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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers¹

This standard is issued under the fixed designation D 4541; 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 (€) indicates an editorial change since the last revision or reapproval.

€¹ NOTE—Research report added editorially in August 1995.

1. Scope

1.1 This test method covers a procedure for evaluating the pull-off strength (commonly referred to as adhesion) of a coating by determining either the greatest perpendicular force (in tension) that a surface area can bear before a plug of material is detached, or whether the surface remains intact at a prescribed force (pass/fail). Failure will occur along the weakest plane within the system comprised of the test fixture, adhesive, coating system, and substrate, and will be exposed by the fracture surface. This test method maximizes tensile stress as compared to the shear stress applied by other methods, such as scratch or knife adhesion, and results may not be comparable. Further, pull-off strength measurements depend upon both material and instrumental parameters. Results obtained using different devices or results for the same coatings on substrates having different stiffness may not be comparable.

1.2 This test method uses a class of apparatus known as portable pull-off adhesion testers.² They are capable of applying a concentric load and counter load to a single surface so that coatings can be tested even though only one side is accessible. Measurements are limited by the strength of adhesion bonds between the loading fixture and the specimen surface or the cohesive strengths of the adhesive, coating layers, and substrate.

1.3 This test can be destructive and spot repairs may be necessary.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *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 2651 Guide for Preparation of Metal Surfaces for Adhesive Bonding³

D 3933 Guide for Preparation of Aluminum Surfaces for Structural Adhesives Bonding (Phosphoric Acid Anodizing)³

D 3980 Practice for Interlaboratory Testing of Paint and Related Materials⁴

2.2 ANSI Standard:

N512 Protective Coatings (Paints) for the Nuclear Industry⁵

2.3 ISO Standard:

4624 Paints and Varnish—Pull-Off Test for Adhesion⁵

3. Summary of Test Method

3.1 The general pull-off test is performed by securing a loading fixture (dolly, stud) normal (perpendicular) to the surface of the coating with an adhesive. After the adhesive is cured, a testing apparatus is attached to the loading fixture and aligned to apply tension normal to the test surface. The force applied to the loading fixture is then gradually increased and monitored until either a plug of material is detached, or a specified value is reached. When a plug of material is detached, the exposed surface represents the plane of limiting strength within the system. The nature of the failure is qualified in accordance with the percent of adhesive and cohesive failures, and the actual interfaces and layers involved. The pull-off strength is computed based on the maximum indicated load, the instrument calibration data, and the original surface area stressed. Pull-off strength results obtained using different devices may be different because the results depend on instrumental parameters (see Appendix X1).

4. Significance and Use

4.1 The pull-off strength of a coating is an important performance property that has been used in specifications. This test method serves as a means for uniformly preparing and testing coated surfaces, and evaluating and reporting the

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² The term adhesion tester may be somewhat of a misnomer, but its adoption by two manufacturers and at least two patents indicates continued usage.

³ *Annual Book of ASTM Standards*, Vol 15.06.

⁴ *Annual Book of ASTM Standards*, Vol 06.01.

⁵ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.