3M

Industrial Adhesives and Tapes Division

ISO9001:2000 FM541346

Company: Mitsubishi Plastics Composites America, Inc.
401 Volvo Parkway, Chesapeake, VA 23320

Contacts: ***Mitsubishi Plastics Composites America, Inc:***
Bill Yanetti, 757-382-5768

3M Specified Construction Specialists:
Blake Brown, SE and South Central US, bmbrown@mmm.com, 678-596-1831
Erik Katchur, NE & Midwest US, capiplick@mmm.com, 330-554-9491
Carl Piplick, Western US, ekatchur@mmm.com, 650-520-5698

Project(s): Adhesion Testing of 3M™ VHB™ Architectural Panel Tape G16F to Alpolic® Composite Material Panels

3M TSR #: USA-IATD-6814-2

Date: January 3, 2012

I. Application Description:

Mitsubishi Plastics Composites America is a manufacturer of Alpolic® metal composite material panels for architectural applications. 3M™ VHB™ Tapes have been used for years in the bonding of Alpolic® composite panels for exterior and interior architectural applications. This includes stiffener bonding, panel to frame bonding, and trim bonding applications with 3M™ VHB™ Tapes.

II. Test Objective(s):

The purpose of this test study was to evaluate the adhesion of 3M™ VHB™ Architectural Panel Tape G16F (3M™ VHB™ Tape G16F) to several Alpolic® panels with common finishes and metal surfaces. 90° peel adhesion tests were performed with 3M™ VHB™ Tape G16F applied to these substrates. The 90° peel adhesion test is the most sensitive test for determining how well the adhesive tape will bond to the substrate finish. The 3M™ VHB™ Tape G16F evaluated in this study is 0.062" (1.6 mm) thick.

III. Test Procedures:

Adhesion was measured using a 90° peel adhesion test based on test method ASTM D3330. 1.0" (25 mm) wide strips of tape were used for this test. The strips of tape were applied to the customer supplied substrates after the application surfaces were prepared utilizing the surface preparation methods listed in Section IV. Three strips of tape were used for each different surface preparation method. The tape was then backed with a 5 mil (0.13 mm) thick anodized aluminum foil strip and allowed to dwell for 3 days at 70°F/50% RH (21°C/50% RH) conditions to allow bond strength to develop. The 90° peel adhesion tests were completed at these same environmental conditions. Laboratory retained production samples of the 3M™ VHB™ Tape G16F were used for this study and average peel test data is reported in pounds per inch width (lbs/in) and Newtons per centimeter width (N/cm) of adhesive tape.

IV. Surface Preparation:

The following different surface preparation methods were evaluated in this study. Proper surface preparation is critical for achieving high bond strength. Kimberly-Clark WypAll X60 towels were utilized for all surface preparation techniques involving a wiping/cleaning procedure.

a. **IPA/Water ONLY** - Clean bonding surface area with a 50:50 mixture of isopropyl alcohol (IPA) and water.

b. 3M Adhesion Promoter 111 (AP 111) - Clean bonding area with 50:50 IPA/water solution first and then prime surface with AP 111 solution. This primer was applied by wiping the bonding surface with a clean wetted towel. Tape was applied at least one minute after cleaning/priming.

c. 3M Primer 94 - Clean bonding area with 50:50 IPA/water solution first and then prime surface with 3M Primer 94 solution. This solution is applied wet with a Designetics dauber bottle and then allowed to dry without further wiping.

d. Abrasion – Lightly abrade bonding area with a 3M Scotchbrite™ 7447 pad mounted to random orbit sander and then wipe surface clean with 50:50 IPA/water solution.

e. Abrasion + AP 111 – Lightly abrade bonding area with 3M Scotchbrite™ 7447 pad mounted to random orbit sander and then wipe clean with 50:50 IPA/water solution. Follow cleaning step with an application of 3M AP 111 as described in Section IV.b.

f. Abrasion + 3M Primer 94 – Lightly abrade bonding area with 3M Scotchbrite™ 7447 pad mounted to random orbit sander and then wipe clean with 50:50 IPA/water solution. Follow cleaning step with an application of 3M Primer 94 as described in Section IV.c.

V. Summary of Results:

A 90-degree average peel force result of >25 lbs/in (>44N/cm) is generally desired for most construction applications as well as a cohesive failure mode (foam split, partial foam split, or mostly foam split). Cohesive failure demonstrates the adhesive bond line strength is greater than the internal strength of the acrylic foam core. This is the most desirable failure mode demonstrating maximum achievable adhesive bond strength.

As mentioned above, a number of different surface preparation methods were evaluated in this study. The attached table provides average test results for each substrate and a specific surface preparation method. Results are provided only for those tape (3M™ VHB™ Tape G16F) and surface preparation combinations which meet 3M's adhesion requirements for construction applications (>25 lbs/in (>44N/cm) cohesive failure mode type).

Substrate	Appropriate Surface Preparation Method	Avg Peel	
		lbs/in	N/cm
Alpolic® SWT (Polyester)	IPA/Water only	37.2	65.1
	IPA/Water + AP111	38.1	66.7
	IPA/Water + Primer 94	35.8	62.7
	Abrasion + IPA/Water	39.9	69.8
	Abrasion + AP 111	38.8	67.9
	Abrasion + Primer 94	37.0	64.7
Alpolic® HPP Polyester TRD - Red	IPA/Water + Primer 94	35.7	62.4
	Abrasion + IPA/Water	38.4	67.2
	Abrasion + AP 111	41.0	71.7
	Abrasion + Primer 94	36.4	63.7
Alpolic® SMX (FEVE)	Abrasion + IPA/Water	38.8	67.9
	Abrasion + AP 111	37.2	65.1
	Abrasion + Primer 94	37.4	65.5

V. Summary of Results (Continued):

Substrate	Appropriate Surface Preparation Method	Avg Peel	
		lbs/in	N/cm
Alpolic® CUX (Polyester)	IPA/Water + Primer 94	**36.7**	**64.3**
	Abrasion + IPA/Water	**39.4**	**68.9**
	Abrasion + AP 111	**38.8**	**67.9**
	Abrasion + Primer 94	**39.0**	**68.4**
Alpolic® CUX (Kynar)	Abrasion + Primer 94	**38.7**	**67.7**
Alpolic® ZCM (Umicore Quartz Zinc)	IPA/Water only	**38.0**	**66.6**
	IPA/Water + AP111	**36.9**	**64.7**
	IPA/Water + Primer 94	**37.2**	**65.2**
	Abrasion + IPA/Water	**38.2**	**67.0**
	Abrasion + AP 111	**39.4**	**69.1**
	Abrasion + Primer 94	**38.3**	**67.1**
Alpolic® CCM (Natural Copper Skin)	IPA/Water + Primer 94	**37.5**	**65.6**
Alpolic® CCM FR Sample #1	IPA/Water + AP111	**42.8**	**74.9**
	IPA/Water + Primer 94	**39.8**	**69.7**
Alpolic® CCM FR Sample #2	IPA/Water + AP111	**44.6**	**78.1**
Alpolic® CCM with "Stuart Dean" Coating	IPA/Water only	**36.9**	**64.6**
	IPA/Water + AP111	**35.8**	**62.7**
	IPA/Water + Primer 94	**36.0**	**63.0**
Alpolic® TCM (Natural Titanium Skin)	Abrasion + IPA/Water	**39.1**	**68.5**
	Abrasion + AP 111	**38.4**	**67.3**
	Abrasion + Primer 94	**37.9**	**66.4**
Alpolic® 220M Stainless (NSS220M Stainless Steel)	IPA/Water + AP111	**37.7**	**66.0**
	IPA/Water + Primer 94	**35.0**	**61.4**
	Abrasion + IPA/Water	**37.8**	**66.2**
	Abrasion + AP 111	**40.0**	**70.0**
	Abrasion + Primer 94	**37.8**	**66.3**

VI. Conclusion:

3M™ VHB™ Tape G16F formed high bond strength to all the Alpolic® composite panel substrates evaluated in this adhesion study. The different Alpolic® composite panel types and finishes required specific surface preparation methods to achieve high bond strength. Please refer to the data table in Section V for the appropriate surface preparation method(s) for the specific Alpolic® composite panel type. To validate acceptable adhesion performance, an independent adhesion test should be conducted on all panel finishes for each project.

Please note: the adhesion results in this test report are only relevant for the specific Alpolic® composite panel finishes/types tested in this study. Alternative Alpolic® composite panel finishes/types should be tested for adhesion by 3M prior to the commencement of a bonding project.

It is must also be noted that the bonding of 3M™ VHB™ Tape G16F to the Alpolic® CCM (Natural Copper Skin) and CCM FR composite panels should only be considered for interior panel bonding applications due to the corrosive nature of copper in exterior environments. A protective coating should be applied to the bond area of the Alpolic® CCM and CCM FR composite panels if they are to be used for exterior panel or stiffener bonding with 3M™ VHB™ Tape G16F. A "Stuart Dean" copper protective coating was evaluated in this adhesion study on the Alpolic® CCM composite panel. High bond strength of the 3M™ VHB™ Tape G16F was observed to this copper coating. However, 3M makes no statements regarding the durability of this protective coating and suggests the user contact the coating manufacturer for further details about the performance and durability of this coating. The adhesion of the 3M™ VHB™ Tape G16F to alternative protective coatings should be tested by 3M prior to commencement of the project.

VII. Additional Considerations – Design & Fabrication:

1. Work Area & Substrate Temperatures: While surface preparation is critical to achieving good bonding performance of 3M™ VHB™ Tapes, it is equally important to apply the adhesive tape in a work area with a temperature >60°F (15°C). In addition, the bonding substrates must be at the same temperatures (thermal equilibrium). The use of an adhesion promoter will likely lower the minimum application temperature to approximately 50°F (10°C) if this is a requirement for an application. This should be verified by the customer prior to fabricating parts at temperatures <60°F (15°C). Once fabricated and full bond strength is achieved, the bonded parts are capable of withstanding cold exterior temperatures.
2. Application Pressures: It is also important to provide adequate pressure to the tape after it has been applied to the first prepared substrate surface and then after the two parts are joined together. The application of pressure facilitates good contact and adhesion of the adhesive tape to both substrate surfaces. Hand pressure alone should not be considered adequate pressure for the final application of pressure to the assembled parts. The use of pressure application equipment (J-roller, clamps, etc…) is strongly encouraged for the final pressure application step.
3. Static Loads: 3M™ VHB™ Tapes have a static load design guideline strength of 0.25 psi (1.7 kPa). This means that there should be 4 in^2 of 3M™ VHB™ Tape for every 1 lb of weight (60 cm^2 of tape per 1 kg) it will support on a constant basis. If a panel bonding application will involve a constant static load acting on the 3M™ VHB™ Tape, the customer should verify that an appropriate amount of adhesive tape is utilized to satisfy this design guideline.
4. Dynamic Loads: 3M™ VHB™ Tape has a dynamic load design guideline strength of 12 psi (85 kPa). Dynamic loads are short term forces applied to the 3M™ VHB™ Tape such as a high wind gust. The customer should verify that their design will satisfy 3M's design guideline should the architectural panel substrates be subject to dynamic loads such as wind loads in exterior applications when the 3M™ VHB™ Tape is utilized for panel attachment.
5. Equipment: The application of adhesion promoters, 3M™ VHB™ Tape, and pressure can be enhanced through the use of equipment. This can result in faster and more robust manufacturing

processes. Please consult with a 3M Specified Construction Field Specialist for more information on application equipment.

Testing should be conducted by the customer to determine if a 3M™ VHB™ Tape will meet all the performance requirements for their application. The data reported in this document is to be used as a representation of how well the tested 3M™ VHB™ Tape G16F will bond to the specific customer-supplied substrates with the same surface preparation methods and environmental conditions. A thorough evaluation should be done by the customer to verify if a 3M™ VHB™ Tape is capable of meeting the total needs of the application, including those that were not anticipated with this testing.

Sincerely,

Steve Austin

Steve Austin
3M Global Technical Service Specialist
3M™ VHB™ Tapes - Architectural Markets
3M Center, Bldg 230-2S-29
St. Paul, MN 55144
Tel: 651-736-1259
www.3m.com/vhb/architecturalpanel