



# Adhesion Testing Technical Bulletin

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## MANUFACTURER

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## COATING ADHESION TESTING

The adhesion of a coating to a substrate may be tested according to ASTM D 4541, which covers a method for evaluating the “pull-off” strength of a coating by determining the required perpendicular force (in tension) that a surface area can bear before becoming detached or whether the surface remains intact at a prescribed level of force. Pull-off strength measurements are highly dependent upon many variables including:

- Coating and substrate physical properties
- Geometry of the coating and substrate surfaces
- Testing instrument parameters, type and condition
- Testing method
- Consistency and rate of applied tensile load
- Operator skill
- Physical properties of the adhesive employed

The value of adhesion testing in the coatings market has been an issue for many years. Although new testing equipment available in the coatings inspection industry has reduced some of the error causing variables, engineers and inspectors must take into account the myriad of issues involved in performing and evaluating adhesion test results. The intent of the test is to ensure the compatibility of the substrate and the coating and, to an extent, to evaluate the quality of surface preparation and coating installation. However, there are limitations to adhesion testing. The pull-off strength of a coating does not determine the life expectancy of the interface or overall coating performance, it does provide a tool to evaluate the integrity of the installed system and potential for intended performance. Adhesion test values should be used as a benchmark with an evaluation performed in a manner that weighs the location and type of failure more heavily than the point of tensile failure.

Testing the same coating using different testing apparatus or on different substrates may not be comparable. Therefore, minimum test values should be established based upon coating type, thickness, environmental conditions, testing equipment and the physical properties of the coating and substrate. Acceptable test values should be used as a criteria to determine the need for further examination and not for unequivocal acceptance or rejection. In summary, adhesion testing can be an important tool in evaluating the performance of a coating when used properly. However, the comparison or setting of performance standards using different testing equipment, non-similar coating/substrate combinations or the use of test results to predict coating life expectancy is not recommended.

Refer to ASTM D 4541 or 7234 for a detailed explanation of the methods, procedures and equipment for pull-off strength of coatings using portable adhesion testers. A report should be made including a summary of the test procedure, equipment, and materials. An evaluation of the test results should also be discussed. Test results are subject to interpretation and the reviewing parties should weigh the test results only when taking into account the overall scope and purpose of the coating application and testing methods. In addition, a testing schedule should be determined and agreed upon prior to coating applications. The testing schedule should reflect the fact that any destructive test, such as adhesion testing, violates the integrity of the coating. Such testing should be minimized to the greatest extent possible while still providing reliable data. A preferred method is to perform a number of tests during the initial phase of a project and, if results are acceptable, reduce the frequency of subsequent testing.

### SCORING OF ADHESION TESTS

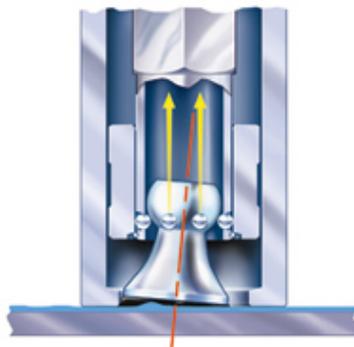
According to ASTM D 4541 “Scoring around the fixture violates the fundamental test criterion that an unaltered coating be tested. If scoring around the test surface is employed, extreme care is required to prevent micro cracking in the coating, since cracks may cause failures at diminished strengths. Scored samples constitute a different test, and this procedure should be reported with the results.” Scoring of thick film coatings ensures that only the coating directly beneath the test dolly is being tested. However, care should be taken during the scoring process to reduce the chances of cracking the coating, applying side loads to the test dolly or fracturing the substrate, all of which affect test results. Use of a sharp and properly sized cutting instrument is critical to minimizing altered results.

### ACCEPTABLE ADHESION TEST RESULTS

Acceptable adhesion test results are dependent upon many variables as discussed previously. When testing coatings on substrates such as concrete or masonry materials, it is generally accepted to expect the adhesion strength of a coating to approach that of the tensile strength of the substrate itself. Ultimately, it is the objective of the coating to achieve a degree of adhesion which would cause the failure point to occur primarily within the substrate. Acceptable results should exhibit such a failure point. Typically, acceptable values for adhesion on concrete will range from 200 to 400 psi, depending upon the concrete strength and project restrictions on the ability to perform adequate surface preparation. Adhesion testing on metal substrates will exhibit different results. Typically, acceptable results range from a few hundred psi, to well over a thousand depending upon the strength of the coating. A qualified individual should examine the materials involved, surface preparation methods employed, test methods and equipment used, test environment and other issues prior to determining acceptable adhesion test results.



**View of pull-off adhesion dolly  
and testing device**



### ADHESION TESTING FOR RAVEN COATINGS

The following sections depict equipment, procedures and documents pertinent to performing adhesion testing on Raven coatings. Other types of coatings or composite systems may require alternative methods, procedures, equipment and materials. In all cases the testing requirements should be determined by the specifying party and documented in detail within the coating specifications.

### SUPPLIES AND EQUIPMENT REQUIRED

- Testing apparatus such as a DeFelsko PosiTest or Elcometer 106
- Two component epoxy adhesive such as Duro 5 Minute High Strength Epoxy available at hardware stores or Araldite epoxy available from testing equipment suppliers (the adhesive should have a tensile strength greater than the expected testing range, generally 1,500 psi or more).
- Small mixing stick or other suitable device for mixing and applying the adhesive
- Medium or fine grit sandpaper (80-120)
- Clean rags and solvent such as acetone or MEK
- Duct tape
- Permanent marker
- Scoring device (if required)

### TESTING PROCEDURE

- Select a test area with a smooth finish and sufficient flat area to accommodate the test dolly and the testing apparatus, typically 3-4 square inches.
- Clean the coating surface of the coating using a method that will not affect the integrity of the coating or leave a residue. A solvent wipe using a clean rag and solvent is sufficient.
- Lightly abrade the coating surface in the test area to the size of the test dolly using medium or fine grit sandpaper.
- Remove loose material and dust from the test area using a clean rag and/or solvent wipe.
- Clean and abrade the contact area of the test dolly using the same method.
- Mark the test area and dolly with the test ID number. Document the location of the test area, the test ID number and any environmental and ambient conditions which may have a bearing on the test.
- Thoroughly mix the adhesive according to the manufacturer's recommendations.
- Apply a minimal amount of adhesive to the test area and the contact surface of the test dolly.
- Position the test dolly onto the test area and remove excess adhesive.
- Secure the position of the dolly using a method which will maintain constant pressure until the adhesive sets. This can typically be accomplished using quality duct tape especially on vertical or overhead surfaces.
- Allow the adhesive to cure according to the manufacturer's recommendations. A minimum of 12 hours at 75 degrees is recommended.
- Following cure of the adhesive, remove the duct tape or other securing device from the dolly. Inspect the dolly and adhesive to ensure that tape did not relax allowing the dolly to separate from the surface.
- Scoring around the dolly should be done only if specified and should be accomplished using a suitable device properly sized and designed for such. Score the coating to the substrate taking care to cut slowly and with minimal pressure. Avoid applying side loads to the dolly. If the dolly is dislodged or otherwise compromised the test should be discarded.
- Zero the testing device gauge and prepare the instrument for testing according to the manufacturer's instructions.
- Attach and align the testing apparatus to the dolly using care not to apply stress to the test dolly. When performing tests on vertical or overhead surfaces be sure to adequately support the weight of the test device.
- Increase the load to the dolly in as smooth and continuous a manner as possible until the dolly is removed or the maximum stress is applied.
- Record the force attained, retain the dolly, and document any departures from the standard procedure such as misalignment, hesitations in force application, etc.
- Document the estimated percent of adhesive and cohesive failure in accordance with their respective areas as outlined in ASTM D4541 section 8.3.1 (see sample test results).
- Document the test method, equipment, supplies, procedures, results and interpretations as required in a report (see attached sample reports).

# Adhesion Testing

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## **SAMPLE COATING ADHESION TEST RESULTS & EVALUATION**

Project: Midwest City Manhole Rehab

Owner: Midwest City

Contractor: ACE Coatings

Testing By: John Doe, Project Foreman, ACE Coatings

Observed By: Jack Doe, Project Engineer, Midwest City

Location: Main Street & 1st Avenue, MH # 100

Description of Structure: Sanitary sewer manhole, brick construction

Test Date: August 31, 2002, 4 PM

Coating Type: Raven 405, 100% Solids, two part epoxy

Substrate Type: Brick with approximately 1/2" of high early strength cement applied to the surface

Date & Time of Coating Application: Coating applied in two coats starting on 8/29/02 at 12 PM and completed at 4 PM the same day.

Testing Apparatus: DeFelsko PosiTest AT-CM hydraulic (Type V as specified in ASTM D4541) adhesion tester utilizing 20 mm testing dollies

Adhesive: Araldite 2011, two part, 100% solids epoxy (cure time of 15 hours @ 77F)

Dolly Application: Two (2) test dollies were applied to at various points in the manhole on 8/30/02 at approximately 8 AM. The dollies were secured in place using duct tape.

Ambient Conditions: Air temp 75 F, Surface temp 65-72 F, RH 90%+

Scoring: One of the dollies was selected to be scored to the substrate prior to testing so as to provide coating thickness samples without increasing the number of destructive tests employed.

## **SAMPLE SUMMARY OF TEST PROCEDURE**

Test areas were selected based upon varying testing locations (i.e. position on wall or bench) and smoothness of coating surface. The surface of the coating was abraded using 80 grit sandpaper and then cleaned using a clean, dry cloth. The contact surface of the test dolly was similarly prepared. The adhesive was then mixed according to the manufacturer's recommendation and applied to the dolly. The dolly was pressed onto the test area and secured in place using a length of duct tape. The adhesive was allowed to cure for a minimum of 15 hours, as recommended by the manufacturer. Each test was marked with a letter designation and description of the location. Each dolly was also marked with a letter designation.

For unscored tests the duct tape was carefully removed from the dolly and the testing unit placed on the dolly. For scored tests the duct tape was carefully removed from the dolly and the scoring device was used to cut through the coating until the substrate was reached. The testing unit was then placed on the dolly and the gauge reading was zeroed. The testing unit was pressurized by pumping the handle until the dolly was removed from the surface. Pressure readings from the gauge were recorded and photographs taken before and after the test. Computation of the relative pressure applied was not necessary since the unit directly correlates applied force units in PSI when using 20 mm dollies.

## SAMPLE ADHESION TEST DATA & EVALUATION

### Test A

Location: North Wall of MH at 4' up from bench

Scored Around Dolly: No

Pull-Off Strength: 675 psi

Failure Mode: Cohesive failure within the epoxy coating

Observed Coating Thickness: NA

Evaluation: The coating exhibited expected strength when subjected to the test and did not separate from the substrate. This test is acceptable according to the specification.

### Test B

Location: West Wall of MH at 1' up from bench

Scored Around Dolly: Yes

Pull-Off Strength: 425 psi

Failure Mode: Substrate failure of 70%, Coating to Substrate failure of 15%, Coating cohesive failure of 15%

Observed Coating Thickness: 200 mils

Evaluation: The coating exhibited good adhesive strength when subjected to the test and also displayed that a majority of the failure occurred within the substrate. This test is acceptable according to the specification.

### Overall Evaluation

Test results and evaluation do not indicate any areas of concern. Due to the fact that the coating did not disbond from the substrate, or displayed an effective bond with appropriate failure mode, these two cases indicate a proper degree of adhesion of the coating to the substrate. Only one sample could be used to verify coating thickness, which met the required thickness.





Adhesion Test Photo Log

Project Name/ID: XYZ Sewer Rehab Project # 12345  
Structure ID: Wet Well #54

Date of Testing: 9/12/05  
Tested By: Bob Smith

