**Designation: ~~F3195 – 16~~ F3195 – 21**

# Standard Guide for
# Estimating the Volume of Oil Consumed in an In-Situ Burn[1]

This standard is issued under the fixed designation F3195; 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 relates to the use of in-situ burning of oil spills. The focus of the guide is in-situ burning of spills on water, but the techniques described in the guide are generally applicable to in-situ burning of land spills as well.

1.2 The purpose of this guide is to provide information that will enable spill responders to estimate the volume of oil consumed in an in-situ burn.

1.3 This guide is one of several related to in-situ burning. Other standards cover specifications for fire-containment booms and the environmental and operational considerations for burning.



1.4 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4.1 *Exception*—Table 1, Table 2 and Fig. 2 provide inch-pound units for information only.

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



1.6 *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]
F818 Terminology Relating to Spill Response Booms and Barriers
F1788 Guide for In-Situ Burning of Oil Spills on Water: Environmental and Operational Considerations

## 3. Terminology

3.1 *burn efficiency*—the percentage of the oil removed from the water by burning. **F1788**

[1] This test method is under the jurisdiction of ASTM Committee F20 on Hazardous Substances and Oil Spill Response and is the direct responsibility of Subcommittee F20.15 on In-Situ Burning.

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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.

3.2 *gap ratio*—sweep width divided by boom length. **F818**

3.3 *residue*—the material, excluding airborne emissions, remaining after the oil stops burning. **F1788**

3.4 *sweep width* —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. (Also known as *swath*.) **F818**

## 4. Significance and Use

4.1 This guide describes a methodology for estimating the effectiveness of an in-situ burn. It is intended to aid decision-makers and spill-responders in contingency planning, spill response, and training.

4.2 This guide is not intended as a detailed operational manual for the ignition and burning of oil slicks. The guide does not cover the feasibility of an in-situ burn, or the evaluation of airborne emissions from a burn.

4.3 It is generally accepted that a precise determination of the burn effectiveness will not be possible. However, the methodology presented in this guide can be used to provide a consistent and reasonable estimate.

4.4 Burn effectiveness can be reported as total volume burned or burn ~~efficiency, or both~~ efficiency (that is, volume burned of that ~~available.)~~available), or both.

## 5. Evaluation Approach



5.1 For most oils and under most conditions, oil slicks burn at a rate of between 2 and 4 mm/min. By accurately observing the total area of an in-situ burn and the total duration of the burn it is possible to estimate the volume of oil consumed in the burn.

5.2 If it is necessary to estimate the burn effectiveness, defined as the percentage of oil burned of that available for burning, one must also estimate either: the volume of oil spilled or available for burning; or, the volume of residue remaining after the burn.

5.3 In most cases an estimate of the spill volume or of the residue volume will be much less accurate than that of the volume of oil consumed in the burn. If all three components can be estimated independently, the calculation procedure can be refined and the overall accuracy increased.



5.4 Potential errors are described in Section 8.

## 6. Estimating Volume of Oil Burned

6.1 Estimating the volume of oil burned comprises three variables: burn rate of the oil, burn duration, and burn area. Note that the area actively engaged in burning must be estimated, not simply the total slick area.

6.2 The volume of oil burned is calculated as:

$$\text{Volume burned}(\text{m}^3) = \text{burn rate}(\text{mm/min}) \times \text{duration}(\text{minutes}) \times \text{burn area}\ (\text{m}^2) \times 0.001\ \text{m/mm} \quad (1)$$

6.3 Table 1 lists the burning rate for various oils. The specified burn rates represent the accepted median values for given oil types; the ranges reflect potential variability.

6.4 Discontinuities in slicks can occur due to the presence of ice or debris within the burning area. For discontinuous slicks, burn durations should be recorded for discrete portions of the slick.

6.5 For slicks of emulsions, heat from the fire may cause emulsion to break, and may lead to variations in burning rate. In this instance, estimates of the burn area should make note of the variations in slick area that is burning with time.

6.6 There are a number of methods that can be used to aid in estimating the slick area, including: the use of photographs, video,

TABLE 1 Burn Rate for Various Oils (1)

| Oil Type | Burn rate, (mm/min) | Burn rate range, (mm/min) | Burn Rate[A] (L/m²/h) | Burn Rate (gal/ft²/h) |
|---|---|---|---|---|
| Gasoline | 4 | 3.5 to 4 | 240 | 5.9 |
| Diesel fuel | 3.5 | 3 to 3.7 | 210 | 5.2 |
| Light crude | 3.5 | 3 to 3.7 | 210 | 5.2 |
| Medium crude | 3.5 | 3 to 3.7 | 210 | 5.2 |
| Heavy crude | 3 | 3 to 3.5 | 180 | 4.4 |
| Weathered crude | 2.8 | 2.8 to 3.5 | 170 | 4.1 |
| Crude oil amongst dense ice | 2 | 2 to 2.5 | 120 | 2.9 |
| Light fuel oi1 | 2.5 | 2.5 to 3 | 150 | 3.7 |
| Heavy fuel oil | 2.5 | 2.5 to 2.8 | 150 | 3.2 |
| Lube oil | 2 | 2 to 2.5 | 120 | 2.9 |
| Emulsified crude oil | 1.5 | 1 to 2 | 90 | 2.2 |

[A] Burn rate in gal/ft²/h provided for information only.~~(1)~~

or output from remote sensing devices; the use of timed overflights; and reference to objects of known dimensions in the vicinity (for example, response vessels, containment boom). Hand-held laser range-finders can also be used to estimate lateral slick dimensions.

6.7 Fig. 1 and Table 2 (**2**)[3] provide data to estimate oil slick area in a typical catenary-shaped booming configuration based on the length of the slick within the boom.

For example, for the following conditions:

*(1)* a boom length of 150 metres;

*(2)* towed in a catenary configuration with a swath width of 50 metres (that is, a gap ratio of 0.33);

*(3)* with the boom approximately one-quarter full; and

*(4)* a slick length of 17 metres measured up-current of the apex of the boom;

*(5)* the burn area is estimated to be approximately 530 m$^2$.

In using the graph in Fig. 1, the *y*-axis dimension, that is, the length of the slick measured up-current of the apex of the boom should be used. This will lead to better accuracy in that the y-axis can be more precisely estimated in most instances and the estimate of burn area is less sensitive to small changes in estimating the *y*-dimension than the *x*-dimension (slick width). The data in Fig. 1 and Table 2 have been determined only for a gap ratio of 0.33, which is the commonly accepted gap ratio for effective oil containment.



6.8 Fig. 2 shows the conversion of burn rate from the units of mm/min to a more useful litres per square metres per hour (L/m$^2$/h) and barrels per square feet per hour (bbl/ft$^2$/h). For example, diesel or light crude has a burn rate of 3.5 mm/min, which equates to an areal burn rate of 210 L/m$^2$/h. This is calculated as (3.5 mm/min) ~~x~~× (1 L/m$^2$/mm) ~~x~~× (60 min/h).

## 7. Estimating Burn Efficiency

7.1 There are two methods of estimating burn efficiency; both methods require an estimate of the volume of oil burned (see 6.2). The first method requires an estimate of the volume of oil available for burning; the second requires an estimate of the volume of burn residue. Both methods should be used if possible to increase confidence in accuracy.

7.2 *Estimate of efficiency using volume available for burning:*

7.2.1 In many cases it will be difficult to make an accurate estimate of this due to the difficulties in accurately estimating the slick thickness and its variation over the slick.

7.2.2 If the source of the spill is known, an estimate may be possible based on such information as the tank size, pumping rate, and so on.

7.2.3 Burn efficiency when using volume available for burning is calculated as:

$$\text{Burn efficiency } (\%) = \left(\frac{\text{volume of oil burned}}{\text{volume available for burning}}\right) \times 100 \quad (2)$$

[3] The boldface numbers in parentheses refer to a list of references at the end of this standard.

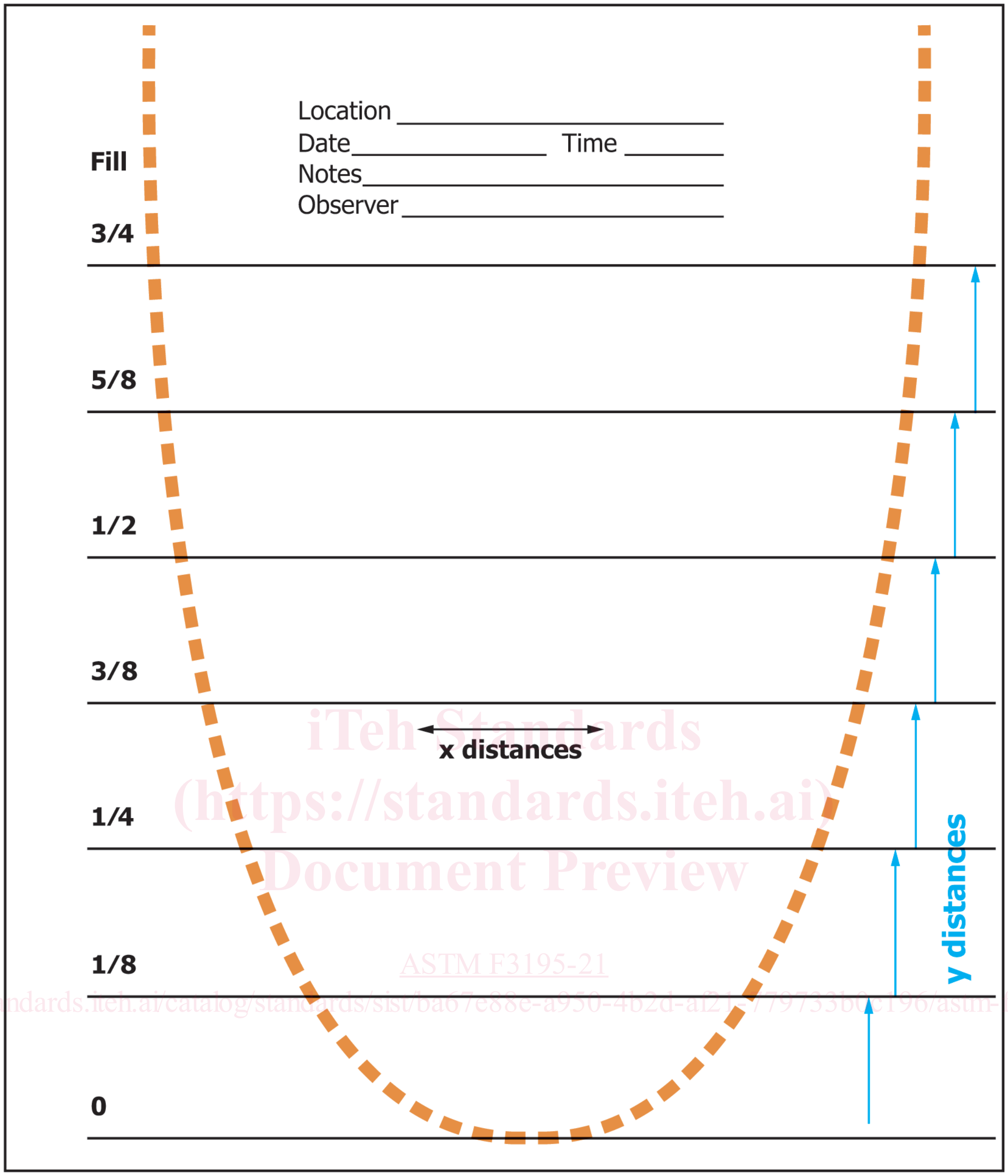




**FIG. 1 Estimation of Slick Area within a Boom**

7.3 *Estimate of efficiency using volume of burn residue*—If the residue is readily recoverable, the volume can be measured directly. Otherwise an estimate can be made of the residue volume by estimating the area and thickness of the residue, the number and size of tarballs, etc.

7.3.1 Burn efficiency when using volume of burn residue is calculated as:

$$\cancel{\text{Burn efficiency}(\%)=} \qquad (3)$$

$$\frac{(\text{volume of oil burned})}{\cancel{(\text{volume of oil burned} + \text{volume of residue})}}\times 100 \qquad (3)$$

$$\text{Burn efficiency}(\%) = \frac{(\text{vol. of oil burned})}{(\text{vol. of oil burned} + \text{vol. of residue})}\times 100 \qquad (3)$$

7.3.2 Alternatively, an estimate of the burn residue can be used in combination with an estimate of the volume of oil available for burning.