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Specification Section 16124 Medium Voltage Cables

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Revision 1

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This document has undergone formal review and approval and been reviewed by a Derivative Classifier, and its contents have been deemed unclassified/unlimited release.



U.S. DEPARTMENT OF
ENERGY



Change Log

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CONSTRUCTION STANDARD SPECIFICATION**SECTION 16124****MEDIUM VOLTAGE CABLES**

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CONSTRUCTION STANDARD SPECIFICATION

SECTION 16124

MEDIUM VOLTAGE CABLES

PART 1 - GENERAL

1.01 SUMMARY

- A. This specification includes medium voltage and accessories for systems rated above 2001 volts to 15,000 volts.

1.02 REFERENCES

- A. Association of Edison Illuminating Companies (AEIC)
 - 1. CS8-00, Specification for Extruded Dielectric Shielded Power Cables rated 5 through 46 kilovolt (kV)
- B. American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE)
 - 1. C2, National Electrical Safety Code®
 - 2. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
 - 3. 404, Standard for Cable Joints for Use with Extruded Dielectric Cable Rated 5000V Through 46,000V and Cable Joints for Use with Laminated Dielectric Cable Rated 2500V through 500,000V
- C. American National Standards Institute/National Fire Protection Association® (ANSI/NFPA)
 - 1. 70, National Electrical Code® (NEC)
- D. American Society of Testing and Materials (ASTM)
 - 1. B3, Standard Specification for Soft or Annealed Copper Wire
 - 2. B8, Standard Specification for Concentric Lay Stranded Copper Conductors, Hard, Medium Hard, or Soft
- E. Institute of Electrical and Electronics Engineers (IEEE)

1. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations
2. 592, Standard for Exposed Semiconducting Shields on High Voltage Cable Joints and Separable Insulated Connectors

F. Insulated Cable Engineers Association (ICEA)

1. S-93-639/ National Electrical Manufacturers Association[®] (NEMA) WC74, Shielded Power Cable 5-46kV
2. S-97-682, Utility Shielded Power Cable rated 5-46kV
3. T-25-425, Guide for Establishing Stability of Volume Resistivity for Conducting Polymeric Components of Power Cables

G. Underwriters Laboratories, Inc. (UL)

H. 1072, Medium-Voltage Solid Dielectric

1.03 SUBMITTALS

A. Test Reports

1. Certified copies of production sampling and completed cable test reports described in paragraph 1.04 of this specification shall be submitted prior to shipping cable and shall be in a legible and coherent format. This data should include the X-Y plot of the partial discharge test per ICEA.
2. Test reports shall be in a legible and coherent format and reported in accordance with AEIC CS6.

B. Catalogue data: Submit catalogue data showing physical information, specifications used for manufacturing, and materials used to manufacture cable.

C. Submittal data shall include:

1. Letter stating cable meets specification and the date of cable manufacture
2. Conductor size
3. Conductor shield materials
4. Insulation material
5. Insulation thickness
6. Diameter over insulation
7. Insulation semiconductor thickness
8. Jacket material
9. Jacket thickness
10. Cable diameter
11. Weights per length of cable

- D. The contractor shall submit a certification of attendance to, and for the approval of the Sandia Delegated Representative (SDR), which contains the names of personnel who have successfully completed course(s) as specified in section 1.04G of this specification on the splicing and termination of medium-voltage cables approved for installation under this contract. The certificate of attendance shall be current within five years of performing any cable terminations. Persons listed by the contractor may be required to perform a dummy or practice splice and termination in the presence of the SDR before being approved as a qualified installer of medium-voltage cables. If that additional requirement is imposed, the SDR shall provide short sections of the approved types of cables along with the approved type of splice and termination kits and detailed manufacturer's instructions for the proper splicing termination of the approved cable types. The certification shall be accompanied by satisfactory proof of the training and experience of persons listed by the contractor as cable installers.

1.04 QUALITY ASSURANCE

- A. The contractor must meet the certification requirements per Sandia Construction Specification 16001, *Electrical Work*, section 1.05.
- B. Cable furnished under this specification shall conform to the latest edition of Insulated Cable Engineers Association (ICEA S-93-639) or its successors, except as specifically modified herein.
- C. The completed cable shall meet or exceed all ICEA, NEMA, and AEIC physical and electrical tests. Tests shall be performed and frequency of sampling shall be in accordance with the latest edition of ICEA S-93-639, except as modified herein. All tests required by this specification, AEIC, and ICEA shall be performed.
- D. Cable shall be manufactured and tested using good care and workmanship.
- E. Ethylene propylene rubber (EPR)-insulated cable shall be manufactured by a dry or steam curing process.
- F. The conductor shield, the insulation, and the semiconducting insulation shield extrude in a triple tandem, dual tandem, or true triple process.
- G. All contractors working on Sandia National Laboratories' (SNL) high-voltage system shall require training on medium-voltage terminations.
 - 1. Contractor personnel terminating 600 Amp 15kV non-loadbreak T-splices and 200 Amp 15kV loadbreak connectors shall attend a minimum of four hours of a "Hands-On" training seminar conducted by an Elastimold[®] factory representative. Each individual shall be required to participate in the termination of the above-mentioned connectors. The training shall consist of the following items:
 - a. General cable and stress relief theory

- b. The manufacturer's recommended method for cable preparation of 15kV and 5kV tape shield EPR cable; this shall include the recommended tools and products for cable preparation.
 - c. The manufacturer's recommended method for the installation of 20MA and 30MA ground adapters, and 655CA cable adapters on a 15kV tape shield EPR cable.
 - d. The manufacturer's recommended method for the crimping of the conductor contact. The manufacturer shall review all approved tools that shall be used to crimp the conductor contact.
 - e. The manufacturer's recommended method for installation of the 655LR Connector.
 - f. The manufacturer's recommended method for installation of 650BIP basic insulating and dead-end plugs. The recommended method for the installation of the 650CP connecting plug for the assembly of a two-way T-splice. The manufacturer shall review all recommended tools for this assembly.
 - g. Once a complete 600 Amp 655LR assembly has been terminated, the manufacturer shall suggest cable routing/positioning to prevent cable stress.
 - h. The manufacturer shall review the testing of a 600 Amp 655LR through the capacitive test point.
 - i. The manufacturer's recommended method for the installation of 168LR connectors on to 15kV and 5kV tape shield EPR cable. This shall include the correct method for crimping the compression lug and tightening of the probe.
 - j. The manufacturer's recommended method for the insertion and removal of the 168LR connector on to or from loadbreak bushing. Manufacturer shall review cable routing/positioning to prevent cable stress.
2. Each contractor personnel who terminates 15kV 5630 Series Quick Term II Cold Shrink Terminations connectors shall attend a minimum of four hours of a "Hands-On" training seminar conducted by a 3M factory representative. Each individual shall be required to participate in the termination of the above-mentioned connector. The training shall consist of the following items:
- a. General cable theory and stress relief theory
 - b. The manufacturer's recommended method for cable preparation of 15kV and 5kV tape shield EPR cable. This shall include the recommended tools and products for cable preparation.

- c. The manufacturer's recommended method for the installation of a 5630K Series Quick Term Cold Shrink on to 15kV tape shield EPR cable. This shall include the proper installation of the ground strap.
 - d. The manufacturer's recommended method for the crimping of the conductor lug. The manufacturer shall review all approved tools that shall be used to crimp the conductor contact.
 - e. The manufacturer's recommended sealing method at the ground strap and conductor lug.
 - f. The manufacturer's suggested cable routing/positioning to prevent undue cable stress.
3. Each contractor personnel who terminates 15kV TFT-ESG Raychem® Cold Shrink Terminations connectors shall attend a minimum of four hours of a “Hands-On” training seminar conducted by a Raychem factory representative. Each individual shall be required to participate in the termination of the above-mentioned connector. The training shall consist of the following items:
- a. General cable theory and stress relief theory
 - b. The manufacturer’s recommended method for cable preparation of 15kV and 5kV tape shield EPR cable. This shall include the recommended tools and products for cable preparation.
 - c. The manufacturer’s recommended method for the installation of a TFT-ESG Raychem Cold Shrink on to 15kV tape shield EPR cable. This shall include the proper installation of the ground strap.
 - d. The manufacturer’s recommended method for the crimping of the conductor lug. The manufacturer shall review all approved tools that shall be used to crimp the conductor contact.
 - e. The manufacturer’s recommended sealing method at the ground strap and conductor lug.
 - f. The manufacturer’s suggested cable routing/positioning to prevent undue cable stress.
4. Each attendee shall receive a certificate showing successful completion of the training class. The date of attendance and instructor must be listed.
- a. The contractor shall be responsible for scheduling the training classes for each product manufacturer and for notifying SNL of the date(s).
 - b. The contractor shall be responsible for furnishing all necessary cable samples and manufacturer product for a complete assembly.

- H. Production sampling tests shall be in accordance with ICEA S-93-639, ICEA S-97-682, and AEIC CS8.
- I. Alternating current (AC) Voltage Tests: Each factory reel length shall withstand AC voltage tests by the manufacturer at the factory in accordance with ICEA S-93-639.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All cable furnished shall be installed within 12 months of manufacture date. Labeling of cable shall be per NEMA and shall contain no less than the following information:
 - 1. Name of manufacturer
 - 2. NEC designation
- B. Cable shall be operated at 60 Hertz, single or three phase, at system voltage of 5kV or 15kV. Suitable installations include in conduit for wet or dry locations, and in open air in sunlight.

2.02 CONDUCTOR

- A. The conductor shall be Class B concentric lay stranding, uncoated copper in accordance with ASTM B3 and B8 and ICEA S-93-639 with the minimum number of wires noted below:

Conductor Size <u>Range</u>	Number <u>of Strands</u>
8 - 2	7
1 - 4/0	19
250 - 500	37
501 - 1000	61

- B. Conductor shall be free from moisture, corrosion, and excessive drawing lubricant before conductor shielding is applied.

2.03 CONDUCTOR SHIELD (STRAND SCREEN)

- A. The strand screen shall consist of an extruded semiconducting thermosetting compound applied over the conductor. It shall be of a material compatible with the thermal characteristics of this conductor metal and insulation, shall be uniformly and firmly bonded to the overlying insulation, and shall be free stripping from the conductor. A semiconducting tape may be applied between the conductor and the extruded conductor screen. Okonite EPR-based semiconductor is an approved exception.

- B. The D-C volume resistivity of the extruded conductor shield shall not exceed 1,000 meter-ohms at the maximum normal operating and emergency operating temperature accordance with ICEA Publication T-25-425.
- C. The extruded strand shield shall have a minimum elongation of 100% after an air oven test at 121°C for seven days and a brittleness temperature not warmer than -10°C.
- D. The contact area between the insulation and conductor shield shall not exhibit projections or irregularities which extend from the cylindrical surface of the conductor shield by more than five mils (.127 mm) toward the insulation or 10 mils (.254 mm) away from the insulation.

2.04 INSULATION

- A. Insulation shall conform to ICEA S-93-639, except as modified herein and shall be the following, or a prior approved equal:
 - 1. The insulation shall be a high quality heat, moisture, ozone, and corona resistant, high dielectric strength ethylene propylene rubber compound. It shall be contrasting in color from the extruded strand and insulation screens. It shall contain less than 5% polyethylene, and the ethylene content of the elastomer shall not exceed 72.5% by weight of ethylene to limit susceptibility to treeing.
 - 2. Insulation shall be for use in wet or dry locations at conductor temperatures not exceeding 105°C for continuous operation, 140°C emergency overload conditions, and 250°C short circuit conditions.
- B. The insulation shall have a minimum and maximum thickness for a 133% insulation level as specified in Table II below:

TABLE II

Rated Circuit Voltage (kV) <u>(Phase to Phase)</u>	Conductor Size <u>(AWG or kcmil)</u>	Minimum Insulation <u>Thickness (mils)</u>	Maximum Insulation <u>Thickness (mils)</u>
5	8 - 1000	85 (2.16 mm)	120 (3.05 mm)
8	6 - 1000	135 (3.43 mm)	170 (4.32 mm)
15	2 - 1000	210 (5.33 mm)	250 (6.35 mm)

- C. Insulation shall be homogeneous and free of gels or discolorations larger than 10 mils (.254 mm).
- D. The insulation shall meet or exceed the requirements of all tests specified in ICEA S-93-639.

- E. The interface between the insulation and insulation shield shall be free of contaminants larger than 4 mils. The insulation shall be free from contaminants, gels and agglomerates larger than 10 mils.

2.05 INSULATION SHIELD (INSULATION SCREEN)

- A. Insulation shield shall conform to ICEA S-93-639, except as modified herein.
- B. The insulation screen shall consist of an extruded, semiconducting, thermosetting compound applied over and compatible with the insulation. It shall be of a material compatible with the thermal and chemical characteristics of the insulation and the overlaying metallic shield. Okonite EPR-based semiconductor material is an approved exception.
- C. The thickness with corresponding minimum and maximum points shall be as specified in Table III:

TABLE III

<u>Calculated</u> <u>Minimum Diameter</u> <u>over Insulation</u> <u>(inches)</u>	<u>Insulation</u> <u>Shield</u> <u>Minimum Point</u> <u>Thickness</u>	<u>Insulation Shield</u> <u>Maximum Point</u> <u>Thickness (mils)</u>
0 - 1.000	24	60
1.001 - 1.500	32	60
1.501 - 2.000	40	75
2.001 and Larger	40	90

- D. The insulation shield shall not alter its physical or electrical properties from exposure to sunlight or the elements.
1. The extruded insulation shield shall have a minimum elongation of 100% after an air oven test at 121°C for 7 days and a brittleness temperature not warmer than -30° C.
- E. The D-C volume resistivity of the extruded insulation shield shall not exceed 75 meter-ohms, at 90°C, when tested in accordance with ICEA Publication T-25-425.
- F. The insulation shield shall be free stripping from the insulation, and the tension necessary to remove the extruded insulation shield shall be 3 to 24 pounds (to 10.886 Kg), at room temperature, when tested in accordance with ICEA S-93-639.
- G. The contact area between the insulation and insulation shield shall not exhibit projections or irregularities, which into the insulation from the insulation shield more than 5 mils and into the insulation shield from the insulation more than 7 mils.

2.06 METAL TAPE SHIELD

- A. Cable shall have a metal tape or metal tape with wire shield.
- B. A copper tape with nominal thickness of 0.005 inches (.127mm) shall be applied directly over the insulation shield. The tape shall be of suitable width and shall lap at least 12.5% of its width. The tape shall be free from burrs and where jointed, shall be made electrically continuous. (If wire shield is used, it shall be mechanically and electrically comparable.)
- C. Application of tape shield or wire shield shall not deform the insulation.

2.07 JACKET

- A. The jacket shall be black polyvinyl chloride compound meeting the requirements of ICEA S-93-639.
- B. The average thickness of the jacket shall be not less than the values specified in the following table. The minimum thickness of the jacket at any point shall be no less than 80% of the specified minimum average thickness.

TABLE IV

<u>Calculated Diameter of Cable under Jacket (inches)</u>	<u>Min. Thickness of Jacket (mils)</u>
0.700 and Smaller	55 (1.40mm)
0.701 - 1.500	70 (1.78mm)
1.501 - 2.500	100 (2.54mm)
2.501 and Larger	125 (3.17mm)

- C. Linear shrinkage of the jacket shall not exceed the linear shrinkage of the insulation.
- D. The jacket shall be sunlight resistant in accordance with the requirements of UL 1072.

2.08 CABLE DIMENSIONS

- A. Cable dimensions shall be in accordance with ICEA S-97-682.
- B. Diameters over insulation shall be in accordance with ICEA S-97-682.

2.09 PACKAGING

- A. The cable shall be placed on the shipping reel with both ends of cable accessible for proof testing in Appendix A. Ends of cable shall be sealed with weatherproof material prior to shipment.

2.10 MANUFACTURERS

- A. Primary EPR-insulated power cables as manufactured by Okonite, Prysmian-P, and Southwire® are acceptable.
- B. The cable manufacturer shall have a minimum of 10 years proven and successful experience with the manufacturing of EPR-insulated cables.

2.11 CABLE TERMINATIONS

- A. Outdoor: Terminations that are exposed to the weather, such as riser poles.
 - 1. Terminations of the shielded power cables shall be manufactured molded rubber terminations, IEEE 48, Class 1. Elastimold type 35MTG, or approved equal with the grounding device for the metallic shield (Elastimold Type 20 MA for metallic type shield) and NEMA 2-hole, long-barrel terminal connector. The connector shall be listed for copper/aluminum applications.
- B. Indoor: Terminations that are inside equipment or weatherproof compartments of outdoor equipment, such as transformers and switchgear.
 - 1. Terminations of shielded power cables rated 15kV or less shall be done with an IEEE Standard 48 Class 1 termination. It shall either be a one-piece design where high-dielectric constant stress control is integrated within a skirted insulator made of silicone rubber, gray in color, or provide for positive placement of the stress control with the installation of a stress patch. The termination shall not require heat or flame for installation. The terminations shall be 3M Brand 5630K Series Quick Term II cold shrink Termination Kits or Raychem TFT-E-SG. Only a NEMA 2-hole, long-barrel terminal connector shall be used. The connector shall be listed for copper/aluminum applications.
- C. Cable terminations shall have voltage ratings of no less than 15,000 volts (ungrounded neutral). The standard withstand test voltage of the completed terminations shall conform to IEEE Standard No. 48.

2.12 SPLICES AND TAPS

- A. Unless specified otherwise, all splices and taps shall be as per items A and B below. Only where hand-made splices are called out on the contract documents, shall Item C apply.

- B. In manholes, splices for feeders shall only be 600 Amp non-loadbreak power distribution connectors. Approved manufacturers are Elastimold Catalog #K655BLR and Cooper Catalog #SSPL625AX* (where *-X is replaced by number of T-bodies). Order manufacturer's corresponding cable adapter and compression connector sized per phase conductor. Elastimold or Cooper insulating plug, basic insulating plug, and/or connecting plug shall be required for assembly. Manufacturer's approved tape shield adaptors are required.
- C. In above ground sectionalizing cabinets and below-grade pull boxes, splices shall be 200 Amp Elastimold 168LR-W*X** load-break connectors with test points mounted on Z-point load-break junction 163J-Z. Order one 168LR-W*X** and one 20MA-W* grounding device per phase. The Z-point load-break junction is to be mounted on a universal mounting bracket with parking stands.
 - 1. *W is replaced by symbol per table in catalogue for insulation diameter. Size for cable supplied.
 - 2. **X is replaced by symbol per table in catalogue for conductor size. Size for cable supplied.
 - 3. ***Z is number of circuits to be terminated on to load-break junction.
- D. Handmade splices to cable may be handmade from tape kits 3M 5700 series. Refer to manufacturer's catalogue selection guide for voltage, conductor size and type information for ordering. Reference drawings for application of handmade splices.

2.13 CABLE IDENTIFICATION TAGS

- A. The cables shall have identification tags in manholes (at conduit entrances and splices) and at equipment terminations, indicating feeder number and routing (Example: Routing: "To MH-36", "To SW0893-1B", Feeder: "3501"). The tags shall be one-inch polypropylene plastic (Almetek EZH9), affixed to cables with plastic or nylon ties (see standard drawing WP5021STD, Example Feeder Labeling).
- B. At underground riser poles where feeders make a transition from underground to overhead, the feeder number will be 2" x 2" (50.8 mm x 50.8 mm) black letters on yellow background adhesive-backed numbers. These numbers shall be attached to an aluminum strip nailed to wood or banded to steel pole above the cable terminator bracket.

2.14 FIREPROOFING

- A. Cables in manholes shall be fireproofed with one layer of one half-lapped 3M 77 tape applied and held in place with 3M 69 tape. The fireproofing tape shall completely cover each cable and hand-taped splice from duct entrance to duct exit. All three-phase cables shall be fireproofed together ending a minimum of 6 feet (1.829 mm) from the T-splice, and then individually wrapped up to the T-splice.

Extend the fireproofing one-inch into duct. The fireproofing tape shall extend one-inch (minimum) onto the splice/T-connector body.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. All work on primary conductors shall be done only when such conductors and equipment are de-energized. Unless otherwise noted on drawings, or directed, any tie-ins or connections to existing utilities or equipment that necessitate interruptions shall be performed on Saturday or Sunday, without additional contract costs. The contractor shall not interrupt any main electrical utility without a written request for an outage and a subsequent approval by Sandia National Laboratories/New Mexico.
 - 1. Written request for outages shall be submitted 21 calendar days in advance of the outage date. This request will delineate the particular circuit or service interrupted and the approximate hours the utility shall be off.
 - 2. The work to be performed during an interruption of electrical utilities will be preceded by all possible preparation and will be carefully coordinated to minimize the duration of the interruption. Work will proceed continuously until the system is restored to normal.
 - 3. Phasing of reconnected feeders shall be identical to the existing phasing.
- B. Install and terminate primary cables in accordance with the manufacturer's approved recommendations and tools suggestions. The conductors shall be free of kinks and twists, and all bends shall be formed with a smooth radius not smaller than 12 times the diameter of the cable, nor smaller than the minimum radius recommended by the manufacturer, whichever is greater. All 600 Amp and 200 Amp terminations shall be mounted to avoid any stress on the terminations.
- C. The two-hole cable connectors shall be crimped with only the manufacturer's approved tool recommendations.
- D. All cables in one conduit shall be pulled in together using a suitable patented grip on the conductors with a basket weave grip over the insulation, arranged so the stress of pulling is applied to the conductor and not the insulation.
- E. Use a swivel between the cable grip and pulling rope.
- F. Lubricate cables with Cablelube or Minerallac[®] cable pulling compound or the type approved by the cable manufacturer.
- G. Maximum pull tensions shall not exceed values recommended by the cable manufacturer or as specified on the drawings. Pulls shall be made in the directions shown on the plans.

- H. Install cables in manholes along wall as specified on drawing providing proper support. In manhole, route cables a minimum of $\frac{3}{4}$ of manhole perimeter.
- I. Cable shield shall be grounded with #6 bare copper to manhole ground at all terminations to provide permanent, low-resistance bond.
- J. After cables have been terminated or spliced and fireproofing tape is applied, each cable shall have a spiral wrap of colored $\frac{1}{2}$ " wide tape 3M #35 vinyl plastic applied over the fireproofing tape. Spiral wrap of colored tape shall be over the total length of cable, with maximum of a 5-inch (127 mm) separation between spirals. The color coding shall be as follows:
 - 1. 2400 volt - No Colored Tape Required
 - 2. 4160 volt - Red Tape (3M #10224)
 - 3. 12470 volt - Blue Tape (3M #10240)
- K. Seal all duct runs in manholes going inside buildings with a water-tight seal.
- L. Cables of the same circuit shall be identified by tags in manholes (at conduit entrances and T-splice) and entrances into equipment. Information on tags shall include: circuit number and routing (circuit number will be confirmed at the outage coordination meeting). Tags shall be installed on each cable after fireproofing (see part 2.14).
- M. Cables of the same circuit shall have the phasing identified with color tape in manhole. Phase A with one wrap, Phase B with two wraps, and Phase C with three wraps.

3.02 CABLE ENDS

- A. After cutting, if cable ends are not to be terminated in same working day cut, immediately protect cable ends from damage or moisture by sealing with cable caps and silicone sealant. Provide stress relief at all terminations. Provide correct phasing of the conductors of each circuit at all terminations. Provide proper connections of tape shield and drain wire to ground.

3.03 TESTS AND RECORDS

- A. Prior to energizing the cable, testing of the cable shall be performed in the presence of the Sandia Construction Observer (SCO) in accordance with Appendix A.
- B. Exposed ends of cable shall be prepared and cleaned prior to testing in order to minimize any leakage current.
- C. Cable circuit ends must be cleaned and guarded for personnel safety during cable testing. Circuits not under test in the immediate vicinity shall be grounded.

- D. Exposed circuit ends under test require a minimum separation from all elements not subjected to a test of one-inch (25.4 mm) per 10kV of test potential. After testing, cables shall be grounded for a minimum of four times as long as the test voltage was applied during the hi-potential tests to assure complete discharge.
- E. When all cable, splices, and terminations have been tested in accordance with Appendix A, and test results have been accepted by the SCO, the cable system may be placed in service as per the outage procedure.

END OF SECTION

APPENDIX A: HIGH VOLTAGE DC TESTING

After the installation of the primary cables, the contractor shall employ an independent third party electrical testing firm to test cables per this specification. The testing firm shall be a full member company of the InterNational Electrical Testing Association (NETA). The testing firm shall submit proof documenting membership.

The electrical testing firm contractor shall use calibrated test equipment for "Hi-potting" cables. The "Hi-pot" tests shall be performed at the times directed in this specification. The contractor shall furnish all instruments and personnel required for the tests, and electrical power will be furnished to the contractor on an "as is available" basis; otherwise contractor supplies generator. A Cable High Potential Test Certificate (blank form) will be furnished to the contractor. The contractor shall fill out the appropriate information on this form at the time of making the test for approval. The SDR shall file the form with the project file, and send a copy to the High Voltage Engineer or Technologist in Department 4821. See attached Forms A through D at the end of this appendix.

APP1.01 TEST PROCEDURE

All medium voltage cables installed and existing cables spliced to the new cables shall be tested as follows, using DC hi-potential. (Note: This is not a grounding or switching procedure; see outage procedure for grounding and switching sequence.)

- A. Field Testing of New Cables After Installation: The cable shall be tested according to 1.01A after installation and installation of stress relief devices as in 1.01A. Both ends of the cable shall be isolated from air break switches, transformers, etc. Remove all grounds from cable to be "hi-potted". (Note: If conductors are left connected to the equipment, the hi-pot test shall not exceed the rating of the equipment). For cables terminated with a 200 Amp elbow connector, elbows shall be placed on an insulated parking bushing prior to test. For cables terminated with a 600 Amp T-splice connector, the T-splice shall be capped prior to test.
- B. Field Testing of New Cables Jointed to Existing Cable
 1. After acceptance tests for new cables, rated at 5KV or 15KV, have been made and new cables are spliced to existing cables, a second test of the entire cable run from termination to termination, shall be made. This is only applicable where an existing cable is introduced into the circuit.
 2. The procedure for testing shall be the same as indicated in paragraph 1.01 above, except that the test voltage will be reduced to the values indicated on the appropriate form. Appropriate records shall be made, as indicated on Forms A through D.

3. This test is also applicable for testing of existing 5kV and 15kV rated cable where it is important to test the integrity of the cable.
- C. Dissipation of the charge build-up on the conductors shall be allowed to drain off through the test set and voltmeter circuit. After the potential drops below 95% of the test value, the conductor shall be solidly grounded. The grounds shall be left on all conductors for a minimum of four times as long as the test voltage was applied during hi-potential tests and/or as long as someone is handling the conductors.

APP1.02 FAULTY CABLE

- A. Contractor Furnished: In the event that any new contractor-furnished cable fails to meet any of the above tests, the entire faulty cable shall be removed and new cable shall be installed and tested at no increase in the contract price.

- End of Appendix A -

APPENDIX B: MEDIUM-VOLTAGE CABLE TESTING REPORT FORMS

PREPARED BY:		SANDIA NATIONAL LABORATORIES/ NEW MEXICO	FORM A
CHECKED BY:		CABLE HI POTENTIAL TEST CERTIFICATE, 15KV CLASS NEW INSTALLATION	SPEC. NO.: 16124
DATE:	REV. B 10/01		ELECTRICAL

CONTRACT NO. _____		DATE _____
CABLE OR DESIGNATION _____		
LOCATION _____		
CABLE SIZE _____		
INSULATION AND JACKET TYPE _____		LENGTH _____ FT
MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED _____		
CABLE ACCEPTABLE _____		NOT ACCEPTABLE _____
TEST CONDUCTED BY: _____		
TEST WITNESSED BY: _____		
REMARKS: _____		
TEMPERATURE: _____ °F WEATHER CONDITIONS: _____		

15KV RATED, EPR, 133% INSULATION LEVEL, HI-POTENTIAL TEST FOR INITIAL
INSTALLATION TEST (NEW CABLE)

STEP	VOLTAGE LEVEL**	DURATION	TIME ELAPSE	MICRO AMPS *	POLARIZATION INDEX = = <u>STEP 4</u> STEP 9
1	15KV	1 Min.	1 Min.		_____
2	30KV	1 Min.	2 Min.		
3	45KV	1 Min.	3 Min.		
4	50KV	1 Min.	4 Min.		
5	50KV	1 Min.	5 Min.		
6	50KV	1 Min.	6 Min.		
7	50KV	1 Min.	7 Min.		
8	50KV	1 Min.	8 Min.		
9	50KV	1 Min.	9 Min.		

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.
 ** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.
 NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

POLARIZATION RESULTS:
 IF 1.25 - 2.0 GOOD
 IF BELOW 1.0 FAILURE
 IF 1.0 - 1.25 MARGINAL

PREPARED BY:		SANDIA NATIONAL LABORATORIES/ NEW MEXICO	FORM B
CHECKED BY:		CABLE HI POTENTIAL TEST CERTIFICATE, 15KV CLASS EXISTING INSTALLATION	SPEC. NO.: 16124
DATE:	REV. B 10/01		ELECTRICAL

CONTRACT NO. _____ DATE _____
 CABLE OR DESIGNATION _____
 LOCATION _____
 CABLE SIZE _____
 INSULATION AND JACKET TYPE _____ LENGTH _____ FT
 MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED _____

CABLE ACCEPTABLE _____ NOT ACCEPTABLE _____
 TEST CONDUCTED BY: _____
 TEST WITNESSED BY: _____
 REMARKS: _____
 TEMPERATURE: _____ °F WEATHER CONDITIONS: _____

15KV RATED, EPR, 133% INSULATION LEVEL, HI-POTENTIAL TEST FOR EXISTING CABLE AND FOR NEW CABLE SPLICED TO EXISTING CABLE.

STEP	VOLTAGE LEVEL**	DURATION	TIME ELAPSE	MICRO AMPS *	POLARIZATION INDEX = $\frac{\text{STEP 2}}{\text{STEP 7}}$
1	15KV	1 Min.	1 Min.		_____ = _____
2	22V	1 Min.	2 Min.		
3	22V	1 Min.	3 Min.		
4	22V	1 Min.	4 Min.		
5	22V	1 Min.	5 Min.		
6	22V	1 Min.	6 Min.		
7	22V	1 Min.	7 Min.		

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.

** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.

NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

POLARIZATION RESULTS:

IF 1.25 - 2.0 GOOD
 IF BELOW 1.0 FAILURE
 IF 1.0 - 1.25 MARGINAL

PREPARED BY:		SANDIA NATIONAL LABORATORIES/ NEW MEXICO	FORM C
CHECKED BY:		CABLE HI POTENTIAL TEST CERTIFICATE, 5KV CLASS NEW INSTALLATION	SPEC. NO.: 16124
DATE:	REV. B 10/01		ELECTRICAL

CONTRACT NO. _____ DATE _____
 CABLE OR DESIGNATION _____
 LOCATION _____
 CABLE SIZE _____
 INSULATION AND JACKET TYPE _____ LENGTH _____ FT
 MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED _____

CABLE ACCEPTABLE _____ NOT ACCEPTABLE _____
 TEST CONDUCTED BY: _____
 TEST WITNESSED BY: _____
 REMARKS: _____
 TEMPERATURE: _____ °F WEATHER CONDITIONS: _____

5KV CABLE, HI-POTENTIAL TEST FOR INITIAL INSTALLATION TEST (NEW CABLE)

STEP	VOLTAGE LEVEL**	DURATION	TIME ELAPSE	MICRO AMPS *	POLARIZATION INDEX = = <u>STEP 5</u> STEP 10
1	5KV	1 Min.	1 Min.		
2	10KV	1 Min.	2 Min.		
3	15KV	1 Min.	3 Min.		
4	20KV	1 Min.	4 Min.		
5	25KV	1 Min.	5 Min.		
6	25KV	1 Min.	6 Min.		
7	25KV	1 Min.	7 Min.		
8	25KV	1 Min.	8 Min.		
9	25KV	1 Min.	9 Min.		
10	25KV	1 Min.	10 Min.		

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.
 ** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.
 NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

POLARIZATION RESULTS:
 IF 1.25 - 2.0 GOOD
 IF BELOW 1.0 FAILURE
 IF 1.0 - 1.25 MARGINAL

PREPARED BY:		SANDIA NATIONAL LABORATORIES FACILITIES DEPARTMENT	FORM D
CHECKED BY:		CABLE HI POTENTIAL TEST CERTIFICATE, 5KV CLASS EXISTING INSTALLATION	SPEC. NO.: 16124
DATE:	REV. B 10/01		ELECTRICAL

CONTRACT NO. _____ DATE _____

CABLE OR DESIGNATION _____

LOCATION _____

CABLE SIZE _____

INSULATION AND JACKET TYPE _____ LENGTH _____ FT

MAX. CURRENT AFTER 100% TEST VOLTAGE APPLIED _____

CABLE ACCEPTABLE _____ NOT ACCEPTABLE _____

TEST CONDUCTED BY: _____

TEST WITNESSED BY: _____

REMARKS: _____

TEMPERATURE: _____ °F WEATHER CONDITIONS: _____

5 KV CABLE, HI-POTENTIAL TEST FOR EXISTING CABLE AND FOR NEW CABLE SPLICED TO
EXISTING CABLE

STEP	VOLTAGE LEVEL**	DURATION	TIME ELAPSE	MICRO AMPS *	POLARIZATION INDEX = $\frac{\text{STEP 2}}{\text{STEP 7}}$
1	5KV	1 Min.	1 Min.		_____ = _____
2	8KV	1 Min.	2 Min.		
3	8KV	1 Min.	3 Min.		
4	8KV	1 Min.	4 Min.		
5	8KV	1 Min.	5 Min.		
6	8KV	1 Min.	6 Min.		
7	8KV	1 Min.	7 Min.		

* READING AT END OF 1 MIN. DURATION PRIOR TO RAISING VOLTAGE TO NEXT STEP.

** BETWEEN EACH STEP RAISE VOLTAGE UNIFORMLY.

NOTE: STOP TEST IF CURRENT STEADILY INCREASES AT CONSTANT VOLTAGE.

POLARIZATION RESULTS:

IF 1.25 - 2.0 GOOD

IF BELOW 1.0 FAILURE

IF 1.0 - 1.25 MARGINAL