

## SECTION 01 81 16.16 – LOCK APPURTENANCES

**1.01 SUMMARY:** <sup>A16</sup>This Section covers the Contractor's design and specifications of miscellaneous equipment and appurtenances required for the complete operation of the locks; and where specified, the fabrication, assembly, transportation, delivery, full installation, and testing. The following items are included. <sup>A16</sup>

A. **Fenders:** The purpose of the fenders is to prevent the vessels or Lock Structures from being damaged during Transits and to increase throughput. They shall be installed <sup>A7</sup>at <sup>A7</sup>the following locations:

1. Approach structures.
2. Lock chambers.
3. Locations requiring corner protection.

B. **Bollards:** These are short, single-column fittings that extend up from a base plate secured to the structure. The purpose of the bollards is to secure vessels in the locks by means of mooring lines.

C. **Safety Devices:**

1. **Lifesaving Rings:** The purpose of the lifesaving rings is to provide a means for personnel on the lock walls to aid someone in the event of an accident (in which someone falls into the water).
2. **Guardrails:** The purpose of the guardrails is to prevent accidental falls into the water. They shall be located at non-operational areas where there is exposure to water or risk of falls due to differing elevations.
3. **Fixed Ladders:** The purpose of the ladders is to provide a means of escape or egress.

D. **Operational Fixtures – Station Posts:** The purpose of the station posts is to provide an elevated surface on which to place:

1. Chamber-distance markings.
2. Telephones.
3. Public-address systems.
4. Electrical receptacles.

E. **Maintenance:** Facilities for floating equipment performing maintenance at low water levels (i.e. bollard recesses in lock wall).

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

A. American Society for Testing and Materials (ASTM) International Standards.

**B. Code of Federal Regulations (CFR):**

29 CFR 1910 Subpart D, Walking - Working Surfaces.

29 CFR 1917 Subpart B, Marine Terminal Operations.

**C. Junta Técnica de Ingeniería y Arquitectura (JTIA) Standard:**

REP 2004 Reglamento Estructural de Panamá.

**<sup>A7</sup>D. Permanent International Association of Navigation Councils (PIANC):**

Guidelines for the Design of Fender Systems: 2002<sup>A7</sup>

**1.03 GENERAL REQUIREMENTS:**

**A. Design:**

**1. Fenders:**

a. **General:** The Contractor shall design and write specifications for the fender system to:

- 1) Ensure the safety of vessels and Lock Structures.
- 2) Maximize the capacity of the locks.
- 3) <sup>A7</sup>Handle different vessel mixes. Table 1, Table 2, and Table 3 of Subparagraph 1.04.A.4. of this Section provide some examples of vessels.<sup>A7</sup>
- 4) <sup>A16</sup>Avoid a technological risk by using a system with a minimum of years of successful installation under similar circumstances as those outlined in the requirements.<sup>A16</sup>
- 5) Be easy to maintain and/or replace. <sup>A16</sup>Maintenance and replacement must be possible with minimum disruption to traffic.<sup>A16</sup>
- 6) Provide required durability and functionality in the marine tropical environment to which it will be exposed.<sup>A7</sup>
- 7) <sup>A16</sup>Ensure a good service life for lock Operations. Minimum required maintenance and an extended life expectancy of the system shall be considered in the selection of the fender system.
- 8) Be commercially available as off-the-shelf items to the extent possible.
- 9) Fenders shall be supplied and installed by the Contractor as part of the Works.

- b. **Approach Structures:** As the vessels make their approach to the lock, fenders are required to prevent damage to vessels or structures when contact occurs, and to increase throughput by facilitating the pre-positioning of vessels.
- 1) Fender placement shall take into account the variations in the water level due to the tides and lake-level fluctuations, as well as vessel configurations.
  - 2) Fenders shall be designed to be placed on the approach structures and to adequately fulfill the design criteria.
  - <sup>A8</sup>3) Fixed fender systems shall be of modular construction to facilitate removal and installation. The fender systems shall meet one of the following requirements:
    - i. Heaviest component weight less than 4 tons for replacement by floating equipment.
    - ii. Heaviest component weight less than 5 tons for replacement by land based crane. If this option is utilized, access must be provided for the crane. The access can be fixed or a removable/portable bridge.
    - iii. Heaviest component weight less than 5 tons for replacement by a pillar crane or other means fixed to the structure that will achieve the same result. <sup>A8</sup>
  - 4) If fender systems float they shall be designed to include the possibility of being towed away.
  - 5) Sharp edges shall be avoided in the design.
- c. **Lock Chambers:** Fenders are required to avoid contact between the vessel and the wall, to ensure the safety of the vessel, and to prevent damage to the vessel or the locks when vessels are moving from chamber to chamber or during filling and emptying operations.
- 1) The fender system shall take into account the variations in the water level due to the different Equalization levels to avoid removal by vessels as they are raised or lowered.
  - 2) Fenders shall not extend more than 0.3 m from the face of the wall in order to avoid a reduction in the maximum beam of vessels that can transit the lock.
  - 3) Fenders shall be able to keep the ship from contacting the wall or any hardware securing the fender to the wall.
  - 4) The systems shall be designed to allow vessels of different configurations to maintain contact with the fenders while the vessels are in motion, as part of normal Operations.
  - 5) The Contractor's design of the fender system shall be considered in the Contractor's design and construction of the lock-chamber

walls so that all necessary provisions are made for incorporating the fender system into the lock walls.

- d. **Corner Protection:** Fenders are required to protect the vessel and edge of the wing wall as the vessel approaches the entrance to the lock chamber.
  - 1) The fender system shall take into account the variations in the water level due to tides and fluctuations in lake levels.
  - 2) The fender system shall help to guide the vessel and permit the vessel to slide into the lock chamber.
  - 3) The fender system shall be located in a manner to prevent vessels from making contact with the wing wall.

2. **Bollards and Capstans:**

- a. Bollards shall be located along the lock walls and approach structures and spaced at a maximum interval of 15 m.
- b. <sup>A19</sup>Capstans shall be located along the lock walls so that at least one is available for use with up to 8 bollards. <sup>A19</sup>
- c. If the approach structures are not continuous, at least 1 bollard shall be located on each structure.
- d. Bollards shall be offset from the lock wall a sufficient distance to permit proper anchorage to the Lock Structure while still securing the vessel at differing line angles during the various stages of the filling and emptying process.
- e. The design shall include provisions to avoid line abrasion or flaking due to contact with the wall edges.
- f. Bollard design shall prevent lines from slipping off the top of the bitt as the line angle changes with variations in the water levels.
- g. <sup>A16</sup>The Contractor shall design and write specifications for bollards and capstans to require minimum maintenance and facilitate whatever maintenance is needed.
- h. They shall be commercially available as off-the-shelf items to the extent possible.
- i. Refer to Section 01 86 13 (*Plant - Mechanical Systems and Equipment*) for capstan requirements.
- j. [Bollards and capstans shall be supplied, installed and tested as part of the Works.](#)

3. **Safety Devices:**

a. **Lifesaving Rings:**

- 1) The locations shall be clearly marked for quick access.
- 2) They shall be located at each of the personnel break rooms identified in Section 01 81 36 (*O&M Buildings and Facilities – Program*).
- 3) They shall be located on stands that are easily accessible, offset from the face of the wall by no more than 6 m, and provide protection from the rain and sun.
- 4) <sup>A16</sup>They shall have a design life of 10 years.
- 5) They shall require only minimum maintenance.
- 6) They shall be standard and commercially available as off-the-shelf items to the extent possible.
- 7) The Contractor shall design and write specifications for the life saving rings that will be purchased and installed by the Employer. The Contractor shall perform all construction necessary for the installation of the lifesaving rings in a manner that will permit installation by the Employer without the need to demolish any part of the Works.
- 8) Ease of installation and replacement shall be considered in the design. <sup>A16</sup>

b. **Guardrails:**

- 1) <sup>A16</sup>Refer to Subparagraph 1.01 C.2., for locations. <sup>A16</sup>
- 2) They shall include removable sections at areas where equipment access will be required (for maintenance).
- 3) <sup>A16</sup>They shall have a design life of 20 years.
- 4) They shall require minimum maintenance.
- 5) They shall not be made of wood.
- 6) The Contractor shall design and write specifications for the guardrails which shall be supplied and installed by the Contractor as part of the Works.
- 7) Ease of installation and replacement shall be considered in the design. <sup>A16</sup>

c. **Fixed Ladders:** Refer to Section 01 81 16 (*Lock Structures*) for locations.

- 1) <sup>A16</sup>They shall have a design life of 20 years.

- 2) They shall require minimum maintenance.
- 3) They shall not be made of wood.
- 4) They shall be standard, commercially available off-the-shelf items to the extent possible.
- 5) The Contractor shall design and write specifications for the ladders that will be purchased and installed by the Employer. The Contractor shall perform all construction necessary for the installation of the ladders in a manner that will permit installation by the Employer without the need to demolish any part of the Works.
- 6) Ease of installation and replacement shall be considered in the design.<sup>A16</sup>

4. **Operational Fixtures:**

a. **Station Posts:**

- 1) Each such post shall be formed by a single shaft.
- 2) They shall not be made of wood, plastic, or fiberglass.
- 3) They shall be made of a material that will provide a minimum design life of 20 years in the lock environment.
- 4) Their height shall permit the installation of all required fixtures in a way to allow each fixture to perform its function without interference from the others.
- 5) The post diameter shall be sufficient to permit the installation of all fixtures.
- 6) The posts shall be capable of supporting all imposed loads from the installed fixtures as well as the external loads on the poles and installed fixtures. Telephones shall be as required in Section 27 31 23 (*IP-Based Telephone Systems*); public-address systems shall be as required in Section 27 51 16 (*Public Address Systems*).
- 7) Commercially available products shall be used when possible.
- 8) The Contractor shall design and write specifications for the station posts which shall be supplied and installed by the Contractor as part of the Works.
- 9) Ease of installation and replacement shall be considered in the design.<sup>A16</sup>

b. **Chamber-Distance Markings on Posts:**

- 1) The markings shall be located 3 m above the top of the lock wall.

- 2) There shall be a flat vertical surface on which the numbers identifying the distance traveled/remaining in the chamber are placed. The posts shall be spaced at intervals of 30.48 m (100 feet) and located along the chamber so that the markings on the upstream faces are the reciprocals of the markings on the downstream faces. The distance markings shall be in feet.
- 3) The numbers reflected in the markings shall have a minimum height of 33 cm and a minimum thickness of 4 cm.
- 4) The markings shall be attached to the station pole in a manner that will resist imposed loads without requiring replacement or maintenance for 10 years.
- 5) They shall be placed so that they are visible from both Northbound and Southbound vessels entering the chamber and shall not be obstructed by other fixtures on the post.
- 6) The Contractor shall design and write specifications for the chamber distance markings which shall be supplied and installed by the Contractor as part of the Works.
- 7) Ease of installation and replacement shall be considered in the design.<sup>A16</sup>

c. **Chamber-Distance Markings on the Walls:**

- 1) There shall <sup>A7</sup>be flat horizontal and vertical surfaces<sup>A7</sup> on which the numbers identifying the distance traveled/remaining in the chamber are placed. The distances markings shall be in feet.
- 2) The numbers shall have a minimum height of 26 cm and a minimum thickness of 5 cm and shall be displayed in an area 2 m wide by 35 cm high.
- 3) The markings shall be placed so they are visible from both Southbound and Northbound vessels entering the chamber and shall not be obstructed by other fixtures in the area.
- 4) The markings shall be clearly visible for quick reference from a top view <sup>A7</sup>or side view<sup>A7</sup> and should be embedded in the chamber side wall at least 6 m above the lowest water level of each chamber for reference by the tugboat master. They shall be spaced at maximum intervals of 15.24 m (50 feet).
- 5) The Contractor shall design, write specifications for, supply and install the chamber distance markings.

d. **General Requirements for Chamber-Distance Markings:**

- 1) The colors for the numbers shall have a sharp contrast with the background.
- 2) The Materials shall be such that there will be no need for maintenance or replacement within a minimum of 10 years.
- 3) Numbers shall be clearly visible by day or by night from vessels entering the chamber.

B. **Construction:** <sup>A16</sup> (Reserved) <sup>A16</sup>

**1.04 DESIGN CRITERIA/SYSTEM DESCRIPTION AND PERFORMANCE:**

A. **Fenders:**

1. **Approach Structures:**

- a. The Contractor shall design and write specifications for approach-structure <sup>A7</sup>fenders for <sup>A7</sup>a 160,000-ton displacement vessel approaching at an angle of 5 degrees and a speed of <sup>A7</sup>1 <sup>A7</sup>knot <sup>A7</sup>under normal operating conditions<sup>A7</sup>. The design shall also take into consideration vessels that will be using the locks with displacements ranging from 75,000 tons to the maximum of 160,000 tons.
- b. The fender system shall be designed to absorb the corresponding forces of an impact under the conditions described in Subparagraph 1.04 A.1.a. of this Section without damage to the vessel (limit face pressure) <sup>A7</sup>or structure<sup>A7</sup>.
- c. For pile structures, the structure and fender system shall be designed to absorb the energy of an impact under the conditions described in Subparagraph 1.04 A.1.a. of this Section without damage to the vessel (limit face pressure) <sup>A7</sup>or structure<sup>A7</sup>.
- <sup>A7</sup>d. Under normal operating conditions, the Contractor shall assume 15 vessel movements at each location in a 24-hour period.
- e. In addition to the requirements of 1.04 A.1.a. through d., the Contractor shall design for the 160,000-ton displacement vessel approaching at a speed of 2 knots and an angle of 5 degrees without damage to the vessel (limit face pressure) and with only repairable damage to the fender and structure. The damage should be repairable within a period of 6 weeks.<sup>A7</sup>

2. **Lock Chambers:**

- a. The Contractor shall design and write specifications for lock-chamber <sup>A7</sup>fenders for <sup>A7</sup>a 160,000-ton displacement vessel approaching at an angle of 1 degree and a speed of 1 knot <sup>A7</sup>under normal operating conditions<sup>A7</sup>. The design shall also take into consideration vessels that



will be using the locks with displacements ranging from 75,000 tons to the maximum of 160,000 tons. Further consideration <sup>A7</sup>shall<sup>A7</sup> be given to variations in approach angles, according to the LOA and beam of the vessel.

- b. The fender system shall be designed to absorb the corresponding forces of an impact under the conditions described in Subparagraph 1.04 A.2.a. of this Section without damage to the vessel (limit face pressure<sup>A7</sup>) or Lock Structure<sup>A7</sup>.
- c. The lock-chamber fenders shall permit the vessels to slide along them without being removed or damaged.
- <sup>A7</sup>d. Under normal operating conditions, the Contractor shall assume 30 vessel movements at each location in a 24-hour period.
- e. In addition to the requirements of 1.04 B.1.a. through d., the Contractor shall design for the 160,000-ton displacement vessel approaching at a speed of 2 knots and an angle of 1 degree without damage to the vessel (limit face pressure) and with only repairable damage to the fender and structure. The damage should be repairable within a period of 6 weeks.<sup>A7</sup>

### 3. Corner Protection:

- a. Wheel fenders at the Knuckle supported by the wall or pile and floating fender systems may be used for corner protection.
- b. <sup>A19</sup>The fender system shall be designed for the conditions described in Subparagraph 1.04 A.1.a. and 1.04 A.1.b. of this Section.<sup>A19</sup>

### <sup>A7</sup>4. Additional Ship Information:

<b>Table 1</b>	<b>Container Vessels</b>							
Nominal TEU capacity	LOA (m)	Beam (m)	Maximum (max.) <sup>A17</sup> TFW Draft <sup>A17</sup> (m)	Displacement (tons) at max. draft	Freeboard at max. draft	Mooring station height at max. draft (forward)	Mooring station height at max. draft (aft)	Block coefficient
8,000 - 9,000	323 - 339	42.8 - 45.8	15.24	135,000	10.3	10.3	7	0.7
9,000 - 10,000	335 - 350	45.6	15.24	150,000	12.7	12.7	9.4	0.7
10,000 - 11,500	365	48.8	15	< 200,000	12.7	12.7	9.4	0.7
6,000 - 7,000	300	40	15	117,000	10.1	10.1	6.8	0.7
4,000 - 5,000 <sup>1</sup>	294	32.2	13.3	80,000	9.3	9.3	6	0.7
<sup>1</sup> Panamax plus								

<b>Table 2</b>	<b>Dry-Bulk Vessels</b>							
Deadweight	LOA (m)	Beam (m)	Maximum (max.) A <sup>17</sup> TFW Draft <sup>A17</sup> (m)	Displacement (tons)	Freeboard at max. draft	Mooring station height at max. draft (forward)	Mooring station height at max. draft (aft)	Block coefficient
135,000 <sup>1</sup>	290	45	15.2	160,000	8.6	8.6	8.6	0.85
85,000	254	40	15	100,000	6	6	6	0.85
165,000 <sup>1</sup>	312	50	15.2	211,000	10.1	10.1	10.1	0.85
75,000 <sup>2</sup>	225	32.26	14.5	90,000	5.35	5.35	5.35	0.85
<sup>1</sup> Deadweight at 15.2 m TFW Draft								
<sup>2</sup> Panamax plus								

<b>Table 3</b>	<b>Tanker Vessels</b>							
Deadweight	LOA (m)	Beam (m)	Maximum (max.) A <sup>17</sup> TFW Draft <sup>A17</sup> (m)	Displacement (tons)	Freeboard at max. draft	Mooring station height at max. draft (forward)	Mooring station height at max. draft (aft)	Block coefficient
115,000	250	44	15.2	135,000	5.8	5.8	5.8	0.8
80,000 <sup>1</sup>	290	48	12.6	105,000	13.9	13.9	10.6	0.7
145,000 <sup>2</sup>	274	48	15.2	165,000	9.2	9.2	5.9	0.8
75,000 <sup>3</sup>	230	32.26	14.6	90,000	6.1	6.1	6.1	0.8
<sup>1</sup> LNG (gas carrier)								
<sup>2</sup> Deadweight at 15.2 m TFW Draft								
<sup>3</sup> Panamax plus								

**B. Bollards and Capstans:**

- Each bollard shall be capable of withstanding the load specified in Section 01 81 16 (*Lock Structures*).
- In determining load ratings and load factors, the Contractor shall consider that the load on each bollard shall be applied at least 20 times per day.
- Bollards shall be made of cast steel meeting the requirements of ASTM A 27/A 27M.
- Refer to Section 01 86 13 (*Plant - Mechanical Systems and Equipment*) for capstan-design criteria.
- Refer to Section 09 96 00 (*Corrosion Control Coatings*) for corrosion-protection requirements.

**C. Safety Devices:**

- Lifesaving Rings:** They shall meet the requirements of 29 CFR 1917.26.
- Guardrails:**
  - They shall meet the requirements of 29 CFR 1910.

- b. Refer to Section 09 96 00 (*Corrosion Control Coatings*) for corrosion-protection requirements.
  - 3. **Fixed Ladders:**
    - a. They shall meet the requirement of 29 CFR 1910.27.
    - b. Refer to Section 09 96 00 (*Corrosion Control Coatings*) for corrosion-protection requirements.
- D. **Operational Fixtures:**
  - 1. **Station Posts:**
    - a. Both the post itself and the fixtures installed on it shall be designed for the loads specified in REP 2004.
    - b. A hinged base to permit removal or replacement of fixtures without the need to remove the post is preferred.
  - 2. All fixtures shall be resistant to deterioration caused by environmental conditions.
  - 3. Refer to Section 09 96 00 (*Corrosion Control Coatings*) for corrosion-protection requirements.

#### 1.05 SUBMITTALS:

- A. All drawings and other submittals shall be submitted in accordance with the requirements of Section 01 33 00 (*Submittal Procedures*) and the requirements of this Section for the following phases.
- B. **Intermediate <sup>A17</sup>Design: <sup>A17</sup> <sup>A16</sup>**When the design has advanced sufficiently to allow the Employer to review the design, the Contractor shall submit the following to the Employer's Representative. <sup>A16</sup>
  - 1. **For Fenders:**
    - a. Reaction-energy-percent compression curve.
    - b. Dimensions.
    - c. Fender material specifications, including expected design life.
    - d. Design calculations.
    - e. Drawings showing the locations of the fenders.
    - f. Drawings with details on the fenders and their anchorage to the structures.
    - g. Maintenance and replacement plans.

- h. <sup>A16</sup>The Contractor shall make design calculations and drawing for floating fenders (hydrodynamic forces as a result of floating conditions).<sup>A16</sup>

2. **For Bollards:**

- a. Detailed design calculations demonstrating that the proposed bollards and anchorages meet the load requirements.
- b. Drawings showing the location of the bollards and capstans.
- c. Drawings with details on the bollards and their anchorage to the structures.
- d. Material specifications, including expected design life.
- e. Maintenance requirements.

3. **For Safety Devices:**

a. **Lifesaving Rings:**

- 1) Drawings showing their location along the lock walls.
- 2) Drawings with details on the support stands and anchoring systems.
- 3) Manufacturers' data.

b. **Guardrails:**

- 1) Drawings showing their locations
- 2) Drawings with their details.
- 3) Manufacturers' data or design calculations.
- 4) Maintenance requirements.

c. **Fixed Ladders:**

- 1) Drawings showing their locations.
- 2) Drawings showing their details.
- 3) Manufacturers' data or design calculations.
- 4) Maintenance requirements.

- C. **Final** <sup>A17</sup>**Design:** <sup>A16</sup>When the design has reached a level that is apt for construction, the Contractor shall submit the following for review to the Employer's Representative. <sup>A16</sup>

1. **For Fenders:**

- a. **Factory Test Reports:** Tests shall have been performed on the selected fender within 5 years of submittal of the reports. Test reports shall be

accompanied by notarized certificates from the manufacturer certifying that the tested material is of the same type, quality, manufacture, and make as that proposed to be supplied. When applicable, testing shall include:

- 1) Minimum tensile strength.
- 2) Shore hardness (measured with a durometer).
- 3) Modulus at 400 percent elongation.
- 4) Maximum Compression Set.
- 5) Tear resistance.
- 6) Minimum elongation.
- 7) Ozone resistance.
- 8) Low-temperature impact resistance.
- 9) Water absorption.
- 10) Heat resistance.
- 11) Compression-deflection resistance.
- 12) Fender-compression tests.
- 13) Angular-fender compression tests.
- 14) Friction factors.

b. **Elastomer Property Requirements.**

2. **For Bollards:**

- a. Mill test certificates for each heat number.
- b. Certificates of conformance for line-pull ratings.
- c. Records showing heat numbers and serial numbers.

3. **For Safety Devices:** Manufacturers' information showing compliance with the requirements for lifesaving rings.

**1.06 QUALITY ASSURANCE:** All requirements in Section 01 40 00 (*Quality Requirements*) shall apply to this Section. The Contractor shall verify conformance with the requirements of this Section and implement the inspection procedures to carry out the requirements. The inspection procedures shall document the acceptance criteria for:

- A. <sup>A16</sup>Bollards at the Site.
- B. The installation of bollards. <sup>A16</sup>

**END OF SECTION**

<sup>A16</sup>**THIS PAGE NOT USED**<sup>A16</sup>