MIL-E-16400G(NAVY)
24 December 1974
SUPERSEDING
MIL-E-16400F(NAVY)
24 February 1966
(See 6.4 and 6.5)

MILITARY SPECIFICATION

ELECTRONIC, INTERIOR COMMUNICATION AND NAVIGATION EQUIPMENT,

NAVAL SHIP AND SHORE:

GENERAL SPECIFICATION FOR

This specification is approved for use by all interested Commands of the Department of the Navy and the Marine Corps and is available for use by all other Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 This specification covers the general requirements applicable to the design and construction of electronic, interior communication and navigation equipment intended for Naval ship or shore applications. This specification defines the environmental conditions within which equipment must operate satisfactorily and reliably; the process for selection and application of general material and parts; and the means by which equipment as a whole will be tested to determine whether it is acceptable to the Navy. Requirements for individual equipments shall be as specified in the individual equipment specification (see 6.2.1). Unless otherwise specifically stated in the individual equipment specification, the requirements of this specification and any and all specifications cited therein shall apply when this specification is invoked.

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

FEDERAL

QQ-A-591 - Aluminum Alloy Die Castings.
QQ-A-596 - Aluminum Alloy Permanent and Semi-permanent Mold Castings.
QQ-A-601 - Aluminum Alloy Sand Castings.
QQ-B-654 - Brazing Alloy, Silver.
QQ-C-320 - Chromium Plating (Electrodeposited).
QQ-N-290 - Nickel Plating (Electrodeposited).
QQ-P-416 - Plating, Cadmium (Electrodeposited).
QQ-S-365 - Silver Plating, Electrodeposited, General Requirements For.
QQ-Z-325 - Zinc Coating, Electrodeposited, Requirements For.
TT-C-490 - Cleaning Methods And Pretreatment Of Ferrous Surfaces For Organic Coatings.
TT-P-664 - Primer, Coating Synthetic, Rust-Inhibiting, Lacquer-Resisting.
TT-P-1757 - Primer Coating, Zinc Chromate, Low Moisture Sensitivity.

MILITARY

MIL-E-1 - Electron Tubes, General Specification For.
MIL-T-27 - Transformers and Inductors (Audio, Power, and High-Power Pulse), General Specification for.
MIL-I-631 - Insulation, Electrical, Synthetic-resin Composition, Nonrigid.
MIL-P-642/1 - Plugs, Telephone (Types PJ-047B and PJ-047R) and Accessory Screws.
MIL-P-642/2 - Plugs, Telephone, (Types PJ-051B and PJ-051R) and Accessory Screws.
MIL-P-642/4 - Plugs, Telephone (Types PJ-055B, PJ-055R and PJ-055M) and Accessory Screws.
MIL-P-642/5 - Plugs, Telephone (Type PJ-068) and Accessory Screws.
MIL-B-857 - Bolts, Nuts And Studs.
MIL-S-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment And Systems Requirements for.

MILITARY (con.)

MIL-C-915 - Cable and Cord, Electrical, For Shipboard Use General Specification for.
MIL-T-981 - Transformer, Power, Voltage Regulating.
MIL-R-2765 - Rubber Sheet, Strip Extruded And Molded Shapes, Synthetic, Oil Resistant.
MIL-M-3171 - Magnesium Alloy, Processes For Pretreatment And Prevention of Corrosion on.
MIL-G-3787 - Glass, Laminated, Flat; (Except Aircraft).
MIL-C-3849 - Cord, Electrical (Tinsel)
MIL-G-5514 - Gland Design Packings, Hydraulic, General Requirements for.
MIL-P-5516 - Packing, Preformed, Petroleum Hydraulic Fluid Resistant, 160°F.
MIL-C-5541 - Chemical Conversion Coatings on Aluminum And Aluminum Alloys.
MIL-P-7788 - Panels, Information, Integrally Illuminated.
MIL-T-7928 - Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specifications for.
MIL-A-8625 - Anodic Coatings, for Aluminum And Aluminum Alloys.
MIL-S-8660 - Silicone Compound.
MIL-Q-9858 - Quality Program Requirements.
MIL-T-10727 - Tin Plating, Electrodeposited or Hot-dipped, for Ferrous and Non-Ferrous Metals.
MIL-C-11693 - Capacitors, Feed Through, Radio Interference Reduction, AC And DC. (Hermetically Sealed In Metallic Cases.) Established and Non-Established Reliability, General Specification for.
MIL-R-12934 - Resistor, Variable, Wirewound, Precision General Specification for.
MIL-C-14550 - Copper Plating (Electrodeposited).
MIL-P-15024 - Plates, Tags and Bands for Identification of Equipment.
MIL-P-15024/5 - Plates, Identification.
MIL-E-15090 - Enamel, Equipment, Light-Gray (Formula No. 111).
MIL-P-15328 - Primer (Wash), Pretreatment, Blue (Formula No. 117-B For Metals).
MIL-C-15370 - Couplers, Directional (Coaxial Line or Waveguide) General Specification for.
MIL-R-15624 - Rubber Gasket Material 50 Durometer Hardness (Maximum).
MIL-F-15733 - Filter, Radio Interference, General Specification for.
MIL-F-16552 - Filters, Air Environmental Control System Cleanable Impingement (High Velocity Type).
MIL-I-16923 - Insulating Compound, Electrical, Embedding.
MIL-M-17185 - Mounts, Resilient; General Specifications and Tests for (Shipboard Application).
MIL-M-17191 - Mount Resilient, Portsmouth Bonded Spool Type.
MIL-I-17214 - Indicator, Permeability; Low-Mu (Go-No Go).
MIL-M-17508 - Mounts, Resilient: Types 6E200, 6E900, 6E900BB, 7E450, 7E450BB, 6E150, and 6E100.
MIL-B-17931 - Bearings, Ball, Annular, for Quiet Operation.
MIL-F-18327 - Filters; High Pass, Low Pass, Band Pass, Band Suppression, and Dual Functioning, General Specification for.
MIL-C-18388 - Coils, Tube Deflection; and Coils, Tube Focusing.
MIL-M-19379 - Mounts, Resilient, Mare Island Types 11M15, 11M25, and 10M50.
MIL-S-19622 - Stuffing Tubes, (Nylon) General Specification.
MIL-M-19633 - Motor Generator, 60 Cycle, AC To 400 Cycle AC (Voltage and Frequency Regulated) Shipboard Service.
MIL-M-19863 - Mount, Resilient, Type 5B5000H.
MIL-C-19978 - Capacitors, Fixed, Plastic (Or Paper-Plastic) Dielectric (Hermetically Sealed in Metal, Ceramic, Or Glass Cases), Established and Non-Established Reliability, General Specification for.
MIL-A-21180 - Aluminum-Alloy Castings, High Strength.
MIL-W-21965 - Water Cooling of Shipboard Electronic Equipment, General Specification for.
MIL-E-21981 - Electronics Type Designations, Identification Plates and Markings, Requirements for.

MILITARY (con.)

MIL-C-22520 - Crimping Tool, Terminal, Hand, Wire Termination, General Specification for.
MIL-T-22910 - Tools, Crimping, Hand, for Crimp Style Electric Terminals And Shield Ferrules.
MIL-C-23183 - Capacitors, Fixed or Variable, Vacuum Dielectric, General Specification for.
MIL-P-24441 - Paint, Epoxy-Polyamide, General Specification For.
MIL-C-26074 - Coatings, Electroless Nickel, Requirements for.
MIL-F-28717 - Filter, Air, Viscous Impingement Type, Cleanable And Reusable, for Equipment Enclosures, and Impingement Oil General Specifications for.
MIL-C-28777 - Cable Assembly, Power, Electrical.
MIL-C-39001 - Capacitors, Fixed Mica Dielectric, Established Reliability, General Specification For.
MIL-C-39003 - Capacitors, Fixed, Electrolytic, Solid-Electrolyte, Tantalum Established Reliability, General Specification For.
MIL-C-39006 - Capacitor, Fixed, Electrolytic (Nonsolid Electrolyte) Tantalum, Established Reliability, General Specification For.
MIL-C-39018 - Capacitors, Fixed, Electroyltic (Aluminum Oxide), General Specification For.
MIL-T-43435 - Tape, Lacing and Tying.
MIL-G-45204 - Gold Plating, Electrodeposited.
MIL-C-45662 - Calibration System Requirements.
MIL-R-46085 - Rhodium Plating, Electrodeposited.
MIL-C-55514 - Capacitors, Fixed Plastic (Or Metalized Plastic) Dielectric DC In Nonmetal Cases, Established Reliability, General Specification For.
MIL-C-55543 - Cable, Electrical, Flat Multiconductor, Flexible, Unshielded.
MIL-C-55544 - Connectors, Electrical, Environmental Resistant, For Use With Flexible Flat Conductor Cable And Round Wire, General Specification For.
MIL-T-55619 - Tools, Crimping, For Coaxial, Radio Frequency, Connectors General Specification For.
MIL-C-81562 - Coating, Cadmium And Zinc (Mechanically Deposited).
MIL-P-81728 - Plating, Tin Lead (Electrodeposited).

STANDARDS

MILITARY

MIL-STD-108 - Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment.
MIL-STD-143 - Standards and Specifications Order of Precedence for the Selection of.
MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited).
MIL-STD-198 - Capacitors, Selection and Use of.
MIL-STD-242 - Electronic Equipment Parts (Selected Standards).
MIL-STD-275 - Printed Wiring for Electronic Equipment.
MIL-STD-415 - Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for.
MIL-STD-454 - Standard General Requirements For Electronic Equipment.
MIL-STD-461 - Electromagnetic Interference Characteristics, Requirements For Equipment.
MIL-STD-462 - Electromagnetic Interference Characteristics, Measurement Of.
MIL-STD-469 - Radar Engineering Design Requirements, Electromagnetic Compatability.
MIL-STD-740 - Airborne And Structureborne Noise Measurements And Acceptance Criteria Of Shipboard Equipment.
MIL-STD-749 - Preparation And Submission Of Data For Approval Of Nonstandard Parts.
MIL-STD-756 - Reliability Prediction.
MIL-STD-781 - Reliability Tests, Exponential Distribution.
MIL-STD-810 - Environmental Test Methods.

MILITARY (con.)

MIL-STD-882 - System Safety Program for Systems and Associated Subsystems and Equipment, Requirements for.
MIL-STD-1310 - Shipboard Bonding, Grounding And Other Techniques For Electromagnetic Compatibility And Safety.
MIL-STD-1326 - Test Points, Test Point Selection And Interface Requirements For Equipments Monitored By Shipboard On-Line Automatic Test Equipment.
MIL-STD-1364 - Standard General Purpose Electronic Test Equipment.
MIL-STD-1378 - Requirements For Employing Standard Hardware Program Modules.
MIL-STD-1399 - Interface Standard for Shipboard Systems.
Section 101 - Cooling Water for Support of Electronic Equipment.
Section 103 - Electric Power, Alternating Current.
Section 401 - DC Magnetic Field Environment.
MIL-STD-1472 - Human Engineering Design Criteria For Military Systems, Equipment And Facilities.
MIL-STD-1600 - Reliability Prediction of Monolithic Integrated Circuits.
MS-15571 - Lamps, Incandescent, T-3-1/4, Miniature Bayonet, Single Contact.

HANDBOOKS

MILITARY

MIL-HDBK-176 - Guidance for Flexible Flat Multiconductor Cable (Flat Conductors).
MIL-HDBK-217 - Reliability Prediction of Electronic Equipment.
MIL-HDBK-225 - Synchros Description and Operation.
MIL-HDBK-472 - Maintainability Prediction.

DRAWINGS

NAVAL SEA SYSTEMS COMMAND

NAVSHIPS

9000-S6504-73687 - Standard Dial Markings for Interior Communication Order and Indicating Systems.
9000-S6405-74222 - Glassware and Plasticware for Electrical Fixtures and Fittings (Sheet 103).

PUBLICATIONS

NAVAL SEA SYSTEMS COMMAND

NAVSHIPS

0518-093-2500 - Navy System Design Guidelines Manual (formerly NAVMAT P-3940).
0901-006-0000 - Design Data Manual.
0967-319-5010 - Handbook for the Prediction of Shipboard and Shore Electronic Equipment Reliability (formerly 93820).
0969-019-7000 - Electronic Test Equipment Application Guide (formerly 91727(A)).
0981-052-8140 - Electrical Equipment Small Stray Magnetic Field Manual for Design of (formerly 250-660-35).

NAVAL ELECTRONICS SYSTEMS COMMAND

0967-437-7010 - Reliability Design Handbook for Terminal Applications.

BULLETINS

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Report 880 - Guide for the Selection and Application or Resilient Mounts to Shipboard Equipment.

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

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

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
ASTM-A-153 - Iron And Steel Hardware, Zinc Coating (Hot Dip)
ASTM-B-209 - Aluminum-Alloy Sheet And Plate
ASTM-D-1868 - Method For Corona Measurement (Tentative)

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

U. S. COMMITTEE ON EXTENSION TO THE STANDARD ATMOSPHERE
U. S. Standard Atmosphere, 1962

(Application for copies should be addressed to the Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402.)

3. REQUIREMENTS

3.1 Definitions. The definition of terms used in this specification shall be in accordance with 6.3.

3.2 First article. Unless otherwise specified (see 6.2.1), first article(s) in the quantity specified (see 6.2) shall be furnished for first article inspection as specified in 4.2.1. The first article shall be completely representative of the production models.

3.3 Characteristics.

3.3.1 Performance characteristics. The equipment shall meet the performance requirements specified in the individual equipment specification (see 6.2.1) and the requirements specified herein.

3.3.1.1 Accelerated life. The equipment shall meet the performance parameters specified in the individual equipment specification when subjected to the accelerated life tests of 4.8.8.

3.3.2 Physical characteristics. The equipment shall meet all physical characteristics specified in the individual equipment specification (see 6.2.1) and the characteristics specified herein.

3.3.2.1 Weight. Equipment weight shall be within the limits specified in the individual equipment specification (see 6.2.1).

3.3.2.2 Size. Unless otherwise specified (see 6.2.1), the equipment size limitations shall be as specified herein.

3.3.2.2.1 Maximum height. Equipment intended for installation within internal shipboard spaces shall be not over 72 inches overall height, including resilient mounts when their use is permitted (see 3.7.4).

3.3.2.2.2 Surface ship installation. Equipment intended for installation within internal surface ship spaces shall be capable of passage through a doorway 26 inches wide by 45 inches high (reduced further by round corners on an 8-inch radius) and through a hatch 30 inches long by 30 inches wide (reduced further by round corners on a 7-1/2-inch radius).

3.3.2.2.3 Submarine installation. Equipment intended for installation within internal submarine spaces shall be capable of passage through a circular tube (submarine entrance hatch) 25 inches in diameter and through a doorway 20 inches wide by 38 inches high (reduced further by round corners on a 10-inch radius).

3.3.2.2.4 Shore installation. The maximum size limitations of equipment intended for shore installation shall be as specified in the individual equipment specification (see 6.2.1).

3.3.2.3 Modular construction. Unless otherwise specified (see 6.2.1), all equipment shall use modular construction. During the design and development phases, consideration shall be given to the use of the packaging techniques described in the Publication 0518-093-2500, and unless otherwise specified (see 6.2.1), the equipment modular construction shall conform to the standard hardware program module requirements of MIL-STD-1378. The selection of specific assembly design and packaging techniques shall reflect the reliability and maintainability requirements of the individual equipment specification.

3.3.2.4 Human engineering. Guidelines in applying human engineering design criteria and principles in the design of the equipment shall be in accordance with requirement 62 of MIL-STD-454.

3.3.3 Reliability. Reliability shall be in accordance with requirement 35 of MIL-STD-454, and as specified herein.

3.3.3.1 Reliability requirement. The quantitative reliability requirements expressed in mean-time-between-failures (MTBF), mean-cycle-between-failures (MCBF), or others, shall be as specified in the individual equipment specification (see 6.2.1).

3.3.3.2 Reliability prediction. Unless otherwise specified (see 6.2.1), a reliability prediction shall be performed in accordance with the procedure of type II of MIL-STD-756. MIL-HDBK-217 shall be used as the basic data source, supplemented where necessary by MIL-STD-1600 and Publication 0967-319-5010. The prediction shall be based on a detailed thermal/electrical/mechanical stress analysis of each part and shall reflect the part derating requirement of 3.4.6. Reliability prediction report shall be as specified (see 6.2.2).

3.3.3.3 Failure modes, effects and criticality analyses (FME&CA). Failure modes, effects and criticality analyses shall be as specified (see 6.2.2).

3.3.4 Maintainability. Maintainability shall be in accordance with requirement 54 of MIL-STD-454 and as specified herein.

3.3.4.1 Maintainability requirement. The maintainability requirement, expressed as the mean-time-to-repair (MTTR), equipment repair time (ERT), or other, shall be as specified in the individual equipment specification (see 6.2.1).

3.3.4.2 Maintainability prediction. Unless otherwise specified (see 6.2.1), a maintainability prediction shall be performed in accordance with procedure II, part A of MIL-HDBK-472. Maintainability prediction report shall be as specified in the CDRL (see 6.2.2).

3.3.5 Environmental service conditions. The equipment, or portions therof to be utilized in sheltered or exposed areas (weather, gunblast, external sea pressure, or other) as specified in the individual equipment specification (see 6.2.1), shall be capable of continuous reliable operation, within the performance limits specified in the individual equipment specification, under the environmental conditions specified herein. The equipment shall operate within tolerances throughout the tests specified, without alinement or adjustment, other than accessible controls normally employed for operation of the equipment.

3.3.5.1 Operating temperature ranges.

3.3.5.1.1 Equipments exposed to weather (unsheltered). The equipment, or portions thereof, exposed to the weather (unsheltered) shall maintain specified performance when exposed to the high and low operating temperatures shown in table I for temperature range I and II, as specified in the individual equipment specification (see 6.2.1).

3.3.5.1.2 Equipment utilized in a sheltered area. The equipment, or portions thereof, to be utilized in a sheltered area shall maintain specified performance when exposed to the high and low operating temperatures shown in table I, for temperature range 3 or 4, as specified in the individual equipment specification (see 6.2.1).

3.3.5.2 Non-operating temperature ranges. Unless otherwise specified (see 6.2.1), the equipment shall not be damaged nor shall operational performance be degraded when restored to the operating temperature range after being subjected to the non-operating temperature range listed in table I.

Table I - Temperature ranges (ambient).

Range	Environmental condition	Operating	Nonoperating
		°C	°C
1	Exposed-unsheltered (ship or shore)	-54 to +65	-62 to +71
2	Exposed-unsheltered (ship)	-28 to +65	-62 to +71
3	Sheltered non-controlled environment (shore)	-40 to +52	-62 to +71
4	Sheltered controlled environment (ship or shore)	-0 to +50	-62 to +71

3.3.5.3 Humidity. The equipment shall maintain the specified performance when exposed to a relative humidity of 95 percent for both continuous and intermittent periods, including conditions wherein condensation takes place in and on the equipment in the form of both water and frost.

3.3.5.4 Salt fog (spray). When specified in the individual equipment specification (see 6.2.1), the complete equipment or portions thereof as specified shall be capable of withstanding the effects of the salt fog test specified herein. After completion of the test and cleaning, the base metal of the part or structure shall not be visible through the finish or coating, nor shall there be any evidence of blistering, softening, separation from the base metal, corrosion products, or other coating failure.

3.3.5.4.1 Exposed equipment. The equipment, or portions thereof, exposed to the weather shall maintain the specified performance after completion of the salt fog test of 4.8.3.5.1.

3.3.5.4.2 Sheltered equipment. Parts and structures of equipment to be utilized in a sheltered area shall be subjected to the salt fog test of 4.8.3.5.2.

3.3.5.5 Sunshine. The equipment, or portions thereof, exposed to the weather shall maintain the specified performance after the sunshine test of 4.8.3.6.

3.3.5.6 Fungus. The equipment shall be resistant to fungi in both the operating and nonoperating condition and shall not be adversely affected when tested in accordance with 4.8.3.7.

3.3.5.7 Wind velocity. The equipment, or portions thereof, exposed to the weather shall opperate normally in winds having a relative velocity of 75 knots and shall be capable of withstanding, without damage, winds having a relative velocity as great as 100 knots.

3.3.5.8 Icing. The equipment, or portions thereof, exposed to the weather shall be capable of withstanding an ice load of 4.5 pounds per square foot (lb/ft^2) of exposed surface without structural damage. Moving junctions shall be housed or provided with heating elements to allow essential motion when subjected to icing conditions.

3.3.5.9 Hydrostatic pressure. Any part, accessory, gasket, material or structural member of the equipment specified in the individual equipment specification as exposed to external sea pressure, shall be capable of withstanding the specified hydrostatic pressure (see 6.2.1) without physical or electrical damage, and without causing leakage into the pressure hull.

3.3.5.10 Underwater explosion. When specified in the individual equipment specification (see 6.2.1), the equipment, or portions thereof, which is exposed to external sea pressure and which may be exposed to an underwater explosion shall be capable of withstanding the test of 4.8.3.11 without mechanical or electrical damage which would cause equipment malfunction or nonoperation.

3.3.5.11 Gunblast. When specified in the individual equipment specification (see 6.2.1), the equipment, or portions thereof, which may be directly exposed to gunblast shall be capable of withstanding a peak shock and air blast pressure front of 9.5 pounds per square inch gage (lb/in^2g) when tested in accordance with 4.8.3.12.

3.3.5.12 Nuclear air blast. When specified in the individual equipment specification (see 6.2.1), the equipment, or portions thereof, exposed to the weather shall be capable of withstanding the nuclear air blast pressure environment without significant impairment which would cause equipment malfunction or nonoperation after the pressure wave has passed. The values for the peak overpressure, the peak dynamic pressure and the positive phase durations of figure 1 and the method of verification by calculations or the blast tests of 4.8.3.13 shall be as specified in the individual equipment specification (see 6.2.1).

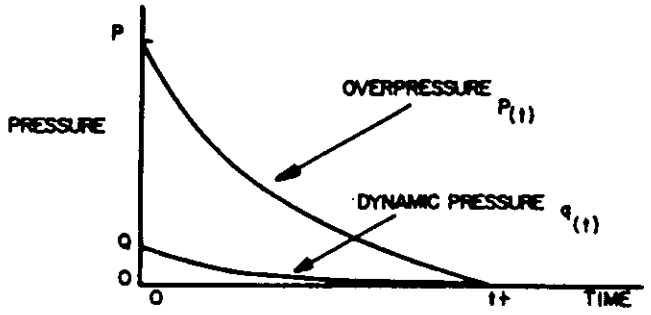


Figure 1 - Free field air blast pressures.

$$\text{at } t = O,\ p_{(t)} = P,\ q_{(t)} = Q$$

$$\text{for } t^+ > t > O,\ p_{(t)} = P\left(1 - \frac{t}{t^+}\right) e^{-\frac{t}{t^+}}$$

$$q_{(t)} = Q\left(1 - \frac{t}{t^+}\right)^2 - \frac{2t}{t^+} e$$

Where:

$p_{(t)}$ and $q_{(t)}$ are the pressures at any time (t) after arrival of shock front

P = Peak overpressure lb/in^2

Q = Peak dynamic pressure lb/in^2

t^+ = Duration of positive phase second(s)

NOTE: The overpressure and dynamic pressure both rise from zero to peak value at time zero (t = o)

Figure 1 - Free field air blast pressure.

3.3.5.12.1 Nuclear air blast calculations. Calculations demonstrating the resistance to the specified nuclear air blast requirements shall be prepared as specified (see 6.2.2).

3.3.5.13 Shock. Unless otherwise specified (see 6.2.1), shipboard equipment shall be capable of withstanding the grade A, type A, class I, shock test of MIL-S-901.

3.3.5.14 Vibration. Unless otherwise specified (see 6.2.1), shipboard equipment shall be capable of withstanding the type I vibration test of MIL-STD-167-1.

3.3.5.15 Inclination. Unless otherwise specified (see 6.2.1), shipboard equipment shall be capable of withstanding the inclination test of 4.8.3.16. Inclination angle shall be 45 or 60 degrees as specified in the individual equipment specification (see 6.2.1).

3.3.5.16 Magnetic field environment. The equipment shall be compatible with the magnetic field environment interface constraints of section 401 of MIL-STD-1399.

3.4 Parts, materials and processes. Parts, materials and processes selected in accordance with 3.4.1 shall not relieve the contractor of the responsibility for complying with all equipment performance and other requirements set forth herein and in the individual equipment specification.

3.4.1 Selection. The following documents, in this order of precedence, shall be used in the selection of parts, materials and processes for equipment procured in accordance with this specification:

(a) MIL-STD-242
(b) Other standards, specifications, and requirements specified herein, but not included in MIL-STD-242.
(c) MIL-STD-143

When (a) or (b) fails to provide an applicable specification, standard, or requirement, the contractor shall use other specifications and standards in the order of precedence set forth in MIL-STD-143. All parts and materials, except as covered in (a) and (b), will require written approval of the command or agency concerned in accordance with 3.4.3. Approval will not be granted for parts of special or novel design where parts specified herein can be used and are available.

3.4.2 Standard parts. Standard parts are those parts specified in:

(a) MIL-STD-242
(b) Other standards, specifications and requirements listed herein (where no selected standard has been established in MIL-STD-242 for that standard, specification or requirement).

3.4.3 Approval of non-standard parts. The approval for use of non-standard parts shall be in accordance with requirement 22 of MIL-STD-454. The preparation and submission of data for approval of non-standard parts shall be in accordance with MIL-STD-749 as specified (see 6.2.2).

3.4.4 Used or damaged parts or materials. Used or damaged parts or materials shall not be used in equipment to be delivered to the Navy.

3.4.5 Choice of parts and materials. The contractor shall select and use items having the broadest characteristics and of the greatest allowable tolerances that will fulfill the performance requirements of the equipment. Equipment performance shall not be dependent on the selection of special values for individual parts.

3.4.6 Derating. Derating of electronic parts and materials shall be accomplished in accordance with requirement 18 of MIL-STD-454.

3.4.7 Interchangeability. Interchangeability shall conform to requirement 7 of MIL-STD-454.

3.4.8 Parts.

3.4.8.1 Batteries. Unless otherwise specified (see 6.2.1), batteries shall not be used. When specified, batteries shall conform to requirement 27 of MIL-STD-454.

3.4.8.2 Bearings. The selection and application of bearings shall conform to requirement 6 of MIL-STD-454, and as specified herein.

3.4.8.2.1 Bearing, sleeve-type. Unless otherwise specified (see 6.2.1), sleeve-type bearings shall not be used.

3.4.8.2.2 Bearings, noise tested. Unless otherwise specified (see 6.2.1), noise tested bearings, for quiet operation, shall conform to MIL-B-17931.

3.4.8.3 Blowers and fans. Whenever thermal design of equipment requires the use of blowers or fans, they shall be selected from those listed in MIL-STD-242. The size of the blowers or fans selected shall be such that while meeting the noise level requirements of the equipment, they will overcome the differential pressure drop of the equipment, and deliver the quantity of air necessary to meet the cooling requirements of the equipment.

3.4.8.4 Cable, interconnecting. Coaxial cable, multiconductor cable and portable power and control cable used to interconnect separately mounted enclosures of the equipment and the equipment with shipboard support systems shall be selected from MIL-STD-242.

3.4.8.4.1 Cable, assemblies, power. When necessary to meet the safety ground requirements of 3.10.11.2, power cable assemblies shall be in accordance with MIL-C-28777.

3.4.8.5 Cable, coaxial (RF). Coaxial radio frequency (RF) cable shall be selected in accordance with MIL-STD-242.

3.4.8.6 Cable, electrical.

3.4.8.6.1 Cable and cords, electrical. Cables and cords for watertight or non-watertight, flexing and non-flexing service shall be selected from MIL-C-915.

3.4.8.6.2 Cable, electrical, flat multiconductor. Where required to meet minimum equipment size, weight and, space saving, consistent with service requirements, flat multiconductor cable shall be selected from MIL-C-55543. MIL-HDBK-176 provides guidance in the use and application of flat multiconductor cable.

3.4.8.7 Capacitors. Capacitors shall be selected in accordance with MIL-STD-242, and as specified herein.

3.4.8.7.1 Capacitors, fixed, dry electrolytic (aluminum foil). The use of fixed, dry, electrolytic (aluminum foil) capacitors shall be restricted to power filter applications, and only where the application meets the following criteria:

(a) Capacitance values above those listed in MIL-C-19978.
(b) Capacitance values and associated voltage values above those listed in MIL-C-39003 or MIL-C-39006.

When the capacitor application meets the criteria indicated in (a) and (b), fixed, dry, electrolytic capacitors (aluminum foil) conforming to MIL-C-39018 shall be used. These capacitors shall be used only in applications where the equipment internal operating temperature will not exceed the limits specified in the applicable capacitor specification.

3.4.8.7.2 Capacitors, fixed, paper or paper-plastic (non-metallic case). Unless otherwise specified (see 6.2.1), paper or paper-plastic fixed capacitors with non-metallic cases shall not be used, except that non-metallic plastic wrapped capacitors may be used in encapsulated or hermetically sealed assemblies. The plastic wrapped capacitors shall conform to MIL-C-55514.

3.4.8.7.3 Mica-dielectric capacitors. Mica-dielectric capacitors (molded cases, molded case potted, and ceramic case potted) shall be in accordance with MIL-C-39001. The capacitors shall be used in applications where the frequency range does not exceed the limits specified in the applicable detail specification sheet for MIL-C-39001. The current rating shall not exceed the limit for the respective frequency, as listed in the applicable detail specification sheet. All fixed mica-dielectric capacitors which are to carry RF currents in excess of those listed in MIL-C-39001, or are to be used in applications where the frequency range is outside that listed in MIL-C-39001, shall be considered as a non-standard part.

3.4.8.7.4 Capacitors, fixed, paper dielectric. Fixed paper dielectric capacitors shall not be used except as permitted by 3.4.8.7.5.

3.4.8.7.5 Capacitors, radio interference. Feed-through radio interference capacitors shall conform to MIL-C-11693.

3.4.8.7.6 Capacitors, variable, air-dielectric. Air-dielectric variable capacitors shall conform to requirement 2 of MIL-STD-454.

3.4.8.7.7 Capacitors, vacuum and gas dielectric. Vacuum and gas dielectric capacitors shall be selected from those listed in MIL-STD-242. When a vacuum or gas dielectric capacitor is required which is not listed in MIL-STD-242, the non-standard capacitor shall be selected from those types listed on specification sheets associated with MIL-C-23183. When a vacuum or gas dielectric capacitor is required which is not listed in either MIL-STD-242 or the specification sheets associated with MIL-C-23183, complete information on the non-standard capacitor, using the format of the specification sheets as a guide, shall be submitted to the command or agency concerned for approval in accordance with 3.4.3. All non-standard vacuum or gas dielectric capacitors shall be subjected to first article inspection which shall consist of all tests listed under qualification in MIL-C-23183.

3.4.8.8 Circuit breakers. The application of circuit breakers shall conform to requirement 37 of MIL-STD-454 and the selection shall be from MIL-STD-242.

3.4.8.9 Clamps and straps, cable. Cable clamps and adjustable cable straps shall be used only for internal identification and tie down applications and shall be selected from MIL-STD-242.

3.4.8.10 Connector, electrical and radio frequency. Electrical and radio frequency connectors shall conform to the requirements specified herein and shall meet the performance and environmental requirements specified for the equipment.

3.4.8.10.1 Connectors, internal. All multi-contact connector receptacles and plugs used internally to the equipment shall be selected from MIL-STD-242.

3.4.8.10.1.1 Connectors, flat multiconductor cable. Where required to meet minimum equipment size, weight, and space saving, connectors for flat multiconductor cable shall be selected from MIL-C-55544. MIL-HDBK-176 provides guidance in the use and application of connectors for flexible flat multiconductor cable.

3.4.8.10.2 Connector receptacles, interconnection. All connector receptacles used for interconnection of separately mounted enclosures of the equipment and the equipment with shipboard support systems shall be selected from MIL-STD-242. Connector receptacles which continue to be energized after unmating shall have socket type contacts.

3.4.8.10.3 Connector plugs, mating. Mating connector plugs shall be furnished with all inter-connection radio frequency and multi-contact connector receptacles. The mating connector plug shall be compatible with the specified interconnecting cables required by 3.4.8.4 without modification to either the connector plug or the cable and without the use of special adapters. The cable conductor size and connector contact size shall be compatible. Multi-contact connector plugs used on jacketed cables shall be selected from MIL-STD-242. Connector plugs which continue to be energized after unmating shall have socket type contacts.

3.4.8.10.4 Connectors, radio frequency. Radio frequency coaxial connectors shall be selected from MIL-STD-242. All connectors shall be compatible with the specified cables required by 3.4.8.5 without modification to either the connector or the cable and without the use of special adapters.

3.4.8.10.5 Extra contacts and conductors. The extra unused connector contacts as specified in requirement 10 of MIL-STD-454 shall be located on the periphery (outer contacts) of the connector. Extra unused interconnecting cable conductors shall be provided and shall terminate in the unused connector contacts.

3.4.8.10.6 Connectors, crimped type. Unless otherwise specified (see 6.2.1), all crimped type connectors used internal or external to the equipment, which require special crimping tools to assemble, shall be directly replaceable by an equivalent soldered type or by a crimped type connector whose contacts can be crimped by a tool conforming to MIL-C-22520, MIL-T-22910, or MIL-T-55619.

3.4.8.10.7 Improper application prevention. Multi-contact connectors shall be keyed, polarized, or so arranged in a distinctive configuration which will prevent improper connection, positioning or mating.

3.4.8.10.8 Plugs, banana. Banana plugs shall not be used.

3.4.8.10.9 Plugs, telephone. Telephone plugs shall be selected from MIL-STD-242. Plugs used for switchboard and patch panel applications shall conform to part number M642/1-1 of MIL-P-642/1. Plugs for microphone application shall conform to part number M642/5-1 of MIL-P-642/5. Other three-conductor applications shall use plugs conforming to part number M642/2-2 of MIL-P-642/2 and plugs for two-conductor applications shall conform to part number M642/4-1 of MIL-P-642/4.

3.4.8.11 Cordage, tinsel. Unless otherwise specified (see 6.2.1), tinsel cordage shall conform to MIL-C-3849.

3.4.8.12 Couplers, directional (coaxial and waveguide). Directional couplers shall conform to MIL-C-15370.

3.4.8.13 Fastener hardware. The selection and use of fastener hardware shall confrom to requirement 12 of MIL-STD-454 and as specified herein.

3.4.8.13.1 Fastener hardware selection. The selection of fastener hardware shall be of a type, style, and material which will meet the requirements of the equipment for environmental service conditions, the degree of enclosure, physical and mechanical structural requirements, and the maintenance concept for accessibility and frequency of use.

3.4.8.14 Filters, air. Air filters for air conditioning and ventilating systems of equipment shall be of the cleanable type and mounted so as to be capable of being readily examined and replaced from the outside of the equipment, when the equipment is normally installed.

3.4.8.14.1 Filters, air, high velocity. For air velocities 400 feet per minute (ft/min) and over, the filters shall conform to MIL-F-16552.

3.4.8.14.2 Filters, air, low velocity. For air velocities below 400 ft/min, filters shall conform to MIL-F-28717.

3.4.8.15 Filters, high pass, low pass, band pass, band suppression, and dual functioning. High pass, low pass, band pass, band suppression, and dual functioning filters shall conform to MIL-F-18327.

3.4.8.16 Filters, radio interference. When necessary to meet EMI requirements of MIL-STD-461, primary power line filters shall conform to the readily removable type in accordance with MIL-F-15733.

3.4.8.17 Fuses and fuseholders. Unless otherwise specified (see 6.2.1), the application of fuses and fuseholders shall conform to requirement 39 of MIL-STD-454 and shall be selected from MIL-STD-242.

3.4.8.18 Indicators and associated items. Indicators and associated items shall be selected from MIL-STD-242 and shall conform to the requirements of MIL-STD-1472. Legend lights shall be used in preference to simple indicator lights, except where design considerations demand that simple indicator lights be used. Indicator lights shall conform to requirement 50 of MIL-STD-454.

3.4.8.19 Meters, electrical indicating and accessories. Electrical indicating meters and accessories shall be selected from MIL-STD-242 and shall conform to requirement 51 of MIL-STD-454 and MIL-STD-1472.

3.4.8.19.1 Meter adjustment. All panel indicating meters shall have external zero adjusters.

3.4.8.20 Micro electronic devices. The selection and application of microelectronic devices shall conform to requirement 64 of MIL-STD-454.

3.4.8.21 Motors, dynamotors, rotary power converters, and motor-generators. Motors, dynamotors, rotary power converters, and motor-generators shall be selected in accordance with requirement 46 of MIL-STD-454 and shall be marked in a permanent manner to show direction of rotation where applicable to the function of the equipment. The use of motor-generators conforming to MIL-M-19633 shall be limited to cases where voltage and frequency regulation is required.

3.4.8.22 Quartz crystal units. The selection and application of quartz crystal units shall conform to requirement 38 of MIL-STD-454.

3.4.8.23 Relays. Relays shall conform to requirement 57 of MIL-STD-454, and shall be selected from those listed in MIL-STD-242. Relays shall not be used for switching currents in excess of 10 amperes.

3.4.8.24 Resilient mounts. When the use of resilient mounts is permitted (see 3.7.4), they shall conform to MIL-M-17191, MIL-M-17508, MIL-M-19379, or MIL-M-19863, as applicable. Other resilient mountings, if required, shall be tested and approved in accordance with MIL-M-17185 prior to use.

3.4.8.25 Resistors, variable, wire-wound precision. Variable wire-wound precision resistors shall be selected from those listed in MIL-STD-242. When a resistor is required which is not listed in MIL-STD-242, the non-standard resistor shall be selected from those types listed on specification sheets in accordance with MIL-R-12934. When a resistor is required which is not listed in either MIL-STD-242 or the specification sheets in accordance with MIL-R-12934, complete information on the non-standard resistor using the format of the specification sheets as a guide shall be submitted to the command or agency concerned for approval, in accordance with 3.4.3. All non-standard resistors shall be subject to first article testing of MIL-R-12934.

3.4.8.26 Rotary servo devices (servomotors, synchros, resolvers, tachometer generators, transolvers and encoders.) Unless otherwise specified (see 6.2.1), the selection and application of servomotors, synchros, resolvers, tachometer generators, transolvers, and encoders shall conform to requirement 56 of MIL-STD-454.

3.4.8.27 Semiconductor devices. The selection and application of semiconductor devices shall conform to requirement 30 of MIL-STD-454.

3.4.8.28 Sockets, shields, and clamps. Sockets, shields and clamps for plug-in electronic parts shall conform to requirement 60 of MIL-STD-454 and as specified herein.

3.4.8.28.1 Tube shields. All tube shields, except for cathode ray tubes, shall be of non-magnetic material. Heat-dissipating shields shall be used on all miniature and sub-miniature tubes.

3.4.8.29 Shunts. External meter shunts shall conform to requirement 40 of MIL-STD-454.

3.4.8.30 Switches and associated hardware. Switches and associated hardware shall conform to requirement 58 of MIL-STD-454 and shall be selected from those listed in MIL-STD-242.

3.4.8.31 Terminals (terminal boards and strips, binding posts and lugs). Terminals, terminal boards and strips, binding posts, and lugs shall be selected from MIL-STD-242 and shall conform to requirement 19 of MIL-STD-454, and as specified herein.

3.4.8.31.1 Terminals, spare. Terminal boards and strips used in interconnecting assemblies shall have 10 percent extra unused terminals but in no case less than two.

3.4.8.31.2 Terminal lugs. Terminal lugs for fitting to ship's cable shall not be provided by the equipment manufacturer.

3.4.8.32 Transformers, inductors and coils. Transformers, inductors, and coils shall conform to requirement 14 of MIL-STD-454 and as specified herein.

3.4.8.32.1 Transformers and inductors, grade, and class. When grade 4 (of MIL-T-27) transformers and inductors are used in equipment operating at an internal operating temperature 65°C, or higher, potting or liquid fillings are prohibited. Class S of MIL-T-27 (or any other class conforming to MIL-T-27, with a maximum operating temperature greater than 130°C, selected from requirement 14 of MIL-STD-454) shall be used when equipment is required to operate at an internal operating temperature of 65°C, or higher.

3.4.8.32.2 Electrostatic shield. All power and audio input transformers shall have grounded electrostatic shields.

3.4.8.32.3 Power transformers, automatic voltage regulating. Automatic voltage regulating power transformers shall conform to MIL-T-981.

3.4.8.32.4 Coils, radio frequency. Radio frequency coils shall be selected from MIL-STD-242.

3.4.8.32.5 Coils, tube deflection and tube focusing. Tube deflection and tube focusing coils shall conform to MIL-C-18388.

3.4.8.33 Tubes, electron. Electron tubes shall conform to requirement 29 of MIL-STD-454.

3.4.8.34 Tubes, stuffing. Stuffing tubes shall be of the nylon type and shall conform to MIL-S-19622.

3.4.8.35 Transmission lines and related RF parts. Transmission lines and related RF parts shall be as specified herein.

3.4.8.35.1 Waveguide. Waveguide and flanges shall be selected from MIL-STD-242.

3.4.8.35.2 Rigid coaxial, lines, and flanges. Rigid coaxial lines and flanges shall be selected from MIL-STD-242.

3.4.8.35.3 Related RF parts. Related RF parts for use with transmission lines shall be selected from MIL-STD-242.

3.4.8.36 Wire, hookup, internal. The selection and application of internal electrical hookup wire shall conform to requirement 20 of MIL-STD-454, except as specified in 3.4.8.36.1.

3.4.8.36.1 Wire, shielded triad. Shielded triad wire in accordance with MIL-C-915 may be used, when applicable, for internal hookup wiring.

3.4.8.37 Wiring, printed. Printed wiring shall conform to requirement 17 of MIL-STD-454. Type II (plated-through hole) interfacial connections of MIL-STD-275 shall be used.

3.4.9 Materials.

3.4.9.1 Adhesives. Adhesives shall conform to requirement 23 of MIL-STD-454.

3.4.9.2 Arc-resistant materials. Arc-resistant materials shall conform to requirement 26 of MIL-STD-454.

3.4.9.3 Encapsulation and embedment. When specified in the individual equipment specification (see 6.2.1), the encapsulation or embedment of assemblies shall conform to requirement 47 of MIL-STD-454. Rigid materials used for embedding electronic parts in assemblies shall conform to MIL-I-16923.

3.4.9.4 Fibrous material, organic. Organic fibrous material shall conform to requirement 44 of MIL-STD-454.

3.4.9.5 Flammable materials. Flammable materials shall conform to requirement 3 of MIL-STD-454.

3.4.9.6 Fragile or brittle materials. Cast iron, ebonite (hard vulcanized rubber), asbestos, porcelain, and other similar materials shall not be used, except when used in the fabrication of an approved standard part or when specifically approved by the command or agency concerned in accordance with 3.4.3.

3.4.9.7 Fungus-inert materials. Fungus-inert materials shall conform to requirement 4 of MIL-STD-454.

3.4.9.8 Gaskets and seals.

3.4.9.8.1 Dial window gaskets. Gaskets for dial windows shall provide a watertight seal and shall conform to MIL-R-2765.

3.4.9.8.2 Static seals. For static seals (between unit case and cover), "O" ring gaskets in accordance with MIL-P-5516 shall be used. For square or rectangular enclosure, the inside radius of the "O" ring at the corners of the enclosure shall be 1/2 inch minimum. The gaskets shall be lubricated in accordance with MIL-S-8660.

3.4.9.8.3 Reciprocating or rotary motion seals. For reciprocating motion seals (push button shafts) and for rotary motion seals (illumination rheostat shafts or operating knob shafts where the rotational speed is less than 10 rev/min) "O" ring gaskets in accordance with MIL-P-5516 shall be used. Gaskets shall be lubricated in accordance with MIL-S-8660. Clearances and other installation data as specified in MIL-G-5514 shall be used. The "O" ring retaining groove shall be cut in the shaft. Where lubrication in service is required, it shall be provided as specified for pneumatic seals in MIL-G-5514.

3.4.9.8.4 Watertight joints. All gasketed watertight joints subjected to sea pressure, shall be so constructed as to prohibit lateral flow of the gasket material when the two members between which the gasket forms a seal, are forced together by the hydrostatic pressure.

3.4.9.8.5 Flat gaskets. The use of flat gaskets shall be held to a minimum and shall be used only between smooth, regular surfaces and shall conform to the degree of enclosure and frequency of accessibility requirements of the equipment. Gaskets which are not penetrated with mounting screws are preferred. Gasket materials shall be in accordance with MIL-R-15624 for other than low temperature (minus 28.9°C, minimum) applications.

3.4.9.9 Glass. Glass shall not be used, except where included in completed parts or materials and the use of such parts or materials is acceptable to the command or agency concerned. All glass for use in equipment for protection of instruments, meters, cathode ray tube faces, and for viewing dials and indicators shall be clear, presenting no evidence of distortion when viewed from any angle. Glareproof glass shall be used when the equipment to be viewed will be illuminated from an outside source or when the equipment is designed for use in dark adapted spaces. All glass shall conform to class 1, type I of MIL-G-3787.

3.4.9.10 Insulating materials, electrical. Electrical insulating materials shall conform to requirement 11 of MIL-STD-454.

3.4.9.11 Lacing tape. Lacing tape for cable harnesses and other applications shall conform to type I, size 3, finish B of MIL-T-43435.

3.4.9.12 Lubricants. Lubricants shall conform to requirement 43 of MIL-STD-454.

3.4.9.13 Metals and alloys. Metals and alloys shall be corrosion-resisting or shall be given a corrosion-resistant treatment or coating. Special consideration shall be given to corrosion protection for equipment subject to sea water immersion.

3.4.9.13.1 Corrosion-resisting and nonmagnetic metals. The following are considered corrosion-resisting for structural purposes and are generally nonmagnetic metals:

(a) Alloys, aluminim - 5086-H32 and 6061-T6
(b) Alloy, copper-beryllium
(c) Alloy, copper-nickel
(d) Alloy, copper-nickel-zinc
(e) Alloy, nickel-copper
(f) Alloy, nickel-copper-aluminum
(g) Alloy, nickel-copper-silicon
(h) Brass
(i) Bronze
(j) Silver
(k) Steel corrosion-resisting 302, 303, 304L, 309, 310, 316 (Passivation treatment is required)

3.4.9.13.2 Dissimilar metals. Unless otherwise specified in the individual equipment specification (see 6.2.1), metal-to-metal contacts shall be limited to those metals which, when coupled, are designated by an open square, an open circle, or open delta, or an open delta with a cross bar as shown in table II under the following conditions:

(a) For combinations of metals subject to immersion, splashing, or spray from sea water, condition S, E, or L, as applicable, in table II shall apply.
(b) For combinations of metals exposed to atmosphere but not subject to immersion, splashing, or spray from sea water, condition E in table II shall apply.

Table II

SEA WATER CORROSION OF GALVANIC COUPLES

Legend

□ The corrosion of the metal under consideration will be reduced considerably in the vicinity of the contact.
○ The corrosion of the metal under consideration will be reduced slightly.
△ The galvanic effect will be slight with the direction uncertain.
△ The corrosion of the metal under consideration will be increased slightly.
▲ The corrosion of the metal under consideration will be increased moderately.
● The corrosion of the metal under consideration will be increased considerably.

S Exposed area of the metal under consideration is small compared with the area of the metal with which it is coupled.
E Exposed area of the metal under consideration is approximately equal to that of the metal with which it is coupled.
L Exposed area of the metal under consideration is large compared to that of the metal with which it is coupled.

METAL CONSIDERED ↓ / IN CONTACT WITH →		Magnesium	Magnesium Alloys	Zinc	Galvanized Steel	Aluminum 52S	Aluminum 4S	Aluminum 2S	Alclad	Aluminum 53S-T	Aluminum 61S-T	Cadmium	Aluminum A17S-T	Aluminum 17S-T	Aluminum 24S-T	Mild Steel	Wrought Iron	Low-Alloy Steels	Cast Iron	Low-Alloy Cast Irons	4-6% Chromium Steel	Ni Cast Iron	12-14% Chromium Steel	Lead-Tin Solders	16-18% Chromium Steel	Lead	Tin	Muntz Metal	Manganese Bronze	Naval Brass	Nickel	Yellow Brass	Admiralty Brass	Aluminum Bronze	Red Brass	Copper	Silicon Bronze	Nickel Silver	70-30 Copper Nickel	Composition G Bronze	Composition M Bronze	Ironsteel	Silver Solder	70-30 Nickel Copper	25-30% Chromium Steel	Cr-Ni Stainless Steel	Cr-Ni-Mo Stainless Steel	Graphite
Magnesium	*S*	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	△	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Magnesium Alloys	*S*	○	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	○	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	○	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Zinc	*S*	□	□	△	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
	L	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△
Galvanized Steel	*S*	□	□	□	△	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
	L	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	▲
Aluminum 52S	*S*	△	△	△	□	□	△	△	△	△	△	△	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	●	●	□	□	□	△	△	△	△	△	△	△	▲	▲	●	●	●	●	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	△	△	○	○	○	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Aluminum 4S	*S*	△	△	□	□	□	△	△	△	△	△	△	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	●	●	□	□	□	△	△	△	△	△	△	△	▲	▲	●	●	●	●	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	△	△	○	○	○	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Aluminum 2S	*S*	△	△	□	□	□	△	△	△	△	△	△	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	●	●	□	□	□	△	△	△	△	△	△	△	▲	▲	●	●	●	●	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	△	△	○	○	○	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Aluminum 53S-T	*S*	△	△	□	□	□	△	△	△	△	△	△	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	●	●	□	□	□	△	△	△	△	△	△	△	▲	▲	●	●	●	●	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	△	△	○	○	○	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Aluminum 61S-T	*S*	△	△	□	□	□	△	△	△	△	△	△	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	●	●	□	□	□	△	△	△	△	△	△	△	▲	▲	●	●	●	●	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	△	△	○	○	○	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Cadmium	*S*	□	□	□	□	○	○	○	○	○	○	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	△	△	△	△	△	△	▲	▲	▲	●	●	●	●	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	○	○	○	○	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Aluminum A 17S-T	*S*	○	○	□	□	□	□	□	□	□	□	□	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	●	●	□	□	□	□	□	□	□	□	□	△	▲	▲	●	●	●	●	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	△	△	○	○	○	○	○	○	○	○	○	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Aluminum 17S-T	*S*	○	○	□	□	□	□	□	□	□	□	□	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	●	●	□	□	□	□	□	□	□	□	□	△	▲	▲	●	●	●	●	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	△	△	○	○	○	○	○	○	○	○	○	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Aluminum 24S-T	*S*	○	○	□	□	□	□	□	□	□	□	□	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	●	●	□	□	□	□	□	□	□	□	□	△	▲	▲	●	●	●	●	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	△	△	○	○	○	○	○	○	○	○	○	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲

Table II - (con.)

SEA WATER CORROSION OF GALVANIC COUPLES — *Continued*

Legend

- □ The corrosion of the metal under consideration will be reduced considerably in the vicinity of the contact.
- ○ The corrosion of the metal under consideration will be reduced slightly.
- △ The galvanic effect will be slight with the direction uncertain.
- ◬ The corrosion of the metal under consideration will be increased slightly.
- ▲ The corrosion of the metal under consideration will be increased moderately
- ● The corrosion of the metal under consideration will be increased considerably.
- *S* Exposed area of the metal under consideration is small compared with the area of the metal with which it is coupled.
- *E* Exposed area of the metal under consideration is approximately equal to that of the metal with which it is coupled.
- *L* Exposed area of the metal under consideration is large compared to that of the metal with which it is coupled.

METAL CONSIDERED ↓ / IN CONTACT WITH →		Magnesium	Magnesium Alloys	Zinc	Galvanized Steel	Aluminum 52S	Aluminum 43	Aluminum 32	Alclad	Aluminum 53	Aluminum 356-T	Aluminum 618-T	Cadmium	Aluminum A17S-T	Aluminum 17S-T	Aluminum 24S-T	Mild Steel	Wrought Iron	Low-Alloy Steels	Cast Iron	Low-Alloy Cast Irons	4-6% Chromium Steel	Ni Cast Iron	12-14% Chromium Steel	Lead-Tin Solders	16-18% Chromium Steel	Lead	Tin	Muntz Metal	Manganese Bronze	Naval Brass	Nickel Silver	Yellow Brass	Admiralty Brass	Aluminum Bronze	Red Brass	Copper	Silicon Bronzes	Nickel Silver	70-30 Copper Nickel	Composition G Bronze	Composition M Bronze	Tinned	Silver Solder	70-30 Nickel Copper	25-30% Chromium Steel	Cr-Ni Stainless Steel	Cr-Ni-Mo Stainless Steel	Graphite
Mild Steel	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	○	○	○	○	○	○	○	○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	
Wrought Iron	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬
Low-Alloy Steels	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬
Cast Iron	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬
Low-Alloy Cast Iron	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬
4-6% Cr Steel	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	○	○	○	○	○	○	○	○	○	○	○	○	○	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬
Ni Cast Iron	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬
12-14% Chromium Steel	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	▲	●	▲	●	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	○	○	○	○	○	○	○	○	○	○	○	○	○	□	□	□	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	●
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬	●
Lead-Tin Solders	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬	▲
16-18% Chromium Steel	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	●
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬	●
25-30% Chromium Steel	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	●	●	●	●	●	●	●	●	●	●	●	●	△	□	△	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	◬	○	◬	●
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬	●
Austenitic Cr-Ni Stainless Steel	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	●	●	●	●	●	●	●	●	●	●	●	●	△	△	◬	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	◬	◬	◬	●
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬	●
Austenitic Cr-Ni-Mo Stainless Steel	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	●	●	●	●	●	●	●	●	●	●	●	●	△	□	△	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	◬	○	◬	●
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬	▲
Lead	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬	▲
Tin	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	◬	◬	▲

Table II - (con.)

SEA WATER CORROSION OF GALVANIC COUPLES — *Continued*

Legend

- □ The corrosion of the metal under consideration will be reduced considerably in the vicinity of the contact.
- ○ The corrosion of the metal under consideration will be reduced slightly.
- △ The galvanic effect will be slight with the direction uncertain.
- ⏢ The corrosion of the metal under consideration will be increased slightly.
- ▲ The corrosion of the metal under consideration will be increased moderately.
- ● The corrosion of the metal under consideration will be increased considerably.

S Exposed area of the metal under consideration is small compared with the area of the metal with which it is coupled.

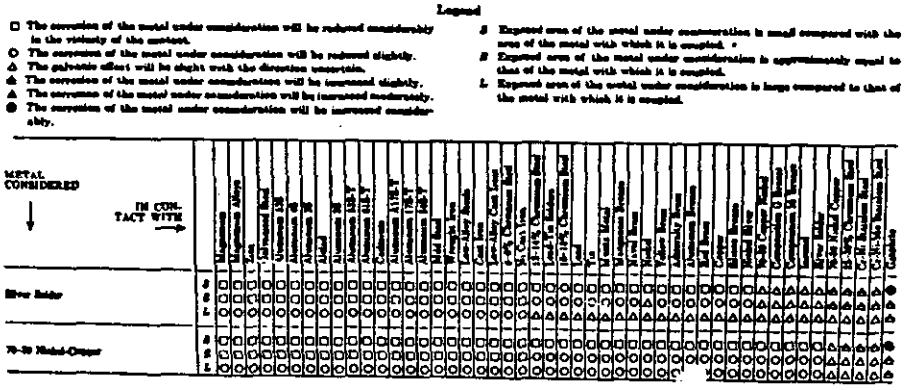
E Exposed area of the metal under consideration is approximately equal to that of the metal with which it is coupled.

L Exposed area of the metal under consideration is large compared to that of the metal with which it is coupled.

METAL CONSIDERED ↓ / IN CONTACT WITH →		Magnesium	Magnesium Alloys	Zinc	Galvanized Steel	Aluminum 52S	Aluminum 43	Aluminum 25	Alclad	Aluminum 2S	Aluminum 53S-T	Aluminum 61S-T	Cadmium	Aluminum A17S-T	Aluminum 17S-T	Aluminum 24S-T	Mild Steel	Wrought Iron	Low-Alloy Steels	Cast Iron	Low-Alloy Cast Irons	4-6% Chromium Steel	Ni Cast Iron	13-15% Chromium Steel	Lead-Tin Solders	16-18% Chromium Steel	Lead	Tin	Monel Metal	Manganese Bronze	Naval Brass	Nickel	Yellow Brass	Admiralty Brass	Aluminum Bronze	Red Brass	Copper	Silicon Bronze	Nickel Silver	70-30 Copper-Nickel	Composition G Bronze	Composition M Bronze	Cupronickels	Inconel	Silver Solder	70-30 Nickel Copper	25-30% Chromium Steel	Cr-Ni Stainless Steel	Cr-Ni-Mo Stainless Steel	Graphite
Monel Metal	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	▲	●	▲	▲	△	●	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	▲	●	▲	▲	△	●	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	▲	▲	●	▲	▲	△	●	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Manganese Bronze	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	▲	●	▲	▲	□	△	□	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	▲	●	▲	▲	△	●	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	▲	▲	●	▲	▲	△	●	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Naval Brass	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	▲	●	▲	▲	△	●	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	▲	●	▲	▲	△	●	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	▲	▲	●	▲	▲	△	●	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	▲
Nickel	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	●	△	△	□	□	□	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	△	●	△	△	○	○	○	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	●	△	△	△	△	△	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	▲
Inconel (13% Cr, 6.5% Fe, Bal. Ni)	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	●	△	△	□	□	□	△	●	●	●	●	●	●	●	●	●	●	●	△	△	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	△	●	△	△	○	○	○	△	●	●	●	●	●	●	●	●	●	●	△	△	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	●	△	△	△	△	△	△	●	●	●	●	●	●	●	●	●	●	△	△	●	●	●	▲
Yellow Brass	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	▲	●	▲	▲	□	△	□	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	△	▲	●	▲	▲	○	○	○	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	▲	●	▲	▲	○	○	○	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Admiralty Brass	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	▲	▲	□	□	□	△	●	●	●	▲	●	●	●	□	△	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	▲	●	▲	▲	○	○	○	△	●	●	●	▲	●	●	●	○	△	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	▲	●	▲	▲	○	○	○	△	●	●	●	▲	●	●	●	○	△	●	●	●	●	●	●	▲
Aluminum Bronze	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	▲	▲	□	□	□	△	●	●	●	▲	●	●	●	△	△	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	▲	●	▲	▲	○	○	○	△	●	●	●	▲	●	●	●	△	△	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	▲	●	▲	▲	○	○	○	△	●	●	●	▲	●	●	●	△	△	●	●	●	●	●	●	▲
Red Brass	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	▲	▲	□	□	□	△	●	●	●	●	●	●	●	□	△	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	▲	●	▲	▲	○	○	○	△	●	●	●	●	●	●	●	○	△	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	▲	●	▲	▲	○	○	○	△	●	●	●	●	●	●	●	○	△	●	●	●	●	●	●	▲
Copper	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	▲	▲	□	□	□	□	□	□	□	△	●	△	△	□	□	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	△	●	△	△	○	○	○	○	○	○	○	△	●	△	△	○	○	●	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	●	△	△	○	○	○	○	○	○	○	△	●	△	△	○	○	●	●	●	●	●	●	▲
Silicon Bronze	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	▲	▲	□	□	□	□	□	□	□	△	●	△	△	□	□	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	△	●	△	△	○	○	○	○	○	○	○	△	●	△	△	○	○	●	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	●	△	△	○	○	○	○	○	○	○	△	●	△	△	○	○	●	●	●	●	●	●	▲
Nickel Silver	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	▲	▲	□	□	□	□	□	□	□	△	●	△	△	□	□	●	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	△	●	△	△	○	○	○	○	○	○	○	△	●	△	△	○	○	●	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	●	△	△	○	○	○	○	○	○	○	△	●	△	△	○	○	●	●	●	●	●	●	▲
70-30 Copper Nickel	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	▲	▲	□	□	□	□	□	□	□	□	□	□	□	□	□	□	●	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	△	●	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	●	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●	▲
Composition G Bronze (88% Cu, 2% Zn, 10% Sn)	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	▲	▲	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	△	●	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	●	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●	▲
Composition M Bronze (68% Cu, 2% Zn, 4.5% Sn, 1.5% Pb)	*S*	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	▲	●	▲	▲	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	●	●	●	●	●	●
	E	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	○	△	●	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●	●	▲
	L	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	●	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●	▲

Table II - (con.)

SEA WATER CORROSION OF GALVANIC COUPLES — Continued



"Reproduced by permission from 'CORROSION HANDBOOK' edited by H.H. Uhlig, published by John Wiley & Sons, Inc. 1948."

3.4.9.13.2.1 Insulation of dissimilar metals. Where it is necessary that dissimilar metals are assembled in intimate contact with each other, an interposing material compatible to each shall be used. No insulating material will be required between corrosion resistant steel inserts and aluminum castings when the inserts are integrally cast in the aluminum.

3.4.9.13.3 Ferrous alloys, corrosion resistant. Ferrous alloy shall conform to requirement 15 of MIL-STD-454.

3.4.9.13.4 Non-ferrous metals. Non-ferrous metals, except as specified herein, shall be subject to the approval of the command or agency concerned.

3.4.9.13.5 Lightweight metal (aluminum alloy). Where the use of lightweight metal is desired, aluminum alloy shall be used. Aluminum alloys, except castings, shall conform to ASTM-B-209. Aluminum alloy casting shall conform to QQ-A-591, QQ-A-596, or alloy B443 temper F, alloy A356, or alloy 295 of QQ-A-601. Where aluminum alloy castings for high strength and high quality applications are required, they shall conform to MIL-A-21180.

3.4.9.13.6 Silver brazing alloy. Silver brazing alloy shall conform to QQ-B-654.

3.4.9.13.7 Zinc. Zinc shall not be used where the increased electrical resistance of the surface, due to the protective treatment, has a deleterious effect on electrical performance.

3.4.9.14 Springs. Material for springs shall conform to requirement 41 of MIL-STD-454.

3.4.10 Unacceptable materials. The following types or kinds of materials shall not be used, except where such materials are fabricated into completed approved standard parts or use of the material(s) is approved by the command or agency concerned:

(a) Cellulose, acetate
(b) Cellulose, nitrate
(c) Cellulose, regenerate
(d) Cork
(e) Felts, hair or wool
(f) Fiber, asbestos electrical insulation
(g) Jute
(h) Leather
(i) Linen
(j) Magnesium or magnesium alloy

(k) Organic fiberboard
(l) Paper and cardboard
(m) Plastic (using cotton linen or wood flour as a filler)
(n) Wood

3.4.10.1 Mercury and radioactive material. Mecury and radioactive material shall not be used in any form, except in certain electron tubes as specified in MIL-E-1 and electronic parts as specified in MIL-STD-242. Any use of such tubes and parts that contain mercury or radioactive material shall be used only upon approval of the command or agency concerned.

3.4.11 Processes.

3.4.11.1 Castings. Castings shall be in accordance with requirement 21 of MIL-STD-454. Zinc castings shall not be used.

3.4.11.2 Corrosion protection/corrosion-resisting treatments. Unless otherwise specified (see 6.2.1), corrosion-resisting treatments shall not be applied to surfaces which are in functional contact where gouging or binding may be a factor, or where the treatment might interfere with normal functioning, or where electrical grounding through the surface is required. Corrosion protection and corrosion-resisting treatments shall conform to requirement 15 of MIL-STD-454 and as specified herein.

(a) Zinc coating (hot dip galvanizing) shall conform to ASTM-A-153 for parts, other than threaded fasteners, unless part specifications contain other requirements.
(b) Electroplating or mechanical deposition of zinc shall conform to class 2, type II of QQ-Z-325, or MIL-C-81562 for surfaces not to be painted, except that class 3 thickness may be used for externally threaded parts, bolts, studs, and washers. Class 2, type I plating of QQ-Z-325 shall be used on parts which are continuously exposed to temperatures in excess of 65.6°C or are intermittently exposed for short periods to temperatures of approximately 149°C. Either type II, class 2 or type III, class 2 of QQ-Z-325 shall be used on surfaces that are to be painted.
(c) Electroplating or mechanical deposition of cadmium shall conform to type II, class 1 of QQ-P-416 or MIL-C-81562 for surfaces not to be painted, except that type I, class 1 of QQ-P-416 shall be used on parts which are continuously exposed to temperatures in excess of 65.6°C or are intermittently exposed for short periods to temperatures of approximately 149°C. Type II, class 3 of QQ-P-416 shall be used for threaded devices. Castings conforming to type II, class 1 or type III, class 1 of QQ-P-416 coatings shall be used on surfaces that are to be painted. Electroplating of cadmium shall not be used internally in any instrument or equipment, and shall not be used on the following parts when contained in an enclosure:

    (1) Parts in grease or oil chambers
    (2) Lock washers
    (3) Threaded parts

(d) Electroplating of chromium shall conform to type I of QQ-C-320, except that it shall have an undercoating of nickel 0.0012 inch minimum thickness, or nickel on copper 0.0012 inch minimum total thickness. The nickel coating on the copper undercoat shall be 0.0006 inch minimum thickness. All brass parts shall have a copper undercoat of 0.0003 inch minimum thickness.
(e) Electroplating of nickel shall conform to QQ-N-290.
(f) Electroless nickel plating shall conform to MIL-C-26074.
(g) Electroplating of copper shall conform to MIL-C-14550.
(h) Electroplating of silver shall conform to QQ-S-365.

(i) Electroplating of gold shall be to a thickness that is adequate to pass the salt fog test specified in 4.8.3.5. Goldplating shall be bright gold in accordance with type II, class 1 of MIL-G-45204.
(j) Anodic treatment shall conform to MIL-A-8625 for aluminum surfaces not to be painted. For surfaces to be painted, either the method of MIL-A-8625 or chemical treatment in accordance with MIL-C-5541 may be used. Aluminum gear teeth contact surfaces shall not be anodized, the anodization shall be removed from these surfaces prior to assembly.
(k) Platinum sheathing, when used, shall be at least 0.003 inch thick to withstand continuous immersion in salt water.
(l) Magnesium and magnesium alloys, when approved (see 3.4.10), shall be finished in accordance with MIL-M-3171.
(m) Rhodium plating, when used, shall be class 3 of MIL-R-46085 and of adequate thickness and so continuous as to pass the salt fog test specified in 4.8.3.5.
(n) Tin plating, when used, shall be type I of MIL-T-10727. Tin-lead alloy plating, when used, shall conform to MIL-P-81728. Plating of tin and lead-tin alloys shall be of adequate thickness and so continuous as to pass the salt fog test specified in 4.8.3.5.
(o) Plating is not required on parts, such as bearings, gears, and shafts fabricated or machined from brass, bronze, or corrosion-resistant steel, unless they are in contact with dissimilar metals under corrosive conditions. The interposing material may be an electro-deposited, a mechanically deposited, a metallic compound deposited, or a thermal sprayed coating of a properly selected metal.

3.4.11.3 Painting. The exterior and interior surfaces of all metal equipment enclosures shall be painted in accordance with the requirements specified herein, except that for equipment used in dark adapted spaces the painting shall also meet the requirements of 3.7.8.5. Plastic enclosures normally will not be painted.

3.4.11.3.1 Protected equipment (interior use).

3.4.11.3.1.1 Aluminum and aluminum alloys, painting of. Prior to painting, aluminum and aluminum alloys shall be anodized in accordance with MIL-A-8625 or chemically treated in accordance with MIL-C-5541. All residues and contaminants shall be removed prior to applying a primer. Primer shall conform to 3.4.11.3.1.3(c).

3.4.11.3.1.2 Ferrous metals, painting of. After all machining, welding, and brazing operations are completed, the exterior and interior surface of all enclosures shall have all rust or other corrosion products and flux removed by abrasive blasting, sanding, wire brushing, or other mechanical means. This surface shall be thoroughly cleaned of all grease, oil, and dirt by solvent wiping and rinsing, vapor degreasing, or caustic washing followed by rinsing.

3.4.11.3.1.3 Primer. Primer shall be applied in accordance with one of the following methods:

(a) One coat of primer pretreatment in accordance with MIL-P-15328 (0.0002 to 0.0005 inch dry film thickness) followed by primer conforming to TT-P-1757 or TT-P-664.
(b) A hot-dip tank phosphate treatment conforming to type I of TT-C-490 (0.0006 to 0.001 inch dry film thickness) followed by primer conforming to TT-P-664 or TT-P-1757.
(c) Primer conforming to TT-P-1757 or TT-P-664 shall be applied as one coat (0.0006 to 0.0008 inch dry film thickness).

3.4.11.3.1.4 Enamel. Two coats of gray enamel conforming to class 2 of MIL-E-15090 shall be applied as continuous films approximately 0.001 inch thick. For portable shipboard equipment, the enamel shall conform to class 1 of MIL-E-15090.

3.4.11.3.2 Exposed equipment (exterior use). Unless otherwise specified (see 6.2.1), the equipment, or portions thereof, exposed to the weather shall be painted with three coats of epoxypolyamide paint in accordance with MIL-P-24441. The first coat shall be formula 150 (thickness of 3 to 4 mils), the second coat formula 155 (thickness of 2 to 3 mils), and the third coat formula 151 (thickness of 2 to 3 mils). The total dry film thickness shall be 7 to 9 mils minimum.

3.4.11.4 Soldering. Soldering shall conform to requirement 5 of MIL-STD-454. Soft solder shall not be used for mechanical support.

3.4.11.5 Welding, structural. Structural welding shall conform to requirement 13 of MIL-STD-454.

3.4.11.6 Welds, resistance (electrical interconnections). Unless otherwise specified (see 6.2.1), the use of welding techniques to make electrical connections shall conform to requirement 24 of MIL-STD-454.

3.5 Electrical design and construction.

3.5.1 Electrical power characteristics.

3.5.1.1 Shipboard ac power source. Shipboard equipment shall be designed to operate from electrical power having characteristics as specified for type I of section 103 of MIL-STD-1399 and unless otherwise specified (see 6.2.1) shall be 440V, 60 Hz.

3.5.1.2 Shore station ac power source. Equipment intended for shore installation shall operate from one of the following types of ac power systems:

Nominal voltage ac	220V 3 Phase	115V 1 Phase
Nominal frequency (Hz)	50 or 60	50 or 60
Voltage regulation	± 10 percent	± 10 percent
Frequency regulation	± 5 percent	± 5 percent

3.5.2 Electrical overload protection. Electrical overload protection shall conform to requirement 8 of MIL-STD-454 for class 1 equipment.

3.5.2.1 Blown fuse indicators. Unless otherwise specified (see 6.2.1), fuses shall have front panel blown fuse indicators.

3.5.3 Corona and electrical breakdown prevention. Corona and electrical breakdown prevention shall conform to requirement 45 of MIL-STD-454 and as specified herein.

3.5.3.1 Dielectric withstanding voltage. The electrical circuits of the equipment as specified in the individual equipment specification (see 6.2.1), shall be capable of withstanding the dielectric withstanding voltage test of 4.8.5.10. There shall be no disruptive discharge or deterioration to the circuit or parts within the circuit. Disruptive discharge is evidenced by flash-over (surface discharge, sparkover (air discharge) or breakdown (puncture discharge). The dielectric withstanding voltage test of 4.8.5.10 shall be monitored by a means of a device, such as a fault indicator, that will indicate the occurence of disruptive discharge and leakage current in case it is not visually evident in the item under test.

3.5.3.2 Insulation resistance. The electrical circuits of the equipment, as specified in the individual equipment specification (see 6.2.1), shall be capable of withstanding the insulation resistance test of 4.8.5.7.

3.5.3.3 Electrical creepage and clearance distances. Clearances between any two electrical circuits or between any electrical circuit and ground (metal enclosures or chassis) shall be such as to meet the test conditions for insulation resistance and dielectric withstanding voltage specified in 4.8.5.7 and 4.8.5.10, respectively. The minimum creepage and clearance distances between electric circuits or between any electric circuit and ground specified in requirement 69 of MIL-STD-454 shall be met. The values shown in requirement 69 of MIL-STD-454 represent the desired minimum acceptable limits for non-arcing rigid construction and that they take into consideration only the average degree of enclosure and service exposure. Where uninsulated parts are arc rupturing, or where the item is not rigidly mounted, or are used in higher voltage equipment, or subjected to exceptionally severe exposure, the minimum creepage and clearance distances shall be increased, as necessary, consistent with minimum space and weight requirements, to assure equipment reliability.

3.5.3.3.1 Insulating barriers. Insulating barriers shall be used whenever practicable, to avoid a continuous unidirectional surface creepage path.

3.5.4 Electromagnetic interference control (EMI). Electromagnetic interference control shall conform to requirement 61 of MIL-STD-454 and as specified herein.

3.5.4.1 EMI class and sub-class designations. The individual equipment specification shall specify the EMI class and sub-class designation required in MIL-STD-461 (see 6.2.1).

3.5.5 Leakage current, phase to ground.[1/] The r.m.s leakage current caused by electrical filters (capacitors) connected from phase to ground shall be limited to 30 mA. per phase for each unisolated input to the equipment. The leakage current (IL) shall be defined as the total rms current (up to the frequency specified) per phase which will pass through the filters from phase to ground when a voltage waveform having the following voltage and frequency characteristics is impressed from the input phase to ground of the equipment. The particular waveform to be used shall be based on the voltage and frequency rating of the equipment power input.

(a) 440 volt, 60 Hz input power

rms Voltage		Frequency of voltage component
440 volts	@	60 Hz
13.2	@	180
11.0	@	300
8.8	@	420
6.6	@	540
4.4	@	660
2.2	@	60 N

where N = 13, 15, 17 etc. 39

(b) 115 volt, 60 Hz input power

rms voltage		Frequency of voltage component
115 V	@	60 Hz
3.4	@	180
2.9	@	300
2.3	@	420
1.7	@	540
1.2	@	660
0.6	@	60 N

where N = 13, 15, 17 etc. 39

(c) 115 volt, 400 Hz input power

rms voltage		Frequency of voltage component
115 V	@	400 Hz
2.1	@	1200
1.7	@	2000
1.3	@	2800
1.0	@	3600
0.6	@	4400
0.4	@	400 N

where N = 13, 15, 17 etc. 39

(d) 440 V, 400 Hz input power

rms voltage		Frequency of voltage component
440 V	@	400 Hz
8.0	@	1200
6.6	@	2000
5.1	@	2800
4.0	@	3600
2.5	@	4400
1.5	@	400 N

where N = 13, 15, 17 etc. 39

[1/] The leakage current for 220 volt, 50 and 60 Hz, and 115 volt, 50 Hz shall be as specified in the individual equipment specification (see 6.2.1).

3.5.5.1 Input impedance. The input impedance to ground of the equipment filters per phase and per electrical power input terminal as a function of frequency shall satisfy the following equations based on the type of power input:

(a) For 440 V 60 Hz power input:

$$\text{Total leakage Current per phase} = I_L = 30\ \text{mA maximum} = \left[\left(\frac{440}{Z@60Hz}\right)^2 + \left(\frac{13.2}{Z@180Hz}\right)^2 + \left(\frac{11.0}{Z@300Hz}\right)^2 + \left(\frac{8.8}{Z@420Hz}\right)^2 + \left(\frac{6.6}{Z@540Hz}\right)^2 + \left(\frac{4.4}{Z@660Hz}\right)^2 + \sum_{\substack{N=13 \\ N\text{-odd}}}^{N=39} \left(\frac{2.2}{Z@60N}\right)^2\right]^{1/2}$$

(b) For 115 V, 60 Hz power input:

$$\text{Total leakage Current per phase} = I_L = 30\ \text{mA maximum} = \left[\left(\frac{115}{Z@60Hz}\right)^2 + \left(\frac{3.4}{Z@180Hz}\right)^2 + \left(\frac{2.9}{Z@300Hz}\right)^2 + \left(\frac{2.3}{Z@420Hz}\right)^2 + \left(\frac{1.7}{Z@540Hz}\right)^2 + \left(\frac{1.2}{Z@660Hz}\right)^2 + \sum_{\substack{N=13 \\ N\text{-odd}}}^{N=39} \left(\frac{0.6}{Z@60N}\right)^2\right]^{1/2}$$

(c) For 115 V, 400 Hz power input:

$$\text{Total leakage Current per phase} = I_L = 30\ \text{mA maximum} = \left[\left(\frac{115}{Z@400Hz}\right)^2 + \left(\frac{2.1}{Z@1200Hz}\right)^2 + \left(\frac{1.7}{Z@2000Hz}\right)^2 + \left(\frac{1.3}{Z@2800Hz}\right)^2 + \left(\frac{1.0}{Z@3600Hz}\right)^2 + \left(\frac{0.6}{Z@4400Hz}\right)^2 + \sum_{\substack{N=13 \\ N\text{-odd}}}^{N=39} \left(\frac{0.4}{Z@400N}\right)^2\right]^{1/2}$$

(d) For 440 V, 400 Hz power input:

$$\text{Total leakage Current per phase} = I_L = 30\ \text{mA maximum} = \left[\left(\frac{440}{Z@400Hz}\right)^2 + \left(\frac{8.0}{Z@1200Hz}\right)^2 + \left(\frac{6.6}{Z@2000Hz}\right)^2 + \left(\frac{5.1}{Z@2800Hz}\right)^2 + \left(\frac{4.0}{Z@3600Hz}\right)^2 + \left(\frac{2.5}{Z@4400Hz}\right)^2 + \sum_{\substack{N=13 \\ N\text{-odd}}}^{N=39} \left(\frac{1.5}{Z@400N}\right)^2\right]^{1/2}$$

Z = is the impedance of the filters to ground (defined as that impedance which results in leakage current to ground which is unisolated from the input electric distribution system) per phase at the frequency specified for each electrical input to the equipment.

3.5.5.2 Isolation transformers. When the filter impedance cannot meet the leakage current limits, isolation transformers shall be provided to isolate the equipment from the electrical power source. Isolation transformers shall have separate primary and secondary windings not directly connected electrically. The transformer may be one which performs voltage transformation at the input of the equipment, or a transformer having a one-to-one voltage transformation ratio if power at the distribution voltage is required.

3.5.5.3 Leakage current calculations. Leakage current calculations shall be prepared as specified (see 6.2.2).

3.5.6 Bonding and grounding. All equipment enclosures shall be furnished with provisions for securing bond straps to the cabinets. The location, design, and number of bonding points shall conform to MIL-STD-1310. Each chassis within an enclosure shall be grounded to the enclosure.

3.5.6.1 Bonding, electrical. All internal metal-to-metal faying surfaces shall be electrically bonded to minimize radio frequency impedance between bonded surfaces, and to reduce noise generation. These bonds shall be achieved by welding, brazing, swaging, soldering or bolting. Protective finishes shall be omitted (or removed) from bonding surfaces. Design shall assure permanence of low impedance bond over long periods in the presence of humid and saline atmospheres.

3.5.7 Internal wiring and cabling. Internal wiring and cabling shall be as specified herein.

3.5.7.1 Support. Twine or tape shall not be used for securing wire and cable to cabinets, chassis, and racks. Metal clamps, if used, shall be insulated and not form a complete loop around the conductor.

3.5.7.2 Protection. Where wires or cables pass through passage holes in metal partitions, shields or similar items which are less than 1/8 inch in thickness, the passage holes shall be fitted with insulating grommets. Passage holes 1/8 inch, or greater, in thickness shall be fitted with grommets or shall have the edges of the hole rounded to a minimum radius of 1/16 inch. Grommets for wires operating at radio frequencies shall be of ceramic material or plastic material, except for coaxial cables which have outside protection, where rubber or neoprene is acceptable.

3.5.7.3 Attachment of wires and leads.

3.5.7.3.1 Soldered connections. The attachment of wires and leads by soldered connections shall conform to requirement 5 of MIL-STD-454.

3.5.7.3.2 Pressure contacts. Electrical pressure contacts shall not depend on conductors clamped between a metallic material and an insulating pliable material.

3.5.7.3.3 Crimped type connections. With the exception of pigtail leads or parts requiring solder connections, wire and parts terminating on terminals, terminal boards, and strips shall be terminated by solderless crimp type lugs in accordance with requirement 19 of MIL-STD-454. Insulated solderless lugs are preferred and shall conform to MIL-T-7928. Where thermal or other considerations prevent the use of insulated lugs, noninsulated solderless lugs conforming to MIL-T-7928 may be used.

3.5.8 Mounting of parts. Parts having a diameter of 1/2 inch or more or whose weight exceeds 1/4 ounce per lead shall be securely fastened by clamps. Tantalum capacitors whose weight exceeds 1/8 ounce per lead or whose density exceeds 80 grams per cubic inch (g/in^3) shall also be securely fastened by clamps. Ceramic or composition resistors which are secured by screws shall have pliable washers inserted under the screws to prevent undue stress on resistors.

3.5.8.1 Part replacement. The arrangement of parts on repairable items shall be such that replacement of any part is possible without removal of or damage to adjacent parts.

3.5.8.2 Stress relief bends. Stress relief bends shall be provided for each part lead in accordance with requirement 5 of MIL-STD-454.

3.5.9 Synchros. The types of synchros to be used (60 and 400 Hz) and the load impedance on the secondary winding of synchro control transformers shall be as specified (see 6.2.1).

3.5.9.1 Synchro capacitors. Synchro capacitors shall be connected across the primary (stator) leads of all differential synchros and across the primary leads of all synchro control transformers or equivalent devices and shall be installed in the equipment enclosure containing the differential synchro or synchro control transformers.

3.5.9.1.1 Synchro capacitor values. Unless otherwise specified (see 6.2.1), the methods and logic in Design Data Sheet DDS 9650-2 of Publication 0901-006-0000 shall be used as guidance in computing synchro capacitor values. The synchro capacitor working voltage rating shall be based on the frequency and peak voltage of the alternating current in accordance with the application criteria of MIL-STD-198.

3.5.9.2 Connections and markings. Synchro connections and markings shall conform to the requirements of MIL-HDBK-225.

3.5.9.3 Electrical and mechanical zero. Unless otherwise specified (see 6.2.1), electrical and mechanical zero shall be physically positioned to the same reference point. Electrical zeroing methods shall be as specified in MIL-HDBK-225.

3.6 Maintenance design. Unless otherwise specified (see 6.2.1), the equipment design for maintainability shall conform to MIL-STD-1472 and as specified herein. The maintenance design and fabrication of the equipment shall reflect the maintenance concept resulting from the reliability and maintainability requirements (see 3.3.3 and 3.3.4) and shall be in consonance with the application of modular design to the equipment (see 3.3.2.3).

3.6.1 Test provisions. Test provisions of the equipment shall be in accordance with requirement 32 of MIL-STD-454 and the specific test capability and class of test provisions specified in the individual equipment specification (see 6.2.1). Equipment with test provisions in accordance with class A or B of MIL-STD-415, to be monitored by online automatic test equipment (ATE), shall be in accordance with MIL-STD-1326. The test provisions of the equipment shall provide the capability for a straight-forward logical step-by-step testing sequence, as well as providing for an end-to-end performance check.

3.6.1.1 Built-in monitoring devices. Built-in monitoring devices shall be designed for ease of removal to permit calibration and repair.

3.6.2 Test equipment. The equipment shall be designed in such a manner as to permit the use of test equipment in accordance with MIL-STD-1364 or Publication 0969-019-7000, as specified in the individual equipment specification (see 6.2.1).

3.6.3 Special tools. Special tools shall be in accordance with requirement 63 of MIL-STD-454. Special tools shall be designed to withstand the intended use throughout the life of the equipment.

3.6.4 Test cables. Unless otherwise specified (see 6.2.1), test cables and extender cards shall be provided and fitted with the proper connectors to allow removable subassemblies to be electrically reconnected for maintenance.

3.6.5 Power receptacles. Convenience power receptacles shall not be provided.

3.6.6 Accessibility. Unless otherwise specified (see 6.2.1), accessibility shall be in accordance with requirement 36 of MIL-STD-454 except that access to all parts, with chassis withdrawn or access doors open, shall be from the front of the enclosure and withdrawal slides shall be provided with automatically operated locks to lock the chassis in both the operating and servicing positions.

3.6.6.1 Hinged covers. Hinged covers shall be designed to minimize interference with adjacent equipment when opened for servicing and shall be capable of being retained in the open position. Hinged covers shall be made readily removable for servicing and replacement.

3.6.7 Part protection. The equipment shall be so designed that parts will not be susceptible to damage during servicing and maintenance of the equipment.

3.6.8 Protective caps. All externally mounted connector receptacles which are not in continuous use shall be provided with a protective cap to prevent damage to the connector receptacle when the mating connector is not installed. The protective cap shall be affixed adjacent to the connector receptacle.

3.7 Mechanical design and construction.

3.7.1 Construction. Equipment construction shall be of the lightest weight consistent with sturdiness, safety, and reliability. Equipment may include cast or fabricated construction.

3.7.1.1 Castings. Castings shall be designed and constructed in accordance with requirement 21 of MIL-STD-454. Die castings may be used for aluminum enclosures only. Castings shall be webbed or otherwise reinforced where required for strength and rigidity. Exterior webbing or reinforcement will be considered in the dimensional limitations. Zinc castings shall not be used.

3.7.2 Enclosures. The equipment enclosures shall conform to requirement 55 of MIL-STD-454 and as specified herein.

3.7.2.1 Degree of enclosure. The degree of enclosure for equipment shall be in accordance with MIL-STD-108, and shall be as specified (see 6.2.1). The degree of enclosure specified for equipment exposed to the weather shall be watertight. The degree of enclosure specified for enclosures intended for installation within internal ship spaces shall be dripproof (45 degrees). Other degree of enclosures shall be as specified (see 3.10.11.4(a) and (b) and 6.2.1) and shall conform to MIL-STD-108.

3.7.2.2 Extraneous light. Unless otherwise specified (see 6.2.1), enclosures shall be designed to prevent extraneous light escape.

3.7.2.3 Structural integrity. Unless otherwise specified (see 6.2.1), the self-resonances of enclosures shall be above 50 Hz, when subjected to the tests of 4.8.4.1.

3.7.2.4 Rigidity. Large flat sheet metal surfaces shall have grooves along diagonals or be provided with other means to improve rigidity.

3.7.2.5 Rounded corners and edges. All edges and corners of surfaces normally exposed or to be painted, shall be rounded. Sharp edges and points of any kind shall be avoided.

3.7.2.6 Moisture pockets. The preclusion of moisture pockets within equipment enclosures shall conform to requirement 31 of MIL-STD-454.

3.7.2.7 Handling. Equipment or portions thereof weighing more than 150 pounds shall be provided with lifting eyes. "LIFT HERE" shall be marked adjacent to the lifting eyes. When removable lifting eyes are used, provision shall be made in the equipment for their storage upon removal. Handles and bales shall be provided for removing units or chassis from enclosures. Handles or bales on the front panels of the equipment shall be positioned to protect the front panel instruments and controls when the units or chassis are withdrawn and when the front panel is placed in a down position.

3.7.2.8 External connections. The method of external connections to equipment enclosure(s) shall be as specified in the individual equipment specification (see 6.2.1), and shall conform to applicable requirements for connectors (3.4.8.10), terminal boards (3.4.8.31), and stuffing tubes (3.4.8.34). Unless otherwise specified (see 6.2.1), external connections, excluding test connections, shall not be located on the front or back of the enclosures.

3.7.2.8.1 Cable entrance (cast enclosure). On cast enclosures with a wall thickness greater than 3/16 inch, bosses, drilled and tapped with the proper NPT for stuffing tubes, as applicable, shall be provided in the top, bottom or sides of the enclosure. Plastic protective cap-plugs (Ca-Plugs, or equal) shall be installed in cable entrance holes to provide protection during shipment or handling prior to installations.

3.7.2.8.2 Cable entrance plates. When specified (see 6.2.1), the enclosure shall be provided with cable entrance plates capable of preserving the degree of enclosure specified. Space shall be provided inside the enclosure between the stuffing tubes and the terminal boards so that the ships wiring will not be crushed or distorted when the internal sub-assembly is mounted in the enclosure.

3.7.2.8.3 Terminal board accessibility. Access to terminal boards and test points shall not be dependent upon removal of cable entrance plates and cables.

3.7.3 Equipment mounting. The method of equipment mounting shall be as specified in the individual equipment specification (see 6.2.1), and shall conform to one or more of the mounting arragements specified herein.

3.7.3.1 Bulkhead mounting. Equipment intended for bulkhead mounting (except switchboards) shall have mounting pads on the rear surfaces of the enclosure. A minimum of two pads shall be above the center of gravity of the enclosed equipment and additional pad(s) positioned to transmit loads to the supporting structure. Bulkhead mounting shall normally not be used for equipment exceeding 200 pounds.

3.7.3.2 Deck or table mounting. Equipment intended for deck or table mounting shall have mounting features which permit through bolts to be installed perpendicular to the mounting surface and additional features to provide for installing sway brace(s) to the upper rear of the equipment enclosure when necessary for stability.

3.7.3.3 Panel mounting. Equipment intended for front panel mounting shall incorporate a flange for securing the panel in a vertical position in the enclosure. The enclosure shall not project more than 1-1/2 inches from the face of the panel (not including operating handles).

3.7.3.4 Overhead mounting. Equipment enclosures intended for overhead mounting shall be limited to lightweight devices and shall incorporate mounting features so located to suspend the enclosure and to transmit the load to the overhead structure.

3.7.3.5 Through bolting. Unless otherwise specified (see 6.2.1), through bolting or through threading into watertight enclosures will not be permitted. Bosses shall be provided in cast enclosures to preclude through bolting or threading. Blind tapped continuous welded buttons shall be used in sheet metal enclosures.

3.7.3.6 Mounting bolts. Calculations for minimum diameter of deck and bulkhead attachment bolts shall be based on the minimum elastic-proof load for grade 2 carbon and alloy steel as specified in MIL-B-857.

3.7.4 Resilient mounts. Unless otherwise specified (see 6.2.1), resilient mounts shall not be used. When their use is permitted, such mounts shall conform to the requirements of 3.4.8.24 and shall be treated as nonstandard parts. The information required by figure 2 shall be submitted as part of the non-standard parts documentation (see 3.4.3). The correct resilient mounting system shall be determined in accordance with procedures set forth in Naval Ship Research and Development Center Report No. 880. The complete calculation for the mounts selected shall be prepared as specified in the CDRL (see 6.2.2). Test samples may be required at the option of the command or agency concerned. Resilient mounts for equipment requiring low magnetic signature shall be of non-magnetic material. The approved resilient mounts shall be furnished with the equipment.

3.7.4.1 Mounting information plates. Information plates shall be supplied in accordance with type A or B of MIL-P-15024, showing the following information:

(a) For equipment designed for solid mounting, the information plates shall read "Install solidly. Resilient mounts shall not be used."
(b) For equipments which have resilient mounts, the information plates shall state the location and number of mounts required, the load ratings, resonant frequencies, manufacturer's name, date of manufacture, type and Federal stock number. Example: "Resilient Mounts; Bottom, four each, 50 lbs., 48Hz, Back, two each, 30 lbs., 35 Hz, XYZ Company, January 1966, Type 5, FSN 5340-000-0000."

3.7.5 Airborne and structureborne noise. Unless otherwise specified (see 6.2.1), the equipment shall meet the airborne and structureborne noise acceptance limits specified in MIL-STD-740. The grade and type shall be as specified (see 6.2.1).

3.7.6 Magnetic requirements. When specified (see 6.2.1), the equipment shall conform to the magnetic requirements specified herein. Equipment intended for application in ships which have magnetic signature limitations (such as minesweepers) shall also conform to 3.7.6.4.

3.7.6.1 Magnetic characteristics. The equipment shall have a minimum magnetic signature and shall employ no material which has a magnetic permeability greater than 2.0, except for magnetic material absolutely required for the electrical functioning of the equipment.

3.7.6.2 Magnetic shielding. The use of magnetic shielding around individual parts or groups of parts will be permitted when it is necessary to meet the requirements of this specification or the individual equipment specification.

3.7.6.3 Stray magnetic fields. The equipment shall be designed to emanate a minimum stray magnetic field using Publication 0981-052-8140 for guidance.

3.7.6.4 Eddy current magnetism of enclosures. When specified (see 6.2.1), enclosures constructed of electrically continuous conducting material shall conform to the dimensional requirements.

3.7.6.4.1 Skin of enclosures. The skin of enclosures constructed of electrically continuous conductive material shall conform to the requirements shown in table III.

Table III - Dimensions of skin of enclosure.

Conductivity of material (Relative to copper)-percent	Cross sectional area in in^2 1/	Thickness of material (inch)	Limiting area of enclosure FACE (ft^2) 2/
Less than 1/2	Less than 24	Any	No restrictions
Between 1/2 and 10	Less than 24	Less than 0.25	30
Less than 10	Between 24 to 48	Between 0.25 and 1	20
10 and greater	Less than 10	Less than 0.25	12
10 and greater	10 to 48	0.25 to 2	5

1/ Determine cross sectional area by multplying the thickness of the material perpendicular to the FACE by the dimension of the enclosure perpendicular to that FACE.

2/ The FACE of the enclosure is that side having the largest electrically continuous conductive area.

3/ If there are two or more similar enclosures of an equipment that would optimally be installed in one compartment or within 10 feet of each other, these enclosures shall be considered as one item in the following manner:

(a) Use "Area of Face" of largest enclosure under consideration.
(b) The cross sectional area equals the number of enclosures times the cross sectional area for one enclosure, or a thickness equal to the number of enclosures times the thickness of one enclosure.
(c) Either cross section or thickness may be used. Cross section will permit the use of thicker material, in general, depending on the shape of the enclosure.

4/ The limits in footnotes 1, 2, and 3 are for nonrotating items only. The description of rotating items shall be submitted to the command or agency concerned for approval.

3.7.6.4.2 Framework of enclosures. The framework of enclosures constructed of electrically continuous conductive material shall conform to the requirements shown in table IV.

Table IV - Dimensions of framework of enclosures.

Conductivity of material relative to Copper 1/	Cross sectional area (in^2) 2/	Limiting enclosed area (ft^2) 3/
Less than 10	Less than 24	30
Less than 10	Between 24 to 48	20
Less than 10	Between 48 to 100	12
Less than 10	Greater than 100	5
10 and Greater	Less than 10	12
10 and Greater	Between 10 to 48	5
10 and Greater	Greater than 48	2.5

1/ Percentage of conductivity refers to the electrical conductivity of materials relative to copper. Common materials having conductivity less than 10 percent of copper are steel (all types) and nickel-copper-alloy.

Footnotes continued on next page.

2/ For non-uniform cross sectional areas, an equivalent cross sectional area may be used. This equivalent cross sectional area shall be that which will provide the same electrical resistance around the loop as the non-uniform cross sectional area.

3/ The area enclosed by the largest dimensions of the framework shall not exceed the values of this column.

3.7.7 Gears and cams. The design, manufacture and assembly of gears and cam shall be in accordance with requirement 48 of MIL-STD-454.

3.7.7.1 Life expectancy. The life expectancy of gears and cams in terms of hours of equipment operation or number of gear operations shall be as specified (see 6.2.1).

3.7.7.2 Shaft locking devices. Unless otherwise specified (see 6.2.1), positive locking devices shall be used to secure collars, gears, cams, and similar parts to their associated shafts. The shaft locking devices shall be resistant to loosening. Taper pins and set screws shall not be used for gear trains and cams.

3.7.8 Controls, indicators and panel layout.

3.7.8.1 Controls. Controls shall conform to requirement 28 of MIL-STD-454.

3.7.8.2 Illumination. Controls, switches, and dials shall be illuminated by lighting sources integral with associated equipment. All light sources, including indicator lights, shall be dimmer controlled, either singly or in a group, either optically or electrically, from minimum discernible intensity to full brilliance, and shall provide uniform illumination. Dials and other displays shall be readable in all levels of illumination from 28 footcandles (fc) (white), to 0.03 fc (red) of incident illumination. Where the observation of an object or surface is critical to the operation of equipment, the illumination shall be from two or more sources.

3.7.8.3 Panel illumination. When panel illumination is specified (see 6.2.1), integrally illuminated panels shall be in accordance with MIL-P-7788. If the two-piece panel system is used, it shall be in accordance with type VII of MIL-P-7788.

3.7.8.4 Dial lamps. Dial lamps shall be energized from the secondary of a transformer and the lighting circuit shall be equipped with a rheostat, or other control device, to vary light intensity from maximum value to minimum discernible intensity when all lamps, or 50 percent of the lamps are operative. At 115 volts input to the transformer and with all lamps operative, the lamp socket voltages shall not exceed the values as shown in MS-15571. Dial lamps shall not be connected in series.

3.7.8.5 Design for dark adapted areas. When specified (see 6.2.1), equipment shall be designed for use in dark adapted areas. Indicators shall use clear lamps with red filters and stencil type marker discs. Light globes shall use red transparent, heat resistant acrylic plastic material having transmission characteristics that essentially follow the curve of fixture X (curve of light transmission of red material shown on sheet 103 of Drawing 9000-S6405-74222). There shall be no bright reflective surfaces visible to the operator.

3.7.8.6 Selection of color for indicating and display. Unless otherwise specified (see 6.2.1), the selection of colors for indicating and display shall conform to MIL-STD-1472.

3.7.8.7 Dials and pointers for units having self-contained red illumination. Dials and pointers for units having self-contained red illumination shall have dark faces and white numerals, graduations and lettering when viewed under high level ambient illumination and shall present red numerals, graduations and lettering when the internal illumination is energized and viewed under low level ambient illumination. In units having a single indication, the pointer shall have a white border. In units having two concentric indications, distinctive numerals and shapes in addition to a white border shall be as specified (see 6.2.1).

3.7.8.8 Dials and pointers for units not having self-contained illumination. Dials and pointers for units not having self-contained illumination shall have white faces with black numerals, graduations, and lettering. In units having a single indicator, the pointer shall be black. In units having two concentric indicators, the numeral and pointer colors shall be as specified (see 6.2.1).

3.7.8.9 Dial sizes. The size dial markings, dial window openings, and dial windows shall be as specified (see 6.2.1).

3.7.8.10 Dials and pointers. Unless otherwise specified (see 6.2.1), dials and pointers for applications other than tuning (see 3.7.8.11), shall conform to the following requirements. Dials shall be of plastic materials. Pointers shall be of plastic materials for illuminated units and of aluminum for non-illuminated units. The face of the dial with the markings, lettering and graduations shall be placed as close as practicable to the dial window. The dial faces, markings, lettering, graduations and pointers shall have a matte finish. "Order system" dial markings shall be in accordance with Drawing 9000-S6504-73687. The markings shall be free from distortion with clear and sharp edges. The width of the pointer tip shall be the same width as the minimum dial graduations. The pointer shall not cover the graduations to which it refers but shall extend only to the nearer edge of the graduations.

3.7.8.11 Tuning dial mechanisms. Tuning dial mechanisms shall conform to requirement 42 of MIL-STD-454.

3.7.8.12 Windows. Where operating controls are so arranged as to require the reading of dials through windows in the panels or the control housings, the window shall be provided with glass (see 3.4.9.9) secured to the panels by means of clips or other devices. The use of cement alone for securing the glass is not acceptable. Requirements for dial windows for submersible units shall be as specified (see 6.2.1).

3.7.8.13 Panel layout. Panel layout and arrangement shall be subject to review by the command or agency concerned as specified (see 6.2.2) and conform to requirement 28 of MIL-STD-454.

3.7.8.14 Time totalizing meters. The time totalizing meters shall be provided in accordance with requirement 51 of MIL-STD-454 to indicate elapsed time for both standby and operation. Time meters shall not be of the electrochemical type. Circuits to be monitored by the time meters shall be as specified in the individual equipment specification (see 6.2.1).

3.8 Thermal design. The thermal design requirements and criteria shall be in accordance with requirement 52 of MIL-STD-454. The TDC (thermal design conditions) shall be the thermal environment and electrical operating mode(s) specified herein and in the individual equipment specification.

3.8.1 Heat removal methods. The heat removal method selected shall be the simplest and most effective system that will remove 80 percent of the total heat generated within the heat generating circuitry. Publication 0967-437-7010 shall be used as guidance in the design and selection of the cooling method employed.

3.8.1.1 Forced air-cooling. When forced air is used as a cooling method, the inlet to outlet temperature differential shall not exceed 14°C.

3.8.1.2 Water. The requirements and methods for water cooling shall conform to MIL-W-21965 and the interface compatibility requirements of section 101 of MIL-STD-1399.

3.8.1.3 Ventilation openings. Ventilation openings shall be consistent with the degree of enclosure specified in the individual equipment specification and ducting requirement for hazardous atmosphere (see 3.10.11.4).

3.8.1.4 Air filters. When forced air cooling is used, air filters shall be located at all air intakes and shall be readily removable for cleaning without disassembly of the equipment.

3.8.1.5 Cooling during maintenance. Unless otherwise specified (see 6.2.1), equipment containing heat critical parts which may be damaged by excessive heat when a chassis is withdrawn for maintenance and adjustment shall be provided with an integral cooling system to preclude such damage.

3.8.2 Parts application. The operating temperature of heat dissipating and heat sensitive parts shall be within the thermal stress identified in the reliability predication report (see 3.3.3.2) and the part derating requirement of 3.4.6. Heat sensitive parts shall be thermally isolated from heat sources by one or more of the following:

(a) Physical separation.
(b) Use of thermal insulation techniques.

(c) Placement of such parts upstream in the cooling fluid or path, and heat sources downstream.
(d) Maximum use shall be made of conduction techniques to remove heat from heat dissipating parts along short metallic paths of large cross-sectional area to the heat sink or exchanger.

3.8.3 Surface temperature. Temperature of exposed parts, including equipment enclosures, front panels and operating controls that will be a safety hazard to operating and maintenance personnel shall be in accordance with requirement 1 of MIL-STD-454.

3.8.4 Thermal instrumentation. Unless otherwise specified (see 6.2.1), equipment employing forced-air/liquid cooling shall have those temperature, pressure, and flow-rate indicators that are necessary to permit operating and maintenance personnel to determine and evaluate the performance of the heat removal system.

3.8.4.1 Thermal sensor location. Sensing elements shall be installed at appropriate locations inside the equipment to detect abnormal temperatures and operate automatic alarms and protective devices. The number and location of these devices shall be such that failure of any portion of the heat removal system will be detected.

3.8.4.2 Automatic shutdown. Unless otherwise specified (see 6.2.1) each unit containing heat sensitive parts shall be provided with automatic shutdown device(s) which shall, when the maximum thermal stress is reached, automatically shut off operating power to the unit and other units which would be damaged by the shutdown. This automatic shutdown shall not cut off power to the thermal indicator(s) and internal cooling devices such as fans and pumps. A positive action switch (battle short) shall be provided for manually overriding the automatic shutdown feature.

3.8.5 Thermal survey. Unless otherwise specified (see 6.2.1), a thermal survey to measure and record all thermal data shall be performed on those parts dissipating 1 percent, or more, of the total power dissipation of the unit in which the part is located and to ensure that heat sensitive parts as specified in the individual equipment specification (see 6.2.1) are within the thermal stress identified in the reliability prediction report and the part derating requirement. The thermal data shall include but not be limited to the actual operating temperature of the part and any visible evidence of deterioration of the equipment.

3.8.5.1 Survey conditions. The survey shall be made on equipment under the following conditions:

(a) Maximum operating temperature range as specified in the individual equipment specification (see 3.3.5.1).
(b) Operating mode(s) which will cause the maximum steady state power dissipation.
(c) Continuous equipment operation for a time span that will achieve thermal stabilization.
(d) Cooling system operational, if other than natural methods.
(e) Equipment cabinets closed.

3.8.5.2 Proper techniques. Proper techniques such as thermocouples, infra-red photography, chemicals or calibrated thermal sensitive materials that will accurately measure temperatures shall be utilized in the survey. The method used to measure temperatures shall not affect the accuracy of the measurement as a result of the "Heat Sink" effect or for any other reason.

3.9 Identification and marking.

3.9.1 Nomenclature (item name and type designation). Unless otherwise specified (see 6.2.1), item names and type designations of the equipment shall be established in accordance with requirement 34 of MIL-STD-454.

3.9.2 Serial numbers. Unless otherwise specified (see 6.2.1), serial numbers are required for each item level of the equipment to which an identification plate is to be applied and shall comply with the requirements of MIL-E-21981.

3.9.3 Request for nomenclature and serialization. Request for nomenclature and serialization shall be in accordance with MIL-E-21981 and shall be prepared as specified in the CDRL (see 6.2.2).

3.9.4 Marking. Marking of the equipment and items thereof shall conform to requirement 67 of MIL-STD-454 and as specified herein. Unless otherwise specified (see 6.2.1), marking shall conform to the normal service requirements of MIL-P-15024/5.

3.9.4.1 Material. The material selected for identification/information plates and their fastening device(s) shall be compatible with the material of the item on which the plate is mounted.

3.9.4.2 Mounting and location. Identification plates and information plates shall be mounted in a conspicuous space generally on the front panel of the item level to which it applies. When space does not permit mounting the plate on the front or front panel, they may be mounted externally or internally in locations easily accessible and the Government assigned identification and serial numbers shall be permanently marked on the front panel.

3.9.4.3 Adhesive backed identification plates. Unless otherwise specified (see 6.2.1), adhesive backed identification plates type G of MIL-P-15024 shall not be used.

3.9.4.4 Conductor identification. Conductor identification shall be in accordance with requirement 20 of MIL-STD-454. All non-insulated wire leads in excess of 4 inches shall be color coded by means of colored lacquer spotted near terminals, except when the leads terminate at marked terminals or when the terminal designations and the placement of the leads provide easy lead identification.

3.9.4.5 Terminal end identification. The ends of all conductors which terminate in lugs shall be clearly and permanently marked with the conductor identification. Markings shall be made on white synthetic resin tubing conforming to type F, grade a, form U, class I of MIL-I-631 or on polyvinyl chloride pressure sensitive adhesive marking tape. All wire markings shall be clearly visible in the assembled equipment. The tape markers shall be tightly wrapped with at least two turns around the wire.

3.9.5 Labeling. Labeling on equipment shall conform to MIL-STD-1472.

3.10 System Safety program. When specified in the individual equipment specification (see 6.2.1), the contractor shall develop and maintain an effective system safety program that is planned and integrated into all phases of design, production, and testing of the equipment. The system safety program shall provide a disciplined approach to identify hazards and prescribe corrective actions in a timely cost effective manner. The system safety program tasks shall be specified in a formal plan (System Safety Program Plan). The plan shall include requirements to be imposed on each subcontractor to assure compatibility with the system safety program for the equipment. MIL-STD-882 shall be used as guidance for preparing the System Safety Program Plan (SSPP) as specified (see 6.2.2).

3.10.1 Safety testing. Tests shall be proposed in the SSPP to validate the safety of the equipment.

3.10.2 Integration of associated disciplines. The contractor shall indicate in the SSPP how safety will interface with other disciplines in order to prevent duplication of effort.

3.10.3 Design review. Safety shall be an integral part of all design reviews held for all the equipment, subsystems, and parts. The contractor shall conduct system safety program reviews. Where possible, the system safety program reviews shall be conducted as part of the overall program review to assess the status of compliance with the overall safety objectives. This review shall identify any deficiencies of the system with respect to safety and provide guidance for further analysis or design effort which may be required. Qualified contractor system safety personnel shall attend these design reviews. The command or agency concerned shall be notified prior to each system safety program review, to permit participation by a representative of the command or agency concerned. A summary of the safety design review shall be prepared as specified (see 6.2.2).

3.10.4 System safety criteria and considerations. The equipment design and operational procedures developed by the contractor shall consider, but not be limited to the following:

(a) Avoiding, eliminating, or reducing identified hazards by analysis, design selection, material selection, or substitution.
(b) Controlling and minimizing hazards to personnel, equipment, and material which cannot be avoided or eliminated.

(c) Isolating hazardous substances, parts, and operations from other activities, areas, personnel, and incompatible materials.
(d) Incorporating "fail-safe" principles where failures would disable the system or cause a catastrophe through injury to personnel or damage to equipment.
(e) Locating equipment parts so that access to them by personnel during operation, maintenance, repair, or adjustment shall not require exposure to hazards such as chemical burns, electrical shock, cutting edges, sharp points, or toxic atmospheres.
(f) Avoiding undue exposure of personnel to physiological and psychological stresses which might cause errors leading to mishaps.
(g) Providing warning and caution notes in operations, assembly, maintenance, and repair instructions; and distinctive markings on hazardous parts, equipment, or facilities for personnel protection.
(h) Minimizing damage or injury to personnel and equipment in the event of an accident.

3.10.5 System safety precedence. Actions for satisfying safety requirements in order of precedence are specified hereinafter. However, a lower level action shall not be taken unless the higher level action is not possible or practical:

(a) Design for minimum hazard
(b) Safety devices
(c) Warning devices
(d) Special procedures

3.10.6 System safety check list. A system safety check list shall be prepared as specified (see 6.2.2). The system safety check list is a formal means of providing assurance that all required and identified safety requirements that minimize, control or eliminate hazards have been incorporated in the system or equipment design and as-built hardware and verified by review, test, or other method approved by the command or agency concerned.

3.10.7 Safety analyses. Safety analyses shall be performed to identify hazardous conditions for the purpose of their elimination or control. Analyses shall be made to examine the equipment, subsystems, parts and their interrelationship to include logistic support, training, maintenance and operational environments.

3.10.8 Conceptual safety analysis (CSA). As an initial effort, a CSA shall be performed for the system. This analysis shall be a comprehensive, qualitative study. Areas to be considered shall include, but are not limited to the following:

(a) System environmental constraints.
(b) Compatibility of materials.
(c) Design of critical controls to prevent inadvertent activation and employment of electrical interlocks.
(d) Safe operation and maintenance of the system.
(e) Training and certification pertaining to safe operation and maintenance of the system.
(f) Life support requirements and their safety implications.
(g) Fire ignition and propagation sources and protection.
(h) Fail safe design considerations.
(i) Protective clothing, equipment, or devices.

3.10.9 Design safety analysis (DSA). The contractor shall conduct a design safety analysis for the equipment. This shall be an expansion of the conceptual safety analysis. It shall be performed to determine from a safety consideration, the functional and interface relationships of parts and equipment comprising the system.

3.10.10 Functional safety analyses. Analyses shall be performed to identify activities or operations which can, by their inherent nature, lead to a situation containing a potential for injury to personnel or damage to equipment. The areas of the analyses shall include but not be limited to the following:

(a) Specific safety installation requirements.
(b) Specific safety testing requirements.
(c) Specific operating requirements.

(d) Specific safety supervision.
(e) Specific safety handling requirements.
(f) Safety training requirements.

CSA, DSA, engineering data, procedures and instructions developed from the engineering design shall be used in support of this effort.

3.10.11 Safety criteria. Equipment shall be designed and constructed in a way that will ensure safety to operating and maintenance personnel. External moving parts which are a potential hazard to personnel shall be avoided wherever practicable. When their use is unavoidable, positive protection in the form of a guard shall be provided. Sharp corners and projections which may cause injury in a rough sea or on which clothing may catch shall be avoided. The following are some of the known safety criteria that apply, others are contained in documents such as MIL-STD-454, and 3.10.11.1 through 3.10.11.6. The unknown safety criteria are those that are developed as a result of safety analyses. All safety criteria shall be included in the system safety check list (see 3.10.6).

3.10.11.1 Safety (personnel hazard). Safety (personnel hazard) shall conform to requirement 1 of MIL-STD-454 and as specified herein.

3.10.11.2 Safety ground. A safety ground shall be included in all power cable assemblies that utilize convenience outlets as a source for primary power. The safety ground shall be accomplished by utilizing: three pin connectors, three conductor cables, having one black, one white and one green color coded conductors. The green wire whall be connected to the grounding blade or pin "B" for the type connector used. Input power cable assemblies shall be fabricated in accordance with 3.4.8.4.1.

3.10.11.3 Interlock indicator. Interlocks shall have an indicator (illuminated jewel or globe), located in a position clearly visible to personnel, on the chassis co-related with the safety interlock to indicate that it has been disabled.

3.10.11.4 Hazardous atmosphere. When specified in the individual equipment specification (see 6.2.1), the equipment, or portions thereof exposed to an environment with a hazardous atmospheric mixture (see 6.3.3), the equipment, or portions thereof, shall be protected by one of the following methods:

(a) Enclosed in a heavy-duty, explosion-proof housing as defined by MIL-STD-108.
(b) Hermetically sealed conforming to the hermetic enclosure requirement of MIL-STD-108.
(c) Embedded (potted).
(d) Provided with pressurized ventilation ducting which prevents the hazardous atmosphere from coming in contact with the sparking mechanism.

3.10.11.5 Reference/signal voltages. Unless otherwise specified (see 6.2.1), equipment utilizing external reference/signal voltages in excess of 30 V, shall have the provision for interrupting the reference/signal voltages during maintenance actions.

3.10.11.6 Leakage current (equipment). When practicable, the leakage current of the equipment shall not exceed 5 mA to ground, whether or not such equipment contains radio interference filters or capacitors. On equipments which have an unavoidable leakage current in excess of 5 mA, a warning plate shall be attached to the front panel reading:

"DANGER - Do not energize this equipment unless frame and all exposed metal parts are grounded."

3.11 Workmanship. Workmanship shall conform to requirement 9 of MIL-STD-454.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Contractor's quality control system. The supplier shall provide and maintain an effective quality control system acceptable to the Government covering the supplies and services being procured. Unless otherwise specified (see 6.2.1), the quality program shall be in accordance with MIL-Q-9858 and when specified, a quality assurance plan shall be prepared as specified (see 6.2.2).

4.1.2 Government verification. All quality assurance operations performed by the supplier will be subject to Government verification at any time. Verification will consist of (a) surveillance of the operations to determine that practice, methods, and procedures of the written system are being properly applied, (b) Government product inspection to measure quality of product to be offered for acceptance, and (c) Government inspection of delivered items to assure compliance with this specification and as specified in the contract or order (not excluding any requirement of the specification for which detailed tests are not specified herein).

4.2 Classification of inspection. The methods of inspection fall within the following classifications

(a) First article inspection
(b) Quality conformance inspection
(1) Production inspection (Group A)
(2) Production control inspection (Group B)
(3) Environmental inspection (Group C)

4.2.1 First article inspection. The item(s) designated for first article inspection as specified (see 6.2), shall be subjected to all examination and tests necessary to determine compliance with this specification and the individual equipment specification. Unless otherwise specified (see 6.2.1), first article inspection shall include examination and test shown in table V and shall be performed as approved in accordance with 4.3.

4.2.2 Quality conformance inspection.

4.2.2.1 Production inspection (group A). Unless otherwise specified (see 6.2.1), production inspection shall be made on every item offered for delivery. This inspection shall comprise such examination and tests which will prove the workmanship and reveal omissions and errors of the production process such as, functional and performance test at a limited number of points in the required range, tests which detect deviations from design, tests of controls/adjustments, and tests which detect hidden defects of materials. Unless otherwise specified (see 6.2.1), production inspection shall include the examination and tests shown in group A of table V and shall be performed as approved in accordance with 4.3.

4.2.2.2 Production control inspection (group B). Production control inspection shall be conducted on a sampling basis as specified (see 6.2.1). This inspection shall consist of the examination and tests which encompass functional and performance tests throughout the entire range of operation; tests which will detect any deterioration of the design by wear of such items as dies, molds, and jigs, and by substitution of different parts; tests which detect deviations in the processing of the materials; tests to determine temperature rise produced in operation and ability of equipment to withstand this heat; tests of efficiency; and tests of the performance with other equipment in a system. These tests shall be performed on the complete equipment as offered for delivery. Unless otherwise specified (see 6.2.1), production control inspection shall include the examination and tests shown in group B of table V and shall be performed as approved in accordance with 4.3.

4.2.2.3 Environmental inspection (group C). Environmental inspection shall be conducted on a sampling basis as specified (see 6.2.1). This inspection shall encompass environmental tests to prove the durability of the materials, parts, units, and the equipment as a whole; life tests, simulated service tests; test of the effects of changes of environment (such as extremes of temperature and humidity, effect of salt air); and tests of the effects of shock, vibration and inclination. Unless otherwise specified (see 6.2.1), environmental inspection shall include the examination and tests shown in group C of table V and performed as approved in accordance with 4.3.

4.3 Examination and test plan. The supplier shall submit a written examination and test plan which contains the procedures, data forms, a list of test equipment to be used and the sequence of tests for performing first article and quality conformance inspection to the command or agency concerned via the Government inspector for approval prior to beginning inspection as specified in the CDRL (see 6.2.2). Examination and tests shall be identified in accordance with 4.2.

Table V - Examination and tests.

Subject	Requirement	Test method	First article	Quality conformance inspection		
				Group (A)	Group (B)	Group (C)
Surface examination		4.8				
Weight	3.3.2.1	4.8.1(a)	X	X		
Size	3.3.2.2	4.8.1(b)	X	X		
Parts and materials	3.4	4.8.1(c)	X	X		
Finish	3.4.11.3	4.8.1(d)	X	X		
Marking	3.9	4.8.1(e)	X	X		
Safety	3.10	4.8.1(f)	X	X		
Workmanship	3.11	4.8.1(g)	X	X		
Pre-performance		4.7.2	X	X		
Performance	3.3.1	4.8.2	X	X		
Temperature						
Sequence	3.3.5	4.8.3.1	X		X	X
Low temperature	3.3.5.2.1 and 3.3.5.2.2	4.8.3.2	X		X	X
High temperature	3.3.5.2.1 and 3.3.5.2.2	4.8.3.3	X		X	X
Humidity	3.3.5.3	4.8.3.4	X			X
Salt fog	3.3.5.4	4.8.3.5	X			X
Sunshine	3.3.5.5	4.8.3.6	X		X	
Fungus	3.3.5.6	4.8.3.7	X			
Wind velocity	3.3.5.7	4.8.3.8	X			
Icing	3.3.5.8	4.8.3.9	X			
Hydrostatic pressure	3.3.5.9	4.8.3.10	X			
Underwater explosion	3.3.5.10	4.8.3.11	X			
Gunblast	3.3.5.11	4.8.3.12	X			
Nuclear air blast	3.3.5.12	4.8.3.13	X			
Shock	3.3.5.13	4.8.3.14	X			X
Vibration	3.3.5.14	4.8.3.15	X			X
Inclination	3.3.5.15	4.8.3.16	X			X
Magnetic field environment	3.3.5.16	4.8.3.17	X			X
Structural integrity	3.7.2.3	4.8.4.1	X			
Airborne and structureborne noise	3.7.5	4.8.4.2	X			X
Enclosure	3.7.2.1	4.8.4.3	X		X	
Magnetic	3.7.6.1	4.8.4.4	X		X	
Weld	3.4.11.5 and 3.4.11.6	4.8.4.5	X		X	
Steady state voltage and frequency	3.5.1	4.8.5.1	X		X	
Transient voltage	3.5.1	4.8.5.2	X			
Transient frequency	3.5.1	4.8.5.3	X			
Spike voltage	3.5.1	4.8.5.4	X			
Power interruption	3.5.1	4.8.5.5	X		X	
Power and power factor	3.5.1	4.8.5.6	X		X	
Insulation resistance	3.5.3.2	4.8.5.7	X		X	
Corona measurement	3.5.3	4.8.5.8	X			
Leakage current	3.10.5	4.8.5.9	X			
Dielectric withstanding voltage	3.5.3.1	4.8.5.10	X		X	
Electromagnetic interference	3.5.4	4.8.6.1	X			
		4.8.6.2			X	
		4.8.6.3			X	
Thermal design	3.8	4.8.7.1	X		X	
Water cooling	3.8.1.2	4.8.7.2	X		X	
Accelerated life	3.3.1.1	4.8.8	X			X
Reliability test and demonstration	3.3.3.1	4.8.9	X			
Maintainability demonstration	3.3.4	4.8.10	X			

4.3.1 Test procedures. Test procedures shall contain step-by-step information for each inspection, test and demonstration to be performed. The test procedures shall include preparation for test, connections, adjustments, measurements, including test parameters and tolerance limits, and disconnection of item under test.

4.3.1.1 Test equipment listing. The test equipment list shall identify the test equipment to be used by name, model, range and accuracy. Special test equipment shall also be listed and identified as to its capability to correctly perform the tests.

4.3.1.2 Test data forms. Test data forms shall be prepared for each of the procedures. These forms shall be organized to indicate the acceptance test limits of the test and the actual readings observed. In addition, the form shall indicate a statement of acceptance or rejection after each test. When test data forms are specified by the referenced specification, they shall be utilized. The form shall contain a signature and date block for certification of the data by the test engineer.

4.4 Test reports.

4.4.1 First article inspection report. A first article inspection report containing results of all tests shall be prepared as specified in the CDRL (see 6.2.2). When the tests are performed in accordance with referenced documents, the test data and test data forms shall comply with these referenced documents.

4.4.2 Quality conformance inspection reports. Quality conformance inspection reports containing the results of all tests performed shall be prepared as specified (see 6.2.2). The report shall list the serial numbers of the equipment tested, and the date tested. When tests are performed in accordance with referenced documents, the test data and test data forms shall comply with these referenced documents.

4.4.3 Failure reporting. Any failure occurring during or as a result of tests specified herein shall be included in the reports of 4.4.1 and 4.4.2, together with the probable cause of failure and corrective action taken.

4.5 Test facilities, chambers, and apparatus. Test facilities, chambers, and apparatus used in conducting the tests specified herein shall be capable of meeting all of the applicable test conditions.

4.5.1 Test chamber.

4.5.1.1 Volume of test chamber. The volume of the test chamber shall be such that the bulk of the item under test will not interfere with the generation and maintenance of applicable test conditions.

4.5.1.2 Heat source. The heat source of the test facility shall be so located that radiant heat will not fall directly on the test item, except where the application of radiant heat is one of the test conditions.

4.5.1.3 Location of temperature sensors. Unless otherwise specified (see 6.2.1), thermocouples or other temperature sensors utilized to determine or control the specified chamber temperature shall be centrally located within the test chamber where possible, or in the return air stream, and shall be baffled or otherwise protected against direct impingement of supply air and against radiation effects.

4.5.2 Accuracy of test apparatus. The accuracy of instruments and test equipment used to control the test parameters, whether located at a Government testing laboratory, at the contractors plant or at an independent testing facility shall satisfy the requirements of MIL-C-45662 for calibration cycle of specific instruments. Records of calibration history shall be maintained and the latest calibration date shall be attached to each test instrument. All instruments and test equipment used in conducting the tests specified herein shall:

(a) Conform to laboratory standards whose calibration is tracable to prime standards at the U.S. National Bureau of Standards;
(b) Have an accuracy of at least one-third the tolerance for the parameters to be measured. In the event of conflict between this accuracy and a requirement for accuracy in any one of the specific test methods, the specific test method shall govern;
(c) Be appropriate for measuring the test parameters.

4.5.3 Stabilization of test temperature. Unless otherwise specified (see 6.2.1), temperature stabilization will have been attained when the temperature of any part of the test item considered to have the longest thermal lag does not change more than 2.0°C (3.6°F) per hour.

4.5.4 Altitude conditions. The equivalent pressure corresponding to altitude may be obtained from U.S. Standard Atomsphere 1962.

4.6 Standard test conditions. Unless otherwise specified herein or in the individual equipment specification (see 6.2.1), all measurements and tests shall be made under the following standard ambient conditions:

(a) Temperature 23° ± 1.4°C (73° ± 2.5°F).
(b) Relative humidity 50 ± 5 percent
(c) Atmospheric pressure 725^{+50}_{-75} mm of mercury (28.5 $^{+2.0}_{-3.0}$ inches of mercury).

4.6.1 Performance measurement. All performance measurements shall be made with instruments of the accuracy specified in 4.5.2.

4.6.2 Tolerance. Unless otherwise specified (see 6.2.1), tolerance of test conditions shall be as follows:

(a) Test chamber.
  (1) Air temperature at the control sensor: ±1.4°C (±2.5°F). Temperature gradient across the cross-sectional area occupied by the test item shall not exceed 0.3°C (0.5°F) per foot in any direction.
  (2) Pressure: When measured by devices such as manometers, ±5 percent or ±1.5 mm (0.059 inches) of mercury, whichever provides the greatest accuracy.
  (3) Relative humidity at the control sensor: ±5 percent.
(b) Other tolerances.
  (1) Vibration amplitude: Sinusoidal, ±10 percent.
  (2) Vibration frequency: ±2 percent, or ±1/2 Hz below 20 Hz.

4.7 Performance of test.

4.7.1 Installation of test item in test facility. The test item shall be installed in the test facility in a manner that will simulate service usage making connections and attaching instrumentation as necessary. Plugs, covers, and inspection plates not used in operation, but used in servicing shall remain in place. When mechanical or electrical connections are not used, the connections normally protected in service shall be adequately covered. For tests where temperature values are controlled, the test chamber shall be at standard ambient conditions when the test item is installed. The test item shall then be operated to determine that no malfunction or damage was caused due to faulty installation or handling. The requirement for operation following installation of the test item in the test facility is applicable only when operation is required during or immediately following exposure to the specific test.

4.7.2 Pre-performance test. Prior to preceding with any of the test methods, the test item shall be operated under the standard ambient conditions (see 4.6) and a record made of all data necessary to determine compliance with required performance. These data shall provide the criteria for checking satisfactory performance of the test item either during or at the conclusion of the test or both, as required.

4.7.3 Performance check during test. When operation of the test item is required during the test exposure, the operation and performance checks shall be of sufficient duration or shall be repeated at appropriate intervals to insure a record of comprehensive comparative data for comparison with data recorded under standard ambient conditions.

4.7.4 Visual examination and failure criteria. When specified herein, the test item shall be visually examined and a record made of any damage or deterioration resulting from the test. If a test chamber is used for the test, a visual examination of the test item within the chamber shall be performed at test conditions, when possible. Upon completion of the test, a visual examination of the test item shall be performed again, after the test item has been returned to standard ambient conditions. Deterioration, corrosion, or change in tolerance limits of any internal or external parts which could in any manner prevent the test item from meeting operational service or maintenance requirements shall provide reason to consider the test item as having failed to withstand the conditions of the test. Leakage or discoloration of impregnating compounds shall be considered damage and cause for rejection

4.8 Test methods.

4.8.1 Surface examination. The equipment shall be examined to ensure compliance with the applicable referenced specifications with respect to:

(a) Weight (see 3.3.2.1).
(b) Size (see 3.3.2.2).
(c) Parts and materials (see 3.4).
(d) Finish (see 3.4.11.3).
(e) Marking (see 3.9).
(f) Safety (see 3.10).
(g) Workmanship (see 3.11).

In the process of examination, the item shall not be disassembled in a manner that will affect the performance, durability or appearance of the item. The examination shall include a check of all operating controls, circuit functions, test provisions and adjustments.

4.8.2 Performance test. The equipment shall be subjected to a performance test including all operating controls to determine compliance with the performance parameters and safety requirements herein and the individual equipment specification.

4.8.3 Environmental tests.

4.8.3.1 Temperature test sequence. Unless otherwise specified (see 6.2.1), the operating and non-operating test sequence shall be as specified herein.

4.8.3.2 Low temperature. The low temperature test shall be in accordance with method 502 of MIL-STD-810, except as follows:

(a) Step 2 - Storage or non-operating temperature shall be minus 62°C $^{+0°C}_{-5°C}$ for a duration of 24 hours.
(b) Step 4:
Temperature range 1: minus 54°C.
Temperature range 2: minus 28°C.
Temperature range 3: minus 40°C.
Temperature range 4: minus 0°C.
(c) The combined duration of Steps 4 and 5 shall be not less than 12 hours, at least 2 of which shall be in the stabilized condition (see 4.5.3) prior to conducting tests.

4.8.3.3 High temperature. The high temperature test shall be in accordance with method 501, procedure I, of MIL-STD-810, except as follows:

(a) Step 4 - Applicable high operating temperature for the range specified in the individual equipment specification (see 3.3.5.1).
(b) The combined duration of steps 4 and 5 shall be not less than 12 hours, at least 6 of which shall be in the stabilized condition (see 4.5.3) prior to conducting tests.
(c) Step 7 - The equipment shall operate for a period of at least 2 hours in the stabilized condition before the step 7 tests are performed.

4.8.3.4 Humidity. Humidity tests shall be in accordance with method 507, procedure IV of MIL-STD-810, except as follows:

(a) Step 5 - Equipment performance measurements for temperature range 3 shall be made at plus 52°C and temperature range 4 at 50°C (122°F).
(b) Step 9 - The equipment shall be carefully examined in detail to detect evidence of physical degradation in accordance with 4.7.4. Blistering of organic coatings shall be a cause for rejection.

4.8.3.5 Salt fog.

4.8.3.5.1 Exposed equipment. The completed equipment or portion thereof exposed to the weather shall be subjected to the salt fog test specified in method 509 of MIL-STD-810.

4.8.3.5.2 Sheltered equipment. The salt fog test specified in method 509 of MIL-STD-810 shall be applied to the finishes and coatings on parts and frame and enclosure structures as finally assembled for use. Sample corner structures and any other critical sections may be used for the test. The test shall not be applied to the complete equipment.

4.8.3.6 Sunshine. The equipment shall be subjected to the sunshine test specified in method 505, procedure II of MIL-STD-810.

4.8.3.7 Fungus. The equipment shall be subjected to the fungus test specified in method 508 of MIL-STD-810.

4.8.3.8 Wind velocity. The equipment shall be subjected to the wind test specified in the individual equipment specification (see 6.2.1).

4.8.3.9 Icing. The equipment shall be tested to determine conformance with 3.3.5.8 as specified in the individual equipment specification (see 6.2.1).

4.8.3.10 Hydrostatic pressure. The equipment shall be tested to determine conformance with 3.3.5.9 as specified in the individual equipment specification (see 6.2.1).

4.8.3.11 Underwater explosion. The equipment shall be subjected to one of the following conditions as specified in the individual equipment specification (see 6.2.1).

4.8.3.11.1 Actual condition. The item shall be mounted in the center of a steel plate having minimum dimensions of 3 feet in height, 3 feet in width and 1/4 inch in thickness. The plate shall be suspended vertically at a depth of 30 feet below the surface of the water. A 55-pound standard TNT charge shall be suspended at a depth of 30 feet below the surface of the water at a distance of 30 feet from the plate, on the same side of the plate as the item being tested, and on a line perpendicular to the face of the plate at the center. The total depth of water shall be in a minimum of 60 feet in the area of the test. The test, consisting of the detonation of the charge, shall be made a total number of four times.

4.8.3.11.2 Simulated condition. The equipment shall be tested using the hydraulic shock machine at the U.S. Naval Shipyard, Portsmouth, New Hampshire. The machine shall be adjusted to requirements specified in the individual equipment specification (see 6.2.1).

4.8.3.12 Gunblast. Gunblast test shall be conducted as a simulated test wherein the item shall be mounted on the carriage of the U.S. Navy simulated gunblast equipment. The front edge of the item shall be positioned in the test plane, and the axis shall be coincident with that of the explosion chamber. The item being tested shall be subjected to 30 rounds of blast at a peak pressure of 9.5 lb/in^2g. For a large item, such as a super-power loudspeaker, where the loudspeaker mouth area exceeds the face area of the explosion chamber (17-1/2 by 17-1/2 inches or 18 inches in diameter), but which employ individual horn assemblies, the area of each of which is less than the face area of the explosion chamber, the item shall be so positioned that the axis of one of the individual horns is coincident with that of the explosion chamber.

4.8.3.13 Nuclear air blast. The equipment shall be tested to determine conformance with 3.3.5.12 as specified in the individual equipment specification (see 6.2.1).

4.8.3.14 Shock. Equipment intended for shipboard installation shall be tested to determine conformance with 3.3.5.13. The equipment shall be energized and fully operating during and after the shock test. The mounting fixture shall be as specified in the individual equipment specification (see 6.2.1). The use of simulated loads such as weights or other rigid dummy masses is not acceptable. The test shall be performed with the normal assemblies and units in their functionally operating positions. For those equipments weighing more than 60,000 pounds, or which, for any other reason cannot be tested to the requirements of MIL-S-901, the design shall be analyzed in accordance with the requirements of the individual equipment specification (see 6.2.1).

4.8.3.15 Vibration. Equipment intended for shipboard installation shall be tested to determine conformance with 3.3.5.14. The equipment shall be energized and fully operating during the test. The use of simulated loads such as weights or other rigid dummy masses is not acceptable. The test shall be performed with the normal assemblies and units in their functionally operating positions. Stand-mounted equipment shall be mounted on the stand for the test. Dials and other indicators of stand-mounted equipment shall be readable throughout the test.

4.8.3.16 Inclination. The equipment shall be subjected to the test limits specified herein. The equipment shall be energized and fully operating during the test.

4.8.3.16.1 Inclination test limits (surface ship installations). The equipment shall be inclined at the rate of five to seven cycles per minute in one plane to angles of 45 degrees on either side of the vertical for a period sufficiently long to determine the characteristics under such motion or for a minimum of 30 minutes. The test shall be repeated with the equipment reoriented 90 degrees to the plane in which it was originally tested. At the conclusion of these cyclic tests, the cyclic motion shall be stopped and the inclination adjusted to an angle of 15 degrees. The equipment shall then be operated for a sufficient period to insure that continuous operation can be maintained. The equipment shall then be rotated through the veritcal to 15 degrees in the opposite direction, and the test for continuous operation shall be repeated.

4.8.3.16.2 Inclination test limits (submarine installations). Equipment intended for submarine installations shall be subjected to the test of 4.8.3.16.1, except that maximum angle shall be 60 degrees.

4.8.3.17 Magnetic field environment test. The equipment shall be located at the center of a coil of sufficient ampere-turn capacity to produce a steady-state and variable magnetic field of 20 oersteds at the center. The field produced by the coil shall be calibrated prior to placing the equipment in the field. Equipment shall be tested for a period sufficiently long to determine the characteristics in constant fields of 0 to 20 oersteds and in a field varying at the rate of 20 oersteds per second, in order to determine compliance with 3.7.6.2. The results of this test shall be recorded and included in the inspection test report (see 4.4).

4.8.4 Mechanical and structural tests.

4.8.4.1 Structural integrity. Equipment enclosures, chassis, or cabinets shall be tested to determine conformance with 3.7.2.3. All such housings shall be tested solidly mounted.

4.8.4.2 Airborne and structureborne noise. The equipment shall be tested to determine compliance with 3.7.5.

4.8.4.3 Enclosure tests. Enclosures shall be subjected to the degree of enclosure tests of MIL-STD-108 to determine conformance with 3.7.2.1 and 3.10.11.4(b). For dripproof enclosures, the actual drip test shall be conducted. For first article inspection, the enclosure test shall be conducted after completion of the vibration, inclination, shock, structural integrity and noise tests, as applicable (if these tests apply for the particular equipment being tested).

4.8.4.3.1 Explosionproof enclosure test. Explosionproof enclosures shall be tested in accordance with procedure I of method 511 of MIL-STD-810.

4.8.4.4 Magnetic test. Equipment shall be checked for compliance with the magnetic requirements (see 3.7.6) using a permeability indicator, low-mu (Go-No-Go), in accordance with MIL-I-17214.

4.8.4.5 Weld test. When specified (see 6.2.1), sample pieces representative of production, and welded on the machines used therefor, shall be tested to destruction to determine conformance with 3.4.11.5.

4.8.5 Electrical tests.

4.8.5.1 Steady state voltage and frequency. The equipment shall be operated for at least 15 minutes in each of the conditions A thru E of table VI. Performance readings shall be measured and recorded for each condition. Failure in any performance parameter shall be cause for rejection.

Table VI - Steady state voltage and frequency.

Condition	Voltage			Frequency		
	Lower limit	Normal	Upper limit	Lower limit	Normal	Upper limit
A (reference condition)		X			X	
B	X			X		
C			X	X		
D			X			X
E	X					X

4.8.5.2 Transient voltage.[2/]

4.8.5.2.1 Upper limit. With the equipment operating in the upper limit of steady state voltage, a transient voltage of plus 18 percent of normal voltage recovering to the steady state voltage within 2 s shall be superimposed. The equipment shall be capable of normal operation following the transient.

4.8.5.2.2 Lower limit. With the equipment operating on the lower limit of steady state voltage, transient voltage of minus 18 percent of normal voltage recovering to the steady state voltage within 2 s shall be superimposed. The equipment shall be capable of normal operation following the transient.

4.8.5.2.3 Transient (700V). In addition to the tests of 4.8.5.2.1 and 4.8.5.2.2, equipment containing transistors or semi-conductor devices shall be subjected to an input supply line transient of 700 V amplitude and 2 ms duration while the equipment is operating at normal supply line voltage and frequency. The equipment shall be capable of normal operation immediately following the transient.

4.8.5.3 Transient frequency.

4.8.5.3.1 Upper limit. With the equipment operating at 5 percent above the normal frequency, the frequency shall be increased by an additional 3 percent, recovering to the steady state frequency (±5 percent of normal) within 2 s. The equipment shall be capable of normal operation following the transient.

4.8.5.3.2 Lower limit. With the equipment operating at 5 percent below the normal frequency, the frequency shall be decreased by an additional 3 percent, recovering to the the steady state frequency (+ percent of normal) within 2 s. The equipment shall be capable of normal operation following the tranient.

4.8.5.4 Spike voltage test.[2/] In addition to the tests of 4.8.5.3.1 and 4.8.5.3.2, the equipment shall be subjected to an input supply line voltage spike of 2500 V positive peak amplitude; the waveshape shall correspond with that of the figure for the "spike voltage (short time transient) wave shape", Section 103 of MIL-STD-1399. This spike shall be impressed at normal supply line voltage and frequency while the equipment is in operation. The equipment shall be capable of normal operation immediately following the test.

4.8.5.5 Power interruption. With the equipment operating within the steady state tolerances of voltage and frequency, the external power supply shall be suddenly interrupted, and after an interval between 3 and 4 s, the power supply, within the steady state tolerances, shall be reapplied. After the equipment has been operated long enough to detect any major performance degradation and to include any recycling time, the power shall be interrupted for an interval of 29 to 30 s. The cycle, consisting of three such interruptions, shall be repeated for a total of four times. During, and as a result of these tests, no damage to the equipment shall be incurred, and any noted effects of power interruption or reapplication shall fall within the performance tolerances of the individual equipment specification. Where an equipment has more than one significant operating mode, the power interruption tests shall be performed in each of the modes.

4.8.5.6 Power and power factor. Measurements of input kVA, power, and power factor shall be made at normal line voltage and frequency on each primary supply line to each unit of the equipment, including each pase of three-phase supplies, under each principal mode of operation of the equipment. During any mode of equipment operation which imposes cyclic or random load changes on the primary supply line, the input power variation shall be measured to determine conformance with the requirements of 3.5.1. The power factors and power inputs measured during these tests shall be recorded and included in the inspection test report.

4.8.5.7 Insulation resistance. The insulation resistance of electrical circuits following the dielectric test specified in 4.8.5.10 shall be not less than 10 megohms at 50 Vdc at a temperature of 23° ± 1.4°C and at a relative humidity of 50 ± 5 percent. All synchros shall be disconnected during this test.

[2/] Applicable test for shipboard ac power source (see 3.5.1.1).

4.8.5.8 Corona measurement test. Unless otherwise specified (see 6.2.1), corona measurement shall be in accordance with procedures outlined in ASTM-D-1868; corona test results shall be included in the inspection test reports.

4.8.5.9 Leakage current. The leakage current between the power line and equipment enclosure shall be measured through a 1500-ohm resistive load at normal power line voltage to determine conformance with 3.10.11.6.

4.8.5.10 Dielectric withstanding voltage test. Dielectric withstanding voltage test between electrical circuits and ground shall be tested with a closely sinusoidal source of 60 Hz, having a capacity of at least 1 kW. Root mean square (rms) values of test voltage shall be as shown in table VII.

Table VII - Rms values of test voltage.

Circuit voltage of equipment tested	RMS value of dielectric test voltage
Less than 60	450
60 to 120	900
Above 120 and less than 240	1200
240 to 480	1500
Above 480	Twice rated voltage plus 1000

Radio interference filters or capacitors having a voltage rating of less than the test voltage specified herein shall be disconnected from the equipment during this test. All synchros shall be disconnected during this test. In dielectric tests, the voltage shall be raised gradually to the specified value and shall be maintained at that value for the periods specified herein. For dielectric tests conducted as part of first article inspection, the test voltage shall be maintained at the specified value for 1 minute + 5 s. For dielectric tests conducted as part of quality conformance inspection the test voltage shall be maintained at the specified value for 5 + 1 s. The dielectric test shall not be applied to electronic/electrical circuitry which uses low voltage parts such as transistors, electrolytic capacitors, diodes and other voltage sensitive parts. Chassis and other removable assemblies shall be removed during the tests. The tests shall be monitored for evidence of disruptive discharge and leakage current as specified in 3.5.3.1.

4.8.6 Electromagnetic interference characteristics.

4.8.6.1 Electromagnetic interference tests, first article. Electromagnetic interference emission and susceptability and self-compatibility tests conducted for first article inspection shall be performed in accordance with MIL-STD-462 or MIL-STD-469, as applicable.

4.8.6.2 Electromagnetic interference tests, quality conformance. Electromagnetic interference emission and susceptibility tests conducted for quality conformance inspection shall include, as a minimum, the following tests of MIL-STD-462:

(a) CEO3.
(b) CEO6, where applicable.
(c) REO2.
(d) RSO3.

(See MIL-STD-461 tables for classes of equipment and test requirements applicable to equipment classes).

4.8.6.3 Very low frequency and low frequency equipments. Unless otherwise specified (see 6.2.1), tests in accordance with methods of CEO1 and REO1 of MIL-STD-462 shall be performed on very low frequency and low frequency equipments, in addition to requirements of 4.8.6.2. When specified in the individual equipment specification (see 6.2.1), tests in accordance with methods CEO1 and REO1 shall be performed on other than very low frequency and low frequency equipments which are to be installed aboard submarines.

4.8.7 Thermal test.

4.8.7.1 Thermal performance test. A thermal performance test shall be conducted to determine conformance with 3.8. The test shall include the measurement and recording of thermal data on the following:

(a) Parts that operate at 75 percent or more of rated value.
(b) Parts that dissipate 10 percent or more of the total power dissipated by the unit in which they are installed.
(c) Surface temperatures of enclosures, front panels and controls.
(d) Inlet and outlet temperature differentials when forced air cooling is utilized.
(e) Cooling system efficiency.

Upon completion of the thermal performance test a visual examination shall be made to detect any evidence of deterioration of the parts and materials used in the equipment.

4.8.7.1.1 Test conditions. The test shall be made on equipment under the following conditions:

(a) Maximum operating temperature of the range as specified in the individual equipment specification (see 3.3.5.1).
(b) Operating mode(s) which will cause the maximum steady state power dissipation.
(c) Continuous equipment operation for a time span that will achieve thermal stabilization (see 4.5.3).
(d) Cooling system operational, if other than natural methods.
(e) Equipment cabinets closed.

4.8.7.1.2 Proper techniques. Proper techniques such as thermocouples, infra-red photography, chemicals or calibrated thermal sensitive materials that will measure temperatures shall be utilized in the test. The method used to measure temperatures shall not affect the accuracy of the measurement as a result of the "Heat Sink" effect or for any other reason.

4.8.7.1.3 Thermal performance test report. Thermal performance test data shall be reported as specified (see 6.2.2).

4.8.7.2 Water cooling. When water is used as a cooling method, the equipment shall also be subjected to the water cooling tests specified in MIL-W-21965. If at any time during the 8 hour period of the emergency cooling test, the internal equipment temperature exceeds the safe operating temperature, the test shall be terminated and the equipment shall be considered to have failed the test.

4.8.8 Accelerated life tests. Unless otherwise specified (see 6.2.1), accelerated life tests shall be performed for a period of 360 hours as specified herein to determine compliance with specified performance parameters (see 3.3.1.1).

4.8.8.1 Standard test conditions.

(a) Equipment set up in a temperature-controlled chamber at 25° ± 5°C and relative humidity of 50 ± 5 percent.
(b) Equipment energized and operating with:
  (1) Normal line voltage and frequency specified.
  (2) Cooling system in normal operation.
  (3) Fully operational for a period of 2 hours.
(c) When equipment internal temperature has stabilized, performance parameters shall be measured and recorded as "reference test data" for comparison with subsequent tests.

4.8.8.2 Temperature cycling conditions.

(a) Reduce chamber temperature, at a uniform rate in not less than 4 hours to the lowest operating temperature of the range specified.
(b) Maintain chamber temperature at the lowest operating temperature of the range for a period of 10 hours.
(c) Near the end of the 10 hour period, measure and record the performance parameters.
(d) Increase chamber temperature, at a uniform rate in not less than 6 hours, to the highest operating temperature of the range specified and relative humidity at 50 ± 5 percent.

(e) Maintain chamber temperature at the highest operating temperature of the range specified for a period of 8 hours.
(f) Near the end of the 8 hour period, measure and record the performance parameters.
(g) Reduce chamber temperature, at a uniform rate in not less than 6 hours, to the lowest operating temperature of the range specified.
(h) Maintain chamber temperature at the lowest operating temperature of the range specified for a period of 2 hours.

4.8.8.3 Voltage/frequency cycling conditions.

(a) After completion of the 2 hour low temperature conditioning period specified in 4.8.8.2(h), decrease the input voltage to 90 percent of normal value.
(b) Operate for a period of 1 hour and record performance parameters.
(c) Return input voltage to normal value. Decrease input frequency to 95 percent of normal value.
(d) Operate for a period of 1 hour and record performance parameters.
(e) Return input frequency to normal value.
(f) Increase temperature 25° ± 5°C and relative humidity at 50 ± 5 percent. Maintain this condition for a period of 2 hours.
(g) With equipment operating at 25° ± 5°C and relative humidity at 50 ± 5 percent, decrease input voltage to 90 percent and frequency to 95 percent of normal value. Maintain this condition for a period of 1 hour and record performance parameters.
(h) Repeat 4.8.8.3(g) with input voltage at 110 percent and frequency at 95 percent of normal value.
(i) Repeat 4.8.8.3(g) with input voltage at 110 percent and frequency at 105 percent of normal value.
(j) Repeat 4.8.8.3(g) with input voltage at 90 percent and frequency at 105 percent of normal value.
(k) Repeat uniform temperature rise test 4.8.8.2(d).
(l) Record performance parameters at the end of the uniform temperature rise test of 4.8.8.3(k).
(m) With equipment operating at highest operating temperature of the range and relative humidity of 50 ± 5 percent, increase input voltage to 110 percent of normal value, maintaining frequency at 105 percent of normal value.
(n) Operate for a period of 8 hours and record performance parameters.
(o) Maintain voltage/frequency conditions of 4.8.8.3(m) but increase relative humidity to 95 ± 5 percent.
(p) Operate for a period of 2 hours and record performance parameters.
(q) Maintain frequency at 105 percent of normal value and relative humidity at 95 ± 5 percent, but decrease input voltage to 90 percent of normal value.
(r) Operate for a period of 1 hour and record performance parameters.
(s) Maintain high temperature and humidity conditions but return input voltage and frequency to normal value.
(t) Operate for a period of 1 hour and record performance parameters.
(u) Repeat high temperature voltage/frequency cycling tests of 4.8.8.3(o) through (t) for not less than 59 cycles.
(v) Repeat high temperature voltage/frequency cycling test of 4.8.8.3(o) through (t) with relative humidity of 15 ± 5 percent for not less than 15 cycles.

4.8.8.4 Acceptance or rejection. Acceptance or rejection of the equipment shall be in accordance with 4.7.4 and as specified herein.

4.8.8.4.1 Failure. Failure shall be defined as any malfunction or parameter deviation that prevents the equipment from performing within the operational requirements set forth in the individual equipment specification. All failures shall be considered relevant, unless determined by the procuring activity to be caused by a condition external to the equipment under test which is not a test requirement and not encountered in service. Only relevant failures shall be counted during the accelerated life test for an accept or reject decision. All failures shall be analyzed and a failure analysis shall be prepared in accordance with 4.4.3.

4.8.8.4.2 Rejected equipment. When equipment has been rejected as a result of the accelerated life test, the equipment shall be reworked as necessary, reinspected and retested.

4.8.9 Reliability test and demonstration. Reliability test and demonstration shall be as specified in the individual equipment specification (see 6.2.1).

4.8.10 Maintainability demonstration. The maintainability requirements specified in 3.3.4 shall be demonstrated as specified in the individual equipment specification (see 6.2.1).

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery shall be as specified in the individual equipment specification (see 6.2.1).

6. NOTES

6.1 Intended use. This specification is intended to incorporate those general requirements which are common in the procurement of electronic, interior communication and navigation equipment intended for Naval ship or shore applications. The general requirements for airborne electronics equipment are covered in MIL-E-5400.

6.2 Ordering data. Procurement documents shall specify the following:

(a) Title, number and date of this specification.
(b) Title, number and date of equipment specification.
(c) First article sample and quantity required (see 3.2 and 4.2.1).

6.2.1 Guidance for equipment specification. Since this specification is general in scope, attention is invited to the items listed herein which should be considered in the preparation of equipment specifications:

(a) First article requirements, if other than specified (see 3.2).
(b) Performance requirements to be specified (see 3.3.1).
(c) Physical characteristics to be specified (see 3.3.2).
(d) Weight limits to be specified (see 3.3.2.1).
(e) Size if other than specified (see 3.3.2.2).
(f) Size for shore installation (see 3.3.2.2.4).
(g) Requirement to use modular construction if other than specified (see 3.3.2.3).
(h) Compliance to Standard Hardware Program Module requirements of MIL-STD-1378 if other than specified (see 3.3.2.3).
(i) Reliability requirements expressed in MTBF, MCBF or other (see 3.3.3.1).
(j) Reliability prediction if other than specified (see 3.3.3.2).
(k) Maintainability requirements expressed in MTTR, ERT or other (see 3.3.4.1).
(l) Maintainability prediction if other than specified (see 3.3.4.2).
(m) Identification of the equipment, or portions thereof to be utilized in sheltered or exposed areas (see 3.3.5).
(n) Operating temperature ranges (see 3.3.5.1).
(o) Non-operating temperature ranges if other than specified (see 3.3.5.2).
(p) If the salt spray requirement for exposed and sheltered equipment is applicable (see 3.3.5.4).
(q) Quantitative value for hydrostatic pressure (see 3.3.5.9).
(r) If underwater explosion requirement applies (see 3.3.5.10).
(s) Gunblast requirements, if applicable (see 3.3.5.11).
(t) Nuclear air blast requirements, if applicable (see 3.3.5.12).
(u) Quantitative value for nuclear air blast and method of verification (see 3.3.5.12).
(v) Shock requirements, if other than specified (see 3.3.5.13).
(w) Vibration requirements other than specified (see 3.3.5.14).
(x) Inclination angle (see 3.3.5.15).
(y) Inclination requirements, other than specified (see 3.3.5.15).
(z) Battery use restriction, if other than specified (see 3.4.8.1).
(aa) Sleeve-type bearings use restriction if other than specified (see 3.4.8.2.1).
(bb) Noise tested bearings, if other than specified by MIL-B-17931 (see 3.4.8.2.2).
(cc) Paper or paper-plastic fixed capacitors with non-metallic case use restrictions if other than specified (see 3.4.8.7.2).
(dd) Crimp style connectors if other than specified (see 3.4.8.10.6).
(ee) Tinsel cordage, if other than specified by MIL-C-3849 (see 3.4.8.11).
(ff) Fuses and fuseholders, if other than specified (see 3.4.8.17).
(gg) Rotary servo devices, if other than specified (see 3.4.8.26).
(hh) When encapsulation and embedment is required (see 3.4.9.3).
(ii) Dissimilar metals requirement, if other than specified (see 3.4.9.13.2).

(jj) Corrosion-resisting treatments if other than specified (see 3.4.11.2).
(kk) Painting of exposed equipment if other than specified (see 3.4.11.3.2).
(ll) Welding techniques for electrical connections if other than specified (see 3.4.11.6).
(mm) Electrical power characteristics if other than specified (see 3.5.1).
(nn) Blown fuse indicators if other than specified (see 3.5.2.1).
(oo) Electrical circuits required to withstand dielectric withstanding voltage test (see 3.5.3.1).
(pp) Electrical circuits required to withstand insulation resistance test (see 3.5.3.2).
(qq) EMI class and sub-class designations of MIL-STD-461 to be specified (see 3.5.4.1).
(rr) Leakage current for 220 volt 50 and 60 Hz and 115 volt, 50 Hz equipment (see 3.5.5).
(ss) Type of snychros to be used and the load impedance (see 3.5.9).
(tt) Computing of synchro capacitor values if other than specified (see 3.5.9.1.1).
(uu) Electrical and mechanical zero if other than specified (see 3.5.9.3).
(vv) Maintenance design if other than specified (see 3.6).
(ww) Test capability and class of test provisions required (see 3.6.1).
(xx) Preferred test equipment list to be used (see 3.6.2).
(yy) Test cables if other than specified (see 3.6.4).
(zz) Accessibility if other than specified (see 3.6.6).
(aaa) Degree of enclosure required for equipment exposed to weather if other than watertight (see 3.7.2.1).
(bbb) Other degree of enclosures, if required (see 3.7.2.1).
(ccc) Extraneous light prevention if other than specified (see 3.7.2.2).
(ddd) Structural integrity if other than specified (see 3.7.2.3).
(eee) Method of external connections (see 3.7.2.8).
(fff) Location of external connections if other than specified (see 3.7.2.8).
(ggg) Requirement to provide cable entrance plates (see 3.7.2.8.2).
(hhh) Method of equipment mounting (see 3.7.3).
(iii) Through bolting restriction if other than specified (see 3.7.3.5).
(jjj) Resilient mount use if other than specified (see 3.7.4).
(kkk) Airborne and structureborne noise limits if other than specified (see 3.7.5).
(lll) Grade and type of noise limits of MIL-STD-740 (see 3.7.5).
(mmm) When conformance to magnetic requirements is required (see 3.7.6).
(nnn) Eddy current magnetism of enclosures dimensional requirements when specified (see 3.7.6.4).
(ooo) Quantitative values for life expectancy of cams and gears (see 3.7.7.1).
(ppp) Shaft locking devices other than specified (see 3.7.7.2).
(qqq) When panel illumination is required (see 3.7.8.3).
(rrr) When equipment is for use in dark adapted areas (see 3.7.8.5).
(sss) Colors for indicating and display if other than specified (see 3.7.8.6).
(ttt) Numerals and shapes of dials and pointers for units having self-contained red illumination with two concentric indications (see 3.7.8.7).
(uuu) Numeral and pointer colors for dials having two concentric indicators and not having self-contained illumination (see 3.7.8.8).
(vvv) Dial sizes (see 3.7.8.9).
(www) Dials and pointers if other than specified (see 3.7.8.10).
(xxx) Requirements for dial windows in submersible units (see 3.7.8.12).
(yyy) Circuits to be monitored by time meters (see 3.7.8.14).
(zzz) Cooling during maintenance if other than specified (see 3.8.1.5).
(aaaa) Thermal instrumentation if other than specified (see 3.8.4).
(bbbb) Automatic shutdown if other than specified (see 3.8.4.2).
(cccc) Nomenclature if other than specified (see 3.9.1).
(dddd) Serial number requirement if other than specified (see 3.9.2).
(eeee) If severe service marking requirement applies (see 3.9.4).
(ffff) Adhesive backed identification plates restriction if other than specified (see 3.9.4.3).
(gggg) If system safety program is required (see 3.10).
(hhhh) When hazardous atmosphere protection is required (see 3.10.11.4).
(iiii) Provisions for interrupting reference/signal voltages if other than specified (see 3.10.11.5).
(jjjj) Quality control system, if other than specified (see 4.1.1).
(kkkk) First article inspection, if other than specified (see 4.2.1).
(llll) Production inspection, if other than specified (see 4.2.2.1).
(mmmm) Production control inspection sampling (see 4.2.2.2).
(nnnn) Production control inspection, if other than specified (see 4.2.2.2).

(oooo) Environmental inspection sampling (see 4.2.2.3).
(pppp) Environmental inspection, if other than specified (see 4.2.2.3).
(qqqq) Location of temperature sensors, if other than specified (see 4.5.1.3).
(rrrr) Stabilizations of test temperature, if other than specified (see 4.5.3).
(ssss) Standard test conditions, if other than specified (see 4.6).
(tttt) Test conditions tolerances, if other than specified (see 4.6.2).
(uuuu) Temperature test sequence, if other than specified (see 4.8.3.1).
(vvvv) Wind velocity test requirements (see 4.8.3.8).
(wwww) Icing test requirements (see 4.8.3.9).
(xxxx) Hydrostatic pressure test requirements (see 4.8.3.9).
(yyyy) Underwater explosion test condition to be conducted (see 4.8.3.11).
(zzzz) Hydraulic shock machine adjustment requirements for underwater explosion test (see 4.8.3.11.2).
(aaaaa) Nuclear air blast test requirements (see 4.8.3.13).
(bbbbb) Mounting fixture for shock test (see 4.8.3.14).
(ccccc) Shock test for equipment weighing over 60,000 pounds (see 4.8.3.14).
(ddddd) When weld tests are to be performed (see 4.8.4.5).
(eeeee) Corona test if other than specified (see 4.8.5.8).
(fffff) Very low and low frequency test if other than specified (see 4.8.6.3).
(ggggg) If methods CE01 and RE01 apply (for equipments intended for submarines) (see 4.8.6.3).
(hhhhh) If accelerated life test is not required (see 4.8.8).
(iiiii) Reliability test and demonstration to be performed (see 4.8.9).
(jjjjj) Maintainability demonstration to be performed (see 4.8.10).
(kkkkk) Preparation for delivery requirements (see 5.1).

6.2.2 Contract data requirements. When this specification is used in a procurement invoking the provisions of the Armed Services Procurement Regulation (ASPR), paragraph covering "requirements for data", and which incorporates a Contract Data Requirements List (CDRL) DD Form 1423, the following data requirements should be specified for delivery on DD Form 1423. When the ASPR provisions are not invoked, the following data should be specified for delivery in the contract or order:

(a) Reliability prediction report (see 3.3.3.2).
(b) Failure modes, effects and criticality analyses (see 3.3.3.3).
(c) Maintainability prediction report (see 3.3.4.2).
(d) Nuclear air blast calculations (see 3.3.5.12.1).
(e) Non-standard item approval (see 3.4.3).
(f) Leakage current calculations (see 3.5.5.3).
(g) Resilient mount calculations (see 3.7.4).
(h) Panel layout drawing (see 3.7.8.13).
(i) Request for nomenclature and serialization (see 3.9.3).
(j) System safety program plan (see 3.10).
(k) Summary of safety design review (see 3.10.3).
(l) System safety check list (see 3.10.6).
(m) Quality assurance plan (see 4.1.1).
(n) Examination and test plan (see 4.3).
(o) First article inspection reports (see 4.4.1).
(p) Quality conformance inspection reports (see 4.4.2).
(q) Thermal performance test report (see 4.8.7.1.3).

6.3 Definitions. For the purpose of this specification, the following definitions shall apply:

6.3.1 Individual equipment specification. An individual equipment specification is the specification defining the detailed characteristics of particular equipment.

6.3.2 Item levels, exchangeability, and models. The terms of item levels, item exchangeability and models shall be as defined in MIL-STD-280 and as specified herein.

6.3.2.1 Equipment. The term equipment is generic and applies to any or all item levels as defined in MIL-STD-280.

6.3.3 Hazardous atmosphere. The term hazardous atmosphere is a vapor or gas mixture with air which, under normal conditions of temperature and pressure, can be ignited by a spark or flame to produce a sustained, self-propagating, combustion wave.

6.4 Superseding data. This specification should be used in lieu of MIL-I-983 for new design interior communication equipment.

6.5 Changes from previous issue. Markings (#) are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Review activities:
Navy - EC, AS, OS
User activity:
Navy - MC

Preparing activity:
Navy - SH
(Project MISC-NA49)

RESILIENT MOUNT DATA SHEET

1. Mount is to be used in _____ (Item Name and Type Designation)

_____

2. List of items and locations where mounts will be used:

3. Prime contractor _____

4. Contract No. and date _____

5. Subcontractor (if applicable) _____

6. Description of mount: (Detailed technical description) if other than standard Navy resilient mount, submit report showing conformance to the test procedures of MIL-M-17185.

7. Contractor's drawing No. and part No. _____

8. Actual Manufacturer and his part No. _____

9. Previously approved to _____ for use in _____

10. Requester's signature _____ Date _____

Title _____ Company _____

11. Government inspector's endorsement:

Signature _____ Date _____

Figure 2 - Resilient Mount Data Sheet.

Index

INDEX (con.)

INDEX (con.)

INDEX (con.)

INDEX (con.)

INDEX (con.)

INDEX (con.)

INDEX (con.)

INDEX (con.)

INDEX (con.)

INDEX (con.)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

OMB Approval
No. 22-R255

INSTRUCTIONS: The purpose of this form is to solicit beneficial comments which will help achieve procurement of suitable products at reasonable cost and minimum delay, or will otherwise enhance use of the document. DoD contractors, government activities, or manufacturers/vendors who are prospective suppliers of the product are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments submitted on this form do not *constitute or imply authorization* to waive any portion of the referenced document(s) or to amend contractual requirements. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.

DOCUMENT IDENTIFIER AND TITLE

NAME OF ORGANIZATION AND ADDRESS

CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?
   A. GIVE PARAGRAPH NUMBER AND WORDING.

   B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY DOCUMENT REQUIREMENT CONSIDERED TOO RIGID

3. IS THE DOCUMENT RESTRICTIVE?

   ☐ YES ☐ NO *(If "Yes", in what way?)*

4. REMARKS

SUBMITTED BY *(Printed or typed name and address - Optional)*

TELEPHONE NO.

DATE

DD FORM 1 JAN 72 1426 REPLACES EDITION OF 1 JAN 66 WHICH MAY BE USED

S/N 0102-014-1802