TECHNICAL PERFORMANCE CAPABILITIES STUDIES

Contents

CHEMEON Technical Performance Capabilities Studies are technical data sheets describing the performance capabilities of anodized surfaces using the CHEMEON technology. All documents are supported by scientific analysis and research. Full reports are maintained at the CHEMEON Tech Center and non-proprietary research support data may be available for purchase, subject to execution of appropriate confidentiality protection documents.

Corrosion Resistance

Introduction

One of the benefits of the CHEMEON Technology is improved corrosion resistance. Corrosion resistance is typically measured using a salt spray procedure (ASTM B117) where the anodized samples are exposed to a heated salt spray to accelerate corrosion. In order to pass MIL-A-8625F, Type II anodized samples must last 336 hours in the salt spray chamber before significant corrosion occurs.

Experimental Procedure

Testing was performed on six common alloys: 2024-T3, 3003-H14, 5005-H34, 6061-T6, 6063-T52, and 7075-T6. Ten aluminum coupons (4"x 4") of each alloy were anodized to 0.7 mil under Type II conditions using the CHEMEON Technology. The anodized samples were then sealed in a nickel acetate solution. The corrosion resistance of the samples was measured according to ASTM B117 and MIL-A-8625F procedures which states that the test specimens show no more than 5 isolated pits in a total of 30 square inches of test material from one or more test pieces. In this case, a failure occurs when two coupons (30 square inches) have a total of 6 pits. Both the anodizing and the corrosion testing were performed at the CHEMEON Tech Center.

Results

The following table contains the corrosion resistance results.

Corrosion Resistance Results

Alloy	Salt Spray Hours at Failure
2024-T3	4566
3003-H14	4065
5005-H34	4065
6061-T6	4065
6063-T52	4732
7075-T6	4065

Conclusion

The MIL-A-8625F corrosion resistance requirement for Type II sealed samples is 336 hours. All six alloys in this study which were anodized using the CHEMEON Technology and subsequently sealed demonstrated consistent performance greatly exceeding MIL Spec requirements.

Wear/Abrasion Resistance

Introduction

The wear or abrasion resistance of aluminum anodic coatings is one of the most important characteristics of hard anodized aluminum. Anodized aluminum is used for such components as pistons, cylinders, and hydraulic gear, which require a very wear resistant surface. Although there are other anodizing process suppliers who claim that their technologies are able to meet or exceed MIL-A-8625F specification, few of them can provide quantified Taber test results to verify their commercial statements regarding abrasion resistance. In the CHEMEON Technical Performance Capabilities Studies, Taber indices, which are the common measure for the wear of abrasion resistance of anodic coatings on aluminum alloys, are provided for three typical aluminum alloys anodized by the CHEMEON-III process. The results obtained show that the CHEMEON-III process substantially outperforms the wear resistance specification of MIL-A-8625F.

Procedure

Aluminum alloys 2024-T3, 6061-T6 and 7075-T6 were used in this experiment. 12 coupons (4"× 4") for each alloy were anodized to 2 mil using the CHEMEON Type III anodizing process. Anodized coupons were put in a desiccator for 24-72 hours prior to Taber tests. Taber abrasion tests were performed on both sides of the anodized coupons using a 5150 ABRASER (Taber Industries) with CS-17 Taber wheels at 1000 g load and 10,000 cycles at 70 rpm. The abrasion resistance, expressed as wear index, is given at the weight loss per 1,000 cycles.

Results

Taber results for three typical aluminum alloys anodized by the CHEMEON Type III anodizing process are listed in the following table. The average values shown below calculated from 24 Taber data obtained for each alloy, respectively. The abrasion resistance specified by MIL-A-8625F for these three alloys are also listed for a comparative purpose.

CHEMEON Wear Resistance Testing Results Mg/1,000 cycles		
Alloy	Measured Wear Index (Average)	Max. Allowable Wear Index (MIL-A-8625F)
6061-T6	0.89	1.5
7075-T6	0.65	1.5
2024-T3	1.22	3.5

Conclusion

The CHEMEON Type III anodizing process produces hard anodic coatings on aluminum alloys with the excellent wear resistance which far exceeds the requirements specified in MIL-A-8625F specification. In particular, the wear Indices for alloys 7075 and 2024 are two to three times lower than the allowable wear indices in the MIL-A-8625F specification. With the CHEMEON technology, anodizers can easily and confidently pass the MIL-A-8625F specification.

CHEMEON Technical Performance Capabilities Studies

Microhardness

Introduction

Vickers microhardness testing was performed on three alloys: 2024, 7075, and 6061. Samples of these three alloys were anodized under Type III conditions using the CHEMEON Technology. The results were compared to the acceptance values for the Vickers microhardness test specified in the ISO 10074 standard.

Experimental Procedure

Microhardness testing was performed on 2024-T3, 7075-T6, and 6061-T6 coupons (4"x 4") anodized to 2 mils under Type III (CHEMEON-III) conditions at the CHEMEON Tech Center. Five coupons of each alloy were anodized individually on titanium racks. Two of the coupons were anodized at 24 A/ft^2 and three coupons at 30 A/ft^2. The microhardness of the samples was measured according to ASTM E92 with a 0.050 kgf load by a certified, independent laboratory. Each sample was measured in three separate locations. The tolerance of the instrument used was ±30 (H_v). The results were compared to the acceptance values listed in the ISO 10074 standard.

Results

The following table contains the Vickers microhardness results. According to the ISO 10074 standard, alloy 2024-T3 is a member of the Class 2 (a) grouping which has a Vickers microhardness acceptance level of 250 H_v, alloy 7075-T6 is a member of the Class 2 (b) grouping which has a Vickers microhardness acceptance level of 300 H_v, and alloy 6061-T6 is a member of the Class 1 grouping which has a Vickers microhardness acceptance level of 400 H_v.

Vickers Microhardness Results

Alloy	ISO 10074 Acceptance Value for Vickers Microhardness (H_v)	Current Density (A/ft^2)	Average MLT-III Vickers Microhardness (H_v)*
2024-T3	250	30	336 (24)
		24	347 (28)
7075-T6	300	30	346 (19)
		24	370 (25)
6061-T6	400	30	405 (3)
		24	407 (3)

* The number in parenthesis is the standard deviation.

Conclusion

All coupons in this study exceeded the ISO 10074 acceptance values for Vickers microhardess.

Aluminum Buildup Rate

Introduction

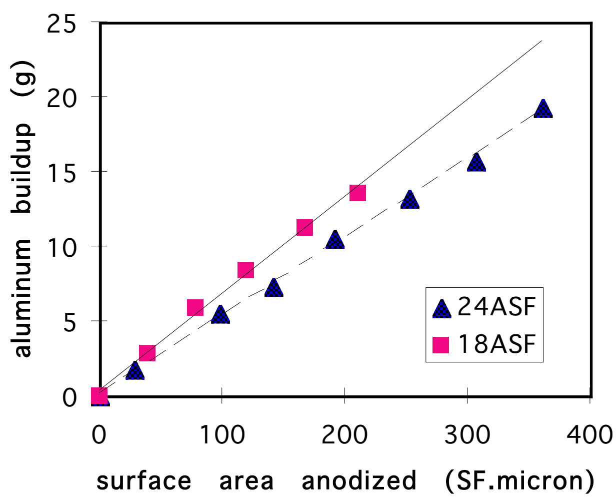
The aluminum buildup rate is an important aspect in assessing the efficiency of an anodizing process. It will determine the decant rate, and in turn will affect the anodizing costs which are related to chemical costs and waste treatment. This CHEMEON Technical Performance Capabilities Studies provides detailed data of the aluminum buildup rate under Type II CHEMEON anodizing conditions. With this data the anodizers can accurately estimate the aluminum buildup rate according to the tank size and the amount of material anodized.

Procedure

One hundred panels (4"x 4") of various aluminum alloys were anodized in a 4 L beaker to investigate the aluminum buildup rate. The concentration of the aluminum ions in the anodizing solution was measured after anodizing a certain number of aluminum samples. The thickness of the anodic coating formed on each coupon was 20 microns.

Results

The relationship between the weight of aluminum dissolved in the solution and the amount of material anodized at different anodizing current densities (18 and 24 ASF) using the CHEMEON anodizing technology is shown in the following figure.



The aluminum build up rates in the CHEMEON solution under Type II anodizing conditions are summarized in the following table.

Al buildup rates in the CHEMEON solution under the Type II anodizing conditions

Current density	Aluminum buildup rate
24 ASF	0.052 g/SF•micron
18 ASF	0.065 g/SF•micron

If the tank size, anodizing load, and desired thickness of anodic coating are known, the actual aluminum buildup can be estimated using the following formula:

$$\text{Al Buildup} = 0.065 \text{ (or } 0.052) \times \frac{\text{Anodizing Load} \times \text{Desired Thickness of Anodic Coating}}{\text{Tank Size} \times 3.785}$$

where:

Al Buildup is in grams per liter

Anodizing Load is in square feet

Desired Thickness is in microns

Tank Size is in gallons

Conclusion

The CHEMEON anodizing technology significantly decreases the decant frequency of tanks due to the high current density used in the CHEMEON anodizing technology and the prevention of burning provided by the CHEMEON additive.

CHEMEON Technical Performance Capabilities Studies

Depth Profile of Wear Resistance in Hard Anodic Coatings

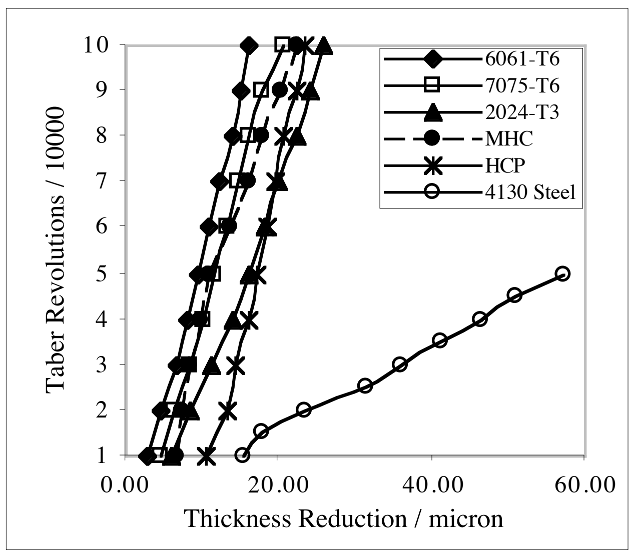
Introduction

Depth profile of wear resistance is one of the major characteristics of hard anodic coatings. This Technical Performance Capabilities Studies provides the depth profiles of the wear resistance in the anodic coatings formed on three typical alloys with the CHEMEON-III process. The outcomes were compared with the best result reported from the M.H.C. process, cited widely in literature, and the results from hard chrome plating (HCP) and hardened carbon steel.

Experimental Procedure

The depth profiles of the wear resistance in the anodic coatings were measured on 2024-T3, 6061-T6 and 7075-T6 coupons (4"x 4") anodized to 2 mil under Type III (CHEMEON-III) conditions. Two coupons of each alloy were anodized individually on a titanium rack at 30 A/ft^2. The wear testing of the samples was performed according to FED-STD-141, Method 6192, using CS-17 wheels that were resurfaced after every 10,000 revolutions. The coating thickness was measured both prior to and after every 10,000 revolutions in accordance with ASTM B244 using a calibrated Eddy-Current instrument. A total of 100,000 revolutions were performed on each side of the coupons. The average coating thickness reduction of four sides on two coupons were reported with a standard deviation less than 2 microns.

Results



The figure on the right presents the depth profiles of the wear resistance in the anodic coatings produced on three alloys using the CHEMEON-III process. The best result reported using the MHC process and the wear resistance of hard chrome plating and hardened 4130 steel are also plotted in the figure for the purpose of comparison.

Conclusion

All the anodic coatings produced on three alloys using the CHEMEON-III process showed virtually constant wear resistance in the depth profiles. This finding suggests that the anodic coatings produced with the CHEMEON-III process are very homogeneous and uniform in structure and composition. The wear resistance of the anodic coatings formed on 6061-T6 and 7075-T6 is superior to the best result from the M.H.C. process and those of hard chrome plating and 4130 steel. Even the anti-wearing performance of the anodic coating on 2024-T3 is substantially better than that of both hard chrome plating and 4130 steel.

Coating Weight & Conversion Efficiency

Introduction

The conversion efficiency (ζ) of an anodizing process, one of the performance criteria, is defined as the percentage of the weight (W_C) of anodic coating produced over the theoretical weight of the aluminum oxide calculated from Faraday's law. The higher the conversion efficiency, the better the performance of the anodizing process. The conversion efficiency of the CHEMEON-II & III processes was determined on the most commonly used materials and provided in this spec. Accordingly, the coating weight on each alloy was determined as well.

Experimental Procedure

Four pre-weighed coupons (4" x 4") of each alloy were anodized to 0.7 mil and 1.5 mil under the CHEMEON-II and CHEMEON-III conditions, respectively. The anodized coupons were dried in an oven, then weighed after cooling to room temperature, and stripped in accordance with MIL-A-8625F to determine the coating weight produced and aluminum consumed during the anodizing process with the precision of 3%.

Results

The following table presents the conversion efficiency and the coating weights resulting from the CHEMEON process. It is specified by MIL-A-8625F that at least 1000 mg/ft^2 is required for Type-II coatings and a minimum weight of 4320 mg/ft^2 is required for Type-III coatings. The conversion efficiency of traditional anodizing processes is only about 61% under the most favorable conditions, according to well-recognized literature.

Resultant Coating Weight & Conversion Efficiency of the CHEMEON Process

Anodizing Type	Alloy	W_C, mg/ft^2	ζ, %
II	1100 –H14	4348	78.7
	2024 – T3	3313	54.4
	6061 – T6	4124	80.7
	7075 – T6	3820	79.0
III	1100 –H14	8618	93.4
	2024 – T3	7816	83.5
	6061 – T6	8305	93.5
	7075 – T6	8172	97.3

Conclusion

The coating weights produced by the CHEMEON-II & III processes are much higher than the minimum requirements specified by MIL-A-8625F. In addition, the CHEMEON process has conversion efficiencies higher than 78%, except in the case of alloy 2024-T3 under Type-II conditions. This indicates that the CHEMEON technology outperforms MIL-A-8625F specification and is evidently superior to traditional anodizing processes.

CHEMEON Technical Performance Capabilities Studies

Sealing Quality

Introduction

Post sealing treatment is normally specified for the anodic coatings formed on aluminum when corrosion protection is a primary concern. The better the sealing quality, the higher the corrosion resistance. Both anodizing process and sealing process influence the sealing quality. Acid dissolution test (ADT) is a widely accepted standard method for evaluating the sealing quality of anodic coatings. This spec provides a set of comprehensive ADT results on the sealing quality of the anodic coatings produced by the CHEMEON-II process.

Experimental Procedure

Four coupons (4"x 4") of each alloy placed on a titanium rack were anodized to 0.7 mil using the CHEMEON-II process at different current densities, then sealed in either nickel acetate solution (190 °F) or boiling DI water (212 °F), in accordance with the operational parameters specified by each sealing process, respectively. The acid dissolution tests were performed according to ASTM B680-80. The precision of the ADT method is 1 mg/dm^2. The results were reported on the average of data from the four coupons of each alloy under an identical condition.

Results

The following table presents the ADT results. An acid dissolution of < 40 mg/dm^2 is generally considered passing. Furthermore, the sealing shall be considered to be satisfactory if the loss of mass does not exceed 30 mg/dm^2 of the anodic coating, according to ISO 7599 specification for the assessment of sealing quality.

ADT results of CHEMEON-II coatings

Alloy	Seal	Weight loss of anodic coating in an acid dissolution test, mg/dm^2	
		Anodizing current density, 18 A/ft^2	Anodizing current density, 24 A/ft^2
1100-H14	Nickel acetate solution	< 1	< 1
	Boiling DI water	10	10
2024-T3	Nickel acetate solution	< 1	< 1
	Boiling DI water	90	42
3003	Nickel acetate solution	< 1	< 1
	Boiling DI water	13	10
5005	Nickel acetate solution	< 1	< 1
	Boiling DI water	11	11
6061-T6	Nickel acetate solution	< 1	< 1
	Boiling DI water	11	11
7075-T6	Nickel acetate solution	<1	<1
	Boiling DI water	22	20

Conclusion

All the ADT results of the CHEMEON-II coatings sealed in nickel acetate solution in this study far exceeded the ISO 7599 satisfactory value for sealing quality. In boiling DI water the sealing quality of all the CHEMEON-II coatings, except those formed on 2024-T3 aluminum, substantially outperformed ISO 7599 specification as well. The results in the above table indicate that the anodic coatings produced at higher current density have better sealing quality than those produced at lower current density, as in the case of the boiling DI water sealing process. It is strongly recommended to employ nickel acetate sealing process for the Type-II coatings on 2xxx series aluminum.

CHEMEON Technical Performance Capabilities Studies

Current Efficiency

Introduction

The current efficiency (η) of an anodizing process, one of the performance criteria, is defined as the percentage of the mass of the alloy consumed over the theoretical consumption of the alloy mass calculated from Faraday's law. The higher the current efficiency, the less the burning chance of the anodizing process. The current efficiency of the CHEMEON process was determined on the most commonly used materials and provided in this spec.

Experimental Procedure

Four pre-weighed coupons (4" x 4") of each alloy were anodized to 0.7 mil and 1.5 mil under the CHEMEON-II and CHEMEON-III conditions, respectively. The anodized coupons were dried in an oven, then weighed after cooling to room temperature, and stripped in accordance with MIL-A-8625F to determine the mass of the alloy consumed during the anodizing process. The precision of this method is 3% due to the limitation of the accuracy of the current output of the rectifier employed.

Results

The following table presents the current efficiency of the CHEMEON process. For the purpose of comparison, the current efficiency of traditional anodizing processes under Type-II conditions is included in the table. Unfortunately, there is no reported data of current efficiency available for the conventional Type-III coatings.

Current Efficiency of the CHEMEON Process

Anodizing Type	Alloy	η (CHEMEON), %	η (Reported), %
II	1100 –H14	97.8	~97
	2024 – T3	90.7	~81
	6061 – T6	99.3	~94
	7075 – T6	98.3	~97
III	1100 –H14	100	-
	2024 – T3	92.2	-
	6061 – T6	96.7	-
	7075 – T6	98.9	-

Conclusion

The current efficiency of the CHEMEON process is close to 100%, in most cases. Even for alloys that are considered difficult to anodize, such as 2024-T6, the current efficiency of the CHEMEON process is above 90%, about 10% higher than that of traditional anodizing processes. This result provides a reasonable explanation for the fact that, as observed in anodizing job shops, the CHEMEON process considerably reduces the burning rejects, compared to traditional anodizing processes.

CHEMEON Technical Performance Capabilities Studies

Breakdown Voltage

Introduction

Breakdown voltage testing was performed on the anodic oxide generated on 6061-T6 material under Type III anodizing conditions using the CHEMEON Technology. The effects of oxide thickness and sealing in hot deionized water were examined.

Experimental Procedure

6061-T6 coupons (4"x 4") were anodized to approximately 2, 3, and 4 mils under Type III (CHEMEON-III) conditions at the CHEMEON Tech Center. Six coupons were anodized at each thickness. Three coupons were left unsealed and three coupons were sealed in hot deionized water for one hour per mil of oxide. The breakdown voltage of the samples was measured according to ISO 2376. A single ball electrode was used with a 500 g load. The voltage was increased at a rate of 25 V/second. Breakdown was defined as passing 100 µA. Each sample was measured in ten separate locations.

Results

The following table contains the breakdown voltage results.

Breakdown Voltage Results

Average Oxide Thickness (µm)	Sealed/ Unsealed	Average Breakdown Voltage (VDC)	Average Breakdown Voltage per Micron(V/µm)
49.7 (0.8)	Unsealed	2080 (230)	41.9 (4.6)
50.9 (0.5)	Sealed	2630 (260)	51.7 (5.2)
73.2 (1.5)	Unsealed	4050 (300)	55.3 (4.0)
73.5 (1.6)	Sealed	4110 (60)	55.9 (1.5)
92.3 (1.5)	Unsealed	4240 (370)	45.9 (4.0)
90.1 (0.9)	Sealed	4740 (120)	52.6 (1.4)

*The numbers in the parenthesis are the absolute uncertainties.

Conclusion

The breakdown voltage increases with increasing oxide thickness. However, the breakdown voltage per micron increased between 2 and 3 mils, but then decreased between 3 and 4 mils. Sealing increased the breakdown voltage at each oxide thickness.

CHEMEON Technical Performance Capabilities Studies

Surface Smoothness of Anodic Coatings

Introduction

The surface roughness of aluminum alloys anodized using the CHEMEON process has been measured and the results are summarized in this spec.

Experimental Procedure

The original surface roughness of each material was determined after anodizing samples in a 5% oxalic acid electrolyte at 80 °F and 12 A/ft^2 to produce about 1 μm oxide film. Four coupons (4" x 4") of each alloy were anodized to 0.7 mil at 18 A/ft^2 under the CHEMEON-II conditions and 1.5 mil at 24 A/ft^2 under the CHEMEON-III conditions, respectively. The surface roughness of the anodized samples was measured using SURFOMETER (Model PDA-400-ao, Precision Devices, Inc.) with a stroke of 0.220 inches and a cutoff of 0.030 inches. The surface roughness is reported on the average of the results obtained from the four samples of each alloy with eight measurements evenly distributed on both sides of each sample.

Results

The following table presents the surface roughness of each alloy before and after anodizing with the CHEMEON process. The surface roughness of anodic coatings is generally affected by original metal surface roughness, alloy, and anodizing conditions.

Surface roughness of anodic coatings produced by the CHEMEON-II & III Processes

Anodizing Type	Alloy	Base metal surface roughness R_a (min)* Long. / Trans.	Coating surface roughness R_a (min)* Long. / Trans.
MLT - II	1100 – O	4.1(0.3) / 6.9(0.6)	5.5(0.7) / 7.3(1.0)
	2024 – T3	16.8(1.3) / 20.8 (1.0)	17.7(2.3) / 22.6(1.5)
	3003 – H14	10.6(1.6) / 16.4(1.3)	13.9(1.1) / 16.9(1.0)
	5052 – H32	6.8(1.0) / 14.7(2.1)	10.4(1.4) / 14.4(1.1)
	6061 – T6	7.8(1.0) / 14.4(0.5)	14.2(1.4) / 18.8(1.4)
	7075 – T6	12.1(1.9) / 20.8(1.6)	15.4(1.6) / 20.9(1.2)
MLT - III	1100 – O	4.1(0.3) / 6.9(0.6)	13.7(2.4) / 16.1(1.5)
	2024 – T3	16.8(1.3) / 20.8 (1.0)	21.9(2.2) / 29.7(2.3)
	3003 – H14	10.6(1.6) / 16.4(1.3)	27.4(1.8) / 30.791.2)
	5052 – H32	6.8(1.0) / 14.7(2.1)	16.2(1.9) / 24.5(1.9)
	6061 – T6	7.8(1.0) / 14.4(0.5)	21.3(2.1) / 29.1(1.6)
	7075 – T6	12.1(1.9) / 20.8(1.6)	21.7(2.2) / 32.5(2.3)

*The numbers in parentheses are the standard deviations.

Conclusion

The surface roughness of the anodic coatings resulting from the CHEMEON-II process only increases slightly, while the surface roughness of aluminum anodized with the CHEMEON-III process increases by about 10-15 μin. It was reported that the surface roughness of aluminum anodized with a conventional hard coating process usually increases by more than 10-20 μin.

Paint Adhesion

Introduction

Anodic coatings provide an excellent base for paints, lacquers, and resins. Painted anodic oxides can have excellent paint adhesion, corrosion resistance, and wear resistance. Both the aircraft and marine industries have applications for parts with this combination of performance characteristics. The aircraft industry has very specific performance requirements for the adhesion of paint on anodized aluminum. In this study, the paint adhesion of 2024-T3 aluminum anodized with the CHEMEON-II process and sealed in two different chromate seals was evaluated using a dry tape test, unscribed wet tape test, and a scribed wet tape test according to Boeing specifications.

Experimental Procedure

Panels (4 by 12 inches) of 2024-T3 aluminum were anodized using the CHEMEON-II process to an average oxide thickness of 0.4 mil. One set of six panels was sealed in a 5% sodium dichromate seal per P.S. 13201[1] section 6.5.2 and another set of six panels was sealed in a dilute chromate seal per BAC 5884[2] section 9.6. Two different primers were used on each set of panels. Three panels of each set were painted a waterborne chromated primer, Deft 425-44-GN-72 and three panels of each set were painted with a solvent based chromated primer, Spraylat EEAY051. The primers were applied per P.S. 13646[3] "N" within 6 days after anodizing. The primer thickness on the panels was in the range of 0.6-0.9 mil. The primer coatings were cured for 7 days prior to testing. A dry tape test, unscribed wet tape test, and scribed wet tape test were performed in accordance with the Boeing specification P.S. 21313[4] using the Laboratory Methods. The scribe procedure is described in ASTM D3359 Method A (X-Cut Tape Test). Three locations were tested on each panel for each of the three test methods.

Results

The paint adhesion test results are shown in Table 1. All locations on every specimen had a rating of 5A. A rating of 5A corresponds to no peeling or removal per ASTM D3359.

Table 1. Paint adhesion of the anodized and sealed 2024-T3 panels

<table>
<tr><th>Sample No.</th><th>Oxide Thickness (μm)</th><th>Seal</th><th>Primer</th><th>Dry Tape Test</th><th>Unscribed Wet Tape Test</th><th>Scribed Wet Tape Test</th></tr>
<tr><td>5116a</td><td>10.8(0.8)</td><td rowspan="6">Dilute Chromate Seal</td><td rowspan="3">EEAY051</td><td rowspan="12" colspan="3">5A</td></tr>
<tr><td>5116b</td><td>10.3(0.7)</td></tr>
<tr><td>5116c</td><td>11.2(0.6)</td></tr>
<tr><td>5117a</td><td>10.8(0.7)</td><td rowspan="3">425-44-GN-72</td></tr>
<tr><td>5117b</td><td>11.3(0.8)</td></tr>
<tr><td>5117c</td><td>10.7(0.8)</td></tr>
<tr><td>4841a</td><td>9.8(0.7)</td><td rowspan="6">5% $Na_2Cr_2O_7$ solution</td><td rowspan="3">EEAY051</td></tr>
<tr><td>4841b</td><td>11.8(0.6)</td></tr>
<tr><td>4841d</td><td>11.2(0.6)</td></tr>
<tr><td>4881a</td><td>10.2(0.5)</td><td rowspan="3">425-44-GN-72</td></tr>
<tr><td>4881b</td><td>9.6(0.5)</td></tr>
<tr><td>4881c</td><td>11.3(0.6)</td></tr>
</table>

Conclusion

According to Boeing's specification P.S. 21313[4], an area fails the tape adhesion test if the paint film was removed from an area larger than 1 square inch. All cases in this study had no paint removal, which far surpasses the requirements of P.S. 21313[4]. In addition, panels anodized and sealed in both a 5% dichromate solution and a dilute chromate solution according to the above-mentioned parameters passed the corrosion requirements of BAC 5884[2].

Boeing specifications:

1. P.S. 13201 "Anodizing, Aluminum Alloys"; revision V; May 24, 1999.
2. BAC 5884 "Anodizing of Aluminum Alloys"; revision D; April 21, 1995.
3. P.S. 13646 "Painting of F-15 Aircraft"; revision N; August 25, 1999.
4. P.S. 21313 "Coating Adhesion Tests"; revision 24, 1999.