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USACE / NAVFAC / AFCESA / NASA **UFGS-35 59 13.16 (April 2006)**

Preparing Activity: NAVFAC **Replacing without change UFGS-02396 (May 2003)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 1 April 2006
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DIVISION 35 - WATERWAY AND MARINE CONSTRUCTION

SECTION 35 59 13.16

RESILIENT FOAM-FILLED MARINE FENDERS

04/06

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References are in agreement with UMRL dated 1 April 2006
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SECTION 35 59 13.16

RESILIENT FOAM-FILLED MARINE FENDERS
04/06

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NOTE: This guide specification covers the requirements for resilient foam-filled marine fenders.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
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NOTE: The following information shall be shown on the project drawings:

1. Location and mounting elevation of fenders.

2. Connection details to wharf or pier.
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PART 1 GENERAL

1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature

when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2006) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A 123	(1989a) Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2005) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM D 1052	(1985; R 1999e1) Measuring Rubber Deterioration-Cut Growth Using Ross Flexing Apparatus
ASTM D 1630	(1994; R 2000) Rubber Property - Abrasion Resistance (Footware Abrader)
ASTM D 1667	(2005) Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam)
ASTM D 2240	(2005) Rubber Property - Durometer Hardness
ASTM D 3575	(2000e1) Flexible Cellular Materials Made From Olefin Polymers
ASTM D 412	(1998a; R 2002e1) Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D 470	(1999) Crosslinked Insulations and Jackets for Wire and Cable

1.2 SYSTEM DESCRIPTION

1.2.1 Design Requirements

The Contractor shall provide a fender of his own design which is configured as required by paragraph entitled "Configuration." The Contractor's design shall utilize the products and materials as specified to provide a fender which will meet the general intent of use and the minimum testing requirements. In addition, the Contractor's design shall be adequate to

assure a usable ten-year fender life, without major damage. Wherever minimum limits are given in paragraph entitled "Configuration," the Contractor shall construe these minimums to be lower construction limits on his design. These construction minimums shall be exceeded wherever required by the Contractor's design in order to meet the provisions of this specification.

1.2.2 Intent of Use

The intended use of this fender is that the fender shall be mounted to the [wharf] [pier] [_____] as indicated on the drawings. The vessel, an [FFG-7] [_____], shall be assumed to dock and undock at least [120] [_____] times during the fender's 10-year life and will be assumed to impart the energy specified in paragraph entitled "Performance Requirements" to fenders at each docking occurrence. The vessel will approach the berth, contact the fender, and then be positioned longitudinally along the berth to reach its moored position. Each berthing operation will impart the specified energies and forces to each fender including the longitudinal forces specified in paragraph entitled "Fender Pull-Through Test." While moored at a berth, the vessel will impart lateral forces to each fender equal to the sustained loads specified in paragraph entitled "Fender Sustained-Load Test" for a minimum of [200] [_____] times for [24] [_____] hours each occurrence during its 10-year life.

1.2.3 Performance Requirements

The resilient, foam filled marine fenders shall be designed so that when compressed across its diameter by two parallel flat plates extending the full length and width of the fender, the fender shall absorb [300,265] [_____] joules [221,500] [_____] foot-pounds of energy ±15 percent when [60] [_____] percent compressed (i.e. to a dimension of [40] [_____] percent of its original diameter) with a corresponding load of not more than [712,000] [_____] N [160,000] [_____] pounds ±15 percent. The fender shall also be designed to withstand a sustained reaction force of 667,200 [_____] N 150,000 [_____] pounds for a duration of not less than 24 hours each occurrence for at least 200 occurrences during its 10-year life.

1.3 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority.

Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Resilient, foam filled marine fenders

Include dimensions, material specifications, and method of manufacture.

SD-05 Design Data

Resilient, foam filled marine fenders

Submit calculations, including computer analysis and other design data.

SD-06 Test Reports

Fender compression test

Fender cyclic-compression test

Fender sustained-load test

Fender pull-through test

Elastomeric skin thickness test

Submit copies of reports of tests specified herein. The tests shall have been performed within three years of submittal of the reports for approval. Also, submit reports for tests specified in referenced documents which are applicable to the particular material furnished for use.

1.4 QUALITY ASSURANCE

1.4.1 Elastomer Skin

The elastomer skin of the fender shall be free from cracks, burrs, warpage, checks, chipped or blistered surfaces, and shall have a smooth surface.

1.4.2 Steel Fabrication

The steel used in fabrication shall be free from kinks, sharp bends, and other conditions which would be detrimental to the finished product. Manufacturing processes shall not reduce the strength of the steel to a value less than intended by the design. Manufacturing processes shall be done neatly and accurately. Make bends by controlled means to insure uniformity of size and shape.

1.4.3 Foam Core

The foam core shall be homogeneous and of one piece fabricated construction and shall not be in chip or granular form. The form core shall not contain scraps, strips, or sheets of foam either rolled or stuffed into the required shape unless pieces are bonded together in layers of uniform patterns to form a homogeneous, one piece core. Homogeneous foam rings of adequate thickness to insure performance of the fender are acceptable provided the Contractor can show a minimum 5-year performance of similar fenders.

1.4.4 Welding

AWS D1.1/D1.1M. Welds shall be of sufficient size and shape to develop the full strength of the parts connected by the welds. Welds shall transmit stress without permanent deformation or failure when the parts connected by the weld are subjected to proof and service loadings.

1.5 DELIVERY, STORAGE, AND HANDLING

Fenders shall be undamaged when delivered and shall be handled and stored so as to prevent damage such as bending or abrading end fittings or cutting of rubber. Protect fenders from exposure to damaging liquids, oils, and greases.

1.6 WARRANTY

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NOTE: The warranty requirements in this guide specification have been approved by a Level I Contracting Officer in accordance with the requirements of NAVFAC P-68. The paragraphs in this guide specification may be used without further approval.
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Furnish the manufacturer's warranty. The warranty shall be issued directly to the Government and shall not be limited in dollar value. The warranty period shall be not less than 10 years from the date of Government acceptance of the work.

PART 2 PRODUCTS

2.1 CONFIGURATION

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NOTE: The following tables are provided by SEAWARD International, Inc.

SUGGESTED REFERENCE TABLE FOR STANDARD NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
2 x 4	600	19	1200	19	3.53	29.8	200	19
2 x 6	600	19	1800	19	3.53	36.6	245	19
2 x 8	600	19	2400	19	3.53	43.4	289	19
2 x 10	600	19	3000	19	4.26	56.9	369	19
3 x 6	900	19	1800	19	3.53	52.9	254	19
3 x 8	900	25	2400	19	4.9	74.5	329	25
3 x 10	900	25	3000	22	6.35	96.3	427	25
3 x 12	900	25	3600	22	6.35	118.0	512	25
3 x 14	900	31	4200	25	8.98	139.6	623	31
4 x 6	1200	25	1800	25	6.35	82.7	316	25
4 x 8	1200	25	2400	25	6.35	120.7	436	25
4 x 10	1200	25	3000	25	6.35	160.0	556	25
4 x 12	1200	31	3600	25	8.98	198.0	672	31
4 x 14	1200	38	4200	28	12.79	237.3	787	38
4 x 16	1200	38	4800	31	12.79	275.2	930	38
4 x 18	1200	38	5400	31	12.79	314.5	1045	38
4 x 20	1200	38	6000	31	12.79	352.5	1156	38
5 x 8	1500	25	2400	25	6.35	183.0	525	25
5 x 10	1500	31	3000	25	8.98	244.0	672	31
5 x 12	1500	31	3600	25	8.98	303.7	818	31
5 x 14	1500	38	4200	28	12.79	364.7	979	38
5 x 16	1500	38	4800	31	12.79	424.4	1139	38
5 x 18	1500	44	5400	35	18.5	484.0	1277	38
5 x 20	1500	44	6000	35	18.5	543.7	1455	38
6 x 10	1800	38	3000	25	12.79	320.0	756	38
6 x 12	1800	38	3600	25	12.79	406.7	934	38
6 x 14	1800	38	4200	28	12.79	492.2	1116	38
6 x 16	1800	44	4800	31	18.5	579.0	1299	38
6 x 18	1800	50	5400	35	28.75	664.4	1490	44
6 x 20	1800	50	6000	38	28.75	751.1	1681	44
7 x 12	2100	44	3600	31	18.5	542.3	1094	38
7 x 14	2100	44	4200	31	18.5	660.3	1299	38
7 x 16	2100	44	4800	31	18.5	776.9	1503	38
7 x 18	2100	50	5400	35	28.75	894.8	1712	44
7 x 20	2100	50	6000	38	28.75	1011.4	1930	44
7 x 22	2100	50	6600	44	28.75	1129.4	2180	44
8 x 14	2400	50	4200	31	28.75	745.7	1330	44
8 x 16	2400	50	4800	31	28.75	993.8	1699	44
8 x 18	2400	50	5400	38	28.75	1148.4	1953	44
8 x 20	2400	50	6000	41	28.75	1303.0	2197	44
8 x 22	2400	63	6600	44	45.26	1457.5	2446	50
9 x 16	2700	50	4800	35	28.75	1205.3	1873	44
9 x 18	2700	50	5400	35	28.75	1399.2	2131	44
9 x 20	2700	63	6000	38	45.26	1593.1	2402	50
9 x 22	2700	63	6600	44	45.26	1787	2682	50

SUGGESTED REFERENCE TABLE FOR STANDARD NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
10 x 18	3000	50	5400	38	28.75	1706	2366	44
10 x 20	3000	63	6000	38	45.26	1946	2660	50
10 x 22	3000	63	6600	44	45.26	2186	2967	50
11 x 22	3300	63	6600	41	45.26	2590	3220	50
12 x 24	3600	63	7200	44	45.26	3363	3834	50
13 x 26	3900	75	7800	47	74.19	4275	4496	63
14 x 28	4200	75	8400	47	74.19	5339	5213	63

(A) NOM DIAMETER (mm)
(B) END SHACKLE (mm)
(C) NOM LENGTH (mm EYE/EYE)
(D) MIN. SKIN THICKNESS (mm)
(E) FENDER SWL (METRIC TONS)
(F) ENERGY ABSORPTION (kiloJOULES) (AT OR BEFORE 60 PERCENT COMPRESSION)
(G) REACTION FORCE (kiloNewton) (AT PREDICTED ENERGY ATTAINMENT)
(H) NOMINAL CHAIN (Internal) SIZE, mm

SUGGESTED REFERENCE TABLE FOR LOW-REACTION NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
2 x 4	600	19	1200	19	3.53	28.5	186.8	19
2 x 6	600	19	1800	19	3.53	32.5	213.5	19
2 x 8	600	19	2400	19	3.53	35.3	244.6	19
2 x 10	600	19	3000	19	4.26	39.3	267	19
3 x 6	900	19	1800	19	3.53	39.3	186.8	19
3 x 8	900	25	2400	19	4.9	46.1	222.4	25
3 x 10	900	25	3000	22	6.35	69.1	320.2	25
3 x 12	900	25	3600	22	6.35	77.3	364.7	25
3 x 14	900	31	4200	25	8.98	105.8	484.8	31
4 x 6	1200	25	1800	25	6.35	90.8	329.2	25
4 x 8	1200	25	2400	25	6.35	105.8	378	25
4 x 10	1200	25	3000	25	6.35	119.3	431.5	25
4 x 12	1200	31	3600	25	8.98	135.6	484.8	31
4 x 14	1200	38	4200	28	12.79	165.4	578.2	38
4 x 16	1200	38	4800	31	12.79	208.8	725	38
4 x 18	1200	38	5400	31	12.79	223.7	778.4	38
4 x 20	1200	38	6000	31	12.79	240.0	831.8	38
5 x 8	1500	25	2400	25	6.35	132.9	400.3	25
5 x 10	1500	31	3000	25	8.98	155.9	467	31
5 x 12	1500	31	3600	25	8.98	179.0	533.8	31
5 x 14	1500	38	4200	28	12.79	226.4	658.3	38
5 x 16	1500	38	4800	31	12.79	279.3	809.5	38
5 x 18	1500	44	5400	35	18.5	318.6	898.5	38

SUGGESTED REFERENCE TABLE FOR LOW-REACTION NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
5 x 20	1500	44	6000	35	18.5	341.7	960.8	38
6 x 10	1800	38	3000	25	12.79	198.0	516	38
6 x 12	1800	38	3600	25	12.79	231.8	591.6	38
6 x 14	1800	38	4200	28	12.79	290.1	725	38
6 x 16	1800	44	4800	31	18.5	349.8	858.8	38
6 x 18	1800	50	5400	35	28.75	417.6	1009.7	44
6 x 20	1800	50	6000	38	28.75	494.9	1183.2	44
7 x 12	2100	44	3600	31	18.5	344.4	751.7	38
7 x 14	2100	44	4200	31	18.5	391.8	849.6	38
7 x 16	2100	44	4800	31	18.5	436.6	943	38
7 x 18	2100	50	5400	35	28.75	513.9	1094.2	44
7 x 20	2100	50	6000	38	28.75	603.3	1263.2	44
7 x 22	2100	50	6600	44	28.75	760.6	1556.8	44
8 x 14	2400	50	4200	31	28.75	467.8	916.3	44
8 x 16	2400	50	4800	31	28.75	527.4	1023	44
8 x 18	2400	50	5400	38	28.75	669.8	1254.3	44
8 x 20	2400	50	6000	41	28.75	779.6	1441.1	44
8 x 22	2400	63	6600	44	45.26	896.2	1641.3	50
9 x 16	2700	50	4800	35	28.75	671.2	1169.8	44
9 x 18	2700	50	5400	35	28.75	745.7	1290	44
9 x 20	2700	63	6000	38	45.26	863.7	1467.8	50
9 x 22	2700	63	6600	44	45.26	1050.8	1743.6	50
10 x 18	3000	50	5400	38	28.75	926.0	1450	44
10 x 20	3000	63	6000	38	45.26	1018.2	1583.5	50
10 x 22	3000	63	6600	44	45.26	1224.3	1854.8	50
11 x 22	3300	63	6600	41	45.26	1350.4	1908.2	50
12 x 24	3600	63	7200	44	45.26	1759.8	2281.8	50
13 x 26	3900	75	7800	47	74.19	2237.1	2677.7	63
14 x 28	4200	75	8400	47	74.19	2794.3	3104.7	63

(A) NOM DIAMETER (mm)
(B) END SHACKLE (mm)
(C) NOM LENGTH (mm EYE/EYE)
(D) MIN. SKIN THICKNESS (mm)
(E) FENDER SWL (METRIC TONS)
(F) ENERGY ABSORPTION (kiloJoules) (AT OR BEFORE 60 PERCENT COMPRESSION)
(G) REACTION FORCE (kiloNewton) (AT PREDICTED ENERGY ATTAINMENT)
(H) NOMINAL CHAIN (Internal) SIZE, mm

SUGGESTED REFERENCE TABLE FOR EXTRA-HIGH CAPACITY NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
2 x 4	600	19	1200	19	3.53	51.5	369.2	19
2 x 6	600	19	1800	19	3.53	75.9	520.4	19
2 x 8	600	19	2400	19	3.53	97.6	662.8	19
2 x 10	600	19	3000	19	4.26	122	818.4	19
3 x 6	900	19	1800	19	3.53	116.6	578.2	19
3 x 8	900	25	2400	19	4.9	168.1	805	25
3 x 10	900	25	3000	22	6.35	235.9	1089.8	25
3 x 12	900	25	3600	22	6.35	288.8	1312.2	25
3 x 14	900	31	4200	25	8.98	363.4	1623.5	31
4 x 6	1200	25	1800	25	6.35	277.9	1005.2	25
4 x 8	1200	25	2400	25	6.35	362	1294.4	25
4 x 10	1200	25	3000	25	6.35	454.2	1592.4	25
4 x 12	1200	31	3600	25	8.98	550.5	1899.3	31
4 x 14	1200	38	4200	28	12.79	606.0	2077.2	38
4 x 16	1200	38	4800	31	12.79	729.4	2464.2	38
4 x 18	1200	38	5400	31	12.79	821.6	2766.6	38
4 x 20	1200	38	6000	31	12.79	915.2	3064.7	38
5 x 8	1500	25	2400	25	6.35	530.1	1576.6	25
5 x 10	1500	31	3000	25	8.98	676.6	1952.7	31
5 x 12	1500	31	3600	25	8.98	821.6	2326.3	31
5 x 14	1500	38	4200	28	12.79	992.5	2757.8	38
5 x 16	1500	38	4800	31	12.79	1167.4	3207	38
5 x 18	1500	44	5400	35	18.5	1212.1	3318.2	38
5 x 20	1500	44	6000	35	18.5	1355.8	3691.8	38
6 x 10	1800	38	3000	25	12.79	939.6	2321.9	38
6 x 12	1800	38	3600	25	12.79	1148.4	2771.1	38
6 x 14	1800	38	4200	28	12.79	1383.0	3269.3	38
6 x 16	1800	44	4800	31	18.5	1608	3745.2	38
6 x 18	1800	50	5400	35	28.75	1834.4	4225.6	44
6 x 20	1800	50	6000	38	28.75	2088	4768.3	44
7 x 12	2100	44	3600	31	18.5	1566	3291.5	38
7 x 14	2100	44	4200	31	18.5	1862.9	3834.2	38
7 x 16	2100	44	4800	31	18.5	2149	4359	38
7 x 18	2100	50	5400	35	28.75	2431	4875	44
7 x 20	2100	50	6000	38	28.75	2761.8	5480	44
7 x 22	2100	50	6600	44	28.75	3156.3	6191.6	44
8 x 14	2400	50	4200	31	28.75	2338.8	4301.2	44
8 x 16	2400	50	4800	31	28.75	2703.5	4884.4	44
8 x 18	2400	50	5400	38	28.75	3171.3	5631	44
8 x 20	2400	50	6000	41	28.75	3586.1	6294	44
8 x 22	2400	63	6600	44	45.26	4003.7	6965.6	50
9 x 16	2700	50	4800	35	28.75	3414	5564.5	44
9 x 18	2700	50	5400	35	28.75	3883	6236	44
9 x 20	2700	63	6000	38	45.26	4387.4	6934.4	50
9 x 22	2700	63	6600	44	45.26	4965	7771	50

SUGGESTED REFERENCE TABLE FOR EXTRA-HIGH CAPACITY NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
10 x 18	3000	50	5400	38	28.75	4769.8	6986.4	44
10 x 20	3000	63	6000	38	45.26	5346	7721.7	50
10 x 22	3000	63	6600	44	45.26	6037.5	8602.4	50
11 x 22	3300	63	6600	41	45.26	7146.5	9376.4	50
12 x 24	3600	63	7200	44	45.26	9239.9	11,129	50
13 x 26	3900	75	7800	47	74.19	11745.4	13,059	63
14 x 28	4200	75	8400	47	74.19	14669.9	15,141	63

(A) NOM DIAMETER (mm)
(B) END SHACKLE (mm)
(C) NOM LENGTH (mm EYE/EYE)
(D) MIN. SKIN THICKNESS (mm)
(E) FENDER SWL (METRIC TONS)
(F) ENERGY ABSORPTION (kiloJoules) (AT OR BEFORE 60 PERCENT COMPRESSION)
(G) REACTION FORCE (kiloNewton) (AT PREDICTED ENERGY ATTAINMENT)
(H) NOMINAL CHAIN (Internal) SIZE, mm

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NOTE: The following tables are provided by SEAWARD International, Inc.

SUGGESTED REFERENCE TABLE FOR STANDARD NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
2 x 4	24	0.75	48	0.75	3.9	22	45	0.75
2 x 6	24	0.75	72	0.75	3.9	27	55	0.75
2 x 8	24	0.75	96	0.75	3.9	32	65	0.75
2 x 10	24	0.75	120	0.75	4.7	42	83	0.75
3 x 6	36	0.75	72	0.75	3.9	39	57	0.75
3 x 8	36	1	96	0.75	5.4	55	74	1
3 x 10	36	1	120	0.875	7.0	71	96	1
3 x 12	36	1	144	0.875	7.0	87	115	1
3 x 14	36	1.25	168	1	9.9	103	140	1.25
4 x 6	48	1	72	1	7.0	61	71	1
4 x 8	48	1	96	1	7.0	89	98	1
4 x 10	48	1	120	1	7.0	118	125	1
4 x 12	48	1.25	144	1	9.9	146	151	1.25
4 x 14	48	1.5	168	1.125	14.1	175	177	1.5
4 x 16	48	1.5	192	1.25	14.1	203	209	1.5
4 x 18	48	1.5	216	1.25	14.1	232	235	1.5
4 x 20	48	1.5	240	1.25	14.1	260	260	1.5
5 x 8	60	1	96	1	7	135	118	1
5 x 10	60	1.25	120	1	9.9	180	151	1.25

SUGGESTED REFERENCE TABLE FOR STANDARD NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
5 x 12	60	1.25	144	1	9.9	224	184	1.25
5 x 14	60	1.5	168	1.125	14.1	269	220	1.5
5 x 16	60	1.5	192	1.25	14.1	313	256	1.5
5 x 18	60	1.75	216	1.375	20.4	357	287	1.5
5 x 20	60	1.75	240	1.375	20.4	401	327	1.5
6 x 10	72	1.5	120	1	14.1	236	170	1.5
6 x 12	72	1.5	144	1	14.1	300	210	1.5
6 x 14	72	1.5	168	1.125	14.1	363	251	1.5
6 x 16	72	1.75	192	1.25	20.4	427	292	1.5
6 x 18	72	2	216	1.375	31.7	490	335	1.75
6 x 20	72	2	240	1.5	31.7	554	378	1.75
7 x 12	84	1.75	144	1.25	20.4	400	246	1.5
7 x 14	84	1.75	168	1.25	20.4	487	292	1.5
7 x 16	84	1.75	192	1.25	20.4	573	338	1.5
7 x 18	84	2	216	1.375	31.7	660	385	1.75
7 x 20	84	2	240	1.5	31.7	746	434	1.75
7 x 22	84	2	264	1.75	31.7	833	490	1.75
8 x 14	96	2	168	1.25	31.7	550	299	1.75
8 x 16	96	2	192	1.25	31.7	733	382	1.75
8 x 18	96	2	216	1.5	31.7	847	439	1.75
8 x 20	96	2	240	1.625	31.7	961	494	1.75
8 x 22	96	2.5	264	1.75	49.9	1075	550	2
9 x 16	108	2	192	1.375	31.7	889	421	1.75
9 x 18	108	2	216	1.375	31.7	1032	479	1.75
9 x 20	108	2.5	240	1.5	49.9	1175	540	2
9 x 22	108	2.5	264	1.75	49.9	1318	603	2
10 x 18	120	2	216	1.5	31.7	1258	532	1.75
10 x 20	120	2.5	240	1.5	49.9	1435	598	2
10 x 22	120	2.5	264	1.75	49.9	1612	667	2
11 x 22	132	2.5	264	1.625	49.9	1910	724	2
12 x 24	144	2.5	288	1.75	49.9	2480	862	2
13 x 26	156	3	312	1.875	81.8	3153	1011	2.5
14 x 28	168	3	336	1.875	81.8	3938	1172	2.5

(A) NOM DIAMETER (inches)
(B) END SHACKLE (inches)
(C) NOM LENGTH (inches EYE/EYE)
(D) MIN. SKIN THICKNESS (inches)
(E) FENDER SWL (TONS)
(F) ENERGY ABSORPTION (FT-KIPS) (AT OR BEFORE 60 PERCENT COMPRESSION)
(G) REACTION FORCE (KIPS) (AT PREDICTED ENERGY ATTAINMENT)
(H) NOMINAL CHAIN (Internal) SIZE, inches

SUGGESTED REFERENCE TABLE FOR LOW-REACTION NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
2 x 4	24	0.75	48	0.75	3.9	21	42	0.75
2 x 6	24	0.75	72	0.75	3.9	24	48	0.75
2 x 8	24	0.75	96	0.75	3.9	26	55	0.75
2 x 10	24	0.75	120	0.75	4.7	29	60	0.75
3 x 6	36	0.75	72	0.75	3.9	29	42	0.75
3 x 8	36	1	96	0.75	5.4	34	50	1
3 x 10	36	1	120	0.875	7.0	51	72	1
3 x 12	36	1	144	0.875	7.0	57	82	1
3 x 14	36	1.25	168	1	9.9	78	109	1.25
4 x 6	48	1	72	1	7.0	67	74	1
4 x 8	48	1	96	1	7.0	78	85	1
4 x 10	48	1	120	1	7.0	88	97	1
4 x 12	48	1.25	144	1	9.9	100	109	1.25
4 x 14	48	1.5	168	1.125	14.1	122	130	1.5
4 x 16	48	1.5	192	1.25	14.1	154	163	1.5
4 x 18	48	1.5	216	1.25	14.1	165	175	1.5
4 x 20	48	1.5	240	1.25	14.1	177	187	1.5
5 x 8	60	1	96	1	7.0	98	90	1
5 x 10	60	1.25	120	1	9.9	115	105	1.25
5 x 12	60	1.25	144	1	9.9	132	120	1.25
5 x 14	60	1.5	168	1.125	14.1	167	148	1.5
5 x 16	60	1.5	192	1.25	14.1	206	182	1.5
5 x 18	60	1.75	216	1.375	20.4	235	202	1.5
5 x 20	60	1.75	240	1.375	20.4	252	216	1.5
6 x 10	72	1.5	120	1	14.1	146	116	1.5
6 x 12	72	1.5	144	1	14.1	171	133	1.5
6 x 14	72	1.5	168	1.125	14.1	214	163	1.5
6 x 16	72	1.75	192	1.25	20.4	258	193	1.5
6 x 18	72	2	216	1.375	31.7	308	227	1.75
6 x 20	72	2	240	1.5	31.7	365	266	1.75
7 x 12	84	1.75	144	1.25	20.4	254	169	1.5
7 x 14	84	1.75	168	1.25	20.4	289	191	1.5
7 x 16	84	1.75	192	1.25	20.4	322	212	1.5
7 x 18	84	2	216	1.375	31.7	379	246	1.75
7 x 20	84	2	240	1.5	31.7	445	284	1.75
7 x 22	84	2	264	1.75	31.7	561	350	1.75
8 x 14	96	2	168	1.25	31.7	345	206	1.75
8 x 16	96	2	192	1.25	31.7	389	230	1.75
8 x 18	96	2	216	1.5	31.7	494	282	1.75
8 x 20	96	2	240	1.625	31.7	575	324	1.75
8 x 22	96	2.5	264	1.75	49.9	661	369	2
9 x 16	108	2	192	1.375	31.7	495	263	1.75
9 x 18	108	2	216	1.375	31.7	550	290	1.75
9 x 20	108	2.5	240	1.5	49.9	637	330	2
9 x 22	108	2.5	264	1.75	49.9	775	392	2

SUGGESTED REFERENCE TABLE FOR LOW-REACTION NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
10 x 18	120	2	216	1.5	31.7	683	326	1.75
10 x 20	120	2.5	240	1.5	49.9	751	356	2
10 x 22	120	2.5	264	1.75	49.9	903	417	2
11 x 22	132	2.5	264	1.625	49.9	996	429	2
12 x 24	144	2.5	288	1.75	49.9	1298	513	2
13 x 26	156	3	312	1.875	81.8	1650	602	2.5
14 x 28	168	3	336	1.875	81.8	2061	698	2.5

(A) NOM DIAMETER (inches)
(B) END SHACKLE (inches)
(C) NOM LENGTH (inches EYE/EYE)
(D) MIN. SKIN THICKNESS (inches)
(E) FENDER SWL (TONS)
(F) ENERGY ABSORPTION (FT-KIPS) (AT OR BEFORE 60 PERCENT COMPRESSION)
(G) REACTION FORCE (KIPS) (AT PREDICTED ENERGY ATTAINMENT)
(H) NOMINAL CHAIN (Internal) SIZE, inches

SUGGESTED REFERENCE TABLE FOR EXTRA-HIGH CAPACITY NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
2 x 4	24	0.75	48	0.75	3.9	38	83	0.75
2 x 6	24	0.75	72	0.75	3.9	56	117	0.75
2 x 8	24	0.75	96	0.75	3.9	72	149	0.75
2 x 10	24	0.75	120	0.75	4.7	90	184	0.75
3 x 6	36	0.75	72	0.75	3.9	86	130	0.75
3 x 8	36	1	96	0.75	5.4	124	181	1
3 x 10	36	1	120	0.875	7.0	174	245	1
3 x 12	36	1	144	0.875	7.0	213	295	1
3 x 14	36	1.25	168	1	9.9	268	365	1.25
4 x 6	48	1	72	1	7.0	205	226	1
4 x 8	48	1	96	1	7.0	267	291	1
4 x 10	48	1	120	1	7.0	335	358	1
4 x 12	48	1.25	144	1	9.9	406	427	1.25
4 x 14	48	1.5	168	1.125	14.1	447	467	1.5
4 x 16	48	1.5	192	1.25	14.1	538	554	1.5
4 x 18	48	1.5	216	1.25	14.1	606	622	1.5
4 x 20	48	1.5	240	1.25	14.1	675	689	1.5
5 x 8	60	1	96	1	7.0	391	354	1
5 x 10	60	1.25	120	1	9.9	499	439	1.25
5 x 12	60	1.25	144	1	9.9	606	523	1.25
5 x 14	60	1.5	168	1.125	14.1	732	620	1.5
5 x 16	60	1.5	192	1.25	14.1	861	721	1.5
5 x 18	60	1.75	216	1.375	20.4	894	746	1.5

SUGGESTED REFERENCE TABLE FOR EXTRA-HIGH CAPACITY NETLESS STYLE FENDERS

FENDER SIZE	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
5 x 20	60	1.75	240	1.375	20.4	1000	830	1.5
6 x 10	72	1.5	120	1	14.1	693	522	1.5
6 x 12	72	1.5	144	1	14.1	847	623	1.5
6 x 14	72	1.5	168	1.125	14.1	1020	735	1.5
6 x 16	72	1.75	192	1.25	20.4	1186	842	1.5
6 x 18	72	2	216	1.375	31.7	1353	950	1.75
6 x 20	72	2	240	1.5	31.7	1540	1072	1.75
7 x 12	84	1.75	144	1.25	20.4	1155	740	1.5
7 x 14	84	1.75	168	1.25	20.4	1374	862	1.5
7 x 16	84	1.75	192	1.25	20.4	1585	980	1.5
7 x 18	84	2	216	1.375	31.7	1793	1096	1.75
7 x 20	84	2	240	1.5	31.7	2037	1232	1.75
7 x 22	84	2	264	1.75	31.7	2328	1392	1.75
8 x 14	96	2	168	1.25	31.7	1725	967	1.75
8 x 16	96	2	192	1.25	31.7	1994	1098	1.75
8 x 18	96	2	216	1.5	31.7	2339	1266	1.75
8 x 20	96	2	240	1.625	31.7	2645	1415	1.75
8 x 22	96	2.5	264	1.75	49.9	2953	1566	2
9 x 16	108	2	192	1.375	31.7	2518	1251	1.75
9 x 18	108	2	216	1.375	31.7	2864	1402	1.75
9 x 20	108	2.5	240	1.5	49.9	3236	1559	2
9 x 22	108	2.5	264	1.75	49.9	3662	1747	2
10 x 18	120	2	216	1.5	31.7	3518	1570	1.75
10 x 20	120	2.5	240	1.5	49.9	3943	1736	2
10 x 22	120	2.5	264	1.75	49.9	4453	1934	2
11 x 22	132	2.5	264	1.625	49.9	5271	2108	2
12 x 24	144	2.5	288	1.75	49.9	6815	2502	2
13 x 26	156	3	312	1.875	81.8	8663	2936	2.5
14 x 28	168	3	336	1.875	81.8	10820	3404	2.5

(A) NOM DIAMETER (inches)
(B) END SHACKLE (inches)
(C) NOM LENGTH (inches EYE/EYE)
(D) MIN. SKIN THICKNESS (inches)
(E) FENDER SWL (TONS)
(F) ENERGY ABSORPTION (FT-KIPS) (AT OR BEFORE 60 PERCENT COMPRESSION)
(G) REACTION FORCE (KIPS) (AT PREDICTED ENERGY ATTAINMENT)
(H) NOMINAL CHAIN (Internal) SIZE, inches

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Fenders shall have cylindrical mid-bodies with conical or hemispherical shaped ends terminating in an end fitting on the cylinder's centerline at each end. The diameter of the mid-body shall be [1829] [_____] mm [72] [_____] inches minimum, and the length of the mid-body shall be [1981]

[_____] mm [78] [_____] inches minimum. If conical ends are provided, they shall have an angle of 1.05 to 1.31 rad 60 to 75 degrees, when measured from the central axis of the fender. The fittings at either end shall be connected through the center of the fender by a chain, shall terminate in a clevis fitting sized for a [44] [_____] mm [1 3/4] [_____] inch shackle and shall swivel to allow the end fitting to rotate freely on the axis of the fender. The length of the fender from eye to eye of the end fittings shall be a minimum of [3.66] [_____] m [144] [_____] inches. Design end fitting as small as possible to transmit the ultimate load of the shackle to the fender. End fitting shall be sized so as not to contact loading surfaces when the fender is compressed to 30 percent of its original diameter (70 percent compression). Fill interior of the fender with energy absorbing closed-cell foam as specified. The use of chipped or particulate foam is not acceptable.

2.2 FOAM CORE

The energy absorbing foam core shall be a closed-cell cross-linked polyethylene foam with the following properties:

a. Density, ASTM D 1667, [52.86 to 104.12] [_____] to [_____] kg per cubic meter [3.3 to 6.5] [_____] to [_____] lbs/ft3

b. Tensile strength, ASTM D 3575 or ASTM D 412, [552] [_____] to [_____] kPa [80] [_____] to [_____] psi minimum

c. Elongation (ultimate), ASTM D 3575 or ASTM D 412, [40 percent] [_____] to [_____] minimum

d. Water absorption percent volume after 24 hour exposure, ASTM D 1667, [5.0 percent] [_____] maximum

e. Continuous service temperature, [-54 to 49 degrees C] [-65 to +120 degrees F] [_____] to [_____]

f. 25 percent compressive set, ASTM D 1667, [8 percent] [_____] maximum *

g. 50 percent compressive set, ASTM D 3575, [12 percent] [_____] maximum *

* Contractor option: Compressive Set of foam core material shall be based on either the 25 percent or the 50 percent requirement listed.

2.3 FENDER SKIN

The outer fender skin shall be minimum [32] [_____] mm [1.25] [_____] inches thick and constructed of elastomer as specified. Reinforcing is optional as required by the Contractor's design. If reinforcing is used, [twelve] [_____] separate filament reinforcing wraps shall be applied as specified under Filament Wrap. The filament wraps shall be evenly distributed in the inner 80 percent to 90 percent of the coating thickness. The outer 10 percent to 20 percent of elastomer shall have no filament reinforcing. The elastomer and filaments shall be applied in a continuous manner to assure adhesion between the various layers. The connection of the skin to the end fittings shall be designed and sized to transmit twice the safe tensile capacity of the chain into the fender skin.

2.3.1 Elastomer

The elastomer used in the fender skin shall be 100 percent PTMEG (polytetramethyleneether glycol) polyether urethane elastomer, with the following unreinforced properties:

a. Shore A. hardness, ASTM D 2240, [80 to 95] [_____] to [_____].

b. Tensile strength, ASTM D 412, [19.3] [_____] MPa [2800] [_____] psi minimum.

c. Elongation (ultimate), ASTM D 412, [300 percent] [_____] minimum.

d. Tear strength, ASTM D 470, [1.25] [_____] kg per mm [70] [_____] Lbs/inch minimum.

e. Flex life (Ross), ASTM D 1052, [200,000] [_____] cycles minimum.

f. Abrasion resistance (NBS), ASTM D 1630, [100] [_____] minimum.

2.3.2 Filament Wrap

If filament reinforcing is required by the Contractor's design, construct each filament reinforcing wrap of continuous filaments applied in a helical pattern, at a helix angle of 0.79 to 1.05 rad 45 to 60 degrees to the longitudinal axis of the buoy. A wrap shall consist of two such filament helixes of equal but opposing helix angles. The spacing between the filaments in the same helix shall be no more than 3 mm 1/8 inch, measured in a direction parallel to the longitudinal axis of the fender. Each wrap shall extend along the entire longitudinal axis of the fender and shall also encase the fender end fittings and secure them to the fender body.

2.3.3 Filament Reinforcing

If filament reinforcing is required by the Contractor's design, the reinforcing filaments in the outer skin shall be nylon tire cord of 0.00028 kg per m 2540 denier weight with the following properties:

a. Breaking strength, [236] [_____] N [53] [_____] pounds

b. Elongation (ultimate), [18] [_____] percent

2.3.4 Hardware

The internal chain connecting the two end fittings and the two end fittings shall be galvanized in accordance with ASTM A 123 or ASTM A 153/A 153M as appropriate. The chain and end clevis fitting shall have a minimum ultimate tensile capacity of [640,512] [_____] N [144,000] [_____] pounds. The internal chain and end clevis fitting shall have a minimum ultimate tensile capacity of [578,240] [_____] N [130,000] [_____] pounds. Shackles shall be [45] [_____] mm [1 3/4] [_____] inches and shall have a minimum ultimate tensile capacity of [289,120] [_____] N [65,000][_____] pounds.

2.3.5 Color

Fender skin color shall be black throughout the entire thickness. Galvanized hardware shall be unpainted.

2.3.6 Repairability

The fender casing shall be repairable in the event of tears or punctures in the elastomer skin. The repaired area shall have not less than 90 percent of the properties as specified in paragraph entitled "Elastomer." Required repair materials shall be readily available from the fender manufacturer.

2.4 SOURCE QUALITY CONTROL

2.4.1 Fender Compression Test

Compress fender along its diameter between two parallel flat plate surfaces to a compressed dimension of [40] [_____] percent of its original diameter. Record load and the corresponding deflection at 25 mm one inchincrements and plot as a graph of load versus deflection. The load-deflection curve shall then be integrated to generate an energy-deflection curve for the fender. The fender shall meet the energy and force performance requirements of the paragraph entitled "Performance Requirements." After compression of the fender to [40] [_____] percent of its original diameter ([60] [_____] percent compression) the fender shall rebound to [90] [_____] percent of its original diameter within two minutes after the load is removed, and to 95 percent of its original diameter within 30 minutes after the load is removed.

2.4.2 Fender Cyclic-Compression Test

Compress the fender along its diameter between two parallel flat plate surfaces to a compressed dimension of 40 percent of its original diameter. Release the load and recompress as before. Repeat the compression and release cyclic loadings for a minimum of 10 full cycles of compression. Permanent deformation, cracking, or tearing of the fender skin, fender core, or end fittings shall constitute failure of this test.

2.4.3 Fender Sustained-Load Test

Apply a [667,200] [_____] N [150,000] [_____] pound compressive load as in paragraph entitled "Fender Compression Test," and hold this load for 24 hours. Record load and deflection each hour. Immediately after release of the load, measure rebound of the fender. Continue to record fender rebound for 24 hours. Failure of the fender or foam core to rebound to 90 percent of its original diameter after 24 hours shall constitute failure of this test. If the foam core is not bonded to the skin of the fender, devise and execute a means for measuring rebound of the foam core and for measuring the void between the foam core and the skin. The maximum rate of compression per minute shall be 20 percent of the total reaction force at 60 percent compression. The full compression cycle, not including rebound, shall take a minimum of 5 minutes.

2.4.4 Fender Pull-Through Test

Devise and perform a test which will measure the resistance of the end fittings and internal chain to pull through the longitudinal axis of the fender. Failure of the chain, end fittings, or skin to resist at least [177,920] [_____] N [40,000] [_____] pounds of pull-through tension shall constitute failure of this test. After loading, evidence of permanent deformation, cracking, or tearing of the fender or end fittings shall also constitute failure of this test.

2.4.5 Elastomeric Skin Thickness Test

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NOTE: The suggested number of fenders that should be tested is as follows:

Fenders Procured	Number to test
1 - 3	1
4 - 8	2
9 - 20	3
21 and above	4

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[After delivery of all of the fenders to the construction site and before fender installation, perform a minimum of [3] [_____] skin thickness tests per fender for each of [1][2][3][4] fenders to be selected at random by the Contracting Officer.] [After fabrication of all of the fenders and prior to fender shipment to the construction site, perform a minimum of [3] [_____] skin thickness tests per fender for each of [1] [2] [3] [4] fenders to be selected at random by the Contracting Officer.] Test locations on the fenders will be selected by the Contracting Officer. Each test shall consist of taking a 6 mm 1/4 inch diameter (minimum) to 13 mm 1/2 inch diameter (maximum) core from the fender skin which can be removed from the skin and examined for thickness of elastomer and placement of reinforcing (when reinforcing is required). Take skin thickness measurements from the core sample and record measurements noting placement of reinforcing. Where the skin thickness measurement is less than the specified minimum, or the minimum required by the Contractor's design (whichever is greater) by more than 10 percent, reject the fender. In addition, if the average of skin thickness tests for one fender is not equal to or greater than the specified minimum, or the minimum required by the Contractor's design (whichever is greater), reject the fender. If tested fender is rejected, at the option of the Contracting Officer, the Contractor shall then conduct thickness tests for additional fenders. Replace rejected fenders with fenders meeting the provisions of this specification. Test replacement fenders for skin thickness as specified herein. Skin thickness tests will be witnessed by the Contracting Officer. The Contractor shall notify the Contracting Officer 10 working days prior to conducting skin thickness tests. After skin thickness testing, patch core holes with elastomer of the same composition and thickness as the specified elastomer skin. Nylon reinforcing is not required in core hole patches.

PART 3 EXECUTION

3.1 INSTALLATION

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NOTE: This article should be modified as necessary to fit individual application for each project.

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Install fenders [as indicated on the drawings.] [in a floating condition beside the wharf at locations as directed by the Contracting Officer. Attach fenders to the standard Navy mooring cleats provided along the wharf by means of standard Navy mooring lines. The mooring lines will be furnished by the Government for the Contractor's use in installation.]

-- End of Section --