NUGLAZE

NuGlaze Rain Erosion Test
Boeing Report

Work Request 200803109-S00 – "Paint Sealant Evaluation in Support of CITAP 2214; Assessment of ""NuGlaze with PFS", " " materials".

Background and Test Goals:

This testing is in support of potential use on derivative 747 aircraft flown by the United States Air Force. The intended use of these products is to apply them to the exterior decorative topcoat to enhance the appearance of the topcoat and to extend the glossy appearance of paint throughout flight operations. The three tests to be performed by Boeing Commercial Airplane laboratories are:

1. Tendency of the product to compromise subsequent coating adhesion. Approximately 42 rain erosion test specimens will be coated with BMS10-72 exterior primer and topcoat, and then the candidate materials applied over the coating according to the manufacturer's instructions. Boeing lab personnel will then alkaline clean, sand, clean again, and re-apply topcoat to the test specimens. The test specimens will then be subjected to the standard Boeing rain erosion test (specimens mounted horizontally on a propeller, which is subjected to simulated rain and run at ~385 miles per hour for 30 minutes). If the candidate paint sealant/protectant compromises adhesion, the secondary topcoat layer will fail.
2. Approximately 21 rain erosion test specimens will be coated with BMS10-72 exterior paint and cured. The candidate sealants will then be applied to the entire coated surface and then the test specimens will be subjected to the standard Boeing rain erosion test (specimens mounted horizontally to a propeller, which is subjected to simulated rain and run at ~385 miles per hour for 30 minutes). Infrared spectroscopy will be used before and after the rain erosion testing to determine the ability of the sealant to withstand this common exterior environment.
3. Approximately 18 large, flat, aluminum test panels will be coated with BMS10-72 exterior paint and the paint cured. Select surface measurements will be collected from each panel (gloss, orange peel, possibly surface tension), and then the candidate sealants will be applied to the entire coated surface. The surface measurements will be repeated and comments will be documented regarding the application of each of the sealants (difficulty, ease, etc.).

Paint Sealant Materials Tested:

Product	Manufacturer
NuGlaze w/PFS - Paint Sealant/Glosser with PFS	Nuvite Chemical Compounds

Conclusions Drawn from Test Results:

Based on the results of the overcoat adhesion testing, the following conclusions are drawn:

1. All of the paint sealants negatively affected overcoat adhesion
2. Compared to the negative control (aged topcoat that was not sanded prior to over-coating), the NuGlaze product performed similarly to the un-sanded topcoat.
3. Based on infrared spectroscopy data and adhesion data, the process of solvent wiping, abrading with a maroon Scotchbrite pad, and solvent wiping again removes all of the paint sealant materials tested.

Based on the erosion resistance test run, the following conclusions can be drawn:

1. All of the paint sealants withstood 30 minutes of simulated rain erosion per BSS7393 type II (385 miler per hour average) and remained present on the painted rain erosion foil.

M&PT Statement:

Based on the test results from WR 200803109, M&PT has no technical objection to the use of these materials on the exterior topcoat of the VC-25/A aircraft. This approval is conditional based on the proper removal of these paint sealants prior to repainting the aircraft.

___{signed page above}_____
Mark P. Johnson,
Material and Process Engineer, Corrosion and Finishes

1. Test 1 – Affect of Paint Sealants on Subsequent Topcoat Adhesion:

Test Matrix for Intercoat Topcoat Adhesion Rain Erosion

Substrate	42 Rain Erosion Foils, Aluminum, 2024-T3 Clad													
Original Paint System	BMS10-72 Ty VIII (10P20-44/CA8000B70846/CA8000B/CA8000C)													
Paint Treatment	None										NuGlaze			
Reactivation	None	D6-1816	None	D6-1816	None	D6-1816	None	D6-1816	None	D6-1816	None	D6-1816	None	D6-1816
Secondary Topcoat	BMS10-72 Ty VIII Topcoat (CA8000B70846/CA8000B/CA8000C)													

1.1 Preparation and Coating of Aluminum Rain Erosion Foils:

1.1.1 ScotchBrite Abrade per BMS10-72, section 8.1.2.2a.

1.1.2 Apply Alodine 1000 or AC-131-CB per BMS10-72 (except do not rinse the foils if the AC-131-CB is used, BMS10-72 Section 8.1.2.3b. is incorrect in Rev. W).

1.1.3 Apply 10P20-44 primer to all the foils and allow primer to dry at 75°F and ~30%-60% relative humidity for ~1-3 hours.

1.1.4 Apply primer to an aluminum witness panel.

1.1.5 Apply the topcoat to all of the foils at normal thickness of 2.5 ± 0.5 mils. Apply three coats of paint, waiting approximately 30 minutes between coats. Use the slowest thinner (CA8000C).

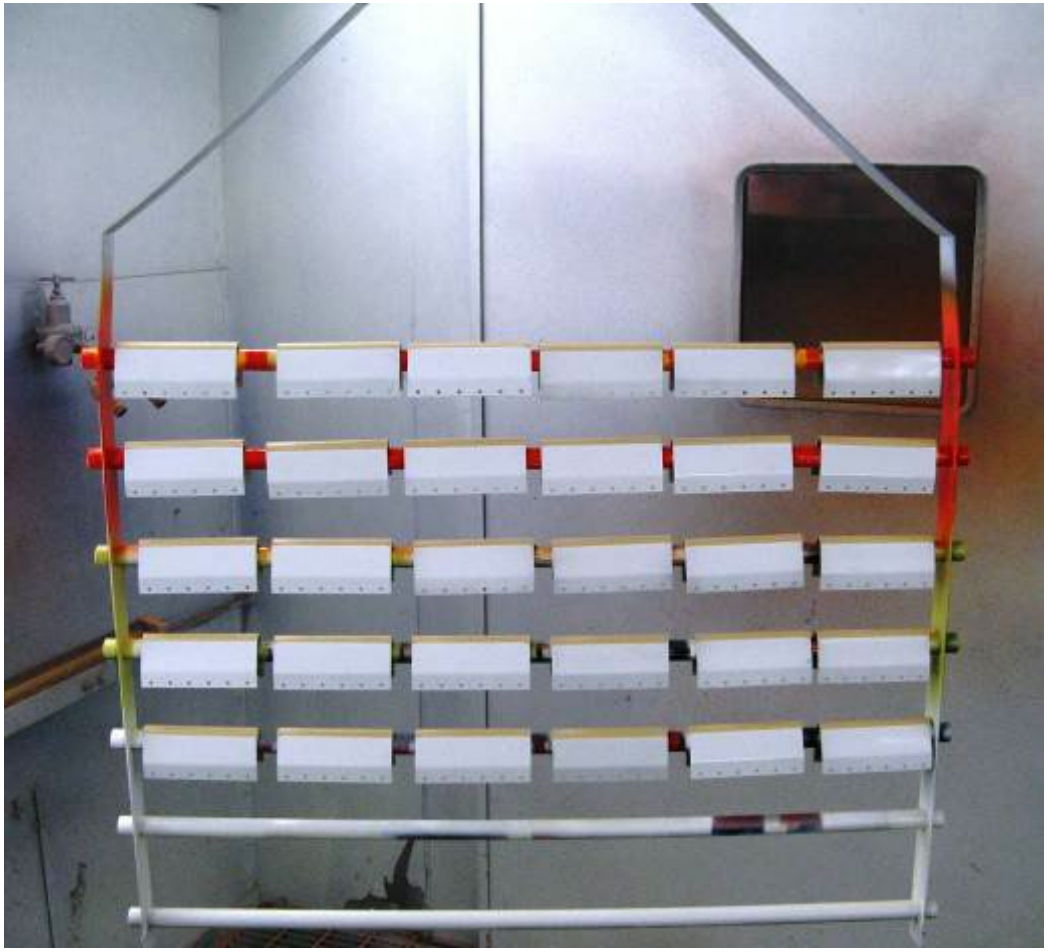
1.1.6 NOTE – for the foil painting above, paint the entire rain erosion foil per BSS7393, Type II.– do not mask off the leading edge at this stage.

1.1.7 Cure all of the foils continuously for 14 days at 75°F/50% RH prior to applying paint sealants.

1.1.8 Measure and record total coating thickness in data table below. Collect at least three coating thickness readings per rain erosion foil and record the average in the table.

1.1.9 Work was completed on 8/28/08.

1.1.10 Foils were cured for 3.5 days at 120°F and 50% RH as an option to 14 days at 75°F and 50%RH in order to meet schedule requirement.



Picture 1.1-1; Rain Erosion Foils Being Over-coated

1.2 **Application of Paint Sealants:** Following 14 day cure of the paint system, apply the paint sealants according to the test matrix and per the manufacturers instructions detailed below. Each paint sealant will be applied using the same application process to six (6) replicate rain erosion foils.

Completed on 4SEP2008 in the 2-122 panel prep lab. 70°F and 49 %RH

Picture 1.2-1; Example of Paint Sealant Application to Rain Erosion Foils

1.2.1.1 NuGlaze Application:

1.2.1.2 Apply NuGlaze "as-is" to clean terry or smooth cotton towel or to mophead.
1.2.1.3 Wipe material evenly onto surface and agitate to ensure full coverage.
1.2.1.4 Allow to fully dry on surface (usually no more than 5-20 minutes depending on humidity conditions).
1.2.1.5 Remove by buffing out by hand with clean, cotton flannel, dry terry towel (turn cloth frequently) or mophead to shine.

Picture 1.2-5; NuGlaze

1.2.1.6 No paint sealant applied to 6 control foils.

1.2.2 Following application of paint sealants to rain erosion foils, perform infrared spectroscopy analysis on one location of each foil, on the side of the foil where the secondary layer of topcoat will be applied. Have the analytical lab document the instrument used and the infrared spectroscopy method used to analyze the surface.

1.2.3 FTIR completed on 06-07SEP2008.

1.3 Reactivation of Coated and Sealed Foils

1.3.1 According to the test matrix, three (3) foils of each condition receive reactivation (for a total of 21 foils)

1.3.2 Reactivate these foils per D6-1816, Section 8.5.3.1b:

> Reactivate the surface by sanding with progressively finer abrasive paper or pads. Final sanding should end with 220 grit abrasive papers or very fine grade abrasive pads (Section 5.6c) or finer. (Solvent clean with materials listed in Section 5.1 prior to sanding if contaminants are present or suspected to be present.) Sand glossy enamel surfaces until gloss is removed.
> Remove sanding dust. Tack rag (Section 5.4) surface prior to painting. Sanded enamel surfaces may be primed before overcoating with enamel.

1.3.3 Summary of cleaning and reactivation process

1.3.3.1 Foils were solvent cleaned/wiped with BMS15-5 wipers saturated with MEK meeting the requirements of ASTM D740 Type I.

1.3.3.2 Following solvent cleaning, the foils were all abraded using an air-powered jitterbug and the following abrasive;

> Scotch-Brite Pad, Maroon Color, Very Fine, Aluminum Oxide, Non-woven, Resin Bonded; 7447 or Clean and Finish, Grade A, Very Fine, 3M Co.

1.3.3.3 Following abrasion, the foils were blown clean using compressed air meeting the requirements of BSS7217.

1.3.3.4 The foils were tack-rag wiped using the Tack Rag C-60 from the Chemical Cleaning Cloth Co.

1.3.3.5 Following tack wiping, the foils were solvent cleaned again using BMS15-5 wipers and MEK.

Picture 1.3-1; Example of Topcoat Reactivation and Paint Sealant Removal On Rain Erosion Foils

1.4 Specific cleaning/removal instructions for coated and treated foils that get reactivated:

1.4.1 Following reactivation and cleaning, perform infrared spectroscopy analysis on one location of each foil, on the side of the foil where the secondary layer of topcoat will be applied.

1.4.2 Following infrared spectroscopy analysis, solvent clean the foils again to remove possible contaminants.

1.4.3 Cleaning, reactivation and post-cleaning FTIR analysis was completed on 09SEP2008

1.5 Application of Secondary Topcoat to All Foils: (completed on 9/10/08 @ 40% RH and 74°F)

1.5.1 Mask bullnose of each foil per BSS7393

1.5.2 After infrared analysis and bullnose masking, and additional/final solvent wipe, apply BMS10-72 type 8 topcoat (CA8000B70846/CA8000B/CA8000C) per BMS10-72, Section 8.2.17 (4.0 ± .5 mils).

1.5.3 Cure for 2 weeks minimum and run rain erosion per BMS10-72/BSS7393 type II.

Intercoat Topcoat Adhesion Rain Erosion Matrix and Data Table:

Foil #	Treatment Applied	Reactivation Performed	Initial Topcoat Thickness	Initial Topcoat Thickness After Reactivation	Total Topcoat Thickness	Secondary Topcoat Thickness (target = 4.0 mils)	Rain Erosion Result	Failure Description
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31	NuGlaze	D6-1816	2.7	2.4	8.1	5.7	10	N/A
32	NuGlaze	D6-1816	2.6	2.4	7.7	5.3	10	N/A
33	NuGlaze	D6-1816	2.3	2.2	7.5	5.3	10	N/A
34	NuGlaze	None	2.3	2.3	8.3	6.0	2	Between topcoats
35	NuGlaze	None	2.9	2.9	9.4	6.5	3	Between topcoats
36	NuGlaze	None	2.2	2.2	7.7	5.5	3	Between topcoats
37								
38								
39								
40								
41								
42								

Picture 1.5-1; Typical Example of Secondary Topcoat De-wetting When Applied over Topcoat with Paint Sealant Applied

10 No loss

9 Very slight chipping

8 Slight chipping to 0.10 inches

7 No tear greater than 0.25 inches

6 Tears greater thatn 0.25 inches with maximum 10 percent loss of coating

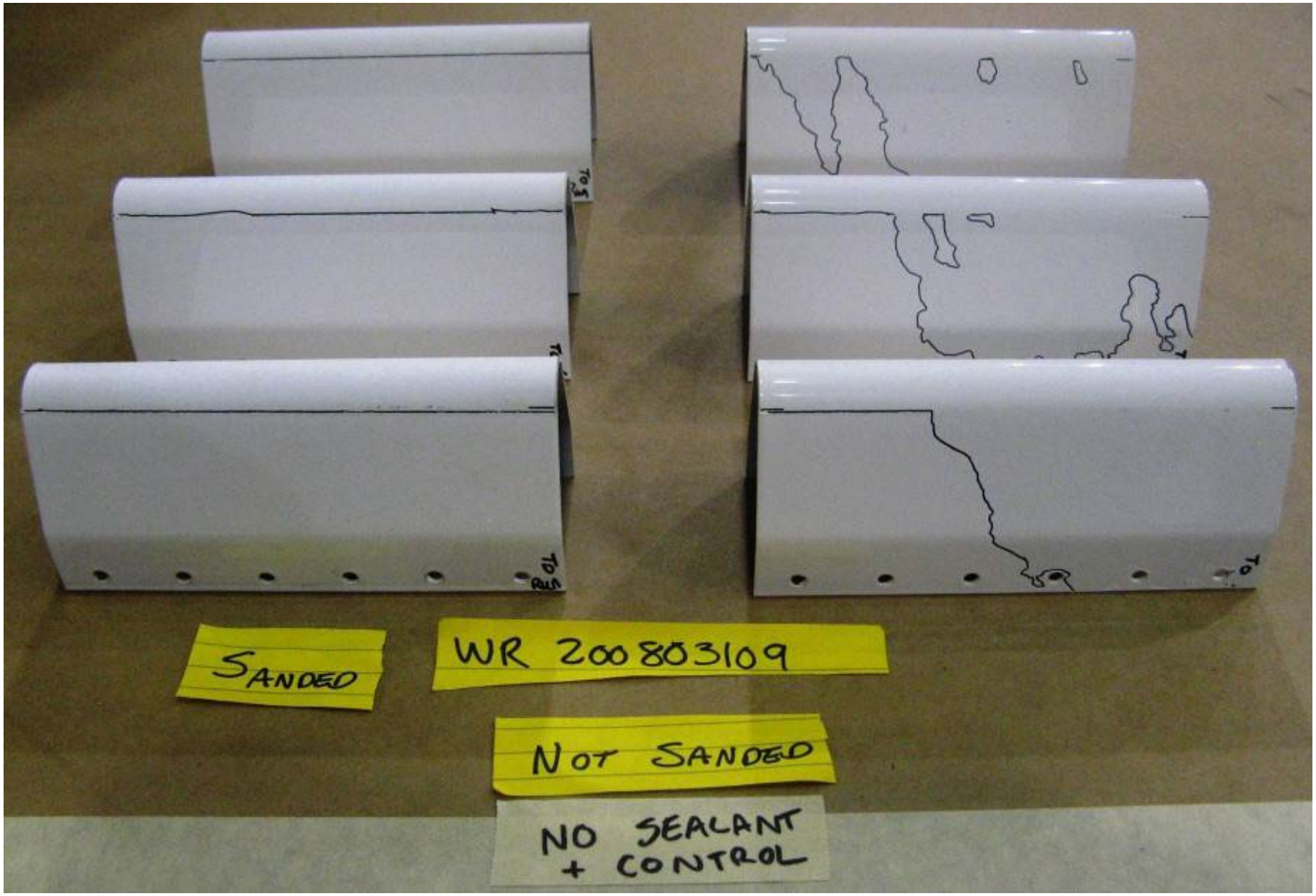
5 25 percent loss of coating

4 40 percent loss of coating

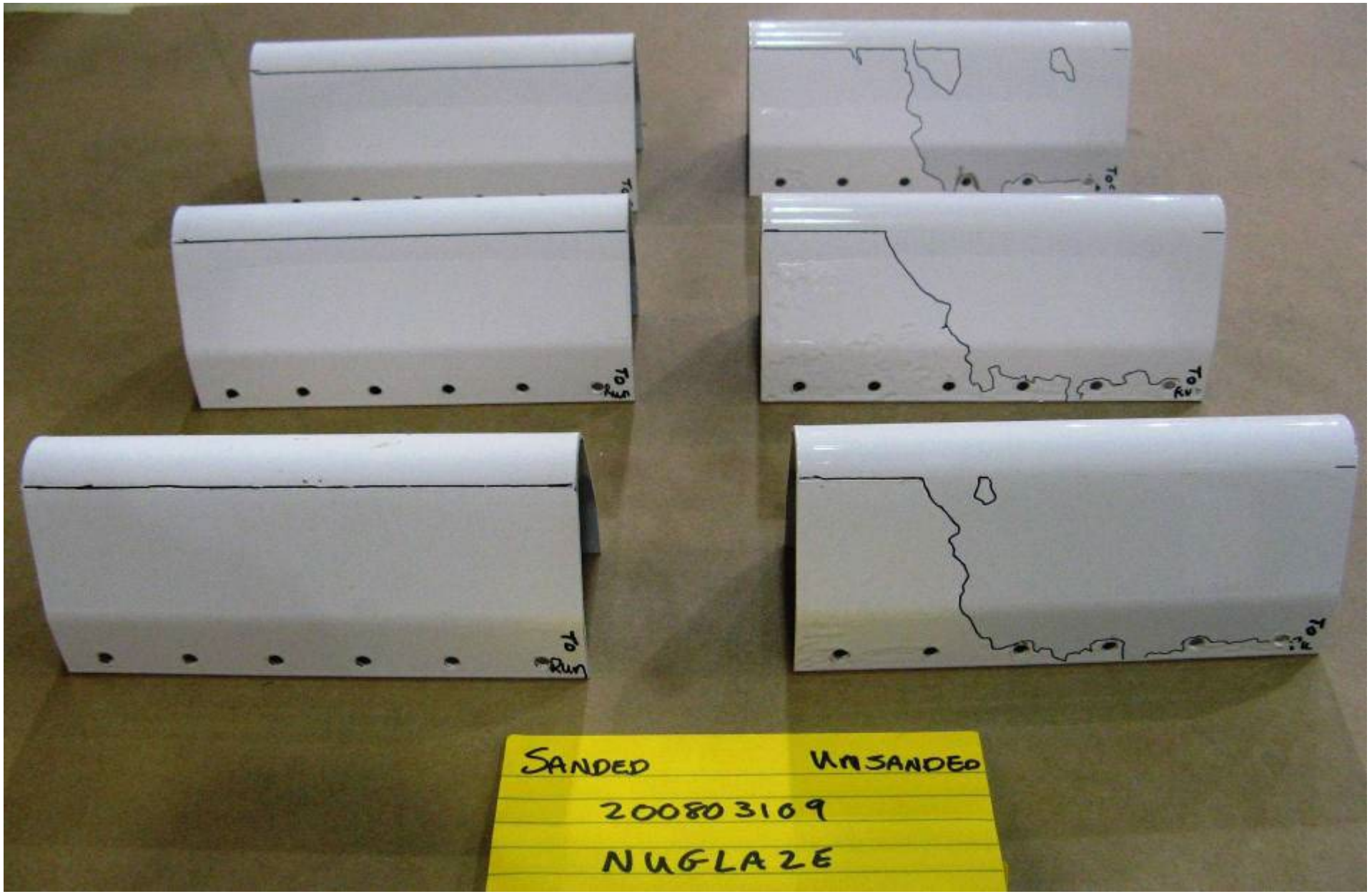
3 50 percent loss of coating

2 75 percent loss of coating

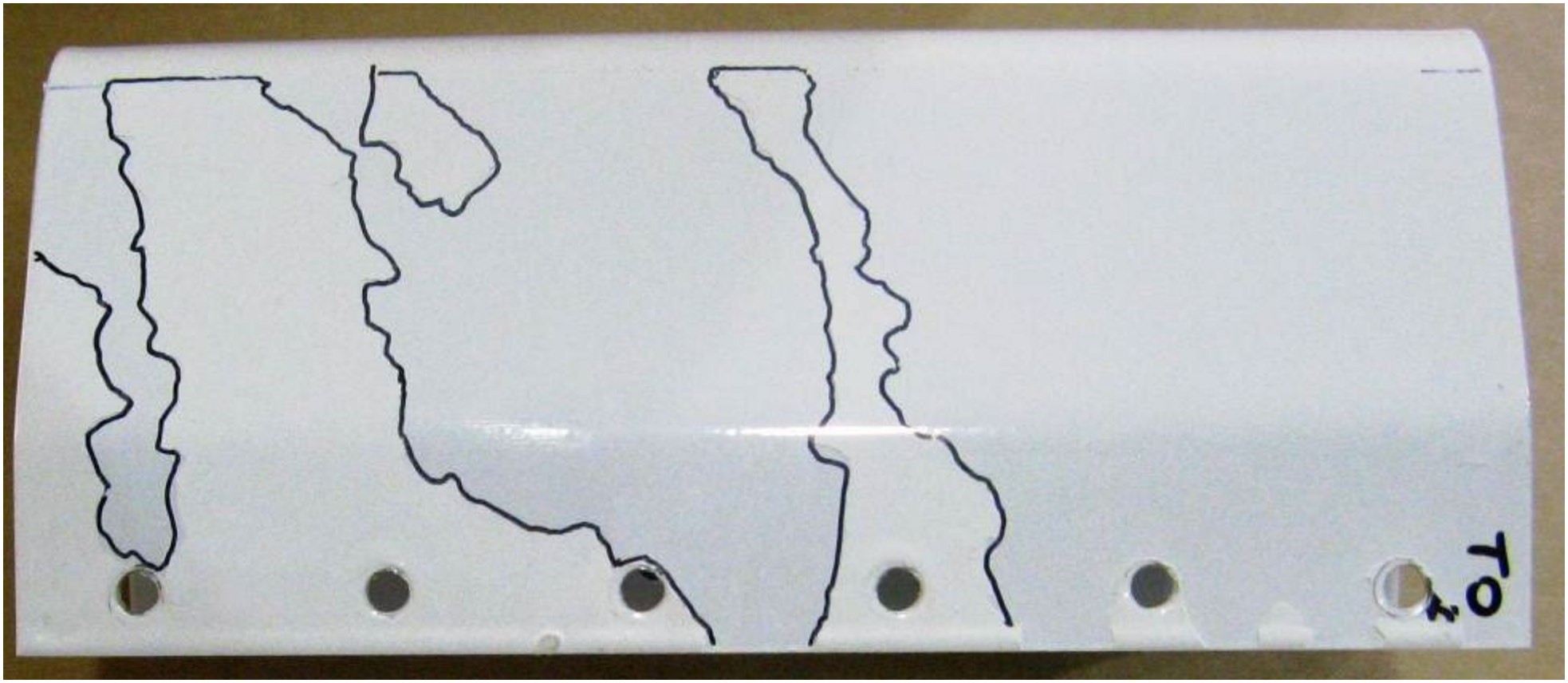
1 100 percent loss of coating



Picture 1.5-4; Post Rain Erosion, Overcoat Adhesion, No Paint Sealant, Control Foils



Picture 1.5-6; Post Rain Erosion, Overcoat Adhesion, NuGlaze



Picture 1.5-9; Close-Up of Completed Rain Erosion Foil. Black Lines Highlight Remaining Secondary Topcoat

Based on the results of this overcoat adhesion testing, the following conclusions are drawn:

4. All of the paint sealants negatively affected overcoat adhesion.
5. Based on infrared spectroscopy data and adhesion data, the process of solvent wiping, abrading with a maroon Scotchbrite pad, and solvent wiping again removes all of the paint sealant materials tested.

2 Test 2 – Determination of Rain Erosion Resistance

2.1 Preparation and Coating of Aluminum Rain Erosion Foils:

2.1.1 To 24 rain erosion foils, ScotchBrite Abrade per BMS10-72, section 8.1.2.2a.

2.1.2 Apply Alodine 1000 or AC-131-CB per BMS10-72 (except do not rinse the foils if the AC-131-CB is used, BMS10-72 Section 8.1.2.3b. is incorrect in Rev. W).

2.1.3 Apply 10P20-44 primer to all the foils and allow primer to dry at 75°F and ~30%-60% relative humidity for ~1-3 hours.

2.1.4 Apply primer to an aluminum witness panel.

2.1.5 Apply the topcoat to all of the foils at normal thickness of 2.5 ± 0.5 mils. Apply three coats of paint, waiting approximately 30 minutes between coats. Use the slowest thinner (CA8000C).

2.1.6 NOTE – for the foil painting above, paint the entire rain erosion foil per BSS7393, Type II.– do not mask off the leading edge.

2.1.7 Cure all of the foils continuously for 14 days at 75°F/50% RH prior to applying paint sealants.

2.1.8 Measure and record total coating thickness in data table below. Collect at least three coating thickness readings per rain erosion foil and record the average in the table.

2.1.9 Work completed on 28AUG2008 at 72°F and 49% RH.

2.2 **Application of Paint Sealants:** Following 14 day cure of the paint system, apply the paint sealants according to the test matrix and per the manufacturers instructions detailed below. Each paint sealant will be applied using the same application process to 3 (3) replicate rain erosion foils.

2.2.1 Follow Section 1.2 above.

2.2.2 Completed on 04SEP2008 at 70 °F and 49% RH

2.2.3 Following application of paint sealants to rain erosion foils

2.2.3.1 Collect 20 and 60° gloss levels from each of the foils

2.2.3.2 Perform infrared spectroscopy analysis on three locations of each foil, on a location of the foil where the secondary layer of topcoat will be applied. Map the location of each FTIR reading.

Spectroscopy Instrument was a SOC400 handheld instrument with a specular reflectance head.

Spectral curves for Test 2 are included in Appendix B below.

Picture 2.1-1 and 2.1-2; SOC 400 (left) and Infrared Spectroscopy Analysis of Paint Sealant on Painted Rain Erosion Foil (right)

2.3 Erosion testing:

2.3.1 Following gloss and spectroscopy readings, subject the painted and sealed foils to rain erosion per BMS10-72 except omit water immersion prior to rain erosion (30 minutes at 385 mph).

2.3.2 Following completion of rain erosion, collect gloss and spectroscopy data using the same locations and methods as in 2.2.8 above.

2.3.3 Note any appearance changes or noteworthy observations.

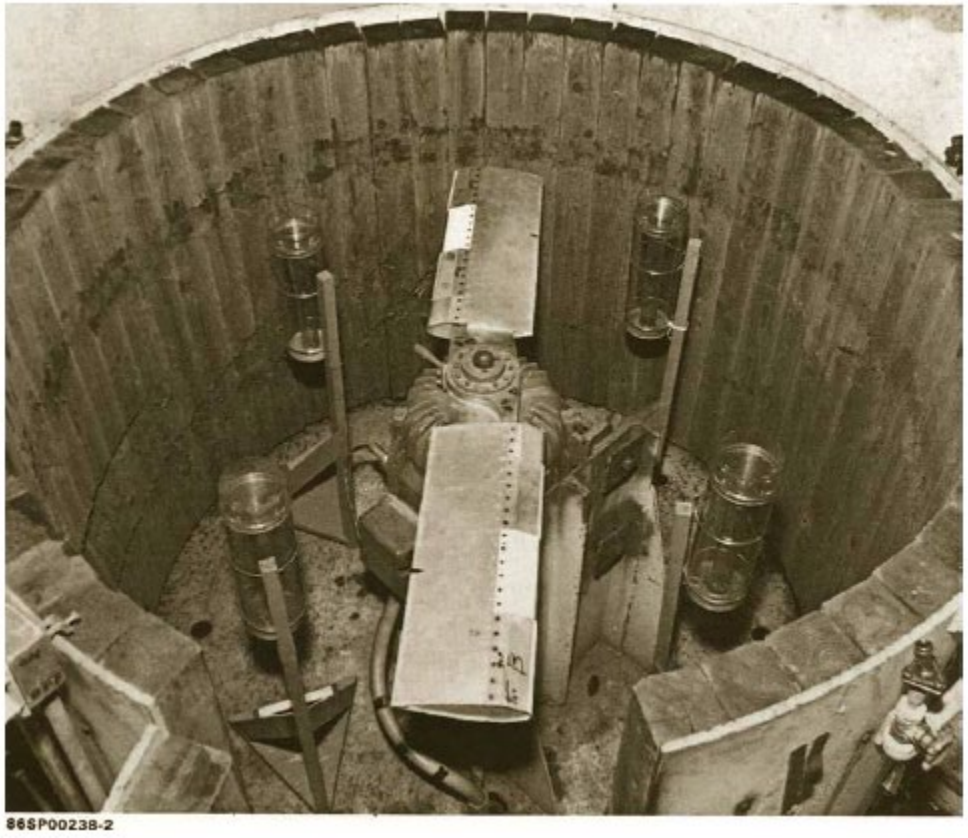
2.3.4 Photograph all completed foils

Erosion Resistance Test Matrix:

Substrate	21 - 2024-T3 Clad Aluminum Rain Erosion Foils						
Primer and Topcoat	BMS10-72 ty VIII (10P20-44 + CA8000/B70846/CA8000B/CA8000C)						
Topcoat Treatment	None				NuGlaze		

Full Matrix and Data Table for Erosion Resistance Test:

Rain Erosion Foil #	Treatment Applied	Gloss Before Application		Gloss After Application		Gloss After Rain Erosion		Gloss Difference Between After Application and After Rain Erosion		20 Deg Gloss Difference, Avg
		20°	60°	20°	60°		60°	20°	60°	
43										
44										
45										
46										
47										
48										
49										
50										
51										
52										
53										
54										
55										
56										
57										
58	Nu Glaze	79.2	93.9	80.7	94.2		93.8	6.7	0.4	
59	Nu Glaze	80.6	94.4	85.5	94.6		92.7	6.3	1.9	
60	Nu Glaze	82.9	93.7	81.8	93.4	4.3	92.2	0	1.2	4.3
61										
62										
63										
64										
65										
66										



Picture 2.3-1; Picture of Boeing M&PT Rain Erosion Test Fixture

Picture 2.3-2; All Painted and Sealant-Treated Rain Erosion Foils Following Rain Erosion

Based on the erosion resistance test run, the following conclusions can be drawn:

2. All of the paint sealants withstood 30 minutes of simulated rain erosion per BSS7393 type II (385 miler per hour average) and remained present on the painted rain erosion foil.

3 Paint Protectant/Sealant Application and Appearance Test

3.1 To 42 clad, 2024-T3 panels, 12 inches by 12 inches by 0.040 inches, apply primer and topcoat as follows:

3.1.1 Apply Alodine 1000 or AC-131-CB per BMS10-72 (except do not rinse the foils if the AC-131-CB is used, BMS10-72 Section 8.1.2.3b. is incorrect in Rev. W).

3.1.2 Apply 10P20-44 primer to all the panels and allow primer to dry at 75°F and ~30%-60% relative humidity for ~1-3 hours.

3.1.3 Apply primer to an aluminum witness panel.

3.1.4 Apply the topcoat to all of the panels at normal thickness of 2.5 ± 0.5 mils. Apply three coats of paint, waiting approximately 30 minutes between coats. Use the slowest thinner (CA8000C). Follow the test matrix to apply BAC5071 blue topcoat to 21 panels and BAC793 white topcoat to half of the panels. Note – total coating thickness was measured to be approximately 2.6 mils (primer + topcoat).

3.1.5 Cure all of the panels continuously for 14 days at 75°F/50% RH prior to applying paint sealants.

3.1.6 Measure and record total coating thickness in data table below. Collect at least three coating thickness readings per panel and record the average in the table.

3.1.7 Measure and record 20° gloss

3.1.8 Measure and record orange peel, using the Tension scale

3.2 Apply the paint sealants according to the test matrix and the following instructions.

3.2.1 NuGlaze Application:

3.2.2 During the application of the paint protectants/sealants, record notes regarding the application of each (ease, practicality, problems etc.). Assign an arbitrary rating based on ease of use and final appearance. Rating to be between 1 and 6, with 1 being the easiest to use and having the best appearance.

NOTE – paint sealants were applied to appearance test panels on 9/24/08 at 72°F and 42 % RH.

Material	Comments	Arbitrary Rating
NuGlaze	Dried quickly , very difficult to remove once dry. Very difficult to remove if applied too thick. Appeared to have a short window between “easy to buff” and “dried hard”. Easy to see where it has been applied.	6

3.3 After paint sealant/protectant application, collect thickness, gloss and orange peel readings per 3.1.6-8.

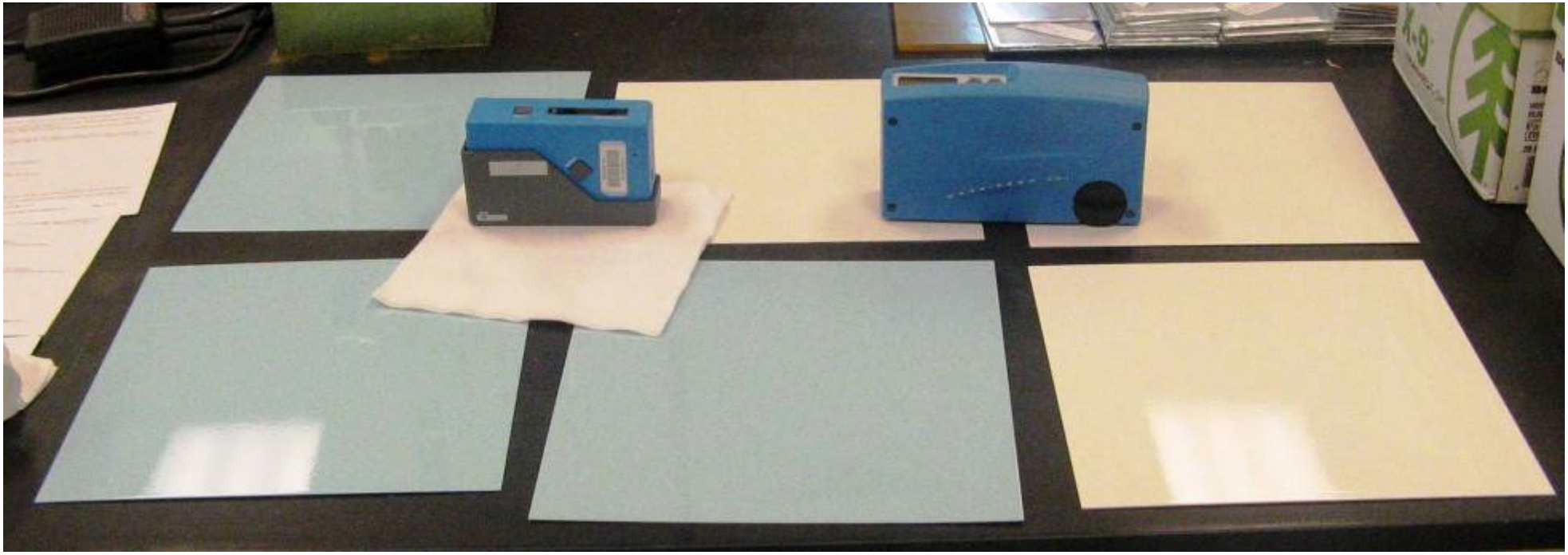
Appearance and Application Test Matrix:

Substrate	42 - 2024-T3 Clad Aluminum Rain Erosion Foils													
Primer and Topcoat	BMS10-72 ty VIII (10P20-44 + CA8000/B**5071**/CA8000B/CA8000C)							BMS10-72 ty VIII (10P20-44 + CA8000/B**793**/CA8000B/CA8000C)						
Topcoat Treatment	None				NuGlaze			None				NuGlaze		

Appearance and Application Test Full Matrix and Data Table:

Panel #	BAC Color	Topcoat Treatment	20 Degree Gloss Before Treatment	20 Degree Gloss After Treatment	Tension Orange Peel Before Treatment	Tension Orange Peel After Treatment	Average 20Deg Before Treat	Average 20 Deg After Treat	Loss in gloss due to treatment
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13	BAC5071	NuGlaze	84	85.4	12.6	11.7			
14	BAC5071	NuGlaze	84.2	82.6	12	11.9			

15	BAC5071	NuGlaze	84.5	83	9.9	10.4	84.2	83.7	0.6
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34	BAC793	NuGlaze	85.2	82	11	10.5			
35	BAC793	NuGlaze	83.6	77.5	11.4	11.1			
36	BAC793	NuGlaze	85.5	83.8	12.6	12.1	84.8	81.1	3.7
37									
38									
39									
40									
41									
42									



Picture 3.3-1; Example of Gloss and Orange Peel Measurements Taken from Appearance Panels

From the small-scale application test, the following conclusions can be drawn:

4. **Coating Information**

4.1 Info for Sections 1.1 and 2.1 above:

	Product Designation	Batch Number	DOM	Date Applied	Mix Info
Conversion Coating	Alodine 1000 or AC-131-CB	-----	-----		-----
Primer	10P20-44	JA5287	02/2008	28AUG2008	178.9 grams:39 grams:47 grams
	EC-265	JA5284	01/2008		Mixed at 7:30, applied at 8:30
	TR-114	JA4830	12/2007		73°F and 36 % RH
White Topcoat	CA8000/B70846	141287	01/2008	28AUG2008	73°F and 36 % RH
	CA8000B	227437	11/2007		Mixed at 9:00, applied starting at 9:30
	CA8000C	135834	01/2008		
NuGlaze	B-11635				

Info for Section 1.5 Above:

	Product Designation	Batch Number	DOM	Date Applied	Mix Info
White Topcoat	CA8000/B70846	141287	01/2008	10SEP2008	72°F and 41 %RH
	CA8000B	227427	09/2007		
	CA8000C	130534	01/2008		Sprayed at 31%RH and 75°F

Info for Section 3.1 Above:

	Product Designation	Batch Number	DOM	Date Applied	Mix Info
	10P20-44	JA5287	02/08	9/19/08	Mixed at 10:05 and sprayed at 10:35
	EC-265	JA5284	01/08		
	TR-114	JA4830	12/07		
Blue	CA8000/B5071	13-79-3-5071X /71930/ BR009YTO	2/1/08	9/19/08	Mix 12:15, spray 12:40/1:10/1:40
Off-White	CA8000/B793	13-79-3-793X 47822 BR009CKL	12/1/07	9/19/08	Mix 12:45, spray 1:45/2:15/2:45
Cure	CA8000B	227437	11/07		Coated at 74°F and 40% RH
Thinner	CA8000C	130534	01/2008		

5. Description of Primary Equipment

Equipment Used Table - FT-IR Analysis

Equipment	Model	Notes
Primer Paint Gun	DeVilbiss EXL	1.5 mm fluid nozzle, 2000 air cap, 24 psig at the wall. Used for Section 1.1 and 2.1 above
Topcoat Paint Gun	DeVilbiss EXL	1.5 mm fluid nozzle, 2000 air cap, 24 psig at the wall. Used for Section 1.1 and 2.1 above

Picture 5-1; Gloss meter

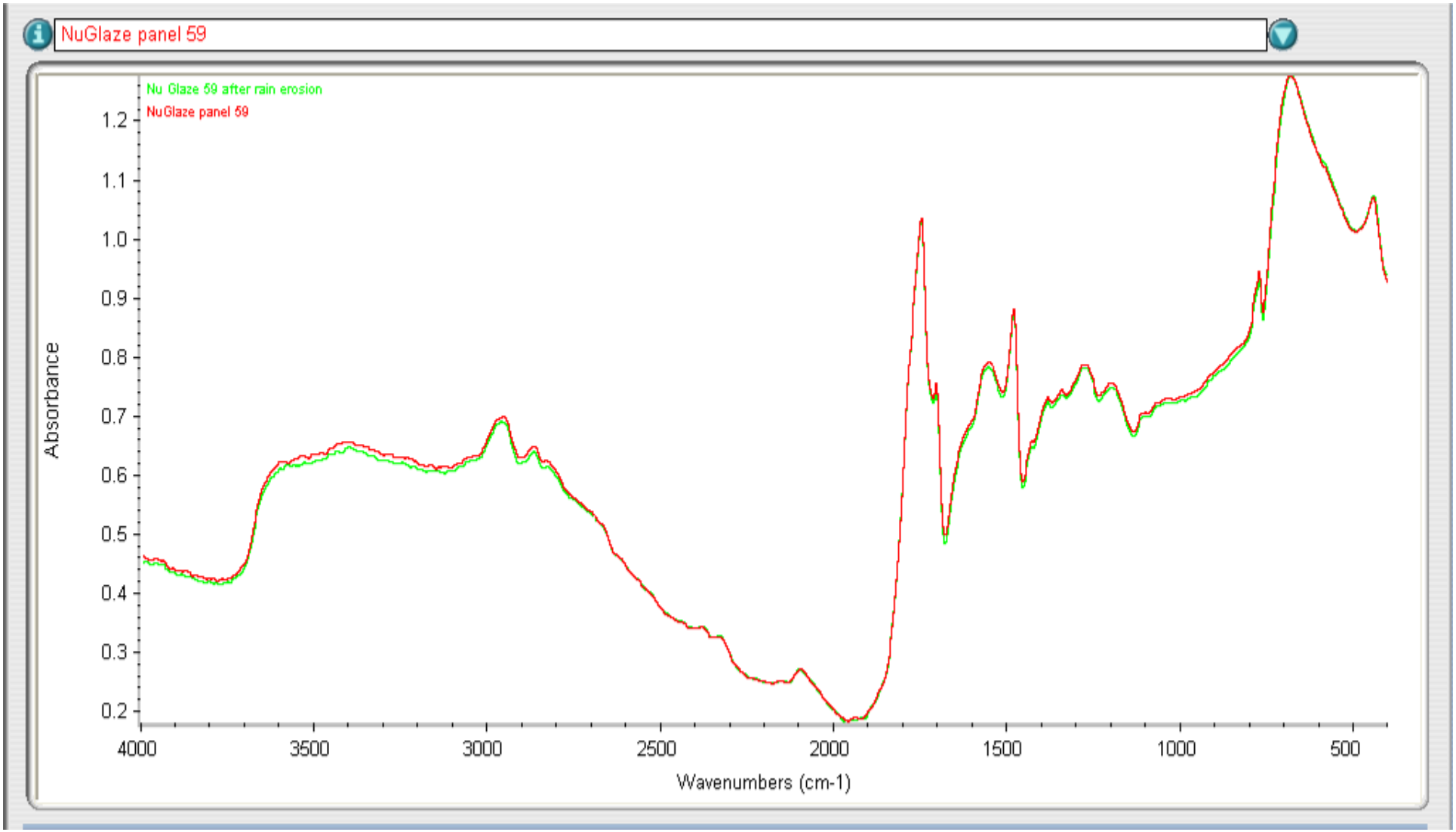
Picture 5-2; Iscoscope

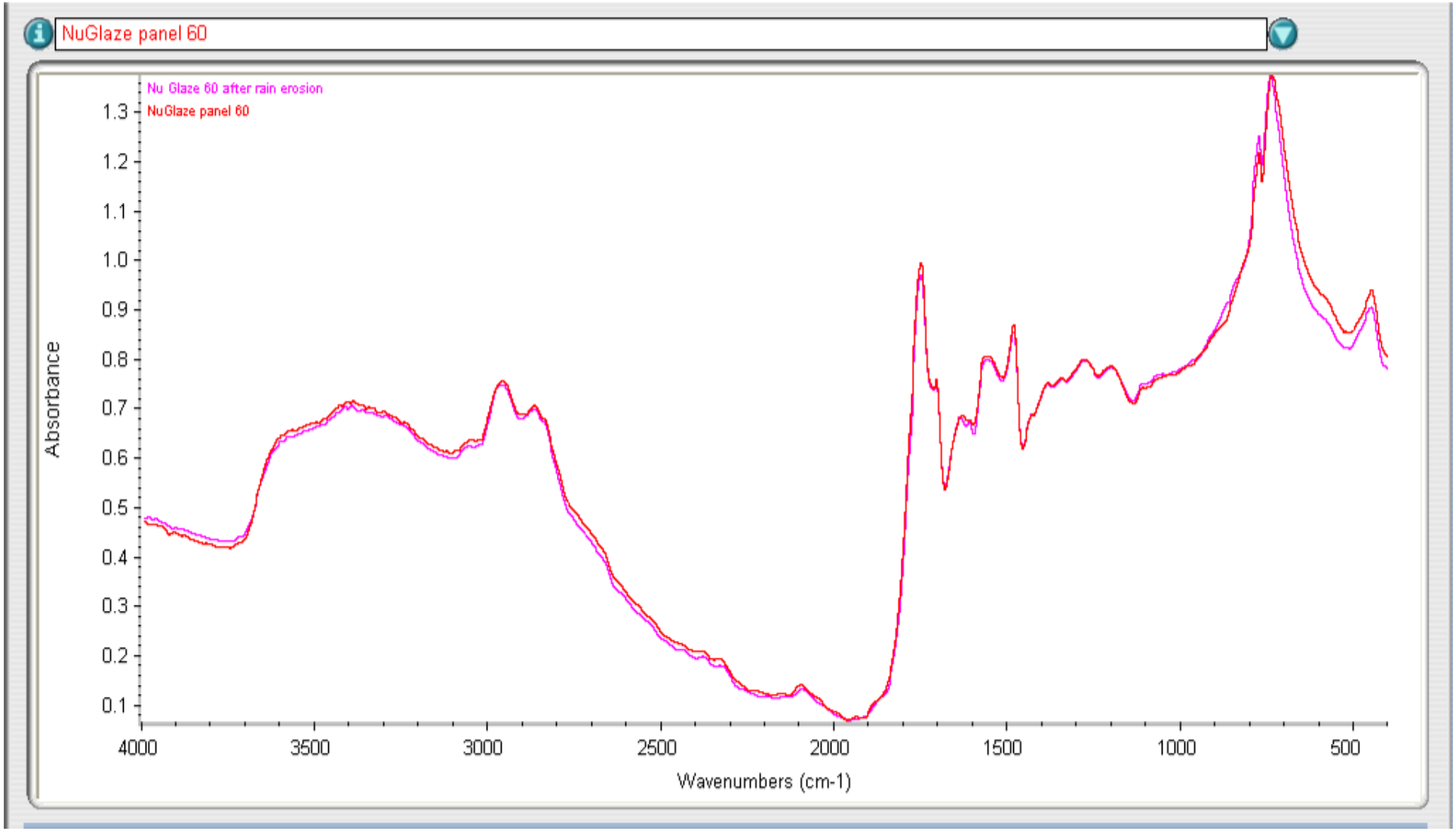
Picture 5-3; Paint Equipment:

Picture 5-4; Temperature and Humidity Gauge

Picture 5-5; Temperature and Humidity Gauge, Boeing Certification

Picture 5-6; Temperature and Humidity Gauge, Manufacturer Info


NuGlaze panel 59
Nu Glaze 59 after rain erosion
NuGlaze panel 59
Absorbance
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
4000
3500
3000
2500
2000
1500
1000
500
Wavenumbers (cm-1)


NuGlaze panel 60
Nu Glaze 60 after rain erosion
NuGlaze panel 60
Absorbance
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
4000
3500
3000
2500
2000
1500
1000
500
Wavenumbers (cm-1)