

STACBOND TEST REPORT

SCOPE OF WORK

AAMA 2605 ORGANIC COATING PERFORMANCE EVALUATION ON WHITE AND BLACK PVDF COATED ALUMINUM COILS PVDF 70/30 (POLYVINYL FLOURIDE)

REPORT NUMBER

J9810.01-106-31 R0

TEST DATES

10/25/19 - 04/23/20

ISSUE DATE

07/14/20

RECORD RETENTION END DATE

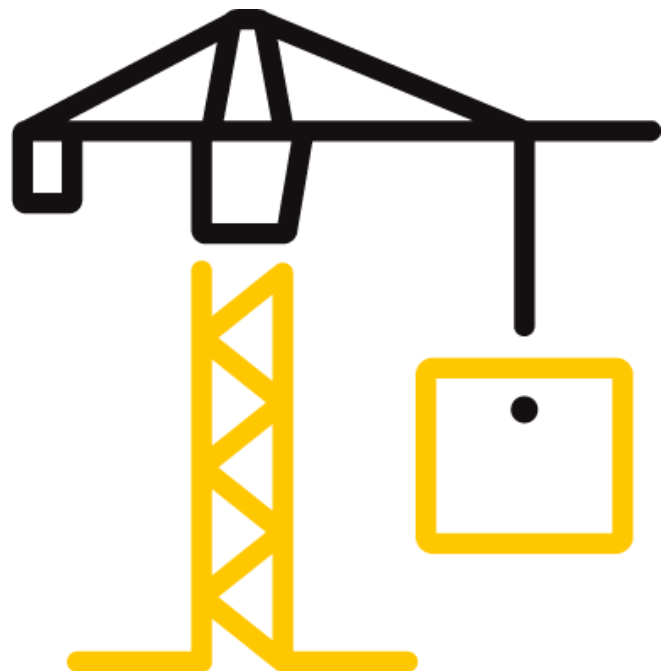
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REPORT ISSUED TO

STACBOND

Polígono Industrial Picusa La Matanza
Padrón, A Coruna 15900, Spain

SECTION 1

SCOPE

Products: PVDF coated aluminum coils PVDF 70/30 (Polyvinyl Flouride)

Intertek Building & Construction (B&C) was contracted by STACBOND to evaluate PVDF coated aluminum coils PVDF 70/30 (Polyvinyl Flouride) in accordance with AAMA 2605. Results obtained are tested values and were secured by using the designated test methods. Testing was conducted at the Intertek B&C test facility in York, Pennsylvania, with Florida 10-year weathering conducted at the Intertek facility in West Palm Beach, Florida

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

For INTERTEK B&C:

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SECTION 2

SUMMARY OF TEST RESULTS

PROPERTY	REQUIRED	COLOR	RESULT	OUTCOME
Color Uniformity	$\Delta E_h \leq 2.0$	Black	Max. $\Delta E_h=0.10$	PASS
		White	Max. $\Delta E_h=0.30$	PASS
Specular Gloss	30-50	Black	35.8	PASS
	25-40	White	27.5	PASS
Dry Film Hardness	No rupture of film	Black	No rupture of film	PASS
Film Adhesion	$\geq 4B$ (Dry)	Black	5B	PASS
	$\geq 4B$ (Wet)	Black	5B	PASS
	$\geq 4B$ (Boil)	Black	5B	PASS
Impact Resistance	No removal of film	Black	No film removal	PASS
Abrasion Resistance	≥ 40	Black	51.9	PASS
Chemical Resistance Muriatic Acid	No blistering or visual change	Black	No blister/change	PASS
		White	No blister/change	PASS
Chemical Resistance Mortar	No adhesion loss or visual change	Black	No loss/change	PASS
		White	No loss/change	PASS
Chemical Resistance Nitric Acid	$\Delta E_h \leq 5.0$	Black	Max. $\Delta E_h=0.65$	PASS
		White	Max. $\Delta E_h=0.83$	PASS
Chemical Resistance Detergent	No adhesion loss, blisters, visual change	Black	No loss/change	PASS
		White	No loss/change	PASS
Chemical Resistance Window Cleaner	No film removal, blisters, visual change	Black	No removal/change	PASS
		White	No removal/change	PASS
Corrosion Resistance Humidity Resistance	Blister size $\leq$ No. 8	Black	No blisters	PASS
		White	No blisters	PASS
Corrosion Resistance Cyclic Corrosion	Scribe rating (S) ≥ 7 Blister rating (B) ≥ 8	Black	S ≥ 7 ; B ≥ 8	PASS
		White	S ≥ 7 ; B ≥ 8	PASS
Weathering Color Retention	$\Delta E_h \leq 5.0$	Black	In-Progress	TBD
		White	In-Progress	TBD
Weathering Chalk Resistance	Chalking $\geq$ No. 8	Black	In-Progress	TBD
	Chalking $\geq$ No. 6	White	In-Progress	TBD
Weathering Gloss Retention	$\geq 50\%$	Black	In-Progress	TBD
		White	In-Progress	TBD
Weathering Erosion Resistance	< 10% film loss	Black	In-Progress	TBD
		White	In-Progress	TBD
T-Bend Test	No pick-off	Black	No pick-off	PASS
Reverse Impact	No removal of film	Black	No removal of film	PASS

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SECTION 3**TEST METHODS**

The specimens were evaluated in accordance with the following:

AAMA 2605-17a, *Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels*

ASTM D2244-11, *Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates*

ASTM D523-08, *Standard Test Method for Specular Gloss*

ASTM D7091-12, *Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals*

ASTM D3363-05 (Reapproved 2011)^{e2}, *Standard Test Method for Film Hardness by Pencil Test*

ASTM D3359-17, *Standard Test Methods for Measuring Adhesion by Tape Test*

ASTM D968-05 (Reapproved 2010), *Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive, Method A*

ASTM D2247-11, *Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity*

ASTM G85-11, *Standard Practice for Modified Salt Spray (Fog) Testing, Annex 5*

ASTM G7/G7M-13, *Standard Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials*

ASTM D4145-10 (Reapproved 2018), *Standard Test Method for Coating Flexibility of Prepainted Sheet*

SECTION 4**MATERIAL SOURCE**

The coated aluminum materials were provided by STACBOND. The following were received in good condition on 10/7/2019: 120 each, nominally 6-inch long by 3-inch wide by 0.02-inch thick, black and white coated aluminum plates. The black panels were identified as STB-415, and the white panels were identified as STB-420. Refer to the product description photos in Section 10. The material was tested as received. Representative materials/test specimens will be retained by Intertek B&C for a minimum of four years from the test completion date.

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SECTION 5

LIST OF OFFICIAL OBSERVERS

NAME	COMPANY
Joshua A. Kennedy	Intertek B&C
Joseph M. Brickner	Intertek B&C

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.

Color Uniformity

The color uniformity of the black and white coated aluminum panels was determined utilizing a GretagMacBeth Color i5 benchtop spectrophotometer (ICN: 004725) with a diffuse spherical geometry and a xenon lamp, CIELAB color space, illuminant D65, and 10° observer. The specular component was included in the measurements. Each specimen was used as a standard to compare all other specimens as a trial to determine the ΔE_h range. Each specimen was measured in three equally spaced regions to obtain an indication of uniformity.

Specular Gloss

The specular gloss of the black and white coated aluminum panels was determined utilizing a glossmeter (ICN: 005609) with 60° geometry. The calibration tile measured 105.9 with a standardized reference value of 106.0. Each specimen was measured at ten equally spaced locations. The coating thickness was measured utilizing a Byko-test 4500 dry film thickness gauge (ICN: 005618). Gloss values shall be within ± 5 units of the manufacturer's specification of 30-50 units for black and 25-40 units for white.

Dry Film Hardness

The dry film hardness of the black coated aluminum panels was determined utilizing graded hardness pencils. Each pencil was prepared according to the method and pushed forward at a 45° angle to the film surface using as much downward pressure to crumble the lead without breaking it. AAMA 2605 requires no rupture of film with a grade F pencil per ASTM D3363. A rupture is the exposure of the substrate.

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Film Adhesion

The film adhesion of the black coated aluminum panels was determined utilizing a cross cutter tool (ICN: Y002881) to produce a lattice of 100 squares with an area of 1.0 mm² per square. Elcometer 99 adhesive (ASTM D3359) tape was adhered over the lattice and sharply pulled off at a right angle to the plane of the surface. Five specimens each were tested dry, after a 20-minute immersion in boiling deionized water, and after an immersion in deionized water at 38°C for 24 hours. AAMA 2605 requires that a Level 4B classification per ASTM D3359 shall be achieved.

Direct Impact Resistance

The direct impact resistance of the black coated aluminum panels was determined utilizing a Gardner Impact Tester (ICN: Y000146) to strike the coated side of the panels at 24 in·lb_f to produce a 3.0 ±0.3 mm deformation. After impact, Elcometer 99 adhesive (ASTM D3359) tape was applied over the deformation and sharply pulled off at a right angle to the plane of the surface. Impact depth was measured with a Fowler digital caliper (ICN: INT 01066). AAMA 2605 requires no removal of film from substrate.

Abrasion Resistance

The abrasion resistance of the black coated aluminum panels was determined utilizing a falling-sand abrasion test apparatus. Each specimen was placed at a 45° angle, one inch under a 0.75-inch inner diameter tube. Two liters of sand were poured incrementally into the apparatus until a nearly 4.0 mm diameter of substrate was exposed, then 200 mL of sand were poured incrementally until a continuous 4.0 mm diameter of substrate was exposed. The coating thickness was measured with a Byko-test 4500 dry film thickness gauge (ICN: 005618), the abrasion width was measured with a Fowler digital caliper (ICN: INT01066).

Chemical Resistance

The chemical resistance of the black and white coated aluminum panels was determined utilizing muriatic acid, mortar, nitric acid, detergent, and window cleaner. Ten drops of 10% by volume muriatic acid solution were applied to specimens and covered with watch glasses for 15 minutes. Wet pats of mortar about 1300 mm² in area were applied to specimens for 24 hours at 100% relative humidity and 38°C in a humidity box (ICN: 005987) with a temperature control box (ICN: 005157). Three specimens each were placed painted side down over the mouth of nitric acid bottles for 30 minutes, rinsed with water, wiped dry, and measured for color change using the same procedure as color uniformity. Three specimens each were immersed in a 3% by weight detergent solution for 72 hours at 38°C in a Lindberg Blue M oven (ICN: Y002568), then Elcometer 99 adhesive (ASTM D3359) tape was applied along the entire length of the specimen and sharply pulled off at a right angle to the plane of the surface. Ten drops of window cleaner were applied to specimens and covered with watch glasses for 24 hours, rinsed with water, dried for four hours, scored by a cross cutter tool (ICN: Y002881) to produce a lattice of 100 squares with an area of 1.0 mm² per square, and Elcometer 99 adhesive (ASTM D3359) tape was adhered over the lattice and sharply pulled off at a right angle to the plane of the surface.

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Humidity Resistance

The humidity resistance of the black and white coated aluminum panels was determined by exposing the specimens for 4,000 hours at 38°C and 100% relative humidity in a humidity box (ICN: 005987) maintained with a temperature control box (ICN: 005157).

Corrosion Resistance

The humidity resistance of the black and white coated aluminum panels was determined by exposing the specimens for 2,000 hours in a Q-Fog CCT Chamber (ICN: 005959) in accordance with ASTM G85, Annex A5. The specimens were scored through the coating to reveal the substrate. After exposure, Elcometer 99 adhesive (ASTM D3359) tape was applied along the score of the specimen and sharply pulled off at a right angle to the plane of the surface.

Weathering

Color retention, chalk resistance, gloss retention, and erosion resistance are being determined by exposing specimens for 10 years in southern Florida at a 45° angle facing south, maintained and operated in accordance with ASTM G7. Weathering is currently in progress.

T-Bend Coating Flexibility

The flexibility of the coating was determined utilizing ASTM D3359 Tape to assess coating adhesion after the coating aluminum panels underwent T-bends. The T-bends were produced utilizing a vise to flatten the plates upon themselves across the rolling direction of the sheet. After the tape was rubbed flat and rapidly removed at a 180° angle, the coating and tape were examined for pickoff.

Reverse Impact Resistance

The reverse impact resistance of the black coated aluminum panels was determined utilizing a Gardner Impact Tester (ICN: Y000146) to strike the uncoated side of the panels at 24 in·lb_f to produce a minimum 3.0 ±0.3 mm deformation. After impact, Elcometer 99 adhesive (ASTM D3359) tape was applied over the deformation and sharply pulled off at a right angle to the plane of the surface. Impact depth was measured with a Fowler digital caliper (ICN: INT 01066). AAMA 2605 requires no removal of film from substrate.

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TEST SPECIMEN DESCRIPTIONS

TEST PROCEDURE	NUMBER OF SPECIMENS	NOMINAL SPECIMEN DIMENSIONS	VISUAL CHARACTERISTICS
Color Uniformity	4 black, 4 white	6 x 3 x 0.02 inch	Coated Aluminum
Specular Gloss	3 black, 3 white	6 x 3 x 0.02 inch	Coated Aluminum
Film Hardness	3 black	6 x 3 x 0.02 inch	Coated Aluminum
Film Adhesion	3 black	6 x 3 x 0.02 inch	Coated Aluminum
Direct Impact	3 black	6 x 3 x 0.02 inch	Coated Aluminum
Abrasion Resistance	3 black	6 x 3 x 0.02 inch	Coated Aluminum
Chemical Resistance	15 black, 15 white	6 x 3 x 0.02 inch	Coated Aluminum
Humidity Resistance	3 black, 3 white	6 x 3 x 0.02 inch	Coated Aluminum
Corrosion Resistance	3 black, 3 white	6 x 3 x 0.02 inch	Coated Aluminum
Color Retention	4 black, 4 white	6 x 3 x 0.02 inch	Coated Aluminum
Chalk Resistance	3 black, 3 white	6 x 3 x 0.02 inch	Coated Aluminum
Gloss Retention	3 black, 3 white	6 x 3 x 0.02 inch	Coated Aluminum
Erosion Resistance	3 black, 3 white	6 x 3 x 0.02 inch	Coated Aluminum
T-Bend	3 black, 3 white	6 x 3 x 0.02 inch	Coated Aluminum
Reverse Impact	3 black, 3 white	6 x 3 x 0.02 inch	Coated Aluminum

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TEST RESULTS

Color Uniformity Coordinates, Black

SPECIMEN	L	a	b
1	21.71	0.00	-0.35
2	21.69	-0.03	-0.40
3	21.69	0.00	-0.40
4	21.61	0.01	-0.35

Color Difference, Black

STANDARD SPECIMEN	TRIAL SPECIMEN (ΔE_h)			
	1	2	3	4
1	N/A	0.06	0.05	0.10
2	0.06	N/A	0.03	0.10
3	0.05	0.03	N/A	0.09
4	0.10	0.10	0.09	N/A

Color Uniformity Coordinates, White

SPECIMEN	L	a	b
1	92.44	-0.63	3.68
2	92.32	-0.66	3.56
3	92.44	-0.59	3.76
4	92.50	-0.60	3.80

Color Difference, White

STANDARD SPECIMEN	TRIAL SPECIMEN (ΔE_h)			
	1	2	3	4
1	N/A	0.17	0.09	0.14
2	0.17	N/A	0.24	0.30
3	0.09	0.24	N/A	0.07
4	0.14	0.30	0.07	N/A

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Specular Gloss, Black

MEASUREMENT	SPECIMEN 1	SPECIMEN 2	SPECIMEN 3
1	35.9	36.8	35.5
2	35.7	36.9	35.2
3	35.7	36.9	35.0
4	35.9	36.7	34.8
5	35.9	36.8	34.9
6	35.7	36.9	34.8
7	35.9	36.7	33.9
8	35.7	36.8	34.2
9	36.2	36.7	34.9
10	36.0	36.7	33.8
Average	35.9	36.8	34.7
Coating Thickness (mil)	1.19	1.18	1.10

Specular Gloss, White

MEASUREMENT	SPECIMEN 1	SPECIMEN 2	SPECIMEN 3
1	28.3	27.6	27.8
2	27.5	27.3	27.7
3	27.8	27.3	27.2
4	27.9	27.2	27.2
5	27.7	27.3	27.3
6	27.4	27.7	27.5
7	27.2	27.5	27.1
8	27.5	27.6	26.8
9	27.9	27.9	26.9
10	27.6	27.7	27.1
Average	27.7	27.5	27.3
Coating Thickness (mil)	1.22	1.29	1.25

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Dry Film Hardness, Black

PENCIL HARDNESS	Determination 1		Determination 2	
	Gouge	Scratch	Gouge	Scratch
3H	No	Yes	Yes	Yes
2H	No	Yes	No	Yes
H	No	Yes	No	Yes
F	No	No	No	No
PENCIL HARDNESS	Specimen 1	Specimen 2	Specimen 3	
F	No rupture	No rupture	No rupture	

Film Adhesion, Black

SPECIMEN	SET	RATING	OBSERVATIONS
1	DRY	5B	No removal of film or lattice detachment; no blistering
	BOIL	5B	No removal of film or lattice detachment; no blistering
	WET	5B	No removal of film or lattice detachment; no blistering
2	DRY	5B	No removal of film or lattice detachment; no blistering
	BOIL	5B	No removal of film or lattice detachment; no blistering
	WET	5B	No removal of film or lattice detachment; no blistering
3	DRY	5B	No removal of film or lattice detachment; no blistering
	BOIL	5B	No removal of film or lattice detachment; no blistering
	WET	5B	No removal of film or lattice detachment; no blistering

Direct Impact Resistance, Black

SPECIMEN	IMPACT DEPTH (mm)	OBSERVATIONS
1	3.05	No removal of film from substrate
2	3.22	No removal of film from substrate
3	3.18	No removal of film from substrate

Abrasion Resistance, Black

SPECIMEN	FILM THICKNESS (mil)	SAND VOLUME (L)	ABRASION COEFFICIENT
1	1.17	60.2	51.5
2	1.18	63.6	54.1
3	1.19	59.6	50.2
Average	1.18	61.1	51.9

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Chemical Resistance, Black

CHEMICAL	SPECIMEN	TIME	OBSERVATIONS
Muriatic Acid	1	15 min.	No blistering; no visual change
	2		
	3		
Mortar	1	24 hours	Mortar dislodged easily; no loss of film adhesion or change in appearance
	2		
	3		
Nitric Acid	1	30 min.	Chemical burn, $\Delta E_h=0.57$
	2		Chemical burn, $\Delta E_h=0.65$
	3		Chemical burn, $\Delta E_h=0.56$
Detergent	1	72 hours	No loss of adhesion, no blistering, no visual change
	2		
	3		
Window Cleaner	1	24 hours	No change in visual appearance, no blistering, no removal of film
	2		
	3		

Chemical Resistance, White

CHEMICAL	SPECIMEN	TIME	OBSERVATIONS
Muriatic Acid	1	15 min.	No blistering; no visual change
	2		
	3		
Mortar	1	24 hours	Mortar easily removed; no loss of film adhesion or change in appearance
	2		
	3		
Nitric Acid	1	30 min.	Slightly discolored, $\Delta E_h=0.83$
	2		Slightly discolored, $\Delta E_h=0.67$
	3		Slightly discolored, $\Delta E_h=0.77$
Detergent	1	72 hours	No loss of adhesion, no blistering, no visual change
	2		
	3		
Window Cleaner	1	24 hours	No change in visual appearance, no blistering, no removal of film
	2		
	3		

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Humidity Resistance, Black

SPECIMEN	EXPOSURE (hour)	OBSERVATIONS
1	4,000	No blisters; no visible deleterious effects
2	4,000	No blisters; no visible deleterious effects
3	4,000	No blisters; no visible deleterious effects

Humidity Resistance, White

SPECIMEN	EXPOSURE (hour)	OBSERVATIONS
1	4,000	No blisters; no visible deleterious effects
2	4,000	No blisters; no visible deleterious effects
3	4,000	No blisters; no visible deleterious effects

Corrosion Resistance, Black

SPECIMEN	SCRIBE RATING	BLISTER RATING	OBSERVATIONS
1	7	8	Blistering around scribe, tape removed from larger blisters
2	8	9	Blistering around scribe, tape removed from larger blisters
3	7	8	Blistering around scribe, tape removed from larger blisters

Corrosion Resistance, White

SPECIMEN	SCRIBE RATING	BLISTER RATING	OBSERVATIONS
1	10	10	No visible deleterious effects
2	10	10	No visible deleterious effects
3	10	10	No visible deleterious effects

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T-Bend Coating Flexibility, Black

SPECIMEN	T-BEND	PICKOFF	PICKOFF OBSERVATIONS	RATING
1	0T	No	No visible deleterious effects	0T
	1T	No	No visible deleterious effects	
	2T	No	No visible deleterious effects	
2	0T	No	No visible deleterious effects	0T
	1T	No	No visible deleterious effects	
	2T	No	No visible deleterious effects	
3	0T	No	No visible deleterious effects	0T
	1T	No	No visible deleterious effects	
	2T	No	No visible deleterious effects	

Reverse Impact Resistance, Black

SPECIMEN	IMPACT DEPTH (mm)	OBSERVATIONS
1	3.26	No removal of film from substrate
2	3.09	No removal of film from substrate
3	3.53	No removal of film from substrate

SECTION 9

CONCLUSION

The PVDF coated aluminum coils PVDF 70/30 (Polyvinyl Fluoride) meets the specified performance requirements of AAMA 2605 for Color Uniformity, Specular Gloss, Dry Film Hardness, Film Adhesion, Direct Impact Resistance, Abrasion Resistance, Chemical Resistance, Corrosion Resistance, T-Bend Flexibility, and Reverse Impact Resistance.

AAMA product approval is contingent upon Color Retention, Chalk Resistance, Gloss Retention, and Erosion Resistance after AAMA 2065, Section 8.9 Weathering.

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SECTION 10

PHOTOGRAPHS

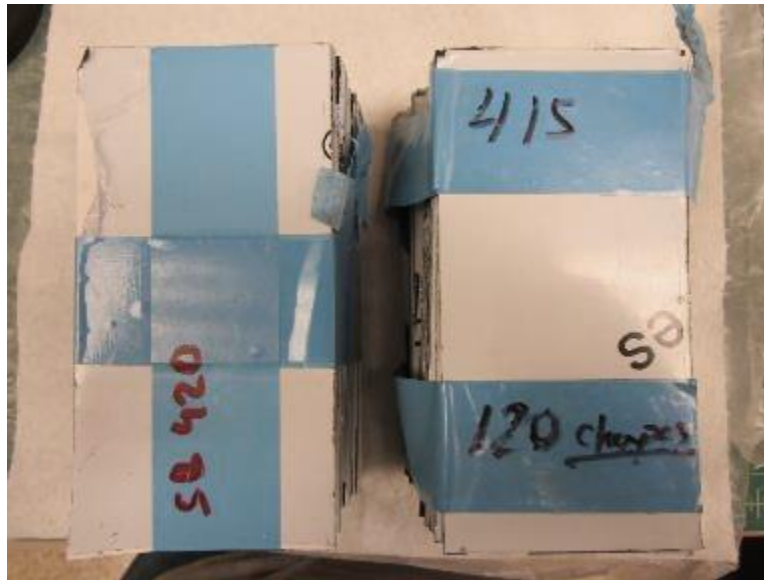


Photo No. 1
Material - As Received



Photo No. 2
Typical Black Panel, Front and Back Detail

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Photo No. 3
Typical White Panel, Front and Back Detail



Photo No. 4
Typical Color Test In-Progress Detail

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Photo No. 5
Typical Gloss Test In-Progress Detail



Photo No. 6
Typical Pencil Hardness Test In-Progress Detail

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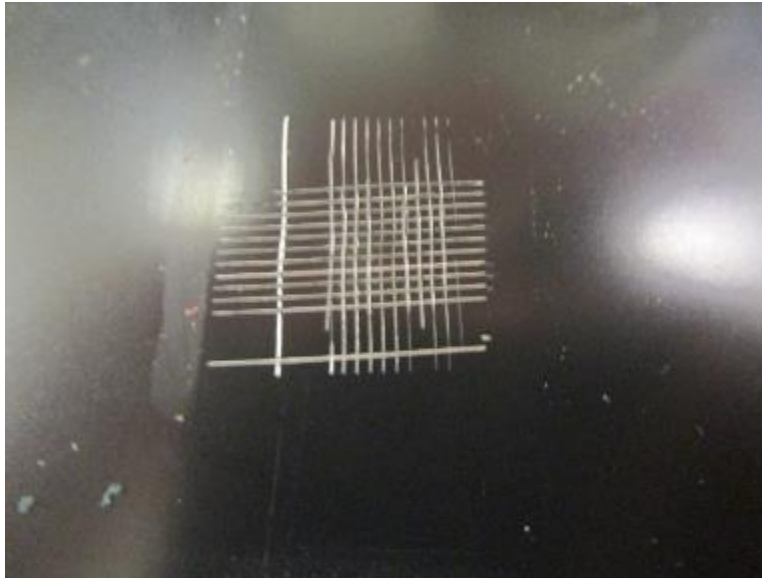


Photo No. 7

Typical Post-Dry Film Adhesion Specimen Lattice Detail



Photo No. 8

Typical Boil Film Adhesion In-Progress

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Photo No. 9
Typical Film Adhesion Tape Detail

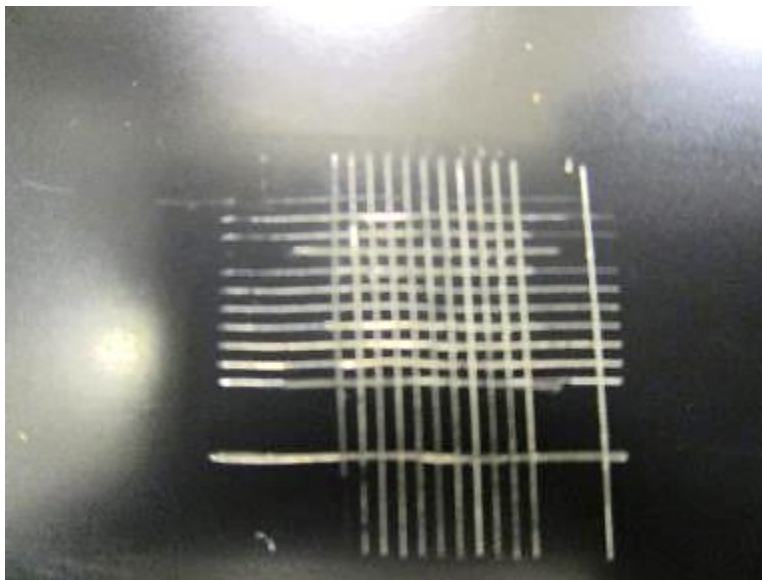


Photo No. 10
Typical Post-Film Adhesion Specimen Lattice Detail

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Photo No. 11
Typical Direct Impact Specimen Detail



Photo No. 12
Typical Post-Tape Direct Impact Specimen Detail

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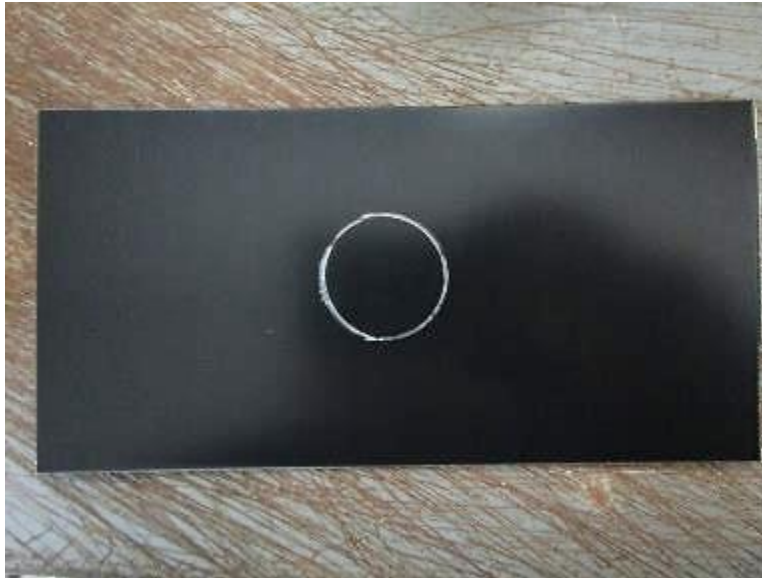


Photo No. 13

Typical Abrasion Resistance Specimen Detail



Photo No. 14

Typical Sand Abrasion Test Setup Detail

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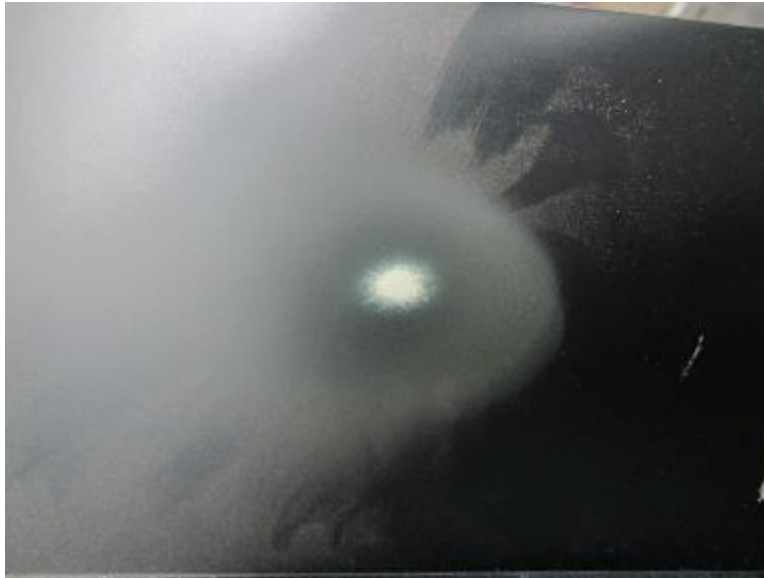


Photo No. 15
Typical Post-Abrasion Specimen Detail

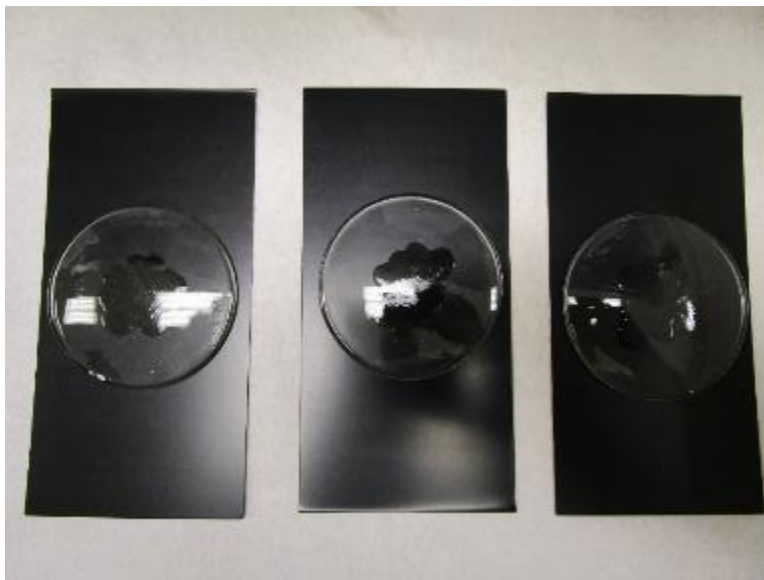


Photo No. 16
Muriatic Acid Chemical Resistance Exposure Detail (Black)

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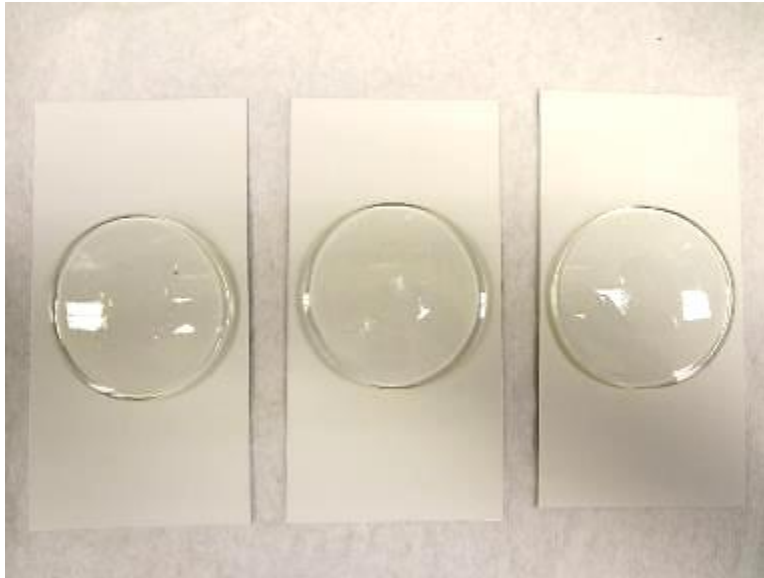


Photo No. 17

Muriatic Acid Chemical Resistance Exposure Detail (White)

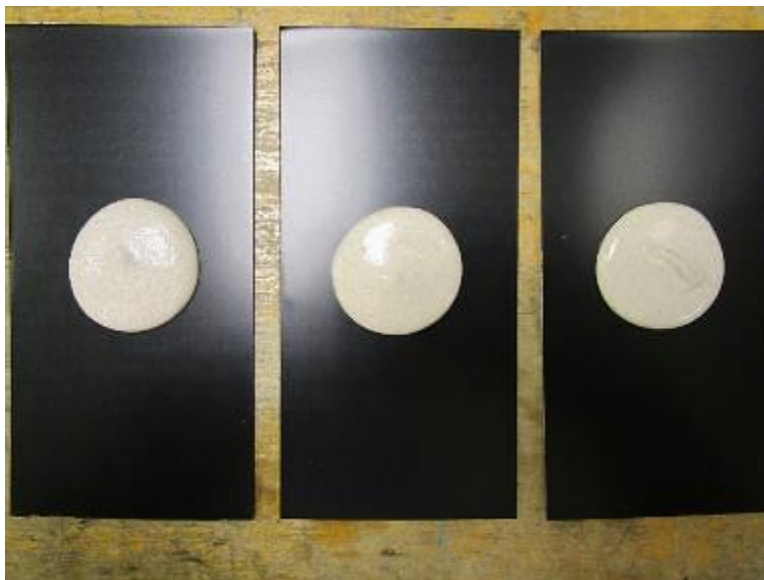


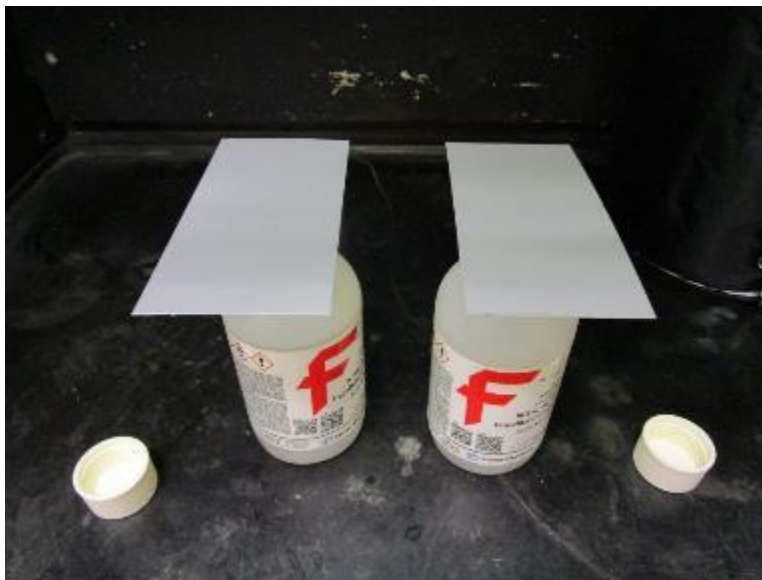
Photo No. 18

Mortar Chemical Resistance Exposure Detail (Black)

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**Photo No. 19****Mortar Chemical Resistance Exposure Detail (White)****Photo No. 20****Typical Nitric Acid Chemical Resistance Exposure Detail**

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Photo No. 21

Typical Post-Exposure Nitric Acid Specimen Detail (Black)



Photo No. 22

Typical Post-Exposure Nitric Acid Specimen Detail (White)

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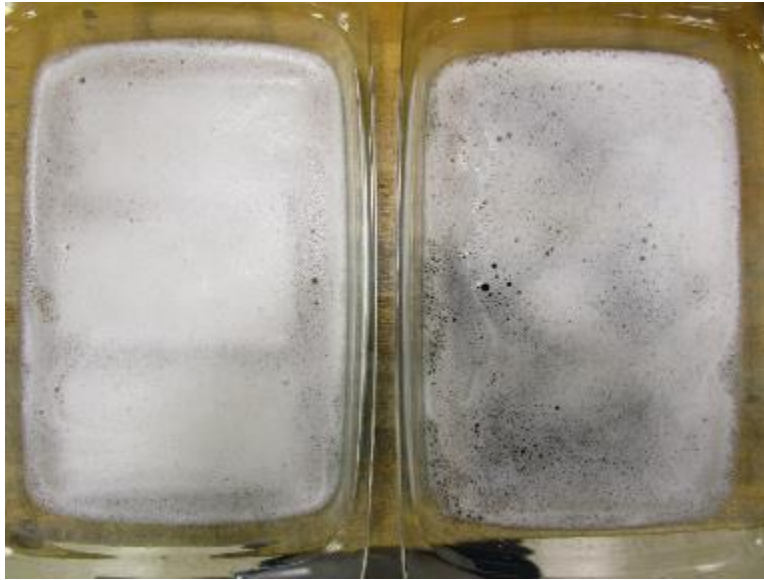


Photo No. 23

Typical Detergent Chemical Resistance Exposure Detail



Photo No. 24

Typical Post-Detergent Tape Detail

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Photo No. 25

Typical Post-Exposure Detergent Specimen Detail (Black)



Photo No. 26

Typical Post-Exposure Detergent Specimen Detail (White)

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Photo No. 27

Window Cleaner Chemical Exposure In-Progress Detail (Black)



Photo No. 28

Window Cleaner Chemical Exposure In-Progress Detail (White)

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Date: 07/14/20

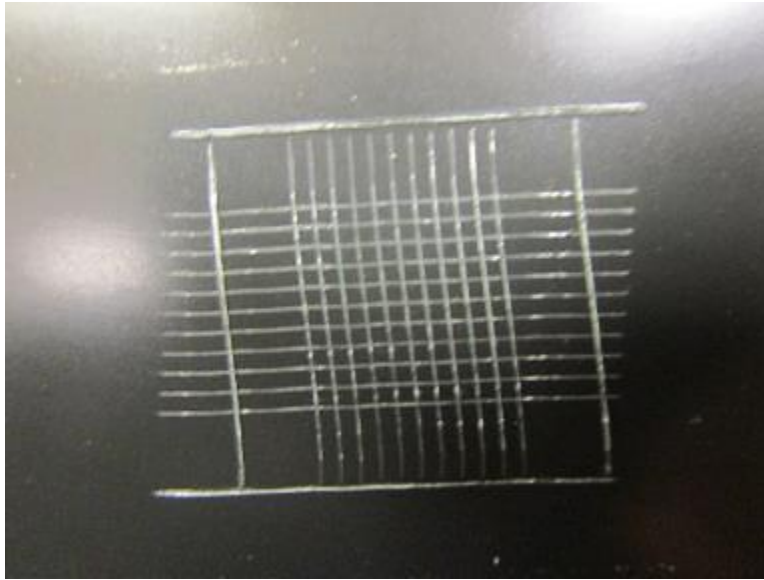


Photo No. 29

Typical Post-Exposure Window Cleaner Specimen Detail (Black)

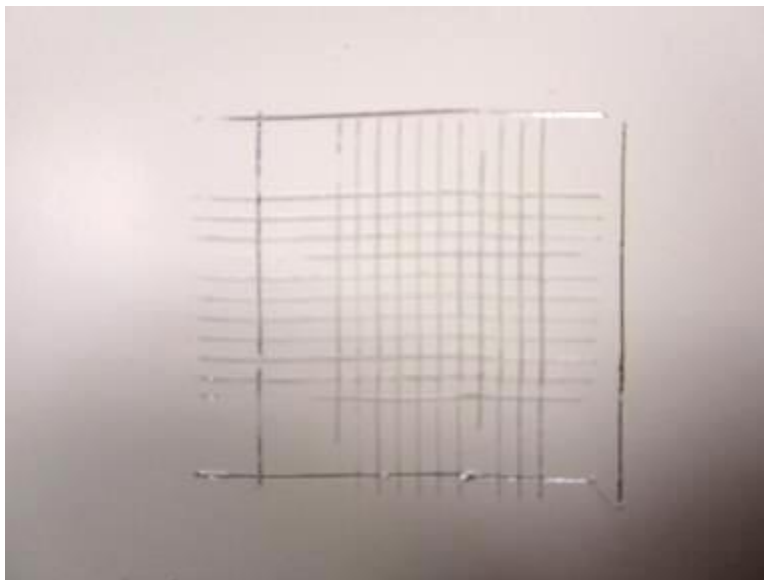


Photo No. 30

Typical Post-Exposure Window Cleaner Specimen Detail (White)

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Photo No. 31
Typical T-Bend Specimen Detail



Photo No. 32
Typical Reverse Impact Specimen Detail

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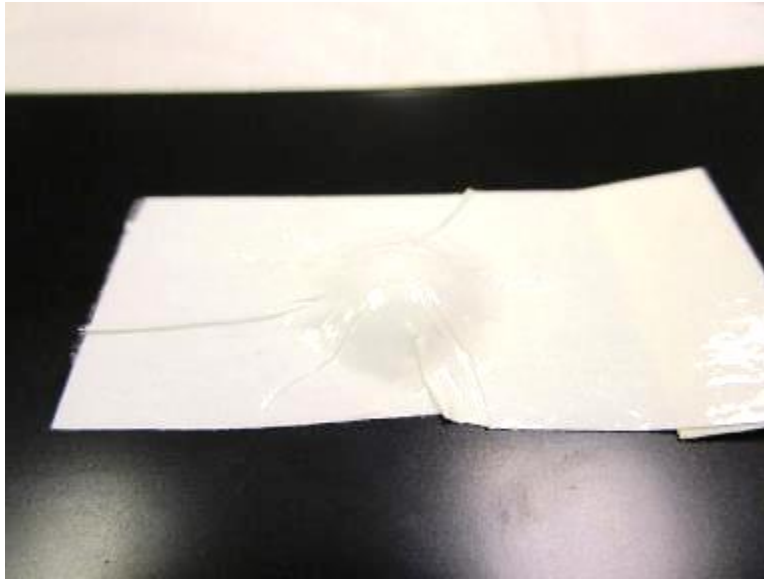


Photo No. 33
Typical Reverse Impact Tape Detail

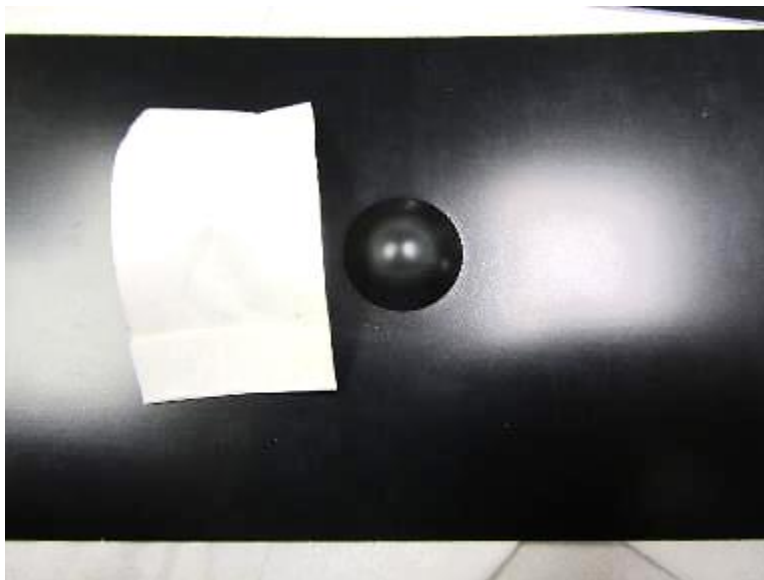


Photo No. 34
Typical Reverse Impact Post-Tape Detail



Total Quality. Assured.

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SECTION 11

DRAWING(S)

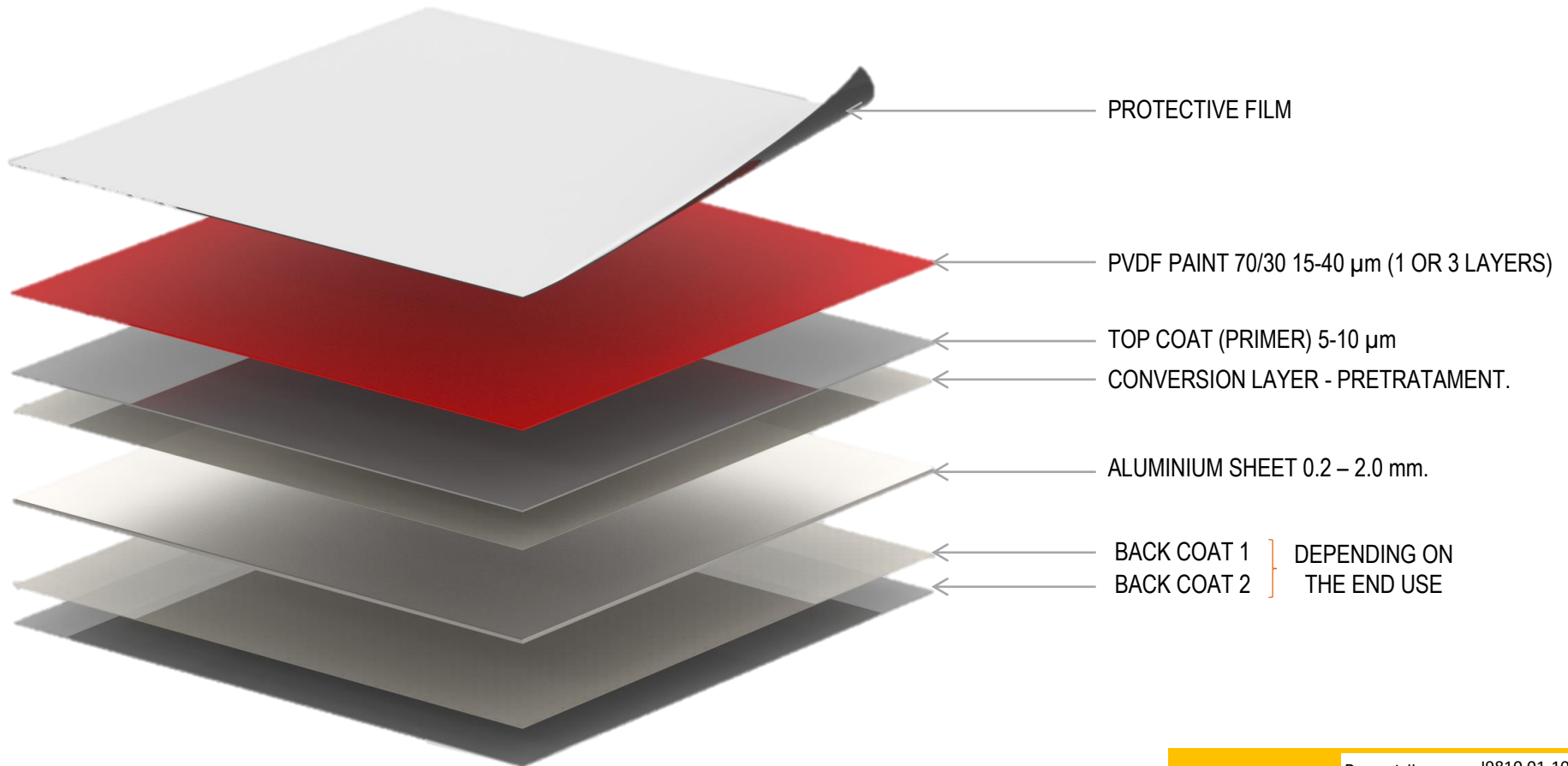
130 Derry Court
York, Pennsylvania 17406

Telephone: 717-764-7700

Facsimile: 717-764-4129

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SECTION 12

REVISION LOG

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