

SECTION 01 81 29 – ELECTRICAL AND LIGHTING SYSTEM

1.01 SUMMARY:

- A. **Basic Function:** The electrical system design and construction shall provide for a system to perform to the ^{A7}required reliability^{A7} for a continuous supply of electrical power to the ^{A7}lock^{A7} operating machinery, communication systems, control systems, fire-fighting equipment, interior and exterior lighting, safety and security systems, and other loads. In order to achieve this reliability the design shall incorporate redundancies and proven ^{A7}durable long life equipment,^{A7} hardware and accessories,^{A7} consistent with the required design life of the system^{A7}. The system shall be integrated with energy efficient equipment and components. The design shall incorporate safety, ease of access, and ease of maintenance for all components of the system. ^{A17}The system in terms of initial cost, operating efficiency, life and maintenance cost shall provide for the lowest life cycle cost. ^{A17} The design shall contemplate that the locks operation is a 24- ^{A7}hours a day^{A7} and 365-days-a-year operation. The design, equipment and accessories shall resist the high humidity, high temperature tropical environment and its close proximity to coastal areas, ^{A7}and be^{A7} consistent with the minimum life expectancy specified. The specifications describe the minimum requirements and equipment, but in no way limit the Contractor in providing ^{A7}complete systems^{A7} with the needed equipment in order to comply with the overall functional requirements.
- B. ^{A7}Scope^{A7}:
1. ^{A16}**General:** This Section covers the overall view of the performance and requirements for the Contractor to design and construct an electrical system for the third set of lock complexes. ^{A16}
 2. ^{A16}**Power Source:** Incoming source voltage to the lock complex shall be 3-phase, 12,000 volts, 60 Hz. The Employer will design, construct ^{A7},^{A7} and extend the required incoming feeders to each of the lock complexes from the Miraflores Substation owned by the Employer on the Pacific side, and the Agua Clara Substation owned by the Employer on the Atlantic side. Feeders will employ different routes and shall be installed in underground concrete ducts. ^{A5}Different routes shall be separated to ensure that a single event (i.e. fire or duct bank collapse) does not affect both feeders simultaneously. ^{A16}
 3. **Lock Complex Medium Voltage Distribution:** Each lock complex internal electrical distribution system shall consist of a 12 kV medium voltage electrical grid configured as shown in drawing No. 5803-400 “One Line Diagram, Legends, Symbols and Connections” for the Pacific lock complex, and drawing No. 5802-400 “One Line Diagram, Legends, Symbols and Connections” for the Atlantic lock complex ^{A17} (Refer to Vol. VI, Part 1 for location of drawings). ^{A17} The mentioned drawings prescribe the minimum redundancy to which the Contractor shall ^{A7}comply in^{A7} his design. ^{A16}The Contractor shall configure the protection schemes to achieve a highly selective protection arrangement that shall take the protection described in Section 26 13 00 (*Medium Voltage Switchgear*),

as a minimum requirement.^{A16} Said scheme shall also contemplate avoiding feedback from the low voltage distribution. The Contractor shall conduct a study of the proposed power grid, as required in Section 26 05 73 (*Short Circuit and Load Flow Coordination Study*). All of the medium voltage circuit breakers shall be controlled by the ^{A7}lock^{A7} operator, except for the incoming medium voltage breakers, which shall be controlled by ^{A17}the Employer's ^{A17} power system dispatcher from a remote location, or by the automatic generator synchronized transfer to normal. Remote control of incoming feeders shall meet the requirements in Section 26 13 00 (*Medium Voltage Switchgear*). Each lock complex shall consist of two loops, each loop having the capacity to carry the entire load of the complex.

4. **Raceways and Electrical Cables:** All exterior electrical cables, including communication, control, and other types of cables, regardless of level of voltage, shall be installed in underground concrete encased ducts. All low voltage feeders, control conductors, communication cables, and any other type of cables being routed through the exterior of buildings shall be installed in underground concrete encased ducts. ^{A16}Interior distribution shall be installed using ducts, conduits, and/or cable trays, as specified in the Employer's Requirements.^{A16} Medium voltage feeders installed in vertical shafts shall be kept separate from other conductors, while medium voltage cables installed at the bottom level of the ^{A17}Crossunder ^{A17} shall be installed in concrete encased ducts. Raceways shall comply with the requirements established in Section 26 05 43 (*Underground Ducts and Raceways for Electrical Systems*). Cables shall be copper ^{A7}, ^{A7} as required in Section 26 05 13 (*Medium Voltage Cables*) and Section 26 20 00 (*Electrical Low Voltage Distribution Work*). Closed circuit video systems (CCVSs) installed outdoors shall comply with Section 33 81 26 (*Outside Plant Pathways for Underground Communications*).
5. **Medium Voltage Switchgear and Transformers:** The electrical distribution grid shall consist of medium voltage switchgears located near the main loads in electrical equipment rooms [ELR], and as required in Section 26 13 00 (*Medium Voltage Switchgear*). Pad mounted transformers located outside the ELR rooms, shall lower the voltage to utilization level to feed the main loads. Pad mounted transformers shall be as required in Section 26 12 19 (*Pad Mounted Liquid Filled Medium Voltage Transformer*). Each switchgear shall be capable of being fed from any of the two available loop feeders. Each pad mounted transformer shall be capable of carrying the entire motor control center load and the associated ^{A17}Water-Saving Basin ^{A17} valve load.
6. ^{A16}**Special Electrical Equipment:** Variable frequency drives shall be provided as required in Section 26 29 23 (*Variable Frequency Drive*) to drive and control the lock gate motors. In addition, equipment specification only, shall be provided for dynamic VAR compensation, as required in Section 26 60 00 (*Dynamic VAR Compensation*).^{A16}
7. **Low Voltage Distribution:** Low voltage electrical works shall be fed from dry type transformers as required in Section 26 22 00 (*Dry Type ^{A7}Transformers*)

and^{A7} Section 26 20 00 (*Electrical Low Voltage Distribution Work*). 480-volt motor loads shall be fed from motor control centers as required in Section 26 24 19 (*Motor Control Centers*) inside the machinery rooms.

8. **Alternate Low Voltage Feeds:** As required in Section 26 24 19 (*Motor Control Center*), each motor control center shall be provided with an alternate low voltage feed. ^{A16}Wiring shall be as shown in Drawing No. 5803-400 "One Line Diagram, Legends, Symbols and Connections" for the Pacific lock complex, and ^{A7}in ^{A7} Drawing No. 5802-400 "One Line Diagram, Legends, Symbols and Connections" for the Atlantic lock complex. ^{A17} (Refer to Vol. VI, Part 1 for location of drawings). ^{A17}

9. **Lighting Systems:** Shall be designed and constructed to provide ^{A7}a functional system, with the required^{A7} comfort and visual acuity for all of the tasks to be performed in the lock complexes. The lighting system shall be designed to match or surpass life expectancy requirements, consistent with the expected wear and tear and environmental conditions of each particular location. The lighting system shall consist of energy-efficient light sources, with provision ^{A7}for daylighting where applicable^{A7} and overall energy efficiency when considered integrally with other systems. The lighting design and installation shall comply with requirements of Section 26 50 00 (*Lighting Systems*).

- ^{A5}10. **Fourth Set of Locks Complex:** ^{A7}Should a fourth set of locks be built in the future its electrical installation will be stand alone and totally independent from the electrical works required for the Third Set of Locks Project. There is no electrical system requirement, nor electrical work to be performed for the fourth set of locks project included in this Contract. ^{A7A5}

- C. ^{A17}**Existing Conditions:** In the process of designing for the new set of lock complexes, the Contractor will find electrical distribution lines in the high voltage, medium voltage and low voltage configurations; telephone lines; fiber optics lines; and other types of utilities existing at the site. The Contractor shall acknowledge such findings and coordinate with the different owners through the Employer's Representative in order to locate, protect and relocate all of the utilities while maintaining the service of these utilities at all times. Known existing utilities and infrastructures are defined as per Section 01 14 00 (*Work Restrictions*), information is included in Volume VI (*Reference Documents*), Part 1 (*Reference Drawings*) as per Vol. III Sub-Clause 5.1 of the *Conditions of Contract*. Coordination with owners/operators is required so that each owner/operator "stakes out" his utility run. Abandoned utilities do not require protection or relocation. The Employer will advise the Contractor of any alternate power source available. The Contractor shall re-route all of the existing utilities that cross the work area through the new set of locks Crossunders. ^{A17} ^{A5}After completion of the construction of the lock complexes, the Contractor shall leave the installations in condition for permanent operation while complying with the applicable specifications. Downtime of the existing relocated utilities shall be kept to a bare minimum. The work requirements include, but are not limited to, those referred to in Section 01 14 00 (*Work Restrictions*) and Section 33 71 00 (*Electrical Power Overhead Line*). ^{A5}

D. ^{A17}Reserved. ^{A17}

E. ^{A16}**Related Sections:** ^{A16}

01 14 00	Work Restrictions
01 81 19	Lock Gates
01 81 23	Culvert and Conduit Valves
01 81 26	Communications, Control, Safety, and Security Systems
01 81 36	O&M Buildings and Facilities - Program
01 81 36.13	O&M Buildings and Facilities – Space Programming
01 86 13	Plant – Mechanical Systems and Equipment
01 91 00	^{A17} Test on Completion and Tests after Completion ^{A17}
09 96 00	Corrosion Control Coatings
26 05 13	Medium Voltage Cables
26 05 26	Grounding and Bonding for Electrical Systems
26 05 43	Underground Ducts and Raceways for Electrical Systems
26 05 53	Identification for Electrical Systems
26 05 73	Short Circuit and Load Flow Coordination Study
26 12 19	Pad Mounted Liquid Filled Medium Voltage Transformer
26 13 00	Medium Voltage Switchgear
26 20 00	Electrical Low Voltage Distribution Work
26 22 00	Dry Type Transformers
26 24 19	Motor Control Centers
26 29 23	Variable Frequency Drive
26 32 13.13	Diesel-engine Driven Generator Set
26 33 00	Direct Current Equipment
^{A17} 26 41 16	Lightning Prevention and Dissipation Systems ^{A17}
26 43 13	Transient Voltage Surge Suppressors
26 50 00	Lighting
26 60 00	Dynamic VAR Compensation
26 90 00	Field Testing Electrical Systems
28 31 00	Fire Alarm Systems for Buildings
33 71 00	Electrical Power Overhead Line

^{A16}**Reserved**^{A16}

^{A16}**1.02 REFERENCES:**^{A16}

A. **Institute of Electrical and Electronics Engineers (IEEE) Standards:**

C2-07 National Electrical Safety Code (NESC)

P519-03 Guide for Applying Harmonics Limits on Power Systems

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

70-08 National Electrical Code

101- 06 Life Safety Code

C. **Code of Federal Regulations (CFR) Publication:**

29 CFR 1926 - 07 Occupational Safety and Health Administration (OSHA),
Department of Labor – Safety and Health Regulations for
Construction

D. **Autoridad del Canal de Panamá Publication:**

ACP – 05 Manual de Seguridad en Operaciones de Alto Voltaje

1.03 REQUIREMENTS:

- A. **Standardization:** All locks shall have the same arrangement and type of equipment. All equipment shall be new, of standard manufacture ^{A7}, ^{A7} and commercially available products.
- B. **Redundancy:** The locks distribution system shall be redundant, so that any equipment shall be capable of being fed from two different power sources, in addition to being supplied by a back-up power generator set in compliance with the minimum requirements as shown in drawing No. 5803-400 “One Line Diagram, Legends, Symbols and Connections” for the Pacific lock complex, and drawing No. 5802-400 “One Line Diagram, Legends, Symbols and Connections” for the Atlantic lock complex. In addition to the mechanical redundancy requirements of Section 01 81 19 (*Lock Gates*) and Section 01 81 23 (*Culvert and Conduit Valves*), the electrical system shall provide a reliable source of power for critical lock ^{A7} components, ^{A7} that is, lock gates, conduit and culvert valves ^{A7}, ^{A7} and controls. Incoming power to the lock complex shall have N+ 2, or better, redundancies ^{A7} in ^{A7} (12 kV) busses and feeders, capable of continuously supplying the operational power requirements of the lock complex, in addition to the starting and running loads for the two fire-fighting pumps. Each motor control center shall have N+1 redundancy or more. ^{A5}N+1 redundancy for the power source indicates single alternate power source availability. N+2 redundancies for the power source

indicate two alternate power sources availability. Redundancy requirements for the electrical system are specified in Sections listed in Subparagraph 1.01 D., no added redundancy is required for the electrical system for seismic conditions.^{A5}

- C. **Design Life:** The electrical system shall be designed to last at least 40 years, based on the expected normal operation and maintenance conditions in the ^{A7}lock^{A7} area. Panama's tropical environment and proximity to ^{A7}the^{A7} sea shall be taken into consideration.
- D. ^{A5}**Aesthetics:** Electrical equipment and exposed conduits shall be installed in interior locations inside rooms and buildings to the extent possible. Electrical equipment and exposed conduits installed outdoors shall be installed so that they are not visible from transiting vessels, unless otherwise approved by the Employer's Representative.^{A5}
- E. **Security:** Electrical equipment installed indoors and outdoors shall be lockable. Similar equipment shall also be provided with locks and keys. Switching devices required to have provisions for locking shall be provided with padlocking devices.
- F. **Physical Protection:** Electrical equipment shall be safeguarded either through its location or by installing perimeter barriers to protect ^{A7}it^{A7} against accidental physical damage by moving equipment and cranes. Wiring shall also be protected from physical damage by using proper raceways ^{A7},^{A7} as required in Section 26 20 00 (*Electrical Low Voltage Distribution Work*).
- G. **Environmental:** Electrical equipment installed outdoors or in open spaces with natural ventilation shall be suitable to withstand a tropical marine coastal environment. Metal enclosures shall be made of corrosion resistant materials or shall have protective coatings suitable for the environmental and service conditions ^{A7},^{A7} as required in Section 09 96 00 (*Corrosion Control Coatings*). Equipment subject to flooding shall be of watertight construction.
- H. **Reliability and Maintenance:** The design of the electrical system shall provide for safety and ease of maintenance, with minimum disturbance and downtime ^{A7}in lock^{A7} operation and other ^{A7}equipment^{A7}. To facilitate maintenance and troubleshooting, all equipment and components shall have safe access with identification as required by NFPA 70, IEEE C2 and Section 26 05 53 (*Identification for Electrical Systems*). Electrical equipment shall be provided with transient voltage protection in accordance with Section 26 43 13 (*Transient Voltage Surge Suppressor*). Design for maintenance shall minimize or eliminate lockage operation downtime during the maintenance process. Operation and maintenance manuals shall be provided for ^{A7}all^{A7} electrical equipment and ^{A7}systems^{A7}. A maintenance schedule shall be developed and shall include all programmed maintenance required for all electrical equipment provided. ^{A16}A basic set of spare parts required by the manufacturer shall be provided as part of the Contractor's maintenance duties in accordance with the requirements of Section 01 93 00 (*Maintenance Services*). In addition, a list of recommended spare parts shall be delivered to the Employer's Representative.^{A16}
- I. **Protection and Coordination:** All electrical equipment shall be designed for the short circuit ^{A7}duty^{A7} in accordance with the ^{A7}calculation results^{A7} of the study required in

Section 26 05 73 (*Short Circuit and Load Flow Coordination Study*). Provision shall be made for protection and auto^{A7}-^{A7}isolation of any faulty equipment.

- J. **Control and Monitoring:** Provisions shall be taken for permanent control and monitoring of equipment parameters as specified. Refer to Section 01 81 26 (*Communications, Controls, Safety, and Security Systems*) and its related Sections. The integration, control^{A7},^{A7} and automatic operation of the backup generator set shall be as required in Section 26 13 00 (*Medium Voltage Switchgear*) and Section 26 32 13.13 (*Diesel-Engine Driven Generator Sets*).
- K. **Life Safety:** The electrical system shall be designed to provide the functionality required without compromising safety of the operation or the safety of the ^{A7}lock^{A7} personnel and visitors.
- L. **Quality:** During the entire process, including design and construction^{A7},^{A7} the Contractor shall maintain strict control quality in accordance with Section 01 40 00 (*Quality Requirements*), in strict compliance with the functional requirements.
- M. **Equipment Operating Environment:** For the environmental conditions prevailing within the Panama Canal environment, refer to ^{A7}Volume VI^{A7}, Part 7 (^{A7}*Hydrometeorological^{A7} Report*). For the outdoor and indoor conditions that the electrical equipment is required to endure, refer to Section 01 81 26 (*Communications, Control, Safety, and Security Systems*) ^{A7}Sub^{A7}paragraph 1.03 J. "Equipment Operating Environment".
- N. ^{A16}**Incoming Feeders Reliability:** The Employer shall design, construct, and extend the required underground concrete ^{A7}encased^{A7} ducts and incoming feeders to each of the lock ^{A7}complexes^{A7}. Feeders at the Pacific side will originate at the Miraflores Substation owned by the Employer. Feeders at the Atlantic side will originate at the Agua Clara Substation owned by the Employer. Feeders will originate from separate busses, Bus A & B in Miraflores Substation and Bus A & C in Agua Clara Substation. The feeders to each of the lock ^{A7}complexes^{A7} will be installed in underground concrete encased ducts, employing different routes, in order to increase the reliability of the incoming sources. Each feeder will have the capacity to carry the entire load of the lock complex.^{A16}
- O. **Improvements:** ^{A16}The requirements related to the electrical specifications Sections 26 05 13 (*Medium Voltage Cables*), 26 05 26 (*Grounding and Bonding for Electrical Systems*), 26 05 43 (*Underground Ducts and Raceways for Electrical Systems*), 26 05 53 (*Identification for Electrical Systems*), 26 05 73 (*Short Circuit and Load Flow Coordination Study*), 26 12 19 (*Pad Mounted Liquid Filled Medium Voltage Transformer*), 26 13 00 (*Medium Voltage Switchgear*), 26 20 00 (*Electrical Low Voltage Distribution Work*), 26 22 00 (*Dry Type Transformers*), 26 24 19 (*Motor Control Centers*), 26 29 23 (*Variable Frequency Drive*), 26 32 13.13 (*Diesel-Engine Driven Generator Sets*), 26 50 00 (*Lighting Systems*), 26 60 00 (*Dynamic VAR Compensation*), 26 90 00 (*Field Testing Electrical Systems*), 28 31 00 (*Fire Alarm Systems for Buildings*), 33 71 00 (*Electrical Power Overhead Line*), and Drawings 5802-400 and 5203-400, may be modified by the Contractor if the modification increases the reliability of the system, increases the operating flexibility, reduces maintenance or reduces operating cost.^{A16}

- P. ^{A17}**Electrical Requirements for Dewatering Pumps:** The Contractor shall design and furnish all permanent and portable electrical installation required to connect the portable pumps. Refer to Section 01 92 00.13 (*Dry Outages*) for the portable pump requirements. The permanent electrical installation shall be complete with raceways, wiring, connection provisions, protection and capacity in the grid, as required for operating the portable pumps, and based in the Contractor’s specifications for these pumps. ^{A17}

1.04 DESIGN CRITERIA:

- A. **Equipment Capacities, Protection and Electrical Safety:** The electrical equipment shall be designed to carry normal and momentary overloads, in addition to having the short circuit withstand capacity for the available short circuit. The protection scheme shall be highly selective in order to isolate only the faulty feeder and/or equipment. The protection system shall be designed to protect equipment, operators ^{A7}, ^{A7} and maintenance personnel.
- B. **Life Safety:** Grounding and bonding of all electrical and mechanical ^{A7}equipment, ^{A7}enclosures, junction boxes, conduits, pipes, metal ^{A7}handrails^{A7}, poles, ^{A7}etc. shall^{A7} be designed and constructed to provide a safe environment for operators, and maintenance personnel. Moving parts shall be provided with removable covers, or guards, to avoid injuries by unintentional contact. In areas subject to water intrusion, oil spillage, or other liquid spills, drainage and/or catch basins shall be provided, with proper considerations to avoid contaminating the environment.
- C. **Equipment and Machinery:** Equipment and machinery shall be provided with pedestals, vibration isolators, and noise control, to provide proper operation of the equipment/machinery and avoid affecting other equipment/machinery or personnel in the area.
- D. **Lightning:** The design shall include a lightning protection system adequate for the lightning activity near ^{A7}the lock area and in ^{A7}accordance with the requirements of Section 26 05 26 (*Grounding and Bonding for Electrical Systems*) ^{A17}and 26 41 16 (*Lightning Prevention and Dissipation Systems*). ^{A17} Lightning frequency shall be based on the U.S. state of Florida frequency of thunderstorms for the worst condition. Surge protection shall be provided for all electrical, control, and communication lines ^{A7}, ^{A7} in accordance with Section 26 43 13 (*Transient Voltage Surge Suppressors*).
- E. **Power Quality:** All equipment installed and the electrical system in general shall be designed to comply with the IEEE P519.
- F. **Incoming Feeders:** ^{A16}The Employer will design, construct and extend incoming feeders into each lock complex incoming cubicles. For the purpose of access to the incoming cubicles by the Employer, the Contractor shall construct incoming ducts lines and manholes up to a predetermined location within the perimeter encircling the ^{A16}^{A17}Footprint of the Lock Structure and identified as “Contractor’s limit line” as per drawings No.5802-27 in the Atlantic and drawing No.5803-54 in the Pacific area (refer to Vol. II part 4, for location of drawings), and as required in Section 26 05 43

(*Underground Ducts and Raceways for Electrical Systems*). The Contractor shall coordinate with the Employer's Representative for the exact location mentioned above.
^{A17}

- G. **Locks Distribution Feeders:** Shall be fully ^{A7}redundant and^{A7} meet the identical specifications of the incoming feeders.
1. **Locks Medium Voltage Grid:** The Medium Voltage Grid shall be composed of metalclad switchgears located in electrical rooms. Each electrical switchgear shall be divided into two separate switchgear assemblies. The switchgear assemblies shall be labeled north and south. The north and south switchgear shall be interconnected by means of a tie breaker. Electrical room switchgears shall be interconnected by means ^{A7}of ^{A7}a tie with each adjacent switchgear in order that at the end it shall form two loops, when having all of the interconnecting tie breakers normally open. Each loop shall be fed by a power substation ^{A7}incoming feeder^{A7} in order to obtain a full redundant scheme. A standby diesel generator shall provide back-up power. Refer to drawings No. 5803-400 "One Line Diagram, Legends, Symbols and Connections" (Pacific side Locks) and No. 5802-400 "One Line Diagram, Legends, Symbols and Connections" (Atlantic side Locks). ^{A17} (Refer to Vol. VI, Part 1 for location of drawings).^{A17}
2. **WSB Feeders:** ^{A11}Each water saving basin conduit valve's motor control center shall be fed from the adjacent electrical room with low voltage, or by means of medium voltage pad mounted transformer, (this alternate source arrangement is not shown on drawings No. 5802-400 and 5803-400) and also be fed from an alternate electrical room by means of a normally open tie breaker.^{A11} ^{A17}(Refer to Vol. VI, Part 1 for location of drawings).^{A17} This tie breaker shall be provided with mechanical interlock (^{A7}kirk key^{A7} interlock) to avoid voltage ^{A7}feedback^{A7}. As required in Section 26 24 19 (*Motor Control Center*) and Drawings No. 5802-400 and No.5803-400.
- H. ^{A17}**Crossunder:** The Crossunder tunnel for electrical, control, communication, and power cables shall be separate from the water, air, and oil tunnel. There shall be at least two electrical/control/communication cable Crossunder ^{A17}tunnels, one in the higher level and another in the lower level. All cables shall be run in cable trays, except medium voltage cables ^{A7}, which^{A7} shall run under the floor in concrete^{A7}-^{A7}encased ducts, with access provided by manholes at both ends of the crossing. Cable trays shall be separate and dedicated for power, as well as separate and dedicated for communication and control. Cable tray and hardware support shall be corrosion resistant. Illumination in the tunnels shall be connected to alternate sources and provided with battery operated emergency power source. Tunnels shall be provided with ^{A7}alarm^{A7} systems to alarm ^{A7}locally, at^{A7} the control building, and at the guard booth, in ^{A7}the event of flooding condition or^{A7} loss of forced air ventilation.
- I. ^{A7}**Utility^{A7} Shafts and Cable Galleries:** ^{A7}Utility shafts^{A7} shall comply with all requirements of the ^{A17}Crossunder, ^{A17}as applicable, in addition to supporting and protecting cables at the transitions to the vertical section. Shall have force ventilation,

drainage, and alarm systems. Cable galleries below rooms housing medium voltage switchgears shall be provided with two exit/entrance ^{A7}accesses located at opposite ^{A7}ends.

- J. **Machinery Rooms:** Shall be designed to allow the installation of all electrical equipment required to power valves, pumps, gate controls ^{A7}, ^{A7} and other loads, with the appropriate clearances for safety and ease of maintenance.
- K. **Foam Concentrate/Water Fire-Fighting and Fire Protection for ^{A7}Building^{A7} Systems:** Monitoring and control of the fire-fighting and fire alarm systems shall be centralized in the main control building [CB], with alarm signals sent automatically in accordance with requirements in Section 28 31 00 (*Fire Alarm System for Buildings*) and Section 01 86 13 (*Plant – Mechanical Systems and Equipment*).
- L. **^{A7}Electrical Rooms [ELRs], Machinery Rooms - Gates [MR-Gs], Machinery Rooms - Culvert Valves [MR-Vs], Machinery Rooms - Water-Saving Basins [MR-WSBs]:** shall all have their electrical equipment rooms with at least two exit doors at each end, with exit signs and with clearances according to IEEE C2, NFPA 70, and NFPA 101.^{A7}
- M. **Main Control Building (CB) and Other Buildings:** Special electrical outlets for control, computer, and critical loads shall be ^{A7}distinguished ^{A7}from normal outlets by color.
- N. **All Buildings:** Buildings and Facilities listed in Section 01 81 36.13 (*O & M Building and ^{A7}Facilities^{A7} – Space Programming*) shall be provided with electrical wiring and power requirements in accordance to the NFPA 70 and egress requirements in accordance with NFPA 101.
- O. **Grounding:** The grounding systems (power, communication, and lightning) shall be 0.5 ohm or less for the power and lightning ^{A7}systems and ^{A7}0.5 ohm or less for communication and other systems. Grounding and bonding shall comply with Section 26 05 26 (*Grounding and Bonding for Electrical Systems*). All grid connections shall be made with exothermic welding system. All structural steel shall be bonded to the grounding system.
- P. **^{A16}Emergency Generator Set:** The Contractor shall provide a complete design so that each lock complex may be provided in the future with a diesel-engine generator set group, to provide backup power. The design shall include the engine group, accessories, fuel tanks, ^{A16} ^{A17}wiring and piping for a complete installation. With the design the Contractor shall deliver the drawings, specifications, equipment plan and mounting arrangement, building dimensions (no building design), and specifications for each equipment meeting the requirements of these specifications. The Contractor shall also deliver the control and transfer schemes and all calculations. Purchase of all equipment and accessories, as well as construction of the building, including the complete retrofit installation will be executed by the Employer in the future. The Contractor shall leave provision in each lock complex for ease of retrofitting the generator feeder into the generator cubicle, including provisions for retrofitting the transfer scheme, by the Employer. The generator medium voltage cubicle shall be provided by the Contractor as

part of the medium voltage switchgear equipment. No training provisions are required to be included by the Contractor.^{A17}

1. **Emergency Power:** The diesel generator^{A17} group shall be capable of carrying continuously the entire normal operating load of the lock complex. Additionally, the generator group^{A17} shall be able^{A7} to^{A7} start up the fire^{A7}-^{A7} fighting system pumps^{A7} while carrying^{A7} all of the essential loads. The Contractor shall minimize the size of the generator by assessing correctly the non-coincident load to the generator, as well as highly reactive motor starting.
2. **Essential Loads:** The following equipments and/or areas shall be considered essential loads: Culvert and WSB conduit valves, rolling gates machinery rooms, CCVS, elevators and man-lift units, main control^{A7} buildings^{A7}, fire-fighting and fire protection systems, area lighting covered by the high mast lighting, security lighting, and monitoring and control loads.
3. **Generator Set Operation:**^{A17} In case of a complete power outage, the generator group shall start automatically, open all incoming feeders, and feed automatically the 12 kV distribution system. When utility power returns, the lock operator shall be able to automatically synchronize both systems and shut down the generator group without a power outage. The generator group controller shall include communication for remote control and annunciation, in addition to remote speed control and paralleling governor system for automatic synchronization.^{A17}
4. **Accessories:** Control power for all^{A7} lock systems^{A7} shall be DC power and capable to last 12 hours without the charging system. Fuel capacity shall be as required in Section 26 32 13.13 (*Diesel-Engine Driven Generator Sets*) and Section 01 86 13 (*Plant – Mechanical Systems and Equipment*).
5. **Foam Concentrate/Water Fire-Fighting System Operation:** In case of a simultaneous occurrence of a fire and a power outage, the generator set shall be capable to start the fire-fighting system pumps in tandem. Refer to Section 01 86 13 (*Plant – Mechanical Systems and Equipment*).

Q. Control and Monitoring:

1. In general, the control power shall consist of a DC system, in accordance with Section 01 81 26 (*Communications, Controls, Safety, and Security^{A7} Systems*) and^{A7} its related Sections. The power system control, ^{A7}PLCs, lock^{A7} machinery^{A7} controls^{A7}, and control buildings shall share this control power. The system shall be monitored for pre-alarms and failures.
2. The electrical system monitoring shall include, but not limited to, the following parameters: voltages^{A7, A7}; current^{A7, A7}; frequency^{A7, A7}; active, reactive^{A7, A7} and apparent power^{A7, A7}; voltage total harmonic distortion THD V^{A7, A7}; current total harmonic distortion THD I^{A7}; and^{A7} Fast Fourier Transformer (FFT). For

harmonic spectrum up to the 63rd, waveform capture with at least 128 samples per cycle.

3. The parameters described above shall be measured on every medium voltage switchgear, motor control center, and main switchboards.

R. Maintenance:

1. **Ease of Maintenance:** The need for sophisticated tools required for maintenance service shall be minimized. The design, fabrication^{A7},^{A7} and^{A7} construction^{A7} of all electrical equipment and system shall provide for easy and safe access for frequent maintenance service.
2. **Maintenance Provisions:** ^{A7}Permanent electrical power supply take off installations shall be provided at each gate^{A7} ^{A17}Recess for maintenance and lock Overhaul of the gates with a dry Recess. Similar permanent installations shall be provided for maintenance of each dry chamber and culvert maintenance/Overhaul.^{A17}
3. **Replaceability:** In the event that any component of the electrical system requires replacement, it shall be possible to replace it without affecting the operation of the lock complex, or in extreme cases^{A7},^{A7} minimizing the impact^{A7} on^{A7} the operation.

S. Corrosion Protection:

1. **Paints and Coatings:** Shall be as required in Section 09 96 00 (*Corrosion Control Coatings*).

T. Construction:

1. **Quality Standards:** The Contractor^{A7} shall have ISO c^{A7}ertification to do the Works. In addition, ^{A7}the Contractor^{A7} shall follow the Employer’s quality system instructions and procedures^{A7} when required^{A7} to work^{A7} in conjunction with the Employer^{A7}, and shall follow 29 CFR 1926 regulations and “Manual de Seguridad en Operaciones de Alto Voltaje” (the Employer’s safety manual for high voltage operations) during construction, electrical^{A7} circuit^{A7} switching^{A7}, and work procedures.
2. **Fabrication:** All equipment and systems supplied shall comply with the standard specified in the particular Section.

- ^{A17}U. Related data to the existing Panama’s area and Canal area integrated electrical grids, are made available in Volume VI, Part 16 (*Electrical Works Reference Data*) for information, as per Vol. III, Sub-Clause 5.1 of the *Conditions of Contract*.^{A17}

1.05 SUBMITTALS:

A. Submittals and Progress Charts:

^{A16}For each set of lock complex ^{A7}, ^{A7} the Contractor shall provide submittals in accordance with Section 01 33 00 (*Submittal Procedures*) and in accordance with Section 01 31 00 (*Project Management and Coordination*).^{A16}

B. Preliminary Existing Electrical Infrastructure Design Data:

^{A16}Within ^{A7}91 days^{A7} of the Commencement Date, the Contractor shall submit to the Employer's Representative for his review, five sets of drawings showing all the existing electrical infrastructure in the area that will be affected by the Works and that will require temporary relocation during construction and a later final relocation before or after the completion of the Works^{A16}. The Contractor shall submit a preliminary design for the temporary relocation of all existing electrical utilities.

C. Preliminary Electrical System Design Data:

^{A17}Within 182 days of the Commencement Date, ^{A17} ^{A16}and after 30% completion of the design and prior to the procurement of Materials or Plant (equipment), the Contractor shall submit, to the Employer's Representative for review, five sets of the **preliminary electrical** system design data. The preliminary 30% electrical system design data for the Atlantic and the Pacific lock complexes shall include, but shall not be limited to the following:^{A16}

1. **Electrical System Design Data:** ^{A7}The system design data shall include, but not be limited to, the specification, description and characteristics of major components of the electrical system Plant (equipment) and loads. Included are switchgears, transformers, cables, motor control centers, motors, drives, generator set, lighting, grounding, and lightning protection. The Contractor shall provide loads sizes, characteristics, dimensions, location, and layout.^{A7} The data shall contain the following drawings and specifications:
 - a) existing electrical infrastructure relocation ^{A7}, ^{A7}
 - b) ^{A16}reserved
 - c) reserved
 - d) reserved^{A16}
 - e) one line diagram ^{A7}, ^{A7}
 - f) distribution plan ^{A7}, ^{A7}
 - g) ^{A16}diesel engine generator group location and connection to grid,^{A16}
 - h) submittals as requested in the particular Sections ^{A7}, ^{A7}
2. **Electrical and Electronic System Data:** The electrical and electronic system data shall include information on electrical power and control circuits and information on components to be used. The Contractor shall submit ^{A7}, ^{A7} to the

Employer’s Representative for review, ^{A7}the^{A7} proposed remote control system and interface with the electrical equipment being controlled and monitored.

3. **Preliminary QCP and TIP:** The preliminary 30% design data shall include the Quality Control Plan, its procedure for identifying and resolving non-conformances, and the documented non-conformances. The quality control program (QCP) and the testing and inspection program (TIP) shall respectively describe the quality assurance and testing and inspection programs. Copies of certifications issued to the Contractor or ^{A7}Subcontractors^{A7} shall be included along with these programs. NDT programs and procedures shall be clearly outlined in the QCP.

D. **Intermediate Design Data:**

^{A17}Within 364 days of Commencement Date ^{A17} ^{A16}and after completion of the intermediate design and prior to the procurement of Materials or Plant (equipment), the Contractor shall submit, to the Employer’s Representative for review, five sets of the design data. The intermediate electrical system design data for the Atlantic and the Pacific lock complexes shall include, but not be limited to, the following. ^{A16}

1. **Electrical System Design Data:** ^{A7}The system design data shall include, but not be limited to, the specifications, description, and characteristics of major components of the electrical system Plant (equipment) and loads. Included are switchgears, transformers, cables, motor control centers, motors, drives, generator sets, lighting, grounding, and lightning protection. Data shall provide load sizes and characteristics, general dimensions, and location. ^{A7} The data shall contain the following drawings and specifications:

- a) existing electrical infrastructure relocation ^{A7,A7}
- b) ^{A16}reserved
- c) reserved
- d) reserved ^{A16}
- e) one line diagram;
- f) distribution plan;
- g) ^{A17}diesel engine generator group ^{A17}
- h) power, lighting, communication, and control for equipment, buildings, and exterior installations;
- i) preliminary short circuit and load flow coordination study;
- j) electrical grid protection and control scheme;
- k) submittals as requested in the particular Sections.

- ^{A7}2^{A7}. **Electrical and Electronic System Data:** The electrical and electronic system data shall include information on electrical power and control circuits and information on components to be used. The Contractor shall submit, to the

Employer's Representative for review, ^{A7}the^{A7} proposed remote control system and interface with the electrical equipment being controlled and monitored. Data shall include control ^{A7}sequences^{A7}.

^{A7}3^{A7}. **Corrosion Control Coating Schedules:** Technical sheets and ^{A7}material^{A7} safety data sheets of coating ^{A7}materials^{A7} for equipment shall be provided.

^{A7}4^{A7}. **QCP and TIP:** The quality control program (QCP) and the testing and inspection program (TIP) shall respectively describe the quality assurance and testing and inspection programs. Copies of certifications issued to the Contractor or Subcontractor shall be included along with these programs. NDT programs and procedures shall be clearly outlined in the QCP.

E. Before Construction:

Before construction of the electrical installation, the Contractor shall **submit the electrical system final design**. Complete sets of electrical drawings shall be provided for all electrical, signaling and control systems. Drawings shall provide complete and detailed information regarding the systems and equipment to be installed. Electrical drawings for each system shall provide cable routing, cable identification, cable sizes, loads, protective devices settings, circuit data, conductor termination detail, material lists and detailed control ^{A7}sequences^{A7}. ^{A16}The Contractor shall submit the proposed remote control system to the Employer's Representative for review Data shall include, but not be limited to, the following: ^{A16}

1. **Electrical System Design Data:** The data shall contain the following drawings and specifications:
 - a) existing electrical infrastructure relocation;
 - b) ^{A16}reserved
 - c) reserved
 - d) reserved ^{A16}
 - e) one line diagram;
 - f) distribution plan ;
 - g) ^{A17}diesel engine generator group retrofit installation and transfer equipment and control schemes^{A17}
 - h) power, lighting, communication, and control for ^{A7}equipment^{A7}, buildings, and exterior installations^{A7,A7};
 - i) short circuit ^{A7}and^{A7} load flow coordination study^{A7,A7};
 - j) electrical grid protection and control scheme^{A7,A7};
 - k) submittals as requested in the particular Sections^{A7,A7}.
2. **Field Installation Drawings:** Field installation drawings and specifications shall be provided at least ^{A7}28^{A7} days prior to field installation. Field installation

drawings and specifications shall provide a detailed description of the field installation procedures.

F. **Before^{A7} Taking-Over:^{A7}**

1. **Shop Drawings, Manufacturing Data, Detail Drawings, and Installation Drawings:** Shop drawings and manufacturing data shall be provided in accordance with Section 01 40 00 (*Quality Requirements*) and Paragraph 1.06 of this ^{A7}Section^{A7}. The Contractor shall submit ^{A7},^{A7} to the Employer’s Representative for his review, five copies ^{A7}(hard copy) and one^{A7} electronic ^{A7}file^{A7} of all data produced or required for the electrical installation for the lock gates and valves power, control ^{A7},^{A7} and communication system. The data shall include, as a minimum, shop drawings, detail drawings, specifications, quality control, erection instructions, and testing procedures.

2. **^{A7}As-Built^{A7} Drawings:**

^{A17}Prior to the Taking-Over Certificate being issued^{A17} ^{A16}all as-built drawings of the completed electrical systems and sub-systems, shall be delivered to the Employer’s Representative. The submittal shall represent the 100% completed set of drawings and specifications. The submittal drawings and specifications shall include the update performed by the Contractor to reflect all changes made by the Contractor until the date of the Taking-Over Certificate.^{A16}

G. **Material Safety Data Sheet and Technical Data Sheet:**

The Contractor shall submit to the Employer’s Representative ^{A17}for review ^{A17}a Material Safety Data Sheet (MSDS) and a Technical Data Sheet for each type of hazardous material such as chemicals, insulation, abrasives, coatings, grease, oil ^{A7},^{A7} and ^{A7}lubricants^{A7}, before incorporating them in the design, construction ^{A7},^{A7} and installation of the systems and equipment specified. The Contractor shall disclose the name, formula, and approximate percentage by weight and volume of each ingredient in each product; the results of toxicological testing of the product; its pyrolysis products; and all other information as may be needed to permit an accurate appraisal of problems associated with the handling, storage, application, use, removal, disposal, or combustion of the material.

1. **^{A7}Material^{A7} Safety Data Sheet:** The Contractor shall submit to the Employer’s Representative all the information required by the MSDS form for each hazardous material. A copy of a MSDS sample form is available at ^{A7}the^{A7} following URL: <http://www.osha-slc.gov/dsg/hazcom/msdsformat.html>.
2. **Technical Data Sheet:** The Technical Data Sheet shall include the complete manufacturer’s technical data with the manufacturer’s name, trade name, generic name, intended use, chemical contents of each hazardous ingredient, and other ^{A7}hazardous material^{A7} information.

H. Documents and Manuals:

1. ^{A17}**General:** The Contractor shall submit documents in accordance with Section 01 93 00 (*Maintenance Services*).^{A17}
- ^{A7}2. **Documents for Employer Representative's Review^{A7}:** Instructions and maintenance books, manuals, part lists, etc. of all electrical ^{A7}Plant (^{A7}equipment)^{A7} and installations as made by the Contractor, shall be delivered in fourfold on paper to the Employer's Representative in the English language.
- ^{A17}3. **Documents in their Final Form^{A17}:** Instruction books and parts lists shall be provided to the Employer's Representative in the original ^{A7}format^{A7} as normally delivered by the manufacturers of the relevant items, one set (7 copies) in the English and one set (7 copies) in the Spanish language. All instruction books, produced by the Contractor shall also be provided to the Employer's Representative in a digital form (PDF or ^{A7}other, as approved by the Employer's Representative^{A7}) on DVD / CD ^{A7}-^{A7}ROM. Manuals shall be provided to the Employer's Representative for approval in hard copy and electronic editable form, at least ^{A7}56^{A7} days before shipping the ^{A7}equipment^{A7}.

I. Major Purchased Components List:

The Contractor shall submit, for review by the Employer's Representative within ^{A7}28^{A7} days prior to the delivery of major electrical ^{A7}equipment^{A7}, a list of all major purchased components. 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. After review of the submitted lists, ^{A7}four copies^{A7} of these lists shall be provided in the English language and two copies on DVD/CD ^{A7}-ROM^{A7} in the Microsoft Access (latest edition).

J. Training Program Details:

The Contractor shall submit to the Employer's Representative for review, an outline of the content and other detailed information of the training session proposed by the Contractor. This submission shall be made ^{A7}28^{A7} days in advance for local training sessions.

K. Spare Parts List:

^{A16}In accordance with Section 01 93 00 (*Maintenance Services*), the Contractor shall submit, to the Employer's Representative a list of all the electrical equipment and electrical system proposed spare parts.^{A16} The list shall include all critical spare parts and Materials. These critical spare parts shall include, as a minimum, all long-lead time items necessary to maintain the lock complex at an acceptable level of functionality with minimum downtime. The list shall be organized by systems and major ^{A7}components and^{A7} shall identify parts that are recommended by the Contractor for routine maintenance or ^{A17}Overhaul^{A17}. The list shall contain complete ordering information ^{A7},^{A7} including but not limited to ^{A7},^{A7} manufacturer's name and address, part description, Contractor's and Subcontractor's part numbers, F.O.B. Contractor's ^{A7}plant^{A7} prices and approximate lead-time. All price lists shall be delivered in duplicate ^{A7}for the^{A7} hard

^{A7}copy and one copy in electronic DVD/CD-ROM medium in a database format (latest Microsoft Access compatible).^{A7}

L. Testing and Inspection Reports:

The Contractor shall provide to the Employer’s Representative for his review a report on all tests and inspections, showing in detail each test procedure and inspection results. Five copies of the certified test reports shall be submitted to the Employer’s Representative in booklet form and in electronic (DVD/CD) format.

1.06 QUALITY ASSURANCE:

A. Testing and Inspection:

1. At the Employer’s Cost, the Employer has the right to inspect and witness equipment manufacture that the Employer considers critical.
2. Testing of electrical systems, as a minimum, shall be in accordance with the requirements of Section 26 90 00 (*Field Testing Electrical Systems*)^{A17} and 01 91 00 (*Tests on Completion and Tests after Completion*).^{A17}

END OF SECTION