GUAM POWER AUTHORITY
P.O. BOX 2977
HAGATNA, GUAM 96910

TRANSMISSION & DISTRIBUTION SPECIFICATION

Specification No. E-001

FOR

15 KV UNDERGROUND POWER CABLE, SINGLE CONDUCTOR WITH CONCENTRIC NEUTRAL, TYPE MV-90, EXTRUDED TR-XLPE INSULATION

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1.0 SCOPE

1.1. This specification covers GPA requirements for 15 kV single conductor,133% insulation level, Type MV-90, 220 mils nominal insulation thickness, Tree-Retardant Cross-Linked Polyethylene (TR-XLPE) insulated power cable, with a concentrically wound copper neutral, and a High Density Polyethylene (HDPE) jacket.

1.2. The phase conductors shall be Class B stranded copper or aluminum as specified.

1.3. The concentric neutral conductors shall consist of annealed, round uncoated copper wires, providing a full neutral or one-third neutral as specified.

1.4. The cable is intended for use in wet or dry locations in a 15kV solidly grounded neutral underground system, suitable for either direct burial or installation in ducts, with conductor temperature of 90 degrees C for normal operation.

1.5. The cables may be used in single-phase and multi-phase circuits.

2.0 CONFORMANCE TO STANDARDS AND SPECIFICATIONS

2.1. Except where provisions therein conflict with the requirements of this specification, the cable shall meet all applicable provisions of American National Standards Institute/Insulated Cable Engineers Association, Inc. (ANSI/ICEA) S-94-649.

2.2. The cable shall meet the requirements of the following standards, including the latest revisions with respect to material, design and tests.

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

2.2.2. ANSI/IEEE C2, "National Electrical Safety Code"

2.2.3. ICEA S-97-682, "Utility Shielded Power Cables Rated 5 Through 46 kV"

2.2.4. ICEA T-31-610, "Guide for Conducting a Longitudinal Water Penetration Resistance Test for Sealed Conductor"

2.2.5. ICEA T-32-645, "Guide for Establishing Compatibility of Sealed Conductor Filler Compounds with Conductor Stress Control Materials"

2.2.6. ASTM B 3, "Specification for Soft or Annealed Copper Wire"

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

2.2.8. ASTM B 230, "Specification for Aluminum 1350-H19 Wire for Electrical Purposes"

2.2.9. ASTM B 231, "Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors"

2.2.10. ASTM B 609, "Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes"

2.2.11. ASTM B 901, "Specifications for Compressed Round Stranded Aluminum Conductors Using Single Input Wire Construction"

2.2.12. ASTM B 902, "Specifications for Compressed Round Stranded Copper Conductors Using Single Input Wire Construction"

2.2.13. ASTM D 746, "Test Method for Brittleness Temperature of Plastics and Elastomers by Impact"

2.2.14. ASTM D 1248, "Specification for Polyethylene Plastics Molding and Extrusion Materials"

2.2.15. ASTM D 1693, "Test Method for Environmental Stress-Cracking of Ethylene Plastics"

2.2.16. ASTM D 2275, "Test Method for Voltage Endurance of Solid Electrical Insulating Materials Subjected to Partial Discharges (Corona) on the Surface"

2.2.17. ASTM D 2765, "Test Methods for Determination of Gel Content and Swell Ratio of Cross-Linked Ethylene Plastics"

2.2.18. ASTM D 3349, "Test Method for Absorption Coefficient of Ethylene Polymer Material Pigmented with Carbon Black"

2.2.19. ASTM D 4496, "Test Method for DC Resistance or Conductance of Moderately Conductive Materials"

2.2.20. ASTM E 96, "Test Methods for Water Vapor Transmission of Materials"

2.3. Deviations And Non-Conformance Requirements

2.3.1. Deviations from this specification or changes in materials or design after the Purchase Order has been placed must be approved by the GPA Engineering Department and acknowledged by a Purchase Order Amendment.

2.3.2. Units received with deviations or non-conformances which are not acknowledged as specified in Sub-Paragraph 2.3.1 are subject to rejection. The Supplier is responsible for any corrective action including but not limited to materials, labor and transportation necessary to dispose of, or make the units conform to the specification.

2.3.3. Notification of defects discovered before or after installation that are believed to be inherent to manufacturing problems or workmanship shall be made and forwarded to the Supplier. The description of the item, documentation of the problem and the described information, disposition and/or follow-up (as appropriate) that GPA expects from the Supplier will be specified. The Supplier's response shall be made within thirty (30) days unless an extension is acknowledged and approved in writing by the GPA Manager of Engineering.

2.3.4. GPA shall be allowed two (2) weeks to review and approve drawings without affecting the shipping date. Delays in delivery due to drawings which are not approved during this review period are the responsibility of the Supplier.

2.4. Warranty – the Supplier shall warrant the cable to be free from defects in material and workmanship under normal use and service conditions. The term of the Warranty shall be the lesser of twelve (12) months from the date of initial installation or eighteen (18) months from date of manufacture.

2.5. Statement of Compliance - The Supplier shall provide a signed statement verifying that the products being supplied fully comply with the specifications and drawings. Items not in

full compliance with the specification and drawings will be identified with a description of the deficiency and any proposed substitutions. Items not in full compliance with the specifications and drawings must be approved by the GPA Engineering Department, as described in Section 2.3.1.

3.0 SUBMITTALS

3.1. The bidder shall provide with their bid the following data:

3.1.1. Cable manufacturing specifications.

3.1.2. Shop drawings indicating details of construction.

3.1.3. The positive and zero impedance in ohms per mile, and the susceptance (B) of the cable shall be submitted to GPA Engineering for review and approval.

3.2. Drawings returned to the Supplier as approved shall be considered authorization to proceed with the work. The approval of GPA shall in no way abrogate the requirements of this specification.

3.3. The Supplier shall furnish one copy of certified test reports of all the tests covered by this Specification to the GPA Manager of Engineering prior to each shipment.

4.0 QUALIFICATIONS

4.1. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of fifteen years.

4.2. For all equipment specified herein, the manufacturer shall have a quality system that is ISO 9001 certified.

5.0 QUALITY ASSURANCE

5.1. The manufacturer shall have a formal Quality Assurance Program. The manufacturer's Quality Assurance Manual shall consist of systematic procedures that provide confidence that the work is in accordance with the manufacture's standard design, codes and standards referenced above, and these specifications for controlling activities affecting quality. Formal training of individuals performing the work shall be an element of the Quality Assurance Program. Inspections and audits shall be conducted to insure that the Quality Assurance Program is being followed.

5.1.1. The manufacturer's Quality Assurance Manual shall be available at GPA's request and shall include descriptive information and details of the program, including program organization, documentation requirements, and quality control procedures.

5.1.2. The Quality Assurance Program shall include testing procedures, acceptance criteria, repair methods and the quality control requirements of these specifications.

6.0 TESTS AND TEST REPORTS

6.1. Cable shall be tested in accordance with American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI) and Insulated Cable Engineers Association, Inc. (ICEA). Electrical Tests shall be performed after jacketing. The

following production sampling tests shall be run and the results shall be reported in certified test reports.

6.2. Qualification Tests. The manufacturer shall submit certified test data results that detail full compliance with ANSI/ICEA S-94-649 for each cable design.

6.2.1. 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.

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

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

6.3. Partial Discharge Tests. Manufacturers shall demonstrate that their cable complies with Section 6.3.1 or 6.3.2 of this specification.

6.3.1. 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.

6.3.2. 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.

6.4. Accelerated water/electrochemical treeing test shall be performed on all completed cables.

6.5. Jacket Tests. Tests described in this section shall be performed on cable jackets from the same production sample as in Section 6.3 of this specification.

6.5.1. 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.

6.6. A Spark Test shall be performed on non-conducting 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 non-conducting jacket and the concentric neutral for not less than 0.15 second.

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

6.8. All test results shall be furnished to GPA manager of Engineering within two weeks of cable delivery. If test results indicate the cable is not in compliance with acceptable standards, delivery may not be made.

7.0 CONSTRUCTION

7.1. The cable shall be manufactured to the specifications listed in the table below:

TABLE A

CONDUCTOR SIZE (AWG / kcmil)	CONDUCTOR NUMBER OF STRANDS	CONCENTRIC NEUTRAL Number - Size	CONDUCTOR SHIELD THICKNESS (minimum mils)	INSULATION SHIELD THICKNESS (minimum / maximum mils)	JACKET THICKNESS (nominal mils)
ALUMINUM CONDUCTORS – full neutral					
#2 AWG	7	10 - #14 AWG	15	30 / 60	80
#2/0 AWG	19	13 - #12AWG	15	30 / 60	80
#4/0 AWG	19	13 - #10 AWG	15	40 / 75	80
COPPER CONDUCTORS –1/3 neutral					
500 kcmil	37	17 - #10AWG	25	40 / 75	80
750 kcmil	61	24 - #10AWG	30	40 / 75	110
1000 kcmil	61	33 - #10AWG	30	55 / 90	110

CONDUCTOR SIZE (AWG / kcmil)	CONDUCTOR OVERALL DIAMETER (mils)	NOMINAL DIAMETER OVER INSULATION (mils)	NOMINAL DIAMETER OVER INSULATION SHIELD (mil)	NOMINAL DIAMETER OVER JACKET (mils)
#2 AWG	292	770	840	1080
#2/0 AWG	418	900	970	1240
#4/0 AWG	528	1010	1080	1390
500 kcmil	813	1290	1390	1730
750 kcmil	998	1480	1580	1960
1000 kcmil	1152	1640	1770	2150

7.2. Conductors – the conductors specified shall conform to ANSI/ICEA S-94-649:

7.2.1. Copper wire shall be uncoated, Class B stranded soft annealed copper in accordance with ASTM B 3. The conductors shall conform to ASTM B 8 for Class B compressed stranding. The copper conductors shall be annealed after stranding.

7.2.2. Aluminum wire shall be Class B stranded aluminum alloy #1350 H26 semi-annealed after strain hardening, three quarter hard drawn in accordance with ASTM B 609. The conductors shall conform to ASTM B-231 for Class B compressed stranding.

7.2.3. 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.

7.2.4. 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.

7.3. Conductor Shielding – conductors shall be covered with a super-smooth layer of extruded semi-conducting cross-linked polyethylene strand shield (stress control layer) with a uniform cylindrical surface. The extruded layer shall be firmly bonded to the cable insulation and shall meet the resistivity requirements of ANSI/ICEA S-94-649.

7.3.1. The conductor shield minimum thickness at any point shall be in accordance with ANSI/ICEA S-94-649, except minimum thickness requirements as shown on Table A shall also be met.

7.3.2. The conductor shield shall have a temperature rating equal to, or higher than, that of the insulation.

7.3.3. The void and protrusion limits on the conductor shield shall be in compliance with the ANSI/ICEA S-94-649.

7.4. Insulation – the insulation shall be chemically cross-linked thermosetting tree retardant polyethylene (TR-XLPE) meeting the applicable requirements of ANSI/ICEA S-94-649. The insulation nominal thickness shall be 220 mil. The minimum thickness shall be not less than 210 mils and the maximum thickness shall not be greater than 250 mils.

7.4.1. The pellets used in the manufacture of the insulation shall be the Dow Chemical Company HFDB-4202 EC compound "extra-clean" high-molecular-weight polyethylene.

7.4.2. Insulation shall be applied in one continuous extension and shall be homogeneous, solid, free of any contaminants, gels, or discolorations larger than 7 mils in any dimension, and free of porosities and voids larger than 3 mils.

7.5. Insulation Shield – the insulation shield and protective covering shall consist of an extruded layer of semi-conducting cross-linked polyethylene over the insulation in accordance with ANSI/ICEA S-94-649.

7.5.1. The shielding shall be in intimate contact with the outer surface of the insulation and shall be free stripping, leaving no conducting particles or other residue on the surface of

the insulation. The shield shall be applied such that all conducting material can be easily removed without the need for externally applied heat. Stripping removal tension values shall be a minimum of six (6) pounds and a maximum of eighteen (18) pounds.

7.5.2. The insulation shield thickness shall be not less than as specified on Table A. The maximum concentric neutral indent for cable sizes #2 AWG to 750 kcmil shall be 15 mils and 20 mils for 1000 kcmil.

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

7.6. Concentric neutral – 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.

7.6.1. A full neutral is required for #2 and #2/0 AWG conductors.

7.6.2. A one-third neutral is required for 500, 750 and 1000 kcmil conductors.

7.6.3. The number of wires and wire size for the concentric neutral are listed in Table A.

7.7. Jacket – an electrically non-conducting outer jacket shall be applied directly over the concentric neutral conductors. Jackets shall consist of black polyethylene compound meeting the requirements of ANSI/ICEA S-94-649. Jacket material may be Cross-linked Polyethylene (XLPE), High Density Polyethylene (HDPE) or Linear Low Density Polyethylene (LLDPE). Polyvinyl chloride (PVC) or chlorinated polyethylene (CPE) jackets are not acceptable.

7.7.1. 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 from underlying insulation shield and wires. The jacket shall have three red stripes longitudinally extruded into the jacket surface 120° apart as per ANSI/ICEA S-94-649.

7.7.2. The jacket shall be of smooth and uniform composition free of hole, cracks, blisters, and other imperfections.

7.7.3. The jacket is for corrosion and insulation protection, moisture entry prevention, and mechanical protection for conduit installation.

7.7.4. The jacket shall be such that it will not deteriorate or alter its physical or electrical properties from exposure to sunlight or the elements.

7.8. Extrusion and Curing Process – the extrusion and curing processes shall be performed in a closed system Class 1000 clean room to insure maximum cleanliness.

7.8.1. The conductor shield, insulation, and insulation shield shall be extruded over the conductor using the 3-in-1 triple method, using a true triple-head unit.

7.8.2. The cable shall be cured using the dry curing method.

7.9. Identification Markings:

7.9.1. All cable jackets shall have a durable (lifetime) surface identification showing manufacturer's name, conductor size and type, insulation type, and thickness, voltage and ampere rating, sequential footage, and year of manufacture. The jacket shall be marked with the symbol required by Rule 350G of the National Electrical Safety Code and shall have three red stripes longitudinally extruded into the jacket surface 120° apart as per ANSI/ICEA S-94-649.

7.9.2. Identification shall be repeated along the cables at regular surface intervals with unmarked surfaces not exceeding twelve inches. There shall be no more than six inches of unmarked spacing between text label sequences.

7.9.3. Identification shall be sized as to be easily readable by workers holding the cable.

7.10. Moisture – there shall be no water in the strands and between the jacket and insulation of the cable when shipped. Each end of each conductor shall be made watertight with an end seal or a thick wall heat shrinkable cap. Free water present anywhere in the cable is grounds for rejection of the cable.

8.0 PACKAGING AND SHIPPING REQUIREMENTS

8.1. The cable shall be furnished in lengths specified by Guam Power Authority.

8.1.1. One single conductor cables shall be supplied on reels with length of cable per reel as shown in the table below, unless otherwise specified.

#2 AWG	2,000 feet
#2/0 AWG	2,000 feet
500 kcmil	1,000 feet
750 kcmil	1,000 feet
1000 kcmil	1,000 feet

8.2. Reels:

8.2.1. Reels shall be designed to support the weight of the cable and withstand handling in accordance with industry practices.

8.2.2. The inner drum end of the cable, when allowed to project through the flange of the reel, shall be protected to avoid injury to the cable or cable seal.

8.2.3. Wooden reels shall have steel collars with an outer flange of at least one half inch to withstand handling by GPA. Reels with at least 72 inch flanges shall be four ply and at least three ply above 60 inches. Mandrel hole shall have at least two inches of uncut wood all around the hole.

8.2.4. Mandrel hole size shall be 3 ½ inches, minimum.

8.2.5. A durable, non-fading label shall be securely attached to a flange of the reel plainly stating GPA's Purchase Order Number, shipping length in feet of cable on reel, beginning and ending sequential footage number, number, type and size of conductors, thickness and type of insulation, voltage and ampere rating, and tare weight.

8.2.6. Each reel shall be marked with an arrow and suitable stenciled working on the flange of the reel indicating the direction the reel should be rolled.

8.3. Each end of each length of cable shall be durably sealed, conforming to paragraph 7.10 of this specification and pressurized with dry nitrogen to 10 P.S.I. before shipment to prevent entrance of moisture. Evidence of water in the cable as received shall be cause for rejection.

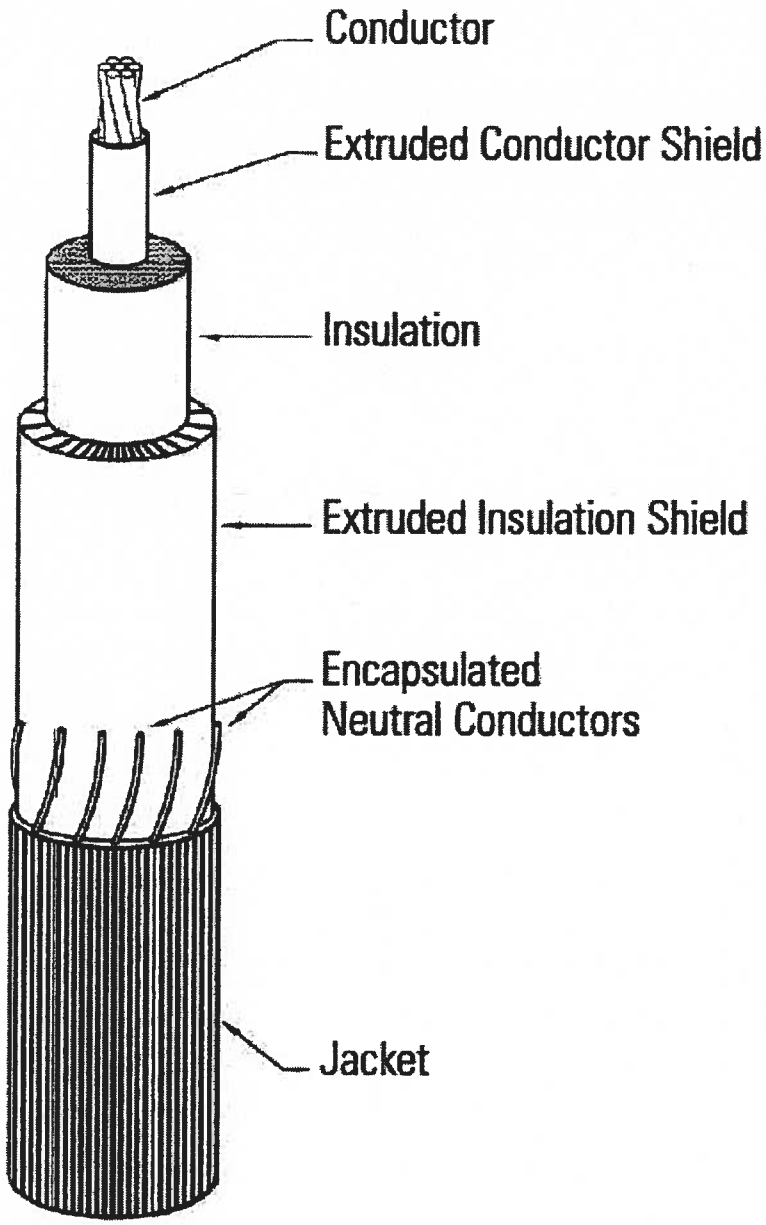
8.4. The cable shall be placed on the reels in such a manner that it will be protected from injury during shipment. Care shall be taken to prevent the reeled cable from becoming loose. Each end of the cable shall be firmly and properly secured to the reel.

8.5. The reels shall be lagged or covered with suitable material to provide physical protection for the cable during transit and during ordinary handling operations and storage, and the materials and system used shall be approved by the GPA Engineering Department.

8.6. Reels shall be transported upright and securely blocked in position so that they will not shift during transit.

8.7. Reels must be stored upright (NOT FLAT) in a secured and suitably paved area with adequate drainage. Reels should not be stored in a continuous damp environment; ideally, a covered area is preferred.

9.0 DIAGRAM


Conductor
Extruded Conductor Shield
Insulation
Extruded Insulation Shield
Encapsulated
Neutral Conductors
Jacket