INCH-POUND

QQ-N-286G
07 December 2000
SUPERSEDING
QQ-N-00286F(SH)
29 November 1990
QQ-N-286E
02 August 1985

FEDERAL SPECIFICATION

NICKEL-COPPER-ALUMINUM ALLOY, WROUGHT (UNS N05500)

The General Services Administration has authorized the use of this federal specification by all federal agencies.

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers all nickel-copper-aluminum alloy wrought forms formerly classified as class A. This alloy is designated under the Unified Numbering System for Metals and Alloys as UNS N05500. Except for cases where nonmagnetic properties are paramount, this alloy is intended to be age hardened prior to placing the material in service.

1.2 Classification.

1.2.1 Forms and conditions. The material should be furnished in the following forms and conditions, as specified (see 6.2).

Form 1 - Bar, rod, unaged.

Condition:	Hot finished, unaged Cold drawn, unaged. Annealed (hot finished or cold drawn), unaged.

Form 2 - Bar, rod, age hardened.

Condition:	Hot finished and age hardened Cold drawn and age hardened Annealed (hot finished or cold drawn), and age hardened.

Beneficial comments, recommendations, additions, deletions, clarifications, etc., and any data that may improve this document should be sent to: Commander, Naval Sea Systems Command, Department of the Navy, SEA 05Q, - 2531 Jefferson Davis Hwy, Arlington, VA 22242-5160.

Form 3 - Sheet.

Condition: Cold rolled and annealed.
Cold rolled, annealed, and age hardened.

Form 4 - Strip.

Condition: Cold rolled and annealed.
Cold rolled, annealed, and age hardened.
Cold rolled, half or full hard, as rolled.
Cold rolled, half or full hard, and age hardened.

Form 5 - Wire.

Condition: Cold, as drawn.
Cold drawn and annealed.
Cold drawn, spring temper, as drawn.
Cold drawn, annealed, and age hardened.
Cold drawn (as drawn) and age hardened.
Cold drawn, spring temper, and age hardened.

Form 6 - Plate.

Condition: Hot rolled and annealed.
Hot rolled, annealed, and age hardened.

Form 7 - Forgings (Including bar and rod formed by forging).

Condition: Hot finished, unaged.
Annealed, unaged.
Hot finished and age hardened.
Annealed and age hardened.

(Note: Constant cross-section bars and rods formed by forging are considered to be "forgings" only for purposes of:

A) Sample frequency for mechanical properties (see 4.2.2.4 and 4.2.2.5).

B) Visual and dimensional inspections (see 4.2.2.6).

C) Ultrasonic testing requirements (see 4.3.3.2).

Constant cross-section bars and rods are not otherwise considered to be "part forgings" or "intricate or complex shape forgings."

1.2.2 Finishes. The material shall be furnished in the following finishes, as specified (see 6.2). Age hardened condition of finishes (a)-(d) and (g) below shall be furnished with the age hardening oxide intact:

A) Hot finished.

B) As drawn.

C) Rough turned or rough ground (rounds only).

D) Semismooth machined (rounds only).

E) Smooth finished machined (rounds only).

F) Bright finish (shafting only).

G) Pickled.

2. APPLICABLE DOCUMENTS

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

2.1.1 Specifications and standards.

FEDERAL

STANDARD

FED-STD-182 Continuous Identification Marking of Nickel and Nickel Base Alloys.

(Activities outside the Federal Government may obtain copies of Federal specifications, standards, and commercial item descriptions as outlined under General Information in the Index of Federal Specifications, Standards and Commercial Item Descriptions. The index, which includes cumulative bimonthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402.)

(Copies of listed Federal and Military standards and specifications, Commercial Item Descriptions (CIDS), Handbooks and associated documents listed in the Department of Defense Index of Specifications and Standards (dodiss) should be obtained from the DOD Single Stocking Standardization Documents Ordering Desk, 700 Robbins Avenue, Building 4D, Philadelphia PA 19111-5094. Copies of industry association documents should be obtained from the sponsor. Copies of all other listed documents should be obtained from the contracting activity or as directed by the contracting officer.)

(Federal Government activities may obtain copies of Federal Standardization documents and the Index of Federal Specifications, Standards and Commercial Item Descriptions from established points in these agencies.)

MILITARY

STANDARD

MIL-STD-1684 - Control of Heat Treatment.

MIL-STD-2132 - Nondestructive Examination Requirements for Special Applications.

(Unless otherwise indicated, copies of Federal and Military specifications and standards are available from the Standardization Documents Order Desk, 700 Robbins Avenue, Building 4D,Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents, drawings and publications. The following other Government documents, drawings and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation (see 6.2)

PUBLICATIONS

NAVAL SEA SYSTEMS COMMAND

T9074-AS-GIB-010/271 - Requirements for Nondestructive Testing Methods.

(Copies of this publication are available from the Naval Inventory Control Point, 700 Robins Avenue, Philadelphia, PA 19111-5094)

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

AMERICAN PETROLIUM INSTITUTE (API)

6A, Appendix H Recommended Practice for Heat Treating Equipment Qualification, Specification for Wellhead and Christmas Tree Equipment.

(Application for copies should be addressed to API, 1220 L Street, Northwest, Washington, DC 20005.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

E 8	Tension Testing of Metallic Materials.
E 10	Standard Test Method For Brinell Hardness of Metallic Materials.
E 18	Standard Test Method For Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials.
E 76	Methods for Chemical Analysis of Nickel-Copper Alloys.
E 112	Methods for Determining Average Grain Size
E 290	Standard Test Method for Semi-Guided Bend Test for Ductility of Metallic Materials
E 340	Method for Macroetching Metals and Alloys
E 602	Method for Sharp Notch Tensile Testing with Cylindrical Specimens

(Application for copies should be addressed to ASTM, 100 Bar Harbor Drive, W. Conshohocken, PA 19428-2959.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

AMS 2750 - Pyrometry

(Application for copies should be addressed to Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Processing. Nickel-copper-aluminum alloy shall be produced by the electric furnace (EAF) or vacuum induction furnace (VIM) process and further refined by any process proved adequate to pass the slow strain rate tensile test (see 3.4 and 4.3.6). Casting may be by ingot or continuous cast methods. Cast ingots or billets shall be hot worked to a fine uniform grain structure. Final processing shall be by hot working or cold working, and heat treating.

3.1.1 Forgings as final product. For all forgings other than bar or rod, a forging sketch shall be prepared when specified (see 6.2). Forgings with final forged diameter or distance across parallel surfaces of 4 inches or greater shall be to such a configuration that they can be ultrasonically inspected 100 percent by volume with three directional coverage.

3.1.2 Heat treatment. Heat treatments shall be controlled in accordance with one of the following specifications:

A) AMS 2750 and meet the minimum requirements for a class 2, type RM furnace with a uniformity requirement of $\pm$25°F.

B) Appendix H of API Specification 6A. Furnaces with one working sensor in each control zone have been surveyed within the last three months and furnaces with more than one working sensor in each control zone have been surveyed within the last six months.

c) MIL-STD-1684.

3.1.2.1 Solution treatment. Solution treating shall be accomplished by holding at a minimum temperature of 1600°F, followed by water quenching. The time at temperature must be such that the entire volume of material is heated to the solution treating temperature.

3.1.2.2 Age hardening. Age hardening shall be accomplished by any process proved adequate to meet the mechanical property requirements.

3.2 Chemical requirements. Chemical composition of the material shall conform to table I. When a product (check) analysis is specified (see 6.2), the material shall conform to the requirements of table I, subject to the permissible tolerances for check analysis.

3.3 Mechanical properties. Mechanical properties shall be as specified in tables II through VI, as applicable. Unaged material shall meet the mechanical properties specified after heat treatment.

3.3.1 Unaged material. Material ordered in the unaged condition shall, after proper heat treatment, be capable of meeting the mechanical properties of the corresponding heat treated condition of the forms specified in tables II through VI, as applicable.

3.3.2 Bending properties (sheet and strip). Sheet and strip, except half hard and age hardened or full hard and age hardened strip, shall not crack when subjected to cold bending (See 4.3.2.5).

3.4 Susceptibility to intergranular cracking. The material shall not be susceptible to intergranular cracking (see 4.3.6).

3.5 Duplex grain structure. Duplex grain structure is not permitted in barstock with a diameter of 3½ inches or less. Duplex grain structure is defined as any structure in which the average grain sizes for the two grain size specimens, prepared in accordance with 4.3.5, differ by more than 5 ASTM grain size numbers. The uniformity of grain size shall be determined for bar and rod as specified in 4.3.5. Plate, sheet, strip, and wire shall be excluded from this requirement.

3.6 Recovered materials. The offeror/contractor is encouraged to use recovered materials to the maximum extent practicable, in accordance with paragraph 23.403 of the Federal Acquisition Regulation (FAR).

TABLE I. Chemical composition.

Elements	Requirements, percent (Maximum unless a range or a minimum is indicated.)	Product (check) analysis variations, under minimum or over maximum, of the specified limit of the element, percent
Nickel 1/	63.0 minimum	0.45
Aluminum	2.30 - 3.15	0.20
Carbon(total)	0.18	0.02
Iron	2.0	0.05
Manganese	1.5	0.04
Silicon	0.50	0.03
Titanium	0.35 - 0.85	0.03 (minimum) 0.04 (maximum)
Cobalt	0.25	0.03
Sulfur	0.006	0.002
Copper 2/	27.0 - 33.0	0.15 (minimum) 0.20 (maximum)
Tin	0.006	0.002
Phosphorous	0.02	0.005
Zinc	0.02	0.005
Lead	0.006	0.002

1/ Element may be determined arithmetically by difference.

2/ Silver counting as copper.

TABLE II. Mechanical properties (bar, rod, forged parts and plate unaged 1/).

Form	Condition	Size, inches	Hardness(maximum)	
			Brinell (3000 kg)	Rockwell
Rounds	Hot finished	Up to 4¼, incl.	245	C23
		Over 4¼	260	C26
	Hot finished and annealed	All	185	B90
	Cold drawn and annealed	All	185	B90
Hexagons, squares, rectangles and forged parts	Hot finished	All	245	C23
	Hot finished and annealed	All	185	B90
	Cold drawn and annealed	All	185	B90
Hexagons	Cold drawn	All	260	C26
Rounds	Cold drawn	¼ to 1, incl.	280	C29
		Over 1 to 3, incl.	260	C26
		Over 3 to 4, incl.	240	C22
Plate:	Hot rolled and annealed	Up to 4, incl	185	B90

1/ No tensile tests are required except as provided for in 4.3.2.2

TABLE III. Mechanical properties (age hardened bar; rod, forged parts and plate).

Form	Condition	Diameter or maximum distance between parallel surfaces (inches)	Tensile strength lb/in² (minimum)	Yield strength 0.2% offset lb/in² (minimum)	Elongation in 2 inches or 4D, percent (minimum) 1/
Rounds	Hot finished and age hardened	Up to 4¼, inc.	140,000	100,000	20.0
		Over 4¼	140,000	100,000	17.0
	Annealed and age hardened 3/	Up to 1	130,000	90,000	20.0
		1 and over	130,000	85,000	20.0
Hexagons, squares, rectangles and forged parts 2/	Hot finished and age hardened	All sizes	140,000	100,000	20.0
	Annealed and age hardened 3/	Up to 1	130,000	90,000	20.0
		1 and over	130,000	85,000	20.0
Rounds	Cold drawn and age hardened	¼ to 1, incl	145,000	110,000	15.0
		Over 1 to 3, incl	140,000	100,000	17.0
		Over 3 to 4, incl	135,000	95,000	20.0
Hexagons	Cold drawn and age hardened	¼ to 2, incl.	140,000	100,000	15.0
Plate	Hot rolled, annealed and age hardened	Up to 4, incl.	130,000	80,000	20.0

1/ Not applicable to subsize tensile specimens less than 0.250 inch diameter (see 4.3.2.3).

2/ When specified (see 6.2), for forged rings and discs, hardness measurements may be utilized in lieu of tensile tests.

3/ Applicable to both hot finished and cold drawn material.

TABLE IV. Mechanical properties of sheet and strip.

Form and condition		Tensile strength lb/in² (minimum)	Yield strength at 0.2% offset (minimum) 1/	Elongation in 2 inches, percent (minimum) 1/	Rockwell hardness
Sheet	Cold rolled and annealed				B85 Max
	Cold rolled, annealed, and age hardened	130,000	90,000	15	
Strip	Cold rolled and annealed				B85 Max
	Cold rolled, annealed, and age hardened	130,000	90,000	15	
	Cold rolled, half hard, as rolled				C20 Min
	Cold rolled, half hard, and age hardened	145,000	110,000	8	
	Cold rolled, full hard, as rolled				C25 Min
	Cold rolled full hard and age hardened	170,000	130,000	5	

1/ No yield strength or elongation requirements for sheet and strip under 0.020 inch thick.

TABLE V. Tensile strength of cold drawn wire in coils.

Condition	Size (inches)	Tensile strength lb/in²
Cold drawn, as drawn	All sizes	110,000-155,000
Cold drawn and annealed	All sizes	110,000 max
Cold drawn, spring temper, as drawn	0.057 and less 1/	165,000 min
	Over 0.057 to 0.114, inclusive 1/	155,000 min
	Over 0.114 to 0.229, inclusive 1/	150,000 min
	Over 0.229 to 0.312, inclusive 1/	145,000 min
	Over 0.312 to 0.375, inclusive 1/	135,000 min
	Over 0.375 to 0.437, inclusive	125,000 min
	Over 0.437 to 0.563, inclusive	120,000 min
Cold drawn, annealed and age hardened	All sizes	130,000 min
Cold drawn, as drawn, age hardened	All sizes	155,000 min
Cold drawn, spring temper, and age hardened:	Up to 0.114, inclusive	180,000 min
	Over 0.114 to 0.375, inclusive	170,000 min
	Over 0.375 to 0.563, inclusive	160,000 min

1/ Applicable to material in coil. For material in straightened and cut lengths, deduct 15,000 lb/in² from above values.

TABLE VI. Bending properties of cold rolled sheet and strip. 1/

Thickness of sheet and strip (inch)		Radius of pin or mandrel, multiples of the thickness of the material	Angle of bend, degrees		
From	To (incl)		Annealed sheet and strip	Half hard strip	Annealed and age hardened, sheet & strip, & full hard, cold rolled strip
Up to 0.010	0.031	0.5	180	120	90
Over 0.031	0.062	0.5	180	120	90
Over 0.062	0.125	0.5	180	120	90
Over 0.125	0.250	1.0	180	120	90

1/ There are no bending requirements for half hard aged or full hard aged strip.

3.7 Soundness. Material shall be of uniform quality and condition, free of defects harmful to its intended use, such as seams, pipe, cracks, excessive scale, fins, porosity, and segregation as determined by visual examination and nondestructive testing.

3.7.1 Ultrasonic inspection.

3.7.1.1 Large bar and forgings (Forms 2 and 7). Bar, rod, and forgings with a diameter or minimum distance between parallel surfaces of 4 inches or greater shall be ultrasonically inspected as specified in 4.3.3.1 and 4.3.3.2.

Inspection shall be performed after the aging treatment. Ultrasonic procedures other than those specified may be employed but they shall be approved by the command or agency concerned.

3.7.1.2 Small bar, rod, plate and forgings. When specified (see 6.2), bar, rod, plate, and forgings shall be ultrasonically inspected to 4.3.3.1 and 4.3.3.3.

3.7.2 Liquid penetrant inspection. When specified (see 6.2), bar, rod, plate, and forgings shall be liquid penetrant inspected to 4.3.4.

3.8 Wrapping requirements (cold drawn wire).

3.8.1 Cold drawn and annealed, and cold drawn, as drawn ¼ inch diameter or less. Wire of cold drawn and annealed, and cold drawn, as drawn conditions shall withstand wrapping eight consecutive close wound turns, without cracking, around a rod of the same diameter as the wire.

3.8.2 Spring temper ¼ inch diameter or less. Wire of spring temper up to 0.2294 inch diameter, inclusive, shall withstand wrapping eight consecutive close wound turns, without cracking, around a rod of the same diameter. Wire over 0.2294 inch in diameter shall withstand similar wrapping, without cracking, around a rod of twice the wire diameter.

3.8.3 Age hardened or over ¼ inch diameter. There are no wrapping requirements for wire in the age hardened condition or with a diameter greater than ¼ inch.

3.9 Dimensional requirements.

3.9.1 Bar and Rod.

3.9.1.1 Diameter, distance between parallel faces, or thickness. The diameter, distance between parallel faces, or thickness of hot finished or cold drawn bar and rod, aged and unaged, shall not vary at any point by more than the amounts specified in tables VII or VIII, as applicable.

3.9.1.2 Out of roundness. Round rod, cold drawn, and hot finished, all sizes and in straight lengths, shall not be out of round by more than one-half the permissible tolerances in diameter specified in tables VII and VIII.

3.9.1.3 Length.

3.9.1.3.1 Bar and rod. 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 cut ends. Material ordered to cut lengths shall be furnished with square cut or machined ends. Where rod and bar is ordered in multiples of a specified unit length, ¼ inch shall be allowed for each multiple cut unless otherwise specified (see 6.2), and the rod and bar shall have cut ends.

3.9.1.3.2 Permissible variations in length. The permissible variations in lengths of rod and bar, all conditions, shall be as specified in table IX.

3.9.1.4 Edges. Unless otherwise specified (see 6.2), square, rectangular, and hexagonal bar and rod shall have angles and corners consistent with commercial practice.

3.9.1.5 Straightness. The permissible variations in straightness of rod and bar, as determined by the departure from the true straightness (throw in one revolution or depth of chord), shall be as specified in tables X and XI.

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

TABLE VII. Tolerances on diameter or distance between parallel faces of hot finished bar and rod.

Ordered diameter or distance between parallel faces (inches)	Size	Tolerances 1/ 4/, (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	0.063
Round rod, hot finished and rough turned or rough ground:	1 and over	0.031	0.010
Round rod, hot finished, semi-smooth, machined:	Over 3½	0.031	0.000
Round rod, hot finished, smooth finish machined:	Over 3½	0.000	0.005 2/
Forging stock (rounds):	Under 1	0.005	0.010 3/
	1 and over	0.031	0.010 3/
Forging quality bolt stock (rounds only):	¼, 5/16	0.0000	0.0062
	3/8, 7/16, ½	0.0000	0.0066
	9/16, 5/8, 11/16, ¾, 13/16, 7/8	0.0000	0.0082
	15/16, 1	0.0000	0.0098
	1 1/16 to 1½, in 1/16 inch increments	0.0000	0.0112

1/ Tolerances apply to diameter of rounds, to distance between parallel surfaces for 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 specified (see 6.2).

3/ Spot grinding may be permitted to remove minor surface defects. The depth of grinding shall not exceed 3 percent of the diameter.

4/ Areas on the ends of the bar and rod (for approximately 1 inch) that are under the permissible variations in diameter are permitted provided the desired finished surface can be obtained within the machining allowance (see 3.11).

TABLE VIII. Tolerances on diameter or distance between parallel faces of cold drawn rod and bar.

Ordered diameter or distance between parallel faces (inches)		Tolerances (inches)	
		Plus	Minus
Rounds	Under ½	0	0.003
	½ to $^{15}/_{16}$, incl	0	0.002 1/
	Over $^{15}/_{16}$ to $1^{15}/_{16}$, incl	0	0.003 1/
	Over $1^{15}/_{16}$ to 2½, incl	0	0.004 1/
	Over 2½ to 3, incl	0	0.005 1/
	Over 3 to 3½, incl	0	0.006 1/
	Over 3½ to 4, incl	0	0.007 1/
Hexagons	Up to 2, incl	0	0.009

1/ For cold drawn, age hardened, bright finish shafting, an additional minus tolerance of 0.002 inch will be permitted (see 6.7.2).

TABLE IX. Permissible variations in length of bar and rod, all conditions.

Specified length, feet		Shortest acceptable lengths, feet	Maximum acceptable length	Maximum permissible percentage by weight of short length
Random mill lengths 1/		6	24 ft	25% under 9 ft
Nominal (stock) length 2/	16 to 18	16	18 ft, ½ in	100% 16 ft or longer
	14 to 16	14	16 ft, ½ in	100% 14 ft or longer
	12 to 14	12	14 ft, ½ in	100% 12 ft or longer
	10 to 12 3/	10	12 ft, ½ in	100% 10 ft or longer
	8 to 10 3/	8	10 ft, ½ in	100% 8 ft or longer
	6 to 8 3/	6	8 ft, ½ in	100% 6 ft or longer
	4 to 6	4	6 ft, ½ in	100% 4 ft or longer
Cut-to length 4/		Specified length	Specified length to plus ⅛ in	100% specified plus ⅛ in

1/ For hot finished sections weighing over 25 pounds per lineal foot and for smooth forged products, all sections, short lengths down to 2 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 ½ 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.

4/ For diameters over 8 inches, the tolerance shall be plus ¼ inch minus 0.

TABLE X. Permissible variations in straightness of rod and bar.1/

Ordered condition, finish, and size	Permissible deviations in straightness (inches)
Hot finished: 2/ Bar and rod (hot finished surface)	Depth of chord 3/ 0.050 per foot of length
Rounds: Rough turned or rough ground Semismooth machined Smooth finished machined	Throw in one revolution 4/ 0.050 per foot of length 0.0031 per foot of length 0.0015 per foot of length
Cold drawn: Rounds (diameter): Up to 4 inches, incl	Depth of chord 3/ 0.030 per foot of length
Hexagons and squares: All sizes	Depth of chord 3/ 0.030 per foot of length

1/ Not applicable to forging quality rod.

2/ Except forging quality stock.

3/ The maximum curvature (depth of chord) shall not exceed the value indicated multiplied by length in feet.

4/ The throw in one revolution in any 20 feet maximum length shall not exceed the values indicated multiplied by length in feet.

TABLE XI. Permissible variations in straightness of precision straightened cold drawn shafting.

Ordered diameter of shafting, (inches)	Standard distance between supports, (inches)	Permissible variations throw in one revolution from straightness, (inches)
½ to $^{15}/_{16}$, incl	42	0.005
Over $^{15}/_{16}$ to $1^{15}/_{16}$, incl	42	0.006
Over $1^{15}/_{16}$ to 2½, incl	42	0.007
Over 2½ to 4 incl	42	0.008
¾ to $^{15}/_{16}$, incl	Specified lengths of 3 to 10 feet	0.004 plus 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 plus 0.0015 for each foot, or fraction thereof, in excess of 3 feet.

3.9.2 Forged parts dimensions. All forgings shall conform to the sizes and shapes as specified (see 6.2). The responsibility of furnishing forgings 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 gauges as may be specified in the individual cases, shall rest with the contractor.

3.9.3 Plate, sheet, and strip.

3.9.3.1 Thickness. The thickness tolerances of cold rolled nickel-copper-aluminum alloy sheet and strip, all conditions, shall conform to the requirements specified in table XII. The tolerances on thickness of hot rolled nickel-copper-aluminum alloy plate, all conditions, shall conform to the requirements specified in table XIII.

3.9.3.2 Width. The width of sheet and strip shall not vary from the ordered width by more than the amount specified in table XIV and those for plate shall be as specified in table XV.

3.9.3.3 Lengths.

3.9.3.3.1 Sheet. Unless otherwise specified (see 6.2), sheet shall be furnished in cut lengths. The permissible variation in length shall be plus ⅛ inch, minus nothing.

3.9.3.3.2 Strip. Unless nominal or stock lengths or cut lengths are specified, strip, in conditions other than age hardened, shall be furnished in coil in thicknesses up through 0.125 inch and in random straight lengths in thicknesses over 0.125 inch. Unless otherwise specified (see 6.2), age hardened strip shall be furnished in straightened (cut) lengths only.

A) The length of cut length strip shall not vary under or over the ordered length by more than ⅛ inch.

B) Nominal or stock lengths. The length of strip up to 12 inches wide, ordered as nominal or stock lengths, shall not vary from the ordered nominal or stock length by more than ½ inch, except for the permissible amounts of short lengths specified in table XVII. The maximum percentage by weight of short lengths, and the required percentage by weight of ordered stock lengths, in any shipment shall be as specified in table XVII.

3.9.3.3.3 Plate. The permissible variations in length for plate shall be as specified in table XVI. The permissible variations in diameter for circular plate shall be as specified in table XVIII.

TABLE XII. Tolerances on thickness of cold rolled sheet and strip, all conditions.

Ordered thickness, (inches)		Tolerances on thickness for widths given 1/ (inches, plus or minus)		
		Less than 12 inches wide 1/	48 inches or less wide	Over 48 to 60 inches wide, inclusive
Sheet	0.018 to 0.025, incl		0.002	0.003
	Over 0.025 to 0.034, incl		0.003	0.004
	Over 0.034 to 0.043, incl		0.004	0.005
	Over 0.043 to 0.056, incl		0.004	0.005
	Over 0.056 to 0.070, incl		0.005	0.006
	Over 0.070 to 0.078, incl		0.006	0.007
	Over 0.078 to 0.093, incl		0.007	0.008
	Over 0.093 to 0.109, incl		0.007	0.009
	Over 0.109 to 0.125, incl		0.008	0.010
	Over 0.125 to 0.140, incl		0.008	0.010
	Over 0.140 to 0.171, incl		0.009	0.012
	Over 0.171 to 0.187, incl		0.010	0.013
	Over 0.187 to 0.218, incl		0.011	0.015
	Over 0.218 to 0.234, incl		0.012	0.016
	Over 0.234 to 0.250, incl		0.013	0.018
Strip	0.010 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 2/	0.0045 3/		
	Over 0.156 to 0.250, incl 2/	0.0055 3/		

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

2/ Available in straightened and cut lengths only.

3/ For widths over 8 inches, the permissible variations for cold rolled sheet are applicable.

TABLE XIII. Permissible variations in weight and thickness of hot rolled rectangular plate. 1/2/

Specified 3/ Thickness (inches)	Permissible excess in average weight 4/ per square foot of plate for widths given in inches expressed in percentage of nominal weights									
	Under 48	48-60 excl.	60-72 excl	72-84 excl	84-96 excl	96-108 excl	108-120 excl	120-132 excl	132-144 excl	144-160 excl
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 1¼, excl	4.0	4.0	4.5	5.5	6.0	7.0	7.5	9.0	10.5	12.0
1¼ to 1½, excl	4.0	4.0	4.5	5.5	6.0	7.0	7.5	9.0	10.5	
1½ to 1¾, excl	4.0	4.0	4.5	5.5	6.0	7.0	7.5	9.0		
1¾ 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 overweight of each lot in each shipment shall not exceed the amount shown in the table. Spot grinding will be permitted to remove surface imperfections, such spots not to exceed 0.01 inch under the specified thickness.

3/ All plates shall be ordered by thickness and not weight, per square foot.

4/ The weight of individual plates shall not exceed the nominal weight by more than 1¼ times the amount shown.

TABLE XIV. Tolerances on width of cold rolled sheet and strip, all conditions.

Ordered thickness (inches)		Ordered width (inches)	Tolerances on widths (inches)	
			Plus	Minus
Sheet	All thickness	All widths	0.125	0.000
Strip, Split edge:	0.010 to 0.024, incl	12 and under	0.007	0.007
	Over 0.024 to 0.075, incl	12 and under	0.007	0.007
	Over 0.075 to 0.100, incl	12 and under	0.009	0.009
	Over 0.100 to 0.125, incl	12 and under	0.012	0.012
	Over 0.125 to 0.250, incl 1/	8 and under	0.015	0.015
	Over 0.125 to 0.250, incl 1/ 2/	Over 8 to 12, incl	0.125	0.

1/ Available in straightened and cut lengths only.

2/ Slit edge or sheared edge.

TABLE XV. Permissible variations in width of sheared, machined, abrasive or plasma torch cut rectangular plate.1/ 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	
		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		
	5/16 to 1/2, excl	1/4	1/8	3/8	1/8	3/8	1/8	1/2	1/8	5/8	1/8
	1/2 to 3/4, excl	3/8	1/8	3/8	1/8	1/2	1/8	5/8	1/8	3/4	1/8
	3/4 to 1, excl	1/2	1/8	1/2	1/8	5/8	1/8	3/4	1/8	7/8	1/8
	1 to 1 1/4, incl	5/8	1/8	5/8	1/8	3/4	1/8	7/8	1/8	1	1/8
Machined or abrasive cut 4/ 5/	3/16 to 1 1/4, incl	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
	Over 1 1/4 to 4 inc	3/16	1/8	3/16	1/8	3/16	1/8	3/16	1/8	3/16	1/8
Plasma tourch cut 6/	3/16 to 2, excl	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0
	2 to 3, incl	5/8	0	5/8	0	5/8	0	5/8	0	5/8	0

1/ Permissible variations in width for powder cut or inert arc cut plate or machined, powder cut or inert arc cut circular plate shall be as agreed upon between the manufacturer and the Command or agency concerned.

2/ Tolerances for plasma torch cut sketch plate shall be as agreed upon between the manufacturer and the Command or agency concerned.

3/ The minimum sheared width is 10 inches for material ¾ inch and under in thickness and 20 inches for material over ¾ inch in thickness.

4/ The minimum abrasive cut width is 2 inches.

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

6/ Tolerances shown for plasma torch cutting may be obtained all on the minus side, or divided between the plus and minus side, as specified (see 6.2).

TABLE XVI. Permissible variations in width 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 - 5/16, excl	3/16	1/8	1/4	1/8	3/8	1/8	1/2	1/8	5/8	1/8	3/4	1/8		
	5/16 - 1/2, excl	3/8	1/8	1/2	1/8	1/2	1/8	1/2	1/8	5/8	1/8	3/4	1/8	7/8	1/8
	1/2 - 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	1/8
	3/4 - 1, excl	5/8	1/8	5/8	1/8	5/8	1/8	3/4	1/8	7/8	1/8	1 1/8	1/8	1 3/8	1/8
	1 – 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 5/8	1/8
Machined or abrasive cut: 3/	3/16 - 1 1/4, 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 1/4 - 4, incl	3/16	1/8	3/16	1/8	3/16	1/8	3/16	1/8	3/16	1/8	3/16	1/8	3/16	1/8
Plasma Torch Cut: 4/5/	3/16 - 2, incl	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0
	2 – 2 1/4	5/8	0	5/8	0	5/8	0	5/8	0	5/8	0	5/8	0	5/8	0

1/ Permissible variations in length for powder cut or inert arc cut plate or machined, powder cut or inert arc cut circular plate shall be as agreed upon between the manufacturer and the Command or agency concerned.

2/ The minimum sheared length is 10 inches.

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

4/ Tolerances for plasma torch cut sketch plate shall be as agreed upon between the manufacturer and the Command or agency concerned.

5/ Tolerances for plasma torch cutting may be obtained all on the minus side, or divided between the plus or minus side as specified (see 6.2).

TABLE XVII. Permissible variations in stock lengths of strip, up to 12 inches wide.

Ordered nominal or stock length (feet)	Required percentage by weight of stock length	Maximum permissible percentages, by weight, of short lengths				
		Over 8 to 10 feet, incl	Over 6 to 8 feet, incl	Over 4 to 6 feet, incl	Over 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

TABLE XVIII. Permissible variation in diameter for circular plate.

Specified diameter, (inches)		Thickness (inches, maximum)	Permissible variations over specified diameter for thickness given (inches)					
			Thickness to 3/8, incl		3/16 to 2, excl		2 to maximum thickness	
			Plus	Minus	Plus	Minus	Plus	Minus
Sheared plate	20 to 32, excl	3/8	1/4	0				
	32 to 84, excl	3/8	5/16	0				
	84 to 108, excl	3/8	3/8	0				
	108 to 140, excl	3/8	7/16	0				
Plasma torch cut plate 1/ 2/	19 to 20, excl	3			1/2	0	5/8	0
	20 to 22, excl	2 3/4			1/2	0	5/8	0
	22 to 24, excl	2 1/2			1/2	0	5/8	0
	24 to 28, excl	2 1/4			1/2	0	5/8	0
	28 to 32, excl	2			1/2	0	5/8	0
	32 to 34, excl	1 3/4			1/2	0		
	34 to 38, excl	1 1/2			1/2	0		
	38 to 40, excl	1 1/4			1/2	0		
	40 to 140, excl	3			1/2	0	5/8	0

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

2/ Permissible variations in plasma torch cut sketch plate shall be as agreed upon between the manufacturer and the Command or agency concerned.

3.9.3.4 Edges.

3.9.3.4.1 Sheet. Unless otherwise specified (see 6.2), sheet shall be furnished with edges as would result from slitting, sawing, or shearing.

3.9.3.4.2 Strip. Unless otherwise specified (see 6.2), strip shall be furnished with the type of edge as specified in table XIX.

TABLE XIX. Type of edge of strip.

Thickness (inches)	Width (inches)	Type of edge
0.125 and less	12 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.

3.9.3.4.3 Plate. Unless otherwise specified (see 6.2), plate 1¼ inch in thickness and less shall be furnished with sheared edges; and plate over 1¼ inch in thickness shall be furnished with machined, abrasive or plasma torch cut edges.

3.9.3.5 Straightness. The edgewise curvature or maximum departure from straight line in any longitudinal edge on sheet and strip cut to length or in random, nominal or stock lengths shall not exceed 0.05 inch per foot of length.

3.9.4 Wire.

3.9.4.1 Diameter. The permissible tolerances in diameter of all conditions of wire shall be as specified in table XX.

3.9.4.2 Out of roundness. Wire shall not be out of round by more than one-half the total permissible tolerances specified in table XX.

3.9.4.3 Coil and spool weights. Permissible variations in coil and spool weights of cold drawn wire shall be as stated in tables XXI and XXII.

3.10 Marking. Unless otherwise specified (see 6.2), bar, rod, sheet, strip, and plate shall be marked in accordance with FED-STD-182 and in addition, shall be marked with the lot number. Individual forgings shall be marked with the specification number, heat and lot number. Identification number and markings shall not be made by chisel or other sharp instruments.

3.11 Machining allowance for hot finished material. Machining allowances shall be made for hot finished material as specified in table XXIII.

TABLE XX. Tolerances in diameter of cold drawn wire, all conditions.

Specified diameter(inches)	Tolerances (inches)	
	Plus	Minus
To 0.0044, incl	0.0002	0.0002
Over 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

TABLE XXI. Permissible variation in weight of cold drawn wire in coils and on spools (except Air Force use).

Condition	Wire diameter (inches)	Standard spool weight (pounds)	Maximum weight wire on each spool (pounds)
Spools (all conditions)	Under 0.010	2	2½
	0.010 to 0.018, incl	5	6
	Over 0.018 to 0.040, incl	10	15
Condition	Wire diameter (inches)	Approximate mean coil diameter (inches)	Maximum weight per coil (pounds)
Coils (all conditions)	Under 0.010	8	15
	0.010 to 0.018, incl	8	25
	Over 0.018 to 0.040, incl	8 to 12	40
	Over 0.040 to 0.081, incl	16 to 20	100
	Over 0.081 to 0.312, incl	18 to 22	200
	Over 0.312 to 0.563, incl	22 to 30	200

TABLE XXII. Permissible variation in weight of cold drawn wire in coils and on spools(Air Force use only).

Condition	Wire diameter (inches)	Core diameter (inches)	Maximum weight 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 XXIII. Machining allowances for hot finished rod and bar (allow the following oversizes).

Condition 1/	Dimensions (inches)	Machining allowances (inch) 2/			
		Diameter	Across flats (hexagons and squares)	Thickness (rectangles)	Width (Rectangles)
Hot finished	Up to 0.875	0.125	0.125	0.125	0.187
	Over 0.875 - 1.875	0.125	0.187	0.125	0.187
	Over 1.875 - 2.875	0.187	0.250		0.187
	Over 2.875 - 3.812	0.250			0.187
	Over 3.812	0.250			0.375
Rough turned or rough ground 2/ 3/	0.500 - 0.875	0.005			
	Over 0.875 - 4.000	0.062			
	Over 4.000 - 12.000	0.125			
	Over 12.000 - 20.000	0.125			
Semismooth machined 3/	Up to 2.500 (Up to 10’ lengths)	0.062			
	Over 2.500 - 4.000 (Over 10-20’ lengths)	0.125			
	Over 4.000 – 10.000 (up to 30' lengths)	0.125			

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

2/ The allowances are recommended for rounds to be machined in lengths 36 inches or less (such as stepdown shafts) and for squares, hexagons, and rectangles to be machined in lengths 24 inches or less. Lengths longer than those cited should show the finish, cross-sectional dimensions, and also the length in which the material is to be machined in order that material may be supplied with sufficient oversize, including allowance for out-of-straightness.

3/ The allowance for hot finished rod, rough turned or semismooth machined, provide for sufficient excess metal to insure straightness in finished shafts within the limits indicated above.

3.12 Workmanship. The material shall be uniform in quality and condition, clean, smooth, flat, commercially 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, rough turned or semismooth machined surface may contain surface imperfections that shall not be considered injurious unless they exceed the recommended machining allowance specified in table XXIII. Inspection procedures for hot finished or machined material shall be as specified in 4.2.3.3.1.

4. QUALITY ASSURANCE PROVISIONS

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

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's over all inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products supplied to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as a part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Quality conformance inspection.

4.2.1 Definition of lot.

4.2.1.1 Visual inspection, duplex grain size and mechanical tests. A lot shall consist of material of one heat, form, condition, finish (for visual only), and size, and heat treated in the same furnace charge when ordered in the heat treated condition.

A) Heat treated conditions shall include age hardened, annealed and age hardened, and annealed only.

B) For duplex grain size and mechanical tests, size shall refer to the same thickness of sheet, strip, or plate, and the same cross-section of other products.

4.2.1.2 Chemical analysis. A lot shall consist of material from one heat.

4.2.1.3 Slow strain rate tensile tests. A lot shall consist of material from one heat that has been heat treated in accordance with the same or equivalent heat treating procedure (see 4.3.6.1.1).

4.2.2 Sampling of lots.

4.2.2.1 Chemical analysis. One representative sample shall be obtained from each lot.

A) Ladle analysis may be used.

B) For wire 0.032 inch diameter and less, samples may be taken from the final starting size prior to the final cold reduction.

4.2.2.2 Slow strain rate tensile tests. Three specimens shall be prepared and tested per lot. They shall be taken from one end of a bar, rod, or forging at the quarter diameter (half radius) and in the longitudinal direction. **B**ars, rods, or forgings too small to have a slow strain rate test specimen taken from the quarter diameter that are taken from a lot (see 4.2.1.3) that does not have any larger sizes shall have the specimens taken from the center and in the longitudinal direction. **B**ars, rods, or forgings too small to have a slow strain rate test specimen taken from the center that are taken from a lot (see 4.2.1.3) that does not have any larger sizes shall be taken from the heat at the latest intermidiate rolling or forging step that a slow strain rate test specimen can be taken from the mid radious and heat treated using the same heat treatment procedures used on the production heat. Specimens shall be taken after the final heat treatment. When the material is shipped in the annealed condition, specimens may be taken after the final anneal and shall be heat treated in accordance with 4.3.6.1.

4.2.2.3 Mechanical, bend and wire wrapping tests for rod, bar, wire, and flat products. One test specimen shall be taken from each lot of 30,000 pounds, or less. Two test specimens shall be taken from lots weighing over 30,000 pounds.

4.2.2.4 Sampling of lots for mechanical tests of forged parts, 250 pounds and less. Specimens from the lot shall be taken from prolongations unless the shape of the finished part permits a suitable specimens to be removed without loss of the forging, or the specimens may be taken from extra forgings. One specimen shall be taken from lots of 30,000 pounds or less and two specimens shall be taken from lots over 30,000 pounds.

4.2.2.5 Sampling of lots for mechanical tests of forged parts, greater than 250 pounds. Each forging shall be tested. Specimens shall be taken from prolongations unless the shape of the finished part permits a suitable sample piece to be removed without loss of the forging.

4.2.2.6 Sampling for visual and dimensional examination.

4.2.2.6.1 Small forged parts (less than 250 pounds) and all other forms. From each lot, representative samples for inspection of visual and dimensional characteristics including packaging, packing, and marking requirements shall be taken in accordance with table XXIV. In case of wire, a unit shall be one coil of wire.

TABLE XXIV. Sample size for visual and dimensional inspections.

Lot size	Sample Size
2 to 8	All
9 to 15	8
16 to 90	8
91 to 150	12
151 to 280	19
281 to 500	21
501 to 1200	27
1201 to 3200	35
3201 to 10000	38

4.2.2.6.2 Forged parts weighing 250 pounds or more. Each forging weighing 250 pounds or more shall be subjected to surface inspection for workmanship and dimensions.

4.2.2.7 Sampling for ultrasonic tests. When required (see 3.7.1), each piece of each lot shall be inspected 100 percent by volume.

4.2.2.8 Sampling for liquid penetrant tests. When required (see 3.7.2), each piece of each lot shall be inspected.

4.2.2.9 Sampling for duplex structure examination. A sample for duplex structure examination shall be taken from a slice at least ⅜ inch thick from one end of a bar, rod or forging representing each heat treat lot.

4.2.3 Examination methods.

4.2.3.1 Straightness of rod. In determining straightness in the standard 42 inch distance between supports or in determining straightness when supported at the ends, the rod shall be placed on a precision table equipped with ballbearing 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. Straightness in terms of depth of chord shall be determined with a straightedge, the length of which is not less than that of the piece being measured.

4.2.3.2 Straightness of bar, sheet, and strip. Straightness in terms of depth of chord shall be determined with a straightedge and shall not exceed the permissible variations in 3.9.1.5 and 3.9.3.5.

4.2.3.3 Visual and dimensional acceptance criteria. Each sample taken in accordance with 4.2.2.6 shall be subjected to surface inspection for workmanship and dimensions. Any sample lot unit containing one or more visual or dimensional defects shall be rejected.

4.2.3.3.1 Inspection of hot finished 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 XXIII for the applicable size and form, the product will be acceptable.

4.3 Test procedures.

4.3.1 Chemical analysis. The sample selected in accordance with 4.2.2.1 shall be analyzed by the wet chemical or spectrochemical methods to determine conformance with table I. In case of disagreement, the chemical composition shall be determined in accordance with ASTM E 76.

4.3.2 Mechanical tests.

4.3.2.1 Aged material. Mechanical tests required for material shipped in the aged condition shall be done on a sample taken from the material after the final heat treatment. Mechanical tests used to demonstrate the capability of a lot to meet the mechanical test requirements (see 4.3.2.2) may not be used certify a lot of material shipped in the aged condition.

4.3.2.2 Unaged material. When mechanical tests are required for material ordered in the unaged condition to demonstrate the capability of the lot to meet the mechanical testing requirements (see 6.2), the test specimens, taken from each lot per 4.2.2.2, 4.2.2.3, 4.2.2.4 and 4.2.2.5, shall be obtained from the material as it is to be to be shipped or from a forged test coupon, when applicable and heat treted as specified (see 6.2). When no heat treatment is specified, the specimen shall be annealed, if the material to be shipped has not been annealed, and aged in accordance with 4.3.2.2.1. Mechanical tests on a lot from the same heat that has previously been tested in the same condition (see 1.2.1), heat treated as specified above, and found to meet the requirements of this specification may be used to demonstate the capability of the lot of unaged material to meet the mechanical test requirements.

4.3.2.2.1 Heat treatment of unaged mechanical test specimens. Unless otherwise specified (see 6.2), age hardening of the test specimens in 4.3.2.2 shall be performed by heating to 1100-1125°F, holding at temperature for 8 to 16 hours depending on hardness of material and desired hardness after aging, furnace cooling to an aim temperature of 900°F then air cooling to room temperature.

4.3.2.3 Bar, rod, rectangles, and forged parts. All bar, rod, rectangles, and forged parts shall be tested full-size when practicable. When a machined specimen becomes necessary, enough metal may be removed from the gauge 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. When the product being tested is of such size that an ASTM E 8 round specimen less than 0.250 inch diameter is needed, minimum elongation requirements of table III shall not apply.

4.3.2.3.1 Axis of the test specimens. For bar, rod, rectangles, and forged parts up to and including 1½ inches in diameter or thickness, the axis of the test specimen shall coincide with the central axis of the piece; over 1½ inches, the axis shall be located midway between the center and surface of the piece.

4.3.2.3.2 Axis of tension. The axis of tension test specimens for bar, rod, rectangles, and forged parts shall be parallel to the direction of rolling, drawing, or flow of metal.

4.3.2.4 Tension test specimens of plate, sheet, and strip. Tension test specimens for plate, sheet, and strip under 0.500 inch thick shall be machined to the form and dimensions of a standard 2 inch gauge length flat in conformance to ASTM E 8. Tension test specimens for plates 0.500 inch and over in thickness shall be machined to the form and dimensions of the largest obtainable standard round in conformance to ASTM E 8.

4.3.2.4.1 Direction of tensile test specimens. Tensile specimens from plate, sheet, and strip shall be taken transverse to the direction of rolling when width will permit.

4.3.2.5 Bend test specimens of sheet and strip. Bend tests taken from sheet and strip shall be full thickness longitudinal specimens tested in conformance with ASTM E 290. The radius of the pin or mandrel and the angle of bend shall be as specified in table VI.

4.3.2.6 Tension test specimens of wire. Tension test 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.

4.3.2.7 Wrapping test specimens of wire. Wrapping test specimens shall be full-size sections of wire of a suitable length. The specimens shall be wrapped around a rod as specified in 3.8.1 and 3.8.2 and examined for cracks by liquid penetrant inspection.

4.3.2.8 Yield strength. The yield strength shall be determined by the offset method.

4.3.2.9 Hardness. The hardness shall be determined in accordance with ASTM E 10 or E 18, as applicable.

4.3.2.10 Rejection and retests. If any specimen fails to meet the requirements of this specification, the entire lot shall be rejected, subject to the retest provisions specified in 4.3.7.1.

4.3.3 Ultrasonic test.

4.3.3.1 General test requirements.

4.3.3.1.1 Testing requirements. Ultrasonic testing shall be performed in accordance with NAVSEA T9074-AS-GIB-010/271 or MIL-STD-2132, as modified by the requirements specified herein. Testing shall be done by a longitudinal wave or shear wave technique as specified herein.

4.3.3.1.2 Surface of rounds. Round rod, $1\frac{3}{16}$ inches and under, shall be ordered with a ground or turned surface when ultrasonic testing is specified.

4.3.3.1.3 Surface finish. Hot finished surfaces shall be 250 Ra micro inches or smoother.

4.3.3.1.4 Acoustic compatibility check. Due to the variable attenuation of nickel-copper-aluminum, an attenuation check shall be performed before each inspection where a reference standard is used. A comparison shall be made

between the part to be inspected and the specific reference standard to be used. For longitudinal wave inspections, the attenuation check shall be based on a comparison between a back reflection obtained from similar geometrical areas on the part to be inspected and the reference standard. For shear wave inspections, the attenuation check shall be based on a comparison between a corner reflection signal or a pitch-catch signal obtained from similar geometrical areas on the part to be inspected and the reference standard. A minimum of three areas shall be evaluated on the component to be inspected. Differences in attenuation, measured in decibels (db), shall be compensated for by adding or subtracting the appropriate number of db from the instruments gain setting after the calibration reflector height or DAC curve is determined and marked on the screen. The most attenuative area evaluated shall be used to determine the attenuation correction value. If the attenuation checks indicate less than a 1 db difference, no correction is required. When acoustic compatibility check is performed, the reference standard does not need to meet the signal amplitude comparison test in the acoustic similarity requirements of NAVSEA T9074-AS-GIB-010/271 or MIL-STD-2132.

4.3.3.2 Procedure for ultrasonic inspection of large size bars, rods and forgings. Coarse grained material may result in an unacceptable ultrasonic signal to perform the required inspections. A single, distinct signal which is clearly discernable from noise shall be used for the inspections. If such a signal is not obtainable using the lowest frequency allowed and with the transducers positioned for the shortest sound path, the material shall be considered uninspectable and rejected. Inspection shall be performed using either longitudinal wave end scan or shear wave pitch-catch methods as specified in 4.3.3.2.1 through 4.3.3.2.2. When the procedures of 4.3.3.2.1 are applied to long bars/rods, ultrasonic instruments with high-energy pulses and extended range capability may be required.

4.3.3.2.1 Longitudinal wave end scan. Inspection shall be performed from the end of the form as illustrated on figure 1. A 1 inch diameter, 2.25 megahertz (mhz) transducer shall be used whenever possible. If the 2.25 mhz transducer does not result in a valid calibration, a one inch diameter, 1 mhz transducer may be used. A distance calibration shall be made for the length tested. This shall be accomplished using multiple reflections across the cross-section of the test piece or by the use of a nickel-copper-aluminum reference standard. The signal from the opposite end shall be set to a minimum of 80% full screen height. Ensure that the location of the signal from the opposite end represents the form’s full length. Both ends of the bar, rod or forging shall be scanned 100% with an overlap of at least 25%. Additionally, caution must be used to ensure that only the reflected longitudinal wave signal is used for evaluation as opposed to the mode converted signals which trail the primary longitudinal wave signal.

A) Qualification of inspection. The ultrasonic inspection shall be qualified by demonstrating the ability to reject (see 4.3.3.4.1.1) a maximum one inch diameter flat bottomed hole machined in an acoustically similar bar, rod or forging with the same or greater diameter as the item to be inspected at a test metal distance at least as long as the item to be inspected.

4.3.3.2.2 Shear wave pitch-catch scan. Inspection shall be performed with two scans, 90 degrees apart, along the length of the bar, rod or forging. For hexagonal bar, three scans are required. The scans shall be directed so that the sound beam passes through the center of the form. The pitch-catch technique illustrated in figure 2 shall be used. The maximum dimension of the transducer active element shall not exceed 1 inch. The nominal transducer frequency shall be a minimum of 1 mhz. The pitch (sending) transducer and the catch (receiving) transducer shall be from the same manufacturer and of the same type, size, and frequency. The sound beam angle shall be as shown on figure 2 (plus or minus 2 degrees). The 41 degree transducers may be used for

the end scan procedure, still using the specified ¼ inch grid lines if their use results in an acceptable signal presentation (the 41 degree transducers typically provide enough 45 degree sound energy to perform the required inspections).

A) Center scan. The catch transducer shall be placed in position R1 or R2 (see figure 2) for the center scan depending on the ease of fixturing and the ability to penetrate highly attenuative material. The transducers for the center scan shall be fixtured and locked in position during scanning. The fixture shall be adjustable to compensate for different sizes and to peak the signal during initial set up. With the transducers aligned and locked into place, the transmitted signal shall be set between 80 and 90% full screen height. The transducers shall be scanned along the entire length of the bar, rod or forging. Changes in material attenuation will be shown by gradual change in signal amplitude and will occur gradually along the length of the form - either highest or lowest in the center and gradually increasing or decreasing as the fixture is scanned toward the bar ends. Gradual changes in signal amplitude shall be compensated for with the instrument gain control to maintain 50 to 90% signal along the entire length of the bar, rod or forging.

B) End scan. The end of the bar, rod or forging shall be scanned with a similar technique. For end scans, fixturing is not practical and an indexing system shall be used to track transducer positions. As illustrated in figure 3, the end of the form shall be marked at ¼ inch increments across the diameter. One side of the form shall be similarly marked in ¼ inch increments for a length of one diameter. The transducers are initially placed nose to nose at the corner of the form and an 80 to 90% full screen height signal is obtained. The transducers shall then be indexed one mark at a time simultaneously and the signal is read for each index position. It is mandatory to hold the transducers at their index positions and then read the signal - do not peak the signal for the maximum signal amplitude. Changes in attenuation due to the changing sound path and changes in material attenuation will be shown by a gradual change in signal amplitude while the transducers are indexed. Gradual changes in signal amplitude shall be compensated for with the instrument gain control to maintain a 50 to 90% signal along the entire scan length.

4.3.3.3 Procedure for other ultrasonic inspections. The following paragraphs describe the requirements for ultrasonic inspection of rod, bar, ring, hollow round products, disc and pancake forgings and plate. Sheet, strip, and wire are specifically excluded from these requirements. Unless otherwise specified below, inspection shall be in accordance with NAVSEA T9074-AS-GIB-010/271 or MIL-STD-2132.

(a) Ring and hollow round products. In addition to the circumferential scan required by NAVSEA T9074-AS-GIB-010/271 or MIL-STD-2132, products shall be inspected with a longitudinal wave test in the radial and axial directions.

(b) Plate. Calibration shall be performed on a flat bottomed hole in lieu of the plate back reflection specified in NAVSEA T9074-AS-GIB-010/271 or MIL-STD-2132. For plate thicknesses up to and including 4 inches, a ¼ inch diameter hole shall be used. For plate thicknesses greater than 4 inches, a ½ inch diameter hole shall be used. The hole shall be drilled into the test piece or into a separate defect-free specimen of the same size (within

plus or minus 1/8 inch), shape, and material (or acoustically similar material). The hole shall be drilled to a depth of one-half the thickness or 1 inch whichever is less. Plate shall be scanned continuously on either a 24 inch grid and one diagonal on each grid, or a 12 inch grid.

4.3.3.3.1 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.

4.3.3.4 Acceptance criteria.

4.3.3.4.1 For ultrasonic inspection for large size bars, rods and forgings.

4.3.3.4.1.1 Longitudinal end scan. A 90 percent or greater loss of back reflection signal (except when the transducer is within one transducer diameter of the side of the bar) or any discontinuity signal greater than 25 percent of the established reference level shall be cause for rejection.

4.3.3.4.1.2 Shear wave pitch-catch scan. Abrupt reductions in signal amplitude (6 db or more in one inch or less of length) shall be cause for rejection.

4.3.3.4.2 Other ultrasonic inspections.

A) Shear wave. Any material which produces indications equal to or larger than the response from the reference notch or higher than the straight line joining the two peak amplitudes shall be rejected.

B) Longitudinal wave. Any material which produces indications equal to or larger than the response from the reference hole, or contains areas which result in a 90 percent or greater loss of back reflection (except when the transducer is within one transducer diameter of the side of the bar) shall be rejected. Material shall be tested using a square, rectangular, or circular transducer having an effective area of 1 square inch or less, but no dimensions 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 1⅛ inch diameter transducer or one whose area falls within this range.

4.3.4 Liquid penetrant inspection.

4.3.4.1 Procedure. Liquid penetrant inspection shall be in accordance with NAVSEA T9074-AS-GIB-010/271 or MIL-STD-2132.

4.3.4.2 Surface requirements. The surface produced by hot working is not suitable for liquid penetrant testing. Therefore, liquid penetrant testing will not be applicable to products ordered with a hot finished surface.

4.3.4.3 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 tolerance of the material.

4.3.5 Duplex structure determination. The sample selected for duplex structure determination shall be macroetched to reveal the grain structure. The sample shall be prepared so that the surface to be etched has a suitable

finish for macroetching and be etched according to ASTM E 340. The macroetched surface shall be visually examined (unaided visual or low power, up to 10X magnification). One grain size specimen shall be taken from the coarsest grained area and one from the finest grained area of the macroetched surface. The selected grain size specimens shall be prepared and inspected in accordance with ASTM E 112. The inspected surface of the specimen shall be perpendicular to the major direction of working.

4.3.6 Slow strain rate tensile test procedure. The slow strain rate tensile test will determine if a lot of metal is susceptible to intergranular cracking. The slow strain rate test specimens shall be heat treated using the final heat treatment procedure used on the lot before being placed into service. Any lot that has been rejected shall not be submitted for acceptance.

4.3.6.1 Heat treatment of slow strain rate test specimens. Specimens representing lots of material sold in the annealed condition shall be heat treated as specified (see 6.2). Lots of material that are aged or re-solution annealed and aged with a heat treating procedure that is not equivalent, per 4.3.6.1.1, to the procedure used on the slow strain rate tensile test shall be re-tested using specimens taken from the material after the final heat treatment.

4.3.6.1.1 Slow strain rate tensile test specimen heat treatment. For the purpose of sampling slow strain rate tensile tests in accordance with 4.2.1.3 two heat treatments shall be considered to be equivalent if the following conditions hold:

A) If the material is solution annealed, the solution annealing temperatures are between 1600 and 1900◦F or, if above 1900°F, are within 50◦F of each other.

B) The age hardening temperatures for the highest temperature age hardening step are within 50◦F of each other. Variations in the aging time and the cooling method under 1000◦F are allowed.

C) Variations in aging times, variations in aging temperatures other than the highest-temperature aging step, and variations in cooling rates between aging steps, and after the last aging step, do not affect the definition of equivalence, for purposes of determining slow strain rate test sampling frequency.

4.3.6.2 Slow strain rate tensile test. Each specimen selected in accordance with 4.2.2.2 shall be machined to the dimensions of the specimen of ASTM E 602 except that the notch root radius shall be 0.002±0.0005 inches. The tensile tests shall be conducted in accordance with ASTM E8 at a temperature of 700◦F. The displacement rate for two of the three specimens shall not exceed 0.001 in./in. Of the distance between the grips per minute. The third specimen shall be tested at a displacement rate between 0.05 and 0.5 in./in. Of the distance between the grips per minute. Alternatively, if an extensometer is used to measure displacement, the displacement rate for two of the specimens shall not exceed 0.001 in./in./min. and it shall be between 0.05 and 0.5 in./in./min. for the third specimen. Loading below 50 percent of the minimum yield strength of the material can be conducted at any rate under 100,000 psi/minute.

4.3.6.3 Grain size determination. The average grain size of the half of the slow strain rate tensile specimen not used for fracture surface analysis in accordance with 4.3.6.4 shall be determined as specified in ASTM E 112. The grain size shall be measured such that the average grain size in

micrometers is determined. The grain size shall be taken parallel to the fracture surface and as close to the fracture surface as practical.

4.3.6.4 Fracture surface analysis. After fracture, the fracture surface of each specimen shall be examined and the fracture mode characterized as follows:

4.3.6.4.1 Fracture surface photography. A series of eight (8) photographs shall be taken of the fracture surface at equally spaced intervals of 45 degrees around the specimen circumference, with the first site selected randomly. Each photograph shall be taken using a scanning electron microscope (SEM) at a magnification scaled to the grain size using the relationship below:

$$M = 10,000/G$$

Where M is the magnification and G is the grain size in micrometers, μm. If the calculated magnification is not a preset level on the SEM being used, the magnification shall be decreased to the nearest preset level. For grain sizes larger than 15 μm, a small portion of the machined notch root must be visible in each photograph. For grain sizes smaller than 15 μm, the center of each photograph must be approximately 150 μm from the notch root.

4.3.6.4.2 Determination of intergranular fracture sites. The photographs of 4.3.6.4.1 shall be used to determine intergranular fracture features. An intergranular fracture feature shall be defined as two adjacent and contiguous facets demarcated by a distinct grain boundary or three adjacent and contiguous facets demarcated by grain boundaries that come together at a triple point. The facets shall be clearly identifiable as a grain surface, otherwise they shall not be considered in defining a site of intergranular fracture.

4.3.6.4.3 Quantification of intergranular fracture sites. The template illustrated in Figure 4 shall be transferred to a transparency that shall be placed over each of the nominal 3½ x 4½ inch photographs obtained in 4.3.6.4.1 above. Intercepts with intergranular fracture features with the circles on the template shall be counted for each photograph. An intercept shall be defined as the intersection of one intergranular fracture feature with a circle on the template. If one intergranular fracture feature extends over several circles on the template, it shall be counted as one feature. The intercepts from all of the photographs of each fracture surface shall be totaled.

4.3.6.4.4 Testing Laboratory. When specified, the slow strain rate tensile test shall be done at the laboratory specified by the purchaser (see 6.2).

4.3.6.5 Acceptance criteria. The total number of intercepts counted in 4.3.6.4.3 for any fracture surface evaluated shall not exceed 100.

4.3.6.6 Rejection and retests. If any specimen fails to meet the requirements of this specification, the entire lot shall be rejected, subject to the retest provisions specified in 4.3.7.2.

4.3.7 Replacement, Retest, Rejection and Resubmittal.

4.3.7.1 Mechanical property retests.

4.3.7.1.1 Discarded tests. If any test specimen shows defective machining or develops flaws which cause inaccurate test results it may be discarded and a replacement test specimen substituted.

4.3.7.1.2 Low elongations. If the percentage of elongation of any tension test specimen is less than that specified and any part of the fracture is outside of the middle two-thirds of the gage length or in a punched or scribed mark within the reduced section, a retest shall be allowed.

4.3.7.1.3 Retests. If the test results of the test on one of the specimens fails to meet the acceptance criteria two additional specimens shall be taken (one from the same piece as the failed specimen and one from a different sample piece) as tested. The results of the tests on both of these specimens shall meet the specified requirements.

4.3.7.2 Slow strain rate tensile test retests. If any test specimen shows defective machining or has not been tested in accordance with 4.3.6.2, it may be discarded and a replacement test specimen substituted. A slow strain rate tensile tests may not be repeated because it fails to meet the acceptance criteria.

4.3.7.3 Rejection. When any test specimen, except those test specimens discarded in accordance with 4.3.7.1.1 and 4.3.7.1.2, and the one mechanical test permitted to be retested in accordance with 4.3.7.1.3, does not conform to specification requirements for the characteristics being tested the lot represented by the specimen shall be rejected.

5. PREPARATION FOR DELIVERY

5.1 Packaging requirements. The requirements for packaging shall be in accordance with ASTM D 3951, unless detailed requirements are specified in the contract.

6. NOTES

(This section contains information of a general nature that may be helpful, but is not mandatory.)

6.1 Intended use.

6.1.1 General Nickel-copper-aluminum alloy, UNS N05500 is used where a combination of high strength and resistance to corrosion are needed. For optimum tool life the annealed condition is recommended. Cold drawn material is intended for automatic machining operations.

6.1.2 Annealed sheet and strip Nickel-copper-aluminum alloy sheet and strip in the annealed condition may be used in the manufacture of articles in which heading, bending, curling, drawing, forming, lock-seaming, welding, and so forth, operations are involved.

6.1.3 Cold rolled strip Cold rolled strip of half hard and full hard temper are used where light deformations or liberal bending radii are involved, for applications such as springs.

6.1.4 Annealed wire Nickel-copper-aluminum alloy wire in the annealed condition is intended for severe forming, cold heading, and roll threading operations.

6.1.5 Spring temper wire Nickel-copper-aluminum alloy wire, spring temper in the as drawn condition is intended for coiling of helical springs which are to be aged hardened after coiling in order to obtain maximum strength and hardness. Where helical springs are to be cold pressed, the cold pressing is to be done after coiling and aging.

6.2 Ordering data. Acquisition documents must specify the following:

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

b) Form, condition, and surface finish of material required (see 1.2.1 and 1.2.2).

c) Issue of dodiss cited and if different than that listed in the dodiss, the specific issue of individual documents referenced (see 2.1.1, 2.1.2, and 2.2).

d) Whether a forging sketch is required (see 3.1.1).

e) Size required (see applicable table).

f) If a product check analysis is required (see 3.2).

g) When hardness measurements may be utilized for forged rings and discs (see footnote 4 of table III.).

h) When tolerances other than those specified are permitted (see footnote 2 of table VII; footnote 6 of table XV; footnote 5 of table XVI and footnote 2 of table XVIII).

i) If optional ultrasonic inspection is required (see 3.7.1.2)

j) If optional liquid penetrant inspection is required (see 3.7.2).

k) The lengths required and whether cut-to-length, random mill lengths, nominal (stock) lengths, or multiples of specified lengths (see 3.9.1.3.1, 3.9.3.3.1 and 3.9.3.3.2).

l) If multiples of a specified length are ordered, whether a ¼ inch allowance should be made for each cut (see 3.9.1.3.1).

m) If edges are other than specified (see 3.9.1.4, 3.9.3.4.1, 3.9.3.4.2, and 3.9.3.4.3).

n) Forging dimensions (see 3.9.2).

o) If marking should be other than specified (see 3.10).

p) When mechanical tests are required for rod and bar intended for reforging (see 4.3.2.2).

q) If mechanical testing is to be done on material ordered in the unaged condition, to demonstrate its capability of being aged to meet the required mechanical properties, and, if desired, the heat treating procedure to be used on the test specimens (See 4.3.2.2 and 4.3.2.2.1).

r) The final heat treatment procedure to be used on the lot before being placed into service and on the slow strain rate tensile test specimens (see 4.3.6.1).

s) When the laboratory conducting the slow strain rate tensile test is selected by the purchaser (see 4.3.6.4.4)

t) Packaging, packing, and marking requirements (see 5.1).

6.3 Certification of quality conformance. Certification of quality conformance should provide quantitative results and requirements for all specified chemical, duplex grain size, slow strain rate tensile and mechanical tests. A slow strain rate tensile test report should contain the temperatures, holding times and cooling methods of the last heat treatment procedures used on the material when the slow strain rate tensile test was taken from it and all the heat treatment procedures used on the test specimens, the average grain size of the test specimens, the displacement rate, the notch tensile strength, the photographs, with transparencies, marked to show the intercepts counted as intergranular fracture features, the photomagnification of the photographs, and the number of intercepts counted. Material supplied in the unaged condition, the certification should prominently display the words: "AS-SUPPLIED MATERIAL CONDITION IS UNAGED", and include the statement: "This certifies that the material contained in this lot, when properly age hardened, is capable of meeting the mechanical properties for the corresponding age hardened condition specified in QQ-N-286"

6.4 Reinspection of rejected lots.

6.4.1 Rejected lots.

6.4.1.1 Slow strain rate tensile test. Lots rejected for failing the slow strain rate tensile tests should not be resubmitted.

6.4.1.2 Mechanical tests. A lot rejected for failing mechanical tests may be resubmitted for acceptance testing only after rework is performed to correct the nonconforming condition without adversely affecting the conforming properties. All mechanical and slow strain rate testing, including those which were initially conforming, should be repeated after rework.

6.4.1.3 Dimensional tests. A lot rejected for failing visual or dimensional tests, that has been reworked to bring it into conformance with the requirements of the specification, may be resubmitted for acceptance testing. Rework, performed to correct the nonconforming condition, shall not adversely affecting the conforming properties. Mechanical and slow strain rate tests should be repeated only when the lot is reheat treated.

6.4.1.4 Individual pieces. When a lot, rejected for failing visual or dimensional inspection, consists of more than one piece, each remaining piece in the lot may be resubmitted for testing for the nonconforming characteristic and each piece that conforms to all specification requirements may be considered for acceptance.

6.5 Cushioning and wrapping materials. Materials having properties for resistance to fire and acceptable for use within interior (unit or intermediate) packs and shipping containers for Navy acquisitions are:

Material	Specification
Paper, Kraft, Treated (Fire Resistant)	A-A-1894
Paper, Kraft, Wrapping	UU-P-268, Type II, Grade C or D
Fiberboard	PPP-F-320, Class - Domestic and Weather Resistant/Fire Retardant
Plastic Film, Flexible, Cellular	PPP-C-795, Class 3 - Fire Retardant
Polystyrene Expanded, Resilient	PPP-P-850, Grade SE
Plastic Open Cell, Cushioning	PPP-C-1842, Type 1, Style B

Material	Specification
Bound Fiber	PPP-C-1120, Type III or IV, Class C
Rubber, Latex Foam	MIL-R-5001, Grade A
Rubber, Cellular	MIL-R-6130, Grade A
Fibrous Glass	MIL-C-17435
Polystyrene Foam	MIL-P-19644, Type II
Rubber Cellular Synthetic	MIL-R-20092, Class 5
Polyurethane Foam	MIL-P-26514
Polyurethane Foam, Flexible, Open Cell	MIL-P-81334
Foam in Place Packaging, Materials: General Specification for	MIL-F-83671
Foam, Combustion Retardant for Cushioning Supply Items Aboard Navy Ships	MIL-F-87090 (SA)

6.6 Alternate ultrasonic inspection procedure. Consideration may be given to alternate ultrasonic inspection procedures. These procedures must be reviewed by the Command or agency concerned.

6.7 General information (material availability).

6.7.1 Age hardened. Age hardened material is supplied with thin, dark oxide finish in all forms, excepting bright finished cold drawn shafting and smooth machined rounds.

6.7.2 Shafting. Bright finish, cold drawn and age hardened shafting is available in round rods for shafting. The bright finish consists of grinding or polishing to remove the light oxide film resulting from the age hardening treatment.

6.7.3 Bolts. Hot finished round rod with a cold drawn pass is available to close tolerances for hot upsetting of bolts. The tolerances are such as to meet the requirements of class 3A of American Standard screw thread.

6.7.4 Annealed sheet and strip. Annealed sheet and strip is furnished with a plain finish resulting from descaling or annealing in an atmosphere that yields a bright finish.

6.7.5 Hardened strip. Half and full hard strip is furnished with a surface varying from bright to slight oxide discoloration.

6.7.6 Allowances on hot finished material. When ordering hot finished material, allowances should be made as listed in table XXIII to allow for clean-up to the users finished cross-sectional dimensions.

6.8 Hot working cautions.

6.8.1 Cooling. Material should not be cooled slowly following hot working operations. Slow cooling will result in self hardening as cooling takes place through the precipitation hardening range. Generally, sections ¾ inch thick and smaller will air cool or can be cooled with an air blast rapidly enough to prevent self hardening, provided the parts are not piled one on top or against each other. Sections over ¾ inch are normally water quenched.

6.8.2 Interruption of forging operation. Should a forging operation on this material be interrupted to the extent that the heated bars are likely to

cool blow 1450°F, the material should be quenched rather than be permitted to air cool below that temperature.

6.8.3 Heating requirements. With reference to the heating times shown herein, care must be taken to obtain the proper temperature throughout the cross-section on large diameters or thicknesses. Also it should be understood that material should be brought to annealing temperature or hot working temperature as rapidly as possible to avoid aging of the material on the way up to temperature, otherwise cracking or thermal splitting of the material might occur, particularly in subsequent hot working operations.

6.8.4 Maximum forging temperature. This material is usually hot worked at a maximum temperature of 2100°F. Heating to higher temperatures could promote excessive grain growth and oxidation.

6.9 Heat treatment guidance. There is no one prescribed heat treatment for this alloy. Times and temperatures are approximate and may be modified to account for the size, shape, microstructure and condition of the metal to be heat treated.

6.9.1 Annealing. Unheat treated material is usually solution heat treated by the manufacturer and should not need to be solution annealed again. If, for any reason, it is desired to soften hard material during fabrication, this may be accomplished by holding at 1600 - 1900°F for a time commensurate with section thickness followed by water quenching. A temperature of 1900°F should be used followed by water quenching to final anneal cold drawn rods. For products other than cold drawn rods, a temperature of 1800°F should be used followed by water quenching for final annealed products.

6.9.2 Age hardening Aging (hardening) may be accomplished by holding the metal at 1100 - 1125°F for 8 - 16 hours followed by furnace cooling to 900°F at a rate of 15 to 25°F per hour and then air cooling. Age hardening may also be accomplished by holding the metal at 1100°F for a period of 16 hours, furnace cooling to 1000°F, holding for a period of 6 hours, furnace cooling to 900°F, holding for a period of 8 hours, and air cooling.

6.10 This specification covers various forms of nickel-copper-aluminum alloy for the fabrication of finished components. Component specifications should be consulted for the requirements relevant to individual products.

6.11 Subject term (key word) listing.

Rods
Bars
Forgings
Ultrasonic

6.12 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

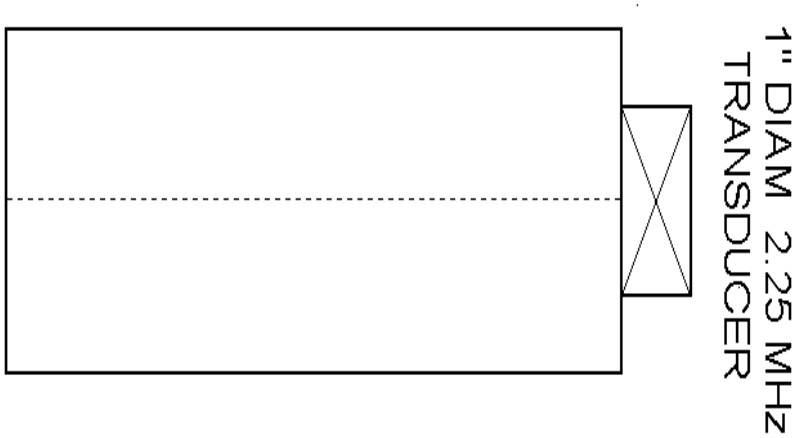

FIGURE 1. Longitudinal end scan inspection technique for large bar, rod and forgings.

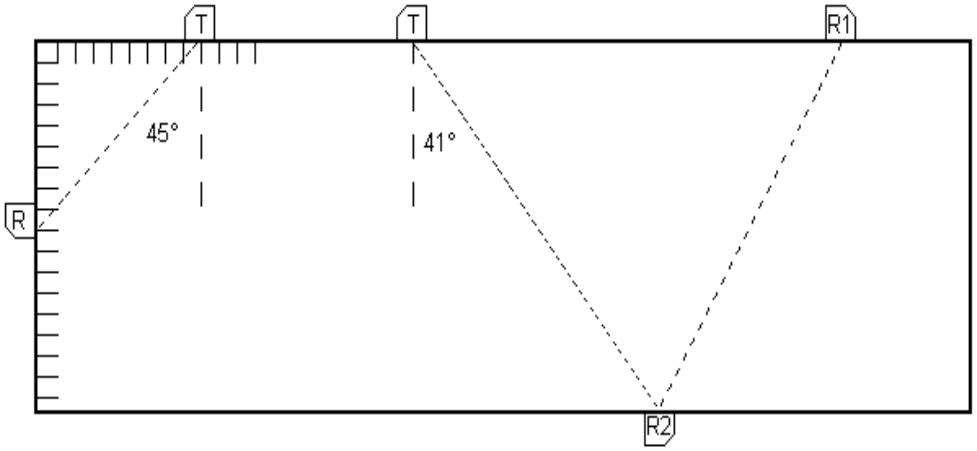

FIGURE 2. Shear wave pitch-catch technique for large bar, rod and forgings.

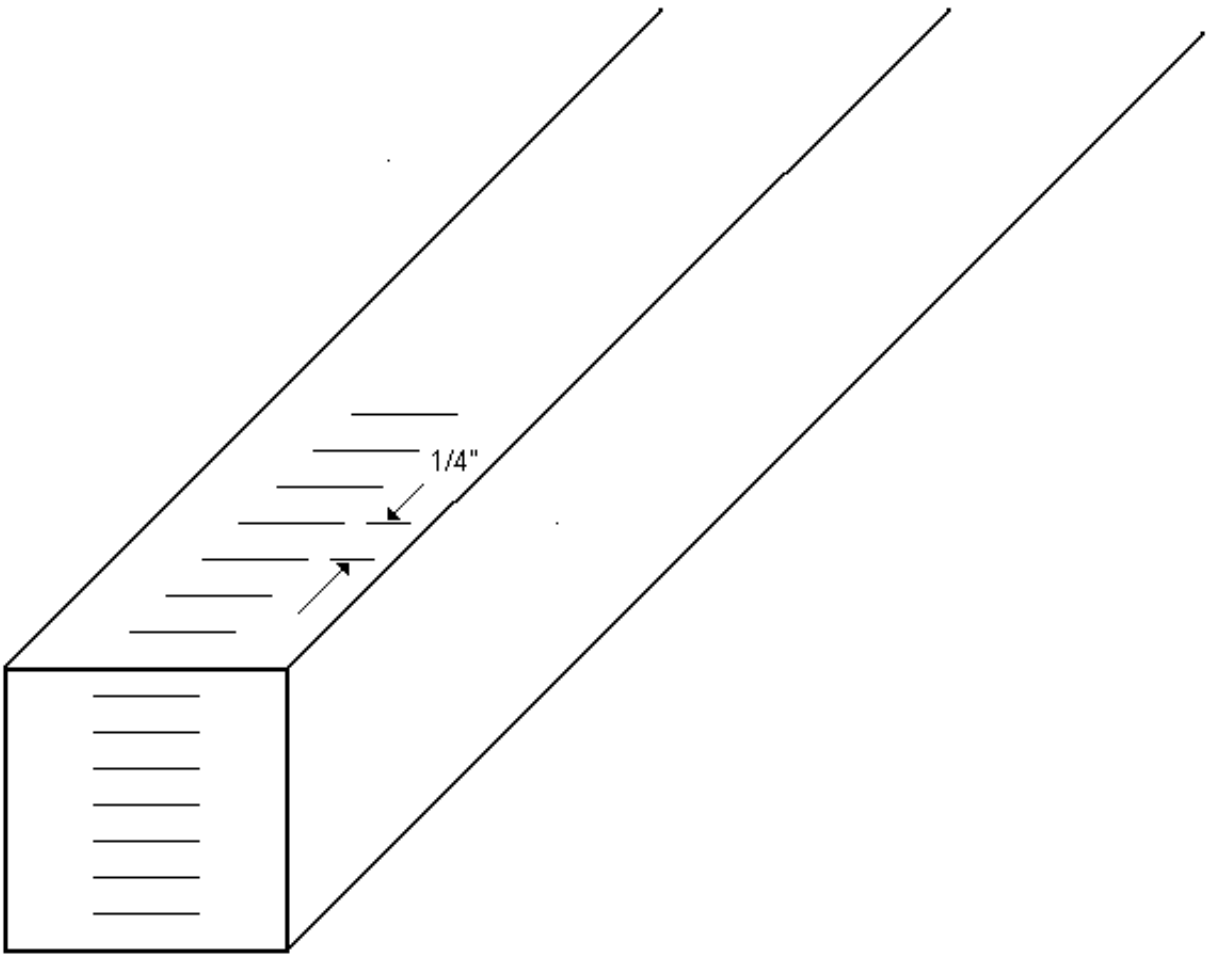

FIGURE 3. Index marking layout for shear wave pitch-catch end scan of large bar, rod and forgings.

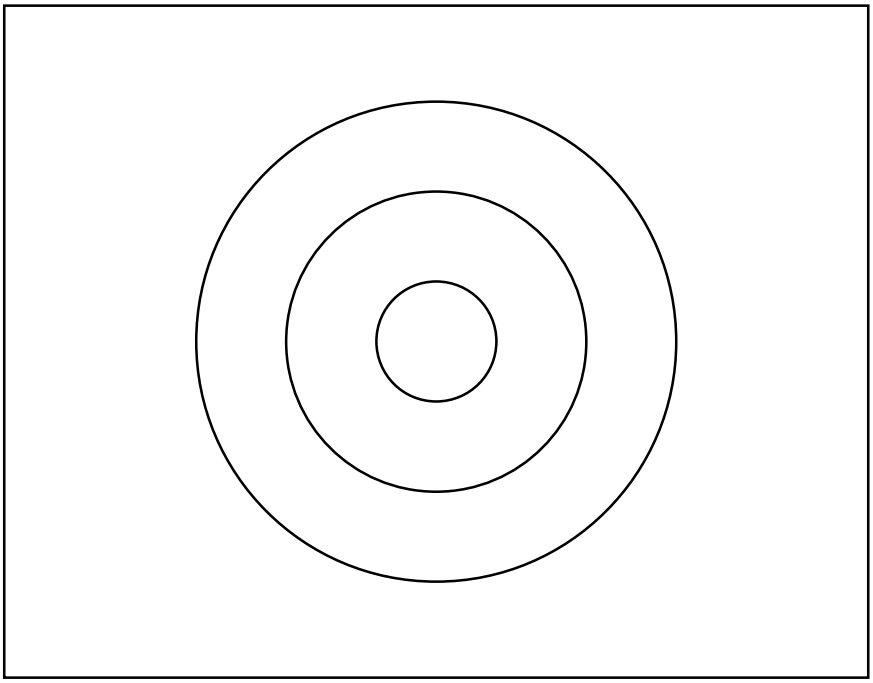

FIGURE 4. Template for slow strain rate fracture test evaluation. Concentric Circles 2.5000, 1.5625, and 0.9375" in diameter in a 3.5 by 4.5" frame.

MILITARY INTERESTS:

Custodians
Army – MR
Navy – SH
Air Force - 11

Review activities
Army – AV, CR, GL
Navy - OS
Air Force - 84, 99
DLA - IS

CIVIL AGENCY COORDINATING ACTIVITIES:
GSA - FSS, PCD

PREPARING ACTIVITY:
Navy – SH
(Project 9525-N014)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4,5,6, and 7 and send to preparing activity.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER QQ-N-286G	2. DOCUMENT DATE *(YYYYMMDD)* 20001207

3. DOCUMENT TITLE
NICKEL-COPPER-ALUMINUM ALLOY, WROUGHT (UNS N05500)

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) DSN *(if applicable)*	7. DATE SUBMITTED *(YYYYMMDD)*

8. PREPARING ACTIVITY NAVSEA SH 05Q

a. NAME Mr. John Allison NSWCCD	b. TELEPHONE *(Include Area Code)* (1) Commercial (301) 227-5087 (2) DSN
c. ADDRESS *(Include Zip Code)* Commander, Naval Sea Systems Command ATTN: SEA 05Q, 2531 Jefferson Davis Hwy Arlington, VA 22242-5160	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533, Fort Belvoir, VA 22060-6221