



Standard Test Method for Testing Antifouling Panels in Shallow Submergence¹

This standard is issued under the fixed designation D 3623; 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 a procedure for testing antifouling compositions in shallow marine environments and a standard antifouling panel of known performance to serve as a control in antifouling studies.

NOTE 1—Subcommittee D01.45 has a revised rating procedure now being evaluated by round robin.

1.2 *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 application of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

A 569/A569M Specification for Steel, Carbon (0.15 Maximum Percent), Hot-Rolled, Sheet and Strip, Commercial Steel²

D 2200 Pictorial Surface Preparation Standards for Painting Steel Surfaces³

2.2 U.S. Military Specifications (See also Annex A1):

MIL-P-15328D Primer Pretreatment (Formula 117 for Metals)⁴

MIL-P-15929C Primer Coating, Shipboard, Vinyl-Red Lead (Formula 119—For Hot Spray)⁴

MIL-P-15931B Paint, Antifouling, Vinyl, Red (Formula 121/63)⁴

MIL-S-22698A Steel Plate, Carbon, Structural⁴

3. Terminology

3.1 Definitions:

3.1.1 *shallow submergence*—an immersion to depths between 1 and 10 ft (0.3 and 3.0 m).

3.2 Abbreviations:

3.2.1 The following abbreviations are used in reporting test results:

Al	algae
Barn	barnacles
E.B.	encrusting bryozoans
Hyd	hydroids
Sl	slime
Tun	tunicates
C.F.	completely fouled
F.R.	fouling resistance rating
A.F.	antifouling rating
A.C.	anticorrosive rating
O.P.	overall performance rating
CO	coelenterates
F.B.	filamentous bryozoans
Mol	molluscs
PC	polychaetes

3.2.2 Algal Mups may be delineated by classification notation by phylum as follows:

Al-b	Phaeophyta (brown)
Al-bg	Cyanophyta (blue-green)
Al-g	Chlorophyta (green)
Al-r	Rhodophyta (red)

4. Significance and Use

4.1 This method is designed as a screening test in evaluating antifouling coating systems. Results of the standard system in a specific marine environment are included to assist in interpreting results (see Annex A2).

4.2 Antifouling systems providing positive comparisons with the standard system should be considered acceptable for use in protecting underwater marine structures.

4.3 The degree and type of fouling will vary depending on the environment. Hence, differences in geographic location of test sites, in time of year when panels are exposed, and in weather conditions from 1 year to the next can affect results. Therefore, a fouling census on a nontoxic surface is taken. For the exposure to be valid the nontoxic surface should show heavy fouling, and the standard system should show significantly less fouling than the nontoxic surface (see Annex A3 and Annex A4).

5. Apparatus

5.1 *Blast Cleaning Apparatus* capable of preparing panels in compliance with 8.1.

5.2 *Application Equipment* consisting of brush, roller, conventional spray, or airless spray. Usually the equipment is dictated by the physical properties of the coating and the film thickness desired.

5.3 *Exposure Rack* to provide firm positioning of the specimen panels such that they are held vertically in place in spite

¹ This test method is under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.45 on Marine Coatings.

Current edition approved Oct. 27, 1978. Published January 1979. Originally published as D 3623 – 78. Last previous edition D 3623 – 78.

² *Annual Book of ASTM Standards*, Vol 01.03.

³ *Annual Book of ASTM Standards*, Vol 06.02.

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

of the current and are electrically insulated from metallic contact with the rack or other panels. The rack should be positioned such that the prevailing tidal currents will move parallel to the panel face, and the panels will be immersed to a depth of a minimum of 1 ft (0.3 m) and a maximum of 10 ft (3 m). In a rack where the panels are stacked front to back, they should be spaced at least 2½ in. (60 mm) apart, with the two end positions filled with blank panels. In a rack where the panels are mounted side by side, the distance between adjacent panels should be a minimum ½ in. (1.5 mm).

6. Materials

6.1 *Test Panel*—The substrate for the standard antifouling coating system shall be medium low-carbon steel plate per Specification A 569,⁵ ⅛ in. thick by 6 to 10 by 10 to 12 in. (3 mm thick by 150 to 250 mm by 250 to 300 mm) with a minimum area per side of 72 in.² (465 cm²). A ¼-in. (6-mm) diameter hole, ½ to 1 in. from the top and centered shall be drilled for holding the panel while handling and painting. The test coating system shall be applied to that substrate for which it is designed provided there is a minimum area per side of 72 in.² (466 cm²).

6.2 *Standard Coating System*—The standard antifouling coating system shall consist of:

6.2.1 Green pretreatment coating conforming to U.S. Military Specification MIL-P-15328B (Formula 117), B revision only.

6.2.2 Vinyl red lead primer conforming to U.S. Military Specification MIL-P-15929C (Formula 119), C revision only.

6.2.3 Vinyl antifouling coating conforming to U.S. Military Specification MIL-P-15931B (Formula 121/63), B revision only.

6.3 *Test Coating System*—The test antifouling coating may be applied to the standard primer system, or to any other suitable anticorrosive primer system.

7. Safety Precautions

7.1 **Caution**—Antifouling paints contain toxic materials that could cause skin and eye irritation on contact and adverse physiological effects if ingested or inhaled. In the preparation of panels and the application of various types of antifouling paints the use of appropriate protective clothing and equipment is required consistent with local, state, and federal government regulations, and recognized industrial and technical standards. Spills, overspray, and unused material should not be flushed down the drain, but should be disposed of as hazardous waste.

8. Procedure

8.1 Abrasive blast the required number of panels to near-white metal (Sa 2½ of Method D 2200) to obtain a profile of 1 to 1.5 mils (25 to 38 µm).

NOTE 2—A profile of 1 to 1.5 mils (25 to 38 µm) can be obtained with the following parameters: (1) Type and size of grit, No. 46 (sand); (2) Pressure, 90 psi (620 kPa); (3) Angle, 90 deg; (4) Distance from surface, 3 to 5 in. (75 to 125 mm); (5) Nozzle size, ⅜ in. (9 mm).

8.2 On the clean, dry, uncontaminated, blasted surface apply

to each standard panel one coat of pretreatment coating MIL-P-15328D to give a nominal dry film thickness of ½ mil (13 µm).

NOTE 3—All coating drying times are for a minimum temperature of 21°C and a maximum relative humidity of 70 %.

8.3 Within 24 h of application of the pretreatment coating apply the first coat of red lead vinyl primer MIL-P-15929C. Apply a total of four coats of red lead vinyl primer to give a nominal dry film thickness of 6 mils (150 µm). Allow a minimum of 2 h and a maximum of 24 h drying between coats of red lead vinyl primer.

8.4 Allowing a minimum of 2 h and a maximum of 24 h drying after the last coat of red lead vinyl primer, apply the first coat of vinyl antifouling coating MIL-P-15931B to the standard panels, and the test coating to the test panels. A ¾-in. (19-mm) numbered vinyl tape can be applied before the second coat of antifouling coating for identification. Allowing a minimum of 2 h and a maximum of 24 h drying after the first coat, apply a second coat of the respective antifouling coating to give a nominal dry film thickness for both antifouling coats of 4 mils (100 µm).

8.5 Before immersion permit the second coat of antifouling coating to dry a minimum of 4 h and a maximum of 2 weeks, the latter time allowing for shipping the panels to the immersion site.

8.6 Expose for a minimum period of 1 year at an immersion site with a high incidence of fouling as indicated by attachments on a dark nontoxic surface such as slate. A monthly fouling census as well as a yearly accumulation when appropriate is required.

8.7 Evaluate the antifouling panels for surface fouling and physical condition of the film system at least monthly as follows using the report form in Table 1.

8.7.1 *Fouling on Surfaces*—Rate fouling present on that portion of the antifouling test surface which is intact at the time of inspection (see 9.1). Rate both sides of the panel if appropriate. Ignore fouling present on the substrate or on anticorrosive undercoats. Barnacles, polychaetes, coelenterates, etc., that are immature or loosely attached should be so reported in the appropriate space. Report fouling by initial algal germination, low-form algae and diatoms as “algal slime.” Report absorbed organic and inorganic chemicals, trapped silt and detritus, and other unidentified slimes as “silt.”

8.7.2 *Physical Condition*—Rate the condition of coating films in accordance with 9.2. Record qualitative descriptions of film deterioration and discoloration in this column, and unless otherwise specified, refer only to the antifouling test surface. Indicate deterioration of undercoats, when evident, by the notation “A.C.”. For example, “Peeling, A.F. from A.C.” or “Chipping, A.C. from steel”.

9. Calculations:

9.1 *Fouling Resistance* (F.R.)—Award each test surface free of fouling except for the presence of algal spores and other biological slimes a rating of 100. Reduce the rating to 95 if only incipient fouling is present. If mature forms of fouling are present, obtain the rating by subtracting from 95 the sum of the number of individuals present and percent surface covered by

⁵ See also U.S. Military Specification MIL-S-22698, Type 1, Class A.

TABLE 1 Behavior Report of Experimental Surfaces

 Origin:
 Series:
 Base:
 Size:

 Place of Immersion:
 Depth of Immersion:
 Date Immersed:
 Date Inspected:
 Inspected by:

Test Surface No.		Fouling on Surfaces ^A	Physical Condition	Percent Ratings			
				F.R.	A.F.	A.C.	O.P.
		Barn: E.B.: Others:					
		Barn: E.B.: Others:					
		Barn: E.B.: Others:					
		Barn: E.B.: Others:					
		Barn: E.B.: Others:					
		Barn: E.B.: Others:					
		Barn: E.B.: Others:					

^AFouling reported as found on the more heavily fouled surface. Solitary forms reported numerically; colonial forms by percent surface covered, Al: algae; Barn: barnacles; E.B.: encrusting bryozoans; Hyd: hydroids; Tun: tunicates; C.F.: completely fouled; CO: coelenterates; F.B.: filamentous bryozoans; Mol: molluscs; PC: polychaetes.

colonial forms. For example, if the “fouling on surface” is:

Barn	6, 3 to 10 mm
E.B.	None
Others	Mol 1, 20 mm Al-g (green) 10 %

then the F.R. percent rating would be $95 - (6 + 1 + 10) = 78$.

9.2 Physical Condition:

9.2.1 *Antifouling Film* (A.F.)—Award an antifouling test surface having no physical defects a rating of 100. Subtract the percent surface affected by film defects from 100 to obtain the rating for imperfect films.

9.2.2 *Anticorrosive Film* (A.C.)—Obtain the rating by the same procedure as 9.2.1.

9.3 *Overall Performance* (O.P.)—For overall performance, award the panel the lowest percent rating of the three preceding values.

9.4 *Normalization*—The rating system described above is based on a minimum test on one side area of 72 in.²(465 cm²). Correct the percent ratings for test surfaces of nonstandard dimensions for the difference between the minimum standard panel area of 72 in.²(465 cm²) and the area on one side of the test specimen.

10. Report

10.1 Report the results of the immersion test in terms of fouling resistance and overall performance for both the material under test and the standard system.

10.2 *Other Data*—Report the place, depth, and date of

immersion, whether mounted from a dock or a floating raft, date the panels were removed and inspected, panel size, and panel identification number. A census of fouling on a nontoxic surface taken each month for the period of exposure must be included in the report.

11. Precision

11.1 The precision statements are based on an interlaboratory study in which seven laboratories prepared pairs of panels coated with the standard antifouling system, submerged them, and after 1 year rated the fouling. The within-laboratory standard deviation was found to be 2.08. The between-laboratory standard deviation was found to be 4.67. Based on these standard deviations, the following criteria should be used to judge the acceptability of results at the 95 % confidence level:

11.1.1 *Repeatability*—Two results each the mean of duplicates obtained by the same operator should be considered suspect if they differ by more than seven units.

11.1.2 *Reproducibility*—Two results each the mean of duplicates obtained by operators in different laboratories should be considered suspect if they differ by more than 16 units.

12. Keywords

12.1 antifouling; antifouling coatings; fouling; immersion; performance; static

ANNEXES
(Mandatory Information)
A1. STANDARD COATING SYSTEM FORMULAS
TABLE A1.1 Green Pretreatment Coating, MIL-P-15328D (Formula 117)

	Pounds per 100 gal of Mixed Material	Gallons per 100 gal of Mixed Material
Ingredients of resin component (80 gal):		
Polyvinyl-butylal resin ^A	56	6.10
Zinc chromate (insoluble type) ^B	54	1.78
Magnesium-silicate (Type A or B of Specification MIL-M-15173)	8	0.34
Lampblack (Specification TT-L-70)	0.6	0.04
Butyl alcohol, normal (Spec. TT-B-846)	125	18.48
Isopropyl alcohol, 99 % ^C	353	53.80
Water	15	1.80
Ingredients of acid component (20 gal):		
Phosphoric acid (Class A of Spec. O-P-313)	28	2.0
Water	25	3.0
Isopropyl alcohol, 99 % ^C	99	15.0

^AThe resin shall be a polyvinyl partial butylal resin containing only poly(vinyl butyral), poly(vinyl alcohol), and poly(vinyl acetate) in the molecule. The resin shall contain 18.0 to 20.0 % vinyl alcohol, and not more than 1.0 % of vinyl acetate. A 6 % solution of the resin in methanol shall have a viscosity of 12 to 18 cP at 20°C. The specific gravity of the resin shall be 1.05 to 1.15.

^BThe zinc chromate shall be of an insoluble type, showing an analysis of 16 to 19 % CrO₃, and 67 to 72 % ZnO, and not more than 1 % water-soluble salts.

^CIsopropyl alcohol, 99 % shall have a specific gravity of 0.785 to 0.790 at 20/20°C and a distillation range not greater than 1.5°C and this range shall include 82.3°C.

TABLE A1.2 Vinyl Red Lead Primer, MIL-P-15929C (Formula 119)

Ingredients	Specifications	Pounds per 100 gal	
		Composition G	Composition L
Red lead, 98 % Pb ₃ O ₄		247.0	247.0
Organic suspension agent 24 % NV		8.2	8.2
Vinyl resin ^A		162.8	162.8
Tricresyl phosphate	TT-T-656	16.8	16.8
Methyl isobutyl ketone	TT-M-268	284.7	
Methyl <i>n</i> -butyl ketone ^B	TT-M-261		273.2
Methyl ethyl ketone	TT-M-261	47.0	105.5
Toluene	TT-T-548	217.7	75.1
Aliphatic naphtha ^C	TT-N-95,(I)		81.1

^AHydroxyl containing vinyl chloride-acetate copolymer (89.5 to 91.5 % vinyl chloride, 5.3 to 7.0 % vinyl alcohol and 2 to 4.0 % vinyl acetate); white powder, specific gravity not under 1.35, not less than 98 % through sieve 20.

^BTo contain not over 5 volume % of branched chain ketones.

^CTo contain not over 11 volume % of aromatic hydrocarbons.

TABLE A1.3 Vinyl Antifouling Coating, MIL-P-15931B (Formula 121/63)

Ingredients	Specifications	Pounds ^A
Cuprous oxide	MIL-P-15169	1440
Rosin	LLL-R-626, Class A, Grade WW	215
Vinyl resin ^B		55
Tricresyl phosphate	TT-T-656	50
Methyl isobutyl ketone	TT-M-286	165
Xylene	TT-X-916	115
Antisettling agent ^C		5 to 9

^AThe formula given is slightly in excess of 100 gal to allow for normal manufacturing loss, may be proportioned to the size batch desired.

^BThe resin shall be a vinyl chloride-vinyl acetate copolymer. It shall contain 85 to 88 % vinyl chloride and 12 to 15 % vinyl acetate. The resin shall have a specific gravity of 1.35 to 1.37. Material shall be furnished as a powdered white solid, not less than 98 % of which shall pass through a No. 20 sieve, conforming to RR-S-366.

^CThe antisettling agent shall be sufficient to prevent hard pigment settling and otherwise meet requirements of Military Specification MIL-P-15328D, Section 3.4.6.

A2. RESULTS OF EXPOSURE OF STANDARD ANTIFOULING PANELS 1 YEAR AT MIAMI BEACH, FLA., AT A MINIMUM DEPTH OF 1 FT (0.3 m) UNDER A FLOATING RAFT

NOTE 1—Physical condition or its extent indeterminate, or both, due to intensive, extensive algae spore growth. Ratings for A.F. and A.C. are as recorded before surface became obscured by spore foulings.

Origin:	ASTM Subcommittee 45	Place of Immersion:	Miami Beach
Series:	#1	Date Immersed:	11 June 1971
Base:	Steel	Date Inspected:	11 June 1972
Size:	10 by 12 in. and 6 by 12 in. and 8 by 10 in.	Inspected by:	F. Lepicard

Test Surface No.		Fouling on Surfaces ^A	Physical Condition	Percent Ratings			
				F.R.	A.F.	A.C.	O.P.
VAL/1	numbered	Barn: incipient E.B.: 2 % Others: A1 (green and red) 1 % A1 (spores) 85 %	soft pinhead blistering (extent indeterminate), see note	92	98	100	92
VAL/1	unnumbered	Barn: 10,4–7 mm E.B.: 6 % Others: A1 (spores) 85 %	soft pinhead blistering (extent indeterminate), see note	79	99	100	79
NN/1	numbered	Barn: 2,3 to 10 mm E.B.: 14 % Others: A1 (spores) 90 %	soft eroding (extent indeterminate), see note	79	98	100	79
NN/1	unnumbered	Barn: incipient E.B.: 3 % Others: A1 (spores) 95 %	soft (extent indeterminate), see note	92	99	100	92
MMR/1	numbered	Barn: none E.B.: 1 % Others: A1 (spores) 30 %	eroding	94	90	100	90
MMR/1	unnumbered	Barn: incipient E.B.: none Others: A1 (spores) 50 %	eroding	95	95	100	95
VAL/2	numbered	Barn: incipient E.B.: 2 % Others: A1 (spores) 80 %	indeterminate, see note	93	100	100	93
VAL/2	unnumbered	Barn: incipient E.B.: 4 % Others: A1 (spores) 80 %	indeterminate, see note	91	100	100	91
NN/2	numbered	Barn: 4,3 to 6 mm E.B.: 3 % Others: A1 (spores) 85 %	indeterminate, see note	88	100	100	88
NN/2	unnumbered	Barn: incipient E.B.: 10 % Others: A1 (spores) 90 %	indeterminate, see note	85	100	100	85
MMR/2	numbered	Barn: none E.B.: none Others: A1 (spores) 45 %	indeterminate, see note	100	100	100	100
MMR/2	unnumbered	Barn: none E.B.: 1 % Others: A1 (spores) 40 %	indeterminate, see note	94	100	100	94
NLC/1	unnumbered	Barn: none E.B.: 2 % Others: A1 (spores) 85 %	indeterminate, see note	93	100	100	93
NLC/2	numbered	Barn: incipient E.B.: 5 % Others: A1 (spores) 65 %	indeterminate, see note	90	100	100	90
NLC/2	unnumbered	Barn: none E.B.: none Others: A1 (spores) 90 %	indeterminate, see note	100	100	100	100
EPA 171	numbered	Barn: 9,3 to 11 mm E.B.: 2 % Others: A1 (red) 1 % A1 (spores) 80 %	indeterminate, see note	83	100	100	83
EPA 171	unnumbered	Barn: none E.B.: 4 % Others: A1 (spores) 85 % Barn: none	indeterminate, see note	91	100	100	91

Test Surface No.		Fouling on Surfaces ⁴		Physical Condition	Percent Ratings			
					F.R.	A.F.	A.C.	O.P.
EPA 271	numbered	E.B.:	none	indeterminate, see note	94	100	100	94
		Others:	A1 (red) 1 % A1 (spores) 90 %					
		Barn:	incipient					
EPA 271	unnumbered	E.B.:	12 %	indeterminate, see note	81	100	100	81
		Others:	A1 (green and red) 2 % A1 (spores) 80 %					
		Barn:	incipient					
EPA 371	numbered	E.B.:	1 %	indeterminate, see note	93	100	100	93
		Others:	A1 (red) 1 % A1 (spores) 80 %					
		Barn:	incipient					
EPA 371	unnumbered	E.B.:	6 %	indeterminate, see note	89	100	100	89
		Others:	A1 (spores) 95 %					
		Barn:	incipient					
EPA 471	numbered	E.B.:	3 %	indeterminate, see note	90	100	100	90
		Others:	A1 (green and red) 2 % A1 (spores) 90 %					
		Barn:	incipient					
EPA 471	unnumbered	E.B.:	1 %	indeterminate, see note	93	100	100	93
		Others:	A1 (green and red) 1 % A1 (spores) 85 %					
		Barn:	none					
SW/1	numbered	E.B.:	7 %	indeterminate, see note	88	100	100	88
		Others:	A1 (spores) 65 %					
		Barn:	incipient					
SW/1	unnumbered	E.B.:	5 %	indeterminate, see note	90	100	100	90
		Others:	A1 (spores) 75 %					
		Barn:	incipient					
SW/2	numbered	E.B.:	2 %	indeterminate, see note	93	100	100	93
		Others:	A1 (spores) 90 %					
		Barn:	none					
SW/2	unnumbered	E.B.:	none	indeterminate, see note	92	100	100	92
		Others:	A1 (green and red) 3 % A1 (spores) 85 %					

FIG. A2.1 Behavior Report of Experimental Surfaces

⁴Fouling reported as found on the more heavily fouled surface. Solitary forms reported numerically; colonial forms by percent surface covered, Al: Algae; An: Anomia; Barn: Barnacles; Bug: Bugula; E.B.: Encrusting Bryozoans; Hyd: Hydroids; Oy: Oyster; Sp: Sponge; T. W.: Tube worms; Tun: Tunicates; C.F.: Completely fouled.

Reprinted Courtesy of Miami Marine Research, Inc.

A3. FOULING CENSUS—JUNE 1971 TO JUNE 1972A

Test Surface: 8 by 10 in. Slate (Nontoxic)
 Exposure: From raft, 1 ft (0.3 m) beneath water surface

Date	Barnacle Count	Tube Worm Count	Oyster Count	Tunicates	Hydroids	Algae	Encrusting Bryozoa	Bugola
June 1971	209	44	7	70 %	10 %	3 %	1 %	2 %
July 1971	618	24	9	65 %	8 %	5 %	1 %	2 %
Aug. 1971	225	44	1	95 %	18 %	5 %	1 %	none
Sept. 1971	2206	5	7	55 %	3 %	5 %	none	none
Oct. 1971	1090	none	50	20 %	10 %	15 %	2 %	none
Nov. 1971	1354	2	10	5 %	3 %	7 %	none	none
Dec. 1971	983	57	none	2 %	15 %	8 %	3 %	1 %
Jan. 1972	660	157	3	5 %	60 %	35 %	6 %	2 %
Feb. 1972	176	145	none	5 %	60 %	85 %	3 %	1 %
March 1972	726	560	4	5 %	50 %	85 %	40 %	1 %
Apr. 1972	1120	560	1	10 %	40 %	92 %	25 %	1 %
May 1972	1618	150	7	10 %	30 %	20 %	1 %	none
June 1972	900	350	10	20 %	15 %	10 %	1 %	none

Reprinted courtesy of Miami Marine Research, Inc.

A4. SUMMARY OF BARNACLE SETTLEMENT FOR EXPOSURE PERIOD OF ANNEX 2.

Fig. A4.1

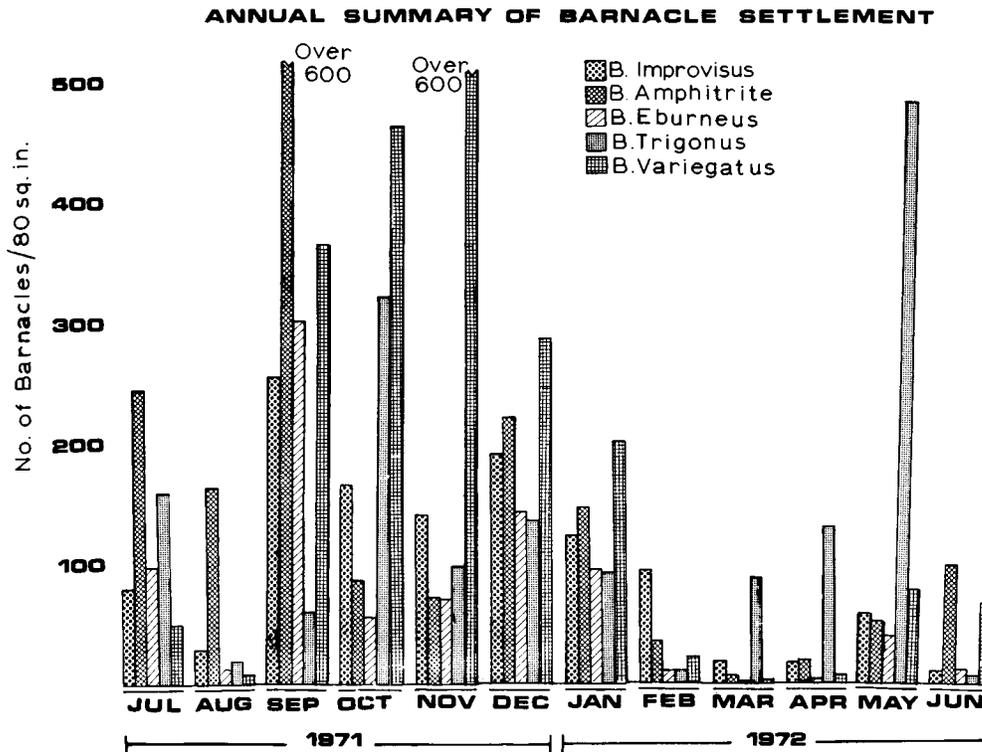


FIG. A4.1 Summary of Barnacle Settlement.

 **D 3623**

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 100 Barr Harbor Drive, West Conshohocken, PA 19428.