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An American National Standard

Standard Test Method for Determining and Reporting the Berthing Energy and Reaction of Marine Fenders[1]

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INTRODUCTION

A marine fender is an energy-absorbing device that is typically secured against the face of a marine facility or a ship's hull for the purpose of attenuating the forces inherent in arresting the motion of berthing vessels safely. Most modern fenders fall into three general classifications based on the material used to absorb energy: (*1*) solid rubber fenders in which the material absorbs the energy, (*2*) pneumatic (air-filled) fenders in which air absorbs the energy, and (*3*) foam-filled fenders in which the foam core absorbs the energy.

1. Scope

1.1 This test method covers the recommended procedures for quantitative testing, reporting, and verifying the energy absorption and reaction force of marine fenders. Marine fenders are available in a variety of basic types with several variations of each type and multiple sizes and stiffnesses for each variation. Depending on the particular design, marine fenders may also include integral components of steel, composites, plastics, or other materials. All variations shall be performance tested and reported according to this test method.

1.2 There are three performance variables: berthing energy, reaction, and deflection. There are two methods used to develop rated performance data (RPD) and published performance curves for the three performance variables.

1.3 The primary focus is on fenders used in berthside and ship-to-ship applications for marine vessels. This testing protocol does not address small fendering "bumpers" used in pleasure boat marinas, mounted to hulls of work boats, or used in similar applications; it does not include durability testing. Its primary purpose is to ensure that engineering data reported in manufacturers' catalogues are based upon common testing methods.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Significance and Use

3.1 *General:*

3.1.1 All testing shall define fender performance under velocities that decrease linearly or that are proportional to the square root of percent of remaining rated energy.

3.1.2 Rated performance data (RPD) and manufacturers' published performance curves or tables, or both, shall be based on: (*1*) initial deflection (berthing) velocity of 0.15 m/s and decreasing to no more than 0.005 m/s at test end, (*2*) testing of fully broken-in fenders (break-in testing is not required for pneumatic fenders), (*3*) testing of fenders stabilized at 23 ± 5°C (excluding pneumatic fenders; see 6.3), (*4*) testing of

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

fenders at 0° angle of approach, and (*5*) deflection (berthing) frequency of not less than 1 h (use a minimum 5-min deflection frequency for pneumatic fenders.).

3.1.3 Catalogues shall also include nominal performance tolerances as well as data and methodology to adjust performance curves or tables or both for application parameters different from RPD conditions. Adjustment factors shall be provided for the following variables: (*1*) other initial velocities: 0.05, 0.10, 0.20, 0.25, and 0.30 m/s; (*2*) other temperatures: +50, +40, +30, +10, 0, −10, −20, −30; and (*3*) other contact angles: 3, 5, 8, 10, 15°. In addition, RPD shall contain a cautionary statement that published data do not necessarily apply to constant-load and cyclic-loading conditions. In such cases, designers are to contact fender manufacturers for design assistance.

3.1.4 Adjustment factors for velocity and temperature shall be provided for every catalogue compound or other energy absorbing material offered by each manufacturer.

3.2 *Fender Testing*—Performance testing to establish RPD must use either one of two methods:

3.2.1 *Method A*—Deflection of full-size fenders at velocities inversely proportional to the percent of rated deflection or directly proportional to the square root of percent of remaining rated energy. Test parameters shall be as defined for published RPD. RPD tests shall start at 0.15 m ⁄s. Tests to establish adjustment factors for initial berthing velocities other than 0.15 m/s shall start at those other initial velocities.

3.2.2 *Method B*—Deflection of full size fenders at constant velocity with performance adjusted by velocity factors developed from model tests. Velocity factors shall be the ratio of performance test results of models under the following conditions: (*1*) a constant strain rate similar to the strain rate of the full-size fender at its test speed, and (*2*) decreasing speed deflection with initial strain rate similar to that of the full-size fender under RPD deflection conditions.

3.2.3 The RPD for pneumatic fenders shall be determined using either Method A or Method B with miniature-size fenders; in which case, the compression performance of air shall be directly extrapolated from the test data of reduced scale models.

4. Apparatus

4.1 The test apparatus shall be equipped with load cell(s) and linear transducer(s) capable of providing continuous monitoring of fender performance. The test apparatus shall be capable of recording and storing load-cell and transducer data at intervals of $<0.01\ H$, where H is a fender's nominal height, and storing manually entered inputs. Output information shall include, as a minimum:

4.1.1 Serial number and description of test item,

4.1.2 Date, time at start, and time at end of test,

4.1.3 Location of test facility and test apparatus ID,

4.1.4 Stabilization temperature of test specimen,

4.1.5 Test ambient temperature, and

4.1.6 Graphic plot(s) of: (*1*) deflection velocity versus deflection (optional) (If not plotted, deflection velocity and its characteristics shall be separately noted.), (*2*) reaction versus deflection, and (*3*) energy versus deflection.

4.2 For fender tests, all equipment used to measure and record force and deflection shall be calibrated and certified accurate to within ±1 %, in accordance with ISO or equivalent JIS or ASTM requirements. Calibration shall be performed within one year of the use of the equipment, or less, if the normal calibration interval is shorter than one year. Calibration of test apparatus shall be performed by a qualified third-party organization, using instrumentation that is traceable to a certified, national standard.

4.3 The test apparatus shall deflect specimens according to Section 5.

5. Procedure

5.1 The performance test shall deflect specimens according to either of the two methods listed below. Clear and unambiguous calculations must be provided for any adjustments made to the test results.

5.2 *Method A:*

NOTE 1—Steps 5.2.1 and 5.2.2 do not apply to pneumatic fenders. Step 5.2.3 may be omitted for pneumatic fenders, provided internal pressure is adjusted to the manufacturer's specified value for the ambient test temperature.

5.2.1 Break in the specimen by deflecting it three or more times to its rated deflection, or more, as recommended by the manufacturer.

5.2.2 Remove load from specimen and allow it to "recover" for 1 h or more, as recommended by manufacturer.

5.2.3 Before conducting performance test, stabilize fender temperature in accordance with 6.1. Temperature-stabilizing time can include time for 5.2.1 and 5.2.2.

5.2.4 Deflect specimen once at a continuously decreasing deflection velocity as defined in one of the equations below:

$$V = V_0\,(D - d)/D \text{ or } 0.005 \text{ m/s whichever is greater} \tag{1}$$

or

$$V = V_0\sqrt{(E - e)/E} \text{ or } 0.005 \text{ m/s whichever is greater} \tag{2}$$

where:

V = instantaneous deflection velocity of fender,
V_0 = initial deflection velocity, where $V_0 = 0.05$, 0.10, 0.15, 0.20, 0.25, or 0.30 m/s,
D = rated deflection,
d = instantaneous deflection,
E = rated energy absorption of fender, kN/m, and
e = instantaneous running total of energy absorbed, kN/m.

Initial velocity shall be appropriate for particular testing purpose.

5.2.5 Stop test when deflection reaches rated deflection, or more, as recommended by the manufacturer.

5.2.6 Adjust performance to rating temperature (23 ± 5°C), if required, or to desired application temperature by multiplying both energy and reaction results by temperature factor (*TF*) (see 6.3).

5.3 *Method B:*

NOTE 2—Steps 5.3.1 and 5.3.2 do not apply to pneumatic fenders. Step 5.3.3 may be omitted for pneumatic fenders, provided internal pressure is