

SECTION 01 81 23 – CULVERT AND CONDUIT VALVES

1.01 SUMMARY:

- A. **Basic Function:** Remotely operated culvert and conduit valves shall be provided as required to control water flow between contiguous chambers of the lock facilities and between the lock chambers and Water-Saving Basins (WSBs). In general, culvert valves control water flow between successive chambers, and conduit valves control flow between the lock chambers and the WSBs. The design, location, and characteristics of the valve system shall provide maximum hydraulic efficiency, as well as a high level of redundancy to minimize downtime due to failures or maintenance operations. Culvert valve system design shall allow normal lockage operations to continue when one valve is taken out of commission for extended periods of time. WSB conduit valve system design shall allow lockage operations to continue with minimum delay when individual valves are taken out of commission for extended periods of time. Wherever the valve drive system is indicated in the Employer's Requirements, the system shall be of the hydraulic type.
- B. **Scope of Work:** The work under this Section includes, but shall not be limited to, the design, fabrication, assembly, testing, transportation, delivery, and installation of lock culvert and WSB conduit valves.
- ^{A7}1. **Lock Culvert and Conduit Valves:** The lock culvert and conduit valves shall be designed, fabricated, assembled, tested, transported, delivered, and installed complete with components such as structural components, drive units, tracks, seal assemblies, limit switches, electric power conductors, and controls.
2. **Special Equipment and Tools:** The Contractor shall provide all required special equipment and special tools for operation, testing, and maintenance.
3. **Factory Testing and Support:** **Factory Testing and Support:** The Contractor shall conduct required factory inspection and testing, including operational tests of major components. [The Employer's representative reserves the rights to witness the factory tests and inspections.](#)
4. **On-Site Installation, Field Testing, and Support:** The Contractor shall conduct all required installation, assembly, preliminary testing, final testing, and support during the field testing, in accordance with the requirements of this Section and Section 01 40 00 (*Quality Requirements*).
5. **Training:** ^{A16}The Contractor shall provide training to Employer's Personnel in the operation, testing and maintenance of equipment.^{A16}
6. **Auxiliary Equipment:** The Contractor shall design, fabricate, test, deliver, and install auxiliary equipment for the locks culvert and conduit valves. The auxiliary equipment shall include, but shall not be limited to, intake screens,^{A17} and bulkheads. The Contractor shall provide ^{A17}portable dewatering pumps, and pump systems in accordance with ^{A9}Subparagraph 1.04 M.3.b. of this Section.^{A9}

7. **Technical Support Services:** The Contractor shall provide technical support in accordance with the services proposed by the Contractor and accepted by the Employer at the date of the Letter of Acceptance. ^{A16}Refer to Section 01 78 23 (*Operation and Maintenance Data*) and Section 01 93 00 (*Maintenance Services*).^{A16A7}
8. **Culvert and Conduit Bulkheads:** Culvert and conduit bulkheads shall be designed and constructed for use during dry maintenance of the valves and guides.
- ^{A79}9. **Bulkhead Slots:** Vertical bulkhead slots shall be provided at all culvert or conduit valve pit locations and where required for dry culvert isolation. The vertical slots shall be designed and constructed for the use of bulkheads during dry outages.
10. **A Means for Dry Culvert Isolation:** Bulkheads shall be provided to isolate the culverts of either the east wall or west wall of each lock complex from the chambers and Water-Savings Basins. The purpose of the dry culvert isolation at the Atlantic and Pacific Locks complexes is to allow dry culvert maintenance and repair work without stopping the lockage of vessels. Dry culvert isolation shall be in accordance with Section 01 92 00.13 (*Dry Outages*).
11. **Parts Embedded in Second-Stage Concrete:** The Contractor shall design and construct all parts embedded in second-stage concrete. For parts embedded in first stage concrete refer to Section 01 81 16 (*Lock Structures*).

C. **Related Sections:**

1. 01 42 13 (*Acronyms and Units*).
2. 01 42 16 (*Definitions*).
3. 01 81 13 (*Filling and Emptying Systems*).
4. 01 81 16 (*Lock Structures*).
5. 01 81 36 (*O&M Buildings and Facilities –Program*).
6. 01 81 36.13 (*O&M Buildings and Facilities – Space Programming*).
7. 01 81 29 (*Electrical and Lighting System*).
8. ^{A16}01 91 00 (*Commissioning and Testing*).^{A16}
9. 01 92 00.13 (*Dry Outages*)
10. 05 50 13.13 (*Metallizing and Coating Hydraulic Structures*).
11. 01 86 13 (*Plant - Mechanical Systems and Equipment*).
12. 09 96 00 (*Corrosion Control Coatings*).
13. 40 91 00 (*Primary Process Measurement Devices*).

14. 40 95 13.13 (*Process Control Hardware for Locks Machinery Control System*).^{A7}

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

- A. **American Concrete Institute (ACI).**
- B. **American Gear Manufacturers Association (AGMA).**
- C. **American Institute of Steel Construction (AISC).**
- D. **American Iron and Steel Institute (AISI).**
- E. **American National Standard Institute (ANSI):**
A10.4-04 Personnel Hoists and Employee Elevators.
- F. **American Society of Mechanical Engineers (ASME).**
- G. **American Society for Non-destructive Testing (ASNT).**
- H. **American Society for Testing and Materials (ASTM)** ^{A9} **International:**
D 3951-98(04) Commercial Packaging.
- I. **American Welding Society (AWS).**
- J. **Anti-Friction Bearing Manufacturers Association (AFBMA).**
- K. **Comité Européen de Normalización (CEN).**
- L. **Institute of Electrical and Electronic Engineers (IEEE):**
IEEE Y32.9-72 Graphic Symbols for Electrical Wiring and Layout Diagrams.
- M. **International Electrotechnical Commission (IEC).**
- 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. **Society of Automotive Engineers (SAE).**

- U. **Underwriters Laboratories, Inc. (UL).**
- V. **United States Coast Guard (USCG).**
- W. **United States Army Corps of Engineering (USACE).**
- X. **National Association of Corrosion Engineers (NACE).**
- ^{A5}Y. **Deutsches Institut für Normung Standards (DIN) ^{A5}**

1.03 REQUIREMENTS:

- A. **Operating Machinery:** The operating machinery of the culvert and conduit valves shall be in accordance with accepted industry practices. Each system's operation shall be adjustable for maximum smoothness and shall meet all Contract requirements. Wherever the valve drive system is indicated in this Section, it shall be of the hydraulic type.
- B. ^{A5}**Intake Screens:** The Contractor shall design, construct, install and test removable trash racks or screens for the locks culvert and WSB water intakes. The intake screens or trash racks shall prevent the entry of debris and vegetation that may affect the operation of the culvert and conduit valves. The location of each trash rack slots shall be easily accessible for removal and replacement with an Employer's land-based crane. Trash racks or intake screens shall not require the service of divers during installation or removal. Trash racks or screens shall be designed for the maximum differential head condition, debris impact loading, and water-flow conditions including debris loading. Trash racks or intake screens shall consist of parallel bars with a maximum gap or opening of 15 cm x 15 cm. The presence of trash racks shall be considered in the filling and emptying system's hydraulic design.^{A5}
- C. ^{A7}**Bulkheads for Dry Outages^{A7}:**
 - 1. **Culvert and Conduit Bulkheads:**
 - a. **General Requirements:** The bulkhead structure shall be designed with the same parameters as the valves. The Contractor shall design and construct bulkhead slots on the culvert and conduit valves intake and discharge sides, and wherever they are required to allow lock operations to continue during maintenance and repair of each valve. ^{A16}Culvert bulkhead slots exposed to the locks chambers shall be recessed to allow normal operating ship clearances with the bulkheads installed. The Contractor shall provide handling and storage procedures for these removable bulkheads. Refer to Section 01 93 00 (*Facilities Maintenance and Operations Support*) for the number of bulkheads that are required.^{A16}
 - b. **Outage Requirements:** The installation or removal time of each pair of bulkheads shall not exceed 4 hours. During a valve outage, the installed culvert and conduit intake and discharge bulkheads shall be configured to prevent water flow in that section of culvert or conduit. The installed

bulkheads shall hold the water and prevent water from entering the valve space while it is dewatered. After the dewatering of the valve space is complete, Employer's Personnel shall be capable of safely entering the area under dry conditions. The installation or removal shall not require the service of divers.

2. ^{A7}**Bulkheads Required for Culvert Isolation:** The bulkheads provided shall isolate or shut off the main and secondary culverts of either the east or west walls of the Pacific and Atlantic Locks complexes. The bulkheads provided to isolate the culvert shall comply with the requirement of this ^{A9}Section^{A9} and Section 01 92 00.13 (*Dry outages*).
 - a. **Leakage:** The maximum leakage rate shall not exceed the rate specified in ^{A9}Subparagraph 1.04 L. of this Section.^{A9}
 - b. **Loading Condition:** The Contractor shall design and construct the bulkheads for all loading conditions specified in ^{A9}Subparagraph 1.04 E. of this Section.^{A9A7}
- D. **Lubrication:** The use of self-lubricating materials shall be considered in the design to the maximum extent feasible.
- E. **Spare Valves Sets:** ^{A16}Refer to Section 01 93 00 (*Facilities Maintenance and Operations Support*) for the spare valve set requirements.^{A16}
- F. **Corrosion Prevention and Protection:** In addition to other requirements, culvert and conduit valves, valve-lifting frames, lateral roller guide supporting structure, valve-access covers, bulkheads, ^{A7}culvert isolation bulkheads,^{A7} and embedded metal shall be designed, fabricated, and constructed for 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 also take into consideration a means for preventing corrosion. Refer to 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, prevent corrosion and minimize the requirement for maintenance.
 - c. **Dissimilar Metals:** Contact between dissimilar metals shall be avoided. Dissimilar metals in contact shall be as close as possible in the galvanic table. Dissimilar metals shall be electrically insulated from each other by

means of non-conducting coatings, gaskets, synthetic material bolt sleeves and 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 submerged metal surfaces. Joints shall be designed to avoid crevice corrosion.
- e. **Accessibility for Painting:** The design shall provide proper accessibility for maintenance and painting. Enclosed spaces shall be provided with 2 separate entry/exit access manholes.

2. **Corrosion Protection:**

- a. **General:** Metal surfaces of culvert and conduit valves, valve-lifting frames, lateral roller-guide supporting structures, valve-access covers, and embedded metal^{A11} protected against corrosion by means of corrosion control coatings in accordance with Section 09 96 00 (*Corrosion Control Coatings*) and cathodically protected in accordance with Section 26 42 00 (*Cathodic Protection*).^{A11} Valve-operating equipment and accessories and bulkheads shall be protected against corrosion by the application of protective coatings, in accordance with Section 09 96 00 (*Corrosion Control Coatings*).^{A11} As an alternative, selected surfaces may be metallized and coated in accordance with Section 05 50 13.13 (*Metallizing and Coating Hydraulic Structures*).^{A11}
- 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.

G. **Packaging:** 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. Component parts preservation shall be suitable for a minimum of 2 years' storage. The Contractor shall also comply with the following requirements.

- 1. **Corrosion Prevention:** All finished parts and surfaces that are subject to corrosion shall be coated and protected with a corrosion-resistant compound.
- 2. **Material and Equipment Cleaning:** The equipment, spare parts, tools, inventory and material shall be clean and free of all foreign material.
- 3. **Repainting:** Surfaces of each lock valve or equipment where paint has been damaged during shipment shall be cleaned and touched-up with a surface preparation and paint matching the^{A9} original^{A9} coating system.

H. ^{A16}(Reserved)^{A16}

1.04 DESIGN CRITERIA/SYSTEM DESCRIPTION AND PERFORMANCE:

A. **Structure:**

1. **General Description:** The structural design shall take into account the constructability of the valve as well as the means required to transport the valves from the fabrication facility to the final position in the valve chambers. The design of the valves shall take into account all the possible effects arising from manufacturing and erection tolerances of the tracks. Additionally, valve design shall take into account all changes in the support conditions according to the setting and deformation rate to be expected in the bearing elements on the lock walls. These effects shall be minimized in the design by selection of a suitable system for the solid structure and its foundation.
2. **Materials:** The main structure of the valves, including but not limited to shell plating, stiffeners, and beams, shall be made of welded structural steel. The steel grade shall be selected according to the required strength of the specific elements of the lock valve. Different materials shall be allowed for special items or components, which due to their specific nature may require special mechanical properties or special wear and durability requirements. These may include bearings materials, castings, rollers, seals, seal retainers, and others. If anti-friction (ball bearings or roller bearings) are used, the bearings shall comply with the applicable mandatory and advisory requirements of AFBMA Standards. The main structure of the valves shall be designed and constructed by making extensive use of commercially available plates and shapes, except where the Contractor demonstrates that a suitable standard material is not available.
3. **Minimum Requirements:** Structural steel to be used in the construction of the valves shall have a minimum yield stress $f_y=248$ MPa [36,000 psi]. In order to facilitate fabrication and future field maintenance or repairs, the use of very high-strength steel for which $f_y>355$ MPa [55,000 psi] or alloy steel that requires extensive and complicated welding procedures shall be avoided on the valve-leaf structure. Unless a substitute method is submitted to and approved by the Employer's Representative, all welds shall be completely sealed to provide tightness against leakage and to avoid water intrusion to 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. The structural design of the joints shall consider 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. Welding shall be in accordance with the applicable AWS standards. The Contractor shall assume 365 days of operation per year with an average of 25 cycles per day.
4. **Design Approach:** Specific codes or regulations utilized by the Contractor in the development of the structural design shall be clearly stated in the design documents. The final structural design of the valve shall be accomplished by

means of a full structural model that can accurately capture the interaction that exists between the various framing elements. Connections and joints that may not be easily analyzed or designed by simple methods shall be modeled independently to demonstrate their adequacy. The valve system shall have enough built-in redundancy to avoid global failure, progressive collapse, or loss of operability due to damage of certain primary members. As part of the serviceability calculations, deformation characteristics of the structure shall be carefully analyzed to ensure proper motion of the valve, adequate sealing, and trouble-free machinery operation.

5. **Structural Design:** Structural design of the culvert and conduit valves shall consider all possible failure modes including, but not limited to, yielding or excessive deformation, buckling or instability, subcritical or unstable crack growth, excessive vibration, fatigue, and others. Failure modes not specifically addressed by design codes shall be taken into account by using sound engineering principles.

B. Operating Machinery Design Considerations and Criteria:

1. **Operating Time:** Valve opening and closing time shall be in accordance with the requirements of Section 01 81 13 (*Filling and Emptying Systems*).
2. **Equipment Loadings:** Machinery for culvert and conduit valves shall be designed to provide the force required to open the valve under maximum differential hydrostatic head conditions and to close the valve under maximum differential hydrostatic head and water-flow conditions. In addition, valve equipment shall be able to open or close the valves during installation, dry testing, or servicing. Culvert and conduit valves shall be designed and constructed to be capable of closing with their own weight under all operating conditions. The design, construction, installation, and operation of the culvert and conduit valves shall prevent water-hammer effect under all operating conditions. The culvert and conduit valves shall be designed and constructed to prevent sudden closures under all conditions, especially during power outages and equipment failure.
3. **Operating Machinery Drive and Control:** The valve drive systems shall be of the hydraulic type with redundant features that permit operation with 1 drive inoperative. The drives shall be capable of being operated locally and remotely. Valve opening and closing time shall be in accordance with the requirements of Section 01 81 13 (*Filling and Emptying Systems*). Hydraulic power systems shall be in accordance with Section 01 86 13 (*Plant – Mechanical Systems and Equipment*). Chains or wire ropes shall not be included in the design of the operating machinery.^{A7} Double wall hydraulic piping is not required. With the exception of the cylinder rod, all operating machinery drive system shall be located aboveground and above the highest water level of the corresponding chamber.^{A7}
 - a. **Valve Operation:** The valve shall operate from fully closed to fully open or from fully open to fully closed. When the operator starts the

open or close operation, the system shall automatically operate the valve from standstill to normal operating speed, travel the required distance, proceed to slow down, and finally stop accurately at the required open or closed position, without further intervention by the operator. It shall be possible for the operator to stop, stop and proceed, or stop and reverse the valve operation in a safe manner before completing the open or close valve operation. Valve closure or opening shall be possible for culvert / conduit openings at any percent, as desired. The required start, travel, and stop operations shall be achieved safely and smoothly without jolts, jerks, or vibrations.

b. **Instrumentation, Control, Indication, and Alarm:**

- 1) Control and indication shall be in accordance with Section 40 95 13.13 (*Process Control Hardware for Locks Machinery Control System*).
- 2) **Process Control, Instrumentation and Sensors:** Refer to Section 40 91 00 (*Primary Process Measurement Devices*).
4. **Standardization:** The Contractor shall identify all the conditions and load combinations that could occur to determine the rated capacity of the operating machinery. The culvert and conduit valve machinery shall be dimensioned and selected for the maximum equipment load condition. The operating machinery at the Atlantic and Pacific lock complexes shall be identical for all culvert valves and identical for all conduit valves.
5. **Redundancy:** **Redundancy:** ^{A16}For reliability of the culvert and conduit valves, two (2) motor-pump units in parallel shall be required to close or open the valve. Each motor-pump unit shall be able to operate the valve under normal conditions during an extended operating time, so that any failure of either unit shall not stop the operation of the valve.^{A16}
6. **Auxiliary System:** Valve operators shall be provided with an auxiliary system to permit operation of the valve by other means during power failure. Four auxiliary valve operators shall be provided (2 for each lock facility). Auxiliary operators shall be capable of opening or closing valves within 15 minutes.
7. **Safety and Health Protection:** Safety and health protection shall be in accordance with Sections 01 35 23 (*Health and Safety Requirements*) and 01 35 29 (*Health and Safety Management / Emergency Response Procedures*).
8. ^{A7}**Vibration and Shock^{A7}:** Equipment and materials shall withstand the effects of random shocks and vibration. All equipment shall be designed, specified, constructed, and installed to minimize vibration and resonance at all speeds up to the maximum equipment running speed. Equipment shall be provided with vibration-isolating mountings or dynamically balanced as required. Equipment shall be designed and constructed to prevent cavitation.
9. **Other Requirements:** Culvert and conduit valve operating machinery shall consist of standard manufactured products (catalog items) that satisfy the installation and operating conditions, except where the Contractor demonstrates

that a suitable product is not available. The design and sizing of all systems, equipment, and components shall include allowance for the increased friction and load resulting from normal use over the equipment’s design life. All components of the same size and ratings shall be identical.

- C. **Geometry and Description:** Culvert and conduit valve design shall be based on valve configurations used with success on similar projects. The valves shall be wide enough to span the width of the culverts or WSB conduits in which they are located and, at the same time, obtain proper support on the lateral bearing plates. The height of the valves shall be sufficient to allow the upper portion of the valve to seal against the valve lintel while the bottom is resting on the valve seal seat. The valves shall be complete and shall include all subassemblies including, without limitation, the following.
1. The valve body assembly, including skin plate, supporting beams and girders, bracings, and seals, shall be designed and constructed to seal adequately and comply with all the requirements specified.
 2. Valves shall be of the fixed wheel type. The wheel assembly shall include the main and side rollers, lubrication provisions, and mounting brackets.
 3. The embedded seal path assemblies, including side seal, sill seat, and anchors shall be designed, constructed, and installed.
 4. Valve rolling tracks shall be bolted to the embedded parts.
- D. **Water Levels:** The Contractor’s design of the culvert and conduit valves shall consider all anticipated water-level conditions, including the varying water levels of the chambers, WSBs, lake, and oceans.
- E. **Operating Conditions:** All valves for the lock culverts and WSB conduits shall be designed to prevent cavitation and water-hammer effect. The Contractor’s design of the culvert and conduit valves shall consider all anticipated operating conditions including, without limitation, the following.
1. **Normal Conditions:** The valves are subject to gravity effects and operating heads, which will depend on the final design of the lock chambers and filling and emptying systems, including WSBs. Culvert and conduit valves shall be designed to open under maximum head and close against water flow at maximum head. Culvert and conduit valves shall be designed to allow normal lock operation without the use of the WSBs, as well as with WSB use.
 2. **Extreme Conditions:**
 - A⁷ a. **Earthquake:**^{A⁷} ^{A¹⁶}The valve design shall take into account the seismic loads indicated in Volume VII, Part 3 (*Seismic Design Criteria Data*) and Section 01 81 16.13 (*Seismic Design Criteria*).^{A¹⁶} All possible operating conditions and water levels, as well as the in-the-dry condition, shall be investigated to determine the maximum effects of seismic loads on the valve.

- ^{A7}b. **Flooding:** See Volume VI, Part 7, (*Hydrometeorological Report*).
3. **Stresses and Deformations Produced by Maximum Hydrostatic Load^{A7}:** Culvert valves, conduit valves, and bulkheads at all locations shall withstand the stresses produced by a hydrostatic load with a maximum head on the upstream side and an empty culvert or conduit on the downstream side. All allowable “serviceability limit states” including, but not limited to deformations, shall be maintained for maximum hydrostatic load.
- F. **Standardization and Interchangeability:** All culvert valves for the 2 lock complexes shall be of identical size and construction in order to ensure interchangeability between them. All WSB conduit valves shall be of identical size and construction in order to ensure complete interchangeability between them. All culvert bulkheads shall be identical and completely interchangeable. Likewise, all conduit bulkheads shall be identical and completely interchangeable. There shall be no difference between the bulkheads located upstream and downstream of each valve.
- G. **Redundancy:**
1. **Culvert Valves:** There shall be 100% redundancy on culvert valves and operating machinery. Maintenance of any valve machinery shall not increase the required chamber filling and emptying times, unless bulkheads are installed or if the valve is unable to operate from a closed position. There shall be enough redundancy to permit removal of any valve for extended maintenance while maintaining the required chamber filling and emptying times. Removal of any valve shall not restrict culvert flow. The removal time shall be a maximum of 12 hours, including the time required to install the bulkheads, dewater the valve chamber, remove the valve, and remove the bulkheads.
 2. **Conduit Valves:** Each WSB shall be provided with enough conduits and conduit valves so that failure or maintenance of any valve shall not increase chamber filling and emptying times by more than 10%.
- H. **Design Life:** Culvert and conduit valves and maintenance bulkheads shall be designed and constructed in accordance with the following minimum design-life requirements.

DESIGN LIFE			
Description	Items	Minimum operating period or cycles of operation (whichever occurs first)	
		Years	Cycles*
Culvert and Conduit Valves	Embedded metals	100	900,000
	Valve body	50	450,000
	Maintenance bulkheads	70	
	Valve seals	10	90,000
	Bearing components, wheel assembly, and other wearing surfaces fastened to the valve body or leaf	10	90,000

DESIGN LIFE			
Description	Items	Minimum operating period or cycles of operation (whichever occurs first)	
		Years	Cycles*
	Seal seats, guide plates, and other parts fastened to embedded parts	20	180,000
Operating machinery	Machine elements and their electrical equipment (does not refer to wear parts)	35	320,000

*Note: One valve cycle is the complete opening and closing sequence of a valve in which the valve returns to its starting position. For example, the valve starts movement at its closed position, opens completely, and stops. Then, the valve closes to end at its closed position. The combination of opening and closing operation is considered one complete valve cycle.

- I. **Embedded Metals:** Embedded metals and anchoring shall be designed to withstand all loads imposed on them. All items embedded in the concrete walls, as well as their anchorages, shall be designed to avoid their removal for at least 100 years, the expected service life of the locks. Components fastened to embedded items shall be designed for a minimum service life of 20 years and for easy replacement when required. Hardware shall be corrosion and wear resistant, designed to avoid vibration and loosening.
- J. **Underwater Components:** All the embedded underwater component parts of the valve assembly shall be designed for 100 years, the minimum expected life of the locks. ^{A7}Seal seats shall be designed for a minimum service life of 20 years and for easy replacement. Bearing components, guide plates, ^{A7} and other wearing surfaces shall be designed for a minimum service life of 10 years and for easy replacement when required. All underwater components shall be corrosion and wear resistant. Embedded metals and anchoring shall be designed to withstand all loads imposed on them.
- K. **Seals:** All seals and sealing surfaces shall be made of heavy-duty materials and of a type that allows possible misalignments of the sealing surfaces while still maintaining adequate watertightness. All sealing surfaces shall be corrosion and wear resistant. ^{A7}Seals shall ^{A7} be easily replaced. Hardware shall be corrosion and wear resistant, designed to avoid vibration and loosening. Seals shall not be allowed to be fixed to the valves by means of welded-on threaded studs or welded-on bolts. In the case of electrometric seals, splices, direction changes, or other connections shall be made by hot vulcanizing using a joint mold or any other means that produces a continuous length of seal. Required hardness of the seals shall be determined by the Contractor. Seal fastening strips and spacers shall have rounded or chamfered corners on the seal side. The design, detailing and arrangement of seals, sealing surfaces and their supporting hardware shall prevent leakage induced vibrations on the valve.
- L. ^{A5}**Leakage:** Valves and bulkheads shall be designed, constructed, installed and tested for a maximum allowable leakage rate of 1.25 liters per minute per meter of seal under all conditions. ^{A5}

M. Maintenance Considerations:

1. **Maintainability:** The Contractor's design, construction, and installation of the valves shall enable preventive maintenance and major maintenance requirements of the operating equipment, related mechanisms, and main parts to be performed with minimum impact on operations. All underwater components in the Contractor's design shall be accessible for maintenance. All components shall be designed for removal and installation with standard tools and equipment. Special tools and fixtures shall not be required. All materials used in the valves shall be of a top-quality industrial/marine type.
2. **Inspection and Preventive Maintenance Intervals:** The Contractor's design, construction and installation for the valves shall provide for the following inspection and maintenance intervals.

INSPECTION AND PREVENTIVE MAINTENANCE INTERVALS				
Description	Item	Preventive maintenance	Minimum frequency of maintenance and/or inspection	
			Years	Cycles
Culvert and conduit valves	Valve body	Inspection, minor structural repair, and touch-ups painting	10	90,000
		Complete Overhaul including repainting	20	180,000
	Maintenance bulkhead	Minimal maintenance touch-up painting	10	
		Complete repainting	20	
	^{A7} Seal Seats	Inspection and minor repairs	10	
		Replacement	20 ^{A7}	
	Seals	Inspect and repair as required	5	45,000
	^{A7} Valve wheel assembly	Inspection and minor repairs	5	45,000
		Replacement	10	90,000 ^{A7}
Operating machinery	Machine elements	Replace bearing components, seal seats, guide plates, and other wearing elements	10	90,000
	Hydraulic system	Inspect and replace oil, seals, and other components	Per manufacturer's recommendations	

- a. **Valve Preventive Maintenance:** The valves programmed preventive maintenance shall include the frequencies indicated in the inspection and preventive maintenance intervals listed in this Section.
- b. **Valve Overhaul Intervals:** Complete Overhaul including, repainting of any 1 valve, shall be as indicated in the inspection and preventive maintenance intervals listed in this Section. This Overhaul shall include valve structural repairs, complete repainting, and replacement of all underwater moving mechanisms.

3. **Provisions for Valve Overhaul:**

- a. **Valve Overhaul Outage Requirements:** It is expected that conduit and culvert valve outages shall be required for programmed maintenance or emergency repairs. For a valve outage, two bulkheads shall be installed in the corresponding slots upstream and downstream of the valve and the valve body disconnected and removed. The valve assembly shall be designed, constructed, and installed to facilitate removal of components with a crane. The valve body or leaf shall be designed and constructed so that it can be removed in 1 piece with a crane without the prior need to install bulkheads and dewater the valve pit.
- b. ^{A17}**Dewatering Pump System:** During dry outages, the dewatering systems shall be designed to dewater the space between the upper and lower bulkheads. The Contractor shall provide space for the complete portable pumping/dewatering system. For pump dewatering time requirements, refer to Section 01 92 00.13 (*Dry Outages*). Refer to Section 01 93 00 (*Maintenance Services*) for the quantity of pump systems required. Valve pits shall be provided with suitable catch basins or sumps to install portable pumps. After dewatering, the system shall be capable of maintaining dry conditions. An entrance shaft to the valve pits shall be provided to allow for personnel access, dewatering equipment and care of water after valve pit dewatering. See Section 01 81 16 (*Lock Structures*) for shaft requirements. This shall allow access by technicians to this internal space so that inspections and emergency repairs of embedded steel components can be performed. The sizing, capacity of the pumps, and characteristics of the dewatering pump system shall be provided with the Contractor’s Technical Proposal. The design shall take into account that all pumps are interchangeable and are capable of functioning effectively when used with installed bulkheads at any valve pit and at any water level. The design shall take into account that the pump system shall have a ^{A17} ^{A16} discharge piping of sufficient length capable of working efficiently at any valve pit. See Section 01 86 13 (*Plant – Mechanical Systems and Equipment*) for portable dewatering pump specifications.^{A16}
- c. **Filling Dewatered Spaces:** After all work is concluded, the Contractor’s design shall provide a safe means of filling any dried dewatered spaces and removing the bulkheads.
- d. **Space for ANSI A10.4 Personnel Hoist:** ^{A16}The shaft space shall be adequate for ANSI A10.4 personnel hoists, as specified in Section 01 86 13 (*Plant – Mechanical Systems and Equipment*). The Contractor shall specify the personnel hoist and provide space requirements. However, the Employer will purchase the personnel hoists.^{A16}

4. ^{A7} (Reserved)^{A7}

1.05 SUBMITTALS: Submittal procedures shall be in accordance with Section 01 33 00 (*Submittal Procedures*).

- A. **Progress Charts:** Progress charts shall be provided in accordance with Section 01 31 00 (*Project Management and Coordination*).
- B. **Preliminary Design Data:** ^{A16}Within 140 days of the Commencement Date, the Contractor shall submit to the Employer's Representative for his review, 5 sets of design data.^{A16} In addition to the data required in this Section, the Contractor shall submit a preliminary version with at least 30% design completion of the documents submitted with the Contractor's ^{A17} Technical ^{A17} Proposal.
1. **Valve Design Data:** The valve data shall contain the general arrangement, calculations, critical dimensions, and overall dimensions. The design data shall include design analysis of all the forces acting on each lock valve.
 2. **System Design:** The system design data shall include the major systems, such as the electrical and mechanical systems and their main components. It shall provide the final general dimensions, exact location of major components, and electrical components.
 3. **Structural Frame:** The structural frame data shall include, but shall not be limited to, the calculations, structural frame design, ^{A7} seismic performance and ^{A7} drawings showing general dimensions and arrangement of auxiliary equipment.
 4. **Electrical and Electronic System:** This data shall include information on electrical power, control circuits, control sequence, and information on standard components to be used. The Contractor shall submit any proposed remote-control system, including the frequencies to be used, to the Employer's Representative for review.
 5. **Corrosion Control Coatings Schedules:** Technical sheets and material safety data sheets for coating materials for valves, bulkheads, embedded steel, and other metal shall be provided. ^{A11}Refer to Section 09 96 00 (*Corrosion Control Coatings*) and ^{A11} to Section 05 50 13.13 (*Metallizing and Coating Hydraulic Structures*).
 6. **Weight, Center of Gravity, Lifting Points, and Other Relevant Data:** The Contractor shall submit, for the review of the Employer's Representative, an estimate of weight, center of gravity, lifting points, calculations, and other relevant data for the culvert and WSB valves. Weight, center of gravity, lifting points, and other relevant data shall be submitted for all major components.
 7. **Historical Data, Accelerated Tests, and Calculations:** The Contractor shall submit historical data (of equal or more-severe design conditions), accelerated test results, and/or calculations that demonstrate that the proposed valve system complies with the design life specified in Subparagraph 1.04 H. of this Section. The Contractor shall be required to explain how the data meets or exceeds the design life specified.
- C. **Intermediate Design Data:** ^{A16}Within 322 days of the Commencement Date, after completion of at least 60% of the design, the Contractor shall submit to the Employer's Representative for his review, 5 sets of intermediate design data.^{A16}

The design data shall include the intermediate version of the documents submitted with Contractor’s ^{A17} Technical ^{A17} Proposal and the documents required in ^{A9}Subparagraphs 1.05 B.1. through 7. of this Section.^{A9} Items not indicated in this Subparagraph shall be in accordance with the Section 01 33 00 (*Submittal Procedures*).

D. **Final Design Data:** ^{A16}Within 497 days of the Commencement Date, after completion of the design, the Contractor shall submit to the Employer’s Representative for his review, 5 sets of final design data.^{A16} The design data shall include all documents for 100% completion that are indicated in ^{A9}Subparagraphs 1.05 B.1. through 7. and Subparagraph 1.05 C. of this Section.^{A9} Items not indicated in this Subparagraph shall be in accordance with the Section 01 33 00 (*Submittal Procedures*).

E. **Shop Drawings, Manufacturing Data, Detail Drawings, and Installation Drawings:** Drawing and manufacturing data shall be provided in accordance with Section 01 40 00 (*Quality Requirements*), Section 01 42 23 (*Acronyms and Units*), Paragraph 1.06 of this Section, and the following requirements.

1. **Shop Drawings and Manufacturing Data:** The Contractor shall submit, to the Employer’s Representative for his review, all data produced or required for the lock valves, power system, components, and assembly. The data shall include, as a minimum, shop drawings, detail drawings, manufacturing specifications, quality control, and erection instructions and testing procedures. ^{A7}(Deleted text)^{A7} 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 shall be in accordance with ANSI/IEEE Y32.9 or an equivalent international standard. Electrical drawings for each system shall provide cable routing information, cable identification, cable sizes, loads, protective devices settings, circuit data, conductor termination detail, and material lists. The Contractor shall submit data on any proposed remote-control system, including the frequencies, to the Employer’s Representative for review.
2. **Detail Drawings:** The Contractor’s detail drawings, including fabrication drawings, shop assembly drawings, delivery drawings, and field installation drawings, shall include catalog cuts; templates; fabrication and assembly details; and type, grade, and class 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 ^{A9}28 days^{A9} before 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 ^{A9}28 days^{A9} before 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 of installation and

handling equipment, provisions to be taken to protect concrete and other work during installation, method of maintaining components in correct alignment, etc.

- F. **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 such as chemicals, insulation, abrasives, coatings, grease, oil, 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 any toxicological testing of the product; its pyrolysis products; and any other information as may be needed to permit an accurate appraisal of any problem associated with the handling, storage, application, use, removal, disposal, or combustion of the material. Refer to Section 01 35 23 (*Health and Safety Requirements*).
1. **Materials 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 following URL link:

<http://www.osha-slc.gov/dsg/hazcom/msdsformat.html>
 2. **Technical Data Sheet:** The technical data sheet shall include the complete manufacturer's technical data with the manufacturer's name, trade name, generic name, intended use, chemical contents of each hazardous ingredient, and other information on the hazards.
- G. **"As-Built" Drawings:** ^{A16}Before the Taking-Over Certificate of the whole of the Works is issued, all as-built drawings of the completed Locks valves shall be submitted to the Employer's Representative.^{A16} After delivery, a revised general arrangement plan shall be submitted to the Employer's Representative ^{A9}for review.^{A9} Refer to Section 01 31 00 (*Project Management and Coordination*). The drawings shall be updated by the Contractor to reflect all changes made by the Contractor until the date of the Taking-Over Certificate.
- H. **Documents and Manuals:** Instructions, operation, installation, and maintenance books, manuals, part lists, etc. of all machinery and installations shall be submitted to the Employer's Representative in 4 sets of paper copies. Instruction books and parts lists shall be provided to the Employer's Representative in the original format delivered by the manufacturers of the relevant items, one set (7 copies) in the English and one set (7 copies) in the Spanish language. All instruction books produced shall also be provided to the Employer's Representative in a digital form (PDF or other). Manuals shall be provided to the Employer's Representative for review at least ^{A9}63 days^{A9} before shipping the equipment. The Contractor shall include in the manuals complete fabrication, operation, maintenance, and installation procedures of all major components.
- I. **List of Major Purchased Components:** The Contractor shall submit, for review by the Employer's Representative within ^{A9}28 days^{A9} before the delivery of the lock valves, a list of all major purchased components that are installed in or on the lock valves. 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. Four copies of lists shall be submitted to the Employer’s Representative in the English language together with 2 copies on digital medium in the latest Microsoft compatible database format).

- J. **Training Program Details:** The Contractor shall submit, to the Employer’s Representative for his review, an outline of the content and other detailed information of the ^{A17} operation and maintenance training sessions proposed by the Contractor. This submission shall be made 28 days in advance of the local training sessions. The duration of the training services and the type and number of employees to be trained shall be clearly indicated in the outline. ^{A17}
- K. **Spare Parts List:** ^{A9}Twenty eight days^{A9} before delivery of the lock valves, the Contractor shall submit to the Employer’s Representative a list of all the lock valve parts. The list shall include all critical spare parts, materials and equipment to be provided with the lock valves. These critical spare parts shall include, as a minimum, all long-lead time items necessary to maintain the lock valves 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 ^{A9}Subcontractor’s^{A9} part numbers, F.O.B. Contractor’s plant prices and approximate lead time. All price lists shall be delivered in duplicate to the Employer’s Representative in both hard copy and on a digital medium in a database format compatible with the latest Microsoft version.
- L. **Testing and Inspection Reports:** The Contractor shall furnish, to the Employer’s Representative for his review, a report on all tests and inspections, showing in detail each test procedure and inspection result. Five copies of the certified test reports shall be submitted to the Employer’s Representative in booklet form.
- M. **Storage and Installation Instructions:** At least ^{A9}63 days^{A9} before the delivery of the lock valves, components, and accessories, the Contractor shall submit, to the Employer’s Representative for review, its storage and installation requirements and instructions. This shall include how the seals and other critical components will be protected from damage during shipment, storage, and installation.
- N. **Certificates of Conformance:** ^{A16}The Contractor shall submit certification from the manufacturers attesting that materials and equipment to be furnished for the Works comply with the requirements specified. ^{A16} Pre-printed certifications will not be acceptable; certifications shall be in the original. The certification shall not contain statements that could be interpreted to imply that the products do not meet all requirements specified, such as “as good as”, “achieve the same end use and results as materials formulated in accordance with the referenced publications”, or “equal or exceed the service and performance of the specified material”. Instead, the certification shall simply state that the product conforms to the requirements specified.
- O. **Standards:** Before using standards from organizations or codes other than those listed in Paragraph 1.02 of this Section, the Contractor shall submit them to the Employer’s Representative for review. The Contractor shall prove that the proposed standard is applicable to the performance requirements of this Section.

- P. **Third-Party Independent Organization Certificate:** In order to guarantee the quality and the durability of the paints and coatings systems, the proposed paints and coating systems shall be certified before field testing of the completed lock complexes by a third-party independent organization such as the Association for Certification and Qualification of Anticorrosive Paintwork (ACQPA) or other equivalent organization.^{A16} Certification from the third-party independent organization attesting that the paints and coating systems furnished for the Works comply with the requirements specified shall be submitted to the Employer's Representative.^{A16}

1.06 QUALITY ASSURANCE:

- A. **Facility Quality Standards:** Valves 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 CBR (Major Steel Bridge) with a fracture critical and sophisticated paint endorsement. Facilities meeting or exceeding this quality level, and possessing a certification from a recognized certifying agency, shall be accepted.
- B. **Workmanship:** The workmanship in the fabrication and installation of the valve assembly shall be such that the valve body shall form a watertight barrier when lowered to the seated position. Fabrication, assembly, delivery, and installation of culvert and conduit valves shall be in accordance with accepted industry practice. Structural fabrication shall conform to the applicable requirements of AISC and AWS or any 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 in accordance with accepted industry practice and applicable requirements of the valve design. The Contractor shall comply with all project requirements and shall perform tests, inspections, and verifications of the valve construction.^{A9} These inspections shall be undertaken in accordance with the quality control and test plans submitted by the Contractor and reviewed by the Employer, per Section 01 40 00 (*Quality Requirements*).^{A9} The Employer's Representative reserves the right to independently inspect all phases of the work, by using the Employer's Personnel or third-party inspection services.
- D. **Inspection and Tests at Contractor's Plant: Inspection and Tests at Contractor's Plant:** Tests shall be conducted as specified below and certified copies of the test results shall be furnished to the Employer's Representative for review within ^{A9}28 days^{A9} after the day on which the tests were run. The Employer reserves the right to witness all testing of the conduit and culvert valves and their components. [For additional factory testing and inspection requirements see Section 01 40 00.](#)
1. **Factory Testing of Major Components:** The Contractor shall test all components before assembly of the conduit and culvert valves. These tests may be run at Subcontractor's plant. The Contractor shall notify the Employer's Representative at least ^{A9}28 days^{A9} before testing each machinery unit. This notification shall include information on how many units will be tested, testing

procedures, blank testing forms, and the estimated time frame involved with each test. The witnessing of a particular test may be waived by the Employer’s Representative; however, the reviewed shop test procedures, notification, and documentation shall still be performed as required by this Section. Once informed that Employer’s Personnel will witness the test(s), the Contractor shall notify the Employer’s Representative that a particular test is scheduled as planned a minimum of 48 hours prior to the test. The Contractor should perform all necessary preparations and preliminary testing prior to issuing the 48 hour notification. Testing shall commence upon the arrival of Employer’s Personnel at the scheduled location and time. The Contractor shall design and furnish all rigs and fixtures suitable for performing the tests. Details of the test fixtures or rigs shall be submitted for evaluation and review of the Employer’s Representative. The submittal shall address aspects including adequacy of rig strength, foundations, access to the test rig, availability of suitable power and cranes, how the work will be protected, how the test measurements will be made, and how test results can be verified.

2. **Factory Inspection and Testing of Assembled Conduit and Culvert Valves:**

- a. **Factory Inspection of Assembled Conduit and Culvert Valves:**
Inspections shall comply with the requirements of Section 01 40 00 (*Quality Requirements*). 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 and parallel.
- b. Shop assembly requirements for valve, body frame, and appurtenant items shall be in accordance with accepted industry practice. Valve body, frame, guides, and appurtenant items shall be assembled and tested completely in the shop to ensure satisfactory field installation and operation. These mating surfaces shall be “match” marked to aid field assembly and alignment.

E. **Field Tests and Inspections:**

1. **Field Operation Tests:** ^{A16}After each valve assembly has been installed, including its operating machinery, the Contractor shall operate the valve throughout its full operating range for at least 20 cycles to demonstrate proper operation and compliance with this Section and shall document the testing per Section 01 40 00 (*Quality Requirements*).^{A16} Adjustments shall be made to the operation and control apparatus until all components function as required. The valve leaf assembly, including the skin plate, supporting beams and girders, bracing, rubber seals, wheel assemblies, lubrication system, embedded seal path assembly, operating machinery, and other appurtenances shall be inspected to ensure proper workmanship and operation. Operating assemblies and other appurtenances shall also be inspected to ensure proper operation. Required repairs or replacements to correct defects, as determined by the Employer’s Representative, shall be made at no additional cost to the Employer. The trial operation and testing shall be repeated after defects are corrected. 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 a local manual basis.

2. **Leakage Tests:** After the valves have been installed, the Contractor shall test each valve to measure the leakage rate along of the entire valve body. The Contractor shall measure the leakage rate per meter along the valve body seal. The measured leakage rate at any point along the seal shall be less than the allowable unit leakage rate per meter of seal length. Refer to Subparagraph 1.04 L. of this Section. The Contractor shall demonstrate that the measured leakage rates are less than the specified maximum allowable rates. The Contractor shall perform testing on all conduit and culvert valves. Leakage tests shall be performed under the same parameters for culvert and conduit bulkheads.

1.07. ^{A16}**QUALIFICATION OF THE CONTRACTOR'S PERSONNEL:**^{A16} The Contractor's Personnel shall comply with the requirements of Section 01 40 00 (*Quality Requirements*).

- A. **Experience of Supervisors, Engineers, Technicians, and Trainers:** The Contractor shall have engineers, technicians, and trainers who have a minimum of 7 years' experience within the last 9 years supervising the construction and installation, project managing, testing, and maintenance of lock valves or products of similar type and equivalent level of complexity.
- B. **Skilled Workers:** The Contractor shall have skilled workers, such as mechanics, electricians, welders, and pipe fitters, employed to install, supervise, and test, who have not less than 4 years of experience within the last 6 years installing, supervising, or testing equipment of the type and rating specified, except that helpers or apprentices with less than 3 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 rules shall do the welding under this Contract. The Contractor shall bear the expense of conducting these tests. The Employer's Representative will review all welders, including those that 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 of 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 rules shall do the non-destructive examination for the purpose of assessing quality of welds and materials in connection with the work described in the Employer's Requirements. 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.

1.08. TRAINING PROGRAM AND SERVICES: ^{A16}The Contractor shall provide training services in accordance with the training programme proposed by the Contractor and accepted by the Employer.^{A16} 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 Panama Canal area, as directed by the Employer’s Representative. Refer to Section 01 79 00 (*Demonstration and Training*).

- A. **Training Services:** Training services shall start with the installation of the last 2 valve assemblies. All other training services shall commence after the systems are functionally complete, but before Taking–Over Certificate tests. Instructors fluent in English or Spanish shall conduct the training sessions for the Employer’s Personnel. The duration of the training services shall be at least 10 work days of 8 hours. The training services shall be for 20 workers of the Employer’s Personnel per lock complex.
- 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 valves.

1.09. ^{A16}ON-SITE TECHNICAL SUPPORT SERVICES BEFORE ISSUANCE OF TAKING-OVER CERTIFICATE.^{A16}

- 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 lock valves into initial operation for conducting on-site testing, in accordance with the Employer’s Requirements.
- B. **Support During On-Site Testing:** In coordination with the Employer’s Personnel for the lock valve units, the Contractor shall designate personnel to support the on-site testing conducted by the Contractor’s Personnel, per Section 01 40 00 (*Quality Requirements*) and other Employer’s Requirements, for the periods prescribed therein for each type of unit. During these periods, the Contractor shall provide maintenance to the lock valves and correct any deficiencies that occur or become apparent during testing and shall provide the necessary spare parts and labor.

END OF SECTION