UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2022
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DIVISION 35 - WATERWAY AND MARINE CONSTRUCTION

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EXTRUDED AND MOLDED MARINE FENDERS

11/21

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USACE / NAVFAC / AFCEC / NASA **UFGS-35 59 13.16 (November 2021)**

Preparing Activity: NAVFAC

Superseding
UFGS-35 59 13.16 (May 2011)
UFGS-35 59 13.19 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 35 59 13.16

EXTRUDED AND MOLDED MARINE FENDERS
11/21

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NOTE: This guide specification covers the requirements for extruded and molded marine fenders.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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NOTE: Fender type should be selected based on the following considerations:

1. Performance, including energy, berthing angle, reaction, and hull pressure.

2. Geometry, including stand-off, dock configuration, vessel configuration, and tidal variation.

3. Configuration and construction, including corrosion resistance, netted vs not netted, magnetic permeability, buoyancy and portability.

The following information shall be shown on the project drawings:

1. Location, size,and mounting elevation (if applicable) of each fender type.

2. Connection details to the waterfront structure. Include connection sizes, material type, embedment, plate sizes and hole sizes and locations, as applicable.

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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 Reference Identifier (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	(2020; Errata 1 2021) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A479/A479M	(2021) Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM B695	(2021) Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
ASTM D256	(2010; R 2018) Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
ASTM D395	(2016; E 2017) Standard Test Methods for Rubber Property - Compression Set
ASTM D412	(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D471	(2016a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D573	(2004; R 2019) Standard Test Method for Rubber - Deterioration in an Air Oven
ASTM D575	(1991; R 2012) Rubber Properties in Compression
ASTM D624	(2000; R 2020) Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D746	(2014) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D1171	(2018) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking Outdoors (Triangular Specimens)
ASTM D1894	(2014) Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM F593	(2017) Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	(2009; R 2020) Standard Specification for Stainless Steel Nuts

ASTM F648	(2021) Standard Specification for Ultra-High-Molecular-Weight Polyethylene Powder and Fabricated Form for Surgical Implants
ASTM F844	(2019) Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F2192	(2005; R 2022) Standard Test Method for Determining and Reporting the Berthing Energy and Reaction of Marine Feeders

INTERNATIONAL NAVIGATION ASSOCIATION (PIANC)

PIANC 2002	(2002) Guidelines for the Design of Fender Systems: 2002

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-PRF-907	(2020; Rev H) Antiseize Thread Compound, High Temperature

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS RR-C-271	(Rev H; Am 1) Chains and Attachments, Carbon And Alloy Steel

1.2 SYSTEM DESCRIPTION

1.2.1 Extruded Fenders

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NOTE: Extruded fender systems typically absorb a minimum amount of energy. Therefore, they are typically used at the wale elevation of fender pile systems. They have also been used as festoon fenders, rub strips and as an energy absorbing element in a separator.

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Extruded fenders are elements typically manufactured in a long length by an extrusion process. After manufacture, the elements are cut to length. These fender elements are typically used as fenders for small craft, rub strips on marine structures,and energy absorbing elements at the wale. Examples of extruded fender shapes are 'Side Mounted Hollow Bore', 'Cylindrical', 'D', 'Square', 'W' and 'Wing'.

1.2.2 Molded Fenders

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NOTE: Molded fenders are typically mounted to the vertical face of a marine structure. These systems are used to berth ships of similar size and hull curvature. Therefore, they are usually found in commercial ports.

****

Molded fenders are elements manufactured by the molded process. They typically have embedded metal plates cast into the molds. The fender elements are typically used as fenders for medium to large, flat sided vessels. The elements can be used as stand-alone fenders, combined with multiple fenders and a face panel, and energy absorbing elements at the wale. They include the shear fenders which absorb energy by deflecting parallel to the attachment plane. Examples of molded fender shapes are 'Leg Type', 'Arch Type', 'Cell Type', and 'Cone Type'.

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, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panels; G[, [_____]]

SD-03 Product Data

Stainless Steel Hardware; G[, [_____]]

Galvanized Steel Hardware; G[, [_____]]

Restraint Chains; G[, [_____]]

Facing; G[, [_____]]

Extruded Fender; G[, [_____]]

Molded Fender; G[, [_____]]

SD-05 Design Data

****

NOTE: Performance requirements: the rated energy of the fender shall be no less than the calculated berthing energy and the rated fender reaction shall not exceed the allowable load on the structure supporting it.

The maximum reaction divided by the corresponding contact area, shall be less than or equal to the maximum specified hull pressure for fender panels.

Structural components shall be sized in accordance with the latest edition of AISC allowable stress design, including effects for internal spacing of stiffeners. Panel loads shall be based on the greater of:

1. Horizontal line contact applied at any elevation over the flat height of the panel.

2. Simultaneous horizontal line contacts at top and bottom edge of the front face of the panel.

Design factor for attachment points, restraints and nets shall be based on 1.5 times the dynamic shear. The end attachment load shall not exceed 80 percent of yield. Restraints shall be sized such that the load applied to the weakest component does not exceed 50 percent of its breaking strength.

A weak link, preferably a shackle, swivel or other readily replaceable, cost effective component shall be designed to fail first. Concrete embedments shall have a break out capacity of at least 1.5 times the characteristic load of the weakest link.

Mechanical hardware, such as fasteners shall be sized with a design working load that does not exceed 60 percent of the lower of the yield or breaking load.

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Rubber Fenders; G[, [_____]]

Energy-Deflection Curve; G[, [_____]]

Load-Deflection Curve; G[, [_____]]

SD-06 Test Reports

Minimum Tensile Strength

Shore Hardness (Durometer)

Modulus at 200 Percent Elongation

Maximum Compression Set

Tear Resistance

Minimum Elongation

Ozone Resistance; G[, [_____]]

Low Temperature Impact Resistance; G[, [_____]]

Water Absorption; G[, [_____]]

Heat Resistance; G[, [_____]]

Compression Deflection Resistance

Fender Compression Test

SD-07 Certificates

Galvanized Steel Hardware Certificates; G[, [_____]]

Stainless Steel Hardware Certificates; G[, [_____]]

SD-08 Manufacturer's Instructions

Installation Instructions

SD-10 Operation and Maintenance Data

Fender Manual

1.4 DELIVERY, HANDLING AND STORAGE

Fenders must be undamaged when delivered. Handle and store fenders so as to prevent damage, such as bending or abrading end fittings, cutting of rubber, or damage to coating of hardware. Protect fenders from exposure to damaging liquids, oils, greases and extended exposure to sunlight.

1.4.1 Rejection

Fenders that are delivered to the site in a damaged condition or that are not in conformance with this specification are subject to rejection. Replace any rejected materials with suitable materials, at no additional cost to the Government.

1.4.2 Fender Marking

Unless unsuitable for specified fender or otherwise specified, identify all fenders in readable characters at least 25 mm 1 in high, either directly or on corrosion- and sunlight resistant permanently attached tags. The markings must include the following:

a. Full or abbreviated manufacturer name,

b. fender size model or part number designation,

c. fender serial number, and

d. other information as the purchase specification or contract requires.

1.4.3 Fender Instructions and Manual

Provide installation instructions and a fender manual describing maintenance requirements for each fender type.

1.4.4 Handling Coated Material

Store, handle and place coated material in a manner that will minimize damage to the coating and will not reduce its effective protective value. Repair damaged surfaces as directed and per the Manufacturer's recommendations. Handle coated work which is flexible in a manner that will prevent flexing sufficient to crack coating, especially when temperature is below 4 degrees C 40 degrees F. Do not place coated surfaces on strips or skids until coating has hardened thoroughly. Wide fabric slings used for lifting, and strips, slings, blocks, skids, cradles, and other supports must provide ample bearing areas. In transporting, fasten and protect coated materials in a manner that will prevent movement and preclude chafing and rubbing, and when unloading, do not dump or drop. Place coated material in position carefully on suitably prepared beds and with a minimum of handling.

1.5 QUALITY ASSURANCE

1.5.1 Extruded Fenders, Molded Fenders

Fender elements must be manufactured of rubber, homogeneous and free from any defects, impurities, pores or cracks. Where internal plates are used, the rubber must be bonded to integral steel mounting plates. The plates must be fully encased in rubber to a minimum thickness of 2 mm 1/16 inch.

1.5.2 Elastomer Skin

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

1.5.3 Steel Fabrication

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

1.5.4 Welding

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

PART 2 PRODUCTS

2.1 EXTRUDED AND MOLDED FENDERS

2.1.1 Configuration

Provide dimensions, material specifications, and method of manufacture for each type of fender.

2.1.1.1 Extruded Fender

Fenders must be extruded and continuous in the length indicated. The fenders must be black in color. The fenders must have a truncated "A" cross section shape and be attached to the structure at the base, the widest dimension, of the arch. The connecting hardware must be fully exposed. No encased hardware or molded fenders are allowed. The fender and hardware must be designed and factory tested to the loads per linear meter foot of fender specified in paragraph PERFORMANCE. Fender anchor bolts and method of anchorage must be of the size and spacing required by the manufacturer's design and testing; however, the size and spacing of anchor bolts indicated must be construed to be the minimum required, unless exceeded by the requirements of the fender manufacturer's design.

2.1.1.2 Molded Fender

Fenders must be molded and continuous in the length indicated up to the maximum mold size available. Molded sections must not be mechanically bonded. The fenders must be black in color. Each fender must be molded of rubber, homogeneous and free from any defects, impurities, pores or cracks, and bonded to integral, steel mounting plates. The mounting plates must be fully encased in rubber with a minimum thickness of 2 mm 1/16 inch. The fender and hardware must be designed for and be factory tested to the loads specified. Fender anchor bolts and method of anchorage must be of the size and spacing dimensions required by the manufacturer's design and testing; however, the size and spacing of anchor bolts indicated must be construed to be the minimum required, unless exceeded by the requirements of the fender manufacturer's design.

2.1.2 Elastomer

The elastomer must be the ethylene propylene dimonomer (EPDM) or a blend of NR/SBR, as specified in ASTM D2000, with the following line callout:

****

NOTE: Coordinate values with calculated design requirements. The 3BA 720 compound is the typical compound. The 3BA 620 compound has approximately 70 percent of the energy capacity and a reduced reaction. Other compounds may be available.

****

a. 3BA 720 A_{14} B_{13} C_{12} EA_{14} $F1_{7}$

[b. 3BA 620 A_{14} B_{13} C_{12} EA_{14} $F1_{7}$

] The elastomer must have the following properties:

****

NOTE: Coordinate values with calculated design requirements.

****

ELASTOMER PROPERTY REQUIREMENTS	
Minimum Tensile Strength (ASTM D412)	[14][_____] MPa [2000][_____] psi
Shore Hardness (Durometer) (ASTM D412)	[70 plus 5][_____]
Modulus at 200 Percent Elongation (ASTM D412)	[6.2][_____] MPa [900][_____] psi
Maximum Compression Set (ASTM D395 Method B, Maximum Percent 22 Hr. at 70 degrees C 158 degrees F)	[25][_____] Percent
Tear Resistance (ASTM D624; DIE B Min. 26.8 kg/cm 150 lb/in)	53.6 kg/cm 300 lb/in
Minimum Elongation (ASTM D412)	[500][_____] Percent
Ozone Resistance (ASTM D1171 Exposure Method B; 70h Bent Loop at 38 degrees C 100 degrees F; 50 pphm)	[80][_____] H plus
Low Temperature Impact Resistance (ASTM D746 Procedure B; Non-Brittle at minus 55 degrees C minus 67 degrees F)	[0][_____] degrees C [minus 40][_____] degrees F
Water Absorption (ASTM D471 Method B; 70h at 100 degrees C 212 degrees F; Volume Change plus 5 Percent	[10.0][_____] Percent
Heat Resistance (ASTM D573; 70h at 100 degrees C 212 degrees F Ch Tensile, Elong. minus 25 Percent, Hardness plus 10	Shall exceed requirements
Compression Deflection Resistance (ASTM D575 Method B; 3 S Dwell at 23 degrees C 73 degrees F	Shall exceed requirements

2.1.3 Performance Requirements

****

NOTE: This performance criteria should be tailored for extruded and molded shapes. Coordinate values with calculated design requirements.

****

Submit rated performance data (RPD) and published performance curves per ASTM F2192 or PIANC 2002 for the rubber fenders.

Each of the rubber fenders must have the following performance characteristics:

SIZE	ENERGY ABSORPTION	REACTION FORCE
	at rated deflection	at predicted energy attainment
[_____] m x [_____] m[_____] ft x [_____] ft	[_____] kN-m [_____] ft-kips	[_____] kN x [_____] [_____] kips

When vertically compressed by a plate extending the full length and width of a 1 meter 3.28 feet section of the fender, the fender must absorb [_____] [_____] newton-meters [_____] foot-pounds of energy with a corresponding load of not more than [_____] [_____] N [_____] [_____] pounds.

2.1.4 Test Reports

Perform tests on the specified fender within 5 years of submittal of the reports for approval. Test reports must be accompanied by notarized certificates from the manufacturer certifying that the tested material is of the same type, size, quality, manufacture and make as that proposed to be supplied. Perform the following tests:

a. Minimum Tensile Strength

b. Shore Hardness (Durometer)

c. Modulus at 200 Percent Elongation

d. Maximum Compression Set

e. Tear Resistance

f. Minimum Elongation

g. Ozone Resistance

h. Low Temperature Impact Resistance

i. Water Absorption

j. Heat Resistance

k. Compression Deflection Resistance

l. Fender Compression Test

****

NOTE: Coordinate values with calculated design requirements.

****

Compress fender along its longitudinal axis between two parallel flat plate surfaces to its rated deflection. Record load and the corresponding deflection at 6 mm 1/4 inch increments and plot as a graph of load versus deflection. The Load-Deflection curve must then be integrated to generate an Energy-Deflection curve for the fender.

2.1.5 Break-In Deflection

Break-in deflection is required for buckling type fenders with reaction ratings of 100 tonnes or more, or if the energy-absorbing material has a reaction decrease of more than 10 percent between its original deflection and and its fifth deflection. Break-in deflection must be to at least the manufacturer's rated deflection. The number of break-in cycles must be sufficient to assure each elements first on-dock reaction will not exceed it fully broken-in reaction by more than 10 percent.

2.1.6 Fender Hardware

Provide manufacturer's product data for all fender hardware, including bolts, anchor bolts, inserts, nuts, washers, chains, turnbuckles, dimensions, material specifications, working loads and ultimate loads, as applicable. For anchor bolts and inserts, include methods and materials for installation.

2.1.6.1 Stainless Steel Hardware

Submit stainless steel hardware certificates of compliance certifying that materials meet the requirements specified herein.

****

NOTE: It is recommended that all concrete inserts be of stainless steel materials.

****

2.1.6.1.1 Plates and Angles

ASTM A479/A479M, Type 316L stainless steel for plates, angles, and miscellaneous hardware required to attach the fenders to the structure.

2.1.6.1.2 Bolts, Nuts, and Washers

ASTM F593 or ASTM F594, Group 2 (316 alloy) stainless steel for nuts and bolts. ASTM F844 for washers, except fabricate washers of 316 alloy stainless steel.

2.1.6.1.3 Antiseize Compound

MIL-PRF-907.

2.1.6.2 Galvanized Steel Hardware

****

NOTE: Galvanized steel hardware may be used at locations where the hardware can be easily replaced.

****

All hardware must be hot-dip galvanized in accordance with ASTM A123/A123M, ASTM A153/A153M or ASTM B695, as applicable.

Submit galvanized steel hardware certificates of compliance certifying that materials meet the requirements specified herein. In addition, when the coating is shop applied, submit certificates of conformance or compliance certifying that surface preparation, coverage, and thickness meet the requirements specified.

2.1.6.2.1 Plates

ASTM A36/A36M.

2.1.6.2.2 Bolts, Nuts and Washers

Bolts must be ASTM A307. Nuts must be ASTM A563, grade A heavy hex. Washers must be ASTM F844 of carbon steel.

2.1.6.2.3 Restraint Chains and Shackles

Chain and shackles must meet the requirements of FS RR-C-271. The chain assembly must have a design safety factor of 3:1 based on minimum breaking strength.

2.1.7 Panels

Panel design must be of closed box construction for optimum strength and corrosion resistance. Material thickness must be 10 mm 3/8 inch minimum when one side is exposed and 12 mm 1/2 inch minimum when both sides are exposed. Submit shop drawings indicating the dimensions of the panels.

2.1.7.1 Facing

Provide UHMWPE (ultra high molecular weight polyethylene) facing per ASTM F648 on the panels that is ultraviolet stabilized with 2.5 percent carbon black or equivalent, minimum 12 mm 1/2 inch wear thickness and 12 mm 1/2 inch clamping thickness, with a 0.20 maximum coefficient of friction per ASTM D1894. The UHMWPE must exhibit no failure when tested per ASTM D256, Method B. Configure the facing connections to account for the thermal properties of the polyethylene.

PART 3 EXECUTION

3.1 EXTRUDED FENDERS AND MOLDED FENDERS

Tighten the bolts per the manufacturers requirements.

3.2 WELDING

Perform welding in accordance with AWS D1.1/D1.1M.

3.3 CONNECTIONS

3.3.1 Antiseize Compound

Coat threads of bolts prior to applying washers and nuts. Recoat bolt thread projection beyond nut after tightening.

-- End of Section --