Designation: D 5618 – 94 (Reapproved 2000)

Standard Test Method for Measurement of Barnacle Adhesion Strength in Shear[1]

This standard is issued under the fixed designation D 5618; 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 test method covers the measurement of barnacle adhesion in shear to surfaces exposed in the marine environment. It is used to establish the ability of a surface to reduce biofouling adhesion. Surfaces with known barnacle adhesion strengths are included to serve as controls.

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

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 3623 Test Method for Testing Antifouling Panels in Shallow Submergence[2]

2.2 *U.S. Military Specifications:*

MIL-P-24441/1 Primer, Epoxy (Formula 150, Formula Sheet 24441/1)[3]

3. Summary of Test Method

3.1 Test surfaces and coatings are immersed in the marine environment according to TestMethod D 3623. When barnacles are observed to have settled on the surface, the strength of adhesion of individuals is measured. Barnacle adhesive shear strength is calculated by dividing the shear force required to remove the barnacle by the surface area of the barnacle base plate. This test method is most suited to small barnacles (generally with base diameters between 5 to 20 mm).

3.2 The diameter of the barnacle base is measured and an increasing shear force is applied to the base of the barnacle until it is removed from the surface.

4. Significance and Use

4.1 This test method is designed as a screening test in the evaluation of coating systems and other materials designed to resist biofouling attachment.

4.2 The degree and type of barnacle fouling will vary according to the geographic location of test sites and the time of year when tests are implemented. Surfaces with known barnacle adhesive shear strength should be exposed to provide comparative data.

5. Interferences [4]

5.1 Variations in barnacle adhesion strength may occur due to differences in species, age, and physical condition.

5.2 Incomplete removal of the barnacle base plate from the surface during testing may lead to erroneous adhesion values.

5.3 Care must be taken not to dislodge the barnacle during base diameter measurements.

6. Apparatus

6.1 *Hand-Held Probe*, used to apply force to the barnacle base. It is recommended that a 14- by 14-mm stainless steel plate be attached to the end of a 8-mm diameter stainless steel rod that is attached to a force measuring device (see Fig. 1).

6.2 *Force Measuring Device*, maybe a spring scale or force transducer.

6.2.1 The force measuring device should be capable of recording values between 0 to 150 N (0 to 34 lb) to an accuracy of ±0.5 N (±0.1125 lb).

7. Procedure

7.1 Test and control surfaces are immersed in the marine environment according to Test Method D 3623. Control surfaces should include polytetrafluoroethylene and MIL-P-24441 primer epoxy.

7.2 Barnacles between 5 to 20 mm in diameter are selected for testing and identified with regard to species and condition. Test only barnacles that are at least 20 mm from the edges of the test panel and not in direct contact with other barnacles.

7.3 The barnacle base area is estimated from an average base diameter, d_a. This is obtained by measuring the barnacle base with calipers in four directions (0, 45, 90, 135°). The barnacle base area, A, is then calculated as follows:

$$A = \frac{1}{4}\pi d_a^{\,2} \quad (1)$$

[1] This test method 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.

Current edition approved Oct. 15, 1994. Published December 1994.

[2] *Annual Book of ASTM Standards*, Vol 06.02.

[3] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[4] Swain, G. W. J., Griffith, J., Bultman, D., and Vincent, H.," Barnacle Adhesion Measurements for the Field Evaluation of Candidate Antifouling Surfaces, *Biofouling*, Vol 6, 1992, pp. 105–114.

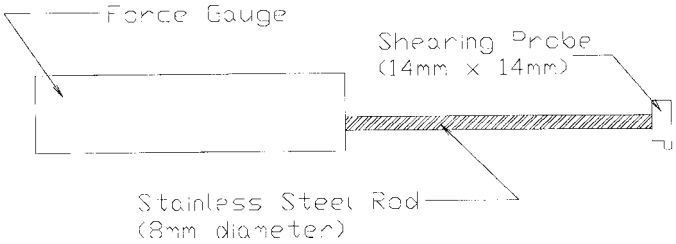

FIG. 1 Probe Design for the Detachment of Barnacles

7.4 The probe is placed at the base of the barnacle.

7.5 A shear force is applied with a hand-held probe to the barnacle base at a rate of approximately 4.5 N/s (1 lb/s) until the barnacle becomes detached. Take care to apply the force parallel to the surface.

7.6 The force required for detachment is noted, and observations are made as to the mode of failure. If more than 10 % of the barnacle base plate is left attached to the substrate, the test is deemed void.

8. Calculations and Interpretation of Results

8.1 The strength of adhesion, τ, (Pascals) is calculated by dividing the force required to remove the barnacle, F, (Newtons) by the area of the barnacle base plate, A, (square metres) as follows:

$$\tau = F/A \quad (2)$$

8.2 For each test surface the mean and standard deviation of the strength of adhesion, τ, is calculated.

8.3 The strength of adhesion values for test surfaces are compared to the control surfaces of known adhesion.

9. Report

9.1 Report the following information:

9.1.1 For test panels report the substrate employed, the type of coating, and the days exposed,

9.1.2 Report the number of tests, their mean and range, and the species of barnacle,

9.1.3 Report the overall fouling and condition of the surface according to Method D 3623, and

9.1.4 Provide similar data for the exposed control surfaces so that comparative conclusions with regard to adhesion strength can be drawn.

10. Precision and Bias

10.1 *Precision*—On the basis of static immersion of control surfaces at Florida Institute of Technology[5] (polytetrafluoroethylene and MIL-P-24441 primer epoxy) the following results were obtained:

Test Surface	MIL-P-24441 primer epoxy	Polytetrafluoroethylene
Barnacle species	*Balanus eburneus*	*Balanus eburneus*
Date	September 2, 1992	September 2, 1992
Days exposure	20	57
Number of readings	14	10
Mean, MPa	2.060	0.896
Standard deviation MPa	0.527	0.165
95 % Confidence interval	0.304	0.118
99 % Confidence interval	0.424	0.169

10.2 *Bias*—Bias is being determined.

11. Keywords

11.1 antifouling; barnacle adhesion; shear strength

[5] The tests were run at the Florida Institute of Technology Static Immersion Site, Indian River Lagoon, Grant, Florida.