

## SECTION 26 05 43 – UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

### 1.01 <sup>A7</sup>SUMMARY:<sup>A7</sup>

- A. **Basic Function (Functional Requirement):** <sup>A7</sup>An underground duct and raceway systems shall be designed and constructed **by the Contractor** to provide the Atlantic and Pacific lock complexes with a secure and protected means of running and securing all of the different types of cables required for the lock complexes operation. Cables shall be lodged in ducts and raceways in distinct runs considering the nature of the cables, redundancy, protection and its importance to the continued operation of the locks, including maintenance, and the possibility of cable failures. The underground ducts and raceways for all of the cables required for the lock complexes shall provide for ease of installation, protection, and accessibility for maintenance.<sup>A7</sup>
- B. **Scope:** <sup>A7</sup>This Section contains the performance and prescriptive specifications for the design and construction of underground ducts and raceways for the electrical, communication, control, closed-circuit video system (CCVS), fiber optic, and security system cables and for other cables as required for the operation and control of the Atlantic and Pacific lock complexes.<sup>A7</sup>

### <sup>A16</sup>1.02 REFERENCES:<sup>A16</sup>

- A. **American Association of State Highway and Transportation (AASHTO) Standard**  
H 25                                      Wheel Loading
- B. **American Society for Testing and Materials (ASTM) Specification Standard**  
<sup>A7</sup>C 478-08                                      Precast Reinforced Concrete Manhole Sections<sup>A7</sup>
- C. **National Electrical Manufacturing Association (NEMA) Standards**  
TC 2-03                                      Electrical Polyvinyl Chloride (PVC) Conduit  
TC 3-04                                      <sup>A7</sup>Polyvinyl Chloride (PVC) Fittings for use with Rigid  
PVC Conduit and Tubing<sup>A7</sup>  
TC 6-03                                      Polyvinyl Chloride (PVC) Plastic Utilities Duct for  
Underground Utilities
- D. **National Fire Protection Association (NFPA) Publications**  
70-08                                      National Electrical Code (NEC)
- <sup>A16</sup>E. **Institute of Electrical and Electronics Engineers (IEEE) Standards:**  
835 – 94                                      Standard Power Cable Ampacity Tables<sup>A16</sup>

### 1.03 <sup>A7</sup>REQUIREMENTS:<sup>A7</sup>

- A. <sup>A7</sup>**General:** An underground duct and raceways system shall be designed and constructed as required for the installation of medium voltage and low voltage electrical wiring, communication and control cables, security, CCVS, and other types of cables for the Atlantic and Pacific lock complexes, so as to accommodate all cables required for the initial installation and provide enough flexibility for future expansion. Separate duct bank and raceway systems shall be used for medium voltage power cables; low voltage power distribution cables; and communication, control, security, and CCVS cables. Each duct bank and raceway system shall include different manholes, cable trays, cable risers, etc. so that power cable fire or explosions do not disrupt the service of critical cables.<sup>A7</sup>
- B. <sup>A7</sup>**Ease of Maintenance and Avoidance of Catastrophic Damage:**<sup>A7</sup> Duct runs shall be designed to drain toward manholes. However, all used and unused duct lines shall be plugged to avoid the entrance of water and debris. Manholes shall be provided with ample space for quick entrance/egress and for working inside them. <sup>A7</sup>Ducts lines, vertical cable risers, and cable tray runs shall provide for separation of cables to minimize the possibility that failure/fires in power cables could inflict catastrophic damages to adjacent cables and impair lockage operations.<sup>A7</sup>
- C. **Cable Galleries:** <sup>A7</sup>Cable galleries shall be constructed below each medium voltage switchgear to provide a means to run all incoming and outgoing medium and low voltage cables, control cables, communication cables, CCVS cables, and any other type of cables called for in the specifications or performance requirements. Separation of medium-voltage cables and other cables is required as noted in paragraph 1.01.A.<sup>A7</sup> Walking space and other provisions of the cable gallery shall be as required in Section 26 13 00 (*Medium Voltage Switchgear*).
- <sup>A16</sup>D. **Incoming Feeders Duct Lines:** The Contractor shall design and construct an underground concrete encased duct line to enable the Employer to have access to the incoming medium voltage switchgear cubicles. The duct line(s) shall extend from the cable gallery located below the incoming switchgear(s) to a point 5 meters from the end of the perimeter encircling the Footprint of the Lock Structures and in the direction in which the Owner constructed duct line will be oriented towards the lock complex. This applies to both lock complexes. The duct line shall end in a manhole. The Contractor shall coordinate with the Owner for the final exact location of the final manhole. Distance between manholes shall not be more than 100 meters. The minimum amount of ducts shall be adequate to lodge two three phase circuits. Each circuit will consist of three single copper conductor cables with extruded insulation, duct arrangement and circuit capacity shall be as per the load calculated by the Contractor and in accordance with IEEE 835. In addition the Contractor shall leave 100% duct spare capacity, plus four 100 mm ducts to be used for a ground conductor and fiber cables.<sup>A16</sup>

### 1.04 <sup>A7</sup>Design and Performance Requirements:<sup>A7</sup>

- A. **Duct Lines:** <sup>A7</sup>Electrical ducts shall be sized no less than 10 cm nominal diameter. Duct lines shall be concrete-encased PVC ducts (conduits) Schedule 40 wall type, which shall extend between manholes for the installation of medium voltage, low voltage, control, communication, security, CCVS and other type of cables as required by the design and construction of the lock complex. Control, communication, security, CCVS, fiber-optic, and other types of critical

operation low voltage control cables shall not occupy the same manhole spaces as medium- and low voltage power cables.<sup>A7</sup> Numbers and sizes of ducts shall be as required. However, additional ducts shall be provided as spare capacity. Duct lines shall be laid with a minimum slope of 100 mm per 30 m run. <sup>A7</sup>Depending on the contour of the finished grade, the high point may be at a cable trench, a manhole, or a pull-hole or located between manholes or pull-holes. Manufactured 90-degree duct bends shall be used only for pole or equipment risers, unless specifically indicated as acceptable.<sup>A7</sup> The minimum manufactured bend radius shall be 45 cm for ducts of less than 7.5 cm in diameter, and 91 cm for ducts 7.5 cm or greater in diameter. <sup>A7</sup>Otherwise, long sweep bends having a minimum radius of 7.6 m shall be used for any change of direction of more than 5 degrees, either horizontally or vertically.<sup>A7</sup> Both curved and straight sections may be used to form long sweep bends as required, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in manholes, pull-holes, or cable trenches. Duct line markers shall be provided as indicated at the ends of long duct line stub-outs or for other ducts whose locations are indeterminate because of duct curvature or terminations at completely below-grade structures. In lieu of markers, a 5-mil (1 mil is 0.001 inches) brightly colored plastic tape not less than 7.5 cm wide and suitably inscribed at not more than 3 m on centers with a continuous metallic backing and a corrosion resistant 1-mil metallic foil core to permit easy location of the duct line, shall be placed approximately 30 cm below finished grade levels.

1. **Treatment:** <sup>A7</sup>Ducts shall be kept clean of concrete, dirt, and foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and shall match factory tapers.<sup>A7</sup> After a duct line is completed, a standard flexible mandrel shall be used for cleaning followed by a brush with stiff bristles. Mandrels shall be at least 30 cm long and have diameters 6.4 mm less than the inside diameter of the duct being cleaned. Pneumatic rodding may be used to draw in lead wires. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. <sup>A7</sup>Ducts shall be stored to avoid warping and deterioration, with their ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.<sup>A7</sup>
2. **Concrete Encasement:** <sup>A7</sup>Each single duct shall be completely encased in concrete with a minimum of 8 cm of concrete around each duct, except that only 5 cm of concrete are required between adjacent electric power or adjacent communication ducts of the same type. However, 10 cm of concrete shall be provided to separate adjacent electric power and communication ducts from each other.<sup>A7</sup> Duct line encasements shall be monolithic construction. Where a connection is made to a previously poured encasement, the new encasement shall be well bonded or doveled to the existing encasement. At any point, tops of concrete encasements shall be not be less than 60 cm below finished grade or paving. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed no further apart than 1.2 m on centers. <sup>A7</sup>Ducts shall be securely anchored to prevent movement during the placement of concrete, and joints shall be staggered at least 15 cm vertically and horizontally. Concrete strength shall be no less than 3,000 pounds ultimate compressive strength at 28 days.<sup>A7</sup>

3. **Installation of Couplings:** <sup>A7</sup> Joints in each type of duct shall be made up with the manufacturer's recommended couplings. Duct joint couplings shall be made watertight.<sup>A7</sup>
4. **Plastic Duct and Fittings:** Duct joints shall be made by brushing plastic solvent cement on insides of plastic coupling fittings and on outsides of duct ends. Each duct and fitting shall then be slipped together with a quick one-quarter-turn twist to set the joint tightly. <sup>A7</sup>Care shall be taken to prevent solvent cement from entering the interior of the joint.<sup>A7</sup> Plastic ducts and accessories shall be in accordance with NEMA TC-2, TC-3, and TC-6.
5. **Spare Ducts:** The Contractor shall leave spare ducts amounting to 100% of the ducts used to accommodate the various cables required by the final design.

B. <sup>A7</sup>**Manholes and Pull-Holes**<sup>A7</sup>

1. **General:** The exact location of each manhole shall be determined after careful consideration has been given to the location of other utilities, grading, and paving. Manholes shall be of ample interior space to accommodate the amount of conductors/cables routed through the manhole, to avoid sharp bends, and to provide ample space for qualified personnel to perform splices, accommodate conductors/cables, pulling, tagging, and other functions as may be required to install and maintain throughout the life of the installation. <sup>A7</sup>Manhole tops, walls, and bottoms shall consist of reinforced concrete.<sup>A7</sup> Walls and bottoms shall be of monolithic concrete construction. The Contractor may at his option utilize monolithically constructed pre-cast-concrete manholes having the required strength established by ASTM C 478. Frames and covers shall be made of gray cast iron. <sup>A7</sup>A machine-finished seat shall be provided to ensure a matching joint between the frame and cover.<sup>A7</sup> Frames and covers shall be delivered on the job unpainted and, after approval, shall be given two coats of asphalt paint. In paved areas, frames and covers for manhole and hand-hole entrances in vehicular traffic areas shall be rated for the vehicle load expected. However, load rating shall be not less than 20,000 lb minimum wheel load, in accordance with AASHTO H25. The top of manhole covers shall be flush with the finished surface of the paving. In unpaved areas, the top of manhole covers shall be approximately 1.3 cm above the finished grade. <sup>A7</sup>Manhole covers shall be sized no smaller than as shown in the reference drawing No. 6170 "Power Manhole Details".<sup>A7</sup> Where duct lines enter manholes, the sections of duct may be either cast in the concrete or may enter the manhole through a square. A sump shall be provided at each manhole. A cable-pulling iron shall be installed in the wall opposite each duct line entrance. Manhole covers shall be marked "HIGH VOLTAGE ELECTRICAL", "LOW VOLTAGE ELECTRICAL" or "COMMUNICATION" in relation to the type of cables lodged in the manhole. All manholes shall be provided with sumps for drainage by a portable pump.
2. **Hardware:**
  - a. <sup>A7</sup>**Electrical Manholes:**<sup>A7</sup> Cables shall be securely supported from walls by hot-dip galvanized cable racks with a plastic coating over the galvanizing and equipped with adjustable hooks and insulators. <sup>A7</sup>Sufficient number of cable racks shall be installed in each manhole as required to support cables not to exceed the cable manufacturer recommendation, and not less than two square hooks shall be installed on each cable rack, with additional space provide to incorporate additional

hooks in the future.<sup>A7</sup> Insulators shall be made of high-glazed porcelain. Insulators will not be required on spare hooks.

- b. **Communications Manholes:** <sup>A7</sup>Sufficient number of hot-dip galvanized cable racks with a plastic coating over the galvanizing shall be installed in each communication manhole as required to support cables not to exceed the cable manufacturer recommendation.<sup>A7</sup> Each cable rack shall be provided with no less than two cable hooks, with provisions to incorporate additional hooks in the future.
- c. **Ground Rods:** <sup>A7</sup>In each electrical manhole and at a convenient point close to the wall, two ground rods shall be installed, each in a diagonally opposing corner. Ground rods shall be as detailed in Section 26 05 26 (*Grounding and Bonding for Electrical Systems*).<sup>A7</sup>
- d. **Grounding:** All metallic cable racks shall be grounded by means of bare copper conductors extended to ground rods installed in the interior of the manhole. <sup>A7</sup>Grounding shall be as per Section 26 05 26 (*Grounding and Bonding for Electrical Systems*).<sup>A7</sup>

C. **Crossunder and Vertical Shaft Raceways:**

- 1. **General:** The Contractor shall provide vertical raceways as pathways for all cables to be routed through the **Crossunders**. From the manholes at the lower end to the upper portion of the shaft there shall be provided raceways to house all types of cables to be routed, in order to provide physical and fire propagation protection of the cables. <sup>A7</sup>Adequate support of the raceways shall be provided, and cables shall be anchored and supported so as not to be subjected to damaging stress or insulation/covering creepage.<sup>A7</sup> Medium voltage cable raceway runs shall be installed in PVC schedule 40 conduits encased in concrete, in a similar fashion as required in paragraph 1.04 A. Pouring of concrete shall be coordinated to avoid collapsing the PVC conduits. Other cable raceways shall be **rigid galvanized steel conduit** if installed exposed.
  - a. **Spare Raceways:** The Contractor shall leave spare raceways amounting to 100% of the raceways used to accommodate the various cables required by the final design.
  - b. **Sump Pumps:** All **Crossunders** shall be provided with sumps and sump pumps permanently installed at both ends of each crossing, strategically located to automatically remove any water build up and to send an alarm to the Main Control Building [CB]. Sump pumps shall be in accordance with Section 01 86 13 (*Plant – Mechanical Systems and Equipment*).
  - c. **Installation and Maintenance:** Raceways shall be installed to permit ease of installation and maintenance. <sup>A7</sup>For this purpose, the design shall provide personnel with easy access to the cables in the vertical runs, as applicable. Readily available escape routes shall be provided in these accesses for evacuation of personnel in the event of an emergency.<sup>A7</sup>

## 1.05 SUBMITTALS:

### <sup>A16</sup>A. After Commencement Date: <sup>A16</sup>

1. <sup>A7</sup>General plan arrangement of each lock's **underground duct** and **raceway system**, including a written explanation of the system design and the equipment selection. It shall contain a summary of the criteria of the preliminary design. The justification for each major selection and design decision shall be clearly stated, with supporting calculations, when applicable.<sup>A7</sup> The design raceway capacity and spare capacity provision for future use shall be clearly indicated. The preliminary design analysis shall include, but not be limited to, the following.
  - a. <sup>A7</sup>Capacity, rating, principal arrangement, burial depth, preliminary design calculations, and name and brand of major components.<sup>A7</sup>
  - b. Features incorporated in the design to provide personnel safety.
  - c. Features in the design incorporated to provide ease of maintenance.

### B. Before Installation/Construction:

1. **Final Design Data:** <sup>A7</sup>After 100% completion of the design and prior to the procurement of materials or equipment, the Contractor shall submit final design data to the Employer's Representative for his review.<sup>A7</sup> The design data shall include, as a minimum, a description of the system or components, design calculations, design drawings, diagrams, design specifications, equipment data, and material specifications.
  - a. **Ducts and Raceways System:** <sup>A7</sup>The final design data shall contain each typical arrangement, calculations, dimensions, and detailed descriptions of all equipment.<sup>A7</sup>
  - b. **System Design:** <sup>A7</sup>The final design data shall provide the final drawings showing the exact location of duct routes, manholes, cable supports, and accessories.<sup>A7</sup>

### C. Taking Over Submittals:

1. **General:** The Contractor shall comply with the requirements of Section 01 77 00 (*Taking-Over Procedures*).
2. **"As Built" Drawings:** The Contractor shall submit as built drawings, which shall include all revisions and changes made during construction and installation. Drawings shall include plan view, grid nodes, and the electrical parameters of the grid.
3. **Final Report:** <sup>A7</sup>The Contractor shall submit a final report, including all revised calculations, assumptions, database and inputs, tabulations, equipment

characteristics, equipment ratings and test records in both printed and digital form.<sup>A7</sup>

## 1.06 Quality Assurance:

### A. <sup>A7</sup>Testing and Inspection:<sup>A7</sup>

1. **General:** During construction and after completing the installation, the Contractor shall inspect ground conductors, ground rods, hardware, and connections for conformance with the required performance and workmanship.  
<sup>A7</sup>Testing of ground paths. In addition to the requirements for testing in this Section, field testing shall conform to Section 26 90 00 (*Field Testing Electrical Systems*).<sup>A7</sup>
  - a. **Visual and Mechanical Inspection:** Inspect ground system for compliance with the drawings and specifications.
  - b. Inspect ground conductors and connections for conformance with design specifications and for adequacy.
  - c. Maintain each ground rod isolated from the associated ground rods for tests on individual rods for resistance to earth.
  - d. <sup>A7</sup>Include associated ground rods and interconnecting wiring in resistance to earth tests.<sup>A7</sup>
2. **Electrical Tests:** <sup>A7</sup>Tests on individual ground rods shall conform to Section 26 05 26 (*Grounding and Bonding for Electrical Systems*) and Section 26 90 00 (*Field Testing Electrical Systems*).<sup>A7</sup>
3. **Records:** <sup>A7</sup>Make complete records of all tests. Include resistance values obtained, calculations of the same, and methods used for testing and calculation.<sup>A7</sup>
4. **Acceptance:** Grounding materials and connections must pass all inspections and must meet all specified maximum and minimum values.

**END OF SECTION**

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