UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Electrification Administration

BULLETIN 1753F-207(PE-87)

SUBJECT: **REA Specification for Terminating Cables**

TO: All Telephone Borrowers
REA Telephone Staff

EFFECTIVE DATE: July 14, 1994.

EXPIRATION DATE: Date of change in 7 CFR 1755.870 by rulemaking.

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

PREVIOUS INSTRUCTIONS: This bulletin replaces REA Bulletin 345-87, REA Specification for Terminating (TIP) Cable, PE-87, issued December 19, 1983.

FILING INSTRUCTIONS: Discard REA Bulletin 345-87, REA Specification for Terminating (TIP) Cable, PE-87, dated December 19, 1983, and replace with this bulletin. File with 7 CFR 1755 and on REANET.

PURPOSE: This specification covers REA requirements for terminating cables intended primarily to connect incoming outside plant cable to the vertical side of the main distributing frame in a telephone central office. This bulletin is a user friendly guide and a reformat of the text codified in 7 CFR 1755.870 published at 59 FR 30505, dated June 14, 1994.

Every effort has been made to ensure the accuracy of this document. However, in case of discrepancies, the regulations at 7 CFR 1755.870 are the authorized sources.

Wally Beyer — 7/14/94

Administrator — Date

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ABBREVIATIONS

ANSI	American National Standards Institute
ASTM	American Society For Testing and Materials
AWG	American Wire Gauge
°C	Centigrade temperature scale
CMR	Communication Riser Cable
dB	Decibel
dB/1000 ft	Decibels per 1000 feet
dB/km	Decibels per 1 kilometer
dc	Direct current
EIA	Electronic Industries Association
F_o	Known frequency
F_x	New frequency
FEXT	Far-end crosstalk
ft	Feet
in.	Inches
in./min	Inches per 1 minute
IR	Insulation resistance
K_o	Known far-end crosstalk
K_x	New far-end crosstalk
km	Kilometer
kHz	Kilohertz
L_o	Known length
L_x	New length
lbf	Pound force
m	Meter
M-S	Mean minus sigma
Max.	Maximum
Min.	Minimum
micromhos/km	Micromhos per 1 kilometer
MPa	Megapascals
mm	Millimeter
mm/min	Millimeters per 1 minute
N	Newton
NEXT	Near-end crosstalk
nF/km	Nanofarad per 1 kilometer
nF/mile	Nanofarad per 1 mile
ohms/1000 ft	Ohms per 1000 feet
%	Percent
pF/km	Picofarads per 1 kilometer
pF/1000 ft	Picofarads per 1000 feet
psi	Pounds per square inch
PVC	Polyvinyl Chloride
REA	Rural Electrification Administration
rms	Root mean square
UL	Underwriters Laboratory

1. SCOPE

1.1 This specification establishes the requirements for terminating cables used to connect incoming outside plant cables to the vertical side of the main distributing frame in a telephone central office.

1.1.1 The conductors are solid tinned copper, individually insulated with extruded solid dual insulating compounds.

1.1.2 The insulated conductors are twisted into pairs which are then stranded or oscillated to form a cylindrical core.

1.1.3 The cable structure is completed by the application of a core wrap, a shield, and a polyvinyl chloride jacket.

1.2 The number of pairs and gauge size of conductors which are used within the REA program are provided in the following table:

American Wire Gauge (AWG)	22	24
Pairs	12	12
	50	50
	100	100
	200	200
	300	300
	400	400
	600	600
	800	800

Note: Cables larger in pairs from those shown in this table shall meet all the requirements of this specification.

1.3 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.

1.4 Materials, manufacturing techniques, or cable designs not specifically addressed by this specification may be allowed if accepted by REA. Justification for acceptance of modified materials, manufacturing techniques, or cable designs shall be provided to substantiate product utility and long term stability and endurance.

2. CONDUCTORS AND CONDUCTOR INSULATION

2.1 Each conductor shall be a solid round wire of commercially pure annealed tin coated copper. Conductors shall meet the requirements of the American Society for Testing and Materials (ASTM) B 33-91 except that requirements for Dimensions and Permissible Variations are waived.

2.2 Joints made in conductors during the manufacturing process may be brazed, using a silver alloy solder and nonacid flux, or they may be welded using either an electrical or cold welding technique. In joints made in uninsulated conductors, the two conductor ends shall be butted. Splices made in insulated conductors need not be butted but may be joined in a manner acceptable to REA.

2.3 The tensile strength of any section of a conductor, containing a factory joint, shall not be less than 85 percent of the tensile strength of an adjacent section of the solid conductor of equal length without a joint.

2.4 Engineering Information: The sizes of wire used and their nominal diameters shall be as shown in the following table:

	Nominal Diameter	
AWG	millimeters	(inches)
22	0.643	(0.0253)
24	0.511	(0.0201)

2.5 Each conductor shall be insulated with a primary layer of natural or white solid, insulating grade, high density polyethylene or crystalline propylene/ethylene copolymer and an outer skin of colored, solid, insulating grade, polyvinyl chloride (PVC) using one of the insulating materials listed in Paragraphs 2.5.1 through 2.5.3 of this specification.

2.5.1 The polyethylene raw material selected to meet the requirements of this specification shall be Type III, Class A, Category 4 or 5, Grade E9 in accordance with ASTM D 1248-84(1989).

2.5.2 The crystalline propylene/ethylene raw material selected to meet the requirements of this specification shall be Class PP 200B 40003 E11 in accordance with ASTM D 4101-82(1988).

2.5.3 The PVC raw materials selected to meet the requirements of this specification shall be either Type PVC-64751E3X0, Type PVC-76751E3X0, or TYPE PVC-77751E3X0 in accordance with ASTM D 2287-81(1988).

2.5.4 Raw materials intended as conductor insulation furnished to these requirements shall be free from dirt, metallic particles, and other foreign matter.

2.5.5 All insulating raw materials shall be accepted by REA prior to their use.

2.6 All conductors in any single length of cable shall be insulated with the same type of material.

2.7 A permissible overall performance level of faults in conductor insulation when using the test procedures in Paragraph 2.8 of this specification shall average not greater than one fault per 12,000 conductor meters (40,000 conductor feet) for each gauge of conductor.

2.8 The test used to determine compliance with Paragraph 2.7 of this specification shall be conducted as follows:

2.8.1 Samples tested shall be taken from finished cables selected at random from standard production cable. The samples tested shall contain a minimum of 300 conductor meters (1,000 conductor feet) for cable sizes less than 50 pairs and 1,500 conductor meters (5,000 conductor feet) for cable sizes greater than or equal to 50 pairs. No further sample need be taken from the same cable production run within 6,000 cable meters (20,000 cable feet) of the original test sample from that run.

2.8.2 The cable sample shall have its jacket, shield, and core wrap removed and its core shall be immersed in tap water for a minimum period of 6 hours. In lieu of removing the jacket, shield, and core wrap from the core, the entire cable may be tested. In this case, the core shall be completely filled with tap water, under pressure; then the cable assembly shall be immersed for a minimum period of 6 hours. With the cable core still fully immersed, except for end connections, the insulation resistance (IR) of all conductors to water shall be measured using a direct current (dc) voltage of 100 volts to 550 volts.

2.8.3 An IR value of less than 500 megohms for any individual insulated conductor tested at or corrected to a temperature of 23°C is considered a failure. If the cable sample is more than 7.5 meters (25 feet) long, all failing conductors shall be retested and reported in 7.5 meter (25 foot) segments.

2.8.4 The pair count, gauge, footage, and number of insulation faults shall be recorded. This information shall be retained on a 6 month running basis for review by REA when requested.

2.8.5 A fault rate, in a continuous length in any one reel, in excess of one fault per 3,000 conductor meters (10,000 conductor feet) due to manufacturing defects is cause for rejection. A minimum of 6,000 conductor meters (20,000 conductor feet) is required to develop a noncompliance in a reel.

2.9 Repairs to the conductor insulation during manufacturing are permissible. The method of repair shall be accepted by REA prior to its use. The repaired insulation shall be capable of meeting the relevant electrical requirements of this specification.

2.10 All repaired sections of insulation shall be retested in the same manner as originally tested for compliance with the Paragraph 2.7 of this specification.

2.11 The colored composite insulating material removed from or tested on the conductor, from a finished cable, shall be capable of meeting the following performance requirements:

Property	Composite Insulation
Tensile Strength Minimum, Megapascals (MPa) (Pounds per square inch (psi))	16.5 (2,400)
Ultimate Elongation Percent, Minimum	125
Cold Bend Failures, Maximum	0/10
Shrinkback Maximum, Millimeters (mm) (Inches (in.))	9.5 (3/8)
Adhesion Maximum, Newtons (N) (Pound-force (lbf))	13.3 (3)
Compression Minimum, N (lbf)	1780 (400)

2.12 Testing Procedures: The procedures for testing the composite insulation samples for compliance with Paragraph 2.11 of this specification shall be as follows:

2.12.1 Tensile Strength and Ultimate Elongation: Samples of the insulation material, removed from the conductor, shall be tested in accordance with ASTM D 2633-82(1989), except that the speed of jaw separation shall be 50 millimeters/minute (50 mm/min) (2 inches/minute (2 in./min)).

Note: Quality assurance testing at a jaw separation speed of 500 mm/min (20 in./min) is permissible. Failures at this rate shall be retested at the 50 mm/min (2 in./min) rate to determine specification compliance.

2.12.2 Cold Bend: Samples of the insulation material on the conductor shall be tested in accordance with ASTM D 4565-90a at a temperature of -40 ± 1°C with a mandrel diameter of 6 mm (0.25 in.). There shall be no cracks visible to normal or corrected-to-normal vision.

2.12.3 Shrinkback: Samples of insulation shall be tested for four hours at a temperature of 115 ± 1°C in accordance with ASTM D 4565-90a.

2.12.4 Adhesion: Samples of the insulation material on the conductor shall be tested in accordance with ASTM D 4565-90a with a crosshead speed of 50 mm/min (2 in./min).

2.12.5 Compression: Samples of the insulation material on the conductor shall be tested in accordance with ASTM D 4565-90a with a crosshead speed of 5 mm/min (0.2 in./min).

2.13 Other methods of testing may be used if acceptable to REA.

3. IDENTIFICATION OF PAIRS AND TWISTING OF PAIRS

3.1 The PVC skin shall be colored to identify:

a. The tip and ring conductor of each pair; and

b. Each pair in the completed cable.

3.2 The colors used to provide identification of the tip and ring conductor of each pair shall be as shown in the following table:

	Color	
Pair No.	Tip	Ring
1	White	Blue
2	White	Orange
3	White	Green
4	White	Brown
5	White	Slate
6	Red	Blue
7	Red	Orange
8	Red	Green
9	Red	Brown
10	Red	Slate
11	Black	Blue
12	Black	Orange
13	Black	Green
14	Black	Brown
15	Black	Slate
16	Yellow	Blue
17	Yellow	Orange
18	Yellow	Green
19	Yellow	Brown
20	Yellow	Slate

21	Violet	Blue
22	Violet	Orange
23	Violet	Green
24	Violet	Brown
25	Violet	Slate

3.3 **Standards of Color:** The colors of the insulated conductors supplied in accordance with this specification are specified in terms of the Munsell Color System (ASTM D 1535-89) and shall comply with the "Table of Wire and Cable Limit Chips" as defined in ANSI/EIA-359-A-84. (Visual color standards meeting these requirements may be obtained directly from the Munsell Color Company, Inc., 2441 North Calvert Street, Baltimore, Maryland 21218).

3.4 Positive identification of the tip and ring conductors of each pair by marking each conductor of a pair with the color of its mate is permissible. The method of marking shall be accepted by REA prior to its use.

3.5 Other methods of providing positive identification of the tip and ring conductors of each pair may be employed if accepted by REA prior to its use.

3.6 The insulated conductors shall be twisted into pairs.

3.7 In order to provide sufficiently high crosstalk isolation, the pair twists shall be designed to enable the cable to meet the capacitance unbalance and the crosstalk loss requirements of Paragraphs 8.2, 8.3, and 8.4 of this specification.

3.8 The average length of pair twists in any pair in the finished cable, when measured on any 3 meter (m) (10 foot (ft)) length, shall not exceed 152 mm (6 in.).

4. FORMING OF THE CABLE CORE

4.1 Twisted pairs shall be assembled in such a way as to form a substantially cylindrical group.

4.2 When desired for lay-up reasons, the basic group may be divided into two or more subgroups called units.

4.3 Each group, or unit in a particular group, shall be enclosed in bindings of the colors indicated for its particular pair count. The pair count, indicated by the color of insulation, shall be consecutive as indicated in Paragraph 4.5 of this specification through units in a group.

4.4 Threads or tapes used as binders shall be nonhygroscopic and nonwicking. The threads shall consist of a suitable number of ends of each color arranged as color bands. When tapes are used as binders, they shall be colored. Binders shall be applied with a lay of not more than 100 mm (4 in.). The colored binders shall be readily recognizable as the basic intended color and shall be distinguishable from all other colors.

4.5 The colors of the bindings and their significance with respect to pair count shall be as shown in the following table:

Group No.	Color of Bindings	Group Pair Count
1	White-Blue	1-25
2	White-Orange	26-50
3	White-Green	51-75
4	White-Brown	76-100
5	White-Slate	101-125
6	Red-Blue	126-150
7	Red-Orange	151-175
8	Red-Green	176-200
9	Red-Brown	201-225
10	Red-Slate	226-250
11	Black-Blue	251-275
12	Black-Orange	276-300
13	Black-Green	301-325
14	Black-Brown	326-350
15	Black-Slate	351-375
16	Yellow-Blue	376-400
17	Yellow-Orange	401-425
18	Yellow-Green	426-450
19	Yellow-Brown	451-475
20	Yellow-Slate	476-500
21	Violet-Blue	501-525
22	Violet-Orange	526-550
23	Violet-Green	551-575
24	Violet-Brown	576-600

4.6 The use of the white unit binder in cables of 100 pair or less is optional

4.7 When desired for manufacturing reasons, two or more 25 pair groups may be bound together with nonhygroscopic and nonwicking threads or tapes into super-units. The group binders and the super-unit binders shall be colored such that the combination of the two binders shall positively identify each 25 pair group from every other 25 pair group in the cable.

4.8 Super-unit binders shall be of the colors shown in the following table:

Pair No.	Binder Color
1-600	White
600-1200	Red

5. CORE WRAP

5.1 The core shall be completely covered with a layer of nonhygroscopic and nonwicking dielectric material. The wrap shall be applied with an overlap.

5.2 The core wrap shall provide a sufficient heat barrier to prevent visible evidence of conductor insulation deformation or adhesion between conductors, caused by adverse heat transfer during the jacketing operation.

5.3 **Engineering Information:** If required for manufacturing reasons, white or uncolored binders of nonhygroscopic and nonwicking material may be applied over the core and/or core wrap.

6. SHIELD

6.1 An aluminum shield, plastic coated on one side, shall be applied longitudinally over the core wrap.

6.2 The shield may be applied over the core wrap with or without corrugations (smooth) and shall be bonded to the outer jacket.

6.3 The shield overlap shall be a minimum of 3 mm (0.125 in.) for cables with core diameters of 15 mm (0.625 in.) or less and a minimum of 6 mm (0.25 in.) for cables with core diameters greater than 15 mm (0.625 in.). The core diameter is defined as the diameter under the core wrap and binding.

6.4 General requirements for application of the shielding material shall be as follows:

6.4.1 Successive lengths of shielding tapes may be joined during the manufacturing process by means of cold weld, electric weld, soldering with a nonacid flux, or other acceptable means;

6.4.2 The metal shield with the plastic coating shall have the coating removed prior to joining the metal ends together. After joining, the plastic coating shall be restored without voids using good manufacturing techniques;

6.4.3 The shields of each length of cable shall be tested for continuity. A one meter (3 ft) section of shield containing a factory joint shall exhibit not more than 110 percent of the resistance of a shield of equal length without a joint;

6.4.4 The breaking strength of any section of a shield tape containing a factory joint shall not be less than 80 percent of the breaking strength of an adjacent section of the shield of equal length without a joint;

6.4.5 The reduction in thickness of the shielding material due to the corrugating or application process shall be kept to a minimum and shall not exceed 10 percent at any spot; and

6.4.6 The shielding material shall be applied in such a manner as to enable the cable to pass the bend test as specified in Paragraph 9.1 of this specification.

6.5 The dimensions of the uncoated aluminum tape shall be 0.2030 ± 0.0254 mm (0.0080 ± 0.0010 in.).

6.6 The aluminum tape shall conform to either Alloy AA-1100-0, AA-1145-0, or AA-1235-0 as covered in the latest edition of Aluminum Standards and Data, issued by the Aluminum Association, except that the requirements for tensile strength are waived.

6.7 The singled-sided plastic coated aluminum shield shall conform to the requirements of ASTM B 736-92a, Type I Coating, Class 1 or 2, or Type II Coating, Class 1. The minimum thickness of the Type I Coating shall be 0.038 mm (0.0015 in.). The minimum thickness of the Type II Coating shall be 0.008 mm (0.0003 in.).

6.8 The plastic coated aluminum shield shall be tested for resistance to water migration by immersing a one meter (3 ft) length of tape under a one meter (3 ft) head of water containing a soluble dye plus 0.25 percent (%) wetting agent.

6.8.1 After a minimum of 5 minutes, no dye shall appear between the interface of the shield tape and the plastic coating.

6.8.2 The actual test method shall be acceptable to REA.

6.9 The bond between the plastic coated shield and the jacket shall conform to the following requirements:

6.9.1 Prepare test strips approximately 200 mm (8 in.) in length. Slit the jacket and shield longitudinally to produce 4 strips evenly spaced and centered in 4 quadrants on the jacket circumference. One of the strips shall be centered over the overlapped edge of the shielding tape. The strips shall be 13 mm (0.5 in.) wide. For cable diameters less than 19 mm (0.75 in.) make two strips evenly spaced.

6.9.2 Separate the shield and jacket for a sufficient distance to allow the shield and jacket to be fitted in the upper and lower jaws of a tensile machine. Record the maximum force required to separate the shield and jacket to the nearest newton (pound-force). Repeat this action for each test strip.

6.9.3 The force required to separate the jacket from the shield shall not be less than 9 N (2 lbf) for any individual strip when tested in accordance with Paragraph 6.9.2 of this specification. The average force for all strips of any cable shall not be less than 18 N (4 lbf).

7. CABLE JACKET AND EXTRANEOUS MATERIAL

7.1 The jacket shall provide the cable with a tough, flexible, protective covering which can withstand stresses reasonably expected in normal installation and service.

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

7.3 The raw material used for the cable jacket shall be one of the following four types:

a. Type PVC-55554E0X0 in accordance with ASTM D 2287-81(1988);

b. Type PVC-65554E0X0 in accordance with ASTM D 2287-81(1988);

c. Type PVC-55556E0X0 in accordance with ASTM D 2287-81(1988); or

d. Type PVC-66554E0X0 in accordance with ASTM D 2287-81(1988).

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

Property	Jacket Performance
Tensile Strength-Unaged Minimum, MPa (psi)	13.8 (2,000)
Ultimate Elongation-Unaged Minimum, Percent (%)	200
Tensile Strength-Aged Minimum, % of Original	80
Ultimate Elongation-Aged Minimum, % of Original	50
Impact Failures, Maximum	2/10

7.5 Testing Procedures: The procedures for testing the jacket samples for compliance with Paragraph 7.4 of this specification shall be as follows:

7.5.1 Tensile Strength and Ultimate Elongation-Unaged: The test shall be performed in accordance with ASTM D 2633-82(1989), using a jaw separation speed of 50 mm/min (2 in./min).

Note: Quality assurance testing at a jaw separation speed of 500 mm/min (20 in./min) is permissible. Failures at this rate shall be retested at the 50 mm/min (2 in./min) rate to determine specification compliance.

7.5.2 Tensile Strength and Ultimate Elongation-Aged: The test shall be performed in accordance Paragraph 7.5.1 of this specification after being aged for 7 days at a temperature of 100 ± 1°C in a circulating air oven conforming to ASTM D 2436-85.

7.5.3 Impact: The test shall be performed in accordance with ASTM D 4565-90a using an impact force of 4 newton-meter (3 pound force-foot) at a temperature of -10 ± 1°C. The cylinder shall strike the sample at the shield overlap. A crack or split in the jacket constitutes failure.

7.6 Jacket Thickness: The nominal jacket thickness shall be as specified in the following table. The test method used shall be either the End Sample Method (Paragraph 7.6.1 of this specification) or the Continuous Uniformity Thickness Gauge Method (Paragraph 7.6.2 of this specification):

No. of Pairs	Nominal Jacket Thickness mm (in.)
25 or less	1.4 (0.055)
50	1.5 (0.060)
100	1.7 (0.065)
200	1.9 (0.075)
300	2.2 (0.085)
400	2.4 (0.095)
600	2.9 (0.115)
800 and over	3.3 (0.130)

7.6.1 End Sample Method: The jacket shall be capable of meeting the following requirements:

Minimum Average Thickness	90 % of nominal thickness
Minimum Thickness	70 % of nominal thickness

7.6.2 Continuous Uniformity Gauge Method:

7.6.2.1 The jacket shall be capable of meeting the following requirements:

Minimum Average Thickness	90 % of nominal thickness
Minimum (Min.) Thickness	70 % of nominal thickness
Maximum (Max.) Eccentricity	55 %

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

7.6.2.2 Maximum and Minimum Thickness Values: The maximum and minimum thickness values shall be based on the average of each axial section.

7.7 The color of the jacket shall be either black or dark grey in conformance with the Munsell Color System specified in ASTM D 1535-89.

7.8 There shall be no water or other contaminants in the finished cable which would have a detrimental effect on its performance or its useful life.

8. ELECTRICAL REQUIREMENTS

8.1 Mutual Capacitance and Conductance:

8.1.1 The average mutual capacitance (corrected for length) of all pairs in any reel shall not exceed the following when tested in accordance with ASTM D 4566-90 at a frequency of 1.0 ± 0.1 kilohertz (kHz) and a temperature of 23 ± 3°C:

Number of Cable Pairs	Mutual Capacitance nanofarad/kilometer	(nanofarad/mile)
12	52 ± 4	(83 ± 7)
Over 12	52 ± 2	(83 ± 4)

8.1.2 The root mean square (rms) deviation of the mutual capacitance of all pairs from the average mutual capacitance of that reel shall not exceed 3.0 % when calculated in accordance with ASTM D 4566-90.

8.1.3 The mutual conductance (corrected for length and gauge) of any pair shall not exceed 3.7 micromhos/kilometer (micromhos/km) (6.0 micromhos/mile) when tested in accordance with ASTM D 4566-90 at a frequency of 1.0 ± 0.1 kHz and a temperature of 23 ± 3°C.

8.2 Pair-to-Pair Capacitance Unbalance: The capacitance unbalance as measured on the completed cable shall not exceed 45.3 picofarad/kilometer (pF/km) (25 picofarad/1000 ft (pF/1000ft)) rms when tested in accordance with ASTM D 4566-90 at a frequency of 1.0 ± 0.1 kHz and a temperature of 23 ± 3°C.

8.3 Pair-to-Ground Capacitance Unbalance:

8.3.1 The average capacitance unbalance as measured on the completed cable shall not exceed 574 pF/km (175 pF/1000 ft) when tested in accordance with ASTM D 4566-90 at a frequency of 1.0 ± 0.1 kHz and a temperature of 23 ± 3°C.

8.3.2 When measuring pair-to-ground capacitance unbalance all pairs except the pair under test are grounded to the shield except when measuring cable containing super-units in which case all other pairs in the same super-unit shall be grounded to the shield.

8.3.3 Pair-to-ground capacitance unbalance may vary directly with the length of the cable.

8.4 Crosstalk Loss:

8.4.1 The rms output-to-output far-end crosstalk loss (FEXT) measured on the completed cable in accordance with ASTM D 4566-90 at a test frequency of 150 kHz shall not be less than 68 decibel/kilometer (dB/km) (73 decibel/1000 ft (dB/1000 ft)). The rms calculation shall be based on the combined total of all adjacent and alternate pair combinations within the same layer and center to first layer pair combinations.

8.4.2 The FEXT crosstalk loss between any pair combination of a cable shall not be less than 58 dB/km (63 dB/1000 ft) at a frequency of 150 kHz . If the loss K_O at a frequency F_O for length L_O is known, then K_X can be determined for any other frequency F_X or length L_X by:

$$\text{FEXT loss } (K_X) = K_O - 20 \log_{10} \frac{F_X}{F_O} - 10 \log_{10} \frac{L_X}{L_O}$$

8.4.3 The near-end crosstalk loss (NEXT) as measured within and between units of a completed cable in accordance with ASTM D 4566-90 at a frequency of 772 kHz shall not be less than the following mean minus sigma (M-S) crosstalk requirement for any unit within the cable:

Unit Size	M-S decibel (dB)
Within Unit:	
12 and 13 Pairs	56

18 and 25 Pairs	60
Between Unit:	
Adjacent 13 Pairs	65
Adjacent 25 Pairs	66
Nonadjacent (all)	81

Where M-S is the Mean near-end coupling loss based on the combined total of all pair combinations, less one Standard Deviation, Sigma, of the mean value.

8.5 Insulation Resistance: Each insulated conductor in each length of completed cable, when measured with all other insulated conductors and the shield grounded, shall have an insulation resistance of not less than 152 megohm-kilometer (500 Megohm-mile) at 20 ± 1°C. The measurement shall be made in accordance with the procedures of ASTM D 4566-90.

8.6 High Voltage Test:

8.6.1 In each length of completed cable, the dielectric strength of the insulation between conductors shall be tested in accordance with ASTM D 4566-90 and shall withstand, for 3 seconds, a direct current (dc) potential whose value is not less than:

a. 3.6 kilovolts for 22-gauge conductors, or

b. 3.0 kilovolts for 24-gauge conductors.

8.6.2 In each length of completed cable, the dielectric strength between the shield and all conductors in the core shall be tested in accordance with ASTM D 4566-90 and shall withstand, for 3 seconds, a dc potential whose value is not less than 10 kilovolts.

8.7 Conductor Resistance: The dc resistance of any conductor shall be measured in the completed cable in accordance with ASTM D 4566-90 and shall not exceed the following values when measured at or corrected to a temperature of 20 ± 1°C:

	Maximum Resistance	
AWG	ohms/kilometer	(ohms/1000 ft)
22	60.7	(18.5)
24	95.1	(29.0)

8.8 Resistance Unbalance:

8.8.1 The difference in dc resistance between the two conductors of a pair in the completed cable shall not exceed the values listed in this paragraph when measured in accordance with the procedures of ASTM D 4566-90:

	Resistance Unbalance - Maximum for any Reel	
AWG	Average Percent	Individual Pair Percent
22	1.5	4.0
24	1.5	5.0

8.8.2 The resistance unbalance between tip and ring conductors shall be random with respect to the direction of unbalance. That is, the resistance of the tip conductors shall not be consistently higher with respect to the ring conductors and vice versa.

8.9 Electrical Variations:

8.9.1 Pairs in each length of cable having either a ground, cross, short, or open circuit condition shall not be permitted.

8.9.2 The maximum number of pairs in a cable which may vary as specified in Paragraph 8.9.3 of this specification from the electrical parameters given in this specification are listed in this paragraph. These pairs may be excluded from the arithmetic calculation:

Nominal Pair Count	Maximum Number of Pairs with Allowable Electrical Variation
12-100	1
101-300	2
301-400	3
401-600	4
601 and above	6

8.9.3 Parameter Variations:

8.9.3.1 Capacitance Unbalance-to-Ground: If the cable fails either the maximum individual pair or average capacitance unbalance-to-ground requirement and all individual pairs are 3280 pF/km (1000 pF/1000 ft) or less the number of pairs specified in Paragraph 8.9.2 of this specification may be eliminated from the average and maximum individual calculations.

8.9.3.2 Resistance Unbalance: Individual pair of not more than 7 percent for all gauges.

8.9.3.3 Far-end Crosstalk Loss: Individual pair combination of not less than 52 dB/km (57 dB/1000 ft).

Note: REA recognizes that in large pair count cables (600 pair and above) a cross, short, or open circuit condition occasionally may develop in a pair which does not affect the performance of the other cable pairs. In theses circumstances rejection of the entire cable mat be economically unsound or repairs may be impractical. In such circumstances the manufacturer may desire to negotiate with the customer for acceptance of the cable. No more than 0.5 percent of the pairs may be involved.

9. MECHANICAL REQUIREMENTS

9.1 Cable Cold Bend Test: The completed cable shall be capable of meeting the requirements of ASTM D 4565-90a after conditioning at -20 ± 2°C except that the mandrel diameters shall be as specified below:

Cable Outside Diameter	Mandrel Diameter
<40 mm (1.5 in.)	15x
≥40 mm (1.5 in.)	20x

9.2 Cable Flame Test: The completed cable shall be capable of meeting a maximum flame height of 3.7 m (12.0 ft) when tested in accordance with Underwriters Laboratories (UL) 1666 dated January 22, 1991.

9.3 Cable Listing: All cables manufactured to this specification at a minimum shall be listed as Communication Riser Cable (Type CMR) in accordance with Sections 800-50 and 800-51(b) of the 1993 National Electrical Code.

10. SHEATH SLITTING CORD (OPTIONAL)

10.1 Sheath slitting cords may be used in the cable structure at the option of the manufacturer.

10.2 When a sheath slitting cord is used it shall be non-hygroscopic and nonwicking, continuous throughout a length of cable, and of sufficient strength to open the sheath without breaking the cord.

10.3 Sheath slitting cords shall be capable of consistently slitting the jacket and/or shield for a continuous length of 0.6 m (2 ft) when tested in accordance with the procedure specified in Appendix B of this specification.

11. IDENTIFICATION MARKER AND LENGTH MARKER

11.1 Each length of cable shall be permanently identified as to manufacturer and year of manufacture.

11.2 The number of conductor pairs and their gauge size shall be marked on the jacket.

11.3 The marking shall be printed on the jacket at regular intervals of not more than 1.5 m (5 ft).

11.4 An alternative method of marking may be used if accepted by REA prior to its use.

11.5 The completed cable shall have sequentially numbered length markers in FEET OR METERS at regular intervals of not more than 1.5 m (5 ft) along the outside of the jacket.

11.6 The method of length marking shall be such that for any single length of cable, continuous sequential numbering shall be employed.

11.7 The numbers shall be dimensioned and spaced to produce good legibility and shall be approximately 3 mm (0.125 in.) in height. An occasional illegible marking is permissible if there is a legible marking located not more than 1.5 m (5 ft) from it.

11.8 The method of marking shall 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 shall 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.

11.9 The accuracy of the length marking shall be such that the actual length of any cable section is never less than the length indicated by the marking and never more than one percent greater than the length indicated by the marking.

11.10 The color of the initial marking for a black colored jacket shall be either white or silver. The color of the initial marking for a dark grey colored jacket shall be either red or black. If the initial marking of the black colored jacket 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. If the initial marking of the dark grey colored jacket fails to meet the requirements of the preceding paragraphs, it will be permissible to either remove the defective marking and re-mark with the red or black color or leave the defective marking on the cable and re-mark with yellow. No further re-marking is permitted. Any re-marking shall be on a different portion of the cable circumference than any existing marking when possible and have a numbering sequence differing from any other existing marking by at least 5,000.

11.11 Any reel of cable which contains more than one set of sequential markings shall be labeled to indicate the color and sequence of marking to be used. The labeling shall be applied to the reel and also to the cable.

12. PRECONNECTORIZED CABLE (OPTIONAL)

12.1 At the option of the manufacturer and upon request by the purchaser, cables 100 pairs and larger may be factory terminated in 25 pair splicing modules.

12.2 The splicing modules shall meet the requirements of REA Bulletin 345-52, REA Specification for Telephone Splicing Connectors (Incorporated by Reference at § 1755.97), and be accepted by REA prior to their use.

13. ACCEPTANCE TESTING AND EXTENT OF TESTING

13.1 The tests described in Appendix A of this specification are intended for acceptance of cable designs and major modifications of accepted designs. REA decides what constitutes a major modification. These tests are intended to show the inherent capability of the manufacturer to produce cable products having long life and stability.

13.2 For initial acceptance, the manufacturer shall 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. To periodic plant inspections;

d. 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 (7 U.S.C. 901 et seq.);

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

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

13.3 For requalification acceptance, the manufacturer shall 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 (7 U.S.C. 901 et seq.) for acceptance by June 30 every three years. The required data and certification shall have been gathered within 90 days of the submission.

13.4 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.

13.5 Tests on 100 Percent of Completed Cable:

13.5.1 The shield of each length of cable shall be tested for continuity using the procedures of ASTM D 4566-90.

13.5.2 Dielectric strength between all conductors and the shield shall be tested to determine freedom from grounds in accordance with Paragraph 8.6.2 of this specification.

13.5.3 Each conductor in the completed cable shall be tested for continuity using the procedures of ASTM D 4566-90.

13.5.4 Dielectric strength between conductors shall be tested to ensure freedom from shorts and crosses in accordance with Paragraph 8.6.1 of this specification.

13.5.5 Each conductor in the completed preconnectorized cable shall be tested for continuity.

13.5.6 Each length of completed preconnectorized cable shall be tested for split pairs.

13.5.7 The average mutual capacitance shall be measured on all cables. If the average mutual capacitance for the first 100 pairs tested from randomly selected groups is between 50 and 53 nanofarad/kilometer (nF/km) (80 to 85 nanofarad/mile (nF/mile)), the remainder of the pairs need not be tested on the 100 percent basis. (See Paragraph 8.1 of this specification).

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

13.6.1 Performance requirements for conductor insulation and jacket material;

13.6.2 Bonding properties of coated or laminated shielding materials;

13.6.3 Sequential marking and lettering;

13.6.4 Capacitance unbalance and crosstalk;

13.6.5 Insulation resistance;

13.6.6 Conductor resistance and resistance unbalance;

13.6.7 Cable cold bend and cable flame tests; and

13.6.8 Mutual conductance.

14. SUMMARY OF RECORDS OF ELECTRICAL AND PHYSICAL TESTS

14.1 Each manufacturer shall maintain suitable summary of records for a period of at least 3 years for all electrical and physical tests required on completed cable by this specification as set forth in Paragraphs 13.5 and 13.6 of this specification. The test data for a particular reel shall be in a form that it may be readily available to the purchaser or to REA upon request.

14.2 Measurements and computed values shall be rounded off to the number of places of figures specified for the requirement according to ASTM E 29-90.

15. MANUFACTURING IRREGULARITIES

15.1 Repairs to the shield are not permitted in cable supplied to the end user under this specification.

15.2 No repairs or defects in the jacket are allowed.

16. PREPARATION FOR SHIPMENT

16.1 The cable shall be shipped on reels unless otherwise specified or agreed to by the purchaser. The diameter of the drum shall be large enough to prevent damage to the cable from reeling or unreeling. The reels shall be substantial and so constructed as to prevent damage to the cable during shipment and handling.

16.2 A waterproof corrugated board or other means of protection acceptable to REA shall be applied to the reel and shall be suitably secured in place to prevent damage to the cable during storage and shipment.

16.3 The outer end of the cable shall be securely fastened to the reel head so as to prevent the cable from becoming loose in transit. The inner end of the cable shall be securely fastened in such a way as to make it readily available if required for electrical testing. Spikes, staples, or other fastening devices which penetrate the cable jacket shall not be used. The method of fastening the cable ends shall be accepted by REA prior to it being used.

16.4 Each length of cable shall be wound on a separate reel unless otherwise specified or agreed to by the purchaser.

16.5 The arbor hole shall admit a spindle 63 mm (2.5 in.) in diameter without binding. Steel arbor hole liners may be used but shall be acceptable to REA prior to their use.

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

16.7 Each reel shall be stenciled or labeled on either one or both sides with the name of the manufacturer, year of manufacture, actual shipping length, an inner and outer end sequential length marking, description of the cable, reel number and the REA cable designation.

CABLE DESIGNATION

CT
Cable Construction
Pair Count
Conductor Gauge

A = Coated Aluminum Shield
P = Preconnectorized Cable

Example: CTAP 100-22

Terminating Cable, Coated Aluminum Shield,
Preconnectorized, 100 pairs, 22 AWG

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

UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Electrification Administration

APPENDIX A

TERMINATING CABLE

Qualifications Test Methods Bulletin 1753F-207(PE-87)

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 shall be performed on lengths removed sequentially from the same 25 pair, 22 gauge jacketed cable. This cable shall not have been exposed to temperatures in excess of 38°C since its initial cool down after sheathing. The lengths specified are minimum lengths and if desirable from a laboratory testing standpoint longer lengths may be used.

2.1.1 Length A shall be 12 ± 0.2 meters (40 ± 0.5 feet) long. Prepare the test sample by removing the jacket, shield, and core wrap for a sufficient distance on both ends to allow the insulated conductors to be flared out. Remove sufficient conductor insulation so that appropriate electrical test connections can be made at both ends. Coil the sample with a diameter of 15 to 20 times its sheath diameter. Two lengths are required.

2.1.2 Length B shall be 300 millimeters (1 foot) long. Three lengths are required.

2.1.3 Length C shall be 3 meters (10 feet) long and shall maintained at 23 ± 3°C for the duration of the test. Two lengths are required.

2.2 **Data Reference Temperature:** Unless otherwise specified, all measurements shall be made at 23 ± 3°C.

3. ENVIRONMENTAL TESTS

3.1 Heat Aging Test

3.1.1 Test Samples: Place one sample each of lengths A and B in an oven or environmental chamber. The ends of sample A shall exit from the chamber or oven for electrical tests. Securely seal the oven exit holes.

3.1.2 Sequence of Tests: Sample B referenced in Paragraph 3.1.1 of this appendix shall be subjected to the insulation compression test outlined in Paragraph 3.2 of this appendix.

3.1.3 Initial Measurements

3.1.3.1 For sample A, measure the open circuit capacitance and conductance for each odd pair at 1, 150, and 772 kHz after conditioning the sample at the data reference temperature for 24 hours. Calculate the average and standard deviation for the data of the 13 pairs on a per kilometer (per mile) basis.

3.1.3.2 Record on suggested formats attached 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 for 14 days at a temperature of 65 ± 2°C.

3.1.4.2 At the end of this period measure and calculate 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 Electrical Deviation

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

3.1.5.2 The stability of the electrical parameters after completion of this test shall be within the following prescribed limits:

a. Capacitance: The average mutual capacitance shall be within 10 percent of its original value;

b. The change in average mutual capacitance shall be less than 10 percent over the frequency range of 1 to 150 kilohertz; and

c. Conductance: The average mutual conductance shall not exceed 3.7 micromhos/kilometer (6 micromhos/mile) at a frequency of 1 kilohertz.

3.2 Insulation Compression Test

3.2.1 Test Sample B: Remove jacket, shield, and core wrap being careful not to damage the conductor insulation. Remove one pair from the core and carefully separate and straighten the insulated conductors. Retwist the two insulated conductors together under sufficient tension to form 10 evenly spaced 360 degree twists in a length of 100 millimeters (4 inches).

3.2.2 Sample Testing: Center the mid 50 millimeters (2 inches) of the twisted pair between two smooth rigid parallel metal plates measuring 50 millimeters (2 inches) in length or diameter. Apply a 1.5 volt direct current potential between the conductors, using a light or buzzer to indicate electrical contact between the conductors. Apply a constant load of 67 newtons (15 pound-force) on the sample for one minute and monitor for evidence of contact between the conductors. Record results on suggested formats attached in Paragraph 5 of this appendix or on other easily readable formats.

3.3 Temperature Cycling

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

3.3.2 Immediately after completing the measurements, subject the test samples to 10 cycles of temperature between -40°C and +60°C. The test samples shall be held at each temperature extreme for a minimum of 1.5 hours during each cycle of temperature. The air within the temperature cycling chamber shall be circulated throughout the duration of the cycling.

3.3.3 Repeat Paragraphs 3.1.4.2 through 3.2.2 of this appendix.

4. CONTROL SAMPLE

4.1 Test Samples: One length of sample B shall have been maintained at 23 ± 3°C for at least 48 hours before the testing.

4.2 Repeat Paragraphs 3.2 through 3.2.2 of this appendix.

4.3 Surge Test

4.3.1 One length of sample C shall be used to measure the breakdown between conductors while the other length of C shall be used to measure core to shield breakdown.

4.3.2 The samples shall be capable of withstanding, without damage, a single surge voltage of 20 kilovolts peak between conductors, and 35 kilovolts peak between conductors and the shield as hereinafter described. The surge voltage shall be developed from a capacitor discharge through a forming resistor connected in parallel with the dielectric of the test sample. The surge generator constants shall be such as to produce a surge of 1.5 x 40 microseconds wave shape.

4.3.3 The shape of the generated wave shall be determined at a reduced voltage by connecting an oscilloscope across the forming resistor with the cable sample connected in parallel with the forming resistor. The capacitor bank is charged to the test voltage and then discharged through the forming resistor and test sample. The test sample will be considered to have passed the test if there is no distinct change in the wave shape obtained with the initial reduced voltage compared to that obtained after the application of the test voltage.

5. TEST DATA FORMATS

5.1 The following suggested formats may be used for submitting the test data to REA.

Environmental Conditioning ______________________________

FREQUENCY 1 KILOHERTZ

Pair Number	Capacitance nF/km (nF/mile)		Conductance micromhos/km (micromhos/mile)	
	Initial	Final	Initial	Final
1	________	______	________	______
3	________	______	________	______
5	________	______	________	______
7	________	______	________	______
9	________	______	________	______
11	________	______	________	______
13	________	______	________	______
15	________	______	________	______
17	________	______	________	______
19	________	______	________	______
21	________	______	________	______
23	________	______	________	______
25	________	______	________	______
Average $\bar{x}$	________	______	________	______

Overall Percent
Difference in

Average $\bar{x}$ ________________ ____________________

Environmental Conditioning________________________________

FREQUENCY 150 KILOHERTZ

Pair Number	Capacitance nF/km (nF/mile)		Conductance micromhos/km (micromhos/mile)	
	Initial	Final	Initial	Final
1	________	______	________	______
3	________	______	________	______
5	________	______	________	______
7	________	______	________	______
9	________	______	________	______
11	________	______	________	______
13	________	______	________	______
15	________	______	________	______
17	________	______	________	______
19	________	______	________	______
21	________	______	________	______
23	________	______	________	______
25	________	______	________	______
Average $\bar{x}$	________	______	________	______
Overall Percent Difference in Average $\bar{x}$	__________________		______________________	

Environmental Conditioning________________________

FREQUENCY 772 KILOHERTZ

Pair Number	Capacitance nF/km (nF/mile)		Conductance micromhos/km (micromhos/mile)	
	Initial	Final	Initial	Final
1	______	______	______	______
3	______	______	______	______
5	______	______	______	______
7	______	______	______	______
9	______	______	______	______
11	______	______	______	______
13	______	______	______	______
15	______	______	______	______
17	______	______	______	______
19	______	______	______	______
21	______	______	______	______
23	______	______	______	______
25	______	______	______	______
Average $\bar{x}$	______	______	______	______
Overall Percent Difference in Average $\bar{x}$	____________		____________	

INSULATION COMPRESSION

	Failures
Control	________
Heat Age	________
Temperature Cycling	________

SURGE TEST (kilovolts)

Conductor to Conductor	______________
Shield to Conductors	______________

UNITED STATED DEPARTMENT OF AGRICULTURE
Rural Electrification Administration

APPENDIX B

Sheath Slitting Cord Qualification

1. This test procedure described in this appendix is for qualification of initial and subsequent changes in sheath slitting cords.

2. SAMPLE SELECTION: All testing shall be performed on two 1.2 m (4 ft) length of cable removed sequentially from the same 25 pair, 22 gauge jacketed cable. This cable shall not have been exposed to temperatures in excess of 38°C since its initial cool down after sheathing.

3. TEST PROCEDURE

3.1 Using a suitable tool, expose enough of sheath slitting cord to permit grasping with needle nose pliers.

3.2 The prepared test specimens shall be maintained at a temperature of 23 ± 1°C for at least 4 hours immediately prior to and during the test.

3.3 Wrap the sheath slitting cord around the plier jaws to ensure a good grip.

3.4 Grasp and hold the cable in a convenient position while gently and firmly pulling the sheath slitting cord longitudinally in the direction away from the cable end. The angle of pull may vary to any convenient and functional degree. A small starting notch is permissible.

3.5 The sheath slitting cord is considered acceptable if the cord can slit the jacket and/or shield for a continuous length of 0.6 m (2 ft) without breaking the cord.