UNITED STATES DEPARTMENT OF AGRICULTURE
USDA Rural Development Utilities Programs

BULLETIN 1728F-U1

SUBJECT: Specification for Primary Underground Power Cable

TO: USDA Rural Development Utilities Programs Borrowers and Electric Staff

EFFECTIVE DATE: Six Months from Date of Publication in the Federal Register.

OFFICE OF PRIMARY INTEREST: Distribution Branch, Electric Staff Division, Utilities Program.

FILING INSTRUCTIONS: This bulletin supersedes Bulletin 50-70 (U1), "REA Specification for 15 kV and 25 kV Primary Underground Power Cable," dated December 22, 1987.

AVAILABILITY: This bulletin can be accessed through the Internet at http://www.usda.gov/rus/electric/bulletins.htm.

PURPOSE: This bulletin provides USDA Rural Development Utilities Programs (Agency) electric borrowers and staff with the specifications for 15, 25, and 35 kV single-phase and multi-phase primary underground power cable with tree retardant cross-linked polyethylene or ethylene propylene rubber insulation operated at 15 or 25 kV. Both cable insulation types will also utilize concentric neutral, and an overall outer jacket. Agency electric borrowers can construct rural underground electric distribution systems and distribute electrical energy utilizing these cable designs.

_____ _____

James R. Newby
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Date

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SPECIFICATIONS AND STANDARDS

Underground Cable

ABBREVIATIONS

AC – Alternating current
ANSI – American National Standards Institute
ASTM – American Society for Testing and Materials
AWG – American Wire Gauge
CPE – chlorinated polyethylene
EPR – ethylene propylene rubber
HDPE – high density polyethylene
HMW – high molecular weight
ICEA – Insulated Cable Engineering Association, Inc.
IEEE – Institute of Electrical and Electronics Engineers, Inc.
LDPE – low density polyethylene
LLDPE – linear low density polyethylene
MDPE – medium density polyethylene
PVC – polyvinyl chloride
XLPE – cross-linked polyethylene
TR-XLPE – tree retardant cross-liked polyethylene

DEFINITIONS

EPR Insulating Compound – A mixture of ethylene propylene base resin and selected ingredients.

TR-XLPE Insulating Compound – A tree retardant crosslinked polyethylene (TR-XLPE) insulation compound containing an additive, a polymer modification filler, which helps to retard the growth of electrical trees in the compound.

Agency - The Rural Utilities Service, an agency delivering the United States Department of Agriculture's (USDA) Rural Development Utilities Programs, hereinafter referred to the Agency.

1 SUMMARY

a Purpose: To announce the issuance of revised Bulletin 50-70 (U-1), "REA Specification for 15 kV and 25 kV Primary Underground Power Cable," to be issued as Bulletin 1728F-U1, "Specification for Primary Underground Power Cable." This revision supersedes Bulletin 50-70 (U-1) dated December 22, 1987.

b Principal Revisions:

(1) Water blocking sealant shall be required in all cables utilizing stranded conductors.

(2) Plain cross-linked polyethylene (XLPE) has been removed as an acceptable insulation material and tree-retardant cross-linked polyethylene (TR-XLPE) insulation has replaced it due to the significantly improved reliability.

(3) The minimum allowed nominal insulation thickness on 25 kV cable has been reduced from 345 mils (8.76 mm) to 260 mils (6.60 mm).

(4) This bulletin includes provision for semiconducting jacket cable for use in area's with soil resistivity greater than 25 ohm-meter.

2 GENERAL SPECIFICATIONS

a Bulletin 1728F-U1 details requirements for 15 and 25 kV single phase, V-phase, and three-phase power cables for use on 12.5/7.2 kV (15 kV rated) and 24.9/14.4 kV (25 kV rated) underground distribution systems with solidly multi-grounded neutral. Cable complying with this specification shall consist of solid or strand-filled conductors which are insulated with tree-retardant cross-linked polyethylene (TR-XLPE) or ethylene propylene rubber (EPR), with concentrically wound copper neutral conductors covered by a nonconducting or semiconducting jacket. 35 kV rated cables may be used in 24.9/14.4 kV application where additional insulation is desired.

b The cable may be used in single-phase, two (V)-phase, or three-phase circuits.

c Acceptable conductor sizes are: No. 2 AWG (33.6 mm^2) through 1000 kcmil (507 mm^2) for 15 kV cable, No. 1 AWG (42.4 mm^2) through 1000 kcmil (507 mm^2) for 25 kV, and 1/0 (53.5 mm^2)through 1000 kcmil (507 mm^2) for 35 kV cable.

d Except where provisions therein conflict with the requirements of this specification, the cable shall meet all applicable provisions of ANSI/ICEA S-94-649-2004. Where provisions of the ANSI/ICEA specification conflict with this bulletin, Bulletin 1728F-U1 shall apply.

3 REFERENCED SPECIFICATIONS

a The following specifications/standards are considered pertinent to this bulletin:

ANSI/ICEA S-94-649-2004 – "Standard for Concentric Neutral Cables Rated 5,000-46,000 Volts"

ICEA T-31-610-1994 – "Guide for Conducting a Longitudinal Water Penetration Resistance Test for Sealed Conductor"

ICEA T-32-645-1993 – "Guide for Establishing Compatibility of Sealed Conductor Filler Compounds with Conductor Stress Control Materials"

ASTM B 3-2007 – "Specification for Soft or Annealed Copper Wire"

ASTM B 8-2004 – "Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft"

ASTM B 33-2004 – "Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes"

ASTM B 230-2007 – "Specification for Aluminum 1350-H19 Wire for Electrical Purposes"

ASTM B 231-2004 – "Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors"

ASTM B 400-2004 – "Specification for Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductors"

ASTM B 496-2004 – "Specification for Compact Round Concentric-Lay-Stranded Copper Conductors"

ASTM B 609-2004 – "Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes"

ASTM B 786-2002 – “Specification for 19 Wire Combination Unilay-Stranded Aluminum 1350 Conductors for Subsequent Insulation”

ASTM B 787-2004 – “Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation”

ASTM B 800-2005 – “Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers”

ASTM B 801-2007 – “Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation”

ASTM B 835-2004 – “Specification for Compact Round Stranded Copper Conductors Using Single Input Wire Construction”

ASTM B 836-00 (2005) – “Specification for Compact Round Stranded Aluminum Conductors Using Single Input Wire Construction”

ASTM B901-04 – “Specification for Compressed Round Stranded Aluminum Conductors Using Single Input Wire Construction”

ASTM B902-04a – “Specification for Compressed Round Stranded Copper Conductors, Hard, Medium-Hard, or Soft Using Single Input Wire Construction”

ASTM D 412-2006 – “Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension”

ASTM D 746-2007 – “Test Method for Brittleness Temperature of Plastics and Elastomers by Impact”

ASTM D 1248-2005 – “Specification for Polyethylene Plastics Molding and Extrusion Materials”

ASTM D 1693-2007 – “Test Method for Environmental Stress-Cracking of Ethylene Plastics”

ASTM D 2275-2001 – “Test Method for Voltage Endurance of Solid Electrical Insulating Materials Subjected to Partial Discharges (Corona) on the Surface”

ASTM D 2765-01 (2006) – “Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics”

ASTM D 3349-2006 – “Test Method for Absorption Coefficient of Ethylene Polymer Material Pigmented with Carbon Black”

ASTM D 4496-2004 – "Test Method for D-C Resistance or Conductance of Moderately Conductive Materials"

ASTM E 96-2005 – "Test Methods for Water Vapor Transmission of Materials"

b Availability of publications

(1) Copies of American Society for Testing and Materials (ASTM) publications referenced in this specification can be obtained from ASTM for a fee at the address indicated below:

ASTM
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959
Telephone: (610) 832-9585
Web Site: http://astm.org

(2) Copies of the National Electrical Safety Code (NESC) can be obtained from IEEE for a fee at the address indicated below:

Institute of Electrical and Electronics Engineers, Inc. (IEEE)
IEEE Service Center
445 Hoes Lane
Piscataway, NJ 08855
Telephone: (800) 678-4333
Web Site: http://shop.ieee.org/ieeestore/

(3) Copies of the American National Standards Institute/Insulated Cable Engineers Association, Inc. (ANSI/ICEA) S-94-649-2004 publication can be obtained from Global Engineering Documents for a fee at the address indicated below:

IHS
Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112
Phone: (303) 397-7956 (800)-854-7179
Fax: (303) 397-2740
E Mail: global@ihs.com
Web Site: http://global.ihs.com

4 PHASE CONDUCTORS

a Central phase conductors shall be copper or aluminum as specified by the borrower within the limit of section 2.c.

b Central copper phase conductors shall be annealed copper in accordance with ASTM B 3. Concentric-lay-stranded phase conductors shall conform to ASTM B 8 for Class B stranding. Compact round concentric-lay-stranded phase conductors shall conform to ASTM B 496. Combination unilay stranded phase conductors shall conform to ASTM B 787. Compact Round Stranded Copper Conductors Using Single Input Wire Construction shall conform to ASTM B835. Compressed Round Stranded Copper Conductors, Hard, Medium-Hard, or Soft Using Single Input Wire Construction shall conform to ASTM B902-04a. If not specified, stranded phase conductors shall be Class B stranded.

c Central aluminum phase conductors shall be one of the following:

(1) Solid: Aluminum 1350 H12 or H22, H14 or H24, H16 or H26, in accordance with ASTM B 609.

(2) Stranded: Aluminum 1350 H14 or H24, H142 or H242, H16, or H26, in accordance with ASTM B 609 or Aluminum 1350-H19 in accordance with ASTM B 230. Concentric-lay-stranded (includes compacted and compressed) phase conductors shall conform to ASTM B 231 for Class B stranding. Compact round concentric-lay-stranded phase conductors shall conform to ASTM B 400. Combination unilay stranded aluminum phase conductors shall conform to ASTM B 786. If not specified, stranded phase conductors shall be class B stranded.

d. The interstices between the strands of stranded conductors shall be filled with a material designed to fill the interstices and to prevent the longitudinal migration of water that might enter the conductor. This material shall be compatible with the conductor and conductor shield materials. The surfaces of the strands that form the outer surface of the stranded conductor shall be free of the strand fill material. Compatibility of the strand fill material with the conductor shield shall be tested and shall be in compliance with ICEA T-32-645. Water penetration shall be tested and shall be in compliance with ICEA T-31-610.

e. The center strand of stranded conductors shall be indented with the manufacturer’s name and year of manufacture at regular intervals with no more than 12 inches (0.3 m) between repetitions.

5 CONDUCTOR SHIELD (STRESS CONTROL LAYER)

a A non-conducting (for discharge resistant EPR) or semi-conducting shield (stress control layer) meeting the applicable requirements of ANSI/ICEA S-94-649 shall be extruded around the central conductor. The minimum thickness at any point shall be in accordance with ANSI/ICEA S-94-649. The void and protrusion limits on the conductor shield shall be in compliance with ANSI/ICEA S-94-649. The shield shall have a nominal operating temperature equal to, or higher than, that of the insulation.

6 INSULATION

a The insulation shall conform to the requirements of ANSI/ICEA publication S-94-649 and may either be tree retardant cross-linked polyethylene (TR-XLPE) or ethylene propylene rubber (EPR), as specified by the borrower. The void and protrusion limits on the insulation shall be in compliance with ANSI/ICEA S-94-649

b The thickness of insulation shall be as follow:

Cable Rated Voltage	Nominal Thickness	Minimum Thickness	Maximum Thickness
15 kV	220 mils (5.59 mm)	210 mils (5.33 mm)	250 mils (6.35 mm)
25 kV	260 mils (6.60 mm)	245 mils (6.22 mm)	290 mils (7.37 mm)
35 kV	345 mils (8.76 mm)	330 mils (8.38 mm)	375 mils (9.53 mm)

7 INSULATION SHIELD

a A semi-conducting thermosetting polymeric layer meeting the requirements of ANSI/ICEA S-94-649 shall be extruded tightly over the insulation to serve as an electrostatic shield and protective covering. The shield compound shall be compatible with, but not necessarily the same material composition as, that of the insulation (e.g., cross-linked polyethylene shield may be used with EPR insulation). The void and protrusion limits on the semi-conducting shields shall be in compliance with the ANSI/ICEA S-94-649.

b The thickness of the extruded insulation shield shall be in accordance with ANSI/ICEA S-94-649.

c The shield shall be applied such that all conducting material can be easily removed without the need for externally applied heat. Stripping tension values shall be 3 through 18 pounds (1.36 through 8.16 kg) for TR-XLPE and EPR

discharge free cables. Discharge resistant cables shall have strip tension of 0 through 18 pounds (0 through 8.16 kg).

d The insulation shield shall meet all applicable tests of ANSI/ICEA S-94-649.

8 CONCENTRIC NEUTRAL CONDUCTOR

a A concentric neutral conductor shall consist of annealed round, uncoated copper wires in accordance with ASTM B 3 and shall be spirally wound over the shielding with uniform and equal spacing between wires. The concentric neutral wires shall remain in continuous intimate contact with the extruded insulation shield. Full neutral is required for single phase and 1/3 neutral for three phase applications unless otherwise specified. The minimum wire size for the concentric neutral is 16 AWG (1.32 mm^2).

b When a strap neutral is specified by the borrower, the neutral shall consist of uncoated copper straps applied concentrically over the insulation shield with uniform and equal spacing between straps and shall remain in intimate contact with the underlying extruded insulation shield. The straps shall not have sharp edges. The thickness of the flat straps shall be not less than 20 mils (0.5 mm).

9 OVERALL OUTER JACKET

a An electrically nonconducting (insulating) or semi-conducting outer jacket shall be applied directly over the concentric neutral conductors.

(1) The jacket material shall fill the interstice area between conductors, leaving no voids. The jacket shall be free stripping. The jacket shall have three red stripes longitudinally extruded into the jacket surface 120^o apart.

(2) Nonconducting jackets shall consist of low density, linear low density, medium density, or high density HMW black polyethylene (LDPE, LLDPE, MDPE, HDPE) compound meeting the requirements of ANSI/ICEA S-94-649, and ASTM D 1248 for Type I, Class C, Category 4 or 5, Grade J3 before application to the cable. Polyvinyl chloride (PVC) and chlorinated polyethylene (CPE) jackets are not acceptable.

(3) Semi-conducting jackets shall have a maximum radial resistivity of 100 ohm-meter and a maximum moisture vapor transmission rate of 1.5 g/m^2/24 hours at 38^o C (100^o F) and 90 percent relative humidity in accordance with ASTM E 96.

b The minimum thickness of the jacket over metallic neutral wires or straps shall comply with the thickness specified in ANSI/ICEA S-94-649.

10 TESTS

a As part of a request for Agency consideration for acceptance and listing, the manufacturer shall submit certified test data results to the Agency that detail full compliance with ANSI/ICEA S-94-649 for each cable design.

(1) Test results shall confirm compliance with each of the material tests, production sampling tests, tests on completed cable, and qualification tests included in ANSI/ICEA S-94-649.

(2) The testing procedure and frequency of each test shall be in accordance with ANSI/ICEA S-94-649.

(3) Certified test data results shall be submitted to the Agency for any test, which is designated by ANSI/ICEA S-94-649 as being "for Engineering Information Only," or any similar designation.

b Partial Discharge Tests. Manufacturers shall demonstrate that their cable is not adversely affected by excessive partial discharge. This demonstration shall be made by completing the procedures described in paragraph b(1) or b(2) of this bulletin.

(1) Each shipping length of completed cable shall be tested and have certified test data results available indicating compliance with the partial discharge test requirements in ANSI/ICEA S-94-649.

(2) Manufacturers shall test production samples and have available certified test data results indicating compliance with ASTM D 2275 for discharge resistance as specified in the ANSI/ICEA S-94-649. Samples of insulated cable shall be prepared by either removing the overlying extruded insulation shield material, or using insulated cable before the extruded insulation shield material is applied. The sample shall be mounted as described in ASTM D 2275 and shall be subjected to a voltage stress of 250 volts per mil of nominal insulation thickness. The sample shall support this voltage stress, and not show evidence of degradation on the surface of the insulation for a minimum of 100 hours. The test shall be performed at least once on each 50,000 feet (15,240 m) of cable produced, or major fractions thereof, or at least once per insulation extruder run.

c Jacket Tests. Tests described in paragraph c of this section shall be performed on cable jackets from the same production sample as in section 10.b of this bulletin.

A Spark Test shall be performed on nonconducting jacketed cable in accordance with ANSI/ICEA S-94-649 on 100 percent of the completed cable prior to its being wound on shipping reels. The test voltage shall be 4.5 kV AC for cable diameters<1.5 inches and 7.0 kV for cable diameters

> 1.5 inches, and shall be applied between an electrode at the outer surface of the nonconducting (insulating) jacket and the concentric neutral for not less than 0.15 second.

d Frequency of sample tests shall be in accordance with ANSI/ICEA S-94-649.

e If requested by the borrower, a certified copy of the results of all tests performed in accordance to this section shall be furnished on all orders.

11 MISCELLANEOUS

a All cable provided under this specification shall have suitable markings on the outer surface of the jacket at sequential intervals not exceeding 2 feet (0.61 m). The label shall indicate the name of the manufacturer, conductor size, type and thickness of insulation, center conductor material, voltage rating, year of manufacture, and jacket type. There shall be no more than 6 inches (0.15 m) of unmarked spacing between texts label sequence. The jacket shall be marked with the symbol required by Rule 350G of the National Electrical Safety Code and the borrower shall specify any markings required by local safety codes. This is in addition to extruded red stripes required in paragraph 9a(1) of this bulletin.

b Watertight seals shall be applied to all cable ends to prevent the entrance of moisture during transit or storage. Each end of the cable shall be firmly and properly secured to the reel.

c Cable shall be placed on shipping reels suitable for protecting it from damage during shipment and handling. Reels shall be covered with a suitable covering to help provide physical protection to the cable.

d A durable label shall be securely attached to each reel of cable. The label shall indicate the purchaser's name and address, purchase order number, cable description, reel number, feet of cable on the reel, tare and gross weight of the reel, and beginning and ending sequential footage numbers.

MEDIUM VOLTAGE
UNDERGROUND POWER CABLE SPECIFICATION

Attachment "A"

Cooperative Name: _____ Contact: _____

Phone #: _____ Fax #: _____ E-Mail: _____

Conductor Material: (Circle One) Aluminum Copper

Conductor Type: (Circle One) Solid Stranded

Conductor Size: _____

Voltage Rating: (Circle One) 15 kV 25 kV 35 kV

Conductor Shield Compound(s): _____

Insulation Type: (Circle One) EPR TR-XLPE EITHER

Neutral Design: (Circle One) Full 1/3 1/6 1/8 1/12

Outer Jacket Design: (Circle One) Non-Conducting Semi-Conducting

Returnable Reel: (Circle One) Required Not Required

Wood Lagging Required: Yes _____ No _____

Maximum Reel Size (inches): Width _____ Diameter _____

Maximum Allowable Loaded Reel Weight (pounds): _____

Shipping Address: _____

_____

_____

Shipping Method: (Circle One) Flanges parallel with trailer centerline
Flanges perpendicular to trailer centerline

AXIS OF ARBOR HOLES MUST BE HORIZONTAL DURING SHIPMENT

ALL CABLE SHALL BE IN COMPLIANCE WITH RUS BULLETIN 1728F-U1

Signature: _____