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MILITARY SPECIFICATION

ANTENNA SYSTEMS, SUBMARINE; DESIGN, LOCATION, AND INSTALLATION; GENERAL SPECIFICATION

1. SCOPE

1.1 This specification covers the general mechanical and electrical requirements for design, and for location and installation on Submarines of antennas for electronic equipment, and is primarily for the use of antenna system manufacturers.

1.1.1 Electronic equipment covered by this specification is primarily external to the pressure hull. In addition to the radiating elements (both active and passive), antenna systems within the scope of this specification consist of the radio-frequency transmission line from the connector at the inboard detecting or transmitting equipment to the outboard receiving or radiating element, and all components which serve to tune, erect, protect or interconnect the antenna. The hydraulic system from the erecting mechanism back to the first distribution manifold is part of the system. Electrical control cables from the actuating equipment out to and including the outboard antenna components are part of the system. Functional parts of the submarine such as the snorkel tube and periscope which also serve as antenna masts shall conform to the requirements of their primary purpose, suitably modified for subject multi-purpose use. The term system as employed within this specification refers to military operational function as a subsystem of a submarine rather than to electrical, electronic, mechanical and hydraulic equipment divisions. Antenna systems are essential for the safety and continued combat capability of the ship.

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 the specification to the extent specified herein:

SPECIFICATIONS

MILITARY

MIL-C-17 - Cables, Radio frequency: Coaxial, Dual Coaxial, Twin Conductor and Twin Lead.

FSC 5985

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MIL-S-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-C-915 - Cable, Cord and Wire, Electrical (Shipboard Use).
MIL-D-963 - Drawings, Electrical, Hull and Mechanical Equipment for Naval Shipboard Use.
MIL-R-978 - Reports: Research and Development (for Electronic Equipment).
MIL-C-2194 - Cables, Power, Electrical, Reduced Diameter Type, Naval Shipboard.
MIL-C-2212 - Controllers, Alternating-Current, Naval Shipboard.
MIL-P-5514 - Packings, Installation and Gland Design, Hydraulic, General Specification for.
MIL-Q-9858 - Quality Control System Requirements.
MIL-M-15071 - Manuals, Equipment and Systems.
MIL-E-16400 - Electronic Equipment, Naval Ship and Shore: General Specification.
MIL-I-16910 - Interference Measurement, Radio, Methods and Limits; 14 Kilocycles to 1000 Megacycles.
MIL-I-16923 - Insulating Compound, Electrical Embedding.
MIL-E-17362 - Electronic Repair Parts Requirements, Procedures for Provisioning Technical Documentation and Stock Numbering.
MIL-E-17555 - Electronic and Electrical Equipment and Associated Repair Parts; Preparation for Delivery of.
MIL-C-21367 - Connectors and Associated Fittings for Flexible Solid-Dielectric, Radio-Frequency Cables.
MIL-E-21981 - Electronic Type Designations, Identification Plates and Markings; Requirements for.
MIL-R-22732 - Reliability Requirements for Shipboard and Ground Electronic Equipment.
MIL-E-22843 - Equipment, Low Noise Level (Naval Shipboard Use).
MIL-C-23020 - Cable, Coaxial (for submarine use).
MIL-M-23127 - Milestone Cost Plan.
MIL-M-23313 - Maintainability Requirements for Shipboard and Shore Electronic Equipment and Systems.
MIL-D-70327 - Drawings, Engineering and Associated Lists.

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STANDARDS

MILITARY

MIL-STD-10 - Surface Roughness, Waviness and Lay.
MIL-STD-196 - Joint Electronics Type Designation System (AN System).
MIL-STD-740 - Noise Measurements of Shipboard Machinery and Equipment.
MIL-STD-758 - Packaging Procedures for Submarine Repair Parts Utilizing Transparent, Flexible, Heat Sealable Film.

PUBLICATIONS

BUREAU OF SHIPS

NAVSHIPS 93793 - O-Ring Seals for Submarine Antenna Systems.
NAVSHIPS 94500 - Preparation Guide for Electronic Equipment Technical Manuals.
NAVSHIPS 250-371 - Ship Acoustical Surveys

(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.)

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3. REQUIREMENTS

3.1 General - The requirements for antenna operations in a submarine environment are peculiar to submarines in that systems must operate at or near the ocean surface under severe mechanical and hydrodynamic conditions while performing normal electromagnetic functions. Antenna systems must be able to survive the hydrostatic pressure of deep submergence, to survive dynamic loads of maneuver and vibration, to survive shock of underwater explosion, to survive cycling of temperature and pressure occasioned by changes in submarine operating depth, to resist corrosion under the most rigorous service conditions, to withstand under ice operations, to function for extended periods without maintenance accessibility, and must be absolutely reliable in providing communications. Because of these requirements, submarine antenna systems demand a unique compromise among electronic, mechanical hydraulic, metallurgical and chemical parameters, no one of which may be ignored without jeopardizing the strategic mission of the submarine weapon system. This compromise involves a trade between efficiency of electromagnetic propagation and paramount reliability-maintainability factors.

3.1.1 Identification and marking of CFE antennas and components - The contractor shall determine the identification and marking requirements for contractor furnished equipment (CFE) antennas in conformance with the applicable requirements of MIL-E-21981 and MIL-STD-196. Previous government nomenclature assignments shall remain unchanged regardless of changes in installation or application.

3.2 Design, location and installation

3.2.1 General - The requirements for design, location, and installation are grouped together because of interdependencies established by the submarine weapon and certain of its subsystems. Problems associated with antenna location and interference become more difficult as the number of installations on board increase. Location within narrow limits is specified for the class or classes of submarines concerned in applicable ships plans. However, the resultant difficulties shall not be considered justification to relax requirements for operational effectiveness of any one antenna installation. Antennas are cited herein as radiating elements because of the reciprocal relationship of receiving and transmitting functions. Among the design parameters to be considered are:

(a) Whether operations require a fixed, flexible, retractable or removable (Portable) unit, operating independently or in conjunction with another unit either structurally or electrically.

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(b) Hydrodynamic flow and impact loads (wave slap)

(c) Anticipated service wind and ice load

(d) Power handling requirements

(e) Standing wave ratio tolerance

(f) Frequency response

(g) Whether a fixed beam, rotatable beam, or omni-directional effect is required

(h) Restrictions as to total mast height, height above water surface shield or ground plane or other reference, erecting mechanism including power source employed, reaction time or time base provided for erecting and lowering.

(i) Freedom from hydrostatic pressure collapse and or seawater penetration of the interior of the antenna or internal water condensation to cause electrical shorting

(j) Corrosion resistance

(k) Vulnerability to pressure shock, high impact shock, thermal shock and vibration

(l) Radar cross sections or relative vulnerability to enemy detection by any means including underwater sound generation

(m) Operation when inclined at any angle up to 20° from its normal operating position, or under dynamic loading in the operational environment

(n) Capable of storage in a stable position on a flat surface or deck without damage and without the benefit of unusual packaging materials or support

(o) Operability (Human engineering considerations), maintainability, safety and fail-safe design.

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3.2.1.1 Electrical properties - Electrical properties governing the design, location and installation of an antenna shall be such as to provide satisfactory functional operation of each particular antenna system and the aggregate system for the entire submarine under all service conditions. Electrical properties for antennas shall be compatible with the requirements for the equipment served as specified in the individual equipment specifications. Performance parameters considered for electrical design evaluation are:

(a) The antenna must operate satisfactorily over the specified frequency range and bandwith for transmission and reception.

(b) The voltage standing wave ratio at rated power output must not exceed the specified value.

(c) The specified gain must be realized.

(d) The radiation pattern must be as specified.

(e) Polarization must be as specified.

(f) Limits of height above water surface shield or ground plane must be met.

(g) Power requirements to be compatible with ship's power.

(h) The antenna must operate satisfactorily at the specified antenna mast height and ships operating speed, and must continue to operate without change in performance at any combination of speed and mast height within the values specified.

(i) The antenna must operate satisfactorily within the specified time after erection to the specified antenna mast height (Includes precalibration, tune up, dry off, etc.). A concomitant requirement is that flooded mast fairings drain off sea water content to ambient surface level within the time base allocated.

(j) All of the above restrictions must be met in the intended operational environment.

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3.2.1.2 Physical properties - Design, location and installation of submarine antennas shall be such as to provide optimum operational characteristics for the class of submarine concerned. Physical properties considered shall include structural strengths, size, weight, and center of gravity location, hydrodynamic loads, vibration and flutter, dissimilar metal galvanic coupling, thermal shock, pressure and mechanical shock, corrosion resistance, hydrodynamic pressure resistance against penetration by sea water (seals and encapsulation). Among operational parameters considered for mechanical design evaluation are:

(a) Reliability

(b) Maintainability

(c) Standardization, Interchangeability of parts

(d) Vulnerability (to damage, to environmental factors)

(e) Versatility (multipurpose and growth potential)

(f) Operability (human engineering considerations + safety)

(g) Systems integration (submarine compatibility)

(h) Cost and logistic support

(i) Packageability or transportability

3.2.2 Detail - Antenna design, location and installation requirements are outlined in detail in the following paragraphs.

3.2.2.1 Structural design criteria

(a) Antennas shall be so designed and installed as to withstand without mechanical or electrical breakdown, the maximum combined stresses imposed by the operational environment. The reference elevation datum for submarine antennas is the snorkel waterline which is defined for all classes of submarines to relate the median or still water sea surface to ship's structure for near surface operations. Antennas designed for above surface operation shall be supported in such a manner that the lowest active element of the antenna shall be at least 4-1/2 feet above the snorkel waterline.

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Unless electromagnetic performance requirements permit no alternative, antenna masts shall be non-penetrating or entirely outboard of the pressure hull and shall have three normal operating positions - raised, normally housed or faired, and fully lowered, with the latter sometimes referred to as the "ice-housed" position. The raised position shall be interpreted to include the capability for operation at any mast height within a range of travel prescribed in detail specifications for the ship concerned. Where direct lift of the radiating element or elements cannot provide sufficient elevation, required height may be obtained by staging or telescoping mast structure. In all instances a means must be provided for holding any selected position and an anti-creep feature shall be incorporated to prevent unwanted movement.

(b) Deceleration shall be provided in the hoisting gear at the upper and lower limits of travel of all retractable masts. A properly designed antenna mast system will have an overall co-efficient of friction which shall not exceed 0.3 after run-in and accordingly if accidentally freed of hoisting gear constraints will accelerate due to its own weight. A penetrating mast under hydrostatic pressure is capable of hi-shock loading the pressure hull under these conditions. For safety, resilient stops or snubbers shall be applied to both extremes of travel for all antenna/masts. For penetrating masts, the lower stop shall be capable of reducing the highest probable impact of an unrestrained mast to safe hull stress levels. Under normal operations, raising or lowering shall be accomplished within thirty seconds, however, the maximum rate of mast travel (first or primary stage) shall not exceed one foot per second both for reasons of personnel safety and ease of snubbing at extremes of travel utilizing the simplest control system feasible. All stages of an antenna/mast individually or in conjunction, shall be capable of being stalled under full retraction or erection power without damage to the system.

(c) Unless otherwise specified, antenna/mast installations shall be such that fairwater openings are closed or faired to fairwater contour with the mast in the normally housed position. This may be accomplished either through use of a separate closure cap or by configuring the antenna top to achieve this same result. The design shall be such that in ramming the fairwater through the ice pack during polar surfacing operations dynamic ice loads are borne by the fairwater and not by the antenna/mast system. Where the closure

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device bridges and therefor transfers dynamic loads directly to the fairwater, it may be termed an "ice-cap". Otherwise it shall be identified as a "faired-cap". The interaction between the antenna/mast system and the fairwater during the shock of underwater explosion must be considered concurrently with the choice of closure in avoiding unnecessary transfer of dynamic loads to the antenna/mast system. Where a faired cap is utilized, an additional antenna mast position designated "fully lowered", shall be provided such that the faired cap is a minimum of six inches below the top of the fairwater measured at the centerline of the mast. Caps, whether ice or faired which are fixed to the radome or radiating element of the antenna, shall not adversely affect the antenna patterns.

(d) Antenna/masts other than whip types or others of similar flexibility shall be rigid assemblies enclosed in or formed with streamlined fairings not susceptible to excessive torsional or bending deflections, eccentricities, chatter, flutter or displacement between moving parts. It will be necessary to show sufficient durability to yield a minimum estimated life of 10,000 cycles under operational service conditions. Antenna mast power systems shall provide sufficient power to actuate antennas under survival conditions cited in 3.2.2.2, presuming structural integrity has been retained. The natural frequency of an antenna/mast as supported in the raised position shall be at least fifty percent greater than eddy shedding frequencies at design speed. A design safety factor of 1.5 and 2.0 shall be applied to all antenna/mast design computations, reference section 3.2.2.2. Yield rather than ultimate strengths of materials shall be used as a basis for design except:

(1) For glass reinforced plastics use ultimate strengths and provide for cold flow in applications where structures may be heavily loaded for extended periods.

(2) For vibrating structures such as whips, use the endurance limit in salt water as the basis for design.

3.2.2.2 Hydrodynamic flow loads - Antenna/masts shall survive 16 knots speed with submarine partly or fully submerged and masts fully raised without loss of functional integrity. Antenna/mast sections unscreened by or exposed above the fairwater in the course of erection

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shall be streamlined or faired to an approximation of a minimum drag cross section which ideally has a chord length of two and one-half to three and one-half times its thickness or maximum frontal width. In the absence of a specified maximum speed for near surface operations of a given class or classes of submarines, 16 knots may be assumed, with the entire portion of the fully erected antenna/mast unscreened by the fairwater subjected to either wave slap or the athwartship resultant hydrodynamic force, whichever results in the greater loading. Wave slap shall be computed at 500 pounds per square foot (times safety factor of 2.0) of maximum projected or planform area. Hydrodynamic loading may be calculated as follows:

Athwartship Resultant in pounds force (frequently described as lift force which produces a rolling moment on ship)

$$F = FS \times C \times \frac{P}{2} \times A \times (1.69V)^2$$

$$F = FS \times C \times A \times 2.84V^2$$

Where F = hydrodynamic load in pounds

FS = Factor of Safety = 1.5

C = Force Co-efficient, whose value depends on yaw angle, mast cross sectional profile, but not size, Reynolds number, finite aspect ratio and near surface flow effects.

The use of an arbitrary value of 1.0 (unity) is allowed in lieu of more refined computations of normal and drag components added vectorially. The condition is assumed to be a severe turning maneuver verging on hydrodynamic stall of hydrofoil involved.

P = Mass density of seawater = 1.99 inch slugs per cubic foot. P/2 may be considered unity.

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A = Maximum projected area in square feet. Note that this is planform area and shall include projected area of the antenna portion. This same method of area determination applies to "wave slap" loading.

V = Ships speed in knots (1.69 is the conversion factor from knots to feet per second).

3.2.2.1 A force co-efficient of one shall also be applied to circular cross sectioned masts. In all cases, the maximum load shall be applied in a direction calculated to produce the maximum bending stress in the mast. i.e. Athwartship force components govern the design since these usually exceed longitudinal (drag) components and act in a direction where the sectional modulus of a hydrofoil is least.

3.2.2.2 The use of an arbitrary force co-efficient is based on a rigid body assumption that the eddy shedding frequency of the mast does not coincide with its resonant or near resonant requency. A flutter mode produces a large drag rise. This is critical for circular mast sections, particularly whips where the drag rise is divergent. The eddy shedding frequency may be computed by the formula:

$$F = \frac{KV}{D}$$

where F = frequency in cps

V = flow velocity in feet per sec. (1.69 x knots)

D = effective diameter in feet

K = Strouhal number = 0.2

3.2.2.3 The Strouhal number varies with length between 0.2 for an infinitely long mast and 0.09 for a short mast. A value of 0.2 may be assumed. For ice load criteria see 3.2.2.3. For shock load criteria see 3.2.2.14.

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3.2.2.4 Since the application of these criteria will result in a conservatively designed structure which can be expected to survive speeds greater than the design objective of 16 knots, and since it is operationally useful to know the limiting speed to which a mast could be subjected in an emergency, calculations of structural strength shall be extended to determine the maximum survival speed for a thirty minute period, considering hydrodynamic flow load only with a reduced safety factor of 1.1.

3.2.2.3 Ice loads and operations within polar icepack - Antennas, antenna fairings or housings shall be so designed, located and installed as to withstand severe icing conditions encountered in polar operations combined with wind loads of 100 knots. Structurally, maximum ice loads will be assumed as two inches of glaze ice measured radially and covering the entire exposed surface in an erected condition. A dead weight of 4.5 pounds per square foot of exposed surface may be used for design purpose. Assume wind pressures of $P=0.0042V^2$ on flat surfaces and $P=0.0028V^2$ on curved surfaces where P=pressure in pounds per square foot of ice augmented area and V is wind velocity in miles per hour (knots x 1.15). To this load shall be added 500 pounds per square foot wave slap (times FS of 2). It is anticipated that mast retraction will not be attempted while in a heavily iced condition. Design and test requirements shall provide for mast retraction with up to 1/8 inch glaze ice measured radially. With heavier coatings, non-destructive stalling will be acceptable unless otherwise specified. Due allowance shall be made by the procuring agency for reduced antenna performance caused by propagation difficulties while iced or within the polar ice pack.

3.2.2.4 Voltage standing wave ratio - The voltage standing wave ratio of submarine antennas, as measured at the transmitter or receiver, shall be the minimum practicable throughout the frequency range(s) of the equipment(s) with which the antenna is to be used. In any event, the VSWR shall not exceed 4 to 1 for receiving antennas or 2 to 1 for transmitting antennas, unless otherwise specified in specifications governing the design of specific antennas or equipments. VSWR shall be derived from measurements performed on or referred to a transmission line having a characteristic impedance equivalent to the nominal input or output impedance of the electrical equipment with which the antenna is to be used (Normally 50 ohms).

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3.2.2.5 Bonding, conductivity, discontinuities - All metallic elements, either part of or adjacent to the radiating system and not intentionally insulated from each other, shall be securely bonded. The mating surfaces between all metallic parts of the antenna system intentionally designed to be electrically continuous to RF currents shall be clean metal surfaces free from anodic film, grease, paint, lacquer, or other high resistance film. All portions of the antenna system which are required to carry RF currents or which would, during operation, have high surface current densities, shall have a high surface conductivity. Antenna locations close to skin discontinuities or surface irregularities are undesirable and shall be avoided insofar as practicable.

3.2.2.6 Interference control - Interference control shall be applied to RF transmission lines inboard with emphasis applied to LF and VLF. Electromagnetic interference within the submarine (principally 400 cycle and 60 cycle interior communications circuits) can blank out the extremely low level VLF and LF signals which communication and navigation receivers are otherwise capable of detecting. RF cables carrying such signals shall be shielded to provide at least 100 decibels attenuation of a 10 kc noise source. Loops or reels if located where the electromagnetic field exceeds 160 decibels below 1 gauss shall be shielded. It is desirable to design, locate and install antennas initially so that the need for interference control with its attendant reduced antenna efficiency will be minimized. Measures shall be taken to minimize deficiencies stemming from parasitic radiation, shadowing of radiated energy, changes in antenna impedance, reflections, resonance and antiresonance phenomena, or any other causes. Tuning components of each antenna system must be capable of compensating for such effects caused by the presence of other antenna masts on the ship. The coupling between antennas shall be kept as low as practicable. Antennas operating in the VHF and UHF frequency range shall be spaced not less than 3/8 wavelength apart, at the lowest frequency of operation of any antennas involved when they are similarly polarized and are not used in a multipurpose installation. Antennas and associated fairings and housing shall be designed, located and installed in such a way as to minimize undesirable performance effects caused by precipitation static, and corona discharge. Electrical cables and connectors shall be rigidly anchored to minimize flexure, abrasion and noise voltage due to flexing high impedance coaxial cable leads. The provisions of MIL-I-16910 shall govern.

3.2.2.7 Electromagnetic propagation and distribution - The primary functional property of any antenna system resides in its ability to provide the field strength coverage established by the fundamental energy distribution requirements. The effects of side lobes, directional gain, axial ratio and any other relevant factor shall be evaluated in terms of the fundamental distribution requirement. Antenna systems requiring special energy distribution such as radar, counter-measure, direction finders and certain communications antennas, shall be designed, located and installed in accordance with applicable specifications for directionality.

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3.2.2.8 Multipurpose and multicoupled installations - In view of the concentration of antenna systems within the fairwater, strenuous effort should be made to accommodate more than one antenna per location or installation, or conversely, one antenna shall be used to serve more than one electronic unit or system. Multipurpose installations shall include such filters, balancing units, coupling devices, matching networks, and other interference control devices as necessary to provide for such devices operating as a fixed component(s) in the system. In addition, the penetrations of the pressure hull, within the specifications for stuffing tubes, hull tube adapters or pin connectors shall be held to an irreducible minimum. Any proposals for revision of existing arrangements shall be proposed in terms of existing contract plans for the given class submarine installation cited by the procuring agency.

3.2.2.9 Location antenna masts; underwater sound criteria - Specific antenna masts shall be installed in the approximate locations indicated on applicable ships plans, and unless otherwise specified, shall be fully housed within the fairwater to minimize turbulence and drag and to utilize ship's structure as shielding against dynamic loads. Antennas, housings, cablings, etc. shall be so located and installed that they will not create obstruction or suffer abrasion resulting from an unsupported, unprotected location. Vision from periscopes shall not be unduly impaired by antennas. Antennas, unless otherwise specified, shall be retractable to not less than six inches below the all purpose periscope horizontal line of sight while the antenna remains functional.

3.2.2.9.1 Antenna systems involving the use of rotating machinery such as direction finders, radar training mechanisms etc., shall be very quiet along a noise transmission path such as a mast or waveguide. Acoustic energy is transmitted with little loss along such channels. The resultant airborne noise does not usually pose a ships vulnerability threat, but such noise is evidence of improper design leading to excessive wear and unacceptable service life. Manufacturers may present airborne acoustic measurements performed in accordance with MIL-STD-740 as an indication of proper design from a standpoint of dynamic balance, both lateral and torsional, gear mesh noise caused by excessive tooth contact pressure, improper tooth shape or finish, mesh speed noise caused by excessive clearance and variable torque load caused by misalignment. Evidence of acceptability in terms of upper allowable limits of sound pressure shall be 75 db broadband and 66 db average over 4 octave bands from 300 to 4800 cycles per second frequency range (re 0.0002 dynes per sq. cm.).

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3.2.2.2 Antenna installations pose a major source of underwater noise during maneuvering at higher submerged speeds with buoy antenna mechanisms, rattling mast bearings, cable flutter and hoist system operations contributing. Manufacturers are advised that the design review of antenna equipment prior to release for fabrication will cover waterborne , structureborne and airborne noise producing potential of the design. After antenna system installation, Navshipyds will conduct submarine dockside and underway acoustical surveys in accordance with applicable ships specifications. In connection with acoustical surveys familiarity with the content of MIL-E-22843, Navships 250-371 and MIL-STD-740 is recommended. For antenna manufacturers guidance, values are given for overside noise of machinery and equipment. The dockside waterborne noise pressure levels shall not exceed 80 db broadband (re 0.0002 dynes per sq. cm.) at a hydrophone position of 10 feet from the driving source, erecting mechanism, etc. The structureborne noise level of motor and hoisting system shall not exceed 65 vdb (velocity decibels, Navy Standard re 10^{-6} cm/sec).

3.2.2.10 Collection of sea water or condensate - Antennas and antenna housings shall be designed so that no liquid or condensate can accumulate in any portion of the antenna or housing. Dry gas hermetic sealing, vacuum sealing, adequate dehydration techniques or filling with insulating solids are all permissible techniques for excluding moisture. In addition, a redundant or backup water sealing system (encapsulation) may be applied to sealed units of the antenna assembly, exposed or external to the pressure hull.

3.2.2.11 Encapsulation - The primary purpose of encapsulation is to provide a backup hydrostatic seal to the primary O-ring system. A secondary major function is to provide a water shedding surface to reduce the electromagnetic shielding effect of a water film on antenna surfaces. Auxiliary functions are to prevent electrolytic action between dissimilar metals exposed to seawater and to protect notch sensitive whip antenna surfaces. Methods for application and removal of encapsulation shall be compatible with shipyard or shipboard environmental conditions and within shipyard capabilities and techniques. Removal of encapsulation should not render antenna components unserviceable. The provisions of MIL-I-16923 shall apply to the determination of required characteristics for encapsulation compounds and also methods for determination of the following criteria:

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(a) Adhesion or bond to metal strength sufficient to exclude air and moisture under 3000 psi ultimate pressure

(b) Negligible moisture absorption

(c) Low power dissipation factor and low dielectric constant

(d) High dielectric strength

(e) Adequate low temperature flexibility, with thermal conductivity and thermal expansion co-efficient not to be critical in breaking bond.

(f) Thermal shock capability of withstanding "hot spots" and temperature gradients between extremes of -54° C(-65°F) to +155° C in the ultimate. Refer to par. 3.2.2.17 on thermal shock for specifics

(g) Shrinkage during cure not to be critical

(h) NON-corrosive and abrasive resistant

(i) Moderate loss of flexural elasticity under all submarine enviromental factors so that a minimum service life of three years is assured.

3.2.2.12 Materials - For guidance in selection and technical control of materials and of interchangeability of parts such as mechanical fasteners, the requirements of MIL-E-16400 shall apply. Materials not listed in MIL-E-16400, can be used only if sources of data on the composition, availability, fabrication, testing and performance of the material is made available to, and approved by the procuring agency. All exposed materials for submarine antenna applications shall be corrosion protected and corrosion resistant in accordance with MIL-E-16400. Only monel fasteners shall be used outboard with due selection of monel classes to reduce seizure. Aluminum or magnesium shall not be used. Substitute materials of unknown composition or strength shall not be used. Varieties of stainless steel which do not weld easily or corrode excessively at weldments or exhibit magnetic properties shall not be used. Galvanic coupling of dissimilar metals shall be limited in conformance with MIL-E-16400. Corrosion preventative maintenance on exposed surfaces shall not be required at intervals of less than 3 years. No component or part shall be used inboard which introduces either radioactivity or toxicity in any form. This includes mercury, mercury vapor, radioactive paints, fluorescent coatings, electrical and thermal insulations, paints fluids, etc. Within the closed ecology of the inboard enviroment, substances capable of passing to vapor or gaseous states under normal or emergency conditions shall be approved by the procuring agency on an item by item basis.

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3.2.2.13 Efficiency - Antenna design shall be such as to provide optimum transfer of energy between the associated electronic equipment and free space. Designs which permit large circulating currents through appreciably resistive conductors, or which permit RF heating of insulators and dielectrics, are undesirable. Each component of the antenna system, including cable, wave guides, connectors, insulators, insulating or encapsulation materials, RF switches, matching devices, interference control devices, the antenna assembly, and installation, and other related components, shall provide the highest efficiency commensurate with other fixed parameters and the state-of-art in component development.

3.2.2.14 Shock, pressure and high impact, underwater explosion - Shock occurs when a structure is subjected to a large suddenly applied external force, which is usually taken to mean a build-up of 90 percent of peak in less than 10 milliseconds. In general shock is defined as a pulse in units of gravitational acceleration (g's) having a given wave form in milliseconds duration, or, is defined in terms of test conditions outlined in Specification MIL-S-901 for Grade A equipment. The combined effects of underwater explosion are threefold: (a) Pressure Shock, (b) Mechanical or Hi-Impact Shock, and (c) Vibration; which are analyzed as three separate phenomenon.

(a) Pressure Shock - Loss of water tightness of sealed masts, as a result of the large pressure rise of the shock wave (plus ambient depth hydrostatic pressure). The time duration of the high or excess pressure zone for a given shock wave profile relative to the dimension of the mast in the direction of wave travel is the most significant parameter. For structures having equal hydrostatic strength the one with the smaller cross section has the greater vulnerability. In the case of the smaller section the time period for elastic deformation will in greater likelihood be exceeded by the duration of excess pressure, resulting in plastic deformation, or rupture.

(b) Mechanical or Hi-Impact Shock - Large acceleration forces are induced by impingement of the advancing pressure wave front on the pressure hull of the submarine. Given a constant shock wave velocity, the physical length or time dimension of the pressure hull in the direction of wave travel is sufficient to experience a pressure differential large enough to accelerate the pressure hull. Conversely the flooded fairwater presents little or no length-time over which to develop a comparable pressure differential. The resultant interaction between the pressure hull and the antenna masts within the fairwater, results in mechanical shock (high impact) on antenna mast systems.

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(c) Vibration - Transient vibration of the mast at its natural frequency as a result of the forces of (a) and (b). Cantilevering of antenna masts or other components should be minimized since such mountings deflect excessively producing large bending stresses and local collision damage with other ships structure. Any condition of near resonance with the ship can be expected to produce excessive shock response. Gravity and/or friction shall not be depended upon as a means for retaining relative position of antenna masts or other dynamic elements of antenna components such as tuners. A positive means for both down haul and clamping must be provided in lieu of any frictional device regardless of its apparent static holding power. For flange type O-ring seals proper bolt pre-stressing is essential to prevent momentary flange parting under shock with attendant O-ring displacement from hydrostatic forces. Bolts less than 1/2 inch diameter shall not be used because of inherent danger of overstressing during initial or subsequent tightening.

3.2.2.15 Shock design criteria - The methods and provisions of MIL-S-901 for Grade A equipment except as further specified herein shall apply. For design purposes the hydrostatic equivalent of hydrodynamic pressure shock shall be assumed at 3000 psi for sealed masts of ductile material, tuners, RF cables, connectors and associated hull fittings having a cross sectional dimension of the order of one foot. On a one time basis only, designs shall be subjected to 3000 psi for not less than one hour in actual demonstration. Mechanical shock criteria will be derived from the heavy weight equipment test involving the Floating Shock Test Platform defined in MIL-S-901. A characteristic submarine antenna mounting aboard the platform will be to incline the mast 60° from the vertical to simulate a beam attack by underwater weapons at relatively deeper depths. The item under test is mounted in a normally housed position in a direct simulation of sail structure if an entire mast is involved, or attached to a mast if a component is involved. For analytic purposes the vertical shock motion of the platform can be characterized as a triangular pulse of velocity. For the most severe shot this velocity has a peak value of approximately 15 feet per second, a rise time of one millisecond and a total duration of 30 milliseconds. Design guidance information is referenced in MIL-S-901. For the purposes of this specification, the damping effect of seawater on transmissibility or the augmented mast weight due to seawater content of flooded mast fairings may be neglected.

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3.2.2.16 Shock acceptance criteria - Unless otherwise specified by the procuring agency, a written analytic treatment plus findings on the one time 3000 psi hydrostatic test shall be forwarded in the lieu of full scale shock tests on submarine antennas. The design reviewing authority, normally the designated USN/USL project engineer may accept or refer these findings to the procuring agency for additional action. Requirements for physical tests, use of government testing facilities, equipment orientation and mounting, operations under test, instrumentation, inspections, probable disposition and/or repairs to the test items and reporting shall then be made known to the manufacturer by the procuring agency.

3.2.2.17 Thermal shock - Thermal shock tests on submarine antenna masts, cabling and components are necessary to determine the effects of sudden changes of temperature from near boiling in a sun heated fairwater to near freezing through deep submergence in a matter of minutes. The following actual extremes are encountered in the submarine antenna environment:

In air: -65° to + 185° F

In seawater: +28° to + 90° F

The most severe thermal shock likely to be encountered is a temperature change from -65° F in air to + 28° F in water. The tests provided herein are based upon the requirement for accelerated testing to predict the effect of long term environmental stress. Cracking and rupture by differential expansion and contraction is the principal difficulty anticipated with particular investigation to be applied to areas where dissimilar materials are bolted or bonded together. Encapsulated metal parts shall be tested. Owing to the difficulties inherent in subjecting large antenna components to cold fluids the following air chamber test shall be accepted. Antennas or components shall be raised to a temperature of 85° C (185°F) and maintained for a period of not less than four hours. At the conclusion of this time period the test item shall, within five minutes be transferred to a cold air chamber with an internal temperature of -54° C (-65°F). The equipment shall be exposed to this temperature for a period of not less than four hours and then shall within five minutes be returned to the high temperature chamber maintained at 85° C. This constitutes one cycle of which three continuous cycles shall be performed. At the conclusion of the last low temperature cycle the antenna shall be removed from the test chamber inspected, operated and subsequently hydrostatically tested. Where smaller component size permits the use of hot and cold fluid chambers as opposed to air chambers, the number of cycles shall be stepped up to ten times with a dwell time of thirty minutes in each fluid at the above specified temperatures. Water and methanol are suggested as hot and cold fluids, respectively.

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3.2.2.18 Cables, connectors, hull fitting, hydrostatic pressure seals - Hydrostatic pressure leakage considered acceptable for most engineering applications is unacceptable for deep submarine operations and constitutes total failure when applied to submarine antennas, RF cables, connectors and associated hull fittings. The seal must be absolute, with no measurable leakage. A stain or wetting which does not actually form a drop is unacceptable as this quantity of salt water will be continually pumped with pressure and temperature cycling. The primary sealing device is the rubber O-ring in which the radial rather that the flange type design application is preferred. Refer to NAVSHIPS 93793 for approved O-ring design detail. All sealing surfaces shall have a roughness height rating of 32 and shall be free from flaws as defined in MIL-STD-10 unless otherwise specified. Manufacturing repair of sealing surfaces by inserting monel metal seating material and re-machining is not authorized.

3.2.2.18.1 The preferred RF cable penetration is with straight-thru design hull fittings unless otherwise specified. Refer to Specification MIL-C-21367 and MIL-C-23020 for detail. To assure low temperature flexibility, all cable intended for outboard flexing service must be subjected to the cold bend test in accordance with Specification MIL-C-17. For multiconductor electrical control cable to be used in outboard flexing service, MIL-C-915 shall apply except in connection with cold working tests where MIL-C-2194 provides a more appropriate test. This test shall be conducted on a specimen which has been preconditioned by soaking in salt water at room temperature for three weeks and without delay followed by conditioning at -54° C (-65° F). The total bends in each direction shall be ten times without damage to insulation or sheath.

3.2.2.18.2 Each antenna and associated outboard electronic enclosures shall be pressure tested with cables attached prior to installation. This pressure test is not to be nullified by disassembly during the course of installation or inspection. All antennas shall be independently capable of withstanding an external hydrostatic pressure of 3000 psi (see 3.2.2.16) and a one time design proof test shall be accomplished to establish this capability. Routine antenna assembly operations require hydrostatic testing of all antenna assemblies on a no exceptions basis prior to shipment or installation to within one and one-half times the submergence test pressure of the submarine class in which the antenna

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is to be installed. Enclosures designed for vacuum shall be evacuated and checked for any loss of vacuum over a four hour period prior to hydrostatic test. Hydrostatic testing shall be conducted in the following sequence:

(a) Low pressure test at 6 psi ± 4 psi held for one hour

(b) High pressure test at one and one-half times the submergence test pressure of the submarine class in which the antenna is to be installed held for ten minutes

(c) Low pressure test as in (a) above for ten minutes.

(d) High pressure test as in (b) above for one hour.

The above times are minimums. Longer time at high pressure and additional cycling may be imposed. During and after completion of pressure tests, insulation resistance and electrical continuity shall be measured for degradation.

3.2.2.18.3 Because of the critical nature of the interface between the antenna and the submarine a considerable body of preferred practices and installation standards are available to aid the contractor in design selection. The contractor shall review procuring agency, furnished BuShips Instruction documents relating to preferred installation practices, and standards, and thereafter arrange a conference with the designated project engineer, normally a US Navy Underwater Sound Laboratory Engineer, early in the design. One copy of any preliminary drawings, layouts or sketches which are developed shall be furnished the project engineer in order that his comments and recommendations may be incorporated into the design before fabrication is started. Refer to 3.2.2.21 for design approval requirement prior to commencement of fabrication of prototype. Satisfactory design practices are arrived at only by detailed experimental test and the contractor must take into account experience factors available before starting fabrication of any device to be used operationally aboard a submarine.

3.2.2.19 Radomes or radome type enclosures (antenna housings) - Electrical properties affecting radomes are dielectric constant and loss tangent. These in turn are influenced by frequency, composition, moisture absorption, weathering or erosion and temperature. In general the dielectric constant and loss tangent of glass-fiber plastic laminates decrease with increasing frequencies above VHF frequencies.

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Increases in dielectric constant and loss tangent resulting from moisture absorption can render antennas useless. Erosion sufficient to expose bare glass fibres makes such water absorption possible. Minimum service life shall exceed three years in the submarine environment. The radome or hydrostatic pressure proof enclosure shall be designed to allow transmission of not less than 95 percent of the energy radiated by the antenna equipment throughout its entire frequency range when dry or not less than 90 percent when wet. Erratic radiation caused by the radome must not exceed five percent of the power of the main beam radiated by the antenna. The maximum polarization shift must not exceed an amount which will result in a loss of more than eight percent in power in either horizontal or vertical polarization, including the loss due to the radome material. Except as the following tolerances indicate, radiation characteristics must be uniform throughout a 360° rotation of the antenna. The complete radome must not:

(a) Cause the transmitted power to differ by more than eight percent with respect to the power transmitted without the radome.

(b) Cause a shift of axis of the transmitted beam either in vertical or horizontal axis in excess of 0.1°.

(c) Increase the width of the transmitted beam by more than five percent based on half power point measurements made with and without the radome.

(d) Increase the side lobes of the pattern distribution by more than one db and the symmetry of the main lobe should not be affected as compared with measurements made without the radome.

(e) Cause the voltage standing wave ratio of the antenna feed system to change by more than ten percent when measured with a slotted line, as compared with similar measurements made without the radome.

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3.2.2.19.1 The total maximum weight of the radome will be specified. When in excess of forty pounds provision will be made for handholds or lifting sling attachment points. The color shall match the paint color prescribed for the appropriate submarine fairwater. Where the color is obtained through specialized painting or encapsulation, electromagnetic propagation characteristics shall be measured with coating applied. The letters "DO NOT PAINT" in 3/4 inch high letters shall be displayed on the outside of the radome adjacent to the attachment flange in order to prevent routine maintenance painting. Inside the radome, in letters not less than 1/2 inch high shall appear the manufacturer's part or drawing number, AN nomenclature if assigned, detailed specifications number, contract number, manufacturer's name and the symbols U.S. An O-ring seal(s), single or multiple, shall be used. Splicing or alteration of an O-ring is expressly prohibited.

3.2.2.20 Quality assurance system - The Quality Assurance System requirement is for "Factory to Fairwater" information and data adequate to assure:

(a) That the quantitative design characteristics of reliability and maintainability as shall be proposed by the contractor are in terms of known reliability and maintainability success parameters (refer to para. 3.2.2.21) are being met.

(b) That Quality Control or the contractor proposed effort for preserving the full reliability/maintainability potential inherent in the developed end item is exercised throughout the course of production/procurement and final installation aboard a submarine.

It is the responsibility of the contractor to include as a separate part of a submarine antenna system development proposal, a comprehensive plan herein referred to as a Quality Assurance Plan incorporating to a degree indicated by the complexity of the end item in view, the basic elements of a reliability plan as set forth in MIL-R-22732, a maintainability assurance program as set forth in MIL-M-23313 and a production quality control system as set forth in MIL-Q-9858. The plan shall list both tasks and an organic group with the necessary capability to assure quantitative or analytic determination and acceptable demonstration of system or end item reliability/maintainability as proposed. The plan shall be compatible with the requirement for 100 percent inspection of submarine antenna system components. During contract negotiations the plan shall be detailed to program status, describing the methods for achieving design assurance, piece part assurance, production assurance and end product assurance in a series of pre-

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planned steps, which will permit technical audit by the procuring agency. The program shall be updated periodically to reflect changes in requirements and may be subject to contract negotiations. Note that planned provision for obtaining approval of preproduction samples does not relieve the contractor of responsibility for compliance with the provisions of this specification or other equipment specifications subsequent to approval action. Approved preproduction samples shall be used as guides throughout production.

3.2.2.20.1 Since other equipment including Government furnished or associate contractor supplied equipment are integrated in providing an operational submarine antenna system the contractor shall use known or estimated reliability/maintainability values for these equipments. The procuring activity will make provisions for the contractor to obtain known or estimated data from associate contractors or GFE suppliers. The contractor shall report problems introduced by deficient GFE or other associated equipment over which he has no control and shall indicate the degree of improvement necessary to make his equipment consonant with the end item in view. The procuring activity reserves the right to review, approve or disapprove the Quality Assurance Program at any time it deems the situation warrants.

3.2.2.21 Reliability/Maintainability - The success parameter for submarine antenna system equipment shall be three years of failure-free operation with the basic time constant being the unit mission or submarine patrol. The submarine patrol is arbitrarily defined as a sixty day mission during which time the antenna system shall be 95 percent reliable. This implies on a theoretical basis that the mean-time-between-failures (MTBF) is twenty patrols or forty months. However, an MTBF of three years corresponding to the normal overhaul period of the submarine is viewed as an attainable reliability goal and shall be required. Antenna systems equipment is cycle sensitive rather than continuous duty "on-line." The number of cycles to wearout under combined enviromental stresses, coupled with the fact of an MTBF measured in years, makes actual demonstration of reliability unfeasible. Maintainability, or the probability of effecting a repair within a specified period of time is also limited to dockside maintenance since restoration cannot normally be accomplished at sea. Accordingly, the design assurance portion of the Quality Assurance Plan (reference 3.2.2.20) shall provide for an analytic quantitative prediction of reliability in accordance with MIL-R-22732 to be submitted to the procuring agency for approval prior to equipment fabrication. This is to be accompanied by preliminary drawings (reference 3.2.2.18.3).

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3.2.2.21.1 All antenna systems parameters discussed in the contractors design shall show a relationship to reliability/maintainability. In addition to quantifying reliability, the probable dominant failure mode shall be identified, compared with similar equipment and the advance in the state-of-art shown. The maintenance concept for submarine antennas is the "no maintenance," concept of the sealed unit from which the outboard environment is absolutely excluded. To approach this objective every effort must be made to limit the requirement for periodic on-board maintenance by reducing the number of moving parts. Mean Time To Repair (MTTR) shall be predicated upon dockside removal and replacement "from the top," of the two basic modules, the radiating elements and the associated transmission lines with minimum time loss to the submarine.

3.2.2.21.2 Although the "no maintenance" concept normally involves the sacrifice of accessibility, certain accessibility criteria shall be observed. Where an antenna mast is designed as a multistage telescoping unit it shall be possible to remove the damage prone upper stage without the necessity for removing the entire unit from the submarine. The antenna base or feed point shall be accessible for disconnecting and replacing transmission lines and for servicing remote tuning units, matching units, servos or other related devices located near or adjacent to the antenna terminals or feedpoint. In general preferred materials, parts, arrangements and installation standards are detailed in BuShips instruction documents which will be made available by the procuring agency. In view of extremely limited on-board facilities and resources including skills, detailed analysis shall be applied to any requirement for integrated checkout equipment (self-checking designs such as integrated leak detectors, etc.), separate test equipment not normally available, spares and special tools not available in standard tool kits.

3.2.2.21.3 The contractor shall show cause where designs deviate from specific recommendations shown. Reliability/maintainability demonstrations and evaluations are cited herein as an integral part of the system test program (3.3.2C)) and shall be demonstrated during the course of performance tests. Reliability decisions having an impact upon other submarine equipment subsystems (other than communications) shall be coordinated with appropriate technical codes of the Bureau of Ships with the cognizance of the procuring agency.

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3.2.2.22 Human engineering and safety - Human factors data shall be reported to the procuring agency in terms of design accomplishments of the antenna system contractor with respect to performance capability and safety of personnel as follows:

(a) Workspace dimensions, integrated control display, accessibility to system components, lighting, labelling and color coding.

(b) Necessary communications between crew members prior to operations control and maintenance functions.

(c) Normal operations and emergency operations in event of probable failure modes relative to the normal time base provided for antenna functions. A single focal point designated Ballast Control Panel for mast control capable of deactivating or isolating remote controls is necessary and is normally provided by the shipbuilder. Mast position is to be indicated on all control panels.

(d) Observance of fail-safe principles throughout the design. Either an interlock device or a command sequence involving positive warning or deactivating devices shall be applied to antenna masts upon entry of personnel into mast wells. The act of deactivation shall eliminate all prior commands inserted into the system which energizes mast travel. The circuit logic of the most probable failure modes must be analyzed to preclude the introduction of exceptional hazard as a result of a failed condition.

3.2.2.23 Antenna mast control and indication systems - Control and position indication of antenna masts shall be divided between two stations designated Ballast Control Panel (BCP) and Remote Operating Panel (ROP). The BCP will be the master control station and shall have over-riding control. In addition to these two stations, the entire electrical control system for the mast contained within the pressure hull shall be enclosed within one housing and shall be designated as the Mast Controller (MC). The BCP operator will have over-riding control to raise, normally house and fully lower (ice-house) the antenna/mast system. He must know the position status of the mast at all times, and where the fully lowered position is required, a minimum of three indication lights labelled as follows shall be provided to convey the following mast positions:

(a) "Up" to convey any position above normally housed.
(b) "Fair" for normally housed.
(c) "Down" for fully lowered (where required).

Where an independently operated closure cap is provided the positions indicated shall be "open" and "shut." Suitable interlocks shall be provided to prevent faulty sequencing or collision between the antenna mast and closure cap. The BCP will contain the control circuit fuses for all positioning controls

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and shall have a conveniently accessible means to remove same for de-energizing the entire system electrically. Equipment necessary for control and indication of antenna system functions shall be as specified in pertinent ships specifications under general requirements for interior communications equipment. All switch throws, unless otherwise specified, shall be vertical. All switches shall be of the "on-off" type (not spring-loaded-to-neutral) unless otherwise specified and shall have a "pull-out-to-throw" safety interlock feature. Position lights shall employ the "round board and "straight board" display principle for interpretation at a distance. Pictorial analogue displays are also acceptable where opportunity exists for an integrated antenna system display. The ROP will also have position lights to convey raised, normally housed and fully lowered positions all of which are in parallel with those on the BCP. In addition the ROP will contain a continuously indicating variable height indicator which has the capability of giving actual height of the mast in feet above the ships keel, and its input or sensor shall derive its signal directly from the physical motion of the antenna/mast over its entire range. The ROP will contain a three position momentary contact switch (spring return to off), with the following positions: (1) UP, (2) OFF, (3) DOWN. This switch will be so connected that the BCP switch must be in the "UP" position before the mast may be moved. When the BCP switch is in either the Fair or Down position, the ROP switch shall have no control. Jogging or intermediate raising or lowering between the raised and normally housed position shall be accomplished at the ROP by temporarily holding the switch in proper position to raise or lower, and upon releasing the switch to its off position, the mast shall stop and hold without significant creep for at least twenty minutes. Where design testing of a given antenna system reveals that tuning may be accomplished without use of the "UP" control on the ROP, "Down" control only shall be incorporated. In a further effort to reduce complexity, if circuit lengths, current levels and the number of switching operations performed do not require relays, these shall be omitted. Only shockproof circuit elements in accordance with Specification MIL-C-2212 shall be utilized.

3.2.2.23.1 The tolerance for mast positioning control at a random height position is ±3 inches and accordingly the position indicator shall be calibrated over a linear scale showing six inch intervals, such that the resolution of actual height is discernible to an error no greater than three inches. At the extremes of travel, control tolerances will decrease to ±1 inch, except in the normally housed position where streamlining of antenna faired caps require ±1/4 inch.

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3.3 Data and reports -

3.3.1 Contracts for production equipment usually include requirements for a developmental prototype or preproduction model. The extent of compliance with specifications, standards, drawings and publications in connection with the specific procurement involved will be determined by the procuring activity. Normal requirements for technical data provide the government with information for identification, selection, development, approval and acquisition of production quantities, and provisioning of maintenance parts. Approval will be based on considerations which affect overall submarine systems compatibility and submarine communications sub-system compatibility plus demonstrations. The type of data to be delivered, delivery dates, quantity and destinations will be established in the contract.

3.3.2 Technical data - The submission of technical data shall be as follows:

(a) Preliminary development programming or data regarding recommended developmental equipment: Such data will constitute the contractor proposed basis for the work statement of a contract when associated with a proposed antenna system performance requirement and will be made available at the time of solicitation of bids in the form of a proposed statement of work. After contract negotiation such data will include firm milestone versus forecasted achievement date and cumulative cost plan in conformance with Specification MIL-M-23127.

(b) Program status reports (progress reports): The contractor shall prepare and furnish, monthly, twelve non-reproducible copies of an interim engineering report. These reports shall be furnished monthly after the date of contract and shall cover contractor managed antenna research and development on systems as follows:

(1) New type antennas

(2) Existing type antennas with changes which require a new or different design

(3) A new method of use invoving additional components

(4) A combination of (2) and (3) of the foregoing.

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Anntennas for one or more electronic systems may be covered in one or more reports per period. If work has not been done on an antenna system from the time the last report was submitted to the time another is due, then a progress report on the system is not required; however, the circumstance shall be reported in the lieu thereof. Detailed reports are unnecessary; however, the reports shall describe technical objectives, the pertinent facts, method of test, test results and future plans. Computations shall be summarized indicating assumptions made, sources of data, formulas and constants used, and conclusions reached.

(c) Test program plan: The contractor shall prepare and submit a separate document that defines the means and procedures by which the contractor plans to demonstrate the capability of the system or component to accomplish the required operational performance. The document shall describe the experimental design steps for obtaining data (including delineation of functions and tolerances) and shall explain the standards, tests, associated analysis and other means which shall constitute proof upon completion of development that an acceptable performance can be achieved in operational use. The test procedures shall indicate the location, extent of Bureau of Ships participation, as will be required in shipyard and cruise tests, instrumentation and other facilities required. All tests specified by the procuring agency (or best obtainable simulation or analysis thereof) shall be included. This document may be incorporated within the initial progress report or submitted separately. Tests actually accomplished will be reported in the regular reports with emphasis on analysis of actual results, comparison with expected results and plans for feedback of conclusions into system design.

(d) Technical manual data (installation, checkout, performance, operational and maintenance data):

(1) Four copies of a sketch or illustration of an appropriate submarine which shows system installation arrangement and general location of the proposed design with respect to other antenna/mast systems shall be forwarded concurrently with the first progress report(s) required in 3.3.2(b), or prior to 90 days after date of contract. Relevant recommendation data along the following lines shall be forwarded simultaneously: Key design features, design integration with the total system, such as integrated mast control panels, both electrical and hydraulic; integrated hull stop valve racks, multipurpose RF switching panels, system safety engineering features, both electrical and mechanical to prevent injury during operation or maintenance, fail-safe features applied, interlocking control circuits, and use of special purpose tools or test equipment during operations.

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(2) During the period of system development the contractor shall develop operating techniques which will lead to fulfillment of the requirement for data necessary to prepare operational manuals in anticipation of production for inventory type contracts. The test program plan 3.3.2(c) shall provide for verification of techniques and procedures developed. A preliminary technical manual which is informal in nature and generally in accordance with the provisions of Specification MIL-M-15071 which relate to experimental equipment manuals written for engineers (Type IIa) shall be prepared in connection with antenna system or component development contracts. This preliminary manual shall provide the basis for later refinement to the Type II formal document required for use with fleet inventory equipment which may be prepared utilizing NavShips 94500 as a guide. Included shall be pictorial, graphic and written material to describe location, installation, checkout and repair at both ships force and shipyard level, in addition to operating and performance information. Performance data shall include voltage standing wave ratio curves and radiation patterns. Insofar as practicable, impedance data shall be presented in Smith Chart form and radiation patterns shall be plotted, including a reference indicator that can be used to predict the operating range characteristics of the electronic system. Approval of this data is normally based on performance tests monitored by a designated representative of the procuring agency, normally the USN Underwater Sound Laboratory. Twelve copies of the technical manual shall be furnished for approval as early as practicable, prior to delivery of the preproduction antenna system or component.

(e) Systems compatibility data (final engineering report): The contractor shall forward to the procuring activity within 60 days after acceptance of the first antennas under the terms of the contract, a reproducible and 12 non-reproducible copies of a final engineering report. Format and general requirements shall conform to MIL-R-978. Design features covering submarine operational suitability and submarine compatibility will be stressed.

(f) Procurement and provisioning data (engineering):

(1) Drawings: After the design features which affect operational utilization of the equipment have been accepted by the procuring activity, all further manufacturing and procurement data released by the contractor shall not conflict with or change what has

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already been accepted, without approval of the procuring activity. The intent of this provision is that once the major features of the design are accepted, that manufacturing data shall be developed. Acceptance of any data or drawings by the government shall not relieve the contractor for accuracy, completeness of detail, deviations from specifications or standards or proper fit and function of contractor controlled design and fabrication of parts and assemblies. Manufacturing drawings in conformance with Specification MIL-D-963, shall be furnished to the procuring activity within 60 days after formal approval by Chief, Bureau of Ships of the preliminary technical manual. Drawing practices not otherwise specified shall conform to Specification MIL-D-70327. It is important that the overall arrangement plan incorporate reference lines for establishing horizontal and vertical distances, normally the center line of the body and the snorkel water line respectively. The external outlines, mounting requirements, orientation of attachments, access requirements, and piping and cabling locations shall be shown. Overall weight and center of gravity is also required for submarine stability data. Drawings are the principal data source for authoritative maintenance information. Wear, tolerances, adjustment limits, lubrication requirements and other significant maintenance factors shall be recorded on drawings.

(2) Provisioning: In anticipation of equipment repair parts requirements associated with the end item, the contractor shall provide for provisioning documentation and stock numbering in conformance with MIL-E-17362. Where a reprocurement is involved the contractor shall assure the existence and adequacy of completed data.

(3) Specifications: For each CFE antenna type or model the contractor shall furnish to the procuring activity three copies of a proposed procurement specification which shall follow the general format for military specifications. To this specification shall be appended a configuration list which shall include government furnished equipment as well as those items to be supplied by the contractor.

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a. The list shall be broken down by each subsystem of the system with the components of the system listed under it. Each component shall be identified by its assigned identification (Model No. or Part No.) specification or drawing. Wordage and references shall be specific or detailed rather than general so that design features and characteristics may be readily understood.

4. QUALITY ASSURANCE PROVISIONS

4.1 General - Program direction and all program matters, whether developmental, production/procurement or logistic support affecting the design, location and installation of submarine antenna systems shall be subject to inspection and review by the procuring agency through its authorized government development engineering project representatives and authorized government inspectors of Navy material. Unless otherwise specified by the procuring activity, the developmental engineering project agency shall be the US Navy Underwater Sound Laboratory, Fort Trumbull, New London, Connecticut. Inspection procedures by inspectors of Navy material are in accordance with the general requirements for design and construction (Section 9020-0) of the applicable ships specification. Additionally, authority to conduct source inspections or perform other contract administrative functions may be delegated by the procuring agency. The Submarine Antenna Quality Assurance Facility of the Philadelphia Naval Shipyard (Code 1600) will normally make determinations and findings relative to quality control of production and standards of workmanship.

4.2 Applicability of requirements - Satisfactory evidence of compliance with the requirements of this specification shall be submitted to the procuring activity for each new type of antenna design, and thereafter for each new model or variation thereof in which there has been a significant change in antenna configuration, and then only to the extent necessary to fully evaluate the change. The authorized Government Inspector may require such additional testing as he may deem necessary to assure production quality control. The provisions of MIL-Q-9858 shall be applied to all contracts for submarine antenna systems. A critical defect is one which judgment and experience indicate could lead to antenna flooding, structural failure, contribute to flooding of the pressure hull or otherwise jeopardize themission effectiveness of the submarine. In production type contracts the government reserves the right to inspect every unit submitted by the supplier for critical defects and to reject the remainder of the lot immediately after a critical defect is found.

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4.3 Physical tests for CFE antennas -

4.3.1 Environmental tests -

(a) Environmental test procedures for submarine antenna systems and components shall be established to assure that all elements will be functionally suitable under all operational environments encountered. Test procedures shall be selected in accordance with MIL-E-16400 except as otherwise specified herein. The procedures may be modified or new procedures proposed for approval by the procuring agency when MIL-E-16400 provisions are considered inadequate. The practicability of a test shall be considered with respect to weight, shape and volume of the test item and the characteristics of the test facilities. Test procedures shall be revised as required by negotiation with the procuring agency. Environmental problem areas requiring research and development effort shall be indicated. The design alone does not qualify the product from an environmental standpoint. Specifications MIL-R-22732 and MIL-Q-9858 shall not be construed as negating tests specified in MIL-E-16400.

4.3.2 Operational demonstration tests - CFE antennas shall be observed both during and after a submarine shakedown cruise requiring submergence plus other demonstrations prescribed by the procuring activity involving function, reliability and maintainability. Antenna installation acceptability shall be subject to the approval of the authorized government inspector as far as contractor demonstration tests are concerned.

4.4 Electromagnetic performance tests - The procuring agency shall arrange for submarine system tests to determine the performance of contractor-installed or located antennas. Such tests shall consist of either of the following or a combination of the two.

4.4.1 Predeparture or shipyard - Predeparture tests shall consist of an investigation of all factors pertinent to operation of a submarine antenna system, including maintenance operations and excluding such tests as could only be performed under cruise conditions. The results of such tests should include resistance and reactance data insofar as practical, voltage standing wave ratio data when not previously known, and radiation patterns taken under restricted circumstance. Detailed requirements for predeparture tests shall be as specified by the procuring activity for the particular antenna, or type or class of antennas.

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4.4.2 Shakedown cruise tests - These shall consist of those tests specified for demonstrating satisfactory operations of antenna systems and associated electronic equipments. Data shall be obtained such as radiation patterns, bearing accuracy curves, distance of operation, noise and interference measurements, impedance and VSWR measurements, operations at snorkel depth, etc. Electronic equipment test specifications specify in detail the operating tests of each equipment. Assuming all else proves satisfactory, such tests can be used to determine antenna performance capabilities. However, cruise tests are conducted at much too late a date to obtain preproduction assurance of satisfactory antenna system performance; thus their results will best serve to corroborate predeparture test results. When not otherwise specified by the procuring activity, cruise test procedures shall be as proposed by the contractor, subject to the approval of the procuring activity.

4.5 Test procedures - The procedures and methods for conducting all necessary tests, when not specified by the procuring activity, shall be prepared by the contractor and sent to the procuring activity for approval as required in 3.3.2(c).

4.6 Rejection and retest - Rejected antenna design, location or installations shall not be resubmitted for inspection or approval without furnishing full particulars concerning previous rejection and measures taken to overcome the defects.

4.7 Workmanship - Manufactured parts shall be of high quality workmanship, free of burrs, flaws and blemishes. Castings shall be dense, homogeneous and free of voids or inclusions. Emphasis shall be placed on proper design and machining of O-ring grooves and surfaces in accordance with Navships 93793 and Specification MIL-P-5514. Assembly of component parts shall be such that all parts will work freely without scraping or binding and replacement parts shall be readily interchangeable. Workmanship shall reflect first class skill levels in all of the requisite production technologies. The Submarine Antenna Quality Assurance Facility, reference 4.1, will define and demonstrate where necessary, acceptable standards of workmanship.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, packing and marking - Shall conform to applicable provisions of MIL-E-17555. For major equipments covered by service manuals, assembly instructions or other printed material, at least two copies shall be prepared for each equipment shipped in accordance with MIL-M-15071. When it is ascertained that repair parts are being delivered for storage as spares aboard a submarine the provisions of MIL-STD-758 shall apply. All O-rings shall be packaged separately in sealed paper envelopes stamped with date of cure. O-rings older than 24 months are not acceptable for shipment.

6. NOTES

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6.1 Intended Use - The equipment is designed for use aboard submarines to carry out specific naval missions and is part of the communications, electronic warfare, or navigation sub-systems of the submarine weapon.

6.2 Precedence – When any of the requirements of the submarine contract, the submarine contract specifications, General Communications System Specifications pertinent to submarine operations, the equipment installation and test specification, this specification, or applicable subsidiary specifications are in conflict, the procuring agency shall be notified, and the following order of precedence will apply unless otherwise directed:

(a) The submarine contract

(b) The submarine contract specification

(c) General communications system specifications as these pertain to submarines

(d) Equipment installation and test specifications directly applicable to this contract

(e) This specification

(f) Subsidiary specifications

6.3 Technical data to be furnished by procuring agency - The procuring agency will make available the following technical data:

(a) Procurement specification reference 3.3.1 and 3.3.2

(b) This specification including all specifications, standards and NAVSHIPS publications cited in 2.1

(c) Pertinent ship, type and class plans on loan

(d) Current BuShips instructions and NavShips publications pertaining to installation and inspection standards of submarine antenna systems

(e) Technical manual for a comparable end item, on loan.

(f) Best obtainable failure rate data including NAVShips 93820 and MIL-HDBK-217 on loan

(g) Prior to design release for fabrication of prototype:

(1) Formal acceptance of Quality Assurance Plan with particular emphasis applied to reliability assurance analysis

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(2) Formal acceptance of preliminary design drawings.

(3) Formal acceptance of shock design analysis or further requirements for full scale testing.

(4) Formal acceptance of Test Plan with indication of availability of government test facilities either as proposed by the manufacturer or required by the procuring agency. Submarine tests will be scheduled where feasible.

6.4 Deviations - This specification is not intended to preclude techniques, processes, designs, materials and methods of design and installation which will lead to improvement of submarine antenna systems. The contractor's proposal shall cite specifications deemed to have marginal value from a standpoint of misapplication, over or under-specification, obsolescence, conflicts, improper referencing, etc., so that a review may be achieved during negotiation. Subsequent to contract award the contractor shall request the approval of the procuring activity to make any deviations from this specification or from subsidiary specifications where applicable. Deviations are not approved unless specific written authority to deviate is received from the procuring activity.

Preparing activity:
Navy - Ships
(Project 5985-N123Sh)

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SPECIFICATION ANALYSIS SHEET

Form Approved Budget Bureau No. 119-R004

INSTRUCTIONS

This sheet is to be filled out by personnel either Government or contractor involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity.

SPECIFICATION

ORGANIZATION	CITY AND STATE

CONTRACT NO.	QUANTITY OF ITEMS PROCURED	DOLLAR AMOUNT
		$

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A GIVE PARAGRAPH NUMBER AND WORDING

B RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2 COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

☐ YES ☐ NO IF "YES", IN WHAT WAY?

4 REMARKS *(Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)*

SUBMITTED BY *(Printed or typed name and activity)*	DATE

DD FORM 1 APR 63 1426 REPLACES NAVSHIPS FORM 4863, WHICH IS OBSOLETE

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