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MILITARY SPECIFICATION

RADOMES, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 This specification covers the general design and performance requirements for radomes (see 6.3) used in flight vehicles, surface vehicles and fixed ground installations.

1.2 Classification

1.2.1 Radomes shall be of the following types:

Type I. Low frequency radomes. Radomes used at or below 2.0 GHz.

Type II. Directional guidance radomes. Radomes used at microwave frequencies, and having specified directional accuracy requirements including boresight error rates, pattern distortion and specified effects upon antenna side lobes.

Type III. Narrow band radomes. Radomes used at microwave frequencies over a bandwidth less than 0.10 (see 6.3).

Type IIIa. Narrow-band, low reflection radomes. Radomes having specified low reflection requirements, in excess of 40 db below the reference antenna signal.

Type IV. Multiple frequency radomes. Radomes used at two or more discreet narrow frequency bands.

Type V. Broadband radomes. Radomes used at microwave frequencies with bandwidths between 0.10 and 0.667 (see 6.3).

Type VI. Very broadband radomes. Radomes used at microwave frequencies with bandwidths greater than 0.667 (see 6.3).

1.2.2 Grade. Radomes shall be graded according to safety and system function.

Grade A. Primary radomes, damage to which can affect the airworthiness of the flight vehicle, personnel safety, or the loss of, or damage to the antenna.

Grade B. Secondary radomes, damage to which can not seriously affect the airworthiness of the flight vehicle, personnel safety, the loss of, or damage to the antenna.

1.2.3 Class. Radomes shall be classed according to the general application.

Class I. Flight vehicles

Class II. Surface vehicles

Class III. Fixed ground installations.

1.2.4 Style. Radomes shall be constructed according to one of the following styles unless otherwise authorized by the procuring activity.

Style a. Half-wave wall. The wall thickness of the radome is one-half wavelength at the design incidence angle and frequency.

Style b. Thin-wall. The wall thickness of the radome is less than one-tenth wavelength at the design incidence angle and frequency.

Style c. A sandwich. The wall of the radome is constructed of three layers: two skins and a core material. The dielectric constant of the skin materials is higher than the dielectric constant of the core material.

Style d. Multilayer sandwich. The wall of the radome is constructed of some odd number of layers of skins and cores greater than three.

Style e. Dielectrically loaded form core sandwich. The wall of the radome is constructed of three layers: two skins and a dielectrically loaded foam core. The core material is dielectrically loaded to match the dielectric constant of the skin materials. Wall thickness is essentially the same as style a.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

L-P-383	Plastic Material, Polyester Resin, Glass Fiber Base, Low Pressure Laminated

Military

MIL-B-5087	Bonding, Electrical, and Lightning Protection, for Aerospace Systems
MIL-C-7439	Coating System, Elastomeric, Rain Erosion Resistant and Rain Erosion Resistant with Anti-Static Treatment, for Exterior Aircraft and Missile Plastic Parts
MIL-R-7575	Resin, Polyester, Low Pressure Laminating
MIL-C-8073	Core Material, Plastic Honeycomb, Laminated Glass Fiber Base, for Aircraft Structural Applications
MIL-C-8087	Core Material, Foamed In-Place Polyester Diisocyanate Type
MIL-I-8500	Interchangeability and Replaceability of Component Parts for Aircraft and Missile
MIL-M-8856	Missiles, Guided: Strength and Rigidity: General Specification for
MIL-A-8860	Airplane Strength and Rigidity, General Specification for
MIL-A-8869	Airplane Strength and Rigidity, Special Weapons Effects
MIL-S-9041	Sandwich Construction, Plastic Resin, Glass Fabric Base, Laminated Facings and Honeycomb Core for Aircraft Structural Applications
MIL-C-9084	Cloth, Glass, Finished, for Polyester Resin Laminates
MIL-R-9299	Resin, Phenolic, Laminating
MIL-R-9300	Resin, Epoxy, Low-Pressure Laminating
MIL-P-9400	Plastic Laminate Materials and Sandwich Construction, Glass Fiber Base, Low Pressure Aircraft Structural, Process Specification Requirements
MIL-Q-9858	Quality Program Requirements
MIL-F-18264	Finishes, Organic, Weapon Systems, Application and Control of
MIL-C-22750	Coating, Epoxy - Polyamide
MIL-P-23377	Primer Coating, Epoxy Polyamide, Chemical and Solvent Resistant

MIL-R-25042	Resin, Polyester, High Temperature Resistant, Low Pressure Laminating
MIL-S-25392	Sandwich Construction, Plastic Resin, Glass Fabric Base, Laminated Facings and Polyurethane Foamed-in-Place Core, for Aircraft Structural Applications
MIL-P-25395	Plastic Materials, Heat Resistant, Low Pressure Laminated Glass Fiber Base, Polyester Resin
MIL-P-25421	Plastic Materials, Glass Fiber Base-Epoxy Resin, Low Pressure Laminated
MIL-R-25506	Resin, Silicone, Low-Pressure Laminating
MIL-P-25515	Plastic Materials, Phenolic-Resin, Glass-Fiber Base, Laminated
MIL-P-25518	Plastic Materials, Silicone Resin, Glass Fiber Base, Low Pressure Laminated
MIL-C-27315	Coating Systems, Elastomeric, Thermally Refelective and Rain Erosion Resistant
MIL-C-81773	Coating, Polyurethane, Aliphatic, Weather Resistant
MIL-C-83231	Coatings, Polyurethane, Rain Erosion Resistant for Exterior Aircraft and Missile Plastic Parts
MIL-C-83286	Coating, Urethane, Aliphatic Isocyanate, for Aerospace Applications
MIL-Y-83370	Yarn, Roving and Cloth, Hi Modulus, Organic Fiber
MIL-A-83377	Adhesive Bonding for Aerospace Systems, Guidelines for

STANDARDS

Federal

FED-STD-5	Standard Guides for Preparation of Item Identification
FED-STD-102	Preservation, Packaging and Packing Levels
FED-STD-406	Plastics, Methods of Testing

Military

MIL-STD-100	Engineering Drawing Practices
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U. S. Military Property
MIL-STD-210	Climatic Extremes for Military Equipment
MIL-STD-401	Sandwich Constructions and Core Materials; General Test Methods
MIL-STD-490	Specification Practices
MIL-STD-794	Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-810	Environmental Test Methods

Naval Air Systems Command

NAVAIR 01-1A-22 Maintenance Instruction Manual - Aircraft Radomes and Antenna Covers

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

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

Aerospace Industries Association

ATC Report ARTC-4 Electrical Test Procedures for Radomes and Radome Materials

(Application for copies should be addressed to Aerospace Industries Association, 1725 De Sales St. N.W., Washington, D. C., 20036).

American Society for Testing and Materials

ASTM C-177	Methods of Test for Thermal Conductivity of Materials by Means of the Guarded Hot Plate
ASTM C-373	Test for Water Absorption, Bulk Density, Apparent Porosity, nad Apparent Specific Gravity of Fired Porous Whiteware Products
ASTM C-407	Compressive Crushing Strength of Fired Whiteware Materials
ASTM C-674	Flexural Properties of Ceramic Whiteware Materials
ASTM E-228	Linear Thermal Expansion of Rigid Solids With a Vitreous Silica Dilatometer

(Application for copies should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa 19103.)

3. REQUIREMENTS

3.1 Detail specification. The individual item requirements shall be as specified herein and in accordance with the applicable detail specification (see 4.5.2).

3.2 First article inpsection. This specification makes provisions for first article inspection.

3.3 Design and construction

3.3.1 Design (General). The selected radome configuration shall represent an optimized design considering all of the applicable requirements specified herein. Special design features such as allowable weights, physical size, vulnerability factors, access doors, special security requirements, safety features or specific transport and storage requirements, shall be specified in the detail specification. In the design of radomes no particular requirement shall take precedence over all other requirements. Electrical, environmental, structural, cost, weight, and maintenance factors shall all be considered equally in the selection of the radome configuration materials, manufacturing methods, wall style and special features. Compromises may be made, with approval of the procuring activity, where necessary to achieve the best possible electrical performance without degrading the structural, environmental and service life requirements. Careful consideration shall be given to the long-term electrical performance of the radome throughout its service life including the probable maintenance and repair actions.

3.3.1.1 Reliability

3.3.1.1.1 Class I. Class I repairable radomes shall be designed to provide maximum service life with minimum maintenance. The design goal is to provide radomes which will require zero repair or replacement during the life of the vehicle. It is intended as a minimum that the radome provide zero failures between scheduled depot overhaul of the aircraft and shall require not more than recoating of the exterior surface between overhaul periods. If the radome cannot be designed to the above level of reliability, a low cost, non-repairable type radome design may be considered for some applications provided that substantiating data is furnished to the procuring activity for approval, justifying the use of a disposable type radome. Disposable type radomes shall be capable of providing not less than 500 flight hours mean-time-between-failures (MTBF).

3.3.1.1.2 Class II and III. Class II and III radomes shall be capable of providing not less than 3 years service between repair with an expected service life of not less than 25 years.

3.3.1.2 Installation. All practical features consistent with dependable operation shall be incorporated in the radome design and construction to enable installation or removal of the radome with minimum time and effort and to provide easy access for service and repair of the antenna subsystem within.

3.3.1.3 Drain hole. A reinforced drain hole shall be provided, when permitted by the local pressures, to prevent collection of any liquid in the bottom portion of the radome.

clockwise position shall yield maximum receiver gain.

3.3.1.4 Inserts. All holes subject to unusual wear and abrasion resulting from frequent insertion and removal of bolts or screws shall be fitted with suitable inserts which shall provide sufficient bearing surface to minimize wear. Such inserts shall be specified in the detail specification.

3.3.1.5 Structural

3.3.1.5.1 Flight vehicles (class I)

3.3.1.5.1.1 Aircraft. Primary radomes (grade A) shall be designed in accordance with the structural requirements of MIL-A-8860 with the application of critical loads, safety margins and structural testing as specified in the detail specification. Secondary radomes (grade B) shall comply with MIL-A-8860 to the extent dictated by its design, airframe location, and aircraft mission.

3.3.1.5.1.2 Rotorcraft. In general radomes for rotary wing aircraft may be treated as Grade B structures unless a specific application can be classified as critical to the airworthiness of the aircraft. Structural requirements shall be as specified in the detail specification.

3.3.1.5.1.3 Missiles. Primary radomes (Grade A) for either air launched or surface launched missiles shall be designed in accordance with the strucural requirements of MIL-M-8856 with the application of critical loads, thermal shock safety margins and structural testing as specified in the detail specification. For secondary radomes (Grade B) the requirements of MIL-M-8856 apply to the extent considered advisable for each individual radome considering its design, location, handling, mission, reliability and maintenance.

3.3.1.5.2 Surface vehicles (Class II). Radomes for both land craft and water craft shall be treated as Grade B structures unless a specific application can be classified as critical to the basic function or mission of the craft. Structural requirements shall be as specified in the detail specification.

3.3.1.5.3 Fixed ground installations (Class III). Fixed site installations shall be designed in accordance with the world wide all weather exposure criteria established by MIL-STD-210 and the intended application, location and life expectancy.

3.3.1.6 Interchangeability. All radomes designed to the same detail specification shall be interchangeable, without modification, as required by MIL-I-8500.

3.3.1.7 Size and Weight. The radome size and weight shall be as specified in the detail specification.

3.3.2 Construction

3.3.2.1 General. The fabrication process used in radome construction shall be in accordance with MIL-P-9400 unless the design is such that new or special materials are required to meet mission objectives and there is approval by the procuring activity. The construction style and material to be utilized in the fabrication of a particular radome shall be determined through analysis considering all applicable performance requirements. Verification of the acceptability of the proposed radome design shall be determined by tests performed on samples of the proposed radome wall construction and approved by the procuring activity prior to fabrication of first article radomes.

3.3.2.2 Solid wall. This type construction includes both style a and style b.

3.3.2.2.1 Laminate construction. One of the following specifications, as applicable, shall apply where solid laminate wall construction is used unless otherwise specified in the detail specification:

a. L-P-383

b. MIL-P-25395

c. MIL-P-25421

d. MIL-P-25515

e. MIL-P-25518

Other cloth resin systems, such as glass or quartz polyimide, may be used when authorized by the procuring activity.

3.3.2.2.1.1 Wall thickness. The solid laminate wall thickness shall be as specified in the detail specification for a particular type radome. Under no condition shall a Class I, Grade A or a Class I, Grade B radome wall thickness be less than .050 inch or .030 inch respectively.

3.3.2.2.2 Molded plastics. Injection molding, vacuum forming and other manufacturing methods may be used in the construction of nonrepairable radomes if compatible with the structural, environmental and electrical requirements for the intended application. Radomes using this type construction shall not have a finished thickness less than .050 inch for any application. The selection and use of this construction method shall have the prior approval of the procuring activity.

3.3.2.2.3 Ceramic radomes. Ceramic radomes shall be used only for applications where other dielectric radomes could not survive the thermal environment without serious electrical or structural degradation. When using ceramics, the minimum or average value for each of the following properties shall be specified in the detail specification:

Dielectric constant	Compressive strength
Loss tangent	Water absorption
Thermal expansion	Porosity
Thermal conductivity	Density
Thermal diffusivity	Hardness
Specific heat	Young's modulus
Emissivity	Bulk modulus
Modulus of rupture	Shear modulus
Tensile strength	Poisson's ratio

Ceramic materials should not be used for Grade A radomes on manned vehicles unless fully supported by a qualified back-up structure. Thin wall structures less than .080 - .100 inch should not be considered.

3.3.2.3 Sandwich construction. This type construction includes Styles c, d, and e.

3.3.2.3.1 Honeycomb core. Where honeycomb core construction is utilized, the requirements of MIL-S-9041 shall apply. The outer skin shall be preformed and cured before the addition of the core. The core shall be bonded to the outer skin and cured before the assembly of the inner skin. A single step cure is acceptable with the use of prepreg materials. The core may be bonded to the skins with either resin or a film adhesive as applicable. A bond ply is recommended for use on the inner skin. Class I, Grade A radomes shall have honeycomb with a minimum core density of 5.5 pounds per cubic foot, with cell size and minimum skin thickness as listed below. Class I, Grade B radomes shall have honeycomb with a minimum core density of 4.5 pound per cubic foot, and cell size and minimum skin thickness as listed below.

CELL SIZE	GRADE A MINIMUM SKIN THICKNESS	GRADE B MINIMUM SKIN THICKNESS
1/4 inch	.040 inch	.030 inch
3/16 inch	.030 inch	.020 inch
1/8 inch	.020 inch	.015 inch

3.3.2.3.2 Foam core (Style c and d). Where a foam core construction is used for Styles c and d the requirements of MIL-C-8087 and MIL-S-25392 shall apply. Foam core radomes must be structurally and environmentally equivalent to honeycomb core construction (3.3.2.3.1). Other foam core construction may be used only with specific approval of the procuring activity.

3.3.2.3.3 Foam core (Style e). Dielectrically loaded foam core construction may be used when approved by the procuring activity and specified in the detail specification. Foam core radomes must be structurally and environmentally equivalent to honeycomb core construction (3.3.2.3.1).

3.3.2.3.4 Ceramics. The use of sandwich construction for ceramic radomes is prohibited unless specifically authorized by the procuring activity.

3.3.2.4 Other types. Special types of unique construction shall require the specific approval of the procuring activity.

3.3.3 Materials

3.3.3.1 Resins

3.3.3.1.1 Laminating resins. The resins used in glass reinforced radome construction shall be in accordance with one of the following specifications:

a. MIL-R-7575
b. MIL-R-25042
c. MIL-R-25506
d. MIL-R-9299
e. MIL-R-9300

For exposures to high temperatures up to 600°F, polyimide resins may be used. Data on the polyimide resins proposed for use shall be submitted to the procuring activity for approval. Other type resins may be used only with prior approval of the procuring activity.

3.3.3.1.2 Molding resins. For some radomes, molding resins may offer a better method of construction. The resins must have a low dielectric constant, low loss tangent and acceptable environmental and structural stability. Any radome construction using these resins must have specific authorization from the procuring activity for each particular radome design.

3.3.3.2 Reinforcement

3.3.3.2.1 Fiber

3.3.3.2.1.1 Woven cloth. Cloth used in reinforced radome construction shall be in accordance with MIL-C-9084 or MIL-Y-83370. Other cloths, such as quartz, may be used with prior approval of the procuring activity.

3.3.3.2.1.2 Continuous filaments. Continuous fibers of glass are acceptable for filament wound radomes when the radome geometry is properly suited to the filament winding process.

3.3.3.2.1.3 Chopped fibers. This material shall not be used for Class I, Grade A applications. It may be acceptable for Class I, Grade B or for Class II and III radomes only when nonrepairable, noncritical electrical performance is specified in the detail specification and approved by the procuring activity.

3.3.3.3 Core material

3.3.3.3.1 Honeycomb. Honeycomb used in sandwich constructed radomes shall be in accordance with MIL-C-8073.

3.3.3.3.2 Foam core. Foamed core shall comply with MIL-C-8087. Polyimide foam core, not covered by MIL-C-8087, may be utilized when approved by the procuring activity.

3.3.3.4 Additives and nondielectrics

3.3.3.4.1 Resin fillers. Any filler used in the resin shall not change the dielectric constant or loss tangent nor effect the physical properties.

3.3.3.4.2 Dielectric loading. Any material added to the resin to increase its dielectric constant shall not cause an increase in loss tangent or cause a change in any of the mechanical or physical properties that makes it unacceptable for the intended application.

3.3.3.5 Adhesive bonding. Adhesive bonding utilized in the radome fabrication shall comply with MIL-A-83377.

3.3.3.5.1 Honeycomb bonding. The use of core film adhesives is acceptable when defined in the detail specification and approved by the procuring activity.

3.3.3.5.2 Erosion boot adhesive. Bonding systems for erosion boots shall be low dielectric materials compatible with the laminate dielectric properties. No contact adhesives shall be acceptable.

3.3.3.6. Finishes and protective coatings

3.3.3.6.1 Paints

3.3.3.6.1.1 Metallic parts. Exterior metal parts should be primed with MIL-P-23377 primer prior to application of MIL-C-81773 paint. MIL-C-22750 and MIL-C-83286 paints are also acceptable and may be utilized. Metal parts shall be finished in accordance with MIL-F-18264.

3.3.3.6.1.2 Dielectric parts. Class II and III radomes shall be painted with MIL-C-81773 paint. MIL-C-81773 paint shall not be used for Class I radomes unless specified in the detail specification and approved by the procuring activity. No zinc chromate primer or any other metallic base paint shall be used in the window area of the radome. Parts shall be finished in accordance with MIL-F-18264.

3.3.3.6.2 Erosion coating. Class I radomes subject to rain erosion shall be finished with an erosion coating MIL-C-83231 Type I or MIL-C-83231 Type II when an anti-static top coating is required. Coating systems, Type I or Type II, complying with MIL-C-7439 may be used when approved by the procuring activity. Fluoroelastomer type coating systems may be utilized for high temperature (400° - 500°F) applications when approved by the procuring activity.

3.3.3.6.2.1 Molded boot. Use of this erosion protection system shall be stated in the detail specification subject to approval by the procuring activity. Tests and analysis shall establish the electrical acceptability of this system.

3.3.3.6.3 Thermal radiation coating. Thermal radiation coatings, when required by the detail specification, shall be in accordance with MIL-C-27315 or as otherwise specified or approved by the procuring activity.

3.3.3.6.4 Other coatings. The use of other types of coatings such as moisture sealers, oblation layers, or ceramics shall be used only with specific approval of the procuring activity.

3.3.3.7 Ceramic materials. Ceramic radome materials shall be used only when required under 3.3.2.2.3 herein.

3.3.3.8 Metallic materials. Metallic materials and materials containing electrical conducting impurities shall not be employed in the window area of any radome without specific authorization from the procuring activity for each particular radome design.

3.3.4 Workmanship

3.3.4.1 Plastic radomes. Plastic radomes shall be uniformly smooth and free of voids, blisters, porosity, resin starved areas, delamination, soft spots, resin pockets, wrinkle solvent areas, surface tackiness, metal particles and other defects. Patching to build up skin thickness, to repair holes and dents, or for other reasons shall not be permitted in the window area of the radome when such patches degrade the strength, thickness or electrical performance of the item below the minimum requirements for a particular type radome.

3.3.4.2 Ceramic radomes. Ceramic radomes shall be free from chips, cracks, crazing, scratches, voids, porosity, metal particles or other defects. Surface finish, finishing methods, allowable defects and other quality control items shall be specified in the detail specification.

3.3.5 Construction samples. One flat test panel, identical to the proposed radome window construction, shall be submitted to the procuring activity for test and approval. For plastic construction the panel shall be 24 x 36 inches; for ceramic construction the panel shall be 8 x 10 inches. The test panel shall be submitted during the sample test phase and prior to fabrication of first article radomes.

3.4 Performance

3.4.1 Electrical requirements (general). The radome shall comply with the following electrical performance requirements unless otherwise specified in the detail specification and approved by the procuring activity.

3.4.1.1 Transmission. The minimum and average one-way power transmission through the radome shall not be less than the limits specified in table I. Average transmission shall be specified either for the total scan envelope of the antenna or for discrete segments of the antenna scan envelope.

3.4.1.2 Power reflection. The power reflected back into the antenna by the radome shall not exceed the value specified in table I.

3.4.1.3 Main-lobe beamwidth. The change in antenna free space mainlobe beamwidth at the half-power points shall not exceed the values specified in table I.

3.4.1.4 Pattern ripple. Unless otherwise specified the change in the antenna free space pattern ripple over the half power beamwidth shall not exceed the limit listed in table I.

3.4.1.5 Side lobes. The antenna free space side lobe level relative to the main beam shall not increase by more than the limit specified in table I.

3.4.1.6 Axial ratio. The change in antenna free space axial ratio due to the radome shall be as specified in the detail specification.

3.4.1.7 Beam deflection. The antenna beam deflection error shall not exceed the values specified in table I. The detail specification shall include a definition of antenna beam deflection to be one of the following:

a. Antenna beam deflection (non-conically scanning systems). A change in the direction of the antenna beam axis.

b. Antenna boresight error (conical scanning systems). A shift in pattern crossover point.

c. Antenna boresight error (monopulse systems). A shift in pattern null.

3.4.1.8 Beam deflection rate. The rate of change of antenna beam deflection per degree of angular scan shall not exceed the values specified in table I.

3.4.1.9 Dielectric constant and loss tangent. Dielectric constant and loss tangent requirements for plastic and ceramic materials to be used in the radome fabrication shall be as specified in the detail specification.

Table I. Electrical Performance Characteristics.

	APPLICABLE PARAGRAPH	RADOME TYPE I	II	III	IIIA	IV	V	VI	UNIT
TRANSMISSION									
Average	3.4.1.1	95	85	85	85	85	80	80	%
Minimum	3.4.1.1	85	75	70	70	75	70	70	%
REFLECTION	3.4.1.2	2	2	2	.01	2	2	2	%
BEAMWIDTH	3.4.1.3	5	5	10	10	10	10	10	%
PATTERN RIPPLE	3.4.1.4	.1	0	.1	.1	.1	.2	.2	db
SIDE LOBE	3.4.1.5	2	2	2	2	2	*	*	db
BEAM DEFLECTION ERROR	3.4.1.7	2	2.0	2	2	2	3	3	mr
BEAM DEFLECTION ERROR RATE	3.4.1.8	*	0.60	*	*	*	*	*	mr/de

*Not applicable unless specified in the detail specification

3.4.1.10 Insertion phase delay (IPD). Insertion phase delay requirements and measurement shall be as specified in the detail specification.

3.4.2 Environmental requirements. The environmental conditions to which a radome will be subjected are listed in table II. The electrical tests shall be conducted prior to and after each environmental test. (See table IV)

3.4.2.1 Rain impact. Class I, radomes shall be designed to prevent delamination or fracture of the wall under rain impact. Unless previously qualified, a sample of the radome wall with the finish coating shall be tested on an approved rain erosion test apparatus. The sample shall be exposed at the maximum angle of impact that the radome will experience in flight. The rain field shall have the drop size distribution and intensity of a natural one inch/hour rain. The sample shall be tested at the maximum speed for the clean configuation of the vehicle operating under 10,000 feet. For supersonic vehicles, the sample shall withstand the test for one minute without delamination or fracture. For subsonic vehicles, the sample shall withstand the test for five minutes without delamination or fracture.

Table II. Environmental Requirements.

	RADOME CLASS		
	1	2	3
Rain Impact	3.4.2.1	N/A	N/A
Rain Erosion	3.4.2.2	N/A	N/A
Hail Impact	3.4.2.3.1	3.4.2.3.2	3.4.2.3.2
Icing	*	3.4.2.4	3.4.2.4
Lightning	3.4.2.5.1	3.4.2.5.1	3.4.2.5.1
Static Electricity	3.4.2.5.2	3.4.2.5.2	3.4.2.5.2
Gun Blast	3.4.2.6	3.4.2.6	3.4.2.6
Sunshine	3.4.2.7	3.4.2.7	3.4.2.7
Temperature-Humidity-Altitude	3.4.2.8	N/A	N/A
Temperature-Humidity	N/A	3.4.2.9	3.4.2.9
Thermal Shock	3.4.2.10	N/A	N/A
Thermal Ablation	3.4.2.11	N/A	N/A
Nuclear Weapons Effects	3.4.2.12	3.4.2.12	3.4.2.12
Fluids	3.4.2.13	3.4.2.13	3.4.2.13

*Not required unless specified in detail specification

3.4.2.2 Rain erosion. All Class I, radomes subject to rain erosion shall be designed and qualified in accordance with the vehicle mission and altitude-velocity characteristics. The rain probability data of the proposed geographical areas of operation for the aircraft mission and the projected flight hours between depot level maintenance shall be considered in the design of the radome. The design shall produce a repair/replacement life expectancy that will result in an acceptable number of organizational level maintenance actions within an overhaul period. Unless previously qualified, a sample of the radome wall with the finish coating shall be tested on an approved rain erosion test apparatus to determine its life expectancy in a normal rain environment. The test samples shall be tested at the maximum impact angle that the radome will experience in flight. The test shall use a natural rain drop size distribution with an intensity of 1 inch/hour. The samples shall be tested at the average cruise velocity for the primary or basic mission configuration of the vehicle.

3.4.2.3 Hail impact

3.4.2.3.1 Class I. All Class I radomes vulnerable to in-flight hail impact shall be designed to withstand the impact of hailstones 3/4 inch in diameter at the cruise velocity of the aircraft at the rate of six impacts per square inch per minute for one minute without catastrophic failure.

3.4.2.3.2 Classes II and III. The radome shall be designed to withstand the impact of hailstones three inches in diameter at a velocity of sixty feet per second and a rate of six impacts per square foot per minute for five minutes without catastrophic failure.

3.4.2.4 Icing. No special provisions shall be required for ice prevention on the outer surface of Class I radomes unless specified in the detail specification. Ice prevention or control systems for Class II and III radomes shall be specified in the detail specification for radomes used with systems on which ice accumulation may significantly degrade the system performance.

3.4.2.5 Atmospheric electricity

3.4.2.5.1 Lightning protection. Lightning protection systems shall be incorporated in the design of all Class I radomes vulnerable to lightning strikes. The protection system shall comply with the requirements of MIL-B-5087. Class II and III radomes generally require lightning protection. The protection system, if required, shall be as specified in the detail specification and MIL-B-5087.

3.4.2.5.2 Static electricity. All Class I, II and III radomes exposed to airflow resulting in triboelectric charging of the external surface of the radome to a level detrimental to equipment performance and personnel safety shall be coated as specified in 3.3.3.6.2 or as required by the detail specification. The measured resistance of the coating shall not be greater than 25 megohms or less than .5 megohms per unit area.

3.4.2.6 Gun blast. When required by the detail specification all Class I radomes shall withstand during flight or laboratory simulation the blast and vibration resulting from the firing of at least two fillings of the magazine of each gun. Equivalent vibration can be achieved as described in MIL-STD-810. Class II and III radomes shall be tested as described in MIL-STD-810 without resulting damage to the dielectric material, attached hardware or associated equipment. Testing of Class II and III radome may be deleted by the detail specification when warranted by separation distance between the radome and gun installations.

3.4.2.7 Sunshine. Plastic radomes shall withstand 100 hours of exposure as described in MIL-STD-810, method 505, with no degradation of its physical or electrical properties. The radome shall be coated as specified in the detail specification.

3.4.2.8 Temperature-humidity-altitude. The radome shall meet all the requirements of this specification after exposure to method 518 of MIL-STD-810. Testing shall not produce:

a. Alteration of attachment adversely affecting installation

b. Physical interference between the radome and the contained equipment

c. Degradation in the electrical performance below the minimum specified values.

d. Permanent deflections, distortions, or damage.

3.4.2.9 Temperature-humidity. Class II and III radomes shall meet all the requirements of this specification after exposure to methods 501, 502 and 507 of MIL-STD-810. Testing shall not produce a through d of 3.4.2.8 herein.

3.4.2.10 Thermal shock. Aircraft and missile radomes with maximum aerodynamic heating surface temperatures above 150°F shall be exposed to temperature time heat flux as defined by the critical thermal history with no cracking, breaking or degradation to its physical or electrical properties.

3.4.2.11 Thermal ablation. Missile radomes employing materials with temperature resistance below the peak in-flight surface temperature may utilize low dielectric noncharring ablation coatings for temperature protection. The use of such ablation coatings must be adequately defined in the detail specification and properly demonstrated during qualification testing to not degrade the electrical performance requirements.

3.4.2.12 Nuclear weapons effects

3.4.2.12.1 Thermal effects. If applicable Class I, II and III radomes shall withstand the effects of nuclear thermal conditions specified in the detail specification and MIL-A-8869.

3.4.2.12.2 Blast effects. If applicable Class I, II and III radomes shall be designed to withstand the overpressure and associated gust effects of a nuclear blast as specified in the detail specification and MIL-A-8869.

3.4.2.13 Fluids. The radome shall not be softened or permanently damaged by contact with petroleum products or other fluids common to operation and maintenance of the radome.

3.5 Nameplates or product markings. The radome shall be marked for identification in accordance with MIL-STD-130. Outside marking shall consist of the words DO NOT PAINT in 3/4 inch letters stamped on the radome adjacent to the attachment area. An identification plate shall be securely attached to the inside of the radome, adjacent to the radome attachment area. Nameplate markings shall be in the following order as applicable:

Manufacturer's part or drawing number

For disposable radomes, add the words NON REPAIRABLE

AN nomenclature (if assigned)

Detail specification number and title

Contract or order number

Manufacturer's serial number

Manufacturer's code number

U. S. property.

3.5.1 Nomenclature. Nomenclature shall be in accordance with FED-STD-5.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein unless disapproved by the Government. 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 inspections. The examining and testing of the radome shall be classified as follows:

a. Construction sample inspections (see 4.3)

b. First article inspections (see 4.3.3)

c. Quality conformance inspections (see 4.3.4).

4.3 Construction sample inspections.

4.3.1 Construction samples. Samples of the proposed radome wall design, as required by 3.3.2.1, shall be fabricated and subjected to the required sample tests prior to fabrication of first article test radomes.

4.3.2 Sample tests

4.3.2.1 Electrical. Tests as required by table III shall be performed in accordance with section 3.2.2, 3.3 and 3.4 of ARTC-4 or as specified in the detail specification and approved by the procuring activity.

4.3.2.2 Environmental. Tests as required by table III shall be performed as follows:

4.3.2.2.1 Rain impact and erosion. The construction samples shall be tested on an approved rain erosion test facility. A minimum of two flat test samples shall be exposed at the maximum rain impact angle of the radome. Tests shall be performed in accordance with the requirements of 3.4.2.1 and 3.4.2.2.

Table III. Construction Sample Tests

	RADOME TYPE					
	I	II	III	IV	V	VI
Electrical						
Dielectric and Loss Tangent	D	A	A	A	A	A
Panel Transmission	D	A	A	A	D	D
Insertion Phase Delay	D	D	D	D	D	D
Environmental						
Rain Impact and Erosion (Class I)	A	A	A	A	A	A
Hail Impact (Class I)	A	A	A	A	A	A
(Class II and III)	D	D	D	D	D	D
Weathering	P	P	P	P	P	P
Sunshine	P	P	P	P	P	P
Nuclear Weapons Effect	D	D	D	D	D	D
Thermal Ablation	D	D	D	D	D	D
Fluids	P	P	P	P	P	P
Mechanical						
Flexural Strength/Modulus of Rupture	A	A	A	A	A	A
Shear Strength	P	P	P	P	P	P
Tensile Strength	P	P	P	P	P	P
Compression Strength	P	P	P	P	P	P
Young Modulus	C	C	C	C	C	C
Poisson's Ratio	P	P	P	P	P	P
Flexural Fatigue	P	P	P	P	P	P
Thermal						
Flammability	P	P	P	P	P	P
Thermal Expansion	A	A	A	A	A	A
Thermal Conductivity	C	C	C	C	C	C
Specific Heat,	C	C	C	C	C	C
Maximum Use Temperature	A	A	A	A	A	A

Table III. Construction Sample Tests (Cont'd)

	RADOME TYPE					
	I	II	III	IV	V	VI
Physical						
Density	A	A	A	A	A	A
Porosity	A	A	A	A	A	A
Hardness	A	A	A	A	A	A
Water Absorption	A	A	A	A	A	A
Void Content	P	P	P	P	P	P

A - Applicable
D - As required by detail specification
P - Applicable to plastic radomes only
C - Applicable to ceramic radomes only

4.3.2.2.2 Hail impact. Test procedures shall be as specified in the detail specification.

4.3.2.2.3 Sunshine. Unless previously qualified, plastic radome construction shall be sunshine tested in accordance with procedure I, method 505 of MIL-STD-810. The test period shall be no less than 100 hours after which the test panel shall be cut into test samples. The exposed test samples shall be tested as required by table III.

4.3.2.2.4 Nuclear weapons effects. Class I radomes shall be tested in accordance with MIL-A-8869 and the detail specification. Class II and III radomes shall be tested as specified in the detail specification.

4.3.2.2.5 Thermal ablation. Simulation may be accomplished using quartz lamps or air arc heaters properly spaced and programmed to generate the critical temperature time conditions or heat flux on the radome surface. Conditions for test, number of test samples, and test methods shall be defined in the detail specification.

4.3.2.2.6 Fluids. Test samples of the radome wall shall be immersed for four hours in fluids common to the operation and maintenance of the radome. When the sample is removed, it shall not have been softened or permanently damaged.

4.3.2.3 Mechanical. The test methods for mechanical properties listed in table III shall be specified in the applicable materials and process specification. For plastic materials the test methods shall be those defined in FED-STD-406 or MIL-STD-401. For ceramic materials the test methods shall be those given by ASTM E-228, C-674, and C-407. Methods for testing ceramics not covered by the ASTM testing procedures shall be defined by the manufacturer and approved by the procuring activity.

4.3.2.4 Thermal. The test methods for thermal properties listed in table III shall be specified in the applicable materials and process specification. For plastic materials the test methods shall be those defined in FED-STD-406 or MIL-STD-401. For ceramic materials the test methods shall be those given by ASTM C-177. Methods for testing ceramics not covered by the ASTM testing procedures shall be defined by the manufacturer and approved by the procuring activity.

4.3.2.5 Physical. The test methods for physical properties listed in table III shall be specified in the applicable materials and process specification. For plastic materials the test methods shall be those defined in FED-STD-406 or MIL-STD-401. For ceramic materials the test methods shall be those given by ASTM C-373-56. Methods for testing ceramics not covered by the ASTM testing procedures shall be defined by the manufacutrer and approved by the procuring activity.

4.3.3 First article tests. The first article tests of table IV shall be performed on a production prototype radome complete with attachment hardware, external coating, lightning protection system and including any additional item peculiar to the design requirements for a particular weapon system as specified in the detail specification.

4.3.3.1 Electrical. Tests as required by table IV shall be performed in accordance with the applicable sections of ARTC-4 or as specified in detail specification and approved by the procuring activity. The test range measurement accuracy shall be specified in the detail specification and certified by the procuring activity. Free space patterns of the antenna under test shall be identical to those furnished and certified by the antenna manufacturer.

4.3.3.2 Environmental. Environmental tests required by table IV shall be performed as follows:

4.3.3.2.1 Icing. If required, test procedures shall be as specified in the detail specification.

Table IV. First Article Tests.

	RADOME TYPE					
	I	II	III & IIIA	IV	V	VI
Electrical						
Transmission	A	A	A	A	A	A
Reflection	A	A	A	A	A	A
Beamwidth	A	A	A	A	A	A
Ripple	A	A	A	A	A	A
Side Lobe	A	A	A	A	A	A
Beam Deflection Error	D	A	D	D	D	D
Beam Deflection Error Rate	D	A	D	D	D	D
Environmental						
Icing	D	D	D	D	D	D
Atmospheric Electricity	A	A	A	A	A	A
Gun Blast	D	D	D	D	D	D
Temperature-Humidity-Altitude	D	D	C	C	D	D
Temperature-Humidity	D	D	D	D	D	D
Mechanical						
Dynamic Loads (Class II & III)	A	A	A	A	A	A
Ground Handling Loads (Class I, II and III)	D	D	D	D	D	D
Flight Loads (Class I)	A	A	A	A	A	A
Dynamic Ground Loads (Class I)	A	A	A	A	A	A
Vibration (Class I, II, III)	D	D	D	D	D	D
Acoustic Noise (Class I)	D	D	D	D	D	D
Linear Acceleration (Class I)	D	D	D	D	D	D
Thermal						
Thermal Shock	C	C	C	C	C	C
Physical						
Contour & Dimensions	A	A	A	A	A	A
Weight	A	A	A	A	A	A

A - Applicable
D - As required by detail specification
C - Applicable to ceramic radomes only

4.3.3.2.2 Atmospheric electricity

4.3.3.2.2.1 Lightning. Test procedures for the lightning protection system shall be as specified in the lightning test plan of 4.5.2.4.

4.3.3.2.2.2 Static electricity. Test procedures for anti-static coatings applied to the radome surface shall be as specified in MIL-C-83231 or MIL-C-7439 as applicable.

4.3.3.2.3 Gun blast. Test procedures shall be as specified in method 519.1 of MIL-STD-810 when required by the detail specification.

4.3.3.2.4 Temperature-humidity-altitude. Test procedures shall be as specified in method 518 of MIL-STD-810.

4.3.3.2.5 Temperature-humidity. Test procedures shall be as specified in methods 501, 502 and 507 of MIL-STD-810.

4.3.3.3 Mechanical tests. As specified in table IV.

4.3.3.3.1 Class I radomes

4.3.3.3.1.1 Dynamic loads

4.3.3.3.1.1.1 Flight loads. Radomes shall be tested in accordance with the airloads in inertial loads as applicable and as stated in the detail specification.

4.3.3.3.1.1.2 Ground loads. Radomes shall be tested as specified in MIL-STD-810, methods 513.1 and 516.1, procedure I for the acceleration and shock experienced during catapult take off and landing.

4.3.3.3.1.2 Ground handling loads. Radomes shall be tested in accordance with the critical loads and load distributions where applicable and as stated in the detail specification.

4.3.3.3.1.3 Acoustic noise. The radome shall be tested as specified in MIL-STD-810, method 515.1 at the levels specified in the detail specification.

4.3.3.3.1.4 Vibration. Test procedures covering both resonance dwell and random vibration tests shall be as specified in MIL-STD-810, method 514.1, procedure II, parts 1 and 3. Vibration levels shall be as specified in the detail specification.

4.3.3.3.1.5 Linear acceleration. The radome shall be tested in accordance with MIL-STD-810, method 513.1, procedure II, at the levels specified in the detail specification.

4.3.3.3.2 Class II radomes

4.3.3.3.2.1 Dynamic loads. Radomes shall be tested in accordance with the critical loads resulting from motion, vibration and other contributing factors as applicable and as stated in the detail specification.

4.3.3.3.2.2 Ground handling loads. Radomes shall be tested in accordance with the critical loads and load distribution where applicable and as stated in the detail specification.

4.3.3.3.3 Class III radomes

4.3.3.3.3.1 Dynamic loads. Radomes shall be tested in accordance with the critical loads resulting from wind, gusts, vibration, snow, ice and other contributing factors where applicable and as stated in the detail specification.

4.3.3.3.3.2 Ground handling loads. Radomes shall be tested in accordance with the critical loads and load distributions where applicable and as stated in the detail specification.

4.3.3.4 Thermal tests. As specified in table IV.

4.3.3.4.1 Thermal shock. Test procedures shall be as specified in the detail specification.

4.3.3.5 Physical tests. As specified in table IV.

4.3.3.5.1 Contour and dimensions. Contours, dimensions, wall thickness and other pertinent dimensional information shall be checked against the radome detail drawings and ordinates with the use of precision templates and gages. Specific gage equipment, measurement techniques and tolerances shall be defined on the radome drawing and in the detail specification. Precautions shall be taken to insure dimensional stability of the measurement equipment. Physical configuration characteristics controlled by parent tooling shall be verified by periodic inspection of that tooling.

4.3.3.5.2 Weight. All radomes shall be measured as specified in the detail specification. Class I radomes having a finished weight in excess of 2 pounds shall be weighed to a measuring accuracy of $\pm$0.1 pound.

4.3.4 Quality conformance tests

4.3.4.1 Electrical tests. Electrical tests as specified in table V shall be performed in accordance with test procedures specified under 4.3.3 for first article tests. The radomes shall have complete electrical tests performed on the first five production radomes. Thereafter, all radomes shall be tested at a reduced level as necessary for quality control and as specified in the detail specification.

4.3.4.2 Mechanical, thermal and physical tests. Tests as required by table V shall be performed in accordance with 4.3.2 (sample tests) or 4.3.3 (first article tests) as applicable. The detail specification for all radomes shall make provisions for limited flexural strength testing on test samples taken from the edges of the production article or from samples prepared at the time of manufacture using the same material and processes. Not less than 5% of the production radomes shall have such quality control testing. All production ceramic radomes shall be subjected to the thermal shock test. The physical properties of all production radomes shall be measured to determine compliance with MIL-I-8500.

4.4 Rejection and retest. The procuring activity shall have the option of rejecting the radome covered by this specification on the basis of unsatisfactory electrical performance or physical characteristics. Rejected radomes shall not be retested and resubmitted for approval without furnishing full particulars concerning the previous rejection and the measures taken to overcome the defects.

4.5 Data requirements. When specified in the contract or purchase order, the data specified herein shall be prepared and submitted to the procuring activity for approval.

4.5.1 Preliminary design report. The supplier shall prepare a radome design development report prior to the development of detail specifications, drawings and process specifications. These reports shall contain the design approach information including radome configurations, wall construction, material selection, load criteria, attachment methods, electrical requirements and thermal loads if applicable.

4.5.2 Detail specification. Detail specifications shall be prepared for all radomes by the supplier responsible for the design and test of the radome including a detailed quality program plan per MIL-Q-9858. Radomes of the same type and similar applications may be detailed within the same detail specification.

Table V. Quality Conformance Requirements.

	RADOME TYPE					
	I	II	III	IV	V	VI
Electrical						
Transmission	A	A	A	A	A	A
Reflection	D	D	D	D	D	D
Beamwidth	D	D	D	D	A	A
Ripple	D	A	D	D	A	A
Side Lobe	D	A	A	D	D	D
Boresight Error	NA	A	D	D	NA	NA
Boresight Error Rate	NA	A	D	D	NA	NA
Mechanical						
Flexural Strength/Modulus of Rupture	A	A	A	A	A	A
Thermal						
Thermal Shock	C	C	C	C	C	C
Physical						
Wall Thickness	A	A	A	A	A	A
Template	A	A	A	A	A	A
Weight	A	A	A	A	A	A

A - Applicable
D - As required by detail specification
NA - Not applicable
C - Applicable to ceramic radomes only

4.5.2.1 Format. The detail specification shall conform to the format of MIL-STD-490.

4.5.2.2 Drawings. Radome drawings shall be made in accordance with MIL-STD-100 and shall contain all dimensions, tolerances, materials, structural details, reference drawings, applicable detail and process specifications and any other necessary information. Drawings in conjunction with the applicable materials process specification shall constitute a complete fabrication specification.

4.5.2.3 Materials process specification. A detailed description of the manufacturing process and methods of quality assurance shall be prepared by the supplier as required by MIL-P-9400. The process specification shall be considered a part of the detail specification. Copies shall be made available by the supplier for use by authorized government inspectors at the suppliers plant. The process specification shall contain the identification, source, and application of all materials allowable defects, repairable defects, nonrepairable defects, defect repair methods and inspection procedures shall be included in the process specification. Where an applicable process specification has previously been approved by the same procuring activity the approved specification shall be referenced in the detail specification and submitted with the other required documents.

4.5.2.4 Atmospheric electricity test plan. A detail test plan shall be prepared covering the test approach and test procedures to be used for test of the radome lightning protection system and static electricity reduction system proposed for a particular radome. The test plan will be considered a part of the detail specification.

4.5.3 Radome repair procedures. Repair procedures shall be prepared for all repairable radomes. For Navy Class I radomes the repair format shall be of the form of Section II of NAVAIR Maintenance Instruction Manual 01-1A-22. For USAF Class I, II, and III radomes the repair format shall be as specified by the procuring activity. Preparation of the repair procedures shall consider the following:

a. Field level maintenance. No special maintenance training shall be required at this level. Maintenance guidelines and materials for Navy Class I radomes will be provided by NAVAIR 01-1A-22 and Radome Antenna Cover Repair Kit and Supplement FSN-IRM-5985-261-3419MF and FSN-5985-261-3359MF. For USAF Class I, II, and III type radomes, special consideration shall be given to operational level maintenance guidelines within the detail specification.

whether or not the ... and would count as a full day of confinement

b. Depot level maintenance. Repair techniques and repair material shall be selected which are readily adaptable to existing facilities and the experience of competent plastic technicians at the depot level. For Navy aircraft radomes NAVAIR 01-1A-22 shall be used for repair guidelines in conjunction with the availability of all conventional plastic materials. For USAF Class I radomes, the detail specification shall specify guidelines compatible with USAF depot level maintenance facilities and personnel.

4.5.4 First article test reports. The required first article tests shall be reported either by individual reports or within one comprehensive first article test report.

4.5.5 Quality conformance test data. Production radome test data records shall be retained, submitted, or approved as specified in contract or purchase order.

5. PREPARATION FOR DELIVERY

5.1 General. Radomes shall use preservation, packaging and packing in accordance with Level B, FED-STD-102. When authorized by the detail specification, in cases of special shipment and immediate installation, Level C, FED-STD-102 shall be acceptable.

5.2 Preservation, packaging and packing. Radomes shall use preservation, packaging and packing methods in accordance with MIL-STD-794.

5.3 Markings. Marking shall be in accordance with MIL-STD-129. The following information shall appear on each carton:

Manufacturer's part or drawing number
AN nomenclature
Serial number
Contract or order number
Manufacturer's identification code
Federal stock number
U.S. property

6. NOTES

6.1 Intended use. The radomes covered by this specification are intended for use in all categories of flight vehicles, surface vehicles, and fixed ground installations.

6.2 Ordering data. Procurement document should specify the following:

a. Part or drawing number

b. Vehicle and system model designation where applicable

c. Detail specification number

d. Number of first article samples

e. Point of inspection

f. Selection of applicable levels of preservation, packaging and packing.

6.2.1 Contract data requirements. When required, the data specified under 4.5 will be listed directly on a DD Form 1423 incorporated into the contract.

6.3 Definitions

6.3.1 Bandwidth. For the purpose of this specification, bandwidth is defined by the following formula:

$$\text{Bandwidth} = \frac{2(f_{max} - f_{min})}{f_{max} + f_{min}}$$

where

f_{max} = highest frequency

f_{min} = lowest frequency

of the frequency band to be covered

6.3.2 Item definition. A radome/antenna cover is defined as an electromagnetically transparent structure or enclosure for protecting an antenna from its environment and for the preservation of some desired body shape. The terms radome and antenna cover are synonymous; the word radome will be used for the purpose of this specification.

Custodian:
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6. REMARKS

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