Designation: F1093 − 99 (Reapproved 2012)

Standard Test Methods for Tensile Strength Characteristics of Oil Spill Response Boom[1]

This standard is issued under the fixed designation F1093; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover static laboratory tests of the strength of oil spill response boom under tensile loading.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.* For a specific hazard statement, see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F818 Terminology Relating to Spill Response Barriers

F962 Specification for Oil Spill Response Boom Connection: Z-Connector

3. Terminology

3.1 *Definitions:*

3.1.1 The following definitions, quoted from Terminology F818, are used in these test methods.

3.1.2 *anchor point*—a structural point on the end connector or along the length of a boom section designed for the attachment of anchor or mooring lines.

3.1.3 *ballast*—weight applied to the skirt to improve boom performance.

3.1.4 *boom section*—the length of boom between two end connectors.

3.1.5 *boom segment*—repetitive identical portion of the boom section.

3.1.6 *curtain-type boom*—a boom consisting of a flexible skirt supported by flotation. See Appendix X1.

3.1.7 *end connector*—a device permanently attached to the boom used for joining boom sections to one another or to other accessory devices.

3.1.8 *fence-type boom*—a boom consisting of self-supporting or stiffened membrane supported by floatation. See Appendix X1.

3.1.9 *float*—that separable component of a boom that provides buoyancy.

3.1.10 *freeboard*—the vertical height of the boom above the water line.

3.1.11 *hinge*—location between boom segments at which the boom can be folded back 180° upon itself.

3.1.12 *skirt*—the continuous portion of the boom below the floats.

3.1.13 *tension member*—any component which carries horizontal tension loads imposed on the boom.

4. Summary of Test Method

4.1 A specimen of spill containment boom is tested by subjecting the specimen to cyclic tests to 100 % of the manufacturer's rated tensile strength, and by applying tensile loading which progressively deforms the specimen to the point of failure. Similarly, a typical anchor point and towing device are tested in an additional tensile test. For each phase of the test, values of tensile load and deformation are observed and recorded, and modes of failure are described.

5. Significance and Use

5.1 Boom sections are frequently combined into assemblages hundreds of meters in length prior to towing through the water to a spill site. The friction of moving long boom assemblages through the water can impose high tensile stresses on boom segments near the tow vessel.

5.2 Tensile forces are also set up in a boom when it is being towed in a sweeping mode. The magnitude of this tensile force can be related to the immersed depth of the boom, the length 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.

boom involved, the width of the bight formed by the two towing vessels, and the speed of movement.

NOTE 1—When the towing speed exceeds about 1 knot (0.5 m/s), substantial oil will be lost under the boom.

5.3 Knowledge of maximum and allowable working tensile stresses will help in the selection of boom for a given application and will permit specification of safe towing and anchoring conditions for any given boom.

6. Apparatus

6.1 *Load Application Device*—A suitable load application device, such as a hydraulic jack, shall be provided. The device must be capable of applying loads somewhat in excess of the predicted failure load on the boom.

6.2 *Tensiometer*—A tensiometer shall be selected which will encompass the range of values from no load up to the maximum boom tensile load which might reasonably be expected prior to failure of the boom.

6.3 *End Supports*—The test bed provided shall have end supports of sufficient strength and rigidity to resist significant deformation under the maximum loads expected during testing.

6.4 *Towing Devices and Connectors*—At least one of the manufacturer's standard tow bridles or towing devices shall be used at the leading end of the boom specimen (where the load is applied). A similar tow bridle or towing device shall be used at the trailing end if the test apparatus is long enough. However, if it is not, the connector at the trailing end of the specimen may be attached directly to a connector fixed to that end support of the test apparatus. Suitable shackles, cables, chains, and so forth, shall be provided to connect the towing adapters to the test equipment, as diagrammed in Figs. 1-3.

6.5 *Gage Points*—Gage points shall be affixed to each end of the test specimen to facilitate measurement of elongation during the course of the test.

6.6 *Elongation Measurement Scale*—A suitable measuring device shall be provided so that elongation measurements may be made periodically throughout the test. The device shall have a precision equal or better than $1/1000$ th the distance between gage points (that is, 3 mm precision for 3 m gage point separation).

6.7 *Boom Specimens to be Tested*—Equipment shall be arranged to apply tensile loading to a specimen consisting of at least two complete boom segments of standard length as supplied by the manufacturer. Boom segments of less than standard length may be used for this test provided that the tension member length is proportional, the hinge area between them, the connector assemblies at each end, and the anchor point are fabricated identically to the manufacturer's full size standard boom section provided the total specimen is at least 10 ft (3 m) in length.

6.8 *Alternative Apparatus*—Because production lengths of boom are normally longer than 15 ft and because undue stress due to gravity forces may be placed on such boom if tested with the apparatus described above, the following described apparatus may be substituted. Test apparatus which lays the boom in a horizontal and continuously supported manner or one which provides support similar to that provided by the water (that is, a split table supporting the boom in an upright manner) will be satisfactory.

7. Hazards

7.1 Failure of a loaded containment boom can release a substantial amount of energy. During testing, personnel and equipment shall be positioned and protected so that sudden failure of the test specimen is unlikely to cause injury or damage.

8. Procedure

8.1 *Determination of Boom Tensile Strength:*

8.1.1 *Test Bed Preparation*—Prepare a test bed with two end supports separated with sufficient clearance for the boom specimen, two towing devices, and testing equipment as shown in Fig. 1. Mount the specimen with one towing device attached directly to one of the end supports. Alternately, the connector at the trailing end of the test specimen may be attached to a Specification F962 connector fixed to the end support of the test apparatus as shown in Fig. 2. The tensiometer is used to link the towing device at the other end of the boom specimen to the load application device and hence to the second end support. Suitable shackles, chains, cable, and so forth, can ordinarily be used for making connections. However, in some cases it may be necessary to design and fabricate special connecting devices to distribute loads satisfactorily.

8.1.2 *Cyclic Loading to 100 % of Manufacturers Rated Strength*—Load the boom specimen to 100 % of the manufacturer's rated tensile strength. Then reduce the load to 10 % of the manufacturer's rated strength. Note the positions of gage points on the specimen while under full tensile load, and at

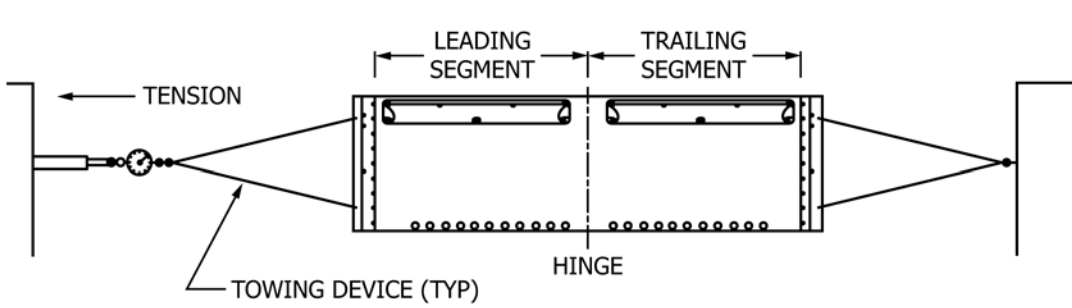

FIG. 1 Test Bed

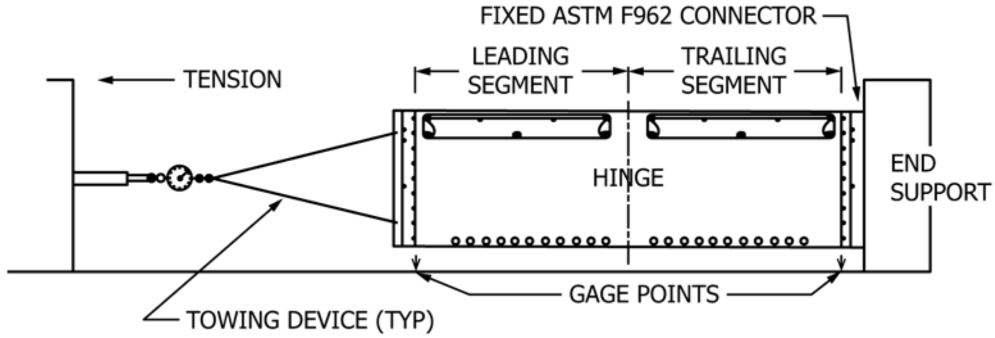

FIG. 2 Alternate Tensile Strength Test Bed

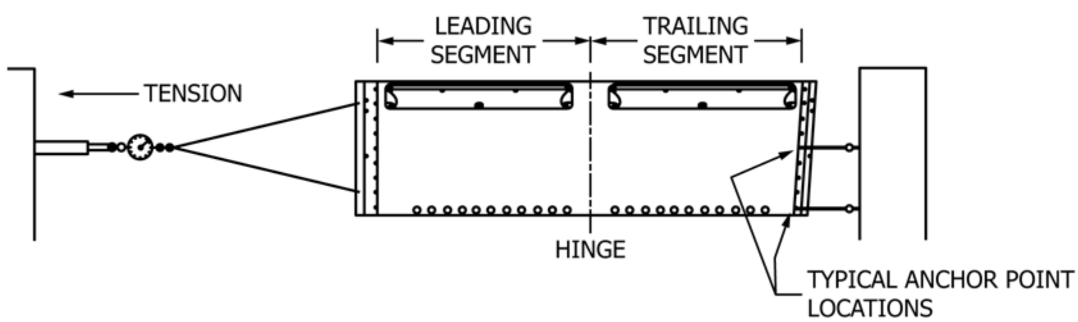

FIG. 3 Anchor Point Test

10 % of full tensile load. Then repeat this loading cycle until the specimen has been subjected to a total of ten complete cycles.

8.1.3 *Test to Ultimate Failure or Permanent Deformation*—If the specimen has not failed during the cyclic loading phase, it is then subjected to increasing loading until failure occurs. "Failure" is defined here as the inability to function or the rupture of the tension member, skirt material, or connector.

8.2 *Determination of Anchor Point Strength:*

8.2.1 *Test Bed Preparation*—Mount a second specimen, consisting of one or more standard boom segments, in the test bed with one end of the specimen attached to the tensiometer using a standard towing device, as in the previous portions of the test. The anchor point on the specimen is then linked to the other end of the test bed as shown in Fig. 3.

8.2.2 *Cyclic Loading*—Then apply progressively increasing loading to the specimen. If the manufacturer provides a rated anchor point strength, that value is used as the maximum load for the test. If the manufacturer does not provide such a strength rating, then the anchor point shall be subjected to a tensile loading of 50 % of the manufacturer's rated tensile strength for the boom. The positions of gage points on the specimen are noted while under full tensile load and at 10 % of full tensile load. This loading cycle is then repeated ten times.

8.2.3 *Test to Ultimate Failure or Permanent Deformation*—If the specimen has not failed during the cyclic loading phase, it is then subjected to increased loading until failure occurs. Failure is defined here as the inability to function or the rupture of the tension member, skirt, material, anchor point hardware or connector.

9. Report

9.1 The test report shall provide a description of the boom tested, including the name of the manufacturer and model number. For each phase of the test, values shall be reported for length of specimen and initial positions of gage points. The report shall also provide a tabulation with columns for periodically observed data including boom elongation values, load values, and notes regarding any damage to boom fabric or other components. Consideration should be given to recording all gage point positions and tensiometer values photographically. During the test to ultimate failure, sufficient data shall be taken to permit plotting a curve of deformation versus loading. The ultimate loading on the boom or anchor point at the time of failure shall be recorded.

9.2 The report shall also include photographs and descriptions of any damage observed. The report shall identify boom components involved in the failures and provide descriptions of how the failures occurred.

9.3 Any deviations from the test procedures or specimens described above shall be identified with reasons for such deviations given.

APPENDIX

(Nonmandatory Information)

X1. BACKGROUND DISCUSSION

X1.1 In general, oil spill response boom designs provide one or more floatation elements which provide buoyancy to support the boom assembly in the water, a membrane which prevents floating material such as oil from passing from one side of the boom to the other, and one or more tension members which transfer tensile loads along the boom. In some designs the membrane material also acts as a tensile member. Boom designs may also provide for ballast to help position and stabilize the boom in the water. Additionally, boom is generally manufactured in sections to facilitate handling and application in a variety of situations. Sections are joined one to another using end connectors.

X1.2 Boom designs can be classified as fence-type or as curtain-type. Fence booms typically provide a stiffened barrier designed to float vertically in the water. One or more horizontal tension members may be used, positioned to minimize any tendency of the boom section to rotate under an applied load. Curtain booms are provided with flexible material for the under water portion of the membrane (called the skirt). One or more tension members are typically located at or near the bottom of the membrane.[3]

X1.3 Towing adapters, for towing or attachment to fixed objects, may be provided by the boom manufacturer or fabricated by the user. Because of their differences in design, fence boom and curtain boom handle tensile loads quite differently, and towing adapter designs must take this difference into account.

[3] Schulze, R., *World Catalog of oil Spill Response Products: Complete Listing of Booms and Skimmers*. Port City Press, Baltimore, 1986, contains additional background information and a compendium of data on commercially available booms.