

## SECTION 01 81 19 – LOCK GATES

### 1.01 SUMMARY:

- A. **Scope of Work:** The work under this Section includes the design, specification, fabrication, assembly, testing, transportation, delivery, installation, and commissioning of complete lock gates and operating equipment. The Contractor's work under this Section shall include, but not be limited to, the following.
1. **Lock Gates and Operating Equipment:** The lock gates and operating equipment shall be designed, specified, fabricated, assembled, tested, transported, delivered, and installed complete with components including, but not limited to, structural assemblies, embedded parts, drive units, sealing systems, limit switches, sensors, rolling equipment, ballast tanks, buoyancy chambers, dewatering systems, electric power conductors, and controls. <sup>A17</sup>The locks gate designs shall be based on locks facilities complete with all 16 rolling gates. <sup>A17</sup>
  2. <sup>A16</sup>**Auxiliary Equipment:** The Contractor shall design, fabricate, test, deliver and install auxiliary equipment for the lock gates including, but not limited to, gate Recess closures, and interfaces that allow pedestrian passage across all gates and vehicular traffic across selected gates. <sup>A16</sup>
  3. <sup>A17</sup>Reserved <sup>A17</sup>
  4. <sup>A10</sup>**Maintenance Closure System:** The Contractor shall design and specify maintenance closure system for the locks, complete with all components and accessories including, but not limited to, lifting fixtures, release fixtures, and storage areas. Fabrication, installation, and testing of the maintenance closure systems and accessories are included as a Provisional Sum in the Contract <sup>A10</sup> <sup>A17</sup>as stated in the Schedule of Project Elements and Prices and which may be instructed by the Employer Representative pursuant to Sub-Clause 13.5 of the Conditions of Contract. The design shall take into account that the closure system will be used at the lake entrance and at the sea entrance of the Atlantic and Pacific locks facilities. <sup>A17</sup>
  5. **Factory Testing and Support:** **Factory Testing and Support:** The Contractor shall perform factory inspection and testing, including operational tests of major components during the fabrication of the lock gates and associated equipment. <sup>A19</sup>The Employer's representative reserves the rights to witness the factory tests and inspections. <sup>A19</sup> The Contractor shall provide support facilities and services to the Employer's Representative and other Employer's Personnel at the factory.
  6. **On-Site Installation, Field Testing, and Support:** The Contractor shall conduct all required installation, alignment, assembly, and preliminary and final testing and shall provide support to the Employer's Representative during the field testing.

7. <sup>A16</sup>**Special Equipment and Tools:** The Contractor shall provide all required special equipment, and tools for operation, testing, and maintenance.<sup>A16</sup>
  8. **Technical Support:** The Contractor shall provide technical support in accordance with the requirements of Section 01 78 23 <sup>A17</sup> (*Operations Data*)<sup>A17</sup> and Section 01 93 00 (*Maintenance Services*).
  9. **Training:** The Contractor shall provide training in accordance with the requirements of Section 01 79 00 (*Demonstration and Training*).
  10. **Spare Equipment Sets:** <sup>A16</sup>Refer to Section 01 93 00 (*Maintenance Services*).<sup>A16</sup>
  11. <sup>A10</sup> (Reserved)<sup>A10</sup>
- B. **Basic Function (Functional Requirements):** A pair of remotely operated rolling lock gates of the horizontal rolling type shall be designed at each end of each lock facility and between each adjacent chamber. When closed, the gates shall serve as dams sealing the lock chambers and allowing vessels to be raised or lowered within them. The gates shall provide a damming surface during all possible operating conditions and during their entire design life. When opened and retracted into the gate <sup>A17</sup>Recesses,<sup>A17</sup> the gates shall allow vessels to enter or leave the chambers. The opening and closing operation of the gates with a minimum head differential shall not create adverse effects on the ships in the chamber. In a pair of gates, each gate shall be capable of operating individually or simultaneously. Each gate shall be remotely operated and shall also permit local operation.<sup>A19</sup>Refer to Section 40 95 13.13 (Process Control Hardware for Locks Machinery Control System) and 40 96 45.13 ((Process Control Software for Locks Machinery Control System).<sup>A19</sup> The design shall be suitable for the severe marine tropical outdoor environment of the Canal. The design and fabrication shall incorporate current technology, and use as many commercially available parts as possible.
- C. **Related Sections:** The following is a list of related Sections. See them for more details.
1. 01 42 13 (*Acronyms and Units*).
  2. 01 42 16 (*Definitions*).
  3. 01 42 19 (*Reference Standards*).
  4. 01 79 00 (*Demonstration and Training*).
  5. 01 81 16 (*Lock Structures*).
  6. 01 81 29 (*Electrical and Lighting System*).
  7. 01 81 36 (*O&M Buildings and Facilities – Program*).
  8. 01 86 13 (*Plant - Mechanical Systems and Equipment*).
  9. 01 91 00 <sup>A17</sup> (*Tests on Completion and Tests after Completion*).<sup>A17</sup>

10. 40 95 13.13 (*Process Control Hardware for Locks Machinery Control System*).

11. Volume VI, Part 1 (*Reference Drawings*).

Note: The reference drawings are provided as information only. <sup>A17</sup>See Sub-Clause 5.1 of the Conditions of Contract. <sup>A17</sup>

12. Volume VI, Part 7 (*Hydrometeorological Report*).

<sup>A7</sup>D. <sup>A11</sup>**Lock Head Numbering:** <sup>A16</sup>Refer to Section 01 10 00 (*General Project Requirements*) for lock head numbering definition. <sup>A16</sup>

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

- A. American Association of State Highway and Transportation Officials (AASHTO).
- B. American Bearing Manufacturers Association (ABMA).
- C. American Gear Manufacturers Association (AGMA).
- D. American Institute of Steel Construction (AISC).
- E. American National Standard Institute (ANSI).
- F. American Society of Mechanical Engineers (ASME) International.
- G. American Society for Non-destructive Testing (ASNT).
- H. American Society for Testing and Materials (ASTM) International.
- D 3951-04 Commercial Packaging
- <sup>A19</sup>E29 Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications <sup>A19</sup>
- I. American Welding Society (AWS).
- J. Deutsches Institut für Normung Standards (DIN).
- K. Comité Européen de Normalisation (CEN).
- L. International Association of Classification Societies (IACS).
- M. Institute of Electrical and Electronics Engineers (IEEE).
- N. International Organization for Standardization (ISO).
- O. National Association of Corrosion Engineers (NACE).
- P. National Electrical Manufacturers Association (NEMA).

- Q. **National Fire Protection Association (NFPA).**
- R. **Occupational Safety and Health Administration (OSHA).**
- S. **Society for Protective Coatings (SSPC).**
- T. **United States Coast Guard (USCG).**

### **1.03 REQUIREMENTS:**

- A. **Lock Gate Rolling Equipment:** The lock gates shall be of the horizontal rolling type. Lock gates shall be designed and constructed with rolling wagons that allow efficient operation and maintenance. All rolling wagons shall be serviceable when the gate is in the dewatered Recess and removable when the gate is in a floating condition. Each of the wagon attachments to the gate shall be designed to allow wagon replacement in less than 4 hours. Design of the wagons shall take into account the load cases and combinations which produce the worst effects. The design of the lock gate rolling equipment shall take into account all the possible effects arising from component wear and the allowable tolerances due to manufacturing and erection. The design of the underwater wagons shall permit easy removal and installation by a crane when the gate is in the floating condition. The support wagons shall be designed to support an additional vertical load due to the accidental flooding of 25% of the watertight zones at the same time. This additional load depends on the position of the flooded zone (to be chosen appropriately for each wagon) and the size of the compartment. The design of the lock gate and of the upper support wagons shall be such that floating of the lock gate inside the gate Recess (e.g. for maintenance purposes) shall be possible without disconnecting the equipment attached to the upper part of the lock gate. Support wagons shall be equipped with wheel crash supports that shall ensure that, in case a single wheel crashes, the support wagon will have only a limited downward displacement and afterward will rest on the wheel crash support in combination with the remaining wheels. The design of these wheel crash supports shall be such that the vertical load on the support wagon can be taken without further damage to the support wagon, the lock gate, or the trackway. Support wagons shall be equipped with the necessary number of jacking points and lifting lugs. Wheel guards shall be mounted in front of leading wheels at each end of the wagon and above the centerline of the track way. <sup>A16</sup>Specific procedures for protection of the rolling wagons during dry outages shall be clearly stated on the design documents. Lock gate rolling equipment shall be limited to a maximum of two different types and sizes in both Locks complexes, Atlantic and Pacific. With the exception of the two different sizes, lock gate rolling equipment shall be equal and interchangeable at both locks complexes.
- B. **Buoyancy Chambers and Ballast Tanks:** The lock gates shall have buoyancy chambers and ballast tanks to reduce their operating weight, limit loads on the supporting elements, and reduce power requirements for operating components. <sup>A19</sup>Ballast tanks and buoyancy chambers shall facilitate the stable opening or closing operation of the gates under all operating conditions and for all possible operating water levels in the lock chambers and the lock gate Recesses. <sup>A19</sup>Additionally, buoyancy chambers and ballast tanks shall be provided to allow the

lock gates to float in a stable manner, to provide sufficient draft to the gate (in a floating condition) for all possible water levels, to allow removal and relocation of the gates, and to permit replacement of underwater components. In general, the top level of the chambers shall be chosen so that the buoyancy chamber remains entirely submerged during the opening and closing of the gates, thus avoiding excessive loading on the support wagons. The top level of the air chambers shall be below the lowest water level at which the normal opening and closing of the gates may take place. <sup>A5</sup> (deleted text) <sup>A5</sup>

1. **Access, Subdivisions, and Compartmentalization:** There shall be a horizontal longitudinal passageway connecting all the watertight compartments, accessible from the top of the gate by means of at least 3 vertical man shafts with built-in ladders and fall-protection systems, both meeting the applicable requirements of OSHA. The passageway and access shafts shall be watertight. The inner diameter of the vertical shafts shall be at least 1 m. The inner diameter of the horizontal passageway shall be at least 2.3 <sup>A17</sup> meters. <sup>A17</sup> If vertical shafts and horizontal passageways do not have circular sections, the above-mentioned diameter dimensions must fit completely inside their cross sections. The horizontal passageway shall have an anti-slip floor (grating or equivalent). Watertight doors that can be opened from the inside or outside shall be installed to provide access from the horizontal passageway to the watertight compartments and to provide the proper separation between compartments. Each door leading into a watertight compartment at a level of 1 meter or more above the compartment's bottom shall have a permanently installed ladder inside the compartment. The inside of the buoyancy chambers and ballast tanks shall be readily accessible. To provide safety during maintenance, each buoyancy chamber or ballast tank shall have at least 2 means of personnel access and egress directly accessible from the horizontal passageway. See Subparagraph 1.04 Y. of this Section. <sup>A5</sup> Additionally, each buoyancy chamber/ballast tank shall have one watertight manhole with cover plate in its top plate. <sup>A5</sup> The buoyancy chambers and ballast tanks shall be proportioned and located in such a way that damage to a chamber shall not flood the contiguous compartments. Vertical separation bulkheads shall be provided for this purpose. Sufficient subdivisions of ballast compartments all along the gate shall be provided to ensure redundancy of buoyancy and ballast capability. Ballast tanks shall be provided with a means to verify water intrusion or flooding without the need to enter the watertight compartment. This verification must be a continuously measuring system, whose results must be reported to a remote location or control room. The results must also be visually verifiable from inside the connecting longitudinal passageway mentioned above, even in the absence of all auxiliary electrical power supply.
2. **Watering and Dewatering of Ballast Tanks:** <sup>A19</sup> Ballast tanks shall be proportioned and properly equipped to be filled with lake water in order to provide the lock gates with a positive reaction on the rolling wagons after being floated into position. Additionally, it shall be possible to remove ballast water from the tanks in order to completely float the gate in a stable manner for removal, transport, or maintenance. Design of the

lock gates shall take into account and minimize any free surface effects, of the water contained in the ballast tanks during all operating and floating conditions.<sup>A19</sup> Measures to preclude the accumulation of dirt silt, and marine life inside the gates shall be included in the floating design parameters. All wall transitions with water or air pipes of tanks, passageways, and man shafts shall be made watertight. The design shall be such that water or air pipes going from one tank to an adjacent tank are avoided. Instead, pipes should go into and out of a tank, from or to the passageway or the outside (tank top, tank bottom). Primary inlet sections of water pipes shall have adequate grating or similar protection to prevent particles greater than 10 mm from entering the pipe system. All tanks shall have bottom plugs, which shall allow a complete emptying of the tank during maintenance. Valves, gauges, manometers, and other regulating equipment, if used, shall be accessible and located entirely inside the horizontal passageway, the vertical access shafts, or on the lock gate above the maximum water level. The design shall be made in such a way that, with the lock gate in the gate Recess under drydock conditions, the water piping system can be emptied completely. This requirement may imply the use of suitable hand-operated valves at the highest and lowest points of the pipe systems. All equipment inside tanks, the horizontal passageway, and the vertical access shafts shall be designed for removal (for repair or replacement) through the manholes and access shafts. The design shall be made in such a way that electrical cabling on the lock gate is avoided as much as possible, and when used, electrical installations shall be explosion-proof, in accordance with Section 26 20 00 (*Electrical Low Voltage Distribution Work*). Electrical cabling inside tanks shall not be allowed. Control and indication shall be in accordance with Section 40 95 13.13 (*Process Control Hardware for Locks Machinery Control Systems*).

3. **Ballast Tank Provisions for Vessel Impact:** The location and number of ballast tanks shall be decided <sup>A17</sup>taking into account <sup>A17</sup> the most probable and the most critical vessel-impact areas on the gate. See also Subparagraph 1.04.O. (*Vessel Impact*) of this Section. <sup>A7</sup>The lock gate, rolling wagons and operating machinery shall be designed to allow the gate to be able to be retracted into the Recess with at least 25% of buoyancy compartments and ballast tanks flooded after vessel impact.<sup>A7</sup>
4. **Automatic Dewatering Sump Pump System:** Each lock gate shall have an automatic dewatering sump pump system to remove water intrusion in the horizontal passageway and in the man shafts. This dewatering pump system shall be completely independent from all other pumping systems (e.g. those used to remove ballast water from the tanks). One spare pump assembly set shall be provided for the Pacific lock complex and one for the Atlantic lock complex. Control and indication shall be in accordance with Section 40 95 13.13 (*Process Control Hardware for Locks Machinery Control Systems*).
5. **Ventilator and Lighting:** The Contractor shall provide ventilation and lighting systems that comply with OSHA requirements. Fixed heavy-duty industrial ventilators and ventilation ducts shall be provided in the

horizontal passageway and man shafts for ventilation prior to confined-space entry and during maintenance work.

C. **Interior Access, Walkways, and Ladders:** Easy access to the interior of the lock gate shall be provided at all times. All internal access points, walkways, and ladders shall be fully OSHA compliant and shall include fall-protection devices or systems. There shall be a minimum of three vertical man shafts accessible from the top of the gate providing access to the longitudinal tunnel connecting all air chambers. All access doors shall be capable of being easily opened and closed from the inside or outside by one person, for the duration of the design life.

D. **Seals, Bearing Blocks, and Maintenance Supports:** <sup>A17</sup>With the exception of the LH-4 ocean side gates, all gates shall be able to bear on the lock structure and seal correctly when subjected to hydrostatic loads applied from the upstream side. For additional requirements specific to the ocean side gates, see Subparagraph 1.04 Q of this Section. <sup>A17</sup>

1. **Seals:** <sup>A16</sup>Sealing between the lock gate and the structure of the lock shall be by means of continuous seals fixed to the lock gate that make contact with bearing surfaces on the structure of the lock. The seals shall be located at the bottom (sill seal) and at the sides (lock-side seal). Lock gate seals shall be designed to withstand all imposed loads for the service life indicated in Subparagraph 1.04 J. (*Design Life*) of this Section. The seals and their associated installation hardware shall be designed to facilitate removal and installation in the event that their replacement is required due to wear or accidental damage. <sup>A16</sup> Lock gate seals shall be made of heavy-duty materials and of a type that allows possible misalignments of the sealing surface, while still providing adequate watertightness within the allowable leakage limits as specified in Subparagraph 1.04 G. of this Section. Seals shall not be fixed to the gate by means of welded threaded studs or welded bolts. <sup>A5</sup>Any <sup>A5</sup>elastomeric seals, splices, direction changes, or other connections shall be made by hot vulcanization using a joint mold or other means that produces a continuous length of seal, unless not required by design to comply with the allowable leakage limit. The required hardness of the seals shall be determined by the Contractor in order to properly seal under all conditions of minimum and maximum load combinations. In the case of wooden seals, high-strength material such as azobe wood shall be used. Seal-fastening strips and spacers shall have rounded corners on the seal side large enough to prevent crimping <sup>A5</sup>and <sup>A5</sup>cause tearing. The Contractor shall take necessary measures to prevent water leakage through bolt holes, without obstructing future disassembly. <sup>A10</sup>The above requirements for lock gate seals shall be applicable for seals used for gate-Recess closures. <sup>A10</sup>

2. **Bearing Surfaces:** Lock gate bearing surfaces shall be designed to withstand all imposed loads and for a service life as indicated in <sup>A9</sup>Subparagraph 1.04 J. (*Design Life*). <sup>A9</sup> Sill and lateral bearings shall be adequate for the loads imposed by the gate. These bearings shall be of

<sup>A5</sup>durable<sup>A5</sup> and commercially available material and <sup>A5</sup>shall be<sup>A5</sup> designed to facilitate removal and installation. The design of the gate structure near the sill bearings and the lateral bearings shall be made such that local uplift of the seals from the bearings does not occur. The above requirements for lock gate bearings are also applicable for bearings used for the gate-Recess closures and the <sup>A10</sup>maintenance closures.<sup>A10</sup>

3. **Bearing Blocks:** Lock gate bearing blocks shall be designed to withstand all imposed loads for the service life indicated in <sup>A9</sup>Subparagraph 1.04 J. (*Design Life*).<sup>A9</sup> The lock gate shall have a sufficient number of bearing blocks at its bottom to support the lock gate on the bottom of the gate Recess during drydock conditions. These bearing blocks are mainly loaded in the vertical direction, by the weight of the lock gate.
  4. **Maintenance Supports:** Maintenance supports that are capable of hanging the rolling lock gates from above shall be provided. The maintenance supports shall allow access to the bottom of the gates for maintenance or repair purposes.
- E. **Minimum Depth of Gate Sills and Fixed Underwater Components:** Lock gate sills and fixed underwater components shall be located at a minimum water depth of 18.3 m from the lowest operational water level in the chamber.
- F. **Visual Aids to Navigation:** Lock gates shall have a horizontal strip of reflective paint on the top 60 cm of both vertical faces (on both sides) to improve sighting of the gate location by pilots and tugboat captains. For additional visual aids to navigation, refer to alignment lights and VDS semaphores in Section 35 10 00 (*Waterway and Marine Signaling and Control Equipment*).
- G. **Operating Machinery:** The gate shall be operated with operating machinery that consists of electrically powered motors connected to gear boxes. A wire-rope winch system shall be provided for the operation of the lock gate. The lock gate shall be moved by steel wire ropes connected at anchorage points. Electrical motors shall comply with the requirements of Section 01 86 13 (*Plant - Mechanical Systems and Equipment*). The gate-operating machinery shall consist of available manufactured products (catalog items) that satisfy the installation and operating conditions. The gate-operating machinery shall be from well-known and reputable manufacturers that have a proven record of successful operations over more than 5 years in similar conditions and installations.
- H. **Lock Gate Recess Equipment:** The lock gate Recesses shall be built perpendicular to the lock walls and function as storage for the retracted gates. When dewatered, the Recesses shall function as dry docks for lock gate maintenance and inspection. The Recesses shall be dimensioned to provide clearance as specified in Section 01 81 16 (*Lock Structures*) between the outer plating of the gate and the concrete walls, with the exception of the gate seal and bearing area on the lock chamber wall. For the lock gate Recess structure, refer to Section 01 81 16 (*Lock Structures*). The lock gate Recess equipment shall include, but shall not be limited to, the following.



1. **Gate Recess Closures:** Gate Recess closures, consisting of slot bulkheads, caissons, or stop logs, shall be provided for dewatering purposes. See Subparagraph 1.03 M. (*Lock Gate Recess Closures*) of this Section.
  2. **Dewatering Shafts and Catch Basins:** Each Recess shall be provided with the required means to dewater by means of portable dewatering pumps. Dedicated shafts shall be provided in the concrete structure for installation of these dewatering pumps without interruption of lock operations. Gate Recesses shall be provided with suitable catch basins to install separate portable dewatering pumps to handle leakage and rainwater. For gate Recess dewatering and filling, refer to <sup>A5</sup>Subparagraph <sup>A5</sup> 1.03 I. of this <sup>A5</sup>Section.<sup>A5</sup>
  3. **Oil-Water Separator System:** Above-ground traction wire rope tunnels shall have rainwater drainage to a central point with an oil-water separator system. For gravity oil-water separator requirements, refer to Section 01 86 13 (*Plant – Mechanical Systems and Equipment*).
  4. <sup>A16</sup>**Space for Personnel Hoists:** Lateral shafts shall be provided in the concrete wall to allow installation of ANSI A10.4 personnel hoists outside the working clearance around the gate. The Contractor shall only provide the detailed specifications for the personnel hoist. The Employer will purchase the personnel hoists.<sup>A16</sup>
  5. <sup>A16</sup>(Reserved)<sup>A16</sup>
- I. **Gate Recess Dewatering and Filling:**
1. **Gate Recess Pumping/Dewatering System.** <sup>A19</sup>All pumps shall be interchangeable and shall include discharge piping long enough to be able to function effectively at each recess and at all water levels. <sup>A19</sup>Gate Recess pump dewatering time shall be in accordance with Section 01 92 00.13 (Dry Outages), Subparagraph 1.02 B. Pumps shall be in accordance with Section 01 86 13 (Plant – Mechanical Systems and Equipment). Gate Recess pump controls and indications shall be in accordance with Section 40 95 13.13 (Process Control Hardware for Locks Machinery Control System). <sup>A16</sup>Refer to Section 01 93 00 (*Maintenance Services*).<sup>A16</sup>
  2. **Recess Filling System:** The Contractor's design shall provide a safe means of filling the Recess to allow removal of the gate Recess closure. This filling system shall be capable of equalizing the Recess water level with that of the lock chamber and maintaining the levels equalized during the whole Recess-closure removal procedure. The Contractor shall design the system to avoid back pressure in the Recess closure during the filling process.
- J. **Walkway and Handrails:** All lock gates shall have the capability to serve as personnel bridges when closed. <sup>A19</sup>The minimum design live load of the walkways for personnel use shall be a uniformly distributed load of 5 kN/m<sup>2</sup>, or a

concentrated load of 9 kN at any point.<sup>A19</sup> A suitable interface between the lock wall and the top deck of the gate shall be provided for pedestrian traffic. For gates that are designated to carry roadways for vehicular traffic, the pedestrian way shall be physically separated from the roadway in accordance with AASHTO standards. Additionally, it shall be possible to walk across the gate Recesses when the gates are in the open or closed position. This walkway shall be located as close as practicable to the edge of the lock wall to allow personnel uninterrupted passage along the whole length of the lock wall. The top deck of gates shall be provided with an adequate slip resistant pattern on the walkway portion. Walkway and handrail design and construction shall comply with ANSI and OSHA requirements. The slope of the walkway interface shall be limited to 10%. Walkway and handrail controls and indications shall be in accordance with Section 40 95 13.13 (*Process Control Hardware for Locks Machinery Control Systems*).

<sup>A8</sup>K. **Bridgeways:** The Contractor's design and construction of the locks shall include two bridgeways at each set of locks, Atlantic and Pacific, to carry vehicular traffic.

1. **Types of Bridgeways:** Bridgeways shall be located at the top deck of the rolling gates, or as completely independent movable structures.

a. **Bridgeways Located on Top of the Rolling Gates:** If bridgeways are located on top of the rolling gates, the Contractor shall comply with the following requirements. At each set of locks, the top deck of one lakeside gate of the upper level and one <sup>A17</sup>ocean side <sup>A17</sup>gate of the lower level as well as roadway interfaces at each lock facility shall be designed and constructed for the use as motor vehicle bridgeways. The bridgeways shall be provided with a suitable permanently fixed road interface between the lock wall and the top deck of the gate to allow vehicular traffic anytime the gate is closed.

b. **Completely Independent Bridgeways:** If bridgeways are completely independent of the rolling gates, the Contractor shall comply with the following requirements. The location of independent bridgeways shall be at the extreme ends of the lock facilities and outside of the lock chambers, in order to allow bridge traffic without interfering with lock operations. Operation and location of independent bridgeways shall not impair ship navigation in the lock. Closing and opening times of independent bridgeways shall be approximately equal to operation time of the lock gates.

2. **General Bridgeway Requirements:**

a. **Bridgeway Design Requirements:** As a minimum, bridgeways shall be designed for HS20-44 truck loading, according to AASHTO standard specifications. Additionally, the bridgeways shall be able to support a maintenance vehicle with a minimum wheel load of 10 metric tons located at any point. The total

weight and dimensions for the maintenance vehicle loading condition shall be based on the largest wheel crane expected to be required for lock maintenance, but shall be not be less than the weight of a 40 metric ton capacity crane. The Contractor shall define the required crane weight and the maximum size and weight of the equipment to be lifted. The Contractor shall design and construct the roadway deck using the appropriate wheel loads and wheel spacing based on data from different crane manufacturers. At no point shall the interface or the bridgeway itself shall have a vertical gradient change exceeding 10%. The Contractor shall design, construct, and install barriers such as vehicular railings, guard rails and curb walls suitable for the expected traffic in accordance with AASHTO standards. The final roadway shall have the capacity and a sufficiently large turning radius to allow adequate conditions for traffic of the wheel crane or a fire truck with the following characteristics.

- 1) **Fire truck with load:** 31,000 kg.
- 2) **Truck length (minimum):** 12.8 m.
- 3) **Width (minimum):** 2.74 m.
- 4) <sup>A19</sup>**Truck Ladder length:** 25.9 m. (extended). The ladder will be completely retracted on the fire truck when it is traveling on the bridgeway. <sup>A19</sup>
- 5) **Wheel base:** 6.68 m.

- b. **Effect of Vehicle Impact:** The Contractor shall make the design so that the effects of vehicle impact on the bridgeway are limited to parts that can easily be repaired or replaced with a minimum of traffic interruption. This requirement may be fulfilled by using dedicated protection.
- c. **Bridgeway Controls:** Bridgeway controls and indications shall be in accordance with Section 40 95 13.13 (*Process Control Hardware for Locks Machinery Control Systems*) and Section 28 16 46 (*Vehicular Control Systems*).<sup>A8</sup>

- L. **Lock Gate Rolling Track Cleaning System:** Design and construction of the track shall minimize accumulation of sediment and debris that may interfere with the rolling stock. Additionally, all rolling stock shall be equipped with a suitable track-cleaning system. This system shall be capable of removing large debris and smaller foreign items such as lock wall fenders that may be located on top of the rolling track and impair adequate motion of the gate. Track-cleaning system control and indication shall be in accordance with Section 40 95 13.13 (*Process Control Hardware for Locks Machinery Control Systems*). Further information about the tracks can be found in Section 01 81 16 (*Lock Structures*).

- M. **Lock Gate Recess Closures:** All lock gate Recesses shall be capable of being closed and used as drydocks for gate-maintenance and repair purposes. Lock gate Recess closures shall be provided to prevent chamber water from entering the Recess while the gate Recess is being dewatered for use as a dry dock. <sup>A5</sup>Lock operations shall be maintained during the dewatered-Recess maintenance periods. The gate-Recess closures shall be designed for all possible loading conditions acting on them during dewatered-Recess maintenance periods with duration of not less than one month. <sup>A5</sup> <sup>A16</sup>Gate Recess closure systems consisting of bulkheads or stoplogs installed with land based or floating equipment may be provided. For these systems, adequate storage space shall be identified and installation procedures using cranes shall be provided. The Contractor may include the use of Employer's floating crane Titan (see lifting capacities in Paragraph 1.03 N. of this Section). An alternate system with floating caissons may also be provided. The installation or removal of locks gate-Recess closures shall be under balanced head conditions. Dewatering of the locks gate Recess shall begin only after the closures have been set in place. The installation or removal time for the gate-Recess closures shall not exceed 6 hours if hoisting is performed from the chamber and shall not exceed 8 hours if hoisting is performed from the shore side. <sup>A17</sup>For the purpose of cost effectiveness, gate Recess closure sizes and types may be standardized to the maximum extent feasible. The Contractor shall provide 1 set of each size and type of gate Recess-closure assemblies for the Pacific lock complex and 1 set of each size and type <sup>A17</sup>for <sup>A5</sup>the Atlantic complex. For seals, refer to <sup>A5</sup>Subparagraph <sup>A5</sup>1.03 D. of this Section.

1. **Transport, Installation, Hoisting Requirements, and Removal Procedures and Equipment:** The design shall indicate the recommended transport, installation, removal, and hoisting procedures and equipment required for the placing and removal <sup>A17</sup>of each size and type of the closure. Hoisting requirements shall be clearly indicated and shall not exceed the capacity of the Employer's Floating Crane Titan. Refer to the table in Subparagraph 1.03 N of this Section, <sup>A17</sup> for information on the Employer's Floating Crane Titan which is available to perform hoisting from the chamber side should the Contractor determine it feasible.
2. <sup>A16</sup>**Storage and Maintenance Requirements:** The design shall indicate the recommended storage and maintenance requirements <sup>A17</sup>for each size and type of closure. <sup>A17</sup>
3. <sup>A19</sup>**Use of Crane Titan by the Contractor:**
  - a. <sup>A20</sup>**General:** Where the Contractor exercises the use of Employer's floating crane Titan to install the lock gate recess closure pursuant to paragraph 1.03 M above, the Contractor shall be responsible for all costs (including the Employer's costs) arising therefrom. The current commercial rental rate for the crane Titan is US\$2,520.00 per hour. The Contractor shall be charged the rate in effect at the time the services are actually provided. At all times, the crane Titan shall be under the operation and control of the Employer's Personnel. <sup>A20</sup>

- b. <sup>A20</sup>**Coordination Prior to Use:** A request for crane services shall be submitted to the Employer's Representative within a minimum of 60 days and a maximum of 120 days prior to the date in which the service is required. The Employer's Representative will evaluate the request and determine if the conditions under which the service is to be provided are within the Employer's capabilities to warrant safe and efficient service. It shall be understood that in the event that Employer's Personnel operating the crane consider that the service requested to be conducted does not warrant safe and efficient operation be it for reasons of current crane capability, performance, or others, the Employer's Representative, at its absolute discretion, will have the right to deny performance of such service. The amount of time the crane will be used shall be agreed upon and logged.
- c. **Availability:** The Employer's Representative will make every effort leading to provide the service stated in subparagraph b., above, when and as requested by the Contractor; however, it shall be understood that vessel transits and locks operations shall have priority, and that the Employer's Representative does not warrant that the service will always be provided without delays.<sup>A20</sup>

N. <sup>A17</sup>**Employer Heavy Lifting Equipment:**<sup>A17</sup>

<sup>A16</sup> <b>Employer Cranes and Heavy Equipment</b> <sup>A16</sup>	
<b>Notes:</b>	
1. <sup>A16</sup> This information is for reference only. Capacity of Employer heavy-lifting equipment. <sup>A16</sup>	
2. 1 ton = 2,000 lbs. = 0.9071847 metric ton	

Floating crane name	Maximum capacity (in tons)
Titan	386

<u><b>Titan</b></u>		
Capacity (in tons)	Radius from center pin (in feet)	Reach (Over side or distance from fender (in feet))
386	114	59
364	117	62
331	120	65
287	137	82
220	153	98
143	173	118
110	193	136
55	212	157

- O. **Lubrication:** Lubrication shall be in accordance with the equipment manufacturers' recommendations. All new parts requiring lubrication shall be

lubricated prior to delivery and tagged to show the type of lubricant used. The Contractor shall supervise the complete lubrication of all systems prior to starting the installed gate. To the maximum extent feasible, self-lubricating bearings requiring no additional lubricants shall be used in the design and construction of the rolling gates and accessories. Wagon bearings shall be self-lubricating requiring no additional lubricants during their design service life. Lubrication systems shall be designed and constructed to prevent contamination to lock waters. Where feasible, the Contractor shall use biodegradable lubricants. The design and construction of the lubrication system shall prevent the entrance of contaminants and water from the locks. If controls are used, lubrication control and indication shall be in accordance with Section 40 95 13.13 (*Process Control Hardware for Locks Machinery Control System*).

- P. **Corrosion Prevention and Protection:** In addition to other requirements, rolling gates, upper and underwater wagons, maintenance supports, trackway and track-supporting structures, rolling-gate operating equipment and accessories, gate Recess closures, and embedded metal shall be designed, fabricated, and constructed to provide the best corrosion-prevention and protection in an industrial, tropical coastal marine environment, in accordance with applicable standards and recommended practices of the Society for Protective Coatings (SSPC) and National Association of Corrosion Engineers (NACE) International.

1. **Corrosion Prevention:**

- a. **Design:** In addition to other requirements, the design shall consider means for preventing corrosion. Refer to the National Association of Corrosion Engineers (NACE) International publication “Fundamentals for Designing for Corrosion Control – A Corrosion Aid for the Designer” by R. James Landrum.
- b. **Materials Selection:** Materials shall be selected and protected to fulfill all design requirements and, at the same time, to avoid corrosion and minimize the requirement for maintenance. Steel hardware, except for stainless steel, shall be galvanized with the hot dip process.
- c. **Dissimilar Metals:** Where at all possible, contact between dissimilar metals shall be avoided. Dissimilar metals that are in contact shall be as close as possible in the galvanic table and shall be electrically insulated from each other by means of non-conducting coatings, gaskets, synthetic material bolt sleeves, washers, etc.
- d. **Water Drainage:** Design and construction practices shall prevent the accumulation of water or debris on above-water metal surfaces and the accumulation of silt or debris on underwater metal surfaces. Joints shall be designed to prevent crevice corrosion.

- e. **Accessibility for Painting:** The design shall provide proper accessibility for maintenance and painting. Enclosed spaces shall be provided with two separate entry/exit access manholes.

2. **Corrosion Protection:**

- a. **General:** Metal surfaces of rolling gates including structural metal and skin plates; flotation and ballast compartments;<sup>A5</sup> piping, valves, and related underwater components;<sup>A5</sup> passageways; trackway and track-supporting structures; underwater and upper support wagons; and embedded metal<sup>A11</sup> shall be coated in accordance with Section 09 96 00 (*Corrosion Control Coatings*) and cathodically protected in accordance with Section 26 42 00 (*Cathodic Protection*). As an alternative, selected surfaces may be metallized and coated in accordance with Section 05 50 13.13 (*Metallizing and Coating Hydraulic Structures*).<sup>A11</sup>
- b. **Temporary Protection:** Metals, equipment, machinery, and other metallic parts shall be protected with suitable protective coatings and protective compounds during temporary storage and sea transportation.
- c. **Cathodic Protection:** Steel surfaces that have been metallized and high-strength steels shall not have cathodic protection.

Q. **Tolerances:**

- 1. **Allowable Tolerances:** The Contractor shall ensure that all fabrication and construction tolerances are compatible with each other and meet the design and operational requirements.
- 2. **Embedded Parts for Rolling Gates:** Tolerances for embedded parts of the rolling gates shall not exceed the <sup>A5</sup>tolerance values<sup>A5</sup> specified in DIN 19704-2, tolerance class 1.
- 3. **Tolerances for Rolling Gates:** Tolerances of the rolling gates shall be adapted to the tolerances of the embedded parts.

R. **End Stops for Lock Gates:** At both ends of its horizontal stroke during normal operation, each lock gate shall make contact with the concrete foundation through elastic blocks (of rubber or an equivalent material) positioned on both sides of the gate (upstream/downstream). The inward end of the horizontal stroke of the lock gate when pulled into its gate Recess for maintenance shall also make contact with the concrete foundation, though elastic blocks (of rubber or an equivalent material) positioned on both sides of the gate (upstream and downstream). The design of these end stops shall be made in such a way that their removal or replacement can be made easily, using light mobile lifting equipment.

S. <sup>A16</sup>(Reserved)<sup>A16</sup>

T. **Packaging and Delivery:**

1. **Packaging and Marking:** All equipment, spare parts, tools, and inventory, shall be protected to withstand rough handling and corrosive environments during ocean shipment. Packing shall be in accordance with ASTM D 3951.
    - a. **Corrosion Prevention:** All finished parts and surfaces that are subject to corrosion shall be coated and protected with a corrosion-resistant compound.
    - b. **Materials and Equipment Cleaning:** The equipment, spare parts, tools, inventory, and materials shall be clean and free of all foreign material.
    - c. **Repainting:** The surfaces of each lock gate or equipment where paint has been damaged during shipment shall be cleaned and touched-up with a surface preparation and paint matching the approved coating system.
  2. **Delivery:** The Contractor shall deliver the lock gates and components in accordance with these specifications. Items that, in the opinion of the Employer's Representative, are damaged or defective shall be replaced<sup>A17</sup> by the Contractor at its own cost.<sup>A17</sup> Unless otherwise indicated, each lock gate shall be delivered to its designated destination, in accordance with the Contract's delivery schedule.
- U. <sup>A16</sup>**Spare Components and Equipment Sets:** Refer to Section 01 93 00 (*Maintenance Services*).<sup>A16</sup>
- V. **Numerical Hydraulic Models:** The Contractor shall provide the following numerical hydraulic models.
1. **Floating Stability Model:** Numerical models of each size of gate shall be provided to confirm its buoyancy and stability under all possible conditions.
  2. **Moving Forces Model:** Numerical models of each size of gate shall be provided to verify the forces acting on the lock gate during the acceleration, movement, and deceleration of the gate. The model shall take into account the displacement of water when the gate is moving, especially into and out of the Recess. The model shall identify the forces needed to move the gate, size the operating machinery, and demonstrate that the required opening and closure time can be met under all conditions.
- W. <sup>A16</sup> (Reserved)<sup>A16</sup>
- X. <sup>A10</sup> (Reserved)<sup>A10</sup>
- Y. <sup>A16</sup>**Maintenance Closure Systems Design:** The Contractor shall design and prepare complete drawings and specifications for the maintenance closures with all components and accessories. The system is to be used for maintenance closure of the lakeside and sea side of each new lock complex, Atlantic and



Pacific, and shall be located upstream from the lakeside gates and downstream from the <sup>A17</sup>ocean side gates. <sup>A17</sup> The design shall be based on the use of one maintenance closure or stoplog system. <sup>A20</sup> The maintenance closure system shall be capable of being installed to function effectively at any of the four Atlantic and Pacific locks complex entrances. There are four Atlantic and Pacific locks complex entrances (2 lakeside entrances and 2 sea side entrances). <sup>A20</sup> The dimensions of the slots in the locks walls at each lock complex entrance shall permit the installation of the maintenance closure or stoplogs system. <sup>A16</sup> <sup>A10</sup> The design of the systems shall include all components and accessories including, but not limited to structure, bearing surfaces, seals, safety devices, and fixtures. The systems shall be independent from the lock operating gates and shall not interfere with vessel traffic at any time, except when in the closed position across the chamber. Each closure system shall cover the entire chamber width when closed. The system shall be housed and supported by the structures indicated in Section 01 81 16 (Lock Structures). For seals, refer to Subparagraph 1.03 D.1. The Contractor shall provide only the design for the maintenance closure systems under <sup>A10</sup> <sup>A17</sup> the Contract; its fabrication, delivery, and testing is a Provisional Sum. <sup>A17</sup>

1. <sup>A16</sup>**Designed to Facilitate Future Installation:** Maintenance closure system shall be designed to facilitate its future installation at each lock facility as a retrofit if the fabrication Provisional Sum is not exercised. <sup>A16</sup> The Contractor shall perform all the civil works, including embedded parts such as castings and sealing surfaces, deemed necessary to allow future installation of its proposed maintenance system, without the need to require a continuous interruption of lock operations. <sup>A10</sup> Lock outages required for future installation of the <sup>A10</sup> maintenance closure system <sup>A10</sup> shall not exceed 7 periods of no more than 12 hours each. Future installation of the systems shall not require demolition of completed structures, with the exception of parts specifically designed and detailed for future removal. Refer to Section 01 81 16 (*Lock Structures*) for installation and demolition requirements.
2. **Designed for Operation under Extreme Conditions:** <sup>A10</sup> Maintenance closure systems <sup>A10</sup> shall be suitable for use in the conditions listed in <sup>A9</sup> Subparagraph 1.04 R. <sup>A9</sup>
3. <sup>A10</sup> (Reserved) <sup>A10</sup>
4. <sup>A10</sup>**Designed to Facilitate Maintenance:** Maintainability shall be in accordance with Subparagraph 1.04 W.1. In addition, the maintenance closure system shall be designed with all operating equipment aboveground and above the highest water level of the Gatun Lake, Atlantic entrance and Pacific Ocean entrance. Corrosion prevention shall be in accordance with Subparagraph 1.03 P.
5. **Transport, Installation, Hoisting Requirements, and Removal Procedures and Equipment:** The design shall indicate the recommended transport, installation, removal, and hoisting procedures and equipment required for the placing and removal of the maintenance closures. Hoisting requirements shall be clearly indicated. <sup>A19</sup> Refer to

the table in Paragraph 1.03 N., for information on the Employer's floating crane Titan and to paragraph 1.03.M.3 for the use of crane Titan by the Contractor.<sup>A19</sup>

6. **Storage and Maintenance Requirements and Procedures:** The design shall indicate the recommended storage and maintenance requirements and procedures.<sup>A10</sup> The systems shall be designed to be maintained in place under dry conditions.

#### 1.04 DESIGN CRITERIA AND PERFORMANCE

- A. **Suitability with Lock Limiting Features:** The lock gates, Recess closures,<sup>A10</sup> maintenance closures,<sup>A10</sup> and operating equipment shall be suitable for use with the limiting design features and infrastructure of the locks as indicated in Section 01 81 16 (*Lock Structures*), Paragraphs 1.03 and 1.04.
- B. **Geometry:**<sup>A9</sup> The lock gates shall be of the horizontal rolling type, and of sufficient length to span the width of the chamber and achieve proper support on the lateral bearings built into the lock walls. The height of the lock gates shall allow the gate to provide a minimum freeboard of 1 meter over the maximum water level in each chamber, while resting on the bottom trackway. The width of the lock gates shall provide the required structural strength, floatability, and serviceability for all possible load conditions. The lock gate shall also be able to float in an upright, stable manner when the ballast tanks are partially or completely filled with air for transport, removal, maintenance, or other purposes. The shape of the gate and of the air and ballast tanks shall be optimized to minimize hydrodynamic forces acting on the gate during motion.<sup>A9</sup>
- C. **Operating Water Levels:** Water levels for the design of the lock gates shall be established according to the Equalization levels of the chambers. These levels shall depend on the final design adopted for the lock chambers, which shall be established according to the required operating levels for the entire lock complexes. Refer to Section 01 81 13 (*Filling and Emptying Systems*) for the required operating water levels for the lock complexes.
- D. **Normal Operating Conditions:** Refer to Subparagraph 1.04 U. for design considerations and criteria for operating machinery. As a minimum, the following operating conditions shall be considered during the design of the lock gates.
  1. **Regular Operating Heads:** These shall depend on the final design of the lock and the depth to the sills. Each lock gate shall be designed to withstand the maximum hydrostatic head due to water-level differentials during normal lockages. Different water densities shall be considered.
  2. **Movement of the Gate into / out of the Recess:** Lock gates shall be able to operate with a differential head of <sup>A5</sup>0.1 meter.<sup>A5</sup>
  3. **Vehicle Traffic on Top of the Lock Gate:** See Subparagraph 1.03 K. of this Section.

4. **Waves:** The Contractor shall design, specify, construct, and install lock gates capable of withstanding the additional loads generated by the presence of environment- and vessel-produced waves. The Contractor shall evaluate the characteristics of the wave loads on the gate for each specific location; however, the minimum design wave height shall be 1 m above the maximum non-storm, water level on the upstream side of the gate. Wave loads may be present during all phases of normal lockage and maintenance, and the Contractor's design shall consider the most severe effects.
5. **Effect of Propeller Jets from <sup>A5</sup>Transiting Vessels:** The design and construction of the Lock gates shall <sup>A17</sup>take into account the effect of the propeller jets from transiting vessels. The design shall take into account <sup>A17</sup>propeller jets at all possible operating water levels at Up Lockages and Down Lockages. Refer to Section 01 81 13 (*Filling and Emptying Systems*) for balanced and unbalanced head conditions to be considered. The design and construction of the Lock gates shall include but shall not be limited to the effect of the propeller jets of the "Design Vessel". For specifications of the "Design Vessel", refer to Section 01 10 00 (*General Project Requirements*), Subparagraph 1.02 A. The Contractor shall design and construct each lock gate to withstand the effects of the following "Design Vessel" propeller characteristics:
  - a. Minimum diameter of 9.5 meters
  - b. Minimum of 82 RPM or "Design Vessel" engine RPM at 50% Load (half ahead.)
  - c. Distance from the lock gate to the propeller shall be within 30 meters. <sup>A5</sup>
6. <sup>A19</sup>**Wind Loads (Atlantic and Pacific):** As a minimum, the lock gate design shall take into account the wind loads generated by three-second gust velocities of 115 km/h on the Pacific side and 140 km/h on the Atlantic side. The wind direction causing the worst possible effects on the gate or its operating machinery shall be assumed. <sup>A19</sup>

E. **Extreme Conditions:**

1. **Earthquake:** <sup>A16</sup>Lock gate design shall take into account the seismic loads indicated in Section 01 81 16.13 (*Seismic Design Criteria*) and Volume VII, Part 3 (*Seismic Design Criteria Data*). <sup>A16</sup>
2. **Vessel Impact:** <sup>A9</sup>See Subparagraph 1.04 O. of this Section. <sup>A9</sup>
3. **Flooding:** <sup>A16</sup>Gates shall be designed to withstand the loads caused by the PMF based on the Contractor's interpretation of the Hydro-meteorological Report included in Volume VI, Part 7. <sup>A16</sup>
4. <sup>A19</sup>(Reserved). <sup>A19</sup>

5. **Extreme Low Lake Level:** In addition to the lake levels shown in Section 01 81 13 (*Filling and Emptying Systems*), the rolling gates shall be able to operate normally when Gatun Lake level is drawn down to an elevation of 22.7 m (74.5 feet) PLD, as could be expected during drought caused by severe “El Niño” years. <sup>A16</sup>Refer to Volume VI, Part 7 (*Hydrometeorological Report*) for details on “El Niño” which is provided for <sup>A17</sup>information purposes only. <sup>6</sup>Refer to Sub-Clause 5.1 of the Conditions of Contract. <sup>A17</sup>

F. **Erection and Maintenance Conditions:**

1. <sup>A7</sup>**Dry Chamber Outage:** All lock gates<sup>A7</sup> shall be able to seal correctly and withstand the stresses produced by a hydrostatic load with maximum head on the <sup>A7</sup>gate<sup>A7</sup> upstream side and an empty chamber on the <sup>A7</sup>gate<sup>A7</sup> downstream side, <sup>A7</sup>with the exception of the <sup>A7</sup><sup>A17</sup>ocean side gates. In the case of the ocean side lock gates, the lowest gate downstream level shall be taken as the extreme low tide. Additionally, for the ocean side lock gates, a condition of reverse head shall also be considered <sup>A17</sup>, and the gates shall be able to seal correctly and support the hydrostatic load caused by the maximum sea level on the <sup>A7</sup>gate<sup>A7</sup> downstream side and <sup>A7</sup>an empty lower chamber<sup>A7</sup>. Extreme tides and maximum lake levels shall be considered for the dry chamber condition. <sup>A7</sup>Refer to Section 01 92 00.13 (*Dry Outages*). <sup>A7</sup>
2. **Dewatered Recess:** For maintenance purposes, a lock gate will enter into its Recess, which will then be closed and dewatered as a dry dock. When inside its Recess, the gate shall be able to be floated and supported approximately 2.1 meters above the Recess floor before dewatering. Maintenance supports capable of supporting the gates without any permanent gate-distortion shall be provided inside the Recesses. Each lock gate shall have its own maintenance supports independent of the maintenance supports for the adjacent lock gate. The supports shall be capable of withstanding the design earthquake and all possible forces, without loss of load-carrying capacity while supporting the weight of the drydocked gate.
3. **Erection Conditions:** The Contractor shall design in such a way that the lock gate structure, gate Recess closures, track maintenance support wagons, parts of the mechanical drive, and other components associated with the gates can take all possible loads during all phases leading to completion of the lock <sup>A17</sup>Contract, <sup>A17</sup>e.g. assembly, testing, shipment, and erection. Possible loads during these phases shall also be considered for erection equipment, auxiliary materials, etc.

- G. **Leakage:** The <sup>A5</sup>maximum <sup>A5</sup>allowable leakage rate per meter of lock gate seals and sealing surfaces at any point shall not exceed <sup>A5</sup>10 liters/minute <sup>A5</sup>when the gate is subjected to normal and maintenance operating conditions. <sup>A5</sup>The overall average leakage rate per meter of lock gate seals and sealing surfaces shall not exceed 5 liters/minute. <sup>A5</sup>This requirement shall also apply to the lock gate closures. <sup>A19</sup>See also Subparagraph 1.06 E. (*Tests on Completion*) of this Section. <sup>A19</sup>

- H. <sup>A7</sup>**Standardization and Interchangeability:** <sup>A17</sup>For the purposes of cost effectiveness, gate sizes and types may be standardized to the maximum extent feasible. As a minimum, the following standardization shall be provided: <sup>A17</sup>
- <sup>A10</sup>1. **Atlantic Lakeside Gates:** The two gates located at <sup>A11</sup>lock head <sup>A11</sup> LH-1 shall be identical and interchangeable.
  2. **Pacific Lakeside Gates:** The two gates located at <sup>A11</sup>lock head <sup>A11</sup> LH-1 shall be identical and interchangeable.
  3. **Atlantic Locks Internal Gates:** <sup>A19</sup>The two gates located at lockheads LH-2 and the two gates located at lockheads LH-3 of the Atlantic lock facility shall be identical and interchangeable. <sup>A19</sup>
  4. **Pacific Locks Internal Gates:** <sup>A19</sup>The two gates located at lockheads LH-2 and the two gates located at lockheads LH-3 of the Pacific lock facility shall be identical and interchangeable. <sup>A19</sup>
  5. <sup>A17</sup>**Atlantic Ocean** <sup>A17</sup> <sup>A16</sup>**Gates:** The two gates located at lock head LH-4 shall be identical and interchangeable. <sup>A16</sup>
  6. <sup>A17</sup>**Pacific Ocean** <sup>A17</sup> <sup>A16</sup>**Gates:** The two gates located at lock head LH-4 shall be identical and interchangeable. <sup>A16</sup>
  7. <sup>A16</sup>Unless otherwise indicated, the gate equipment and components of equal size and type shall be interchangeable to allow relocation within the Pacific and Atlantic lock complexes. <sup>A16</sup>
  8. <sup>A16</sup>**Gate Rolling Equipment:** Lock gate rolling equipment shall be limited to a maximum of two different types and sizes for both Locks complexes, Atlantic and Pacific. With the exception of the two different sizes, lock gate rolling equipment shall be equal and interchangeable at both locks complexes. <sup>A16</sup>
- I. **Redundancy:** With the exception of the bridge decks on each end of a new lock complex, each lock head shall have two parallel identical lock gates in independent Recesses at each required location to provide redundancy to the system and to allow for scheduled maintenance on one of the <sup>A7</sup>gates. In the <sup>A7</sup>event of a ship collision with a pair of chamber gates, the design (including distance between gates) shall permit the first gate impacted to serve as an energy absorber. As a result, no subsequent damage shall be transmitted to the second gate. See also <sup>A9</sup>Subparagraph 1.04 O. (*Vessel Impact*) of this Section. <sup>A9</sup>Redundancy shall be provided for all critical systems and components (those whose malfunction would interfere with the safe and continuous operation of the Canal).
- J. **Design Life:** <sup>A7</sup>The Contractor shall design, specify, and construct the lock gate and gate Recess closure structures for a minimum service life of 50 years. <sup>A7</sup>Other gate features shall be designed for a minimum service life according to the following table:

DESIGN LIFE			
Description	Items	Minimum operating period or cycles of operation (whichever occurs first)	
		Years	Cycles
<sup>A7</sup> Rolling gates/Recessed Closures <sup>A7</sup>	<sup>A7</sup> Embedded metals <sup>A7</sup>	100	900,000
	Above-water wagons <sup>A7</sup> for rolling gates <sup>A7</sup>	50	450,000
	<sup>A7</sup> Rolling gate track way <sup>A7</sup>	30	270,000
	Pumps	30	270,000
	Underwater wagons <sup>A7</sup> for rolling gates <sup>A7</sup>	15	135,000
	Seals	15	135,000
	Bearing <sup>A7</sup> surfaces <sup>A7</sup>	15	135,000
Operating machinery	Wire rope	10	90,000
	Machine elements and their electrical equipment (does not refer to wear parts)	35	320,000

**Note:** One lock gate cycle is the complete opening and closing sequence of a gate in which the gate returns to its starting position. For example, the gate starts movement from its closed position, opens completely, and stops. It then closes to end at its closed position. Both the opening and the closing operation are considered together as 1 complete gate cycle.

K. **Embedded Metals:** All partially or totally embedded metallic items in the concrete walls, as well as their anchorages, shall be designed to have the expected service life of the concrete lock structure. Embedded metals and anchoring shall be designed to resist the maximum loads that may be imposed on them under all conditions. Installation of embedded components shall be performed with careful consideration of alignment and setting tolerances. Components to be fastened to embedded items shall be designed for removal and replacement when required. Welded and shrink-fitted connections are excluded from these components. Refer to Section 01 81 16 (*Lock Structures*) for fixed underwater trackway systems.

L. **Special Provisions for Underwater Components:** All underwater components embedded in the lock floor shall be designed and constructed for the required expected service life of the facilities. Bearing components, seals, and wearing surfaces that cannot meet this requirement shall be designed to facilitate removal and installation without the need to empty the chamber, and if required, these components shall be capable of being removed or installed by divers. All underwater components shall be corrosion resistant. The use of self-lubricating material shall be considered.

M. **Floating Stability and Floating Body Design Loads:**

1. **Floating Stability:** The design and construction of the lock gates shall <sup>A17</sup>take into account <sup>A17</sup> the floating stability of the gate. The floating stability calculations shall show proof of adequate intact stability by complying with an IACS member dictated stability criteria applicable for this particular type of floating structure. All lock gates shall be stable

while floating upright without the aid of additional floating equipment, cables, or supports. <sup>A19</sup>Floating stability shall be taken into account for the transportation of the gates under tow between the new Pacific and Atlantic lock complexes, as well as during all possible maintenance, installation or non-operating conditions that require the gate to float without support of its rolling wagons. <sup>A19</sup>

2. **Floating Body Design Loads:** Floating body design loads shall be calculated in conformance with a marine regulatory body member of the International Association of Classification Societies Ltd. (IACS) applicable to this type of equipment and intended use. <sup>A7</sup>
- N. **Towing Arrangement:** The lock gates shall be provided with specific towing and pushing points, as required to pull or push the floating gate from one location to another. All towing and pushing locations shall be clearly marked on the gate and provided with the required structure and hardware for safe operation.
- O. **Vessel Impact:** Lock gates shall be designed and constructed to be able to resist, when closed, the impact of a 160,000 metric ton displacement vessel traveling at a speed of 1 knot without compromising their <sup>A7</sup>structural integrity<sup>A7</sup> or the capability of being moved into their Recesses <sup>A7</sup>or be floated out of the lock chamber. After a vessel impact, the gates shall maintain proper support on the bearing surfaces located on the locks structure. <sup>A7</sup> The Contractor shall obtain the information on the ship's hull design that is required to correctly model the ship collision from either direction. <sup>A7</sup>Only localized structural damage<sup>A7</sup> without loss of floatability shall be expected after a <sup>A7</sup>vessel impact with less than the impact specified in this <sup>A9</sup>Section<sup>A9</sup> and the operation of the gates shall be possible after complete flooding of watertight zones. <sup>A9</sup>(refer to 1.03 B.3.).<sup>A9</sup> For the purposes of absorbing part of the impact energy, the use of an energy dissipating system shall be permitted; however, the system shall not reduce the useful length of the lock chamber. Impact loading on the gates shall be assumed to act independent of hydrostatic loading. <sup>A7</sup>
- P. **Removal and Relocation of Lock Gates:** The lock gates and gate Recess components shall be designed and constructed to facilitate removal and installation of the lock gates. Lock gate removal shall be accomplished without the need of special cranes or auxiliary floating equipment for stability. The lock gate shall be made buoyant by relieving its weight through the dewatering of strategically located ballast chambers, which shall be ballasted with water during regular operations. All connections of the lock gates and supporting bearings shall be designed and constructed for simple removal or disconnection in order to be able to float the gate out of the Recess with a minimum quantity of work.
- Q. **Relocation of Outer Lock Gates for Chamber Dewatering:** The Contractor's design shall allow for the <sup>A5</sup>gates of the outer lock heads<sup>A5</sup> of each lock complex to be removed from their normal operating position, without their rolling wagons, for relocation to a separate support bearing for use as chamber-dewatering caissons. For such purposes, the <sup>A5</sup>gates<sup>A5</sup> on the lakeside of the upper chamber and the <sup>A5</sup>gates<sup>A5</sup> on the <sup>A17</sup>ocean side <sup>A17</sup> of the lower chamber of each lock complex shall be capable of being floated out of <sup>A5</sup>their<sup>A5</sup> corresponding Recesses and relocated to the outer gate slots as specified in Section 01 81 16

(*Lock Structures*). The sea gates shall be provided with bearings and seals on their upstream face as well, thus permitting the <sup>A5</sup>gates<sup>A5</sup> to be used for reverse head conditions. The sea gates shall also be capable of being relocated without the need to turn them around.

R. **Design of Maintenance Closure System:** <sup>A20</sup>The design shall be based on the use of one maintenance closure or a stoplog system to function effectively at any of the four Atlantic and Pacific locks complex entrances. There are four Atlantic and Pacific locks complex entrances (2 lakeside entrances and 2 sea side entrances).<sup>A20</sup>

1. The systems shall be designed for chamber closure under the following conditions:
  - a. **Maintenance Operations:** The systems are positioned across the chamber for closure in equalized conditions, with no flow of water. The variable water levels of Gatun Lake at the time of chamber closure shall be of the same as the design water levels of the lakeside rolling gates. <sup>A16</sup>The variable water levels of the Atlantic or Pacific Ocean at the time of chamber closure shall be the same as the design water levels for the respective <sup>A16</sup> <sup>A17</sup>ocean side rolling gate.<sup>A17</sup>
  - b. <sup>A10</sup>(Reserved)<sup>A10</sup>
  - c. <sup>A10</sup>At the upper level, after closure, the <sup>A10</sup> water level at the downstream side of the closure systems shall be the one resulting from a complete drawdown of the upper lock chamber. <sup>A10</sup>At the lower level, after closure, the water level at the upstream side of the closure system shall be the one resulting from a complete drawdown of the lower chamber.<sup>A10</sup>
  - d. In addition to the hydrostatic head, the following loads shall act on the <sup>A10</sup>maintenance systems:<sup>A10</sup>
    - 1) **Wind Loads:** <sup>A9</sup>See Subparagraph 1.04 E. of this Section.<sup>A9</sup>
    - 2) **Earthquake Loads:** See Section 01 81 16.13 (*Seismic Design Criteria*) for seismic design criteria. The Systems shall be able to withstand the seismic demands at any operating position and water head (closed or opened positions.)
    - 3) **Wave Loads:** <sup>A9</sup>See 1.04 D. of this Section.<sup>A9</sup>
2. Allowable leakage rates of the closed <sup>A10</sup>maintenance system<sup>A10</sup> when used for maintenance operations shall not exceed the allowable leakage rates for the rolling gates shown in <sup>A9</sup>Subparagraph 1.04 G. of this Section.<sup>A9</sup>
3. Design of <sup>A10</sup>maintenance closure system<sup>A10</sup> shall be based on internationally recognized standards as stated for the rolling gates in <sup>A9</sup>Subparagraph 1.04 V.2., 3., and 4. (of this Section)<sup>A9</sup> with the exception of the fatigue requirements.



4. <sup>A16</sup>The Contractor shall design, and specify, the maintenance closure system structural metals for a minimum service life of 70 years.<sup>A16</sup> Embedded metals required for the installation and operation of the system shall be designed to have the expected service life of the concrete lock structure.
  5. <sup>A10</sup>Machinery and movable parts necessary for the operation of the maintenance closure system shall be located above the highest water level of Gatun Lake, Atlantic Ocean entrance and Pacific Ocean entrance and shall be easily accessible for inspection and routine maintenance.<sup>A10</sup>
- S. **Equalization between Gates:** Lock design shall include a reliable means of equalizing the water level in the space between a pair of gates with that of the adjacent lock chamber or to allow proper gate operation if the water level between a pair of gates drops due to leakage of the sealing surfaces. It shall be possible to maintain, repair and replace any means of Equalization from the dry gate Recess. This system shall allow for all possible modes of operation and the possibility of having one gate out of service.
- T. **Sealing Surfaces:** All sealing surfaces shall be readily replaceable, corrosion resistant, and wear resistant.
- U. **Operating Machinery:** Steel wire ropes shall be in accordance with ASTM A 1023. The safety factor against breakage of the wire rope with the highest possible load shall not be less than 5. The wire rope diameter ratio between the drum and sheaves shall be carefully selected to obtain an adequate wire rope service life with respect to the cycles of operation indicated in Subparagraph 1.04 J. (*Design Life*) of this Section. This shall be demonstrated using detailed calculations. Bearings shall be in accordance with ABMA standards and shall be calculated accordingly. Gearing of the gearboxes shall comply with AGMA. Electric motors shall comply with NEMA standards and shall be calculated accordingly.
1. **Design Considerations and Criteria:** The lock gate operating system, including support wagons, shall be designed and constructed for a service life not less than that indicated in Subparagraph 1.04 J. of this Section. Trackway and wire ropes shall require replacement as indicated in Subparagraph 1.04 J. (*Design Life*) of this Section. Seals and bearing blocks are considered minor items and shall be replaced as indicated in Subparagraph 1.04 J. (*Design Life*).
    - a. **Normal Loads:** The lock-gate machinery shall be selected to provide the force required to operate the gate under all normal operating conditions. Refer to <sup>A5</sup>Subparagraph <sup>A5</sup>1.04 D. of this <sup>A9</sup>Section.<sup>A9</sup> Gates and operating machinery design shall take into account friction loads that act during operation. For such purposes, suitable ranges of friction coefficients shall be selected depending on the contact surface materials. All combinations of minimum and maximum loads plus new and worn conditions must be accounted for in the selection of the coefficients and the sizing of the machinery.

- b. **Temporal Loads:** In addition to the normal loads, the lock-gate machinery must be designed to move and control the gate when forces due to a hydrostatic differential head of <sup>A5</sup>0.1 m<sup>A5</sup> are present between its upstream and downstream sides.
  - c. **Impact Loads:** The Contractor shall take into account impact factors in the design of all components, including crane-lifting lugs, hoisting lugs, pulling lugs, etc. Design, construction, and installation shall be in accordance with all applicable standards and these specifications.
  - d. **Gate Operating Time:** The minimum gate opening or closing time (time of operation) shall be 4.0 minutes, and maximum gate opening or closing time shall not exceed 5.0 minutes. <sup>A19</sup>The gate opening or closing times includes the duration of the acceleration phase (at start) and deceleration phase (at finish).<sup>A19</sup>
  - e. **Standardization:** The gate machinery shall be identical <sup>A11</sup>, where feasible, <sup>A11</sup> for all rolling gates.
  - f. **Redundancy:** For reliability of the gate-operating machinery, 2 drive motors in parallel shall be provided. Each gate shall be normally operated by 1 motor, with 1 in operating mode and 1 in standby mode. The system shall be capable of automatic switching between motors and simple switching from a remote location. “Automatic switching” means that an automatic control system switches between the 2 motors, without human intervention, according to a previously programmed schedule. “Simple switching from a remote location” means that an operator can make the switch between the 2 motors by remote control.
2. **Operating Machinery Drives and Control:** Two main drives and a smaller auxiliary emergency drive shall operate each gate. Each drive shall operate from a 3- phase, 480 volt, and 60 Hz power supply system. The main and auxiliary electrical drives shall consist of AC variable speed drives. Normal operation shall be for one of the main drives to open and close each gate. <sup>A19</sup>The control shall automatically alternate the main drives, so that wear is shared between these main drives. For the purpose of alternation, the controls shall provide a manual and automatic alternation mode of operation. Under the automatic mode of alternation the controls shall provide an adjustable period range for alternation after each cycle up to 10,000 cycles.<sup>A19</sup> The auxiliary drive shall be selectable for manual operation by an operator in case the main drives are inoperable. The gates shall be capable of local and remote operation.
- a. **Gate Operation:** The gate shall operate from fully closed to fully open or from fully open to fully closed. After the operator activates the open or close operation, the system shall automatically operate the gate from standstill to normal operating speed, travel the required distance, proceed to slow down, and finally stop accurately and automatically at the

required open or close position, without further intervention by the operator. It shall be possible for the operator to stop, stop and proceed, or stop and reverse the gate operation before completing the open or close gate operation. The drives shall stop in case of traction (pulling), wire rope rupture, excessive slack, or excessive load demanded due to obstruction or other cause. Wire rope rupture, excessive slack, and excessive load shall be automatically detected, causing an automatic stop, without any intervention from the operator. See also below <sup>A9</sup>Subparagraph b.1).<sup>A9</sup> The required start, traveling, and stop operations shall be achieved without jolts, jerks, or vibrations. The rolling gate assembly and all equipment shall be designed to minimize vibration and resonance under all normal operating conditions.

- b. **Instrumentation, Control, Indication, and Alarm:** Control and indication shall be in accordance with Section 40 95 13.13 (*Process Control Hardware for Locks Machinery Control Systems*).
  - 1) **Pedestrian Crossing Alarms:** All local crossing alarms to alert pedestrians of an impending gate operation shall consist of red flashing lights of 1,000 candelas with audible alarms capable of being heard at a distance of at least 250 meters. <sup>A17</sup>The lights shall have a minimum flashing rate of 60 flashes per minute. <sup>A17</sup> The loudness of the alarms shall not have harmful effects on the personnel in the area. The flashing lights and the audible alarms shall remain on during the entire operation. Alarms shall initiate before the actual operation and shut off after the actual operation. At each pedestrian crossing, 2 red flashing lights with audible alarms shall each be mounted on a 1.8 meter pole adjacent to the entrance of the lock gate crossing; 1 shall be located on the east wall and the other on the west wall. Also, one audiovisual alarm shall be located in the middle of the lock gate. Pedestrian crossing alarm control and indication shall be in accordance with Section 40 95 13.13 (*Process Control Hardware for Locks Machinery Control Systems*).
  - 2) **Vehicular Crossing:** Remotely operated local barriers with audiovisual alarms shall be installed at each end of the vehicular gate crossings. Local barriers shall be in accordance with applicable regulations. Vehicular barrier and crossing alarm controls and indications shall be in accordance with Section 40 95 13.13 (*Process Control Hardware for Locks Machinery Control Systems*).

3) **Process Control, Instrumentation, and Sensors:**  
Refer to Section 40 91 00 (*Primary Process Measurement Devices*).

- c. **Drives:** Each electrical drive shall consist of a variable-frequency drive of an adequate capacity to support the operation as specified. Refer to Section 26 29 23 (*Variable Frequency Drive*) for details.

3. **Auxiliary Emergency Electric Drive:** The Contractor shall design, install and test an auxiliary emergency electric drive to move the gate at reduced speed if the two main drives are not available. This emergency electric drive shall not be permanently connected to the system. The maximum quantity of time for full opening or closing of a lock gate with the use of the emergency electric drive shall be 30 minutes, including acceleration and deceleration.

V. **Structure Design:**

1. **General Description:** Structural design and construction of the lock gates shall be based on proven systems for gates of similar dimensions and operating conditions.

- a. <sup>A16</sup>(Reserved)<sup>A16</sup>
- b. The location and final layout of framing elements shall be decided by the Contractor based on the location and magnitude of all applied loads as described in <sup>A9</sup>Subparagraphs 1.04 D., E., and F. of this Section.<sup>A9</sup>
- c. The structural design shall take into account the constructability of the gate as well as the means to transport the gates from the fabrication facility to the final position in the lock heads. For this purpose, the Contractor shall provide a complete fabrication and installation procedure subject to the review by the Employer's Representative. Structural design calculations shall demonstrate the capability of the gate to withstand all possible <sup>A5</sup>design-load combinations<sup>A5</sup> and provide adequate strength and stiffness during the specified life cycle of the gate.
- d. Independently of the fabrication method, the gate shall be a 1 piece integral unit when put into final service. The only acceptable exceptions are rolling stock and wagons, which shall be removable.

2. **Materials:** The main structure of the lock gate, including vertical and horizontal diaphragms, shell plating, stiffeners, and truss elements, shall be made of welded structural steel. Different materials shall be allowed for special items or components that, due to their specific nature, might need special mechanical properties or special wear and durability requirements. These may include bearing materials, castings, rollers, wheels, shafts, seals, seal retainers, and others. The main structure of the

gate shall be designed and constructed by making extensive use of commercially available plates and shapes. Custom-made or specially produced shapes shall be minimized to the fullest extent.

3. **Minimum Requirements:** Welded structural steel to be used in the construction of the gate shall have a minimum yield stress  $f_y=248$  MPa (36,000 psi). Welding shall be in accordance with the applicable AWS standards.
  - a. <sup>A16</sup>(Reserved)<sup>A16</sup>
  - b. Steel plates shall have a minimum thickness of 6 mm (for closed tubes) or 8 mm (for main structures). <sup>A7</sup>Welded plates thicker than 50 mm shall be avoided on the shell plating, however, such thick plates may be used at locations with concentrated loads.<sup>A7</sup>
  - c. The Contractor shall verify if the above-mentioned thick plates can be assembled with the steel structure using bolts instead of welding. Plates with important transversal traction loads, e.g. with welded lifting eyes on them, shall have a material quality with special resistance to lamellar tearing.
  - d. Unless a substitute method is submitted and reviewed by the Employer's Representative, all welds shall be completely sealed to provide tightness against leakage and to avoid water infiltration into the interior of welded structural joints. Use of intermittent welds shall not be allowed. When welding material is not required for structural resistance, seal welds shall be provided in order to fulfill this requirement.
  - e. The structural design of the joints shall <sup>A17</sup>take into account <sup>A17</sup>the structural behavior of completely welded joints in order to avoid non-compliance with accepted codes and to avoid joint failure caused by improper detailing.
  - f. <sup>A7</sup>For fatigue design purposes, 250,000 cycles of operation shall be <sup>A7</sup> <sup>A17</sup>taken into account. <sup>A17</sup> See also Subparagraph 1.04 J. (*Design Life*) of this Section. Fatigue design shall also take into account the influence of local welds used for assembling small items to the main structure, even those used only for erection.
  - g. Welds of temporary parts shall be carefully removed to avoid permanent fatigue influence.
4. **Design Approach:** The structural design shall be based on internationally recognized and accepted design approaches used consistently throughout the <sup>A17</sup>Works. <sup>A17</sup> <sup>A7</sup>Safety factors associated with the rolling gate design shall be equal or better to those obtained by using DIN 19704. In any case, specific<sup>A7</sup> codes or regulations utilized in the development of the structural design shall be clearly stated in the design documents.

- a. The final structural design of the gate shall be accomplished by means of a full three-dimensional structural model that can accurately capture the interaction between the various framing elements.
  - b. Connections and joints that may not be easily analyzed or designed by simple methods shall be modeled independently if required to prove their adequacy. The calculations shall also include verification of the steel structure against fatigue, taking into account the loads during the service life, construction details, weld qualities, inspection level, and consequences of failure.
  - c. The gate structural system shall have enough built-in redundancy to avoid global failure, progressive collapse, or loss of operability due to damage of primary members.
  - d. As part of the design process, the Contractor shall demonstrate the load-carrying capacity and serviceability of the proposed gate design.
  - e. As part of the serviceability calculations, deformation characteristics of the structure shall be carefully analyzed to ensure proper motion of the gate, adequate sealing, and trouble-free machinery operation.
  - <sup>A5</sup>f. Load cases described in Subparagraphs 1.04 D., E. and F. of this Section shall be combined according to the selected design standard and design criteria for the Works.<sup>A5</sup>
5. **Limit States:** Structural design of the lock gates shall <sup>A17</sup>take into account <sup>A17</sup>all possible failure modes and limitations. Failure modes not specifically addressed by the design codes shall be taken into account by using sound engineering principles.

**W. MAINTENANCE CONSIDERATIONS:**

- 1. **Maintainability:** Locks shall be designed and constructed with all equipment necessary for performing maintenance and repair of the lock gates, gate-support wagons, trackway, and gate operating machinery, with minimum impact on lock operations.
  - a. Safe and easy accesses to the various maintenance points shall be provided. Accesses shall be of a permanent nature, unless otherwise agreed to by the Employer's Representative.
  - b. All parts shall be designed for fast removal and installation using standard tools and equipment where possible.
  - c. Redundancy of critical parts shall also be provided.

- d. Where feasible, self-lubricating systems shall be used. Equipment that requires additional lubrication (e.g. gear units, bearings, wire ropes, etc.) shall have an automatic lubricating system with a minimum impact on maintenance personnel.
- e. Detailed procedures shall be included for each type of maintenance.
- f. The Contractor shall also provide operations and maintenance manuals for all components and systems, clearly identifying all parts and clearly providing instructions for their use, maintenance, and replacement.

2. **Required Inspection and Preventive Maintenance Intervals:**

<b>REQUIRED INSPECTION AND PREVENTIVE MAINTENANCE INTERVALS</b>				
<b>Description</b>	<b>Item</b>	<b>Preventive maintenance</b>	<b>Minimum frequency of maintenance and inspection* (whichever occurs first)</b>	
			<b>Years</b>	<b>Cycles</b>
<b>Rolling Gates</b>	Gate structure	Inspection, minor structural repair, and touch-up painting. Replace with new bearing <sup>A7</sup> surfaces <sup>A7</sup> .	10	90,000
		<sup>A11</sup> Complete Overhaul including repainting – sea gates	15	135,000
		Complete Overhaul including repainting – other gates	20	180,000
		(Deleted text) <sup>A11</sup>		
	Gate Recess closure	Minimal maintenance touch-up painting.	10	
		Complete repainting.	20	
		<sup>A11</sup> (Deleted text) <sup>A11</sup>		
	Upper wagons	Inspect and replace (with new components if required) bearings, wheels, shafts, etc. and perform minor painting and repair.	5	45,000
	Underwater wagons		5	45,000
	Seals		5	45,000
	Bearing surfaces	Inspect and repair as required.	5	45,000
	Trackway (upper and lower)	Inspect and repair as required.	15	135,000

REQUIRED INSPECTION AND PREVENTIVE MAINTENANCE INTERVALS				
Description	Item	Preventive maintenance	Minimum frequency of maintenance and inspection* (whichever occurs first)	
			Years	Cycles
Operating Machinery	Wear machine elements	Replace bearings, mechanical seals, couplings, etc. (Replace with new components.)	10	90,000
	Wire ropes	Inspect.	Per ANSI and manufacturer's recommendations.	
	Safety devices	Inspect.	Per ANSI and manufacturer's recommendations	

\***Note:** Whichever occurs first (cycles or years of operation).

X. **Safety and Health Protection:** See Section 01 35 23 (*Health and Safety Requirements*) and Section 01 35 29 (*Health and Safety Management/Emergency Response Procedures*).

<sup>A19</sup>1. **Draft Marks and Lights:** Each lock gate shall have permanent draft marks conforming to maritime regulations near to the 4 corners (upstream, downstream, lock-side, and quay side).<sup>A19</sup> Other floating equipment described in this Section (e.g. floating caissons used as gate Recess closures and <sup>A10</sup> maintenance closures), <sup>A10</sup> shall also have permanent draft marks if required by regulations. When being transported into or out of the gate Recess or to the erection site by flotation, each lock gate shall be equipped with temporary navigation lights, signaling, etc. in conformance with maritime regulations.

<sup>A19</sup>2. **Bridgeways and Walkways Safety:** Pedestrian walkways shall be marked, signaled, etc. according to applicable traffic regulations.<sup>A19</sup> Bridgeway gates and independent bridgeways intended for vehicular traffic shall be marked and signaled according to applicable traffic regulations.

<sup>A19</sup>3. **Permanent Warnings:** Permanent safety warnings shall be provided on Site, in accordance with the applicable regulations related to specific dangers (e.g. electrical tensions, piping under pressure, high-temperature parts, manholes leading to tanks that may be filled with water, rotating machinery, moving parts, overhead traveling cranes, dangerous fluids, etc.).<sup>A19</sup> Water piping, air piping, hydraulic-oil piping, etc. shall be marked to indicate contents, internal flow direction, etc., according to applicable regulations.

<sup>A19</sup>4. **Operational and Maintenance Safety:**<sup>A19</sup>



- a. Rotating machinery, moving parts, etc. shall be protected to the extent practically possible for the safety of operating personnel, maintenance personnel, and the general public and in accordance with applicable safety regulations. At (or near) every location where lock gate operation may be controlled or maintenance activities to the lock gate or its drive may be performed, an emergency mushroom type stop button shall be provided. Noise, vibrations, etc. generated by electrical motors, pumps, fans, etc. shall be limited by applicable regulations.
- b. Main power failures, failure of electrical drives, detection of excessive speed, etc, shall lead to an automatic emergency stop of the mechanism (e.g. all brakes closing by spring action). The design shall be made in such a way that an unwanted restart shall be avoided after normal stop, emergency stop, stop due to power failure, etc.
- c. <sup>A19</sup>The design shall include features that prevent human errors and avoid dangerous conditions for vessels in transit, vehicles, and pedestrians. There shall be a means to prevent the opening or closing of the gates in situations that could lead to unsafe and dangerous conditions. Switching from remote to local control shall not have any adverse effect on the safe operation of the gates. Refer to Section 40 95 13.13 (Process Control Hardware for Locks Machinery Control System) and 40 96 45.13 ((Process Control Software for Locks Machinery Control System)).<sup>A19</sup>
- d. Manholes shall have a useable space (free for passage) with a diameter of at least 500 mm or, for rectangular shapes with rounded corners, at least 400 x 600 mm.

Y. **Ventilation Ducts:** Ventilation ducts <sup>A5</sup>and fixtures <sup>A5</sup> shall be designed and built to be suitable for the tropical marine environment. Water shall not be permitted to enter into the internal spaces through the ventilation ducts. Refer to Section 01 35 23 (*Health and Safety Requirements*). Ventilation duct material shall be explosion and flame resistant. Refer to Section 01 86 13 (*Plant – Mechanical Systems and Equipment*).

Z. **Vibration and Shock:** Equipment and materials shall withstand the effects of random shocks and vibration. All equipment shall be designed and constructed to minimize rattling and resonance at all speeds up to the maximum equipment running speed, under all possible working conditions. All equipment and structures shall be designed and constructed to minimize rattling and resonance at all expected wind speeds.

**1.05 SUBMITTALS:** Whenever data as required below is <sup>A17</sup>for the review of <sup>A17</sup> Employer's Representative, the results of the review by the Employer's Representative will be communicated to the Contractor within 35 days after the Employer's Representative's receipt of the required data.

- A. **Progress Charts:** Progress charts shall be provided in accordance with Section 01 31 00 (*Project Management and Coordination*).
- B. <sup>A19</sup>**Preliminary Design Data:** <sup>A16</sup>Within 91 days after Commencement Date and after completion of at least 30% of the design, the Contractor shall submit to the Employer’s Representative for his review, 5 sets of its preliminary design data.<sup>A16</sup> This shall include the quality-control plan, the procedure for identifying and resolving non-conformances, and the documented non-conformances. The preliminary design data shall include, but shall not be limited to, the following.  
<sup>A19</sup>
1. **Lock Gate Data:** The data shall contain the general arrangement drawings, calculations, critical dimensions, and overall dimensions including installation drawings for the gate and concrete-embedment sequence.
  2. **System Design Data:** The system-design data shall include, but shall not be limited to, the major systems, such as the electrical, hydraulic, and mechanical systems and their main components, such as motors, gear units, wire rope winch drums, pumps, and valves. It shall provide the final general dimensions and exact location of major components and electrical components. It shall include design analysis of all the forces acting on each lock gate.
  3. **Structural Frame Data:** This data shall include, but shall not be limited to, the calculations, structural frame design, <sup>A7</sup>seismic performance calculations,<sup>A7</sup> and drawings showing general dimensions and arrangement of auxiliary equipment, as indicated in <sup>A9</sup>Subparagraphs 1.01 B.2., and B.3. of this Section.<sup>A9</sup>
  4. **Electrical and Electronic System Data:** The electrical and electronic system data shall include drawings and information on electrical power and control circuits and information on standard components to be used. The Contractor shall submit its proposed remote control system including the frequencies to the Employer Representative <sup>A9</sup>for review.<sup>A9</sup> Data shall include control sequence.
  5. **Pedestrian and Vehicular Crossing Equipment Data:** The pedestrian and vehicular crossing equipment design data shall include general dimensions and details on other auxiliary equipment for pedestrian and vehicular crossings.
  6. **Weight, Buoyancy, Center of Gravity, and Other Stability Data:** The Contractor shall submit for review by the Employer’s Representative estimates on the weight, buoyancy, and center of gravity, as well as stability calculations and other relevant data. Buoyancy calculations for all load conditions shall also be submitted for review by the Employer’s Representative.

7. **Purchased Equipment Data:** The Contractor shall submit, for the review of the Employer's Representative, a list of equipment for intended purchase with technical documentation attached, including the catalog items mentioned in <sup>A9</sup>Subparagraph 1.04 U. (*Operating Machinery*) of this Section.<sup>A9</sup>
  8. **Historical Data, Accelerated Tests, and Calculations:** The Contractor shall submit historical data (of equal or more severe design conditions), accelerated test results, and calculations that prove compliance with the design life specified in Subparagraph 1.04 J. of this Section. The Contractor shall be required to explain how this data demonstrates the ability to meet or exceed the design life specified.
  9. **Numerical Models:** A three-dimensional numerical model of each gate size shall be provided. Numerical models shall be provided, as a minimum, for structural adequacy, floating stability verifications, <sup>A7</sup>seismic performance,<sup>A7</sup> and hydrodynamic load effects on gate structure and operating machinery.
  10. **Corrosion Control Coating Schedules:** <sup>A11</sup>Coating schedules, technical sheets and material safety data sheets for coating materials for the <sup>A17</sup>Recess <sup>A17</sup>closures, rolling gates, trackway, pedestrian and vehicular traffic areas, handrails and traffic rails, equipment, and piping shall be provided. See Section 09 96 00 (*Corrosion Control Coatings*).<sup>A11</sup>
  11. **Preliminary QCP and TIP:** The quality-control program (QCP) and the testing and inspection program (TIP) shall describe the quality-assurance and testing and inspection programs, respectively. Copies of certifications issued to the Contractor or <sup>A9</sup>Subcontractors<sup>A9</sup> shall be included along with these programs. NDT programs and procedures shall be clearly outlined in the QCP.
  12. **Gate Recess Pumping/Dewatering System <sup>A17</sup>Design <sup>A17</sup>Data:** Design data about the gate <sup>A17</sup>Recess <sup>A17</sup>pumping/dewatering system shall be provided as specified. The size and capacity of each pump shall be clearly indicated.
  13. **Data on Recess Closures, <sup>A10</sup>Maintenance Closures,<sup>A10</sup>** This data shall contain the general arrangement drawings, calculations, critical dimensions, and overall dimensions.
- C. **Intermediate Design Data:** <sup>A19</sup>Within 266 days after the Commencement Date, the Contractor shall submit to the Employer's Representative for review, 5 sets of intermediate design data. This shall include, but shall not be limited to the intermediate version of the data listed in Subparagraph 1.05 B.1 through 13 of this Section. Refer to Section 01 33 00 (*Submittal Procedures*).<sup>A19</sup>

**D. Shop Drawings, Manufacturing Data, Detail Drawings, and Installation Drawings:**

1. Shop drawings and manufacturing data shall be provided in accordance with Section 01 40 00 (*Quality Requirements*) Paragraph 1.06, of this Section, and the following requirements. The Contractor shall submit, to the Employer's Representative for his review, 5 hard copies and 5 electronic copies of all data produced or required for the lock gates, power system, operating machinery, components, and assembly. The data shall include, as a minimum, shop drawings, detail drawings, manufacturing specifications, quality control, erection instructions, and testing procedures. <sup>A7</sup>(deleted text)<sup>A7</sup> 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 information, cable identification, cable sizes, loads, protective-device settings, circuit data, conductor termination details and material lists. The Contractor shall submit details on the proposed remote-control system (including the frequencies) to the Employer's Representative <sup>A9</sup>for review.<sup>A9</sup>
2. **Detail Drawings:** Detail drawings, including fabrication drawings, shop assembly drawings, delivery drawings, and field-installation drawings, shall include catalog cuts, templates, fabrication and assembly details and types, grades, and classes of material as appropriate. Elements of fabricated items inadvertently omitted on Contract drawings shall be detailed by the fabricator and indicated on the detail drawings.
3. **Delivery Drawings:** Delivery drawings shall be provided at least <sup>A9</sup>28 days<sup>A9</sup> prior to delivery of the equipment. Delivery drawings shall provide descriptions of methods of delivering components to the Site, including details for supporting fabricated components during shipping to prevent distortion or other damages, as well as weight, center of gravity and lifting points of all equipment.
4. **Field Installation Drawings:** Field installation drawings shall be provided at least <sup>A9</sup>28 days<sup>A9</sup> prior to field installation. Field installation drawings shall provide a detailed description of the field installation procedures. The description shall include the location and method of support for installation and equipment handling; provisions to be taken to protect concrete and other work during installation; methods for maintaining components in correct alignment; etc.
5. **Assembly and Erection Procedures:** Assembly and erection procedures shall be provided at least <sup>A9</sup>28 days<sup>A9</sup> prior to any assembly or erection work. The Contractor shall submit assembly and erection procedures as follows.

- a. **Assembly and Erection Method for Lock Gate Mechanisms:** This shall include the central drive mechanism, rope drums, gear unit, motors, and couplings.
  - b. Assembly and erection of rope sheaves and rollers.
  - c. Operational test (no load) in workshop.
  - d. Assembly and erection of lower support wagon(s).
  - e. Assembly and erection of the lock gate.
  - f. Assembly and erection of the upper support wagon.
  - g. Connection of lock gate to upper and lower wagon.
  - h. No-load test on site.
- E. **Material Safety Data Sheet and Technical Data Sheet:** The Contractor shall submit to the Employer's Representative a material safety data sheet (MSDS) and a technical data sheet for each type of hazardous material, including chemicals, insulation, abrasives, coatings, greases, oils and lubricants, before incorporating them in the design, construction, 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. **Material 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 URL <http://www.osha-slc.gov/dsg/hazcom/msdsformat.html>.
  2. **Technical Data Sheet:** This 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 hazard information.
- F. **"As-Built" Drawings:** <sup>A16</sup>Prior to the issuance of the Taking-Over Certificate of the whole of the Works, all relevant as-built drawings shall be delivered to the Employer's Representative. <sup>A16</sup>After delivery, a revised general arrangement plan shall be handed to the Employer's Representative <sup>A9</sup>for review. <sup>A9</sup>The drawings shall be updated by the Contractor to reflect all changes made by the Contractor until the date of the Taking-Over Certificate.
- G. **Documents and Manuals:**
1. **Documents for Employer Representative's Review:** As produced by the Contractor, instructions and maintenance books, manuals, part lists, etc. of all machinery and installations shall be delivered in fourfold in paper format to the Employer's Representative in the English language. <sup>A9</sup>Manuals shall be provided to the Employer's Representative for review

in hard copy and electronic editable form at least 63 days before shipping the equipment. Included documentation to be made by Contractor:<sup>A9</sup>

- a. Trim and stability book including calculations.
- b. Damage stability book.
- c. Sounding tables for all tanks.
- d. All calculations, design criteria, reports, etc.

2. **Final Part Lists, Instruction and Maintenance Manuals:** Final instruction and maintenance manuals including parts lists shall be provided to the Employer's Representative in their original format as delivered by the manufacturers of the relevant items, one set (7 copies) in the English language and one set (7 copies) in the Spanish language. All instruction and maintenance manuals, produced by the Contractor shall also be provided to the Employer's Representative in a digital format (PDF or other) on DVD/CD-ROM

- H. **Major Purchased Components List:** Within <sup>A9</sup>28 days<sup>A9</sup> prior to the delivery of the lock gates, the Contractor shall submit for review by the Employer's Representative a list of all major purchased components that are installed in or on the lock gates. 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, 4 copies of the lists shall be provided in the English language in physical format and 2 copies in Microsoft Access (latest edition) files on DVD/CD-ROM.
- I. **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 <sup>A9</sup>28 days<sup>A9</sup> in advance of local training sessions.
- J. **Spare Parts List:** <sup>A9</sup>Twenty eight days<sup>A9</sup> before delivery of the lock gates, the Contractor shall submit to the Employer's Representative a list of all the proposed spare parts for the lock <sup>A17</sup>gates.<sup>A17</sup> The list shall include all critical spare parts and equipment to be provided with the lock gates. Critical spare parts shall include, as a minimum, all items that have long lead times and that are necessary to maintain the lock gates at an acceptable level of functionality with minimum downtime. The list shall be organized by systems and major components and shall identify parts that are recommended by the Contractor for routine maintenance or Overhauls. It shall contain complete ordering information including, but not limited to, manufacturer's name and address, part description, Contractor's and <sup>A9</sup>Subcontractor's<sup>A9</sup> part numbers, F.O.B. Contractor's plant prices, and approximate lead time. All price lists shall be delivered in duplicate, both in hard copy and electronically on DVD/CD-ROM in a format compatible with the latest Microsoft Access database version.
- K. **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 the 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-ROM) format.

- L. **Storage and Installation Instructions:** The Contractor shall submit <sup>A9</sup>for review<sup>A9</sup> by the Employer's Representative the storage and installation requirements and instructions at least <sup>A9</sup>63 days<sup>A9</sup> prior to the delivery of the lock gates, components, and accessories. These instructions shall also explain how the seals and other critical components will be protected from damage during storage and installation.

#### 1.06 QUALITY ASSURANCE:

- A. **Facility Quality Standards:** Lock gates shall comply with the requirements of Section 01 40 00 (*Quality Requirements*) and shall be constructed in AISC certified facilities. The minimum level of certification shall be Major Steel Bridge (CBR) with a fracture critical and sophisticated paint endorsement. Facilities meeting or exceeding this quality level and possessing a certification from a recognized certifying agency will be accepted.
- B. **Workmanship:** The workmanship of the fabrication and installation of the gate assembly shall be such that the gate structure shall form a watertight barrier when moved to the closed position. Structural fabrication shall conform to the applicable requirements of AISC, AWS, or other recognized agencies. Unless otherwise specified, all welding shall be in accordance with the applicable AWS code or other equivalent recognized regulation. All welding procedures and welding performance qualifications to be used shall be in accordance with AWS requirements.
- C. **Tests, Inspections, and Verifications:** Tests, inspections, and verifications for materials and fabricated items shall be specified by the Contractor to conform to applicable requirements of the gate design. The Contractor shall confirm compliance of all <sup>A17</sup>Contract <sup>A17</sup> requirements and shall carry out the tests, inspections, and verifications of the gate. These inspections shall be undertaken after the Employer's Representative has reviewed the quality-control and test plans submitted by the Contractor. The Employer's Representative reserves the right to inspect independently all phases of the work, by using Employer's Personnel or third-party inspection services.
- D. **Factory or Shop Assembly and Tests:** Shop assembly requirements for the lock gate, gate frame, and appurtenant items shall be in accordance with accepted industry practice. Gates, frames, guides, and appurtenant items shall be assembled completely in the shop to ensure satisfactory field installation. Shop-assembled components shall be inspected for accurate fit and compliance with dimensional tolerances. Sealing, guiding, and connecting surfaces shall be inspected to determine if their planes are true, parallel, and in uniform contact with opposing surfaces. Watertightness tests shall be performed by applying air pressure with a hose, using a minimum air pressure of 125% of the maximum pressure to which the chambers will be subjected at the nozzle, to one face of the skin plate with a light coating of soapsuds on the opposite face. Disclosed leaks shall be sealed by welding. Additionally, all hollow cavities designed to remain watertight shall be tested with compressed air in accordance with the applicable

sections of the ASME International Boiler and Pressure Vessel Code (BPVC). Test pressure shall be applied for a minimum of 12 hours.<sup>A19</sup> The Contractor shall perform factory inspection and testing, including operational tests of major components during the fabrication of the lock gates and associated equipment. The Employer's representative reserves the rights to witness the factory tests and inspections. For additional factory testing and inspections requirements see Section 01 40 00.<sup>A19</sup>

E. **Tests**<sup>A17</sup> **on Completion:** Tests on completion shall include but shall not be limited to the following tests:<sup>A17</sup>

1. **Buoyancy Chambers and Ballast Tanks Watertightness Tests:**<sup>A17</sup> All<sup>A17</sup> hollow cavities, such as buoyancy chambers and ballast tanks, shall remain watertight and shall be air-pressure tested at a minimum test pressure of 30 kPa (0.3 bars). Test pressure shall be applied for a minimum of 12 hours. The Contractor shall seal discovered leaks by welding. The Contractor may propose alternate watertightness test methods for the review of the Employer's Representative.
2. **Operational Tests:**<sup>A19</sup> After the gate assembly, including operating machinery, has been installed, the Contractor shall carry out operational tests. During these tests the gate structure shall be operated through its entire travel a sufficient number of times to indicate that all parts and equipment are in good operating condition and to ensure that the gate is in true alignment and that necessary clearances have been provided.<sup>A19</sup> Adjustments shall be made to the operation and control system until all components function as required. Required repairs or replacements to correct defects, as determined by the Employer's Representative, shall be made at no additional cost to the Employer. Tests shall also be performed on all redundant systems, equipment, and components. The primary systems, equipment, and components shall be temporarily taken out of service, as required, to perform these tests. The operational tests shall be performed on a remote automatic as well as local basis.
3. **Performance Tests and Time Measurements:**
  - a. <sup>A19</sup>**Performance Tests:** The Contractor shall carry out performance testing of each of the gates as follows. The Contractor shall operate each gate throughout its full normal operating range for 20 complete consecutive cycles in one 12-hour period (this shall constitute a single performance test for a gate) to demonstrate that each gate conforms to the criteria specified in this Section and elsewhere in the Employer's Requirements. Compliance with gate closing and opening times (refer to paragraph 1.04 U-1-d, of this Section for the maximum gate opening and closing times) shall be verified during each gate performance test.<sup>A17</sup> The Contractor shall comply with the following sequence for each cycle during each gate performance test as provided below:<sup>A19</sup>



- <sup>A19</sup>1) **Activation:** The Contractor shall activate the gate starting with the gate at the normal open condition completely retracted in its recess closure. Prior to initial activation, the gate shall be at rest for at least 10 minutes. The rest period between cycles shall not exceed 10 minutes.
- 2) **Acceleration at Closing:** Gate starts to close accelerating to its design speed.
- 3) **Deceleration at closing:** Gate decelerates
- 4) Gate stops at its final closed normal condition.
- 5) Gate remains in closed position (at rest) for no more than 10 minutes.
- 6) Activation with gate at closed condition
- 7) **Acceleration at opening:** Gate starts to open by accelerating to its design speed.
- 8) **Deceleration at opening:** Gate decelerates.
- 9) Gate stops at final opened condition. Gate shall be completely retracted in its recess closure.
- 10) Gate remains in its open position at rest and completely retracted in its recess closure. <sup>A19</sup>

<sup>A19</sup>b. **Time Measurements:** Time shall be measured for each test cycle as stated above in each performance test to the nearest 1 second. Measured times that are less than a second shall be rounded down or up to the closest whole second in accordance with ASTM E29 using the "round-to-even method". The Contractor shall comply with the following sequence for each time measurement as provided below: <sup>A19</sup>

- <sup>A19</sup>1) For gate closing, start timing at the precise moment that the gate closing sequence has been activated. Stop timing when the gate has completely stopped moving at its final closed normal condition.
- 2) For gate opening, start timing at the precise moment that the gate opening sequence has been activated. Stop timing when the gate has completely stopped moving at its final open condition, completely retracted in its recess closure.
- 3) The combined gate closing time plus gate opening time is the sum of the gate closing time plus gate opening time, for any particular cycle, not including rest time.

- 4) The average lock gate closing and opening times to be determined as stated below shall be rounded up or down to the nearest tenths (1 decimal place) in accordance with ASTM E29 using the "round-to-even method". For the purposes of calculating:
  - i) For the average gate closing time plus gate opening time for a particular gate (paragraph (5) below); and
  - ii) for the overall average gate closing time plus gate opening time for the Atlantic locks as a result of the Atlantic gate performance tests (paragraph (6) below); and
  - iii) for the overall average gate closing time plus gate opening time for the Pacific locks as a result of the Pacific gate performance tests (paragraph (7) below); if any one or more gate closing times or gate opening times is below the minimum permitted in paragraph 1.04 U-1-d of this Section that time shall be substituted with 240 seconds."
- 5) The 20 combined gate closing times plus gate opening times for each particular gate performance test shall be averaged to arrive at the average gate closing time plus gate opening time for that particular gate.
- 6) The 160 individual Atlantic locks gate closing times plus gate opening times from the performance tests shall be averaged to<sup>A19</sup>

<sup>A19</sup>c. **Failure to Pass Performance Tests:** In any given performance test for a gate, all 40 measured individual closing and gate opening times must comply with the gate closing and opening times in paragraph 1.04 U-1-d of this Section. Therefore, a single failure in relation to any of the 40 measured individual closing and gate opening times in each performance test for a gate will constitute a failure of that performance test. Refer to paragraph 1.06 of Section 01 91 00 (*Tests on Completion and Tests after Completion*) regarding the consequences of failure to pass any of the tests on completion.<sup>A19</sup>

3. **Leakage Through Gates<sup>A5</sup> and Recess Closures:** The gate and<sup>A17</sup> Recess<sup>A17</sup> closure design, fabrication and erection shall be such that, when in the closed position, the gates shall form a watertight barrier across the lock under all ranges of head, except for the specified maximum allowable leakage rate through the side and sill seals. The total unit leakage rate per meter and the average leakage rate per meter of seal length at each point along the seal shall not exceed the allowable leakage rate specified in Subparagraph 1.04 G. of this Section. The

Contractor shall, in his commissioning plan, propose a test procedure and execute the tests to verify that the requirements in this paragraph are met for all gates under all conditions.<sup>A5</sup>

4. <sup>A16</sup>(Reserved)<sup>A16</sup>

#### 1.07 QUALIFICATION OF THE CONTRACTOR'S TECHNICAL PERSONNEL:

- A. **Experience of Supervisors, Engineers, Technicians, and Trainers:** The Contractor shall have engineers, technicians, and trainers that have a minimum of 7 years experience (within the last 15 years) supervising the construction and installation of, project managing, testing, and maintaining lock gates or products of an equivalent level of complexity.
- B. **Skilled Workers:** The Contractor shall have employed skilled workers, such as mechanics, electricians, welders, and pipe fitters, employed for installation, supervision, and testing, who shall have not less than 4 years (within the last 6 years) of experience installing, supervising, or testing equipment of the type and rating specified, except that helpers or apprentices with less than 2 years experience will be permitted to work under the direct supervision of a certified skilled worker.
- C. **Welders:** Only welders who have successfully passed the qualification tests of recognized regulatory bodies acceptable to AWS (or approved equivalent regulatory bodies) shall do the welding under this Contract. The Contractor shall bear the expense of conducting these tests. The Employer's Representative will confirm all welders, including those who have successfully passed the prescribed tests and hold current, valid certifications. The Contractor shall require any welder to repeat these tests when, in the opinion of the Employer's Representative, the work of the welder indicates a reasonable doubt as to his proficiency. In such cases, the welder shall be disqualified from any welding under this Contract until he has successfully passed the retest. The Contractor shall maintain records of each welder's certification during the course of the Contract. The records are to be available for examination upon the request of the Employer's Representative.
- D. **Non-Destructive Examination Operators:** Only operators who have successfully passed the qualification tests of regulatory bodies acceptable to AWS/ASNT requirements shall do the non-destructive examination for the purpose of assessing quality of welds and materials in connection with the work described in these specifications. The Contractor shall bear the expense of conducting these tests. Records of operators and their current certificates are to be kept and made available for examination upon the request of the Employer's Representative or his authorized representative.

1.08 **TRAINING PROGRAM AND SERVICES:** <sup>A16</sup>The Contractor shall provide training services in accordance with the training program proposed <sup>A17</sup>in the Contractor's Technical Proposal. The training shall include all the items contained in the operation and maintenance manuals. On-site training shall be performed at the Employer's facilities located in the Canal <sup>A17</sup> area as directed by the Employer's Representative. Instructors

fluent in English or Spanish shall conduct the training sessions for the Employer's Personnel.

**A. Training Services:**

1. **Services Prior to Final Taking-Over Certificate:** Training services shall start with the installation of the last two rolling gates. All other training services shall commence after the systems are complete, but prior to the final tests and issuance of the Taking-Over Certificate. The duration of the training services shall be for at least 10 days of 8 hours, during the Employer's normal working hours.
2. **Services after Final Taking-Over Certificate:** <sup>A16</sup>Refer to Section 01 93 00 (*Maintenance Services*) for services required after Final Taking-Over Certificate.<sup>A16</sup>

- B. Training Program:** The program shall emphasize the training of the Employer's Personnel including, but not limited to, operational crew, maintenance and technical support personnel, and engineers. The program shall give the Employer's Personnel a thorough understanding of the operation and maintenance procedures. The program shall be designed to develop skilled Employer operators and technicians in the safe and efficient operation and maintenance of the lock gates.

**1.09 <sup>A16</sup>ON-SITE SUPPORT SERVICES BEFORE ISSUANCE OF TAKING-OVER CERTIFICATE.**<sup>A16</sup>

- A. Final Assembly and Operational Start-Up:** The Contractor shall perform final assembly and shall provide all the necessary labor and material to put the gate into initial operation for conducting of on-site testing, in accordance with these specifications. See also Subparagraph 1.06 E. (*Field Tests and Inspections*) of this Section.
- B. Support during On-Site Testing:** The Contractor shall designate personnel to support the on-site testing witnessed by the Employer's Representative for the lock gate units, in accordance with these specifications and for the periods prescribed therein for each type of unit. During these periods, the Contractor shall provide maintenance to the lock gates, correct any deficiencies that may occur or become apparent during testing, and provide the necessary spare parts and labor.

**END OF SECTION**