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Ships and marine technology — Marine environment protection: performance testing of oil skimmers —

Part 2: Static water conditions

Navires et technologie maritime — Protection de l'environnement marin: essais de performance des écumeurs du pétrole —

Partie 2: Conditions en eau calme

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21072-2 was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 2, *Marine environment protection*.

ISO 21072 consists of the following parts, under the general title *Ships and marine technology — Marine environment protection: performance testing of oil skimmers*:

— *Part 1: Moving water conditions*

— *Part 2: Static water conditions*

— *Part 3: High viscosity oil*

Introduction

ISO 21072 (all parts) standardizes the performance testing of oil skimmers used in marine pollution control.

Some oil skimmers have previously been performance tested under non-standard conditions and procedures, with declared performance parameters being of limited value to the end user, especially under field conditions.

ISO 21072 (all parts) provides for carrying out, and recording results of, full-scale tests for a skimmer under a variety of test conditions, where there is limited or no access to specialist test facilities.

Ships and marine technology — Marine environment protection: performance testing of oil skimmers —

Part 2: Static water conditions

1 Scope

This part of ISO 21072 specifies a methodology for establishing quantitative performance data for oil skimmers under static water conditions, so the end user can objectively judge, compare, and evaluate the design and performance of different skimmers. The methodology applies to testing in a basin and requires control of oil properties and oil slick characteristics.

The method is applicable to all types of skimmers provided that the equipment dimensions are within the physical limitations of the test basin. The test procedure provides full-scale test results for the unit tested, under controlled conditions, and for one or more classes of oil. Attention is drawn to the care required when applying the test results to predict skimmer performance under field conditions.

For dedicated/inbuilt systems, the test procedures outlined in this part of ISO 21072 can only be used for the skimming device as such, not the entire skimming system.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16165, *Ships and marine technology — Marine environment protection — Terminology relating to oil spill response*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16165 and the following apply.

3.1
data collection period
the period of time within the **steady-state period** (3.9) when recovered fluid is collected for establishing performance data

[ISO 21072-1:2009]

3.2
debris
solid or semi-solid substance that could interfere with the operation of a spill control system

[ISO 21072-1:2009]

3.3
emulsification factor
EF
amount of water emulsified into the oil as a result of the skimming/pumping process, not including water originally in the test fluid

NOTE It is expressed as a decimal fraction between 0 and 1.

[ISO 21072-1:2009]

3.4
fluid recovery rate
FRR
total volume of fluid recovered per time

NOTE It is expressed in cubic metres per hour.

[ISO 21072-1:2009]

3.5
recovery efficiency
RE
ratio of test fluid (oil or emulsion) recovered to the total volume of fluid recovered

NOTE It is expressed as a percentage.

[ISO 21072-1:2009]

3.6
oil recovery rate
ORR
volume of test fluid (oil or emulsion) recovered per unit time

NOTE It is expressed in cubic metres per hour.

[ISO 21072-1:2009]

3.7
oily phase
oil that is water-free or incorporates emulsified or encapsulated water that does not readily separate out

[ISO 21072-1:2009]

3.8
oil skimmer
skimmer
mechanical device used to remove oil from the water surface

[ISO 21072-1:2009]

3.9
steady-state period
period of time during which the test conditions and operating parameters are constant or within acceptable variability ranges

[ISO 21072-1:2009]

4 Test facility requirements

This part of ISO 21072 is applicable to any test arrangement that allows for the control and monitoring of the test conditions.

The test facility shall be designed and equipped to control the following parameters.

— **Oil properties**. The facility shall be able to maintain the oil properties for the duration of the test. Oil analytical equipment shall be available for measuring oil properties (see 9.2).

— **Air and water temperature**. Testing may be carried out at any water temperature, provided that requirements with respect to oil properties are met. The test temperature shall always be well above the pour point of the oil, unless the purpose is to assess the collection of non-flowing/semi-solid oil. The facility shall be able to maintain the water temperature in the test basin at a selected test temperature with maximum variation of ± 2,0 °C.

— **Oil slick thickness**. The test facility shall incorporate means of measuring oil slick thickness before and after the test, with a proven accuracy of at least ± 20 %.

— **Measuring tanks**. In order to provide for sufficient replicates during the test process, the test facility shall incorporate a sufficient number of calibrated tanks to accurately measure FRR, ORR, and water uptake. The tank volumes shall correspond to the expected recovery rate of the unit to be tested so as to provide data collection periods of sufficient duration and with sufficient measuring accuracy (see 10.1).

5 Clearance requirements

Throughout testing, there shall be sufficient clearance between the skimmer and the tank walls and any containment device, so as not to restrict oil flow to the skimmer or otherwise impede normal operation of the unit.

Since the necessary clearance varies with oil viscosity and unit recovery rate, adequate oil in-flow to the skimmer shall be demonstrated in each specific case, through oil flow observations or slick thickness measurements. Ensure that the clearance between the tank wall and outer limit of the skimmer is at no point less than 50 % of the greatest width (diameter or equivalent dimension) of the skimmer under test.

In considering the depth of water on which the oil layer is floating, the skimmer or its oil/water interface shall at all times be able to free-float on the water. The clearance between the unit and the tank floor shall be sufficient to not interfere with normal operations of the skimmer.

6 Test parameters

6.1 General

Testing shall establish quantitative performance data for the unit as a function of the following parameters:

— test oil properties;

— oil slick thickness;

— skimmer operating parameters;

— debris interference.

6.2 Test oil properties

Perform testing with oils meeting the specifications shown in Table 1.

To minimize problems associated with flow characteristics of the test oils, carry out testing at water temperatures at least 3 °C above the pour point of the test oil.

Measure oil and emulsion viscosity at two of the three shear rates: 1 s^{-1}, 10 s^{-1}, or 100 s^{-1}. The third shear rate may be determined by interpolation or extrapolation.

In this part of ISO 21072, oil is categorized as non-emulsified (fresh) even if it contains up to 20 % volume fraction of water. Such oil may be used for testing as a "water-free" oil provided that the viscosity is within the ranges specified in Table 1.

All oils and emulsions may be reused provided that the properties of the test fluids remain within the ranges defined in Table 1.

Table 1 — Ranges for oil properties and related slick parameters

Oil class	Target viscosity cP [a]	Target viscosity range cP	Density kg/l	Slick thickness [b] mm	Example
1	10	5 to 20	0,85 to 0,9	10	Fresh crude, very light bunker
2	200	170 to 230	0,9 to 0,93	30	Light bunker
				50	Light bunker
3	2 000	1 800 to 2 200	0,92 to 0,95	50	Medium bunker
4	20 000	19 000 to 21 000	0,95 to 0,98	50	Heavy bunker
5	20 000	19 000 to 21 000 [c]	0,95 to 0,98	50	Emulsion of medium bunker
6 [c]	50 000	40 000 to 60 000 [c]	0,96 to 0,99	10	Emulsion of heavy bunker

[a] 1 cP = 1 mPa·s.

[b] Acceptable variation: ± 20 %.

[c] At shear rate 10 s^{-1}.

6.3 Oil slick thickness

For each specific test oil, the initial slick thickness shall be as specified in Table 1.

Measure the initial oil slick thickness after sufficient settling time has been allowed from the deployment of the oil on the water, at three different measuring points throughout the area of the oil slick, and record the results.

Reject tests if slick thickness deviates by more than 20 % from the specification in Table 1.

Only start the test after the oil has settled to a uniform thickness.

6.4 Skimmer operating parameters

There are a number of operating parameters that can affect the skimmer performance, including adhesion surface speed, inclination angles, pump flow rates, skimmer draft, and weir depth.

Record the operating parameters for each test result.

6.5 Debris interference

Following the test of the skimmer with oil and water only, carry out a debris interference test to assess the skimmer's ability to operate in the presence of various forms of debris in the oil slick. This examination is qualitative in nature and is intended to provide the end user with a general indication of the effects of different materials that are often found in oil spill recovery situations. Record the effects of debris on oil intake, essential mechanical elements of the unit (e.g. scrapers, wringers, pumps), and overall processing of the recovered oil.

Introduce the materials in Table 2 into the tank and move them towards the skimmer inlet so that they make contact. Observe and report their impacts; then clear the materials from the testing area before the next group is introduced.

Table 2 — Materials to be introduced into the tank

Materials	Specifications
Loose materials	Shredded wood bark or wood shavings, bulk volume 5 l (size range: 5 mm to 25 mm, bulk volume 5 l)
Soft wood pieces	One board, of dimensions 1,0 m × 50 mm × 100 mm Ten blocks, each of dimensions 10 mm × 25 mm × 40 mm
Plastic containers	Four 0,5 l soft drink bottles Two 3,0 l plastic tubs
Plastic bags	Four plastic bags (supermarket type), of approximate dimensions 300 mm × 300 mm Two large plastic bags (domestic garbage type), of approximate dimensions 500 mm × 1 000 mm
Ropes	Two lengths, each of 1,0 m, of polypropylene rope with 25 mm minimum diameter Two lengths, each of 1,0 m, of polypropylene rope with 8 mm minimum diameter Four lengths, each of 0,6 m, of polypropylene rope with 75 mm minimum diameter

7 Test procedures

7.1 Preparations prior to testing

Carry out the following prior to testing.

a) Prepare the required quantity of test oil, ensuring that the oil properties are according to Table 1, with due reference to the water temperature in the test basin.

b) Measure and record oil properties as specified in 9.2.

c) Preload the tank with the test oil until the desired thickness (see Table 1) is obtained. Record initial oil slick thickness as per 6.3.

d) Install the skimmer in the enclosed test area/tank.

e) Ensure that the requirements with respect to clearances specified in Clause 5 are met.

7.2 Actions during testing period

Perform the following actions during the actual testing.

a) Set the operating parameters to the desired settings (speed, draft, etc.) and start the skimmer; if this is not possible, then start the skimmer and re-circulate the recovered fluid back into the test tank for a maximum of 30 s, then proceed to b).

b) Direct the recovered fluid to the first measuring tank and maintain for the desired collection period or until the desired volume is collected (see 10.1). Record the start time of the measuring period.

c) Record any deviations from the desired test conditions.

d) Once the measuring period is ended, divert flow back to the recovered fluid tank. Record the end time of the measuring period.

e) Repeat points b) to d) if more than one measuring tank is available.

f) Stop skimmer operation.

7.3 Actions after testing

Perform the following after testing.

a) Allow the recovered fluid in the measuring tanks to settle for at least 30 min.

b) For each measuring tank, record total fluid quantity, quantity of water and quantity of oily phase.

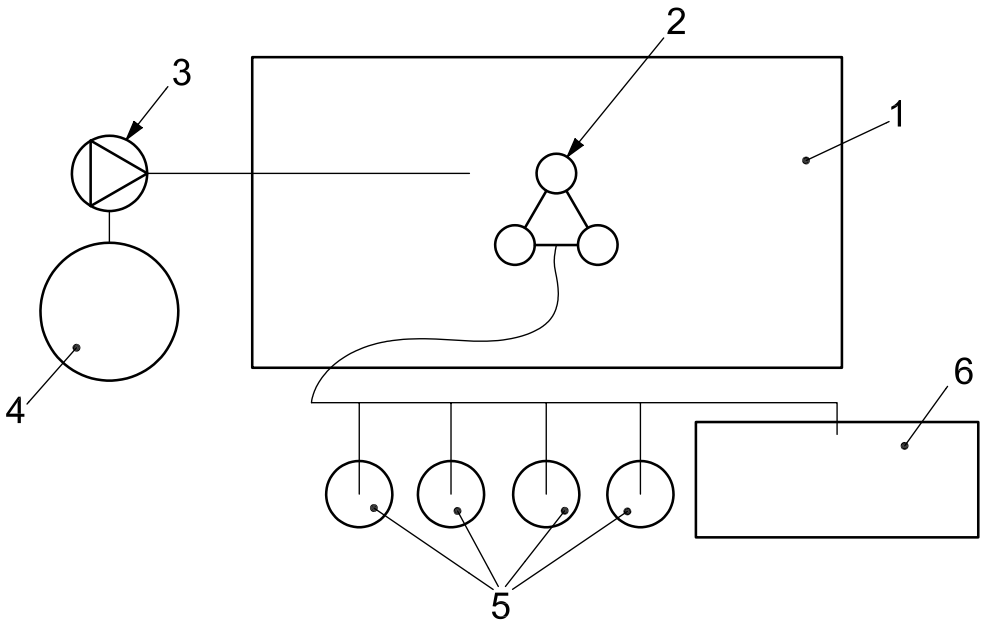
c) Take a minimum of three samples of the oily phase from the measuring tank(s) for subsequent analysis.

d) Measure and record the water content in the oily phase samples.

NOTE Suitable test methods are given in ISO 3733[1], ASTM D95[2] and ASTM D6304[3].

e) Calculate performance parameters as specified in Clause 8.

Figure 1 is a schematic representation of a testing facility arrangement. A specific geometry of the test basin is not required. If the test basin is separated from bigger waters, e.g. by oil barriers, the perimeter geometry under test conditions should remain a stable shape.



Key

1 test basin
2 skimmer
3 oil distributor
4 test oil tank
5 measuring tanks
6 recovered fluid tank

Figure 1 — Example of testing arrangements

8 Performance parameters

Performance of the skimmer shall be defined by the following parameters.

8.1 Fluid recovery rate

The fluid recovery rate (FRR) is given by

$$\text{FRR} = \frac{\text{recovered fluid}}{\text{time}}$$

where

"fluid recovered" is the total amount, in cubic metres, of fluid recovered;

"time" is the duration, in hours, of the data collection period.

8.2 Emulsification factor

The emulsification factor (EF), expressed as a decimal volume fraction between 0 and 1, is a measure of the tendency of the skimmer systems to form emulsion. It is given by

$$\text{EF} = \frac{\text{WC(recovered oily phase)} - \text{WC(test fluid)}}{100}$$

where

"WC(recovered oily phase)" is the water content (emulsified), expressed as a percentage volume fraction, in the recovered oil;

"WC(test fluid)" is the water content, expressed as a percentage volume fraction, in the original test fluid.

EF is a function of both the test oil properties (e.g. asphaltene, wax, resins) and the design and operation of the skimmer. Therefore, EF comparisons are meaningful only for tests with identical oils.

Determine water content in accordance with 7.3 d).

8.3 Oil recovery rate

The oil recovery rate (ORR) is given by

$$\text{ORR} = \frac{\text{recovered oily phase}}{\text{time}} \times (1 - \text{EF})$$

where

"recovered oily phase" is the total amount, in cubic metres, of test fluid recovered;

"time" is the duration, in hours, of the recovery period;

"EF" is the emulsification factor to adjust for additional water mixed into the oily phase during recovery.

ORR applies to emulsions as well as fresh oils, since the additional water emulsified into the oil is accounted for.

8.4 Recovery efficiency

The recovery efficiency (RE), expressed as a percentage, is given by

$$RE = \frac{ORR}{FRR} \times 100$$

where

"ORR" is the oil recovery rate;

"FRR" is the fluid recovery rate.

9 Measurements and reporting

9.1 General

Record at least the measurements listed in this clause in the final report.

9.2 Oil properties

Measure the following test oil properties prior to testing:

a) viscosity, in centipoise, at the test temperature and at 20 °C (for comparison purposes) at shear rates of 1 s^{-1}, 10 s^{-1} or 100 s^{-1}, with at least two of these rates being measured, with the third permitted to be determined by interpolation or extrapolation;

b) density, in kilograms per litre, at the test temperature and at 20 °C;

c) pour point, in degrees Celsius;

d) water content, expressed as a percentage volume fraction.

After testing, measure the water content of the recovered oil to determine the EF.

9.3 Environmental parameters

Measure and record the following environmental parameters for each test:

a) air temperature, in degrees Celsius;

b) water temperature, in degrees Celsius.

9.4 Skimmer operating parameters

Report the settings of the skimmer operating parameters, e.g.

a) speed of adhesion surfaces;

b) pump speed;

c) drafts;

d) angles.

9.5 Other test parameters

Record other test parameters such as:

a) oil quantity, in cubic metres;

b) clearances, in metres, to sides and tank bottom;

c) slick thickness, in millimetres.

9.6 Recovery parameters

Record, for each measurement, the following:

a) total recovered fluid, in cubic metres;

b) recovered oily phase, in cubic metres;

c) recovered water, in cubic metres;

d) duration, in minutes, of measuring period.

9.7 Performance parameters (calculated parameters)

Based on the recovery parameters (9.6), calculate and report the following performance parameters (see Clause 8):

a) FRR;

b) ORR;

c) RE;

d) EF.

9.8 Equipment specification and test documentation

The test report shall include a technical specification of the skimmer unit tested and a narrative of the testing process. At a minimum, the technical specification shall include descriptions of the physical dimensions, construction materials, operating principle, power unit and power consumption.

10 Quality control

10.1 Test duration and fluid volume

The test-measuring period (the period during which recovered fluid is collected in the measuring tank) shall be determined in consultation with the test facility operators and third-party inspection service in relation to the test facility measuring tank size, amount of oil to be introduced into the tank, size of test tank and expected recovery rate of the skimmer. See Table 3.

Table 3 — Suggested minimum duration of the data collection period

Expected FRR m^3/h	Minimum recovered fluid volume m^3	Minimum data collection period min
5	0,5	6
10	0,5	3
20	0,5	1,5
50	0,8	1
100	1,7	1
150	2,5	1
200	3,3	1
300	5	1

10.2 Repetitions

Base performance data on a minimum of three tests performed under the same test conditions with an ORR standard deviation of less than 15 %.

Reject individual tests if the individual test ORR deviates by more than 20 % from the mean.

Bibliography

[1] ISO 3733, *Petroleum products and bituminous materials — Determination of water — Distillation method*

[2] ASTM D95, *Standard test method for water in petroleum products and bituminous materials by distillation*

[3] ASTM D6304, *Standard test method for determination of water in petroleum products, lubricating oils, and additives by coulometric Karl Fischer titration*

[4] *Standard for performance testing of oil spill skimmers*, Det Norske Veritas, 2002

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