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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 3913A

Issued 10-15-80
Revised 4-1-89

Superseding AMS 3913

RADOME, FOAM SANDWICH
Hot-Melt, Addition-Type Polyimide

1. SCOPE:

1.1 Form: This specification covers the material and process requirements for fabricating sandwich radomes having hot-melt, addition-reaction 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 230°C (446°F).

1.3 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.

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 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 3698 - Adhesive Film, Hot-Melt, Addition-Type Polyimide, For Foam Sandwich Structure, -55° to +230°C (-67° to +450°F)
AMS 3709 - Syntactic Foam Tiles
AMS 3751 - Microspheres, Hollow Glass
AMS 3755 - Powder, Fumed Silicon Dioxide
AMS 3824 - Cloth, Type "E" Glass, Finished for Resin Laminates
AMS 3844 - Cloth, Type "E" Glass, Style 7781 Fabric, Hot-Melt, Addition-Type, Polyimide Resin Impregnated
AMS 3849 - Cloth, Quartz, Style 581 Fabric, Hot-Melt, Addition-Type, Polyimide Resin Impregnated
AMS 4770 - Brazing Filler Metal, Silver, 50Ag - 18Cd - 16.5Zn - 15.5Cu, 1160° - 1175°F (625° - 635°C) Solidus-Liquidus Range

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM C273 - Shear Test in Flatwise Plane of Flat Sandwich Constructions 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 D790M - Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials (Metric)
ASTM D792 - Specific Gravity (Relative Density) 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 Publication and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 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:
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Component	Parts by Weight
AMS 3751 Glass Microspheres, Class 15	100
AMS 3619 Polyimide Resin	140
Fine Aluminum Powder	15
1/4-Inch (6.4-mm) Chopped Glass	7.2
Acetone, Technical Grade	40
N-Methylpyrrolidone (NMP)	55

3.1.2 Polyimide Surface Filler Formulation:
Ø

Component	Parts by Weight
Fine Inorganic Filler	80
N-Methylpyrrolidone (NMP)	40
AMS 3619 Polyimide Resin	60
AMS 3755 Fumed Silicon Dioxide Powder	1

3.2 Procedure:

3.2.1 Mandrel Preparation: The mandrel on which the shell is to be built shall be cleaned with acetone or with 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 inch (0.018 mm) total indicator reading (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 inch (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 inch ± 0.25 (12.7 mm ± 6.4) wide. The layup temperature shall not exceed 70°C (158°F) prior to the curing operation.

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 (158°F).

3.2.3.3 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 not less than 24 inches (610 mm) of mercury (Hg). There shall be three vacuum lines, one at the nose and two, 180 degrees apart, at the radome base.

3.2.4 Inner Skin Fabrication:

3.2.4.1 Layup: Six plies of AMS 3849 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: A peel ply shall be used over the lay-up only (do not connect with bleeder system), and the entire assembly vacuum-bagged using nylon film. A non-perforated film and dry glass fabric "breather" ply between the peel ply and bag shall be used. Bleeder system shall be such that bleeding is through the top surface of the lay-up only and not from the edges.

3.2.4.3 Cure: The assembly shall be placed in an autoclave for cure. Vacuum not less than 24 inches (610 mm) Hg shall be applied and maintained throughout the cure cycle. The assembly shall be heated to a temperature within the range 82° - 93°C (180° - 199°F) and held at the selected temperature within ±5°C (±9°F). Autoclave pressure of 90 psi ± 5 (621 kPa ± 34) shall then be applied and the temperature increased to 180°C ± 5 (356°F ± 9). Assembly shall be cured for not less than 90 minutes at 180°C ± 5 (356°F ± 9) and 90 psi ± 5 (621 kPa ± 34). During cool-down, autoclave pressure shall be maintained until part has cooled below 120°C (248°F) and vacuum shall be maintained on assembly until it has cooled below 90°C (194°F).

3.2.5 Solid Laminate Layup:

3.2.5.1 The unfinished glass fabric, Style 128 or 7628, peel ply, shall be stripped from the part in the buildup areas.

3.2.5.2 Sufficient plies of AMS 3844 Style 7781, E-glass, hot-melt, addition-type, polyimide-resin-impregnated fabric 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 shall be cut and laid up as shown on the drawing, using AMS 3849 resin-impregnated cloth.

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

3.2.6 Preparation of Foam Core Tiles: The foam tiles shall be fabricated in accordance with AMS 3709 to the requirements of the applicable drawing.

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 skin. A ply of AMS 3698 polyimide adhesive film shall be applied to the peeled area.

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 inch ± 0.030 (3.81 mm ± 0.76) 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 inches (610 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 ± 2 (365°F ± 4) at a rate of 1.5 - 2.0C (2.5 - 3.5F) degrees per minute and raise the pressure to not less than 50 psi (345 kPa). When the coolest-part thermocouple reaches 170°C (338°F) the part shall be maintained at 180°C ± 5 (356°F ± 9) for not less than 90 minutes. The part shall be cooled to 100°C (212°F) or below under vacuum and at least 50 psi (345 kPa) pressure before debagging.

3.2.8 Core Joint Grouting:

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

3.2.8.2 Apply a thin coat of AMS 3619 polyimide resin 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 ± 2 (149°F ± 4) and hold for 60 minutes ± 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 inches (610 mm) mercury.

3.2.8.7 Heat the radome to 115°C ± 5 (239°F ± 9) and hold for not less than 45 minutes; raise radome temperature to 175°C ± 5 (347°F ± 9), and hold for not less than 90 minutes. Cool the radome under full vacuum to below 65°C (149°F) before debagging.

3.2.9 Pregrind: The part shall be centered in the grinder with a maximum deviation of 0.0007 inch (0.018 mm) TIR at the nose and a maximum of 0.0010 inch (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 inch (-2.08 mm), +0. The solid laminate base area shall be ground to the total thickness shown on the applicable drawing, -0.072 inch (-1.83 mm), +0. After grinding, the radome surface shall be vacuum cleaned.

3.2.10 Outer Skin Layup:

3.2.10.1 At least two plies more than the six required for the final outer skin shall be laid over the entire surface of the radome using AMS 3849 resin-impregnated cloth.

3.2.10.2 The outer skin layup shall be debulked in accordance with 3.2.3.2 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.

3.2.11.1 Temperature shall be uniformly increased in stages to 190°C ± 5 (374°F ± 9) over a 2-hour ± 0.1 period and maintained at temperature for not less than 12 hours.

3.2.12 Final Grind: The radome window area shall be ground to the electrical design configuration as 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 (347°F ± 9) at a rate of 2 - 3C (4 - 5F) degrees per minute, cured for 60 minutes ± 5 at 175°C ± 5 (347°F ± 9), and cooled to room temperature.

3.2.13.4.2 Ø All internal and external radome surfaces shall be lightly sanded with No. 100 to 180 (150 to 80 µm) grit sandpaper to remove the gloss. The dust shall be removed by using clean cheesecloth dampened with MEK. Silicone resin shall be diluted for spraying with a 3 to 1 by weight mixture of xylene. All interior radome surfaces shall be sprayed to a dry film thickness of 0.001 - 0.002 inch (0.025 - 0.051 mm). The radome shall be heated to 175°C ± 5 (347°F ± 9) at a rate of 2 - 3C (4 - 5F) degrees per minute, cured for 60 minutes ± 5 at 175°C ± 5 (347°F ± 9), and cooled to room temperature.

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. 100 to 180 (150 to 80 µm) grit sandpaper. The sanded radome and strip surfaces shall be wiped dust-free with clean cheesecloth dampened with MEK.

3.2.13.5.2 AMS 3698 polyimide film adhesive shall be applied to the bonding surface of the radome.

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 inches (610 mm) Hg shall be applied and the bondline temperature shall be raised to 175°C ± 5 (347°F ± 9) at a rate of 2 - 3C (4 - 5F) degrees per minute. The part shall be cured for 60 minutes ± 5 at 175°C ± 5 (347°F ± 9). The part shall be cooled to below 70°C (158°F) under full vacuum before debagging.

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. 100 to 180 (150 to 80 µm) grit sandpaper and coating with AMS 3619 polyimide resin. The resin shall be dried for not less than 45 minutes at 105°C ± 5 (221°F ± 9). A second coat of polyimide resin 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 245°C ± 5 (473°F ± 9) at a rate of 2 - 3C (4 - 5F) degrees per minute, held at 245°C ± 5 (473°F ± 9) for 4 hours ± 0.5, and cooled to ambient temperature in not less than 2 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, or equivalent.

3.2.14.1 All surfaces to be coated shall be lightly sanded with No. 100 to 180 (150 to 80 µm) grit sandpaper and wiped clean with a MEK dampened cheesecloth. The lightning-diverter strip buttons shall be masked off during the spraying operation.

3.2.14.2 The fluoroelastomer erosion-resistant coating material shall be catalyzed in accordance with manufacturer's instructions. The coating material 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 inch (0.23 - 0.33 mm).

3.2.14.4 After a three-day ambient cure, the buttons shall be unmasked and the coated radome assembly cured for at least 1 hour each at 95°C (203°F), 120°C (248°F), and 150°C (302°F); tolerance on temperature shall be ±2°C (±4°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-inch (0.71-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 to the diverter-strip buttons in accordance the applicable drawing using AMS 4770 filler metal. 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 3619 polyimide resin and the assembly cured for 60 minutes ± 5 at 175°C ± 5 (347°F ± 9).

3.3 Properties: The radome 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 ± 2 (77°F ± 4)	280 psi (1.93 MPa)	300 psi (2.07 MPa)
At 230°C ± 2 (446°F ± 4)	230 psi (1.59 MPa)	250 psi (1.72 MPa)

3.3.1.2 Flatwise Tensile Strength: ASTM C297

	Minimum Individual	Minimum Average
At 25°C ± 2 (77°F ± 4)	325 psi (2.24 MPa)	350 psi (2.41 MPa)
At 230°C ± 2 (446°F ± 4)	200 psi (1.38 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 (1148°F ± 45)

3.3.2.3 Void Content: See 4.5.1

Inner Skin	5%, maximum
Outer Skin	10%, maximum

3.3.2.4 Flexural Strength: ASTM D790 or ASTM D790M

	Minimum Individual	Minimum Average
At 25°C ± 2 (77°F ± 4)	54,000 psi (372 MPa)	60,000 psi (414 MPa)
At 230°C ± 2 (446°F ± 4)	40,000 psi (276 MPa)	45,000 psi (310 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 and erosion-resistant coating, radome shells shall be inspected by photochromic or other suitable non-destructive test method on both inner and outer surfaces for internal imperfections such as disbonds or crushed core. All suspected imperfections shall be subjected to review for disposition of the part.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of radomes shall supply all samples for vendor's tests and shall be responsible for performing all 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 radomes conforms to the requirements of this specification.

4.2 Classification of Tests: Tests to determine conformance to all technical Ø requirements of this specification are classified as acceptance tests and as preproduction tests shall be performed prior to or on the initial shipment of radomes to a purchaser, on test panels representing each lot, when a change in material and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

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

4.3 Sampling: Shall be as follows; a lot shall be all radomes produced in a Ø single production run from the same batches of raw materials under the same fixed conditions, and presented for vendor's inspection at one time.

4.3.1 The sandwich test panel representing the radome shall be not less than 12 x 12 x T inches (305 x 305 x T mm), where "T" is the thickness of the radome wall and shall be prepared and cured alongside the radome shell.

4.3.2 Samples for laminate property tests shall be cut from the tag end overtrim on the solid laminate buildup of the radome.

4.3.3 Inspection Unit: Shall be each radome.

4.3.4 When a statistical sampling plan and acceptance quality level (AQL) have Ø been agreed upon by purchaser and vendor, sampling shall be in accordance with such plan in lieu of sampling as in 4.3.1 and 4.3.2 and the report of 4.6 shall state that such plan was used.

4.4 Approval:

4.4.1 A sample radome shall be approved by purchaser before radomes for production use are supplied, unless such approval be waived by purchaser. Results of tests on production radomes shall be essentially equivalent to those on the approved sample radome.