

TERRACORE PANELS, LLC TEST REPORT

SCOPE OF WORK

AC05 (PARTIAL SCOPE) TESTING OF TWO ADHESIVES (H.B. FULLER AND LUSHAN) ADHERED TO ALUMINUM AND FIBERGLASS SUBSTRATES

REPORT NUMBER

H2716.01-106-31 R0

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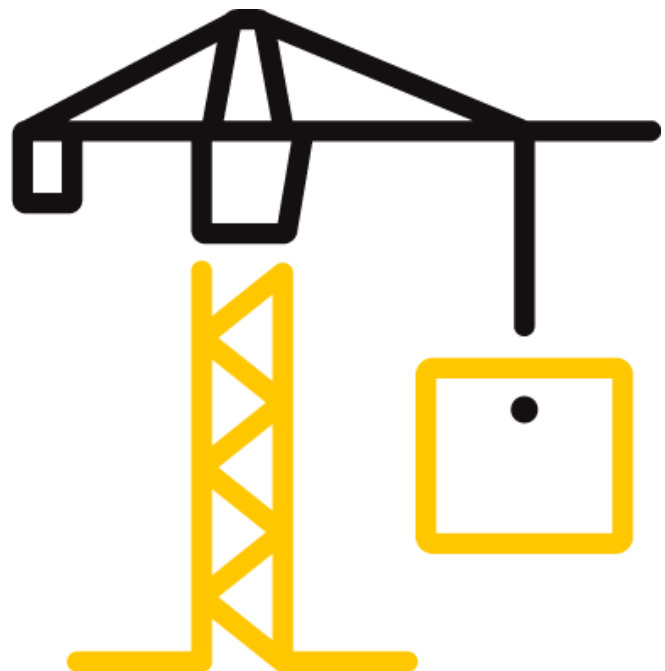
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TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

REPORT ISSUED TO

TERRACORE PANELS, LLC

2030 Irving Boulevard,
Dallas, Texas 75207

SECTION 1

SCOPE

Products: Two adhesives (H.B. Fuller and Lushan) adhered to aluminium and fiberglass substrates

Intertek Building & Construction (B&C) was contracted by TerraCore Panels, LLC, to evaluate two adhesives (H.B. Fuller and Lushan) in accordance with the referenced sections of ICC-ES™ AC05 as required for a Class 2 adhesive designation. Results obtained are tested values and were secured by using the designated test method(s). Testing was conducted at the Intertek B&C test facility in York, Pennsylvania, with oxidation and ozone exposure conducted at separate facilities referenced herein.

This report does not constitute certification of this product nor an opinion or endorsement by this laboratory.

For INTERTEK B&C:

COMPLETED BY:	Andrew D. Cook
TITLE:	Technician II Materials Laboratory
SIGNATURE:	
DATE:	04/10/18

ADC:sds/kf

REVIEWED BY:	Scott D. Scallorn
TITLE:	Project Engineer Materials Laboratory
SIGNATURE:	
DATE:	04/10/18

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

SECTION 2

SUMMARY OF TEST RESULTS

TEST COMPONENT		ADHESIVE	BONDED SUBSTRATES	CONDITIONING	MEAN RESULTS (psi)
AC05 SECTION	DESCRIPTION				
8.3	Block Shear	H.B. Fuller	Aluminum-Aluminum	Control	2,736
				Accelerated Aging	3,019 (+10.3%)
				Water Immersion	2,398 (-12.4%)
			Aluminum-Fiberglass	Control	1,753
				Accelerated Aging	1,955 (+11.5%)
				Water Immersion	1,744 (-0.05%)
8.5	Bond	H.B. Fuller	Aluminum-Aluminum	Control	729
				Accelerated Aging	759 (+4.1%)
				Water Immersion	625 (-14.3%)
			Aluminum-Fiberglass	Control	491
				Accelerated Aging	546 (+11.2%)
				Water Immersion	568 (+15.7%)
8.7	Oxidation	H.B. Fuller	Aluminum-Aluminum	Control	2,141
				Post-Oxidation	1,948 (-9.1%)
8.7.2	Ozone	H.B. Fuller	Aluminum-Aluminum	Control	2,141
				Post-Ozone	1,918 (-10.4%)
		Lushan	Aluminum-Aluminum	Control	1,040
				Post-Ozone	897 (-13.8%)

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

SECTION 3

TEST METHODS

The specimens were evaluated in accordance with the following, as governed by ICC-ES™ AC05:

ICC-ES™ AC05 (Editorially Revised July 2015), *Acceptance Criteria for Sandwich Panel Adhesives*

ASTM C297/C297M-16, *Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions*

ASTM D905-08 (2013), *Standard Test Method for Strength Properties of Adhesive Bonds in Shear by Compressive Loading*

ASTM D1002-10, *Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)*

ASTM D1183-03 (2011), *Standard Practices for Resistance of Adhesives to Cyclic Laboratory Aging Conditions*

ASTM D572-04 (2015), *Standard Test Method for Rubber - Deterioration by Heat and Oxygen*

ASTM D1149-07 (2012), *Standard Test Methods for Rubber Deterioration - Cracking in an Ozone Controlled Environment*

SECTION 4

MATERIAL SOURCE

The materials were selected by Intertek B&C personnel at Allcomb: Sanjiang Village, Leping Town, Sanshui District, Foshan, Guangdong Province, China. The materials were tagged prior to shipment on 07/19/2017, (Reference Intertek B&C Test Specimen Selection Report No. 170719023GZU_ATI_Pacific sampling July 19, 2017_H2716.01, dated 07/19/2017, included in Section 11 of this report). Refer to the product description photos in Section 10. The material was tested as received with the exception of and preconditioning as specified in the associated sections of the AC05 document and subsequent attachment of either aluminum or steel pull tabs to test specimens with a high-performance epoxy (LOCTITE® EA E-40HT™ HYSOL®) as required for testing. Representative test specimens/materials will be retained by Intertek B&C for a minimum of four years from the test completion date.

SECTION 5

LIST OF OFFICIAL OBSERVERS

NAME	COMPANY
Andrew D. Cook	Intertek B&C
Scott D. Scallorn	Intertek B&C

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

SECTION 6**TEST PROCEDURES**

All conditioning of test specimens and test conditions were at standard laboratory conditions unless otherwise reported. Refer to the test related photos in Section 10.

AC05 Section 8.3 - Block Shear

The AC05, Section 8.3 Block Shear testing was performed on three sets of five specimens for both aluminum-to-aluminum and aluminum-to-fiberglass bond conditions for the H.B. Fuller adhesive: Control (laboratory conditioned as per AC05, Section 6.0 [7 days at $23 \pm 2^\circ\text{F}$ [$22.7 \pm 1.1^\circ\text{C}$]]), Accelerated Aging per AC05, Section 7.1 (ASTM D1183, Procedure C for three cycles with the freeze condition raised to -40°F [-40°C] as per AC05, Section 7.1), and water immersion/drying cycle as per AC05 Section 7.2 (Total: 30 block shear assemblies). All preconditioned specimens were further conditioned for a minimum of 7 days at standard laboratory conditions (per AC05, Section 7.2) before testing was performed. Prior to loading in shear, aluminum blocks were mounted to each aluminum to-fiberglass bonded specimen, allowed to fully cure, and the width and depth of the bond area of each of the block shear assemblies was measured using a digital caliper (ICN: 65688). The specimens were then secured into appropriate fixturing on the test stage of a Satec 50UD Universal Test Machine (ICN: Y002011), operating with a 50,000 lb. load cell (ICN: 557624) allowing one side of the specimen to remain unsupported. The unsupported block side of the specimen was then loaded in compression at the rate of 0.015 in/min (as specified in AC05, Section 8.3) until failure occurred. Peak load and failure mode were documented for each test specimen and shear bond strength was calculated and averaged for each test series. The mean post-exposure shear strength for both accelerated aging and water immersion sets for each substrate combination was further evaluated against the associated control series mean result to determine compliance with the performance requirement as stated in AC05, Section 9.1.2.

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05 Section 8.5 - Bond

The AC05, Section 8.5 Bond evaluation was performed on three sets of five specimens for both aluminum-to-aluminum and aluminum-to-fiberglass bond conditions for the H.B. Fuller adhesive: Control (laboratory conditioned as per AC05, Section 6.0 [7 days at $23 \pm 2^\circ\text{F}$ [$22.7 \pm 1.1^\circ\text{C}$]), Accelerated Aging per AC05, Section 7.1 (ASTM D1183, Procedure C for three cycles with the freeze condition raised to -40°F [-40°C] as per AC05, Section 7.1), and water immersion/drying cycle as per AC05 Section 7.2 (Total: 30 Bond Strength assemblies). All preconditioned specimens were further conditioned for a minimum of 7 days at standard laboratory conditions (per AC05, Section 7.2) before testing was performed. Prior to loading in tension, steel pull-tabs were affixed to each bonded specimen, allowed to fully cure, and the width and depth of the bond area of each of the flatwise tensile bond assemblies was measured using a digital caliper (ICN: 65688). The specimens were then secured into appropriate fixturing on the test stage of a Satec 50UD Universal Test Machine (ICN: Y002011), operating with a 50,000 lb. load cell (ICN: 557624) and tensile load was applied at the rate of 0.02 in/min until failure occurred. Peak load and failure mode were documented for each test specimen and tensile bond strength was calculated and averaged for each test series. The mean post-exposure tensile bond strength for both accelerated aging and water immersion sets for each substrate combination was further evaluated against the associated control series mean result to determine compliance with the performance requirement as stated in AC05, Section 9.1.2.

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05 Section 8.7 - Oxidation

The AC05, Section 8.7 Oxidation Exposure evaluation specimens (both the Lushan adhesive H.B. Fuller adhesive) were submitted to a qualified laboratory (Akron Rubber Development Laboratory [ARDL, Inc.] located in Akron, OH. for exposure as specified in ASTM D572 as modified by AC05, Section 8.7 (500 hour exposure period at 500 ± 15 psi in a chamber maintained at $158 \pm 5^\circ\text{F}$ [$70 \pm 2.8^\circ\text{C}$]). Post-immediate return to the Intertek test facility in York, PA, the H.B. Fuller lap shear specimens were evaluated in accordance with ASTM D1002 on SATEC 50 UD Universal Testing Machine (ICN: Y002011) employing a 5,000 lbf capacity load cell (ICN: 516509A). A total of 5 control series specimens and 5 post-oxidation exposure series specimens were loaded in tension at a rate of 0.015 in/min (modified per AC05, Section 8.7.1) until failure was observed. Lap Shear Strength was calculated for each specimen and averaged for each test series. Mean post-oxidation exposure lap shear strength was further evaluated against the associated control series mean result to determine compliance with the performance requirement as stated in AC05, Section 9.1.2.

- The submitted Lushan adhesive specimens were returned from the ARDL outsource laboratory exposure in a condition too deteriorated for further evaluation and, as a reactive component as referenced in AC05, Section 8.7 was a potential cause, an AC05, Section 8.7.2.2 alternative ozone exposure evaluation was initiated as detailed in the follow section.

AC05 Section 8.7.2 - Ozone (Oxidation Alternative)

The AC05, Section 8.7.2 Ozone Exposure evaluation specimens (both the Lushan adhesive H.B. Fuller adhesives) were submitted to a qualified Intertek laboratory located in Kentwood, MI. for exposure as specified in ASTM D1149 as modified by AC05, Section 8.7.2-8.7.2.1 (72 hour exposure period at an ozone concentration of 50 parts per 1000,000,000 by volume in a chamber maintained at $122 \pm 2^\circ\text{F}$ [$50 \pm 1.1^\circ\text{C}$]). Post-immediate return to the Intertek test facility in York, PA, the lap shear specimens were evaluated in accordance with ASTM D1002 on SATEC 50 UD Universal Testing Machine (ICN: Y002011) employing a 5,000 lbf capacity load cell (ICN: 516509A). A total of 5 control series specimens and 5 post-ozone exposure series specimens were loaded in tension at a rate of 0.015 in/min (modified per AC05, Section 8.7.2.1) until failure was observed. Lap Shear Strength was calculated for each specimen and averaged for each test series. Mean post-ozone exposure lap shear strengths were further evaluated against the associated control series mean results to determine compliance with the performance requirement as stated in AC05, Section 9.1.2.

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

SECTION 7

TEST SPECIMEN DESCRIPTIONS

TEST PROCEDURE	NUMBER OF SPECIMENS	NOMINAL SPECIMEN DIMENSIONS	VISUAL CHARACTERISTICS
AC05, Section 8.3 - Block Shear (Test Specimens per ASTM D905)	Aluminum to Aluminum: H.B. Fuller - 15	2.0 in. x 2.25 in. x 1.5 in. overall, (2.0 in. x 1.75 in. overlap bond area)	Two 0.25 in. offset aluminum blocks bonded over a nominal 3.5 in ² area
	Aluminum to Fiberglass: H.B. Fuller - 15	2.0 in. x 2.25 in. x 1.5 in. overall, (2.0 in. x 1.75 in. overlap bond area) *Supplemental aluminium blocks bonded to exterior facings for testing	Two 0.25 in. offset sheet facings (nominal 0.04 in. thick aluminium and 0.03 in. thick fiberglass) bonded over a nominal 3.5 in ² area
AC05, Section 8.5 - Bond (Test Specimens per ASTM C297)	Aluminum to Aluminum H.B. Fuller - 15	3.0 in. square x 0.09 in.	Two bonded sheets (both nominal 0.04 in. thick aluminium))
	Aluminum to Fiberglass H.B. Fuller - 15	3.0 in. square x 0.08 in.	Two bonded sheets (nominal 0.04 in. thick aluminium and 0.03 in. thick fiberglass)
AC05, Section 8.7 - Oxidation (Test Specimens per ASTM D1002)	Aluminum to Aluminum	7.5 in. long overall, 1.0 in. x 0.5 in. overlap bond area	Two 0.5 in. offset sheet facings (nominal 0.04 in. thick aluminium) bonded over a nominal 0.5 in ² area
AC05, Section 8.7.2 - *Ozone Alternative (Test Specimens per ASTM D1002)	Aluminum to Aluminum H.B. Fuller - 15 Lushan - 15	7.5 in. long overall, 1.0 in. x 0.5 in. overlap bond area	Two 0.5 in. offset sheet facings (nominal 0.04 in. thick aluminium) bonded over a nominal 0.5 in ² area

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

SECTION 8

TEST RESULTS

AC05, Section 8.3 Block Shear Evaluation (ASTM D905) - ALUMINUM / ALUMINUM

SPECIMEN DETAILS					
ADHESIVE & BONDED FACINGS	CONDITIONING	NO.	BOND DIMENSIONS (in)		BOND AREA (in ²)
			WIDTH	HEIGHT	
H.B. Fuller Aluminum - Aluminum	Control	C-1	1.996	1.506	2.994
		C-2	1.994	1.491	2.991
		C-3	1.997	1.524	2.996
		C-4	2.008	1.498	3.012
		C-5	2.006	1.511	3.009
	Aged	A-1	2.001	1.523	3.002
		A-2	2.006	1.495	3.009
		A-3	1.998	1.499	2.997
		A-4	1.999	1.505	2.998
		A-5	2.001	1.490	3.002
	Water Immersion	W-1	2.007	1.497	3.001
		W-2	2.006	1.517	3.009
		W-3	1.998	1.508	2.997
		W-4	2.006	1.494	3.009
		W-5	2.008	1.509	3.012

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05, Section 8.3 Block Shear Evaluation (ASTM D905) - ALUMINUM / ALUMINUM

ADHESIVE & BONDED FACINGS	CONDITIONING	NO.	PEAK LOAD (lbf)	SHEAR STRENGTH (psi)	FAILURE MODE
H.B. Fuller Aluminum - Aluminum	Control	C-1	9,498.0	3,172	Adhesive Bond
		C-2	10,267.8	3,433	Adhesive Bond
		C-3	8,054.9	2,689	Adhesive Bond
		C-4	5,465.5	1,815	Adhesive Bond
		C-5	7,734.0	2,570	Adhesive Bond
Control Series Average				2,736	--

H.B. Fuller Aluminum - Aluminum	Aged	A-1	7,427.6	2,475	Adhesive Bond
		A-2	9,400.6	3,124	Adhesive Bond
		A-3	10,682.0	3,564	Adhesive Bond
		A-4	8,336.0	2,780	Adhesive Bond
		A-5	9,454.6	3,150	Adhesive Bond
Accelerated Aging Series Average				3,019	--
% Strength Change (vs. Control Series)				+10.3	
AC05, Section 9.1.2 Performance Criteria		Requirement		Less than 20% strength loss	
		Result		Meets as Stated	

H.B. Fuller Aluminum - Aluminum	Water Immersion	W-1	5363.8	1,782	Adhesive Bond
		W-2	4908.9	1,631	Adhesive Bond
		W-3	8710.7	2,906	Adhesive Bond
		W-4	8149.0	3,041	Adhesive Bond
		W-5	7920.0	2,629	Adhesive Bond
Water Immersion Series Average				2,398	--
% Strength Change (vs. Control Series)				-12.4	
AC05, Section 9.1.2 Performance Criteria		Requirement		Less than 20% strength loss	
		Result		Meets as Stated	

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05, Section 8.3 Block Shear Evaluation (ASTM D905) - ALUMINUM / FIBERGLASS

SPECIMEN DETAILS					
ADHESIVE & BONDED FACINGS	CONDITIONING	NO.	BOND DIMENSIONS (in)		BOND AREA (in ²)
			WIDTH	HEIGHT	
H.B. Fuller Aluminum - Fiberglass	Control	C-1	2.048	1.469	3.072
		C-2	2.004	1.421	3.006
		C-3	2.002	1.506	3.003
		C-4	2.014	1.457	3.021
		C-5	2.017	1.457	3.026
	Aged	A-1	1.998	1.459	2.997
		A-2	2.023	1.419	3.035
		A-3	2.016	1.385	3.024
		A-4	1.999	1.401	2.998
		A-5	2.011	1.431	3.016
	Water Immersion	W-1	1.982	1.423	2.973
		W-2	1.998	1.457	2.997
		W-3	1.998	1.400	2.997
		W-4	2.008	1.443	3.012
		W-5	1.995	1.472	2.992

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05, Section 8.3 Block Shear Evaluation (ASTM D905) - ALUMINUM / FIBERGLASS

ADHESIVE & BONDED FACINGS	CONDITIONING	NO.	PEAK LOAD (lbf)	SHEAR STRENGTH (psi)	FAILURE MODE
H.B. Fuller Aluminum - Fiberglass	Control	C-1	4,639.1	1,510	Fixture/Facing Bond
		C-2	5,817.9	1,935	Cohesive Fiberglass
		C-3	5,099.0	1,698	Cohesive Fiberglass
		C-4	3,845.9	1,273	Fixture/Facing Bond
		C-5	7,098.9	2,346	Cohesive Fiberglass
Control Series Average				1,753	--

H.B. Fuller Aluminum - Fiberglass	Aged	A-1	5,061.5	1,689	Cohesive Fiberglass
		A-2	3,439.3	1,133	Adhesive Bond
		A-3	6,354.2	2,101	Cohesive Fiberglass
		A-4	6,938.6	2,314	Cohesive Fiberglass
		A-5	7,657.3	2,538	Cohesive Fiberglass
Accelerated Aging Series Average				1,955	--
% Strength Change (vs. Control Series)				+11.5	
AC05, Section 9.1.2 Performance Criteria		Requirement		≤20%	
		Result		Meets as Stated	

H.B. Fuller Aluminum - Fiberglass	Water Immersion	W-1	7,818.2	2,630	Cohesive Fiberglass
		W-2	6,351.9	2,119	Cohesive Fiberglass
		W-3	3,984.8	1,330	Cohesive Fiberglass
		W-4	3,344.5	1,110	Fixture/Facing Bond
		W-5	4,586.7	1,533	Fixture/Facing Bond
Water Immersion Series Average				1,744	--
% Strength Change (vs. Control Series)				-0.05	
AC05, Section 9.1.2 Performance Criteria		Requirement		Less than 20% strength loss	
		Result		Meets as Stated	

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05, Section 8.5 Bond Evaluation (ASTM C297) - ALUMINUM / ALUMINUM

SPECIMEN DETAILS					
ADHESIVE & BONDED FACINGS	CONDITIONING	NO.	BOND DIMENSIONS (in)		BOND AREA (in ²)
			LENGTH	WIDTH	
H.B. Fuller Aluminum - Aluminum	Control	C-1	3.038	3.066	9.315
		C-2	3.051	3.055	9.321
		C-3	3.032	3.027	9.178
		C-4	3.076	3.057	9.403
		C-5	3.054	3.057	9.345
	Aged	A-1	3.087	3.099	9.567
		A-2	3.062	3.046	9.327
		A-3	3.002	3.018	9.060
		A-4	3.086	3.047	9.403
		A-5	3.071	3.041	9.339
	Water Immersion	W-1	3.023	3.083	9.320
		W-2	3.070	3.027	9.293
		W-3	3.044	3.060	9.315
		W-4	3.040	3.046	9.260
		W-5	3.062	3.070	9.400

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05, Section 8.5 Bond Evaluation (ASTM C297) - ALUMINUM / ALUMINUM

ADHESIVE & BONDED FACINGS	CONDITIONING	NO.	PEAK LOAD (lbf)	TENSILE BOND STRENGTH (psi)	FAILURE MODE
H.B. Fuller Aluminum - Aluminum	Control	C-1	6,147.9	660	Fixture/Facing Bond
		C-2	7,007.9	752	Fixture/Facing Bond
		C-3	6,931.9	755	Fixture/Facing Bond
		C-4	6,658.6	708	Fixture/Facing Bond
		C-5	7,199.7	770	Fixture/Facing Bond
Control Series Average 6789.2				729	--

H.B. Fuller Aluminum - Aluminum	Aged	A-1	7,404.5	774	Fixture/Facing Bond
		A-2	7,679.1	823	Fixture/Facing Bond
		A-3	6,626.7	731	Fixture/Facing Bond
		A-4	7,604.7	809	Fixture/Facing Bond
		A-5	6,117.3	655	Fixture/Facing Bond
Accelerated Aging Series Average				759	--
% Strength Change (vs. Control Series)				+4.1	
AC05, Section 9.1.2 Performance Criteria		Requirement		Less than 20% strength loss	
		Result		Meets as Stated	

H.B. Fuller Aluminum - Aluminum	Water Immersion	W-1	4,829.6	518	Fixture/Facing Bond
		W-2	5,771.9	621	Fixture/Facing Bond
		W-3	5,278.3	567	Fixture/Facing Bond
		W-4	6,153.0	664	Fixture/Facing Bond
		W-5	7,092.9	755	Fixture/Facing Bond
Water Immersion Series Average				625	--
% Strength Change (vs. Control Series)				-14.3	
AC05, Section 9.1.2 Performance Criteria		Requirement		Less than 20% strength loss	
		Result		Meets as Stated	

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05, Section 8.5 Bond Evaluation (ASTM C297) - ALUMINUM / FIBERGLASS

SPECIMEN DETAILS					
ADHESIVE & BONDED FACINGS	CONDITIONING	NO.	BOND DIMENSIONS (in)		BOND AREA (in ²)
			LENGTH	WIDTH	
H.B. Fuller Aluminum - Fiberglass	Control	C-1	3.058	3.060	9.357
		C-2	3.064	3.060	9.376
		C-3	3.062	3.076	9.416
		C-4	3.076	3.057	9.406
		C-5	3.077	3.049	9.318
	Aged	A-1	3.027	3.089	9.350
		A-2	3.130	3.097	9.694
		A-3	3.086	3.060	9.443
		A-4	3.077	3.085	9.493
		A-5	3.084	3.034	9.357
	Water Immersion	W-1	3.017	3.081	9.573
		W-2	3.009	3.038	9.141
		W-3	3.049	3.100	9.452
		W-4	3.045	3.061	9.321
		W-5	3.045	3.070	9.367

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05, Section 8.5 Bond Evaluation (ASTM C297) - ALUMINUM / FIBERGLASS

ADHESIVE & BONDED FACINGS	CONDITIONING	NO.	PEAK LOAD (lbf)	TENSILE BOND STRENGTH (psi)	FAILURE MODE
H.B. Fuller Aluminum - Fiberglass	Control	C-1	4,195.7	448	Fixture/Facing Bond
		C-2	5,762.5	615	Fixture/Facing Bond
		C-3	4,861.1	516	Fixture/Facing Bond
		C-4	4,839.7	515	Fixture/Facing Bond
		C-5	3,382.6	363	Fixture/Facing Bond
Control Series Average				491	--

H.B. Fuller Aluminum - Fiberglass	Aged	A-1	4,096.1	438	Fixture/Facing Bond
		A-2	2,403.8	248	Fixture/Facing Bond
		A-3	4,852.7	514	Fiberglass Cohesive
		A-4	5,619.5	592	Fiberglass Cohesive
		A-5	5,981.4	639	Fixture/Facing Bond
Accelerated Aging Series Average				546	--
% Strength Change (vs. Control Series)				+11.2	
AC05, Section 9.1.2 Performance Criteria		Requirement		Less than 20% strength loss	
		Result		Meets as Stated	

Note: Specimen C-2 showed poor fixture bond so is struck from the series average as presented

H.B. Fuller Aluminum - Fiberglass	Water Immersion	W-1	5,118.1	535	Fixture/Facing Bond
		W-2	4,765.4	521	Fixture/Facing Bond
		W-3	6,617.6	700	Fixture/Facing Bond
		W-4	5,266.8	565	Fixture/Facing Bond
		W-5	4,844.4	518	Fixture/Facing Bond
Water Immersion Series Average				568	--
% Strength Change (vs. Control Series)				+15.7	
AC05, Section 9.1.2 Performance Criteria		Requirement		Less than 20% strength loss	
		Result		Meets as Stated	

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05, Section 8.7 Oxidation Evaluation (ASTM D1002)

SPECIMEN DETAILS		NO.	BOND AREA (in ²)	PEAK LOAD (lbf)	LAP SHEAR STRENGTH (psi)
ADHESIVE & BONDED FACINGS	CONDITIONING				
H.B. Fuller Aluminum - Aluminum	Control	C-1	0.5	1,141.6	2,192.4
		C-2	0.5	1,093.7	2,100.4
		C-3	0.5	1,111.5	2,115.9
		C-4	0.5	1,125.2	2,139.9
		C-5	0.5	1,132.9	2,158.8
Control Series Average				1,121.0	2,141.5

H.B. Fuller Aluminum - Aluminum	Oxidation	O-1	0.5	995.2	1,892.7
		O-2	0.5	1,028.8	2,007.3
		O-3	0.5	1,013.3	1,957.6
		O-4	0.5	1,001.3	1,909.8
		O-5	0.5	1,027.1	1,970.6
Oxidized Series Average				1,013.2	1,947.6
% Strength Change (vs. Control Series)				-9.1	
AC05, Section 9.1.2 Performance Criteria		Requirement		Less than 20% strength loss	
		Result		Meets as Stated	

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05, Section 8.7.2 Ozone Exposure Evaluation (ASTM D1002)

SPECIMEN DETAILS		NO.	BOND AREA (in ²)	PEAK LOAD (lbf)	LAP SHEAR STRENGTH (psi)
ADHESIVE & BONDED FACINGS	CONDITIONING				
H.B. Fuller Aluminum - Aluminum	Control	C-1	0.5	1,141.6	2,192.4
		C-2	0.5	1,093.7	2,100.4
		C-3	0.5	1,111.5	2,115.9
		C-4	0.5	1,125.2	2,139.9
		C-5	0.5	1,132.9	2,158.8
Control Series Average				1,121.0	2,141.5

H.B. Fuller Aluminum - Aluminum	Ozone Exposure	O-1	0.5	963.4	1,926.8
		O-2	0.5	967.7	1,935.6
		O-3	0.5	944.5	1,889.0
		O-4	0.5	953.6	1,907.2
		O-5	0.5	966.6	1,933.1
Ozone Exposure Series Average				959.2	1,918.3
% Strength Change (vs. Control Series)				-10.4	
AC05, Section 9.1.2 Performance Criteria		Requirement		Less than 20% strength loss	
		Result		Meets as Stated	

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

AC05, Section 8.7.2 Ozone Exposure Evaluation (ASTM D1002)

SPECIMEN DETAILS		NO.	BOND AREA (in ²)	PEAK LOAD (lbf)	LAP SHEAR STRENGTH (psi)
ADHESIVE & BONDED FACINGS	CONDITIONING				
Lushan Aluminum - Aluminum	Control	C-1	0.5	478.3	915.0
		C-2	0.5	501.5	978.4
		C-3	0.5	578.3	1118.3
		C-4	0.5	586.3	1131.3
		C-5	0.5	543.3	1057.8
Control Series Average				537.5	1040.2

Lushan Aluminum - Aluminum	Ozone Exposure	O-1	0.5	261.0	521.9
		O-2	0.5	498.6	997.2
		O-3	0.5	505.1	1010.2
		O-4	0.5	479.3	958.7
		O-5	0.5	497.4	994.7
Ozone Exposure Series Average				448.3	896.6
% Strength Change (vs. Control Series)				-13.8	
AC05, Section 9.1.2 Performance Criteria		Requirement		Less than 20% strength loss	
		Result		Meets as Stated	

¹ Lushan post-exposure specimen O-1 was inadvertently preloaded within the test fixtures prior to evaluation as reported above. As such, it may reasonably be considered compromised and excluded from the series average as presented (revised series mean lap shear strength: 990.2, % strength loss: -4.8).

SECTION 9

CONCLUSION

The both the H.B. Fuller and Lushan adhesives met the specified performance requirements for the AC05 sections as referenced below:

H.B. Fuller - Sections 8.3 Block Shear, Section 8.5 Bond, Section 8.7 Oxidation, Section 8.7.2 Ozone

Lushan: - Section 8.7 Oxidation (Section 8.7.2 Ozone)

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

SECTION 10 PHOTOGRAPHS



Photo No. 1

AC05 Section 8.3 Block Shear - Aluminum to Aluminum Specimens As Received

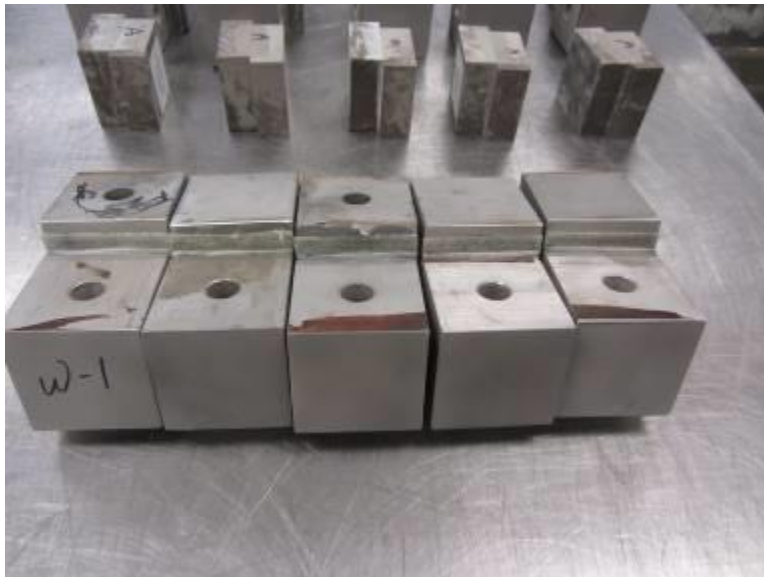


Photo No. 2

AC05 Section 8.3 Block Shear - Aluminum to Fiberglass Specimens as Prepared for Testing

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18



Photo No. 3

AC05 Section 8.3 Block Shear (ASTM D905) Aluminum to Aluminum Test Setup

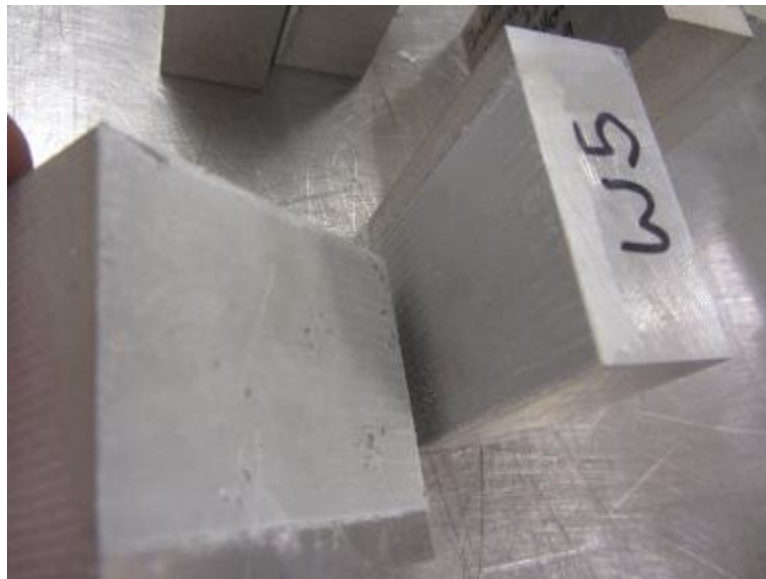


Photo No. 4

AC05 Section 8.3 Block Shear (ASTM D905) Representative A-A Specimen Failure Mode

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18



Photo No. 5

AC05 Section 8.3 Block Shear (ASTM D905) Aluminum to Fiberglass Test Setup



Photo No. 6

AC05 Section 8.3 Block Shear (ASTM D905) Representative A-F Specimen Failure Mode

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18



Photo No. 7

AC05 Section 8.5 Bond Strength - Aluminum to Aluminum Specimens As Received

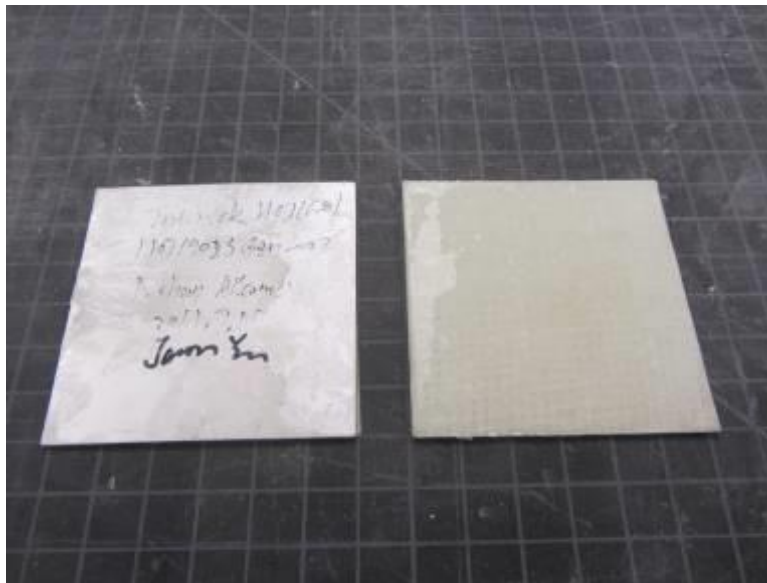


Photo No. 8

AC05 Section 8.5 Bond Strength - Aluminum to Fiberglass Specimens as Received

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18



Photo No. 9

AC05 Section 8.5 Bond Strength (ASTM C297) Depiction of Test-Ready Specimens



Photo No. 10

AC05 Section 8.5 Bond Strength (ASTM C297) Test Setup

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18



Photo No. 11

AC05 Section 8.5 Bond Strength (ASTM C297) Representative A-F Specimen Failure Mode

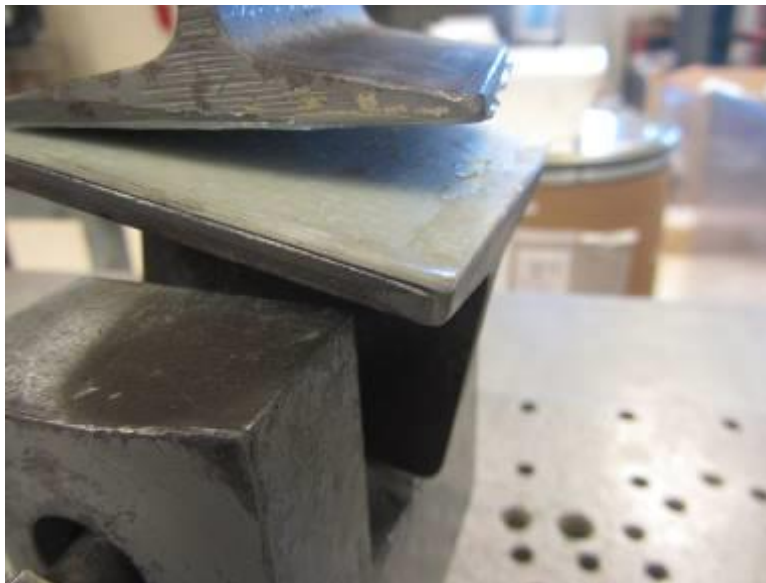


Photo No. 12

AC05 Section 8.5 Bond Strength (ASTM C297) Representative Fixture/Facing Bond Failure

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18



Photo No. 13

AC05 Section 8.7 Oxidation - H.B. Fuller Specimens (Control [Left] and Post Exposure [Right])



Photo No. 14

AC05 Section 8.7 Oxidation - ASTM D1002 Lap Shear Strength Test Setup

TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18



Photo No. 15

AC05 Section 8.7.2 Ozone - Post-Exposure H.B. Fuller Specimen Condition

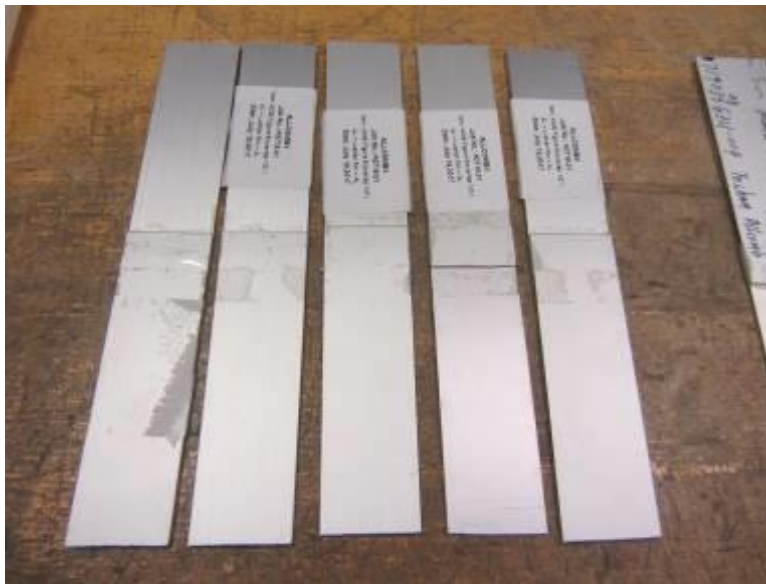


Photo No. 16

AC05 Section 8.7.2 Ozone - Post-Exposure Lushan Specimen Condition



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TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

SECTION 11
REPORT

PRODUCT SAMPLING / WITNESSING FORM

Job Information

Project Manager: **Michael Beaton**

Date Requested: **6/26/17**

Estimated Time Required: **6 hours**

Requested Sampling Date Range: **Jul 19, 2017** to **Jul 19, 2017**

Intertek Job #: **H2716.01**

Sampled By: **Jason Yuan/Martin Guo**

Date Sampled: **Jul 19, 2017**

Arrival Time: **10:00** Departure Time: **17:00**

Facility Information

Company Name: **Allcomb**

Address: **Sanjiang Village, Leping Town, Sanshui District**

City/State/Zip: **Foshan, Guangdong Province**

Country: **China**

Primary Contact: **Elaine**

Phone: **+86 15818075727**

Email: **operation@pacificbedrock.net**

Secondary Contact: **Max Orines**

Phone:

Email: **max@terracorepanels.com**

Sampling / Witnessing Requirements

IN GENERAL: Mark each individual piece that you select (e.g., with permanent marker) with at least the **job number** (00000.00), **date**, and **your initials**. Alternatively, you can mark bundles or packages, permitted that they are marked in a manner that the marking would have to be destroyed in order to open the package or bundle (e.g., signing labels across sealed box seams or signing shrink wrap). Obtain copies of QC/production records that indicate that the products you select conform to the manufacturer's product specifications, which ultimately provides traceability to raw materials. Take photos of available inventory from which you're selecting as well as the markings that you place on the samples.

Shipping Information

Ship To

Attention: **Scott Scallorn / Jennifer Kelley**

Intertek B&C Lab: **York, PA - Materials Testing**

Address: **130 Derry Court**

City/State/Zip: **York, Pennsylvania 17406-8405**

Country: **USA**

Shipping labels supplied

Samples packaged and marked in a tamperproof method

Customer to provide shipping information at a later date

Tracking Information

Date Shipped: **Jul 20, 2017**

Carrier: **DHL**

Method: **Airlift**


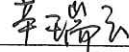

Tracking Number: **53 7096 3592**

PRODUCT SAMPLING / WITNESSING FORM

H2716.01

Witness(es)

At least one witness from Manufacturer / Supplier is required.

Name	Company	Title	Signature	Date
Fang Ruoyun (方若云)	Allcomb	Production Manager		2017.7.19
Xin Ruiyun (辛瑞云)	Allcomb	Assistant		2017.7.19
Luo Jieming (罗杰明)	Allcomb	Lab Technician		2017.7.19

Traceability, Documentation, and Record of Items Sampled / Witnessed

See attached (pages): 3~6

This record is not complete unless total pages indicated are attached.

 
2017.7.19
Intertek Representative Signature

Jason Yuan/Martin Guo

Intertek Representative Name

Date: Jul 19, 2017

PRODUCT SAMPLING / WITNESSING FORM

H2716.01

Traceability, Documentation, and Record of Items Sampled / Witnessed

Product ID/Part No.: AC05 Testing Figure 1	Quantity Pulled: 15 pcs
Product Description: 3" x 3" square samples with the HB Fuller adhesive bonding one aluminum sheet to another aluminum sheet	Identifying Marks: Jason Yuan, 170719023GZU-001, Foshan Allcomb, 2017.7.19 Intertek H2716.01
Quantity Required: 15 When checked, quantity pulled should include an equal <input type="checkbox"/> number of parts for each of XXX product colors (e.g., 27 units split between 3 product colors = 9 white, 9 gray, and 9 tan).	Comments: The product was made on lab, not sampling on production line. Sample making process: 1.Cuted the aluminum sheet for 3"x 3"x 1mm 2.Used the amyl acetic ester cleaned the surface of aluminum sheet. 3.Applying HB fuller adhesive on aluminum sheet. 4.Then glued the two pieces Al-sheet, and pressuring 5kg on the sample for 4 hours.
<input type="checkbox"/> Sampling <input checked="" type="checkbox"/> Witnessing <input type="checkbox"/> Both	
<i>Each product sampled (excluding AAMA CVPM samples) must be accompanied by:</i>	
<input type="checkbox"/> Records that clearly provide traceability to raw material used <input type="checkbox"/> Production and quality records for products selected <input type="checkbox"/> Photos of location/process (with authorization from client)	
Product ID/Part No.: AC05 Testing Figure 2	Quantity Pulled: 20 pcs
Product Description: 3" x 3" square samples with HB Fuller adhesive bonding an aluminum sheet to a fiberglass sheet	Identifying Marks: Jason Yuan, 170719023GZU-002, Foshan Allcomb, 2017.7.19 Intertek H2716.01
Quantity Required: 20 When checked, quantity pulled should include an equal <input type="checkbox"/> number of parts for each of XXX product colors (e.g., 27 units split between 3 product colors = 9 white, 9 gray, and 9 tan).	Comments: The product was made on lab, not sampling on production line. Sample making process: 1.Cuted the aluminum sheet for 3"x 3"x 1mm, and fiberglass sheet for 3"x 3"x 1mm. 2.Used the amyl acetic ester cleaned the surface of aluminum and fiberglass sheet . 3.Applying HB fuller adhesive on aluminum and fiberglass sheet . 4.Then glued the aluminum and fiberglass sheet, and pressuring 5kg on the sample for 4 hours.
<input type="checkbox"/> Sampling <input checked="" type="checkbox"/> Witnessing <input type="checkbox"/> Both	
<i>Each product sampled (excluding AAMA CVPM samples) must be accompanied by:</i>	
<input type="checkbox"/> Records that clearly provide traceability to raw material used <input type="checkbox"/> Production and quality records for products selected <input type="checkbox"/> Photos of location/process (with authorization from client)	

PRODUCT SAMPLING / WITNESSING FORM

H2716.01

Traceability, Documentation, and Record of Items Sampled / Witnessed

<p>Product ID/Part No.: AC05 Testing Figure 3</p> <p>Product Description: HB Fuller adhesive bonding a 2" x 1.75" aluminum sheet to a 2" x 1.75" fiberglass sheet. Offset the two sheets horizontally by 1/4"</p> <p>Quantity Required: 20</p> <p>When checked, quantity pulled should include an equal number of parts for each of XXX product colors (e.g., 27 units split between 3 product colors = 9 white, 9 gray, and 9 tan).</p> <p><input type="checkbox"/> Sampling <input type="checkbox"/> Witnessing <input type="checkbox"/> Both</p> <p><i>Each product sampled (excluding AAMA CVPM samples) must be accompanied by:</i></p> <p><input type="checkbox"/> Records that clearly provide traceability to raw material used</p> <p><input type="checkbox"/> Production and quality records for products selected</p> <p><input type="checkbox"/> Photos of location/process (with authorization from client)</p>	<p>Quantity Pulled: 20</p> <p>Identifying Marks: Jason Yuan, 170719023GZU-003, Foshan Allcomb, 2017.7.19 Intertek H2716.01</p> <p>Comments: The factory already finished these products, auditors was not witnessed the production for those products.</p>
<p>Product ID/Part No.: AC05 Testing Figure 5</p> <p>Product Description: HB Fuller adhesive bonding one 1" x 4" aluminum sheet to another 1" x 4" aluminum sheet. Overlap the two aluminum sheets horizontally by 1/2"</p> <p>Quantity Required: 15</p> <p>When checked, quantity pulled should include an equal number of parts for each of XXX product colors (e.g., 27 units split between 3 product colors = 9 white, 9 gray, and 9 tan).</p> <p><input type="checkbox"/> Sampling <input type="checkbox"/> Witnessing <input type="checkbox"/> Both</p> <p><i>Each product sampled (excluding AAMA CVPM samples) must be accompanied by:</i></p> <p><input type="checkbox"/> Records that clearly provide traceability to raw material used</p> <p><input type="checkbox"/> Production and quality records for products selected</p> <p><input type="checkbox"/> Photos of location/process (with authorization from client)</p>	<p>Quantity Pulled: 15</p> <p>Identifying Marks: Jason Yuan, 170719023GZU-004, Foshan Allcomb, 2017.7.19 Intertek H2716.01</p> <p>Comments: The factory already finished these products, auditors was not witnessed the production for those products.</p>

PRODUCT SAMPLING / WITNESSING FORM

H2716.01

Traceability, Documentation, and Record of Items Sampled / Witnessed

<p>Product ID/Part No.: AC05 Testing Figure 4</p> <p>Product Description: HB Fuller adhesive bonding a 2" x 1.75" aluminum block to another 2" x 1.75" aluminum block. Maple wood blocks have thickness of 3/4." Offset the two maple</p> <p>Quantity Required: 15</p> <p>When checked, quantity pulled should include an equal <input type="checkbox"/> number of parts for each of XXX product colors (e.g., 27 units split between 3 product colors = 9 white, 9 gray, and 9 tan).</p> <p><input type="checkbox"/> Sampling <input type="checkbox"/> Witnessing <input type="checkbox"/> Both</p> <p><i>Each product sampled (excluding AAMA CVPM samples) must be accompanied by:</i></p> <p><input type="checkbox"/> Records that clearly provide traceability to raw material used <input type="checkbox"/> Production and quality records for products selected <input type="checkbox"/> Photos of location/process (with authorization from client)</p>	<p>Quantity Pulled: 15</p> <p>Identifying Marks: Jason Yuan, 170719023GZU-005, Foshan Allcomb, 2017.7.19 Intertek H2716.01</p> <p>Comments: o Maple wood blocks have minimum specific gravity of 0.65 o Maple wood blocks are straight grained and free from defects such as knots, bird's-eyes, short grain and decay.</p> <p>The factory already finished these products, auditors was not witnessed the production for those products.</p>
<p>Product ID/Part No.: AC05 Testing Figure 6</p> <p>Product Description: Lushan adhesive bonding one 1" x 4" aluminum sheet to another 1" x 4" aluminum sheet. Overlap the two aluminum sheets horizontally by 1/2"</p> <p>Quantity Required: 15</p> <p>When checked, quantity pulled should include an equal <input type="checkbox"/> number of parts for each of XXX product colors (e.g., 27 units split between 3 product colors = 9 white, 9 gray, and 9 tan).</p> <p><input type="checkbox"/> Sampling <input type="checkbox"/> Witnessing <input type="checkbox"/> Both</p> <p><i>Each product sampled (excluding AAMA CVPM samples) must be accompanied by:</i></p> <p><input type="checkbox"/> Records that clearly provide traceability to raw material used <input type="checkbox"/> Production and quality records for products selected <input type="checkbox"/> Photos of location/process (with authorization from client)</p>	<p>Quantity Pulled: 15</p> <p>Identifying Marks: Jason Yuan, 170719023GZU-006, Foshan Allcomb, 2017.7.19 Intertek H2716.01</p> <p>Comments: The factory already finished these products, auditors was not witnessed the production for those products.</p>

PRODUCT SAMPLING / WITNESSING FORM

H2716.01

Traceability, Documentation, and Record of Items Sampled / Witnessed

<p>Product ID/Part No.: AC05 Testing Figure 7</p> <p>Product Description: 12" x 12" thin plastic sheets with fully-cured HB Fuller adhesive on one surface</p> <p>Quantity Required: 4</p> <p>When checked, quantity pulled should include an equal <input type="checkbox"/> number of parts for each of XXX product colors (e.g., 27 units split between 3 product colors = 9 white, 9 gray, and 9 tan).</p> <p><input type="checkbox"/> Sampling <input type="checkbox"/> Witnessing <input type="checkbox"/> Both</p> <p><i>Each product sampled (excluding AAMA CVPM samples) must be accompanied by:</i></p> <p><input type="checkbox"/> Records that clearly provide traceability to raw material used <input type="checkbox"/> Production and quality records for products selected <input type="checkbox"/> Photos of location/process (with authorization from client)</p>	<p>Quantity Pulled: 4</p> <p>Identifying Marks: Jason Yuan, 170719023GZU-007, Foshan Allcomb, 2017.7.19 Intertek H2716.01</p> <p>Comments: The factory already finished these products, auditors was not witnessed the production for those products.</p>
<p>Product ID/Part No.: AC05 Testing Figure 8</p> <p>Product Description: 12" x 12" thin plastic sheets with fully-cured Lushan adhesive on one surface</p> <p>Quantity Required: 4</p> <p>When checked, quantity pulled should include an equal <input type="checkbox"/> number of parts for each of XXX product colors (e.g., 27 units split between 3 product colors = 9 white, 9 gray, and 9 tan).</p> <p><input type="checkbox"/> Sampling <input type="checkbox"/> Witnessing <input type="checkbox"/> Both</p> <p><i>Each product sampled (excluding AAMA CVPM samples) must be accompanied by:</i></p> <p><input type="checkbox"/> Records that clearly provide traceability to raw material used <input type="checkbox"/> Production and quality records for products selected <input type="checkbox"/> Photos of location/process (with authorization from client)</p>	<p>Quantity Pulled: 4</p> <p>Identifying Marks: Jason Yuan, 170719023GZU-008, Foshan Allcomb, 2017.7.19 Intertek H2716.01</p> <p>Comments: The factory already finished these products, auditors was not witnessed the production for those products.</p>



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TEST REPORT FOR TERRACORE PANELS, LLC

Report No.: H2716.01-106-31 R0

Date: 04/10/18

SECTION 12

REVISION LOG

REVISION #	DATE	PAGES	REVISION
0	04/10/18	N/A	Original Report Issue