

**NRECA Transmission and Distribution Underground
Subcommittee**

**Sample Specification for 15, 25, and 35 kV Primary
Underground Medium Voltage Concentric Neutral Cable**

Specification UGC1

September 25, 2006

TABLE OF CONTENTS

1	PURPOSE	2
2	GENERAL SPECIFICATIONS	2
3	REFERENCED SPECIFICATIONS	2
4	CONDUCTOR.....	5
5	CONDUCTOR SHIELD (STRESS CONTROL LAYER)	6
6	INSULATION	7
7	INSULATION SHIELDING.....	7
8	CONCENTRIC NEUTRAL CONDUCTOR	8
9	OVERALL OUTER JACKET.....	9
10	DIMENSIONAL TOLERANCES.....	10
11	TESTS.....	10
12	MISCELLANEOUS	12

ABBREVIATIONS

ac - Alternating Current
 ANSI - American National Standards Institute
 ASTM - American Society for Testing and Materials
 AWG - American Wire Gauge
 EPR - Ethylene Propylene Rubber
 ICEA - Insulated Cable Engineering Association, Inc.
 LDPE - Low Density Polyethylene
 LLDPE - Linear Low Density Polyethylene
 RUS - U.S. Department of Agriculture Rural Development - Electric Program
 TR-XLPE - Tree Retardant Cross-linked Polyethylene
 XLPE - Cross-linked Polyethylene

1. PURPOSE

- a. This document is to provide a sample specification for the purchase of medium voltage 15, 25, and 35 kV single-phase and multi-phase medium voltage underground power cable. The NRECA Transmission and Distribution Underground Subcommittee prepared this Sample Specification UGC1. The requirements of this specification are generally consistent with RUS's proposed changes to REA Bulletin 50-70 (U-1). When accepted, the new RUS document will be Bulletin 1728F-U1.

2. GENERAL SPECIFICATIONS

- a. This specification details recommended requirements for 15, 25, and 35 kV power cables for use on 12.5/7.2 kV (15 kV rated), 24.9/14.4 kV (25 kV rated), and 34.5/19.9 kV (35 kV rated) underground distribution systems with multi-grounded neutral. Cable complying with this specification shall consist of a single solid or strand-filled conductor which is 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.
- b. The cable may be used in single-phase and multiphase circuits.
- c. Acceptable conductor sizes are: No. 2 AWG (33.6 mm²) through 1000 kcmil (507 mm²) for 15 kV cable, No. 1 AWG (42.4 mm²) through 1000 kcmil (507 mm²) for 25 kV, and 1/0 (53.5 mm²) through 1000 kcmil (507 mm²) 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.
- e. Where provisions of this specification conflict with the presently approved REA Bulletin 50-70 (U1) or its successor document (1728F-U1), RUS may require conditional approval.

3. REFERENCED SPECIFICATIONS

- a. The following specifications/standards are considered pertinent to this sample specification:

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

Section 3.a. Continued:

ANSI/IEEE C2-“National Electrical Safety Code”

ICEA S-97-682- “Utility Shielded Power Cables Rated 5 Through 46 kV”

ICEA T-31-610- “Guide for Conducting a Longitudinal Water Penetration Resistance Test for Sealed Conductor”

ICEA T-32-645- “Guide for Establishing Compatibility of Sealed Conductor Filler Compounds with Conductor Stress Control Materials”

ASTM B 3- “Specification for Soft or Annealed Copper Wire”

ASTM B 8- “Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft”

ASTM B 230- “Specification for Aluminum 1350-H19 Wire for Electrical Purposes”

ASTM B 231- “Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors”

ASTM B 400- “Specification for Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductors”

ASTM B 496- “Specification for Compact Round Concentric-Lay-Stranded Copper Conductors”

ASTM B 609- “Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes”

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

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

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

ASTM B 836- “Specification for Compact Round Stranded Aluminum Conductors Using Single Input Wire Construction”

ASTM B 901- “Specifications for Compressed Round Stranded Aluminum Conductors Using Single Input Wire Construction”

Section 3.a. Continued:

ASTM B 902- “Specifications for Compressed Round Stranded Copper Conductors Using Single Input Wire Construction”

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

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

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

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

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

ASTM D 2765- “Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics”

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

ASTM D 4496- “Test Method for D-C Resistance or Conductance of Moderately Conductive Materials”

ASTM E 96- “Test Methods for Water Vapor Transmission of Materials

b. Availability of publications

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

IHS 15 Inverness Way East
Englewood, CO 80112
Phone: (303) 397-7956 877-413-5187
Fax: (303) 397-2740
E Mail: global@ihs.com
Web Site: <http://global.ihs.com>

Section 3.b. Continued:

- (2) 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>

- (3) 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 08854
Telephone: (800) 678-4333
Web Site: <http://shop.ieee.org/ieeestore/>

4. CONDUCTOR

- a. Central phase conductors shall be copper or aluminum as specified by the purchaser within the limits of section 2.c.
- b. Central copper phase conductors shall be annealed copper in accordance with ASTM B3. 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. If not specified otherwise by the purchaser, stranded phase conductors shall be Class B compressed strand.
- c. Central aluminum phase conductors shall be one of the following:
 - (1) Solid: Aluminum 1350, H14 or H24, H16 or H26, in accordance with ASTM B 609.

Section 4.c. Continued:

- (2) Stranded: Aluminum 1350 H14 or H24, H16, or H26, in accordance with ASTM B 609. Concentric-lay-stranded (includes 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 otherwise by the purchaser, stranded phase conductors shall be class B compressed strand.
- d. The interstices between the strands of stranded conductors shall be filled with a material designed 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 outer surfaces of the strands that form the outer layer 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.
- b. The minimum thickness at any point shall be in accordance with ANSI/ICEA S-94-649 except minimum thickness requirements shall also be met at all points. See Table 5-1.
- c. The conductor shield shall have a temperature rating equal to, or higher than, that of the insulation.
- d. The void and protrusion limits on the conductor shield shall be in compliance with the ANSI/ICEA S-94-649.

Section 5 Continued:

**Table 5-1
Extruded Conductor Shield Thickness**

Conductor Size AWG or kcmil (mm ²)	Extruded Shield Thickness	
	Minimum Point	
	Mils	mm
8-4/0 (8.37-107)	12	0.30
212-550 (107-279)	16	0.41
551-1000 (279-507)	20	0.51

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 purchaser.
- b. The thickness of insulation shall be as follows:

<u>Cable Rated Voltage</u>	<u>Nominal Thickness</u>	<u>Minimum Thickness</u>	<u>Maximum Thickness</u>
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)

- c. The contamination, void, and protrusion limits on the insulation shall be in compliance with the ANSI/ICEA S-94-649.

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., copolymer shield may be used with EPR insulation). A semi-conducting thermoplastic layer meeting the requirements of ANSI/ICEA S-94-649 will be allowable on discharge resistant EPR cable.

Section 7 Continued:

- b. The thickness of the extruded insulation shield and the concentric neutral indent shall be in accordance with ANSI/ICEA S-94-649. See Table 7-1.
- 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 EPR discharge free cable and 6 through 18 pounds (2.72 through 8.16 kg) for TR-XLPE. Lower stripping tension values for TR-XLPE may be allowed if specified by the purchaser and allowed by RUS. Discharge resistant cables shall have strip tension value of 0 through 18 pounds (0 through 8.16 kg).
- d. The void and protrusion limits on the insulation shield shall be in compliance with the ANSI/ICEA S-94-649.

Table 7-1
Insulation Shield Thickness
Cables with Wire Neutral

Calculated Minimum Diameter Over the Insulation inches (mm)	Insulation Shield Thickness				Maximum Concentric Neutral Indent	
	Minimum Point		Maximum Point		mils	mm
	mils	mm	mils	mm		
0-1.000 (0-25.40)	30	0.76	60	1.52	15	0.38
1.001-1.500 (25.43-38.10)	40	1.02	75	1.91	15	0.38
1.501-2.000 (38.13-50.80)	55	1.40	90	2.29	20	0.51
2.001 and larger (50.83 and larger)	55	1.40	105	2.67	20	0.51

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 insulation shield 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 mm²).

Section 8 Continued:

- b. When a flat strap neutral is specified by the purchaser, the neutral shall consist of 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 or semi-conducting outer jacket shall be applied directly over the concentric neutral conductors.
 - (1) The jacket material shall be an extruded-to-fill jacket that fills the area between the concentric neutral wires and covers the wires to the proper thickness. The jacket shall be free stripping. The jacket shall have three red stripes longitudinally extruded into the jacket surface 120° apart as per ANSI/ICEA S-94-649.
 - (2) Nonconducting jackets shall consist of low density, linear low density, or black thermoplastic polyethylene (LDPE, LLDPE) 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 or Type II before application to the cable. Polyvinyl chloride (PVC) or chlorinated polyethylene (CPE) jackets are not acceptable.
 - (3) Semi-conducting jackets shall have a radial resistivity not exceeding 100 ohm-meters and a maximum water vapor transmission rate of 2 g/m²/24 hours at 38° C (100° F) and 96 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. See Table 9-1.

Section 9 Continued:

**Table 9-1
Extruded-to-Fill Jacket Thickness**

Calculated Minimum Diameter Over the Concentric Neutral Inches (mm)	Insulation Shield Thickness			
	Minimum Point		Maximum Point	
	mils	mm	mils	mm
0-1.500 (0-38.10)	45	1.14	80	2.03
1.501 and larger (38.13 and larger)	70	1.78	120	3.05

10. DIMENSIONAL TOLERANCES

Cables conforming to this specification shall have all dimensional tolerances meeting the requirements of ANSI/ICEA S-94-649.

11. TESTS

- a. Qualification Tests. As part of a request for RUS consideration for acceptance and listing, the manufacturer shall submit certified test data results to RUS 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 RUS 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 complies with paragraph 11.b. (1) or 11.b. (2) of this specification.

Section 11.b. Continued:

- (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 test duration of 100 hours. The test shall be performed at least once on each 50,000 feet (15,240 m) of cable produced, or major fraction thereof, or at least once per insulation extruder run.
- c. Jacket Tests. Tests described in this section shall be performed on cable jackets from the same production sample as in section 11.b of this specification.
- (1) A Cold Bend Test shall be performed in accordance with the applicable provisions of the ANSI/ICEA S-94-649. The test temperature shall be -35°C (-31°F). The sample shall show no cracks visible to the normal, unaided eye at the conclusion of the test. The test shall be performed at least once on each 50,000 feet (15,240 m) of cable produced, or major fraction thereof, or at least once per jacket extruder run.
 - (2) 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 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 purchaser, a certified copy of the results of all tests performed in accordance to this section shall be furnished on all orders.

12. 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 text label sequences. The jacket shall be marked with the symbol required by Rule 350G of the National Electrical Safety Code and the purchaser shall specify any markings required by local safety codes. This is in addition to extruded red stripes required in paragraph 9.a. (1) of this specification.
- 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. After the cable is wound on the reel, it 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 CONCENTRIC NEUTRAL
UNDERGROUND 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 SPECIFICATION UGC-1 (ATTACHED)

Signature: _____