Designation: F1780 – 18

Standard Guide for Estimating Oil Spill Recovery System Effectiveness[1]

This standard is issued under the fixed designation F1780; 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 This guide covers the key factors to consider in estimating the effectiveness of containment and recovery systems that may be used to assist in the control of oil spills on water.

1.2 The purpose of this guide is to provide the user with information on assessing the effective use of spill-cleanup equipment. It is intended for use by those involved in planning for and responding to oil spills.

1.3 Sections of this guide describe calculation procedures for estimating recovery system effectiveness. It should be understood that any such calculations cannot be expected to predict system performance, but are intended to provide a common basis for comparing system performance.

1.4 One of the main reasons that the calculation procedures cannot be used to predict system performance is that the analysis is sensitive to assumptions made on the properties of the oil slick, and particularly the changes in slick thickness and emulsification. It is emphasized that the purpose of this guide is not to provide a standard method for estimating slick property changes, but rather to provide a standard guide for using that information in comparing system performance.

1.5 Consideration should be given to alternative means of estimating response system effectiveness, such as Genwest 2012. [2]

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 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

F808 Guide for Collecting Skimmer Performance Data in Uncontrolled Environments (Withdrawn 1997)[4]

F1523 Guide for Selection of Booms in Accordance With Water Body Classifications

3. Terminology

3.1 *Definitions:*

3.1.1 *advancing skimmer, n*—a skimmer that is designed to be used to sweep out the spill area.

3.1.1.1 *Discussion*—The skimmer may be independent or may be attached to containment boom to increase sweep width. In some cases, the skimmer may not be attached to the boom but is positioned in the pocket of the boom for skimming. As long as the skimmer operates while moving, it is considered to be an advancing skimmer. Some skimmers are used in both an advancing and stationary mode. These are classified according to their application.

3.1.2 *contained spills, n*—a spill that is restricted from spreading by containment boom or natural means.

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

3.1.4 *oil spill recovery system, n*—a combination of devices that operate together to recover spilled oil; the system would include some or all of the following components: (*1*) containment boom, (*2*) skimmer, (*3*) support vessels to deploy and operate the boom and skimmer, (*4*) discharge/transfer pumps, (*5*) oil/water separator, (*6*) temporary storage devices, and (*7*) shore based storage/disposal.

[1] This guide is under the jurisdiction of ASTM Committee F20 on Hazardous Substances and Oil Spill Responseand is the direct responsibility of Subcommittee F20.12 on Removal.

Current edition approved Nov. 1, 2018. Published February 2019. Originally approved in 1997. Last previous edition approved in 2010 as F1780 – 97 (2010). DOI: 10.1520/F1780-18.

[2] Genwest Systems, INC. 2012. EDRC Project Final Report. Prepared for Bureau of Safety and Environmental Enforcement. Sterling, VA.

[3] 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] The last approved version of this historical standard is referenced on www.astm.org.

3.1.5 *recovery system effectiveness, n*—the volume of oil that is removed from the environment by a given recovery system in a given recovery period.

3.1.6 *recovery period, n*—the time available for recovery systems to carry out cleanup operations.

3.1.7 *response time, n*—the time interval between the spill incident and the start of cleanup operations.

3.1.8 *stationary skimmer, n*—a skimmer that is intended to be used in a fixed location and is moved to new accumulations of oil as skimming progresses.

3.1.8.1 *Discussion*—Some stationary skimmers are used in a containment boom system that moves to collect oil, then pauses to permit the skimmer to recover the oil collected. Even though this system moves periodically, the skimmer is still ranked as a stationary skimmer because it operates when the system is at rest.

3.1.9 *uncontained spill, n*—a spill that continues to spread after the recovery effort begins.

4. Summary of Guide

4.1 In evaluating the effectiveness of containment and recovery systems used in response to oil spills, many factors need to be considered of which skimmer performance is but one. The objective of this guide is to describe a range of factors that must be considered in estimating recovery system effectiveness.

4.2 In order to evaluate a recovery system, there are two general types of information required, a set of information to describe the spill scenario against which the system will be measured, and a set of information to describe the performance characteristics of the recovery system.

4.3 Information on the spill is required to adequately define the problem and thereby provide a focus for the evaluation process. The spill should be defined in sufficient detail as to allow an unambiguous interpretation of its behavior in terms of the operating parameters of the countermeasures system. For certain purposes it may be desirable to develop a set of standard spill scenarios against which response system effectiveness would be measured in a quantifiable manner.

4.4 The performance characteristics must be identified for the recovery system and its various components. In general, the information requirements will include the rates or capacities, or both, the operating limitations, and the support requirements.

4.5 This guide covers equipment-related factors that will affect recovery-system effectiveness. Additional important factors that are not covered in this guide but should be considered as being critical to the success of a spill response include: contingency planning; communications plans; government approvals; logistics of supporting manpower and equipment in the field; and training and exercising of manpower.

5. Spill-related Information

5.1 *Spill Type:*

5.1.1 Response strategies will depend to some extent on the type of spill. The spill scenario should be defined as to whether it is an instantaneous or continuous release, whether or not the spill has ceased flowing, and whether the spill is contained or uncontained.

5.2 *Oil Slick Properties*—The following oil slick properties must be specified for the spill scenario. As some of these properties may vary with time, it may be desirable to use computer-based behavior models to produce spill property information for the time period of interest. For certain applications it may be useful to produce standard sets of spill property information that describe spills of interest as a function of time.

5.2.1 *Spill Volume*—The total volume of oil spilled should be specified (m^3). For spills that have not ceased, a spill rate (m^3/h) should also be specified.

5.2.2 *Spill Area*—The total spill area must be estimated in order to calculate estimates of slick thickness. For uncontained spills, the total spill area will increase over time; estimates can be made using computer-based behavior models. Alternatively, a simplified spreading model (Fig. 1: example spreading curves) can be used for first-order estimates.

5.2.3 *Slick Thickness*—Slick thickness is used in subsequent calculations of system encounter rate. Slick thickness is defined as the overall average thickness of the slick, and is estimated by dividing the spill volume by the total spill area at any given time. For this calculation, spill volume should take into account losses from the slick due to evaporation and natural dispersion, and increases to the slick volume due to emulsification. For uncontained spills, natural spreading forces will cause the slick thickness to decline steadily during recovery operations, and may result in a discontinuous slick composed of windows and patches separated by sheen or open water, or both. These factors should be considered in estimating an overall average slick thickness.

5.2.4 *Slick Viscosity*—The viscosity of the spilled product is used as a criteria to evaluate skimmer performance, as many skimming and pumping units will perform less effectively as viscosity increases. The viscosity of the spilled product will generally increase through the recovery period as the oil is subjected to weathering and emulsification processes. The viscosity should be specified as mm^2/s (cSt).

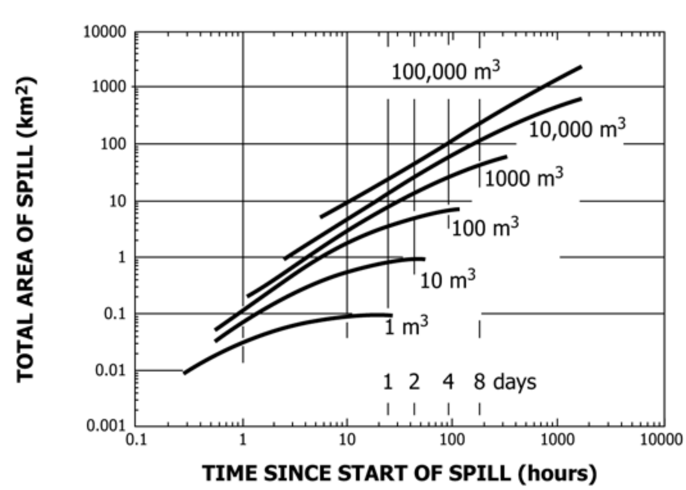

FIG. 1 Total Slick Area versus Time

5.2.5 *Emulsification*—Emulsification is important as a spill process not only for its effect on oil viscosity but also because an emulsified oil represents a greater total volume of spill product that must be handled by skimming and pumping systems. Many crude oils and refined products will tend to emulsify over the life of the spill depending on the properties of the oil and the level of wave energy in the spill environment. The degree of emulsification should be specified as the emulsified water content expressed as a percentage.

5.2.5.1 It is recognized that emulsification rates for oil spilled in the marine environment will vary greatly depending on the oil properties, spill size, sea conditions, and temperature. As noted in 1.4, it is not the intent of this guide to provide standard rates of emulsification for a variety of oil products and environmental conditions. For the purposes of comparing system performance, the data in Table 1 is provided as an example of emulsification data for crude oil over a period of several days. Users of this guide are encouraged to use alternative data that suits their particular oils and environmental conditions.

5.3 *Spill Environment:*

5.3.1 *Temperature*—Water temperature is important as a parameter for estimating oil slick properties as well as the rate of change of those properties due to weathering and emulsification. (It is assumed that the temperature of the oil slick is the same as the water on which the oil is floating.) Water temperature is defined as the temperature of the upper surface layer and should be specified as °C.

5.3.1.1 Air temperature may be important as a parameter for modifying or limiting the performance of skimming and pumping equipment, and should be specified as °C.

5.3.2 *Wind/Waves*—The wind and wave environment is important to the analysis for two reasons; first, as a parameter in estimating the behavior changes of the oil slick, and second, as a limiting factor for recovery operations. For the first purpose, average wind speeds (km/h) should be specified. For the purpose of establishing criteria for limiting recovery operations, exceedance statistics (significant wave height) should be specified for the spill location. Exceedance criteria should be expressed as the percentage of time that conditions will allow recovery operations with reference to the equipment selected for the response and the environmental criteria listed in Practice F625. For example, for spills in open water, wave exceedance data should be specified as the percentage of time that waves are less than or equal to 2 m, which would represent the percentage of time that equipment specified for open water use would be applicable.

5.3.3 *Current*—The presence of water currents may influence the selection of response strategies for a spill scenario, and may lead to a reduction in containment effectiveness in certain applications. The water currents, in m/s, should be specified for a given environment, with due regard to any local variations.

TABLE 1 Example Data for Emulsified Water Content versus Time for Crude Oil

	12 h	1 day	2 days	3 days
% Water Content	30	50	65	75

5.3.4 *Visibility*—Due to concerns with worker safety in poor visibility, as well as the inefficiencies related to the monitoring, tracking, and containment of oil slicks during periods of poor visibility, it is assumed in general that recovery operations are only possible when there is daylight and visibility of greater than 500 m (0.25 n.miles). Both of these factors should be expressed as the percentage of time that conditions exist that would allow effective operations.

5.3.4.1 It may be possible to effectively operate during periods of darkness and poor visibility if the recovery system includes adequate lighting equipment, remote sensing systems for assisting monitoring and containment efforts, or highly accurate navigation systems, or combination thereof. This may be particularly applicable to spills in nearshore and protected waters. In such cases a more liberal criteria for visibility limitations could be specified.

5.3.5 *Summary of Environmental Applicability Factors*—The wave exceedance, daylight, and visibility factors can be combined to produce an overall applicability factor that would represent the percentage of time that a given recovery system could be effectively used for a given spill scenario. For example, for an environment that has waves less than 2 m for 80 % of the time, receives 14 h of daylight, and has visibility greater than 500 m for 95 % of the time (note: all figures should be specified for the time of year of interest), the environmental applicability would be estimated as: $(0.80) \times (14/24) \times (0.95) = 44\ \%$.

5.4 *Spill Location:*

5.4.1 Spill location should be specified with respect to distance of response bases, in order to estimate transit times for the recovery systems, and with respect to shoreline, in order to estimate the time available to respond prior to shoreline oiling. Spill location may also be of importance when evaluating recovery systems that include the shuttling of recovered oil between the recovery site and temporary storage locations, in which case transit times may have to be deducted from the on-site availability of storage systems.

6. Recovery System Information

6.1 *Containment System Operating Factors:*

6.1.1 *Encounter Rate*—The encounter rate of the recovery system is a prime consideration in evaluating performance. The encounter rate is simply the rate (m^3/h) at which the system encounters the oil slick. The encounter rate includes three components: sweep width, encounter speed, and oil slick thickness.

6.1.1.1 The sweep width (or swath) is the width intercepted by a boom in collection mode, and is calculated by multiplying the boom length by the gap ratio. Where the gap ratio is not specified, a value of $1/3$ should be used.

6.1.1.2 The encounter speed is the tow or current speed relative to the containment system. If not specified, a maximum encounter speed of 0.5 m/s (1 knot) should be used.

6.1.1.3 Encounter rate can be calculated as the product of these three factors, taking into account consistency of units. As well, simple nomograms (Fig. 2) can be used to estimate encounter rates for a range of conditions.