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30 Year Outdoor Weathering Study of Construction Sealants

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Momentive Performance Materials

Long-term weather resistance is an important factor to consider when selecting a sealant product for use as an exterior weatherseal for construction applications. In 1983, a variety of sealant types were applied to glass and painted aluminum panels to evaluate long-term durability. These sealants have been monitored over the past three decades for various performance criteria such as appearance, flexibility, hardness and adhesion.
The test site was located in Miami, Florida, at exposure fields operated by the Atlas Weathering Service group – South Florida Test Service (SFTS). A rural area with a climate that provides high levels of ultraviolet radiation, humidity and temperature in a subtropical environment summarized in the table below.

Latitude	25°52’ North
Longitude	80°27’ West
Elevation	3 meters (10 feet)
Avg. Temperature	23°C (73°F)
Avg. Relative Humidity	78%
Total Annual Rain Fall	1685mm (66in.)
Total Radiant Energy: [a] (295-3000 nm)	See web link below 6588MJ/m²
Total UV: [a] (295-385 nm)	280 MJ/m

[a] Measured at latitude tile angle (26° South). From http://atlas-mts.com/services/natural-weathering-testing-services/natural-weathering-testing-sites/north-america/

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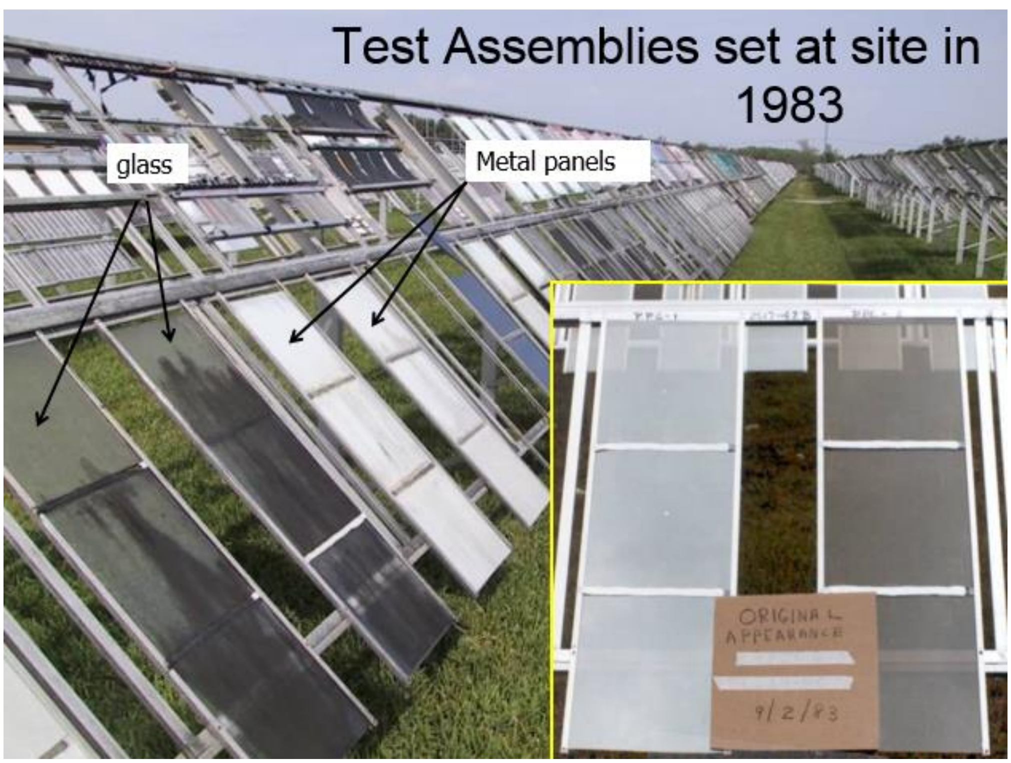
30 year summary of annual weathering data

	Total Solar Radiation Direct @ 45° (MJ/m²)	UV Solar Radiation Direct @45° (MJ/m²)	Average Ambient Temperature °C (°F)	Average Black Metal Panel Temperature °C (°F)	Average Relative Humidity	*Total Time of Wetness @45° (h)	Total Rainfall cm (in.)
Averages	6,274.6	298.2	23.8 (74.8)	28.2 (83.3)	78.9	4,138.3	139 (55)
Totals	194,513	8,648				78,628	4305 (1694)

*Test site stopped recording Total Time of Wetness in the beginning of 2003 (~20 years)

Test Panel Assembly

The test assembly consisted of a series of 12 by 12 inch pieces of glass and painted aluminum set in aluminum channels fastened to create a supporting frame. Each test assembly consisted of three glass or painted aluminum panels with two horizontal in-plane joints. Plastic shims at the left and right edges of the panels were used to create ½ inch wide joints in each assembly. Both joints of each test assembly were filled with the same sealant. No primers were used in this study. The test assemblies were mounted to the outdoor exposure racks at the test site.



Descriptions of Sealants

All the sealants in this study were commercially available products sold in 1983 and marketed for use in construction applications. The table below provides a brief description of the products in this study.

ID#	POLYMER TYPE, DESCRIPTORS	MANUF	FILLER TYPE	COLOR
1	Silicone, 1PT, ±25%, Ac	A	100% Fumed Silica	White
2	Silicone, 1PT, ±50%, Al	A	Calcium Carbonate/Fumed Silica	Grey
3	Silicone, 1PT, ±25%, Ac	B	100% Fumed Silica	Black
4	Polyurethane, 2PT, ±50%	C	Fumed Silica	Black
5	Acrylic Terpolymer, 1PT, X%	C	Calcium Carbonate	Black
6	Polyurethane, 1PT, ±25%	D	Calcium Carbonate/Fumed Silica	Limestone

Note: In this study, the following abbreviated sealant descriptors are used:
1PT = single component product
2PT = multi-component product
±25%, ±50% = manufacturer's published movement capability ,X% = unknown/not provided
Ac = acetoxy chemistry; sealant releases acetic acid during cure phase
Al = alcohol chemistry; neutral cure sealant which releases alcohol during cure phase

Evaluation Methods

Overall Durability Ranking (ODR)

To determine ODR, only performance characteristics deemed to have influence on weathering durability are used (i.e., visual appearance or superficial surface conditions are not included). The following five properties are thought to be fundamental requirements necessary for a product to be capable of withstanding long-term outdoor weathering for use in building construction applications. To evaluate ODR each performance property was ranked:

1. **Adhesion** (ability to maintain long-term adhesive bonding)
   → Adhesive Failure = 1, Partial Adhesion = 2, Cohesive failure = 3
2. **Flexibility maintained** → Excellent = 3, Good = 2, Poor = 1
3. **Resilience (elastic recovery)** → Excellent = 3, Good = 2, Poor = 1
4. **Toughness** → Excellent = 3, Good = 2, Poor = 1
5. **Resistance to hardness change →** 0-33 = 3, 34-66 = 2, 67-100 = 1

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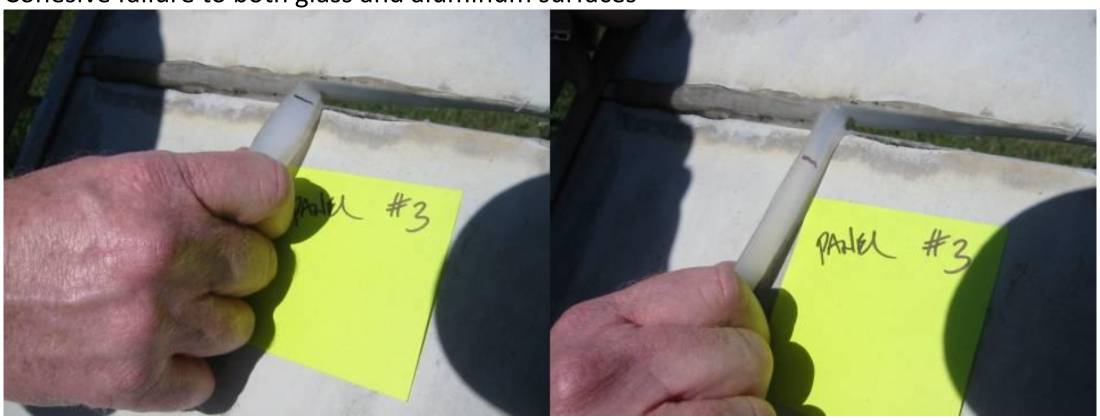
1. Adhesion

Sections of each sealant were physically cut out from each glass and aluminum panel test assembly and at that time the adhesion was qualitatively evaluated by hand pull and visual inspection of the joint bond line for mode of failure (cohesive or adhesive).

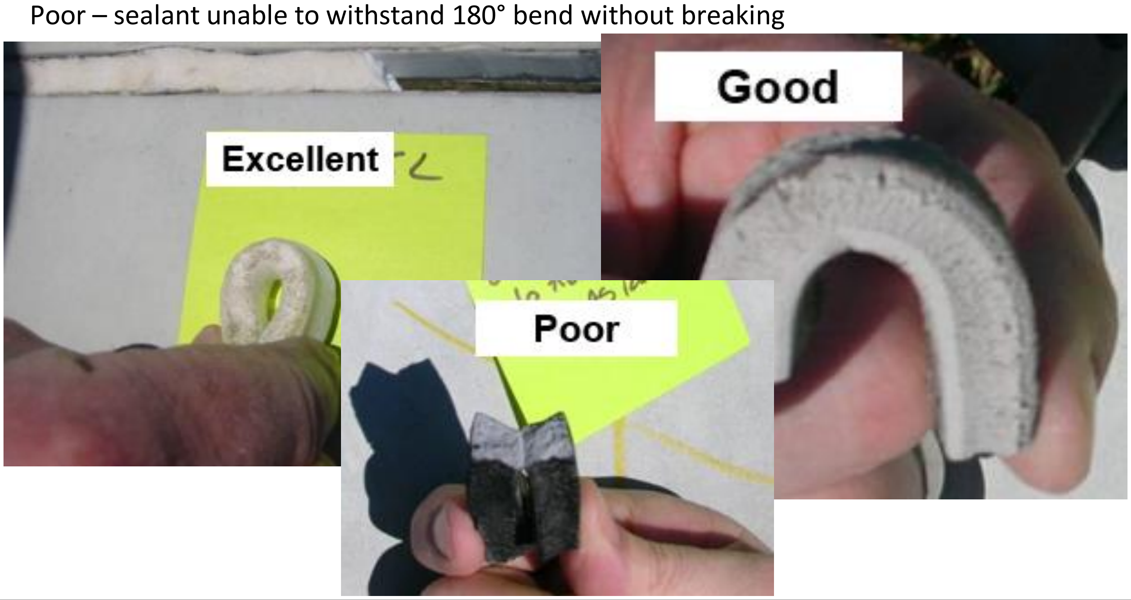
Adhesive Failure to both glass and aluminum surfaces
Partial Adhesion to glass or aluminum surfaces
Cohesive failure to both glass and aluminum surfaces



2. Flexibility –

Flexibility was scored as the capable of being easily bent, without breaking or cracking. Sections of each sealant were cut and manually bent 180°, the results are defined below:

Excellent – sealant able to withstand 180° bend without breaking or cracking
Good - sealant able to withstand 180° bend but with some cracking
Poor – sealant unable to withstand 180° bend without breaking



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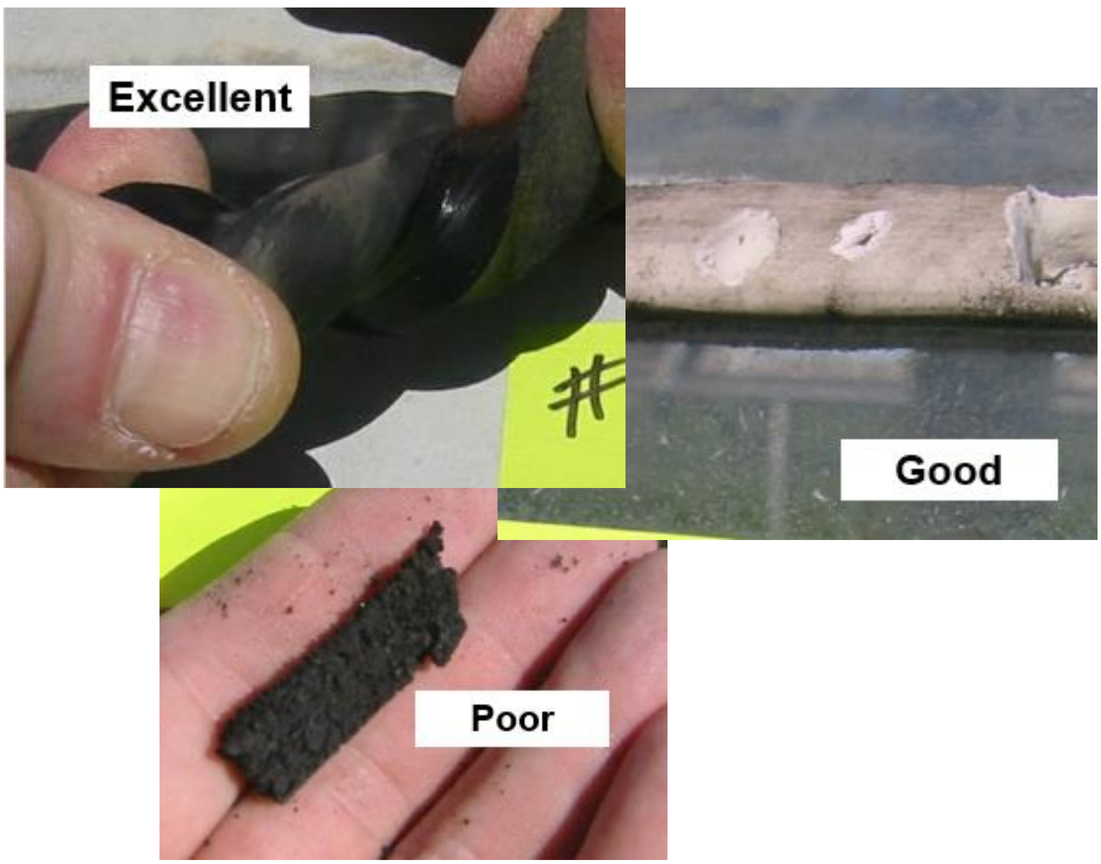
3. Resilience

After each sealant was manually bent 180°, it was then released. Elastic recovery is defined as the % recovery to the original shape within 5 minutes of release. Sealants that broke after being bent 180° could not be assessed for resilience.

Excellent - returned to original shape within 5 minutes
Good - returned, but >5 minutes
Poor - sealant broke

4. Toughness

This study defines a tough sealant as being not easily gouged or defaced



5. Hardness change (Type A indenter)
Sections of each sealant were cut out from each test assembly and measure for hardness. A minimum of three readings were averaged to determine the hardness of the sealants.

Visual Observations – surface appearance and condition

The aged sealants were visually examined for general appearance and surface degradation. The observations recorded included surface condition, dirt pickup and discoloration. A summary of these observations are in the table below. These observations were not deemed vital to the ODR.

ID#	SEALANT TYPE	OVERALL SURFACE CONDITION	DIRT PICKUP	SURFACE IRREGULARITY	DISCOLORATION OR COLOR CHANGE
1	Silicone, 1PT, ±25%, Ac	Excellent	Significant	None	None
2	Silicone, 1PT, ±50%, Al	Excellent	Significant	None	None
3	Silicone, 1PT, ±25%, Ac	Excellent	Significant	None	None
4	Polyurethane, 2PT, ±50%	Poor[b]	N/A[d]	Significant[e]	N/A[b]
5	Acrylic Terpolymer, 1PT, XX	Poor	Light	Significant[g]	N/A
6	Polyurethane, 1PT, ±25%	Poor	Light	Significant[e]	None

[b]Sample exhibited reversion (gummy)
[d]Assessment not practical based on poor overall condition of remaining sample
[e]Surface cracking
[g]Surface irregularity (charcoal or pumice appearance)

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Summary of Observations

1. In all cases, silicone sealants ranked higher than polyurethane and acrylic terpolymer sealants in durability to weathering at this test site location
2. In general, 100% fumed silica filled silicone ranked higher than calcium carbonate/fumed silica filled silicone
3. In general, the silicone sealants performed best of all sealant types in elastic recovery with instantaneous or near-instantaneous 100% rebound
4. The 100% fumed silica filled products performed best in toughness. One polyurethane and acrylic terpolymer products rated high in toughness, though this was due to their high degree of hardness increate that occurred during this 30 year study.
5. With one exception, the silicone showed the least % change in hardness
6. All sealant products below demonstrated the ability to maintain an adhesive bond to the painted aluminum substrate used in this study.
7. The silicone products exhibited the most dirt pickup, one polyurethane and the acrylic sealant evidenced very little dirt pickup.
8. The general overall surface condition of the silicone projects was better than the non-silicone products.

ID#	SEALANT TYPE	FLEXIBILITY	RESILIENCE	TOUGHNESS	CHANGE IN HARDNESS	ADHESIVE BOND DURABILITY	RATING TOTALS
1	Silicone, 1PT, ±25%, Ac	3	3	3	3	3	Σ = 15
3	Silicone, 1PT, ±25%, Ac	3	3	3	3	3	Σ = 15
2	Silicone, 1PT, ±50%, Al	3	3	2	1	3	Σ = 12
5	Acrylic Terpolymer, 1PT, XX	1	1	3	1	3	Σ = 9
6	Polyurethane, 1PT, ±25%	1	1	3	1	3	Σ = 9
4	Polyurethane, 2PT, ±50%	1	1	1	1	3	Σ = 7