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M1601R5

*** Supercedes: BECO E2.9-27.4 and COM 1-0696, 2-0196, & 5-0385 ***

#2 AWG to 1000 KCMIL CONCENTRIC NEUTRAL JACKETED CABLES
RATED 5 - 35 kV

1.0 Scope

These Specifications cover single conductor “Tree Retardant” Crosslinked Polyethylene Insulated (TRXLP) and Ethylene Propylene Rubber (EP Rubber or EPR) Insulated Concentric Neutral Jacketed Cables having either a “standard” or “reduced” overall diameter. These Cables shall be suitable for installation in underground ducts and direct burial in earth in wet and dry locations. The operating voltages and system BIL levels shall be as follows:

<u>Cable Voltage Rating</u>	<u>System Voltage</u>	<u>System BIL</u>
5 kV	2.4/4.16 kV & below	65 kV
15 kV	8.0/13.8 kV & below	110 kV
25 kV (NSTAR South)	13.2/22.9 kV	150 kV
25 kV (NSTAR North)	13.8/24.0 kV	125 kV

- The general system category is in accordance with Table 4-4, Note C of ANSI ICEA S-94-649 (i.e., 100% level).
- 35 kV rated cable will be used at the 13.2/22.9 kV voltage level

2.0 General

2.1 The cable shall be manufactured and tested in accordance with the latest edition of the *ANSI/ICEA Standard S-94-649 “Standard for Concentric Neutral Cables Rated 5 through 46 kV”* and *AEIC Specification CS-8* except as otherwise required by this material specification.

2.2 If a conflict occurs between any of the Standards, Specifications and Publications referenced herein, they shall supersede each other in the following order of priority, except that the referenced AEIC Specification shall take priority over ICEA/ANSI for the Materials Qualification Test.

- A. NSTAR Material Specification M1601 R5
- B. ANSI/ICEA S-94-649
- C. AEIC CS8

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2.0 General, cont'd

Conductors shall be in accordance with the following, as specified by the Purchase Order:

Aluminum

- #1 AWG – 1/0 AWG Solid Aluminum
- 4/0 AWG – 1000 kcmil, Class B Compressed Stranded Aluminum

Copper

- #2 AWG – 4/0 AWG, Class B Compressed Stranded Bare Copper
- 250 kcmil - 1000 kcmil, Compact Round Stranded Bare Annealed Copper

3.0 Conductor Shield (Stress Control Layer)

For cables having compact round conductors, the manufacturer may reduce the conductor shield thickness in accordance with the referenced ANSI/ICEA Standard, paragraph 3.2.1.

4.0 Insulation

- 4.1 Insulation materials shall be qualified by the manufacturer in accordance with AEIC CS8 and specifically approved by the Company. Cables shall have either TRXLP or EPR insulation as specified in the cable ordering specifications on the purchase order. Specific compound or formulation shall be subject to Company approval. AEIC Qualification Long Form Test Report shall be submitted for this approval. Compound supplier and formulation must also be provided and is not subject to change without Company authorization.
- 4.2 The insulation thickness and diameter over the insulation for #2 AWG, #1 AWG, 1/0 AWG, 4/0 AWG, 250 kcmil, 500 kcmil, 750 kcmil and 1000 kcmil 5kV - 35 kV “standard diameter” cables shall be in accordance with the referenced ANSI/ICEA Standard. The 133% level of insulation shall be furnished for #2 AWG & #1 AWG 15 kV cables and 4/0 AWG 5 kV cables while all other 5 kV – 35kV cables shall have the 100% level of insulation.

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4.0 Insulation, cont'd

- 4.3 The insulation thickness for 1000 kcmil copper “standard “diameter” 15kV and 25 kV cables having the 100% level of insulation shall be in accordance with the referenced ANSI/ICEA Standard except that the diameter over the insulation for the 25kV cable shall be 1.605” minimum to 1.700” maximum.
- 4.4 The Minimum, Maximum and Nominal Insulation Thickness and diameter over the insulation for “reduced” diameter” cables shall be in accordance with the following:

<u>Conductor Size/ Voltage Rating</u>	<u>Minimum Point</u>	<u>Maximum Point</u>	<u>Nominal</u>
350 - 700 kcmil, 15 kV**	0.155”	0.195”	0.165”
350 - 700 kcmil, 25 kV**	0.230”	0.275”	0.240”

Diameters over the Insulation for “Reduced Diameter” Cables

<u>Conductor-Voltage, Ins. Tk</u>	<u>Minimum</u>	<u>Maximum</u>
350 kcmil cpt-15 kV, 0.165” Nom.**	0.965”	1.050”
500 kcmil cpt-15 kV, 0.165” Nom.**	1.070”	1.155”
700 kcmil cpt-15 kV, 0.165” Nom.**	1.235”	1.325”
350 kcmil cpt-25 kV, 0.240” Nom.**	1.110”	1.195”
500 kcmil cpt-25 kV, 0.240” Nom.**	1.235”	1.325”
700 kcmil cpt-25 kV, 0.240” Nom.**	1.385”	1.480”

** Insulation and jacket thickness have been reduced to fit into existing conduit

5.0 Extruded Insulation Shield for 15kV to 35kV Cables

- 5.1 The Insulation Shield for 15 kV to 35 kV rated cables shall comply with the referenced ANSI/ICEA Standard except that the Thickness and Indent Requirements for all 250 kcmil – 1000 kcmil copper conductor cables shall be as follows: (The Minimum Point Thickness does not apply to locations at metallic shield indents)

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5.0 Extruded Insulation Shield for 15kV to 35kV Cables – cont'd

<u>Minimum Point</u>	<u>Maximum Point</u>	<u>Maximum Indent</u>
0.024"	0.048"	0.015"

5.2 Metallic Shield grooves or indents on the outer surface of the insulation shield shall not appear on the outer surface of TRXLPE cables and shall not exceed a depth of 0.003" on EPR cables.

6.0 Semi – Conducting Fabric Tape Insulation Shield (5 kV Cables Only)

6.1 For 5 kV rated cables only, the insulation shield shall be a black semi – conducting fabric tape that is conspicuously labeled “semi – conducting” over its entire length. The tape shall be applied so that it can be removed without leaving traces of semi conducting material on the underlying insulation. The manufacturer shall not apply a semi-conducting coating or paint to the surface of the underlying insulation.

6.2 The semi – conducting tape insulation shall not protrude or indent inward toward the conductor from the outer surface of the insulation by more than 0.005" on EPR cables.

7.0 Marker Tape

Cables having a “reduced” overall diameter shall have the Company Name and Year of Manufacture durably applied to a longitudinal, non-hydroscopic marker tape applied directly over the insulation shield. This marker tape may be applied to, but is not required for, cables having a “standard” overall diameter.

8.0 Concentric Neutral

8.1 The concentric neutral for #2 AWG copper and #1 AWG - 1000 kcmil aluminum cables shall consist of a serving of round annealed bare copper wires in accordance with the following table:

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8.0 Concentric Neutral- cont'd

<u>Conductor Size & Voltage Rating</u>	<u>Concentric Neutral X-Section (Appx) Equivalent</u>	<u>Concentric Wires Number & Size</u>
15 kV, #2 AWG Copper	#2 AWG Cu	16 - #14 AWG
15 kV, #1 AWG Aluminum	#4 AWG Cu #3 AWG Cu*	10 - #14 AWG 13 - #14 AWG*
15 kV, 4/0 AWG Aluminum	#3 AWG Cu	12 - #14 AWG
25 kV 1/0 AWG Aluminum	#2 AWG Cu 24.66 kcmil Cu **	16 - #14 AWG 6 - #14 AWG**
25 kV 500 kcmil Aluminum	1/0 AWG Cu	16 - #12 AWG
35 kV 1000 kcmil Aluminum	258.5 kcmil Cu	25 - #10 AWG
* Acceptable Alternative	**When specifically Specified	

8.2 The concentric neutral for 4/0 AWG - 1000 kcmil copper cables shall consist of flat annealed bare or tinned copper straps. The concentric neutral cross section area shall be equivalent to #2 AWG Copper for 4/0 AWG - 500 kcmil cables and 1/0 AWG copper for 700 kcmil - 1000 kcmil cables.

9.0 Jacket

9.1 The jacket thickness for "standard" and "reduced" diameter cables, as measured over the round wires or flat straps shall be in accordance with the following, unless otherwise specified by the Company's Purchase Order.

<u>Conductor-Voltage Rating</u>	<u>Overall Diameter</u>	<u>Minimum Point Thickness</u>	<u>Maximum Point Thickness</u>
4/0 - 500 kcmil - 5 kV	Standard	0.040"	0.075"
#2-750 kcmil-15 kV	Standard	0.045"	0.080"
1000 kcmil-15kV, 25 kV, & 35 kV	Standard	0.070"	0.120"
350-700 kcmil-15 kV & 25kV**	Reduced	0.025"	0.050"

** Insulation and jacket thickness have been reduced to fit into existing conduit

9.2 Jackets over round wire concentric neutral wires for "standard" diameter cables shall be extruded to fill. The material shall be linear low-density polyethylene.

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- 9.3 Jackets over flat strap concentric neutral wires for “standard” diameter cables shall be sleeved and vacuum drawn to, as much as practical, fill the spaces between the flat straps. The portion of jacket material between the flat straps that is in contact with the insulation shield shall be free stripping. The material shall be linear low-density polyethylene.
- 9.4 Jacket material for low smoke cables (specified in the ordering specs on purchase order) shall be a black, non-halogen, flame retardant, thermoplastic, low smoke, low corrosive and low toxic compound.
- 9.5 Jackets for “reduced” diameter cables shall be extruded to overlay the underlying flat straps, without a separator tape over the flat straps. The material shall be a high temperature, high tensile strength, and abrasion resistant compound such as a polyethylene/polypropylene blend that has been specifically approved by the Company.
- 9.6 If the diameter over the insulation and/or concentric neutral of a particular length(s) of single conductor cable is such that the maximum diameter requirements of Section 11.0 of this Specification cannot be met, the manufacturer may seek specific approval from the Company to make appropriate adjustments in the jacket thickness of cables having either a “standard” or “reduced” overall diameter.
- 9.7 The outer surface of all jackets shall be ink indent printed (or approved equal) with the information required by Part 8 of the referenced ANSI/ICES Standard. Jackets for all #2 AWG copper, #1 AWG & 4/0 AWG aluminum conductor 15 kV cables and all aluminum conductor 25 kV - 35 kV cables shall have three equally spaced red stripes extruded along the length of the cable. These stripes shall be approximately 0.3” wide and 5 mil deep and shall not affect the jacket integrity.
- 9.8 The outer jacket surface of one single conductor cable on each parallel lay or triplexed reel put up and all single cable per reel put ups shall have ink indented (or approved equal) sequential footage markings.
- 9.9 The outer jacket surface of each single conductor cable of a parallel lay or triplexed reel put up shall be ink indent printed with **1 1 1**, **2 2 2**, and **3 3 3** respectively for phase identification.
- 9.10 The outer jacket surface of each cable on the reel shall be ink indent printed with the name NSTAR at 2 foot intervals. This requirement applies

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to all 15 & 25 kV, cables, 250 kcmil and larger and any other cables as may be specified on the purchase order.

9.11 The outer jacket of each cable on the reel of low smoke cables shall have 3 equally spaced yellow stripes for identification.

10.0 Maximum Cable Diameters

To facilitate installation of three single conductor triplexed or paralleled cables in existing conduit, the maximum overall diameter of the single conductor cable shall not exceed the following:

<u>Conductor-Voltage, Ins. Tk</u>	<u>Maximum Cable Diameter</u>
4/0 AWG-5kV, 0.115" Nom	1.03"
500 kcmil-5kV, 0.090" Nom.	1.21"
#1 sol & #2 str AWG-15 kV, 0.220" Nom.	1.20"
4/0 AWG – 15 kV, 0.175" Nom.	1.21"
1/0 AWG - 25 kV, 0.260" Nom.	1.29"
500 kcmil str - 25kV, 0.260" Nom.	1.85"
250 kcmil cpt - 15 kV, 0.175" Nom.	1.21"
350 kcmil cpt - 15 kV, 0.165" Nom. **	1.21"
500 kcmil cpt - 15 kV, 0.175" Nom.	1.43"
500 kcmil cpt - 15 kV, 0.165" Nom. **	1.35"
700 kcmil cpt - 15 kV, 0.165" Nom. **	1.51"
750 kcmil cpt - 15 kV 0.175" Mom.	1.63"
350 kcmil cpt - 25 kV, 0.240" Nom. **	1.39
500 kcmil cpt - 25 kV, 0.240" Nom. **	1.51"
700 kcmil cpt - 25 kV, 0.240" Nom. **	1.66"
1000 kcmil cpt – 15kV, 0.175" Nom	1.89"
1000 kcmil cpt -25 kV, 0.260" Nom.	2.06"
1000 kcmil str –35 kV, 0.345" Nom.	2.45"

** Insulation and jacket thickness have been reduced to fit into existing conduit

11.0 Drawings

Drawings shall be submitted for approval. Drawing details shall include reference to applicable NSTAR and industry specifications, NSTAR cat id, diameters of individual layers and overall diameter for triplexed assemblies. Conductor or shield wire Stranding compressed/compact and diameters.

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12.0 Factory Tests

- 12.1 The Manufacturer shall satisfactorily complete all tests required by this specification and all referenced industry Standards, Specifications and Publications. The 5 minute AC withstand production test for all cables and the partial discharge test for 15 kV – 35 kV partial discharge free cables shall be performed in accordance with referenced ANSI/ICEA Standard. The test voltage levels shall be at the 133%voltage rating level for the #2 - #1 AWG conductor sizes and at the 100%voltage rating level for all 1/0 - 1000 kcmil cables (i.e., both “*standard diameter*” and “*reduced diameter*”).
- 12.2 The 5 kV cables having a semi – conducting fabric tape insulation shield shall be tested in accordance with the referenced ICEA/ANSI Standard and AEIC Specification except that maximum level of partial discharge shall be 5 Pico coulombs at 4.8 kV (2X the system voltage to ground) rather than the 200 volts/mil of nominal insulation thickness required for cables having an extruded insulation shield.
- 12.3 The manufacturer shall furnish a certified certificate of compliance stating that each shipping length has been tested in accordance with this specification and that the results of the tests comply with this specification and all applicable industry Standards, Specifications and Publications. The certificate of compliance shall include the information required by AEIC CS8 (except that gross tare and net weight may be omitted), the Company Stock Code and the starting and ending sequential footage marks for each reel.
- 12.4 The Manufacturer shall maintain a paper and/or electronic file of Certified Test Reports in accordance with the referenced AEIC Specification for a minimum of 7 years after the date of shipment. These Certified test reports shall be available to the Company upon request.

13.0 Packaging

- 13.1 All copper conductor cables shall be packaged with one cable per reel or three cables in a triplexed configuration, on steel reels unless otherwise specified. The reels shall have a maximum flange diameter of 84 inches and a maximum width of 57 inches. The maximum width shall include the arbor hub, bolts, and protruding ends. The trailing end of triplexed cables

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shall protrude through an opening in the drum rather an opening in the reel flange. The maximum weight of cable on the reel shall not exceed 16,000 lbs.

13.2 Aluminum conductor cables shall be packaged with one cable per reel or three cables in a parallel put up on wood reels unless otherwise specified.

13.3 The trailing end of all cables shall be tied to reel drum using double rope with two half-hitches spaced two feet apart. Duct tape shall be wrapped over the jacket in the area where the rope is to be applied to prevent slippage. The assembled half - hitches shall be covered with an additional wrapping of duct tape and a tie down rope should be covered by a protective sleeve until it is clear of the drum opening. Use 1/4" 3 Ply Polypropylene Rope, Super Danline manufactured by Tubbs Cordage or approved equal.

13.4 All reels shall have a weatherproof tag or marking showing all information required by AEIC CS8, the Company cat id and the starting and ending sequential footage marks for reel of triplexed or parallel lay cable

14.0 Cable End Seals

Cable ends shall be sealed with sealing mastic and heat shrink caps or approved equal to prevent the entry of moisture.

15.0 Exceptions

If the manufacturer wishes to take exceptions to provisions of this specification or offer alternatives, his proposal shall clearly describe his exceptions and/or recommended alternates.

16.0 Delivery

Shipping lengths and delivery location shall be specified on the Company's Purchase Order.

Approved by: Amin Jessa
Director, Distribution Engineering