

**AEROSPACE
MATERIAL
SPECIFICATION**

AMS-I-23011A

Issued SEP 1998
Reaffirmed OCT 2006
Noncurrent APR 2007

Superseding AMS-I-23011

Iron-Nickel Alloys for Sealing
to Glasses and Ceramic

RATIONALE

AMS-I-23011A has been designated noncurrent because current requirements for this product are adequately addressed by the specifications designated below.

NONCURRENT NOTICE

This specification has been declared "NONCURRENT" by the Aerospace Materials Division, SAE, as of April, 2007. It is recommended, therefore, that this specification not be specified for new designs.

"NONCURRENT" refers to those specifications which have previously been widely used and which may be required for production or processing of existing designs in the future. The Aerospace Materials Division, however, does not recommend these specifications for future use in new designs.

"NONCURRENT" specifications are available from SAE upon request.

Similar but not necessarily identical products are covered in the following specifications. However, this listing is provided for information only and does not constitute authority to substitute these specifications for the "NONCURRENT" specification.

AMS-I-23011 Designation	Similar Specification	UNS Number
Class 1	ASTM F 15, Iron-Nickel-Cobalt Sealing Alloy	K94610
Class 2	ASTM F 30, Iron-Nickel Sealing Alloys	N14052
Class 3	ASTM F 30, Iron-Nickel Sealing Alloys	K94800
Class 4	ASTM F 30, Iron-Nickel Sealing Alloys	K94600
Class 5	ASTM F 30, Iron-Nickel Sealing Alloys	K94100
Class 6	ASTM F 31, 42% Nickel-6% Chromium-Iron	K94760
Class 7	ASTM F 1684, Iron-Nickel and Iron-Nickel-Cobalt Alloys for Low Thermal Expansion Applications	K93603

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Submitted for recognition as an American National Standard

Superseding AMS-I-23011

**Iron-Nickel Alloys for Sealing
to Glasses and Ceramics**

RATIONALE

This document has been reaffirmed to comply with the SAE 5-year Review policy.

NOTICE

This document has been taken directly from U.S. Military Specification MIL-I-23011C, and contains only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of this document is intended to replace MIL-I-23011C. Any part numbers established by the original specification remain unchanged.

The original Military Standard was adopted as an SAE standard under the provisions of the SAE Technical Standards Board (TSB) Rules and Regulations (TSB 001) pertaining to accelerated adoption of government specifications and standards. TSB rules provide for (a) the publication of portions of unrevised government specifications and standards without consensus voting at the SAE Committee level, and (b) the use of the existing government specification or standard format.

Under Department of Defense policies and procedures, any qualification requirements and associated qualified products lists are mandatory for DOD contracts. Any requirement relating to qualified products lists (QPL's) has not been adopted by SAE and is not part of this technical report.

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):

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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.

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
 Centerless ground

Cold drawn or rolled
 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:

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.

2.1 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-C-16173	Corrosion Preventive Compound, Solvent Cutback, Cold-Application
FED-STD-48	Tolerances for Steel and Iron Wrought Products
FED-STD-151	Metal; Test Methods
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-163	Steel Mill Products; Preparation for Shipment and Storage

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 8	Methods of Tension Testing of Metallic Material
ASTM E 18	Methods of Test for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E 112	Methods for Estimating the Average Grain Size of Metals
ASTM E 228	Method of Test for Linear Thermal Expansion of Rigid Solids with a Vitreous Silica Dilatometer

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 E 8, 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 <u>1/</u> (percent)	Class						
	1	2	3	4	5	6	7
Nickel (Ni)	<u>2/</u> 29	<u>2/</u> 50.5	<u>2/</u> 48	<u>2/</u> 46	<u>2/</u> 41	<u>2/</u> 42.0	<u>2/</u> 35.5 - 36.5
Cobalt (Co)	<u>2/</u> 17	0.50	0.50	0.50	0.50	---	---
Chromium (Cr)	---	0.10	0.10	0.10	0.10	<u>2/</u> 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)	<u>3/</u> 0.10	0.10	0.10	0.10	0.10	0.20	<u>3/</u> 0.10
Magnesium (Mg)	<u>3/</u> 0.10	---	---	---	---	---	<u>3/</u> 0.10
Zirconium (Zr)	<u>3/</u> 0.10	---	---	---	---	---	<u>3/</u> 0.10
Titanium (Ti)	<u>3/</u> 0.10	---	---	---	---	---	<u>3/</u> 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-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: 0.500 and under Over 0.500 to 1.000, incl.	Throw in one revolution: 0.003 in 18 inches of length 0.005 in 42 inches of length
Rods - hot rolled: All sizes	Throw in one revolution: 0.150 in 36 inches of length
Bars - cold drawn: All sizes ^{2/}	Depth of chord: 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 varia- tion in width, plus or minus, inch
Under 0.125 0.125 to 0.188, incl.	Over 0.750 to 5, incl.	0.005
	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).

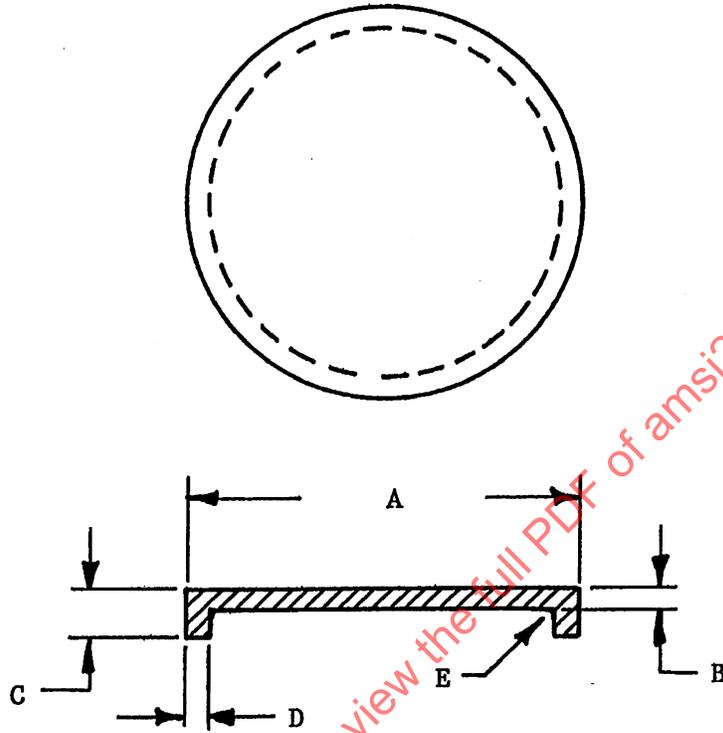
4.3.4 Hardness test: A total of three specimens shall be taken from three individual lengths selected at random from each lot. If the lot consists of less than three lengths, a specimen shall be taken from each length (see 4.5.4).

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, ribbon, 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-STD-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 E 228. 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 E 8 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 E 18 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 E 112. 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 1×10^{-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 specimens 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-STD-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 1 to 2	0.090 + 0.005 0.125 ± 0.005	0.250 0.250	.031 to .047	.031 R Max.

FIGURE 1. Porosity test specimen