Designation: D6990 – 20

Standard Practice for Evaluating Biofouling Resistance and Physical Performance of Marine Coating Systems[1]

This standard is issued under the fixed designation D6990; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice establishes a practice for evaluating degree of biofouling settlement on and physical performance of marine coating systems when panels coated with such coating systems are subjected to immersion conditions in a marine environment. Guidance for preparation or exposure and handling of test specimens can be found in related ASTM standards as noted below (see Section 2).

1.2 This practice and related exposure methodologies are designed as tools for the relative assessment of coating performance, and in no way are to be used as an absolute indicator of long-term performance under all conditions and in all environments. There can be high variability among and within exposure sites with respect to water quality and population or species of fouling organisms, and coating performance may vary with these and other properties.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* A specific hazard statement is given in Section 6.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

Recommended ASTM Methods and Practices for evaluation of antifouling coatings via panel exposure under a variety of exposure conditions:

D3623 Test Method for Testing Antifouling Panels in Shallow Submergence

D4938 Test Method for Erosion Testing of Antifouling Paints Using High Velocity Water

D4939 Test Method for Subjecting Marine Antifouling Coating to Biofouling and Fluid Shear Forces in Natural Seawater

D5479 Practice for Testing Biofouling Resistance of Marine Coatings Partially Immersed

D5618 Test Method for Measurement of Barnacle Adhesion Strength in Shear (Withdrawn 2020)[3]

G141 Guide for Addressing Variability in Exposure Testing of Nonmetallic Materials

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *biofilm, n*—matrix-enclosed populations of microorganisms adherent to each other or to surfaces, or both, or interfaces.

3.1.2 *biofouling adhesion, n*—qualitative or quantitative force required for the successful and complete removal of marine fouling attached to the antifouling coating surface (for example, reference Test Method D5618 for barnacles).

3.1.3 *corrosion eruptions, n*—build up of oxides, exiting through protective paint film.

3.1.4 *damage, n*—limited destruction of portions of paint film due to impact with a foreign article.

[1] This practice is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.45 on Marine Coatings.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

3.1.5 *digging, n*—a term used to describe hard fouling macroorganisms that are growing "into" the coating. That is, where its calcareous shell penetrates/breaks through the coating surface causing physical damage to the coating.

3.1.6 *macroorganism, n*—organisms large enough to be seen with the naked eye and thus would be noted when growing on submerged surfaces.

3.1.7 *microorganism, n*—organisms too small to be seen with the naked eye, which generally include bacteria, protozoa, fungi and microalgae (sometimes collectively called "slime").

3.1.8 *peeling, n*—the phenomenon manifested in paint films where a portion of a film, when pulled, can be removed in strips or relatively large intact pieces, or both.

3.1.9 *silt, n*—sedimentary material consisting especially of mineral particles intermediate in size between those of sand and clay.

3.1.10 *softness, adv*—the phenomenon manifested by paints in transferring some of its pigmentation to a foreign item or substance, upon encountering friction on its surface.

3.1.11 *wearing, n*—gradual loss of the paint film caused by use or exposure to the environment.

4. Summary of Practice

4.1 Test specimens or panels are coated with marine coating systems and exposed to marine immersion conditions for a specified amount of time and under specific sets of conditions as agreed upon by the producer and user. See 2.1 for published ASTM standard methods and practices that provide guidance for exposure of coating systems.

4.2 Coating systems are evaluated in terms of fouling rating (percent of coverage of the coating system by biofouling organisms), and physical deterioration rating (percent area of the coating system affected by physical coating failure(s)). These data are useful in assessing and comparing effectiveness of antifouling coating systems.

5. Significance and Use

5.1 This practice is designed to provide guidance to a panel inspector for quantitative and consistent evaluation of coating performance from test panels coated with marine antifouling coating systems. The practice assesses performance of coating systems based on both antifouling and physical properties.

5.2 The user is cautioned that the results are representative for the specific region and time of year in which the specimens are immersed. It shall be noted that interpretation of results will depend on the geographical location where the test is conducted, whether the coated specimens are exposed either totally or partially immersed, under static or dynamic conditions, and position and orientation.

5.3 Simultaneous testing of a proven standard antifouling coating system (known to minimize fouling accumulation, for example, containing biocide or active agent(s) to prevent fouling settlement/growth) in the specific marine environment shall be included as a reference to assist in interpretation of results. In addition, a negative control (inert surface susceptible to heavy fouling) shall be included on a regular basis. For the exposure to be valid, the surface of the negative control should show heavy fouling relative to the standard system(s).

5.4 Marine coating systems that produce positive results relevant to the standard system(s) show potential for use in protecting underwater marine structures.

5.5 The format can be utilized independent of exposure protocol and coating type, and provides the end user with a consistent practice and format for reporting of performance rating.

6. Safety Precautions

6.1 **Warning—**Certain marine coating systems contain toxic materials (biocides) that may cause skin and eye irritation on contact as well as adverse physiological effects if ingested or inhaled. In the preparation, application, and general handling of panels coated with various types of marine paints, the use of appropriate protective clothing and equipment is required consistent with local, state, federal government regulations and recognized industrial and technical standards.

7. Procedure—Evaluation of Fouling Present on Test Surface

7.1 Controls should be exposed and assessed at the same time as the test materials. More information about the use of control materials in weathering tests can be found in Guide G141. (See also 5.3.)

7.2 Retrieve test panels and any negative controls and reference coatings from immersion site. Note and record the visual percentage coverage by biofilm or silt, or both, or lack thereof in accordance with the guidelines provided below.

7.3 Prior to inspection, it is recommended that panels be rinsed (see below and 7.3.2 for more information) in order to remove silt (may interfere with observation of attached forms) and unattached forms. Alternatives to rinsing such as either gentle agitation of the panels or not rinsing the panels at all may be done but must be specified in the final reports. Whichever preparation is chosen, it must be documented and performed on all panels equally and at each inspection. If rinsed, the test panel surface is to be wetted using low-pressure water. For example, use household water pressures from garden hose sized-nozzles measuring 9.5 to 13 mm (⅜ to ½ in.) in the form of a gentle shower spray or non-forceful flow to allow for a reliable inspection of what is attached to the coating/panel. Nozzles that cause water to be forcefully applied to the panel shall not be used. **Warning—**Risk in rinsing panels is that subsequent biofouling attachment may be affected. Alternatively, panels may be gently agitated in water to remove loose/unattached bacterial biofilm or silt deposits, or both. **Warning—**Risk in not rinsing panels is that silt or slime, or both, may interfere with assessment of biofouling attachment on complete panel surface.

7.3.1 Test panels shall not be allowed to dry during the entire inspection period. A holding tank is useful for accomplishing this.

7.3.2 Rinse water and holding tank water, shall be taken from the immersion site.

7.3.3 Efforts shall be made to minimize the length of time panels remain removed from the normal immersion site, and to not touch the coated surfaces.

7.4 Populations and types of organisms will vary by test site. Some examples of biofouling microorganisms include barnacles, oysters, mussels, bryozoans (arborescent and encrusting), hydroids, tubeworms, tunicates, sponges, and various types of algae. Each type of fouling organism directly attached to the test surface shall be reported by (*1*) the estimated percentage of the panel area covered by all of the same type of biofouling (for example, colonial forms), (*2*) the frequency (number of individuals for the larger and solitary organisms; for example, barnacles, mussels, oysters, tube worms, and some tunicates), and (*3*) the range of size for the individual organisms (for larger, solitary organisms). See Appendix X1 for guidance on estimating percent cover and Fig. X2.1 for a suggested sample antifouling inspection report form.

7.4.1 Make a note of any fouling organisms found to be growing into the paint film, also referred to as "digging."

7.4.2 Note that percentage cover of algae and arborescent bryozoans shall be based on the area covered by the "hold fast" and not the area covered by the "strands" or colony. The type of algae (for example, brown, red, green) shall also be recorded if known.

7.4.3 Only attachment of primary biofouling settlement (that is, biofouling attached directly to the coating system) shall be recorded. Notes on secondary fouling (biofouling attached to other fouling organisms) can be made if desired, but shall not factor into the generation of a "fouling rating."

7.4.4 Percent cover by mud tube-building amphipods shall be reported as a footnote in Fig. X2.1, but shall NOT factor into the generation of a "fouling rating."

7.4.5 *Partial Immersion Test Panels Only*—Panels exposed in accordance with Practice D5479 are partially immersed. The non-immersed area will be subject to splash and may show some fouling attachment, but the area is not included in the determination of a fouling rating. Therefore, the fouling rating is calculated based on the fully immersed surface area, counting the immersed surface area as 100 %.

7.4.6 In addition, antifouling performance of coating systems is often different in the immediate waterline vicinity. Therefore, an estimate of coverage along the first 50 mm (2 in.) of the test panel shall also be made and can then be contrasted with the overall coverage. Fouling occurring in the "above the waterline" area, if any, is not considered when generating a "fouling rating."

7.5 Discount biofouling attachment within 13 mm (½ in.) from all edges of the test panel.

8. Procedure—Evaluation of Physical Deterioration/ Performance of Test Surface

8.1 Prior to the original exposure, inspect all test panels for possible physical deterioration. Record findings. Continue observation of predetermined damage during future inspections. See Fig. X2.2 for a suggested sample physical performance inspection report form.

8.2 Evaluate individual physical performance failure, qualitatively and quantitatively, for each test specimen. Observations of erosion, wearing, blistering, alligatoring, checking, cracking, chipping, peeling, flaking, and damage shall be made. For additional information and guidance for evaluating any of the previous physical deteriorations, refer to Sections 2 and 3. Record the percent surface area affected by each physical parameter.

8.2.1 Observations of physical deterioration shall be performed for each coat visible to the inspector (for example, topcoat, intermediate, primer). The percent surface area affected by each physical parameter shall be estimated based on the visible area of each coat.

8.3 Discount any physical failures within 13 mm (½ in.) from all edges of the test panel.

8.4 Observations of physical deterioration cannot be performed on panel surface areas covered by hard fouling. At the time of inspection do not count this area in the generation of the physical deterioration rating (PDR); see also 11.2. At the end of the panel test period, a final evaluation of physical deterioration rating can be performed after removal of hard fouling in order to determine whether physical deterioration has occurred under areas that had been covered by hard fouling.

9. Procedure—Evaluation of "Softness" of Marine Coating System

9.1 Evaluation of "softness" is intended for marine coating systems (excluding silicone coating systems), and is an indicator of a coating's pigment erosion characteristics. It is measured on a subjective scale of 10 to 0 (see 9.2.1), dependent on the amount of pigment transferred from the coating to a cotton swab.

9.2 After rinsing the test panels (see 7.2), rub a wet cotton swab, exactly 10 strokes in a back and forth motion, over the wet test surface. The cotton swab is held at one of its ends with the thumb and index finger. The cotton swab is positioned at 45° to the coating surface and sufficient pressure is applied so that the cotton swab stem just starts to bend. The strokes shall be made continuously in a back and forth motion, in the same linear pattern, approximately 50 mm (2 in.) in length. Use of proper protective equipment, such as gloves, is recommended.

9.2.1 Softness shall be evaluated on the following subjective scale, where:

10 = no pigment transferred to a cotton swab,
8 = trace amount of pigment transferred to a cotton swab,
6 = slight amount of pigment transferred to a cotton swab,
4 = moderate amount of pigment transferred to a cotton swab,
2 = severe amount of pigment transferred to a cotton swab, and
0 = complete removal of pigment transferred to a cotton swab.

9.3 Softness measurements can be performed anywhere 13 mm (½ in.) or more away from all edges of the test panel. In the case of partially immersed panels, avoid taking measurements in the area affected by partial immersion.