UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Electrification Administration

**BULLETIN 1753F-601(PE-90)**

**SUBJECT:** **REA Specification for Filled Fiber Optic Cables**

**TO:** All Telephone Borrowers
REA Telephone Staff

**EFFECTIVE DATE:** August 4, 1994.

**EXPIRATION DATE:** Date of change in 7 CFR 1755.900 by rulemaking.

**OFFICE OF PRIMARY INTEREST:** Outside Plant Branch, Telecommunications Standards Division.

**PREVIOUS INSTRUCTIONS:** This bulletin replaces REA Bulletin 345-90, REA Specification for Totally Filled Fiber Optic Cable, PE-90, issued May 28, 1986.

**FILING INSTRUCTIONS:** Discard REA Bulletin 345-90, REA Specification for Totally Filled Fiber Optic Cable, PE-90, dated May 28, 1986, and replace with this bulletin. File with 7 CFR 1755 and on REANET.

**PURPOSE:** This specification covers REA requirements for filled fiber optic cables intended for aerial installation either by attachment to a support strand or by an integrated self-supporting arrangement, for underground application by placement in a duct, or for buried installations either by trenching or direct plowing. This bulletin is a user friendly guide and a reformat of the text codified in 7 CFR 1755.900 published at 59 FR 34353, dated July 5, 1994.

Every effort has been made to ensure the accuracy of this document. However, in case of discrepancies, the regulations at 7 CFR 1755.900 are the authorized sources.

Wally Beyer — 8/16/94

Administrator — Date

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## ABBREVIATIONS

| | |
|---|---|
| ASTM | American Society For Testing and Materials |
| °C | Centigrade temperature scale |
| dB | Decibel |
| dB/km | Decibels per 1 kilometer |
| ECCS | Electrolytic chrome coated steel |
| EIA | Electronic Industries Association |
| EIA/TIA | Electronic Industries Association/ Telecommunications Industry Association |
| GE | General Electric |
| HD | High density polyethylene |
| LDHMW | Low density, high molecular weight polyethylene |
| LLDHMW | Liner low density, high molecular weight polyethylene |
| Max. | Maximum |
| MD | Medium density polyethylene |
| MHz-km | Megahertz-kilometer |
| Min. | Minimum |
| NA | Numerical aperture |
| NESC | National Electrical Safety Code |
| OC | Optical cable |
| OF | Optical fiber |
| OSHA | Occupational Safety and Health Administration |
| % | Percent |
| ps/(nm·km) | Picosecond per nanometer times kilometer |
| ps/($nm^2$·km) | Picosecond per nanometer squared times kilometer |
| REA | Rural Electrification Administration |

## DEFINITIONS

**Bandwidth:** The range of signal frequencies that can be transmitted by a communications channel with defined maximum loss or distortion. Bandwidth indicates the information-carrying capacity of a channel. For an optic fiber system bandwidth is usually given as its capacity to transmit information in a specific time period for a specific length, e.g., 10 Mbit/sec/km.

**Cladding:** A layer of glass or other transparent material fused to and concentrically surrounding the core. The cladding has a lower refractive index than the core, so light is internally reflected along the core.

**Core:** The central region of an optical waveguide or fiber through which light is transmitted.

**Cutoff Wavelength:** The shortest wavelength at which only the fundamental mode of an optical wavelength is capable of propagation.

**Dispersion:** The spreading out of light pulses as they travel in an optical fiber, proportional to length.

**Graded Refractive Index Profile:** Any index profile that varies smoothly with radius. Distinguished from a step refractive index profile.

**Loose Tube Buffer:** A protective tube loosely surrounding a cabled fiber, often filled with a gel.

**Mode-Field Diameter:** The diameter of the one mode of light propagating in a single mode fiber.

**Multimode Fiber:** An optical fiber which will allow more than one bound to propagate. It may be either a graded index or step index optical fiber.

**Numerical Aperture (NA):** An optical fiber parameter that indicates the angle of acceptance of light into a fiber.

**Optical Fiber:** Any fiber, made of dielectric material that guides light.

**Optical Waveguide:** Any structure capable of guiding optical power. In optical communications, the term generally refers to a fiber designed to transmit optical signals.

**Single Mode Fiber:** An optical fiber in which only one bound mode can propagate at the wavelength of interest.

**Step Refractive Index Profile:** An index profile characterized by a uniform refractive index within the core and a sharp decrease in refractive index at the core-cladding interface. It corresponds to a power-law profile with profile parameter, g, approaching infinity.

**Tight Tube Buffer:** A material tightly surrounding a fiber in a cable, holding it rigidly in place.

## 1. SCOPE

**1.1** This specification covers the requirement for filled fiber optic cables intended for aerial installation either by attachment to a support strand or by an integrated self-supporting arrangement, for underground application by placement in a duct, or for buried installations either by trenching or by direct plowing.

**1.1.1** The optical waveguides are glass fibers having directly-applied protective coatings, and are called "fibers", herein. These fibers may be assembled in either loose fiber bundles with a protective core tube, encased in several protective buffer tubes, or in tight buffer tubes.

**1.1.2** Fillers, strength members, core wraps, and bedding tapes may complete the cable core.

**1.1.3** The core or buffer tubes containing the fibers and the interstices between the buffer tubes, fillers, and strength members in the core structure are filled with a suitable material to exclude water.

**1.1.4** The cable structure is completed by an extruded overall plastic jacket. This jacket may have strength members embedded in it, in some designs.

**1.1.5** Buried installation requires an armor under the outer jacket.

**1.1.6** For self-supporting cable the outer jacket may be extruded over the support messenger and cable core.

**1.2** The cable is fully color coded so that each fiber is distinguishable from every other fiber. A basic color scheme of twenty-four colors allows individual fiber identification. Colored tubes, binders, threads, stripings, or markings provide fiber group identification.

**1.3** Cable manufactured to this specification must demonstrate compliance with the qualification testing requirements to ensure satisfactory end-use performance characteristics for the intended applications.

**1.4** Optical cable designs not specifically addressed by this specification may be allowed if accepted by REA. Justification for acceptance of a modified design must be provided to substantiate product utility and long term stability and endurance.

**1.5** All cables sold to REA borrowers for projects involving REA loan funds under this specification must be accepted by REA Technical Standards Committee "A" (Telephone). For cables

manufactured to this specification, all design changes to an accepted design must be submitted for acceptance. REA will be the sole authority on what constitutes a design change.

**1.6** REA intends that the optical fibers contained in the cables manufactured in accordance with this specification have characteristics that will allow signals, having a range of wavelengths, to be carried simultaneously.

## 2. OPTICAL FIBERS

**2.1** The solid glass optical fibers must consist of a cylindrical core and cladding covered by either an ultraviolet-cured acrylate or other suitable coating.

**2.2** The optical fiber types must be one of the following:

a. Dispersion-unshifted single mode fiber EIA Class IVa;

b. Dispersion-shifted single mode fiber EIA Class IVb;

c. 50/125 micrometer multimode fiber EIA Class Ia; or

d. 62.5/125 micrometer multimode fiber EIA Class Ia.

**2.3** The dispersion-unshifted single mode fiber core must have either a matched or depressed clad step refractive index profile with a mode-field diameter of 9.0 ± 1.0 micrometers when measured at 1300 nanometers and 10.5 + 1.0 micrometers/ - 1.5 micrometers when measured at 1550 nanometers in accordance with any one of the following test methods:

a. EIA/TIA-455-164A;

b. EIA/TIA-455-165A;

c. EIA/TIA-455-167A; or

d. EIA-455-174.

**2.4** The dispersion-shifted single mode fiber core must have either a segmented core design or depressed clad step refractive index profile with a mode-field diameter of 7.5 + 1.5 micrometers/ - 1.3 micrometers when measured at 1550 nanometers in accordance with any one of the test procedures specified in Paragraph 2.3 of this specification.

**2.5** The core clad off-set of the dispersion-unshifted and dispersion-shifted single mode fibers must not be greater than 1.0 micrometer when measured in accordance with either EIA/TIA-455-45B or EIA/TIA-455-176.

**2.6** The multimode fiber cores must have graded (parabolic) refractive index profiles with core diameters of 50.0 ± 3.0 micrometers or 62.5 ± 3.0 micrometers when measured in accordance with either EIA/TIA-455-58A or EIA/TIA-455-176.

**2.7** The core noncircularity of multimode fibers must not exceed 6 percent when measured in accordance with either EIA/TIA-455-45B or EIA/TIA-455-176.

**2.8** The outside diameter of the glass fiber for both single mode and multimode fibers must be 125 ± 2.0 micrometers when measured in accordance with any one of the following test methods:

a. EIA/TIA-455-45B;

b. EIA/TIA-455-176; or

c. EIA/TIA-455-48B, Methods A or B.

**2.9** The outside diameter of the glass fiber must be nominally concentric with the fiber core as is consistent with the best commercial practice.

**2.10** The individual fibers must be proof tested at a minimum tensile stress of 0.35 gigapascal for approximately one second when measured in accordance with EIA/TIA-455-31B.

**2.11** Factory splices of fibers are allowed provided that prior acceptance from REA is obtained for the splice technique, that all splices are documented and reported to the customer and that the spliced fiber meets all the requirements of this specification.

**2.12** The optical fiber must be coated with a suitable material to preserve the intrinsic strength of the glass having an outside diameter of 250 ± 15 micrometers when measured in accordance with either EIA/TIA-455-55B or EIA/TIA-455-173.

**2.13** The maximum force required to remove 25 millimeters of protective fiber coating must not exceed 13 newtons when measured in accordance with EIA/TIA-455-178.

**2.14** All optical fibers in any single length of cable must of the same type.

## 3. BUFFER/COATING

**3.1** The optical fibers contained in a tube buffer (loose tube), an inner jacket (unit core), a channel or otherwise loosely packaged must have a clearance between the fibers and the inside of the container sufficient to allow for thermal expansions without constraining the fibers. The protective container must

be manufactured from a material having a coefficient of friction sufficiently low to allow the fibers free movement.

**3.2** Optical fibers covered in near contact with an extrusion (tight tube) must have an intermediate soft buffer to allow for thermal expansions and minor pressures.

**3.3** All protective coverings in any single length of cable must be continuous and be of the same material except at splice locations.

**3.4** The protective coverings must be free from holes, splits, blisters, and other imperfections and must be as smooth and concentric as is consistent with the best commercial practice.

**3.5** Repairs to the fiber coatings are not allowed except at splice locations.

**3.6** Both loose tube and tight tube coverings of each color and other fiber package types removed from the finished cable must meet the following shrinkback and cold bend performance requirements. The fibers may be left in the tube.

**3.6.1 Shrinkback:** Testing must be conducted in accordance with ASTM D 4565-90a, Paragraph 14.1, using a talc bed at a temperature of 95°C. Shrinkback must not exceed 5 percent of the original 150 millimeter length of the specimen. The total shrinkage of the specimen must be measured.

**3.6.2 Cold Bend:** Testing must be conducted on at least one tube from each color in the cable. Stabilize the specimen to -20 ± 1°C for a minimum of four hours. While holding the specimen and mandrel at the test temperature, wrap the tube in a tight helix ten times around a mandrel with a diameter not greater than five times the tube diameter. The tube must show no evidence of cracking when observed with normal or corrected-to-normal vision.

Note: Channel cores and similar slotted single component core designs need not be tested for cold bend.

## 4. FIBER AND BUFFER TUBE IDENTIFICATION

**4.1** The colors designated for identification of loose buffer tubes, tight tube buffer fibers and individual fibers in multifiber tubes, slots or bundles are shown in the following table:

| Buffer Tube and Fiber No. | Color |
|---|---|
| 1 | Blue |
| 2 | Orange |
| 3 | Green |
| 4 | Brown |
| 5 | Slate |
| 6 | White |
| 7 | Red |
| 8 | Black |
| 9 | Yellow |
| 10 | Violet |
| 11 | Rose |
| 12 | Aqua |
| 13 | Blue/Black Tracer |
| 14 | Orange/Black Tracer |
| 15 | Green/Black Tracer |
| 16 | Brown/Black Tracer |
| 17 | Slate/Black Tracer |
| 18 | White/Black Tracer |
| 19 | Red/Black Tracer |
| 20 | Black/Yellow Tracer |
| 21 | Yellow/Black Tracer |
| 22 | Violet/Black Tracer |
| 23 | Rose/Black Tracer |
| 24 | Aqua/Black Tracer |

**4.2 Standards of Colors:** Except for the aqua color, the colors of fibers and tubes supplied in accordance with this specification are specified in terms of the Munsell Color System (ASTM D 1535-89) and must comply with the color limits as defined in EIA/TIA-598. (A visual color standard meeting these requirements and entitled "Munsell Color Charts for Color Coding," may be obtained from the Munsell Color Company, Inc., 2441 North Calvert Street, Baltimore, Maryland 21218. The latest edition of the color standard should be used.)

**4.2.1** The aqua color limits using the Munsell Color System must be as follows:

Munsell Notation

| Symbol | Aqua Color |
|---|---|
| Centriod | 10BG 7/6 |
| H++ | 5B 7/6 |
| H-- | 5BG 7/6 |
| V++ | 10BG 8/4 |
| V-- | 10BG 6/6 |
| C++ | None |
| C-- | 10BG 7/4 |

**4.2.2** Other coloring schemes used for providing identification of buffer tubes and optical fibers which deviate from the requirements of Paragraph 4.1 of this specification will not be accepted by REA.

## 5. STRENGTH MEMBERS

**5.1** Strength members must be an integral part of the cable construction, but are not considered part of the support messenger for self-supporting optical cable.

**5.2** The combined strength of all the strength members must be sufficient to support the stress of installation and to protect the cable in service.

**5.3** Strength members may be incorporated into the core as a central support member or filler, as fillers between the fiber packages, as an annular serving over the core, as an annular serving over the intermediate jacket, embedded in the outer jacket or as a combination of any of these methods.

**5.4** The central support member or filler must contain no more than one splice per kilometer of cable. Individual fillers placed between the fiber packages and placed as annular servings over the core must contain no more than one splice per kilometer of cable. Cable sections having central member or filler splices must meet the same physical requirements as unspliced cable sections.

**5.5** Strength member materials and splicing techniques must be accepted by REA prior to their use.

**5.6** In each length of completed cable having a metallic central member, the dielectric strength between the armor and the metallic center member must withstand at least 15 kilovolts direct current for 3 seconds.

## 6. FORMING THE CABLE CORE

**6.1** Protected fibers must be assembled with the optional central support member, fillers and strength members in such a way as to form a cylindrical group.

**6.2** The standard cylindrical group or core designs shall consist of 4, 6, 8, 10, 12, 16, 18, 20, or 24 fibers. Cylindrical groups or core designs larger than the sizes shown above must meet all the requirements of this specification.

**6.3** When treads or tapes are used as core binders, they must be colored either white or natural and must be a nonhygroscopic and nonwicking dielectric material.

**6.4** When treads or tapes are used as unit binders to define optical fiber units in loose tube, tight tube, slotted, or bundled cored designs, they must be colored in accordance with the table listed below and must be a nonhygroscopic and nonwicking dielectric material or be rendered such by the filling compound. The colors of the binders must be in accordance with Paragraphs 4.1 and 4.2.1 of this specification.

| Unit No. | Binder Color |
|---|---|
| 1 | Blue |
| 2 | Orange |
| 3 | Green |
| 4 | Brown |
| 5 | Slate |
| 6 | White |
| 7 | Red |
| 8 | Black |
| 9 | Yellow |
| 10 | Violet |
| 11 | Rose |
| 12 | Aqua |
| 13 | Blue-Black |
| 14 | Orange-Black |
| 15 | Green-Black |
| 16 | Brown-Black |
| 17 | Slate-Black |
| 18 | White-Black |
| 19 | Red-Black |
| 20 | Black-Black-Yellow |
| 21 | Yellow-Yellow-Black |
| 22 | Violet-Black |
| 23 | Rose-Black |
| 24 | Aqua-Black |

## 7. FILLING COMPOUND

**7.1** To prevent the ingress of water into the core, a filling compound must be applied into the interior of the loose fiber tubes and into the interstices of the core. When a core wrap is used, the filling compound must also be applied to the core wrap, over the core wrap and between the core wrap and inner jacket when required.

**7.2** The materials must be homogeneous and uniformly mixed; free from dirt, metallic particles and other foreign matter; easily removed; nontoxic and present no dermal hazards.

**7.3** The individual cable manufacturer must satisfy REA that the filling compound selected for use is suitable for its intended application. The filling compound must be compatible with the

cable components when tested in accordance with ASTM D 4568-86 at a temperature of 80°C.

## 8. CORE WRAP (OPTIONAL)

**8.1** At the option of the manufacturer, one or more layers of nonhygroscopic and nonwicking dielectric material may be applied over the core.

**8.2** The core wrap(s) can be used to provide a heat barrier to prevent deformation or adhesion between the fiber tubes or can be used to contain the core.

**8.3** When core wraps are used, sufficient filling compound must be applied to the core wraps so that voids or air spaces existing between the core wraps and between the core and the inner side of the core wrap are minimized.

## 9. INNER JACKET

**9.1** Inner jackets may be applied directly over the core or over the strength members.

**9.1.1** For armored cable an inner jacket is optional but recommended. The inner jacket may absorb stresses in the cable core that may be introduced by armor application or by armored cable installation.

**9.1.2** For unarmored cable an inner jacket is optional.

**9.2** The inner jacket material and test requirements must be as for the outer jacket material per Paragraphs 13.3 through 13.3.5 of this specification, except that either black or natural polyethylene may be used. In the case of natural polyethylene, the requirements for absorption coefficient and the inclusion of furnace black are waived.

## 10. FLOODING COMPOUND

**10.1** Sufficient flooding compound must be applied between the inner jacket and armor and between the armor and outer jacket so that voids and air spaces in these areas are minimized. The use of floodant between the armor and outer jacket is not required when uniform bonding, Paragraph 11.10 of this specification, is achieved between the plastic-clad armor and the outer jacket.

**10.2** The flooding compound must be compatible with the jacket when tested in accordance with ASTM D 4568-86 at a temperature of 80°C. The floodant must exhibit adhesive properties sufficient

to prevent jacket slip when tested in accordance with the requirements of Appendix A, Paragraph 3.3, of this specification.

**10.3** The individual cable manufacturer must satisfy REA that the flooding compound selected for use is acceptable for the application.

**10.4** In lieu of a flooding compound, water blocking tapes may be applied between the inner jacket and armor and between the armor and outer jacket to prevent water migration. The use of the water blocking tape between the armor and outer jacket is not required when uniform bonding, per Paragraph 11.10 of this specification, is achieved between the plastic-clad armor and outer jacket.

## 11. ARMOR

**11.1** A steel armor, plastic coated on both sides, is required for direct buried cable manufactured under the provisions of this specification. An armor is optional for duct and aerial cable as required by the purchaser. The plastic coated steel armor must be applied longitudinally directly over the core wrap or the intermediate jacket and have a minimum overlap of 3.0 millimeters.

**11.2** The uncoated steel tape must be electrolytic chrome coated steel (ECCS) with a thickness of 0.155 ± 0.015 millimeters.

**11.3** The reduction in thickness of the armoring material due to the corrugating or application process must be kept to a minimum and must not exceed 10 percent at any spot.

**11.4** The armor of each length of cable must be electrically continuous with no more than one joint or splice allowed per kilometer of cable. This requirement does not apply to a joint or splice made in the raw material by the raw material manufacturer.

**11.5** The breaking strength of any section of an armor tape, containing a factory splice joint, must not be less than 80 percent of the breaking strength of an adjacent section of the armor of equal length without a joint.

**11.6** For cables containing no floodant over the armor, the overlap portions of the armor tape must be bonded in cables having a flat, noncorrugated armor to meet the requirements of Paragraphs 17.1 through 17.7.2 of this specification. If the tape is corrugated, the overlap portions of the armor must be sufficiently bonded and the corrugations must be sufficiently in register to meet the requirements of Paragraphs 17.1 through 17.7.2 of this specification.

**11.7** The armor tape must be so applied as to enable the cable to pass the bend test as specified in Paragraph 17.1 of this specification.

**11.8** The protective coating on the steel armor must meet the Bonding-to-Metal, Heat Sealability, Lap-Shear and Moisture Resistance requirements of Type I, Class 2 coated metals in accordance with ASTM B 736-92a.

**11.9** The ability of the plastic-clad metal to resist the flooding compound must be determined as required by ASTM D 4568-86 using a one meter length of coated steel which must be aged for 7 days at 68 ± 1°C. There must be no delamination of the coating from the steel at the conclusion of the test.

**11.10** When the jacket is bonded to the plastic coated armor, the bond between the plastic coated armor and the outer jacket must not be less than 525 newtons per meter over at least 90 percent of the cable circumference when tested in accordance with ASTM D 4565-90a. For cables with strength members embedded in the jacket, and residing directly over the armor, the area of the armor directly under the strength member is excluded from the 90 percent calculation.

## 12. OPTIONAL SUPPORT MESSENGER (AERIAL CABLE)

**12.1** When self-supporting aerial cable containing an integrated support messenger is supplied, the support messenger must comply with the requirements specified in Paragraphs 12.2 through 12.6 of this specification.

**12.2** The fully flooded, stranded support messenger must be 6.35 millimeters diameter, 7 wire, extra high strength grade, Class A galvanized steel strand conforming to ASTM A 640-91 with exceptions and additional provisions as follows:

**12.2.1** The maximum lay of the individual wires of the strand must be 140 millimeters.

**12.2.2** Any section of a completed strand containing a joint must have minimum tensile strength and elongation of 29,500 newtons and 3.5 percent, respectively, when tested in accordance with the procedures specified in ASTM A 640-91.

**12.2.3** The individual wires from a completed strand which contain joints must not fracture when tested according to the "Ductility of Steel" procedures specified in ASTM A 640-91 except that the mandrel diameter must be equal to 5 times the nominal diameter of the individual wires.

**12.3** The support strand must be completely covered with a corrosion protective floodant. The floodant must be homogeneous and uniformly mixed.

**12.4** The floodant must be nontoxic and present no dermal hazard.

**12.5** The floodant must be free from dirt, metallic particles, and other foreign matter that may interfere with the performance of the cable.

**12.6** The floodant must be compatible with the polyethylene outer jacket and must be acceptable to REA.

**12.7** Other methods of providing self-supporting cable specifically not addressed in this section may be allowed if accepted by REA. Justification for acceptance of a modified design must be provided to substantiate product utility and long term stability and endurance.

## 13. OUTER JACKET

**13.1** The outer jacket must provide the cable with a tough, flexible, protective covering which can withstand exposure to sunlight, to atmosphere temperatures and to stresses reasonably expected in normal installation and service.

**13.2** The jacket must be free from holes, splits, blisters, or other imperfections and shall be as smooth and concentric as is consistent with the best commercial practice.

**13.3** The raw material used for the outer jacket must be one of the five types listed in Paragraphs 13.3.1 through 13.3.5 of this specification. The raw material must contain an antioxidant to provide long term stabilization and the materials must contain a 2.60 ± 0.25 percent concentration of furnace black to provide ultraviolet shielding. Both the antioxidant and furnace black must be compounded into the material by the raw material supplier.

**13.3.1** Low density, high molecular weight polyethylene (LDHMW) must conform to the requirements of ASTM D 1248-84(1989), Type I, Class C, Category 4 or 5, Grade J3.

**13.3.2** Low density, high molecular weight ethylene copolymer (LDHMW) must conform to the requirements of ASTM D 1248-84(1989), Type I, Class C, Category 4 or 5, Grade J3.

**13.3.3** Linear low density, high molecular weight polyethylene (LLDHMW) must conform to the requirements of ASTM D 1248-84(1989), Type I, Class C, Category 4 or 5, Grade J3.

**13.3.4** High density polyethylene (HD) must conform to the requirements of ASTM D 1248-84(1989), Type III, Class C, Category 4 or 5, Grade J4.

**13.3.5** Medium density polyethylene (MD) must conform to the requirements of ASTM D 1248-84(1989), Type II, Class C, Category 4 or 5, Grade J4.

**13.3.6** Particle size of the carbon selected for use must not average greater than 20 nanometers.

**13.3.7** Absorption coefficient must be a minimum of 400 in accordance with the procedures of ASTM D 3349-86.

**13.4** The outer jacketing material removed from or tested on the cable shall be capable of meeting the following performance requirements:

| Property | LLDHMW, Ethylene Coploymer | LDHMW Polyethylene | HD or MD Polyethylene |
|---|---|---|---|
| Melt Flow Rate | | | |
| Percent increase from raw material, Maximum | | 50 | 50 |
| < 0.41 (Initial Melt Index) | 100 | -- | -- |
| 0.41 - 2.00 (Initial Melt Index) | 50 | -- | -- |
| Tensile Strength | | | |
| Minimum, Megapascals | 12 | 12 | 16.5 |
| Ultimate Elongation | | | |
| Minimum, Percent | 400 | 400 | 300 |
| Environmental Stress Cracking | | | |
| Maximum, Failures | 0/10 | 2/10 | 2/10 |
| Shrinkback | | | |
| Maximum, Percent | 5 | 5 | 5 |
| Impact | | | |
| Maximum, Failures | 2/10 | 2/10 | 2/10 |

**13.5 Testing Procedures:** The procedures for testing the jacket specimens for compliance with Paragraph 13.4 of this specification must be as follows:

**13.5.1 Melt Flow Rate:** The melt flow rate must be determined by ASTM D 1238-90b, Condition E. Jacketing material must be free from flooding and filling compound.

**13.5.2 Tensile Strength and Ultimate Elongation:** Test in accordance with EIA-455-89A, using a jaw separation speed of 500 millimeters per minute for low density material and 50 millimeters per minute for high and medium density materials.

**13.5.3 Environmental Stress Cracking:** Test in accordance with ASTM D 4565-90a.

**13.5.4 Shrinkback:** Test in accordance with the procedures specified in EIA-455-86 using a temperature of 100 ± 1°C for a 4 hour period for low density material and a test temperature of 115 ± 1°C for a 4 hour period for high and medium density materials.

**13.5.5 Impact:** The test must be performed in accordance with ASTM D 4565-90a using an impact force of 4 newton-meter at a temperature of -20 ± 2°C. A cracked or split in the jacket constitutes failure.

**13.6 Jacket Thickness:** The nominal outer jacket thickness must not be less than 1.3 millimeters. The test method used must be either the End Sample Method (Paragraph 13.6.1 of this specification) or the Continuous Uniformity Thickness Gauge Method (Paragraph 13.6.2 of this specification).

**13.6.1 End Sample Method:** The jacket must be capable of meeting the following requirements:

| | |
|---|---|
| Minimum Average Thickness | 90 % of nominal thickness |
| Minimum Spot Thickness | 70 % of nominal thickness |

**13.6.2 Continuous Uniformity Gauge:**

**13.6.2.1** The jacket must be capable of meeting the following requirements:

| | |
|---|---|
| Minimum Average Thickness | 75 % of nominal thickness |
| Minimum Thickness | 70 % of nominal thickness |
| Maximum Eccentricity | 40 % of nominal thickness |

$$\text{Eccentricity} = \frac{\text{Max. Thickness - Min. Thickness}}{\text{Average Thickness}} \times 100 \text{ Percent}$$

**13.6.2.2** The maximum and minimum thickness values shall be based on the average of each axial section.

**13.7** For jackets having embedded strength members, the jacket thickness must meet the requirements of Paragraph 13.6 of this specification except that the jacket thickness over the strength members must not be less than 0.50 millimeters.

**13.8** The minimum jacket thickness at any point over the support messenger for self-supporting aerial cable utilizing such an element must be 1.1 millimeters.

**13.9** The web dimension for self-supporting aerial cable utilizing such a feature must be as follows:

Height: 2.29 ± 0.750 millimeters

Width: 1.52 $^{+ 0.51}_{- 0.25}$ millimeters

## 14. SHEATH SLITTING CORD (OPTIONAL)

**14.1** A sheath slitting cord is optional.

**14.2** When a sheath slitting cord is used it must be nonhygroscopic and nonwicking or be rendered such by the filling or flooding compound, continuous throughout a length of cable and of sufficient strength to open the sheath over at least a one meter length without breaking the cord at a temperature of 23 ± 5°C.

## 15. IDENTIFICATION MARKER AND LENGTH MARKER

**15.1** Each length of cable must be permanently labeled either OPTICAL CABLE, OC, OPTICAL FIBER CABLE, or OF on the outer jacket and identified as to manufacturer and year of manufacture.

**15.2** Each length of cable intended for direct burial installation shall be marked with a telephone handset in compliance with Rule 350G of the 1993 National Electrical Safety Code (NESC).

**15.3** Mark the number of fibers on the jacket.

**15.4** The markings must be printed on the jacket at regular intervals of not more than 2 meters.

**15.5** An alternative method of marking may be used if acceptable to REA.

**15.6** The completed cable must have sequentially numbered length markers in METERS or FEET at regular intervals of not more than 2 meters along the outside of the jacket.

**15.7** Continuous sequential numbering must be employed in a single length of cable.

**15.8** The numbers must be dimensioned and spaced to produce good legibility and must be approximately 3 millimeters in height. An occasional illegible marking is permissible if there is a legible marking located not more than 2 meters from it.

**15.9** The method of marking must be by means of suitable surface markings producing a clear distinguishable contrasting marking acceptable to REA. Where direct or transverse printing is employed, the characters should be indented to produce greater durability of marking. Any other method of length marking must be acceptable to REA as producing a marker suitable for the field. Size, shape and spacing of numbers, durability and overall legibility of the marker will be considered in acceptance of the method.

**15.10** Agreement between the actual length of the cable and the length marking on the cable jacket must be within the limits of +1 percent, -0 percent.

**15.11** The color of the initial marking must be white or silver. If the initial marking fails to meet the requirements of the preceding paragraphs, it will be permissible to either remove the defective marking and re-mark with the white or silver color or leave the defective marking on the cable and re-mark with yellow. No further re-marking is permitted. Any re-marking must be on a different portion of the cables circumference than any existing marking when possible and have a numbering sequence differing from any other marking by at least 3,000.

**15.12** Any reel of cable that contains more than one set of sequential markings must be labeled to indicate the color and sequence of marking to be used. The labeling must be applied to the reel and also to the cable.

## 16. OPTICAL PERFORMANCE

**16.1** The optical performance of the single mode fibers must be in accordance with the requirements specified in Paragraphs 16.1.1 through 16.1.8 of this specification.

**16.1.1** The attenuation values of the single mode fibers within the cable must not exceed 0.5 decibel per kilometer (dB/km) for dispersion-unshifted single mode fiber at 1310 and 1550 nanometers and must not exceed 0.5 dB/km for dispersion-shifted single mode fiber at 1550 nanometers. The test method used for measuring the attenuation must be in accordance with either:

a. EIA/TIA-455-78A; or

b. EIA/TIA-455-61.

**16.1.2** The attenuation values for wavelengths between 1285 and 1330 nanometers and between 1525 and 1575 nanometers for dispersion-unshifted fibers must not exceed the attenuation at 1310 and 1550 nanometers by more than 0.1 dB/km. The attenuation values for wavelengths between 1525 and 1575 nanometers for dispersion-shifted fibers must not exceed the attenuation at 1550 nanometers by more than 0.1 dB/km. The test method used for measuring the attenuation must be in accordance with any one of the methods specified in Paragraph 16.1.1 of this specification.

**16.1.3** Attenuation discontinuities in the fiber's length must not exceed 0.1 decibel (dB) for dispersion-unshifted fiber at 1310 ± 20 and 1550 ± 20 nanometers and must not exceed 0.1 dB for dispersion-shifted fiber at 1550 ± 20 nanometers when measured in accordance with EIA/TIA-455-59.

**16.1.4** Measurement of the attenuation must be conducted at the wavelength specified for application and must be expressed in decibels per kilometer.

**16.1.5** Because the accuracy of attenuation measurements for single mode fibers becomes questionable when measured on short cable lengths, attenuation measurements are to be made utilizing characterization cable lengths. If the ship length of cable is less than one kilometer, the attenuation values measured on longer lengths of cable (characterization length of cable) before cutting to the ship lengths of cable may be applied to the ship lengths.

**16.1.6** For dispersion-unshifted fiber the zero dispersion wavelength must be between 1300 and 1322 nanometers, and the value of the dispersion slope at the zero-dispersion wavelength must not be greater than 0.092 picosecond per nanometer squared times kilometer (ps/($nm^2$·km)) when measured in accordance with either:

a. EIA/TIA-455-168A;

b. EIA/TIA-455-169A; or

c. EIA/TIA-455-175A.

**16.1.7** For dispersion-shifted fiber, the dispersion over the wavelength range between 1525 and 1575 nanometers must not exceed 3.5 picosecond per nanometers times kilometer (ps/(nm·km)) and must have a maximum dispersion slope of 0.095 ps/($nm^2$·km) at the zero-dispersion wavelength when measured in accordance with any one of the test procedures specified in Paragraph 16.1.6 of this specification.

**16.1.8** The cut off wavelength of the dispersion-unshifted and the dispersion-shifted fibers in a cable must be less than 1260 nanometers when measured in accordance with EIA/TIA-455-170.

**16.2** The optical performance of the multimode fibers must be in accordance with the requirements specified in Paragraphs 16.2.1 through 16.2.6 of this specification.

**16.2.1** The attenuation values of the 50/125 and 62.5/125 micrometer multimode fibers within the cable must not exceed 1.5 dB/km at 1300 nanometers when measured in accordance with either:

a. EIA/TIA-455-46A;

b. EIA/TIA-455-53A; or

c. EIA/TIA-455-61.

**16.2.2** Attenuation discontinuities in the fiber's length must not exceed 0.2 dB for both multimode fiber types at 1300 ± 20 nanometers when measured in accordance with EIA/TIA-455-59.

**16.2.3** Measurement of the attenuation must be conducted at the wavelength specified for application and must be expressed in decibels per kilometer.

**16.2.4** Because the accuracy of attenuation measurements for multimode fibers becomes questionable when measured on short cable lengths, attenuation measurements are to be made utilizing characterization cable lengths. If the ship length of cable is less than one kilometer, the attenuation values measured on longer lengths of cable (characterization length of cable) before cutting to the ship lengths of cable may be applied to the ship lengths.

**16.2.5** The bandwidth of the multimode fibers at the -3 dB optical power of the optical fibers within the cable must be within the limits prescribed in the purchase order.

**16.2.6** The test methods used to measure bandwidth must be in accordance with either EIA/TIA-455-30B or EIA/TIA-455-51A.

**16.3** Numerical aperture (NA) for each multimode optical fiber in the cable must be 0.20 ± 0.015 for the 50/125 micrometer design and 0.275 ± 0.015 for the 62.5/125 micrometer design when measured in accordance with EIA/TIA-455-177A.

## 17. MECHANICAL REQUIREMENTS

### 17.1 Cable Bend Test:

**17.1.1** All cables manufactured in accordance with the requirements of this specification must be capable of meeting the following bend test without exhibiting an increase in fiber attenuation greater than 0.10 dB for single mode fibers and 0.40 dB for multimode fibers.

**17.1.2** Measure the attenuation of dispersion-unshifted single mode fibers at 1310 ± 20 and 1550 ± 20 nanometers, dispersion-shifted single mode fibers at 1550 ± 20 nanometers and multimode fibers at 1300 ± 20 nanometers.

**17.1.3** After measuring the attenuation of the optical fibers, test the cable sample in accordance with EIA/TIA-455-37A, Test Condition E, Turns Test Level 3. The following detailed test conditions shall apply:

a. Section 4.2 - Mandrel diameter must be 20 times the cable diameter.

b. Section 4.5 - Measure the attenuation increase of the wound sample at the test temperature and specified wavelengths in accordance with EIA-455-20.

c. For armored cable, the armor overlap must be on the outside of the bend.

d. For self-supporting cable, the jacketed support messenger and connection web must be removed prior to testing.

**17.1.4** The cable may be allowed to warm to room temperature before visual inspection. the bent area of the cable must show neither visible evidence of fracture of the jacket nor delamination of the bond at the overlap and to the outer jacket in nonflooded cable. After removal of the jacket, there must be no visible evidence of fracture of the armor, when present, and of the components in the core.

**17.2 Cable Impact Test:**

**17.2.1** All cables manufactured in accordance with the requirements of this specification must be capable of meeting the following impact test without exhibiting an increase in fiber attenuation greater than 0.10 dB for single mode fibers and 0.40 dB for multimode fibers, and without cracking or splitting of the cable jacket.

**17.2.2** Measure the attenuation of the optical fibers in accordance with Paragraph 17.1.2 of this specification.
**17.2.3** After measuring the attenuation of the optical fibers, test the cable sample in accordance with EIA/TIA-455-25A.

**17.3 Cable Compression Test:**

**17.3.1** All cables manufactured in accordance with the requirements of this specification must be capable of meeting the following compressive strength test without exhibiting an increase in fiber attenuation greater than 0.10 dB for single mode fibers and 0.40 dB for multimode fibers and without cracking

or splitting of the cable jacket when subjected to a minimum compressive load of 440 newtons per centimeter for armored cable and 220 newtons per centimeters for nonarmored cable.

**17.3.2** Measure the attenuation of the optical fibers in accordance with Paragraph 17.1.2 of this specification.

**17.3.3** After measuring the attenuation of the optical fibers, test the cable in accordance with EIA-455-41 using a rate of 3 millimeters to 20 millimeters per minute and maintaining the load for 10 minutes.

**17.4 Cable Twist Test:**

**17.4.1** All cables manufactured in accordance with the requirements of this specification must be capable of meeting the following twist test without exhibiting an increase in fiber attenuation greater than 0.10 dB for single mode fibers and 0.40 dB for multimode fibers, and without cracking or splitting of the cable jacket.

**17.4.2** Measure the attenuation of the optical fibers in accordance with Paragraph 17.1.2 of this specification.

**17.4.3** After measuring the attenuation of the optical fibers, test the cable in accordance with EIA/TIA-455-85A, using a maximum cable twisting length of 4 meters.

**17.5 Cable Flex Test:**

**17.5.1** All cables manufactured in accordance with the requirements of this specification must be capable of meeting the following flex test without exhibiting an increase in fiber attenuation greater than 0.10 dB for single mode fibers and 0.40 dB for multimode fibers.

**17.5.2** Measure the attenuation of the optical fibers in accordance with Paragraph 17.1.2 of this specification.

**17.5.3** After measuring the attenuation of the optical fibers, test the cable in accordance with EIA/TIA-455-104A, Test Conditions I and II, flexed for 25 cycles using a sheave diameter not less than 20 times the cable diameter (Test condition letter B).

**17.5.4** The completion of the test, the bent area of the cable must show neither visible evidence of fracture of the jacket nor delamination of the bond at the overlap and to the outer jacket in nonflooded cable. After removal of the jacket, there must be no visible evidence of fracture of the armor, when present, and of the components in the core.

**17.6 Water Penetration Test:**

**17.6.1** A one meter length of completed fiber optic cable must be preconditioned for 24 hours at 23 ± 5°C and then tested in accordance with EIA/TIA-455-82B using a one meter water head over the sample or placed under the equivalent continuous pressure for one hour.

**17.6.2** After the one hour period, there must be no water leakage through the sheath interfaces, under the core wrap, between the cable core interstices or through the fiber buffers.

**17.6.3** If water leakage is detected in the first sample, one additional 3 meter sample from EACH END of the same reel must be tested in accordance with Paragraph 17.6.1 of this specification. If either sample exhibits water leakage, the entire reel of cable is to be rejected. If the samples exhibit no leakage, the entire reel of cable is considered acceptable.

**17.7 Compound Flow Test:**

**17.7.1** Three 300 millimeter long test samples must be preconditioned for 24 hours at 23 ± 5°C and then tested in accordance with EIA/TIA-455-81A using a test temperature of 80 ± 1°C.

**17.7.2** The amount of filling or flooding compounds that flowed or dripped from any of the suspended cable specimens must be less than or equal to 0.5 grams of material. The measurement of an amount greater than 0.5 grams for any of the suspended cable specimens constitutes failure.

## 18. PRECONNECTORIZED CABLE (OPTIONAL)

**18.1** At the option of the manufacturer and upon request by the purchaser, the cable may be factory terminated with connectors acceptable to REA.

**18.2** All connectors must be accepted by REA prior to their use.

## 19. ACCEPTANCE TESTING AND EXTENT OF TESTING

**19.1** The tests described in Appendix A of this specification are intended for acceptance of cable designs and major modifications of accepted designs. What constitutes a major modification is a the discretion of REA. These tests are intended to show the inherent capability of the manufacturer to produce cable products that have satisfactory performance characteristics, long life and long-term optical stability but are not intended as field tests.

**19.2** For initial acceptance, the manufacturer must submit:

a. An original signature certification that the product fully complies with each section of this specification;

b. Qualification Test Data, per Appendix A of this specification;

c. A set of instructions for handling the cable;

d. OSHA Material Safety Data Sheets for all components;

e. Agree to periodic plant inspections;

f. A certification that the product does or does not comply with the domestic origin manufacturing provisions of the "Buy American" requirements of the Rural Electrification Act of 1938 (52 Stat. 818);

g. Written user testimonials concerning performance of the product, and;

h. Other nonproprietary data deemed necessary by the Chief, Outside Plant Branch (Telephone).

**19.3** For requalification acceptance, the manufacturer must submit an original signature certification that the product fully complies with each section of the specification, excluding the Qualification Section, and a certification that the product does or does not comply with the domestic origin manufacturing provisions of the "Buy American" requirements of the Rural Electrification Act of 1938 (52 Stat. 818) for acceptance by September 30 every three years. The required data and certification must have been gathered within 90 days of the submission.

**19.4** Initial and requalification acceptance requests should be addressed to: Chairman, Technical Standards Committee "A" (Telephone), Telecommunications Standards Division, Rural Electrification Administration, Washington, DC 20250-1500.

**19.5 Tests on 100 Percent of Completed Cable:**

**19.5.1** The armor for each length of cable must be tested for continuity using the procedures of ASTM D 4566-90.

**19.5.2** Attenuation for each optical fiber in the cable must be measured.

**19.5.3** Optical discontinuities must be isolated and their location and amplitude recorded.

**19.6 Capability Tests:** Tests on a quality assurance basis must be made as frequently as is required for each manufacturer to determine and maintain compliance with:

**19.6.1** Numerical aperture and bandwidth of multimode fibers;

**19.6.2** Cut off wavelength of single mode fibers;

**19.6.3** Dispersion of single mode fibers;

**19.6.4** Shrinkback and cold testing of loose tube and tight tube buffers;

**19.6.5** Adhesion properties of the protective fiber coating;

**19.6.6** Dielectric strength between the armor and the metallic central member;

**19.6.7** Performance requirements for the inner and outer jacketing materials;

**19.6.8** Performance requirements for the filling and flooding compounds;

**19.6.9** Bonding properties of the coated armoring material;

**19.6.10** Sequential marking and lettering;

**19.6.11** Cable bend and cable impact tests;

**19.6.12** Water penetration and compound flow tests;

**19.6.13** Cable twist, cable flex, and cable compression tests; and

**19.6.14** Performance requirements of support messenger.

## 20. RECORDS OF OPTICAL AND PHYSICAL TESTS

**20.1** Each manufacturer must maintain suitable summary records for a period of at least 3 years of all optical and physical tests required on completed cable by this specification as set forth in Paragraphs 19.5 and 19.6 of this specification. The test data for a particular reel must be in a form that it may be readily available to REA upon request. The optical data must be furnished to the purchaser on a suitable and easily readable form.

**20.2** Measurements and computed values must be rounded off to the number of places or figures specified for the requirement according to ASTM E 29-90.

## 21. MANUFACTURING IRREGULARITIES

**21.1** Repairs to the armor, when present, are not permitted in cable supplied to the end user under this specification.

**21.2** Minor defects in the inner and outer jacket (defects having a dimension of 3 millimeter or less in any direction) may be repaired by means of heat fusing in accordance with good commercial practices utilizing sheath grade compounds.

**21.3** Buffer tube repair is permitted only in conjunction with fiber splicing.

## 22. PACKAGING AND PREPARATION FOR SHIPMENT

**22.1** The cable must be shipped on reels. The diameter of the drum must be large enough to prevent damage to the cable from reeling and unreeling. The reels must be substantial and so constructed as to prevent damage during shipment and handling.

**22.2** A circumferential thermal wrap or other means of protection complying with the requirements of Appendix B of this specification must be secured between the outer edges of the reel flange to protect the cable against damage during storage and shipment.

**22.3** Cable manufactured to the requirements of this specification must be sealed at the ends to prevent entrance of moisture. The method of sealing must be accepted by REA prior to its use.

**22.4** The end-of-pull (outer end) of the cable must be securely fastened to prevent the cable from coming loose during transit. The start-of-pull (inner end) of the cable must project through a slot in the flange of the reel, around an inner riser, or into a recess on the flange near the drum and fastened in such a way to prevent the cable from becoming loose during installation.

**22.5** Spikes, staples or other fastening devices must be used in a manner which will not result in penetration of the cable.

**22.6** The arbor hole must admit a spindle 63.5 millimeters in diameter without binding. Steel arbor hole liners may be used but must be accepted by REA prior to their use.

**22.7** Each reel must be plainly marked to indicate the direction in which it should be rolled to prevent loosening of the cable on the reel.

**22.8** Each reel must be stenciled or lettered with the name of the manufacturer.

**22.9** The following information must be either stenciled on the reel or on a tag firmly attached to the reel:

OPTICAL CABLE
Number of Fibers
Armored or Nonarmored
Year of Manufacture
Name of Cable Manufacturer
Length of Cable
Reel Number
REA 7 CFR 1755.900

Example:

OPTICAL CABLE
4 fiber
Armored
XYZ Company
1050 meters
Reel Number 3
REA 7 CFR 1755.900

**22.10** When preconnectorized cable is shipped, the splicing modules must be protected to prevent damage during shipment and handling. The protection method must be acceptable to REA prior to its use.

UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Electrification Administration

# APPENDIX A

# FILLED FIBER OPTIC CABLE

## Qualifications Test Methods Bulletin 1753F-601(PE-90)

**1.** The test procedures described in this appendix are for qualification of initial designs and major modifications of accepted designs. Included in Paragraph 5 of this appendix are suggested formats that may be used in submitting test results to REA.

## 2. SAMPLE SELECTION AND PREPARATION

**2.1** All testing must be performed on lengths removed sequentially from any of the same cables listed below. The cables must not have been exposed to temperatures in excess of 38°C since their initial cool downs after sheathing. The lengths specified are minimum lengths and if desirable from a laboratory testing standpoint longer lengths may be used:

a. 12 single mode fiber jacketed cable consisting of 6 single mode dispersion-unshifted fibers and 6 single mode dispersion-shifted fibers.

b. 12 multimode fiber jacketed cable consisting of 6 50/125 micrometer multimode fibers and 6 62.5/125 micrometer multimode fibers.

c. 24 fiber jacketed combination cable consisting of 6 single mode dispersion-unshifted fibers; 6 single mode dispersion-shifted fibers; 6 50/125 micrometer multimode fibers; and 6 62.5/125 micrometer multimode fibers.

**2.2** Length A shall be a minimum of 500 meters long. Coil the sample with a diameter of 50 to 75 times its sheath diameter. Three lengths are required if only requesting acceptance for either single mode fiber cable (a.), multimode fiber cable (b.), or using the combination fiber cable (c.). Six lengths, 3 lengths of single mode fiber cable (a.), and 3 lengths of multimode fiber cable (b.), are required if requesting acceptance for both single mode and multimode fiber cables.

**2.3** Length B shall be one meter long. Four lengths of either single mode fiber cable (a.), multimode fiber cable (b.) or the combination fiber cable (c.) are required.

**2.4** Length C shall be 600 millimeters long. Four lengths of either single mode fiber cable (a.), multimode fiber cable (b.) or the combination fiber cable (c.) are required.

**2.5 Data Reference Temperature:** Unless otherwise specified, all measurement shall be made at 23 ± 5°C.

## 3. ENVIRONMENTAL TESTS

### 3.1 Heat Aging Test

**3.1.1 Test Samples:** Place one or two samples of length A and one sample each of lengths B and C in an oven or environmental chamber. The ends of sample A must exit from the chamber or oven for optical tests. Securely seal the oven exit holes.

**3.1.2 Sequence of Tests:** The samples are to be subjected to the following tests after conditioning:

a. Water Penetration Test outlined in Paragraph 3.2 of this appendix; and

b. Jacket Slip Strength Test outlined in Paragraph 3.3 of this appendix. (For Flooded Designs Only)

### 3.1.3 Initial Measurements

**3.1.3.1** For sample(s) A measure the attenuation for the single mode dispersion-unshifted fibers at 1310 and 1550 nanometers, for single mode dispersion-shifted fibers at 1550 nanometers and/or for multimode fibers at 1300 nanometers at a temperature of 23 ± 5°C. Also measure the bandwidth of the multimode fibers. Calculate the attenuation data on a per kilometer basis. Calculate the bandwidth data on a megahertz-kilometer (MHz-km) basis.

**3.1.3.2** Record on suggested formats in Paragraph 5 of this appendix or on other easily readable formats.

### 3.1.4 Heat Conditioning

**3.1.4.1** Immediately after completing the initial measurements, condition the sample(s) for 14 days at a temperature of 65 ± 2°C.

**3.1.4.2** At the end of this period note any exudation of cable filler. Measure the parameters given in Paragraph 3.1.3 of this appendix. Record on suggested formats in Paragraph 5 of this appendix or on other easily readable formats.

### 3.1.5 Overall Optical Deviation

**3.1.5.1** Calculate the change in all parameters between the final parameters after conditioning with initial parameters in Paragraph 3.1.3 of this appendix.

**3.1.5.2** The stability of the optical parameters after completion of this test must be within the following prescribed limits:

a. Attenuation: The attenuation of each multimode fiber must not change by more than 0.3 db/km and the attenuation of each single mode fiber must not change by more than 0.1 dB/km.

b. Bandwidth: The bandwidth of each multimode fiber must not change by more than 15 percent from their original values.

### 3.2 Water Penetration Testing

**3.2.1** A watertight closure must be placed over the jacket of length B from Paragraph 3.1.1 of this appendix. The closure must not be placed over the jacket so tightly that the flow of water through pre-existing voids or air spaces is restricted. The other end of the sample must remain open.

**3.2.2** Test per Option A or Option B.

**3.2.2.1 Option A:** Weigh the sample and closure prior to testing. Fill the closure with water and place under a continuous pressure of 10 ± 0.7 kilopascals for one hour. Collect the water leakage from the end of the test sample during the test and weigh to the nearest 0.1 gram. Immediately after the one hour test, seal the ends of the cable with a thin layer of grease and remove all visible water from the closure, being careful not to remove water that penetrated into the core during the test. Reweigh the sample and determine the weight of water that penetrated into the core.

**3.2.2.2 Option B:** Fill the closure with a 0.2 gram sodium fluorscein per liter water solution and apply a continuous pressure of 10 ± 0.7 kilopascals for one hour. Catch and weigh any water that leaks from the end of the cable during the one hour period. If no water leaks from the sample, carefully remove the water from the closure. Then carefully remove the outer jacket, armor, if present, inner jacket, if present, and core wrap one at a time, examining with an ultraviolet light source for water penetration. After removal of the core wrap, carefully dissect the core and examine for water penetration within the core. Where water penetration is observed, measure the penetration distance.

**3.3 Jacket Slip Strength Test** (For Flooded Design Only)

**3.3.1 Sample Selection:** Test sample C from Paragraph 3.1.1 of this appendix.

**3.3.2 Sample Preparation:** Prepare test sample in accordance with the procedures specified in ASTM D 4565-90a.

**3.3.3 Sample Conditioning and Testing:** Remove the sample from the tensile tester prior to testing and condition for one hour at 50 ± 2°C. Test immediately in accordance with the procedures specified in ASTM D 4565-90a. A minimum jacket slip strength of 67 newtons is required. Record the load attained on the suggested formats in Paragraph 5 of this appendix or on other easily readable formats.

**3.4 Temperature and Humidity Exposure**

**3.4.1** Repeat Paragraphs 3.1.1 through 3.1.3.2 of this appendix for separate set of samples A, B and C which have not been subjected to prior environmental conditioning.

**3.4.2** Immediately after completing the measurements, expose the test sample to 100 temperature cyclings. Relative humidity within the chamber shall be maintained at 90 ± 2 percent. One cycle consists of beginning at a stabilized chamber and test sample temperature of 52 ± 2°C, increasing the temperature to 57 ± 2°C, allowing the chamber and test samples to stabilize at this level, then dropping the temperature back to 52 ± 2°C.

**3.4.3** Repeat Paragraphs 3.1.4.2 through 3.3.3 of this appendix.

**3.5 Temperature Cycling**

**3.5.1** Repeat Paragraphs 3.1.1 through 3.1.3.2 of this appendix for separate set of samples A, B, and C which have not been subjected to prior environmental conditioning.

**3.5.2** Immediately after completing the measurements, subject the test sample to 10 cycles of temperature between -40°C and +60°C. The test sample must be held at each temperature extreme for a minimum of 1-1/2 hours during each cycle of temperature. The air within the temperature cycling chamber must be circulated throughout the duration of the cycling.

**3.5.3** Repeat Paragraphs 3.1.4.2 through 3.3.3 of this appendix.

**4. CONTROL SAMPLE**

**4.1** **Test samples:** A separate set of lengths B and C must have been maintained at 23 ± 5°C for at least 48 hours before the testing.

**4.2** Repeat Paragraphs 3.2 through 3.3.3 of this appendix for these samples.

## 5. TEST DATA FORMATS

**5.1** The following suggested formats may be used in submitting the test results to REA.

## Heat Aging Test - Single Mode Cable

| Fiber No. | Attenuation - 1310 nm dB/km | | | Attenuation - 1550 nm dB/km | | |
|---|---|---|---|---|---|---|
| | Initial | Final | Change | Initial | Final | Change |
| 1 | _____ | _____ | _____ | _____ | _____ | _____ |
| 2 | _____ | _____ | _____ | _____ | _____ | _____ |
| 3 | _____ | _____ | _____ | _____ | _____ | _____ |
| 4 | _____ | _____ | _____ | _____ | _____ | _____ |
| 5 | _____ | _____ | _____ | _____ | _____ | _____ |
| 6 | _____ | _____ | _____ | _____ | _____ | _____ |
| 7 | _____ | _____ | _____ | _____ | _____ | _____ |
| 8 | _____ | _____ | _____ | _____ | _____ | _____ |
| 9 | _____ | _____ | _____ | _____ | _____ | _____ |
| 10 | _____ | _____ | _____ | _____ | _____ | _____ |
| 11 | _____ | _____ | _____ | _____ | _____ | _____ |
| 12 | _____ | _____ | _____ | _____ | _____ | _____ |

## Heat Aging Test - Multimode Cable

| Fiber No. | Attenuation - 1300 nm dB/km | | | Bandwidth MHz-km | | |
|---|---|---|---|---|---|---|
| | Initial | Final | Change | Initial | Final | Change(%) |
| 1 | _____ | _____ | _____ | _____ | _____ | _____ |
| 2 | _____ | _____ | _____ | _____ | _____ | _____ |
| 3 | _____ | _____ | _____ | _____ | _____ | _____ |
| 4 | _____ | _____ | _____ | _____ | _____ | _____ |
| 5 | _____ | _____ | _____ | _____ | _____ | _____ |
| 6 | _____ | _____ | _____ | _____ | _____ | _____ |
| 7 | _____ | _____ | _____ | _____ | _____ | _____ |
| 8 | _____ | _____ | _____ | _____ | _____ | _____ |
| 9 | _____ | _____ | _____ | _____ | _____ | _____ |
| 10 | _____ | _____ | _____ | _____ | _____ | _____ |
| 11 | _____ | _____ | _____ | _____ | _____ | _____ |
| 12 | _____ | _____ | _____ | _____ | _____ | _____ |

Heat Aging Test - Combination Cable

| Fiber No. | Attenuation - 1310 nm dB/km | | | Attenuation - 1550 nm dB/km | | | Bandwidth MHz-km | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial | Final | Change | Initial | Final | Change | Initial | Final | Change(%) |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
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| 21 | | | | | | | | | |
| 22 | | | | | | | | | |
| 23 | | | | | | | | | |
| 24 | | | | | | | | | |

Temperature/Humidity Test - Single Mode Cable

| Fiber No. | Attenuation - 1310 nm dB/km | | | Attenuation - 1550 nm dB/km | | |
|---|---|---|---|---|---|---|
| | Initial | Final | Change | Initial | Final | Change |
| 1 | _____ | _____ | _____ | _____ | _____ | _____ |
| 2 | _____ | _____ | _____ | _____ | _____ | _____ |
| 3 | _____ | _____ | _____ | _____ | _____ | _____ |
| 4 | _____ | _____ | _____ | _____ | _____ | _____ |
| 5 | _____ | _____ | _____ | _____ | _____ | _____ |
| 6 | _____ | _____ | _____ | _____ | _____ | _____ |
| 7 | _____ | _____ | _____ | _____ | _____ | _____ |
| 8 | _____ | _____ | _____ | _____ | _____ | _____ |
| 9 | _____ | _____ | _____ | _____ | _____ | _____ |
| 10 | _____ | _____ | _____ | _____ | _____ | _____ |
| 11 | _____ | _____ | _____ | _____ | _____ | _____ |
| 12 | _____ | _____ | _____ | _____ | _____ | _____ |

## Temperature/Humidity Test - Multimode Cable

| Fiber No. | Attenuation - 1300 nm dB/km | | | Bandwidth MHz-km | | |
|---|---|---|---|---|---|---|
| | Initial | Final | Change | Initial | Final | Change(%) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | _____ | _____ | _____ | _____ | _____ | _____ |
| 2 | _____ | _____ | _____ | _____ | _____ | _____ |
| 3 | _____ | _____ | _____ | _____ | _____ | _____ |
| 4 | _____ | _____ | _____ | _____ | _____ | _____ |
| 5 | _____ | _____ | _____ | _____ | _____ | _____ |
| 6 | _____ | _____ | _____ | _____ | _____ | _____ |
| 7 | _____ | _____ | _____ | _____ | _____ | _____ |
| 8 | _____ | _____ | _____ | _____ | _____ | _____ |
| 9 | _____ | _____ | _____ | _____ | _____ | _____ |
| 10 | _____ | _____ | _____ | _____ | _____ | _____ |
| 11 | _____ | _____ | _____ | _____ | _____ | _____ |
| 12 | _____ | _____ | _____ | _____ | _____ | _____ |

Temperature/Humidity Test - Combination Cable

| Fiber No. | Attenuation - 1310 nm dB/km | | | Attenuation - 1550 nm dB/km | | | Bandwidth MHz-km | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial | Final | Change | Initial | Final | Change | Initial | Final | Change(%) |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
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| 21 | | | | | | | | | |
| 22 | | | | | | | | | |
| 23 | | | | | | | | | |
| 24 | | | | | | | | | |

Temperature Cycling Test - Single Mode Cable

| Fiber No. | Attenuation - 1310 nm dB/km | | | Attenuation - 1550 nm dB/km | | |
|---|---|---|---|---|---|---|
| | Initial | Final | Change | Initial | Final | Change |
| 1 | _____ | _____ | _____ | _____ | _____ | _____ |
| 2 | _____ | _____ | _____ | _____ | _____ | _____ |
| 3 | _____ | _____ | _____ | _____ | _____ | _____ |
| 4 | _____ | _____ | _____ | _____ | _____ | _____ |
| 5 | _____ | _____ | _____ | _____ | _____ | _____ |
| 6 | _____ | _____ | _____ | _____ | _____ | _____ |
| 7 | _____ | _____ | _____ | _____ | _____ | _____ |
| 8 | _____ | _____ | _____ | _____ | _____ | _____ |
| 9 | _____ | _____ | _____ | _____ | _____ | _____ |
| 10 | _____ | _____ | _____ | _____ | _____ | _____ |
| 11 | _____ | _____ | _____ | _____ | _____ | _____ |
| 12 | _____ | _____ | _____ | _____ | _____ | _____ |

## Temperature Cycling - Multimode Cable

| Fiber No. | Attenuation - 1300 nm dB/km | | | Bandwidth MHz-km | | |
|---|---|---|---|---|---|---|
| | Initial | Final | Change | Initial | Final | Change(%) |
| 1 | _____ | _____ | _____ | _____ | _____ | _____ |
| 2 | _____ | _____ | _____ | _____ | _____ | _____ |
| 3 | _____ | _____ | _____ | _____ | _____ | _____ |
| 4 | _____ | _____ | _____ | _____ | _____ | _____ |
| 5 | _____ | _____ | _____ | _____ | _____ | _____ |
| 6 | _____ | _____ | _____ | _____ | _____ | _____ |
| 7 | _____ | _____ | _____ | _____ | _____ | _____ |
| 8 | _____ | _____ | _____ | _____ | _____ | _____ |
| 9 | _____ | _____ | _____ | _____ | _____ | _____ |
| 10 | _____ | _____ | _____ | _____ | _____ | _____ |
| 11 | _____ | _____ | _____ | _____ | _____ | _____ |
| 12 | _____ | _____ | _____ | _____ | _____ | _____ |

Temperature Cycling Test Combination Cable

| Fiber No. | Attenuation - 1310 nm dB/km | | | Attenuation - 1550 nm dB/km | | | Bandwidth MHz-km | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial | Final | Change | Initial | Final | Change | Initial | Final | Change(%) |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
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| 21 | | | | | | | | | |
| 22 | | | | | | | | | |
| 23 | | | | | | | | | |
| 24 | | | | | | | | | |

Water Penetration Test

| | Option A | | Option B | |
|---|---|---|---|---|
| | End Leakage grams | Weight Gain grams | End Leakage grams | Penetration millimeters |
| Control | | | | |
| Heat Age | | | | |
| Humidity Exposure | | | | |
| Temperature Cycling | | | | |

Jacket Slip Strength @ 50°C (load in newtons)

| | |
|---|---|
| Control | |
| Heat Age | |
| Humidity Exposure | |
| Temperature Cycling | |

Filler Exudation (grams)

| | |
|---|---|
| Heat Age | |
| Humidity Exposure | |
| Temperature Cycle | |

UNITED STATED DEPARTMENT OF AGRICULTURE
Rural Electrification Administration

# APPENDIX B

## Thermal Reel Wrap Qualification

**1.** This test procedures described in this appendix are for qualification of initial and subsequent changes in thermal reel wraps

**2. SAMPLE SELECTION:** All testing must be performed on two 450 millimeter lengths of cable removed sequentially from the same fiber jacketed cable. This cable must not have been exposed to temperatures in excess of 38°C since its initial cool down after sheathing.

**3. TEST PROCEDURE**

**3.1** Place the two samples on an insulating material such as wood.

**3.2** Tape thermocouples to the jackets of each sample to measure the jacket temperature.

**3.3** Cover one sample with the thermal reel wrap.

**3.4** Expose the samples to a radiant heat source capable of heating the uncovered sample to a minimum of 71°C. A GE 600 watt photoflood lamp or an equivalent lamp having the light spectrum approximately that of the sun shall be used.

**3.5** The height of the lamp above the jacket shall be 380 millimeters or an equivalent height that produces the 71°C jacket temperature on the unwrapped sample shall be used.

**3.6** After the samples have stabilized at the temperature, the jacket temperatures of the samples shall be recorded after one hour of exposure to the heat source.

**3.7** Compute the temperature difference between jackets.

**3.8** For the thermal reel wrap to be acceptable to REA, the temperature difference between the jacket with the thermal reel wrap and the jacket without the reel wrap shall be greater than or equal to 17°C.