

MIL-T-981A(SHIPS)
 11 August 1960
 SUPERSEDING
 MIL-T-981(SHIPS)
 8 July 1953

MILITARY SPECIFICATION

TRANSFORMER, POWER, VOLTAGE REGULATING

1. SCOPE

1.1 Scope.- This specification covers automatic voltage regulating transformers of the dry type, employing natural draft ventilation, for continuous duty with Naval radar and radio equipment.

1.2 Classification.- Transformers shall be of the following types, as specified (see 6.1):

- Type I - Voltage regulator.
- Type II - Voltage regulator with harmonic neutralizer or filter.
- Type III - Voltage regulator with frequency compensation.

2. APPLICABLE DOCUMENTS

2.1 The following specifications and standards, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

SPECIFICATIONS

MILITARY

- MIL-I-10 - Insulating Materials Electrical Ceramic Class L.
- MIL-C-25 - Capacitors, Fixed, Paper-Dielectric, Direct-Current, (Hermetically Sealed in Metallic Cases), General Specification For.
- MIL-W-583 - Wire, Magnet, Electrical.
- MIL-S-901 - Shockproof Equipment, Class HI (High-Impact) Shipboard Application, Tests for.
- MIL-V-1137 - Varnish, Electrical Insulating (for Electro-Motive Equipment).
- MIL-P-15024 - Plates, Identification-Information and Marking for Identification of Electrical, Electronic and Mechanical Equipment.
- MIL-E-15090 - Enamel, Equipment, Light-Gray (Formula No. 111).

- MIL-T-15108 - Transformers, Power Step-Down, Single Phase, 60 Cycle, 1-KVA Approximate Minimum Rating; and Reactors (Balance Coils) - Dry, Naval Shipboard.
- MIL-W-16878 - Wire, Electrical (Insulated, High Temperature).
- MIL-P-17555 - Preparation for Delivery of Electronic Equipment; Miscellaneous Electrical Equipment (Except Rotating Electrical Equipment) and Associated Repair Parts.

STANDARDS

MILITARY

- MIL-STD-108 - Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment.

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

3. REQUIREMENTS

3.1 Material.- Materials not covered by this specification shall be of the best industrial quality available, and shall be satisfactory in every respect for the intended use.

3.1.1 Cast iron.- Cast iron shall not be used for any purpose in the transformer or any part thereof.

3.1.2 Fungus-inert materials.- Only materials which are not nutrients for fungi or insects shall be used.

3.1.3 Wire.- Magnet wire shall be in accordance with Specification MIL-W-583.

3.1.4 Cables.- Cables and hook-up wire shall be in accordance with Specification MIL-W-16878.

3.1.5 Varnish.- Insulating varnish shall conform to Specification MIL-V-1137.

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3.1.6 Ceramic.- Insulating ceramics shall conform to Specification MIL-I-10.

3.2 Parts.- Parts not covered by this specification shall be of the best industrial quality available.

3.2.1 Capacitors.- Capacitors for use on alternating current (a.c.) shall meet the mechanical construction requirements and the mechanical and environmental tests specified in Specification MIL-C-25. They shall be of the oil-filled type and shall have an a. c. voltage rating for operation at the maximum ambient involved that is greater than the maximum voltage impressed across the terminals under the extreme condition of operation of the transformer. Ratings shall be in accordance with good commercial practice and the capacitors shall withstand a dielectric test of twice voltage plus 1000 volts from terminals to enclosure.

3.3 General requirements.-

3.3.1 Size and weight.- The size and weight shall be held to the minimum practical for the particular type of insulation employed.

3.3.2 Insulation.- Insulation shall be class A, E, or H as specified (see 6.1) depending upon the application or service conditions imposed.

3.3.3 Enclosure.- Exposed surfaces of enclosures shall be so protected or constructed that the assembly shall meet the dripproof requirements of Standard MIL-STD-108 without showing signs of electrical failure.

3.3.4 Humidity.- The equipment shall operate satisfactorily at relative humidities ranging up to 95 percent for continuous and intermittent periods, including conditions wherein condensation takes place on the transformer in the form of both water and frost.

3.3.5 Temperature.- The transformers shall be capable of continuous operation over one of the following temperature ranges¹ (see 6.1):

- (a) -10° to +50° Centigrade (C.)
- (b) -30° to +85° C.
- (c) -54° to +65° C.

¹ Size and weight being a consideration, it is necessary to select the range carefully for the application involved; that is, (a) will normally be smaller than (b), and possibly (b) could be smaller than (c).

Practically all voltage regulators employ oil-filled capacitors, and certain oils such as the chlorinated diphenyls work satisfactorily over a given range of temperature. Capacitors employing this material are smaller in size than the mineral oil-filled type.

3.3.5.1 Storage.- The transformers shall be capable of withstanding prolonged storage under temperature conditions of -50° to +85°C. without degradation in operational performance when restored to normal operating temperatures.

3.3.6 Accessibility.- Parts which are subject to replacement, with the exception of parts contained in hermetically sealed subassemblies, shall not be permanently secured by rivets, welding, or other means which prohibit their easy removal. All parts shall be so mounted that their removal or replacement will not result in damage to such parts, damage to adjacent parts, or to interconnecting wires.

3.3.7 Outlet holes.- Outlet holes for the entrance of cable into the transformer shall not be provided unless otherwise specifically stated (see 6.1).

3.3.8 Covers.- The cover shall be held firmly on the case by means of captive screws attached to the cover, and a short chain shall be supplied and connected between the cover and the case so that the cover cannot be lost. This applies generally to any part of the transformer assembly where it is necessary to remove a cover to replace a part or to make electrical connections, and therefore more than one cover may be required.

3.3.9 Terminals.- Terminals shall be of the stud type, using bolts large enough to carry the full load current rating of the transformer, and shall be securely anchored in a panel so they will not turn when a reasonable torque is applied.

3.3.9.1 Terminal marking.- Each terminal shall be identified by a designation applicable to its position in the circuit (for example: Pri. 1, Sec. 1, Gnd.). The designations shall appear on the terminal strip in the vicinity of each terminal within the dripproof compartment.

3.3.10 Mounting.- The transformers shall be designed for bulkhead mounting.

3.3.11 Shock.- Transformers shall withstand the type A tests as specified in Specification MIL-S-901.

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3.3.12 Vibration. - Transformers shall withstand the vibration test specified in 4.5.11.

3.3.13 K. V. A. rating. - The K. V. A. rating shall be as specified (see 6.1).

3.3.14 Finish. - Transformers shall be finished externally in accordance with class 2 of Specification MIL-E-15090.

3.4. Detail requirements. -

3.4.1 Voltage input. - Transformers shall be designed for a nominal voltage input of 115 volts.

3.4.2 Voltage output. - The nominal voltage output shall be 115 volts, ± 2 percent at rated load conditions, with nominal input voltage and frequency, and at an ambient temperature of $25^{\circ} \pm 5^{\circ} \text{C}$.

3.4.3 Efficiency. - The minimum efficiency of the transformer shall be not less than 70 percent at full load and rated power factor when the output rating is 250 volt amperes (V. A.) or more.

3.4.4 Standby load. - The transformer output voltage shall not exceed the maximum rated input voltage of 130 volts nor shall damage result to the transformer when operated at the standby load of 15 percent.

3.4.5 Regulation. -

3.4.5.1 Type I. - The output voltage regulation at full load at 80 to 90 percent power factor lagging and/or with an input voltage variation of 95 to 130 volts and 60 cycles per second (c. p. s.) shall be less than ± 2 percent from the value obtained as specified in 3.4.2. With a voltage input as specified in 3.4.1, the output voltage regulation at full load and 85 percent power factor lagging, shall be less than ± 7 percent when the supply line input frequency is varied from 58 to 62 c. p. s. The output voltage regulation from full load at 85 percent power factor to 60 percent load at 85 percent power factor shall not be more than ± 3 percent from that value obtained when the input voltage is as specified in 3.4.1, and the frequency is 60 cycles.

3.4.5.2 Type II. - Regulation shall be the same as specified in 3.4.5.1 for type I.

3.4.5.3 Type III. - The output voltage regulation at full load at 80 to 90 percent power factor lagging and/or with a supply line input frequency variation

of 58 to 62 cycles shall not exceed ± 3 percent from that value obtained according to 3.4.2. With a voltage input as specified in 3.4.1, and at an input frequency of 60 cycles, the output voltage variation of the regulator shall not exceed ± 5 percent when the load is varied from full load at 85 percent power factor lagging to 60 percent load at 85 percent power factor lagging.

3.4.6 Harmonic content. -

3.4.6.1 Type I. - The total root-mean-square (r. m. s.) harmonic content of the output voltage shall not exceed 20 percent of the nominal voltage. Any single harmonic shall not exceed 16 percent at any load from 60 percent load to full load at 80 to 90 percent power factor lagging, when the input voltage is as specified in 3.4.1 and the frequency is 60 c. p. s.

3.4.6.2 Type II. - The total r. m. s. harmonic content of the output voltage shall not exceed 3 percent of the nominal voltage. Any single harmonic shall not exceed 2 percent at any load from 60 percent load to full load at 80 to 90 percent power factor lagging when the input voltage is as specified in 3.4.1 and the frequency is 60 c. p. s.

3.4.6.3 Type III. - The total r. m. s. harmonic content of the output voltage shall not exceed 6 percent of the nominal voltage at any load from 60 percent load to full load at 80 to 90 percent power factor lagging and/or with a supply line input frequency variation of 58 to 62 cycles and/or with an input voltage variation of 95 to 130 volts.

3.4.7 Electrostatic shield. - If the primary winding is not isolated from the secondary winding by means of a magnetic shunt, an electrostatic shield will be required only if specified (see 6.1). When required, the shield shall be connected to the core and the case of the transformer, and terminated at the ground binding post on the terminal strip.

3.4.8 Audible vibration. - Audible vibration of the transformer, that is, primarily the vibration of the core laminations between 25 and 15,000 c. p. s., shall be kept at a minimum and shall not produce excessive audible disturbance. Any disturbance caused thereby shall not be reflected in the electrical characteristics of the transformer.

3.4.9 Losses. - The maximum loss shall be kept as small as possible, and in no case shall exceed 30 percent of the full load rating of the transformer when the rating of the unit is 250 V. A. or greater.

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3.4.10 Overvoltage surge. - No damage to the transformer shall result from a transient overvoltage surge of 9 to 150 percent of rated input voltage.

3.4.11 Temperature rise. - The maximum temperature of the primary or secondary winding or core shall not exceed 200° C. if class H insulation is used, 125° C. if class B insulation is used, and 100° C. if class A insulation is used. The allowable temperature rise will be the difference between the maximum all-walk temperature and the maximum ambient temperature. This test is to be made under maximum ambient temperature conditions as radiation of heat is greater at higher temperatures. Correlation tests may be run on the first unit or units at the maximum ambient temperature, and any other lower temperature in order to determine the permissible temperature rise at any lower ambient.

3.5 Supplementary requirements.

3.5.1 Identification plates. - Identification plates shall be type A or B, in accordance with Specification MIL-I-15024.

3.5.2 Connection plate. - A plate shall be furnished with each transformer which shall indicate the circuit connections and the type of mounting. This plate shall be prominently and securely affixed in a readily accessible location, preferably on the front of the enclosure.

3.6 Workmanship. - Workmanship shall be first class in every respect. All parts of the transformer shall be of a sturdy construction and shall not show weakness under any reasonable strains which may be placed upon it in service.

4. QUALITY ASSURANCE PROVISIONS

4.1 The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. 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.

4.2 Classification. - The sampling, inspection, and test procedures for transformers shall be considered as falling within the following classifications:

- (a) Acceptability tests.
- (b) Inspection tests.

4.3 Acceptability tests. - Acceptability tests shall be conducted at a designated laboratory or the place of manufacture as specified (see 6.1) on a preproduction model when a preproduction model is required or on the first transformer when no preproduction model is required (see 6.1).

4.4 Inspection tests. - Inspection tests shall be conducted at the place of manufacture under supervision of the inspector, and shall be as specified in 4.4.1, 4.4.2 and 4.4.3.

4.4.1 Group A tests. - Every transformer shall pass, without failure, the following tests, which shall be witnessed by the inspector:

Test	Reference
(a) Dielectric	4.5.9
(b) Power input at standby 15 percent load	4.5.12
(c) Visual inspection	- - -

4.4.2 Group B tests. - The following tests shall be performed on sample transformers selected in accordance with 4.4.2.1:

Test	Reference
(a) Temperature.	4.5.1
(b) Input voltage variation.	4.5.5
(c) Input frequency variation.	4.5.6
(d) Load variation and power factor variation.	4.5.7
(e) Harmonic content.	4.5.8
(f) Electrical (for type I, II, or III as specified (see 6.1))	4.6

4.4.2.1 Sampling for group B tests. - The inspector shall select production units and require that the group B tests be performed on them in order to prove the acceptability of the design. As units are produced and their number increases, sample units shall be selected in accordance with table I. Each of these sample units shall be subjected to all of the group B tests and rejected if it fails in any test. If at any time the number of equipments failing in any test exceeds the approval number of table I for the accumulated number of equipments tested

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at that time, the contractor shall be required to make such change as may be necessary to meet the requirements of this specification. This change

shall be made in every equipment, including those completed ready for delivery, as well as units in process of manufacture.

Table I - Sampling for group B tests.

Cumulated number of transformers of one type produced without change of design	Cumulating number of transformers of one type to be subjected to every group B test	Number nonconforming in any group B test	
		Approval number maximum allowed	Disapproval number
2 to 4	2	0	1
5 or 6	all but 2	0	1
7 to 9	5	0	1
10 to 15	6	0	1
16 to 25	8	0	1
26 to 35	10	0	1
36 to 65	12	1	2
66 to 100	14	1	2
101 to 145	17	1	2

After a design change has been made, sampling for all tests and characteristics affected shall be started with the first entry of table I and progress downward as for a new equipment design.

4.4.3 Group C tests. - The following tests shall be performed on sample units selected by the inspector when production reaches 100 and each multiple of 100 thereafter:

Test	Reference
(a) Operation at low temperature	4.5.2
(b) Effect of humidity changes.	4.5.2
(c) Enclosure (dripproof test).	4.5.4
(d) Shock.	4.5.10
(e) Vibration.	4.5.11

If any transformer fails in any of these tests, the inspector shall notify the bureau or agency concerned and request instructions.

4.5 Tests. -

4.5.1 Temperature test. - The temperature test shall be conducted as specified in Specification MIL-T-15108 and shall be conducted at room temperature or at the maximum ambient condition specified therein.

4.5.2 Storage test. - The transformer shall be connected according to 4.5.3, and then disconnect the load. The ambient temperature in the chamber shall then be lowered to the required value of -54°C .

and maintained at that point until stabilization of the transformer temperature is obtained. Power is then to be applied to the primary, and readings taken after approximately 3 to 5 minutes of operation and according to 4.5.3. Leaving the power on, the ambient is then to be raised to 85°C . and approximately 95 percent relative humidity. The readings specified in 4.5.3 are recorded after the transformer temperature is stabilized.

4.5.3 Operating test. - The transformer shall be connected for nominal input and output during the test. The following readings shall be recorded at each step during the test: (a) percent of relative humidity, (b) ambient temperature, (c) transformer temperature, (d) input volts and amperes, (e) output volts and amperes, (f) K. V. A., (g) power factor and (h) overall efficiency. The tests of 4.5.5, 4.5.6, 4.5.7, 4.5.8, 4.5.9, and 4.5.10, shall be made at normal room temperature.

4.5.4 Dripproof test. - The dripproof test shall be conducted as specified in Standard MIL-STD-108.

4.5.5 Input voltage variation test. - After first connecting the transformer for rated nominal input and output conditions, the input voltage shall be varied from 95 to 130 volts. The following readings shall be

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recorded: (a) ambient temperature, (b) input volts and amperes, (c) output volts and amperes, (d) K. V. A., and (e) overall efficiency.

4.5.6 Input frequency variation test. - After first connecting the transformer for rated nominal input and output conditions, the input frequency shall be varied from 58 to 62 cycles. The following readings shall be recorded: (a) ambient temperature, (b) input volts and amperes, (c) output volts and amperes, (d) K. V. A., and (e) overall efficiency.

4.5.7 Load variation and power factor variation test. - After first connecting the transformer for rated nominal input and output conditions, the output load shall be varied from 80 percent load to full load. Similar tests shall be conducted at 80 percent power factor and 90 percent power factor. The following readings shall be recorded: (a) ambient temperature, (b) input volts and amperes, (c) output volts and amperes, (d) K. V. A., (e) power factor and (f) overall efficiency.

4.5.8 Harmonic content test. - The transformer shall be tested for compliance with 3.4.6. General Radio Company Type 736A Wave Analyzer or Hewlett-Packard Company Type 300A Wave Analyzer or equal will be considered as satisfactory instruments to the bureau or agency concerned in making the required measurements.

4.5.9 Dielectric tests. -

4.5.9.1 General requirements. - The dielectric test shall be made after all tests except shock tests and vibration tests have been completed. This test shall be made upon the completely assembled unit, except that the capacitors may be disconnected before making the test.

4.5.9.2 Applied potential. - The test voltage shall be applied successively between each winding and all other windings with metal parts grounded.

4.5.9.3 Test voltage. - The insulation of the windings shall withstand a dielectric test of 1000 volts plus twice the maximum operating voltage, with a minimum applied potential to any winding of not less than 2000 volts at a frequency of 60 c. p. s. The period of this test shall be one minute.

4.5.9.4 Measurement of test voltage. - The voltmeter method shall be used in measuring the voltage. The instrument shall derive its voltage from the high voltage circuit either directly or through an auxiliary ratio transformer or by means of a voltmeter coil placed in the testing transformer.

4.5.10 Shock tests. - Shock tests shall be conducted in accordance with Specification MIL-S-901

4.5.11 Vibration. - The transformer and any associated equipment shall be mounted on the test platform in the same manner followed for shipboard installation, and then vibrated in a plane perpendicular to the platform and in both directions in a plane parallel to the platform at an amplitude of 1.16 in., and at a rate of from 0 to 2000 cycles per minute for a total period of not less than 30 minutes for each direction of vibration.

4.5.12 Power input at standby load. - The regulating transformer shall be loaded to 15 percent of its rated load and meet the requirements of 3.3.9.

4.6 Electrical tests. -

- (a) Type I. - Electrical test shall be run at full load only, at 85 percent power factor lagging, and for primary variation of 95 to 130 volts.
- (b) Type II. - Electrical test shall be the same as for type I, and in addition to the harmonic content test specified in 4.5.8 shall include a test of harmonics in secondary voltage at full load at 85 percent power factor and at a primary of 115 volts.
- (c) Type III. - Electrical test shall be run at full load only, at 85 percent power factor lagging, and for primary variation of 95 to 130 volts and frequency variation of 58 to 62 cycles when primary voltage is 115 volts.

5. PREPARATION FOR DELIVERY5.1 Preservation, packaging, packing and marking. -

5.1.1 The equipment, accessories, technical publications, equipment and stock repair parts shall be preserved and packaged by Level A or C; packed by Level A, B or C and marked by Level A and B or C as specified in the contract or order in accordance with Specification MIL-P-17555.

6. NOTES

6.1 Ordering data. - Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Type required (see 1.2).

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- (c) Insulation required (see 3.3.2).
- (d) Temperature (see 3.3.5).
- (e) Outlet holes if required (see 3.3.7).
- (f) K. V. A. rating (see 3.3.13).
- (g) Electrostatic shields, if required (see 3.4.7).
- (h) Place of tests (see 4.3).
- (i) Model required (see 4.3).
- (j) Whether delivery will be for domestic shipment - immediate use; domestic shipment and storage; or overseas shipment (see 5.1).

Notice: - When Government drawings, specifications, or other data are used for any purpose other

than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Preparing activity:
Navy-Bureau of Ships
(Project 5950-N046Sh)

SPECIFICATION ANALYSIS SHEET

Form Approved
Budget Bureau No. 119-R-04INSTRUCTIONS

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

SPECIFICATION

ORGANIZATION (of submitter)

CITY AND STATE

CONTRACT NO.

QUANTITY OF ITEMS PROCURED

DOLLAR AMOUNT

\$

MATERIAL PROCURED UNDER A

 DIRECT GOVERNMENT CONTRACT SUBCONTRACT

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

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES.

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

 YES NO IF "YES", IN WHAT WAY?

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

SUBMITTED BY (Printed or typed name and activity)

DATE