SAE INTERNATIONAL

AEROSPACE RECOMMENDED PRACTICE

ARP1524 REV. A

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Superseding ARP1524

Surface Preparation and Priming of Aluminum Alloy Parts for High Durability Structural Adhesive Bonding

RATIONALE

ARP1524A has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE:

1.1 This Aerospace Recommended Practice (ARP) describes the processing system and techniques for the surface preparation and priming of aluminum alloy parts for structural adhesive bonding to achieve optimum bondline durability, corrosion resistance, and manufacturing producibility..

1.2 While this surface preparation has been developed and validated for two high strength aluminum alloys, 2024 and 7075, in the hardened condition it is expected to be applicable to other alloys and tempers.

1.3 This surface preparation system has been validated for use with 180°F (82°C) and with 250°F (121°C) curing elastomer-modified epoxy adhesive and corrosion-inhibiting primer.

1.4 The processes described herein are the result of laboratory evaluation of structural and durability performance.

1.5 Safety - Hazardous Materials:

While the materials, methods, applications, and prcesses described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

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2. DESCRIPTION OF THE PROCESS:

2.1 The use of adhesively bonded aluminum alloy parts in primary structures requires high strength, durable, reliable adhesive bonds. To achieve the high reliability and durability required, special processing techniques must be followed as outlined in the primary steps shown below:

Solvent Cleaning
Alkaline Cleaning
Deoxidizing
Phosphoric Acid Anodizing
Primer Application
Primer Drying or Curing
Adhesive Application
Component Parts Assembly
Structural Assembly Curing

2.2 This document outlines the recommended procedures from solvent cleaning through application and cure of the corrosion-inhibiting adhesive primer. Application of the applicable adhesive and mating the component parts involves individual part geometry and complexity and must be covered in a procedure prepared for each specific assembly.

2.3 In planning a facility for accomplishing adhesive bonding, consideration shall be made for the flow of parts from the beginning of cleaning through all processing operations and the assembly and cure of the structure. Cleaning operations shall be positioned so that parts may be racked, cleaned, and chemically treated and the adhesive primer can be applied without requiring handling or touching the parts with any substance except the rack or holding fixture and the processing solutions. The racks or fixtures shall be designed to prevent parts from touching each other, other racks or fixtures, the sides of the processing tanks, or spray nozzles. It is especially important that the faying surfaces to be bonded are not touched at any time during the entire process. In addition, the cleaning and chemical treating processes, including the necessary inspections, shall be a continuous operation, with the parts not drying during the entire cycle until the oven-dry after phosphoric acid anodizing. Adhesive primer shall be applied as soon as the anodized surface has been dried and inspected, but in no case shall the interval between anodize and prime application be more than 96 h, and then only when conditions of 6.7 are met. After the application and heat cure of the primer, the detail parts may be stored up to 90 days if properly protected and kept in an environmentally controlled area.

3. HANDLING OF PARTS:

3.1 Parts should be racked or suspended from frames in such a manner that the faying surfaces to be adhesively bonded will not be touched or come in contact with any substance, except the applicable solutions, from the time the deoxidizing process begins until after the adhesive primer has been air dried.

3.2 If it becomes necessary to handle or touch parts, clean white gloves should be used and contact should be limited to surfaces not to be adhesively bonded.

3.3 The utmost care should be taken that the parts are not touched at any time during the entire process. This includes contact with adjacent parts, the rack or supporting frame, or any other item, because the surfaces and the phosphoric acid anodic coating are extremely susceptible to contamination or physical damage prior to the application and cure of the primer.

3.4 If parts become contaminated, corrective action shall be accomplished by reprocessing, beginning with alkaline cleaning. If the anodic film has been applied prior to contamination, the film shall be stripped prior to reprocessing.

4. STORAGE OF PARTS:

4.1 Cleaned and phosphoric anodized parts shall not be stored, except as permitted in 2.3 and 6.7. Processing operations shall be scheduled to provide for a continuous operation for each detail part of each assembly, from solvent cleaning, through alkaline cleaning, deoxidation, phosphoric acid anodizing, and application of primer.

4.2 Should parts be delayed in the continuous wet operation, they shall not be allowed to dry, but shall be held in one of the overflowing immersion rinse tanks for not more than 15 min until further processing can proceed.

4.3 At no time shall parts on the faying surfaces to be adhesively bonded be handled or touched, until after application and cure of the adhesive primer; preferably, they shall not be touched at all during the entire process through the mating of the assembled parts and cure of the adhesive.

4.4 Primed and cured parts may be stored in a noncontaminating atmosphere up to 90 days if properly wrapped and protected.

5. EQUIPMENT AND ENVIRONMENT CONTROL:

5.1 Equipment requirements for this process include that equipment normally used in the chemical processing of aluminum alloys, with the following special provisions:

a. Racks and frames shall be constructed of materials that will not cause corrosive reactions with the suspension wires or clips, or the parts, during the entire process. "Picture frame" type racks have performed satisfactorily.

b. Parts should be attached to racks or frames with wires or hooks of 1100 aluminum alloy or with titanium alloy spring clips.

5.1 (Continued):

c. The phosphoric acid anodizing tank lining should be commercial lead (with 6 to 8% antimony) or stainless steel (Type 347 or 316), or equivalent. Other materials should be such that interaction between the solutions, parts, frames, racks, or clips and hangers does not interfere with the anodic process. Tanks shall be equipped with a suitable lid to prevent contamination while not in use, with a surface skimming device to remove surface contamination, a filtering system, and an agitation system for mixing the tank contents. Air lines used for solution agitation shall be equipped with filters and traps for removing airborne dust, moisture, and oil from the air supplied to the tank.

d. Terminations for electrical connections shall be so designed and positioned that parts cannot be "burned".

e. The electrical power system used during the single rack anodic process shall be adequate for producing 10 V DC and maintaining any set voltage within ±1 V DC. Provision shall be included in the system to control the step-wise voltage rise to 10 V DC within a 2 to 5 min time span.

f. Rinse tanks shall be placed adjacent to processing tanks in such a manner that parts can be easily and quickly moved from one solution to another with a minimum of transfer time, so that the parts will not become dry during successive steps of the process. It is recommended that separate overflowing immersion rinse tanks be used, rather than reusing the same tank after different processes have been accomplished.

g. Feed water for rinse operations shall contain not over 150 ppm total dissolved solids and shall have a pH between 5.5 and 8.0. Rinse water may be direct from source water or fed from subsequent rinsing operations, except that acid rinse waters shall not be fed into alkaline rinse waters. Immersion rinse tanks shall be agitated and overflowing during the entire rinsing cycles.

5.2 The atmosphere in the chemical processing area shall be maintained as clean as possible for such operations. Building superstructure should be cleaned periodically to reduce the outfall of dust or other airborne contaminants onto the processing tanks and parts being processed. All tanks shall be covered when not in use.

5.3 Environmental control shall be established immediately after removal of the phosphoric acid anodized parts from the drying oven, as defined in the applicable adhesive primer and adhesive film application documentation. Smoking by personnel and the use of exhaust-producing power equipment shall be prohibited in the controlled environment area.

6. SURFACE PREPARATION SYSTEM FOR ALUMINUM ALLOY PARTS:

6.1 The preparation system described in 2.1 should be performed in a continuous operation as detailed in the flow chart (see Figure 1).

6.2 All fabrication processes, inspections, prefit, and adjustments for individually identified assemblies shall be completed before the start of the preparation cycle.

6.3 All "hand work" shall be completed before parts are started through the surface preparation process.

6.4 Once racked for alkaline cleaning, parts shall not be touched by anything except the applicable processing solution, until the parts are dried after primer application.

6.5 The "wet" processing steps, from alkaline cleaning through drying after phosphoric acid and anodizing, shall be performed in one continuous, uninterrupted sequence of processes, with the parts not drying at any time until the oven drying after phosphoric acid anodizing.

6.5.1 Should the parts become delayed prior to anodizing during this wet processing, hold the parts in the applicable overflowing immersion rinse tank for not more than 15 min until processing may proceed. Parts held in a rinse tank in excess of 15 min shall be removed, dried, and reprocessed beginning with alkaline cleaning.

6.5.2 There shall be no delay in the processing sequence after anodizing, except as permitted in 2.3 and 6.7.

6.6 Should the electric current fail or otherwise be interrupted during the phosphoric acid anodizing, the parts should be removed and be re-deoxidized to remove the oxide coating and then re-anodized.

6.6.1 Under specially controlled processing approved by purchaser, if the potential can be re-established within 2 min, phosphoric acid anodizing may be continued for an additional 20 to 25 min.

6.7 Adhesive primer shall be applied as soon as practicable after the completion of the anodize step, preferably within 2 h. However, if the parts are properly protected and kept in a clean, environmentally controlled area (50% relative humidity or less), they may be held up to 96 h before primer application. If not primed within this 96 h period, the parts must be stripped and reprocessed.

6.8 After the application and cure of the corrosion inhibiting primer in accordance with AMS-3107, the detail parts should have the adhesive applied and the assembly and curing operations completed as soon as practicable to reduce the risk of contamination. If properly wrapped and stored in an environmentally controlled area, the primed and cured detail parts may be stored up to 90 days before adhesive application.

7. QUALITY ASSURANCE PROVISIONS:

7.1 Part Inspection During Processing:

Parts shall be inspected during the continuous processing as noted in Figure 1.

PROCESS	SOLUTION OR OPERATION	TIME (MINUTES)	TEMPERATURE
Solvent Clean	Chlorinated Solvent (See 10.1)		175°F (80°C) max
Alkaline Clean	Nonsilicated Cleaner (See 10.2)	10–15	150°F ± 5 (65°C ± 3)
Rinse–Immersion/Spray	Clean Water (See 5.1.g)	2	65°–110°F (18°–43°C)
Rinse–Immersion/Spray	Clean Water[1]	5	100°–140°F (38°–60°C)
Water Breaks	Inspect for Water Breaks Do Not Dry		
Deoxidize	Deoxidizer (See 10.3)	10–15	(See 10.3)
Rinse–Immersion/Spray	Clean Water[1]	2	65°–110°F (18°–43°C)
Rinse–Spray	Deionized Water	To remove tap water	Ambient
Water Breaks	Inspect for Water Breaks Do Not Dry		
Phosphoric Acid Anodize	Phosphoric Acid (See 7.2.4.1.a) 9–11 weight % in deionized water Apply DC voltage within 1 min Raise voltage stepwise to 10 V DC ± 1	2–5	67°–77°F (19°–25°C)
	Maintain 10 V DC ± 1 for Turn off current	20–25	
Rinse–Immersion within 2 min after current is turned off			
	Agitated and overflowing clean water[2,3]	10–15	
Rinse–Spray	Deionized Water		
	Inspect Wet for Treatment Coverage and Water Breaks		
Oven Dry	Clean Dry Air	30	175°F (80°C) max
Cool to Room Temperature	Clean Air	120 max	Ambient
	Inspect for Presence of Anodic Coating in Accordance with 7.1.2		
Primer Application	Within 96 h after oven drying[5] apply by spraying to each faying surface a wet uniform cross coat[4] To a dry film thickness of 0.0001–0.0002 in (0.003–0.005 mm)[4]		
Air Dry	Clean Air	30[4]	Ambient[4]
	Visually Inspect for Primer Coating Uniformity		
Oven Dry	Clean Air	60[4]	255°F ± 5 (123°C ± 3)[4]
	Inspect for Primer Thickness on Not-To-Be-Bonded Surface		
	Protect and Store in Clean, Environmentally Controlled Area (Not to exceed 90 days)[6]		
	Proceed with Adhesive Film Application and Assembly of Component Parts		

NOTES:
[1]1000 ppm max total dissolved solids after first 30 s of rinsing
[2]5000 ppm max total dissolved solids after first 30 s of rinsing
[3]Use for post-anodizing rinse only
[4]May be modified in accordance with applicable adhesive primer and adhesive film application document
[5]See 6.7 for requirements if primer isn't applied within 2 h
[6]See 6.8

FIGURE 1 – Process Flow Chart

7.1.1 Water-Break Inspection:

7.1.1.1 Cleaned parts shall pass water-break inspection as indicated by maintenance of a continuous film of water on the surface for not less than 30 s.

7.1.1.2 Parts failing water-break inspection shall be reprocessed through the applicable cleaning operation until the surface can maintain the continuous film of water.

7.1.1.3 Parts failing water-break inspection after three cleaning cycles shall be rejected.

7.1.2 Phosphoric Acid Anodic Coating Inspection:

7.1.2.1 After anodizing and during rinsing and draining, there should be no evidence of a water break. There should be no stains, streaks, discoloration, or residue on surfaces of anodized parts after rinsing.

7.1.2.2 When examined visually, the anodic coating shall be continuous, smooth, uniform in appearance, and free from discontinuities, such as scratches, breaks, burned areas, and areas which are not anodized. Small irregularities at points of electrical contact should be acceptable provided they are not on surfaces to be adhesively bonded.

7.1.2.3 The anodized surfaces shall pass the following polarized filter examination:

a. Illuminate the surface using a mercury vapor or fluorescent lamp.

b. Observe the surface at a low angle (0 to 10°) through a photographic polarizing filter held close to the viewer's eye.

c. Anodized surfaces should display "interference colors", which should change to a complementary color when the filter is rotated 90° (for example, from purple to yellow green).

NOTES: 1. Rotation of the filter is necessary as some colors may be pale and not discernible until the complementary color is observed by rotation of the filter.

2. Different aluminum alloys anodized under the same conditions may show different colors through the polarizing filter due to differences in alloy composition and metallurgical condition. The colors most frequently seen are purple, yellow, blue, and green hues.

d. All surfaces to be adhesively bonded shall exhibit the color changes noted above. Abrupt differences from background color occurring in local areas, except at electrical contact points, are not acceptable. Causes of such differences may be fingerprints, abrasion, or other contamination.

e. Parts not passing the polarized filter test shall be rejected.

7.2 Make-Up and Process Control of Processing Solutions:

7.2.1 Water: Water used in solution make-up and replenishment and in the rinses specified herein shall contain not more than 150 ppm total dissolved solids and shall have a pH between 5.5 and 8.0.

7.2.2 Alkaline Cleaner: Make-up, replenishment, and replacement of alkaline cleaning solution shall be developed to produce optimum processing (see 10.2).

7.2.3 Deoxidizer: Two alternative chrome-free methods for deoxidizing the surface have been found in laboratory studies to provide equivalent bond performance and durability. These involve the use of acid solution immersion. The make-up, replenishment, and replacement of the deoxidizer solution should produce optimum processing. Examples of these two solutions are shown in 10.3.

7.2.4 Phosphoric Acid Anodizing Solution:

7.2.4.1 Initial Tank Make-Up:

a. Fill the tank approximately three-fourths full of deionized water or clean tap water not exceeding 150 ppm total dissolved solids and with pH between 5.5 and 8.0.

b. Agitate the water and slowly add 6.3 parts by volume of phosphoric acid (O-O-670, Class I, 85% phosphoric acid) for each 100 parts by volume of final solution. Mix thoroughly.

c. Bring mixture to operating level of the tank with deionized water or clean tap water not exceeding 150 ppm total dissolved solids and pH between 5.5 and 8.0. Mix thoroughly.

7.2.4.2 Maintenance: Maintain the phosphoric acid concentration and operating conditions as specified in Table 1. The level of solution in the tank shall be within the optimum operating level for the surface skimming equipment.

TABLE 1

Material/Operation	Range	Optimum
Phosphoric Acid, 85%, % by weight	9 - 11	10
Temperature (See 7.2.4.2.1)	67 - 77°F (19 - 25°C)	72°F (22°C)
Voltage, DC	9 - 11	10
Anodizing Time, minutes	20 - 25	22.5
In-Tank Time After Power Shutoff, minutes	1 - 2	1

7.2.4.2.1 Other selected temperatures within the range 65 to 90°F (18 to 32°C) may be used after thorough investigation and qualification of a specific facility.