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# Ships and marine technology — Marine environment protection — Testing of ship biofouling in-water cleaning systems

*Navires et technologie maritime — Protection de l'environnement marin — Essais des systèmes de nettoyage des salissures biologiques sans sortir le navire de l'eau*

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# Contents

Page

**Foreword** ..... **v**
**Introduction** ..... **vi**
**1 Scope** ..... **1**
**2 Normative references** ..... **1**
**3 Terms and definitions** ..... **1**
**4 Fundamental information needed for testing of IWC systems** ..... **3**
4.1 Factors that can impact performance ..... 3
4.2 Fundamental parameters ..... 4
**5 Test experimental design** ..... **6**
5.1 General ..... 6
5.2 Classification of IWC system application for testing ..... 8
5.3 Duration and extent of testing ..... 9
5.3.1 General ..... 9
5.3.2 Proactive systems ..... 9
5.3.3 Reactive systems ..... 9
**6 Quantification of biofouling removal and prevention** ..... **10**
6.1 IWC systems ..... 10
6.1.1 General ..... 10
6.1.2 Proactive systems ..... 10
6.1.3 Reactive systems ..... 10
6.2 Fouling rating ..... 10
6.3 Control and treated test locations ..... 11
6.4 Biofouling survey sampling methods ..... 12
6.4.1 General ..... 12
6.4.2 Hull areas ..... 12
6.4.3 Niche areas ..... 13
6.4.4 Hull and niche areas ..... 14
6.4.5 Proactive systems ..... 14
6.5 Dive survey sampling method during low visibility ..... 16
6.5.1 Hull areas ..... 16
6.5.2 Niche areas ..... 16
6.6 Environmental characteristics to quantify ..... 17
**7 Quantification of changes to water quality** ..... **17**
7.1 Water quality measures as proxies for broad environmental impacts ..... 17
7.1.1 General ..... 17
7.1.2 Proactive systems ..... 17
7.1.3 Reactive systems ..... 17
7.2 Water quality parameters to quantify ..... 17
7.3 Water quality sample collection ..... 19
7.4 Environmental characterization ..... 21
**8 Quantification of debris processing and effluent** ..... **21**
8.1 Overview ..... 21
8.2 Sampling the debris processing unit ..... 22
8.3 Water quality parameters to quantify ..... 23
8.4 Solid waste disposal ..... 24
**9 Quantification of IWC impact on ship coatings** ..... **24**
**10 Data management** ..... **24**
10.1 System for data management ..... 24
10.1.1 General ..... 24
10.1.2 Data quality objectives ..... 25
10.1.3 Data quality indicators ..... 25

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10.2 Data recording and archiving ... 25
10.3 Data analysis ... 25
10.3.1 Overview ... 25
10.3.2 Quality assurance and quality control ... 26
10.3.3 Measurement uncertainty ... 26
**11 Quality assessments ... 26**
11.1 Fundamental principles ... 26
11.2 Technical audits ... 27
11.2.1 Overview ... 27
11.2.2 Technical system audit ... 27
11.2.3 Audit of data quality ... 27
11.3 Data quality assessment ... 27
11.4 Non-conforming work and corrective action ... 28
11.5 Audit reporting ... 28
**12 Human health and environmental safety ... 28**
**13 Test report ... 29**
**Annex A** (informative) **Example of biofouling surveys of various surface types ... 30**
**Annex B** (informative) **Optional method for additional determinations of IWC impacts on ship coatings ... 31**
**Bibliography ... 33**

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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.

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 document 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 2, *Marine environment protection*.

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.

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# Introduction

Like all substrates placed in coastal waters, the wetted surfaces of ships are quickly colonized by a succession of diverse sessile or sedentary micro- and macro-organisms, collectively known as biofouling.[1][2][3] The adverse effects of biofouling on ships and their operations are well known and there is a long history of attempting various biofouling management approaches.[4]

Negative impacts of biofouling on the shipping industry include:

— reduced ship performance and fuel efficiency;[5][6][7][8]

— corrosion and decreased durability;[9][10]

— increased greenhouse gas emissions;[11][12]

— failure to meet associated legal/contractual requirements;[13][14]

— increased underwater noise;[15]

— unintended translocation of aquatic species.[16][17][18]

In recent decades, the importance of ship biofouling as a pathway for invasive aquatic species translocations has become increasingly apparent.[17][18][19][20][21] Entire biological communities can be moved around the world by oceangoing ships and a substantial number of species, including pathogens, can be introduced as a result.[22][23][24] While not all invasive aquatic species have immediate noticeable or significant impacts, a subset of invasive aquatic species have a broad range of effects on the aquatic environment and the communities reliant upon local ecosystem services.[25][26][27] Guidelines and regulations to prevent invasive aquatic species introductions via ship biofouling are beginning to emerge to protect environmental, economic, social, and cultural values (e.g. see References [12] [28] [29]).

The International Maritime Organization (IMO) defines antifouling systems (AFS) as various approaches used on a ship to control or prevent the attachment of unwanted organisms.[30] The primary AFS are coatings, applied during dry-docking to surfaces below the maximum waterline of ships, which are designed to either prevent macrofouling attachment (using biocides) or reduce adhesion (foul-release) to wetted surfaces.[31] [32] In some areas (e.g. Baltic Sea), non-ablative or non-polishing hard coatings are used in combination with regular cleaning as a fouling prevention strategy.[33]

The service life of modern coatings for commercial ships is typically five years (e.g. see Reference [32] [34]). Despite substantial improvements over the past 40 years, surface coatings do not consistently prevent biofouling accumulation on all ship surfaces over the course of their service lives.[35][36] Accumulations tend to occur as coatings age[37][38] and when ships have extended stationary periods.[13][14][39][40]

Even when antifouling coatings are used, there are also substantial areas of ships' immersed surfaces that are more prone to biofouling[41][42][43][44] because they:

— cannot be painted (e.g. anodes);

— are prone to damage (e.g. bulbous bow, tug and fender points, areas below anchor chain);

— are challenging to coat (e.g. dry-dock blocking areas); or

— are sub-optimal for coating performance (e.g. gratings, rudders, propellers, and sea chests).

Given the existing limitations of coatings, especially during extended periods between dry-docking, in-water cleaning (IWC) of ship biofouling (within a coating's service life) is often required or advantageous.[12]

IWC of biofouling – used to either maintain or reset ship immersed surfaces to a hydrodynamically smooth state – is a common approach to increase ship performance and fuel efficiency between dry-dockings.[8][45] IWC is also recognized as beneficial for reducing both greenhouse gas emissions[11][12][46] and biosecurity risks.[47][48]

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IWC systems typically involve the use of diver- or remotely-operated cleaning units (i.e. cleaning carts) that remove biofouling from hull surfaces.[49][50] IWC is generally described as either proactive or reactive.[47] Proactive IWC is the periodic removal or reduction of biofilm growth (i.e. microfouling or slime layer) on ship surfaces. Proactive IWC also removes newly settled or attached microscopic stages of macrofouling organisms, to ultimately minimize or prevent macrofouling growth.[47][51] Reactive IWC is typically used to remove already established macrofouling organisms.[47][52] Both proactive and reactive IWC can include debris capture, treatment and disposal.[48][52]

While IWC has the potential to provide significant ship operations and biosecurity benefits, there are two main IWC processes that can result in inadvertent environmental harm:

a) lack of, or incomplete, capture of dislodged debris by the cleaning unit; and

b) release of untreated, or incompletely treated, effluent from debris processing.[47][48]

Potential environmental impacts from these two IWC processes include:

— increased discharge of coating biocides and microplastics to ambient waters;[52][53][54][55]

— release of live biofouling organisms, their propagules, or pathogens, into local habitats;[24][52][54]

— diminished coating condition (e.g. dry film thickness [DFT] or scuffs and chips) that reduces antifouling performance and longevity.[45][56]

Given the potential for environmental harm, independent, transparent, and predictive testing of efficacy is needed to evaluate the performance of both proactive and reactive IWC systems. Such robust and standardized testing is critical for the responsible use of IWC systems and the success of biofouling-related policies and regulations.[48]

This document aims to provide standardized, science-based test procedures that produce the data (and level of confidence) needed by relevant stakeholders when assessing the development and use of IWC systems. This document is based on recent, related international efforts to develop IWC system testing protocols (e.g. see References [50] [57] [58]). It describes how to produce data and report on the efficacy and safety of IWC systems to clean various ship surfaces and for the capture and disposal of cleaning debris. The impartial data and reporting from testing under this document are intended to inform IWC service providers, ship operators, and relevant authorities on the performance of IWC. The procedures and methods in this document can also serve as a resource for technology developers, environmental regulators, and other stakeholders interested in the safe and effective use of IWC systems.

The methods and approaches presented in this document represent consensus among international technical experts on best scientific practices. However, it is also expected that some test methods will evolve or improve over time as collective knowledge of this complex issue grows. Performance and safety of IWC systems is context-dependent with many sources of variation across ships, environments, and associated biota. As a result, the use of this document does not guarantee that a specific IWC system will always, or under circumstances other than those used in testing, operate at the levels reported.

This document was developed so that all forms of IWC systems can be tested in a comprehensive and standardized way. However, this document also provides flexibility for conducting evaluations that are customized and appropriate for individual IWC system designs, operational requirements or limits, and providers' claims. It is expected that end-users will select appropriate aspects of this document to incorporate in any individual testing effort, depending on the specifics of the IWC system being evaluated, the function of the IWC system evaluation, and the resources available.

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# Ships and marine technology — Marine environment protection — Testing of ship biofouling in-water cleaning systems

## 1 Scope

This document provides detailed and rigorous procedures for the independent performance testing of all forms of ship in-water cleaning (IWC), including on all types of biofouling (i.e. biofilms/microfouling and macrofouling), all external submerged surfaces (i.e. hull and niche areas), and both proactive and reactive IWC systems with or without the capture, processing, and disposal of debris. This document also includes testing protocols and describes how to produce data and report on the efficacy and safety of IWC systems to clean various ship surfaces and for the capture and disposal of cleaning debris.

The development of specific IWC performance requirements, criteria, or standards is outside the scope of this document and is the responsibility of individual authorities, agencies, or administrations. Similarly, while some methods and approaches described in this document can apply to other ship biofouling management approaches, systems designed to kill or prevent biofouling on external surfaces without removal (i.e. without in-water cleaning), and systems that remove or treat biofouling on internal surfaces (e.g. seawater pipes) or external surfaces of intricate mechanical components (e.g. external parts of propeller shaft seal), are also outside the scope of this document.

## 2 Normative references

There are no normative references for this document.

## 3 Terms and definitions

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

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

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

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

**3.1**
**antifouling system**
**AFS**
coating, paint, surface treatment, surface or device that is used on a *ship* (3.18) to control or prevent the attachment of organisms

**3.2**
**antifouling coating**
surface coating or paint designed to prevent, repel, or facilitate the detachment of *biofouling* (3.3) from hull and *niche areas* (3.16) that are typically or occasionally submerged

**3.3**
**biofouling**
accumulation of aquatic organisms such as microorganisms, plants, and animals on surfaces and structures immersed in or exposed to the aquatic environment

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