



## Standard Practice for Determining the Performance of Oil/Water Separators Subjected to Surface Run-Off<sup>1</sup>

This standard is issued under the fixed designation D 6104; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This practice covers the procedure, any necessary related apparatus, and the sampling technique to be used in determining the performance characteristics of oil/water separators subjected to contaminated run-off.

1.2 This practice does not address the determination of the performance characteristics of an oil/water separator subjected to the sudden release of a relatively large quantity of hydrocarbons that may appear, in pure form or at high concentration, in the influent to the separator. In this case, refer to Practice D 6157.

1.3 This practice does not address the determination of the performance characteristics of an oil/water separator subjected to a mechanically emulsified influent such as provided by a pump.

1.4 This practice does not investigate the ability of the separator to handle debris or suspended solids, that is, grit or tree leaves.

1.5 While the effluent may meet code requirements for total oil and grease content, this practice does not address the presence of soluble organics, i.e., Benzene, Toluene, Ethylbenzene and Xylene (BTEX's) which may be detected in the effluent. It also does not make any provisions for the effects of detergents, surfactants, soaps, or any water soluble matter (that is, salts), or any portion of an essentially insoluble matter that may be found in solution on separation. (Effects of certain water soluble chemicals or solids may be investigated by adding them to the water at predetermined constant concentrations.)

1.6 In order to estimate the effect of water temperature on the performance of the separator, the tests described in this practice must be performed at two water temperatures. The selected temperatures must be at least 10°C (18°F) apart, with the temperature ranging from a minimum of 0°C (32°F) to a maximum of 50°C (122°F).

1.7 This practice does not make any provisions for the variation of pH or temperature during a test run. Refer to Appendix X1 for further detail.

1.8 This practice can be used with a variety of hydrocarbons. It adopts No. 2 fuel oil with a density<sup>2</sup> of 845 kg/m<sup>3</sup> (52.73 lb<sub>m</sub>/ft<sup>3</sup>) and a viscosity<sup>2</sup> of 1.9 to 4.1 centistokes at 40°C (104°F) and SAE 90 lubricating oil with a density<sup>2</sup> of 930 kg/m<sup>3</sup> (58 lb<sub>m</sub>/ft<sup>3</sup>) at 15.5°C (60°F) and a viscosity (see SAE J313) of 13.5 to < 24 centistokes at 100°C (212°F) as the comparative testing media. It is understood that the results obtained from this practice are only directly applicable to No. 2 fuel oil and SAE 90 lubricating oil for the tested concentrations and only careful interpolation or extrapolation, or both, is allowed to other hydrocarbons. Low viscosity or high density hydrocarbons or hydrocarbons that contain a larger fraction of highly soluble compounds may need to be tested separately.

NOTE 1—No extrapolation outside the range of the tested influent or effluent oil concentrations is allowed as performance may not be linear. Hence, to establish performance at a higher or lower concentration, the separator shall be tested for that specific condition. In addition, linearity must be established prior to using linear interpolation.

1.9 Since regulations are based on effluent total hydrocarbon content, this practice does not set forth any lower limits on oil particle size for the evaluation of separator efficiency. However, a standardized means for mixing oil and water shall be specified to ensure repeatability. It must be noted however that smaller particles, having a greater surface area to volume ratio, rise at a slower rate than their larger counterparts. (Guide F 933 requires that 20 % of all oil particles be smaller than or equal to 50 μm and IMO MEPC 60 (30) does not mention any particle size requirements but asks the user to avoid emulsion causing chemicals.)

1.10 Although the tests described in this practice intend to simulate contaminated storm water run-off separation requirements, they do not cover all possible applications. It is the end user's responsibility to determine whether his separation requirements are within the scope of this practice.

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of D19.06 on Methods for Analysis for Organic Substances in Water.

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<sup>2</sup> Ray E. Bolz and George L. Tuve, *CRC Handbook of tables for Applied Engineering Science*, 2<sup>nd</sup> Edition, CRC Press, 1981.

1.11 A product different from the general description herein may be tested and found to be in compliance with the performance criteria set forth.

1.12 The values stated in either inch-pound units or SI units are to be regarded as standard. Within the text, the inch-pound units are shown in parentheses. The values stated in each system are not exact equivalents. Therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.

1.13 *This practice does not purport to address all the environmental hazards, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate environmentally responsible practices and to determine the applicability of regulatory limitations prior to use.*

1.14 *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:

D 1129 Terminology Relating to Water<sup>3</sup>

D 3370 Practices for Sampling Water from Closed Conduits<sup>3</sup>

D 4281 Test Method for Oil and Grease (Fluorocarbon Extractable Substances) by Gravimetric Determination<sup>4</sup>

D 6157 Practice for Determining the Performance of Oil/Water Separators Subjected to a Sudden Release<sup>4</sup>

F 933 Guide for Evaluation of Oil Water Separation Systems for Spilled Oil Recovery Applications<sup>5</sup>

### 2.2 EPA Standards:

EPA-413.1 “Methods for Chemical Analysis of Water and Wastes”, EPA 600/4-79-020, revised March 1983<sup>6</sup>

EPA-413.2 “Methods for Chemical Analysis of Water and Wastes”, EPA 600/4-79-020, revised March 1983<sup>6</sup>

EPA-1664 H-Hexane Extractable Material (HEM) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM) by Extraction and Gravimetry (Oil and Grease and Total Petroleum Hydrocarbons) EPA-821-B-94-004B, April 1995<sup>6</sup>

### 2.3 SAE Standards:

SAE J306 Axle and Manual Transmission Lubricant Viscosity Classification<sup>7</sup>

SAE J313 Surface Vehicle Recommended Practice (R) Diesel Fuels<sup>7</sup>

## 3. Terminology

3.1 *Definitions:* For definitions of terms used in this practice, refer to Terminology D 1129.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration*—the certified evaluation of the accuracy of a measuring instrument as performed by its manufacturer or an independent licensed or accredited third party.

3.2.2 *contaminated run-off*—rain water which has collected oily contaminants from the surfaces it came in contact with and which may appear in the influent to a separator. Unlike a release, the level of contamination in this case is much lower.

3.2.3 *effluent*—the aqueous release from a separator.

3.2.4 *flow totalizer*—a counter, usually attached to a flow meter, that evaluates the total volume of the fluid that has flowed through over a given time period.

3.2.5 *influent*—the oily aqueous input to a separator.

3.2.6 *oily discharge*—any release of oily contaminants into the environment that exceeds the allowable limit.

3.2.7 *re-entrainment*—the condition in which the level of contamination of the effluent water of a separator containing oil is higher than the influent contamination level due to internal remixing. This definition usually applies to situations where clean water passes through a separator that already contains hydrocarbons stored within and atop the water so as to form an interface.

3.2.8 *release*—any sudden discharge of an oily substance from vessels that are specifically designed to store, contain, or transfer oily products such as storage tanks, pipelines, diked areas, and transfer equipment and which may appear in the influent to a separator.

3.2.9 *separator*—a flow through primary treatment device the primary purpose of which is to separate oil from water.

## 4. Summary of Practice

4.1 The practice evaluates a separator’s ability to reduce the total hydrocarbon content of contaminated run-off. For this, an influent is supplied at the separator’s rated flow for the selected hydrocarbon content (either 350 or 1000 mg/L). The corresponding effluent hydrocarbon content is determined by obtaining and analyzing grab samples.

4.2 The practice also evaluates the effluent of a separator at rated oil storage capacity in relation to a non-contaminated influent and its corresponding rated flow in order to establish its re-entrainment characteristics.

4.3 The data generated in this practice are considered valid for the separators tested only. However, the results of these tests may be extrapolated to smaller or larger size separators provided that applicable geometric and dynamic similitude are maintained. Where the use of extrapolation is not applicable, that size unit must be subjected to testing.

4.4 The flow rate for these tests must equal the manufacturer’s rated flow for the given separator at the given influent contamination level and for the selected effluent peak contamination concentration.

4.5 For the purpose of this test, the water temperature should be between 10°C (50°F) and 21.1°C (70°F) and the pH of the water between 6 and 9.

## 5. Significance and Use

5.1 The Clean Water Act promulgated the implementation of water quality standards and contamination limits for a wide range of pollutants including oil and grease. Specifically, the EPA prohibits “the discharges of oil that cause a film or sheen

<sup>3</sup> Annual Book of ASTM Standards, Vol 11.01.

<sup>4</sup> Annual Book of ASTM Standards, Vol 11.02.

<sup>5</sup> Discontinued. See 2000 Annual Book of ASTM Standards, Vol 11.04.

<sup>6</sup> Environmental Protection Agency, 40 CFR Ch. 1 (7-1-95 Edition)

<sup>7</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

upon or cause discoloration of the surface of the water.” Several state and local agencies have adopted this statement in addition to setting concentration limits, that is, 15 mg/L or even 5 mg/L. The purpose of this practice is to evaluate the performance of a separator in regards to the regulations and user requirements.

5.2 Another purpose of this practice is to establish that a separator containing oil at its rated capacity would still be capable of meeting the above criteria when subjected to run-off.

5.3 This practice is not applicable if the influent to a separator contained a sudden release as much higher concentrations would be expected. For this case, see Practice D 6157.

5.4 This practice is not applicable if the influent to a separator is conveyed by a pumping means.

5.5 The data generated in this method is valid for the separators tested only. The results of these tests may be extrapolated to smaller or larger size separators provided that applicable geometric and dynamic similitude are maintained. Where sound engineering method limits the use of extrapolation, that size unit must be subjected to testing.

5.6 The flow rate for all the tests must equal the manufacturer’s total rated flow for the given separator at a given influent contamination level and for the selected effluent peak contamination concentration.

## 6. Test Set-Up and Apparatus

6.1 *Water Supply*—The water supply can be either a water main, a water reservoir and a pump, or an elevated storage tank capable of providing the volume and flow rate of water necessary for a test run as described in the procedure. If either a storage tank or reservoir is used, the volume shall be at least three times the liquid volume of the separator.

6.1.1 *Flow Totalizer or Sight Glass*—The water supply should be equipped with a calibrated means of indicating the total volume of water dispensed, that is, a flow totalizer or a sight glass. The selected device should be within 5 % accuracy.

6.1.2 *Flow Rate Indicator*—The water supply must also be equipped with a calibrated means of controlling and indicating the flow rate, that is, throttling valve and flow meter, orifice plates or, venturis. The means used for controlling the flow rate must be capable of maintaining the flow within 5 % of the desired value.

6.2 *Oil Supply*—The oil supply should be large enough to store the quantity required for the larger concentration test and for its entire duration. A minimum estimate could be based on three separator liquid volumes.

6.2.1 *Flow Totalizer or Sight Glass*—The oil storage tank should be equipped with a calibrated sight glass or flow totalizer. The selected device should be within 5 % accuracy.

6.2.2 *Flow Rate Indicator*—The oil supply should also be equipped with a calibrated means of controlling and indicating the flow rate, that is, throttling valve and flow meter, orifice plates or, venturis. The means used for controlling the flow rate must be capable of maintaining the flow within 5 % of the desired value.

6.3 *Separator*—A separator with an outlet pipe extending far enough to allow grab sampling as described in Test Method D 3370.

6.4 *Mixer*—A means for mixing the hydrocarbons with the water consisting of a commercially available horizontal PVC pipe section with a minimum surface roughness of 0.000 15 cm (0.000 005 ft.) having a length of at least 20 diameters with one end connected directly to the inlet of the separator. An oil injection port shall be provided at the other end of the pipe and at its bottom portion and shall not extend into the pipe more than one third its diameter in order to prevent stratification<sup>8</sup>. The pipe diameter shall be selected such that it runs full and at a Reynolds number, based on the hydraulic diameter, in excess of 70 000 and a velocity in excess of 1 m/s (3.28 ft/s). The injection port diameter shall be sized to provide, at the higher test concentration, an injection velocity approximately equal to 1 m/s.

6.5 *Influent Sampling Port*—An influent sampling port for temperature and pH reading. (If on-line temperature and pH readers are not available, a small sample should be extracted and the temperature read immediately at the beginning of every test. pH analysis may be performed at a later time.)

## 7. Procedure

7.1 *Test A—Investigation of Re-Entrainment at Rated Oil Storage Capacity:*

7.1.1 Fill the separator with oil to the manufacturer’s rated oil storage capacity.

7.1.2 Allow fresh water to enter the separator at its rated flow until at least three volume changes are achieved and the effluent concentration reaches steady-state. Take an effluent grab sample at every one third ( $\frac{1}{3}$ ) of the separator volume change. Samples must be gathered and handled in accordance with Test Method D 3370.

NOTE 2—Steady-state means that, when analyzed, the last three samples shall depict a “constant” oil and grease concentration with respect to the other samples within the accuracy of the accepted sample analysis method. If this condition cannot be attained within three volume changes then the total volume of water necessary shall be increased until this condition is met.

7.1.3 Each sample container shall be labeled with a serial number and a run number, the date of the test and the initials of the person performing the test.

7.1.4 The run number, date, water temperature and pH, the number of samples taken, the flow rate, influent oil concentration and the total volume of water, the model number of the separator, and a description of any ancillary equipment shall be recorded and the data sheet signed by a registered or licensed third party present during the test.

7.1.5 Samples shall be analyzed by an independent testing laboratory certified for the selected testing method in accordance with Test Method D 4281, EPA 413.1, EPA 413.2, EPA-1664 or other EPA approved standard. The analytical standard used must be specified.

7.2 *Test B—Contaminated Run-Off Tests:*

7.2.1 Make necessary adjustments to the testing apparatus in order to obtain a 350 mg/L oil grease concentration in the influent.

<sup>8</sup> Robert H. Perry and Don Green, *Perry’s Chemical Engineer’s Handbook*, 6<sup>th</sup> Edition, McGraw-Hill, 1984

7.2.2 Fill the separator with oil to its rated capacity minus the estimated amount of oil that would be added to the separator at the end of the run. For example, consider a separator having a 1000 L liquid capacity and 100 L oil storage capacity based on three volume changes at 350 mg/L concentration of No. 2 diesel with 0.83 specific gravity, the volume of No. 2 Diesel that would be added to the separator is  $(350 \times 10^{-6}) \times 3000/0.83 = 1.265$  L. Therefore, the separator shall be filled with 98.735 litres of oil (100 to 1.265).

7.2.3 Allow the mixture to enter the separator at its rated flow for the given test conditions until at least three volume changes are achieved or the effluent concentration reaches steady-state (see Note 2). Take an effluent grab sample at every one third volume change. Samples must be gathered and handled in accordance with Test Method D 3370.

7.2.4 Each sample container shall be labeled with a serial number and a run number, the date of the test, and the initials of the person performing the test.

7.2.5 The run number, date, water temperature and pH, the number of samples taken, the flow rate, influent oil concentration and the total volume of water, the model number of the separator, and a description of any ancillary equipment shall be recorded and the data sheet signed by a registered or licensed third party present during the test.

7.2.6 Samples shall be analyzed by a certified independent testing laboratory in accordance with Test Method D 4281, EPA 413.1, EPA 413.2, EPA 1664 or other EPA approved standard. The analytical standard used must be specified.

7.2.7 Repeat 7.2.1 through 7.2.6 at an influent concentration of 1000 mg/L.

7.3 *General Notes:*

7.3.1 All measuring instruments, metering pumps, and other auxiliary equipment must be calibrated and certified prior to testing.

7.3.2 In the case of custom built equipment, the method of calibration must be clearly described and attached to the report and such calibration must be performed by a certified or registered independent third party.

## 8. Report

8.1 The report shall clearly indicate the tested separator make and model as well as the manufacturer's description, including all standard ancillary equipment.

8.2 The report shall include a copy of all the laboratory sample analysis reports including the analysis method. The report must bear enough pertinent information in order to correlate it to the particular test that was performed as well as the signature of an official laboratory representative.

8.3 Representation of the data shall contain the separator make and model, the initial volume of oil stored within the unit, the total number of volume changes, the date the test was performed, the water temperature and pH, the type of oil used, its specific gravity, viscosity and temperature, the flow rate, the name and signature of person who performed the test, the type of test, that is, Test A, the run starting time, the time each sample was taken, its number, and its corresponding laboratory analysis.

8.4 In the case a type B test was performed, the tabular representation must also include the influent oil concentration and the total volume of oil injected into the system.

8.5 All tables shall have the peak and average effluent contamination values listed.

## APPENDIXES

### (Nonmandatory Information)

#### X1. EFFECTS OF PH AND TEMPERATURE ON SEPARATION

X1.1 Elevated pH levels may reduce the separation efficiency of a separator whereas reduced pH levels may enhance separation. Similarly, changes in temperature may also affect separation efficiency. For example, a reduction in temperature from 18°C to 10°C (65 to 50°F) may cause an increase in the specific gravity of the water of only 0.12 %. However, it causes

a 25 % increase in the dynamic viscosity of the water. Hence, the net effect of a decrease in temperature is adverse on separation efficiency. The same series of tests may be repeated at different pH levels or temperatures in order to determine their effect on separation.

#### X2. PARTICLE SIZE AND SEPARATION

X2.1 Finer dispersions of oil in the water entering a separator will result in reduced separator efficiency. In order to predict the performance of a separator in a given application, the oil droplet size distribution during the test must compare to the oil droplet size distribution in the field. To generate finer dispersions, the Reynolds number in the mixing pipe may be

raised, a pipe with greater surface roughness may be selected or an orifice plate, or a static mixer may be used. As previously mentioned, this practice relies on a standardized mixing device to obtain a datum for comparison as opposed to using relatively expensive and often unreliable particle size measurement equipment.

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