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Standard Guide for Testing Advancing Skimming Systems¹

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1. Scope

1.1 This guide defines a procedure and the measurement criteria to quantify the performance of an advancing skimming system for use in oil spill response.

1.2 This guide is designed to provide data that can be used as inputs to the Estimated Recovery System Potential (ERSP) Calculator,² a planning tool that estimates the performance of an advancing skimming system for each of the first three days following the instantaneous discharge of a batch oil spill, or daily for an ongoing continuous discharge of oil.

1.3 This guide includes the option of testing in waves if the device is intended for nearshore or offshore conditions, and the user wants to use values for throughput efficiency that are greater than the default values in the ERSP Calculator.

1.4 It is accepted that the measured fluid recovery rate, throughput efficiency, and recovery efficiency, as determined by this guide may be higher than what is typically achievable under actual conditions of a spill. However, the results are intended to provide a reasonable estimate of skimmer performance in the conditions simulated in the ERSP Calculator.

1.5 This guide involves the use of test oils that may be considered hazardous materials. It is the responsibility of the user of this guide to procure and abide by necessary permits, regulations, safety, and health considerations for the use and disposal of test oil.

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

1.7 *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 appro-*

priate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.8 *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:³

F625 Practice for Classifying Water Bodies for Spill Control Systems

F631 Guide for Collecting Skimmer Performance Data in Controlled Environments

F818 Terminology Relating to Spill Response Booms and Barriers

F2709 Test Method for Determining a Measured Nameplate Recovery Rate of Stationary Oil Skimmer Systems

3. Terminology

3.1 Definitions:

3.1.1 *advancing skimming system, n*—a system operating in advancing mode (at a speed of advance of 0.4 m/s or greater) to recover oil spilled on the water surface; the system may include containment boom used to collect oil and direct it to the skimmer.

3.1.1.1 *Discussion*—Other ancillary equipment, such as on-board storage, discharge pumps used for decanting or to transfer recovered product, secondary storage, and support vessels, are not tested as part of this protocol.

3.1.2 *fluid recovery rate, n*—the volume of fluid recovered by the device per unit of time (m^3/h). **F631**

3.1.3 *level 1, n*—test parameters based on the ERSP Calculator spill scenario, which specifies an encounter rate based on a 2.5 mm (0.1 in.) slick thickness.

3.1.4 *level 2, n*—alternative test parameters to Level 1, which could include thinner or thicker slicks.

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² Estimated Recovery System Potential (ERSP) Calculator (also known as the Effective Daily Recovery Capacity (EDRC) planning tool). Note that the ERSP Calculator is exclusively in Imperial units. From the Bureau of Safety and Environmental Enforcement (BSEE). Default values found in the ERSP Calculator User Manual. Available at: <https://www.bsee.gov/what-we-do/oil-spill-preparedness/response-system-planning-calculators>.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.5 *oil recovery rate, n*—the volume of oil recovered by the device per unit of time (m^3/h). **F631**

3.1.6 *oil slick encounter rate, n*—the volume of oil slick per unit time actively encountered by the skimmer, and therefore available for recovery (m^3/h). **F631**

3.1.7 *recovery efficiency (RE), n*—the ratio, expressed as a percentage, of the volume of oil recovered to the volume of total fluids recovered. **F2709**

3.1.8 *speed of advance (SOA), n*—the forward speed of the system (m/s).

3.1.9 *steady state collection period, n*—timed period of test for measuring recovery rates (Oil Recovery Rate (ORR) and Fluid Recovery Rate (FRR)), with skimmer operating at steady collection rate and speed of advancement (s).

3.1.10 *sweep width (aka swath), n*—width intercepted by a boom in collection mode, the projected distance between the ends of a boom deployed in a “U,” “V,” or “J” configuration. **F818**

3.1.11 *test duration, n*—length of time from beginning of a test (including getting system up to target speed of advancement and initial operation of collection and recovery equipment to purge any residual fluid from previous tests in the system and recovery hoses), running at steady state conditions, final recovery, and repositioning of equipment back to the starting position (if necessary).

3.1.12 *throughput efficiency (TE), n*—the ratio, expressed as a percentage, of the volume of oil recovered to the volume of oil encountered. **F631**

3.1.13 *untimed portion of test, n*—final portion of a test following the steady-state collection period where oil that was deposited in front of the skimming system is collected for throughput efficiency calculations.

3.1.14 *wave height (significant wave height), n*—the average height, measured crest to trough, of the one-third highest waves, considering only short-period waves (that is, period less than 10 s), (m). **F625**

4. Significance and Use

4.1 Current industry practice has been to claim the capacity of a skimmer based on the throughput of the discharge pump (which is typically measured using water as a test fluid) and then applying a de-rating factor to account for various inefficiencies.

4.2 Existing test protocols (for example, Guide **F631** and Test Method **F2709**) measure stationary or possibly slowly advancing skimmers. This guide will assist spill response equipment manufacturers and users to verify and accurately report skimming system performance for advancing skimmer systems operating at 0.4 m/s (~ 0.75 kt) or greater.

4.3 The Bureau of Safety and Environmental Enforcement (BSEE) recently developed a new planning tool – known as the Estimated Recovery System Potential (ERSP) Calculator² – to better estimate the performance of an advancing skimming system as it encounters, contains, recovers, stores, and offloads its recovered fluids to secondary storage. A test method was

required to provide data for this calculator for users that wish to use values that are different from the default settings.

4.4 The ERSP Calculator requires inputs specific to the skimming system including its speed of advance, its sweep width (which is used to calculate the oil encounter rate), maximum total fluid recovery rate, throughput efficiency, and recovery efficiency. This guide is designed to simulate the system’s speed of advance and oil encounter rate to provide data on the skimmer’s maximum total fluid recovery rate, throughput efficiency, and recovery efficiency.

4.5 This guide encourages performance testing using one or more oil types for comparison purposes.

4.6 Tests shall be conducted under well-documented conditions and generate repeatable results. Alternative test methods for collection of skimmer performance are covered under existing standards (for example, Guide **F631**).

4.7 For skimming systems that include more than one option for the discharge pump, the test described in this guide may be used to measure the performance of the skimming component of the system. Performance of the pumping component can be measured independently using the same viscosity of oil and the discharge head conditions noted in this guide. The measured recovery rate of any specified skimming component and pump combination would be the lesser of the skimming component and the pump capacity.

5. Oil Type and Properties

5.1 Test oils for use with this guide should be selected to fall within the parameters specified in **Table 1** (from Guide **F631**), specifically: viscosity, interfacial and surface tension, and specific gravity (these oils may be crude, refined, or simulated).

5.2 If crude oil is used, it should be weathered to reduce hazardous vapors, more accurately simulate the conditions likely to be found in an actual spill response, and minimize subsequent property changes, specifically density and viscosity. The intent is to use an oil that is moderately weathered, which resembles conditions in the first few days after a large spill.

5.3 The ERSP Calculator estimates the potential for system performance for the first three days of a spill. However, it does not consider how emulsification of the oil may affect a skimming system’s performance, and testing of recovery of emulsions is not required. Emulsification of oil that occurs as the skimming system recovers oil during these tests is measured.

5.4 The ERSP Calculator does not differentiate outputs based on the type of oil or product being recovered. Its design assumptions most closely approximate the spreading and emulsion characteristics of categories II, III, and IV oils. It is a less accurate predictor of non-persistent category I oils such as gasoline or diesel fuel. Therefore, it is recommended that testing be done with category II oil from **Table 1** as it most closely mimics a moderately weathered crude oil and is readily available in appropriate quantities. Exceptions to this recommendation are for those skimmers specifically designed for a

TABLE 1 Candidate Test Oils

NOTE 1—Test oils should be selected to fall within these five categories.

	Viscosity, mm ² /s	Density, g/mL	Oil-Air Interfacial Tension, mN/m	Oil-Water Interfacial Tension, mN/m	Pour Point, °C
I ^A	150 to 250	0.90 to 0.93	28 to 34	20 to 30	< -3
II ^B	1500 to 2500	0.92 to 0.95	30 to 40	20 to 30	< -3
III ^C	17 000 to 23 000	0.95 to 0.98	20 to 40	20 to 40	< 10
IV ^D	50 000 to 70 000	0.96 to 0.99	20 to 40	20 to 40	...
V ^E	130 000 to 170 000	0.96 to 0.99	20 to 40	20 to 40	...

^A 1) Alaska North Slope crude oil, 10 % to 15 % weathered by volume.

2) Fuel oil No. 4 (heavy); can be prepared by blending 40 % fuel oil No. 2 and 60 % fuel oil No. 6.

^B Fuel oil No. 5; can be prepared by blending 20 % to 25 % fuel oil No. 2 with 75 % to 80 % fuel oil No. 6.

^C Residual fuel oil (that is, fuel oil No. 6 prepared to above criteria).

^D Residual fuel oil (that is, heavy cut of fuel oil No. 6).

^E Emulsified crude oil, 50 % to 80 % water content. The oil may be emulsified by blowing compressed air through water on which the oil is floating.

particular oil type. Equipment manufacturer's guidance should be followed in this instance.

5.5 Regular measurements of the test oil physical properties may be needed throughout the tests to ensure they fall within specifications. If the properties of the test oils vary significantly from the recommended ranges, the test report shall discuss the implications of such deviations on the performance of the device.

5.6 The viscosity of oil varies greatly with temperature. Frequently, test oils must be distributed in the test facility at temperatures different from the water temperature. In these situations, the oil will usually quickly reach the surface water temperature of the tank.

5.7 If oils that originally meet the conditions stated in **Table 1** are reused in subsequent tests, their properties may change and should be evaluated prior to reuse.

6. Oil Slick Thickness and Distribution

6.1 Level 1 (minimum required slick thickness):

6.1.1 The default slick thickness assigned for Day 1 of a spill response in the ERSP Calculator (Level 1) is 2.5 mm (0.0025 m).

6.1.2 The test shall be designed to place the skimmer or collection well of the system in a similar operating condition to what is expected when deployed in the field.

6.1.3 The volumetric rate of oil that is distributed in front of the advancing skimmer system is calculated by applying a formula of:

$$V_R = W \cdot SOA \cdot t \cdot 3600 \text{ s/h} \quad (1)$$

where:

V_R = the volumetric rate of oil m³/h,

W = the sweep width (m),

SOA = the speed of advance (m/s), and

t = the slick thickness (m) (0.0025 m is specified).

6.1.4 The oil should be distributed in front of the advancing skimming system across as much of the sweep width as possible.

6.1.5 It is possible that the skimmer may not be capable of recovering the calculated volumetric rate of oil. In this case the oil encounter rate should be reduced to match the recovery rate of the skimmer being tested. This may be accomplished by reducing the speed of advance (but not below 0.4 m/s) or by reducing the sweep width. The slick thickness shall be kept to 2.5 mm for Level 1 testing.

6.1.6 The volumetric rate may be adjusted to reflect expected oil entrainment (losses) if data is available. For example, if the guide boom is predicted to capture 80 % of the oil encountered at the entry to the skimming swath, then V_R should be reduced by 20 %.

6.1.7 If the fielded (operational) sweep width exceeds the width of the testing facility, guide boom should be deployed at the angle normally found in full-scale deployment and V_R should be calculated using the fielded (operational) swath.

6.2 Level 2 (optional alternative slick thickness testing):

6.2.1 Additional testing may be performed at slick thicknesses other than Level 1 conditions. These tests are optional and may be performed at the manufacturer's discretion. For example, the manufacturer may wish to test the skimmer at a volumetric rate greater than the Level 1 slick thickness, for example to investigate higher or maximum ORR. Similarly, slick thicknesses less than 2.5 mm may be conducted to investigate skimmer performance later in a spill response or at smaller spills. In no case shall tests be performed at a speed of advance of less than 0.4 m/s (0.75 knots).

6.2.2 It will be up to the test operators to design the booming and towing system to provide the desired slick thickness at the intended towing speeds. If feasible, additional testing may be conducted to determine the maximum effective speed/slick thickness condition that the skimmer may achieve.

6.3 The oil should be dispensed such that it creates a quiescent slick in front of the skimmer. Discharging in a downward biased stream should be avoided to minimize plunging that may lead to premature entrainment under the collection system.