AEROSPACE MATERIAL SPECIFICATION

AMS3912™	REV. A

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Superseding AMS3912

Radomes, Foam Sandwich
Polyimide/Quartz Cloth Construction

RATIONALE

AMS3912A has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE:

1.1 Form: This specification covers the material and process requirements for fabricating sandwich radomes having polyimide-resin-impregnated quartz cloth shells and polyimide-resin syntactic foam cores.

1.2 Application: Primarily as a radar-transparent structure for use as an electromagnetic window up to 315°C (600°F).

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 3138 - Coating Materials, Fluorocarbon Elastomeric
AMS 3619 - Resin, Polyimide, Laminating, High Temperature Resistant, 315°C (600°F)
AMS 3684 - Resin, Polyimide, Sealing, High-Temperature Resistant, 315°C (600°F), Unfilled
AMS 3686 - Adhesive, Polyimide Resin, Film and Paste, High Temperature Resistant, 315°C (600°F)
AMS 3709 - Syntactic Foam Tiles
AMS 3751 - Microspheres, Hollow Glass
AMS 3803 - Wipes, Cotton, Loosely Woven
AMS 3824 - Cloth, Glass, Finished for Resin Laminates
AMS 3847 - Cloth, Quartz, "B" Stage Polyimide Resin Impregnated, Style 581 Fabric, 315°C (600°F)
AMS 4770 - Brazing Filler Metal, Silver, 50Ag - 18Cd - 16.5Zn - 15.5Cu, 1160° - 1175°F (625° - 635°C) Solidus-Liquidus Range

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For more information on this standard, visit
https://www.sae.org/standards/content/AMS3912A/

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM C273 - Shear Test in Flatwise Plane of Flat Sandwich Construction or Sandwich Cores
ASTM C297 - Tension Test of Flat Sandwich Constructions in Flatwise Plane
ASTM D790 - Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D792 - Specific Gravity and Density of Plastics by Displacement
ASTM D2520 - Complex Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials at Microwave Frequencies and Temperatures to 1650°C
ASTM D2584 - Ignition Loss of Cured Reinforced Resins
ASTM D2734 - Void Content of Reinforced Plastics

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Specifications:

O-A-51 - Acetone, Technical Grade
TT-M-261 - Methyl Ethyl Ketone (MEK)
CCC-C-440 - Cheesecloth

2.3.2 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

3. TECHNICAL REQUIREMENTS:

3.1 Materials: The materials incorporated into the completed radome shall be as specified herein. The several styles of glass cloth specified shall conform to the applicable requirements of AMS 3824.

3.1.1 Polyimide Syntactic Foam Grout Formulation:

Component	Parts by Weight
Glass Microspheres, AMS 3751, Class 15	100
Polyimide Resin, AMS 3619	140
Fine Aluminum Powder, See 8.2	15
l/4-In. (6-mm) Chopped Glass, See 8.3	7.2
Acetone, 0-A-51	40
N-Methylpyrrolidone (NMP)	55

3.1.2 Polyimide Surface Filler Formulation:

Component	Parts by Weight
Fine Inorganic Filler, See 8.4	25
N-Methylpyrrolidone (NMP)	25
Polyimide Resin, AMS 3684	100

3.2 Procedure:

3.2.1 Mandrel Preparation: The mandrel on which the shell is to be built up shall be cleaned with acetone or with TT-M-261 methyl ethyl ketone (MEK) and coated with an appropriate release agent.

3.2.2 Bare Mandrel Calibration:

3.2.2.1 The mandrel shall be centered in the grinder with a maximum deviation of 0.0007 in. (0.018 mm) total indicator reading (TIR) at the nose and 0.0010 in. (0.025 mm) TIR at the base.

3.2.2.2 Using the gaging system on the appropriate grinder, bare mandrel readings relative to the master cam shall be measured to the nearest 0.0010 in.(0.025 mm) at the appropriate stations.

3.2.3 General Fabrication Procedures: Fabrication of the radome shell shall be accomplished in the following sequence:(1) layup and cure the inner skin and solid laminate buildups, (2)bond, grout, and grind precured foam core,(3) layup and cure the outer skin, and(4) postcure, final grind, trim, and assemble finished radome (e.g., nose plug, lightning diverters, erosion coating).

3.2.3.1 Skin Layup: The warp direction of the resin-impregnated fabric shall be parallel to the radome centerline ± 10 degrees. Lap joints shall not be superimposed. Lap joints shall be 0.50 in. ± 0.25 (12.5 mm ± 6.2 wide. The layup temperature shall not exceed 70°C(160°F)prior to the curing operations.

3.2.3.2 Layup Debulk: The uncured layup shall be debulked, after each ply or series of plies is laid up , as required to eliminate wrinkles in the cured skin. Debulking may be accomplished by vacuum bag, wrapping with cord under tension,or by use of shrink tape.Temperatures during debulking operations shall not exceed 70°C (160°F).

3.2.3.3 Layup Devolatilization: Prior to autoclave cure of the layup, the uncured layup shall be devolatilized to a level which results in laminates with less than 5% void content after cure and postcure in accordance with this specification. The proper volatiles level will vary with the mass and thermal conductivity of the mold and cured material under the uncured layup. Devolatilization may be accomplished

3.2.3.3 (Continued):

using a vacuum bag or with the layup exposed. The temperature of the uncured layup shall not exceed 70°C (160°F) during devolatilization, measured by a thermocouple located within the layup no more than one ply from the hot surface.

3.2.3.4 Cures: All autoclave cures shall be carried out in a vacuum bag. There shall be at least one thermocouple buried within the layup to be cured, no more than one ply from the mandrel side of the uncured layup, and located in the base overtrim. As the coolest thermocouple during heatup, this shall be the controlling thermocouple. Not less than four thermocouples shall be taped to the outer surface of the vacuum bag, located at the base trim, at the nose, and at two intermediate locations between these. These thermocouples shall be insulated from the air with pads of glass insulation. Where vacuum is specified, the vacuum pressure shall be no less than 24 in. (600 mm) of mercury (Hg). There shall be three vacuum lines, one at the nose and two at the radome base 180 deg apart.

3.2.4 Inner Skin Fabrication:

3.2.4.1 Layup: Four plies of AMS 3847 resin-impregnated quartz cloth shall be laid up on the mandrel in accordance with 3.2.3.1.

3.2.4.2 Preparation for Cure: After debulking in accordance with 3.2.3.2 and devolatilization in accordance with 3.2.3.3, one ply of unfinished glass cloth, Style 128 or 7628, one ply of release fabric, and one ply of glass cloth, Style 1584, 184, or 1884, shall be applied in sequence and the parts shall be vacuum bagged in accordance with 3.2.3.4.

3.2.4.3 Cure: After properly placing the part in the autoclave, the part shall be cured as follows: with the part under a vacuum of not less than 24 in. (600 mm) of Hg, the autoclave air temperature shall be raised to 120°C, -0, +8 (250°F, -0, +15) at a rate of 2 - 3 C (4 -5 F) deg per min., and the autoclave held at that temperature until the coolest-part thermocouple reaches 80°C (175°F). The autoclave air temperature shall be raised to 150°C ± 8 (330°F ± 15) at a rate of 2 - 3 C (4 - 5 F) deg per min.; when the coolest-part thermocouple reaches 93°C (200°F), pressure of not less than 100 psig (690 kPag) shall be applied with all vacuum lines vented to the atmosphere as pressure is applied. When the coolest-part thermocouple reaches 110°C (230°F), the autoclave air temperature shall be raised to 185°C, -15, +0 (365°F, -25, +0) at a rate of 1 C (2 F) deg per min. and held within that range. When the coolest-part thermocouple reaches 170°C (340°F), the part shall be cured for not less than 2 hr at 170°C, -0, +15 (340°F, -0, +25). After the 2-hr cure, the part shall be cooled under full pressure until the hottest-part thermocouple is below 110°C (230°F).

3.2.5 Solid Laminate Layup:

3.2.5.1 The unfinished glass cloth, Style 128 or 7628, peel ply, shall be stripped from the part in the buildup areas. The stripped areas shall be brush coated with AMS 3619 polyimide resin and dried at 105°C ± 3 (220°F ± 5) for 30 - 60 min., prior to layup.

3.2.5.1 Sufficient plies of Style 7781 glass cloth impregnated with AMS 3619 resin shall be laid up over the aft section of the inner skin to obtain the cured thickness specified on the drawing, plus not less than two excess plies. Patterns may be bias-cut relative to the radome axis. The nose area buildup and the aft buildup tabs shall be cut and laid up as shown on the drawing, using AMS 3847 resin-impregnated cloth.

3.2.5.3 The solid buildup layups shall be debulked in accordance with 3.2.3.2, devolatilized in accordance with 3.2.3.3, vacuum bagged in accordance with 3.2.3.4, and autoclave cured in accordance with 3.2.4.3.

3.2.6 Preparation of Foam Core Tiles:

3.2.6.1 The foam tiles shall be fabricated in accordance with AMS 3709 to the requirements of the applicable drawing.

3.2.6.2 The bonding surface of the tiles shall be sanded with No. 400 - 600 (38 - 29 µm) grit sandpaper and the dust removed by vacuum. The bonding surface shall be coated with a thin layer of AMS 3686 polyimide paste

Ø adhesive, and oven dried for 45 min. ± 5 at 105°C ± 3 (220°F ± 5). One layer of AMS 3686 polyimide film adhesive, shall be applied to each bonding surface and oven dried for 45 min. ± 5 at 105°C ± 3 (220°F ± 5). The prepared tiles shall be stored in moisture-proof bags until they are to be bonded.

3.2.7 Bonding of Tiles to Inner Skin:

3.2.7.1 The remaining 128 or 7628 glass peel ply shall be removed from the inner

Ø skin. A thin coat of AMS 3686 polyimide paste adhesive shall be applied to the peeled area. The adhesive shall be dried at 105°C ± 5 (220°F ± 9) for not less than 60 minutes.

3.2.7.2 The prepared tiles from 3.2.6 shall be positioned on the inner skin in accordance with the applicable drawing so that there is a gap of 0.150 in. ± 0.030 (3.75 mm ± 0.75) around each tile.

3.2.7.3 One layer of glass bleeder fabric shall be laid over the entire radome/tiles surface, the part shall be vacuum bagged, and a vacuum of not less than 24 in. (600 mm) Hg shall be applied.

3.2.7.4 The part shall be placed in an autoclave and cured as follows: simultaneously raise the autoclave air temperature to 185° C ± 3 (365°F ± 5) at a rate of 1.5 - 2.0 C (2.5 - 3.5 F) deg per min. and raise the pressure to not less than 50 psig (345 kPag). When the coolest-part thermocouple reaches 170°C (340°F), the part shall be maintained at 180°C ± 8 (355°F ± 15) for not less than 90 minutes. The part shall be cooled to 105°C (220°F) or below under vacuum and at least 50 psig (345 kPag) pressure before debagging.

3.2.8 Core Joint Grouting:

3.2.8.1 Open all joints to 0.19 in. ± 0.06 (4.8 mm ± 1.5) at the base and taper the sides to approximately 10 deg angle from normal to the radome surface.

3.2.8.2 Apply a thin coat of AMS 3686 polyimide paste adhesive to all joint surfaces.

3.2.8.3 Prepare grout mix in accordance with 3.1.1.

3.2.8.4 Pack grout mix into all foam tile joints.

3.2.8.5 Raise radome temperature to 65°C ± 3 (150°F ± 5) and hold for 60 min. ± 5. Cool to room temperature.

3.2.8.6 One ply of glass release/bleeder fabric shall be placed over all filled joints. Vacuum bag the part and apply a vacuum of not less than 24 in. (600 mm) Hg.

3.2.8.7 Heat the radome to 115°C ± 5 (240°F ± 9) and hold for not less than 45 min.; raise radome temperature to 175°C ± 5 (350°F ± 9) and hold for not less than 90 minutes. Cool the radome under full vacuum to below 65°C (150°F) before debagging.

3.2.9 Pregrind: The part shall be centered in the grinder with a maximum deviation of 0.0007 in. (0.18 mm) TIR at the nose and a maximum of 0.0010 in. (0.025 mm) TIR at the base. The foam core window areas shall be ground to the total wall thickness shown on the drawing, -0.082 in. (-2.05 mm), +0. The solid laminate base area shall be ground to the total thickness shown on the applicable drawing. -0.072 in. (-1.80 mm), +0. After grinding, the radome surface shall be vacuumed clean.

3.2.10.1 Outer Skin Layup:

3.2.10.1 A thin coat of AMS 3686 polyimide paste adhesive shall be applied to all exterior surfaces of the radome.

3.2.10.2 At least two plies more than the six required for the final outer skin shall be laid over that entire surface of the radome using AMS 3847 resin-impregnated cloth.

3.2.10.3 The outer skin layup shall be debulked in accordance with 3.2.3.2, devolatilized in accordance with 3.2.3.3, and autoclave cured in accordance with 3.2.4.3.

3.2.11 Postcure: The radome shall be fitted with not less than four thermocouples taped to the outer surface and located at the base, at the nose, and at two intermediate locations between. The thermocouples shall be insulated from the surrounding medium to reflect the radome temperature. The radome shall be postcured in accordance with the following schedule, as recorded on the coolest thermocouple. Exposure times are minimums and temperatures are ± 8°C (± 15°F):

16 hr at 175°C (350°F), plus
24 hr at 205°C (400°F), plus
24 hr at 230°C (450°F), plus
24 hr at 260°C (500°F), plus
24 hr at 290°C (550°F), plus
8 hr at 315°C (600°F)

3.2.12 Final Grind: The radome window area shall be ground to the electrical design configuration, determined with a one-horn interferometer. Base attach area and nose area shall be ground to the dimensional requirements of the applicable drawing.

3.2.13 Coating and Assembly of Radome:

3.2.13.1 The radome shell shall be removed from the mandrel using an appropriate removal tool.

3.2.13.2 All tooling and drain holes shall be drilled as specified on the applicable drawing.

3.2.13.3 The radome shell shall be trimmed and routed as specified on the applicable drawing, using the proper trim fixture.

3.2.13.4 Surface Sealing:

3.2.13.4.1 The polyimide filler of 3.1.2 shall be applied to the exterior shell surfaces and to all cut or drilled laminate edges. The radome shall be heated to 175°C ± 5 (350°F ± 9) at a rate of 2 - 3 C (4 - 5 F) deg per min. and cured for 60 min. ± 5 at 175°C ± 5 (350°F ± 9).

3.2.13.4.2 All internal and external radome surfaces shall be lightly sanded with No. 400 (38 µm) grit sandpaper to remove the gloss. The dust shall be removed by using AMS 3803 wipes or clean CCC-C-440 cheesecloth dampened with TT-M-261 MEK. AMS 3684 polyimide sealing resin shall be diluted for spraying with a 3 to 1 by weight mixture of NMP and MEK. All interior and exterior surfaces shall be sprayed to a dry film thickness of 0.001 - 0.002 in. (0.025 - 0.050 mm). The radome shall be heated to 175°C ± 5 (350°F ± 9) at a rate of 2 - 3 C (4 - 5 F) deg per min. and cured for not less than 60 min. ± 5 at 175°C ± 5 (350°F ± 9).

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3.2.13.5 Bonding of Lightning-Diverter Strips:

3.2.13.5.1 The lightning-diverter strips shall be located on the radome surface in accordance with the applicable drawing. The bonding surfaces of the radome and the lightning-diverter strips shall be lightly sanded with No. 400 (38 µm) grit sandpaper. The sanded radome and strip surfaces shall be wiped dust-free with AMS 3803 wipes or clean cheesecloth dampened with MEK.

3.2.13.5.2 AMS 3686 polyimide paste adhesive, shall be applied to the bonding surfaces of both the radome and the strips and dried for not less than 60 min. at 105°C ± 5 (220°F ± 9).

3.2.13.5.3 The lightning-diverter strip buttons shall be masked for protection from resin-bleedout.

3.2.13.5.4 The lightning-diverter strips shall be positioned on the radome and covered with one ply of glass release fabric and the part shall be vacuum bagged.

3.2.13.5.5 A vacuum of not less than 24 in. (600 mm) Hg shall be applied and the bondline temperature shall be raised to 175°C ± 8 (350°F ± 15) at a rate of 2 - 3 C (4 - 5 F) deg per minute. The part shall be cured for 60 min. ± 5 at 175°C ± 5 (350°F ± 9). The part shall be cooled to below 70°C (160°F) under full vacuum before debagging.

3.2.13.5.6 Copper wire loops shall be bonded to the inside radome surface with l/2-in. (12.5-mm) wide strips of glass cloth, Style 108, impregnated with polyimide resin conforming to AMS 3619. The configuration shall be in accordance with the applicable drawing. The radome surface shall be prepared in accordance with 3.2.13.5.1 and shall be vacuum bagged and cured in accordance with 3.2.13.5.5.

3.2.13.6 The metal nose plug shall be bonded into the nose. Both bonding surfaces shall be prepared by lightly sanding with No. 400 (38µm) grit sandpaper and coating with AMS 3686 polyimide paste adhesive. The adhesive shall be dried for not less than 45 min. at 105°C ± 5 (220°F ± 9). A second coat of AMS 3686 polyimide paste adhesive shall be applied and the nose plug shall be assembled into the radome in accordance with the applicable drawing.

3.2.13.7 The assembled radome shell shall be placed in an oven and the temperature raised to 290°C ± 5 (550°F ± 9) at a rate of 2 - 3 C (4 - 5 F) deg per minute. The radome assembly shall be held at 290°C ± 5 (550°F ± 9) for 60 min. ± 5. The radome assembly shall be cooled to ambient temperature in not less than two hours.

3.2.14 Application of Erosion-Resistant Coating: The entire outer shell Ø surface, except for the lightning-diverter strip buttons, shall be spray coated with AMS 3138 fluoroelastomer erosion-resistant coating.

3.2.14.1 All surfaces to be coated shall be lightly sanded with No. 400 (38 µm) Ø grit sandpaper and wiped clean with a MEK dampened AMS 3803 wipes or cheesecloth. The lightning-diverter strip buttons shall be masked off during the spraying operation.

3.2.14.2 The AMS 3138 fluoroelastomer erosion coating shall be catalyzed in accordance with manufacturer's instructions. The coating shall be thinned with MEK as necessary for spray application.

3.2.14.3 The fluoroelastomer coating shall be applied and cured in accordance with manufacturer's instructions to produce a dry film thickness of 0.009 - 0.013 in. (0.22 - 0.32 mm).

3.2.14.4 After a three-day ambient cure, the buttons shall be unmasked and the coated radome assembly shall be cured for at least 1 hr each at 95°C (200°F), 150°C (300°F), and 205°C (400°F); tolerance on temperatures shall be ± 3°C (± 5°F).

3.2.15 Hardware Assembly:

3.2.15.1 The radome aft-end attaching hardware shall be assembled to the radome shell in accordance with the applicable drawing.

3.2.15.2 A 0.028-in (0.70-mm) diameter hole shall be drilled through a button in the diverter strip and the solid laminate base area of the radome in accordance with the drawing.

3.2.15.3 The resistor wire shall be fed through the hole and brazed with AMS 4770 filler metal to the diverter-strip buttons in accordance with the applicable drawing. The resistor wire shall then be securely attached to the inside of the attaching hardware as specified on the drawing. This procedure shall be repeated for each diverter strip used. The holes shall then be potted with AMS 3686 polyimide paste adhesive and cured for 60 min. ± 5 at 175°C ± 5 (350°F ± 9):

3.3 Properties: The product shall conform to the following requirements; tests shall be performed on the test panels of 4.3 and in accordance with specified ASTM methods insofar as practicable:

3.3.1 Sandwich Properties: Shall be as follows, determined on three specimens per test:

3.3.1.1 Core Shear Strength: ASTM C273

	Minimum Individual	Minimum Average
At 25°C ± 3 (77°F ± 5)	260 psi (1.80 MPa)	275 psi (1.90 MPa)
At 315°C ± 3 (600°F ± 5)	235 psi (1.60 MPa)	250 psi (1.70 MPa)

3.3.1.2 Flatwise Tensile Strength: ASTM C297

	Minimum Individual	Minimum Average
At 25°C ± 3 (77°F ± 5)	325 psi (2.25 MPa)	350 psi (2.40 MPa)
At 315°C ± 3 (600°F ± 5)	200 psi (1.40 MPa)	225 psi (1.55 MPa)

3.3.2 Laminate Properties: Shall be as follows; flexural strength shall be determined on three specimens per test:

3.3.2.1 Specific Gravity: 1.60 - 1.80 ASTM D792

3.3.2.2 Resin Content: 30 - 40% ASTM D2584, Furnace Temperature: 620°C ± 25 (1150°F ± 50)

3.3.2.3 Void Content:

Inner Skin	58, max
Outer Skin	10%, max

3.3.2.4 Flexural Strength:

	Minimum Individual	Minimum Average
At 25°C ± 3 (77°F ± 5)	63,000 psi (435 MPa)	70,000 psi (485 MPa)
At 315°C ± 3 (600°F ± 5)	36,000 psi (250 MPa)	40,000 psi (275 Mpa)

3.3.3 Composite Dielectric Properties: Shall be 2.90 - 3.40, determined in accordance with ASTM D2520, Method A, at 9.375 GHz at room temperature.

3.4 Quality: Radomes, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the radomes.

3.4.1 After applying the sealer coating but before attaching the diverter strips, wire loops, and erosion-resistant coating, radome shells shall be inspected by photochromic or other suitable nondestructive test method on both inner and outer surfaces for internal imperfections such as disbonds or crushed core. All suspected imperfections shall be subject to review for disposition of the part.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product shall supply all samples for vendor's tests and shall be responsible for performing all Ø required tests. Results of such tests shall be reported to the purchaser as required by 4.6. 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: Tests to determine conformance to all technical Ø requirements of this specification are classified as acceptance tests and shall be performed on test panels representing each lot.

4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests Ø and shall be performed prior to or on the initial shipment of radomes to a purchaser, when a change in material, processing, or both requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.2.1 For direct U.S. Military procurement, substantiating test data and, when Ø requested, a preproduction radome shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be as follows:

4.3.1 For Acceptance Tests:

4.3.1.1 The sandwich test panel representing the radome shall be not less than 12 x 12 x T in. (300 x 300 x T mm), where "T" is the thickness of the radome wall, and shall be prepared and cured along side the radome shell.

4.3.1.2 The laminate properties test samples shall be cut from the tag end overtrim on the solid laminate buildup of the radome.

4.3.1.3 Inspection Unit: Each individual unit produced shall be fully tested to the requirements of this specification.

4.3.2 For Preproduction Tests: As agreed upon by purchaser and vendor. Ø