

## SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

### 1.01 SUMMARY:

- A. **Basic Function (Functional Requirement):** <sup>A17</sup>The grounding and bonding systems shall be designed and constructed by the Contractor <sup>A17</sup> to provide a trouble free installation where the electrical, lighting, communication and control systems shall perform free of interference and protected against damage induced by short circuits and lightning. In addition, the systems shall provide protection against electrical shock for all working and visiting personnel.
- B. **Scope:** <sup>A17</sup>This Section contains the performance and prescriptive specifications for the design and construction of the grounding and bonding of the electrical system for the locks complex and electrical substation work. <sup>A17</sup> The major objective of the grounding and bonding system is to enhance and ensure safety, operations and power quality of the overall electrical, communication, process control, and other systems with high content of electronic equipment. <sup>A17</sup>

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

- A. <sup>A7</sup>**Institute of Electrical and Electronics Engineers (IEEE) Standards:** <sup>A7</sup>
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|---------|--|
| 81-83   | Guide for measuring earth resistivity, ground impedance, and earth potentials of a ground system |
| 118-92  | Standard Test Code for Resistance Measurement  |
| 141-98  | Electric Power Distribution for Industrial Plants  |
| 142-06  | Grounding of Commercial and Industrial Power Systems   |
| 446-95  | Emergency and Standby Power Systems for Industrial and Commercial Applications                   |
| 902-98  | Maintenance, Operation, and Safety of Industrial and Commercial Power Systems.                   |
| 1100-05 | Powering and grounding Sensitive Electronic Equipment.   |
| C2-07   | National Electrical Safety Code (NESC)   |
- B. <sup>A7</sup>**American National Standard Institute (ANSI) Standards:** <sup>A7</sup>
- |             |  |
|-------------|--|
| C2-07       | National Electrical Safety Code (NESC)   |
| C33.8       | Standard for Safety Grounding and Bonding Equipment                                      |
| J-STD-607-A | Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications |
- C. <sup>A7</sup>**National Fire Protection Association (NFPA) Publications:** <sup>A7</sup>
- |        |                                 |
|--------|---------------------------------|
| 70-08  | National Electrical Code (NEC). |
| 780-04 | Lightning Protection Code       |

70E-04 Standard for Electrical Safety Requirements for Employee Workplace

D. <sup>A7</sup>**Underwriters Laboratories (UL) Standards:**<sup>A7</sup>

467-04 Grounding and Bonding Equipment

**1.03 REQUIREMENTS:**

- A. **General:** The grounding system shall be optimized for equipment and personnel safety considerations and to avoid circulating and stray currents. The grounding system shall consist of a grid covering the entire locks complex, and consisting of earth mats, ground rods, bonding system, and equipment for a comprehensive grounding to achieve a ground **resistance of 0.5 ohm maximum** at any one building housing personnel or equipments of the electrical, control, surveillance or communication nature. The ground system shall be fully coordinated with the corrosion control requirements and designed in order to avoid corrosion to buried metal structures, pipes or others. The use of extensive electronic circuitry for the communication and control of the locks equipment require that there be established a **reference point** for all the grounds, bonding and shielding at each facility or building. At each of these reference points the maximum **resistance to earth shall be 0.5 ohm or less**. Each facility reference point shall be accessible for testing and checking the quality of the various grounding systems. Bonding connections to this reference point shall be made from the following list, but not limited to this list:

1. Building structural steel
2. Electrical equipment enclosures grounding conductor
3. Common point from the transformer wye
4. Transient protection equipment
5. Telecommunication equipment reference ground
6. Isolated 60 HZ power circuits
7. Equipment and Cable shields
8. DC power supply common
9. Main metallic water line to buildings
10. Lighting poles
11. Fence, metallic barrier
12. Mechanical equipment, rail and structures

All bonding connections shall be made with exothermic welding process, achieved by employing appropriate tools specifically tailored for each type of welded connection.

- B. **Conformance to Codes and Standards:** The grounding installation shall conform to the requirements of ANSI-J-STD-607-A; IEEE 141; IEEE 142; IEEE 446; IEEE 902; IEEE 1100; NFPA 780.

## 1.04 DESIGN AND PERFORMANCE REQUIREMENT:

### A. <sup>A7</sup>Systems Grounding:<sup>A7</sup>

1. <sup>A7</sup>**12,000 Volts System:**<sup>A7</sup> The 3 phase, 3 wire, 60 Hertz incoming feeders to the new set of locks shall consist of 12,000 volts, 60 Hertz, single conductors cables grounded at the source. <sup>A17</sup>The source at the Pacific side is taken from the existing Miraflores substation, and consist of a grounded 12 kV system derived from an existing Zig Zag transformer. The source at the Atlantic side is taken from the Agua Clara substation, and consist of a 12 kV grounded system.<sup>A17</sup>
2. <sup>A7</sup>**480/277 Volts System:**<sup>A7</sup> The 3 phase, 4 wire, 60 Hertz, 480/277 volts wye connected secondary system, shall have the transformer neutral solidly grounded at the transformer, per NFPA 70.
3. <sup>A7</sup>**240 Volt System:**<sup>A7</sup> The 3-phase, 3 wire, 60 Hertz, 240 volts delta connected secondary system, shall be an ungrounded system, per NFPA 70. Ungrounded systems shall be provided with ground detectors with audible and visual indicators.
4. <sup>A7</sup>**208/120 Volts System:**<sup>A7</sup> The 3 phase, 4 wire, 60 Hertz 208/120 volts wye connected secondary system, shall have the transformer neutral solidly grounded at the transformer, per NFPA 70.
5. <sup>A7</sup>**125 VDC System:**<sup>A7</sup> The direct <sup>A17</sup>current, <sup>A17</sup> 2 wire 125 volts DC system, shall be ungrounded, as per Section 26 33 00 (*Direct Current Equipment*).
6. <sup>A7</sup>**-48 VDC Volts System:**<sup>A7</sup> The <sup>A17</sup>direct current, <sup>A17</sup> 2 wire -48 volts DC system, shall be grounded, as per Section 26 33 00 (*Direct Current Equipment*).

### B. Equipment Grounding:

1. **General:** All non current carrying metallic parts of machinery and equipment shall be connected to ground by means of an equipment grounding conductor. A ground bus shall be provided for each distribution equipment enclosure such as switchgears, panelboards, motor control center and load center. Every low voltage feeder, branch circuit or circuit shall have an equipment ground conductor installed in the same raceway with the phases and neutral conductors. The equipment grounding conductors shall extend unspliced.
2. <sup>A7</sup>**12 kV Cable Shields:**<sup>A7</sup> Cable shields for the 12 kV cables shall be grounded at each splice and at each cable termination.
3. <sup>A7</sup>**Electrical, Mechanical and Machinery Equipments:**<sup>A7</sup> All non-current carrying parts of all electrical and mechanical equipments, switchgears, panelboards, motor controls, winches, motors, utilization devices, metallic junction boxes and enclosures, metallic raceways, metallic cable trays, shall be bonded to the ground bus.

4. <sup>A7</sup>**High Mast, Roadway, and Metallic Sign Poles:**<sup>A7</sup> The grounding lugs of the poles shall be directly connected to a local ground rod and bonded to the locks ground grid.
  5. **Buildings Steel:** Building steel structures shall be grounded at each column base. Bonding and jumpers shall be provided throughout the structure to ensure good ground continuity.
  6. <sup>A7</sup>**High Voltage and Electrical Room Grounding Ground Bus:**<sup>A7</sup> The ground bus at each location shall be directly buried to earth, in addition to being bonded to the common reference point.
  7. <sup>A7</sup>**Telecommunication and Control Rooms:**<sup>A7</sup> At each room there shall be provided a ground bus within the room, and bonded to the common reference ground in accordance with ANSI-J-STD-607-A (ANSI/TIA/EIA 607).
  8. **Perimeter Fence:** <sup>A16</sup>Any Perimeter fence encircling the Locks complex shall be grounded along the entire route, with bonding provisions for pedestrian and vehicular gates.<sup>A16</sup> Other temporary and permanent fences of the project shall also be grounded and bonded.
  9. **Locks Grounding Grid:** A grounding grid shall extend throughout the entire locks. The grounding grid shall consist of a directly buried below the surface of the earth of strategically located ground mats interconnected by copper “flat strip” or **standard bare copper** conductors. Bonding shall be made from each common reference point to this ground grid. <sup>A5</sup>The use and location of ground mats shall respond to the design of an interconnected ground grid, providing a maximum ground **resistance of 0.5 ohm** to the electrical system.<sup>A5</sup>
- C. **Lightning Protection:** Lightning protection shall be provided for all buildings and structures as required by NFPA 78 “Lightning Protection Code”. Air terminal shall be installed in each <sup>A17</sup>high mast pole<sup>A17</sup> and grounded at the base with ground rods, as well as bonded to the grounding grid.
- D. <sup>A7</sup>**Grounding Equipment and Hardware:**<sup>A7</sup>
1. **Common Reference Point:** Groups of copper ground rods or a ground **mat** consisting of a copper flat plate **or standard bare copper conductor** shall be installed as the common reference point directly buried in the ground with “Ground Enhancement Material”. Ground plates shall be installed in a way that they do not tend to loose ground contact after installed.
  2. <sup>A7</sup>**Copper Strips:**<sup>A7</sup> Copper flat strip shall consist of a flat copper strip of ampacity, dimensions and thickness as necessary to carry the ground currents expected and designed to maintain the ground resistance to each building and equipment as specified.
  3. **Ground Rods:** Ground rods shall consist of nickel-plated steel heavily plated in copper meeting UL 467 and ANSI C33.8. Minimum nominal size shall be 1.9 cm in diameter by 3 m long.

4. <sup>A7</sup>**Bonding and Grounding Conductors:**<sup>A7</sup> Bonding and grounding conductors shall be continuous from terminal without splice. Conductors shall be bare copper or with green insulation sized as required by NFPA 70.
  5. **Raceways:** All metal conduits entrances into switchgears, panelboards, metal pull boxes, equipments, or terminating in cable trenches, cable trays, shall be provided with grounding bushings. Bonding of the grounding bushing to ground shall be with a minimum # 10 AWG size copper conductor, and as required by NFPA 70.
  6. <sup>A7</sup>**Grounded Conductors:**<sup>A7</sup> Grounded neutral conductors shall be identified along its full length and branching. Neutral from different sources shall be color differentiated. Grounded conductors shall be colored white, gray or as required and permitted by the NFPA 70.
  7. **Markers:** Markers shall be designed and provided to mark the location and routing of the ground grid. Markers shall identify the depth, direction of the ground flat tape interconnecting the ground grid. The grounding system final drawing shall show the location of these markers and accurately pin point each location by means of an appropriate dimensioning to permanent landmarks.
- E. <sup>A7</sup>**Personnel Safety Grounding:**<sup>A7</sup> Personnel shall be protected against electrical shocks by proper grounding and bonding of all metallic structures, piping, ductwork, fences, handrails, metallic poles, equipment and machinery installations, overhead cranes, metallic doors, and any other conductive structure or equipment, by complying with NFPA 70, and IEEE C2.
1. <sup>A7</sup>**Manholes, Pullholes:**<sup>A7</sup> All manholes and pullholes shall have installed grounding provisions to connect all exposed metal surfaces such as racks, frames, covers, and cable shields to ground. The installation shall conform to the reference drawing No.6170 "Power Manhole Details."
  2. **Fences:** Fences, handrails, metallic poles and equipment supports shall be grounded. Fence grounding shall conform to the reference drawing No.1008-49 "Chain Link Fence Grounding Details."
- F. **Construction:** During construction and after installation, the Contractor shall ensure that no portion of the copper grounding conductor, ground rods or mats are subject to theft.

## 1.05 SUBMITTALS:

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

1. General plan arrangement of each lock's <sup>A17</sup>grounding and bonding system. Including a written explanation of the lock grounding and bonding system design, and equipment selection. <sup>A17</sup> It shall contain a summary of the criteria for the background of the preliminary design. The justification for each major selection and design decision shall be clearly stated, and include supporting calculations, when applicable. The design ground resistance shall be clearly

indicated. The intermediate design analysis shall include but not be limited to the following:

- a. Capacity, rating, principal arrangement, burial depth, intermediate design calculations, name and brand of major components.
- b. Features incorporated in the design to provide personnel safety.
- c. Features in the design incorporated to avoid circulating and stray currents.

**B. Before Manufacturing and Construction:**

1. **Final Design Data:** After 100% completion of the design and prior to the procurement of materials or equipments, the Contractor shall submit to the Employer's Representative for his review, the final design data. 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. **Grounding and Bonding System:** The grounding and bonding system submittal shall contain the general arrangement, calculations, critical dimensions and overall dimensions.
  - b. **System Design:** The Contract drawings shall provide the final general dimensions, exact location of major components. It shall include the design ground resistance at each electrical, communication and control rooms.

**C. Taking-Over Submittals:**

1. **General:** The Contractor shall comply with the requirements of Section 01 77 00 (*Taking-Over Procedures*).
2. **Completion drawings:** As-built drawings at the 100% complete shall be delivered to the Employer's Representative. Drawings shall include: drawings showing plan view, grid nodes, electrical parameters of the grid and details.
3. **Final report:** The final revised report shall be delivered with all calculations, assumptions, input database, graphics, curves, tabulations, equipment characteristics, equipment ratings and test records in a printout and in digital form.

**1.06 QUALITY ASSURANCE:**

**A. Testing and Inspection:**

1. **General:** For the purpose of testing and inspection, the Contractor shall design and construct inspection access inspection boxes at every building location and at strategic locations in order to provide the required inspection and testing access. During construction and after completing the installation the Contractor shall inspect ground conductors, ground busses and connections for conformance with

design specifications and workmanship. The Contractor shall test ground paths for equipment and structural steel or reinforcing bar grounding.

- a. Visual and <sup>A17</sup>mechanical inspection: <sup>A17</sup> Inspect ground system for compliance with the Contract drawings and specifications.
2. **Connections:** Inspect ground conductors, ground busses and connections for conformance with Contract specifications and for adequacy.
  - a. Maintain each ground rod isolated from the associated ground rods for tests on individual rods for resistance to earth.
  - b. Include associated ground rods and interconnecting wiring in test for resistance to earth.
  - c. Include ground bus on equipment, room and pullbox connections, and associated intermediate copper ground conductors in tests on ground paths for electrical equipment.
  - d. Include structural steel or reinforcing bar connection, rod connection and intermediate conductor in tests on ground paths for structural steel or reinforcing bars.
3. **Electrical Tests:**
  - a. **Fall of Potential Test:** Perform fall of potential test in accordance with IEEE No. 81, and required in Section 26 90 (*Field Testing Electrical Systems*).
  - b. **Point Method Test:** Perform the two point method test in accordance with IEEE No. 81, and required in Section 26 90 00 (*Field Testing Electrical Systems*).
  - c. **Alternate method:** Shall be in accordance with Section 26 90 00 (*Field Testing Electrical Systems*).
  - d. **Tests on Individual Ground Rods:** Test shall be as described in IEEE 118 and required in Section 26 90 00 (*Field Testing Electrical Systems*). Maximum acceptable resistance to earth of each rod shall be 5 ohms.
  - e. **Tests on Ground Paths:** Test on ground paths shall be as required in Section 26 90 00 (*Field Testing Electrical Systems*).
4. **Records:** Make complete records of all tests. Include resistance values obtained, calculations of same, and methods of test and calculation.
5. **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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