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MILITARY STANDARD

ANTENNA SUBSYSTEMS, AIRBORNE, CRITERIA FOR DESIGN AND LOCATION OF

FSC 5985

DEPARTMENT OF DEFENSE
Washington, D.C. 20301

Antenna Subsystems, Airborne, Criteria for Design and Location of

MIL-STD-877

1. This Military Standard is mandatory for use by all Departments and Agencies of the Department of Defense.

2. Recommended corrections, additions, or deletions should be addressed to Aeronautical Systems Division, AFSC (ASNPS), Wright Patterson Air Force Base, Ohio 45433.

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TABLES

1. SCOPE. This standard covers the general criteria for the design and location of all antenna subsystems used on flight vehicles. It is not intended to preclude techniques, processes, materials, and methods of design and location which will lead to improvement of military airborne antenna subsystems. This standard is primarily for use by the flight vehicle manufacturer.

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 standard to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-B-5087 - Bonding, Electrical, and Lightning Protection, for Aerospace Systems.

MIL-H-5606 - Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance.

MIL-J-5624 - Turbine Fuel, Aviation, Grades JP-4 and JP-5.

MIL-E-6051 - Electrical - Electronic System Compatibility and Interference Control Requirements for Aeronautical Weapon Systems.

MIL-R-7705 - Radomes, General Specification For.

MIL-L-7808 - Lubricating Oil, Aircraft Turbine Engine, Synthetic Base

MIL-H-8446 - Hydraulic Fluid, Nonpetroleum Base, Aircraft

FEDERAL

O-E-760 - Ethyl Alcohol (Ethanol) Denatured Alcohol, and Proprietary Solvent

O-M-232 - Methanol (Methyl Alcohol).

TT-I-735 - Isopropyl Alcohol.

STANDARDS

MILITARY

MIL-STD-130 - Identification Marking of US Military Property.

MIL-STD-454 - Standard General Requirements For Electronic Equipment.

HANDBOOKS

MILITARY

MIL-HDBK-216 - RF Transmission Lines and Fittings.

MIL-HDBK-660 - Fabrication of Rigid Waveguide Assemblies (Sweep Bends and Twists).

(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.)

3. DEFINITIONS. For the purpose of this standard the following definitions shall apply.

3.1 Antenna. An antenna is a device for radiating or receiving electromagnetic energy.

3.2 Antenna subsystem. An antenna subsystem is the complete interconnection of the antenna, the transmission line (coaxial line and connectors or waveguide and accessories), radome, and all parts which serve to match, tune, isolate, erect, interconnect, and protect the subsystem. From the standpoint of design and operational characteristics, the term "antenna subsystem" also includes the entire flight vehicle since it is an essential portion of that which is scientifically defined as the antenna subsystem and may greatly contribute to its characteristics particularly the distribution of r-f energy. From the standpoint of location and installation, the term "antenna subsystem" shall include only the part(s) and modification(s) added to the flight vehicle to provide satisfactory avionics system operation.

4. GENERAL REQUIREMENTS

4.1 Materials, parts, and processes. Unless otherwise specified herein and in the antenna subsystem detail specifications, materials, parts, and processes utilized in antenna subsystems shall be as specified in MIL-STD-454.

4.1.1 Resistance to fluids. All materials used in the external construction of the antenna subsystem shall withstand total immersion in the fluids shown in table I without causing permanent electrical or mechanical deterioration.

TABLE I. List of fluids.

Fluid	Specification
Water	Tap
Salt water	5%
Lubricating oil	MIL-L-7808
Hydraulic fluid (petroleum base)	MIL-H-5606
Hydraulic fluid (nonpetroleum base)	MIL-H-8446
Jet fuel (grade JP-4)	MIL-J-5624
Isopropyl alcohol	TT-I-735
Ethyl alcohol	O-E-760
Methyl alcohol	O-M-232

4.2 Design and location. The overall design objective for antenna subsystems shall be to enable operating personnel and the flight vehicle to best fulfill the military mission(s) which shall include the capability for personnel to use the airborne avionics systems without deficiencies due to the antenna subsystem. The criteria for design and location are grouped together because of the interdependence of the two in the field of airborne antenna subsystems. The problems associated with antenna subsystem locations and interference usually become more difficult with the increasing number of antennas to be located on the flight vehicle and with the shortage of space for location. The resulting difficulties shall in no way be considered as justification to forego the requirements for satisfactory operation for any subsystem.

4.2.1 Electrical properties. The design and location of antenna subsystems shall provide satisfactory functional operation of each particular subsystem and of the aggregate systems for the entire flight vehicle under all service conditions. Electrical properties of the antenna subsystems shall be compatible with the requirements for the flight vehicle and avionics system involved as set forth in the applicable detail specifications.

4.2.1.1 Energy distribution. The distribution of r-f energy (transmitted or to be received) shall be treated as the most important electrical property affecting realization of the overall design objectives. The effects of side lobes, beam widths, nulls, asymmetry of radiation, lobe centering, cross-polarization ratio, directional gain, axial ratio, energy distribution, and any other relevant factors shall be considered with due regard to the type of avionics system involved and its requirements and the particular flight vehicle and its requirements. The ability to provide maximum or adequate coverage establishes the fundamental distribution requirement. Any different distribution necessary for the operation of an avionics system is labeled a special or peculiar distribution requirement.

4.2.1.2 Special energy distribution. Antenna subsystems requiring special energy distribution, such as radar antenna subsystem, navigational, countermeasure, reconnaissance, and communication antenna subsystems shall be designed and located in accordance with applicable detail specifications at the best available locations.

4.2.1.3 Voltage standing wave ratio (VSWR). The voltage standing wave ratio of airborne antenna subsystems, as measured at or corrected to the antenna feed point of the associated avionics system, shall be no greater than that specified in the detailed antenna subsystem specification or avionics system specification. VSWR shall be derived from the measurements performed on, or referred to a transmission line having a nominal characteristic impedance as specified in the detailed antenna subsystem specification or associated avionics system specification.

4.2.1.4 Efficiency. Antenna subsystem design shall provide optimum transfer of energy between the associated avionics systems and free space. Designs which would permit large circulating currents through appreciably resistive conductors, or would permit r-f heating of insulators and dielectrics, shall not be accepted. Each part of the subsystem, including the antenna, cable, waveguide, connectors, insulators, insulating materials, r-f switches, matching devices, interference control devices, radomes, and other pertinent parts shall provide the highest efficiency commensurate with that of the best part development and consistent with other requirements for the part(s) involved. The total subsystem losses, including resistive losses, r-f heating losses, corona losses, and other losses shall be kept as low as practicable, and shall not become an unduly large percentage of the radiated r-f energy.

4.2.1.5 Bonding, conductivity, discontinuities. All metallic elements which are part of or adjacent to the antenna subsystem and not intentionally insulated from each other shall be securely bonded in compliance with MIL-B-5087. The mating surfaces between all metallic parts of the antenna subsystem intentionally designed to be electrically continuous to r-f currents shall be clean metal surfaces free from anodic film, grease, paint, lacquer, or other high resistance film, when necessary to insure negligible r-f impedance between such parts. All portions of the antenna subsystem which are required to carry r-f currents or which would, during operation, have high-surface current densities, shall have a high-surface conductivity. Antenna locations close to windows, skin discontinuities, and other surface irregularities shall be avoided insofar as possible. Requirements of this paragraph shall not necessarily apply to any antenna subsystem having the airframe as an integral part. However, silver-plated rivets may be used in the airframe, when specified by the flight vehicle specification, to improve the surface electrical conductivity of the airframe.

4.2.1.6 Interference control. The design and location of the antenna subsystems shall conform with all the requirements of MIL-E-6051. The subsystems shall be designed and located, including such interference control techniques and devices as necessary, to provide avionics systems performance with negligible interference from subsystems physical and electrical relationships, one to another and each to its surroundings. Design and location of subsystems shall be such that their relationships minimize the need for interference control devices because of the added weight and decreased subsystem efficiency which may otherwise result. The location of subsystems shall be sufficiently removed from external sources and surrounding fixed installations, including other subsystems; jet, fanjet, or propeller driven lift and/or life cruise engines; landing gear; etc, to allow the avionics systems to perform without deficiencies from parasitic radiation, shadowing of radiated energy, change in subsystem impedance, propeller modulation, propeller reflection, resonance and antiresonance phenomena, or any other causes. The coupling between subsystems

shall be kept as low as practicable. Antennas operating in the VHF and UHF frequency ranges when they are similarly polarized and are not used in a multi-purpose installation shall be spaced as far apart as the available space will allow. A minimum spacing of 3/8 wavelength at the lowest frequency of operation of any antenna involved is desirable. A spacing of a full wavelength is sometimes necessary for transmit functions, depending upon the isolation requirements and antenna locations. Subsystem parts, such as fairings and radomes, shall be designed and located in such a way as to minimize undesirable performance effects caused by precipitation static and corona discharge.

4.2.1.7 Radiation pattern coverage. Pattern coverage of an antenna system designed for an avionics system operating at frequencies above 30 megahertz shall be consistent with the particular function of that system. Consideration shall be given to the maneuverability of the flight vehicle on which the antenna is used, possible polarization losses, and possible difficulties involved in antenna location.

(a) For vertical planes, including the flight vehicle as follows: Radiation patterns in the shape of a figure 8 without deep nulls, maximum component of field strength on the horizon, beamed symmetrically about the horizon and equal beam width in both directions with an angular magnitude that allow the best compromise between shortcomings caused by flight vehicle maneuverability and those caused by availability of finite power and sensitivity for the avionics system involved. In consideration of the degree of maneuverability of most flight vehicles a minimum beam width shall be 50 degrees, and in consideration of polarization losses, and antenna design and location difficulties, a maximum beam width shall be 90 degrees for plane polarized antennas.

(b) For the horizontal plane and other planes within the solid angle plus to minus five degrees about the horizontal plane, including the flight vehicle as follows: Equal radiation in all directions. If compromise is required, coverage in the forward direction takes precedence over coverage in the rearward direction which in turn takes precedence over coverage to the sides of the flight vehicle.

4.2.1.8 Multiple-purpose locations. Whenever practical, one location shall be used to accommodate more than one antenna subsystem and serve a maximum number of avionics systems simultaneously. Multiple-purpose locations shall include such filters, coupling devices, matching networks, and interference control devices as necessary to provide satisfactory interference control.

4.2.2 Physical properties. The design and location of the antenna subsystems shall provide optimum compromises between all the subsystems physical properties and the flight vehicle operational characteristics involved. Antenna subsystem physical properties shall include materials, drag, weight, volume and all other relevant properties. Flight vehicle operational characteristics shall include range, altitude, speed, aerodynamic performance, and all other relevant factors. Antenna subsystem electrical requirements such as aperture, special energy distribution, etc. may be sufficient to demand antenna physical properties of a magnitude great enough to contribute need for a highly significant portion of the total size and weight of the flight vehicle. As antenna subsystem size, weight, or drag become greater, the effect on flight vehicle growth shall be considered when determining which design will best meet the overall objective. When the physical properties of a zero drag antenna impose more penalty than those of an external antenna on the operational characteristics of the flight vehicle, the best compromise shall be effected consistent with the overall design objective.

4.2.3 Transmission lines.

4.2.3.1 Coaxial transmission lines. Coaxial cable, coaxial connectors, and accessories for external (lead-in) coaxial transmission lines shall be selected from the preferential lists of MIL-HDBK-216 and shall comply with the requirements of the applicable military specifications.

4.2.3.2 Waveguide transmission lines. Waveguides and waveguide accessories for external (lead-in) waveguide transmission lines shall be selected from the preferential lists in MIL-HDBK-216 and shall comply with the requirements of the applicable military specifications. MIL-HDBK-660 shall be used as a guide in the fabrication of waveguide bends and twists.

4.2.3.3 Minimum length. The antenna subsystem shall be so designed and located that connection is made to the associated avionics system using a minimum length of lead-in or transmission line to avoid excessive losses in the lines.

4.2.3.4 Nonstandard transmission lines. Nonstandard coaxial or waveguide short length transmission lines may be used in the fabrication of antennas as defined in 3.1, provided all requirements of the applicable avionics systems and antenna detail specifications are met.

4.2.4 Radomes and electromagnetic windows. Radomes and electromagnetic windows shall comply with the requirements of MIL-R-7705 and the applicable radome detail specifications.

4.2.5 Associated parts. All other parts used for tuning, matching, coupling, etc, in the antenna subsystem shall be in accordance with the requirements of the applicable parts detail specifications.

4.2.6 Safety. The antenna subsystems shall be designed and located to promote maximum safety of operating and maintenance personnel and equipment in accordance with MIL-STD-454, requirement 1.

4.2.6.1 Location to avoid damage or physical injury. Each antenna subsystem shall be so designed and located that it or any part will not operate improperly or become damaged as a result of contact with hot or corrosive exhaust gases or be damaged by projectiles or gun blasts originating from the flight vehicle itself. Locations shall not foul folding, rotatable, or variable sweep wings, fins, control surfaces, landing gears, external stores or other structures. The locations shall be such that the subsystems will not be damaged from, or will be protected from flying sand, rock, mud, water, snow, ice, or other debris caused by take off or landing of the flight vehicle. Locations on the underside of a flight vehicle shall be selected to prevent damage and injury to or from personnel, trucks, catapult cables, arresting gear, and other equipment.

4.2.6.2 Electrical overload protection. The antenna subsystem shall be protected from electrical overload as specified in the detailed antenna subsystem specification or associated avionics system specification.

4.2.6.3 Obstruction of visibility. All parts of the antenna subsystems shall be so designed and located as to cause a minimum of interference with the visibility of crew members, particularly the bombardier, gunner, and pilot(s). Especially the pilot's vision during landing procedures shall not be obstructed.

4.2.7 Collection of liquids. All subsystem parts shall be so designed and located that no water or other liquid can collect in any portion of the parts. Adequate drainage in the parts shall be provided to prevent the accumulation of moisture as a result of condensation, except for a hermetically sealed antenna which shall be either filled with a dry gas or provided with adequate dehydration to prevent the condensation of moisture or altitude breathing. Antennas attached to or passing through the skin surface of the flight vehicle shall be designed and located to prevent moisture or other liquids from flowing or seeping into the interior of the flight vehicle.

4.2.8 Aerodynamics. The selection of the type of antenna, either flush, semiflush, or externally mounted, associated radomes, and all other subsystem parts shall be based on minimum effects on the range and speed of the flight vehicle. The requirement for flush mounting to provide a smooth skin contour shall not be considered sufficient justification if the installed weight causes a greater performance reduction than the use of an externally mounted antenna. When external antennas and radomes are used, the portions protruding into the airstream shall be so designed, from an aerodynamic standpoint, that shock waves which may occur during any controlled flight conditions shall not adversely affect flight vehicle control. In addition, the antenna subsystem parts shall be so designed and installed as to withstand, without deleterious effect, the maximum stresses resulting from severest operational conditions of flight.

4.2.9 Accessibility. Each maintainable part of the antenna subsystem and each major subassembly forming a part thereof shall provide easy and ready access to its interior parts, terminals, and wiring for adjustments, complete circuit checking, and the removal and replacement of parts. Unless otherwise specified, wires, cables, waveguides, parts or assemblies shall not be displaced or removed in order to gain access to terminals, soldered connections, mounting screws, and the like. When it is not practicable to avoid such construction, those parts which must be displaced or removed shall be so designed, mounted and otherwise arranged to facilitate their displacement or removal when necessary. If, in order to check or remove a given part, it is necessary to displace some other part, the latter part shall, whenever practicable, be so wired and mounted that it can be sufficiently moved without being disconnected from the circuit and without causing detuning or instability.

4.2.9.1 Terminals. The antenna terminals or feed points shall be accessible for disconnecting and replacing transmission lines and for servicing tuning units, matching units, servos, or other related devices located near or adjacent to the antenna terminals or feed point.

4.2.10 Environmental conditions. The parts of the antenna subsystem shall be so designed that no fixed part or assembly shall become loose; no moving or movable part or assembly become undesirably free or sluggish in operation; no movable part or control be shifted in setting, position, or adjustment; and no degradation be caused in the performance below that specified in this standard, the individual antenna subsystem detail specifications, or the avionics system specification during service operation or storage in the following environmental conditions: Exact numerical values of environmental conditions, modifications, and exceptions to the conditions listed below shall be as specified in the individual antenna subsystem detail specifications or avionics system specification.

(a) Altitude
(b) Temperature-altitude cycling (altitude breathing)
(c) High temperature
(d) Low temperature
(e) Temperature shock
(f) Sunshine
(g) Rain
(h) Humidity (cycling)
(i) Fungus
(j) Salt fog
(k) Sand and dust
(l) Fluid resistance
(m) Acceleration
(n) Vibration
(o) Acoustical noise
(p) Shock
(q) Lightning
(r) Ice
(s) Snow
(t) Precipitation static
(u) Nuclear radiation
(v) Salt water immersion

4.2.11 Reliability. The reliability of the antenna subsystem shall be in accordance with the reliability requirements specified in the individual subsystem detail specifications and the avionics system specifications.

4.2.12 Maintainability. The maintainability of the antenna subsystem shall be in accordance with the maintainability requirements specified in the individual subsystem detail specifications and the avionics system specifications.

4.2.13 Interchangeability. Interchangeability of the antenna subsystem shall be in accordance with MIL-STD-454, requirement 7.

4.3 Workmanship. Workmanship of the antenna subsystem shall be in accordance with MIL-STD-454, requirement 9.

4.4 Packaging and transportability design criteria. Consideration shall be given in the initial design to enhance the packageability and transportability of the assembly, subassembly or component without loss of the desired function. Provisions for simple and ready disassembly of parts should also be considered so that a minimum weight and cube can be accomplished.

4.5 Marking. Marking of the antenna subsystem shall be in accordance with MIL-STD-130.

4.6 Conflict of requirements. When any of the requirements of the aeronautical system contract or specification, the avionics system specification, the antenna subsystem detail specifications, this standard or applicable subsidiary specifications are in conflict, the following order of precedence will apply.

(a) The aeronautical system contract.
(b) The aeronautical system specifications.
(c) Avionics system specifications.
(d) Antenna subsystem detail specifications.
(e) This standard.
(f) Subsidiary specifications.

4.7 Deviations. The contractor shall request the approval of the procuring activity to make any deviations from this standard or from the detail specifications where applicable. Deviations are not approved unless specific written authority to deviate is received from the procuring activity.

5. DETAIL REQUIREMENTS. Detail requirements for the antenna subsystem criteria shall be as specified herein and in accordance with the individual subsystem or avionics system detail specifications.

Custodians:
Army - EL
Navy - AS
Air Force - 11

Review activities:
Army - EL, MI, AV
Navy - AS
Air Force - 11
DSA - ES

User activities:
Army - EL, AV
Navy - AS, CG
Air Force - 19

Preparing activity:
Air Force - 11

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