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Ships and marine technology — Laboratory test method for skin friction of antifouling paints by rotating drum

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 8, *Ship design*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Antifouling paints are widely used to prevent fouling of ships' hulls by marine organisms. Effective antifouling technologies are critical to minimise the skin friction of the hull and to maintain the fuel consumption efficiency of ships. The evaluation of antifouling paints is generally undertaken by adopting a tiered approach whereby paint manufacturers use a battery of laboratory tests, patch tests and full vessel trials. Patch tests and full vessel trials are generally conducted over extended periods of time and are predominantly relied upon for the prediction of coating performance when used commercially.

This document deals with a laboratory test to characterize the skin friction of antifouling paints. It does not necessarily represent the actual performance of antifouling paints on application to the ship hull. Therefore, this document does not provide a validated test for predicting the ability of an antifouling paint to minimize the skin friction of the hull.

Ships and marine technology — Laboratory test method for skin friction of antifouling paints by rotating drum

1 Scope

This document provides a laboratory test method to determine the skin-friction of antifouling paints coated on drums.

The results of the laboratory-tested friction of painted drums over a certain period of time can be used for screening of antifouling paints and characterizing changes in friction for different antifouling paints, amongst other applications and other purposes depending on the user's need.

This document is applicable to both biocidal-based and biocide-free antifouling paints.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1513, *Paints and varnishes — Examination and preparation of test samples*

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 3270, *Paints and varnishes and their raw materials — Temperatures and humidities for conditioning and testing*

ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

ISO 15528, *Paints, varnishes and raw materials for paints and varnishes — Sampling*

ASTMD1141 *Standard practice for the preparation of substitute ocean water*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
antifouling paint
underwater paint/coating that is applied as a top layer coating on the hull to control or prevent attachment of unwanted organisms

3.2
test cycle
complete set of stages of the test process, carried out in a series of specified *test sequences* (3.9)

3.3
drum
cylindrical object onto which the test paints are applied

3.4
dynamic ageing system
system where tested *specimens* (3.10) are immersed in a *testing solution* (3.7) for a certain period of time for ageing of *antifouling paints* (3.1) before conducting tests using the *friction test system* (3.6)

3.5
friction of antifouling paint
skin-friction of an *antifouling paint* (3.1) against a *testing solution* (3.7)

Note 1 to entry: In this document, the friction of antifouling paint is represented by torque.

3.6
friction test system
system where tested *specimens* (3.10) are subject to hydrodynamic friction testing to directly measure a torque value from which the skin friction can be determined

3.7
testing solution
solution used in the test for immersing and testing *specimens* (3.10)

3.8
sample
antifouling paint (3.1) product before its application to the *drum* (3.3)

3.9
test sequence
test procedure that comprises a number of different methods in a defined order of execution

3.10
specimen
drum (3.3) on which an *antifouling paint* (3.1) is applied, ready for test

4 Test instrumentation

4.1 General

The test instrumentation shall include the following two systems:

a) a dynamic ageing system, to age the specimens;

b) a friction test system, to measure the torque of the aged specimens.

4.2 Dynamic ageing system

The dynamic ageing system shall consist of the following:

a) a motor, to rotate the specimen;

b) a cylindrical test chamber, the diameter of which shall be at least 3 times larger than the diameter of the drum, to facilitate the generation of fully developed turbulent flow conditions with a Reynolds number (*Re*) higher than 3×10^5;

NOTE The Reynolds number (*Re*) is defined by Formula (1):

$$\mathrm{Re}=\frac{V\times r}{\nu} \tag{1}$$

where

V is the equivalent linear speed of the surface of the test drum, in m/s;

r is the radius of the drum, in m;

v is the coefficient of solution viscosity, in m^2/s.

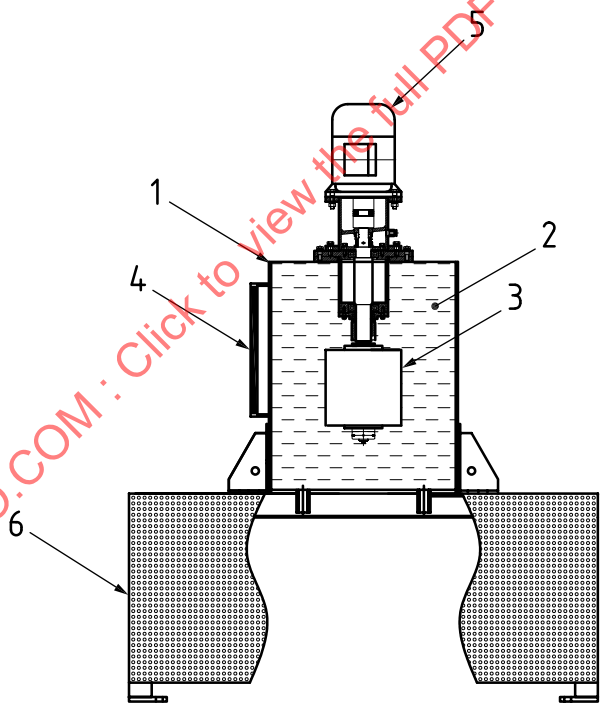
c) a chiller or/and a heater, to control the temperature of the testing solution, if needed;

d) sensors for temperature, pH and salinity;

e) [optional] an activated charcoal filter unit, optionally combined with a styrene-supported iminodiacetic acid chelating ion-exchange resin with a typical particle-size ranging from about 300 µm to 850 µm, capable of removing transition metals from sea water.

In case more than one specimen are tested within the same test chamber, the test chamber shall be divided into separate compartments for each specimen in such a manner that the turbulence of each specimen does not interfere with each other. The length/width of the compartments shall be at least 3 times larger than the diameter of the drums.

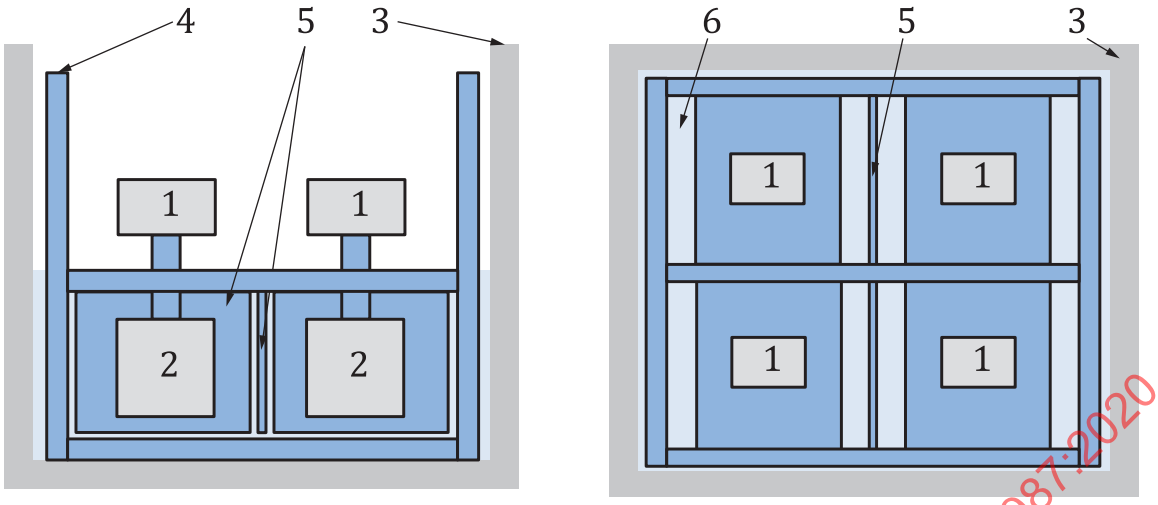
Two sample layouts of the dynamic ageing system are shown in Figure 1 and Figure 2.



Key

1 container
2 testing solution
3 test specimen
4 activated charcoal filter unit
5 motor
6 trestle

Figure 1 — Sample layout of the dynamic ageing system



Key

1 motor
2 specimen
3 chamber
4 trestle
5 baffle
6 testing solution

Figure 2 — Sample layout of the dynamic ageing system

4.3 Friction test system

The friction test system shall consist of the following:

a) a motor, to rotate the specimen;

b) a cylindrical test chamber, the diameter of which shall be at least 3 times larger than the diameter of the drum, to facilitate the generation of fully developed turbulent flow conditions with a Reynolds number (*Re*) higher than 3×10^5;

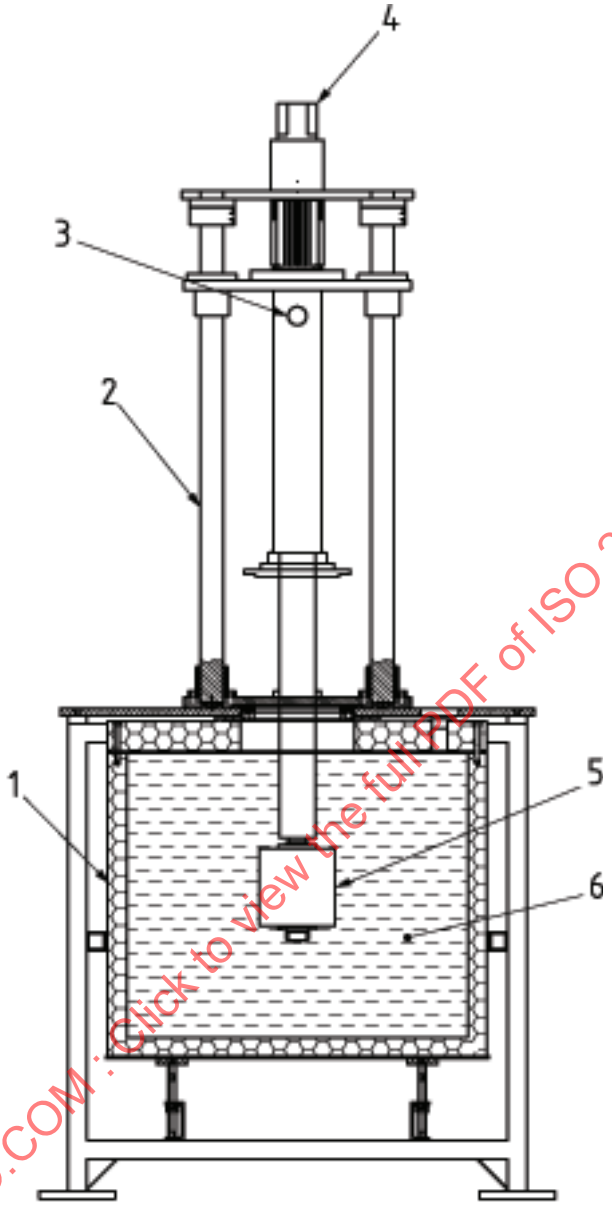
c) a chiller or a heater, to maintain the temperature if needed;

d) a torque sensor, to measure the friction;

e) sensors for temperature, pH and salinity.

For the accuracy of the results, no more than one specimen shall be tested within a friction test compartment.

A sample layout of the friction test system is shown in Figure 3.



Key

1 chamber
2 trestle
3 torque sensor
4 motor
5 specimen
6 testing solution

Figure 3 — Sample layout of the friction test system

4.4 Motors

Motors used to rotate the specimens shall have sufficient capacity to generate the required stable rotation speed.

4.5 Testing solution

Only filtered natural sea water or artificial sea water shall be used as the testing solution.

Artificial sea water shall be prepared according to ASTMD1141.

The prepared testing solution shall meet the following requirements:

— pH: 8,1 ± 0,5;

— salinity: 3,0 % ± 0,3 %;

— temperature: 23 °C ± 2 °C, or as otherwise specified.

4.6 Torque sensor

The torque sensor shall have the sufficient range, with an accuracy no larger than 0,1 % of reading.

5 Drum specification

5.1 Materials

Corrosion-resistant and deformation-resistant materials, such as acrylic, PVC, etc., shall be used.

5.2 Dimension

The dimensions of the drum shall be no less than the following:

— 200 mm in diameter;

— 200 mm in height;

— the maximum tolerance of the dimensions shall be less than 1 mm in diameter and height;

— the drum shall be well-designed to prevent the ingress of water into the cylinder; if end-caps are needed, they shall be assembled in such a way as to provide as smooth a surface as possible and any fixings should be countersunk.

6 Preparation of the test specimen

6.1 Paint sampling

Take a representative sample of the product to be tested (or of each product in the case of a multi-coat system), as specified in ISO 15528.

Examine and prepare each sample for testing as specified in ISO 1513.

6.2 Paint application

Surface preparation and paint application shall be in compliance with the manufacturer's datasheet.

6.3 Drying and conditioning of test specimen

Dry each painted specimen for the specified time under the specified conditions. Unless otherwise specified, condition them at a temperature of 23 °C ± 2 °C and a relative humidity of 50 % ± 5 %, as specified in ISO 3270, for 7 days.

6.4 Dry film thickness

Dried topcoat film thickness shall be 175 µm ± 25 µm.

The paint thickness measuring method shall comply with ISO 2808.

6.5 Sample quantity

A minimum of 2 samples shall be prepared and tested, and the mean value shall be taken as the result.

7 Test procedure

7.1 Test principle

The test shall consist of 6 cycles at a minimum, where each cycle consists of the 4 test sequences shown in Table 1.

Table 1 — Flowchart of friction test principle

One cycle	
Sequence1	2 days of static immersion
	5 days of dynamic rotation
Sequence2	2 days of static immersion
	5 days of dynamic rotation
Sequence3	2 days of static immersion
	5 days of dynamic rotation
Sequence4	2 days of static immersion
	5 days of dynamic rotation

7.2 Test procedure

Throughout the whole test, the pH, salinity and temperature of the testing solution, and the rotation speed of the motor shall be measured and recorded once in every 24 h at a minimum.

Before any friction measurements, measure the initial roughness according to Annex A and torque; the torque sensor shall be checked using a bare drum of which R_z, as specified in ISO4287, is less than 5 µm. The same bare drum shall be used for checking of the torque sensor through the whole test period.

Apply the following.

a) Two days of static immersion in the testing solution in the dynamic ageing system.

b) Five days of dynamic rotation in the dynamic ageing system at the required equivalent linear speed.

During the test, the equivalent linear speed shall be calculated by Formula (2), expressed in m/s:

$$V = 2 \times \pi \times r \times \frac{n}{60} \tag{2}$$

where

V is the equivalent linear speed of surface of test specimen in m/s;

n is the revolutions per minute, in r/min;

r is the radius from the centre of the specimen to the test spot, in m.

c) Repeat 'a' and 'b' 4 times as one cycle.

d) Using the friction test system specified in 4.3, measure and record the torque at intervals of 10 s for at least 15 min to determine the skin friction of the specimen; only the measurements during the continuously stabilized period shall be used to calculate the mean value as the test result in 8.1.

e) On completion of the friction test, measure the roughness of the paint surface according to Annex A.

f) Repeat the whole cycle [a) to e)] at least 6 times.

g) On completion of the whole test, measure the dry film thickness according to ISO 2808.

h) Throughout the test periods, the testing solution shall meet the following requirements:

   1) pH: 8,1 ± 0,5;

   2) salinity: 3,0 % ± 0,3 %;

   3) temperature: (23 ± 2) °C or (30 ± 2) °C;

   4) copper ion concentration: below 200 µg/l.

The testing solution shall be completely flushed out and replaced with a new testing solution at intervals not exceeding 7 days. However, if any of the pH, salinity or copper ion concentration changes over the limit specified above, the testing solution shall be replaced immediately.

8 Calculation and expression of results

8.1 Calculation of torque

Take the mean value of torque of each specimen based on the raw data obtained in each test cycle.

8.2 Determination of roughness

In accordance with Annex A, record the maximum and minimum values of at least 12 points measured on each specimen in each test cycle, taking the mean values, and plot the mean values versus the cycle numbers.

8.3 Calculation of friction reduction rate

If necessary, the friction reduction rate shall be calculated by Formula (3):

$$\text{Friction reduction rate } (\%) = \frac{T_{\text{start}} - T_{\text{end}}}{T_{\text{start}}} \times 100 \tag{3}$$

where

T_{start} is torque before test;

T_{end} is torque after test.

Negative values of friction reduction rate obtained through the calculation indicate the increase of friction and shall be stated in the test report accordingly.

9 Precision

No relevant precision data are currently available.