Technical Report

From: Dennis Booth

Subject: Testing Royal HelioBond® PVA 600BT and PVA 900HM

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Executive Summary

Royal HelioBond® PVA 600BT and PVA 900HM photovoltaic adhesives were tested to a PV backsheet as outlined below. The adhesives performed well and as expected with the bond strengths increasing with dwell time and exposure to high temperatures. There was no indication of incompatibility or other heat aged issues with the adhesive/composite backsheet system. Since the PVA 600BT and PVA 900HM have been tested to every roofing membrane in North America backsheets are tested to themselves since it is known the PVA 600BT and PVA 900HM adhere to all EPDM and TPO roofing membranes and is compatible with all common roofing substrates but PVC. In addition the PVA 900HM is approved for adhering PV modules to asphalt shingles in a steep slope configuration.

Testing Specifics

Sample were set up using the PVA 600BT to bond the rigid composite backsheet to itself. The testing included both cleavage peel and lap shear testing of the PV backsheet. The aging conditions are as noted below. These conditions are chosen to demonstrate the adhesive strength in both the uncured state as well as after cure which is completed by one week at 85°C. This is designed to simulate the heat exposure that the roof and PV may experience during normal operation. The table below shows the test results. All cleavage peel and shear values are the average of 5 individual tests.

Test Results

PVA 600BT

	Cleavage Peel[4]			Lap Shear[5]		
	24 Hrs RT[1]	7 Days RT[2]	7 Days 85°C[3]	24 Hrs RT[1]	7 Days RT[2]	7 Days 85°C[3]
Avg	9.0	10.2	26.3	4.0	4.3	31.0
St Dev	1.0	1.7	2.6	0.4	0.3	3.3

1) *Aged 24 hours at room temperature, samples pulled at room temperature*
2) *Aged 7 Days at room temperature, samples pulled at room temperature*
3) *Aged 7 Days at 85°C, samples pulled at room temperature*
4) *Cleavage Peel testing (ASTM D3807) pulled at 0.2"/minute, all values in pounds per lineal inch (PLI)*
5) *Lap Shear testing (Royal T-307, ASTM D1002) pulled at 0.2"/minute, all values in pounds per square inch (PSI)*
6) *Value reported is the average of 5 sample replicates*

HelioBond® PVA 600BT has been used successfully for installing PVs on a variety of membrane roof systems. The PVA 600BT has been tested many different ways to prove its durability and is in fact a direct offshoot of Royal adhesives that have been used for over 25 years to attach membrane roofs. The PVA 600BT is a crosslinking adhesive that builds strength as it is exposed to the normal heat developed during PV operation as can be seen by the peel and shear strength increase after exposure to 85°C for 7 days. It is designed for the

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highest bond strength in the most demanding situations imaginable. The PVA 600BT is UL listed for direct attachment of PVs to low slope membrane as well as galvanized and painted metal.

PVA 900HM

	Cleavage Peel[4]			Lap Shear[5]		
	24 Hrs RT[1]	7 Days RT[2]	7 Days 85°C[3]	24 Hrs RT[1]	7 Days RT[2]	7 Days 85°C[3]
Avg	7.8	9.1	15.5	4.2	4.9	5.4
St Dev	1.2	1.0	1.8	0.4	0.4	0.1

1) *Aged 24 hours at room temperature, samples pulled at room temperature*
2) *Aged 7 Days at room temperature, samples pulled at room temperature*
3) *Aged 7 Days at 85°C, samples pulled at room temperature*
4) *Cleavage Peel testing (ASTM D3807) pulled at 0.2"/minute, all values in pounds per lineal inch (PLI)*
5) *Lap Shear testing (Royal T-307, ASTM D1002) pulled at 0.2"/minute, all values in pounds per square inch (PSI)*
6) *Value reported is the average of 5 sample replicates*

The PVA 900HM is a thermoplastic adhesive that is particularly well suited to steep slope asphalt shingle applications. It has superior creep resistance and its removability is particularly useful in leased residential systems.

Discussion of Results

Factory Mutual has established a variety of wind categories to define the uplift requirements for different locations and local circumstances. Most of the country is now in the 1-90 category. The 1-90 category requires a minimum uplift resistance of 90 pounds per square foot (0.63 pounds per square inch) which is a built-in 2X safety factor. The lowest peak or initiation value tested, 24 hours at room temperature, is 7.8 PLI. Depending on the module design and the amount of adhesive bonding area this will result in many times the strength required.

The adhesive strength values are typical of other tests performed on other substrate/superstrate combinations and are capable of holding a PV in place under any foreseeable environmental conditions.