International Paint & Printing Ink Council

Efficacy Evaluation of Antifouling Products

Guidance document developed by the IPPIC Antifouling Working Group

Conduct and reporting of static raft tests for antifouling efficacy

Specific scope
This document provides a baseline methodology for evaluating and reporting the efficacy of antifouling coatings. Efficacy is assessed by static raft testing relative to a negative control and, if used, a positive control coating. Efficacy may be indicative of, but has no direct one-to-one relationship with the actual performance of a product under real life conditions.

Document version
First approved in 2011-04.
Revised in 2012-06

1. Scope

Overview: The purpose of this document is to provide a methodology for determining the efficacy of antifouling coatings by panel testing on static floating rafts. The document provides guidance on how to conduct, assess, record, and report results from efficacy evaluations.

Efficacy is evaluated relative to a suitable inert negative control. A positive control of proven antifouling performance may also be included. This static exposure methodology for natural environments is not suitable for establishing absolute performance characteristics of antifouling coatings in service.

Objective: This methodology may be used by industry to obtain efficacy data during the development of new antifouling coatings. This methodology may also be used to provide national registration authorities with the information required to support the label claim of antifouling products. Efficacy is demonstrated when the extent of fouling is visibly less than on a blank panel.

The methodology is especially useful for:
- the persons responsible for writing the protocols for antifouling efficacy trials
- the persons responsible for conducting trials including the evaluation and recording of results
- the persons responsible for assembling and submitting dossiers for the registration of antifouling paints
- the national authorities which are responsible for the assessment of registration dossiers.

Reproducibility and accuracy: In static raft testing the fouling intensity will vary significantly between different geographical locations, between positions on the same rafts, and from season to season. More importantly, fouling will vary from one year to the next even for identical panels

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where exposure starts around the same date in different years. This variability in fouling intensity, and thus the test results, is due to weather conditions, availability of nutrients, and other uncontrollable factors that may affect the type and extent of fouling and its rate of settlement and growth. Therefore, the absolute amount of fouling present on the test coating and controls may not be reproducible at the same site from year to year.

Interpretation of results: The results obtained by this methodology demonstrate the ability of antifouling coatings to prevent settlement of fouling organisms under static conditions relative to a suitable negative control and, if used, a positive control tested simultaneously at the same site. An evaluation of the relative antifouling effect of an antifouling coating compared to the negative control and, if used, the positive control is used as a tool to indicate the potential of a tested coating to protect underwater structures. The results can be used to support appropriate label claims of the antifouling coating tested and to screen for new candidate products.

Efficacy testing on raft panels represents a worst case scenario compared to real life conditions. The main reason is that the exposure is static with limited opportunity for organisms to be removed by hydrodynamic forces. Ships' and boats' movement through water also aid the release of active ingredients from their antifouling. Furthermore, fouling intensity is generally recognised as being greater near the coast relative to the open seas

2. Definitions

Antifouling coating: A material which, when applied as a surface coating, is used to control the settlement and/or growth of fouling organisms on submerged surfaces including ships, boats, aquaculture equipment, offshore oil installations, and other man-made structures.

Negative control: An inert reference surface that does not control fouling, e.g. an anticorrosive coating

Positive control: A reference surface coated with an antifouling coating of appropriate efficacy relevant to the intended end use of the test coating.

Fouling season: The months of the year during which significant settlement and growth of fouling organisms typically occur on a negative control at the test site.

3. Apparatus

The following equipment will be required to undertake efficacy testing according to this methodology.

Panels: Panels are typically made of plastic (e.g. PVC), reinforced polyester, steel, aluminium, marine grade plywood, or other material suitable for extended immersion in natural waters. (Metal panels must be adequately protected with an anticorrosive paint system.)

Panels should be designed to allow them to be securely fixed to the test raft, for example via a suitable panel rack. Where the design requires fixing holes through panels, these holes should be drilled prior to the application of the coating to prevent damage.

The panels may be designed to allow one or more coatings and/or controls to be tested on each individual panel. The total immersed area of each coating or control should be no less than 100 cm^2.

Raft: A free floating platform which has been designed to allow test panels to be affixed and immersed at a constant depth in natural waters. The design of the raft should enable panels to be readily removed for inspection. The minimum depth of water below the raft at low tide should generally be 2.5 m. The floating raft should be of sufficiently rigid construction to withstand prolonged exposure to weather and wave action and prevent excessive flexing or movement of test panels. It should be designed to ensure the occupational safety of users.

The raft should be designed to ensure that all test coatings and controls of the same test series are exposed to similar levels of sunlight and water flow to minimise variation. To increase the testing capacity, panels may be affixed to the raft in rows at the same depth. Where relevant the spacing between parallel rows at the same depth should generally be at least 20 cm to allow sufficient water circulation and illumination.

Generally, the raft design should ensure that panels are fully and permanently immersed. Panels should normally be exposed vertically and at a fixed depth from 0-3 m below the water surface. The lower edge of the panel should always be at least 0.5 m above the sea bed.

The raft may also be designed to allow coatings that are intended for use in darker or lighter areas to be tested under relevant conditions where the coating receives less or more sunlight. In such cases panels may be mounted on the raft facing partly down or up. Shade may also be provided by covering parts of the raft.

4. Safety

This test methodology does not address possible safety, health and environmental concerns associated with its use. All operations should be performed in accordance with all relevant local and national regulations.

Personal protection: Antifouling coatings may contain hazardous materials that could cause skin and eye irritation on contact and adverse physiological effects if inhaled. Thus, application and drying should take place in a well ventilated area and appropriate personal protective equipment should be worn during application. Product safety data sheets should be consulted when available.

Environmental protection: Unused paint and other contaminated material as well as panels after exposure should be disposed of as hazardous waste.

5. Procedure

All controls and test antifouling coatings should be tested under equivalent conditions. The exposure (immersion) of controls and test antifouling should start simultaneously (around the same date) and the exposure should be at the same location at the same depth and orientation.

Panel preparation: The test coating and positive control should be applied to panels according to the manufacturer's guidelines to ensure adhesion during the period of the study. Appropriate drying and recoating intervals and temperature and ventilation requirements for application of the coatings should be followed.

An appropriate means of application should be used. Typical methods include spray, roller, brush, or specialised application equipment like a bar type applicator. Sufficient film thickness, taking the expected polishing and leaching rate characteristics of the product into account, should be applied to last for the planned duration of the test.

Unless both sides of a panel are used as test substrates, the back of the panel may be coated with an antifouling of proven efficacy to prevent fouling on the back. Edges may be painted with the coating under test or with a different coating of proven efficacy. All panels should be marked indelibly with a suitable reference code to aid identification.

Replicates: In cases where the purpose of the test is simply to demonstrate the efficacy of a test coating relative to a negative control, the use of single panels may provide data of sufficient quality. When replication is used, the number of replicates should be appropriate for the specific purpose of the test and should have the same orientation as the test panels and controls. Read-across to efficacy data from other test panels in a test series of similar formulations with the same content of active ingredients may also be used when justified and reasonable to support the results obtained for the test coating.

Exposure time: To verify efficacy, the minimum immersion time for testing is six months. In locations where the fouling season is shorter than six months this period may be reduced. The efficacy test should cover at least one continuous and complete fouling season where appropriate. Since raft panel exposure is static, fouling intensity is high, and the tests may be regarded as an accelerated test for products for vessels.

6. Evaluation

Frequency: Antifouling coatings under test and controls should be regularly inspected and evaluated for surface fouling, typically about every two months during the fouling season. Evaluations are not necessary during periods where there is minimal settlement and growth of fouling organisms (e.g. in cold and temperate regions where winter conditions do not support fouling settlement). Generally, the panels will be removed from the water for evaluation and, except at the end of the test period, returned to the water immediately after evaluation.

Rinsing: Optionally, panels may be rinsed gently with water from the site in order to reduce the influence of non-sessile organisms (that would be removed by low shear forces). Rinsing may

also be carried out to remove possible sedimentary material (clay or silt). If utilised, rinsing must be performed on all panels equally and at each inspection. The method chosen, or if panels are not rinsed, must be specified in the final report.

Evaluation procedure: The type and severity of fouling that is present on the test coating and controls shall be assessed at each inspection. Evaluation may be made by visual assessment on site or any other appropriate method e.g. image analysis. The three major types of fouling observed on the test coating or controls; Slime, algae, and animals, should be separately assessed since the same percentage of coverage may have very different economical penalties during actual in-service use (e.g. effect on the friction of a vessel through water). Also fouling organisms that are known not to attach on moving vessels, but may be frequent on static surfaces, should be assessed separately (e.g. amphipods).

Further classification of the fouling organisms present may, in addition to slime (biological film of microfouling including bacteria, diatoms, micro algae, and extracellular biopolymers), generally be restricted to main categories such as green, red, and brown macro algae, bryozoa, hydrozoa, barnacles, tube worms, ascidians, and mussels. A more detailed determination is generally not necessary since products shall prevent attachment of fouling irrespective of species (or other taxonomic ranking).

As the assessment is based on a visual inspection, it is advised that this is done by a trained operator. This will help to improve consistency and data quality.

Assessment for the severity of fouling for each type of organism should be semi-quantitative, for example using a scale from 0-4, where 0 indicates the absence, and 4 indicates complete coverage of the class of organism in question. Optionally an estimation of the percentage coverage can be used**.**

The assessment of the coverage of algae and other soft fouling (e.g. arborescent bryozoans, and hydroids), should be based on the area covered by the "hold fast" (the attached base of the organisms) and not by the area covered by the "fronds" (leaves of macro algae) or offshoot colonies.

Overall fouling assessment: The individual assessments of the fouling coverage of each type of organism may be combined to provide an overall fouling assessment. To generate this, a weighting of the coverage of the different types of fouling may be applied to rank and characterise the severity of the fouling present.

When the coating under test is intended for use on ships, fouling never seen on active vessels (e.g. amphipods) may be disregarded during the weighting. Biofouling attached to other fouling organisms (secondary fouling) should also be excluded from the overall fouling assessment.

Only the fully immersed surface area (if parts of the panel are subject to splash only) should be included in the determination of the fouling rating. Fouling attached within 1 cm from all edges of the test panel and fouling around the cable ties/studs/etc. may be disregarded in cases where an edge effect is seen. (Fouling around edges is normally attributed to insufficient antifouling paint film thickness around sharp panel edges.)

Fouling caused by physical defects or damage to the substrate or accidental damages of the antifouling should be disregarded. Fouling on exposed anticorrosive paints or other substrates (except where these are used as negative controls) or on other antifouling paints that may be used to coat panel edges, should be excluded from the assessment.

Physical defects (detachment, blistering, cracking, etc.) attributed to the inherent properties of the antifouling paint itself should be recorded and reported.

Photos: Inspection reports should include panel photos from each inspection.

7. Reporting

The report should contain all relevant information obtained from the efficacy trial for a given product. This may include:

- The name of the reporting company (and client if the test is carried out on assignment)
- The geographical location of the test raft(s) (including longitude and latitude)
- The geography (e.g. open sea, bay, estuary, etc.), depth of water, and water exchange conditions (tide, currents) at the raft site
- Typical local conditions. E.g. water temperature, salinity, and pH at the raft site
- Relevant information on the typical fouling community at the test site and seasonal influences where applicable.
- A discussion of any special conditions or variables that may have arisen particular to the specific test
- Orientation and exposure depth of test panels
- Dimensions and type (material) of test panels
- Identification of the tested product and control(s)
- Details on the panel preparation for the product under test and the control(s) (No. of coats, film thickness, application technique, etc.)
- Number of replicates, if used
- Initial date of immersion and the cumulative exposure time (in months) for subsequent inspections
- Raw data from each individual assessment of a test panel
- The overall fouling assessment rating at each inspection during the exposure period
- Photos of test and control panels
- A systematic appraisal of the efficacy of the test product in relation to the negative control and, if used, any positive controls and the method by which that appraisal has been conducted
- A description of the reporting company's weighting system used to provide the overall fouling assessment rating
- A discussion on the validity and acceptability of the test result relative to the intended label claim for the product tested when commercialised [e.g. recommended use area (recreational yachts, ships' niche areas, ships' flat bottoms, ships' water line, etc.) protection time/dry-docking interval, fouling conditions in targeted markets, etc.].
- An interpretation of the test data generated and a conclusion on the efficacy of the coating under test.