MILITARY SPECIFICATION

TRANSFORMER, IMPEDANCE MATCHING, BALANCED TO UNBALANCED (BALUN)

This specification is approved for use by the Naval Electronic Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the requirements and tests for the production of the impedance matching, balanced to unbalanced (balun) transformer, hereinafter referred to as the transformer. The transformer provides efficient transfer of high power radio frequency (RF) energy in the high frequency (HF) range (2 megahertz (MHz) to 30 MHz) between an unbalanced concentric 50-ohm (coaxial) transmission line and a balanced antenna.

1.2 Classification. The transformer shall be of the following types and power ratings, as specified (see 6.2).

Type I	- 50 ohms primary impedance unbalanced, 200 ohms secondary impedance balanced
Type II	- 50 ohms primary impedance unbalanced, 300 ohms secondary impedance balanced
Type III	- 50 ohms primary impedance unbalanced, 600 ohms secondary impedance balanced
Power 1	- 1.0 kilowatt (kw) average, 2 kW peak envelope power (PEP)
Power 2.5	- 2.5 kW average, 5 kW PEP
Power 5	- 5.0 kW average, 10 kW PEP
Power 7.5	- 7 5 kW average, 15 kW PEP
Power 10	- 10 kW average, 20 kW PEP
Power 20	- 20 kW average, 40 kW PEP
Power 25	- 25 kW average, 50 kW PEP
Power 50	- 50 kW average, 100 kW PEP

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

VV-I-530	Insulating Oil, Electrical (For Transformers, Switches, And Circuit Breakers)

MILITARY

MIL-I-10	Insulating Compound, Electrical, Ceramic, Class L
MIL-C-3650	Connectors, Coaxial, Radio Frequency, Series LC
MIL-B-7883	Brazing Of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum, Aluminum Alloys
MIL-C-16173	Corrosion Preventive Compound, Solvent Cutback, Cold-Application
MIL-E-16400	Electronic, Interior Communication And Navigation Equipment, Naval Ship And Shore: General Specification For
MIL-E-17555	Electronic And Electrical Equipment, Accessories, And Repair Parts; Packaging And Packing Of
MIL-F-17655	Field Changes And Field Change Kits; General Specification For

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Electronic Systems Command (ELEX-8111), Washington, DC 20363, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter

STANDARDS

MILITARY

MIL-STD-105	Sampling Procedures And Tables For Inspection By Attributes
MIL-STD-109	Quality Assurance Terms And Definitions
MIL-STD-454	Standard General Requirements For Electronic Equipment
MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-STD-810	Environmental Test Methods And Engineering Guidelines
MIL-STD-1387	Procedures For Submission of Application For Approval Of Non-Standard General Purpose Electronic Test Equipment
MS 91610	Connector, Receptacle, Electrical, Series LC, UG-352B/U

HANDBOOK

MILITARY

MIL-HDBK-419	Grounding, Bonding, And Shielding For Electronic Equipments And Facilities

(Copies of specifications, standards, and handbooks required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.1.2 Other Government publication. The following other Government publication forms a part of this specification to the extent specified herein.

PUBLICATION

FEDERAL COMMUNICATIONS COMMISSION (FCC)

Rules and Regulations, Part 15	Radio Frequency Services

(Application for copies should be addressed to Superintendent of Documents, US Government Printing Office, Washington, DC 20402.)

2.1.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 General. The transformer shall be in accordance with MIL-E-16400, to the extent specified herein.

3.1.1 First article When specified, a sample shall be subjected to first article inspection (see 4.3 and 6.3)

3.1.2 Transformer description. The transformer shall be designed for broadband operation. The transformer shall be suitable for matching the characteristic impedance of HF antennas without adjustment. The transformer shall be complete and ready to install. The transformer shall be mounted exposed to the weather and shall provide the interface coupling between the unbalanced 50-ohm output of an RF transmitter and the balanced input of an antenna.

3.1.3 Parts, materials, and processes. Parts, materials, and processes shall be as specified in 3.1.3.1 through 3.1.3.3.

3.1.3.1 Parts. Parts shall be cleaned after fabrication in accordance with good commercial practice. The cleaning process shall have no deleterious effect. Corrosive material shall be removed completely before parts are mounted. All parts shall be new.

3.1.3.2 Materials. Unless otherwise specified herein, materials shall conform to the Materials paragraph of MIL-E-16400. All materials shall be new. Fiberglass shall not be used. Materials that are capable of producing dangerous gases or other harmful toxic effects under conditions of internal arcing, lightning, or fire shall not be used.

3.1.3.2.1 Dissimilar metals. Unless protected against electrolytic corrosion, dissimilar metals as specified in MIL-E-16400 under conditions for equipment exposed to salt spray, shall not be used in intimate contact with each other. Where it is necessary that dissimilar metals be assembled together, approval is required from the procuring activity.

3.1.3.2.2 Brittle materials. Castings or parts made of ceramic or other brittle material shall not be over-constrained by the means used to secure them. Mating surfaces shall be accurately machined to ensure 360 degree contact between the brittle material and the other surface. Mounting washers of suitable plastic with long-life characteristics or soft metal having slight compressibility shall be provided to prevent breakage or cracking of the parts. Lead washers shall not be used.

3.1.3.2.3 Arc-resistant materials. Arc-resistant materials in accordance with Requirement 26 of MIL-STD-454 shall be used for insulating purposes.

3.1.3.3 Processes. Unless otherwise specified herein, processes shall be in accordance with the Processes paragraph of MIL-E-16400. Laminar X-500 may be used in lieu of the painting specified in MIL-E-16400.

3.1.4 Electrical design. Electrical design shall be as specified in 3.1.4.1 through 3.1.4.2.

3.1.4.1 Wiring and cabling. Internal wiring and cabling shall be designed so that intermittent contact, vibration, and internal part movements will not occur and impair performance.

3.1.4.1.1 Protection. Wires and cables shall be placed and protected to avoid rough or irregular surfaces or sharp edges that could contribute to corona or arc and deterioration. Where wires and cables are held in place by metal partitions, shields, insulators or similar items; wires and cables shall be protected by grommets or bushings. Transformer design shall preclude damage to cabling during conditions of assembly, removal, insertion, and tilting of equipment.

3.1.4.2 Grounding. Grounding shall be in accordance with MIL-HDBK-419. An external grounding terminal shall be provided on the transformer. The ground terminal shall be at least a 0.9525 centimeter (cm) (0.375 inch (in.)) diameter threaded stud plus attaching hardware.

3.1.5 Mechanical design. Mechanical design shall be as specified in 3.1.5.1 through 3.1.5.7.

3.1.5.1 Construction, welding, and soldering. The transformer shall conform to the requirements of MIL-E-16400 regarding construction, rounded corners and edges, welding, attachment of wire and leads, and soldering.

3.1.5.2 Brazing. Brazing of steel, copper alloys, and nickel alloys shall conform to MIL-B-7883.

3.1.5.3 Enclosure material. The enclosure shall be constructed entirely of aluminum, either cast or welded, in accordance with MIL-E-16400.

3.1.5.4 Drilling. Holes shall be cleanly drilled and burrs removed.

3.1.5.5 Riveting. Riveting shall not be used for mounting parts.

3.1.5.6 Securing of parts. Brackets, lugs, flanges, inserts, bolts, and other mounting hardware or accessories shall be such as to retain items securely when subjected to specified service conditions. Parts shall be mounted so that loosening, wear of mounting arrangements, or permanent separation of parts will not occur when the items in which they are used are subjected to specified service, shipment, and installation handling conditions. Friction between mating surfaces shall not be employed as the sole means of preventing movement of fixed parts; parts shall be secured in such a manner that failure of a single screw will not free the part completely.

3.1.5.7 Gaskets. Gaskets shall be in accordance with MIL-E-16400.

3.1.6 Thermal design. Thermal design shall be in accordance with the Thermal design paragraph of MIL-E-16400 and shall conform to the environmental conditions of 3.3. If the transformer is oil-cooled, the contractor shall design the transformer so that under worst electrical and environmental conditions (see 4.5.5.2), the oil-coolant temperature in the enclosure shall remain equal to or below 105° Celsius (C). This is required in order to ensure that the flash point temperature of the oil is not approached.

3.1.6.1 Coolant. Coolant dielectric fluid or insulating oil shall be in accordance with VV-I-530. The transformer shall be complete with the proper amount of coolant needed for specified operation to one-half quart.

3.2 Detailed requirements. Detailed requirements shall be as specified in 3.2.1 through 3.2.3.5.

3.2.1 Weight and dimension. The overall weight and dimension of the transformer shall be an absolute minimum commensurate with good engineering practice. Transformers of dimensions which appear liftable and over 15.88 kilograms (kg) (35 pounds (lbs)) shall be labeled.

3.2.2 Electrical requirements. Electrical requirements shall be as specified in 3.2.2.1 through 3.2.2.10.

3.2.2.1 Frequency range. The frequency range of the transformer shall be a minimum of 2 MHz to a maximum of 30 MHz. All other electrical requirements shall apply for all frequencies in this range.

3.2.2.2 Power. The transformer shall be capable of simultaneously and continuously transmitting a forward power of at least the average and PEP, as specified (see 1.2). All other electrical requirements shall apply for any power level up to and including the maximum power rating.

3.2.2.3 Efficiency. The power transmission efficiency of the transformer shall be 97 percent or better.

3.2.2 4 Matching. The transformer shall be capable of matching a balanced secondary load to the 50-ohm unbalanced primary load (see 1.2).

3.2.2.5 Insertion voltage standing wave ratio (VSWR). The insertion VSWR shall not exceed 1.3:1 with respect to 50 ohms for transformers of Power 1. The insertion VSWR shall not exceed 1.2:1 for all other transformers.

3.2.2.6 Unbalance. The output power transmitted through the transformer shall be balanced with respect to voltage and current to within 5 percent when operating into a balanced load and to within 30 percent when operating into a load with 25 percent impedance unbalanced with respect to ground (see 4.5.2.1.1).

3.2.2.7 Load. The transformer shall not have the power handling capability degraded when terminated with any load that has a VSWR of up to 2.5:1 with respect to nominal output impedance and an unbalance of up to 25 percent with respect to ground.

3.2.2.8 Spurious frequencies. Spurious frequencies generated in the transformer as a result of signal distortion, or other causes, shall not exceed a power level 60 decibels below full power rating. This level shall be as measured at the output of the transformer with any load with VSWR of up to 2.5:1 and unbalanced up to 25 percent with respect to ground.

3.2.2.9 Lightning protection. The transformer shall be provided with spark gap to ground type lightning protection for both output terminals. The gaps shall effectively bypass lightning strokes having the successive current components specified in a through c.

a. An initial component rising from zero to a crest value of 100,000 amperes (A) in 5 microseconds (μs) and decaying to 50,000 A in 10 μs from the beginning of the current and immediately followed by.

b. A second component rising to 2000 A within 5 milliseconds from the beginning of the first component and with a total charge transfer in excess of 20 coulombs, and immediately followed by.

c. A third component consisting of a charge of at least 200 coulombs having a duration of 2 seconds or less

3.2.2.9.1 Repeated operation. The spark gaps shall be capable of bypassing six lightning strokes, each stroke comprised of the current components specified in 3.2.2.9 with no more than 20 percent change in the voltage required for gap breakdown. Twelve such strokes shall be bypassed without failure of spark gap components or any other components in the transformer.

3.2.2.9.2 Repairability. The spark gaps shall be installed on the outside of the transformer in such a way that they can be easily inspected and replaced where the transformer is mounted. Spark gaps shall be held in place by either clamps or bolts. Gap separation shall not be subject to change due to thermal expansion or rotation at point of connection to the transformer. No part of the transformer enclosure shall be degraded, pitted, or otherwise damaged by operation of the gaps.

3.2.2.9.3 Voltage. The spark gap shall be set to arc at a voltage so that when lightning strikes and causes arcing and maximum rated RF power is being applied at any frequency in the specified band, arcing shall not be sustained by the applied RF. The voltage shall be the lowest possible voltage that can be used with the specified power rating.

3.2.2.9.4 Interior arcing. The transformer shall not be damaged when operating at full power and both output terminal spark gaps are arced and currents flow as specified in 3.2.2.9.

3.2.2.10 Electromagnetic interference. In addition to the conducted spurious requirements of 3.2.2.8, the transformer shall be designed to preclude radiation other than as intended for operation, so as to comply with Part 15 of the FCC Rules and Regulations for restricted radiation devices as specified therein.

3.2.3 Mechanical requirements. Mechanical requirements shall be as specified in 3.2.3.1 through 3.2.3.5.

3.2.3.1 Connectors. Connectors shall be as specified in 3.2.3.1.1 through 3.2.3.1.4.

3.2.3.1.1 Input connectors. The input connectors (unbalanced side) of the transformer shall be of the gas-barrier type and shall be capable of sustaining 21,093.0 kg per square meter (kg/m^2) (30 pounds per square inch (psi)) gas pressure. For Power 1, the input connectors shall be a female Type LC in accordance with MIL-C-3650, MS 91610; for powers 2.5, 5, 7.5, and 10, the input connectors shall be a 4.13 cm (1.625 in.) EIA coaxial flange, and for Powers 20, 25, and 50, the input connectors shall be a 7.94 cm (3.125 in.) EIA coaxial flange. The input connectors EIA shall be capable of sustaining the mechanical stresses specified in a through c for indefinite periods of time without loosening of parts, deformations, breakage, or developing of leaks.

	Axial pull and push	Bending moment
a. Power 1:	18.144 kg (40 lbs)	0.6915 kilogram-meter (kg-m) (5 foot-pounds (ft-lbs))
b. Powers 2.5, 5, 7.5, and 10.	45.36 kg (100 lbs)	2 0745 kg-m (15 ft-lbs)
c. Powers 20, 25, and 50	136.08 kg (300 lbs)	4.149 kg-m (30 ft-lbs)

3.2.3.1.2 Output connectors. The output connectors (balanced side) of the transformer shall be in the form of two glazed ceramic feed-through insulators. The insulators shall be alumina ceramic Grade L 624 in accordance with MIL-I-10 The through-bolt stud used with the output insulator shall be 0.9525 cm (0.375 in.) in diameter, hermetically sealed to the insulator, and threaded with 0.9525 cm (0.375 in.) by 24 threads, 1.905 cm (0.75 in.) long. The connectors shall be complete with a nut and washer for the through-bolts.

3.2.3.1.2.1 Insulator terminals. Output terminals on the insulators shall be capable of holding Number 6 wire of either copper or aluminum as specified (see 6.2), without dissimilar metal problems. In the event that encapsulation of the terminal after connection of the wire is required, encapsulating materials shall be supplied and shall be in accordance with MIL-C-16173. The output connectors shall be capable of sustaining the mechanical stresses specified in a through c for indefinite periods of time without loosening of parts, deformations, failures, or developing of leaks.

	Axial pull and push	Bending moment
a. Power 1:	9.072 kg (20 lbs)	0.4159 kg-m (3 ft-lbs)
b. Powers 2.5, 5, and 7.5:	22.68 kg (50 lbs)	1.383 kg-m (20 ft-lbs)
c. Powers 10, 20, 25, and 50:	45.36 kg (100 lbs)	2.0745 kg-m (15 ft-lbs)

The output connectors shall sustain, without damage, all electrical stresses created by the specified operation of the transformer under all environmental conditions in 3.3.

3.2.3.1.3 Connector locations. For a transformer of Power 1, the input connector shall be located on the bottom of the transformer enclosure pointing vertically downward with the output connectors located on the top. The output connector centers shall be a minimum of 5.08 cm (2 in.) apart. For all other transformers, the input connector shall be at the bottom of the transformer enclosure facing vertically downwards. The output connectors shall be located on the side of the transformer opposite the mounting hardware. Transformer enclosures, except those of Power 1, shall be such that when they are set on their bottoms the input connector does not touch the flat surface it is set upon.

3.2.3.1.4 Output terminal strain reliefs. Except for transformers of Powers 1 and 2.5, the transformer shall have a mechanical strain relief located on the outside of the enclosure above each output connector. The two strain reliefs shall be complete with insulated extension rods with hardware, so that they can be used to relieve all mechanical strain from a two-wire transmission line connected to the output terminals. Each strain relief assembly shall be capable of sustaining at least a 136.08 kg (300 lbs) pull in any direction without being damaged. Design of the strain relief assembly shall be such that when the strain relief assembly is secured to the transmission line connected to the input terminals, the strain relief assembly will in no way interfere with normal operation of the transformer nor will it interfere with the transformer's lightning protection.

3.2.3.2 Mounting. The transformer shall have hardware on one side of the enclosure for mounting. The mounting hardware shall be capable of holding the transformer enclosure against a downward force equivalent to five times the transformer's weight. The mounting hardware shall be made for the specific application (see 6.2).

3.2.3.3 Oil level indicator. If the transformer has an oil-filled enclosure, the enclosure shall have an oil level indicator. The oil level indicator shall be in the form of a 3.81 cm (1.5 in.) wide by 7.62 cm (3 in.) high transparent window with a horizontally inscribed line across the middle to coincide with minimum acceptable oil level for the specified operation. The window shall be located on the side of the enclosure in such a position that mounting the transformer will not obscure it.

3.2.3.4 Air cushion. If the transformer has an oil-filled enclosure, the transformer shall be designed so that the enclosure must only be partially filled with oil for proper cooling. When the enclosure is filled to the correct level with oil and all access covers and lids are closed, there shall be an air pocket at the top. The air pocket shall be capable of absorbing or cushioning any expansion of the coolant or any increase in interior pressure brought on by normal operation of the transformer. Interior pressure shall not rise in excess of 7031 kg/m^2 (10 pounds per square inch gage (psig)) when operating under any combination of electrical and environmental conditions specified herein.

3.2.3.5 Pressure. If the transformer has an oil-filled enclosure, the enclosure shall be capable of withstanding an interior pressure of at least 21,093.0 kg/m^2 (30 psig) for an indefinite period of time. This pressure shall not cause the enclosure to leak, rupture, explode, or be bent out of shape when operating under any combination of electrical and environmental conditions specified herein.

3.3 Environmental conditions. The transformer shall be designed for continuous reliable operation under temperature, humidity, wind speed, salt spray, and icing conditions for Range 1 equipments as specified in MIL-E-16400, except that the upper temperature operating limit shall be 71°C in lieu of 65°C. When subjected to the nonoperating temperature limit, the transformer shall not be damaged nor its performance degraded.

3.3.1 Shock and vibration. The transformer shall withstand transit, loading, and unloading shocks and vibrations due to shipment and installation handling without physical damage or performance degradation. The transformer shall be subjected to the shock test of MIL-STD-810, Method 516.3, Procedure IV. The vibration test shall be in accordance with MIL-STD-810, Method 514.3, Procedure I. Transportation shall be by truck, air, rail, or ship.

3.4 Safety. Safety shall be in accordance with Requirement 1 of MIL-STD-454, and the Safety criteria paragraph of MIL-E-16400.

3.5 Enclosure. The transformer enclosure shall withstand an interior pressure at 21,093.0 kg/m^2 (30 psig) without deformation or physical damage.

3.5.1 Leakage. The enclosure leakage rate shall not exceed 4×10^{-5} cubic centimeters per second (cm^3/s)(2.44×10^6 cubic in. ($in.^3$)) at a pressure of 10,546.5 kg/m^2 (15 psig) when measured in accordance with the test specified in 4.5.12.

3.6 Support test instrumentation. Support test instrumentation shall be as specified in 3.6.1 and 3.6.2.

3.6.1 Line operation and maintenance test support. For maintenance and repair procedures in the technical manual, the selection of general purpose electronic test equipment (GPETE) shall be determined to perform the tests specified in a through c.

a. Circuit performance
b Alignment
c. Fault location

3.6.2 GPETE. The utilization of the GPETE, not on the list for support testing, shall be requested in accordance with MIL-STD-1387

3.7 Identification and marking. Unless otherwise specified (see 6.2), identification and marking shall conform to the identification and marking paragraphs of MIL-E-16400.

3.8 Maintainability. Maintainability shall be as specified in 3.8.1 and 3.8.2.

3.8.1 Quantitative maintainability requirements. The transformer shall have an equipment repair time (ERT) of no greater than 2 hours, when repair is accomplished by replacement of parts by an Electronic Technician 3rd Class in a Navy Communications Station. ERT includes fault isolation, disassembly, interchange, reassembly, alignment, and checkout.

3.8.2 Qualitative maintainability requirements. The transformer shall be constructed to provide ease of maintenance, accessibility, and replacement of all parts, and shall be field-repairable.

3 9 Workmanship. Workmanship shall be in accordance with MIL-E-16400.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor 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 Government verification. All quality assurance operations performed by the contractor will be subject to Government verification at any time. Verification will consist of, but is not limited to, a) surveillance of the operations to determine that practices, methods, and procedures of the written quality program are being properly applied, b) Government product inspection to measure quality of the product to be offered for acceptance, and c) Government inspection of delivered products to assure compliance with all inspection requirements of this specification. Failure of the contractor to promptly correct deficiencies discovered by him or of which he is notified shall be cause for suspension of acceptance until corrective action has been taken or until conformance of the product to prescribed criteria has be demonstrated.

4.1.2 Quality assurance terms and definitions. Quality assurance terms used in this specification shall be as defined in MIL-STD-109.

4.2 Classification of inspections. The inspection requirements specified herein are classified as specified in a through c:

a. First article inspection (see 4.3)
b. Quality conformance inspection (see 4.4)
   1. Production inspection (Group A) (see 4.4.1)
   2. Production control inspection (Group B) (see 4.4.2)
   3. Environmental inspection (Group C) (see 4.4.3)
c. Inspection of preparation for delivery (see 4.8)

4.3 First article inspection. Unless otherwise specified (see 6.2), one transformer of each type and power shall be required for first article inspection. First article inspection shall consist of all examination and testing necessary to determine compliance with the requirements of this specification First article inspection shall include the tests specified in TABLE I.

TABLE I. Examinations and tests.

Examination or test	Requirement paragraph	Test paragraph	First article inspection	Quality conformance inspection		
				Group A	Group B	Group C
Surface examination	3.1.3 through 3.1.3.3, 3.1.4.1, 3.1.4.1.1, 3.1.4.2, 3.1.5.1 through 3.1.5.7, 3.1.6.1, 3.2.3.1 through 3.2.3.2, 3.7	4.5.1	X	X		
Workmanship	3.9	4.7	X	X		
Operating	3.2.2.1, 3.2.2.4, 3.2.2.5, 3.2.2.6	4.5.2	X	X		
Weights and dimensions	3.2.1, 3.2.3.1.1	4.5.3	X			
Spurious frequencies	3.2.2.8	4.5.4	X			
Wind speed and icing	3.3	4.5.8	X			X
Enclosure mechanical strength	3.2.3.1.1, 3.2.3.1.2, 3.2.3.1.4, 3.5	4.5.11	X			
Efficiency, power, and load VSWR	3.2.2.1 through 3.2.2.7	4.5.5	X		X	
Lightning	3.2.2.9 through 3.2.2.10	4.5.6	X			
Shock, and vibration	3.3.1	4.5.10	X			X
Salt spray	3.3	4.5.9	X			X
Power	3.2.2.2	4.5.7		X		
Leak and pressure	3.2.3.5, 3.5.	4.5.12	X	X		

4.4 Quality conformance inspection. Quality conformance inspection shall be as specified in 4 4.1 through 4.4.4.

4.4.1 Production inspection (Group A). Production inspection shall be conducted on every transformer offered for delivery. Production inspection shall comprise such examination and testing which will prove the workmanship and reveal the omissions and errors of the production process such as functional and performance tests at a limited number of points, tests which detect deviations from design, tests of adjustment, and tests which detect hidden defects of material. Production inspection shall include the examinations and tests specified in Group A of TABLE I.

4.4.2 Production control inspection (Group B). Production control inspection, including sampling, shall conform to TABLE I and to the inspection procedures for special inspection levels of MIL-STD-105. The inspection level shall be S-3 for normal, tightened, and reduced inspection. Production control inspection shall be performed on transformers that have passed production inspection. The transformers shall satisfactorily conform to the requirements of production control inspection prior to release for shipment. The acceptable quality level shall be 6.5 percent defective.

4.4 2.1 Rejected lots. If an inspection lot is rejected, the contractor may withdraw the lot from further inspection. The contractor may also rework a rejected lot to correct the defective units and reinspect the lot using tightened inspection. Rejected lots shall be kept separate from new lots and shall not lose their identity.

4.4.2.2 Nonconformance and retest. If a sample unit fails the inspection specified in 4.4.2, the contractor shall immediately investigate the cause of failure and shall report to the Quality Assurance Representative (QAR) the results thereof and details of the corrective action taken to correct units of product which were manufactured with the same conditions, materials, and processes; the transformers shall then be retested.

4.4.2.3 Corrective action. If corrective action results in a change of parts, electrical or mechanical layout or function or if the QAR does not consider that the corrective action will enable the product to conform to specified requirements or if the contractor cannot determine the cause of failure, the matter shall be referred to the contracting officer. The procuring activity will require correction to the transformers already delivered under the contract in accordance with MIL-F-17655.

4 4.3 Environmental inspection (Group C). Environmental inspection shall be accomplished on a sampling basis as specified in 4.4.3.1. Environmental inspections shall encompass environmental tests to prove the durability of the materials, parts, and the transformer as a whole; wind speed and icing tests; tests of the effects of changes of environment (such as extremes of temperature and humidity); effects of salt air; and tests of the effects of shock and vibration. Environmental inspection shall include the examinations and tests shown in Group C of TABLE I.

4.4.3.1 Sampling for environmental inspection. One transformer shall be selected from each successive 10 transformers or fraction thereof, produced. The first sample transformer shall be selected from the first month's production.

4.4.3.2 Nonconforming environmental sample units. If a sample unit fails the inspection specified in 4.4.3, the contractor shall immediately investigate the cause of failure and shall report to the QAR the results thereof and details of the corrective action taken to correct units of product which were manufactured under the same conditions, with the same materials, processes, and so forth. If the QAR does not consider that the corrective action will enable the product to conform to specified requirements or if the contractor cannot determine the cause of failure, the matter shall be referred to the contracting officer.

4 4 4 Reinspection of conforming production control and environmental sample transformers. Unless otherwise specified (see 6.2), sample transformers which have been subjected to, and have passed, production control (Group B) or environmental (Group C) inspection, or both, may be accepted on the contract provided all damage has been repaired and the transformers are resubjected to, and pass, production inspection (Group A) specified in 4.4.1.

4.5 Test methods. Test methods shall be as specified in 4.5.1 through 4 5.12.

4.5.1 Surface examination. Transformers shall be examined for conformance to 3.1.3 through 3.1.3 3, 3 1.4.1, 3.1.4.1 1, 3.1.4.2, 3.1.5.1 through 3.1.5.7, 3.1.6,1, 3.2.3 1 through 3.2.3.2, and 3 7 for:

a. Assembly and fit, mechanical safety, and marking
b. Materials, parts, and finish
c. Treatment for prevention of corrosion

4.5.2 Operating test. The transformer shall be energized and subjected to an operating test to ensure, qualitatively, conformance to safety requirements and the proper functioning of the transformer, including as a minimum, the tests specified in 4.5.2.1 and 4.5.2.1.1.

4.5.2.1 Matching Sweep frequency techniques shall be used to demonstrate compliance with 3.2.2.1, 3.2.2.4, 3.2.2.5, and 3.2.2.6.

4.5.2.1.1 Unbalance. The degree of unbalance when feeding a balanced load shall be measured as specified in 4.5.2.1 for conformance to 3.2.2.6 and the degree of unbalance shall be measured as follows: The termination assembly (see FIGURE 1) consists of selected resistors R_1 and R_2, which are connected to the output terminals via transmission lines Z_{o1} and Z_{o2}. The characteristic impedance of Z_{o1} and Z_{o2} is established by the diameter of the connecting wire used and the wire's proximity to the ground plane. To the junction of R_1 and R_2 is brought the neutral voltmeter connection. Capacitors C_1 and C_2, approximately 0.6 picofarad (pF) provide isolation and ensure that impedance loading effects of V_1 and V_2 are minimal. The division ratio must be established in order to relate voltmeter readings to actual terminal-to-ground voltage The manufacturer shall also test the transformer when loaded with a 25 percent unbalanced load. This procedure shall, as a minimum, test for degree of unbalance of output voltage and current. The procedure shall be as specified in a through f:

a. Read C_1, V_c to approximately 0.6 pF capacitance
b. Read V_N on Boonton model 91CA vacuum tube voltmeter, or equivalent
c Read V_1, V_2 on a Volt-o-meter, or equivalent
d. $R_1 = R_2 = Z_{o1} = Z_{o2}$ = one-half of the rated balanced impedance
e. V_{o1} and V_{o2} are the meter voltage readings corrected for voltage division
f. V_N = neutral voltmeter reading

$$\text{Percent unbalance} = \frac{2V_N}{\sqrt{2}\sqrt{V_{o1}^2 + V_{o2}^2 - 2V_N^2}}$$

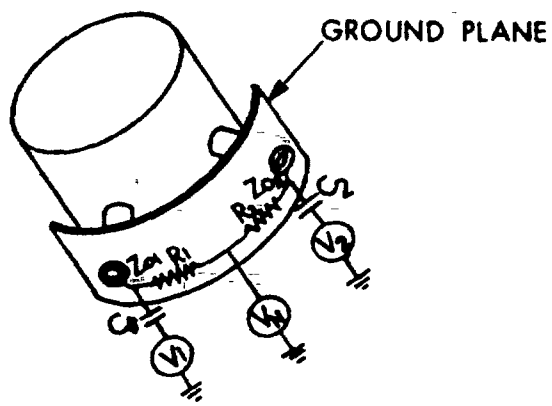

FIGURE 1. Termination assembly.

4.5.3 Weights and dimensions. Weights and dimensions of all units comprising the complete transformer shall be determined for compliance with 3.2.1 Exact dimensions of input connectors shall be determined for compliance with 3.2 3.1.1

4.5.4 Spurious frequencies. The transformer output shall be swept between 0.5 MHz and 500 MHz (excluding the operating frequency) while operating on each of the operating frequencies. 2.0 MHz, 2.5 MHz, 3 MHz, 3.5 MHz, 4 MHz, 6 MHz, 9 MHz, 15 MHz, 20 MHz, 28 MHz, and 30 MHz, at full power to determine compliance with 3.2.2.8.

4.5.5 Efficiency, power, and load VSWR tests. Determining ambient and transformer oil temperature at half-hour intervals is required for the tests specified in 4.5.5.1 and 4.5 5.2.

4.5.5.1 Efficiency. The efficiency of the transformer shall be measured as specified in a and b for conformance to 3.2.2.3:

a. The 50-ohm output of the RF generator (transmitter or equivalent) to be used shall be connected to the 50-ohm input of the transformer. Terminate the balanced terminals in a matched resistive load. Apply full average power to the 50-ohm input end. Ambient room temperature shall be held at 25°C ±2°C. Maintain applied power until transformer temperature is stabilized. Temperature measurement shall not be influenced by the RF field. Stabilization shall have been achieved when temperature rise is less than 0.5°C per half hour.

b. De-energize RF power. Allow the transformer temperature to decrease to room ambient (25°C ±2°C). Without changing physical setups, insert a heating element (Watlow Firerod, or equivalent; heat density shall not exceed 20 watts per square inch) into the transformer and connect to a variable voltage source. Apply power to heating element until transformer temperature stabilizes to same temperature (±0.5°C) as achieved in a. Power input of b is equal to power loss of a. Efficiency shall be computed as follows:

$$\text{Efficiency (percent)} = \frac{(\text{Power input, a} - \text{power input, b}) \times 100}{\text{Power input a}}$$

The efficiency of the transformer shall be confirmed at 2 MHz, 4 MHz, 9 MHz, 15 MHz, 28 MHz and 30 MHz or at any other frequency necessary to establish performance throughout the 2 MHz to 30 MHz region of the RF spectrum. A power circulating device may be used providing the required power flows through the transformer.

4.5.5.2 Power, load VSWR, and thermal design test. The transformer shall be considered to have failed this test if its temperature does not stabilize during the efficiency test. The transformer shall be tested with full (average and PEP) power applied over an uninterrupted 24-hour period. Application of power shall be at the frequency at which efficiency is lowest. The load VSWR shall be 2.5.1 with current peaking at the input terminal and with a 25 percent unbalanced load imposed on the transformer tested. The transformer shall not be exposed to fans or forced drafts during test periods. Ambient conditions shall be 71°C ±2°C. The test shall be repeated with the load chosen to impose a maximum voltage condition at the coaxial terminal of the transformer tested. Arcing, warping, or deterioration of components, pressure exceeding that specified in 3.2.3.4, or leakage of cooling fluid or insulating oil, shall be cause for rejection. This test shall be performed prior to the operating test of 4.5.2 and the spurious frequencies test of 4.5.4.

4.5.6 Electrical overload test. The contractor shall devise first article testing to verify compliance with the requirements of 3.2.2.9 through 3.2.2.10. The tests in this procedure shall accurately include subsequent checks for changes in electrical characteristics including insertion VSWR and unbalance.

4.5.7 Power test. The power test shall be performed as specified in 4.5.5.2, except that temperature and humidity shall be factory ambient and duration shall be until thermal stability is reached (see 4.5.5.1).

4.5.8 Wind speed and icing. Conformance with the wind speed and icing requirements of 3.3 shall be demonstrated by simulated loads.

4.5.9 Salt spray test. The salt spray test shall be performed in accordance with MIL-E-16400. The salt spray test is not required, if metal parts used on the exterior of the transformer are corrosion-resistant as specified in MIL-E-16400.

4.5.10 Shock and vibration. Tests shall be performed to demonstrate compliance with 3.3.1. The transformer shall be in a nonoperating condition during the test and shall be capable of normal operation immediately after each of the tests are completed. The test shall be performed prior to the operating test of 4.5.2, and the leak and pressure test of 4.5.12. The interior shall be examined for loose or deformed parts.

4.5.11 Enclosure mechanical strength test. The enclosure mechanical strength test shall be as specified in 4.5.11.1 through 4.5.11.3.

4.5.11.1 Input and output connectors. The input and output connectors shall be subjected to the axial pull and push, and bending moment forces as specified in 3.2.3.1.1 and 3.2.3.1.2. Each force shall be applied for at least 1 hour. The bending moment shall be applied first in one direction and then in the opposite direction. Any deformation or failure of the connectors or the surfaces to which they are mounted shall constitute failing to pass this test. This test shall be performed prior to the leak and pressure test of 4.5.12.

4.5.11.2 Output terminal strain reliefs. Both strain reliefs shall be simultaneously subjected to the pull specified in 3.2.3.1.4. First, this shall be done with the strain reliefs parallel and in a horizontal plane. Next, the strain reliefs shall be in a horizontal plane and pointing away from each other so as to form a 90-degree angle. Third, the strain reliefs shall be in a plane slanting upward 45 degrees from horizontal and pointing away from each other so as to form a 90-degree angle. Each of the three static pulls shall last at least 1 hour. Any deformation or failure of the strain reliefs or the surfaces to which they are attached shall constitute failing this test.

4.5.11 3 Mounting. The transformer shall first be mounted under the conditions specified (see 6.2). The transformer shall then have a vertically downward force applied to it four times its own weight. Next, the strain relief test of 4.5.11.2 shall be performed. The test of 4.5.11.2 shall only be performed once, provided the test is done simultaneously with the mounting test specified herein. Deformation or failure of the mounting constitutes failing this test.

4.5.12 Leak and pressure test. The transformer enclosure shall be tested for leaks and the ability to withstand internal pressure. Testing for leaks shall consist of first filling the interior of the container with 100 percent fluorocarbon gas to 10,546.5 kg/m^2 (15 psig). All surfaces, welds, gaskets, seams, and connectors shall be examined with a halogen leak detector capable of measuring leaks as small as 4×10^{-5} cm^3/s (2.44×10^6 $in.^2$). Any evidence of leaks of this magnitude or greater shall be cause for rejection of the enclosure. Enclosure strength shall be tested by pressurizing the enclosure to 21,093.0 kg/m^2 (30 psig) and carefully examining the enclosure for deformation. Deformation, rupture, or explosion of the enclosure shall be cause for rejection.

4.6 Maintainability demonstration. Conformance to the maintainability requirements shall be demonstrated in accordance with Test Method 3 of MIL-STD-471. The maintainability demonstration shall be successfully completed prior to the delivery of production transformers.

4.7 Workmanship. The transformer shall conform to the requirements specified in 3.9.

4.8 Inspection of preparation for delivery. Inspection shall be performed to ensure conformance with the requirements of Section 5.

5. PACKAGING

(The preparation for delivery requirements specified herein apply only for direct Government procurements. Preparation for delivery requirements of referenced documents listed in Section 2 do not apply unless specifically stated in the contract. Preparation for delivery requirements for products procured by contractors shall be specified in the individual order.)

5.1 Preservation, packaging, packing, and marking. Unless otherwise specified herein, preparation for delivery shall be in accordance with the applicable levels of preservation, packaging, packing, and marking specified in MIL-E-17555 (see 6.2).

6. NOTES

6.1 Intended use. The transformers covered by this specification are intended for installation at Naval Communication Stations worldwide. The transformers will provide the interface between the unbalanced output of an RF transmitter and the balanced input of an antenna, and will normally be mounted outdoors in a completely unsheltered environment. Although transformers could be used for either transmitting or receiving purposes, Power 1 is primarily intended for receiving purposes and the others for transmitting.

6.2 Ordering data. Procurement documents should specify.

a. Title, number, and date of this specification
b Type and power (see 1.2)
c. Terminal material (see 3.2.3.1.2.1)
d. Mounting (see 3.2.3.2 and 4.5.11.3)
e. Identification and marking (see 3.7)
f. Number of first article samples to be submitted if other than specified in 4.3
g. When reinspected production control and environmental sample transformers may not be accepted (see 4.4.4)
h. Levels of preservation, packaging, packing, and marking (see 5.1)

6.3 First article. When a first article is required, it shall be tested and approved under the appropriate provisions of 7-104.55 of the Defense Acquisition Regulation. The first article should be a first production item. The first article should consist of one transformer of each type and power. The contracting officer should include specific instructions in all procurement instruments, regarding arrangements for examinations, tests, and approval of the first article.

6.4 Field change kits. If field change kits are necessary to correct latent or design defects subsequent to transformer delivery, the kits should be in accordance with MIL-F-17655.

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

Preparing activity:
Navy - EC

(Project 5950-N202)

INSTRUCTIONS. In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge *(DO NOT STAPLE)*, and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

NOTE. This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. 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.

(Fold along this line)

(Fold along this line)

DEPARTMENT OF THE NAVY

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO 12503 WASHINGTON D C

POSTAGE WILL BE PAID BY THE DEPARTMENT OF THE NAVY

Commander
Naval Electronic Systems Command (ELEX 8111)
Washington, DC 20360

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ USER
	☐ MANUFACTURER
	☐ OTHER *(Specify)* _____

5. PROBLEM AREAS

a. Paragraph Number and Wording

b. Recommended Wording

c. Reason/Rationale for Recommendation

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 82 MAR 1426

PREVIOUS EDITION IS OBSOLETE