

Measurement of Adhesion Strength

DeFelsko manufactures a hand-held gage that is ideal for measuring the adhesion strength of coatings on a variety of substrates.



Measurement Challenges

To accurately measure the pull-off strength of coatings with varying bond strengths to their respective substrates.

Adhesion Strength Measurement Solutions

The *PosiTest AT* series of pull-off adhesion testers, along with proper selection of dolly size, enables an operator to accurately measure the bond strength of most types of coating applied to any rigid substrate. The expected tensile pull-off adhesion strength and industry standards are two prime factors in determining the correct instrument for an application.

The *PosiTest AT-M* model is designed to measure pull-off strengths up to 3100 psi (21 MPa). The AT-M uses 20 mm dollies and is typically used for measuring coatings on metals. Due to its range, the PosiTest AT-M provides excellent the greatest versatility of all PosiTest adhesion testers and is often recommended for use when a variety of applications are expected, or when expected pull-off strengths are not known.



When higher pull-off strengths are required, the *PosiTest AT-M* can be used with custom sized dollies to attain higher pull-off strengths. For example, a 14 mm dolly provides double the pull-off strength of a 20 mm dolly. With 14 mm dollies the *PosiTest AT-M* can attain pull-off strengths as high as 6200 psi (42 MPa). Similarly, a 10 mm dolly provides four times the pull-off strength of a 20 mm dolly. With 10 mm dollies the *PosiTest AT-M* can measure up to 12400 psi (84 MPa). When standard 20 mm dollies are used, the PosiTest AT-M is designed to provide a 1:1 relation between the actual pull-off strength and the displayed value on the dial. When custom dollies are utilized the operator simply selects the dolly size and the PosiTest AT automatically calculates and displays the true pull off strength. The operator simply multiplies the displayed value on the gage by an applicable factor which is directly related to the difference in surface areas. For example a 20 mm dolly has 4 times the surface area of a 10 mm dolly, thus the user multiplies the gage reading by 4 to attain the actual pull-off strength. The 10, 14, 20 and 50 mm dollies commonly offered by DeFelsko are shown in the figure below. Other custom sizes are available upon customer request.



The *PosiTest AT-P* model is recommended for applications with expected pull-off values of less than 1000 psi (7 MPa). Typical applications are the bond strength measurement of finishes on plastics or wood. The AT-P is constructed similarly to the AT-M except for a dial that displays only the lower range of pull-off strengths. The dial has marked increments providing a resolution of 10 psi (0.1 MPa) versus 20 psi (0.2 MPa) for the AT-M. Interpolation by the user of readings between markings provides even greater resolution.



A 50 mm accessory kit is available. The *PosiTest AT-C* model is specifically designed for measuring the pull-off strengths of coatings on concrete. The accessory kit includes AT-C utilizes 50 mm dollies which are standard in most specifications that involve the testing of tensile bond strengths of coatings on concrete. When testing on concrete, typical failures are cohesive within the concrete, not between the coating and the concrete. With proper cutting around the dolly, the instrument can be used to measure the tensile strength of uncoated concrete, as well as concrete repairs.



Free Consultation

For current pricing or to order these instruments, please contact us by telephone (315) 393-4450, fax (315) 393-8471, or e-mail techsale@defelsko.com. If you require additional technical information or have questions relating to your particular application, we encourage you to take advantage of our years of experience in recommending the best gage for your application.

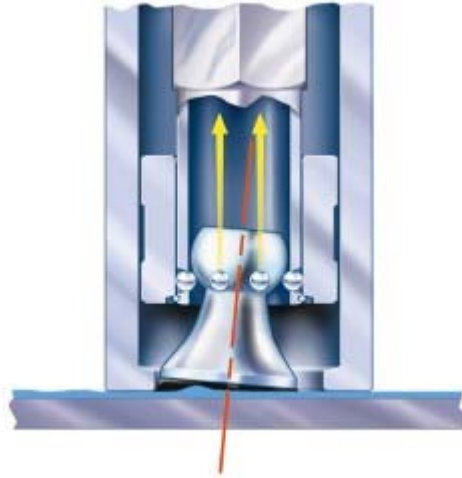
Background on Adhesion Testing

What is Adhesion Testing

Pull-off adhesion testing is a measure of the resistance of a coating to separation from a substrate when a perpendicular tensile force is applied. Coated substrates typically include metals, plastics, concrete, wood and glass. Coatings, finishes and linings vary greatly and include paint films, powder coatings, UV cured, ceramics, epoxies, bitumens (tar enamel, asphalt mastics), thermoplastic resins (polyethylene, vinyl and plastisols), laminates, lacquers, varnishes, specialty resins (urethanes, fluorocarbons, phenolics and polyesters), elastomeric, and inorganics (glass, zinc, and lead).

There are very few industry or application specific pass/fail criteria defined in standards. Expected adhesion testing results are often predetermined by the parties concerned. Dependent on the accuracy and repeatability of equipment involved, large variations have been noted between various equipment

and manufacturers. To minimize these undesired variations, it is critical to utilize an adhesion tester that minimizes shear forces (forces acting parallel as opposed to perpendicular to the coating). The PosiTest AT series is specifically designed for this purpose. It possesses a self-aligning feature that utilizes a spherical articulating dolly head so that it is always pulled vertically by a ring of small bearings in the actuator.



Why Test Adhesion?

Adhesion testing may be performed for quality control purposes, but is more typically undertaken to adhere to industry standards and customer specifications. Dependent on the application, the specific need for maintaining strong adhesion may vary. Coating applications may range from consumer products to large scale construction projects, but a common factor is that premature adhesion failures can have a significant cost. A well known adhesion failure in the automotive industry involved the failure of paint on a particular model of minivan. A commonly reported problem, the cause was eventually attributed to the spray primer utilized. The primer blistered, causing the paint to peel after continued exposure to heat and direct sunlight. Significant warranty claims and reputation loss could have been avoided during the development phase by combining life cycle and environmental testing with adhesion testing.



In construction and maintenance work, the epoxy coatings used to protect steel require strong bonds to prevent wear and corrosion. Failure of a coating applied during a large project such as a 500,000 ft²

(45,000 m²) bridge could result in permanent financial damage to the contractor due to significant rework and lawsuit costs. A PosiTest AT-M was purchased by the company responsible for maintaining the Golden Gate Bridge in San Francisco. Maintenance of such a bridge is a year round activity with no time available for unnecessary repairs or rework.

In the design phase of coatings, as well as their application processes, adhesion testing is often used to test and verify adhesion capabilities. For example a technical article, [Adhesion of Sealers on Thermal Spray Coatings](#)¹ documents the use of a PosiTest AT-M to quantify the adhesion strength of naturally occurring oxide sealers in thermal spray coatings versus the use of actual penetrating seal coats. Pull-off test results for the penetrating sealer identified a 183% improvement over the oxide seal, clearly quantifying their potential adhesion benefits.

Adhesion Testing is also utilized to demonstrate the capability of coatings, a potential requirement of contract negotiations. As identified in an Amchem Products website application note, [Mounded Bullet Tanks](#)², a PosiTest AT-CM was utilized as part of the verification process for 386/9000. Purethane® is a polyurethane coating intended for coating large steel mounded LPG bullet tanks. By following ASTM Standard D-4541, Amchem was able to demonstrate that their product met all the requirements of relative NACE standards.

Even in established coating application processes, many factors can influence the adhesive strength of a coating. Seemingly minor variations in process parameters may have significant impacts on the resulting adhesion strength between the coating and the substrate. As discussed in [Finish Coatings System Adhesion and Test Methods](#)³, some of the variations that may affect mechanical and chemical bond strengths include the thickness of the applied coating, climatic conditions during painting, cure times and temperatures, substrate and coating moisture contents, inadequate surface preparation methods, surface contamination, substrate densities, coating formulation, preparation and mixing parameters.

Where is the Market?

As discussed throughout this article, markets for adhesion testing range from Research and Development Labs that develop and test coating and application processes, through to the Contractors, Coaters, Finishers and Inspectors involved in applying and testing the actual applied coatings.

Industry Specifications

Military

MIL-A-8625 – Anodic Coatings for Aluminum and Aluminum Alloys

MIL-STD-171 - Standard for Finishing and Treating Surfaces

ASTM

D4541 (2002) Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

ASTM D5179-02 Standard Test Method for Measuring Adhesion of Organic Coatings to Plastic Substrates by Direct Tensile Testing

ASTM E736-00 Standard Test Method for Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members

ASTM C633-01 Standard Test Method for Adhesion or Cohesion Strength of Thermal Spray Coatings

ASTM C1583-04 Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)

International Standards

ISO4624:2002 Paints and Varnishes - Pull-off test for adhesion

References

¹JPCL article "Adhesion of Sealers on Thermal Spray Coatings" by John J. Crowe and Michael J. Makosky, G.P.I. (p. 35, December 2003)

²Website application note "Mounded Bullet Tanks" by Amchem Products Pvt. Ltd.

³Wood Digest's Finishing article "Finish Coatings System Adhesion and Test Methods" by Phil Stevenson, American Wood Finishing Institute (p. 18, December 2003)

[PosiTest Adhesion Tester](#)