SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 3726C

Issued OCT 1983
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Superseding AMS 3726B

Shims, Filled Resin Compound

1. SCOPE:

1.1 Form:

This specification covers filled, thermosetting resin compounds capable of being applied and cured in place between the surfaces of mechanically fastened (joined) structures.

1.2 Application:

These products have been typically used as molded shims during assembly of aircraft components and parts requiring good flatwise compression properties and adhesion to metallic or nonmetallic materials, but usage is not limited to such applications. In most applications, the compound will be required to adhere to only one of the mating surfaces; i.e., the compound is not intended to be an adhesive. Each application should be considered individually.

1.3 Classification:

Resin compounds covered by this specification are classified as follows:

Class 1: Two part epoxy or modified epoxy base with separate harder or curing agent.

Class 2: Precatalyzed epoxy or modified epoxy base polymer supplied in sheet form.

Class 3: Precatalyzed epoxy or modified epoxy base polymer supplied as a liquid in a tube or other suitable container.

1.4 Safety - Hazardous Materials:

While the materials, methods, applications, and processes 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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP1524	Surface Preparation and Priming of Aluminum Alloy Parts for High Durability Structural Adhesive Bonding
AMS 3091	Mold Release Agent
AMS 3667	Polytetrafluoroethylene Sheet, Molded, General Purpose Grade, As Sintered
AMS 3894/2	Carbon Fiber Tape and Sheet, Epoxy Resin Impregnated, G 150,000 (1034) Tensile, 20,000,000 (138) Modulus 175 (347)
AMS -QQ-A-250/4	Aluminum Alloy 2024, Plate and Sheet

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 117	Salt Spray (Fog) Testing
ASTM D 696	Coefficient of Linear Thermal Expansion of Plastics
ASTM D 792	Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 1002	Apparent Shear Strength of Single-Lap-Joint by Tension Loading (Metal to Metal) Adhesively Bonded Metal Speciments
ASTM D 1151	Effect of Moisture and Temperature on Adhesive Bonds
ASTM D 2240	Rubber Property - Durometer Hardness
ASTM D 3165	Strength Properties of Adhesives in Shear by Tension Loading of Single-Lap-Joint Laminated Assemblies
ASTM D 3530	Volatiles Content of Carbon-Fiber-Epoxy Prepreg

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

AN960	Washer, Flat (Inactive for Design)
MS21042	Nut, Self Locking, 450 Deg. F, Reduced Hexagon, Reduced Height, Ring Base, Non-Corrosion Resistant Steel (ASG)
MS21084	Nut, Self Locking, 220 ksi Ftu, 450 Deg. F, Flanged, MS33787 Wrenching Element
MS21085	Nut, Self Locking, 260 ksi Ftu, 450 Deg. F, Flanged, MS33787 Wrenching Element
MS21296	Bolt, Tension, Steel, 260 ksi Ftu, 450 Deg. F, External Wrenching, Spline Drive, Flanged Head
MS21297	Bolt, Tension, Steel, 220 ksi Ftu, 450 Deg. F, External Wrenching, Spline Drive, Flanged Head
MS33787	Wrenching Element, External Spline, Dimensions For
MS35650	Nut, Plain Hexagon, Machine Screw, UNF2B

2.4 NAS Publications:

Available from Aerospace Industries Association, Inc., 1250 Eye Street, NW Washington, DC 20005.

NAS 1580 Bolt, 100 Deg. Flush Reduced Head

3. TECHNICAL REQUIREMENTS:

3.1 Material:

Shall be an epoxy or modified epoxy based polymer with a hardener or curing agent. Each may contain fillers or other ingredients necessary to meet the requirements of this specification. Filler materials shall not include asbestos products and shall not cause corrosion of metallic parts.

3.1.1 Class 1 shall be a two part liquid epoxy or modified epoxy base polymer supplied with a separate hardener or curing agent.

3.1.1.1 Storage Life: Compound shall meet the requirements of this specification at any time up to one year from the date of receipt by purchaser when stored as two separate components in the original, unopened containers.

3.1.2 Class 2 shall be precatalyzed epoxy or modified epoxy base polymer supplied in sheet form.

3.1.2.1 Storage Life: Sheets shall meet the requirements of this specification at any time up to six months from the date of receipt by purchaser when stored below -37 °C (-35 °F) in the original, unopened containers.

3.1.2.2 Refrigerated shipping is required consistent with storage requirements.

3.1.2.3 The precatalyzed sheet shall be kept frozen at all times until immediately prior to application.

3.1.2.4 Compound which has thawed shall not be refrozen.

3.1.3 Class 3 shall be a precatalyzed epoxy or modified epoxy base polymer supplied as a liquid in a tube or other suitable container.

3.1.3.1 Storage Life: Precatalyzed liquid shall meet the requirements of this specification at any time up to six months from the date of receipt by purchaser when stored below -37 °C (-35 °F) in the original, unopened containers.

3.1.3.2 Refrigerated shipping is required consistent with storage requirements.

3.1.3.3 The precatalyzed compound shall be kept frozen at all times until immediately prior to application.

3.1.3.4 Compound which has been thawed shall not be refrozen.

3.1.4 Working Life: When resin base and hardener of Class 1 material are mixed in accordance with manufacturer's instructions, the compound shall have a usable working life of 30 to 60 minutes. The working life of Class 2 and Class 3 compounds supplied as frozen premixes shall not be less than 30 minutes following thawing in accordance with manufacturer's instructions.

3.1.4.1 Rapid thawing (within 10 to 15 minutes) of Class 2 and Class 3 frozen premixed compounds will be required to prevent loss of working life. The purchaser should recognize that a facility to accomplish a rapid thaw will be required near the assembly area.

3.1.5 Viscosity: Class 1 and Class 3 liquids shall be workable and spreadable pastes and Class 2 sheet shall be tacky when thawed and now shall not sag or drip when applied to a vertical or overhead surface in thickness up to 0.05 inch (1.3 mm).

3.1.6 Volatile Content: Shall be essentially 100% solids, determined in accordance with ASTM D 3530. A measurable volatile content (weight loss) of up to 0.5% is acceptable for heat exposure up to 175 °C (347 °F).

3.1.7 Curing Time: The product when applied up to .05 inch (1.3 mm) thickness between metal plates shall have sufficient strength after curing for not more than 5 hours at not lower than 21 °C (70 °F) to permit tightening of .375 inch (9.52 mm) diameter bolts to 360 inch-pounds (40.7 N·m) in a typical bolted pattern without cracking or chipping of the shim material, determined in accordance with 4.5.1.

3.2 Cured Properties:

The product shall conform to the requirements of Table 1 and 3.2.9. Tests shall be performed at 20 to 30 °C (68 to 86 °F), unless otherwise specified. Values for strength tests shall be the average of five specimens for each test.

TABLE 1

Paragraph	Property	Requirement	Test Method
3.2.1	Hardness, Durometer D or equivalent, min average	92	ASTM D 2240
3.2.2	Specific Gravity, max	1.60	ASTM D 792
3.2.3	Coefficient of Linear Thermal Expansion, max average -62 to + 93 °C (-80 to +199 °F)	5.4 x 10^{-5} mm/mm per °C (3.0 x 10^{-5} inch/inch per °F)	ASTM D 696
3.2.4	Lap Shear Strength, min average	13.8 MPa (2000 psi)	ASTM D 1002
3.2.5	Lap Shear Residual Strength, Exposed, min average		
3.2.5.1	Salt Spray, 30 days at 50 °C ± (122 °F ± 2)	10.3 MPa (1500 psi)	ASTM B 117
3.2.5.2	Condensing Humidity, 30 days at 60 °C + 1 (140 °F ± 2)		ASTM D 1151
3.2.5.2.1	Classes 1 and 2	11.7 MPa (1700 psi)	
3.2.5.2.2	Class 3	12.4MPa (1800 psi)	
3.2.5.2.3	JP-4 Fuel, 7 days at 60 °C ± 1 (140 °F ± 2)	12.4 MPa (1800 psi) (1800 psi)	ASTM D 3165
3.2.6	Strain Compatibility, Tensile, Constant Amplitude Cycling		
3.2.6.1	Aluminum alloy	20 cycles without failure at -55 °C ± 1 (-67 °F ± 2)	4.5.2
3.2.6.2	Graphite-epoxy laminate	20 cycles without failure at -55 °C ± 1 (-67 °F ± 2	4.5.3
3.2.7	Flatwise Compressive Strength, min	30.0 ksi (207 MPa) stress without failure	4.5.4
3.2.8	Shim-Torque Test, breakaway torque, individual bolt, min.	50% of initial applied torque	4.5.5

3.2.9 Strain compatibility test with graphite-epoxy test coupon shall be the responsibility of the purchaser to perform. This test may be waived if purchaser's applications do not include graphite-epoxy laminated parts.

3.3 Quality:

Product, as received by purchaser, shall be uniform in quality and condition, and free from foreign material detrimental to usage of the compound.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer shall supply all samples and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Requirements shown in Table 2 are acceptance tests and shall be performed on each lot.

TABLE 2 - Acceptance Tests

Requirements	Paragraph Reference
Working Life	3.1.4
Viscosity	3.1.5
Specific Gravity	3.2.2
Flatwise Compression Strength	3.2.7

4.2.2 Preproduction Tests: All technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of compound by the manufacturer. Any change in ingredients and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.2.1 When material from Class 2 is used for preproduction testing, the thickness shall be as specified by the specific test method. The total thickness for test purposes may be obtained by stacking sheets of lesser thickness.

4.3 Sampling and Testing:

4.3.1 For Acceptance Tests: Sufficient product shall be taken at random from each lot to perform all required tests. The number of determinations for each requirement shall be as specified in the applicable test procedure or, if not specified therein, not less than three.

4.3.1.1 A lot shall be all compound produced from the same batches of raw materials processed in one continuous run and presented for manufacturer's inspection at one time.

4.3.1.2 A statistical sampling plan acceptable to purchaser, may be used in lieu of sampling as in 4.3.1.

4.3.2 For Preproduction Tests:

Acceptable to purchaser.

4.4 Approval:

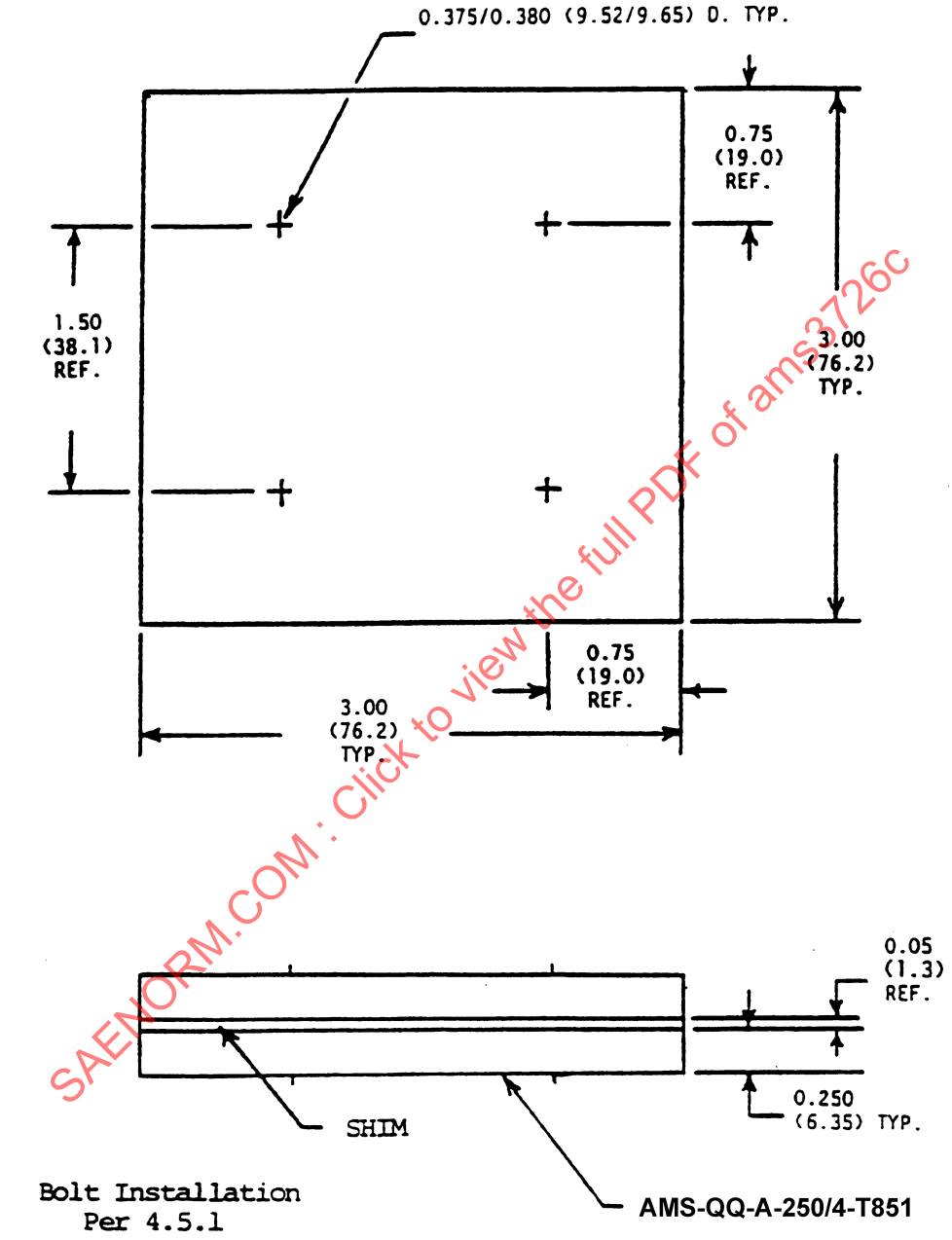
4.4.1 Sample product shall be approved by purchaser before product for production use is supplied, unless such approval be waived by purchaser. Results of tests on production compound shall be essentially equivalent to those on the approved sample. Production compound made by the revised procedure shall not be shipped prior to receipt of reapproval. If necessary to make any change in ingredients, in type of equipment for processing, or in manufacturing procedures, manufacturer shall submit for reapproval a statement of the proposed changes in ingredients and/or processing and, when requested, sample compound.

4.4.2 Manufacturer shall use ingredients, manufacturing procedures and processes, and methods of inspection on production compound which are essentially the same as those used on the approved sample compound.

4.5 Test Methods:

Shall be in accordance with Table 1 and the following:

4.5.1 Curing Time: Prepare two AMS-A-250/4-T851 aluminum alloy plates 76 x 76 x 6.35 mm (3 x 3 x 0.250 inch). Drill four holes through the plates for installation of MS21296-06008 or MS21297-06008 bolts. Hole size shall be 9.525/9.652 mm (0.375/0.380 inch). The hole centerlines shall be located 19.0 mm (0.75 inch) from the two nearest plate edges. The dimension between adjacent holes shall be 38 mm (1.5 inch) referenced dimension. Refer to Figure 1. Deburr all holes and plate edges. Prepare plates for application of compound in accordance with ARP1524. The faying surface of one plate and the bolts shall be coated with AMS 3091 or other suitable release agent. Apply the compound to a thickness of approximately 1.3 mm (0.05 inch) to the other plate. Assemble the two plates. Install bolts and nuts. Use MS35650-202 nuts at this stage. Tighten all nuts sufficiently to make contact with aluminum plates but not to force compound from assembly. Clean compound displaced by installation of bolts prior to hardening. Allow compound to set at room temperature for 5 hours ± 0.2 from time of application of resin. Remove nuts and replace with MS21084L06 or MS21085L06 nuts. Tighten bolts to 360 inch-pounds (41 N·m). Observe compound at edges for cracks or chipping. Disassemble plates and observe compound for interior cracks, chips, or crushing. The compound is acceptable if there are no visible signs of cracking, chipping, or crushing due to the tightening of the bolts.



Dimensions are in inches (millimeters)

FIGURE 1 - Test Panel for Curing Time

4.5.2 Strain Compatibility With Aluminum: Prepare two AMS-QQ-A-250/4-T81 aluminum alloy plates 89 x 152 x 4.06 mm (3.5 x 6.0 x 0.160 inch). Prepare for application of compound in accordance with ARP1524. The faying surface of one plate shall be coated with AMS 3091 or other suitable release agent. Apply the compound to a thickness of approximately 0.38 mm (0.015 inch) to the opposite plate in an area 38.1 mm (1.50 inch) wide parallel to the 152 mm (6 inch) long edge (see Figure 2). Assemble the plates such that the area coated with release agent of one plate overlaps the compound. Refer to Figure 2. Apply uniform pressure of 69 kPa (10 psi). Clean compound squeezed from overlap area from assembly prior to hardening. Allow compound to set at room temperature for 5 hours ± 0.2 prior to further preparation. Keeping plates clamped tightly, drill two lines of 8 holes parallel to the long plate dimension. Edge and side distance for holes shall be 9.52 mm (0.375 inch) from hole centerline to edge (or side) of plate. The holes shall be drilled to have seven equal spaces between holes. The hole size shall be 4.813/4.902 mm (0.1895/0.1930 inch) and shall be countersunk on the side of the assembly to which the compound is bonded to accept a NAS 1580A3T6 bolt. The maximum diameter of the countersink shall be 7.75 mm (0.305 inch). Disassemble the plates, deburr holes, and check compound for cracks or chips. The presence of cracks or chips is unacceptable and cause for rejection of the specimen. Reassemble plates. Install 16 NAS 1580A3T6 bolts using MS21042L3 nuts and AN 960 washers. Tighten bolts to 5.65 N·m (50 inch-pounds). Cut the plates into four equal width coupons as shown in Figure 2. An individual coupon shall be an overlap bolted joint with four bolts per coupon. Refer to individual coupon dimensions of Figure 2. The coupons shall be loaded in tension-tension (constant amplitude) cycling for 20 cycles at -55 °C (-67 °F) at a deflection rate of 2.5 mm (0.10 inch) per inch per minute. The load levels shall be set for a maximum stress (outside of the joint area) of 138 MPa (20.0 ksi) and a minimum stress of 13.8 MPa (2.0 ksi). The test is acceptable if there is no failure of the compound under cyclic loading.

4.5.3 Strain Compatibility With Graphite-Epoxy: This coupon is prepared and tested following the steps of 4.5.2 with the following exceptions:

4.5.3.1 A graphite-epoxy laminate shall be used in place of one of the aluminum plates.

4.5.3.1.1 The graphite epoxy laminate shall be provided according to purchaser's production processing steps. When AMS 3894/2 graphite tape is used, a 30-ply laminate of the following stacking orientation is recommended:

$$[(\pm 45°)_2, (0°/\pm 45°)_3, (\pm 45°)]_s \quad \text{(Eq. 1)}$$

where the 0° dimension is parallel to the reference 89 mm (3.5 inch) dimension. The laminate shall be scuff sanded using aluminum-oxide cloth, and blown free of sanding residue prior to application of the shim compound.

4.5.3.2 The shim compound material shall be bonded to the laminate.

4.5.3.3 The aluminum plate shall have a release agent applied to prevent bonding.

4.5.3.4 The coupons shall be prepared individually by cutting and drilling the laminate and aluminum plate in separate operations. The bolt countersink shall be in the laminate. Refer to Figure 3.

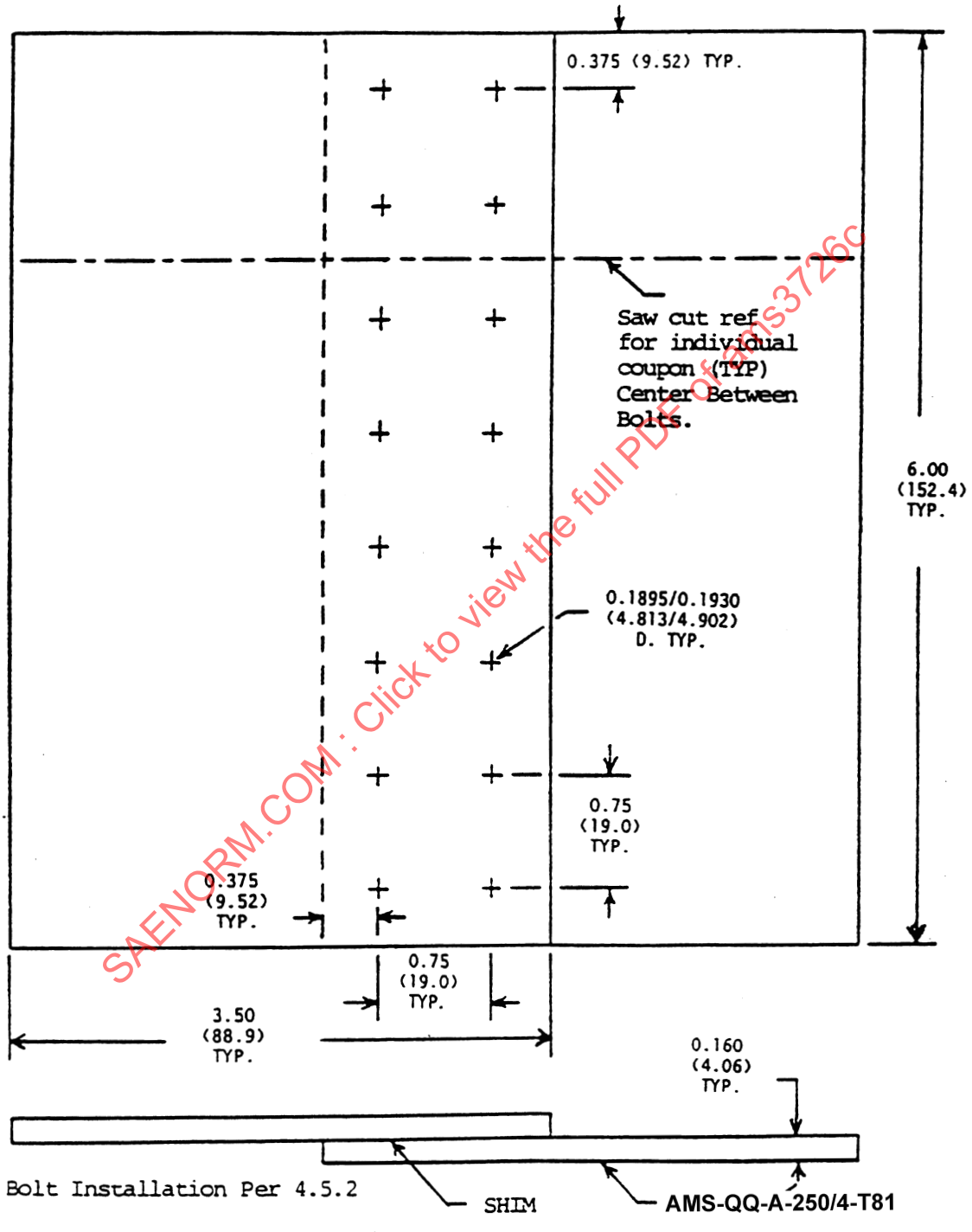
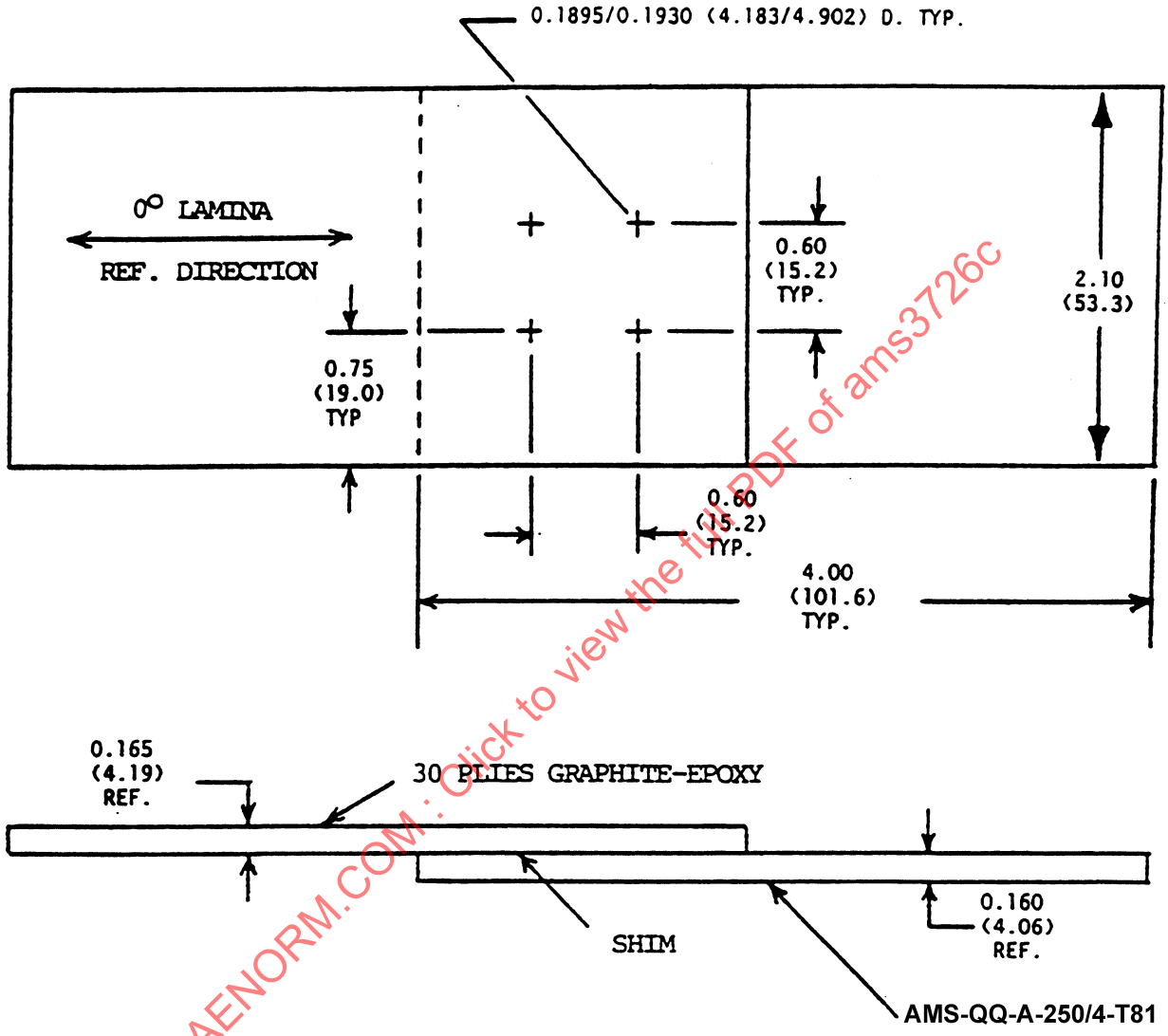


FIGURE 2 - Test Panel for Strain Compatibility Coupons



Dimensions are in inches (millimeters)

Prepare Laminate Per 4.5.3
Bolt Installation Per 4.5.2

FIGURE 3 - Laminate Strain Compatibility Coupon

4.5.3.5 The load levels for the tension-tension cycling shall be 117 MPa (17.0 ksi) maximum to 11.7 MPa (1.7 ksi) minimum, based on the stress in the aluminum plate outside of the joint area.

4.5.4 Flatwise Compressive Strength: Prepare two AMS-QQ-A-250/4 aluminum alloy plates, one to be a 102 x 152 x 12.7 mm (4 x 6 x 0.500 inch) -T851 plate and the other to be 25 x 127 x 3.18 mm (1 x 5 x 0.125 inch) -T81 sheet. Prepare the plates in accordance with ARP1524. Apply AMS 3091 or other suitable release agent to faying surface of the plate. Apply shim compound layer to the sheet approximately 0.38 mm (0.015 inch) thick and assemble to the plate such that the centerlines of the plate and sheet coincide (See Figure 4). Apply a pressure of 69 kPa (10 psi) uniformly to the sheet. Allow assembly to set at room temperature for 24 hours ± 0.5 prior to loading. Apply compression load at centerline of assembly, bearing directly upon sheet material over a 645 mm^2 (1 square inch) area. The load shall be 207 MPa (30.0 ksi). The assembly shall be examined for failure of the compound. Cracking, chipping, or crushing of the compound is unacceptable.

4.5.5 Shim-Torque Panel: The test panel shall be prepared using 102 x 152 x 6.4 mm (4 x 6 x 0.25 inch) thick AMS-QQ-A-250/4-T851 aluminum alloy plates (prepare the plates in accordance with ARP1524). The assembly will require NAS 1580A4T8 bolts, MS21042L4 nuts, and AN960 washers. An AMS 3667 polytetrafluoroethylene spacer, 1.02 mm (0.040 inch) thick, will also be required. Wipe the bonding surface with a suitable solvent to remove all surface dye and foreign materials. Apply a release agent to one of the plates. To the other plate, apply a shim compound layer approximately 1.27 mm (0.050 inch) thick by 25 mm (1.0 inch) wide along the reference 152 mm (6 inch) dimension. Assemble the plates as shown in Figure 5, using the spacer at each end of the overlap. The plates shall be firmly clamped during cure. The assembly shall be set at room temperature until the resin is tack free but not more than 5 hours. Drill the assembly to a hole size of 6.35/6.48 mm (0.250/0.255 inch) on 12.7 mm (0.50 inch) centers as shown in Figure 5. The maximum diameter of the countersink shall be 12.75 mm (0.502 inch). Disassemble and deburr. Reassemble, installing bolts and nuts. Tighten the bolts to 125 inch-pounds (14 N·m). Allow the panel to set at room temperature for not less than 7 days prior to testing. The panel shall be cooled to -55 °C (-67 °F) until the thermocouple monitored glueline temperature reaches equilibrium temperature, then immediately moved into a circulating hot-air oven set to permit a glueline temperature of 132 °C ± 2 (270 °F ± 4). The panel shall be held at 132 °C ± 2 (270 °F ± 4) for 60 minutes ± 6. The assembly shall then be allowed to cool to room temperature. Check the breakaway torque of each fastener using the same torque wrench used to tighten them originally. Breakaway torque is the torque necessary to begin to move the nut when it is turned in the direction to tighten it. Each nut shall require at least 50% of the original torque to start nut movement.

4.6 Reports:

The supplier of the compound shall furnish with each shipment a report from the manufacturer showing the results of tests to determine conformance to the acceptance test requirements and stating that the compound conforms to the other technical requirements. This report shall include the purchase order number, lot number, AMS 3726C, class, manufacturer's identification, lot number, date of manufacture, and quantity.