

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

Sponsor

Power Communications Committee
of the
IEEE Power Engineering Society

Reaffirmed August 1, 2002
Approved August 26, 1994

American National Standards Institute

Reaffirmed March 20, 2002
Approved March 17, 1994

IEEE Standards Board

Abstract: The construction, mechanical and electrical performance, installation guidelines, acceptance criteria, and test requirements for a composite overhead ground wire with optical fibers, commonly known as OPGW are discussed.

Keywords: fiber optic cable, multimode fiber, optical cable, optical ground wire, single-mode fiber, rated breaking strength, stranded metallic wires

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA

Copyright © 1994 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 1994. Printed in the United States of America.

ISBN 0-155937-422-5

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the Technical Committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE that have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason IEEE and the members of its technical committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

IEEE standards documents may involve the use of patented technology. Their approval by the Institute of Electrical and Electronics Engineers does not mean that using such technology for the purpose of conforming to such standards is authorized by the patent owner. It is the obligation of the user of such technology to obtain all necessary permissions.

Introduction

[This introduction is not a part of IEEE Std 1138-1994, IEEE Standard Construction of Composite Fiber Optic Ground Wire (OPGW) for Use on Electric Utility Power Lines.]

The Fiber Optic Standards Working Group is comprised of key personnel from all OPGW manufacturing companies as well as a large sampling of the user base. This standard is a result of both manufacturers and users wanting guidance on which specifications were important and what tests should be performed. Each manufacturer had a different set of specifications while very few customers had sufficient knowledge of the product to determine what tests and test results would guarantee adequate performance. Therefore, each customer required a different set of product tests and each manufacturer was required to perform many overlapping and redundant tests. This standard provides all customers with the same set of specifications and tests procedures so that they are not required to write their own.

This standard represents a compilation of the combined efforts of users and manufacturers and is endorsed by both communities for general customer and manufacturer use.

At the time this standard was completed, the Fiber Optic Standards Working Group had the following membership.

William A. Byrd, Chair

Philip A. Adelizzi
Charles L. Carter
Stewart Cudworth
Patrick E. Dobbins
J. W. Duncan
Robert Emerson
Henry Grad
Tony Hall
James E. Hartpence

Robert E. Bratton, Co-chair

John Johnson
Michael Kieli
Samy Krishnasamy
Ron Lindsay
Konrad Loebel
William M. Malone
Michel Miron
Maurice Murphy
Chi-Than Nguyen

Alan J. Peacock
Jonh Smith
David Sunkle
Dennis G. Theis
Larry Vincent
Brad Warner
Robert Whapham
Stuart Woods

The following persons were on the balloting committee:

Philip Adelizzi
Gordon Allen
Mel J. Anna
Joseph Basileco
Harold Bates
Gerard G. Beaudoin
William E. Blair
John Blose
Sig Bogdanowicz
Lawrence A. Bryant
Myron E. Bulawka
William A. Byrd
James B. Caldwell
Thomas F. Clark
Frances M. Cleveland
T.J. Comerford
R. S. Curtis
Harold J. Fiedler
Jalal Gohari
Henry Grad
Andrew Haban, Jr.

Jerry W. Hagge
Peter Hanson
David E. Hartmann
Willmore F. Holbrow, Jr.
Richard G. Irvine
Daniel R. Jernigan
David E. Kimzey
Harold Kirkham
Stewart L. Larvick
Michael J. Lieb
Robert Linden
Konrad Loebel
Richard C. Madge
Wade P. Malcolm
William M. Malone
Donald J. Marihart
William J. McCoy
Douglas M. Morton
John H. Ng
Jay L. Nicholls
Gary L. Nissen
Stanley D. Overby

Leo J. Perfecky
Matthias C. Perz
Daniel C. Pineda
Peter J. Pongracz
Lester Querry
Roger E. Ray
Charles Russ
William R. Schlinger
J. L. Schnegg
William Silva
Richard D. Sperduto
Roger K. Sullivan
Ted Swingle
John Thorson
Matthew S. Tibensky
Jose Tovar
Donald L. Bandenbroek
S. Walia
J. B. Wallace
Manfred Weinrab
Robert Whapham

When the IEEE Standards Board approved this standard on March 17, 1994, it had the following membership:

Wallace S. Read, *Chair*
Donald C. Loughry, *Vice Chair*
Andrew G. Salem, *Secretary*

Gilles A. Baril
Bruce B. Barrow
José A. Berrios de la Paz
Clyde R. Camp
James Costantino
Stephen L. Diamond
Donald C. Fleckenstein
Jay Forster *
Ramiro Garcia

Donald N. Heirman
Richard J. Holleman
Jim Isaak
Ben C. Johnson
Sonny Kasturi
Lorraine C. Kevra
E. G. “Al” Kiener
Ivor N. Knight

Joseph L. Koepfinger *
D. N. “Jim” Logothetis
L. Bruce McClung
Marco W. Migliaro
Mary Lou Padgett
Arthur K. Reilly
Ronald H. Reimer
Gary S. Robinson
Leonard L. Tripp

* Member Emeritus

Also included are the following nonvoting IEEE Standards Board liaisons:

Satish K. Aggarwal
James Beall

Richard B. Engelman

David E. Soffrin
Stanley I. Warshaw

Rachel A. Meisel
IEEE Standards Project Editor

CLAUSE	PAGE
1. Overview	1
1.1 Scope	1
2. References	1
3. OPGW and components	3
3.1 Description	3
3.2 Stranded metallic wires	3
3.3 Design of central fiber optic unit	4
3.4 Optical fiber	4
3.5 Buffer construction	4
3.6 Color coding	5
4. Test requirements	5
4.1 Cable tests	5
4.2 Fiber tests	7
5. Test methods	10
5.1 Cable tests	10
5.2 Fiber tests	13
6. Sag and tension limits	15
7. Field acceptance testing	16
8. Installation recommendations	16
8.1 Installation procedure	16
8.2 Hardware and accessories	17
9. Packaging requirements	17
10. Bibliography	18
Annex A Short circuit tests (Informative)	19
Annex B Aeolian vibration test (Informative)	21
Annex C Galloping test (Informative)	24
Annex D Sheave test (Informative)	27

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

1. Overview

1.1 Scope

This standard covers the construction, mechanical and electrical performance, installation guidelines, acceptance criteria, and test requirements for a composite overhead ground wire with optical fibers commonly known as OPGW. The OPGW has the dual performance functions of a standard ground conductor with telecommunications capabilities.

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.

2. References

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

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

ASTM B 398-1990, Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes.²

ASTM B 415-1992, Specification for Hard-Drawn Aluminum Clad Steel Wire.

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

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.

IEEE Std 524-1992, IEEE Guide to the Installation of Overhead Transmission Line Conductors (ANSI).⁴

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

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

3. OPGW and components

3.1 Description

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-lay 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.

3.2 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.
- 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 wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.
- d) The preferred length of lay of the various layers of wires is 13.5 times the outside diameter of that layer, but the length of lay shall not be less than 10 nor more than 16 times this diameter.
- e) The rated breaking strength of the completed OPGW shall be taken as 90% of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the appropriate specified minimum tensile strength.
- f) At the manufacturer's option, the rated breaking strength may include the strength of the optical unit. In this case, the manufacturer shall notify the customer if the fiber optic unit is considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.
- g) The finished wires shall contain no joints or splices unless otherwise agreed upon between the manufacturer and the purchaser.
- h) Hybrid designs not included in items a)-f) are not excluded from this standard.

⁴IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

⁵TIA/EIA publications are available from Global Engineering.

3.3 Design of central fiber optic unit

The central 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 and/or channeled aluminum rod, but is not limited to these designs.

3.3.1 Aluminum tube

The fiber optic unit may include an aluminum tube to house the fibers. The aluminum tube may be fabricated as a seamless extruded tube, seam welded, or a tube without a welded seam.

3.3.2 Aluminum rod

An aluminum rod may be fabricated with one or more channels or grooves and formed into a helix to house the optical fibers. An outer protective shield may be applied around the rod such as an aluminum tube or a helically applied overlapping aluminum tape to provide an additional mechanical and environmental barrier.

3.3.3 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 it may come in contact with and shall absorb and/or inhibit generation of hydrogen within the cable.

3.3.4 Central structural member(s)

Structural member(s) may be used to limit the stress on the fiber inside the central fiber optical unit.

3.4 Optical fiber

Single-mode fibers, dispersion-unshifted and dispersion-shifted, and multimode fibers with 50/125 μm and 62.5/125 μm core/clad diameters are considered in this document. The core and the cladding shall consist of all glass which is predominantly silica (SiO_2). The coating, usually made from one or more plastic materials or compositions, shall be provided to protect the fiber during manufacture, handling, and use.

3.5 Buffer construction

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

3.5.1 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 filling compound.

3.5.2 Tight buffer

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

3.6 Color coding

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.

3.6.1 Color performance

The original color coding system shall be discernible throughout the design life of the cable.

4. Test requirements

Each requirement in this clause is complementary to the corresponding paragraph in clause 5, which describes a performance verification or test procedure.

4.1 Cable tests

4.1.1 Design tests

An OPGW cable shall successfully pass the following design tests. However, design tests may be waived at the option of the user if a fiber optic overhead ground wire of identical design has been previously tested to demonstrate the capability of the manufacturer to furnish cable with the desired performance characteristics.

4.1.1.1 Water ingress test

A water ingress test for cables designed for water blocking shall be performed in accordance with 5.1.1.1. No water shall leak through the open end of the 1 m sample. If the first sample fails, one additional 1 m sample, taken from a section of cable adjacent to the first sample, may be tested for acceptance.

4.1.1.2 Seepage of flooding compound

For filled fiber optic cable, a seepage of flooding compound test shall be performed in accordance with 5.1.1.2. The filling and flooding compound shall not flow (drip or leak) at 65 °C.

4.1.1.3 Short circuit test

A short circuit test shall be performed in accordance with 5.1.1.3. An increase in measured optical attenuation greater than 1.0 dB/test fiber km at 1550 nm for single-mode fibers and at 1300 nm for multimode fibers shall constitute failure. Birdcaging or breaking of the conductor strands shall also constitute failure.

Dissection of the cable following the test should show no distortion of any component of the cable, including the optical fibers, buffer tubes, and any aluminum or other components. Distortion of any kind that can be attributed to the test other than test set up procedures or hardware shall constitute failure.

⁶Information on references can be found in clause 2.