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MILITARY SPECIFICATION

ADHESIVE BONDING, PROCESS AND INSPECTION REQUIREMENTS FOR

This specification has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

1. SCOPE

1.1 This specification provides detailed guidance for the preparation of and requirements to be included in the contractor process specification (see 6.2), required for the processing and inspection of adhesive bonded parts, including sandwich constructions bonded with metal-to-metal, metal-to-plastic, and plastic-to-plastic adhesives.

2. APPLICABLE DOCUMENTS

2.1 The following document, of the issue in effect on date of invitation for bids, forms a part of this specification to the extent specified herein:

STANDARD

MILITARY

MIL-STD-105 — Sampling Procedures and Tables for Inspection by Attributes.

2.1.1 Specifications governing the bonding materials and the materials to be bonded shall be as stipulated or approved by the procuring activity. They shall be of the issue in effect on the date of invitation for bids and shall form a part of the process specification.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Prime contractor's process specification, engineering report, and drawings—A detailed description of the manufacturing and fabricating process and methods of control of manufacturing variables in the form of a titled, numbered, and dated process specification shall be prepared by the prime contractor, or obtained from a subcontractor (see 6.2), and approved by the prime contractor. The process specification shall comply with the requirements of this specification, and shall follow its format as closely as possible. The process specification shall be made available by the contractor at the commencement of the production of material to which it applies and, thereafter, during the course of production for use by authorized Government and industry inspectors in the facilities of the contractor, his subcontractors, or his vendors. On request, the process specification, together with an engineering report that describes all tests used as a basis for the specification requirements, or detail design drawings of

the proposed specific end item utilizing adhesive bonded components, or both (if deemed necessary), shall be made available for review by engineers of the procuring activity at least two weeks prior to commencement of production. The contractor shall certify that compliance with such process specification will produce a material meeting all the contract requirements. The specific requirements, processes, inspection methods, and precautions specified hereinafter shall be included and completely described in the process specification.

3.1.1 *Materials.* All materials used in the process shall conform to applicable Government specifications or other specifications as stipulated or approved by the procuring activity.

3.1.1.1 Adhesive to be used in production bonding of parts shall be sampled and tested preceding its use within a period not exceeding one-third of the adhesive shelf life specified by its manufacturer, but not more than 1 week (168 hours) to determine its conformance to the normal (room) temperature and short-time elevated temperature shear strength requirements of the specification governing its use. When approved by the prime contractor or procuring activity, the short-time elevated temperature test may be omitted. When required, the elevated temperature test shall be at the maximum use temperature to which the bonded assembly will be exposed. The faying surfaces of the test specimens shall be treated by the same method and materials as are used on production parts.

3.1.2 *Bonding procedure.* All operations connected with bonding, from the drying and storage of surface-treated parts to be bonded through their assembly for final bonding, shall be conducted in an area that is dust free to the extent that bonding operations are not affected. The process specification shall define the actual ranges of temperature and humidity encountered in production. (However, the contractor is urged to maintain the temperature of the bonding area within the range of 65° to 75° F. (18° to 24° C.); and a relative humidity at 40 to 65 percent.) Bonding under the contractor's specified temperature and humidity conditions shall be limited to the use of such adhesives as will assure adhesion thereunder as proven by previous performance records of the contractor.

3.1.2.1 *Prefitting of parts.* The surfaces shall have good contact over the entire area to be bonded and shall be free of burrs, waves, and other surface imperfections, or as defined in the process specification. When practicable, the surfaces shall be prefitted. Surfaces not prefitted shall conform to the applicable drawings.

3.1.2.2 *Preparation of faying surfaces.* The process specification shall specify procedure for treatment of faying surfaces of parts to be bonded, and precautions to be taken to eliminate contamination of treated surfaces awaiting application of adhesive. The time that treated parts may remain uncoated shall also be specified, and substantiated by tests described in the contractor's engineering report (see 3.1).

3.1.2.2.1 *Suggested procedures for treatment.* Treatment of metal faying surfaces to be bonded may be accomplished as specified in 6.1.

3.1.2.2.2 *Solutions.* All surface-treatment solutions shall be tested and maintained at proper concentration as specified in the process specification.

3.1.2.2.3 *Handling of treated parts.* Cleaned, treated, or cleaned and treated parts shall not be handled with the bare hands nor shall any contamination result from contact with supporting fixtures or mechanical handling equipment. White cotton gloves should be used.

3.1.2.3 *Application of adhesive.* The exact procedures to be followed, and equipment to be used, in the application of the adhesive to the specific material to be bonded shall be described in the process specification. (If the general procedure recommended by the adhesive manufacturer is not followed, the contractor's engineering report (see 3.1) shall include data proving the procedure is adequate for the use intended. After application of the adhesive, the coated parts shall be kept dry and free from dirt, grease, oil, wax, or other foreign material and shall not be handled with the bare hands. The length of time adhesive coated parts are allowed to stand before bonding shall not exceed the open

assembly life of the adhesive and shall be specified in the process specification. Precautions to be taken to eliminate physical contamination of the adhesive coatings shall also be specified therein.

3.1.2.4 *Assembly of parts.* Care shall be taken in assembling parts in the curing fixture or jig to assure that the adhesive is not disturbed and that excessive residual stresses are avoided. Static electricity as generated through curing fixtures and bonded assemblies shall be controlled by grounding or by other means within applicable safety codes. The process specification shall describe procedures to be used in the assembly of parts. (If the assembly instructions of the adhesive manufacturer are not fulfilled, the contractor's engineering report (see 3.1) shall include substantiation for the deviation therefrom.)

3.1.2.5 *Curing of adhesive.* The process specification shall contain detailed curing procedures applicable to the adhesive bonded parts and process equipment to be used. (If the general procedure of the applicable adhesive manufacturer is not followed, the contractor's engineering report (see 3.1) shall include data proving the procedure is adequate for the use intended.) However, heat curing cycles shall be chosen so that, as a result of processing through the maximum number of cycles that may occur during fabrication, there will be no reduction of mechanical or corrosion-resistant properties of the materials being bonded to values below the minimum of the applicable material specification.

3.1.2.6 *Temperature and pressure requirements and controls.* Temperature and pressure requirements and the details of procedures to be followed for their measurement and control during production bonding of parts shall be included in the process specification.

3.1.2.7 *Bonding of subassemblies.* If bonded subassemblies are to be bonded again into final assemblies, a description of precautions to be taken to assure that subsequent surface preparation and bonding operations cause no ill effects on the initially bonded parts shall be included in the process specification.

3.1.3 *Protection of bonded joints.* Complete details of the materials and procedures to be used in the protection of bonded joints shall be included in the process specification when protection by coatings or other means is necessary because of the particular application or materials used in bonding. Bonded joints, such as at the exposed edges of sandwich components, access doors, and windows shall be protected against the entrance of liquids (water, fuel, oil, etc.) into the core of the sandwich. The manufacturer's test for proving the adequacy of the panel sealing against the entrance of moisture into the assemblies must be approved by the prime contractor or procuring activity upon demand prior to production.

3.1.4 Other techniques or precautions required for proper storage, such as control of film thickness, control of application, control of humidity during faying surface preparation, adhesive application, and tooling which may be applicable to the particular adhesive or to the conditions of fabrication being employed, shall be included in the process specification.

3.1.5 The process specification shall comply with section 4 herein and shall contain specific provisions for sampling, lot size, examination, and testing to assure conformance to the requirements.

3.1.6 *Rework or repair.* Provision for rework or repair of defective parts shall be stated in the process specification and shall be subject to approval on demand by the prime contractor or procuring activity.

3.2 Workmanship. The adhesive shall be of an organic or semi-organic resin type manufactured to conform to this specification. It shall be free of suspended foreign matter which may appear later upon application and shall be free of substances which might cause corrosion to metals.

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection responsibility. The supplier is responsible for the performance of all inspection requirements as specified herein. Except as

otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of tests. All of the tests of this specification are classified as acceptance tests, for which the necessary sampling techniques, examination procedures, and methods of testing are specified in this section. Tests shall be performed during the fabrication of adhesive bonded parts which are to be submitted for acceptance under a contract or order.

4.3 Acceptance tests. The primary and continuing purpose of the acceptance tests shall be to see that all the requirements and procedures of the process specification specified in 3.1 are continuously complied with during production of parts. This shall be accomplished by periodic inspection of the production processes, controls, and other items covered by the process specification.

4.4 Sampling and inspection.

4.4.1 *Nondestructive tests.* Nondestructive inspection shall be made of the adhesive bond of each production part. Inspection shall include visual inspection of bond quality, tapping, cutting buttons or plugs from the joints, ultrasonic or other methods as described in the process specification approved by the prime contractor or procuring activity on demand. Details for visual inspection and instrumentation used, its operation, calibration, and correlation with destructive test methods shall be included in the process specification.

4.4.2 *Destructive quantitative strength tests.*

4.4.2.1 *Preparation of extensions, coupons, or standard specimens.* Production bonded parts, that cannot be examined by nondestructive methods, shall incorporate, where possible, extensions or coupons that may be cut from the parts after bonding and will be representative of the bonds obtained in the parts proper. Where extensions cannot be incorporated in the parts, standard specimens shall be fabricated. These shall be bonded at the same time, with the same adhesive, and in the same equipment and under the same conditions as for the assembly they represent. The procedures for their incorporation or fabrication shall be included in the process specification.

4.4.2.2 *Sampling.* The number of extensions, coupons, or specimens prepared in accordance with 4.4.2.1 to be selected shall be specified by the contractor in the process specification.

4.4.2.3 *Test method.* Destructive quantitative strength tests shall be made of the adhesive bonds in the extensions, coupons, or specimens prepared in accordance with 4.4.2.1. The test procedures to be used, and the requirements to be met shall be specified in the process specification.

4.4.3 *Destructive inspection.*

4.4.3.1 *Sampling.* The first bonded part and a sufficient number of succeeding parts (to be specified by the contractor in the process specification) shall be selected from the production run and tested in accordance with 4.4.3.2. Sampling should be in accordance with Standard MIL-STD-105.

4.4.3.2 *Test method.* Destructive inspection shall be made on parts selected in accordance with 4.4.3.1 to insure proper fabrication of parts throughout the production run. Any evidence of improper cure, adhesion, alignment, water penetration (see 3.1.3), etc., shall be immediately corrected by making indicated adjustments in the cure cycles or in tooling. When any changes are made in established curing or tooling, or, when new tooling is introduced, even though it is identical to the established tooling, new tests shall be made. Tests in accordance with 4.4.2 shall be conducted on representative specimens cut from the part, or static or fatigue tests on the entire part. The frequency of the proposed tests shall be predicated on tool life expectancy

and on a realistic learning curve. Checks of tool dimensions and alignment shall be performed after every assembly is completed, or as prescribed in the process specification. Control and test instruments shall be periodically checked and calibrated.

4.4.4 The materials and processes covered by the contractor's process specification, the articles fabricated thereby, and the tests made thereon shall be subjected to the inspection and supervision of authorized Government inspectors. Reports of tests performed under Government inspection and supervision shall be furnished the authorized inspectors.

5. PREPARATION FOR DELIVERY

There are no applicable requirements.

6. NOTES

6.1 Suggested procedures for treatment of metal faying surfaces.

6.1.1 *Wrought aluminum and aluminum alloys (except sandwich cores).* Degrease surfaces with an organic solvent, immerse for 10 minutes at 150° to 160° F. (65.6° to 71.1° C.) in a chromic acid solution of approximately the following composition by weight:

30 parts clean, demineralized, oil free water
10 parts concentrated sulfuric acid (1.84 specific gravity (sp gr))
1 part sodium dichromate ($Na_2Cr_2O_7.2H_2O$ —technical grade).

Rinse in demineralized water at a temperature no higher than 150° F. (65.6° C.) and with a pH no greater than 7.5. Observe immediately for water breaks on the surfaces as evidenced by the water not cascading from the parts or specimens in a smooth, continuous sheet. If water breaks occur, repeat above treatment. Dry the rinsed parts or specimens for 30 minutes, or until thoroughly dry, at a temperature no greater than 150° F. (65.6° C.), and repeat the water-break test or subject to instrumentation test as specified in 6.1.5.

6.1.2 *Stainless steel (except sandwich cores).* Degrease and proceed as specified in 6.1.1, except that immersion will be for 15 minutes at 150° to 160° F. (65.6° to 71.1° C.) in a strong acid-dichromate solution of the following composition:

96.6 percent by volume concentrated sulfuric acid (1.84 sp gr)
3.4 percent by volume saturated water solution of $Na_2Cr_2O_7.2H_2O$.

6.1.3 *Sandwich cores (aluminum alloys).* Degrease and proceed as specified in 6.1.1 except that immersion will be for 15 minutes at 150° to 160° F. (65.6° to 71.1° C.) in a mild acid-detergent solution of the following composition by weight:

92.9 percent clean, demineralized, oil free water
1.0 percent concentrated sulfuric acid (1.84 sp gr)
6.0 percent sodium dichromate ($Na_2Cr_2O_7.2H_2O$—technical grade)
0.1 percent surface active detergent (Pluronic F-68 manufactured by Wyandotte Chemical Corp., Wyandotte, Mich.).

6.1.4 *Sandwich cores (titanium and 302 type stainless steel).* Degrease and proceed as specified in 6.1.1, except that immersion will be for 15 minutes at 150° to 160° F. (65.6° to 71.1° C.) in a detergent solution of the following composition by weight:

94.4 percent clean, demineralized, oil free water
2.0 percent sodium metasilicate (Na_2SiO_3)
3.6 percent surface active detergent. (Triton X200 manufactured by Rohm and Haas Co., Washington Square, Philadelphia, Pa.)

6.1.5 *Water contact angle test.* A drop of distilled or demineralized water placed on a flat, dry, thoroughly prepared metal surface will spread rapidly and uniformly over the surface.

If the water drop does not so disperse itself, the metal surface is not properly prepared for subsequent adhesive bonding and must be reprocessed. With proper instrumentation, the angle of contact of a drop of water with a base surface can be measured. A low contact angle (10 degrees or less) indicates a surface satisfactorily prepared for adhesive bonding. A satisfactory contact angle measuring apparatus consists principally of a telemicroscope with a crosshair in a rotating eyepiece and with a prism on the objective end. The process specification will include an effective quality control provision based on contact angle measurements and instrumentation described herein.

6.1.6 *Treatment of titanium prior to adhesive bonding.* The following treatment is suggested:

(a) Methyl-ethyl-ketone wipe.

(b) Trichloroethylene vapor degrease.

(c) Pickle in the following water solution at room temperature for 30 seconds:
Nitric acid—15 percent by volume of 70 percent nitric acid solution.
Hydrofluoric acid—3 percent by volume of 50 percent hydrofluoric acid solution.

(d) Rinse in tap water at room temperature for 2 minutes.

(e) Immerse in the following water solution at room temperature for 2 minutes:
Trisodium phosphate — 6.68 ounces per gallon of solution.
Potassium fluoride—2.7 ounces per gallon of solution.
or
Sodium fluoride—1.2 ounces per gallon of solution.
Hydrofluoric acid (50 percent solution) 2.6 percent by volume of solution.

(f) Rinse in tap water at room temperature.

(g) Soak in 150° F. tap water for 15 minutes.

(h) Spray with distilled water and air-dry.

Note. If heavy heat-treat scale present, molten salt descale prior to above procedure.

6.1.7 *Treatment of magnesium alloy, AZ-31-H24 prior to adhesive bonding.* The following treatment is suggested:

(a) Degrease panels for 10 minutes at room temperature in trichloroethylene, then treat for 10 minutes at 160° to 190° F. in the following solution:
95.3 percent by weight water
2.2 percent by weight Na_2SiO_3 (metal)
1.1 percent by weight $Na_4P_2O_7$ (pyrophosphate)
1.1 percent by weight NaOH
0.3 percent by weight Nacconol NR [1].

(b) Rinse panels with cold distilled H_2O and then treat for 10 minutes at 155° ±5° F. in a solution of 20 percent CrO_3.

(c) Panels are then given a final rinse in warm distilled H_2O and air-dried.

(d) Prepared surfaces should be primed with adhesive or bonded as soon as possible; elapsed time not to exceed 8 hours.

Note. Proprietary corrosion preventive treatments, such as Dow 7 and Dow 17, produce satisfactory surfaces for adhesive bonding provided a zinc-chromate coating is not applied before bonding.

6.2 Definitions.

6.2.1 *Prime contractor.* A prime contractor is a contractor fabricating items under direct contract with the Government, or subcontracting the fabrication of such items; or a fabricator supplying items directly to the Government. (Whenever the term contractor appears in this specification, it will be construed to be the prime contractor.)

6.2.2 *Subcontractor.* A subcontractor is a fabricator supplying items or components to a prime contractor.

6.2.3 *Process specification.* Whenever the term process specification appears in this specification, it will be construed to be the contractor process (see 6.2.1) specification prepared in accordance with this specification.

[1] (Nacconol NR manufactured by National Aniline Division, Allied Chemical and Dye Corporation, 40 Rector Street, New York 6, N. Y.)

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