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MILITARY SPECIFICATION

# IRON-NICKEL ALLOYS FOR SEALING TO GLASSES AND CERAMICS

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

## 1. SCOPE

1.1 Scope - This specification covers a series of iron-nickel, iron-nickel-cobalt, and iron-nickel-chromium alloys used for sealing to glasses and ceramics in electronic applications (see 6.1).

* 1.2 Classification - The alloys shall be of the following classes, forms, finishes, and conditions, as specified (see 6.2):

* 1.2.1 Classes - Classes shall be as follows:

Class 1 - Iron-nickel-cobalt alloy (29% Ni, 17% Co, remainder Fe)
Class 2 - Iron-nickel alloy (50.5% Ni, remainder Fe)
Class 3 - Iron-nickel alloy (48% Ni, remainder Fe)
Class 4 - Iron-nickel alloy (46% Ni, remainder Fe)
Class 5 - Iron-nickel alloy (41% Ni, remainder Fe)
Class 6 - Iron-nickel-chromium alloy (41% Ni, 5.5% Cr, remainder Fe)
Class 7 - Iron-nickel alloy (36% Ni, remainder Fe)

* 1.2.2 Forms - Alloys shall be in the form specified in Table I.

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TABLE I. Availability of forms

| Forms | Class | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Bar | X | X | X | X | X | --- | X |
| Rods | X | X | X | X | X | --- | X |
| Ribbon | X | X | --- | X | X | X | --- |
| Strip | X | X | X | X | X | --- | X |
| Tubing | X | --- | --- | --- | --- | --- | --- |
| Wire | X | X | X | X | X | X | X |

* 1.2.3 Finishes - Finishes shall be as follows:

Hot rolled or forged — Cold drawn or rolled
Centerless ground — Belt polished

* 1.2.4 Condition and temper - Condition and temper shall be as follows (see Tables IV and V):

Annealed
1/4 Hard (one quarter hard temper)
1/2 Hard (one half hard temper)
Hard (full hard temper)

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

Military

MIL-C-16173 — Corrosion Preventive Compound, Solvent Cutback, Cold-Application

STANDARDS

Federal

Fed. Std. No. 48 — Tolerances for Steel and Iron Wrought Products
Fed. Test Method Std. No. 151 — Metal; Test Methods

STANDARDS (Cont'd)

Military

| | |
|---|---|
| MIL-STD-105 | Sampling Procedures and Tables for Inspection by Attributes |
| MIL-STD-163 | Steel Mill Products; Preparation for Shipment and Storage |

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

* 2.2 Other publications - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply:

American Society for Testing and Materials Publications

ASTM E8 - Methods of Tension Testing of Metallic Material
ASTM E18 - Methods of Test for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E112 - Methods for Estimating the Average Grain Size of Metals
ASTM E228 - Method of Test for Linear Thermal Expansion of Rigid Solids with a Vitreous Silica Dilatometer

(Application for copies of ASTM publications should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.)

3. REQUIREMENTS

3.1 Condition and temper - Unless otherwise specified in the contract or purchase order, rod, ribbon, tubing, and wire shall be bright annealed. Strip shall be annealed properly to have deep drawing or spinning properties (see 6.2).

3.1.1 Drawing and forming - Compounds and lubricants used in drawing and forming operations and during cold working shall be capable of being completely removed by vapor degreasing.

* 3.2 Chemical composition - The chemical composition of the iron-nickel alloys shall be as specified in Table II (see 4.5.1).

* 3.3 Linear coefficient of thermal expansion - The linear coefficient of thermal expansion shall conform to the values for the applicable class as listed in Table III (see 4.5.2).

* 3.4 Tensile strength or hardness - The tensile strength for the applicable class of materials in the finished form and in the specified condition and temper shall conform to Table IV (see 4.5.3). If the size of product prevents the cutting of tensile specimens as defined by ASTM E8, conformance to hardness requirements of Table V may be substituted.

3.5 Grain size - The average grain size of annealed strip materials to be used for deep drawing or spinning purposes shall be no larger than No. 5 and no more than 10 percent of the individual grains may be larger than No. 5 (see 4.5.5). However, for material of Classes 2 to 6, inclusive, which are less than 0.005 inch in thickness, the grain size shall be such that there are no less than 9 grains across the thickness in the short transverse direction.

3.6 Phase transformation - No phase transformation shall occur in the finished forms of the Class 1 alloy from 1,100°C to -80°C (see 4.5.6), except that material having a thickness or diameter exceeding 0.75 inch, some localized transformation may be tolerated if it does not exceed 1 percent of the cross section.

3.7 Porosity - When specified in the contract or order (see 6.2), material shall show no leakage, when tested with a helium leak detector (see 4.5.7).

3.8 Permissible variations in dimensions - The permissible variations in dimensions shall be as shown in applicable paragraph and table for the various forms of material (see 4.4.1).

3.8.1 Bars, rods, and wire diameter, thickness, or width - Bars, rods, and wire, measured on their diameters or between parallel faces, shall not vary at any point from the specified dimensions by more than the amounts shown in Tables VI, VII, VIII, and IX.

3.8.1.1 Straightness - The permissible variation in straightness of rods and bars as determined by the departure from true straightness (thrown in one revolution for rods or depth of chord for bars) shall be as specified in Table X.

3.8.2 Ribbon width - The permissible variation in width of ribbon shall be as specified in Table XI.

*

TABLE II. Chemical compositions

| Elements (percent) 1/ | Class | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Nickel (Ni) | 2/ 29 | 2/ 50.5 | 2/ 48 | 2/ 46 | 2/ 41 | 2/ 42.0 | 2/ 35.5 - 36.5 |
| Cobalt (Co) | 2/ 17 | 0.50 | 0.50 | 0.50 | 0.50 | --- | --- |
| Chromium (Cr) | --- | 0.10 | 0.10 | 0.10 | 0.10 | 2/ 5.6 | 0.25 |
| Manganese (Mn) | 0.50 | 0.60 | 0.80 | 0.80 | 0.80 | 0.25 | 0.50 |
| Silicon (Si) | 0.20 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.25 |
| Carbon (C) | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 | 0.07 | 0.05 |
| Aluminum (Al) | 3/ 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.20 | 3/ 0.10 |
| Magnesium (Mg) | 3/ 0.10 | --- | --- | --- | --- | --- | 3/ 0.10 |
| Zirconium (Zr) | 3/ 0.10 | --- | --- | --- | --- | --- | 3/ 0.10 |
| Titanium (Ti) | 3/ 0.10 | --- | --- | --- | --- | --- | 3/ 0.10 |
| Phosphorus (P) | --- | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.020 |
| Sulfur (S) | --- | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.020 |
| Iron (Fe) | Remainder | Remainder | Remainder | Remainder | Remainder | Remainder | Remainder |

1/ All percentages are maximum, unless otherwise indicated.

2/ Nominal contents. The nominal contents of the alloys shall be adjusted by the supplier so that the alloys meet the requirements for thermal expansion (see 3.4).

3/ Total permissible contents of aluminum, magnesium, zirconium, and titanium shall not exceed 0.20 percent.

* TABLE III. Linear coefficients of thermal expansions

| Temperature range - °C | Linear coefficient of thermal expansion cm. per cm. per °C x $10^{-6}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | Class | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 30-100 | --- | --- | --- | --- | --- | --- | 0.8-1.6 |
| 30-200 | --- | --- | --- | --- | --- | --- | 1.3-2.1 |
| 30-300 | --- | --- | --- | --- | 4.0-4.7 | --- | --- |
| 30-350 | --- | --- | --- | 7.1-7.8 | --- | 8.5-9.2 | 6.2-7.0 |
| 30-400 | 4.6-5.2 | --- | 8.2-9.2 | --- | --- | --- | --- |
| 30-425 | --- | --- | --- | --- | --- | 9.7-10.4 | --- |
| 30-450 | 5.1-5.5 | 9.6-10.1 | --- | --- | 6.7-7.4 | --- | 8.5-9.2 |
| 30-500 | --- | --- | --- | 8.2-8.9 | --- | --- | --- |
| 30-550 | --- | 10.2-10.7 | 9.6-10.3 | --- | --- | --- | --- |

TABLE IV. Tensile strength (1,000 psi)

| Condition | All classes |
|---|---|
| Annealed | 85 max. |
| 1/4 Hard | 90 to 115 |
| 1/2 Hard | 105 to 125 |
| Hard | 120 min. |

* TABLE V. Hardness, Rockwell B

| Condition | Class | | |
|---|---|---|---|
| | 1 | 2,3,4,5,7 | 6 |
| Annealed | 85 max. 1/ | 70 max. 1/ | 70 max. 2/ |
| 1/4 Hard | 90 to 93 | 78 to 83 | 78 to 83 |
| 1/2 Hard | 94 to 96 | 84 to 88 | 84 to 88 |

1/ Hardness for deep drawing strip material less than 0.100 inch shall be Rockwell B82 maximum and Rockwell B85 maximum for material over 0.100 inch.

2/ The maximum hardness for deep drawing strip material shall be Rockwell B90.

3.8.2.1 Ribbon thickness - The permissible variation in thickness of ribbon shall be the same as those applicable to wire in Table VI.

3.8.3 Strip dimensions - The strip dimensions and allowable variation shall conform to Tables XII, XIII, and XIV.

3.8.3.1 Thickness - Permissible variation in thickness of cold rolled strip shall be as specified in Table XII.

3.8.3.2 Strip crown tolerance - Permissible variation in crown tolerance, which is a permissible additive variation at the middle of the strip to the permissible variation at the edge as specified in 3.8.3.1 and Table XI, shall be as specified in Table XIII.

3.8.3.3 Strip width - Permissible variation in width of cold rolled slit edge strip shall be as specified in Table XIV. The dimensions for strip, other than slit edge, shall be as negotiated between the vendor and procuring activity, and permissible variations in width shall be as specified in Fed. Std. No. 48 for low alloy steel strip.

* 3.8.4 Tubing dimensions - Permissible variation in dimensions of cold drawn tubing, either as seamless or welded, shall be as specified in Table XV.

3.9 Identification - Material shall be furnished in lots which shall be identified by this specification number, class number, finish, manufacturer's alloy designation, name or symbol of supplier, melt number and size.

3.10 Workmanship - All forms shall have uniform surface finishes. The surfaces shall be commercially smooth, free from scale, corrosion, cracks, scratches, seams, laps or folds, slivers and other injurious defects which would impair its serviceability for the use intended.

## 4. QUALITY ASSURANCE PROVISIONS

* 4.1 Responsibility for inspection - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

* TABLE VI. Permissible variation in diameter of cold drawn wire and rods

| Specified diameter, inch | Permissible variation plus or minus, inch |
|---|---|
| Under 0.008 | 0.00025 |
| Over 0.008 to 0.015, incl. | 0.0003 |
| Over 0.015 to 0.020, incl. | 0.0004 |
| Over 0.020 to 0.030, incl. | 0.0005 |
| Over 0.030 to 0.040, incl. | 0.0006 |
| Over 0.040 to 0.060, incl. | 0.0007 |
| Over 0.060 to 0.080, incl. | 0.0008 |
| Over 0.080 to 0.125, incl. | 0.001 |
| Over 0.125 to 0.156, incl. | 0.0015 |
| Over 0.156 to 0.188, incl. | 0.002 |
| Over 0.188 to 0.250, incl. | 0.005 |
| Over 0.250 to 0.500, incl. | 0.010 |
| Over 0.500 to 1.000, incl. | 0.020 |

TABLE VII. Permissible variation in distance between parallel surfaces of cold drawn bars

| Specified dimension, inch 1/ | Permissible variation under specified dimension, inch |
|---|---|
| 0.0043 and under | 0.0002 |
| 0.0044 to 0.0079, incl. | 0.00025 |
| 0.008 to .0149, incl. | 0.0003 |
| 0.0150 to 0.0199, incl. | 0.0004 |
| 0.020 to 0.031, incl. | 0.0005 |
| 0.032 to 0.045, incl. | 0.0006 |
| 0.046 to 0.079, incl. | 0.0007 |
| 0.080 to 0.1875, incl. | 0.001 |
| 0.1876 to 0.406, incl. | 0.002 |
| Over 0.406 | 0.002 |

1/ Dimensions apply to the distance between flats for hexagons and squares and separately to width and thickness of rectangles.

TABLE VIII. Permissible variation in diameter of hot rolled rods

| Specified diameter, inch | Permissible variation from specified diameter plus or minus, inch |
|---|---|
| 0.250 to 0.750, incl. | 0.010 |
| Over 0.750 to 1.250, incl. | 0.015 |
| Over 1.250 to 3.500, incl. | 0.025 |

TABLE IX. Permissible variation in diameter of centerless ground rods

| Specified diameter, inch | Permissible variation, inch | |
|---|---|---|
| | Plus | Minus |
| 0.835 and under | 0.000 | 0.002 |
| 0.836 to 1.125, incl. | 0.002 | 0.002 |
| 1.126 to 1.750, incl. | 0.0025 | 0.0025 |
| 1.751 to 2.000, incl. | 0.004 | 0.004 |
| 2.001 to 3.000, incl. | 0.005 | 0.005 |

TABLE X. Permissible variation in straightness of rods and bars

| Specified diameter or distance between parallel surfaces, inch 1/ | Permissible variation in given lengths, inch |
|---|---|
| Rods - cold drawn: | Throw in one revolution: |
| 0.500 and under | 0.003 in 18 inches of length |
| Over 0.500 to 1.000, incl. | 0.005 in 42 inches of length |
| Rods - hot rolled: | Throw in one revolution: |
| All sizes | 0.150 in 36 inches of length |
| Bars - cold drawn: | Depth of chord: |
| All sizes 2/ | 0.150 in 36 inches of length |

1/ Dimensions apply to the diameter of rods, distance between parallel flats for hexagons and squares, and separately to width and thickness of rectangles.

2/ Bars are available with square, rectangular, and hexangular cross-sectional areas.

TABLE XI. Permissible variation in width of ribbon or flattened round wire

| Specified width, inch | Permissible variation in width, plus or minus, inch |
|---|---|
| 0.0156 and under | 0.0015 |
| 0.0157 to 0.0468, incl. | 0.002 |
| 0.0469 to 0.0781, incl. | 0.0025 |
| 0.0782 to 0.1875, incl. | 0.003 |
| Over 0.1875 | 0.005 |

* TABLE XII. Permissible variation in thickness of cold rolled strip 1/

| Specified thickness, inch | Permissible variation in thickness, plus or minus, for given width, inch | | | |
|---|---|---|---|---|
| | Less than 3 inches | Over 3 to 6 inches | Over 6 to 12 inches | Over 12 to 16 inches |
| Under 0.006 | 0.0005 | 0.0005 | --- | --- |
| 0.006 to 0.009, incl. | 0.00075 | 0.00075 | --- | --- |
| 0.0091 to 0.010, incl. | 0.001 | 0.001 | 0.001 | 0.001 |
| 0.0101 to 0.011, incl. | 0.001 | 0.001 | 0.001 | 0.0015 |
| 0.012 to 0.016, incl. | 0.001 | 0.001 | 0.0015 | 0.0015 |
| 0.017 to 0.019, incl. | 0.001 | 0.001 | 0.0015 | 0.002 |
| 0.020 to 0.025, incl. | 0.001 | 0.0015 | 0.002 | 0.002 |
| 0.026 to 0.028, incl. | 0.0015 | 0.0015 | 0.002 | 0.002 |
| 0.029 to 0.034, incl. | 0.0015 | 0.002 | 0.0025 | 0.0025 |
| 0.035 to 0.049, incl. | 0.002 | 0.0025 | 0.003 | 0.003 |
| 0.050 to 0.068, incl. | 0.002 | 0.003 | 0.003 | 0.003 |
| 0.069 to 0.099, incl. | 0.002 | 0.003 | 0.003 | 0.004 |
| 0.100 to 0.160, incl. | 0.002 | 0.003 | 0.004 | 0.004 |

1/ Measurements shall be made at least 3/8 inch from the edge of strips over 1 inch wide.

TABLE XIII. Permissible crown in cold rolled strip

| Specified thickness, inch | Permissible additional thickness at middle of strip over that provided for in Table XI for edge measurements, for given widths, inch | | |
|---|---|---|---|
| | To 5 inches incl. | Over 5 to 12 inches incl. | Over 12 to 24 inches incl. |
| 0.010 and under | 0.00075 | 0.001 | 0.0015 |
| Over 0.010 to 0.025, incl. | 0.001 | 0.0015 | 0.002 |
| Over 0.025 to 0.065, incl. | 0.0015 | 0.002 | 0.0025 |
| Over 0.065 to 0.188, incl. | 0.002 | 0.0025 | 0.003 |

TABLE XIV. Permissible variation in width of cold rolled strip

| Specified thickness, inch | Specified width, inches | Permissible variation in width, plus or minus, inch |
|---|---|---|
| Under 0.125 | Over 0.750 to 5, incl. | 0.005 |
| 0.125 to 0.188, incl. | Over 5 to 16, incl. | 0.010 |

* TABLE XV. Permissible variation in dimensions of seamless or welded cold-drawn tubing

| Specified outside diameter, inch | Permissible variation | | | | |
|---|---|---|---|---|---|
| | Outside diameter, inch | | Inside diameter, inch | | Wall thickness, percent |
| | Plus | Minus | Plus | Minus | Plus or Minus |
| Less than and excluding 3/32 | 0.002 | 0.000 | 0.000 | 0.002 | 10 |
| 3/32 to 3/16, excl. | 0.003 | 0.000 | 0.000 | 0.003 | 10 |
| 3/16 to 1/2, excl. | 0.004 | 0.000 | 0.000 | 0.004 | 10 |
| 1/2 to 1-1/2, excl. | 0.005 | 0.000 | 0.000 | 0.005 | 10 |

4.2 Lot - Unless otherwise specified in the contract or purchase order (see 6.2), a lot shall consist of material of the same class, of one form,of the same cross-sectional area, condition, temper, and finish produced under the same conditions and submitted for delivery at one time.

4.3 Sampling -

4.3.1 Chemical test -

4.3.1.1 Ingot sampling - At least one sample shall be taken from each group of ingots of the same alloy poured simultaneously from the same source of molten metal by the supplier for the test of 4.5.1. Complete ingot analysis record shall be available to the procuring activity.

4.3.1.2 Finished product sampling - When sampling has not been made in accordance with 4.3.1.1, four individual lengths shall be selected at random from each lot of material to provide a composite sample for the test of 4.5.1. If the lot consists of less than 4 lengths, a sample piece shall be taken from each length.

4.3.2 Linear thermal expansion test -

* 4.3.2.1 Ingot sampling - At least one sample from 6 to 10 inches in length and over 1/4 inch in diameter shall be taken from each group or prepared from each group of ingots of the same alloy poured simultaneously from the same source of molten metal by the supplier for test of 4.5.2. The sample shall then be worked down to small rounds for testing. Specimens for thermal expansion tests may be taken from the same sample as the specimens for chemical analysis when dimensions permit.

4.3.2.2 Finished product sampling - Finished products need not be sampled unless in the form of bars and rods over 1/4 inch in diameter. When sampling has not been made in accordance with 4.3.2.1, a sample over 6 inches in length shall be selected at random from each lot to provide a specimen for the test of 4.5.2.

4.3.3 Tensile test - A total of three specimens shall be taken from three individual lengths, selected at random from each lot. If the lot consists of less than three lengths, a specimen shall be taken from each length (see 4.5.3).

4.3.4 Hardness test - A total of three specimens shall be taken from three individual lengths selected at random from each lot. If the lot consists of less than three lengths, a specimen shall be taken from each length (see 4.5.4).

4.3.5 Grain size - Sampling shall be performed only on sheet and strip materials to be used for deep drawing purposes. A total of three specimens shall be taken from three individual lengths selected at random from each lot. If the lot consists of less than three lengths, a specimen shall be taken from each length (see 4.5.5).

4.3.6 Phase transformation test - Unless otherwise specified, one specimen 1/2 inch in length shall be taken from one individual length selected at random from each lot. The specimen shall be taken only from materials whose minimum cross-sectional dimension is less than 7/8 inch. The specimen shall include the entire cross-sectional area of the material if possible (see 4.5.6).

4.3.7 Porosity - When specified, one specimen shall be taken from one individual length selected at random from each lot. The specimen shall be taken only from material which can provide the dimensional requirements specified for a porosity test specimen in Figure 1 (see 4.5.7).

4.3.8 Visual and dimensional - A random sample shall be selected from each lot in accordance with MIL-STD-105, Inspection Level II, Acceptable Quality Level 2.5 percent defective for bars, rods, tubing and flat strip and an Acceptable Quality Level of 2.5 percent defects per 100 feet of coiled strip, robbon, and wire. The sample footage of alloy material shall consist of approximately equal length of strips taken from the outer end of each coil or spool of wire, ribbon, and sheared strip in the lot. The total sample shall consist of a minimum of 50 feet from each lot.

4.4 Examinations -

4.4.1 Visual and dimensional examination - Finished material selected in accordance with 4.3.8 shall be visually inspected to determine compliance with 3.10 and dimensionally examined to determine conformance to dimensional requirements of 3.8.

4.4.2 Preparation for delivery - The entire lot shall be visually examined to assure compliance with the identification requirements of 3.9 and the preservation, packaging, packing, and marking requirements of Section 5.

4.5 Tests -

4.5.1 Chemical analysis - Specimens shall be prepared from the samples selected in accordance with 4.3.1.1 or 4.3.1.2 and tested

in accordance with Method 111 or Method 112 of Fed. Test Method Std. No. 151 to determine conformance to the chemical requirements of Table II. If the ingot sample fails to conform to Table II, the ingot shall be rejected. If the finished product sample fails to conform to Table II, the lot shall be rejected.

4.5.2 Linear thermal expansion - The sample selected as specified in 4.3.2.1 or the bar and rod finished product sample selected as specified in 4.3.2.2 shall be used to determine conformance of the material to 3.3. Dilatometric determination of the linear coefficient of thermal expansion shall be performed in accordance with the procedure described in ASTM E228. Prior to the dilatometric analysis, the specimen shall be heat treated as specified in 4.5.2.1. The linear thermal coefficient of expansion shall be determined from the cooling curve after heating the specimen 25° to 50°C above the highest temperature specified for the thermal expansion of the alloy class in Table III in the dilatometer.

* 4.5.2.1 Heat treatment of specimens - Prior to test, specimens for the thermal linear coefficient of expansion test (see 4.5.2) and phase transformation test (see 4.5.6) shall be heat treated in a furnace atmosphere of hydrogen as follows: Heat Class 1 alloy specimens for 1 hour at 900°C, raise temperature to 1100°C and soak specimens for 15 minutes. Between the 900°C and the 1100°C heat-treatment periods, the specimens may be cooled to room temperature. Heat soak Classes 2 through 5 and Class 7 specimens for 1 hour at 900°C, and Class 6 specimens for 15 minutes at 1100°C. At the end of the soak period, furnace cool to 175°C or less, preferably room temperature,at a cooling rate not to exceed 5°C per minute before removal from the oven.

* 4.5.3 Tensile test - The samples selected in accordance with 4.3.3 shall be tested in accordance with ASTM E8 to assure compliance with the condition or temper specified in 3.4 and Table IV.

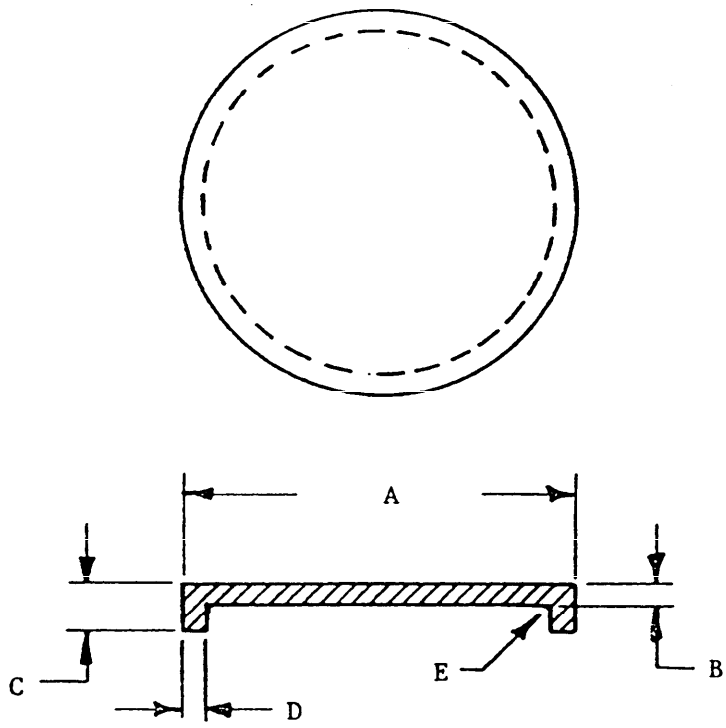
* 4.5.4 Hardness test - The samples selected in accordance with 4.3.4 shall be tested in accordance with ASTM E18 to assure compliance with the condition or temper specified in Table V.

* 4.5.5 Grain size - The specimens selected in accordance with 4.3.5 shall be polished, etched, and examined at 100 magnifications on a metallograph to assure compliance with the requirements of 3.5. Determinations of grain size shall be performed in accordance with ASTM E112. The specified grain size No. 5 represents grains having diameters between 0.060 to 0.064 mm or 16 grains per a square inch of image at 100 magnifications.

4.5.6 Phase transformation test. The specimen selected in accordance with 4.3.6 shall be examined for phase transformation or the presence of the alpha phase as follows: Heat treat as specified in 4.5.2.1. When cool, polish and etch in an etchant, consisting of three parts of concentrated hydrochloric acid and one part of concentrated nitric acid saturated with cupric chloride, prepared from 20 to 60 minutes prior to etching. Soak the etched specimen at -80°C, produced by an excess of dry ice in alcohol, for a minimum of 4 hours. Examine microscopically at 150 magnifications over the entire surface. The presence of an acicular structure at any point on the etched surface shall be cause for rejection as specified in 3.6.

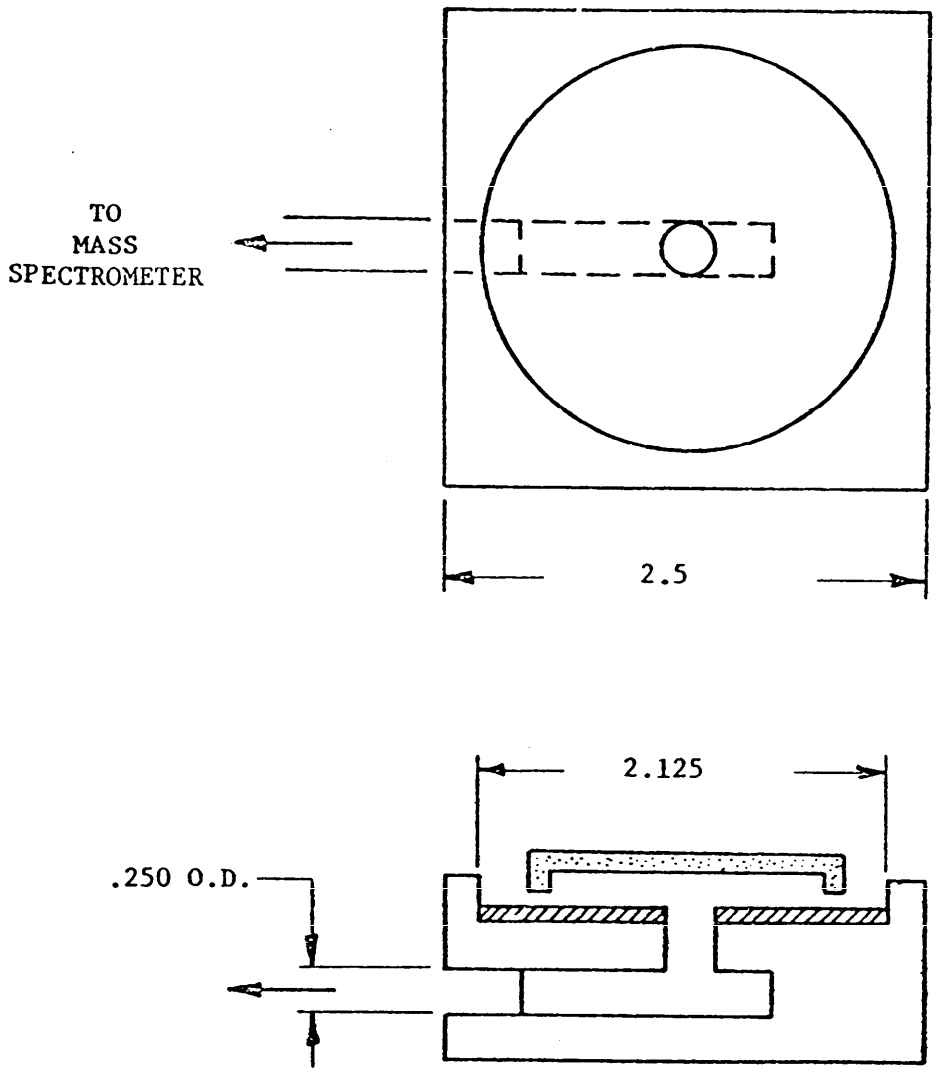
* 4.5.7 Porosity test - When required, the specimen selected as specified in 4.3.7 and machined in accordance with Figure 1, shall be subjected to the porosity test using a helium leak detector sufficiently sensitive to detect a leak of $1 \times 10^{-9}$ cc per second at 20°C and one atmosphere pressure at a deflection of at least 5 percent of full scale. Prior to performing the actual test, the specimen shall be chemically prepared and metallurgically conditioned. Chemical preparation: The machined specimen shall be degreased in a solvent, such as acetone, pickled in an aqueous solution of 1 to 1 inhibited hydrochloric acid, rinsed and dried at a temperature from 105° to 110°C. Metallurgical conditioning: The chemically prepared specimen shall be decarburized in a furnace at 1100°C for 30 minutes and subsequently furnace cooled to 200°C or room temperature at a cooling rate not to exceed 5°C per minute. The furnace atmosphere during decarburization and cooling shall have a controlled hydrogen atmosphere at a dew point from 20° to 30°C. The porosity test shall be performed upon the decarburized specimen, mounted as illustrated in Figure 2, upon the specimen containing fixture. After the decarburizing treatment, specimens should only be handled with tweezers, clean plastic gloves or finger cots. The tubulation of the specimen containing fixture shall be connected to the inlet of a fixed focus mass spectrometer. The fixture shall then be evacuated and the entire surface of the test specimen probed with a helium jet in accordance with Method 441 of Fed. Test Method Std. No. 151. When leakage is detected, the procedure shall be repeated by first squirting or painting alcohol all around the specimen-to-neoprene seal and then probing with the helium jet to prove that the leakage is through the specimen and not at the seal.

4.6 Rejection criteria - Failure of any specimen to conform to this specification, shall be cause for rejection of the lot represented.




| Specimen dimensions, inch | | | | |
|---|---|---|---|---|
| A | B | C | D | E |
| 1/2 to 1<br>1 to 2 | 0.090 ± 0.005<br>0.125 ± 0.005 | 0.250<br>0.250 | .031 to<br>.047 | .031 R<br>Max. |

FIGURE 1. Porosity test specimen




DIMENSIONS IN INCHES

LEGEND: SPECIMEN NEOPRENE SEAL OR EQUAL

FIGURE 2. Specimen containing fixture for porosity test

5. PREPARATION FOR DELIVERY

5.1 Preservation - When specified in the contract or order (see 6.2), the bars, rods, ribbon, strips, tubing, and wire shall be coated with preservative conforming to MIL-C-16173, grade 2.

5.2 Packaging - Packaging of the bars, rods, ribbon, strips, tubing, and wire shall be level A or C, as specified (see 6.2), in accordance with MIL-STD-163.

5.3 Packing - Packing of the bars, rods, ribbon, strips, tubing and wire shall be level A or C, as specified (see 6.2), in accordance with MIL-STD-163.

5.4 Marking - In addition to any special marking specified in contract or order, marking shall be in accordance with MIL-STD-163.

6. NOTES

6.1 Intended use - Material procured by this specification is intended for applications in electronic components where hermetic seals are required between glass and metal or ceramic and metal.

6.1.1 Class 1 alloy is the sealing alloy most commonly used with hard, low expansivity, borosilicate glasses where the applications require glasses of low thermal expansion, high thermal shock resistance, high strength, and high electrical resistance. In current commercial practice, the borosilicates have setting point temperatures ranging from 450° to 472°C and thermal coefficients of expansion at these temperatures ranging from 5.0 to 5.8x$10^{-6}$ cm/cm/°C.

6.1.2 Classes 2, 3, and 6 alloys are the sealing alloys used with soft glasses belonging to the potash-soda-lead and soda-lime series. The setting point temperatures of these glasses range from 410° to 590°C, and the thermal coefficients of expansion at these temperatures range from 9.7 to 10.2x$10^{-6}$ cm/cm/°C.

6.1.3 Class 4 alloy is most frequently used for sealing applications with glazed ceramics.

6.1.4 Class 5 alloy is the sealing alloy used with the softer borosilicate glasses and leaded glasses. The leaded glasses are used where the applications demand glasses with very high surface resistivity or controlled radiation shielding.

* 6.1.5 Class 7 alloy is a low expansion material used as the sealing alloy in special applications, such as with optical glasses, where dimensional changes must be minimized when exposed to low temperatures, such as -40° to 0°C.

* 6.2 Ordering data - Procurement documents should specify:

(a) Title, number, and date of this specification.

(b) Class, form, and finish of material required (see 1.2, 1.2.1, 1.2.2, and 1.2.3).

(c) Condition, and if applicable, temper (see 1.2, 1.2.4, and 3.1).

(d) Porosity test, if required (see 3.7 and 4.3.7).

(e) Diameter of rod and wire, if applicable (see 3.8).

(f) Dimensions of bar stock, if applicable, as well as shape (square, rectangular, or hexangular (see 3.8).

(g) Dimensions of tubing, if applicable (see 3.8).

(h) Thickness dimension of ribbon and strip if applicable (see 3.8).

(i) Quantity of material required (see 4.2).

(j) Additional specimens for phase transformation test (see 4.3.6).

(k) Preservation, if required (see 5.1).

(l) Level of packaging and packing required (see 5.2 and 5.3).

(m) Special marking, if required (see 5.4).

6.3 Bar stock - Bar stock with square, rectangular, or hexagonal cross-sectional areas are generally not stock items, but are available upon request.

* 6.4 Phase transformation - Specimens of Class 1 alloy being microexamined for phase transformation (see 4.5.6) may be compared with the illustrations shown in ASTM F15, specification for Iron-Nickel-Cobalt Sealing Alloy, for presence or absence of an acicular structure. Figure 1 shows specimen with no transformation, whereas Figure 2 shows specimen with partial transformation.

* 6.5 Typical thermal expansion data for the alloys are given in Table XVI to assist in the selection of material and for information only.

* 6.6 For ease and simplicity of referencing this document with those documents issued by the American Society for Testing and Materials, the following cross reference is included for information only:

| MIL-I-23011 | ASTM Designation |
|---|---|
| Class 1 | F15, Iron-nickel-cobalt sealing alloy |
| Class 2 | F30, Alloy No. 52 Iron-nickel sealing alloy |
| Class 3 | F30, Alloy No. 48 Iron-nickel sealing alloy |
| Class 4 | F30, Alloy No. 46 Iron-nickel sealing alloy |
| Class 5 | F30, Alloy No. 42 Iron-nickel sealing alloy |
| Class 6 | F31, 42 percent nickel - 6 percent chromium iron sealing alloy |

6.7 Changes from previous issues - The outer margins of this specification has been marked "*" to indicate where changes (deletions, additions, etc.) from the previous issue have been made. This has been done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notions. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire contents as written irrespective of the marginal notations and relationship to the last previous issue.

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Project No. 9505-0071

**Review/user information is current as of the date of this document. For future coordination of changes to this document, draft circulation should be based on the information in the current Federal Supply Classification Listing of DoD Standardization Documents.**

TABLE XVI. Typical thermal expansion data

| Temperature range °C | Linear coefficient of thermal expansion - cm. per cm. per °C x $10^{-6}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | Class | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 30 to 100 | - | 10.5 | 9.4 | 8.2 | 4.8 | - | 1.18 |
| 30 to 150 | - | 10.5 | 9.4 | 8.1 | 4.6 | - | - |
| 30 to 200 | 5.5 | 10.4 | 9.4 | 7.9 | 4.5 | - | 1.72 |
| 30 to 250 | - | 10.4 | 9.3 | 7.8 | 4.5 | - | - |
| 30 to 300 | 5.1 | 10.2 | 8.8 | 7.5 | 4.5 | 8.2 | 4.92 |
| 30 to 325 | - | - | - | - | 4.7 | - | - |
| 30 to 350 | - | 10.2 | 9.0 | 7.4 | 5.0 | 8.7 | 6.60 |
| 30 to 375 | - | - | - | 7.5 | 5.5 | - | - |
| 30 to 400 | 4.9 | 10.1 | 8.7 | 7.5 | 6.0 | 10.0 | 7.82 |
| 30 to 425 | - | - | 8.9 | 7.6 | - | - | - |
| 30 to 450 | 5.3 | 10.1 | 9.0 | 7.9 | 7.1 | 10.6 | 8.82 |
| 30 to 475 | - | 10.1 | 9.3 | - | - | - | - |
| 30 to 500 | 6.2 | 10.0 | 9.4 | 8.6 | 8.0 | 11.2 | 9.72 |
| 30 to 525 | - | 10.4 | - | - | - | - | - |
| 30 to 550 | - | 10.5 | 10.2 | 9.3 | 8.8 | 11.7 | - |
| 30 to 600 | 7.9 | 10.8 | 10.4 | 9.8 | 9.5 | 12.2 | 11.35 |
| 30 to 700 | 9.3 | 11.7 | 11.3 | 10.7 | 10.5 | 13.0 | 12.70 |
| 30 to 800 | 10.4 | 12.5 | 12.1 | 11.6 | 11.4 | 13.7 | 13.45 |
| 30 to 900 | 11.5 | 13.3 | 13.0 | 12.5 | 12.3 | 14.6 | 13.85 |
| 30 to 1,000 | - | 14.2 | 13.9 | 13.4 | 13.2 | 15.4 | - |

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