This master should be used by designers working on Port of Portland construction projects and by designers working for PDX tenants (“Tenants”). Usage notes highlight a few specific editing choices, however the entire section should be evaluated and edited to fit specific project needs.

SECTION 260513 - MEDIUM-VOLTAGE CABLES

1. GENERAL
	* + 1. DESCRIPTION
				1. This section describes cables and related splices, terminations and accessories for medium-voltage electrical distribution systems.
			2. REFERENCES
				1. AEIC: Association of Edison Illuminating Companies

AEIC CS8: Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 KV

* + - * 1. ANSI: American National Standards Institute

ANSI C119.2: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

* + - * 1. ASTM: American Society for Testing and Materials:

ASTM B8: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

* + - * 1. ICEA: Insulated Cable Engineers Association

ICEA S-93-639: 5-46kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

* + - * 1. IEEE: Institute of Electrical and Electronic Engineers

IEEE 383: Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations

* + - * 1. UL: Underwriters Laboratory

UL 1072: Standard for Medium-Voltage Power Cables

* + - 1. SUBMITTALS
				1. To be considered for “Pre-Bid Approved Equal”, submit the following specific information and product samples:

Each type of proposed cable, 2-foot length, identical in construction and ratings to that specified.

Manufacturer’s product data sheet.

Copies of manufacturer’s certification of cable manufacturing experience.

Copies of manufacturer’s certification of insulation performance.

* + - * 1. Submit manufacturers’ product data for the following materials:

15 kV cable.

5 kV cable.

15 kV terminators.

5 kV terminators.

Splices.

Lubricants.

Cable supports:

Racks.

Standoff Insulators.

Kellums type grips.

Cable grips.

Copies of manufacturer’s certified test results prior to installation of cable.

Copies of manufacturer’s certification that the cable has been produced within the last 12 months.

* + - * 1. Submit the following contractual field test results:

Prior to the work being performed:

Cable pulling and sidewall pressure calculations 2 weeks prior to pull. Submit pulling plan.

Devices used to measure pulling tension, such as a dynamometer specification sheet and calibration.

DC High Potential Test equipment model and calibration date.

After work is performed:

DC high potential tests within 2 weeks of when work was performed.

Cable pulling installation maximum tensions within 5 days of when work was performed.

Phasing test.

* + - 1. QUALITY ASSURANCE
				1. Test each reel of cable in accordance with ICEA and shall meet or exceed ICEA standards.
				2. Each reel of cable shall be newly manufactured (no more than 12 months old), and shall bear a tag containing the name of the manufacturer, NEC designation, and year of manufacture.
				3. Submit documentation from the cable manufacturer demonstrating a minimum of 35 years of experience in cable construction, including formulating and manufacturing the ethylene propylene rubber compound in-house and under direct control of the manufacturer’s quality control and manufacturing processes and standards.
				4. Submit documentation from the cable manufacturer demonstrating a minimum of 30 years of successful performance using the same insulation compound.
				5. The manufacturer shall be a company specializing in manufacturing medium voltage cable and/or accessories with a minimum of 15 years’ documented expertise in producing cable and/or accessories similar to those specified. The cable shall have a 40-year design life.
				6. Ensure that the cable manufacturer maintains a quality testing program consistent with IEEE 383. This standard is intended to demonstrate that a cable insulation system will perform for a minimum of 40 years. The requirements in IEEE 383 include, but are not limited to, long-term aging, long-term moisture resistance, and chemical exposure at elevated temperatures.
				7. Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.
			2. DELIVERY, STORAGE, AND HANDLING
				1. Seal all cable ends to prevent the entrance of moisture during shipping, storage, and installation.
				2. Before accepting cable delivery, inspect the outside of each cable reel and remove protruding nails, fastenings, or other objects which might damage the cable. Inspect for flaws, breaks, or abrasions in the cable sheath as the cable leaves the reel. Damage to the sheath or finish of the cable shall be sufficient cause for rejecting the cable. Cable damaged in any way during installation shall be replaced at no additional cost to the Port.
1. PRODUCTS
	* + 1. GENERAL
				1. Type, size, and number of conductors shall be as specified on the drawings or schedules.
			2. COLOR CODING
				1. Power Conductors: Single‑conductor power conductors shall have 3/4‑inch vinyl colored plastic tape applied in 3‑inch lengths around the cable at each end. The cables shall be colored at terminations and in pull boxes, handholes, and manholes:

Use first table for PDX projects or second table for marine projects. Do not retain both.

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| --- | --- |
| Phase A – | Brown |
| Phase B – | Orange |
| Phase C – | Yellow |
| Ground – | Green |
| Neutral – | White |

|  |  |
| --- | --- |
| Phase A – | Black |
| Phase B – | Red |
| Phase C – | Blue |
| Ground – | Green |
| Neutral – | White |

* + - 1. MEDIUM-VOLTAGE POWER CONDUCTORS AND CABLE IN CONDUIT
				1. The medium-voltage power cable shall be suitable for use in all raceways except cable trays. The cable shall meet the requirements of ICEA S‑93-639 and UL 1072.
				2. Characteristics:

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| --- | --- |
| Voltage: | 5 kV or 15 kV as indicated on the drawings. |
| Conductor: | Single conductor, uncoated copper, Class B, stranded in accordance with ASTM B8. UL tested, listed, labeled, and factory certified for 105ºC operation. |
| Strand shield: | Extruded 100 percent ethylene propylene rubber-based semi-conducting stress relief layer. No polyethylene is permitted as a component of this layer. |
| Insulation: | 100 percent ethylene propylene (EPR), Type MV‑105, rated continuous 105ºC, emergency 140ºC, short circuit 250ºC, wall thickness rated for 133 percent insulation level. No polyethylene is permitted as a component of this layer. |
| Insulation Screen: | Extruded 100 percent ethylene propylene rubber-based semi-conducting stress relief layer. No polyethylene is permitted as a component of this layer. |
| Shield: | 5 mil uncoated copper tape helically applied with 12.5 percent overlap. |
| Jacket: | Polyvinylchloride (PVC)/10 mil thickness flame retardant, MV-105 labeled and listed in accordance with UL 1072. Suitable for wet and dry installations in conduits, underground ducts, and in locations exposed to sunlight. |
| Factory Tests: | Test the cable for corona discharge after manufacturing at the factory in accordance with AEIC CS8 requirements. A copy of the original x-y plot shall be recorded showing the corona test results. Corona discharge shall be below 5 picocoulombs for all voltage levels. |
| Manufacturer: | Okonite, Southwire, or pre-bid approved equal. |

* + - 1. MEDIUM-VOLTAGE POWER CONDUCTORS ARMOR CABLE USED IN CABLE TRAY OR DIRECT BURIAL
				1. The medium-voltage power cable shall be UL listed for use in cable trays or direct burial. The cable shall meet the requirements of ICEA S-93-639 and UL 1072.
				2. Characteristics:

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| --- | --- |
| Voltage: | 5 kV or 15 kV as indicated on the drawings. |
| Conductor: | Uncoated copper, Class B, stranded in accordance with ASTM B8. |
| Strand screen: | Extruded 100 percent ethylene propylene rubber-based semi-conducting stress relief layer. No polyethylene is permitted as a component of this layer. |
| Insulation: | 100 percent ethylene propylene (EPR), Type MV‑105, rated continuous 105ºC, emergency 140ºC, short circuit 250ºC, wall thickness rated for 133 percent insulation level. No polyethylene is permitted as a component of this layer. |
| Insulation Screen: | Extruded 100 percent ethylene propylene rubber-based semi-conducting stress relief layer. No polyethylene is permitted as a component of this layer. |
| Shield: | Coated copper tape with 12.5 percent overlap. |
| Grounding: | Bare copper, Class B, stranded per conductor: ASTM B8, and sized in accordance with UL 1072. |
| Armor: | Continuously welded corrugated aluminum armor overall. |
| Overall jacket: | PVC jacket over the armor. |
| Flame Resistance: | IEEE 383, 210,000 btu/hr. |
| Factory Tests: | Test the cable for corona discharge after manufacturing at the factory in accordance with AEIC CS8 requirements. A copy of the original x-y plot shall be recorded showing the corona test results. Corona discharge shall be below 5 picocoulombs for all voltage levels. |
| Manufacturer: | Okonite C-L-X, Southwire, or pre-bid approved equal. |

* + - 1. SPLICING AND TERMINATING MATERIALS
				1. Medium-Voltage Single Polymeric Conductor and Cable Terminators:

Lug Type: Terminations shall be made with a tin‑plated compression type lug and a compression pressure tool as approved by the manufacturer of the lug. Tool shall be of the hydraulic pump type or the type that crimps to the required size before releasing. Electrical voltage stresses shall be controlled by high permittivity, high resistivity, and heat shrinkable polymeric tubing. Seal termination using heat shrinkable tubing and heat-activated adhesive. Corona extinction level for a completed termination on a cable shall not be less than 1 1/2 times the rated cable phase to ground voltage. Raychem Series HVT‑150, or pre-bid approved equal.

Rated for indoor and outdoor operation.

15 kV nominal rating.

50 kV AC rating one minute.

75 kV DC rating of 15 minutes.

110 kV BIL.

Equal to cable ampacity.

Splices: Splices shall be made with a tin‑plated copper compression connector and a compression tool as approved by the manufacturer of the connector. Tool shall be of the hydraulic pump type or the type that crimps to the required size before releasing. Electrical voltage stresses shall be controlled by utilization of high permittivity, high resistivity, and heat shrinkable polymeric tubing. Seal the splice with a heat‑activated adhesive and an outer heat‑shrinkable jacket tubing. Splice shall provide continuity of the cable shield using a wire mesh and grounding clamps. Raychem Series HVS‑1520, or pre-bid approved equal.

Load‑Break Connectors: Load‑break connectors shall be rated 8.3 kV phase to ground and 14.4 kV phase to phase across contact; 95 kV BIL; 35 kV, 60 Hz, 1 minute; 11 kV Corona extinction; 200 amps continuous, 300 amps, 8 hours; 15,000 amps RMS (ASYM), 12 cycles, 10,000 amps RMS (SYM), 30 cycles; and shall comply with the requirements of ANSI C119.2. Load‑break connectors contact assembly shall match the load break junctions provided in the high-voltage ship service stations supplied by the Port.

Non-Load-Break Connectors and Bushings: Non-load-break cables and bushings shall be rated 8.3 kV phase to ground and 14.4 kV phase to phase; 95 kV BIL; 35 kV, 60 Hz, 1 minute; 11 kV Corona extinction; 600 amps continuous; 900 amps, 8 hours; 40,000 amps RMS (SYM), 4 seconds; and shall comply with the requirements of ANSI C119.2. Connectors and bushings shall be provided with all other things necessary for a complete installation.

Cold shrink splice and termination kits are not allowed, unless approved by the Port.

* + - * 1. Medium-Voltage Three Conductor Lead Sheathed Cable to Single Conductor MV-105 Cable:

Splices shall be made with tin-plated copper compression connector and compression pressure tool. The tool shall be of the hydraulic pump type or the type that crimps to the required size before releasing. Electrical voltage stresses shall be controlled by high permittivity, high resistivity, and heat shrinkable polymeric tubing. A heat shrink type trifurcating joint kit shall be used which is suitable for paper insulated lead covered (PILC) cable and varnished cambric lead covered (VCLC) cables to be spliced to three single-conductor EPR insulated power cables. Materials shall be Raychem Series HVS-T-1580, or pre-bid approved equal.

Rated for operation submerged in water and outdoors in sunlight.

15 kV nominal rating.

50 kV AC rating one minute.

75 kV DC rating of 15 minutes.

110 kV BIL.

90° C continuous operation.

Equal to cable ampacity.

External ground braid.

* + - * 1. 3-Way Splices - 15,000 Volt: Armored cable splice kit including corrosion-resistant aluminum casing and end insulating tapes, splicing material, and potting compounds. PLM Products #ACSJR20Y, or pre-bid approved equal. Submit shop drawings for field splicing of cables indicating details for each phase conductor and splice technique (shielded to non-shielded cable and shielded to shielded cable).
				2. 600 amps, 3-Way Splices - 15,000 Volt: Fully shielded, fully submersible, 600-amp cable splice kit consisting of bolt-together formed cable elbow housings, inserts, and epoxy plugs. Elastimold 650-L3 series with 30MA cable ground device 3M, RTE, or pre-bid approved equal.
				3. Heat-Shrinkable Caps: Thermofit by Raychem Corporation, or equal.
				4. 200 amps, tee splice shall be a continuous RMS current, rated 15 kV. Completed connections shall be insulated, shielded, fully submersible, and waterproof. Tee shall have two plug ends and one receptacle end.

Elastimold tee splice 150T, with bailing assembly to minimize any possibility of separation of assembly due to cable movement, or pre-bid approved equal. Match receptacle end with a 151 SP straight plug. Match plug ends with 151 SR straight receptacles.

* + - 1. ARC-PROOFING MATERIALS
				1. Exposed cables in manholes, vaults, and cable troughs shall be fireproofed.

Arc-proofing tape shall be flexible, conformable, intumescent to 0.03-inch thick compatible with cable jacket. 3M Scotch No. 77, or pre-bid approved equal.

Glass-cloth electrical tape, pressure sensitive adhesive type, 1/2 inch wide. 3M Scotch No. 69, or equal. Install per manufacturer’s recommendations.

1. EXECUTION
	* + 1. GENERAL
				1. Provide notification 2 days prior to all cable pulls.
				2. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
				3. Pull cable into conduit without damaging or putting undue stress on the cable insulation. UL-listed pulling compounds are acceptable lubricants for pulling wire and cable. Grease is not acceptable. Raceway construction shall be complete, cleaned, and protected from the weather before cable is placed.
				4. Provide a cable support wherever a cable leaves a raceway.
				5. Scratch-brush the contact areas when flat bus bar connections are made with unplated bar. Torque bolts to the bus manufacturer’s written recommendations.
				6. Bond cable shield to grounding electrode system at terminations.
			2. MEDIUM-VOLTAGE CONDUCTORS AND CABLE
				1. Terminations shall be in conformance with the written instructions accompanying the splicing or terminator kits. Take special care to ensure that cable insulation is not damaged while stripping back jacket, semiconductor layers or shields, or during penciling operations. Use a ringing tool to strip back nonmetallic layers of the cable. The use of a pocket or jackknife for stripping back or penciling operations is prohibited.

Tenant: Delete all instances of “Port” and replace with name of tenant.

* + - * 1. Installation:

General: Conductor installation shall be in accordance with the cable manufacturer’s recommendations.

Cable placement: Check cable for condition, size, and length before it is pulled into raceways. Cable pulled into the incorrect raceway or cut too short to rack, train, or splice as specified herein shall be removed and replaced at no additional cost to the Port.

Supports: Orient bearing surfaces of cable supports and securing devices parallel to the surfaces of the cable sheath and install to provide adequate support without deformation of the cable jackets or insulation. Place cable with adequate end lengths to avoid longitudinal strains and distorting pressures on the cable at termination points and duct end bells. Final inspection will be made after all cable is in place. Where supports, bushings, and end bells deform the cable jacket, provide additional supports as directed by the Port.

Cable Racks: Provide cable racks as required to provide proper cable support. Space cable racks no more than 36 inches apart and bolt to permanent wall surfaces with anchors or continuous slot concrete inserts.

Cable in Manholes: Support cable at all times during handling, without short bends or excessive sags, and do not permit it to lie on the manhole floor. Seal ends to prevent the entry of moisture or dirt. Provide cable racks or trays for permanent support. Temporary support required during placement shall be with rope slings, timbers, or alternate methods acceptable to the Port.

Cable Pulling:

Pulling Lines: Pull cable and raceway cleaning mandrels with manila hemp line or braided polyester rope to prevent damage to the raceway. Nylon or stranded steel pulling lines will not be allowed. “Fishing” may be done with CO2‑propelled polyethylene cord.

Cable Grips: Use factory‑installed pulling eyes for pulling cable where they are available. Use cable manufacturer-approved pulling eyes for any pull where the calculated tension exceeds 1000 pounds on any one conductor. A basket grip may be used on pulls that are less than 1000 pounds per conductor when recommended by the cable manufacturer. Where pulling eyes are not available, use woven wire cable grips to pull all single‑conductor cable. If a cable grip or pulling eye is used for pulling, cut off and discard the area of the cable covered by the grip or seal, plus 6 inches, when the pull is completed. As soon as the cable is pulled into place, remove the pulling eyes on cable grips and reseal the cable.

Swivels: Insert a reliable, nonfreezing type of swivel, or swivel connection, between the pulling rope and the cable pulling eye, grip, or loop to prevent twisting under strain.

Lubricant: Use a cable lubricant on all conductors in all pulls, of the type and in the quantity recommended by the cable manufacturer.

Pulling Tension: Do not exceed the maximum pulling tension recommended by the cable manufacturer. Pulling mechanisms of both manual and power types shall have the rated capacity (in pounds) clearly marked on the mechanism. A dynamometer shall be used to show the tension on the cable during all pulls and the indicator shall be constantly watched. If excessive strain develops, stop and correct the pulling operation. Motor vehicles may not be used in pulling cable. Any cable so pulled shall be removed and replaced at no additional cost to the Port. The cable play‑out reel shall be equipped with a suitable brake and shall be constantly manned during all pulls.

Sidewall Pressure: To avoid insulation damage from excessive sidewall pressure at bends in raceway runs, the pulling tension in pounds exiting a bend shall not exceed 500 times the radius or also stated, shall not exceed 500 pounds per foot of bending radius.

Cable Bends: Take care during the placement of all cable to prevent tension and bending conditions in excess of the manufacturer’s recommendations. The permanent radius of bend after cable installation shall be in accordance with the cable manufacturer’s recommendations.

Moisture Seals:

Keep cables sealed except when termination and splicing work is being performed. Seal the ends of all cables with heat‑shrinkable caps in sizes as recommended by the cap manufacturer for the cable outside diameter and insulation. Caps shall contain sufficient adhesive that shrinkage of the cap during application results in formation of a positive, watertight seal.

Before and after pulling, the leading end seal of each length of cable shall be examined and replaced if necessary. Promptly seal cut cable ends after cutting except those to be spliced or terminated immediately.

Splices: Power cable circuits may be spliced only at locations acceptable to the Port or where specified. Do not use splices to utilize short lengths of cable or to provide correct lengths on cable initially cut too short for a particular circuit.

Terminations: Do not bend cable in a radius less than the manufacturer’s recommended minimum bending radius. If the cable is bent at any time to a radius less than the minimum bending radius, the Contractor shall, at his own expense, re‑terminate the cable at a point at least 6 inches below the bend. Where the shape and configuration of terminal fittings make workmanlike insulation of the bare connection impractical, the contours of the connection shall be smoothed by filling voids and molding over irregular surfaces with a moldable filler material as recommended by the terminator kit manufacturer before application of the recommended thickness of insulating material.

* + - 1. MEDIUM‑VOLTAGE CABLE INSTALLATION
				1. Mandrel all new and existing conduits prior to installation of medium voltage cable. Provide notification of damaged raceways in writing prior to installation. Contractor shall receive written authorization from the Port prior to installing cables in raceways that contain obstructions.
				2. All ground conductors in raceways shall be insulated.
			2. EXISTING CIRCUITS
				1. Confirm the destination and purpose of each existing circuit before connecting to new equipment and new wiring. Connections shown on the one‑line diagram drawing are the preferred connections in any cases where drawings conflict. Provide notification if there are conflicts.
				2. Remove existing terminations, leaving as much existing cable as possible. Conserve existing cable when making splices to new cables. Existing cable length may require routings within the high‑voltage vault different from those shown on the drawings. Do not unnecessarily cut off any existing cable length.
			3. ARC-PROOFING
				1. Install tightly applied arc-proofing tape, approximately 1/16-inch-thick by 1 1/2 inches wide minimum, around each feeder spirally in one half-lapped wrapping. Install tape with the coated side towards the cable and extend it not less than 1 inch into each duct.
				2. Bundle all phases of the medium voltage cable including the ground conductor, if provided, together with glass-cloth tape at 2-inch centers. Install tape with coated side towards the cable and extend to within 6 inches of each duct.

Tenant: In this article, delete all instances of “Port” and replace with name of tenant.

* + - 1. TESTING MEDIUM-VOLTAGE CONDUCTORS AND CABLE
				1. General:

. New cables spliced to existing cables shall be acceptance-tested before splicing. Provide notification a minimum of 72 hours prior to testing. The Port will be present during the test. Submit all test report data. The test shall be performed by Arnett Testing Lab, Electro‑Test, Inc., or equal testing agency.

Visually inspect cables and terminations. Verify shield grounding, cable support, and termination.

Perform an insulation-resistance test utilizing a megohmmeter with a voltage output of at least 2500 volts. Individually test each conductor with all other conductors and shields grounded. Test duration shall be one minute.

* + - * 1. DC High Potential Testing:

Use DC high potential testing for new medium-voltage conductors and cables.

After insulation resistance testing is completed, perform a DC high potential test on cables. The procedure for DC high potential testing shall be in accordance with NETA.

The test voltage shall be direct current at 80 percent of final factory DC test voltage or approximately 50 percent of the basic impulse level (BIL) voltage. The test voltage shall not exceed the maximum voltages for the lowest-rated component.

The currents resulting from the DC high potential testing shall be recorded and submitted. During the high potential test, leakage current readings shall be taken at 30 second intervals during the first 2 minutes, then at 1-minute intervals for the remainder of the test. Test results shall demonstrate that the leakage current decreases or remains constant after reaching the specified test voltage.

* + - * 1. VLF Hipot Tests: For new or existing medium-voltage conductors and cables, perform high potential acceptance test using very low frequency (VLF) test method in accordance with IEEE 400.2.
				2. If a cable fails testing, the fault shall be located and the cable replaced. All cable in the conduit between the nearest pulling points on each side of the failure shall be withdrawn. Upon re-installing cable, testing shall be repeated on all conductors.

END OF SECTION 260513