PROCEDURES FOR REPORTING TESTS OF
OIL SPILL CONTAINMENT BOOMS AND SKIMMERS

1.0 INTRODUCTION

Many test reports of oil spill containment booms and skimmers are difficult to use because of lack of reasonable organization and, more significantly, a lack of documentation describing equipment that was tested and how tests were performed. These problems make test data difficult to analyze and at times limit the usefulness of the tests themselves.

Work on this present task was undertaken to produce a document that could be used to standardize test reporting procedures and develop a format and list of test reporting requirements that would eliminate the problems of incomplete test documentation. Test reporting requirements are based on two studies that analyze the results of all available test reports, "Oil spill Response performance Review of Skimmers," ASTM Manual MNL 34 (151 pages), and "Oil Spill Response Performance Review of Booms," a follow-on study sponsored by the Mineral Management Service (183 pages). These two studies reveal many problems in test reports and in some cases suggest their solution. These studies were therefore the basis for determining the desired test report format and content. In addition to reviewing these two summary reports, all available original test reports were reviewed again to uncover other problems in test reporting that were not noted in the two reviews of booms and skimmers reports. The result of this survey is a working document describing a preferred report format, requirements for describing devices tested, recommended content, and arrangement of test data.

Although this document is intended to be a complete guide to preparing test reports, it cannot claim to address all problems with test reports. Each new test program presents its own sets of problems. These new problems must be recognized and solved. There is no substitute for good judgement and careful reporting. Here are some suggestions that may be helpful in avoiding problems.

- o Have a technical person who did not work on the tests review the draft report for completeness. People who have worked on the tests daily have all the test information available and sometimes do not realize that they are not recording information needed by report users who have not worked on the tests.
- o Be redundant. Test specifications that have been presented in opening paragraphs often should be repeated on graphs and data sheets so that all pertinent test parameters are available where test results are being analyzed. There is no penalty for repeating important data frequently, and it may save the report user the frustration of constantly looking for data essential to analysis. When in doubt, repeat.

The reports analysis that follows does not cite problems with test reports one by one. Since there were close to one hundred reports reviewed, this would just produce a maze of material that would not be helpful to test engineers. Instead, problems found in reports have been used to suggest how reports should be written and how equipment tests should be documented. The intent is to provide a format for test reporting that can be used to ensure that reports describe the results of tests clearly and completely. In some cases the analysis refers to specific problems in existing test reports that should be corrected, but these references are limited and only serve to illustrate special problems that have occurred.

Finally, the suggested procedures for reporting tests of spill response equipment are not intended to restrict future investigators from using other formats that seem to be required by their work. The intent is rather to provide a check list of factors that should be considered in preparing a report for any test series. The idea is that if all of these things are considered and covered, the report is likely to be complete and clear. Do these things and you are likely to be successful and effective.

2.0 CONTENTS

The suggested procedures for preparing test reports are contained in two chapters, one for booms and the other for skimmers. Since it is anticipated that these documents will be used separately, they remain separate, each with similar sections numbered in the same way and each with its own set of references. Each section is written to stand alone. Sections have similar numbering and titles to encourage standardization in reporting.

CHAPTER 1

FORMAT AND CONTENT OF REPORTS OF TESTS OF OIL SPILL RESPONSE BOOMS IN CONTROLLED AND UNCONTROLLED ENVIRONMENTS

1.0 TEST DESCRIPTION

1.1 Who performed the test - Specify the agency for whom the test was performed and/or the test sponsors.
1.2 When the test was performed (as opposed to when the report was published)
1.3 Where the test was performed - For offshore and river tests, specify the exact location.
1.4 Purpose of the test and other background information.

2.0 BOOM DESCRIPTION

2.1 Describe booms according to type (1). Boom types currently identified include:

- o Fence booms
- o Curtain Booms - which are further identified according to their flotation
  - - Internal foam
  - - External foam
  - - Self-inflatable
  - - Pressure-inflatable
- o External Tension Booms
- o Fire Containment Booms
- o Tidal Seal Booms

If the boom tested does not fall into one of these generally accepted categories, describe the boom in detail and give it a name.

Describe boom characteristics and how the boom is generally used. For example, identify booms that are generally used in permanent installations in harbors and those that are used for first response to spills. Boom flotation configurations and buoyancy to weight ratios are important to various applications and should be explained. This discussion helps the user to understand why the tests are being performed and the expected outcomes.

2.2 Record the boom manufacturer's name and the boom model or designation. Include a simple line drawing showing an overall view of the boom. When appropriate, include sketches of special boom features, such as rigging, attachments, or special compartmentation in inflatable boom.

2.3 A test report should fully describe the booms being tested. This information can be shown in a table format. A sample table follows. Although it would be desirable to show all items listed, some are less important than others and could be omitted. Those shown with a star (*) are considered to be absolutely essential. Fire resistant boom components should be described in greater detail because of special materials used and special methods of construction.

- o *Boom type
- o *Boom manufacturer and model
- o *Dimensions of boom; freeboard, draft, and boom height - mm (inches)
- o *Length - total length of boom tested and section length if appropriate - m (ft)
- o End connectors - report generally accepted connector types or describe the connector in detail. Accepted types include the following (1):
  - - ASTM
  - - Universal Slide
  - - Slide
  - - Slotted tube
  - - Raised channel
  - - Bolt
  - - Notched plate and pin
  - - Hinge & pin
  - - Fireboom U
- o Skirt material

o *Flotation type - Describe shape of flotation, location of flotation, type of flotation material, and length of flotation section as follows:

Shape

- Continuous cylinder
- Segmented cylinder
- Rectangular block
- Square block
- Sphere

Location

- Set on outriggers
- Internal
- Attached to skirt

Type of material

- Foam - specify hollow, rigid or flexible
- Inflatable - specify pressure-inflatable or self-inflatable

Length - Length of flotation segments helps to describe how a boom follows wave patterns

o Boom weight per unit length - kg/m (lb/ft)
o Buoyancy - Specify *reserve buoyancy* or *gross buoyancy*
o *Buoyancy to weight ratio - Specify *reserve buoyancy to weight ratio* or *gross buoyancy to weight ratio*. Gross buoyancy to weight ratio = reserve buoyancy to weight ratio + 1. Describe how the buoyancy to weight ratio was determined.
o Ballast material
o Ballast weight - kg/m (lb/ft)
o Strength of tension members - Newtons (lbs)
o Fabric tensile strength - Newtons/50 mm (lbs/in)
o Fabric tear strength - Newtons (lbs)

3.0 TEST CONFIGURATION

3.1 Describe how the tests were set up. Describe how the boom was towed, i.e., catenary, diversionary mode or J- shape. If towed in the diversionary mode, specify the angle between the boom surface and the current and report changes in this angle on various runs. A Vee-Sweep boom is basically a double diversionary boom. Report the angle both segments of the Vee make with the current or the direction of tow. Boom gap ratio should be clearly stated for each test run. In testing fire resistant boom, a leader boom is often used that is a different size and type from the boom being tested. Be sure to describe the leader boom and record its length.

4.0 TEST OILS

4.1 Report oil type; e.g., diesel, lube oil, special test oil, Bunker C, crude oil, and so forth
4.2 Report oil viscosity and the temperature at which viscosity was determined. *The temperature at which viscosity was determined should be close to the existing water temperature when tests were run.* Reporting oil viscosity at 140°F when the water temperature at test time was 65°F is not helpful. Generally oil viscosity should be reported in Centistokes (cSt). This is equivalent to mm^2/s but it is a more generally recognized term. Viscosity can also be reported in Centipoise (cP), but these units are not used as often. (cP = cSt X density)
4.3 Report oil density. This is a performance parameter because booms often fail in more dense oils at lower tow speeds.

5.0 TEST VARIABLES

Typical test variables include the following:

o Boom Tow Speed - report in knots or meters/second.
o Offshore Currents - Report offshore currents if they exist. Currents, combined with tow speed, can have a significant effect on the relative movement of the boom to the water surface and test oil.

o Oil Type and Viscosity
o Wave Conditions - Report wave length, height, and length to height ratio. Wave period can be reported but wave length should be reported if possible. Reporting wave conditions as a sea state or a range of sea states in offshore tests is too vague for analysis. If waves were variable during tests, report a range of wave heights and lengths. If possible, report wave height and length associated with each test run. For offshore tests, report whether tests were run into the waves or with the waves.
o Wind and temperature conditions - In controlled tests, wind conditions are often not significant because waves are generated artificially and tests are generally delayed if winds become a factor. In offshore tests winds are significant and should be reported. Air and water temperature are generally not significant unless they produce icing or changes is test oil viscosity.
o Boom Freeboard and Draft - Report boom freeboard and draft and changes in freeboard and draft during controlled and offshore tests if possible. Changes in boom tow speed and wave conditions may change freeboard and draft, which can have a significant affect on forces on booms and oil containment effectiveness. For curtain booms, a decrease in boom freeboard does not necessarily result in a corresponding increase in draft. Also, when towing large boom offshore, the water level inside the boom may become higher than the level behind the boom. This should be reported if possible.

Table 1.0 Boom Description

BOOM TYPE			
MANUFACTURER/MODEL			
FREEBOARD mm (inches)			
DRAFT mm (inches)			
BOOM HEIGHT mm (inches)			
LENGTH TESTED m (ft)			
END CONNECTORS			
SKIRT MATERIAL			
FLOTATION TYPE Shape Location Type of material Length			
WEIGHT kg/m (lb/ft)			
BUOYANCY kg/m (lb/ft)			
BUOYANCY/WEIGHT			
BALLAST MATERIAL			
BALLAST WEIGHT lb/ft (kg/m)			
TENSION MEMBER (1)/ STRENGTH (1) N (lbs)			
TENSION MEMBER (2)/ STRENGTH (2) N (lbs)			
TENSION MEMBER (3)/ STRENGTH (3) N (lbs)			
TOTAL STRENGTH lbs (N)			
FABRIC TENSILE STRENGTH N/50 mm (lbs/in)			
FABRIC TEAR STRENGTH N (lbs)			

6.0 DATA ACCURACY

Accuracy of all recorded test variables should be listed. The accuracy of the independent variable, tow speed, is particularly significant. In controlled tests, varying first loss and gross loss tow speeds are recorded with a reported variation of 0.1 knot and even less. In examining the data, then, the user must decide whether reported differences represent a varying performance or whether differences are simply within the range of the accuracy of reported data.

Data accuracy in offshore tests is particularly important. Waves and currents are important to boom performance but difficult to measure offshore. These variables should be recorded as accurately as possible and the estimated accuracy recorded for the user. Boom gap is difficult to maintain offshore and difficult to measure. This parameter is important to boom performance and particularly to the measured force on the boom tow. Boom gap ratio should be reported as accurately as possible and the possible variations in gap ratio discussed.

7.0 TEST PROCEDURE

Describe how the tests were performed in a paragraph or more depending on the complexity of the tests.

7.1 *Stability Tests* - Describe boom stability tests if they were performed before using oil. Report the tow speed at which boom failure occurred in knots or meters/second. Describe the methods of boom failure that occurred. Use standard terminology for methods of boom failure including(1):

- o Entrainment
- o Drainage
- o Splashover
- o Submergence
- o Planing

7.2 Pre-load Tests - These consist of a series of first loss tow speed tests using increasing amounts of oil to determine the volume of oil a boom holds until the addition of more oil has a minimal affect on first loss tow speed. Beginning with a nominal pre-load of oil, the test is repeated with increasing pre-load volumes until the addition of oil has minimal or no effect on the first loss tow speed. The desired pre-load of oil is obtained from a plot of first loss tow speed vs. volume of oil pre-load. The volume of pre-load oil used in the subsequent tests has significant affect on the results obtained in these tests so the process and result should be recorded for each boom tested. Details on how these tests are performed are contained in the "Standard Guide for Collecting Containment Boom Performance Data in Controlled Environments," American Society for Testing and Materials (ASTM) F2084-1 (2). Report the volume of pre-load oil determined by tests in cubic meters or gallons.

7.3 Oil Loss Tests - The tow speed at which the boom first begins to lose oil is called the first loss tow speed. At a higher tow speed, oil is lost at a significantly greater rate, and is called the gross loss tow speed. In controlled tests, these speeds are generally determined using an underwater video camera image. Report the tow speeds at which oil loss occurs in knots or meters/second.

7.4 Oil Loss Rate Tests - In most recent controlled tests, boom loss rates are obtained by towing the boom in calm water with its pre-load of oil at the first loss tow speed plus 0.1 knots and 0.3 knots. The tow speed is constant for the length of the test basin while oil is distributed at a pre-computed rate. Report the first loss rate in cubic meters/hour or gallons/minute and the tow speed at which gross loss occurs in knots or meters/second.

7.5 Critical Tow Speed - This is the maximum speed at which the system can be towed before losing freeboard or draft. Tow speed typically begins at 1 knot and is increased in 0.25 knot increments until failure is observed. The failure occurs when the boom submerges or comes out of the water. This test is run in calm water without oil. Report the critical tow speed in knots or meters/second.

7.6 *Tow Force* - Describe how tow forces were measured. Average tension is often recorded as half the sum of the tension on each of the two tow points. It should be noted that this is half the total tension, sometimes called drag, that is generally computed using formulae for forces on booms. *Be sure to specify reported forces as total tension, or drag, or simply tension, which is half the total tension.* The tension experienced by a boom

is not constant, particularly when towed through waves. As the boom follows the crests and troughs of waves, the tension fluctuates, peaking as the boom catches the front of the wave. Peak and mean tension values are recorded, with the peak loads defined as the 95th percentile of the tension readings recorded for each run. Because a boom must be designed to be able to withstand these peak tensions, the focus of the analysis is on these 95th percentile tension loads. Report tow force in Newtons or pounds of force.
7.7 *Wave Conditions* - Wave conditions tested can be shown in a table with wave height and length in meters or feet. Wave period is an interesting statistic but is not generally helpful in analysis. Wave length is more descriptive. Recent studies show that wave steepness has a significant affect on boom performance. It is therefore important to show the wave length to height ratio, which is a measure of wave steepness. This parameter is most likely to be the key to boom performance in waves.

8.0 TEST RESULTS

Test results are generally reported in tables and graphs. Although a new table may be designed for each set of tests, tables should include all the parameters that affect boom performance. These would include:

<u>Fixed Test Parameters</u>
o Boom type - this can be shown in the table title if all booms tested are of the same type.
o Boom freeboard and draft
o Boom buoyancy to weight ratio
o Wave pattern - wave length, height and length/height ratio
o Gap ratio

<u>Test Variables</u>
o Oil type and viscosity
o Boom tow speed
o First loss and Gross Loss Tow Speeds in calm water and waves
o Oil Loss Rate
o Boom oil loss rate at speeds above the First Loss Tow Speed
o Critical tow speeds for loss of boom freeboard, planing, or mechanical failure
o Method of boom failure
- Entrainment
- Drainage
- Spashover
- Submergence
- Planing

o Forces on booms in various operational conditions

In many cases the boom tow speed is the independent variable and reported in half knot steps; e.g., 0.5 knots, 1.0 knots, 1.5 knots and so forth. Data in the main body of the report should be presented in this way with test results shown in order of the independent variable, generally tow speed. If several runs were made at a single tow speed, these data should be shown together or averaged, if they are not widely dispersed, based on the judgment of the test engineer. Raw data, that is, data recorded in order of test run number or test date, should not be shown in the main body of the report. These data are not processed or arranged in an order in which an analysis would be performed and should be shown in an appendix. Other data that are not likely to affect the outcome of the tests can also be shown in an appendix. These would include test conditions such as air temperature, wind direction and speed, water temperature and so forth. It is important that data presented in the main body of the report be prepared and arranged for analysis. If this is not done, the user's first step is likely to be to prepare new data sheets, which is an extra step that should not be required.

A sample data sheet for a booms test is shown below.

Table 1.0 Boom Test Results

BOOM	FIRST & GROSS LOSS TOW SPEED (kts)				LOSS RATE TEST CALM WATER (gpm @ kts)		CRITICAL TOW SPEED (kts)/ TYPE FAILURE	OIL PRE-LOAD/ VISCOSITY (gallons/cSt)
	WAVE CALM	WAVE H 0.8' L 16.2' L:H 20:1	WAVE H 1.1' L 42' L:H 38:1	WAVE HARBOR CHOP	..FIRST LOSS +0.1 kts	FIRST LOSS +0.3 kts		
A BOOM FB 14" D 16" B/W 8:1 FIRST LOSS GROSS LOSS	1.00 1.20	0.72 0.93	1.07 1.30	0.95 1.10	65 @ 1.10	141 @ 1.30	2.75/ SUBMERGED	600/3,000
B BOOM FB 21" D 26" B/W 2.8:1 FIRST LOSS GROSS LOSS	0.85 1.05	0.40 0.60	0.85 1.05	0.88 1.07	7 @ 0.95	47 @ 1.15	>6.0/ PLANING	350/2,300
C BOOM FB 9" D 21" B/W 3.8:1 FIRST LOSS GROSS LOSS	0.85 1.10	0.72 0.90	0.87 1.15	0.90 1.15	17 @ 0.95	80 @ 1.15	2.25/ SUBMERGED	360/1,600; 3,400; 5,400
D BOOM FB 26" D 44" B/W 3.5:1 FIRST LOSS GROSS LOSS	0.95 1.32	0.75 1.05	0.95 1.20	1.00 1.25	8.5 @ 1.05	40 @ 1.25	2/0/ NO FAILURE	500/2,900
E BOOM FB 18" D 25" B/W 9.5:1 FIRST LOSS GROSS LOSS	0.90 1.22	0.80 - -	1.07 - -	1.00 - -	19.5 @ 1.00	75.5 @ 1.20	3.5/ SUBMERGED	500/1,730

Actual Measured Wave Conditions:
Wave #1: regular sinusoidal wave: H = 0.8', L = 16.2', T = 1.8 sec
Wave #2: regular sinusoidal wave: H = 1.1', L = 42.1', T = 3.1 sec
Wave #3: harbor chop: H = 0.7', L and T not calculated
FB = Freeboard, D = Draft, B/W = Buoyancy/weight ratio

Data shown on the sample table are taken from an actual test with the boom names deleted. This table includes just about all of the variables that need to be evaluated. Although the data are dense, it is clear and useable. If these booms were of differing types, such as fence, pressure-inflatable etc., this information could have been included along with the boom name. This table is actually similar to those recently used for OHMSETT tests except it contains some additional information. In earlier tests, oil slick thickness is sometimes shown. This should be included in the data sheet along with or instead of oil pre-load. It is important for analysis to have all boom performance parameters shown with the collected data so that the analyst can determine which parameters are affecting boom performance. Many other table formats are acceptable, but all should have data completely identified. For example, a series of simple tables may be used with each showing results in terms of one of two variables.

Graphic Presentation Results of tests can also be represented graphically. This can be useful in showing trends of performance, but great care should be taken to be sure data are represented accurately. Here are some considerations for preparing graphs.

- o Nearly all graphical results published recently have been prepared on a computer. Although this is convenient, the result is often not descriptive of test results because the scales shown on the graphs are much too large. Typically computer generated graphs have numbered scale points that are one inch and even more apart. This means it is very difficult to determine exact test values from the graph. To be most useful, graphs should have closely spaced scale markers, no more than 1/4 inch apart whenever possible. Because of the difficulty in obtaining exact numbers from graphs, graphical data should always be backed up with a data sheet.
- o Graphical data should be completely identified. For boom tests, curves showing test results should list test parameters that affect boom performance, such as freeboard, draft, and buoyancy to weight ratio. In addition, great care should be exercised to be sure that the boom description and data match information shown elsewhere in the report. Existing test reports are rife with problems of curves on graphs not being identified, boom descriptive data not being identified, scales not being properly labeled, and even trends shown by curves not matching information on data sheets. Graphs can be helpful in showing performance trends, but only if they are well prepared.

9.0 OVERALL ASSESSMENT OF PERFORMANCE

This is an analysis of what test data show. This may be one paragraph or more depending on the complexity of the data covered. It should be detailed, but not didactic, because the user should be free to draw his own conclusions based on the information presented. In every case, conclusions and performance trends should be supported with numbers shown in test results.

10.0 REPORT SUMMARIES AND EXECUTIVE SUMMARIES

In large tests in which many devices are tested, it is sometimes helpful to provide summary tables that are perhaps less detailed but show trends in performance more clearly. In simplifying and averaging results care should be taken that results are not altered, only clarified. Some reports use executive summaries at the beginning of the report. As with other summaries, care should be taken to be sure that the summary accurately portrays what occurred in the tests. It is important that the executive summary does not contain any new information that is not contained in the body of the report. The executive summary should only condense and assemble points that have already been made or show data that has been shown elsewhere. Use paragraph titles in executive summaries so that data and remarks are easier to find and more easily understood.

11.0 APPENDICES

Detailed reference data should generally be separated from the main body of the report. Information typically contained in appendices includes the following:

- o References
- o Raw test data shown in order of test run and date
- o Manufacturer's literature showing products being tested
- o Test procedures used to determine oil viscosity and other test parameters
- o Details on test configuration and how data were recorded and computations made
- o Methods of statistical analysis employed
- o List of acronyms
- o Units of measure and unit conversions

12.0 UNITS

Although a great effort has been made in recent years to standardize units and particularly shift to metric units, a great many differing sets of units remain in use and in American industry, use of English units predominate. The use of units will, of course, be the option of the test sponsor; however, every effort should be made to use units that reflect generally accepted practice whether they are English units or metric units. Typical or desirable sets of units have already been listed in this section, however, to have all the information needed in one place, they are mentioned again here.

- o <u>Boom Dimensions</u> - In Europe the practice is to use millimeters, in the U.S. inches. Use one or the other.
- o <u>Weights</u> - Boom weight is generally shown in weight per unit length, as is buoyancy and ballast weight. Units are either kg/m or lbs/ft.
- o <u>Strength</u> - Newtons or pounds force.
- o <u>Fabric Tensile Strength</u> - Pounds/inch or Newtons/50 mm. The metric units may be considered unusual, but this is standard.
- o <u>Fabric Tear Strength</u> - Pounds or Newtons.
- o <u>Oil Viscosity</u> - Centistokes (cSt) are preferred but Centipoise (cP) is also used.
- o <u>Speed</u> - Because data report movement on water or movement of water, speed reported in knots is almost universal. Speed is also shown in meters/second, which is approximately half the velocity in knots. Do not use feet per minute or centimeters per second. These are non-standard units and should be avoided.
- o <u>Volume</u> - Cubic meters are the accepted metric units. The oil industry often uses barrels (42 U.S. gallons) and U.S. gallons are often used. Avoid the use of liters.
- o <u>Volume Rate</u> - The most common use in the oil industry is barrels/hour or cubic meters/hour. In the U.S., equipment specifications are often in gallons per minute, which is well understood and acceptable. Some reports show volume rates in liters/minute or liters/second. These units are used less often and should be avoided.

<u>REFERENCES</u>

1) Schulze, Robert, *World Catalog of Oil Spill Response Products*, 1999/2000 edition, Port City Press, Baltimore, Maryland.

2) 2000 Annual Book of ASTM Standards, Section 11, "Water and Environmental Technology," Volume 11.04, <u>Standard Guide for Collecting Containment Boom Performance Data in Controlled Environments</u>, F2084-1, Conshohocken, Pennsylvania, 2000.

CHAPTER 2

FORMAT AND CONTENT OF REPORTS OF TESTS OF OIL SPILL RESPONSE SKIMMERS

IN CONTROLLED AND UNCONTROLLED ENVIRONMENTS

1.0 TEST DESCRIPTION

1.1 Who performed the test - Specify the agency for whom the test was performed and/or the test sponsors.
1.2 When the test was performed (as opposed to when the report was published)
1.3 Where the test was performed - For offshore and river tests, specify the exact location.
1.4 Purpose of the test and other background information.

2.0 SKIMMER DESCRIPTION

2.1 Describe each skimmer according type. Skimmer types currently identified are defined in American Society for Testing and Materials (ASTM) “Standard Guide for Selection of Skimmers for Oil-Spill Response (F1778-97) and include the following (1):

- Boom
- Brush
  - Chain brush
  - Drum brush
- Disc
  - Oleophilic disc
  - Star disc
- Drum
  - Oleophilic drum
  - Helical drum
  - Double drum
  - Drum with internal collection
- Paddle belt
- Rope mop
  - Stationary rope mop
  - Suspended rope mop
  - Zero Relative Velocity (ZRV) rope mop
  - Boom rope mop
- Sorbent belt
- Submersion plane
  - Fixed submersion plane
  - Submersion moving plane
- Suction
  - Stationary suction
  - Air conveyors
- Weir
  - Weir skimmers with external pumps
  - Weir skimmers with integral pumps
  - Induced flow weir
  - Advancing weir
  - Weir separator
  - Sweeping arm weir
  - Oil head weir

If the skimmer tested does not fall into one of these generally accepted categories, describe it in detail and give it a name. See ASTM Standard F1778 for an exact description and characteristics of each skimmer type. For additional definitions, see the recent edition of the World Catalog of Oil Spill Response Products (2).

Describe skimmer characteristics and how the skimmer is generally used. This discussion helps the user to understand why the tests are being performed and expected outcomes.

2.2 Record the skimmer manufacturer’s name and the skimmer model or designation. Include a simple line drawing showing an overall view of the skimmer. When appropriate, include sketches of special skimmer features.

2.3 A test report should fully describe the skimmers being tested. This information can be shown in a table format. A sample table follows. Although it would be desirable to show all items listed, some are less important than others and could be omitted. Those shown with a star (*) are considered to be absolutely essential. More than one skimmer can be shown on a single table, but all other information on a single skimmer should be presented together.

Table 1.0 Skimmer Description

*MODEL			
*SERVICE TYPE			
*OPERATING ENVIRONMENT			
*APPLICATION			
*LENGTH ft (m)			
*WIDTH ft (m)			
*HEIGHT ft (m)			
*MAXIMUM DRAFT ft (m)			
*DRY WEIGHT lb (kg)			
TRANSIT SPEED kts (m/s)			
*SKIMMING SPEED kts (m/s)			
*SWEEP WIDTH ft (m)			
SWEEP RATE NM^2/hr			
SPILL ENCOUNTER RATE 1 mm SLICK BBL/hr (m^3/hr)			
SLICK THICKNESS ~ MAX PUMPING RATE (mm)			
ON BOARD STORAGE BBL (m^3)			
DEBRIS HANDLING			
*PUMP-TYPE -POWER -CAPACITY BBL/hr (m^3/h) -LOCATION			
*BEST IN OIL TYPE (I, II, III, IV, V)			
AUX EQUIPMENT			
OPERATORS REQUIRED			

Most entries on this table are obvious, but the following notes explain those that may require additional information.

o *Service Type* - Show the skimmer type as listed in section 2.1.

o *Operating Environment* - Calm water, protected water, or open water. See definitions of operating environments, Standard Practice for Classifying Water Bodies for Spill Control Systems, F625-94 (3).

o Application - this basically distinguishes between stationary skimmers and advancing skimmers, but there are some additional details to consider:

- Stationary - always used in a fixed location
- Advancing - must have forward movement for the oil to flow into the system
- Self-propelled - an advancing skimmer that is a dedicated skimming vessel with its own power
- Stationary/advancing - skimmers that are generally used in the stationary mode but may be used in

a slowly advancing system or a system that advances to collect oil then pauses to skim

o *Sweep Rate* - This is an entry for advancing skimmers expressed in nautical miles squared/hour (NM^2/hr). It is determined by dividing the Sweep Width in feet by 6,076 feet (1 nautical mile) or the width in meters by 1,852 meters and multiplying by Skimming Speed in knots.

o *Spill Encounter Rate for a 1 mm Slick* - Expressed in barrels/hour (BBL/hr) it is the Sweep Rate multiplied by the constant 21,570, or in m^3/hr, it is the Sweep Rate multiplied by 3,430. This number can be multiplied by the measured slick thickness in mm to determine Spill Encounter Rate for the particular recovery system. Spill encounter rate for a 1 mm slick is a multiplier that can be used with any slick thickness to determine encounter rate in a spill situation. For a specific skimmer test, the test engineer may wish to record the spill encounter rate for that system, so that specific number could be used instead. o *Slick Thickness Corresponding to the Maximum Pumping Rate (mm)* - For an advancing skimmer, this shows the maximum slick thickness that can be handled for the computed spill encounter rate based on the published pumping rate. (It is the pump capacity in BBL/hr divided by Spill Encounter Rate for a 1 mm slick in BBL/hr). This is the thickest slick that can be handled by the system based on pump capacity and spill encounter rate. It is a measure of the adequacy of the skimmer pump.

o *Best in Oil Type* - This shows the oil viscosity, or range of oil viscosities, in which the skimmer is intended to operate. See ASMT Standard F631-99 for oil category definitions (4).

o *Group all information on a single skimmer together* - Many test programs involve the examination of several skimmers. The report of these tests should group all information on a single skimmer in one place. Although the researcher may be interested in the performance of several skimmers, he must gather information on one at a time. Some early test reports begin by listing all skimmers tested, then present a description of each skimmer, followed by test procedures for each skimmer, and so forth. This means that the user must go through several sections of the report, or perhaps even all sections, to gather information on a single skimmer. This can be extremely frustrating and time consuming, with the result that there may be doubt that all the information on a single skimmer has been found. In some cases skimmer description and data results can be combined on a single table, however, be sure that all data pertaining to a single skimmer are grouped together, even if that repeats information that is presented elsewhere.

3.0 PERFORMANCE PARAMETERS

Unlike booms, skimmers have a wide variety of performance parameters depending on skimmer type. Skimmer tests are, in part, intended to determine what the performance parameters are and the extent to which they affect skimmer effectiveness. Skimmer test reports should analyze performance based on established parameters and at times determine new factors that affect performance. Data should be recorded on test runs that show changes in performance parameters along with measures of device effectiveness recorded with the test. This can be used for test analysis as well as for researchers to evaluate test data later. This section lists performance parameters according to skimmer type. Not all of these parameters will be listed in every test and later tests are likely to develop new performance parameters. The list of performance parameters shown below could be considered as a starting point to determine the factors that affect each skimmer's performance. The performance parameters are listed according to skimmer type.

Boom Skimmers

o Number of skimming heads in the boom
o Width of opening for a weir skimmer head
o Boom characteristics - provide a complete description of the boom portion of the system (see the Format for Oil Spill Response Booms)
o Pumping capacity
o Oil viscosity
o Slick thickness
o Currents and waves

Brush Skimmers

o Diameter of the chain brush

o Brush bristle type
o Slant length of chain brush
o Vertical height of chain brush
o Chain brush speed
o Speed of drum brush (rpm)
o Number of chain brush elements in skimming unit
o Width of a drum brush skimmer and number of co-axial wheels
o Pumping capacity
o Oil viscosity
o Slick thickness
o Currents and waves

Disc Skimmers

o Disc diameter - a measure of the area available for oil recovery
o Radial length of disc wetted by oil - a measure of the area of the disc being used to recover oil
o Disc material - affects the affinity of oil to coat the disc surface
o Disc shape - specialized disc shapes, such as a T-disc or off center/elliptical disc, have different recovery characteristics
o Disc spacing - affects the flow of oil into the system and vulnerability to debris
o Disc speed - affects recovery rate and recovery efficiency
o Number of discs per unit - affects total recovery capacity. Test results may show the recovery capacity per disc since different models of the same skimmer type may have a different number of discs.
o Pumping capacity
o Oil viscosity
o Slick thickness
o Currents and waves

Drum Skimmers

o Drum length and diameter
o Drum material
o Drum submergence depth
o Drum speed
o Pumping capacity
o Oil viscosity
o Slick thickness
o Currents and waves

Paddle Belt Skimmers

o Width of ramp
o Length of ramp
o Speed of belt
o Pumping capacity
o Oil viscosity
o Slick thickness
o Currents and waves

Stationary Rope Mop Skimmers

o Diameter of mop
o Mop type (flat or brush type)
o Length of mop deployed on oiled surface
o Mop speed
o Pumping capacity
o Oil viscosity
o Slick thickness
o Currents and waves

Suspended Rope Mop Skimmers

o Diameter of mop

- o Mop type (flat of brush type)
- o Number of mops on skimmer
- o Length of mop deployed on the oiled surface
- o Speed of mop
- o Height of the skimming head above the oiled surface
- o Pumping capacity
- o Oil viscosity
- o Slick thickness
- o Currents and waves

Zero Relative Velocity Skimmers

- o Diameter of mop
- o Mop type (flat or brush type)
- o Sweep width of system
- o Length of mop deployed on the oiled surface
- o Number of mops on skimmer
- o Speed of mop
- o Speed of skimming vessel
- o Bow wave or flow conditions produced by the catamaran hull of the skimming vessel
- o Mop coverage of oil in the skimming area
- o Contact time between the oil slick and the mops
- o Pumping capacity
- o Oil viscosity
- o Slick thickness
- o Currents and waves

Sorbent Belt Skimmers - this classification also includes lifting belt skimmers that simply carry viscous oil to a hopper and are not sorbent

- o Width of belt
- o Belt material
- o Belt speed
- o Slant length of belt
- o Vertical height of ramp
- o Induction pump pressure
- o Sweep width of system
- o Sweep speed
- o Pumping capacity
- o Oil viscosity
- o Slick thickness
- o Currents and waves

Fixed Submersion Plane

- o Width of the plane
- o Slant length of plane
- o Vertical depth of plane
- o Sweep width of the system
- o Sweep speed of the system
- o Pumping capacity
- o Oil/water separation capacity
- o Oil viscosity
- o Slick thickness
- o Currents and waves

Submersion Moving Plane Skimmers

- o Width of belt
- o Speed of belt
- o Slant length of belt
- o Flow control plate opening

o Vertical depth of belt
o Pumping capacity
o Oil/water separation capacity
o Oil viscosity
o Slick thickness
o Currents and waves

Stationary Suction Skimmers

o Size of inlet to suction head
o Size of discharge hose
o Pumping capacity
o Flotation collar
o Oil viscosity
o Slick thickness
o Currents and waves

Air Conveyors

o Size of inlet to suction head
o Size of discharge hatch
o Pumping capacity
o Oil viscosity
o Slick thickness
o Currents and waves

Weir Skimmers

o Size of weir inlet
o Setting weir depth
o Hydraulic balancing
o Pumping capacity
o Oil viscosity
o Slick thickness
o Currents and waves

Advancing Weir Skimmers

o Size of weir inlet
o Type of weir opening, controlled or uncontrolled
o Sweep width of system
o Sweep speed
o Oil/water separation capacity
o Oil viscosity
o Slick thickness
o Currents and waves

3.1 SPECIAL NOTES ON PERFORMANCE PARAMETERS

Some skimmer tests have not done a good job of reporting test results in terms of established performance parameters. Special attention should be given to reporting data with the following skimmers:

o Disc skimmers

- Disc size is always reported but the radial length of disc wetted by oil is not generally recorded. As a result, the area of the disc used in recovering oil is not known. The amount of wetted surface for any unit depends as much on how the unit is positioned in the water as the size of the disc. Units with larger discs that are higher in the water may have no more wetted surface than a device with a smaller disc positioned lower in the water. Skimmers with larger discs would generally be expected to have higher rates of recovery than skimmers with smaller discs, but in some tests this has not occurred. The difference was probably in the wetted area of the discs, which was not reported. The larger discs may not have had a larger wetted area.
- Disc material in a given test is known, but since discs of other materials are not tested at the same time, the difference in performance based on disc material is not known. Although disc material is generally

not a variable in tests, care should be taken to be sure disc material is identified so that results can be linked to a particular system.

- Disc spacing affects performance, but the spacing in any skimmer generally cannot be changed so the influence of spacing on performance cannot be determined. There is reason to believe that skimmers with more widely spaced discs are more effective in higher viscosity oils, but this relationship has not been established.
- Disc shape also affects performance. T-disc skimmers are claimed to have better performance than flat discs because the shape permits higher rotational speeds without throwing the oil off the disc. Tests show T-discs to have better performance per disc, but perhaps not for that reason. Since the top of the T is wet with oil and has its own scraper, improved performance is more likely the result of an increased area of wetted surface and perhaps from using stainless steel or cast aluminum rather than PVC for the collection surface. If the area of wetted surface were reported accurately, the reasons for the differences in performance of flat discs and T-discs could be better evaluated. For T-discs, the flat surface on the top of the T should be added to radial wetted surface.
- Disc speed affects performance substantially, and this difference is generally recorded. A widely held notion concerning disc skimmers has been that, as disc rpm increases, recovery rate increases but recovery efficiency decreases. This is not always true. In most tests of disc skimmers, an optimum disc speed is found for each oil type then the remaining tests are run at that speed. The test report should carefully document results of tests determining optimum disc rpm.

o *Submersion Moving Plane Skimmers* - Early tests of this skimmer list the flow control plate opening (back plate) as a performance parameter. In the main body of a report of tests of this skimmer, the back plate opening is mentioned and performance with various size openings is compared; however, the back plate is not described nor is a sketch provided to show its location. This information is finally provided in an appendix. Since this opening is a significant performance parameter, the sketch should have been provided in the main body of the text describing the skimmer with a discussion of how it works and how its adjustment is likely to affect performance.

o *Zero Relative Velocity Skimmers* - These devices are generally rope mop skimmers. The bow wave and the flow pattern between the catamaran hulls sometimes directs the surface oil to the center of the skimming area so that the outboard mops are only in contact with water. This phemenon, if it exists, should be documented and considered in the performance analysis.

o *Sorbent Belt Skimmers* - Some of these skimmers have an induction pump that draws the oiled water surface through the belt. The setting of the pump is generally recorded as induction pump pressure. This setting is likely to be a performance parameter; that is, skimmer performance is likely to vary with induction pump pressure as well as other performance parameters. The induction pump pressure may be hydraulic pressure in a hydraulic pump, but the available test reports do not describe what induction pump pressure means. Since this pressure is a performance parameter, the meaning of the pressure and the way in which the pump operates should be described.

o *Speed of recovery mechanism* - Skimmers that have moving recovery elements, such as discs, brushes, drums, and moving planes, are generally tested at a variety of recovery element speeds. This may be either a linear speed of a moving plane or revolutions per minute of rotating elements. In most cases, testing begins by varying the speed of the moving element to determine a spread of performance values and to determine the optimum performance speed. Often when the optimum performance speed is determined, that element speed is used in remaining tests. At this point element speed is no longer a test variable. The process of finding the optimum skimming element speed should be discussed in the report and information should be presented about how the optimum speed would be determined in the field or considerations for selecting a desired skimmer element speed.

4.0 OPERATIONAL NOTES

This section can be used to describe the general operational characteristics of the skimmer being tested. This is not, perhaps, absolutely essential information, but helps to establish what is being looked for in the tests. Things that may be discussed in this section include the following:

o Stability
o Recovery rate

o Skimming speed for advancing skimmers
o Recovery efficiency
o Throughput efficiency
o Debris handling
o Oil viscosity range

5.0 TEST PROCEDURE

This provides a complete description of how the test is being run. In some cases it may be desirable to also have a section describing the test configuration if it is especially complicated. This would be optional depending on the tests being run. Special attention in test procedures should be given to the following:

o *Slick Thickness* - Report slick thickness and the method of determining slick thickness. In static tests, slick thickness is often determined by adding a measured volume of oil to an enclosed area. In this case, the slick thickness is determined by dividing the oil volume by the area. Sometimes thickness is measured by taking samples at the oil/water interface, or by a continuously reading measuring device. In all cases, it is important to know what the slick thickness was, how it was measured, and the estimated accuracy of the measurement. Report if slick thickness is being maintained or if thickness is being allowed to decrease as oil is removed. Indicate if recovered oil is being returned to the skimming area as it is recovered. In tests of advancing skimmers, test oil may accumulate in the pocket of the supporting containment boom and therefore become much thicker than in the general containment area. The slick thickness at the skimmer intake should be reported if possible. In some towed skimmer tests, oil is discharged immediately ahead of the skimmer so slick thickness is not measured. This is an acceptable alternative, but the way in which this process was carried out should be described.

o *Volume of Oil* - The volume of oil used in tests should be reported to give the user appreciation of the extent of the test and the amount of oil that was available for recovery.

o *Emulsification* - Report oil emulsification and changes in oil viscosity if recovered oil is being returned to the collection and skimming area.

o *Skimmer capacity* - Note if oil is being presented to the skimmer at a rate that is near the maximum advertised capacity of the skimmer. If it is not, this should be reported.

o *Throughput Efficiency* - This is an important measure of skimmer effectiveness, but it isn't always well measured in tests. Throughput Efficiency (TE) is the percent oil presented to the skimmer that is recovered, or conversely, the percent of the oil that is lost behind the skimmer, which is also significant. In many cases, TE is a function of the containment boom being used with a skimmer rather than the performance of the skimmer itself. In some cases, a skimmer may be tested without containment boom so the TE either isn't measured or is shown as a very low value. If TE isn't recorded in tests, reasons should be explained. If TE is recorded but the skimmer is used without containment boom, or with non-standard boom because of test constraints, this should also be explained.

o *Skimming speed for advancing skimmers* - report speed in knots or meters/second

o *Wave conditions* - report wave length, height, and length to height ratio. Wave steepness, measured by the length to height ratio, has been found to be important to the effectiveness of containment booms and it is likely to be a factor in skimmer effectiveness as well. Wave period can be reported, but wave length should be reported if possible. Reporting wave conditions as a sea state or a range of sea states in offshore tests is too vague for analysis. If waves were variable during tests, report a range of wave heights and lengths. If possible, report wave height and length associated with each test run. For offshore tests, report whether tests were run into the waves or with the waves.

o *Currents* - For offshore tests, report currents present and their direction relative to the movement of the skimmer tow.

o *Wind and Temperature Conditions* - In controlled tests, wind conditions are often not significant because waves are generated artificially and tests are generally delayed if winds become a factor. In offshore tests winds are significant and should be reported. Air and water temperature are generally not significant unless they produce icing or changes is test oil viscosity.

o *Debris* - report debris that was used to determine skimmer effectiveness in severe spill conditions.

o *Test time* - The amount of time taken in each test cycle is significant but rarely reported. Stationary skimmers may be tested for long periods of time, even hours. These tests may be more significant than a test that is performed in a few minutes. In many cases, however, test times are short, which leaves the question of whether the skimmer achieved a steady state recovery condition and whether the skimmer was performing at near its maximum capacity. Most controlled tests of advancing skimmers are very short, even in a large test tank. Depending of tow speed, test time may be only 1 to 4 minutes, and may be even less. The period of time that the skimmer achieves a steady state skimming condition may be less than a minute. In these cases it is most important that test time be recorded and a remark made to indicate if a steady state skimming rate was established and for what period of time.

5.1 TEST OIL PROPERTIES

5.1 Report oil type; e.g., diesel, lube oil, special test oil, Bunker C, crude oil, and so forth. Report if oil is emulsified.
5.2 Report oil viscosity and the temperature at which viscosity was determined. *The temperature at which viscosity was determined should be close to the existing water temperature when tests were run.* Reporting oil viscosity at 140^{o}F when the water temperature at test time was 65^{o}F is not helpful. Generally oil viscosity should be reported in Centistokes (cSt). This is equivalent to mm^2/s but it is a more generally recognized term. Viscosity can also be reported in Centipoise (cP), but these units are not used as often. (cP = cSt X density)
5.3 Report oil density, surface tension, and other oil properties as required.

5.2 DATA ACCURACY

Each skimmer section should contain a general description of how test measurements were made and the estimated accuracy of each. Problems in achieving the desired accuracy of test parameters could also be discussed. A detailed description of how each measurement was made, devices used in measuring, ASTM Standards used in making measurements, can be included in an appendix.

Accuracy of all recorded test variables should be listed. This could include the speed at which the recovery mechanism of a skimming device is being run. For an advancing skimmer, it would include the accuracy of the tow speeds. For all skimmers, it would include the accuracy of the measurement of slick thickness and the way in which slick thickness is being maintained.

6.0 TEST RESULTS

Test results are generally reported in tables and graphs. Although a new table may be designed for each set of tests, tables should include all the parameters that affect skimmer performance. These would include:

Fixed Test Parameters - Section 2.1 contains a list of generally accepted performance parameters according to skimmer type. Other parameters may also be included based on special test requirements.

Test Variables

o Wave height, length, and length to height ratio
o Tow speed for advancing skimmers
o Number of data points
o Slick thickness
o Oil Recovery Efficiency
o Oil Recovery Rate
o Throughput Efficiency
o Oil viscosity - this can be a single entry at the top of a data sheet if viscosity remains constant throughout the test
o Test time

Arrange test data in order of the independent variable. For advancing skimmer tests, this is likely to be tow speed. For stationary skimmers, it may be slick thickness. In any case, raw data arranged in order of test number or test date should be shown in an appendix. Be sure that units of measure are shown for all numbers on data sheets.

Note if the skimmer emulsifies oil as it is skimming and the operating conditions that seem to produce emulsification.

In almost every case, the measures of skimmer effectiveness are oil recovery efficiency, oil recovery rate, and throughput efficiency. Be sure that these results are shown on data sheets for each run and not computed or presented elsewhere. These measures of effectiveness are defined in ASTM Standard F631-99 (4). If other measures of effectiveness are required to describe a skimmer's performance, be sure that they are defined in the text and that reasons for using these special terms are explained.

6.1 TEST DATA SHEETS

Usually data are arranged according to test oil viscosity, but within that category, data should be arranged according to some other controlling test parameter, such as tow speed, slick thickness or other controlling parameter, not the order in which the tests were performed. Many test reports record data in the order that tests were performed. In many cases, tests are repeated at a selected slick thickness or for advancing skimmers, at a selected tow speed. This means that the user must begin the analysis by making up a new data sheet in which runs with similar test parameters are grouped together. This, of course, is a time consuming job. Raw data, that is, data arranged in order of date or test run number, can be shown in an appendix but not in the main body of the report.

Test data sheets can be tailored to each set of test requirements, but they usually follow a fairly set pattern.

o *For Advancing Skimmers* - One set of test data are generally for a single oil viscosity because in a test basin the test must be short (4 to 6 minutes) and oil is not emulsified by pumping. Table 1.0 shows typical data from an actual test with the skimmer name omitted. Sometimes another vertical column is used to show the number of data points that were obtained at each tow speed. Additional information about the test can be added in notes.

o *For Stationary Skimmers* - Tests of stationary skimmers are run for longer periods of time and recovered oil is returned to the collection area, so emulsification becomes a problem. Sometimes oil is not returned so slick thickness decreases during the test. This should also be noted. Table 1.1 shows a typical data sheet for a stationary skimmer.

TABLE 1.0 -- Tests of a boom skimmer
AVERAGE VISCOSITY 178 cSt

WAVE TYPE	TOW SPEED (kts)	SLICK THICKNESS (mm)	RECOVERY EFFICIENCY (RE) %	THROUGH-PUT EFFICIENCY (TE) (%)	OIL RECOVERY RATE (ORR) BBL/hr (m^3/hr)
CALM WATER	0.75 1.0 1.25 1.5	3.1 3.3 3.1 2.6	22 44 42 24	99 68 38 11	104.4 (16.6) 221.4 (35.2) 79.2 (12.6) 88.1 (14.0)
0.5 x 11.6 m WAVE	0.75 1.25 1.5 1.75	3.2 3.1 3.5 2.5	21 59 44 29	99 51 20 14	98.7 (15.7) 250.3 (39.8) 172.3 (27.4) 99.4 (15.8)
0.7 m HC WAVE	0.75 1.25 1.25 1.75	3.1 2.0 3.3 2.9	25 34 67 29	99 41 56 13	98.7 (15.7) 122.0 (19.4) 154.7 (24.6) 104.4 (16.6)

Notes: 1) All data represent one trial.
2) Tests in waves fit the ASTM definition of Protected Water.

TABLE 1.1 -- Disc skimmer performance by oil type
Slick thickness is permitted to decrease during tests.
Average performance for flat discs at optimum rpm. T-discs shown at optimum rpm.

TEST OIL	DIESEL 4-5 cSt		LIGHT CRUDE 10 mm 5-50 cSt 25 mm 500-1 300 cSt	
DISC TYPE	FLAT DISC	T-DISC	FLAT DISC	T-DISC
10 mm CALM WATER				
Emulsification	2.3%	7%	1.2%	0.9%
Recovery Efficiency	95%	89%	99%	99%
Recovery Rate/Disc BBL/hr (m^3/hr)	0.12 (0.019)	0.23 (0.036)	0.11 (0.017)	0.16 (0.025)
10 mm HARBOR CHOP (0.8 m)				
Emulsification	19%	43%	52%	76%
Recovery Efficiency	75%	14%	48%	24%
Recovery Rate/Disc BBL/hr (m^3/hr)	0.06 (0.01)	0.08 (0.012)	0.08 (0.012)	0.08 (0.012)
25 mm CALM WATER				
Emulsification	3.2%	2.8%	4%	0.01%
Recovery Efficiency	96%	97%	96%	100%
Recovery Rate/Disc BBL/hr (m^3/hr)	0.31 (0.05)	0.68 (0.108)	0.31 (0.049)	0.53 (0.084)
25 mm HARBOR CHOP (0.8 m)				
Emulsification	0.7%	7%	35%	54%
Recovery Efficiency	97%	72%	65%	46%
Recovery Rate/Disc BBL/hr (m^3/hr)	0.30 (0.048)	0.60 (0.095)	0.21 (0.034)	0.34 (0.054)

Other performance parameters that remain constant throughout the test can be shown elsewhere. For the disc skimmer, these may include disc size, radial length of the disc wetted by oil, disc material, disc shape, disc spacing and disc speed. If all tests are run at optimum disc speed, this should be recorded. If varying disc speeds are used, they should be shown on the data sheet. Test runs that were used to determine optimum disc speed should be shown on a separate data sheet.

Data sheets should be complete, however, data that remain nearly constant throughout or data that are not generally used in analysis, should not be shown with every test run but rather can be listed separately. Too much data for each test run may just be clutter rather than additional important information. Oil viscosity may be shown for every run if it changes substantially and is considered to be an important test parameter that is changing skimmer performance. On the other hand, more detailed test oil properties or ambient weather conditions are generally not important to test results and do not have to be shown for each run. Examples of data that should generally not be recorded for each test run include oil surface tension, interfacial tension, specific gravity (if it is not a controlling variable), air temperature, water temperature, wind speed, and wind direction.

6.2 GRAPHIC PRESENTATION OF TEST DATA

Results of tests can also be represented graphically. This can be useful in showing trends of performance, but great care should be taken to be sure data are represented accurately. Here are some considerations for preparing graphs.

- o Graphs are useful in visualizing what happened but graphs should not be the only source of data. There are several reasons for this. First, graphs can generally only show two or three test parameters at once. Other important test parameters are left in doubt or are not reported. Second, data taken from graphs are generally only approximate. Actual recorded test data may be much more accurate. Finally, if graphs are used to supplement data sheets, they should contain enough data so that specific test runs can be identified.

o Nearly all graphical results published recently have been prepared on a computer. Although this is convenient, the result is often not descriptive of test results because the scales shown on the graphs are much too large. Typically computer generated graphs have numbered scale points that are one inch and even more apart. This means it is very difficult to determine exact test values from the graph. To be most useful, graphs should have closely spaced scale markers, no more than 1/4 inch apart whenever possible. Because of the difficulty in obtaining exact numbers from graphs, graphical data should always be backed up with a data sheet.

o Graphical data should be completely identified. For skimmer tests, curves showing test results should list test parameters that affect performance of that particular skimmer. In addition, great care should be exercised to be sure that these data match information shown elsewhere in the report. Existing test reports are rife with problems of curves on graphs not being identified, skimmer descriptive data not being identified, scales not being properly labeled, and even trends shown by curves not matching information on data sheets. Graphs can be helpful in showing performance trends, but only if they are well prepared.

7.0 OVERALL ASSESSMENT OF PERFORMANCE

This is an analysis of what test data show. This may be one paragraph or more depending on the complexity of the data covered. It should be detailed, but not didactic, because the user should be free to draw his own conclusions based on the information presented. In every case, conclusions and performance trends should be supported with numbers shown in test results. The assessment of performance will always be tailored specifically to an individual test or set of tests; however, a review of existing tests indicates that some rules or cautions about how data are presented are in order.

o Describe operating procedures that enhance the effectiveness of the skimmer being tested. Operators in the field develop procedures for each piece of equipment and even for special spill situations; however, information based on controlled tests can be helpful to both experienced and inexperienced operators.

o Describe operating conditions, such as slick thickness, oil viscosity, device operating speed, and so forth, that enhance skimming effectiveness.

o In some early tests, data summaries show only maximum values from individual runs. Further, maximum values of Recovery Efficiency and Recovery Rate are shown together even though they did not occur together. In fact, maximums of these two test parameters rarely, if ever, occur together. As Recovery Rate increases Recovery Efficiency goes down for almost all skimming systems. Showing maximum values for these two performance parameters together without describing other conditions is at best misleading and perhaps unethical.

o Test reports should note when data points are averaged, how many points went into the average, and the spread of values that were averaged, particularly when that spread is large. Better, if data points are diverse, they should be shown individually and not averaged. If many data points are available, the report can show weighted averages. This practice should also be noted together with the number of points that went into the weighted averages.

o Test results should note the relationship between the amount of oil available for skimming and the total advertised capacity of the skimmer. A skimmer's rate of recovery should not be shown as a maximum if there was not enough oil available to achieve that maximum.

8.0 REPORT SUMMARIES AND EXECUTIVE SUMMARIES

In large tests in which many devices are tested, it is sometimes helpful to provide summary tables that are perhaps less detailed but show trends in performance more clearly. In simplifying and averaging results care should be taken that results are not altered, only clarified. Some reports use executive summaries at the beginning of the report. As with other summaries, care should be taken to be sure that the summary accurately portrays what occurred in the tests. Some test reports present conclusions that are not supprted by test data. It is important that the executive summary does not contain any new information that is not contained in the body of the report. The executive summary should only condense and assemble points that have already been made or show data that have been shown elsewhere. Use paragraph titles in executive summaries so that data and remarks are easier to find and more easily understood. Summary tables showing varying levels of performance are generally more descriptive of results than noting these results in plain text. Some reports begin with an abstract that also is intended to summarize the results of the report. The same comments apply to preparing the abstract.

9.0 APPENDICES

Detailed reference data should generally be separated from the main body of the report. Information typically contained in appendices includes the following:

- o References
- o Raw test data shown in order of test run and date
- o Manufacturer's literature showing products being tested
- o Test procedures used to determine oil viscosity and other test parameters
- o Details on test configuration and how data were recorded and computations made
- o Methods of statistical analysis employed
- o List of acronyms
- o Units of measure and unit conversions

10.0 UNITS

Although a great effort has been made in recent years to standardize units and particularly shift to metric units, a great many differing sets of units remain in use and in American industry, use of English units predominate. The use of units will, of course, be the option of the test sponsor; however, every effort should be made to use units that reflect generally accepted practice whether they are English units or metric units. Typical or desirable sets of units have already been listed in each section, however, to have all the information needed in one place, they are mentioned again here.

- o Skimmer Dimensions - In Europe the practice is to use meters, in the U.S. feet. Use one or the other.
- o Skimmer Draft - Use meters or feet.
- o Weights - Use pounds or kilograms.
- o Strength - Newtons or pounds force.
- o Speed - The use of knots for skimmers is nearly universal, but meters/second is acceptable.
- o Oil Viscosity - Centistokes (cSt) are preferred but Centipoise (cP) is also used.
- o Sweep Width - Use meters or feet.
- o Sweep Rate - NM^2/hr.
- o Spill Encounter Rate - BBL/hr or m^3/hr.
- o Volume - Cubic meters are the accepted metric units. The oil industry often uses barrels (42 U.S. gallons) and U.S. gallons are often used. Avoid the use of liters.
- o Volume Rate - The most common use in the oil industry is barrels/hour or cubic meters/hour. In the U.S., equipment specifications are often in gallons per minute, which is well understood and acceptable. Some reports show volume rate in liters/minute, liters/second, and cubic meters/second. These units are used less often and should be avoided.

REFERENCES

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3) 2000 Annual Book of ASTM Standards, Section 11, “Water and Environmental Technology,” Volume 11.04, Standard Practice for Classifying Water Bodies for Spill Control Systems, F625-94, Conshohocken, Pennsylvania, 2000.

4) 2000 Annual Book of ASTM Standards, Section 11, “Water and Environmental Technology,” Volume 11.04, Standard Guide for Collecting Skimmer Performance Data in Controlled Environments, F631-99, Conshohocken, Pennsylvania, 2000.