

# BUILDING ENVELOPE TECHNOLOGY SYMPOSIUM

## ADHESION OF AIR AND WATER-RESISTIVE BARRIER MATERIALS: A STICKY SUBJECT

LAVERNE DALGLEISH

AND

SHAUN COLE

*AIR BARRIER ASSOCIATION OF AMERICA*

1600 Boston-Providence Hwy., Walpole, MA 02081

Phone: 866-956-5888 • E-mail: [ldalglish@airbarrier.org](mailto:ldalglish@airbarrier.org)



**RCI, Inc.**<sup>®</sup>

## ABSTRACT

Many air and water-resistive barriers are adhesively installed on substrates. Organizations have required a minimum value when conducting on-site pull testing. Many question the number and wonder where it comes from. There is a lot of discussion on what the loads are for a location and height of a building. Others say that the value has to do with proper installation of the materials. This presentation will cover the origins of the minimum value that is currently being used, how this value relates to installed properties, and what the purpose is of the minimum value. The presentation will also provide the results of a research project that was done to see what actual site values of pull adhesion are based on material, substrate, and other conditions.

## SPEAKER

*LAVERNE DALGLEISH — AIR BARRIER ASSOCIATION OF AMERICA, WALPOLE, MA*



LAVERNE DALGLEISH is the executive director of the Air Barrier Association of America (ABAA). He travels North America to educate building owners and designers on the benefits of effective and working air barrier systems in buildings. He is the secretariat of two ISO committees: ISO TC61 SC10, Cellular Plastics and ISO TC163 SC3, Thermal Insulation Products. He is also chair of the ULC Thermal Performance task force of the Building Environment Standards Committee. Dalglish was the key developer of the ABAA Quality Assurance Program for the installation of air barrier systems in buildings. This program is based on ISO 9000 and ISO 12576-2, but brings the ISO requirements together with practical applications for the air barrier industry.

# ADHESION OF AIR AND WATER-RESISTIVE BARRIER MATERIALS: A STICKY SUBJECT

Adhesive air and water-resistive barriers must stick on the substrate for the life of the building. Further, an air barrier material could be subjected to the full loads (pressure differences) that the building experiences. But is that the right metric? Is that enough? What needs to be taken into consideration for all parameters of enclosure performance?

## HISTORY OF SELF-ADHERED AIR AND WATER-RESISTIVE BARRIER MATERIALS

We have had air barrier materials (materials that restrict or stop the flow of air) from the time we had the first dwelling (Figure 1). Right after keeping the rain off, shelter from wind is the second most important function. For thousands of years, we were happy to simply have a wind break to deflect direct breezes. How good a job you wanted this wind break to do depended upon the climate in which you lived. Generally, the colder the climate, the more you were concerned.

As the years went by, we tried to stop many of the drafts with some success. We chinked the spaces between logs (Figure 2), covered basic structures with mud, and used other such measures to reduce the air flow in and out of our dwellings.

In the 1960s, we started to use more insulation to make our dwellings more comfortable, but we still had the drafts.

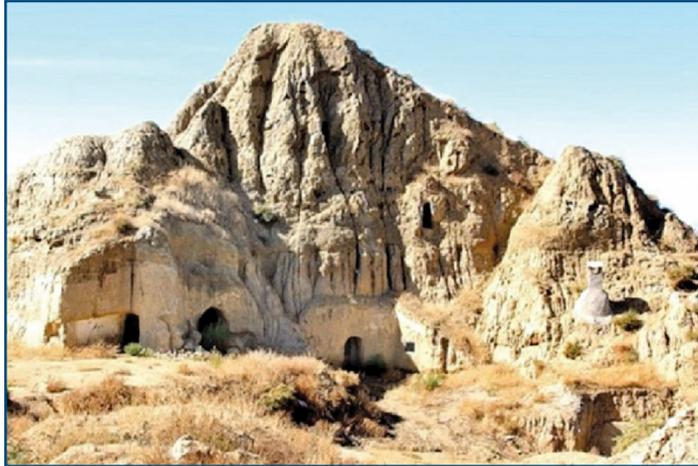


Figure 1 - Cave dwelling.

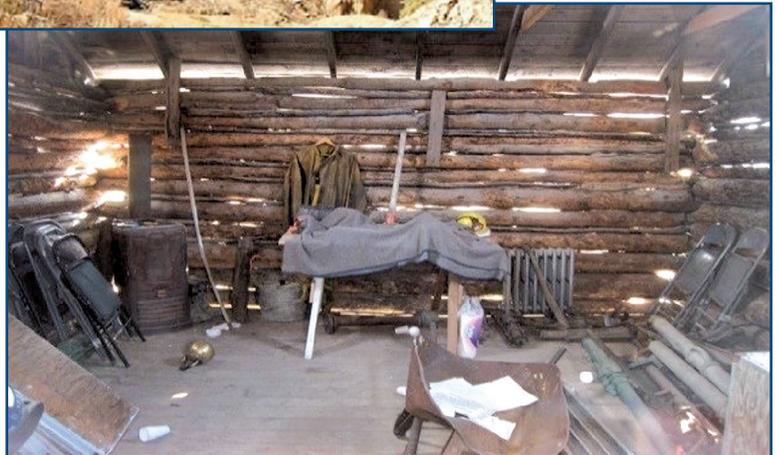


Figure 2 - Chinking the logs.



Figure 3 - Torch-on air barriers.

As we moved into the '70s and '80s, we started to realize that air barriers resolved a lot of moisture problems and really made our dwellings more comfortable. In the '90s, air barriers started to receive full attention in Canada; and starting in 2000, air barriers started to catch on across the United States.

Many of the original air barrier materials were typical construction materials that were already being used—concrete, sheets of gypsum and wood-based materials, metal, glass, etc. However, although air barrier materials were available, more had to be done to turn them into a continuous air barrier system.

One initial effort was to torch-on roofing material to the walls (Figure 3). The question was, if it can be an air and water barrier on the roof, why



**Figure 4 – Material not properly adhered to substrate**

can't it also be an air and water-resistive barrier on the walls? However, you see very little of this material being used in today's construction efforts because you had to melt the asphalt, which took time, but there was also open flame on a construction site, and installers really did not like the job in the summertime. Lastly, the amount

men to melt, productivity increased.

Some of the original material was facetiously dubbed “stick and peel,” as the material sometimes fell to the ground after installation (*Figure 4*). The manufacturers addressed this issue with better installation requirements. However, this also led to the introduction of fluid-applied materials.

of square feet you could install in a day was somewhat limited.

The next material that came on the market was an SRAB (sheet polymer modified-asphalt barrier) where the material would be self-adhering (no open flames). As you did not have to wait for the bitu-

These materials formed a monolithic membrane and increased productivity.

All these different materials only provided you with the function of an air barrier if they remained stuck on the wall for a relatively long period of time. This prompted questions in the industry. What were the loads on these materials? Would the adhesion retain the same value over time? Were the loads the right value to be setting as performance levels?

### AIR BARRIER WALL ASSEMBLY LOADING

The first publicized loading schedule for air barrier wall assemblies was developed by the Canadian Construction Materials Center – Technical Guide for Air Barrier Systems for Exterior Walls of Low-Rise Buildings Masterformat Section 07272, issues 1996-02-09 (*Figure 5*). This technical guide set out loads for sustained, cyclic, and gust loads (see *Table 1* and *Table 2*, respectively).

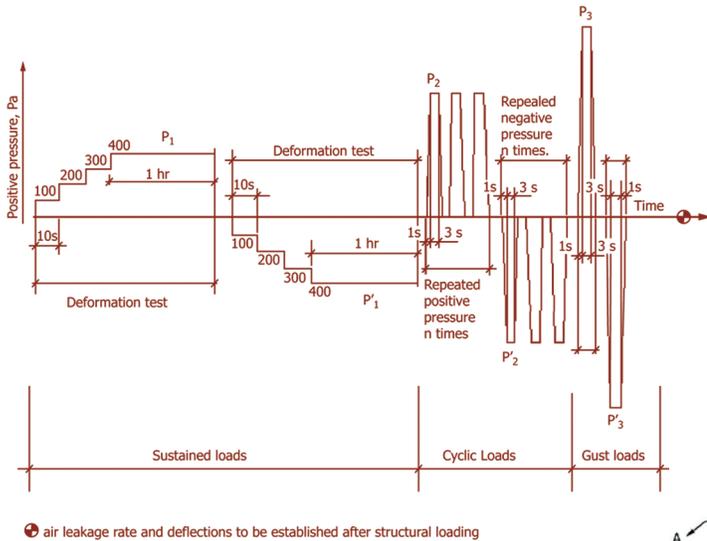
For geographical areas where wind design value is	Specimens as per Appendix A for wood frame, metal, or masonry	P1, P1' sustained for 1 hr. (Pa)	P2, P2' 2000 cycles (1) (Pa)	P3, P3' gust wind (Pa)
Q10 < 0.40 kPa	Specimen 1, 2, 3	400	530	800
Q10 < 0.60 kPa	Specimen 1, 2, 3	600	800	1200

**Table 1 – Sustained loads, cyclic loads, and gust loads.**

Maximum Building Height Above Grade (H), m	Cyclic (P <sub>2</sub> ) <sup>2</sup> , Gust (P <sub>3</sub> ) Pressures, Pa	Sustained 1-in-50 hourly wind pressure (P <sub>1</sub> ), Pa					
		450	550	650	750	850	1000
12	P2	660	800	950	1090	1240	1460
	P3	980	1200	1410	1630	1850	2180
20	P2	720	880	1050	1210	1370	1610
	P3	1080	1320	1570	1810	2050	2410
40	P2	1340	1630	1930	2220	2520	2970
	P3	2000	2440	2880	3320	3770	4430
60	P2	1440	1770	2090	2420	2740	3220
	P3	2160	2640	3120	3610	4090	4810
80	P2	1530	1870	2220	2560	2900	3410
	P3	2290	2800	3310	3820	4330	5090
100	P2	1610	1960	2320	2670	3030	3560
	P3	2400	2930	3460	3990	4530	5320
120	P2	1630	2030	2400	2770	3150	3700
	P3	2480	3040	3590	4140	4700	5520

**Table 2 – Sustained (P1), cyclic (P2), and gust (P3) wind pressures.**

Structural (Wind) Loading Schedule



air leakage rate and deflections to be established after structural loading

Figure 5 – Wind loading schedule.

It is important to note that these loads were applicable for 80% of the buildings across North America of three stories or fewer. In January 2010, the CAN/ULC S742 standard was published and it started to address building heights.

The important information to take away from this discussion is that currently there is no distinction of materials depending on the height of the building or for special locations where the wind loads are even greater than what has been established for buildings that are three stories or fewer.

One architectural firm in Chicago, when shown the loading table from ASTM E2357, stated that the loads were not even close to what the building they were working on would experience.

Work at the standards development level is ongoing to update and clarify much of the information that has been included in various documents. In addition to getting the wall loads updated, we now have ASTM test methods for roofing applications where the wind uplift loads are significantly higher (Figure 6).

The highest pressure difference in a building is typically at the top of the building at the corners, where the loads want to pull/push the air barrier off the building.

**MATERIAL EVALUATION REQUIREMENTS**

The Air Barrier Association of America (ABAA) has set minimum adhesion requirements for any

material that is not mechanically fastened. All materials need to meet a minimum value of 16 psi when tested to a modified ASTM D4541.

This standard has been modified for use with air and water-resistant barrier materials and is currently published as ABAA 0002-2017, *Standard Test Method for Pull-Off Strength of Adhered Air and Water-Resistive Barriers Using an Adhesion Tester* (Figure 7). Although the document is relatively new, it simply is what the industry has been using for years as a modified ASTM D4541.

ABAA’s original intention was for each manufacturer to test and then declare what would be the minimum value to be achieved in the field for their material and possibly for each substrate.

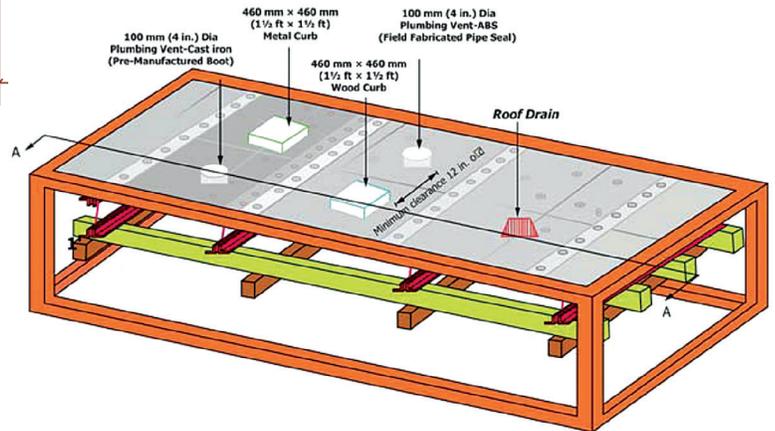


Figure 6 – Low-slope roof air leakage testing apparatus.

**ABAA 0002-2017**

**Standard Test Method for Pull-Off Strength of Adhered Air and Water Resistive Barriers Using an Adhesion Tester**

**1. Scope**

1.1 This test method provides a method for evaluating the pull-off (adhesion) strength (may also be considered tensile stress) of adhered air and water resistive barriers on rigid substrates. The test determines the greatest perpendicular force (in tension) that the surface area of the material can bear. Failure will occur along the weakest plane within the system comprised of the disc, adhesive, air/water resistive barrier material, and substrate.

1.2 This test method determines tensile stress in contrast to other adhesion test methods (such as shear and peel tests) which measures other stress components and results are not comparable between test methods.

1.3 This test method uses a class of apparatus known as pull-off adhesion testers. They can apply a concentric load and counter load to a single surface so that material can be tested even though only one side is accessible. The maximum measured load is limited by the strength of the bond between the disc and the specimen surface, the cohesive strength of the adhesive, the cohesive strength of the air/water barrier composite, the adhesion between the air/water barrier composite and the adhesive (two-bond) and the adhesive bond between adhesive and substrate.

1.4 This test is destructive and when the test is conducted in the field, the area affected will need to be repaired.

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

1.6 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.

Figure 7 – Pull adhesion test method.



**Figure 8 – SPF pulling membrane from brick ledge.**

To date, manufacturers have not published minimum values for field adhesion, and only ABAA has set any requirements for the adhesion of self-adhering membranes.

Over the years, questions have been raised about where this value came from and why it is so high. People have pulled up examples of different wind speeds being lower than 16 psi, and many professionals remain unaware of the history regarding this number.

### WHERE DID THE 16 PSI COME FROM?

The short answer is that it came from the lowest result of several self-adhered members when pull tested in a laboratory. The spray foam industry was suffering from the spray foam pulling the transition membrane away from the wall as the spray foam cooled. The spray foam stuck very well to the membrane, but the membrane was not sticking to the substrate (*Figure 8*).

A spray foam manufacturer, in conjunction with Canada Mortgage and Housing, conducted lab tests to determine how well the self-adhered membrane should be stuck to the substrate. The results are in a published report. Several years later, a second round of laboratory testing was conducted that expanded the number of tests conducted and variations in the test protocol. That report is also available.

The spray foam manufacturer found that 16 psi was the minimum value found when conducting the pull tests (*Figure 9*). When spray foam was installed over the transition material in an air barrier system, the spray foam was not able to pull the

material away from the substrate. That spray foam supplier then set a site-installed value of 16 psi for all transition membranes when they were installed as part of their air barrier system.

As 16 psi was the installed minimum value of all membranes when tested in the laboratory, ABAA used that value as a minimum performance requirement for all air and water-resistive materials for pull adhesion.

### PURPOSE OF CONDUCTING ADHESION TESTING ON-SITE

We know that there will be loads on the air barrier system, and we know that the adhesion value of the material needs to be greater than the loads imposed, so shouldn't site testing values be easy to determine? Unfortunately, it is not that simple.

First, we know that the loads in ASTM E2357 only covered most, but not all, of the buildings that are three stories or fewer. A significant number of the buildings being constructed across North America are three stories or fewer, so the existing loading requirements do have some value. Further confusion is created by what the pull adhesion values mean, as many professionals try to evaluate whether the material will stay intact for the life of the building based on obtained site values, but this information is better served to address proper installation.

We know that the pull adhesion values

**Figure 9 – Conducting pull tests in the lab.**



on a project could swing wildly based on the care that the installer took when applying the air and water-resistive barrier material.

Was the substrate prepared properly? Was there oil, grease, dust, or other contaminants on the substrate? Did the material encounter contaminants after the release paper was removed? (See *Figure 10*.) Was the substrate primed? Was the substrate primed properly? Was the material rolled after installation? Were there areas where the material was not properly supported? What were the weather conditions? Was the weather too hot or too cold? Was it raining or misting? Was there condensation on the surface?

For all these reasons, you could have pull adhesion values that are greater than the expected loads in a certain location, but those values could be significantly less than what would be achieved with proper installation.

At a minimum, it is recommended that the manufacturer conduct pull adhesion of their material on glass fiber-reinforced gypsum-based boards, OSB, plywood and CMU. This information will provide proof that properly installed air and water-resistive barrier material will have a greater



**Figure 10 – Air barrier material installed with release paper attached.**

adhesion value than the loads expected, which may begin to address the currently unknown aspects of what happens to the adhesion over time. The industry knows that material subjected to a low-pressure difference over time may result in the material peeling off, whereas material subjected to a high-pressure difference over a really short time will stay attached.

The key point that site pull testing addresses is whether the material has been installed properly. We are not talking about a material defect, but rather an installation defect.

There has been discussion on whether the field adhesion values should be or could be equal to the laboratory values. Currently, there is no industry consensus on that, but the reasons brought up for the values not being the same deal with site issues; all the elements listed

above that could reduce the pull adhesion value.

To determine what should be done and to make the values more meaningful, the ABAA Research Committee undertook a project to compile the results of field pull adhesion testing 3656 audit reports and daily work records. The work was to determine overall average values for pull adhesion tests conducted on site (Table 3), then to see if there were differences due to

material category/type or substrate. A list of questions was developed, and the data gathered in the project provided a response to the questions. The list of questions is attached in Appendix A.

## WHERE SHOULD WE GO FROM HERE?

The research project has shown that we do have baseline information on field pull adhesion testing. Site pull adhesion tests are important to confirm proper installation of the air and water barrier materials.

Other recommended activities to improve knowledge regarding adhesion values are to address buildings that are greater than three stories, advance work regarding the differences between material types, and determine whether the same material should have different values for each substrate. These issues have been discussed for years, but we have not determined a final position on this.

Over the years, new technologies have come on the market and will continue to be developed and distributed. The air barrier industry has come a long way over the last 18 years, and we will need to modify our existing evaluation criteria to take the new technology into consideration. 

Results of site pull adhesion tests					
Type	Average psi	Median psi	Maximum psi	Minimum psi <sup>1</sup>	n
All	23.32	20.10	80.00	0.081	3,656
Self adhered	21.08	18.40	80.00	0.08	3,656
Fluid applied	24.90	20.37	80.00	0.40	3,656
SPF	23.59	21.00	80.00	0.70	3,656
<b>Substrate</b>					
Gypsum based	21.53	18.40	80.00	0.40	3,656
OSB	30.40	31.83	56.60	7.00	3,656
CMU	23.77	20.40	80.00	0.60	3,656
Concrete	30.77	28.65	80.00	1.14	3,656
Metal	20.40	20.40	20.40	20.40	3,656
Plywood	26.97	23.87	78.00	1.00	3,656
Steel	30.25	30.25	30.25	30.25	3,656

<sup>1</sup> Low value on pull adhesion is typically associated with failure of the disk bonding to the material.

**Table 3 – Field Results for Adhesion Testing. A summary of the results showed that there was valuable information in the data.**

# Pull Adhesion Data-Gathering Project

## Analysis of the data

Based on **all reports** (audit and daily), what are the minimum, maximum, average, and mean values?

Based on **audit reports**, what are the minimum, maximum, average, and mean values?

Based on **daily reports**, what are the minimum, maximum, average, and mean values?

Based on **all reports** (audit and daily), what is the standard deviation value?

By **manufacturer**, based on all reports, what are the minimum, maximum, average, and mean values?

By **manufacturer**, based on audit reports, what are the minimum, maximum, average, and mean values?

By **manufacturer**, based on daily reports, what are the minimum, maximum, average, and mean values?

By **material type**, based on all reports, what are the minimum, maximum, average, and mean values?

By **material type**, based on audit reports, what are the minimum, maximum, average, and mean values?

By **material type**, based on daily reports, what are the minimum, maximum, average, and mean values?

By **actual material**, based on all reports, what are the minimum, maximum, average, and mean values?

By **actual material**, based on audit reports, what are the minimum, maximum, average, and mean values?

By **actual material**, based on daily reports, what are the minimum, maximum, average, and mean values?

By **substrate**, based on all reports, what are the minimum, maximum, average, and mean values?

By **substrate**, based on audit reports, what are the minimum, maximum, average, and mean values?

By **substrate**, based on daily reports, what are the minimum, maximum, average, and mean values?

By **substrate and by material type**, based on all reports, what are the minimum, maximum, average, and mean values?

By **substrate and by material type**, based on audit reports, what are the minimum, maximum, average, and mean values?

By **substrate and by material type**, based on daily reports, what are the minimum, maximum, average, and mean values?

By **substrate and by actual material**, based on all reports, what are the minimum, maximum, average, and mean values?

By **substrate and by actual material**, based on audit reports, what are the minimum, maximum, average, and mean values?

By **substrate and by actual material**, based on daily reports, what are the minimum, maximum, average, and mean values?

Based on **all reports** (audit and daily), what are the number and percentage of failure of the substrate?

Based on **audit reports**, what are the number and percentage of failure of the substrate?

Based on **daily reports**, what are the number and percentage of failure of the substrate?

Based on **all reports** (audit and daily), what are the number and percentage of failure between disk and substrate?

Based on **audit reports**, what are the number and percentage of failure between disk and substrate?

Based on **daily reports**, what are the number and percentage of failure between disk and substrate?

By **state**, based on all reports, what are the minimum, maximum, average, and median values?

By **state**, based on audit reports, what are the minimum, maximum, average, and median values?

By **state**, based on daily reports, what are the minimum, maximum, average, and median values?