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~~SUPERSEDING~~
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April 10, 1967, and
Fed. Spec. QQ-N-281b
October 31, 1966
(See 6.6)

FEDERAL SPECIFICATION

NICKEL-COPPER ALLOY BAR, ROD, PLATE,
SHEET, STRIP, WIRE, FORGINGS, AND STRUC-
TURAL AND SPECIAL SHAPED SECTIONS

This specification was approved by the Commissioner, Federal Supply Services, General Services Administration, for use of all Federal agencies.

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers nickel-copper alloy for applications requiring comparatively high strength and resistance to corrosion.

1.2 Classification. Nickel-copper alloy shall be of the following classes, forms, and conditions, as specified (see 6.2):

Class A.

- Form 1 - Bar and rod.
Condition: Cold drawn (stress relieved).
Hot finished (as hot finished or stress relieved).
Hot finished, high tensile (stress relieved).
Annealed (hot finished or cold drawn).
Forging quality.
- Form 2 - Forged parts.
Condition: Hot finished (as forged or stress relieved).
Forged, high tensile (stress relieved).
Hot finished, annealed.
- Form 3 - Shapes.
Condition: Annealed.
Hot finished.
Cold rolled or cold drawn.
- Form 4 - Sheet.
Condition: Cold rolled (annealed).
Cold rolled (as rolled).
Hot finished (annealed).
- Form 5 - Strip.
Condition: Cold rolled (annealed).
Cold rolled (quarter hard).
Cold rolled (hard, as rolled).
Cold rolled (full hard spring, as rolled).
- Form 6 - Plate.
Condition: Hot finished (annealed).
Hot finished (as rolled).
- Form 7 - Wire.
Condition: Cold drawn (annealed).
Cold drawn (various tempers).

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Class B.

Form 1 - Bar and rod.

Condition: Cold drawn (as drawn or stress relieved).
Hot finished (as hot finished or stress relieved).
Annealed (hot finished or cold drawn).

Form 2 - Wire.

Condition: Cold drawn (annealed).
Cold drawn (various tempers).

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 the specification to the extent specified herein.

FEDERAL STANDARDS:

FED-STD-182 - Identification Marking of Nickel and Nickel Base Alloys.
FED-STD-151 - Metals; Test Methods.

(Activities outside the Federal Government may obtain copies of Federal Specifications and Standards as outlined under General Information in the Index of Federal Specifications and Standards and at the prices indicated in the Index. The index, which includes cumulative monthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402.

(Single copies of this specification and other Federal Specifications required by activities outside the Federal Government for bidding purposes are available without charge from Business Service Centers at the General Services Regional Offices in Boston, New York, Washington, DC, Atlanta, Chicago, Kansas City, MO, Fort Worth, Denver, San Francisco, Los Angeles, and Seattle, WA.

(Federal Government activities may obtain copies of Federal Specifications and Standards and the Index of Federal Specifications and Standards from established distribution points in their agencies.)

MILITARY SPECIFICATION:

MIL-P-116 - Preservation, Methods of.

MILITARY STANDARDS:

MIL-STD-163 - Steel Mill Products, Preparation for Shipment and Storage.
MIL-STD-271 - Nondestructive Testing Requirements for Metals.

(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 (ASTM)

E-8 - Methods of Tension Testing of Metallic Materials.
E-140 - Standard Hardness Conversion Tables for Metals (Relationship Between Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness, and Knoop Hardness).

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

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

3. REQUIREMENTS

3.1 Chemical requirements. The material shall conform to the chemical requirements of table 1.

Table I - Chemical composition.

Class	Nickel ^{1/}	Iron (max)	Alumi-num (max)	Man-ganese (max)	Carbon (max)	Silicon (max)	Sulfur	Lead (max ^{2/})	Tin (max ^{2/})	Zinc (max ^{2/})	Phos-phorus (max ^{2/})	Copper
	Percent	Per-cent	Per-cent	Per-cent	Per-cent	Percent	Per-cent (max)	Percent	Percent	Percent	Percent	Percent Remain-der
A	63-70	2.50	0.5	2.0	0.2	0.5	0.015 (max)	0.006	0.006	0.02	0.02	Remain-der
B	63-70	2.50	0.5	2.0	0.3	0.5	0.025-0.060	0.006	0.006	0.02	0.02	Remain-der

^{1/} Cobalt counting as nickel.

^{2/} If determined basis.

3.2 Thermal treatment (class A cold drawn bar and rod). Class A Drawn bar and rod shall be given a low temperature stress relieving treatment to relieve the major portion of internal stress developed during cold drawing.

3.3 Mechanical properties. Mechanical properties shall be as specified in tables II through VIII.

Table II - Mechanical properties - class A: bar, rod and forged parts; class B: bar and rod.

Conditions and diameter or maximum distance between parallel faces (inches)	Tensile strength	Yield strength at 0.01 percent offset or at extension indicated ^{1/}		Yield strength at 0.02 percent offset or at extension indicated ^{1/}		Elongation in 2 inches or 4 x diam
	psi (min)	psi (min)	Inches in 2 inches	psi (min)	Inches in 2 inches	percent (min)
Class A						
Cold Drawn (stress relieved)						
Rounds, under 1/2	84,000	40,000	0.0033	50,000	0.0078	10 ^{2/}
Rounds, 1/2 to 3-1/2, incl.	87,000	45,000	0.0037	60,000	0.0086	22
Rounds, over 3-1/2 to 4, incl.	84,000	42,000	0.0034	55,000	0.0082	25
Squares, hexagons, and rectangles, all sizes	84,000	40,000	0.0033	50,000	0.0078	22 ^{2/3/}
Hot Finished (as hot finished or stress relieved)						
Rounds, ^{4/} squares, flats up to 12, and hexagons 2-1/8 and under, and forged parts up to 12	80,000	30,000	0.0025	40,000	0.0071	30 ^{5/}
Rounds, squares, flats over 12, and forged parts over 12	75,000	30,000	0.0025	40,000	0.0071	30
Hexagons over 2-1/8 to 2-1/2, incl.	75,000	25,000	0.0021	30,000	0.0063	30
Hot Finished, High Tensile (stress relieved) ^{6/}						
Rounds, 3 to 6, incl.	95,000	52,000	0.0042	70,000	0.0094	20
Rounds, over 6 to 12, incl.	85,000	45,000	0.0037	60,000	0.0086	25
Hexagons, squares, and flats 3 to 12, incl.	85,000	45,000	0.0037	60,000	0.0086	25
Annealed (hot finished or cold drawn)						
All products and all sizes ^{3/}	70,000	---	---	25,000	0.0059	35
Forging Quality ^{7/}						
All sizes	---	---	---	---	---	---

See footnotes

Table II - Mechanical properties - class A: bar, rod and forged parts; class B: bar and rod(cont'd.).

Conditions and diameter or maximum distance between parallel faces (inches)	Tensile strength	Yield strength at 0.01 percent offset or at extension indicated ^{1/}		Yield strength at 0.2 percent offset or at extension indicated ^{1/}		Elongation in 2 inches or 4 x diam
	psi (min)	psi (min)	Inches in 2 inches	psi (min)	Inches in 2 inches	percent (min)
Class B ^{8/}						
Cold Drawn (as drawn or stress relieved)						
Rounds under 1/2	85,000 ^{9/}	---	---	50,000	0.0078	8
Rounds 1/2 to 1, incl.	85,000 ^{9/}	---	---	50,000	0.0078	15
Rounds over 1 to 3, incl.	85,000	---	---	50,000	0.0078	15
Hexagons and squares 2 and less	85,000	---	---	50,000	0.0078	15
Hot Finished (as hot finished or stress relieved)						
Rounds 3 and less	75,000	---	---	35,000	0.0067	30
Hexagons and squares 2 and less	75,000	---	---	35,000	0.0067	30
Hexagons and squares over 2 to 4 incl.	70,000	---	---	30,000	0.0063	30
Annealed (hot finished or cold drawn)						
All products and all sizes ^{4/}	70,000	---	---	25,000	0.0059	35

^{1/} The elastic properties of all class A and B material shall be determined at 0.2 percent offset, unless otherwise specified (see 6.2).

^{2/} Not applicable to diameters or cross-sections under 3/32 inch.

^{3/} For sections up to 1/2 inch, the elongation shall be 10 percent minimum.

^{4/} Only tensile strength shall be required for material, in coil, up to 3/4 inch diameter.

^{5/} For flats 5/16 inch and under in thickness, elongation 20 percent minimum.

^{6/} Applicable to rod and bar only, but procurable in limited shapes and sizes of forged parts.

^{7/} Forging quality rod is furnished to chemical composition and surface inspection only. No tensile strength tests are required. For Naval shipboard applications, the mechanical properties of forging quality rod after hot working are required and shall conform to the applicable product classification of the end item (see form 2 conditions). These conditions are as specified in table II for class A hot-finished forged parts.

^{8/} See 6.1.2.

^{9/} 110,000 psi maximum.

Table III - Mechanical properties of class A, cold rolled and hot finished sheet.

Condition and thickness 1/4 inch, inclusive unless otherwise indicated)	Tensile strength	Yield strength ^{1/} at 0.2 percent offset or at extension indicated		Elongation ^{1/} in 2 inches	Hardness ^{2/}
	psi	psi (min)	Inches in 2 inches	Percent (min)	Rockwell B
Cold rolled sheet					
Annealed (plain finish)	70-85,000	28,000	0.0062	35	(73 max)
Hard (as rolled)	100,000 (min)	90,000	0.0109	2	(93 min)
Hot rolled sheet					
Annealed (plain finish)	70,000 (min)	28,000	0.0062	35	(73 max)

^{1/}No yield strength requirements for material under 0.020 inch thick, and elongation shall be 30 (min).

^{2/}Rockwell B or equivalent hardness. Hardness values are informative only.

Table IV - Mechanical properties of class A, cold rolled strip.

Condition (thickness 1/4 inch and less)	Tensile strength	Yield strength ^{1/} at 0.2 percent offset or at extension indicated		Elongation ^{1/} in 2 inches,	Hardness ^{2/}
	psi	psi (min)	Inches in 2 inches	Percent (min)	Rockwell B
Annealed	70-85,000	28,000	0.0062	35	(68 max)
Quarter hard	78-85,000	45,000	0.0075	20	(74-89)
Hard (as rolled)	100,000 (min)	90,000	0.0109	2	(93 min)
Full hard spring (as rolled) ^{3/}	---	---	---	--	98 min

^{1/}No yield strength requirements for material under 0.020 inch thick, and elongation shall be 30 (min).

^{2/}Rockwell B or equivalent hardness. Hardness values are informative only for those conditions for which tensile requirements are specified.

^{3/}No tensile requirements.

Table V - Mechanical properties of class A, hot finished plate.

Condition (thicknesses 3/16 inch and heavier)	Tensile strength	Yield strength at 0.2 percent offset or at extension indicated		Elongation ^{1/} in 2 inches	Hardness ^{2/}
	psi (min)	psi (min)	Inches in 2 inches	Percent (min)	Brinell
Annealed	70,000	28,000	0.0062	35	(110-140)
As rolled ^{3/}	75,000	40,000	0.0071	25	(125-180)

See footnotes on next page.

- 1/ When round specimens are used, elongation shall be measured in 4 times diameter.
- 2/ Hardness values are for information only and are not to be construed as the basis for acceptance or rejection. If Rockwell readings are made, the following conversion applies:

Brinell hardness number	Rockwell B
110-140	61-77
125-180	70-89

For other hardness conversion values see hardness conversion tables for nickel alloys, ASTM E-140.

- 3/ As rolled plate may be stress relieved subsequent to final rolling.

Table VI - Mechanical properties of class A, shapes.

Condition	Tensile strength	Yield strength at 0.2 percent offset or at extension indicated		Elongation in 2 inches
	psi (min)	psi (min)	Inches in 2 inches	Percent (min)
Annealed	70,000	25,000	0.0059	35
Hot finished	75,000	35,000	0.0067	30
Cold rolled or cold drawn	80,000	45,000	0.0075	20

Table VII - Mechanical properties of cold drawn wire in coil^{1/}

Condition and size, inch	Tensile strength psi		Wrapping test
	(min)	(max)	
Classes A and B: Annealed, all sizes	70,000	85,000	All wire shall wrap around a rod of the same diameter as the wire without cracking.
No. 0 temper, under 1/2	80,000	95,000	
No. 1 temper, under 1/2	90,000	110,000	
Class A (only): Regular temper, under 1/2	110,000	140,000	All wire up to 0.2294 inch, inclusive, shall wrap around a rod of the same diameter as the wire without cracking. Wire over 0.2294 inch diameter shall wrap around a rod of twice the wire diameter without cracking.
Regular temper, 1/2 and over	90,000	130,000	
Spring temper (round wire) 0.028 diameter and less	165,000	-----	
Over 0.028 to 0.057, incl.	160,000	-----	
Over 0.057 to 0.114, incl.	150,000	-----	
Over 0.114 to 0.312, incl.	140,000	-----	
Over 0.312 to 0.375, incl.	135,000	-----	
Over 0.375 to 0.500, incl.	130,000	-----	
Over 0.500 to 0.563, incl.	120,000	-----	

- 1/ Properties are not applicable to wire after straightening and cutting.

Table VII. Grain size and hardness for cold rolled, deep drawing, and spinning quality sheet and strip.

Thickness, inch	Grain size (max)		ASTM micro-grain size number	Rockwell B hardness (max)
	Mm	Inch		
Sheet (56 inches wide and less)				
0.050 and less	0.075	0.0030	4.5	68
Over 0.050 to 0.250, incl.	0.110	0.0043	3.5	68
Strip (all widths)				
0.005 to 0.015, incl.	0.022	0.0009	8	73
Over 0.015 to 0.024, incl.	0.060	0.0024	5.5	70
Over 0.024 to 0.125, incl.	0.075	0.0030	4.5	68

3.4 Deep drawing or spinning quality. Class A "deep drawing" and "spinning quality" sheet and strip shall conform to the requirements of table VIII.

3.5 Ultrasonic inspection. When specified (see 6.2), rod, bar, plate, and simple forged shapes shall pass the ultrasonic inspection test (see 4.4.4). Round bar 1-3/16 inch diameter and under shall be ordered with a turned or ground surface when ultrasonic testing is specified.

3.6 Liquid penetrant test. When specified (see 6.2), material shall be inspected by the liquid penetrant method as specified in 4.4.5.

3.7 Forged parts.

3.7.1 Dimensions. All forged parts shall conform to the sizes and shapes as specified (see 6.2). The responsibility of furnishing forged parts that can be laid out and machined to the finished dimensions within the specified tolerances as shown on the drawings, and that will conform to such gages as may be specified in individual cases, shall rest with the contractor. Sufficient stock shall be allowed for finishing. Forgings unreasonably in excess of the specified size or weight shall be rejected.

3.7.2 Permissible variations. When dimensional tolerances are not included in the contract or order, forged parts measured on their diameters or between parallel faces shall not vary from the specified dimensions by more than the amounts specified in table XIII for rod and bar, and by not more than $\pm 1/32$ inch on smooth forged or $\pm 3/32$ inch on rough machined forged parts other than rod and bar.

3.8 Permissible variations, bar and rod.

3.8.1 Cold drawn.

3.8.1.1 Diameter, thickness, or width. Cold drawn bar and rod measured on their diameters or between parallel faces, shall not vary at any point from specified dimensions by more than the amounts specified in table IX.

Table IX - Permissible variation in diameter or distance between parallel surfaces of cold drawn bar and rod (all classes).

Dimension, inches ^{1/2}	Permissible variation	
	(Inch) plus	(Inch) minus
Hexagons, squares, rectangles: 15/16 and less	0	0.003
Over 15/16 to 1-1/2, incl.	0	0.004
Over 1-1/2 to 2, incl.	0	0.005
Over 2 to 2-3/4, incl.	0	0.006
Over 2-3/4 to 4, incl.	0	0.007

Table IX - Permissible variation in diameter or distance between parallel surfaces of cold drawn bar and rod (all classes) (continued).

Dimension, inches ^{1/}	Permissible variation	
	(Inch) plus	(Inch) minus
Rounds ^{2/}		
Under 1/2	0	0.003
1/2 to 15/16, incl.	0	0.002
Over 15/16 to 1-15/16, incl.	0	0.003
Over 1-15/16 to 2-1/2, incl.	0	0.004
Over 2-1/2 to 3, incl.	0	0.005
Over 3 to 3-1/2, incl.	0	0.006
Over 3-1/2 to 4, incl.	0	0.007

^{1/} Dimensions apply to the diameter of rounds, distance across flats for hexagons and squares, and separately to width and thickness of rectangles.

^{2/} See 6.1.7.

3.8.1.2 Round rod shall not be out-of-round by more than one-half the permissible variation in diameter specified in table IX.

3.8.1.3 Square, rectangular, and hexagonal bar and rod shall have commercially sharp corners, unless otherwise specified (see 6.2).

3.8.1.4 Straightness.

3.8.1.4.1 The permissible variations in straightness of cold drawn rod and bar as determined by the departure from true straightness (throw in one revolution or depth of arc) shall be as specified in table X.

Table X - Permissible variations in straightness of cold drawn rod and bar (see 6.3.5).

Specified diameter or distance between parallel surfaces, inches	Permissible variations in lengths indicated, inches
Rounds: 15/16 and under Over 15/16 to 4, incl.	Throw in one revolution: 0.020 in 42 inch length 0.015 in 42 inch length
Squares, hexagons, flats: All sizes	Depth of arc: 0.025 per foot of length

3.8.1.4.2 The permissible variations in straightness of precision straightened cold drawn round rod and shafting (class A only), as determined by the departure from straightness (throw in one revolution), shall be as specified in table XI. All precision straightened rods shall be checked for straightness when supported on rollers at 42-inch intervals, and also on rollers at the ends of the rods in diameters and lengths as specified in table XI.

3.8.1.4.3 The permissible variations in straightness of hot finished rod and bar as determined by the departure from straightness (throw in one revolution or depth of chord) shall be as specified in table XII.

3.8.2 Hot finished (classes A and B).

3.8.2.1 Diameter, thickness, or width. Hot finished bar and rod, measured on their diameter or between parallel surfaces, shall not vary at any point from the specified dimensions by more than the amounts specified in table XIII.

3.8.2.2 Spot grinding of forging stock, to remove minor defects, may be employed as specified in table XIII.

Table XI - Permissible variations in straightness of precision-straightened cold draw shafting (class A only) (see 6.3.5).

Specified diameter of shafting	Standard distance between supports	Permissible variations (throw in one revolution) from straightness
Inches	Inches	Inches
1/2 to 15/16, incl.	42	0.005
Over 15/16 to 1-15/16, incl.	42	0.006
Over 1-15/16 to 2-1/2, incl.	42	0.007
Over 2-1/2 to 4, incl.	42	0.008
3/4 to 15/16, incl.	Specified lengths of 3 to 10 feet	0.004 + 0.0025 for each foot or fraction thereof in excess of 3 feet
Over 15/16 to 4, incl.	Specified lengths of 20 feet and less	0.005 + 0.0015 for each foot or fraction thereof in excess of 3 feet

Table XII - Permissible variations of straightness in hot finished rod and bar^{1/}

Condition and finish	Permissible variations (inches per foot)
Rod and bar, hot finished	0.050 ^{2/}
Round rod, hot finished, ground or rough turned	0.050 ^{3/}
Round rod, hot finished, semi-smooth machined	0.0031 ^{4/5/}
Round rod, hot finished, smooth machined	0.0015 ^{4/}

^{1/} Not applicable to forging quality rod.

^{2/} The maximum curvature (depth of chord) shall not exceed the values indicated multiplied by length in feet.

^{3/} The throw in one revolution in any 3 feet of length, or fraction thereof.

^{4/} The throw in one revolution in any 20 foot maximum length shall not exceed the values indicated.

^{5/} For shafts over 20 feet, the maximum deviation from straightness (throw in one revolution) shall not exceed 0.062 inch over the entire length when supported at the ends.

Table XIII - Permissible variations in diameter or distance between parallel surfaces of hot finished rod and bar.

Specified dimension, inches ^{1/}	Permissible variations from specified dimensions, inches	
	Plus	Minus
Rod and bar, hot finished:		
1 and under	0.016	0.016
Over 1 to 2, incl.	0.031	0.016
Over 2 to 4, incl.	0.047	0.031
Over 4	0.125	0.068
Round, rod, hot finished, semi-smooth machined, over 4 inches	0.031	0
Round rod, hot finished, and rough-turned or rough ground:		
1 inch and over	0.031	0
Round rod, hot finished, smooth finish machined over 4 inches	0	0.005 ^{2/}
Forging quality rounds: ^{3/}		
Under 1	0.005	0.005
1 and over	0.031	0
Forging quality bolt stock (rounds only):		
1/4, 5/16	0	0.0062
3/8, 7/16, 1/2	0	0.0066
9/16 to 7/8, in 1/16	0	0.0082
15/16 and 1	0	0.0098
1-1/16 to 1-1/2, incl., in 1/16	0	0.0112

^{1/} Dimensions apply to diameter of rounds, to distance across flats of hexagons and squares, and separately to width and thickness of rectangles.

^{2/} Permissible variations available as plus 0.005 inch, minus 0; or plus 0.0025 inch, minus 0.0025 inch when so specified.

^{3/} Spot grinding is permitted to remove minor surface defects. Such spot-ground areas shall not reduce the diameter of the bar at any point by more than 3 percent of the diameter.

3.8.2.3 Round rod in straight lengths, classes A and B, shall not be out-of-round by more than one-half the total permissible variation in diameter specified in table XIII.

3.8.2.4 Square, rectangular, and hexagonal bar and rod shall have sharp corners and angles consistent with commercial practice unless otherwise specified (see 6.2).

3.8.3 Length--all classes, bar and rod.

3.8.3.1 Bar and rod of all sizes may be ordered in cut lengths, random lengths, nominal (stock) lengths, or in multiple lengths as specified (see 6.2).

3.8.3.2 Unless otherwise specified (see 6.2), bar and rod shall be furnished in random mill lengths with cut or sheared ends. Rod and bar furnished to nominal (stock) lengths shall be furnished with either cropped or saw-cut ends. Material ordered to cut lengths shall be furnished with square saw-cut or machined ends. Where rod and bar are ordered in multiple lengths, 1/4 inch will be allowed for each multiple cut unless otherwise specified in the contract or order, and the rod and bar will have cut ends.

3.8.3.3 The permissible variations in lengths of rod and bar, all classes and all conditions, shall be as specified in tables XIV and XV.

Table IV - Permissible variations in length of bar and rod, all classes, all conditions.

Specified length, feet	Shortest acceptable length, feet	Maximum acceptable length	Maximum permissible percentage by weight of short lengths
Random mill lengths ^{1/}	6	24 ft	25 percent under 9 ft
Nominal (stock) length ^{2/}			
16 to 18	16	18 ft, 1/2 in	100 percent 16 ft or longer
14 to 16	14	16 ft, 1/2 in	100 percent 14 ft or longer
12 to 14	12	14 ft, 1/2 in	100 percent 12 ft or longer
10 to 12 ^{3/}	10	12 ft, 1/2 in	100 percent 10 ft or longer
8 to 10 ^{3/}	8	10 ft, 1/2 in	100 percent 8 ft or longer
6 to 8 ^{3/}	6	8 ft, 1/2 in	100 percent 6 ft or longer
4 to 6	4	6 ft, 1/2 in	100 percent 4 ft or longer
Cut-to-length	Specified length	(see table XV)	100 percent specified length (see table XV)

^{1/} Not applicable to smooth forged rod and bar or to hot finished sections weighing over 25 pounds per lineal foot. These items are generally not available in the range of lengths indicated; short lengths down to 2 feet in lieu of 6 feet may be furnished.

^{2/} Other nominal lengths with a specified range of not less than 2 feet, with no shorts allowed, may also be furnished.

^{3/} For cold drawn rod and bar, under 1/2 inch in diameter or distance across flats ordered to nominal or stock lengths with a 2-foot range, at least 93 percent of such material shall be within the range specified, the balance may be in shorter lengths but in no case shall lengths less than 4 feet be furnished.

Table XV - Permissible variations in length of bar machine cut after machine straightening.

Specified size of rounds, squares, hexagons, octagons, and widths of flats, inches	Permissible variations in length, inches			
	To 12 ft, incl.		Over 12 ft	
	Over	Under	Over	Under
To 3, incl.	1/8	0	3/16	0
3 to 6, incl.	3/16	0	1/4	0
6 to 9, incl.	1/4	0	5/16	0
9 to 12, incl.	1/2	0	1/2	0

3.9 Permissible variations, shapes.

3.9.1 The permissible variations in cross sectional dimensions of shapes shall be as specified (see 6.2).

3.9.2 Unless otherwise specified (see 6.2), shapes shall have commercially sharp corners.

3.9.3 Length. A variation of plus 1/8 inch is permitted on shapes ordered to cut-to-length.

3.10 Permissible variations, plate, sheet, and strip.

3.10.1 Thickness. The permissible variations in thickness shall be as specified in tables XVI, XVII, and XVIII.

Table XVI - Permissible variations in thickness of sheet

Permissible variations ^{1/} in thickness for widths given, inches			
Specified thickness, inches	Hot-rolled, annealed and pickled	Cold rolled	
	All widths	48 and under	Over 48 to 60, incl.
	Plus or minus	Plus or minus	Plus or minus
0.018 to 0.025, incl.	0.003	0.002	0.003
Over 0.025 to 0.034, incl.	0.004	0.003	0.004
Over 0.034 to 0.043, incl.	0.005	0.004	0.005
Over 0.043 to 0.056, incl.	0.005	0.004	0.005
Over 0.056 to 0.070, incl.	0.006	0.005	0.006
Over 0.070 to 0.078, incl.	0.007	0.006	0.007
Over 0.078 to 0.093, incl.	0.008	0.007	0.008
Over 0.093 to 0.109, incl.	0.009	0.007	0.009
Over 0.109 to 0.125, incl.	0.010	0.008	0.010
Over 0.125 to 0.140, incl.	0.012	0.008	0.010
Over 0.140 to 0.171, incl.	0.014	0.009	0.012
Over 0.171 to 0.187, incl.	0.015	0.010	0.013
Over 0.187 to 0.218, incl.	0.017	0.011	0.015
Over 0.218 to 0.234, incl.	0.018	0.012	0.016
Over 0.234 to 0.250, incl.	0.020	0.013	0.018

^{1/} Measured 3/8 inch or more from any edge.

Table XVII - Permissible variations in thickness of cold rolled strip.

Specified thickness, inches	Permissible variations ^{1/} , inches for all widths
	Plus or minus
Under 0.006	0.0005
0.006 to 0.009, incl.	0.0008
Over 0.009 to 0.050, incl.	0.0015
Over 0.050 to 0.093, incl.	0.0025
Over 0.093 to 0.125, incl.	0.0040
Over 0.125 to 0.156, incl.	0.0045 ^{2/}
Over 0.156 to 0.250, incl.	0.0055 ^{2/}

^{1/} Measured 3/8 inch or more from any edge except for strip under 1 inch in width which is measured at any place.

^{2/} For widths over 8 inches, the permissible variations for cold rolled sheet are applicable.

3.10.1.1 The permissible thickness variations on sheet and strip shall be based on measurements taken with the micrometer spindle 3/8 inch or more from any edge for material 1 inch or over in width and at any place on strip under 1 inch in width and shall be as specified in tables XVI and XVII.

3.10.1.2 The permissible variations under the specified thickness and the permissible excess in overweight of plates shall be as specified in table XVIII.

Table XVIII - Permissible variations in weight and thickness of hot rolled rectangular plate ^{1/2}/₁.

Specified ^{4/} thickness, inches	Permissible excess in average weight ^{3/} per square foot of plate, for widths given in inches, expressed in percentage of nominal weights										
	Under 48	48 to 60, excl.	60 to 72, excl.	72 to 84, excl.	84 to 96, excl.	96 to 108, excl.	108 to 120, excl.	120 to 132, excl.	132 to 144, excl.	144 to 160, incl.	160, incl.
3/16 to 5/16, excl.	9.0	10.5	12.0	13.5	15.0	16.5	18.0	---	---	---	---
5/16 to 3/8, excl.	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	---	---	---
3/8 to 7/16, excl.	7.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	---	---
7/16 to 1/2, excl.	6.0	7.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	---
1/2 to 5/8, excl.	5.0	6.0	7.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	---
5/8 to 3/4, excl.	4.5	5.5	6.0	7.0	7.5	9.0	10.5	12.0	13.5	15.0	---
3/4 to 1, excl.	4.0	4.5	5.5	6.0	7.0	7.5	9.0	10.5	12.0	13.5	---
1 to 1-1/4, excl.	4.0	4.0	4.5	5.5	6.0	7.0	7.5	9.0	10.5	12.0	---
1-1/4 to 1-1/2, excl.	4.0	4.0	4.5	5.5	6.0	7.0	7.5	9.0	10.5	---	---
1-1/2 to 1-3/4, excl.	4.0	4.0	4.5	5.5	6.0	7.0	7.5	9.0	---	---	---
1-3/4 to 2, incl.	4.0	4.0	4.5	5.5	6.0	7.0	7.5	---	---	---	---

^{1/}The term "lot" applied to the above table means all of the plate of each "group width" and each "group thickness".

^{2/}No plates shall vary more than 0.01 inch under the thickness ordered, and the over-weight of each lot in each shipment shall not exceed the amount shown in the table. Spot grinding is permitted to remove surface imperfections, such spots not exceed 0.01 inch under the specified thickness.

^{3/}The weight of individual plates shall not exceed the nominal weight by more than 1-1/4 times the amount shown.

^{4/}All plates shall be ordered by thickness and not weight per square foot.

3.10.2 Width.

3.10.2.1 The permissible variations in width for sheet and strip shall be as specified in table XIX and those for plates shall be as specified in table XX.

Table XIX - Permissible variations in width of sheet and strip^{1/}

Specified thickness, inches	Width, inches	Permissible variations, inches	
		Plus	Minus
Sheet			
Sheared:			
0.0180 to 0.109, incl.	14 and less	0.062 ^{1/}	0
Over 0.109 to 0.250, incl.	14 and less	0.125 ^{1/}	0
0.018 to 0.250, incl.	Over 14	0.125 ^{1/}	0
Strip			
Slit edge:			
0.009 and less	12 and less	0.005	0.005
Over 0.009 to 0.024, incl.	12 and less	0.007	0.007
Over 0.024 to 0.075, incl.	14 and less	0.007	0.007
Over 0.075 to 0.100, incl.	14 and less	0.009	0.009
Over 0.100 to 0.125, incl.	14 and less	0.012	0.012
Over 0.125 to 0.250, incl.	8 and less ^{2/}	0.015	0.015
Slit or sheared edge:			
Over 0.125 to 0.250, incl.	Over 8 to 14, incl. ^{2/}	0.125	0
Round or square edge strip:			
0.020 to 0.250, incl.	3 and less	0.005	0.005

^{1/}When so specified, sheet shall be furnished with a tolerance of plus 0 with the above tolerance on the minus side or with one-half the above tolerance on the plus side and one-half on the minus side.

^{2/}Available only in straight (random or cut) lengths.

3.10.2.2 Unless otherwise specified (see 6.2), strip shall be furnished with type of edge as follows:

Thickness, inches	Width, inches	Type of edge
0.125 and less	14 and less	Slit ^{1/}
Over 0.125	8 and less	Slit ^{2/}
Over 0.125	Over 8	Slit or sheared ^{2/}

^{1/}In coil or straight (random or cut) lengths.

^{2/}In random or cut straight lengths only.

3.10.3 Length.

3.10.3.1 All sheet and strip in straight lengths ordered cut-to-length shall have a permissible variation of plus 1/8 inch over the specified length.

Table XX - Permissible variations in widths of sheared, machined, abrasive or plasma torch cut rectangular plate ^{1/2}/₂

Specified thickness, inches	Permissible variation in width for widths given, inches												
	Up to 30, incl.		Over 30 to 72, incl.		Over 72 to 108, incl.		Over 108 to 144, incl.		Over 144 to 160, incl.		Over 160, incl.		
	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	
Sheared: ^{3/}													
3/16 to 5/16, excl.	3/16	1/8	1/4	1/8	3/8	1/8	1/2	1/8	5/8	1/8	---	---	
5/16 to 1/2, excl.	1/4	1/8	3/8	1/8	1/2	1/8	5/8	1/8	---	---	---	---	
1/2 to 3/4, excl.	3/8	1/8	1/2	1/8	5/8	1/8	---	---	---	---	---	---	
3/4 to 1, excl.	1/2	1/8	5/8	1/8	---	---	---	---	---	---	---	---	
1 to 1-1/4, incl.	5/8	1/8	---	---	---	---	---	---	---	---	---	---	
Machined or abrasive cut: ^{4/5/6/}													
3/16 to 1-1/2, incl.	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	
Over 1-1/2 to 4, incl.	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	
Plasma torch cut: ^{7/}													
3/16 to 2, incl.	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	
2 to 2-1/4	5/8	0	5/8	0	5/8	0	5/8	0	5/8	0	5/8	0	

^{1/} Permissible variations in width for powder or inert arc cut plate or machined, powder or inert arc cut circular plate shall be as agreed upon between the manufacturer and the purchaser.

^{2/} Tolerances for plasma torch cut sketch plate shall be as agreed upon between the manufacturer and purchaser.

^{3/} The minimum sheared width is 10 inches for material, 3/4 inch and under in thickness and 20 inch for material over 3/4 inch in thickness.

^{4/} The minimum abrasive cut width is 2 inches.

^{5/} Tolerances shown are applicable for lengths up to 240 inches, lengths over 240 inches an additional 1/16 inch is permitted, both plus and minus.

^{6/} Thickness over 4 inches to 8 inches inclusive may be abrasive cut to tolerances as agreed upon between the manufacturer and purchaser.

^{7/} Tolerances shown for plasma torch cutting may be obtained all on the minus side, or divided between the plus and minus side, if so specified in the contract or order.

3.10.3.2 When strip up to 14 inches wide is ordered in nominal (stock) lengths, the pieces shall be cut to the nominal length plus 1/8 inch as a maximum. The shortest acceptable lengths, the maximum permissible percentage by weight of short lengths, and the required percentage by weight of nominal lengths in any one shipment shall be as specified in table XXI.

Table XXI - Permissible variations in length of strip
14 inches wide and less.

Nominal (stock) length, feet	Required percentage, by weight, of nominal length	Maximum permissible percentage, by weight of short lengths				
		Over 8 to 10 feet, incl.	Over 6 to 8 feet, incl.	Over 4 to 6 feet, incl.	2 to 4 feet, incl.	Under 2 feet
10	60	40	30	20	10	0
8	70		30	20	10	0
6	80			20	10	0

3.10.3.3 The permissible variations in length for plates shall be as specified in table XXII.

3.10.3.3.1 Unless otherwise specified (see 6.2), plate 1-1/4 inch thick and under shall be furnished with a sheared edge, and plate over 1-1/4 inch shall be furnished with machined, abrasive or plasma torch cut edges as specified (see 6.2).

3.10.4 Diameter.

3.10.4.1 Circular plate shall have a permissible variation in diameter as specified (see 6.2), in table XXIII.

3.10.5 Curvature (edge waviness).

3.10.5.1 Sheet. Sheet in straightened and cut lengths shall not exhibit edgewise curvature (depth of arc) in excess of 1/4 inch in 8 feet of length.

3.10.5.2 Strip. Strip in straightened and cut lengths shall not exhibit edgewise curvature (depth of arc) in excess of 0.05 inch per foot of length.

3.10.6 Finished edges (strip).

3.10.6.1 When finished edges of strip are specified (see 6.2), the following description shall apply:

"Square-edge" material shall be supplied with finished edge with sharp, commercially square corners without bevel or rounding of any sort.

"Round edge" material shall be supplied with finished edge, semicircular in form, the diameter of the circle forming the edge being equal to the thickness of the strip.

3.10.6.2 When no description of any required form of edge on strip is given, it shall be understood that edges such as would result from slitting or shearing will be acceptable.

3.10.7 Unless otherwise specified (see 6.2), sheets shall be furnished to the specified widths and lengths; strip shall be furnished in random (straight) lengths; plate 1-1/4 inches in thickness and less shall be furnished with sheared edges; and plate over 1-1/4 inches in thickness shall be finished with machined edges.

3.11 Permissible variations, wire.

3.11.1 Diameter. Permissible variations in diameter and out-of-roundness of cold drawn wire shall be as specified in table XXIV.

3.11.2 Coil and spool weights. Permissible variations in coil and spool weights shall be as specified in tables XXV and XXVI (see 6.2).

Table XXII - Permissible variations in length of sheared, machined, abrasive or plasma torch cut rectangular plate^{1/}

Specified thickness, inches	Permissible variation in length for lengths given, inches														
	60 and under		Over 60 to 96, incl.		Over 96 to 120, incl.		Over 120 to 240, incl.		Over 240 to 360, incl.		Over 360 to 450, incl.		Over 450 to 540, incl.		
	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	
Sheared: ^{2/}															
3/16 to 5/16, excl.	3/16	1/8	1/4	1/8	3/8	1/8	1/2	1/8	5/8	1/8	1/8	3/4	1/8	--	--
5/16 to 1/2, excl.	3/8	1/8	1/2	1/8	1/2	1/8	1/2	1/8	5/8	1/8	1/8	3/4	1/8	7/8	1/8
1/2 to 3/4, excl.	1/2	1/8	1/2	1/8	5/8	1/8	5/8	1/8	3/4	1/8	7/8	1/8	1-1/8	1-1/8	1/8
3/4 to 1, excl.	5/8	1/8	5/8	1/8	5/8	1/8	3/4	1/8	7/8	1/8	7/8	1/8	1-1/8	1-3/8	1/8
1 to 1-1/4 incl	3/4	1/8	3/4	1/8	3/4	1/8	7/8	1/8	1-1/8	1/8	1-3/8	1/8	1-3/8	1-5/8	1/8
Machined or abrasive cut: ^{3/4/}															
3/16 to 1-1/2, incl.	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16
Over 1-1/2 to 4, incl.	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
Plasma torch cut: ^{5/6/}															
3/16 to 2, incl.	1/8	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	0
2 to 2-1/4	5/8	0	5/8	0	5/8	0	5/8	0	5/8	0	5/8	0	5/8	0	0

^{1/} Permissible variations in length for powder or inert arc cut plate or machined, powder or inert arc cut circular plate shall be as agreed upon between the manufacturer and the purchaser.

^{2/} The minimum sheared length is 10 inches.

^{3/} Thicknesses over 4 inches to 8 inches inclusive may be abrasive cut to tolerances as agreed upon between the manufacturer and the purchaser.

^{4/} Abrasive cut applicable to a maximum length of 144 to 400 inches depending on the thickness and width ordered.

^{5/} Tolerances for plasma torch cut sketch plate shall be as agreed upon between the manufacturer and purchaser.

^{6/} Tolerances for plasma torch cutting may be obtained all on the minus side, or divided between the plus or minus side if so specified in the contract or order.

Table XXIII - Permissible variation in diameter for circular plate.

Specified diameter, inches	Permissible variations over specified diameter for thickness given, inches				
Sheared plate: ^{1/} 20 to 32, excl. 32 to 84, excl. 84 to 108, excl. 108 to 140, excl.	Thickness to 3/8, incl.				
	1/4				
	5/16				
	3/8				
Plasma torch cut plate: ^{2/3/} 19 to 20, excl. 20 to 22, excl. 22 to 24, excl. 24 to 28, excl. 28 to 32, excl. 32 to 34, excl. 34 to 38, excl. 38 to 40, excl. 40 to 140, excl.	Thickness, max	3/16 to 2, excl.		2 to 3, excl.	
		Plus	Minus	Plus	Minus
	3	1/2	0	5/8	0
	2-3/4	1/2	0	5/8	0
	2-1/2	1/2	0	5/8	0
	2-1/4	1/2	0	5/8	0
	2	1/2	0	5/8	0
	1-3/4	1/2	0	---	---
	1-1/2	1/2	0	---	---
	1-1/4	1/2	0	---	---
	3	1/2	0	5/8	0

^{1/}No permissible variation under.

^{2/}The tolerance for plasma cut plate may be obtained all minus or divided between the plus and minus sides, as specified (see 6.2).

^{3/}Permissible variations in plasma torch cut sketch plates shall be as agreed upon between the manufacturer and the purchaser.

Table XXIV - Permissible variations in diameter of cold drawn wire.

Diameter, inches	Permissible variations ^{1/} , inches	
	Plus	Minus
Under 0.0044	0.0002	0.0002
0.0044 to 0.0079, incl.	0.00025	0.00025
Over 0.0079 to 0.0149, incl.	0.0003	0.0003
Over 0.0149 to 0.0199, incl.	0.0004	0.0004
Over 0.0199 to 0.031, incl.	0.0005	0.0005
Over 0.031 to 0.045, incl.	0.0006	0.0006
Over 0.045 to 0.079, incl.	0.0007	0.0007
Over 0.079 to 0.1875, incl.	0.001	0.001
Over 0.1875 to 0.406, incl.	0.001	0.002
Over 0.406	0.002	0.002

^{1/}Wire shall not be out-of-round by more than one-half the total permissible variations shown.

3.12 Machining allowances for hot finished material.

3.12.1 Machining allowances for hot finished material shall be as specified in table XXVII.

3.13 Identification markings. Unless otherwise specified (see 6.2), identification marking shall be in accordance with FED-STD-182.

Table XXV - Permissible variation in weight of wire in coils and on spools (except Air Force use).

Condition	Wire diameter (inches)	Standard spool weight (pounds)	Maximum weight of wire on each spool (pounds)
Spools (all conditions)	Under 0.010	2	2-1/2
	0.010 to 0.018, incl.	5	6
	Over 0.018 to 0.040, incl.	10	15
Coils (all conditions)	Under 0.010 0.010 to 0.018, incl. Over 0.018 to 0.040, incl. Over 0.040 to 0.081, incl. Over 0.081 to 0.312, incl. Over 0.312 to 0.563, incl.	Approximate mean coil diameter (inches)	Maximum weight per coil (pounds)
		8	15
		8	25
		8 to 12	40
		16 to 20	100
		18 to 20	100
22 to 30	100		

Table XXVI - Permissible variation in weight of wire in coils and on spools (Air Force use only).

Condition	Wire diameter (inches)	Core diameter (inches)	Maximum weight of wire on each spool (pounds)
All conditions	Under 0.035	1	1
	0.035 to 0.063, incl.	4 to 5	1
	0.064 to 0.0915, incl.	----	5
	0.0916 to 0.162, incl.	----	25 ^{1/}

^{1/} Coil

Table XXVII - Machining allowances for hot finished material^{1/}

Finish machined dimensions, inches for conditions as specified herein ^{2/}	Machining allowance, inches			
	On diameter for rounds	Distance between parallel surfaces for hexagons, squares	For rectangles	
			On thickness	On width
Hot finished:				
Up to 7/8, incl.	1/8	1/8	1/8	3/16
Over 7/8 to 1-7/8, incl.	1/8	3/16	1/8	3/16
Over 1-7/8 to 2-7/8, incl.	1/8	1/4	---	3/16
Over 2-7/8 to 3-11/16, incl.	3/16	---	---	3/16
Over 3-13/16	3/16	---	---	3/8
Hot finished rounds:				
Rough turned:				
15/16 to 4, incl. in dia.	1/16	---	---	---
Over 4 to 12, incl. in dia.	1/8	---	---	---
Semismooth machined:				
Over 4 to 10, incl.	1/8 ^{3/}	---	---	---

See footnotes on next page.

- 1/ The allowances for hot finished material are recommended for rounds machined in lengths of 3 feet or less and for squares, hexagons, and rectangles machined in lengths of 2 feet or less. Hot finished material to be machined in longer lengths should be specified showing the finished cross-sectional dimension and the length in which the material will be machined in order that the manufacturer may supply material with sufficient oversize, including allowance for out-of-straightness.
- 2/ Dimensions apply to the diameter of rounds, distance between parallel surfaces of flats or squares and hexagons, and separately to width and thickness of rectangles.
- 3/ Applicable to 30 feet maximum lengths.

3.14 Workmanship. The material shall be uniform in quality and condition, clean, smooth, commercially flat and straight, and be free from foreign material and imperfections such as pipe, laps, cracks, and seams which due to their nature, degree or extent may detrimentally affect the suitability for the service intended. Products ordered with a hot finished or machined surface may contain surface imperfections that shall not be considered injurious unless they exceed the recommended machining allowance specified in table XXVII.

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.

4.2 Lot.

4.2.1 For visual inspection and mechanical tests. A lot shall consist of material of one class, condition, size, and heat and with the finished product heat treated in the same batch or continuous process under the same conditions as to temperature, time and atmosphere. For mechanical tests, size shall refer to the same thickness of sheet, strip, or plate and the same cross section for other products and shall consist of not more than 30,000 pounds.

4.2.2 For chemical analysis. A lot shall consist of material from the same heat.

4.3 Sampling.

4.3.1 Sampling for chemical analysis.

4.3.1.1 One representative sample shall be obtained from each lot. Samples may be taken from the ladle or the finished product. Samples from the finished product shall be taken in accordance with method 111 or 112 of FED-STD-151.

4.3.1.2 For fine wire, 0.032 inch diameter and less, samples for chemical analysis may be taken from the final starting size prior to the final cold reduction.

4.3.2 Sampling for visual and dimensional inspection.

4.3.2.1 Forged parts weighing 250 pounds or more. Each forged part weighing 250 pounds or more shall be subject to surface inspection for workmanship and dimensions.

4.3.2.2 Small forged parts weighing less than 250 pounds and all other forms. From each lot, representative samples shall be selected for inspection of visual and dimensional characteristics with acceptance based on the sampling requirements specified in table XXVIII. In case of wire, a unit shall be one coil of wire.

Table XXVIII - Sampling for visual and dimensional inspection
AQL (approx.) = 1.5 percent defective.

Number of units in lot	Number of units in sample	Acceptance number (defectives)	Rejection number (defectives)
15 and under	7	0	1
16 to 40	15	0	1
41 to 110	25	1	2
111 to 300	35	1	2
301 to 500	50	2	3
501 and over	75	3	4

4.3.3 Sampling for mechanical tests.

4.3.3.1 Rod, bar, and flat products. One tensile specimen shall be taken from each lot.

4.3.3.2 Forged parts.

4.3.3.2.1 Forged parts 250 pounds and less. One sample shall be taken from each lot. Prolongations shall be provided on at least 20 percent of the forged parts unless trepanning is used or the producer may provide extra identical forged parts for test.

4.3.3.2.2 Forged parts greater than 250 pounds. Each forged part shall be tested. Prolongations shall be provided on each forged part unless trepanning is used.

4.3.3.2.3 Ring or disk forged parts. Forged parts under 3-1/2 inches thick may have test specimens removed from separately forged test bars with the same wall thickness, amount of working, and annealed with the same change as the forged parts. Extra forged parts shall be provided for samples when forged parts are over 3-1/2 inches thick.

4.3.3.3 Wire. Samples for mechanical tests and acceptance shall be as specified in table XXIX.

Table XXIX - Sampling for mechanical tests
(tension and wrapping tests)^{1/}

Lot size, pounds	Number of samples for each test	Maximum number of failures allowed
For wires 1/4 inch diameter or less:		
180 and under	1	0
181 to 500	2	0
501 to 800	3	0
801 to 1300	5	0
1301 to 3200	7	0
3201 to 5000	10	1
For wires over 1/4 inch diameter:		
For each 500 lbs or fraction thereof	1	0

^{1/} A wrapping test shall not be required for wire over 1/4 inch diameter.

4.3.4 Sampling for ultrasonic test. When specified (see 6.2), each piece of each lot shall be inspected 100 percent by volume.

4.4 Quality conformance test procedures.

4.4.1 Chemical analysis. The sample selected in accordance with 4.3.1 shall be analyzed by the wet chemical or spectrographic method to determine conformance with table I. A single analysis of a compound sample may be made.

4.4.2 Visual and dimensional examination. Each sample selected in accordance with table XXVIII shall be subjected to surface inspection for workmanship and dimensions. Any sample unit found containing one or more visual or dimensional defects shall be rejected, and if the number of defective units in any sample exceeds the acceptance number for that sample, the lot represented by the sample shall be rejected.

4.4.2.1 Inspection of hot finished or machined material. Rod or bar surface shall be examined to locate imperfections of maximum severity. These imperfections shall be explored by grinding, filing, or otherwise reducing the cross-section dimension at the site of the imperfection. Sufficient material shall be removed to reach the bottom of the imperfection. The cross-section dimension is measured at this point. If the depth of the imperfection does not exceed the machining allowance in table XXVII for the applicable size and form, the product will be acceptable.

4.4.2.2 Straightness. In determining conformance to 3.8.1.4 straightness requirements in the standard 42 inch distance between supports or conformance to straightness when supported at the ends, the rod shall be placed on a precision table equipped with ball-bearing rollers and a micrometer or dial indicator. The rod shall then be rotated slowly against the indicator, and the deviation from straightness in any portion of the rod between the supports shall not exceed the permissible variations specified in tables X and XI. The deviation from straightness (throw in one revolution) is defined as the difference between the maximum and minimum readings of the dial indicator in one complete revolution of the rod.

4.4.3 Tension tests. Each of the specimens selected in accordance with 4.3 shall be subjected to the tension test as follows:

4.4.3.1 Rod, bar, and all flat products shall be tested in full size when practicable. When a machined specimen becomes necessary, enough metal may be removed from the gage section to meet the limitations of the testing machine, or the specimen may be machined to the form and dimensions of the largest standard round specimen in ASTM E-8 obtainable from the product being tested.

4.4.3.2 For rod, bar and all flat products up to 1-1/2 inches in diameter or minimum thickness, the axis of the test specimen shall coincide with the central axis of the piece. For material 1-1/2 inches and over in diameter or thickness, if a machined specimen is used, the axis shall be located midway between the center and the rolled or drawn surface of the piece.

4.4.3.3 For plate, sheet, and strip less than 0.500 inch thick, the test specimen shall be machined to the form and dimensions of the standard plate or sheet type specimens in ASTM E-8. For plates 0.500 inch and thicker, the test specimen shall be machined to the form and dimensions of the largest standard round specimen in ASTM E-8 obtainable from the product being tested.

4.4.3.4 For forged parts, the largest standard round specimen in ASTM E-8 available from the sample material shall be used.

4.4.3.5 For wire, specimens shall be of the full cross-section of the wire and not less than 15 inches in length. Specimens shall be free from sharp bends or kinks. The distance between the jaws of the testing machine, with the specimen in place ready for testing, shall be not less than 10 inches.

4.4.3.6 Wrapping test specimens shall be full size sections of wire of a suitable length. The specimens shall be wrapped at least 360 degrees around a rod of the diameters specified in table VII and examined for cracks. If cracks exist, the sample and the lot represented by the sample shall be rejected.

4.4.4 Ultrasonic tests.

4.4.4.1 General.

4.4.4.1.1 Ultrasonic testing shall be performed in accordance with MIL-STD-271 as modified by the requirements specified herein. Testing shall be done by the longitudinal wave or shear wave technique as specified herein.

4.4.4.1.2 Calibration.

4.4.4.1.2.1 Shear wave. The shear wave test shall be calibrated on two notches; one notch cut into the inside and one into the outside surface. The notches shall be cut axially and shall have a depth of 5 percent of the material thickness or 1/4 inch, whichever is less. Notch length shall not exceed 1 inch. Notches shall be made either in the piece to be examined or in a separate defect-free specimen of the same size (within + 1/8 inch), shape, material, and condition or acoustically similar material. Acoustically similar material is defined as one which has been experimentally proven to have an acoustical velocity within + 3 percent, and an attenuation at the frequency to be used within + 0.25 decibels (dB) per inch of the material to be inspected, using the same wave mode as that used for inspection. The position and amplitude of the response from each notch shall be marked on the instrument screen, or a transparent overlay, and these marks shall be used as the evaluation reference. Indications which appear between these points shall be evaluated on the basis of a straight line joining the two peak amplitudes.

4.4.4.1.2.2 Longitudinal wave. The longitudinal wave test shall be calibrated on a flat bottomed reference hole of a given diameter in accordance with table XXX (or table XXXI, as applicable), for specified material thickness drilled either into the piece to be tested or into a separate defect-free specimen of the same size (within + 1/8 inch), shape, material and condition or acoustically similar material. Acoustically similar material is defined as one which has been experimentally proven to have an acoustical velocity within + 3 percent, and an attenuation at the frequency to be used within + 0.25 dB per inch of the material to be inspected, using the same wave mode as that used for inspection. Holes are to be drilled to midsection and the bottom of the hole shall be parallel to the entrant surface of the ultrasonic beam or to the tangent to the entrant surface. The ultrasonic test instrument shall be adjusted so that the response from the reference hole shall be not less than 25 percent and not more than 75 percent of screen height.

Table XXX - Ultrasonic testing reference hole for rod, bar, disc, pancake forgings, and forged parts.

Material thickness, inches	Hole diameter, inches
Up to and including 6	1/8
Over 6 and including 16	1/4
Over 16	As agreed upon

Table XXXI - Ultrasonic testing reference hole for plate.

Material thickness, inches	Hole diameter, inches
Up to and including 4	1/4
Over 4	1/2

4.4.4.1.3 Recalibration. During quality conformance inspection, any realignment of the search unit which will cause a decrease in the calibrated sensitivity and resolution, or both, or any change in search unit, couplant, instrument settings or scanning speed from that used for calibration shall require recalibration. Recalibration shall be performed at least once per 8 hour shift.

4.4.4.1.4 Procedure. The following paragraphs describe the requirements for rod, bar, and simple forged shapes. Sheet, strip and wire shall be specifically excluded from these requirements. Shapes other than those listed below shall be tested to the extent set forth in the approved procedure.

- (a) Rod. Rod shall be tested using the longitudinal wave technique. The scanning path shall be circumferential or helical with the beam directed along a radius of the rod.
- (b) Bar. Bar shall be tested using the longitudinal wave technique through one side of each pair of parallel sides.

- (c) Ring and hollow round products. Rings and other hollow cylindrical products shall be tested using the shear wave method by the contact or immersion technique. The shear wave entrant angle shall be such to assure reflection from the notch or notches used in calibration. For contact testing, the search unit shall be fitted with a wedge or shoe machined to fit the curvature of the piece being inspected. The product shall also be inspected with a longitudinal wave test from the external circumferential and end surfaces.
- (d) Disk or pancake forged parts. Disk or pancake forged parts shall be inspected with a longitudinal wave technique from both parallel surfaces.
- (e) Plate. Plate shall be inspected by the longitudinal wave technique using the contact or immersion method. For contact, the scanning shall be on a 24 inch grid and one diagonal in each grid. For immersion, the scanning shall be continuous on a 12 inch grid. For either method, the search shall be expanded to determine the full extent of any rejectable indication if the material is to be offered on a waiver basis.

4.4.4.1.5 Acceptance criteria.

4.4.4.1.5.1 Shear wave. Any material which produces indications equal to or larger than the response from the reference notch shall be rejected.

4.4.4.1.5.2 Longitudinal wave. Any material which produces indications equal to or larger than the response from the reference hole or which produces a complete loss of back reflection shall be rejected. Material shall be tested using a square, rectangular, or circular transducer having an effective area of one square inch or less, but no dimension shall be smaller than the diameter of the reference hole. In the event of disagreement on the degree of back reflection loss, it shall be determined by the contact method using a 1 to 1-1/8 inch diameter transducer or one whose area falls within this range.

4.4.4.1.5.3 Reference notch removal. If reference notches or flat-bottomed holes are made in the material to be tested, they shall be so located that their subsequent removal will not impair the suitability of the material for its intended use.

4.4.5 Liquid penetrant inspection.

4.4.5.1 Procedure. Liquid penetrant inspection shall be conducted in accordance with MIL-STD-271.

4.4.5.2 Acceptance criteria. Linear defects revealed by liquid penetrant inspection shall be explored by grinding or other suitable means. Depth of defects shall not exceed the dimensional tolerances of the material.

4.4.6 Rejection. If any specimen fails to meet the requirements of this specification, this shall be cause for rejection of the entire lot except as specified hereinafter:

- (a) When inspecting or testing material in accordance with 4.3.2.1 or 4.3.3.2.2.
- (b) Subject to the retest provisions of FED-STD-151.
- (c) Material not meeting the visual, dimensional, or weight requirements may be offered again if, after rework, it passes all the tests and inspections of this specification.
- (d) Material failing the ultrasonic and liquid penetrant examinations may be retested after overhaul provided such overhaul does not reduce the material below minimum specified dimension. The removal of a defect shall be verified by the method originally used to detect the defect.

4.5 Inspection of preparation for delivery. The preservation packaging, packing, and marking of the items shall be examined to determine compliance with the requirements of section 5.

5. PREPARATION FOR DELIVERY

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

5.1 Nickel-copper alloy products shall be preserved-packaged, packed, and marked level A or C as specified (see 6.1), in accordance with MIL-STD-163, except that for level A preservation-packaging wire products furnished on spools or in coils less than 25 pounds maximum weight shall be individually unit protected in accordance with method III of MIL-P-116. The contractor's standard spool or coil package will be acceptable as the unit package under this procedure.

6. NOTES

6.1 Intended use. Nickel-copper alloys, classes A and B, are used where a combination of high strength, ductility, and excellent resistance to corrosion are involved.

6.1.1 Nickel-copper alloy, class A, is a general purpose alloy and is used by aircraft, building, chemical, houseware, oil refinery, paper and pulp, and many other industries in the manufacture of articles requiring bending, forming, upsetting, and similar operations.

6.1.2 Nickel-copper alloy, class B, is intended primarily for automatic screw machine work, where free cutting and machining are of high importance. Such material is not generally recommended for forged parts, and the producer should be consulted.

6.1.3 Cold rolled sheet, annealed, is intended for forming and fabricating where finish is to be applied afterward.

6.1.4 Annealed cold drawn rod is intended for severe cold working operations such as redrawing, swaging, and upsetting.

6.1.5 Annealed wire and conditions No. 0 and No. 1 temper wires are intended for the manufacture of cold headed bolts, rivets, screws, and nails and for roll threading and similar purposes. The selection of the proper temper will vary, depending on the type of heading machine used and the severity of cold forming involved.

6.1.6 Class A cold drawn nickel-copper alloy wire springs should be given a stress equalizing treatment after forming. The stress equalizing should be of 1 hour duration at 575°F. Whenever springs are to be set or pressed before using, this should be done after the stress equalizing.

6.1.7 Where rounds are ordered for shafting to be used with S.A.E. straight bore couplings, special diameter tolerances can be provided (see 6.2(p)).

6.1.8 Stress relieved rounds, recommended condition for shafting, may have a thin dark oxide surface.

6.1.9 For special applications of deep drawing, deep drawing quality, sheet and strip may be ordered to definite grain size limits (see table VIII).

6.1.10 Plate is available descaled by blasting with iron free mineral grit, when required for welding or other applications where oxide free surface is required.

6.2 Ordering data. Purchasers should select the preferred options permitted herein and include the following information in procurement documents:

- (a) Title, number, and date of this specification.
- (b) Class, form, size, condition, and surface finish of material required (see 1.2).
- (c) When yield strength is to be determined at 0.01 percent offset (see table II).
- (d) Whether ultrasonic inspection is required (see 3.5).
- (e) Whether liquid penetrant test is required (see 3.6).
- (f) The size and shapes of the forged parts required (see 3.7.1).
- (g) Whether square, rectangular, and hexagonal bar, rod, and shapes shall have corners other than commercially sharp (see 3.8.1.3, 3.8.2.4, and 3.9.2).
- (h) The lengths required and whether cut-to-length, random mill lengths, nominal (stock) length, or multiples of specified lengths (see 3.8.3.1, 3.8.3.2, 3.9.3, 3.10.3, and 3.10.7).
- (i) The permissible variations in cross-sectional dimensions of shapes (see 3.9.1).
- (j) If edges are to be other than standard (see 3.10.2.2, 3.10.3.3.1, and 3.10.6.1).

- (k) If the tolerances other than those specified are required (see 3.10.4.1 and table XXIII).
- (l) Weight of coil or spool of wire required (see 3.11.2).
- (m) Whether marking, other than FED-STD-182 is required (see 3.13).
- (n) Whether each piece of each lot shall be inspected 100 percent by volume for ultrasonic testing (see 4.3.4).
- (o) Selection of applicable levels of preservation-packaging and packing required (see 5.1).
- (p) Whether precision straightened, cold drawn shafting is required. Whether these should have special diameter tolerances (see 6.1.7).
- (q) Whether descaled surface is desired (see 6.1.10).

6.1.10 - see back cover #1 of 6.1.10

6.3 General information.

6.3.1 When material is ordered in the form of plate, sheet, or strip, it shall be understood that these terms refer merely to the general form and dimensions of the material and do not have any technical significance as to the methods of manufacture.

6.3.2 Sheet or strip required for deep drawing or spinning is not stretcher leveled and may be slightly wavy.

6.3.3 Plate, sheet, and strip should be ordered in as narrow widths as can be used.

6.3.4 Hot finished "forging quality" rounds (see table XIII) with a cold drawn pass are available to special close tolerances for hot upsetting of bolts.

6.3.5 The commercial straightness tolerances of cold drawn rod and bar are specified in table X and those of precision straightened shafting are specified in table XI. Where material is intended for shafting, the use of precision straightened cold drawn shafting is recommended (see 3.8.1.4).

6.3.6 Where oxide-free plate is desired, such as for parts involving considerable welding where oxidized surface may be objectionable, plates may be furnished descaled (grit-blasted using iron-free mineral grit).

6.3.7 "Plain finish" is the finish resulting from material that has been descaled or that has been annealed in an atmosphere that yields a bright finish.

6.3.8 The following hardness values for class B cold-drawn and class B annealed material are given for information only:

Condition and form	Diameter or distance between parallel surfaces, inches	Hardness, Rockwell B
Cold-drawn:	Under 1/2	84-96
	1/2 to 1, incl.	84-98
	Over 1 to 3, incl.	84-100
Hexagons and squares	1/4 to 2, incl.	80-94
Annealed:		
All products	All	60-75

6.4 The chemical and mechanical property requirements of this specification are similar to ASTM B127, ASTM B164, and ASTM B564.

6.5 Sub-contracted material and parts. The preparation for delivery requirements of referenced documents listed in Section 2 do not apply when material and parts are procured by the supplier for incorporation into the equipment and lose their separate identity when the equipment is shipped.

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