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MILITARY SPECIFICATION

TRANSFORMERS, POWER, STEP-DOWN, SINGLE-PHASE, 60-HERTZ, 1-KILOVOLTAMPERE APPROXIMATE MINIMUM RATING, DRY TYPE, NAVAL SHIPBOARD

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 dry type, 60-hertz (Hz), single-phase, electric transformers of standard mounting dimensions for shipboard use.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

FEDERAL
J-W-1177 - Wire, Magnet, Electrical.

MILITARY
MIL-S-901- Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-E-917 - Electric Power Equipment, Basic Requirements (Naval Shipboard Use).
MIL-E-2036 - Enclosures For Electric and Electronic Equipment, Naval Shipboard.
MIL-P-15024 - Plates, Tags and Bands For Identification of Equipment.
MIL-P-15024/5 - Plates Identification.
MIL-E-16366 - Electrical Clamps, Lug Terminals and Conductor Splices-Pressure Grip.
MIL-W-16878/7 - Wire, Electrical, Type F, 200°C, 600 Volts, (Insulated, High Temperature).
MIL-E-17555 - Electronic and Electrical Equipment Accessories, and Repair Parts; Packaging and Packing of.

STANDARDS

MILITARY
MIL-STD-108 - Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment.
MIL-STD-195 - Marking of Connections for Electric Assemblies.

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

3. REQUIREMENTS

The transformers furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at time set for opening of bids (see 4.3 and 6.3) .

3.2 Definitions. The definitions specified in 3.2.1 through 3.2.11 shall apply to the various technical terms specified herein.

3.2.1 Transformer. A transformer is an electric device without continuously moving parts which by electromagnetic induction transfers electric energy from one or more circuits to one or more other circuits at the same frequency usually with changed values of voltage and current.

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3.2.2 Dry type transformer. A dry type transformer is a transformer cooled by the natural circulation of air.

3.2.3 Primary winding. Primary winding is the winding on the input side.

3.2.4 Secondary winding. Secondary winding is the winding on the output side.

3.2.5 Tap in a transformer. A tap *in* a transfer-r is a connection brought out of a winding at some point between its extremities, usually to permit changing the voltage ratio.

3.2.6 Rated kilovoltampere kVA of a transformer. Rated kVA of a transformer is the output which can be delivered for the time specified at approximately rated secondary voltage and rated frequency without exceeding the specified temperature limitations.

3.2.7 Ratio of a transformer. Ratio of a transformer is the turn ratio of the transformer.

3.2.8 Regulation of a transformer. Regulation of a transformer is the change in secondary voltage, expressed in percent of rated secondary voltage, which occurs when rated kVA output at a specified power factor is reduced from rated value to zero, with the primary impressed terminal voltage maintained constant.

3.2.9 Impedance voltage of a transformer. Impedance voltage of a transformer is the voltage required to circulate rated current through a winding of the transformer when another winding is short-circuited, with the respective windings connected for rated voltage operation and is expressed in percent of the rated voltage of the winding in which the voltage is measured.

3.2.10 Exciting current of a transformer. Exciting current of a transformer is the current which flows in any winding used to excite the transformer when all other windings are open-circuited, and is expressed in percent of the rated current of the winding in which it is measured.

3.2.11 Lead polarity of a transformer. Lead polarity of a transformer is a designation of the relative instantaneous directions of currents in its leads. Primary and secondary leads are said to have the same polarity when at a given instant the current enters the primary lead in question and leaves the secondary lead in question in the same direction as though the two leads formed a continuous circuit. The lead polarity of a single-phase distribution or power transformer may be either additive or subtractive. If one pair **of** adjacent leads from the windings *in* question is connected together and voltage applied to one of the windings:

(a) Lead polarity is additive if the voltage across the other two leads of the windings in question is greater than that of the higher voltage winding alone.
(b) Lead polarity is subtractive if the voltage across the other two leads of the windings in question is less than that of the higher voltage winding alone.

3.3 General requirements. Transformers shall comply with the requirement of MIL-E-917 and the requirements of this specification, except as otherwise specified in the contract or order. If any requirement specified herein conflicts with the requirements of MIL-E-917, the requirements of this specification shall govern.

3.4 Insulation system. The insulation system shall be class 130 as specified in MIL-E-917 or higher. The whole core and coil of each transformer shall have varnish applied by the dipping process or vacuum-pressure process specified in MIL-E-917.

3.5 Painting Painting shall comply with the requirements of MIL-E-917, except that only one coat of gray enamel need be applied. Marks or scratches made due to handling during fabrication and testing shall be repainted by either complete repainting of equipment or by touchup method. Parts to be painted shall consist of those not having a corrosion-resisting treatment or not fabricated of corrosion-resisting materials of the types specified in MIL-E-917 and shall include exterior and interior surfaces of the enclosure.

3.6 Enclosure. Unless otherwise specified in the contract or order, transformers shall be driproof (45 degree), in accordance with class I of MIL-E-2036 for electric equipment and with MIL-STD-108. Enclosure shall provide for the entrance of the ship's cables. Ready accessibility shall be provided with clearance in the vertical direction for installation and maintenance or electrical connections (see table III). Sufficient space shall be provided

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in the terminal compartment for making connections of single-phase transformers in closed delta banks. The terminal compartment shall be so constructed that it is possible to disconnect readily a transformer connected in a three-phase bank without disturbing the cable to the remaining transformers or other unit comprising the bank.

3.7 Ambient temperature. The rating of transformers shall be based upon an ambient temperature of 50°C.

3.8 Rating.

3.8.1 Voltage. Transformers shall be designed for the following voltages, as specified (see 6.2.1):

120 - 120 no-load - Group 1.
450 - 230 no-load - Group 2.
450 - 120 no-load - Group 3.
Special voltage.

3.8.2 Phase. Transformers shall be designed for single-phase operation.

3.8.3 KVA capacity Transformers shall be designed to have the following kVA capacities as specified see 6.2.1):

1.0	25.0
3.0	37.5
5.0	50.0
7.5	75.0
10.0	100.0
15.0	

3.9 Duty. Unless otherwise specified (see 6.2.1), transformers shall be designed for continuous duty .

3.10 Temperature limits. Transformers shall not exceed the values of maximum permissable temperature rises specified table I.

Table I - Maximum permissible temperature rises at 100 percent load.

Name of part	Insulation system class 130
Primary winding	1/ 80°C
Secondary winding	1/ 80°C
Core	2/ 90°C

1/ by resistance method of MIL-E-917.
2/ by thermometer method of MIL-E-917.

3.11 Characteristics. Characteristics of the transformers shall be as specified in table II.

Table II - Transformer characteristics.

Division 1/	kVA	Maximum weight	Maximum volume	Maximum losses		Regulation maximum 3/		Maximum exciting current	Maximum peak inrush current
				No-load	Total 3/	1.0 Power factor	0.8 Power factor		
		Pounds	Cubic inches	Watts	Watts			Percent	Amperes 4/
A	1	30	525	15	58	4.5	5.0	15	67
	3	65	1,020	30	105	2.6	4.5	7.5	200
	5	90	1,450	45	145	2.0	3.5	5	330
	1/ 7.5	116	1,910	55	180	2.0	3.5	5	500

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Table II - Transformer characteristics (con.).

Division[1]	kVA	Maximum weight	Maximum volume	Maximum losses		Regulation maximum[3]		Maximum exciting current	Maximum peak inrush current
				No-load	Total[3]	1.0 power factor	0.8 power factor		
		Pounds	Cubic inches	Watts	Watts			Percent	Amperes[4]
B	10	145	2,250	75	210	2.0	3.5	5	620
	[1]15	206	4,000	100	320	2.0	3.5	5	900
	[1]25	280	5,700	140	550	2.0	3.5	5	1,400
C	37.5	396	[2] 7,500	180	750	2.0	3.5	5	2,000
	50	510	[2]10,025	225	950	2.0	3.5	5	2,600
	[1]75	695	[2]13,000	325	1,240	2.0	3.5	5	3,800
	100	950	[2]17,200	350	1,550	2.0	3.5	5	4,800

[1] Transformer to be submitted from each division for qualification (see 4.3.1) .

[2] Mounting feet and braces included in the "E" and "F" dimensions specified on figures 1 and 2.

[3] Regulation impedance and total losses are to be based on a reference copper temperature of 75°C.

[4] Values for inrush current are applicable to transformers with 450-volt primary. The maximum peak inrush current for transformers with other primary voltage ratings shall be the same percentage of the primary load current.

3.12 Ratio. Transformers' turn ratio shall not vary more than plus or minus 1.0 percent from ratio of rated voltages indicated on the identification plates.

3.13 Polarity. Transformers shall be of additive polarity.

3.14 Shockproofness. Transformers shall be designed to withstand high-impact shock without mechanical damage or failure of parts as specified in MIL-S-901 for grade A, class I, type A (see 4.6.10).

3.15 Short circuit. Transformers shall be designed to withstand the short circuit test specified in 4.6.13.

3.16 Weight. Transformers complete with case and including wiring and mounting provision shall not exceed the weights shown in table II.

3.17 Volume. Transformers' volume shall not exceed the volume in cubic inches shown in table II. Maximum dimension in each direction shall be used in determining the volume.

3.18 Dielectric strength. Transformers shall be designed and constructed so that the insulation system for each separate winding will withstand a root means square (rms) dielectric test voltage of 4000 alternating current (a.c.) volts, sinusoidal waveform, 60 Hz, applied for 1 minute between the winding and all other windings connected together and grounded to the core(s) and frame.

3.19 Mounting. Mounting dimensions of transformers shall be as specified on figures 1 and 2. Holes provided for mounting and bracing shall not be slotted. Transformers with kVA rating 1 through 25 kVA shall be bulkhead mounted. Transformers with kVA rating 37.5 kVA and larger shall be deck mounted. Transformers, when in place onboard ship, are mounted in banks with a minimum distance of 2 inches between units. Under this condition, the temperature rises (see 3.10) shall not be exceeded. Braces will be provided by the shipbuilder.

3.20 Winding resistance. Measured values (see 4.6.1) of winding resistance corrected for temperature difference shall be compared to the design value of applicable winding resistance given on the transformer drawing, and deviations therefrom shall be computed in percent of design value. The algebraic average of all such deviations (for windings) of transformers on each contract or order shall fall within the limits of minus 5 to plus 0 percent, inclusive. Each winding individually shall fall within the range limits of minus 10 plus 5 percent, inclusive.

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3.21 Spot welding or tack welding. Spot welding or tack welding shall not be used for structural parts subject stress or shock.

3.22 Lifting means. Transformers *of* 10 kVA capacity and over shall be provided with means for lifting and handling by use of eye-bolts.

3.23 Windings.

3.23.1 Transformers shall have separate primary and secondary windings insulated from each other and from metal parts.

3.23.2 Windings shall be supported so that mechanical stresses caused by short circuits (see 4.6.13) and shock will not be reflected in the weakening of the insulation, permanent deformation of the windings, or other mechanical or electrical injury.

3.23.3 Taps shall not be permitted.

3.23.4 Magnet wire for transformers shall be in accordance with J-W-1177.

3.24 Core. Laminations shall be properly insulated from each other. In the assembly of the core, care shall be taken to remove all burrs or projecting laminations which might result in injury to the coils. Laminations shall be clamped together in such a manner as to insure a tight core. During the process of manufacture, the assembled core shall be given a varnish dip. Laminations shall be annealed for stress relieving after punching or forming.

3.25 Identification plates.

3.25.1 General. Identification plates shall be as shown *on* figure 3 and in accordance with MIL-P-15024 and MIL-P-15024/5. Plates shall be installed on and furnished as a part of each transformer and shall be located so that they can be easily read at all times without danger to personnel. Unless otherwise specified in the contract or order, the identification plates shall be located on the front *of the* enclosure.

3.25.2 Data on identification plates. The minimum data to be marked on the identification plates for transformers shall be as shown on figure 3.

3.25.3 Connection diagram plate. Connection diagram, schematically showing the actual connections for three-phase operation, instructions for connecting in open delta and the percent kVA capacity for open delta to be provided as shown on figure 3.

3.26 Connections and terminals.

3.26.1 Ship's cable supports shall not be furnished. However, for sizes larger than 50 kVA, a removable angle iron ship's cable support bracket extending horizontally across the cable compartment, shall be furnished. This bracket shall act as a base on which the installing activity may mount, if desired, for the particular installation, a ship's cable support. The top of the bracket shall be 2 inches wide and 2 inches above the core and coils, whichever is highest.

3.26.2 Terminal boards shall not be used. Transformer leads shall be secured by the use of an insulated support and arranged in such a manner that the connections to ship's cables may be made by the use of solderless connectors conforming to MIL-E-16366. Solderless connectors need not be furnished with the transformer.

3.27 Cable compartments.

3.27.1 Location. Location of cable compartments with respect to transformer kVA rating shall be as follows:

(a) 1 through 10 kVA - cable compartment at bottom.
(b) 15 kVA and larger - cable compartment at top.

3.27.2 The minimum thickness of cable compartment removable side plates with respect to transformer kVA size shall be as follows:

(a) 1 through 25 kVA - U.S. gage 16 (0.0598 inch).
(b) 37-1/2 kVA and larger - U.S. gage 15 (0.0747 inch).

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3.27.3 Size. Size of cable compartments shall be as specified in table III.

Table III - Cable compartments.

kVA size	Distance between lead support and cover
	Inches
1	4
3	4
5	5
7.5	5-1/2
10	6
15	8
25	8-1/2
37.5	10
50	11
75	11-3/4
100	14-1/2

3.28 Cable leads. Cable leads for transformers shall be in accordance with MIL-W-16878. Minimum length of the leads shall be the height of the cable compartment.

3.28.1 Cable lead markings. Transformer leads shall be marked in accordance with MIL-STD-195. Markings shall be stamped on aluminum cable bands.

3.29 Impedance. Impedance values for transformers of the same size, design, and type shall vary from the value shown on the drawings by not more than plus or minus 7-1/2 percent.

3.30 Technical data. The supplier shall prepare drawings (figure 3 is a typical transformer drawing) , certification data sheets, test procedures and reports, calculations, and an inspection system plan in accordance with the data ordering documents included in the contract or order (see 6.2.2).

3.30.1 Drawings. In addition to the drawing content required by the data ordering document, the following unique technical features shall be included:

(a) Manufacturer's name.
(b) List of descriptive data including:
  (1) Enclosure.
  (2) Rating (kVA, phase, Hz).
  (3) Duty .
  (4) Maximum temperature rise.
  (5) Maximum ambient temperature.
  (6) Shock classification.
  (7) Mounting.
  (8) Polarity.
  (9) Type (including voltage ratio and group nunber).
  (10) Insulation class.
  (11) National stock number.
(c) Weight and volume of equipment.
(d) Finish, including method of treatment of enclosure for painting, color, and applicable specification of paint.
(e) Method of impregnation of windings including step-by-step procedure.
(f) Table of coil lead data with corresponding volts, bare wire diameter, insulated wire diameter number of wires in stranding, size of wire, and insulation.
(g) Sectional view of windings and insulation.
(h) A table of insulation indicating the location, insulation material, thickness and type used, and the applicable specifications and remarks.
(i) Description of the application of insulating materials, where used, including location and manner of application **of** tape, cord, sleeving, or similar material.

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(j) Outline with cut-away half sections and essential details of the equipment. Front and side views shall be shown. The top view shall also be shown, if necessary, for understanding the drawing. The center-of-gravity shall be shown and dimensioned.
(k) Elementary wiring diagram showing lead markings.
(1) Table of design performance data with corresponding groups, primary no-load voltage, primary rated amperes, secondary no-load voltage, secondary rated amperes, no-load watts loss, total watts loss, regulation at 1.0 power factor (pf), regulation at 0.8 pf, percent exciting current, percent impedance, maximum peak inrush current, turns ratio, and voltage ratio.
(m) Table of winding data with corresponding group number, winding, volts, number of coils, turns, turns per layers, layers, length of layer, dimensions of bare conductor, area of conductor, dimensions of insulated conductor, applicable specification of conductor, weight of conductor, and resistance of winding.
(n) Diagram of connections for three-phase operation.
(o) Cut-away pictorial view of wiring compartment showing method of connecting leads to ship's cable.
(p) Details of cable support bracket or terminal board, where used, showing dimensions.
(q) The title block shall include, in addition to the title, kVA, Hz, phases, temperature rise, and insulation system.
(r) Drawings shall be submitted to NAVSEC and certification data to the procuring activity.

3.30.2 Certification data. In addition to the certification data sheet content required by the data ordering document, the following unique features shall be included:

(a) Transformer.
(b) KVA ratio.
(c) Primary volts.
(d) Secondary volts.
(e) Frequency.
(f) Insulation system class.
(g) Class shock.
(h) Single-phase.
(i) Weight.
(j) National stock number.
(k) Maximum ambient temperature.
(1) Maximum temperature rise in 'C.

3.31 Workmanship Material, workmanship, and design of each transformer shall be in accordance with this specification.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or 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 Inspection system. The supplier shall provide and maintain an inspection system in accordance with the data ordering documents included in the contract or order (see 6.2.2).

4.2 Classification of inspection. The examination and testing shall be classified as follows:

(a) Qualification tests (see 4.3).
(b) Quality conformance inspection (see 4.4).

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4.3 Qualification test. Qualification tests shall be conducted at a laboratory satisfactory to NAVSEC. Qulification tests shall consist of the examination and tests specified in table IV.

Table IV - Qualification and quality conformance inspection.

Inspection	Qualification inspection	Quality conformance tests			Requirement paragraph	Inspection paragraph
		Group A	Group B	Group C		
Resistance	x	x	x	x	3.20	4.6.1
Polarity	x	x	x	x	3.13	4.6.2
Ratio	x	x	x	x	3.12	4.6.3
Impedance voltage and impedance watts	x	-	x	x	3.29	4.6.4
No-load losses	x	-	-	-	3.11	4.6.5.1
Total losses	x	-	-	-	3.11	4.6.5.2
Exciting current	x	x	x	x	3.11	4.6.6
Regulation	x	-	x	x	3.11	4.6.7
Heating	x	-		x	3.10	4.6.8
Weight and volume	x	-	x	x	3.16 and 3.17	4.6.9
Shock	x	-	-	-	3.14	4.6.10
Inspection of transformer test	x	-	-	-	3.14	4.6.10.3
Dielectric strength test	x	x	x	x	3.18	4.6.11
Inrush current	x	-	x	x	3.11	4.6.12
Short circuit	x	-	x	x	3.15	4.6.13
General examination	x	x	x	x	3.31	4.6.14

4.3.1 Sampling for qualification inspection. One representative transformer of each of the division shown in table II shall be subjected to the qualification inspection specified in table IV. The size transformer required as representative for each division is marked with a 1/ in table II. For the purpose of obtaining comparative data on transformer representative of different manufacturer's practices it is highly desirable that all manufacturers submit transformers of the same capacity for test. When such practice is impracticable because the size shown will not be representative of the given division, consideration will be given to the manufacturer's request for test of a size of transformer more representative of that division.

4.4 Quality conformance inspection.

4.4.1 Sampling for quality conformance inspection.

4.4.1.1 Sampling for group A tests. Every transformer shall be subjected to the group A tests specified in table IV.

4.4.1.2 Sampling for group B tests. Transformers selected in accordance with table V shall be subjectied to the group B tests specified in table IV.

Table V - Sampling for group B tests.

Number of transformers on order	Minimum number of transformers to be tested
1 to 30	None
31 to 65	3
66 to 110	5
111 to 180	7
181 to 300	10

#+ 4.4.1.3 Sampling for group C tests. At three year intervals after qualification inspection, one transformer in each of the kVA ranges of the division given in table II shall be subjected to the group C tests specified in table IV.

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4.5 Test reports, procedures, and calculations. The supplier shall prepare test reports, procedures, and calculations in accordance with the data ordering document included in the contract or order (see 6.2.2) and shall include unique features specified in 4.5.1.

4.5.1 Qualification inspection. Three copies of the test report shall be submitted to NAVSEC. A separate report shall be prepared for each transformer including a report number, date and authentication by the cognizant Government representative. The report shall show the tests in sequence as shown in the specification and in a table form. The table shall show the test, test value recorded and the applicable specification limit. Supplemental sheets shall show calculations for various tests such as regulation, heating, inrush current, short circuit, etc.

4.6 Test methods.

4.6.1 Resistance. Resistance of both the primary and secondary windings shall be accurately measured. Temperature at which the resistance readings are taken shall also be recorded.

4.6.2 Polarity. Polarity of each transformer shall be determined by either of the methods specified in 4.6.2.1 and 4.6.2.2 at the manufacturer's option.

4.6.2.1 Polarity by alternating voltage. The left-hand side facing the low-voltage side of the transformer high-voltage and low-voltage outlet leads shall be connected together. Any convenient value of alternating voltage not exceeding rated voltage shall be applied to the high-voltage winding. Readings of the applied voltage and voltage between the right-hand adjacent high-voltage and low-voltage leads shall be observed. If the latter voltage reading is less than the former indicating the approximate difference in voltage between that of the high-voltage and low-voltage windings, the polarity is subtractive. If the latter is greater than the former, the polarity is additive.

4.6.2.2 Polarity by standard transformer. A standard transformer of known polarity and having the same ratio as the transformer to be tested may be used. High-voltage windings of both transformers shall be connected in parallel. Left-hand side low-voltage leads facing the low-voltage side-of both transformers shall be connected together. Right-hand side leads shall be left free. With these connections, a reduced value of voltage shall be applied to the high-voltage windings and the voltage between the two free leads shall be measured. A zero or negligible reading of the voltmeter will indicate that the relative polarities of both transformers are identical.

4.6.3 Ratio. Turn ratio between the primary and the secondary windings shall be accurately determined by either of the methods specified in 4.6.3.1 and 4.6.3.2 at the manufacturer's option.

4.6.3.1 Voltmeter method. The ratio test shall be made with rated or lower voltage at rated or higher frequency applied to either the high- or low-voltage leads of the transformer. Simultaneous readings of a voltmeter in the high-voltage winding and a voltmeter in the low-voltage winding shall be taken and recorded. Meters shall be interchanged and another set of readings obtained; the average of these two sets of readings shall be used in checking the ratio.

4.6.3.2 Standard transformer method. The transformer to be tested shall be connected in parallel with a standard transformer of the same nominal ratio. Secondaries shall also be connected in parallel but with a voltmeter *or* detector in the connection between two terminals of similar polarity and so arranged as to read the difference between the two secondary voltages. If the manufacturer desires, the voltages in each secondary winding may be obtained. When this method is used, however, the voltmeters shall be interchanged and a second set of readings shall be obtained. The average of the results shall be used in determining the ratio.

4.6.3.2.1 Connections for the ratio test by comparison with a standard transformer are shown on figure 4.

4.6.3.2.2 The variation of the value of ratio between transformers of the same size, design, and type shall be within plus or minus one-half of 1 percent of turns ratio shown on the applicable drawing.

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4.6.4 Impedance voltage and impedance watts. Either the primary or the secondary winding shall be short-circuited and voltage at rated frequency applied to the other winding and adjusted to circulate rated currents in the windings. With current and frequency adjusted to rated values shown on the applicable drawing, simultaneous readings shall be taken on the ammeter, voltmeter, wattmeter, and frequency meter. Temperature of the windings during this test shall be determined.

4.6.5 Losses.

4.6.5.1 No-load losses. No-load losses shall be accurately determined. Rated voltage shall be applied to either the primary or secondary windings. The frequencies shall be 60 Hz. Simultaneous readings shall be made of frequency, voltage, watts (low pf wattmeter), and amperes. Actual design value appears on the drawings. No-load loss for transformers of the same size and design may exceed the value shown on the drawing by 10 percent, but shall not exceed the maximum allowable no-load losses specified in table II.

4.6.5.2 Total losses. Total losses shall be determined from the data obtained in the impedance watts test and no-load loss test. Actual design value appears on the drawings. Total loss for transformers of the same size, design, and type may exceed the value for full-load loss watts shown on the drawing by 6 percent, but shall not exceed the value for full-load losses specified in table II.

4.6.6 Exciting current. Exciting current shall be determined during the no-load loss test and shall not exceed the maximum allowable value of exciting current specified in table II.

4.6.7 Regulation. The regulation of a transformer shall be determined by calculation based on the measured values of impedance volts and impedance watts, corrected to 75°C. Either of the following formulae may be used in the calculation of the regulation:

Formula I:

$$\text{Regulation} = pr + qx + \frac{(px - qr)^2}{2}$$

Formula II:

$$\text{Regulation} = a - 1/2a^2 + 1/2a^3 - 5/8a^4$$

Where:

P = cos 0 = power factor of load

$q = +\sqrt{1 - p^2}$

θ = negative phase angle of load current

ϕ = impedance angle of transformer

r = resistance factor = $\frac{\text{impedance loss in kW}}{\text{rated kVA}}$

z = impedance factor = r/cos Ø

X = reactance factor = + 2^2- r^2

$a = z \cos(\phi + \theta) + z^2/2$

The quantities of regulation are on a per unit basis so that the result must be multiplied by 100 to get the regulation in percent.

4.6.8 Heating.

4.6.8.1 General. Heating tests on transformers shall be made under conditions equivalent to normal operating conditions, that is, rated voltage, rated frequency, rated current, and the duty specified. The test methods to be employed and the precautions to be observed shall be as specified in 4.6.8.2 through 4.6.8.5.

4.6.8.2 Assembly of transformer. The heating test shall be made only on the completely assembled transformer.

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4.6.8.3 Duration of test. The heating test for transformers shall be continued until constant temperatures have been attained in all parts of the transformer.

4.6.8.4 Method of loading. The following methods of loading transformers for the heating test are acceptable (see figure 5):

(a) The transformer may be loaded directly with rated voltage applied to the primary and sufficient load on the secondary to load the transformer to rated kVA capacity.
(b) Duplicate single-phase transformers may be tested in banks of two by connecting both the high-voltage. and low-voltage windings in parallel and by applying rated excitation voltage at rated frequency to one set of paralled windings. Connections of the other pair of windings shall be opened at one point and a voltage impressed across the break just sufficient to circulate rated currents through the windings. The circulated current should preferably be at rated frequency.

Note: If other than rated frequency is applied to the opened windings the value of current should be adjusted to yield the true impedance watts of the transformer.

4.6.8.5 Measurement of the ambient temperature. Measurement of the ambient temperature shall be in accordance with the requirements of MIL-E-917.

4.6.9 Weight and volume. The weight and volume of a transformer shall be taken and recorded. The design weight appears on the drawing. Weight of transformers of the same size and design may exceed the value shown on the drawing by 5 percent, but shall not exceed the weight value specified in table II.

4.6.10 Shock.

4.6.10.1 General. The shock test shall be in accordance with grade A, class I, type A of MIL-S-901.

4.6.10.2 Mounting. The transformers shall be mounted on the shock machine in the following manner:

(a) Light-weight machine - Figure 4A of MIL-S-901 (1 through 37.5 kVA).
(b) Medium-weight machine - Figure 9-1 of MIL-S-901 (50 through 100 kVA).

4.6.10.3 Inspection of transformer after shock test. After the shock test, the transformer shall be carefully inspected for damage. Details of all damage shall be recorded. If there are any appreciable injuries, it will be considered that the transformer has failed to meet the requirements of this test.

4.6.10.3.1 Electrical tests. After the mechanical inspection, the transformer shall be subjected to the following electrical tests in the order listed:

(a) No-load losses (see 4.6.5.1).
(b) Exciting current (see 4.6.6).
(c) Short circuit (see 4.6.13).
(d) Dielectric (see 4.6.11).

If the values of no-load loss watts and the exciting current amperes differ by more than plus or minus 5 percent and 10 percent, respectively, from the original values, it shall be cause for rejection. Failure of the transformer to meet the requirements of the short circuit test or the dielectric test shall also be sufficient cause for rejection.

4.6.11 Dielectric strength test.

4.6.11.1 General. The dielectric strength test shall be performed following the completion of all but the weight and shock tests. This test shall be made on the completely assembled transformer at equipment temperature between 10°C and 50°C.

4.6.11.2 Applied potential. Test voltage shall be applied successively between each winding with all other windings and metal parts grounded.

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4.6.11.2.1 Test voltage. Test voltage shall approximate a true sine wave. Insulation of the high voltage winding shall withstand a dielectric test voltage (rms) of 4,000 volts a.c., 60 Hz, for a period of 1 minute with the low-voltage winding and case and core grounded. The low-voltage winding insulation shall withstand a dielectric test voltage (rms) of 4,000 volts a.c., 60 Hz, for a period of 1 minute with the high-voltage winding and case and core grounded. In addition, all other windings other than the one being tested shall be tied to the core and case which are grounded.

4.6.11.2.2 Measurement of test voltage. The voltmeter method shall be used. In measuring the voltage, the voltmeter shall derive its voltage from the high-voltage circuit either directly or through an auxiliary ratio transformer placed across the testing transformer.

4.6.11.3 Induced potential. The test voltage shall be applied to either winding and shall approximate a true sine wave. Insulation of the low-voltage and the high-voltage windings shall withstand a voltage applied to either winding of twice normal operating voltage at a frequency of not less than 120 Hz or a period of not less than 7,200 cycles at the frequency of the applied test voltage. The frequency of the voltage shall be such that the exciting current is not in excess of 30 percent of rated-load current.

4.6.12 Inrush currents. Oscillograph measurements of the maximum inrush currents to the primary winding shall be obtained with rated voltage at rated frequency applied to the primary winding to determine conformance with table II. The secondary winding shall be open-circuited. The following procedure shall be used in conducting this test:

(a) Apply direct current (d.c.) to primary winding. The value of d.c. current shall be equal in amperes to the crest value of the a.c. exciting current.
(b) Gradually remove d.c. current from primary winding.
(c) Apply rated value of a.c. voltage to primary winding. Provision shall be made to Insure that the voltage is applied when the voltage wave is passing through zero (plus or minus a maximum of 15 degrees is permissible) in the direction that adds to the residual.
(d) Record inrush current, primary voltage, and secondary voltage waves on oscillograms. Copies of the oscillograms shall be in the test report.

4.6.13 Short circuit. Rated voltage and frequency shall be applied to one winding, for transformers rated below 15 kVA, the other winding shall be short-circuited. For transformers rated 15 kVA and above, the short-circuit current and duration of short-circuit test shall be as specified in table VI for the corresponding impedance.

Table VI - Short circuit test.

Percent impedance	Minimum values of rms symmetrical short-circuit current to be withstood	Minimum time period
		Seconds
4 or less	25 times rated current	2
5	20 times rated current	3
6	16.6 times rated current	4
7 or more	100 divided by percent impedance times rated current	5

Intermediate valves may be determined by interpolation. There shall be no evidence of shifting of coils or cores or damage to the insulation or loosening of the coil supports.

4.6.14 General examination. Each transformer shall be subjected to a thorough examination to ascertain that the material, workmanship, and design are in conformance with this specification.

4.7 Inspection of preparation for delivery. The packaging, packing, and marking shall be inspected to ensure compliance with section 5 of this document.

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5. PREPARATION FOR DELIVERY

5.1 Preservation-packaging, packing, and marking. Transformers shall be preserved-packaged level A or C, packed A, B, or C as specified (see 6.2.1) and marked in accordance with MIL-E-17555.

6. NOTES

6.1 Intended use. Transformers are used in shipboard electrical power distribution systems in order to step-down or step-up the voltage normally available.

6.2 Ordering data.

6.2.1 Procurement requirements. Procurement documents should specify the following:

(a) Title, number and date of this specification.
(b) Voltage required (see 3.8.1).
(c) KVA capacity required (see 3.8.3).
(d) Duty (see 3.9).
(e) Levels and requirements of preservation, packaging, and marking (see 5.1).

6.2.2 Contract data requirements. When this specification is used in a procurement invoking the data requirement clause of the Armed Services Procurement Regulations (ASPR) paragraph 7-104.9(n) and which incorporates a DD Form 1423 Contract Data Requirements List (CDRL), the data requirements identified below will be developed as specified in the cited Data Item Description (DID) and delivered in accordance with such CDRL. When the ASPR provisions are not invoked, the data specified below shall be delivered in accordance with contract requirements.

Specification paragraph	Data requirements	Service	Applicable DID	Option
3.30.1	Drawings	SH	UDI-E-23174	Category A, F, and G, form 2, type II and III
4.1.1	Inspection system	SH	UDI-R-23574	------
4.5	Test reports	SH	UDI-T-23579	------
4.5	Test procedures	SH	UDI-T-23649	------
4.5	Calculations	SH	UDI-E-23213	------

(Copies of DID's required by the supplier in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.)

6.3 With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in applicable Qualified Products List QPL-15108 whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Naval Ship Engineering Center, Prince George's Center, Center Building, Hyattsville, Maryland 20782, and information pertaining to qualification of products may be obtained from that activity. Application for Qualification tests shall be made in accordance with "Provisions Governing Qualification SD-6" (see 6.3.1).

6.3.1 Copies of "Provisions Governing Qualification SD-6" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

6.4 THE MARGINS OF THIS SPECIFICATION ARE MARKED "#" TO INDICATE WHERE CHANGES (ADDITIONS, MODIFICATIONS, CORRECTIONS, DELETIONS) FROM THE PREVIOUS ISSUE HAVE BEEN MADE. THIS WAS DONE AS A CONVENIENCE ONLY AND THE GOVERNMENT ASSUMES NO LIABILITY WHATSOEVER FOR ANY INACCURACIES IN THESE NOTATIONS. BIDDERS AND CONTRACTORS ARE CAUTIONED TO EVALUATE THE REQUIREMENTS OF THIS DOCUMENT BASED ON THE ENTIRE CONTENT IRRESPECTIVE OF THE MARGINAL NOTATIONS AND RELATIONSHIP TO THE LAST PREVIOUS ISSUE.

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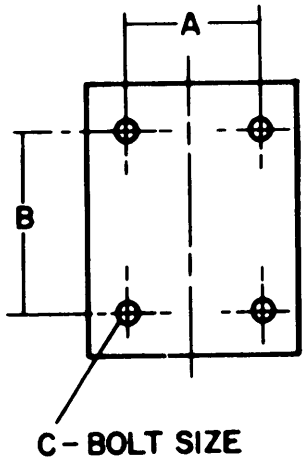

kVA	A 1/	B 1/	C 2/
1	5	7	3/8
3	7-1/4	8-1/2	3/8
5	8	9	3/8
7-1/2	9-1/4	11	1/2
10	9-1/4	11	1/2
15	9-1/2	11-1/4	1/2
25	10	12-1/4	1/2

1/ Tolerance: ± 1/32 inch.

2/ Hole diameter shall equal bolt size ± 1/16 inch.

SH 10852

Figure 1 - Standard mounting dimensions for transformers 25 kVA and smaller.

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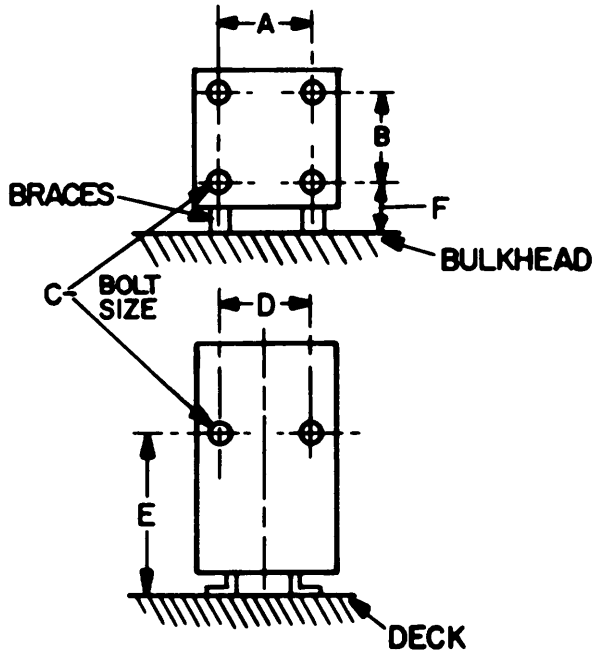

kVA	A 1/	B 1/	C 2/	D 1/	E 1/	F 1/
37 1/2	11	9	3/8	11	16	5
50	11	9	3/8	11	18 3/4	5 3/8
75	12	12	7/8	12	18	5 1/4
100	15	12	7/8	15	19	5 1/2

1/ Tolerance: ±1/32 inch.

2/ Hole diameter shall equal bolt size 1/16 inch for bolt sizes up through 5/8 inch and 3/32 inch for 7/8 inch bolts.

SH 10853

Figure 2 - Standard mounting dimensions for transformers 37-1/2 kVA and larger.

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A. MANUFACTURER ______

B. THE EQUIPMENT SHOWN ON THIS DRAWING IS IN ACCORDANCE WITH SPECIFICATION MIL-T-15108.
NOTE ANY EXCEPTION TO SPECIFICATION MIL-T-15108C, AND REFERENCED SPECIFICATIONS, SHALL BE LISTED.

C. DESCRIPTIVE DATA OF TRANSFORMER
1. ENCLOSURE ______
2. RATING ______ KVA ______ PHASE ______ CYCLES ______
3. DUTY ______
4. TEMPERATURE RISE ______ °C AMBIENT ______ °C
5. SHOCK CLASSIFICATION ______
6. MOUNTING ______
7. POLARITY ______
8. TYPE

	MFR NO.	NATIONAL STK NO.
HV 120 LV 120 GROUP 1		
HV 450 LV 230 GROUP 2		
HV 450 LV 120 GROUP 3		

9. INSULATION CLASS ______

D. WEIGHT GR.1 ___ LBS GR.2 ___ LBS GR.3 ___ LBS

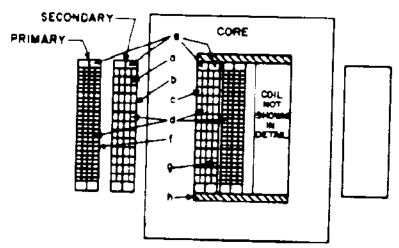
E. FINISH ______

F. IMPREGNATION IS BY THE ______ METHOD IN ACCORDANCE WITH SPEC. MIL-E-917 USING VARNISH IN ACCORDANCE WITH SPEC.

G. COIL LEAD DATA

WINDING	DIAMETER		STRANDING		INSULATION
VOLTS	BARE	INSUL	NO	SIZE	
450					
230					
120					

H. VOLUME ______ CU. IN.



SECTIONAL VIEW OF WINDINGS & INSULATION

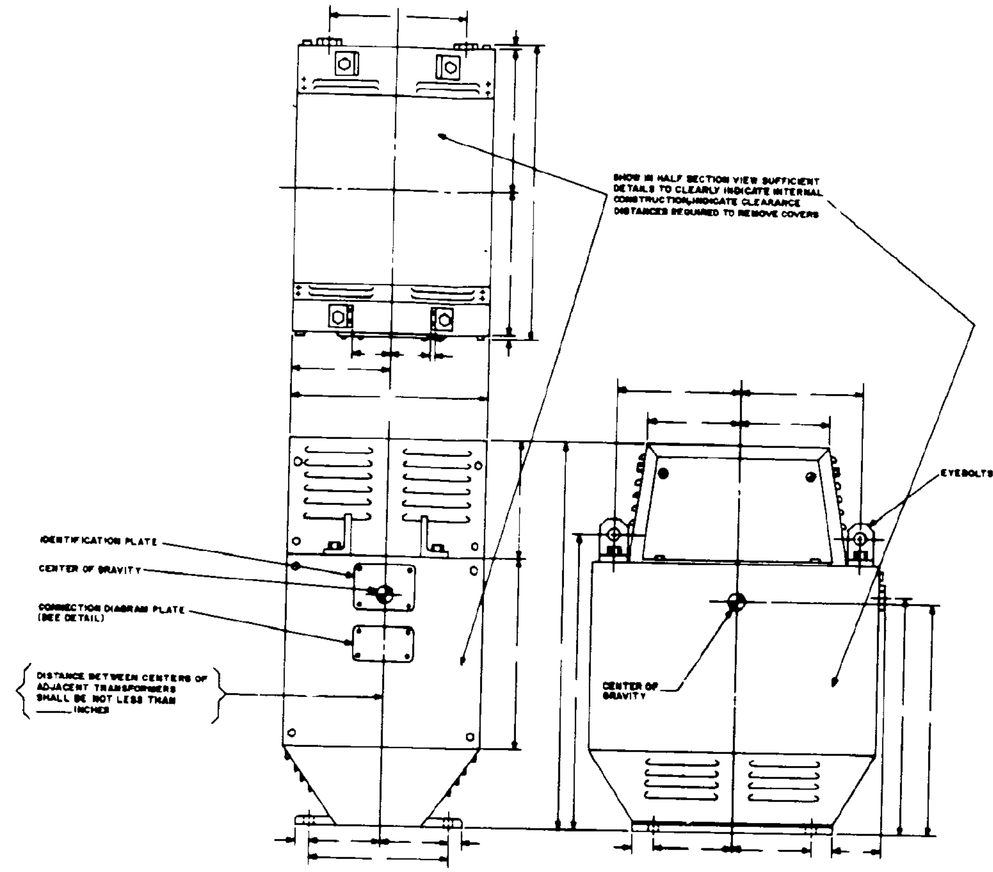
INSULATION MATERIAL				
SYMBOL	LOCATION	MATERIAL	GOV'T. SPEC.	REMARKS
a				
b				
c				

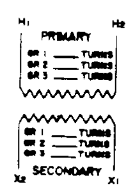
APPLICATION OF FIBER GLASS INSULATION (WHERE USED)

1. (DESCRIBE BRIEFLY APPLICATION OF INSULATION TO CONDUCTOR)

FIBER GLASS TAPE OR SLEEVING IS USED FOR PROTECTIVE COVERING

2. (DESCRIPTION OF ALL OTHER APPLICATIONS eg TYING CORD, SLEEVING AND GROUND INSULATION, LAYER INSULATION).





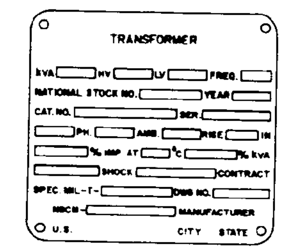
PERFORMANCE DATA														
GROUP	KVA	PRIMARY		SECONDARY		WATTS LOSS		% REGULATION		EXCITING CURRENT	IMPEDANCE	MAXIMUM PEAK INRUSH CURRENT	TURNS RATIO	VOLTAGE RATIO
		NO LOAD VOLTAGE	AMPERES	NO LOAD VOLTAGE	AMPERES	NO LOAD	TOTAL	100% PF	80% PF	%	%	AMPERES		

WINDING DATA													
GR NO.	WINDING	VOLTS	NO. OF COIL	TURNS	TURNS PER LAYER	LAYERS	LENGTH OF LAYER	CONDUCTOR					
								DIMENSIONS BARE	AREA	DIMENSIONS INSUL	NO. SPEC	WEIGHT	RESIST

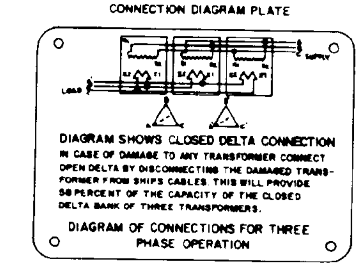
CORE OPENING ______
TONGUE SECTION ______

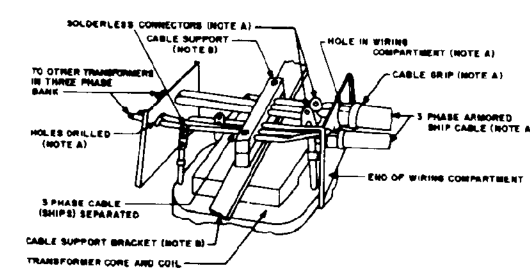
LIST OF MATERIAL – QUANTITIES FOR ONE TRANSFORMER												REVISIONS					
1 SH	2 SH	3 SH	PC NO.	NAME	NO REC'D	MATERIAL	MAT'L SPEC.	CONTRACTOR		EST. WT LB.	REMARKS	REV.	DESCRIPTION	MFR		USN	
								DWG. NO.	SERVICE PART NO.					DATE	APP'D	DATE	APP'D

IDENTIFICATION PLATE



CONNECTION DIAGRAM PLATE





METHOD OF CONNECTING TRANSFORMER TO SHIPS CABLE (WIRING COMPARTMENT WITH COVER REMOVED)

NOTE A: FURNISHED BY SHIPBUILDER.

NOTE B: A REMOVABLE ANGLE IRON CABLE SUPPORT BRACKET IS FURNISHED BY THE TRANSFORMER MANUFACTURER FOR 75 AND 100 KVA SIZES. THE SHIPBUILDER WILL DRILL THIS BRACKET AND PROVIDE A CABLE SUPPORT IF NECESSARY. IT IS NOT CONTEMPLATED THAT CABLE SUPPORTS WILL BE USED ON SIZES SMALLER THAN 75 KVA.

SH 10854

Figure 3 - Typical drawing.

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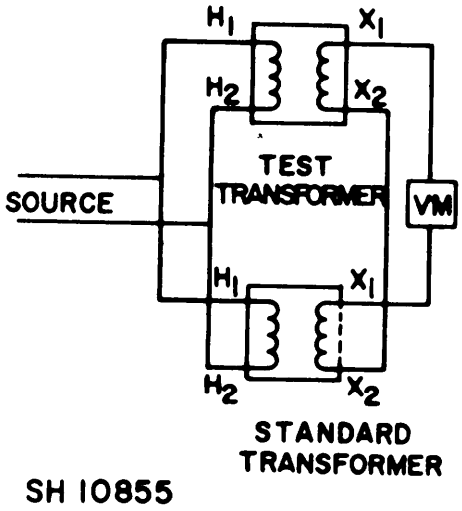
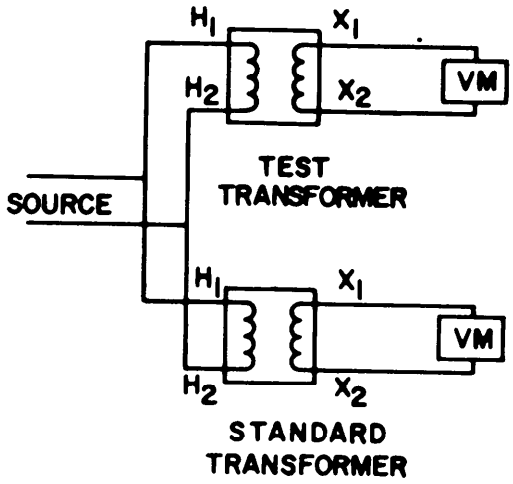


Voltmeter arranged to read the difference between the two secondary voltages.



Voltmeter arranged to read the two secondary voltages. The readings are repeated after interchanging voltmeters.

Figure 4 - Connections for ratio test using standard transformer method.

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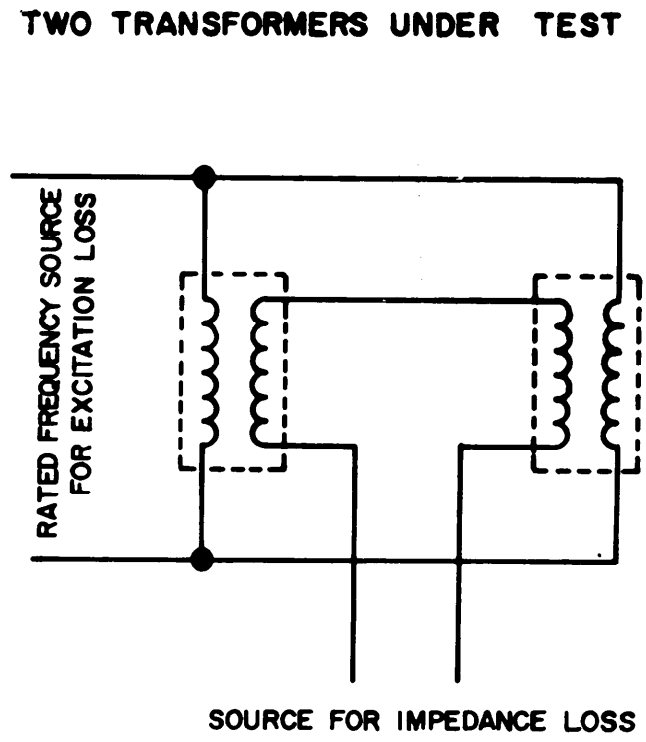

Figure 5 - Method of loading transformers for the heating test.

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