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SUPERSEDING
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(See 6.6)

MILITARY SPECIFICATION

INSTRUMENT AUXILIARIES, ELECTRICAL MEASURING: SHUNTS, RESISTORS, AND TRANSFORMERS

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers electrical measuring instrument auxiliaries as follows (see 6.1 and 6.2.1):

(a) Shunts
(b) Resistors
(c) Current transformers
(d) Potential transformers
(e) Current transformer protective devices

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document shall be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FSC 6625

SPECIFICATIONS

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-P-15024 - Plates, Tags and Bands for Identification of Equipment.
MIL-P-15024/5 - Plates, Identification.
MIL-E-17555 - Electronic and Electrical Equipment, Accessories, and Provisioned Items (Repair Parts): Packaging of.

STANDARDS

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-195 - Marking of Connections for Electric Assemblies.
MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.
MIL-STD-454 - Standard General Requirements for Electronic Equipment.

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

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

C57.13 Instrument Transformers, Requirements for.

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

UNIFORM CLASSIFICATION COMMITTEE AGENT

Uniform Freight Classification Ratings, Rules and Regulations

(Application for copies should be addressed to the Uniform Classification Committee Agent, Tariff Publication Officer, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order, a sample shall be subjected to first article inspection (see 4.4 and 6.3).

3.2 General requirements. The following general requirements applying to the instrument auxiliaries covered by this specification shall be in accordance with MIL-E-917 (see 4.6 and 4.7.2):

(a) Creepage and clearance distances
(b) Corrosion-resistant treatment
(c) Connection marking
(d) Insulation, electrical, including encapsulants
(e) Safety
(f) Prohibited materials
(g) Soldering
(h) Threaded parts
(i) Toxic materials
(j) Temperature measurement

3.3 Dielectric strength. When tested in accordance with 4.7.1, the instrument auxiliaries shall withstand the voltage values shown in table I.

TABLE I. Dielectric strength design values.

Name of part	Ac rms voltage
Shunts:	
For portable instruments	100 plus two times rated voltage
For switchboard mounting	1500
Resistors	1000 plus two times rated voltage
Current transformer	2000 plus 2-1/4 times rated voltage (primary) 2500 (secondary)
Potential transformers	1000 plus two times rated voltage (primary and secondary)
Protective devices	1500

3.4 Temperature rise. When tested in accordance with 4.7.10, the temperature rise shall be not greater than the values shown in table II.

TABLE II. Temperature rise.

Name of part	Temperature rise (50°C ambient)
Shunts	Value which will not cause physical damage
Resistors Class B insulation	75°C
Current and potential transformers Class A Class B	 55°C 75°C
Current transformer protective device	Value which will not cause physical damage

3.5 Shock. Instrument auxiliaries and protective devices shall withstand the grade A, class I, type C shock test for lightweight equipment in accordance with MIL-S-901.

3.6 Insulation resistance. Insulation resistance shall be measured between 500 and 1000 volts direct current (Vdc) and shall be not less than 10 megohms.

3.7 Silver-plated terminals. Connections and terminals for all equipment except resistors shall be silver-plated, except terminals below 30 amperes may be tin plated. Tin plating shall be 0.0005 inch thick.

3.8 Shunts.

3.8.1 Material. Shunts shall consist of an alloy with a minimum temperature coefficient of resistance up to the rated capacity.

3.8.2 Construction. Fabrication shall be by brazing or silver soldering. Soft solder shall not be used.

3.8.3 Thermal electromotive force. The thermal electromotive force produced by continuous operation of the shunt at rated current shall be not greater than the value which would cause a change in the reading (at rated current) of 0.25 percent. The connections to the circuit shall be made so that the opportunity for the escape of heat shall be equal at both terminals.

3.8.4 Polarity. Shunts shall be regarded as being without polarity until installed.

3.8.5 Resistance. Resistance shall be as specified (see 6.2.1).

3.8.6 Mounting. Mounting shall be portable or switchboard type as specified (see 6.2.1).

3.8.7 Voltage drop. The voltage drop at rated current shall be as follows within 0.25 percent (see 6.2.1):

(a) 50 or 100 millivolts for direct current (dc) switchboard shunts.
(b) 50, 100, or 200 millivolts, as approved for dc portable shunts.

3.8.8 Leads.

3.8.8.1 Insulation. Shunt leads shall be insulated flexible conductors. The insulating material shall have a wall thickness of not less than 3/64 inch and a heavy outer braid of cotton or synthetic fiber.

3.8.8.2 Length. The length of the leads shall be not less than 3 feet for portable shunts and not less than 5 feet but not greater than 8 feet for switchboard shunts.

3.8.8.3 Terminals. The leads shall be provided with properly sized flat terminals at both ends. The terminals shall be of the closed type for switchboard instruments.

3.8.8.4 Lead resistance. Lead resistance shall be as specified (see 6.2.1) for the instrument with which the leads are to be used.

3.9 Resistors.

3.9.1 Overload and humidity. Resistors shall withstand the overload and humidity test specified in 4.7.5.

3.9.2 Resistor tolerance. The total resistance of resistors shall not differ from the design value by more than 0.5 percent.

3.9.3 Resistance value. The resistance value shall be as specified (see 6.2.1).

3.9.4 Resistor mounting. Mounting means and dimensions and overall dimensions of cage mounted (separate from the instrument) resistors shall be as approved by the command or activity concerned.

3.10 Current transformers.

3.10.1 Construction. The transformers shall be either sealed or encapsulated.

3.10.2 Primary current and secondary current. The primary and secondary currents shall be as specified (see 6.2.1).

3.10.3 Current transformer mounting. The mounting for current transformers shall be portable, switchboard, bar, wound, or window as specified (see 6.2.1).

3.10.4 Polarity and terminal markings for current transformers.

3.10.4.1 Arrangement of terminals. The terminals of all current transformers shall be arranged with regard to instantaneous polarities.

3.10.4.2 Current transformer polarity marking. Current transformers shall be subtractive and shall be so marked in accordance with MIL-STD-195. These polarity markings shall not be obliterable by paint. They may, however, be supplemented by a durable white paint on the respective primary and secondary terminal.

3.10.5 Current transformer frequency range. No change of current transformer accuracy shall result from frequency change of the current being measured over the range of plus or minus 10 percent of design value. This design value shall be either 60 or 400 hertz (Hz) as specified (see 6.2.1).

3.10.6 Current transformer accuracy and ratio error. Current transformers shall not exceed the ratio error and phase angle limitations shown in table III at rated frequency for the service specified (see 6.2.1).

TABLE III. Current transformer ratio error and phase angle.

Service		Percent of rated current	Phase angle	Ratio error limits (maximum)
Navy designation	ANSI[1/] designation		Minutes (plus or minus)	Percent (plus or minus)
Navy primary service (NPS)	0.3	10 100 ± 10	20 10	0.50 0.25
Navy secondary service (NSS)	0.6	10 100 ± 10	40 20	1.00 0.50
General usage (GU)	1.2	10 100 ± 10	80 40	2.00 1.00

1/ The ANSI C57.13 designations are a combination of that shown in tables III and IV, for example 0.3B-0.1.

3.10.6.1 Current transformer burden. Current transformers shall be furnished in the burdens (at rated current of voltage and frequency) specified in table IV with relation to the accuracy specified in the acquisition document (see 6.2.1).

TABLE IV. Current transformer burden.

Volt-amperes	Percent power factor	ANSI designation 1/
2.5	90	B-0.1
5	90	B-0.2
12.5	90	B-0.5
25	50	B-1
50	50	B-2

1/ The ANSI C57.13 designations are a combination of that shown in tables III and IV, for example 0.3B-0.1.

3.10.7 Short circuit and open circuit limitations.

3.10.7.1 Current transformer on shorted secondary circuit. Under conditions of shorted secondary circuit, current transformers shall withstand without injury 40 times the rated primary current applied for 1 second.

3.10.7.2 Current transformer on open secondary circuit. Under conditions of open secondary circuit, current transformers shall be capable of carrying rated primary current continuously without damage to the insulation and without interruption of service.

3.10.8 Current transformer ratio. Current transformers shall be furnished in the following standard ampere ratios. Nonstandard ratios, if required, shall be as specified (see 6.2.1).

25:5	250:5	1000:5	1/ 3500:5
50:5	300:5	1200:5	4000:5
75:5	400:5	1500:5	5000:5
2/ 80:5	500:5	2000:5	6000:5
100:5	600:5	1/ 2500:5	1/ 7000:5
150:5	750:5	3000:5	8000:5
200:5	800:5		

1/ Not to be used for new construction
2/ 400 Hz only

3.10.9 Current transformer moisture resistance. When specified (see 6.2.1), current transformers shall withstand the moisture resistance test specified in 4.7.14. At the conclusion of the test, the insulation resistance shall be not less than 25 megohms.

3.10.10 Current transformer protective devices. When specified (see 6.2.1), protective devices shall protect the associated current transformer against high open secondary circuit voltages by automatically short-circuiting the secondary terminals of the transformer before the secondary voltage exceeds 450 volts root mean square (Vrms) at 5 amperes root mean square (rms) sine wave.

3.10.10.1 Current transformer mounting. Current transformer protective devices shall be capable of being switchboard mounted separately from the current transformer they protect.

3.10.10.2 Leakage current. Leakage current of protective devices at 10 Vrms shall be not greater than 4 milliamperes.

3.11 Potential transformers.

3.11.1 Construction. Transformers shall be either sealed or encapsulated.

3.11.2 Primary voltage and secondary voltage. The primary voltage and secondary voltage shall be as specified (see 6.2.1).

3.11.3 Potential transformer mounting. Unless otherwise specified (see 6.2.1), the potential transformer mounting shall be for switchboard.

3.11.4 Polarity and terminal markings for potential transformers. The terminals shall be arranged with regard to instantaneous polarities.

3.11.4.1 Potential transformer polarity marking. Potential transformers shall be subtractive and shall be so marked in accordance with MIL-STD-195. These polarity markings shall not be obliterable by paint. They may, however, be supplemented by a durable white paint on the respective primary and secondary terminal.

3.11.5 Potential transformer frequency range. No change of potential transformer accuracy shall result from frequency change of voltage being measured over the range of plus or minus 10 percent of design value. This design value shall be either 60 or 400 Hz as specified (see 6.2.1).

3.11.6 Potential transformer accuracy and ratio error. At any voltage from 90 to 110 percent of the primary voltage rating and at any secondary burden from 0 to 110 percent of the rated volt-ampere capacity over the specified frequency range, the accuracy limitations shown in table V shall apply for the service specified (see 6.2.1).

TABLE V. Potential transformer ratio error and phase angle.

Classification		Phase angle minutes-limits	Ratio error limits
Navy	ANSI 1/		
NPS	0.6	± 20	± 0.5
NSS	1.2	± 40	± 1

1/ The ANSI C57.13 designations are a combination of that shown in tables V and VI, for example 0.6Y.

3.11.6.1 Potential transformer burden. Potential transformers shall be furnished in the burdens (at rated current or voltage and frequency) specified in table VI, with relation to the specified accuracy (see 6.2.1).

TABLE VI. Potential transformer burden.

Volt-amperes	Percent power factor	ANSI designation 1/
12.5	10	W
25	70	X
35	20	M
75	85	Y
200	85	Z

1/ The ANSI C57.13 designations are a combination of that shown in tables IV and V, for example 0.6Y.

3.11.7 Potential transformer ratio. Potential transformers shall be furnished in the following standard ratios. Other standard ratios, when required, shall be selected from ANSI C57.13 as specified (see 6.2.1).

(a) 230 to 115 volts (2/1)
(b) 460 to 115 volts (4/1)
(c) 575 to 115 volts (5/1)
(d) 1100 to 110 volts (10/1)
(e) 2300 to 115 volts (20/1)
(f) 4600 to 115 volts (40/1)

3.11.8 Potential transformer moisture resistance. When specified (see 6.2.1), potential transformers shall withstand the moisture resistance test specified in 4.7.14. At the conclusion of the test, the insulation resistance shall be not less than 25 megohms.

3.12 Markings.

3.12.1 Potential transformer polarity markings. The polarity of all points where external connections are made shall be plainly marked.

3.12.2 Identification plates. Equipment shall be provided with identification plates in accordance with MIL-P-15024 and MIL-P-15024/5. They shall be located in an accessible position where they can be read at all times without danger to personnel. Aluminum shall not be used for identification plates.

3.12.2.1 Current and potential transformers. The following data shall be marked on the identification plates. Items (a), (d), (e), (g), (h) and (i) are required as a minimum.

(a) Manufacturer's name (or symbol)
(b) Manufacturer's serial number
(c) Manufacturer's type and form designation
(d) Ratio in terms of primary and secondary current (current transformers only)
(e) Ratio in terms of primary and secondary voltages (potential transformers only)
(f) Voltage rating of primary winding (potential transformers only)
(g) Volt amperes
(h) Rated frequency
(i) Accuracy classification

3.12.2.2 Shunts and resistors. The following data, which shall be marked on the identification plates apply to self-contained equipment with instrument cases and to portable and switchboard mounting. Items (a), (c), (d) and (e) are required as a minimum.

(a) Manufacturer's name (or symbol)
(b) Manufacturer's type and form designation, or the equivalent
(c) Voltage drop at rated current (shunts only)
(d) Current rating
(e) Resistance (resistors only)

3.13 Workmanship. Instrument auxiliaries shall be manufactured and processed in accordance with good design and sound practice. The instrument auxiliaries shall be free from metal filings, grease, oil, foreign material, dust, or other loose particles which might interfere with normal operation. The workmanship of instrument auxiliaries shall be in accordance with requirement 9 of MIL-STD-454.

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 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.1.2 Inspection system. Unless otherwise specified, the contractor shall provide and maintain an inspection system and a calibration system in accordance with the data ordering documents included in the contract or order (see 6.2.1 and 6.2.2).

4.2 Classification of inspections. The inspections specified herein are classified as follows:

(a) First article inspection (see 4.4)
(b) Quality conformance inspection (see 4.5)

4.3 Reference conditions. Unless otherwise specified (see 6.2.1), the reference conditions shall be as follows:

(a) Temperature: 23 ± 1°C
(b) Relative humidity: 50 to 75 percent
(c) Atmospheric pressure: 650 to 800 millimeters of mercury

4.4 First article inspection. First article inspection shall consist of the examination and tests specified in table VII performed in any order. One or more failures shall be cause for rejection of first article (see 3.1 and 6.3).

4.4.1 First article sample. Prior to beginning production, the contractor shall provide three instrument auxiliaries for each class designation (produced with equipment and procedures used in production) for first article inspection.

TABLE VII. First article inspection.

Name of examination or test	Requirement paragraph	Examination or test paragraph	Applicability				
			Shunt	Resistor	Potential transformer	Current transformer	Current transformer protective devices
General examination	3.2, 3.7, 3.8.1, 3.8.8, 3.9.1, 3.9.4, 3.10.1, 3.10.8, 3.11.1, 3.11.7, 3.12 and 3.13	4.6	X	X	X	X	X
Creepage and clearance	3.2	4.7.2	X	X	X	X	X
Voltage drop	3.8.7	4.7.3	X	—	—	—	—
Resistance	3.9.2	4.7.4	—	X	—	—	—
Polarity	3.10.4	4.7.6.1, 4.7.6.2	—	—	X	X	—
Phase displacement	3.10.6, 3.11.6	4.7.7.1, 4.7.7.2	—	—	X	X	—
Ratio error	3.10.6, 3.11.6	4.7.8	—	—	X	X	—
Overload and humidity	3.9.1	4.7.5	—	X	—	—	—
Dielectric strength	3.3	4.7.1	X	X	X	X	X
Breakdown voltage	3.10.10	4.7.9.1	—	—	—	—	X
Leakage current	3.10.10.2	4.7.9.2	—	—	—	—	X
Temperature rise	3.4	4.7.10	X	X	X	X	—
Short and open circuit	3.10.7	4.7.11	—	—	—	X	—
Shock	3.5	4.7.12	—	X	X	X	X
Insulation resistance	3.6	4.7.13	X	X	X	X	X
Moisture resistance	3.10.9, 3.11.8	4.7.14	—	—	X	X	—

4.5 Quality conformance inspection. The quality conformance inspection shall consist of the examination and tests shown in table VII, as applicable, except that the following tests need not be performed:

(a) Shock
(b) Insulation resistance
(c) Moisture resistance
(d) Temperature rise
(e) Short and open circuit

4.5.1 Inspection lot. Electrical indicating instrument auxiliaries of the same class which are presented for delivery at one time shall be considered a lot for purposes of inspection.

4.5.2 Sampling for quality conformance inspection. A random sample of equipments shall be selected from each inspection lot in accordance with table VIII and shall be subjected to the tests specified in 4.5. The results of each test shall be compared with specification requirements. Failure to conform to this specification for any test shall be considered a defect, and the equipment shall be rejected. Acceptance shall be in accordance with MIL-STD-105 as modified by table VIII. (Acceptable quality level (AQL) equals 1.5 percent defective.)

TABLE VIII. Sampling for quality conformance inspection.

Number of equipment in inspection lot	Number of equipment in sample	Acceptance number (Number of equipment nonconforming on any examination or test)	Rejection number (Number of equipment nonconforming on any examination or test)
15 and under	3	0	1
16 to 40	5	0	1
41 to 110	7	0	1
111 to 300	12	0	1
301 to 500	17	1	2
501 and over	25	2	3

4.6 General examination. Each instrument auxiliary shall be examined thoroughly to ascertain that the material, dimensions, design, marking, and workmanship are in accordance with this specification.

4.7 Test procedures.

4.7.1 Dielectric strength. Dielectric strength tests shall be conducted to determine conformance with this specification. The voltages shown in table I, as applicable, shall be applied for 1 minute. Points of application of test voltages and other test conditions shall be the same as for insulation resistance.

4.7.2 Creepage and clearance. Creepage and clearance distances shall be demonstrated by actual measurement to be in accordance with 3.2.

4.7.3 Voltage drop. Shunts shall be tested at 25, 50, 75, 100 and 150 percent of rated current. The test shall be repeated for each rating of the shunt. Duplicated current settings need not be repeated. Tests shall be done in an ambient of 20 degrees Celsius (°C) and repeated. The current shall be held until the temperature of the shunt is stabilized for settings up to rated current. The 150 percent rated test shall be held for 5 minutes immediately following the rated current test. The voltage drop shall be within 0.25 percent of rating for all tests.

4.7.3.1 Voltage drop between main contacts. The instrument leads shall be reconnected to the main contacts and rated current applied. The voltage drop shall be not greater than 1.0025 times the value between the instrument terminals.

4.7.4 Resistance. The overall resistance of resistors shall be measured by the bridge method to determine whether they are within plus or minus 0.5 percent of the design value. The temperature at which resistance readings are taken shall be recorded.

4.7.5 Overload and humidity. Resistors shall be placed in a chamber with a relative humidity of 95 percent and subjected to 50 cycles as described herein. Each cycle shall consist of energizing the resistors at 120 percent of rated voltage for 2 hours and then deenergizing and permitting them to cool for 1.5 hours. The humidity shall be raised to 100 percent as the temperature decreases. (Precautions shall be taken to prevent dripping on the resistors.) Directly after every five cycles, temperature rise, insulation resistance, resistance, and dielectric strength tests shall be conducted and the results shall be noted.

4.7.6 Polarity.

4.7.6.1 Polarity of current transformers. The polarity of a current transformer shall be tested by one of the following methods:

4.7.6.1.1 Method 1 for current transformers. A standard current transformer of known polarity shall be connected to a wattmeter, the potential coil of which shall be suitably excited. The deflection of the wattmeter shall be noted and compared with the deflection of the transformer under test when connected and operated in the same manner. If in both cases the deflections are in the same direction, the two transformers have the same polarity.

4.7.6.1.2 Method 2 for current transformers. A dc voltmeter or ammeter shall be connected across the low voltage winding of the transformer to be tested. A dry cell and switch shall then be placed across the primary winding. When the switch is closed, the instantaneous deflection of the meter shall be noted. A positive deflection indicates that the secondary lead connected to the positive side of the meter and the primary lead connected to the positive side of the dry cell are of like polarity.

4.7.6.2 Polarity of potential transformers. The polarity of a potential transformer shall be tested by one of the following methods:

4.7.6.2.1 Method 1 for potential transformers. The corresponding high voltage leads of a standard transformer of known polarity and of the transformer being tested shall be connected. Both transformers shall be parallel excited. If, when two of the corresponding low voltage leads of the transformers are connected, a voltmeter reads the difference of the low voltage windings, the two transformers are alike in polarity. If the voltmeter reads the sum of the low voltages of the two transformers, the transformers are of opposite polarity.

4.7.6.2.2 Method 2 for potential transformers. Method 2 shall be as specified in 4.7.6.1.2.

4.7.7 Phase displacement.

4.7.7.1 Phase displacement of current transformers. Current tranformers shall be tested to determine whether the phase angle displacement exceeds the value specified in 3.10.6 by measuring the difference between the phase angle of the transformer being tested and that of a standard transformer of the same rating. This standard transformer shall have been calibrated at the test frequency by a laboratory method of measuring absolute values. Transformers shall be tested at 10, 90, 100 and 110 percent of the rated current for first article tests and at 20 and 100 percent of the rated current for quality conformance tests at the specified frequency and at rated burden.

4.7.7.2 Phase displacement of potential transformers. Potential transformers shall be tested to determine whether the phase angle displacement exceeds the value specified in 3.11.6 by measuring the difference between the phase angle of the transformer being tested and that of a standard transformer of the same nominal rating. This standard transformer shall have been calibrated at the test frequency by a laboratory method of measuring absolute values. The transformer shall be tested at 0, 90, and 110 percent of its rated volt-ampere capacity at the specified frequency and a given power factor. It shall be tested at 90, 100, and 110 percent of the rated voltage for first article tests and at 100 percent of the rated voltage for quality conformance tests.

4.7.7.3 Phase displacement for quality inspection. Phase displacement may be tested in accordance with ANSI C57.13 in lieu of 4.7.7.2.

4.7.8 Ratio error.

4.7.8.1 Ratio error of current transformers. The ratio error shall be tested to determine whether the ratio error exceeds the value specified in 3.10.6 by measuring the difference between the ratio of the transformer being tested and that of a standard transformer of the same nominal rating. These standard transformers shall have been calibrated at the test frequency by a laboratory method of measuring absolute values. The transformer shall be tested at 10, 20, 40, 60, and 100 percent of the rated current for first article tests and at 20 and 100 percent of the rated current for quality conformance tests at the specified frequency and at rated burden.

4.7.8.2 Ratio error of potential transformers. The ratio error shall be tested to determine whether the ratio error exceeds the value specified in 3.11.6 by measuring the difference between the ratio of the transformer being tested and that of a standard transformer of the same nominal rating. This standard transformer shall have been calibrated at the test frequency by a

laboratory method of measuring absolute values. The transformer shall be tested at 0, 90 and 100 percent of the rated volt-ampere capacity at the specified frequency and at a given power factor. It shall be tested at 90 and 110 percent of the rated voltage for first article tests and at 100 percent of the rated voltage for quality conformance tests.

4.7.8.3 Ratio error for quality inspection. Ratio error may be determined in accordance with ANSI C57.13 in lieu of 4.7.8.2.

4.7.9 Current transformer protective devices.

4.7.9.1 Breakdown voltage. The current transformer protective device shall be tested to determine whether it short-circuits the secondary terminals of a current transformer when 450 Vrms is applied to the device.

4.7.9.2 Leakage current. The current transformer protective device shall be tested to determine whether the leakage current at 10 Vrms exceeds 4 milliamperes.

4.7.10 Temperature rise. The test methods and precautions for conducting the temperature rise test shall be as specified in MIL-E-917. The tests shall be made under conditions equivalent to normal operation at rated voltage, frequency, and load to determine that the rises specified herein are not exceeded. Method 1 shall be used for shunts and resistors. Method 2 shall be used for other equipment.

4.7.10.1 Temperature rise for shunts. Shunts under test shall be mounted horizontally on bus bars extending 3 feet to each end and with natural air cooling. The size and number of the bus bars shall conform to commercial practice to carry the required current.

4.7.11 Short and open circuit tests for current transformers.

4.7.11.1 Thermal rating with shorted secondary. The winding temperature under short circuit conditions shall be calculated in accordance with the method specified in ANSI C57.13.

4.7.11.2 Open secondary circuit.

4.7.11.2.1 Open circuit test. With the transformer completely assembled, the rated current shall be applied across the primary circuit with the secondary circuit open. The test shall continue until the temperature of the transformers, as measured in accordance with MIL-E-917, rises to a constant value. Any damage to the insulation or discontinuance of service shall constitute failure of the test.

4.7.12 Shock. The equipment shall be subjected to the shock test specified in MIL-S-901 (see 3.5). Fixture 4A shall be used with the equipment mounted thereon, simulating shipboard installation. After the test, the equipment shall be carefully inspected, and details of the damage shall be recorded. The resistance of each device shall be taken between terminals and terminals to ground. Resistance measurement between terminals shall not change. Resistance to ground shall be not less than 10 megohms. Device shall be fully functional within specified tolerances and be operated with intended device.

4.7.13 Insulation resistance. The insulation resistance shall be measured successively between each circuit and all other circuits and metal parts which are grounded. Window-type current transformers shall be tested with an inserted inductor to simulate the primary winding. The tests shall be performed at room temperature, and the relative humidity shall be recorded.

4.7.14 Moisture resistance. When required in the acquisition document (see 6.2.1), the moisture resistance test of MIL-STD-202, method 106 shall be performed on transformers. The following details and exceptions shall apply:

(a) Mounting: On racks.
(b) Initial measurements: Not applicable.
(c) Conditioning: The 24-hour initial drying period prior to the first cycle may be omitted.
(d) Polarization: Unless otherwise specified (see 6.2.1), polarization is applicable. The polarizing voltage shall be applied during steps 1 to 6 inclusive, between all windings not connected directly to the core or case, and the core or case. When the dielectric-withstanding test voltage is less than 100 Vrms, a 50 volt dc polarizing voltage shall be used. The polarizing voltage shall be positive with respect to the core and the case.
(e) Loading voltage: Not applicable.
(f) Final examinations:
    (1) Sealed transformers, metal encased with either separately fabricated headers or terminals or both: Upon completion of step 6 of the final cycle, transformers or inductors shall be removed from the humidity chamber and shall be conditioned for a maximum of 8 hours at standard inspection conditions (see 4.1.2). After this conditioning period, dielectric withstanding voltage (at reduced voltage), induced voltage, and insulation resistance shall be measured at any temperature above 20°C and at ambient room humidity, but rejections shall be based on measurements made between 20 and 35°C and at a relative humidity not greater than 80 percent. If failure occurs above reference conditions the tests shall be rerun within reference conditions.
    (2) Encapsulated transformers, including molded or embedded constructions, and units with a metal shell, open at one or both ends and filled with encapsulated material: Upon completion of step 6 of the final cycle, transformers or inductors shall be removed from the humidity chamber, and the overload voltage shall be applied to the units as soon as possible after removal from the humidity chamber; in no case shall this interval exceed 6 hours.
(g) Visual examination: Transformers and inductors shall be examined for any visible damage, including corrosion and obliteration of marking.

4.8 Inspection of packaging. Sample packages and packs, and the inspection of the preservation-packaging, packing and marking for shipment and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisition. For the extent of applicability of the packaging requirements of referenced documents listed in section 2, see 6.5.)

5.1 Domestic shipment and early equipment installation.

5.1.1 Preservation and packaging. Preservation and packaging, which may be the contractor's commercial practice, shall afford adequate protection against corrosion, deterioration, and physical damage during shipment from the supply source to the using activity and until early installation.

5.1.2 Packing. Packing shall be accomplished in a manner which will insure acceptance by common carrier at the lowest rate and will afford protection against physical or mechanical damage during direct shipment from the supply source to the using activity for early installation. The shipping containers or method of packing shall conform to the Uniform Freight Classification Ratings, Rules, and Regulations, or other carrier regulations as applicable to the mode of transportation, and may conform to the contractor's commercial practice.

5.1.3 Marking. Shipment marking information shall be provided on interior packages and exterior shipping containers in accordance with the contractor's commercial practice. The information shall include nomenclature, Federal stock number or manufacturer's part number, contract or order number, contractor's name, and destination.

5.2 Domestic shipment and storage or overseas shipment.

5.2.1 Preservation and packaging, packing, and marking. The equipment, accessories and technical publications shall be preserved and packaged at level A or C, packed at level A, B, or C, as specified in the acquisition document (see 6.2.1), and marked in accordance with MIL-E-17555. Method II shall apply for level A packing of equipment.

6. NOTES

6.1 Intended use. The electrical measuring instrument auxiliaries covered by this specification are intended for general use to extend the scale range of measuring instruments or to provide low current for relay circuits. Shunts and current transformer are for use in current circuits to extend their scale ranges. Resistors and potential transformers are for use in potential circuits to extend their scale ranges. Current transformers for relay service provide low current for relay circuits. Current transformer protective devices protect the secondary side of current transformers against excess voltage.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

(a) Title, number, and date of this specification.
(b) Type of instrument auxiliary required (see 1.1). Specific information for each type should be specified as follows:

(1) Shunts
a. Resistance (see 3.8.5)
b. Mounting (see 3.8.6)
c. Current rating and voltage drop (see 3.8.7)
d. Lead resistance (see 3.8.8.4)

(2) Resistors
a. Resistance (see 3.9.3)

(3) Current transformers
a. Primary current (see 3.10.2)
b. Secondary voltage (see 3.11.2)
c. Mounting (see 3.10.3)
d. Frequency range (see 3.10.5)
e. Service (see 3.10.6 and table III)
f. Burden (see 3.10.6.1)
g. Ratio (see 3.10.8)
h. Whether moisture resistance tests are required (see 3.10.9)
i. Whether current transformer protective devices are required (see 3.10.10)

(4) Potential transformers
a. Primary voltage (see 3.11.2)
b. Secondary voltage (see 3.11.2)
c. Mounting (see 3.11.3)
d. Frequency range (see 3.11.5)
e. Service (see 3.11.6 and table V)
f. Burden (see 3.11.6.1)
g. Ratio (see 3.11.7)
h. Whether moisture resistance tests are required (see 3.11.8)

(c) If inspection system is required (see 4.1.2).
(d) What reference conditions apply (see 4.3).
(e) Polarization test required during moisture test (see 4.7.14(d)).

6.2.2 Data requirements. When this specification is used in an acquisition and data are required to be delivered, the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (CDRL), incorporated into the contract. When the provisions of DoD FAR

Supplement, Part 27, Sub-Part 27.410-6 (DD Form 1423) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this specification are cited in the following paragraphs.

Paragraph no.	Data requirement title	Applicable DID no.	Option
4.1.2	Inspection system program plan	DI-R-4803	---

(Data item descriptions related to this specification, and identified in section 6 will be approved and listed as such in DoD 5000.19L., Vol. II, AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.2.2.1 The data requirements of 6.2.2 and any task in sections 3, 4, or 5 of this specification required to be performed to meet a data requirement may be waived by the contracting/acquisition activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item acquired to this specification. This does not apply to specific data which may be required for each contract regardless of whether an identical item has been supplied previously (for example, test reports).

6.3 First article inspection. When a first article inspection is required, the items should be a first article sample. The first article should consist of three units. The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract.

6.4 Definitions.

6.4.1 Multiplier. A multiplier is a particular type of series resistor used to extend the voltage range in an instrument beyond some particular value for which the instrument is already complete.

6.4.2 Phase angle.

6.4.2.1 Phase angle of a current transformer. The phase angle of a current transformer is the angle between the primary current vector and the reversed secondary current vector. For convenience, this angle is considered positive when the reversed secondary current vector leads the primary current vector.

6.4.2.2 Phase angle of a potential transformer. The phase angle of a potential transformer is the angle between the primary voltage vector and the secondary voltage vector reversed. For convenience, this angle is considered positive when the reversed secondary voltage vector leads the primary voltage vector.

6.4.3 Correction factors.

6.4.3.1 Phase angle correction factor. The phase angle correction factor is that factor by which the reading of a wattmeter or watt-hour meter operated from the secondary of a current or potential transformer, or both, must be multiplied to correct for the effect of phase displacement of current and voltage due to the measuring apparatus. This factor equals the ratio of the true power factor to the apparent power factor.

6.4.3.2. Ratio correction factor. The ratio correction factor is that factor by which the marked ratio of a current or potential transformer must be multiplied to obtain the true ratio. This factor is expressed as the ratio of the true ratio to the marked ratio. If a current transformer and a potential transformer are used in connection with a wattmeter or watt-hour meter, the ratio correction factor becomes equal to:

$$\frac{\text{(true C.T. ratio)}}{\text{(marked C.T. ratio)}} \times \frac{\text{(true P.T. ratio)}}{\text{(marked P.T. ratio)}}$$

6.4.4 Power factor.

6.4.4.1 True power factor. The true power factor in an ac circuit is the power factor calculated from instrument indications after all the necessary corrections have been applied, including the correction of the wattmeter reading for the effect of phase displacement of the current and voltage due to the measuring apparatus.

6.4.4.2 Apparent power factor. The apparent power factor in an ac circuit is the power factor calculated from instrument indications after all the necessary corrections have been applied, except the correction of the wattmeter reading for the effect of phase displacement of the current and voltage due to the measuring apparatus.

6.4.5 Primary and secondary windings. The terms "primary" and "secondary" distinguish the windings in regard to energy flow. The primary receives energy from the supply circuit, and the secondary receives energy by electromagnetic induction from the primary.

6.4.6 Ratio.

6.4.6.1 True ratio. The true ratio of a current or potential transformer is the ratio of the rms primary current or voltage to the rms secondary current or voltage under specified conditions.

6.4.6.2 Marked ratio. The marked ratio of a current or potential transformer is the ratio, indicated by the rating plate, of the primary to the secondary current or voltage respectively.

6.4.6.3 Ratio error. The deviation of the true ratio from the marked ratio is called the ratio error.

6.4.7 Rating.

6.4.7.1 Rated primary current of a current transformer. The rated primary current of a current transformer is defined as a current which can be carried for an unlimited period without causing any of the specified limitations to be exceeded.

6.4.7.2 Rated primary voltage. The rated primary voltage of a current or potential transformer is defined as a voltage which can be carried for an unlimited period without causing any of the specified limitations to be exceeded. The rated primary voltage of a current transformer defines a voltage which can be applied from primary winding to ground for an unlimited period without causing any of the specified limitations to be exceeded.

6.4.7.3 Rated burden. The rated burden of a transformer is defined as a burden which can be carried at a specified accuracy for an unlimited period without causing the established limits to be exceeded.

6.4.8 Burden of a transformer. The burden of a transformer is that property of the circuit connected to its secondary which determines the flow of true and reactive power from the transformer. It is expressed either as total ohms impedance, together with the effective resistance and reactance components of the impedance, or as the total volt-amperes and power factor of the secondary devices and leads. The values expressing the burden apply to the condition of rated secondary current or voltage of the transformer and a stated frequency, both of which must be included with the burden expression.

6.4.9 Mounting types.

6.4.9.1 Wound (wound-primary) type current transformers. The wound type current transformer has the primary and secondary windings completely insulated and permanently assembled on the core. The primary is usually a multi-turn winding, but may be a single turn if the turn is complete.

6.4.9.2 Bar type current transformer. The bar type current transformer has the primary and secondary windings completely insulated and permanently assembled on the core. The primary consists of a bar type conductor passing through the core.

6.4.9.3 Window type current transformer. The window type current transformer has a secondary winding completely insulated and permanently assembled on the core but has no primary winding. Complete insulation may or may not be provided for a primary conductor to pass straight through the core window.

6.4.9.4 Switchboard equipment. Switchboard equipment is designed to be permanently mounted on a switchboard for operation with a particular electrical measuring instrument.

6.4.9.5 Self-contained with instrument resistors. A resistor which is self-contained with the instrument is an integral part of the instrument for which it was designed.

6.4.9.6 Cage-type resistor. A cage-type resistor is mounted on or adjacent to the instrument with which it operates.

6.5 Sub-contracted material and parts. The packaging requirements of referenced documents listed in section 2 do not apply when material and parts are acquired by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.6 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.

Custodians:
Army - MR
Navy - SH
Air Force - 99

Review activities:
DESC - ES
Air Force - 82

User activities:
Army - ME
Navy - CG, MC, OS, AS, EC

Preparing activity:
Navy - SH
(Project 6625-0609)