

SECTION 33 71 00 - ELECTRICAL POWER OVERHEAD LINE

1.01 ^{A7}SUMMARY:

- A. **Basic Function:** Existing overhead distribution and transmission lines existing in the area of the site, and affected by the Works shall be temporarily relocated and be placed in their final arrangement as part of the Works. This part of the Works shall be performed in a manner to maintain the high quality of service to all loads and with high standard of quality materials, to guarantee the continuation of the present reliable service.
- B. **Scope of Work:** This Section contains the technical specifications for designing, supplying, installing, testing and commissioning temporary and permanent electrical power overhead distribution lines (12 kV) and electrical power overhead transmission lines (44 kV) that needs to be relocated due to the constructions of the locks complexes. ^{A17}The scope within this Section does not include new works. The new locks complexes do not have requirements for overhead power lines. ^{A17}

1.02 ^{A16}REFERENCES: ^{A16}

- A. **Aluminum Association (AA) Publication:**
50-99 Code Words for Overhead Aluminum Electrical Conductors
- B. **American National Standards Institute (ANSI) Standards:**
C29.1-88(02) Test Method for Electrical Power Insulators
C29.3-86(02) Wet-Process Porcelain Insulators-Spool Type
C29.4-89(02) Wet-Process Porcelain Insulators-Strain Type
C29.7-96(02) Porcelain Insulators-High Voltage Line-Post Type
C29.12-97(02) Insulators Composite – suspension Type
[Reserved](#)
C119.4-04 Electric Connectors - Connectors for Use between Aluminum-to-Aluminum or Aluminum-to-Copper Conductors
O5.3-02 Wood Products - Solid Sawn - Wood Cross - Arms and Braces
- C. **American Society for Testing and Materials (ASTM) International Standards:**
A 123/A 123M-02 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A 153/A 153M-05 Zinc Coating (Hot-Dip) on Iron and Steel Hardware

	A 416/A 416M-06	Steel Strand, Uncoated Seven-Wire for Pre-stressed Concrete
	A 475-03	Zinc-Coated Steel Wire Strand
	B 3-07	Soft or Annealed Copper Wire
	B 415-02	Hard-Drawn Aluminum-Clad Steel Wire
	B 416-02	Concentric-Lay-Stranded Aluminum-Clad Steel Conductors
	C 150-07	Portland Cement
	D 1586-99	Penetration Test and Split-Barrel Sampling of Soils, Test Method
D.	American Wood Preservers' Association (AWPA) Publication:	
	C25-03	Sawn Cross-arms, Pressure Treatment by Pressure Processes
E.	Federal Specifications:	
	A-A-59551	Wire, Electrical, Copper (Uninsulated)
	TT-P-19	Paint, Latex (Acrylic Emulsion, Exterior Wood and Masonry)
	W-F-408	Fittings for Conduit, Metal, Rigid (Thick-wall and Thin-wall (EMT) Type)
	W-R-550	Rods, Ground (With Attachments)
F.	Institute of Electrical and Electronics Engineers (IEEE) Standards:	
	^{A17} C2-07	National Electrical Safety Code (NESC) ^{A17}
	48-03	Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations
	81-83	Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of Ground Systems
	142-06	Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book)
	524-03	Guide to the Installation of Overhead Transmission Line Conductors
	C2-06	National Electrical Code
	C62.11-05	Metal-Oxide Surge Arresters for Alternating Current Power Circuits
	C135.1-99	Standards for Zinc Coated Steel Bolts and Nuts for Overhead Line Construction
G.	National Electrical Manufacturers Association (NEMA) Publication:	
	LA 1-99	Surge Arresters

H. **National Fire Protection Association (NFPA) Publication:**

70-08 National Electrical Code

I. **Autoridad del Canal de Panama (ACP) Publications:**

Manual de Seguridad en Operaciones de Alto Voltaje
(2005)

J. **Underwriters' Laboratories Inc. (UL) Safety Standards:**

Reserved

651-05 Rigid PVC Conduit and Fittings Schedule 40 & 80

467-04 Grounding and Bonding Equipment

1.03 REQUIREMENTS:

- A. **General.** Provide overhead medium voltage power lines in the exterior perimeter of the locks. Overhead distribution lines shall conform to the latest applicable rules of the National Electrical Safety Code, IEEE C2, for light loading conditions, grade B construction; and to the safety requirements of the ACP "Manual de Seguridad en Operaciones de Alto Voltaje". All work on the existing electrical infrastructure shall be in accordance with Section 01 14 00 (*Work Restrictions*). For reference of existing utilities, see Volume VI (*Reference Documents*), Part 1 (*Reference Drawings*).
- B. **Reliability Requirements.** ^{A17}The electrical power overhead distribution and transmission lines that supply electrical power to the existing locks cannot be taken out for maintenance, repair or relocation, unless an alternative service to the existing locks is previously fully coordinated with the Employer's Representative, installed and in service.^{A17}
- C. **Design Life:** Overhead distribution line shall be designed for a life of 10 years for the temporary installations and 50 years for the permanent installations.
- D. **Continuity of Electrical Service or Load:** ^{A17}Any existing service or load affected by the relocation of the existing electrical infrastructure shall be temporarily restored during performance of the Works and restored in a permanent manner before or after completion of the Works.^{A17} Downtime shall be kept to the bare minimum. Work shall be coordinated with the owner of the electric service or load, previous to performing any shutdown of the electrical power supply. Temporary and permanent electrical installations shall conform to IEEE C2 and NFPA 70.

1.04 DESIGN CRITERIA/SYSTEM DESCRIPTION AND PERFORMANCE REQUIREMENTS:

- A. **General:** This Section contains the technical specifications for designing, supplying, installing, testing and commissioning of overhead distribution lines. Electrical installation

shall conform to the latest applicable rules of the National Electrical Safety Code, IEEE C2, for light loading conditions, grade B construction; and to the safety requirements of the ACP's "Manual de Seguridad en Operaciones de Alto Voltage".

- B. **Materials and Equipment:** This Section contains the specifications for products and materials used for overhead distribution lines. Electrical materials and equipment shall be new and shall bear the UL label wherever standards have been established by that agency. In lieu of such label, a written certificate from a nationally recognized testing agency adequately equipped and competent to perform such services may be submitted stating that the items have been tested and that the units conform to the requirements specified herein, including methods of testing of the specified agencies.

1. **For 15 kV Line:**

- a. **Line Conductor:** Conductor shall be 477 Kcmil, all aluminum conductors (AAC).
- b. **Ground Conductors:**
 - 1) **Overhead Shield Wire:** Shield wire shall be bare aluminum-clad steel wire (Alumoweld, or equal), 7 No. 7 strands, conforming to ASTM B 415 and B 416, with minimum 20 percent IACS conductivity at 20 °C (68 °F).
 - 2) **Ground Conductor:** Down ground conductor and down conductor for surge arresters shall be soft-drawn, bare, solid No. 2 AWG copper conductor, conforming to Federal Specification A-A-59551, and ASTM B 3.
- c. **Concrete Poles:** Shall be made by the pre-tensioning method with high-strength, cold-drawn, stress-relieved wire or wire strands having a minimum ultimate tensile strength of 1,700 MPa (250,000 pounds per square inch) conforming to ASTM A 416 and with concrete with a slump of 40 mm (1-1/2 inches) and a minimum compressive strength of 48 MPa (7,000 psi) at 28 days. The concrete shall be composed of Portland cement conforming to ASTM C 150 Type II or III, fine clean sand and coarse aggregate with a maximum size of 19 mm (3/4 inch). Poles shall have a smooth finish, capped with a concrete cap and cured by the steam curing process. Both ends of poles shall be given a coat of asphaltic paint to seal off the ends of the wires, and to prevent the wires from exposure to moisture. Pole shall be manufactured with all holes and features required for field installation of hardware and equipment, without field drilling or modifications.
- d. **Conduit System:** All conduit risers shall be PVC schedule 80 and underground conduits shall be PVC schedule 40.
- e. **Conduit End Bells and Plugs:** Plugs shall provide a watertight joint, and shall be of the same material as the conduit.

- f. **Hardware:** Pole hardware shall be hot-dip galvanized. Curved washers for poles and flat washers elsewhere used on through-bolts shall be approximately 60 mm (2-1/4 inches) square and 5 mm (3/16 inch) thick. The diameter of holes in washers shall be the correct standard size for the bolts on which the washers are used. Square locknuts, Joslyn 9200 West Fullerton Ave. P.O. Box 368, Franklin Park, IL 60131, Phone: (312) 625-1500 type MF No. 1, or equal, size as required, shall be used to permanently set all square nuts. Eyebolts, fasteners, and clevises shall be used wherever required to adequately support and protect the poles, cross-arms, guy wires, insulators, and conductors. Hardware shall conform to IEEE C135 series standards referenced.
- g. **Insulators:**
- 1) **Suspension Insulators:** Shall be rated for 66.7 kN (15,000-pound) design tension. Insulators shall be a one piece assembly, clear color, composed of an epoxy-fiberglass core rod, weather-sheds, and end fittings, as specified. Shall be 25 kV Class Polymer Type, Chance Epoxilator II, Cat. No. C654-2500, or equal.
 - 2) **Tie-Top Post Insulator:** Shall have a minimum rating of 12.45 kN (2,800 lb) cantilever strength. Shall be 25 kV Class, porcelain type, malleable iron base, clear color, conforming to ANSI C29.7, A.B. Chance 210 N. Allen, Centralia, MO 65240, Phone: (314) 682-5521, Fax: (314) 682-8475, Tie-Top Post Insulator, Cat. No. C903-1011, or equal.
 - 3) **Guy Strain Insulator:** Shall be ANSI Class 54-1 conforming to ANSI C29.4. Tensile strength shall not be less than 45 kN (10,000 lbs), and shall be Chance Cat. No. C909-1041, or equal.
 - 4) **Spool Insulator:** Shall be ANSI Class 53-2 conforming to ANSI C29.3, and shall be Chance Cat. No. C909-1032, or equal.
- h. **Guy Wire:** Guy strand shall be seven-strand, zinc-coated steel conforming to ASTM A 475, Utilities grade. Breaking strength shall be not less than 51 kN (11,500 lbs).
- i. **Anchors:** Power installed screw anchors, with 200 mm (8 inch) diameter, double helix for Class 4, 5, and 6 soils, as determined by ASTM D 1586 blow count, complete with rod extensions, number as required, and guy adapters. Shall be installed for pole guys. Components of the anchor system shall be hot-dip galvanized.
- j. **Station Class Surge Arrester:** For the tower section of the 12 kV line, arresters shall be of the Station Class, MOV technology for use on a 12 kV ungrounded system. Lightning arresters shall be Mc Graw-Edison (Cooper Power Systems P.O.Box 2850, Pittsburgh, PA 15230, Phone: (414) 524-3300, Fax: (414) 524-3474), VariStar Type ATZ porcelain-top design Cat. No. ATZ10A15, or equal. Arresters shall be solidly grounded. Necessary accessories required for a complete

installation shall be furnished. Arresters shall conform to NEMA LA 1, with ratings as determined by IEEE C62.11.

- k. **Distribution Class Surge Arrester:** For the pole line section of the 12 kV line, arresters shall be of the distribution class for use on a 12 kV ungrounded system. Lighting arresters shall be Kearney (P.O.Box 49167, Atlanta, GA 30359, Phone No. (404)939-6011, Fax (404)938-5790) Cat. No. 238215 type SGR, or equal. Arresters shall be solidly grounded. Necessary accessories required for a complete installation shall be furnished. Arresters shall conform to NEMA LA 1, with ratings as determined by IEEE C62.11.
 - l. **Cable Terminations:** Shall be single conductor, porcelain, 25 kV, 110 kV BIL, for use with XLPE shielded cable. Cable terminations shall be 3M Electrical Products Division, 6801 River Place Blvd., Austin, TX 78726-9000, Phone: 1-800-245-3573, Fax: 1-800-245-0329, 5900 Series Scotch-cast Porcelain Termination Kits, Cat. No. 5906, or equal. Necessary accessories and mounting bracket required for a complete installation shall be furnished. Cable terminations shall conform to IEEE Standard 48.
 - m. **Ground Rods:** Shall be copper clad steel, 19 mm (3/4-inch) diameter by 2,400 mm (8 feet) long, or equal. Ground rods shall conform to Federal Specification W-R-550.
 - n. **Cross-Arms:** Cross-arms shall be solid wood, distribution type, except cross-sectional area with pressure treatment conforming to AWPA C25, and a 6.4 mm (1/4 inch), 45 degree chamfer on all top edges. Cross-sectional area shall be 120 mm (4-3/4 inches) in height by 95 mm (3-3/4 inches) in depth in accordance with IEEE C2 for Grade B construction. Cross-arms shall be 2.4 m (8 feet) in length. Cross-arms shall be machined, chamfered, trimmed, and bored for stud and bolt holes before pressure treatment. Factory drilling shall be provided for pole and brace mounting, for four pin or four vertical line-post insulators, and for four suspension insulators, except where otherwise indicated or required. Drilling shall provide required climbing space and wire clearances. Cross-arms shall be straight and free of twists to within 2.5 mm per 304.8 mm (1/10 inch per foot) of length. Bend or twist shall be in one direction only. Wood cross-arms shall conform to ANSI O5.3
 - o. **Acrylic Emulsion Paint for Concrete Poles Marking:** Shall be exterior grade emulsion type paint conforming to Federal Specification TT-P-19. Paint shall be factory mixed by a recognized manufacturer and shall be used as mixed at the factory. No thinning of the paint will be permitted.
2. **For 44 kV Line:**
- a. **Line Conductor:** Conductor shall be 477 Kcmil, all aluminum conductors (AAC).

- b. **Ground Conductors:**
 - 1) **Overhead Shield Wire:** Shield wire shall be bare aluminum-clad steel wire (Alumoweld, or equal), 7 No. 7 strands, conforming to ASTM B 415 and B 416, with minimum 20 percent IACS conductivity at 20 °C (68 °F).
 - 2) **Ground Conductor:** Down ground conductor and down conductor for surge arresters shall be soft-drawn, bare, solid No. 2 AWG copper conductor, conforming to Federal Specification A-A-59551, and ASTM B 3.
- c. **Hardware:** Hardware shall be hot-dip galvanized steel. Hardware shall conform to IEEE C135 series standards referenced.
- d. **Suspension Insulators:** Shall be rated for a 69 kV system and made of silicone rubber and shall be of clear color. Insulators shall comply with ANSI C29.12.
- e. **Station Class Surge Arrester:** For the 44 kV line, arresters shall be of the station class for use on a 44 kV ungrounded system. Lighting arresters shall be Kearney (P.O.Box 49167, Atlanta, GA 30359, Phone: (404) 939-6011, Fax: (404) 938-5790), or equal. Arresters shall be solidly grounded. Necessary accessories required for a complete installation shall be furnished. Arresters shall conform to NEMA LA 1, with ratings as determined by IEEE C62.11.
- 3. **Conduit System:** All conduit risers shall be PVC schedule 80 and underground conduits shall be PVC Schedule 40.
- 4. **Conduit End Bells and Plugs:** Plugs shall provide a watertight joint, and shall be of the same material as the conduit.
- C. **Installation:** This Section contains the specifications for overhead distribution line installation.
 - 1. **Aerial Conductors and Wires:**
 - a. **Conductors and Wires:** Unless otherwise indicated, conductors shall be installed in accordance with tables of sags and tensions. Care shall be taken in handling and stringing of conductors to guard against cuts, scratches, and kinks. Conductors and wires shall not be drawn over rough or rocky ground, or around sharp bends. When drawn by machine power, conductors and wires shall be drawn from the mounted reel through stringing blocks in approximately straight lines and clear of all obstructions. Initial stringing sags and tensions shall be in accordance with the tables for the conductor and wires, provided minimum IEEE C2 clearances are maintained. Conductors shall be installed in accordance with IEEE 524, the stringing and sag procedures, and shall be continuous, without splices, from strain tower to strain tower or dead end pole to dead end pole. Initial sag and tension shall be checked by the Contractor, in accordance with the sag

and tension charts, within an elapsed time after installation as recommended by the manufacturer.

- b. **Clamps, Dead ends, and Brackets:** Conductors and wires shall be secured at strain towers with strain clamps and brackets. Conductors and wires shall be supported at dead-end poles and angle poles with strain clamps, or neutral clevises.
 - c. **Splices:** Splices shall be used only if absolutely necessary and if reviewed by the Employer's Representative. Splices under tension shall be electrically secured and shall not have less strength than the conductor. Splice materials shall be non-corrosive and shall not adversely affect the conductor with which they are used. The splices shall be made with automatic compression fittings suitable for the specified line conductor or overhead ground wire and shall have an electrical conductance greater than the corresponding conductor. Splice fittings shall not be drawn through stringing blocks.
 - d. **Conductor-to-Insulator Attachments:** Conductors shall be attached to insulators by means of clamps, or tie wires, in accordance with the type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as required.
 - e. **Connectors:** Specified parallel connectors with compound shall be installed for overhead connections as shown on drawing details. Connectors shall conform to ANSI C119.4 and shall be of the type and style required for the specified conductor or connection. On overhead connections of aluminum and copper, the aluminum shall be installed above the copper.
 - f. **Line Guards:** Line conductors shall be protected at vertical insulators with preformed round line guards suitable for the specified aerial conductor. Line guards shall be packaged as a set and dependably installed as a set, in accordance with the manufacturer's instructions.
2. **Grounding:** The overhead shield wire, surge arresters, and non-current-carrying metal parts of all equipment shall be grounded. Overhead ground shield wire shall be connected directly to a driven ground rod, at each and every pole providing a grounding conductor for the surge arrester and equipment grounding conductors and a separate grounding conductor for the shield wire. The overhead shield wire and surge arrester ground conductor shall each be connected to a copper-clad steel ground rod 2,438 mm (8 feet) long and 19 mm (3/4 inch) in diameter. Ground conductor shall be separate and independent from the surge arrester ground, but shall be bonded together at the ground rods. Ground conductor for station class surge arresters shall be permanently connected to down ground conductor at each tower leg. Installation shall conform to general requirements of IEEE 142.

3. **Conduit System:**

a. **Connections Between Aerial and Underground Systems:** Rigid PVC schedule 80 conduit risers shall be run exposed and securely fastened to towers and concrete poles. Exposed conduit shall run parallel with or at right angles to structures. Conduits shall be equipped with bushings to protect cables and sealed with duct seal to minimize water entry. Cables shall be supported by devices separate from the conduit, near their point of exit from the conduit. Coupling between underground conduit run and riser shall be made with approved fitting.

b. **Securing:** Exposed rigid PVC conduit riser shall be secured to the towers by 1-hole malleable iron pipe strap and clamp back spaced not more than 3,000 mm (10 feet) apart and with 1 strap not more than 300 mm (12 inches) from any bend or termination.

c. **Underground Conduit Section:** Shall be rigid PVC schedule 40 conduit buried in trench so that the top surface of conduit is at least 650 mm (26-inches) below finished grade. Underground conduits shall be installed directly buried in earth in trenches backfilled with selected soil devoid of rocks or other objects which could harm the conduit or its protective coat. End bells shall be provided for conduits terminating in the electrical manhole. Exposed conduit or riser installation shall be supported by means of galvanized iron clamps or hangers. Field made bends shall be made with a conduit bender; field cut conduit shall be reamed. Crushed or deformed conduits are not acceptable.

4. **Running Ground:** A running ground shall be used for each wire or conductor during installation to prevent buildup of electrical charge due to atmospheric conditions and to protect personnel in the case of a lightning strike to the line. A ground cable shall be installed from the running ground assembly to an existing tower down conductor, or, as secondary choice, to a driven ground rod.

5. **Temporary Grounds:** Temporary ground shall be installed at each tower section or pole section before installing new equipment or new conductors. Following the overhead conductor installation, temporary grounds shall be installed so that each completed section of the line is grounded at the beginning and at the end of that section. Grounds shall be moved, as necessary, to comply with this requirement. Grounds shall also be removed before the energization test. Temporary grounds shall be installed and removed in accordance with the applicable instructions in the Manual de Seguridad en Operaciones de Alto Voltage (Electrical Division Safety Handbook).

6. **Surge Arresters:** Shall be provided and shall be rated for the application.

7. **Cable Splices:** Final high voltage splices will be made by the Employer. Temporary splices, if required, shall be made by the Contractor. No splices will be permitted unless previously approved by the Employer's Representative.

8. **Concrete Poles:** ^{A17}Minimum pole-setting depths shall be as per final design Contract drawings and specifications.^{A17} In rocky or swampy ground, pole-setting

depths shall be respectively decreased or increased as required. Where poles are set on hilly terrain, along the edge of cuts or embankments, or where the soil may be washed out, special precautions shall be taken to ensure durable foundations, and the setting depth shall be measured from the lower side of the pole. Holes shall be dug large enough to permit the proper use of tampers to the full depth of the hole. Backfill shall be placed into the hole in 150 mm (6 inch) maximum layers, then thoroughly tamped before the next layer is placed in. Surplus backfill material shall be placed around the pole in a conical shape and packed tightly to drain water away from pole. Set poles in alignment and plumb except at corners and dead-ends, where they shall be set and raked against the strain.

9. **Cross-Arms:** Cross-arms shall be bolted to poles with 15.9 mm (5/8 inch) through-bolts with square washers at each end. Bolts shall extend not less than 3 mm (1/8 inch) or more than 50 mm (2 inches) beyond nuts. On single cross-arm construction, the bolt head shall be installed on the cross-arm side of the pole. Wood cross-arm braces shall be provided on cross-arms. Angle braces are required for 2,440 mm (8 foot) cross-arms and shall be 1,520 mm (60 inch) span by 460 mm (18 inch) drop. Angle braces shall be bolted to arms with 13 mm (1/2 inch) carriage bolts with round or square washers between bolt-heads and cross-arms, and secured to poles with 16 mm (5/8 inch) machine bolts after cross-arms are leveled and aligned. Double cross-arms shall be securely held in position by means of 16 mm (5/8 inch) double-arming bolts. Each double-arming bolt shall be equipped with four nuts and four square washers.
10. **Guys:** Guys shall be provided at poles, as required, in conformity with the National Electrical Safety Code, IEEE C2, wherever conductor tensions are not balanced, such as, at angles, corners, and dead-ends. Where a single guy will not provide the required strength, two or more guys shall be provided. Guy tensions shall not exceed 50% of guy breaking strength. Guy anchors and attachments shall provide a strength exceeding the required guy strength. The guy shall be attached to the pole as near as practical to the center of the conductor load without reducing the insulation level of the cross-arms and braces. A preferred slope of 1:1 shall be maintained for guy wires wherever possible; however, this may be reduced to a steepness limit of 3:2.^{A17} Where field conditions prevent the installation of the indicated guy lead, anchors shall be placed in a location as per final design Contract drawings and specifications.^{A17} Guys shall be terminated at pole bands for dead-end poles and corner poles or at thimbleeyes elsewhere, and fastened with galvanized 3-bolt guy clamp at the pole end and at the anchor rod end. Guys shall be insulated. A two-thirds round guy gray guard shall be installed at the anchor of each guy, securely clamped to the guy or anchor rod at top and bottom.
11. **Anchors:** Anchors shall be provided for each guy wire required, and shall be set opposite to the resultant pull for corner installations, or opposite to the conductor pull for dead-ended installations, except where additional anchors are required. Power installed screw anchors shall be installed in accordance with the manufacturer's instructions using a torque indicator. The anchor system, including the adjustable deadens, shall provide strength exceeding the guy wire breaking limits.
12. **Grounding Electrodes:** Grounding electrodes shall be installed as follows:

- a. **Driven Rod Electrodes:** Unless otherwise indicated, ground rods shall be located approximately 1,200 mm (4 feet) out from base of the pole and shall be driven into the earth until the tops of the rods are approximately 300 mm (1 foot) below finished grade. Multiple rods shall be evenly spaced at least 3,000 mm (10 feet) apart and connected together 600 mm (2 feet) below grade with a No. 2 bare copper conductor. Connections above grade shall be exothermically welded or shall use UL 467 approved connectors. Connections below grade shall be exothermically welded.
- b. **Ground Resistance:** The maximum resistance of a driven ground rod shall not exceed 25 ohms under normally dry conditions. Whenever the required ground resistance is not met, provide additional electrodes interconnected with grounding conductors, to achieve the specified ground resistance. The additional electrodes shall be up to three, 2.4 m (8 feet) rods spaced a minimum of 3,000 mm (10 feet) apart. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Employer's Representative shall be notified immediately.

1.05 SUBMITTALS:

- A. **General:** All submittals required below shall be in accordance with Section 01 33 00 (*Submittal Procedures*). Taking-over submittals shall be in accordance with Section 01 77 00 (*Taking-Over Procedures*).

1. **Before Manufacturing:**

- a. **Intermediate Design Analysis:** The intermediate design analysis shall consist of a written explanation of the overhead line system and equipment selection. It shall contain a summary of the criteria for the background of the intermediate design. The design criteria shall include the basic criteria furnished by the Contract documents, letters, codes, references, conference minutes, pertinent research, and safety requirements. The justification for each major selection and design decision shall be clearly stated, and include supporting calculations, when applicable.
- b. **Intermediate Design Specifications:** The Contractor shall include detailed specifications of the overhead line system. The specifications shall include detailed description of materials, equipment, accessories, tests, and any additional data as may be required for the evaluation.
- c. **Intermediate Design Drawings:** Intermediate design drawings shall be of high quality and complete to permit the Employer's Representative a thorough evaluation of the technical solution provided for the proposed overhead line systems. Drawings shall include capacity, rating, principal arrangement, intermediate design calculations, and the name and brand of major components and materials.

2. **Before Shipment:**

a. **Factory Test Reports:** Shall be submitted for the following:

- 1) Line conductors
- 2) Line hardware
- 3) Insulators
- 4) Surge arresters
- 5) Cable terminations

3. **Before Installation and Construction:**

a. **Descriptive Data:** Submit descriptive literature and technical data sheets that establish exactly what the Contractor proposes to furnish. The descriptive data shall be in sufficient detail and scope to verify compliance with the requirements of the Contract. Submit descriptive data for the following:

- 1) Line conductors
- 2) Overhead shield wire
- 3) Ground conductors
- 4) Concrete pole
- 5) Conduit
- 6) Line hardware
- 7) Insulators
- 8) Anchors, rods, and guards
- 9) Surge arresters
- 10) Cable terminations
- 11) Ground rods
- 12) Cross-arms

b. **Factory Test Reports:** Submit factory test reports for the specified insulators. Reports shall include electrical tests such as dielectric, tracking, and impulse tests; mechanical loading tests; ultraviolet exposure tests; and contamination tests. Reports shall include routine tests as well as production tests performed, showing conformance to standards.

c. **Stringing Procedure:** Submit a written stringing procedure describing the proposed equipment and techniques to install the overhead ground wires and line conductors. All stringing blocks proposed for use, shall be inspected by the Employer's Representative.

- d. **Sag Procedure:** Submit a written sag procedure describing the proposed equipment and techniques to properly sag and tension the overhead ground wires and line conductors.
- e. **Sag-Tension Charts:** Initial and final sag-tension charts for the specified line and overhead ground wire shall be submitted by the Contractor for review. Charts are based on IEEE C2 light loading at various temperatures, 15.5 °C to 100 °C (60 °F to 212 °F), and wind load at 15.5 °C (60 °F), for ruling spans from 30 to 90 m (100 to 300 feet), in 3000 mm (10 feet) increments. Maximum tension is 9 kN (2,000 pounds) at 15.5 °C (60 °F) and 450 kPa (9 psf), with a 1.3 gust factor.
- f. **Overhead Distribution Line Conductor Installation Plan:** ^{A17}The Contractor shall submit a conductor installation plan for all conductors in accordance with the final design Contract drawings and specifications. Conductor installation plan shall include: ^{A17}
 - 1) Site layout drawing with conductor installation sections identified in numeric order of expected installation sequence and direction of installation.
 - 2) List of cable installation equipment.
 - 3) A written conductor installation procedure shall be submitted for review, describing the proposed equipment and techniques to install the overhead conductors. All equipment proposed for use shall be inspected before use, by the Employer's Representative.
- g. **Final Electrical Design Data:** After 100% completion of the intermediate design and prior to the installation or construction of the overhead lines, the Contractor shall submit to the Employer's Representative for review, final design data including, as a minimum, a description of the system or components, design calculations, design drawings, diagrams, design specifications, equipment and material specifications.
- h. **Final Design Specifications:** Submit the electrical system design specifications of the equipment, hardware, and components, including, as a minimum, the final general dimensions, the exact location of major components, and the design ground resistance.
- i. **Final Design Drawings:** Submit final electrical design drawings, for the construction of the electrical line. Drawings shall contain all details, dimensions, subassembly and assembly plans of the equipment, including complete material specifications and installation information, tolerances, mechanical and electrical properties, surface finishes.

4. **Taking-Over Submittal:**

- a. **“As-Built” Drawings:** ^{A17}Submit “as-built” drawings including the deviations, modifications, and changes from the final design Contract drawings and specifications.^{A17} The as-built drawings shall be complete and show the location, size, dimensions, part identification, and other information. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor’s quality control representative and by the Employer’s Representative prior to the completion of the Works.
- b. **Digital Computer Drawings:** The Contractor shall furnish upon completion of the electrical line, reproducible drawings, each on a CD-ROM medium, as per Section 01 33 00 (*Submittal Procedures*).
- c. **Documents:** Instructions and maintenance books, manuals, part lists, etc. of all material and installations shall be delivered as per Section 01 33 00 (*Submittal Procedures*).
- d. **Certified Factory Test Reports:** Submit factory test reports of the routine and production factory tests normally performed by the manufacturer, including test required by standards listed in Paragraph 1.02. Results of factory tests performed shall be certified by the manufacturer, or an approved testing laboratory. The manufacturer pass/fail criteria for tests shall be included. Factory test reports shall include both routine tests as well as production tests. Test reports shall include as a minimum:
 - 1) A list of all equipment used, with calibration certification
 - 2) A copy of all measurements taken
 - 3) The dates of testing
 - 4) The equipment and values to be verified
 - 5) The condition specified for the test
 - 6) The test results, signed and dated
 - 7) A description of all adjustments made
- e. **Field Test Plan:** A proposed field test plan shall be submitted prior to testing the installed system. ^{A16}No field test shall be performed until the test plan is reviewed.^{A16} The test plan shall consist of the manufacturer recommended field test procedures, test equipment required, pass/fail criteria, and tolerance limits. In addition, field testing shall be in accordance with the applicable requirements in Section 26 90 00 (*Field Testing Electrical Systems*).

- f. **Certified Field Test Reports:** After successfully completing the field tests, submit certified field test reports.
- g. **Major Purchased Components List:** Submit a list of all components that are installed in the electrical line. The list shall include but shall not be limited to: the equipment type, manufacturer's name and address, model number, description of component and estimated cost at the time of delivery.
- ^{A16}h. **Reserved.** ^{A16}

1.06 QUALITY ASSURANCE:

- A. **Sag and Tension Test:** ^{A17}The Employer's Representative shall be given a 36-hour advance written notice of the time intended for stringing conductors. ^{A17} The Employer's Representative reserves the right to witness the procedures used so as to ascertain that initial stringing sags and tensions are in compliance with the requirements of the applicable loading district, temperature, and specified conductors.
 - 1. **Ground Resistance Measurements:** Ground resistance of each ground rod shall be taken and certified by the Contractor. The Contractor shall submit, in writing, at the completion of the Works, the measured ground resistance of each ground rod, indicating the location of the rod, as well as the resistance and soil conditions at the time the measurements were made. Ground resistance measurements shall be made in normally dry weather, not less than 48 hours after rainfall, and with the ground under test isolated from other grounds. The resistance to ground shall be measured using the fall-of-potential method described in IEEE 142; earth resistivity shall be measured in accordance with IEEE 81.
 - 2. **High Potential Test:** May be performed on the overhead section of the distribution line by the Employer's Representative before final connections. Each phase conductor shall be given a high potential test by applying a direct current voltage between each conductor and ground, of magnitude 3 times the operating voltage, with the temporary grounds removed.
 - 3. **Field Test:** The Contractor shall perform the field tests in accordance with the field test plan.
 - 4. **Commissioning:** ^{A17}Shall conform to Section 01 91 00 (*Tests on Completion and Tests after Completion*). ^{A17}

END OF SECTION

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