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Standard Guide for Selection of Skimmers for Oil-Spill Response[1]

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1. Scope

1.1 This guide covers considerations for selecting skimmer systems for the recovery of marine-oil spills. The purpose of this guide is to provide oil spill response planners, equipment manufacturers, users, and government agencies with a standard on the equipment selection process for the removal of oil from the marine environment.

1.2 This guide does not address the compatibility of spill-control equipment with spill products. It is the user's responsibility to ensure that any equipment selected is compatible with anticipated products and conditions.

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

1.4 *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.*

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

3. Terminology

3.1 *Definitions:*

3.1.1 *encounter rate*—the volume of oil per unit time actively directed to the removal mechanism. **F631**

3.1.2 *nameplate recovery rate*—the maximum skimming capacity of a device under optimum conditions of oil type, slick conditions, and environmental conditions.

3.1.3 *oil recovery rate*—the volume of oil recovered by the device per unit time. **F631**

3.1.4 *recovery efficiency*—the ratio, expressed as a percentage, of the volume of oil recovered to the volume of total fluids recovered. **F631**

3.1.5 *throughput efficiency*—the ratio, expressed as a percentage, of the volume of oil recovered to the volume of oil encountered. **F631**

4. Significance and Use

4.1 This guide is intended to facilitate the oil spill response equipment selection process for local, regional, and national spill response teams. It is not intended to define rigid sets of equipment standards.

4.2 The effectiveness of the equipment chosen to combat an oil spill will depend on the oil type and environment(s) encountered, as well as other factors. This guide is intended to be used by persons generally familiar with the practical aspects of oil spill cleanup operations including on-scene response coordinators, planners, oil spill management teams, oil spill removal organizations, and plan evaluators.

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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.

4.3 Eleven general types of skimming systems are described in this guide. Each description includes a summary of the operating principle and a list of selection considerations.

4.4 Selection considerations are included to guide the user on the selection of a particular skimmer type or category. Users are cautioned that within each category there may be a wide variation in performance among various skimmers.

4.5 When selecting a skimmer for use in extremely cold conditions, consideration should be given to the effect of ice forming on the skimmer, changes in buoyancy, possible restriction of inlets, and changes to hydraulic efficiency. Because there may be wide variations in skimmer performance at extreme temperatures, even within a given category, ambient temperature is not included as a selection consideration.

5. Skimmer Selection Considerations

5.1 Selecting a type of skimmer for a given application involves examining the skimmer's likely performance against a range of operational requirements. The following are recommended as a guide to this process, with the requirements grouped according to the operating environment, the slick conditions, and skimmer performance criteria. Comments on each of these operational requirements, specific to each skimming type, are given in Section 6.

5.2 *Operating Environment:*

5.2.1 *Wave Conditions*—Depending on the type of skimmer, waves may affect both the oil-recovery rate and the oil-recovery efficiency. In general, most skimmers work best in calm conditions with decreases in recovery rate and efficiency as waves increase; in particular most skimmers are greatly affected by short choppy waves. For each skimming type, comments are given on the sensitivity to different wave environments. (Classification information for calm, protected, and open-water environments is given in Practice F625.)

5.2.1.1 Additional considerations for selecting skimmers for particular wave conditions are that both the skimming device and the required support platform are applicable to the intended environment.

5.2.2 *Currents*—Should the operating environment of concern have significant water currents, this should be considered in the selection process. Many skimmers will not operate effectively in currents greater than 1 knot due to decreases in throughput efficiency. On the other hand, several skimming principles such as the sorbent belt, brush, submersion plane, advancing weir, and boom skimmers rely on relative current for effective operation and are applicable in currents greater than 1 knot. Several skimmer types such as the oleophilic brush and oleophilic rope mop are available as well, in configurations that allow them to operate effectively in high currents.

5.2.2.1 Comments on performance in currents are restricted to those directly related to the skimming device. If containment booms are used to collect or concentrate oil, or both, for skimming, additional operating limitations related to containment boom performance in currents may also apply.

5.2.3 *Water Depths*—Water depths may be a concern for skimming operations in nearshore waters and when supporting a shoreline cleanup operation. It is important to note that any draft limitations would apply to both the skimming device as well as the required support vessel; certain skimmer types, although not requiring deep water for their skimming component, may require large support vessels for deployment and operation.

5.2.3.1 While many skimming types are available in a range of sizes that may allow their operation in shallow waters, certain types are generally applicable to shallow water depths and these are noted in the skimmer descriptions. Skimmer types in this category include rope mop skimmers, vacuum systems, air conveyors, some weir skimmers, and some sorbent belt skimmers.

5.3 *Slick Conditions:*

5.3.1 *Oil Type and Viscosity*—Few skimming principles operate with optimum effectiveness over a wide range of oil viscosities. For many skimmers, recovery rates will tend to be less than the reported maximum rates for oils that have a very low viscosity, and for oils that have a very high viscosity, either initially or as a result of weathering or emulsification, or both. On the other hand, several skimming principles such as brush, drum, and paddle-belt skimmers operate most effectively with more viscous oils.

5.3.1.1 Recommended viscosities for skimmer performance data are given in Guide F631. These include: 200, 2000, and 60 000 mm^2/s. These values are referred to in the skimmer selection considerations as low, medium, and high viscosity oil.

5.3.2 *Slick Thickness*—Slick thickness greatly affects the recovery rate of virtually all skimming principles, nameplate recovery rates only being achieved with thick slicks. Slick thickness also affects the recovery efficiency of most skimmers, in particular those employing suction or weir skimming principles. On the other hand, many skimmers can deal effectively with thin slicks by varying the operating parameters of the device (that is, for oleophilic devices, by reducing the speed of the oleophilic element, and by adjusting the weir settings for weir devices).

5.3.2.1 In evaluating a skimming principle based on expected slick thickness, consideration should be given to whether containment booms can be used to concentrate oil for recovery.

5.3.2.2 In the skimmer descriptions in Section 6, reference is made to device performance in thin slicks, which is defined as continuous slicks less than 1 mm in thickness, or discontinuous patches of oil with an average thickness of less than 1 mm.

5.3.3 *Debris*—The presence of debris presents two concerns in a skimming operation: first; that debris may restrict flow to the skimming head, and second, that debris may interfere directly with the skimming component (that is, clogging or obstructing openings, impeding moving parts). Some skimming types, such as most oleophilic devices, are largely insensitive to the presence of debris. Suction and air conveyor devices are generally tolerant of debris up to the size of the transfer hoses used. Weir devices, in general, are susceptible to clogging with debris; however, many weir devices use integral transfer pumps that can process a range of debris types. Where applicable, comments are made on debris tolerance or sensitivity in the selection considerations comments. It should be noted that these comments pertain to the general skimming type, and that certain skimmers within a given category may include means of dealing with debris. Guidance for a range of debris types respecting skimmer performance can be taken from Guide F631, which lists a number of debris forms for skimmer testing.

5.4 *Performance Requirements:*

5.4.1 *Recovery Rate*—For some applications the most important performance criteria will be the product recovery rate. Although the various skimming categories are available in a range of sizes and capacities, generalizations can be made on expected recovery rates. In this guide, comments are made on expected recovery rates only as they would apply to the various skimming principles and not to particular devices. For example, weir skimmers and boom skimmers are available with high nameplate recovery rates, limited only by the available pumping capacity. On the other hand, oleophilic skimmers tend to have a fixed upper limit of recovery depending on the size of the oleophilic surface used (that is, surface area of discs, length and diameter of rope mop).

5.4.1.1 Although specific skimmer performance data are not included in this guide, users are reminded that a skimmer's nameplate recovery rate should be used with caution as it may not accurately reflect skimmer performance under varying conditions of slick thickness, slick viscosity, and environmental parameters. Where possible, performance data based on field use or experiments should be used, with reference to the slick and environmental conditions of particular concern to the user.

5.4.2 *Recovery Efficiency*—Selection of a skimmer based on the expected recovery efficiency may be particularly important depending upon the availability of storage, the availability of systems to separate free water from the recovered fluids, and the permissibility of discharging decanted water at the recovery site. The expected recovery efficiency will, for most skimming categories, vary greatly depending on the thickness and viscosity of the slick and on the environmental conditions at the spill site.

5.4.2.1 In general, skimmers using oleophilic principles can be expected to have higher recovery efficiencies relative to skimmers using weir or suction principles. Among weir skimmers, devices in the induced flow category can be expected to have a high efficiency. As well, several skimming categories are typically configured with onboard gravity separation, which would enhance their overall efficiency. For skimmers without onboard separation, oil/water separation should be considered to maximize the use of available storage.

5.4.3 *Mode of Application*—Comments on the mode of application include the ability to use in an advancing mode and the applicability to use on a vessel-of-opportunity.

5.4.3.1 Certain skimmer categories, such as oleophilic disc, rope mop, and some weir skimmers are not generally used in an advancing mode. Conversely, devices such as the boom skimmer, the fixed submersion plane, paddle belt, and oleophilic brush skimmers require relative forward motion for effective operation.

5.4.3.2 Vessel-of-opportunity application will in many cases be specific to a skimming device rather than a skimming category. However for those skimming categories that are typically used with vessels-of-opportunity, this is noted in the selection considerations.

6. Description of Main Skimming Types

6.1 The following describes the operating principles and key selection considerations of eleven main types of skimming systems. In several instances, subcategories are used to describe different configurations of a common operating principle.

6.2 *Boom Skimmers:*

6.2.1 *Description*—Boom skimmers include any device in which the skimmer is incorporated in the face of the containment boom, regardless of the skimmer type. This system can include a single skimmer installed in the face of the boom, but in many examples of this concept there are several skimmers used. In most boom skimmers, weir-type skimmers are used. Boom skimmers provide a combined containment and recovery system.

6.2.1.1 Oil spill containment boom is often attached to each side of the mouth of a skimmer in order to increase the sweep width. Although such a system would be similar to a boom skimmer, it would not meet the definition of a boom skimmer because the skimmer in the system could be used apart from the boom. In a boom skimmer, the skimmer is part of the boom and is not intended to be used by itself.

6.2.2 *Selection Considerations:*

6.2.2.1 *Oil Type*—Applicable to low and medium viscosity oils.

6.2.2.2 *Debris Tolerance*—Debris must be screened or removed from the skimmer opening.

6.2.2.3 *Wave Conditions*—Recovery rate and efficiency degraded by choppy waves.

6.2.2.4 *Currents*—May be operated at currents greater than one knot, at reduced recovery efficiency, by pumping at a high rate.

6.2.2.5 *Water Depth*—Generally limited by towing vessels.

6.2.2.6 *Mode of Application*—Requires relative forward velocity: may be operated in stationary mode if current present.

6.2.2.7 *Other*—Typically designed for vessel-of-opportunity application.

6.3 *Brush Skimmers:*

6.3.1 *Description*—Brush skimmers are oleophilic skimmers that pick up oil on the bristles of a brush. There are two main configurations for the brushes: drum brush skimmers, in which the brushes are mounted around the perimeter of a drum; and chain brush skimmers, in which the brushes are mounted on several continuous loop chains. In each case the brushes are rotated through the oil/water interface, picking up oil and some water. The recovered fluid is then combed from the bristles into a sump. Both brush skimmer types are generally used in an advancing mode. Chain brush skimmers are typically configured with the skimmer head facing aft, creating a calm area for oil to accumulate and be recovered, reducing the skimmer's sensitivity to waves.

6.3.2 *Selection Considerations:*

6.3.2.1 *Oil Type*—Applicable to medium and high viscosity oils.

6.3.2.2 *Debris Tolerance*—Effective in most forms of small debris.

6.3.2.3 *Wave Conditions*—Low sensitivity to waves with typical configuration of aft-facing skimmer head.

6.3.2.4 *Currents*—May be operated effectively at advance rates greater than 1 knot.

6.3.2.5 *Water Depth*—Generally limited by support vessel.

6.3.2.6 *Mode of Application*—Requires relative forward velocity: may be operated in stationary mode if current present.

6.3.2.7 *Other*—Some units designed for vessel-of-opportunity application.

6.4 *Disc Skimmers:*

6.4.1 *Oleophilic Disc Skimmers:*

6.4.1.1 *Description*—Oleophilic disc skimmers use the principle of oil adhering to a solid surface, and typically include a series of discs that are rotated through the slick. As each disc is rotated through the oil/water interface, oil adheres to the disc surface and is then removed by scrapers mounted on both sides of each disc. The product is collected in a common sump and pumped away. Disc skimmers are typically powered by a remote power pack (hydraulic or air-driven), which results in a light, compact skimming head that is easily transported and highly maneuverable.

6.4.1.2 *Selection Considerations:*

(1) Oil Type—Applicable to low and medium viscosity oils.

(2) Debris Tolerance—Debris must be managed to allow the flow of oil to the skimmer.

(3) Wave Conditions—Effective in long period waves or short waves with a height not greater than the disc diameter.

(4) Currents—Not generally applicable to use in advancing mode.

(5) Water Depth—Typically available in small portable units with minimal draft.

(6) Mode of Application—Typically used in stationary applications.

6.4.2 *Star Disc Skimmer:*

6.4.2.1 *Description*—The star disc skimmer uses rotating discs to recover oil through mechanical, rather than oleophilic principles. The discs have a series of teeth around their perimeter, similar to a circular saw blade; as the discs are rotated these teeth draw oil into a central sump where it is then removed by a pump.

6.4.2.2 *Selection Considerations:*

(1) Oil Type—Applicable to highly viscous, almost solid oil.

(2) Debris Tolerance—Susceptible to blockage with debris, particularly rope and stringy forms.

(3) Wave Conditions—Low sensitivity to waves.

(4) Currents—Not generally applicable to use in advancing mode.

(5) Water Depth—Typically available in portable units with minimal draft.

(6) Mode of Application—Typically used in stationary applications.

6.5 *Drum Skimmers:*

6.5.1 *Oleophilic Drum Skimmers:*

6.5.1.1 *Description*—An oleophilic drum skimmer uses adhesion of oil to the surface of a cylindrical drum for recovery. As the skimmer drum is rotated through the slick, oil adheres to the drum surface and is scraped off into a sump and then pumped away. Drum skimmers are typically powered by a remote power pack (hydraulic or air-driven), which results in a light, compact skimming head that is easily transported and highly maneuverable.

6.5.1.2 *Selection Considerations:*

(1) Oil Type—Applicable to a range of oil viscosities.

(2) Debris Tolerance—Debris must be managed to allow the flow of oil to the skimmer.

(3) Wave Conditions—Effective in long period waves or short waves with a height not greater than the drum diameter.

(4) Currents—Not generally applicable to use in advancing mode.

(5) Water Depth—Typically available in small portable units with minimal draft.

(6) Mode of Application—Typically used in stationary applications.

6.5.2 *Helical Drum Skimmers:*

6.5.2.1 *Description*—A helical drum skimmer employs the rotation of the drum to generate a current that draws oil into the drum. Once inside the drum, the oil moves through a spiral casing to the center, where a conveyer screw moves it to a sump. Excess water is drained out through perforations in the casing.

6.5.2.2 *Selection Considerations:*

(1) Oil Type—Applicable to high viscosity oils.