fiber Spectral Attenuation Measurements.~~

~~EIA/TIA 455-51A-1991, Pulse Distortion Measurement of Multimode Glass Optical Fiber Information Capacity. EIA/TIA 455-53A-1990, Attenuation by Substitution Measurement for Multimode Graded-Index Optical Fibers or Fiber Assemblies Used in Long Length Communications Systems.~~

~~EIA/TIA 455-54A-1990, Mode Scrambler Requirements for Overfilled Launching Conditions to Multimode Fibers. EIA/TIA 455-55B-1990, End View Methods for Measuring Coating and Buffer Geometry of Optical Fiber. EIA/TIA 455-58A-1990, Core Diameter Measurement of Graded-Index Optical Fibers.~~

~~EIA/TIA 455-59-1989, Measurement of Fiber Point Defect Using an OTDR. EIA/TIA 455-61-1989, Measurement of Fiber or Cable Attenuation Using an OTDR. EIA/TIA 455-62A-1992, Measurement of Optical Fiber Macrobend Attenuation.~~

~~EIA/TIA 455-78A-1990, Spectral Attenuation Cutback Measurement for Single-Mode Optical Fibers. EIA 455-80-1988, Cutoff Wavelength of Uncabled Single-Mode Fiber by Transmitted Power.~~

~~EIA/TIA 455-81A-1991, Compound Flow (Drip) Test for Filled Fiber Optic Cable. EIA/TIA 455-82B-1992, Fluid Penetration Test for Fluid Blocked Fiber Optic Cable.~~

~~EIA/TIA 455-164A-1991, Single-Mode Fiber, Measurement of Mode Field Diameter by Far Field Scanning. EIA/TIA 455-167A-1992, Mode Field Diameter Measurement, Variable Aperture Method in the Far Field.~~

~~EIA/TIA 455-168A-1992, Chromatic Dispersion Measurement of Multimode Graded-Index and Single-Mode Optical Fibers by Spectral Group Delay Measurement in the Time Domain.~~

~~³EIA publications are available from Global Engineering, 1990 M Street NW, Suite 400, Washington, DC, 20036.~~

~~USA/EIA/TIA 455-169A-1992, Chromatic Dispersion Measurement of Single-Mode Optical Fibers by the Phase Shift Method.~~

~~EIA/TIA 455-170-1989, Cable Cutoff Wavelength of Single-Mode Fiber by Transmitted Power.~~

~~EIA/TIA 455-173-1990, Coating Geometry Measurement for Optical Fiber, Side View Method.~~

~~EIA 455-174-1988, Mode Field Diameter of Single-Mode Optical Fiber by Knife-Edge Scanning in the Far Field.~~

~~EIA/TIA 455-175A-1992, Chromatic Dispersion Measurement of Single-Mode Optical Fibers by the Differential Phase Shift Method.~~

~~(ANSI).⁴~~

~~TIA/EIA 455-176-1993, Method for Measuring Optical Fiber Cross-Sectional Geometry by Automated Grey Scale Analysis.^{5, 6}~~

~~ASTM E 29-1990, Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications.~~

~~TIA/EIA 455-177A-1992, Numerical Aperture Measurement of Graded-Index Optical Fibers.~~

3. Definitions

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary: Glossary of Terms & Definitions* should be referenced for terms not defined in this clause.⁸

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

maximum design load (MDL): The maximum design load the cable is expected to experience in service under meteorological loading conditions (e.g., wind, ice loads, temperature). The MDL is used in determining the maximum rated design tension.

maximum rated design tension (MRDT): The maximum tension rating of the cable so it will function over its lifetime without reducing the performance of the optical fibers. This tension rating will be determined by the cable manufacturer. MRDT may be expressed in terms of tension or as a percentage of rated tensile strength (RTS). MRDT may also be known as maximum rated cable load (MRCL).

optical ground wire (OPGW): OPGW cable has the dual performance functions of a ground wire with telecommunications capabilities.

optical time delay 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.

rated tensile strength (RTS): The calculated tensile load that the cable shall withstand without mechanical failure.

sagging tension (SAT): 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 sag relative to other conductors and the ground.

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

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(<http://global.ihs.com/>).

⁸ The IEEE Standards Dictionary: Glossary of Terms & Definitions is available at <http://shop.ieee.org/>.

system (OPGW system): The cable and hardware working together.

NOTE—The cable and hardware described in this standard function as an integrated unit.⁹

4. Description of OPGW cable and components

The composite fiber optic overhead ground wire shall be made up of buffered flexible glass optical telecommunications fibers contained in a protective central fiber optic unit surrounded by concentric layered stranded metallic wires in single or multiple layers. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fiber.

There are multiple acceptable designs of OPGW. Typically, they consist of one or more layers of metallic wires stranded about a cable core comprised of components such as tubes, wires and/or slotted rods, and optical fibers in optical fiber units.

Stranded metallic wires

~~a) The basic construction shall have bare concentric lay stranded metallic wires with the outer layer having left hand lay unless otherwise specified by the purchaser~~

a) The composition and stranding of the metallic wires shall be in accordance with the appropriate industry standard for metallic wires and cabling such as those referenced in Clause 2. For consistency and operability with existing materials and methods used in power transmission lines, the stranded metal wires shall, where applicable, meet the appropriate wire and cabling standards as they will apply to conventional ground wire.

b) At the supplier's option, the rated tensile strength (RTS) may include the strength of the optical unit. In this case, the supplier shall notify the customer if the fiber optic unit is considered a load-bearing tension member when determining the total RTS of the composite conductor.

~~b) The stranded wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay shall be reversed in successive layers.~~

c) The finished galvanized or aluminum-clad steel wires shall contain no joints or splices unless otherwise agreed upon between the supplier and the purchaser.

4.2 Design of fiber optic unit

The fiber optic unit shall be designed to house and protect the optical fibers from damage due to forces such as crushing, bending, twisting, tensile stress, and moisture. The fiber optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibers from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects that may produce hydrogen. The fiber optic unit may include an aluminum tube, channeled aluminum rod, [stainless steel tubing](#), or [aluminum-coated stainless steel tubing](#), but is not limited to these designs.

4.2.1 Metallic tube

The fiber optic unit may include a tube such as stainless steel or aluminum to house the fibers. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam. [The fiber optic unit may include a stainless steel tube with an aluminum protective coating to house the fibers. The coating shall completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc., with the surrounding stranded wires described in 4.1.](#)

⁹ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this stand

4.2.2 Grooved rod or spacer

[A grooved rod or spacer](#) may be fabricated with one or more grooves and formed into a helix to house the optical fibers. [The fibers may be contained inside a tube placed in the groove\(s\).](#) An outer protective shield may be applied around the rod or spacer such as a tube or a helically applied overlapping tape to provide an additional mechanical and environmental barrier.

4.2.3 Filling compound

If required, the interstices of the fiber optic unit shall be filled with a suitable compound to prohibit any moisture ingress from outside or any water migration along the fiber optic unit. The filling compound used shall be compatible with all the components with which it may come in contact.

4.2.4 Structural members of fiber optic unit

Structural member(s) may be used to limit the stress on the fiber inside the central fiber optical unit. [These structural member\(s\) shall be made of non-conductive dielectric materials that do not pose an electrical hazard to the fiber optic splicing or terminations processes.](#)

4.3 Optical fiber

~~Single-mode fibers, dispersion-unshifted and dispersion-shifted, and multimode fibers with 50/125 μ m and 62.5/125 μ m core/clad diameters are considered in this document.~~

The core and the cladding shall consist of all glass that is predominantly silica (SiO₂). The coating is usually made from one or more [synthetic materials, such as](#) plastic or acrylate, or compositions and shall be provided to protect the fiber during manufacture, handling, and [operation. The optical fiber shall be in accordance with the appropriate industry standard such as those referenced in Clause 2.](#)

4.4 Buffer construction

A buffer for protection from physical damage during fabrication, installation, and performance of the OPGW cable may surround the individually coated optical fiber(s). Loose buffer or tight buffer constructions are two types of protection that may be used to isolate the fibers. The fiber coating and buffer shall be strippable for splicing and termination.

4.4.1 Loose buffer

Loose buffer construction shall consist of a tube that surrounds each fiber or fiber group such that the inner diameter of the tube is greater than the outside diameter of the fiber or fiber group. The interstices inside and outside the tube may be filled with a water-blocking compound.

4.4.2 Tight buffer

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

4.4.3 Color coding

The fiber coloring shall be in accordance with an appropriate industry standard for fiber color as referenced in Clause 2. In cases where the number of fibers per unit exceeds the number of fibers per unit provided in the applicable standard, the supplier shall implement other means for identifying fibers in the same unit. In case of multiple fiber units, these units shall be also uniquely identified.

~~Color coding is essential for identifying individual optical fibers and groups of optical fibers. The colors and tolerances shall be in accordance with ANSI/EIA-359-A-1984.6. The color coding method shall be mutually agreed upon by the user and manufacturer.~~

4.4.4 Color performance

The original ~~color coding system shall be~~ identification of fibers and units shall remain discernible throughout the design life of the cable when cleaned and prepared per manufacture's recommendations.

5.1 Electrical

5.1.1 Fault current performance

An OPGW cable shall be designed so that fault currents due to short circuits do not damage the integrity or impair the functionality of any component of the cable and its optical, electrical, and mechanical performance. Fault current is that which enters the OPGW as a result of a line-to-tower short circuit. The end user will provide (1) a description of short-circuit fault current adequate for establishing the required I^2t requirement of the OPGW, or (2) I^2t as specified by the end user.

5.1.2 Lightning performance

An OPGW cable shall be designed so that lightning arcs striking the cable do not impair the long term functionality of any component of the cable and its optical, electrical, and mechanical performance.