MIL-H-22577C
9 September 1982
SUPERSEDING
MIL-H-22577B
20 September 1971
(See 6.4)

MILITARY SPECIFICATION

HEATING ELEMENTS, ELECTRICAL: CARTRIDGE, STRIP AND TUBULAR TYPE

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 heating elements used in various electrically heated equipment (for example: immersion heaters for water or oil, cooking equipment, hospital equipment and space heaters). Heating elements of these types are commonly used in industrial and domestic applications. Except where conflicts exist, industrial and commercial standards may be applied.

1.2 Classification. Heating elements shall be of the following types, as specified (see 6.2).

Type I - Cartridge
Type II - Strip
Type III - Tubular

2. APPLICABLE DOCUMENTS

* 2.1 Government documents.

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

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

FSC 4540

SPECIFICATIONS

MILITARY

MIL-E-917 - Electric Power Equipment, Basic Requirements (Naval Shipboard Use).
MIL-E-17555 - Electronic and Electrical Equipment, Accessories, and Repair Parts; Packaging and Packing of.

STANDARDS

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
DOD-STD-1399, Section 300 - Interface Standard for Shipboard Systems Electric Power, Alternating Current (Metric).

(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 officer.)

* 2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

B 163 - Seamless Nickel and Nickel Alloy Condensor and Heat-Exchanger Tubes. (DoD adopted)
B 344 - Drawn or Rolled Nickel - Chromium and Nickel-Chromium-Iron- Alloys for Electrical Heating Elements.
B 456 - Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium.

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

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

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

3. REQUIREMENTS

3.1 Material.

3.1.1 Material not specified herein shall be selected on the basis of meeting the performance requirements of this specification at minimum cost.

* 3.1.2 Resistance wire. Resistance wire shall be nickel-chromium wire conforming to composition 60Ni-16Cr or 80Ni-20Cr of ASTM B 344.

3.1.3 Insulating material. Granular insulating material shall be high purity magnesium oxide and shall be densely packed. Insulating material for formed parts, such as spacers, cores or bushings shall be high quality electrical grade ceramic of high thermal conductivity, high insulation resistance and formulated for physical strength.

3.1.4 Sheath materials. Sheath materials shall be corrosion-resisting in the surrounding medium and suitable for the temperatures required by a particular application. Table I shall be used as a guide.

* TABLE I. Recommended sheath materials for various applications and temperatures.

Sheath material	Maximum sheath temperature °F 1/	Application 2/
Copper	350	A
Nickel-chromium-plated copper	350	A, B
Steel	750	B, C
Nickel-copper alloy	900	A, C, D, E
Nickel-silver	1000	A, C, D, E
Chrome-steel	1200	A, B, C, D, E
Corrosion-resisting steel	1200	A, B, C, D, E
Nickel-iron-chromium alloy 3/ (Incoloy) UNS N08800	1500	A, B, C, D, E
Nickel-chromium-iron alloy 3/ (Inconel) UNS N06600	1600	A, B, C, D, E

1/ Operation above 1000 degrees Fahrenheit (°F) for end sealed units is not permitted.

2/ Applications:

A - Water immersion
B - Oil immersion
C - Cast-in-metal
D - Contact metal heating
E - Air heating

3/ See ASTM B 163.

* 3.1.4.1 Nickel-chromium plating. Nickel-chromium plating of sheaths shall be in accordance with ASTM B 456, classification Cu/Ni30d Cr r.

* 3.1.5 Asbestos. Asbestos shall not be used.

* 3.1.6 Recovered materials. Unless otherwise specified herein, all equipment, material, and articles incorporated in the products covered by this specification shall be new and shall be fabricated using materials produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise specifically specified.

3.2 Type I, cartridge.

3.2.1 Description. Type I heating elements are metal-sheathed heating elements, round in cross-section, either closed at one end with terminals or lead wires at the opposite end, or terminals at both ends. The sheath encloses resistance wire which shall be carefully positioned in the insulating material. Cartridge type elements are not suitable for bending or forming.

3.2.2 Terminal construction. The terminal end of the heating element shall be constructed so as to minimize the entrance of atmospheric moisture into the heating element. The terminal construction shall be suitable for the application, temperature and atmospheric conditions present. Unless a hermetic, or other special type seal is specified (see 3.5 and 6.2), the terminal design and materials shall be as selected by the manufacturer to satisfy the requirements of a particular application. The type of connection, either threaded terminal studs or flexible leads of high temperature wire, shall be as specified (see 6.2). Nuts and lockwashers for making connections shall be furnished with heating elements having threaded terminal studs. Where provided, flexible leads shall be at least 10 inches long.

* 3.2.3 Insulation resistance, cold. Each heating element shall have a minimum insulation resistance of 25 megohms at room temperature.

* 3.2.4 Insulation resistance, hot. Each heating element shall have a minimum insulation resistance of 10 megohms at the maximum operating temperature for the sheath material (see 3.1.4 and 6.3.2) or actual operating temperature for the element (see 6.2). For heating elements whose maximum operating temperature is in excess of 1000°F, the hot resistance may be tested with its entire system in accordance with MIL-E-917 as outlined in 4.3.6 of this specification.

3.3 Type II, strip.

3.3.1 Description. Type II heating elements are metal-sheathed heating elements, usually rectangular in cross-section with terminals projecting through the sheath, perpendicular to one major plane surface of the sheath. The sheath shall enclose helically coiled resistance wire uniformly spaced over the length and width of the element. Mounting slots or holes shall be provided at both ends of the heating element. Heating elements shall be suitable for lengthwise bending by the manufacturer to a minimum inside radius of 8 inches. Location and description of bends, if desired, shall be as specified (see 6.2). Strip type elements are not designed for use as immersion heaters and are not recommended for use in moist or humid locations or where terminals are located in an air stream.

3.3.2 Terminal construction. Terminals shall be of the threaded stud type and be designed to minimize the entrance of atmospheric moisture into the heating element. Nuts and lockwashers for making connections shall be furnished with the heating elements. The location of terminals for these heating elements are as follows:

(a) One at each end.
(b) Paralleled at one end except on 3/4 and 1-inch widths.
(c) In line at one end.
(d) Offset or staggered at one end.
(e) Three on one end for 3 heat.
(f) Two in center.

Terminal location shall be as specified (see 6.2).

3.3.2.1 Moisture retardment. Each heating element shall have the terminals sealed with a silicone resin to prevent moisture from entering the insulating material during transit or storage. The compound shall be self-dissipating upon initial application of power.

* 3.3.3 Insulation resistance, cold. Each heating element shall have a minimum insulation resistance of 25 megohms at room temperature.

* 3.3.4 Insulation resistance, hot. Each heating element shall have a minimum insulation resistance of 10 megohms at the maximum operating temperature for the sheath material (see 3.1.4 and 6.3.2) or actual operating temperature for the element (see 6.2). For heating elements whose maximum operating temperature is in excess of 1000°F, the hot resistance may be tested with its entire system in accordance with MIL-E-917 as outlined in 4.3.6 of this specification.

3.4 Type III, tubular.

3.4.1 Description. Type III heating elements are metal-sheathed heating elements, formed from a section of tubing and having a terminal projecting at each end. The finished cross-section of the element need not be round. The sheath shall enclose a helically coiled resistance wire centered in magnesium oxide insulating material. High density of the insulating material shall be obtained by reducing the cross-section of the heating element under pressure. The heating element shall be bent or formed into the desired shape. Heating elements shall be capable of being bent by the manufacturer to a minimum inside radius equal to the sheath diameter. It is generally recommended that bends made by other than the heater manufacturer have an inside radius at least five times the sheath diameter. An unheated length shall be provided at the ends of the heating elements to prevent damage to the connections and wire by overheating. Heating elements should not be bent within 1 inch of the unheated length unless approval to perform such bending is obtained from the manufacturer.

3.4.2 Terminal construction. The ends of the heating element and the terminals shall be constructed so as to minimize the entrance of atmospheric moisture. Terminal studs shall be of the threaded type unless brazed lugs are specified (see 6.2). Nuts and lockwashers for making connections shall be furnished with heating elements having threaded terminal studs. The end seal shall be of a type suitable for the application, temperature and atmospheric conditions present. Unless a hermetic or other special type end seal is specified (see 3.5 and 6.2), the end seal design and materials shall be selected by the manufacturer to satisfy the requirements for the application.

3.4.3 Insulation resistance.

3.4.3.1 The insulation resistance of elements at any temperature from room temperature to 1200°F shall be not less than the value computed by the following:

$$R = \frac{50-.02T}{L}$$

Where R = Insulation resistance in megohms
T = Temperature of element sheath in °F
When measuring insulation resistance (cold) (see 4.3.5), T shall be the room temperature
L = Length of element (end to end, Ft)

* 3.4.3.2 The insulation resistance measurements required by 4.3.5 shall be made at room temperature and at maximum operating temperature for the sheath material (see 3.1.4) or actual operating temperature (see 6.2), whichever is the least. For heating elements whose maximum operating temperature is in excess of 1000°F, the hot resistance may be tested with the entire system in accordance with MIL-E-917 as outlined in 4.3.6 of this specification.

* 3.5 End seals.

* 3.5.1 Hermetic end seals for type I and type III elements. Hermetic end seals are superior to other end seals in resisting atmospheric moisture, fumes, grease and water. Hermetic end seals also have greater electrical creepage than most other types. For type I and type III elements in applications where these factors are important considerations, it is recommended that hermetic seals be specified for applications where temperatures do not exceed 1000°F (see 6.2). For example, on duct heaters used in air conditioning systems, moisture is apt to condense on the heating elements during periods when heat is not required and cool air is circulating in the duct. In this case, a hermetic end seal would be advised.

3.5.1.1 Requirements for hermetic seals. The creepage path along the insulated portion of any hermetic seal shall be a minimum of 5/16-inch long for a voltage of 300 volts (V) or less. For more than 300 V, the length of the creepage path shall be a minimum of 1/2-inch long.

3.5.1.2 Ceramic-to-metal hermetic seals for type III elements. On type III elements where the temperature of the heating element end exceeds 250°F, hermetic seal shall be of the ceramic-to-metal type, using a high grade glazed alumina ceramic as the insulator. Ceramic-to-metal type seals shall be brazed to the heating element sheath.

3.5.1.3 Moisture resistance of hermetically sealed terminals. Hermetically sealed terminals shall meet the requirements of 3.2.3, or 3.4.3, as applicable, for insulation resistance and the requirement of 3.9 for dielectric strength after the element has been completely immersed in water for a period of 10 minutes.

* 3.5.2 End seals for commissary cooking equipment. Heating elements for commissary cooking equipment shall be constructed so as to permit any trapped moisture to escape. Elements shall be internally dried before presenting for shipment. Maximum operating temperature shall be specified by the manufacturer when limited by the end seal.

* 3.5.3 Moisture retardment. Unsealed heating elements shall have the terminals sealed with a silicone resin to prevent moisture from entering the insulating material during transit or storage. The resin shall be self-dissipating upon initial application of power.

3.6 Special features. When specified (see 6.2), heating elements shall be provided with special features; examples of which are:

(a) Mounting bushings, screw plug or mounting flanges to facilitate sealing cartridge or tubular heaters in tank walls and so forth.
(b) Fins (for forced air heaters).

3.6.1 Parts such as bushing, flanges, or fins shall be securely brazed to the heating element sheath.

3.7 Wattage. The wattage of the heating element at rated voltage shall be within the range of plus 5 to minus 10 percent of that specified (see 6.2).

* 3.8 Voltage. The operating voltage shall be either 440 or 115 V in accordance with DOD-STD-1399, section 300, as specified (see 6.2). The element shall operate satisfactorily on voltages up to 105 percent of the specified rating. When heating elements are intended for operation on a voltage other than line voltage (by series or wye connections), the line to line voltage shall also be specified. The heating element shall be insulated for the line voltage and shall have electrical creepage and clearance dimensions for line voltage.

3.9 Dielectric strength. Heating elements shall withstand a dielectric test of twice rated line voltage plus 1000 for a period of 1 minute. The voltage wave shall approximate a sine wave and the frequency shall be not less than 60 hertz.

3.10 Descriptive information. The following information, shall be as specified (see 6.2).

(a) Sheath material.
(b) Sheath diameter or cross-section dimensions.

(c) Length of heated portion of element.
(d) Length of sheath.
(e) Overall length of element.
(f) Location and description of bends, if required for strip or tubular elements.
(g) Details of special features such as length of finned portion, fin diameter, distance between flanges of mounting bushings, sizes of mounting bushings, flanges, and so forth.
(h) Dimensional and bending tolerances, if critical. Tolerances, if specified shall be as relaxed as application permits. The manufacturer's normal manufacturing tolerances shall apply if no limits are specified.
(i) Application data, if it is desired that the heater manufacturer select the heating element to best suit the particular application. This shall include data on material to be heated, rate of heating, air velocities, dimensional limitations and so forth.

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.

4.2 Quality conformance inspection.

4.2.1 Inspection lot. All heating elements of the same power rating and type, and made for the same application (see 3.1.4), and offered for delivery at one time shall be considered a lot for purposes of sampling and inspection.

4.2.2. Sampling. Sample heating elements shall be selected from each lot in accordance with inspection level II of MIL-STD-105 and each of these elements shall be subjected to each of the examinations and tests specified in 4.3.1, 4.3.2, 4.3.3, 4.3.4 and 4.3.5, and the results of each test shall be compared with the requirements of this specification. Failure to conform to this specification for any of the examination or tests shall be counted as a defect and the heating element shall not be offered for delivery. The acceptable quality level (AQL) for lots shall be 1.5 percent defective.

4.2.3 Sampling for insulation resistance (hot) tests. Sample elements shall be selected from each lot in accordance with inspection level S-4 of MIL-STD-105 and shall be subjected to the test of 4.3.6. If any element fails this test, it shall not be offered for delivery. Lots shall be accepted or rejected in accordance with AOL 4.0 percent defective.

4.3 Test procedures.

4.3.1 Dimensions, materials, and workmanship. Each of the heating elements shall be subjected to a thorough visual and dimensional examination to ascertain that the materials, workmanship, design and dimensions conform to this specification.

4.3.2 Wattage. The wattage shall be measured to determine compliance with 3.7.

4.3.3 Moisture resistance (elements having hermetically sealed terminals only). Where hermetically sealed terminals are required, each element shall be immersed in water for 10 minutes and the terminals wiped dry prior to the dielectric test of 4.3.4 and the insulation resistance test of 4.3.5.

4.3.4 Dielectric strength. The heating element shall be subjected to and shall withstand for a period of 1 minute, a dielectric test voltage of twice the rated line voltage plus 1000 V applied between the terminal and the sheath as specified in 3.9. The test shall be conducted with the heating element at normal room temperature.

* 4.3.5 Insulation resistance, cold. The insulation resistance shall be measured with 500 V direct current (d.c.) at room temperature to determine compliance with 3.2.3, 3.3.3 or 3.4.3.

* 4.3.6 Insulation resistance, hot. The insulation resistance shall be measured with a minimum of 500 V d.c. within 5 seconds after operation of the element at maximum operating temperature for the sheath material (see 3.1.4), or end seal material (see 3.5), or operating temperature of the element (see 6.2), whichever is the least, to determine conformance with 3.2.4, 3.3.4, or 3.4.3. To prevent the element from being cooled before the test, the ambient fluid shall not be circulated after the power is removed. Heating elements with operating temperatures above 1000°F may be tested in the heater.

4.4 Inspection of packaging. The preservation, packaging, packing, and marking of the heating elements shall be inspected to determine compliance with section 5 of this document.

* 5. PACKAGING

(The preparation for delivery requirements specified herein apply only for direct Government acquisitions).

5.1 Preservation - packaging, packing and marking. Heating elements shall be preserved and packaged level A or C as specified (see 6.2), packed level A, B or C as specified (see 6.2), and marked in accordance with MIL-E-17555. For level A packaging of hermetically sealed elements, method III shall apply.

6. NOTES

6.1 Intended use. This specification covers cartridge, strip and tubular types of electrical heating elements intended to be used as follows:

(a) Type I, cartridge:
  (1) Immersion heating
  (2) Contact metal heating

(b) Type II, strip:
  (1) Contact metal heating

(c) Type III, tubular:
  (1) Immersion heating
  (2) Cast-in-metal
  (3) Contact metal heating
  (4) Air heating

* 6.2 Ordering data. Acquisition documents should specify the following:

(a) Title, number, and date of this specification.
(b) Type of heating element required (see 1.2).
(c) Whether hermetic or other special type end seals are required for type I or type III heating elements (see 3.2.2, 3.4.2 and 3.5.1).
(d) Whether type of connection for type I heating elements shall be threaded terminal studs or flexible leads (see 3.2.2).
(e) Actual operating temperature if required (see 3.2.4, 3.3.4, 3.4.3.2, and 4.3.6).
(f) Location and description of bends if desired, for type II and type III heating elements (see 3.3.1 and 3.10).
(g) Location of terminals for type II heating elements (see 3.3.2).
(h) Whether brazed lug type terminals are required in lieu of standard threaded studs for type III heating elements (see 3.4.2).
(i) Special features (see 3.6).
(j) Wattage (see 3.7).
(k) Voltage (see 3.8).
(l) Descriptive information, details of special features, or application data (see 3.10).
(m) Dimensional tolerances, if required (see 3.10).
(n) Level of preservation, packaging and packing required (see 5.1).

* 6.3 User information.

* 6.3.1 Vibration and shock. Use of fragile materials and design features that would cause the elements to be unusually susceptible to physical damage shall be avoided. The heating elements by themselves need not meet any specific vibration or shock requirements. Specific shock and vibration requirements may be specified for the equipment in which the elements are ultimately installed, in which case, the installed elements shall operate satisfactorily under the specified shock and vibration.

* 6.3.2 Heating elements used in applications above 1000°F. Heating elements used above 1000°F which were tested in the heater (see 4.3.6) should be either insulated from the ship's hull, or should be isolated from the distribution system.

6.4 Changes from previous issue. The margins of this specification are marked with asterisks to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were 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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Army - ME
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Preparing activity:
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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

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1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

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