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Standard Guide for Collecting Performance Data on Temporary Storage Devices[1]

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1. Scope

1.1 This guide covers a guideline for measuring the performance parameters of full-scale temporary storage devices that would be used to store oil and oil-water mixtures.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*Specific precautionary statements are given in 6.2.

1.4 *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]

F625 Practice for Classifying Water Bodies for Spill Control Systems

F631 Guide for Collecting Skimmer Performance Data in Controlled Environments

F715 Test Methods for Coated Fabrics Used for Oil Spill Control and Storage

3. Terminology

3.1 *Definitions:*

3.1.1 *Design Terminology—Terms Associated With Temporary Storage Device Design:*

3.1.2 *accessories—optional* mechanical devices used on or in conjunction with a temporary storage device system but not included with the basic storage device and hose connectors, that is, lights, paravanes, buoys, anchor systems, storage bags, repair kits, etc.

3.1.3 *ancillary equipment*—mechanical devices necessary to the operation of a given temporary storage device system, for example, air pumps, hydraulic power supplies, control manifolds, etc.

3.1.4 *ballast*—the weight applied to the device to improve performance.

3.1.5 *container body*—the continuous portion of the device that serves to provide structural strength and shape to the device to contain the stored material.

3.1.6 *device weight*—the dry weight of a fully assembled temporary storage device.

3.1.7 *draft*—the maximum vertical dimension of the device below the water line.

3.1.8 *flotation*—that portion of the device that provides buoyancy.

3.1.9 *freeboard*—the minimum vertical height of the device above the water line; for open devices, this is the minimum height at which water can enter it.

3.1.10 *handhold*—any strap, handle, depression, or other provision for grasping the device by hand.

3.1.11 *lifting point*—the structural point(s) on the device designed for the attachment of a lifting device, such as a crane.

3.1.12 *liner*—accessory or ancillary equipment that provides containment within the container body.

3.1.13 *mooring point*—the structural point(s) along the length of the device designed for the attachment of anchor or mooring lines.

3.1.14 *overall height*—the maximum vertical dimension of the device.

3.1.15 *sail*—the maximum vertical height of the device above the water-line.

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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.

3.1.16 *shipping weight*—the weight of the device when packaged for transportation.

3.1.17 *shipping volume*—the volume of the device when packaged for transportation.

3.1.18 *stiffener*—a component that provides support to the device.

3.1.19 *temporary storage device*—a collapsible device used to store fluids temporarily.

3.1.20 *tension member*—any component that carries tension loads imposed on the device.

3.1.21 *tow point*—structural point(s) on the device designed for the attachment of towing lines.

3.1.22 *Engineering Terminology— Terms Associated With Temporary Storage Device Engineering:*

3.1.23 *drag force*—the resisting force on a device that results from it being towed.

3.1.24 *gross buoyancy*—the weight of fresh water displaced by the device at the point of submergence.

3.1.25 *gross buoyancy to weight ratio*—the gross buoyancy divided by device weight.

3.1.26 *heave response*—the ability of the device to react to the vertical motion of the water surface.

3.1.27 *maximum capacity*—the maximum volumetric capacity of the device as calculated from physical dimensions.

3.1.28 *maximum dynamic load*—the sum of all instantaneous dynamic loads, including those due to acceleration, wave forces, etc.

3.1.29 *operational capacity*—the maximum volumetric capacity of the device per application.

3.1.30 *pitch response*—the tendency of the device to oscillate about its lateral axis.

3.1.31 *rated pressure*—the maximum continuous operating pressure of the device, as specified by the manufacturer.

3.1.32 *reserve buoyancy*—the gross buoyancy minus device weight.

3.1.33 *reserve buoyancy to weight ratio*—the reserve buoyancy divided by device weight.

3.1.34 *roll response*—the tendency of the device to rotate about its longitudinal axis due to wave, wind, or current forces.

3.1.35 *yaw response*—the tendency of the device to oscillate about its vertical axis.

3.1.36 *Classification Terminology:*

3.1.37 *pillow tank*—a closed, generally rectangular or round coated fabric tank.

3.1.38 *open pool*—an open, generally rectangular or round coated fabric tank, similar in structure to a "wading pool."

3.1.39 *towable pillow tank*—similar to a pillow tank used on land or on deck, but generally made of heavier material and having special rigging for towing.

3.1.40 *towable flexible tank*—a storage device that is generally long and cylindrical in shape and, when full, is largely submerged, characterized by flexibility along the length of the device.

3.1.41 *towable open tank*—an open, inflatable, barge-type vessel that resembles a large inflatable boat, characterized by a portion of the top surface being open to atmosphere.

4. Significance and Use

4.1 This guide covers the collection of quantitative data in the form of storage capacity, strength of materials, filling and offloading rates, and towability under controlled test conditions. The data can be used for evaluating the design characteristics of a particular temporary storage device or as a means of comparing two or more devices. Caution must be exercised whenever the test data are used to predict performance in actual spill situations since the uncontrolled environmental conditions that affect performance in the field are rarely identical to conditions in the test facility. Other variables such as mechanical reliability, the presence of debris, ease of repair, required operator training, operator fatigue, and transportability also affect performance in an actual spill but are not included in this guide. These variables should be considered along with the test data when making comparisons or evaluations of temporary storage devices.

4.2 Although this guide provides data on the performance of temporary storage devices, all of the combinations of actual conditions of use are not simulated in this series of tests. In particular, the resistance of the device to grounding, abrasion resistance of the container body, venting of the device during loading, and other operational issues not covered by this guide should be considered along with the test data when making comparisons or evaluations of temporary storage devices.

5. Overall Observations

5.1 For each of the tests that follow, the total manpower required to conduct the procedure and the required ancillary equipment will be noted in the test record. In addition, the total elapsed time for each portion of the tests will be noted.

5.2 Observations of the buoyancy and stability of the deployed device will be made for the marine testing of towable devices.

5.3 Any observations relative to safety will be entered as part of the test record. These should include any hazardous conditions noted and limitations due to weather conditions, as well as any safety precautions that were observed or should be observed. If the manufacturer's specified operating procedures are found to be deficient relative to safety observations, this should be noted.

5.4 The test series should be videotaped to document the tests and procedures.

6. Initial (Static) Loading Tests

6.1 The storage device, and any enclosed ancillary equipment (for example, flotation collars), should be subjected to the following tests using air or dyed water, as appropriate, in order to confirm the structural integrity and evaluate (qualitatively) any leakage. The following is presented as a guideline in the absence of manufacturer-supplied guidelines for performing initial loading tests.

6.2 Overpressure tests can be extremely dangerous, and precautions should be taken against the possibility of sudden and complete failure of the device. The following tests use large volumes of water or pressurized air, or both, that could cause injury to personnel and serious damage to property if released suddenly.

6.3 *Closed Devices and Enclosed Ancillaries:*

6.3.1 *Leak Test*—The storage device should be inflated with air to a test pressure, calculated as follows:

$$P = \frac{\sigma}{15r}$$

where:

P = test pressure (Pa),
σ = minimum ultimate tensile strength of material (N/m), and
r = radius of largest section (m).

6.3.2 Allow the storage device to stand for 30 min at the test pressure ±10 %. Maintaining the test pressure within ±10 %, apply a soapy water solution liberally to the seam areas, fitting joints, valves, and all fabric areas. Record and mark air seepage.

NOTE 1—The inspector must determine what is an acceptable leak since some small air leaks may not necessarily mean that a liquid would leak through the same hole. Also, some air bubbles may be caused by air forced out between the fabric layers and would not cause a liquid leak.

6.3.2.1 Mark and record the location and extent of any surface or seam irregularities, blisters, or cracks. Recheck these areas carefully for leaks. The inspector must determine the acceptable level of such surface irregularities.

6.3.3 The storage device may be re-tested if leaks can be stopped by tightening the fittings or by minor permanent repairs.

6.3.4 *Overpressure*—Pressurize the device to 150 % of the rated pressure (defined in 4.2). Hold for 30 min, and then reduce the pressure to a safe level and inspect for leaks.

6.3.5 If the device exhibits leaks that are not structural failures, rework it and repeat the leak test of 6.3.1. If the device exhibits leaks that are from structural failure (that is, loose seams, fabric failure, etc.), rework it as necessary and repeat the overpressure test of 6.3.4.

6.3.6 Closed devices may also be tested using the procedures of 6.4 to determine whether minor air bubble leaks permit water to leak through the fabric.

6.4 *Open Devices:*

6.4.1 *Leak Test*—The following leak test for open devices can be performed only with the device out of water. If the device cannot be suspended to allow observation of its bottom when full, a sheet of white water sorbent cloth should be placed under it to indicate leaks.

6.4.2 Fill the device with water to its full operating level. Color the water with a water marker dye that provides a good color contrast with the storage device and sorbent cloth. Allow the device to stand for 2 h.

6.4.3 Observe and mark obvious leaks. Wipe the seam and leaking areas with a white water sorbent cloth, and determine whether colored water has leaked through. Mark and record the leaks. No splits or blisters in the coating or seams shall be acceptable.

6.4.4 The storage device may be re-tested if the leaks can be stopped by tightening the fittings or by minor permanent repairs.

7. Deployment, Loading, and Towing Tests

7.1 *General*—A visual examination of the device will be conducted once the temporary storage device has been made ready for deployment. The material specifications and operational limitations of the hose coupling mechanisms and any other fittings, such as towing bridle, drogue attachments, or securing devices, should be recorded.

7.2 *Towable Devices:*

7.2.1 A test of launching from a pier and preparation for deployment by a towing vessel will be conducted by following the manufacturer's instructions for break-out, deployment, and preparation for towing. The test will be considered concluded when the predesignated vessel is able to tow the device away from the dock in a safe and proper configuration.

7.2.2 Towing tests should be conducted under a range of environmental conditions appropriate to the device's intended use. (Classification criteria for calm, protected, and open water are given in Practice F625.) Any differences during the test should be noted as conditions change. The test will be conducted by following the manufacturer's instructions or, in the absence thereof, by the opinion of the vessel operator for the most suitable course for the launching, filling, towing, and recovery operation. The test will be considered concluded when the response vessel has completed all towing tests and recovered and stowed the device in a safe and proper configuration.

7.2.3 While towing the device, the required towing force will be measured as a function of increasing tow speed. Dynamic loads should be measured using a recently calibrated load cell. During the towing tests, manufacturer-specified maximum design loads must be respected with due regard to maximum dynamic load.

7.2.4 Observations should be noted in the test record concerning the device behavior as the towing speed and wave approach angle are varied. Observations of stability should include vertical stability, twisting, diving, snaking, and yawing. Any distortion of the device or other problem causing instability, loss of recovered product, or unacceptable list, trim, or bow submergence should be noted. The draft and freeboard of the device should be noted in the test record for each of the loading conditions tested.

7.2.5 During the progress of the test, careful monitoring must take place to detect the following: wave-induced motions and inertial or free-surface effects, particularly as they may affect control and maneuverability; pitch, roll, heave, and bow submergence; leaks from vents, gages, loading hoses, and the container body; and breakaway or damage to external flotation or buoyancy devices.

7.2.6 If any of the previously listed or other problems develop during the test, they should be described fully in the test report, including notation of the following data: time,

volume and nature of fluid in the device, direction of impact of the waves, speed at which the device was under tow, and any towing vessel action that may have influenced the problem.

7.2.7 *Empty Temporary Storage Device Towing Test:*

7.2.7.1 The test should be begun by towing the device in an empty condition. The speed should be built up gradually to the manufacturer's recommended maximum towing speed. If it is not possible or practical to attain or maintain this speed, the reasons will be noted and entered as part of the test record. The test should continue at the highest speed practical.

7.2.7.2 While towing the device, it should be subjected to a variety of wave conditions and to varying angles of attack. At 5 min intervals, the movement of the device should be varied in 45-degree increments such that the device encounters waves from each of eight directions.

7.2.8 *Loading Device to Half-Full:*

7.2.8.1 At this point, the testing should pause and the device be prepared for loading. A hose should be connected to the device, and any venting or gaging devices should be checked for proper mounting or operation in accordance with the manufacturer's instructions.

7.2.8.2 The device should then be filled through this hose by a pump that will take suction from a source of dyed water. The loading system should include a flow totalizer or other apparatus to measure the volume of fluid delivered to the device. The pump must be equipped with a quick-acting shut-off device immediately accessible to the volume-measuring apparatus and in view of the device in the water. The filling line should be equipped with a check valve device that will prevent any backflow or siphoning once the pump has been stopped. Care must be taken to ensure that the suction remains immersed fully in the water supply and that no air is delivered accidentally to the temporary storage device. Additional care should be taken to reduce the flow rate when the desired load is approached in order to prevent overfilling.

7.2.8.3 During the course of the loading operation, the functioning of the vents and gaging mechanisms will be noted and entered as part of the test record. In particular, the possibility of the mechanisms admitting sea water to the device due to submergence should be addressed. While this may be unlikely when loading operations are forcing product into the device, similar submergence of a mechanism while the pumping is discontinued could cause such a result.

7.2.9 *Half-Full Tow Test*—The towing test should then be repeated starting with the step given in 7.2.7.1. Observations of stability should be noted in the test record when the towing speed is resumed.

7.2.10 *Loading Device to Operational Capacity:*

7.2.10.1 Testing should pause at this point, and the device should be filled to its operational capacity following the steps given in 7.2.8. Care should be exercised and the flow rate reduced as the operational capacity is approached to prevent damage to the device due to improper or inadequate functioning of the venting mechanisms.

7.2.10.2 Once the temporary storage device has been filled to its operational capacity, its behavior in the water will be evaluated. This capacity should be recorded as the verified operational capacity if the buoyancy of the device meets the manufacturer-specified design criteria.

7.2.10.3 If the temporary storage device, having been filled to its operational capacity, exhibits negative or neutrally buoyant behavior, the device may not function properly for sediment-contaminated heavy oils. Reduction of the capacity would not necessarily improve the performance of the device. This capacity should be recorded in such cases as the verified provisional capacity. Devices exhibiting this problem may be functional for most uses. However, if further testing is desired, some of the performance-related protocols would have to be altered to provide a filling fluid less dense than that in which the device must float. Filling the device with fresh water while conducting the tests in salt water may suffice.

7.2.10.4 After loading the device to its operational capacity, and depending on the testing or test platform environment, the temporary storage device should be monitored for a period of up to 12 h in order to ascertain the integrity of the device subsequent to loading. The device will be monitored for 2 h prior to resuming towing tests at a minimum. Any leakage from the device during the loading operation or subsequent monitoring period should be noted in the test record.

7.2.11 *Full Temporary Storage Device Towing Test:*

7.2.11.1 The towing test should be repeated starting with the step given in 7.2.7.1. Observations of stability should be noted in the test record when the towing speed is resumed.

7.2.11.2 During the towing tests in which the device is filled to its operational capacity, the internal pressure of the contained fluid should be measured to ensure that it does not exceed that recommended by the manufacturer as the maximum allowable.

7.2.12 *Post-Test Monitoring:*

7.2.12.1 At the conclusion of the towing operation, the temporary storage device will be monitored for a minimum period of 12 h, depending on the test facility, in order to ascertain the integrity of the device subsequent to towing. The actual monitoring period should be noted in the test record if the duration of the monitoring is less than 12 h. Any leakage from the device during the towing operation or subsequent monitoring period should be noted in the test record.

7.2.12.2 At the completion of the towing and subsequent monitoring, the temporary storage device will be drained, recovered from the water to the response vessel or a pier, and stowed in the manufacturer's recommended configuration. A summary of the maintenance and cleaning completed to meet the manufacturer's stowage requirements should be noted in the test record.

7.3 *Stationary Devices:*

7.3.1 The first test of deployment will be conducted by following the manufacturer's instructions for break-out, deployment, and erection of the device. The test will be considered concluded when the device is in a safe and proper configuration and ready to receive fluids.

7.3.2 A hose should be connected to the device, and any venting or gaging devices should be checked for proper mounting or operation in accordance with the manufacturer's instructions.

7.3.3 The device should be filled as described in 7.2.8.2 and 7.2.8.3 for towable devices.

7.3.4 After loading the device to its operational capacity, it will be monitored for a period of 12 h in order to ascertain the integrity of the device subsequent to loading. Any leakage from the device during the loading operation or subsequent monitoring period should be noted in the test record.

7.3.5 The device will be disassembled and stored according to the manufacturer's instructions at the completion of the monitoring period. A summary of the maintenance and cleaning completed to meet the manufacturer's stowage requirements should be noted in the test record.

8. Off-Loading Tests

8.1 Additional off-loading tests with a viscous fluid may be desirable to determine any limiting features of the storage device. If additional off-loading tests are conducted with oil, the testing should be performed within secondary containment to contain any possible spillage.

8.2 The temporary storage device will be filled to its operational capacity with a test oil. This oil should be selected based on the intended application of the device. (For comparability with skimmer tests, recommended test viscosities are given in Guide F631.) Loading procedures are detailed in 7.2.8.2. Particular attention should be given to measuring the volume of fluid admitted to the device accurately, in order to estimate the residual amount of fluid after off-loading subsequently.

8.3 A timed test should commence with application of the instructions of the manufacturer of the temporary storage device for off-loading the recovered product. A total of all man-hours expended in the off-loading task will be calculated and entered as part of the test record. Note in the test record whether the time for off-loading is limited by either the storage device or the pump used to off-load.

8.4 Observe the device for any residual amounts of the testing fluid upon completing the off-loading operation. Record an estimate of the residual volume, and an explanation for the amount of residual remaining, if possible.

9. Container Body Tests

9.1 Tests for fabrics used in temporary storage devices are specified in Method F715. The tests include base line tests of the container body material and tests for weather and petroleum resistance. Tests should be selected from Method F715 appropriate to the intended service of the storage device.

10. Test Report

10.1 Prepare a report of the test series in tabular format, including a summary of the measured and observed results, the manufacturer's specified data, and any other features relevant to the operation of the device but not tested in this guide. The following summarizes the key data included in this guide:

10.1.1 *Static Loading*—Qualitative observations of leakage when subjected to normal operating pressure and over-pressure conditions.

10.1.2 *Deployment, Loading, and Towing*—Observations of buoyancy, stability, draft, and freeboard and measurements of average and instantaneous tow loads at various loaded conditions; observations of functioning of vents, gages, and other ancillary equipment during loading; observations of leakage during and subsequent to loading; and verification of device capacity. Include the following in the test report: the frequency characteristics of the load cell and recording device, a summary of the environmental conditions present during the test series, and a comparison of the density of the test fluid relative to the waterbody in which the test is conducted.

10.1.3 *Off-Loading*—Measurement of residual fluid volume following off-loading, and observation of device-limiting features that may hinder off-loading.

10.1.4 *Container Body Tests*—Measurement of container body characteristics: baseline strength, weather, and petroleum resistance.

10.1.5 *Overall Observations*—Time, equipment, and manpower to complete break-out, deployment, launching, recovery, maintenance, cleaning, and stowage; observations of hazardous conditions relating to operation of the device; and deficiencies in manufacturer-specified procedures.

10.1.6 *Manufacturer Supplied Data*—Requirements for maintenance, cleaning, lay-up, inspection, and stowage; and safe working loads for load bearing fittings, including the following: lifting points, tow points, tie-downs, hand-holds, and hose fittings.

11. Keywords

11.1 oil spill; storage device; temporary storage device