PART 1 – GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. The provisions and intent of the Contract, including the General Conditions, Supplementary Conditions and General Requirements, apply to this work as if specified in this section. Work related to this section is described in the following.

1. Section 02 41 00 – Demolition

2. Section 03 60 00 – Grouting

3. Section 05 50 00 – Metal Fabrications

4. Section 09 96 00 – High Performance Coatings

1.02 DESCRIPTION OF WORK

A. The work includes designing, manufacturing, transporting, and installing a complete fender system (39 fender assemblies plus 2 spare fender assemblies) and all necessary materials, labor, and equipment to accomplish the work.

B. A marine fender assembly consists of a steel fender panel attached to an energy-absorbing rubber cone fender, attached to a steel mounting bracket which is anchored to the existing concrete wharf face with adhesive anchor rods.

C. The steel fender panel front face is covered with ultra-high molecular weight polyethylene (UHMW-PE) facing, all bolts and miscellaneous connection hardware, weight chains, tension chains, shackles, spacers, chain length adjustment hardware, and pad eyes.

1.03 REFERENCES

A. American Bureau of Shipping (ABS) “Rules for Building and Classing Steel Ships, Part 2 – Materials and Welding”.

B. American Society for Testing Materials (ASTM), Standard Specifications and Standard Test Methods, designated by basic reference in this section (use the most current edition at the time of bid unless otherwise indicated).

C. Permanent International Association of Navigation Congresses (PIANC), "Guidelines for the Design of Fender Systems: 2002", Report of Working Group 33 – MARCOM.

1.04 QUALITY ASSURANCE

A. All testing required within the Contract shall be at the fender manufacturer's expense, unless noted otherwise.

B. The fender manufacturer shall have a minimum of ten years of experience manufacturing rubber marine cone fenders and fender panels of size similar to those specified and show proof thereof with installation references in accordance with this specification.

C. The fender manufacturer shall carry product liability insurance with an aggregate coverage limit of at least 4 million USD.

D. Approved fender system manufacturers are listed below:

1. ShibataFenderTeam, Inc.: 44084 Riverside Parkway, Suite 210 Lansdowne, VA 20176, USA

2. Trelleborg Marine Systems North America, Inc.: 1186 Petroleum Pkwy, Broussard, LA 70518, USA

TEKMARINE SYSTEMS LLC of The Woodlands, TX will not be approved as a fender system manufacturer for this project.

Other fender system manufacturers may be acceptable, subject to approval by the Engineer.

B. Fender manufacturer shall operate a Quality Management System (QMS) which conforms to ISO 9001:2015 or a recognized equivalent. This system must be certified by an acknowledged and accredited organization (i.e., Bureau Veritas, DNV-GL, ABS or similar).

C. The Manufacturer shall operate its own workshops and/or factories manufacturing, as a minimum (a) the primary rubber unit, (b) the steel fender components being offered and (c) a mixing plant for the rubber compound.

D. All fender system drawings, specifications and structural calculations shall be sealed by a Professional Engineer licensed within the United States.

1.05 SUBMITTALS

A. List of at least 5 installations in the United States within the past five years demonstrating the experience required under the paragraph, “Quality Assurance”. Provide project name, owner, contact name, email address, and telephone number for a minimum of 5 installations.

B. Product liability insurance certificate.

C. Schedule: Submit schedule for providing manufactured fender test and certifications that are required for acceptance of fenders and prior to delivery to the project site.

D. Qualifications of the independent third-party test results verifier.

E. Rated Performance Data (RPD): Per ASTM F2192 and PIANC, provide manufacturer’s full scale RPD test performance curves and/or data tables of fender element to be supplied. Include the nominal performance tolerances and data and to adjust fender type performance curves for other compression velocities, other temperatures, and other contact angles.

F. Material Certifications: Submit copies of material certifications, including but not limited to: (certs of actual product are required)

1. Fender elastomer materials

2. Valid Type approval certificate as per PIANC for proposed fender unit. The Manufacturer shall provide evidence of Type Approval test program for the proposed elastomeric fender units, duly witnessed, and certified by an acknowledged and accredited organization. The Type Approval report shall clearly define which fender types have been tested as well as the minimum and maximum sizes and rubber grades encompassed. Full details of these fender types should be published in the latest edition of the fender manufacturer’s product catalogue. The Type Approval report shall be accompanied by a signed and certified Type Approval Certificate issued by a recognized organization such as DNV-GL, SGS, Bureau Veritas, ABS or agreed equivalent. Proof of authenticity shall be provided.

3. Panel steel

4. UHMW-PE pads

5. Bolts, anchor rods, nuts, and washers

6. Chain assembly components

7. Mounting bracket steel

G. Submit a sample stud and integral nut/washer to be used to connect UHMW-PE facing to the steel fender panels.

H. Shop drawings: Submit for the complete fender system showing complete subassemblies: chain system, fender panel including spool, mounting bracket, anchorage to the wharf, relationships to bull rail and wharf face, attachment of the cone fender to the panel and to the mounting bracket and hardware. All material specifications shall be included. All dimensions shown shall be in both SI and Imperial units or just Imperial units.

I. Durable translucent rigid anchor rod marking template shop drawings.

J. Design Calculations: Submit design computations that indicate the fender system as a whole and the individual components meet or exceed the specified criteria. Computation input and output data and results shall be shown in the Imperial units: feet and inches, pounds, Kips, Ft.-Kips, etc.

K. Fender Endurance Test Results: Provide fender endurance test results.

L. Energy Absorption/Reaction Force Verification Tests: Performance verification tests shall be conducted on (2) of the fenders to be delivered and witnessed by an independent third party, supervising and verifying test and testing facility's compliance with PIANC requirements, and having experience in testing of rubber marine fenders. The independent party shall be approved by the Engineer before commencement of testing. After production and before shipment, submit results certified by the independent party, of energy absorption/reaction force testing per ASTM F2192/PIANC. Results shall include fender element temperature and adjusted tabular and graphical reaction and energy absorption versus deflection based on the element deflection test. Submitted test results to be normalized to PIANC RPD speed, temperature and compression angle and transmitted before delivery of fenders. Shipment can only commence after approval of test reports.

M. Fender Break-In Certification: Submit certification that all fenders have been deflected one time according to these specifications before delivery to the project site.

N. Panel Pressure Testing Certification: Submit certification that panels have been pressure tested according to these specifications before delivery to the project site.

O. Installation Guidelines: Submit fender system installation guidelines for installer to follow.

P. Fender Warranty: Submit written warranty. The proposed warranty form shall be submitted to the Port for approval in advance of placing the order for the fenders.

Q. Rebar and anchor rod mapping

1.06 WARRANTY

A. Furnish a written warranty stating that all components of each fender assembly, including anchorage hardware, are free of defects in material and workmanship for a minimum period of five (5) calendar years from the date of project substantial completion, and that all defects evident during that period shall be removed and replaced, without cost to the Port, within 90 days of notification.

PART 2 – PRODUCTS

2.01 GENERAL

A. Fender systems shall include rubber cone fender, fender panel, UHMW-PE facing, mounting bracket, stiffeners, fittings, fasteners, metal fabrications, spacers, chains, anchor rods, spools, adjustment links, hardware, pad eyes, anchor adhesive and other material, in accordance with the Contract Documents.

B. Each fender assembly as depicted on the drawings is based on the performance, dimensions, and material characteristics of a single ShibataFenderTeam SPC Cone Fender. The system proposed shall be equivalent to the ShibataFenderTeam system. Submit all information, test reports, and product data necessary to demonstrate equivalence. The cost of all labor including any testing necessary to demonstrate equivalence shall be at the fender manufacturer’s expense.

C. Install the fenders at the locations shown in the drawings with the standoff distance shown with subassembly sizes, and fender panel size as indicated. All rubber fenders shall be identical. The fender elements shall be sized to fit within the geometric constraints shown on the drawings and shall meet the performance criteria and material requirements.

D. All steel fabrication and construction within this Section shall be in accordance with Section 05 50 00 – Metal Fabrications.

E. The cone fender manufacturer shall supply all components of the fender assemblies.

2.02 RUBBER CONE FENDER

A. Fenders shall consist of an elastomeric section with a metal plate embedded in and bonded to each end. The bond shall be formed under heat and pressure during the vulcanization process. The metal plates shall be completely encased in rubber for corrosion protection.

B. Under axial loading, the fender shall exhibit a buckling column mode, resulting in efficient, high-energy absorption and low reaction force.

C. Performance Criteria: The fender system provided shall meet or exceed the performance criteria, before application of correction factors for tolerance, angle and temperature, as listed in this section (refer to ASTM F2192 testing parameters when applicable).

1. Absorbing the full energy of the design vessel identified on the drawings when applied to any single fender assembly.

2. RPD Catalog Energy Absorption at Rated Deflection: 493 kip-ft

3. RPD Catalog Reaction Force at Rated Deflection: 265 kips max. Reaction Force is RPD reaction + correction factors.

4. Limit the hull reaction pressure to no more than 5.0 kips/sq ft.

5. Horizontal Contact Angle: 6 degrees, maximum.

6. Operational Temperatures: min. 30°F – max. 100°F

7. Fenders shall resist without damage a shear force equal to 20% of the rated reaction force acting in any direction in a plane that is perpendicular to the fender's longitudinal axis while simultaneously absorbing minimum design impact energy without exceeding the specified maximum reaction.

8. There shall be no contact between the fender panel at its rated deflection and the wharf structure.

2.03 RUBBER PROPERTIES

A. Elastomer shall be a rubber blend of NR and/or SBR, reinforced with carbon black, fine/nano size calcium carbonate and resistant to aging, seawater, abrasion, and ultraviolet rays. The rubber shall be homogenous in quality, free from foreign materials, bubbles, tears, cracks, and other harmful effects. The rubber compound used to mold the fenders shall be produced specially for this project. No recycled, regenerated, or off-spec rubber shall be used for any part of the rubber used to manufacture the fenders. Manufacturer shall submit a certificate of conformance stating the rubber compound meets this requirement and the property requirements listed below:

Property	Test Standard	Condition	Requirement
Tensile Strength	ASTM D 412, Die C ISO 37, 188	Original Aged for 96 hours at 70° C	16 MPa (min) 12.8 MPa (min)
Elongation at Break	ASTM D 412, Die C ISO 37, 188	Original Aged for 96 hours at 70° C	400% (min) 320% (min)
Hardness	ASTM D 2240	Original Aged for 96 hours at 70° C	78° Shore A (max) Original value + 8° points increase
Compression Set	ASTM D 395, Method B	Aged for 22 hours at 70° C	30% (max)
Tear Resistance	ASTM D 624, Die B	Original	70 kN/m (min)
Ozone Resistance	ASTM D 1149	50 pphm at 20% strain at 40° C for 100 hours	No visible cracking
Seawater Resistance	DIN 86076	28 days at 95° C ± 2°C	Shore A +/-10° Vol. +10%, -5%
Abrasion Resistance	DIN 53516	Original	100 mm^3 (max)
Bond Strength Steel to Rubber	ASTM D429 – Method B	-	7 N/mm (min)

B. Any test results furnished under different specifications than those listed above shall be accompanied by the fender manufacturer's documentation explaining how the furnished test results meet or exceed the test

requirements listed above. Test results without this documentation shall be out of compliance with the section and will be rejected.

2.04 UHMW POLYETHYLENE FACING

A. The ultra-high molecular weight polyethylene (UHMW-PE) facing shall have thickness and minimum thickness under the nut/washer as shown on the drawings. UHMW-PE shall be black in color. UHMW-PE shall be made of UV stabilized cross linked virgin resin having a molecular weight not less than 4.5 million grams/mole conforming to ASTM D 4020 and conforming to the following:

Property	Test Method	Acceptance Requirements
Specific Gravity	ASTM D 792	0.93 g/cm^3 (min)
Yield Strength	ASTM D 638	3 ksi
Izod Impact, Notch @ 23 degrees C	ASTM D 256A	34 kJ/m^2
Abrasion resistance	Taber weight loss	18% max
Water Absorption	ASTM D 570	Nil
Coefficient of Friction	ASTM D 1894	0.20 (max)
Hardness	ASTM D 785	63-68
Thermal Expansion	ASTM D 648	9.0x10^{-5} in/in/°F
Color	Not Applicable	Black

2.05 FENDER PANEL

A. Fender panels shall be a closed, watertight, internally stiffened, box-type design. Construct panels of ASTM A36, or ASTM A572, steel. Minimum steel thickness shall be 3/8-inch. Each fender panel shall be pressure tested. Fender panels shall be designed to not exert a hull pressure greater than that allowed in this specification. All exterior panel welds shall be continuous.

B. The spool piece shown in the drawings is part of the fender panel.

C. UHMW-PE facing shall be attached to the frontal panel with minimum 3/4" diameter AISI Type 316 stainless steel studs and integral nut/washer. Integral nut/washer shall have thickness of 3/8”.

D. Bevel all edges of the fender panel as shown in the drawings.

E. Size individual pieces of UHMW-PE facing such that the maximum distance between any adjacent fasteners, along perpendicular lines, is less than or equal to 12 inches. Configure the fasteners such that the

maximum distance between any fastener centerline to edge of UHMW-PE piece is less than or equal to 3 inches. The UHMW-PE facing shall cover the panel beveled edges. Facing pieces shall be no smaller than 36" by 36", except on beveled panel edges. Bevel exposed edges of UHMW-PE facing pieces.

2.06 MOUNTING BRACKET

A. Mounting brackets shall be a closed, watertight, internally stiffened, box-type design. Construct bracket of ASTM A36, or ASTM A572, steel. Each bracket shall be pressure tested. Bracket shall be internally stiffened to resist the cone fender compression pressure and shear loads. The bracket shall be designed to resist out-of-plane bending as a built-up section.

2.07 ANCHOR RODS

A. The mounting brackets shall be fastened to the concrete structure with hot dip galvanized threaded anchor rods, washers and nuts meeting ASTM F1554 Grade 55, unless otherwise noted.

B. Design and detail fender anchor rods and anchor assemblies to minimize interference with the reinforcing steel and other attachments. Provide all anchors a minimum 12 inches embedment into the existing wharf face, and as determined by the fender manufacturer. Anchorage calculations shall assume that the concrete block encasing the fender anchor rods is reinforced with appropriate tension and shear reinforcement and give credit for the same. Assume the existing wharf concrete has a compressive strength of 5,000psi.

2.08 CHAINS, SHACKLES AND HARDWARE

A. Galvanized Grade 3 chain in accordance with ABS. Provide each chain with compatible shackles and special links to adjust the length. Associated hardware shall conform with ABS requirements.

B. Shackles shall be galvanized, drop-forged, with a working load limit greater than the chain using a minimum safety factor of 2.0 on chain working loads. Shackles shall be sized to connect all items and shall have a galvanized bolt, nut and cotter pin.

C. Galvanized chains, shackles, turnbuckles, anchor bolts, hardware and their anchorages on the mounting brackets and the steel fender panels shall be sized to resist the appropriate design forces with a minimum factor of safety of 2.0. The design of the chains shall be based on the full

contact pressure and a minimum friction coefficient, mu = 0.20, for vertical (up and down) and horizontal (side to side) movement.

D. Weight and tension chains, shown in the drawings, are required. It is preferred that the fender system be designed to function without the use of shear chains.

E. Chains shall be designed for the following cases with the worst-case governing:

1. The weight chain shall safely resist the vertical load from the full frame weight, one-half of the fender element weight and a vertical shear force equal to 0.2 times the fender reaction.

2. The weight chain shall safely resist tension as a result of the horizontal and/or vertical angular berthing conditions previously specified.

3. The tension chain shall safely resist tension as a result of the horizontal angular (min. 5°) berthing conditions previously specified as well as a low impact on the bottom edge of the panel.

2.09 SPARE PARTS

A. Provide (2) spare complete fender assembly consisting of one steel fender panel with UHMW-PE facing, one rubber cone fender with connection hardware for each end of cone, all tension and weight chain hardware, mounting bracket and associated connection hardware for wharf face.

PART 3 – EXECUTION

3.01 TESTING

A. Energy Absorption/Reaction Force Verification (Constant Velocity Method):

1. A minimum of (2) fenders shall be selected at random and subjected to uniform axial compression to verify the performance requirements.

2. The test protocol and temperature of the unit and ambient temperature, at the time of testing, shall be in accordance with ASTM F2192/PIANC.

3. After at least three break-in cycles to the rated deflection and temperature stabilization as per PIANC, appendix A, 5.1 of the element, deflect the fender unit after at least 1h resting period once, at a constant deflection velocity of 2 to 8 cm per minute to the rated deflection. Adjust performance results to standard rated temperature of 23 ± 5°C, if required, and to RPD standard velocity of 0.15 m/sec. The adjusted performance results shall be used to determine if at least the minimum energy and no more than the maximum reaction required are achieved within a production tolerance of 10%. Failure to meet the specified values shall be cause for rejection.

4. If there is any failure in the initial test lot, then all the remaining fenders shall be tested. Any fender that fails to meet the specified criteria shall be rejected.

5. Test must be witnessed, and results certified by the fender manufacturer and the independent third party. Test reports shall include the following information as a minimum:
    i. serial number of the tested fender;
    ii. date, time, and location of the fender performance test;
    iii. name of the test supervisor;
    iv. signature of the Quality Manager.

6. Submit test data, tabular and graphical, before delivery of fenders.

B. Break-In Deflection:

1. All fenders for this project shall undergo break-in deflection. Compress each unit at 0° compression angle, one time, to the manufacturer's rated deflection.

2. Break-in cycle must be certified to have been performed by the fender manufacturer or independent third-party lab approved by the Engineer.

3. There is no requirement to measure or record the energy absorption or reaction force for this test.

C. Fender Endurance Testing:

1. Manufacturer shall demonstrate fender endurance by performing cyclic fatigue tests on a full size or scale model of a rubber fender as per PIANC, Appendix A, 7.2.

2. Test shall be made for axial compression to the rated deflection.

3. There shall be no damage to fender or to the rubber encased end plates after 3,000 cycles to the rated deflection at a maximum period of 150 seconds.

4. Testing shall have been or must be witnessed by the fender manufacturer and independent third party. Results must be certified by the fender manufacturer and independent party.

5. Submit certified test report with shop drawing submittal. Submittal shall include photographs of the tested fenders before, during, and at the completion of the test. Certificates do not have to be specific for this project. The endurance test shall not be performed on a fender that will be supplied for this project.

D. COMBINED SHEAR/COMPRESSION TEST

1. The manufacturer shall perform a shear compression test on one full size fender used for this project, with at least 50% compression combined with 30% shear.

2. The test shall we witnessed by an independent third party.

3. The fender shall not show any visible cracks or have permanent deformation after the test. Otherwise, the fender will be rejected, and the test must be performed on two additional fenders from the production lot chosen at random by the independent third party.

E. PRESSURE TEST

1. All fender panels and mounting brackets shall be pressure tested to 7 psi and held for 15 minutes with no pressure drop. If a pressure drop occurs, the leak shall be ground out the full depth of the weld and then rewelded full depth. A wash pass or cover pass of weld metal to cover the leak is not allowed. A certification describing the testing, work piece identifier, and QC signature of acceptable testing results for each work piece shall be submitted to the Engineer for approval.

3.02 CONE FENDER MARKING

All cone fenders shall be permanently marked with a unique reference so that they can be individually identified both during construction and once incorporated into the permanent Works. For the latter case, the marks are to be clearly legible

to someone standing on the supporting structure. The marks on each fender shall be:

A. Identification number related to the material cert submittals;
B. Manufacturer;
C. Size and rubber grade of fender;
D. Date(s) of manufacture.

3.03 INSTALLATION

A. Install fenders at the locations shown on the drawings in an undamaged condition. Do not damage, cut, or tear the rubber or the fender assembly during installation. Canvas slings, wood cradles or other protective devices as recommended by the manufacturer shall be used. Hoisting and slinging by the rubber section may be permitted only when approved by the manufacturer and the Engineer.

B. The UHMW-PE facing shall be pre-attached to the fender panel by the fender manufacturer.

C. The number and size of anchor rods that secure the mounting brackets to the wharf face shall be determined by the fender manufacturer. The fender manufacturer shall state the number of anchors required within each anchor area but allow the anchor installer to choose which anchor rod holes to core and use within each anchor area. There are 5 anchor areas for each mounting bracket. There shall be at least (1) anchor rod installed in each of the 5 anchor areas. Contractor shall install the required number of anchors within each anchor area that minimizes rebar coring and interferences.

D. Contractor shall hire a third-party testing service, certified in the detection method, to mark all existing rebar locations in the vicinity of each mounting bracket using ground penetrating radar (GPR) or other NDT technology, method to be approved by the Engineer. Rebar detection by probing, drilling, or coring is not allowed. The mounting bracket shall be positioned to minimize anchor rod conflicts with rebar and abandoned anchors.

E. Proposed anchor locations shall be marked using a template that matches the mounting bracket anchor pattern. A durable translucent rigid template, e.g., Plexiglas, shall be used by the Contractor to select anchor locations that minimize rebar interferences.

F. The durable translucent rigid template fabrication drawings shall be submitted to the Engineer for approval. The template shall be easy to shift, up/down and left/right while against the wharf face to hunt for the optimal

location that minimizes rebar interferences. Marking holes in the template shall match the diameter of proposed core holes. The template shall extend far above the top of the bull rail so that it can be clamped against the bull rail for repeated loosening and adjusting.

G. A preconstruction activity meeting shall be held to discuss the detection, marking and coring sequence and work plan. The GC, coring subcontractor and Engineer shall be present, including key personnel that will perform the work.

H. The mounting bracket locations shown on the drawings are provided as starting points and shall be shifted as necessary to minimize coring rebar, but only to the extent needed. Engineer shall be notified (2) days prior to rebar locating service. Engineer shall be notified (2) days prior to template installation and proposed anchor hole marking activities. Rebar detection and proposed anchor marks shall be clearly visible, complete, accurate and show the actual size of the proposed core. Contractor shall submit photographs of each proposed mounting bracket location showing the rebar and anchor mapping, i.e., wharf face with rebar and core holes marked, for Engineers approval prior to coring any anchor holes. Any impacts to the Contractor due to anchor hole marks being shifted, at Engineer's request to further minimize interferences, shall be performed at the Contractor's expense.

I. See section 03 60 00 Grouting for anchor rod installation requirements.

J. Wharf face surface irregularities and high spots shall be removed where needed to provide a uniform, square, plane, and true vertical surface for mounting brackets to bear. Grout pads shall be placed where shown on the drawings to provide full bearing area against the back of the mounting brackets, see Section 03 60 00 Grouting.

K. Cut off existing anchors or empty inserts that are abandoned in-place shall be coated or patched, see Section 02 41 00 Demolition and Section 03 60 00 Grouting, respectively.

L. All chains and shackles shall be installed as indicated on the shop drawings. Chains shall be installed taut, with no slack.

END OF SECTION