INCOLOY® alloy 825

INCOLOY® alloy 825 (UNS N08825/W.Nr. 2.4858) is a nickel-iron-chromium alloy with additions of molybdenum, copper, and titanium. The alloy's chemical composition, given in Table 1, is designed to provide exceptional resistance to many corrosive environments. The nickel content is sufficient for resistance to chloride-ion stress-corrosion cracking. The nickel, in conjunction with the molybdenum and copper, also gives outstanding resistance to reducing environments such as those containing sulfuric and phosphoric acids. The molybdenum also aids resistance to pitting and crevice corrosion. The alloy's chromium content confers resistance to a variety of oxidizing substances such as nitric acid, nitrates and oxidizing salt. The titanium addition serves, with an appropriate heat treatment, to stabilize the alloy against sensitization to intergranular corrosion.

The resistance of INCOLOY alloy 825 to general and localized corrosion under diverse conditions gives the alloy broad usefulness. Applications include chemical processing, pollution control, oil and gas recovery, acid production, pickling operations, nuclear fuel reprocessing, and handling of radioactive wastes. Applications for alloy 825 are similar to those for INCOLOY alloy 020.

Table 1 - Limiting Chemical Composition, % of INCOLOY alloy 825

Nickel	38.0-46.0
Iron	22.0 min.
Chromium	19.5-23.5
Molybdenum	2.5-3.5
Copper	1.5-3.0
Titanium	0.6-1.2
Carbon	0.05 max.
Manganese	1.0 max.
Sulfur	0.03 max.
Silicon	0.5 max.
Aluminum	0.2 max.

Physical Constants and Thermal Properties

Some physical constants for INCOLOY alloy 825 are listed in Table 2. Values for thermal expansion, thermal conductivity, and electrical resistivity at various temperatures are in Table 3. Modulus of elasticity and Poisson's ratio over a range of temperatures are given in Table 4. Modulus values, which were determined dynamically, were used to compute Poisson's ratio.

Table 2 - Physical Constants

Density, lb/in^3	0.294
Mg/m^3	8.14
Melting Range, °F	2500-2550
°C	1370-1400
Specific Heat, Btu/lb•°F	0.105
J/kg•°C	440
Curie Temperature, °F	<-320
°C	<-196
Permeability at 200 oersted (15.9 kA/m)	1.005

Table 3 - Thermal Properties

Temperature	Coefficient of Expansion[a]	Thermal Conductivity	Electrical Resistivity
°F	10^{-6}in/in•°F	Btu-in/ft^2•h•°F	ohm•circ mil/ft
-250	-	55	-
-200	-	59	-
-100	-	66	-
0	-	72.6	-
78	-	76.8	678
100	-	78.4	680
200	7.8	85.0	687
400	8.3	97.5	710
600	8.5	109.6	728
800	8.7	119.7	751
1000	8.8	130.9	761
1200	9.1	141.8	762
1400	9.5	154.9	765
1600	9.7	171.8	775
1800	-	192.0	782
2000	-	-	793
°C	µm/m•°C	W/m•°C	µΩ•m
-150	-	7.9	-
-100	-	8.9	-
0	-	10.7	-
25	-	11.1	1.13
100	14.1	12.3	1.14
200	14.8	13.8	1.18
300	15.3	15.4	1.21
400	15.6	16.9	1.24
500	15.8	18.2	1.26
600	16.0	19.6	1.27
700	16.7	21.2	1.27
800	17.3	23.1	1.28
900	-	25.5	1.29
1000	-	-	1.30

[a]Mean coefficient of linear expansion between 80°F (27°C) and temperature shown.

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Mechanical Properties

INCOLOY alloy 825 has good mechanical properties from cryogenic temperatures to moderately high temperatures. Exposure to temperatures above about 1000°F (540°C) can result in microstructural changes (phase formation) that significantly lower ductility and impact strength. For that reason, the alloy is not normally used at temperatures where creep-rupture properties are design factors.

Tensile properties at room temperature are listed in Table 5. As indicated, the alloy can be strengthened substantially by cold work.

High-temperature tensile properties are shown in Figure 1. The tests were conducted on cold-drawn rod of 0.75-in. (19-mm) diameter annealed at 1725°F (940°C)/1 hr.

Compressive yield strength of the alloy is similar to tensile yield strength. Tests on annealed rod of 1.0-in. (25-mm) diameter produced a compressive yield strength (0.2% offset) of 61,400 psi (423 MPa) compared with a tensile yield strength of 57,500 psi (396 MPa). Ultimate tensile strength of the material was 104,500 psi (720 MPa).

INCOLOY alloy 825 has good impact strength at room temperature and retains its strength at cryogenic temperatures. Table 6 gives the results of Charpy keyhole tests on plate.

Table 4 - Modulus of Elasticity

Temperature	Young's Modulus	Shear Modulus	Poisson's Ratio
°F	10^3 ksi	10^3 ksi	
73	29.8	10.51	0.42
200	29.2	10.28	0.42
400	28.2	9.87	0.43
600	27.2	9.48	0.43
800	26.1	9.04	0.44
1000	25.0	8.60	0.45
1200	23.8	8.13	0.46
1400	22.5	7.64	0.47
1600	20.9	7.12	0.47
1800	19.0	6.48	0.47
2000	16.8	5.58	0.51
°C	GPa	GPa	Poisson's Ratio
23	206	72.5	0.42
100	201	70.7	0.42
200	195	68.2	0.43
300	188	65.6	0.43
400	181	63.2	0.43
500	175	60.3	0.45
600	168	57.5	0.46
700	160	54.5	0.47
800	151	51.4	0.47
900	141	48.0	0.47
1000	128	43.7	0.46

Table 5 - Typical Room-Temperature Tensile Properties

Form and Condition	Tensile Strength		Yield Strength (0.2% Offset)		Elongation, %
	ksi	MPa	ksi	MPa	
Tubing, Annealed	112	772	64	441	36
Tubing, Cold Drawn	145	1000	129	889	15
Bar, Annealed	100	690	47	324	45
Plate, Annealed	96	662	49	338	45
Sheet, Annealed	110	758	61	421	39

Table 6 - Charpy Keyhole Impact Strength of Plate

Temperature		Orientation	Impact Strength[a]	
°F	°C		ft-lb	J
Room	Room	Longitudinal	79.0	107
		Transverse	83.0	113
-110	-43	Longitudinal	78.0	106
		Transverse	78.5	106
-320	-196	Longitudinal	67.0	91
		Transverse	71.5	97
-423	-253	Longitudinal	68.0	92
		Transverse	68.0	92

[a]Average of three tests.

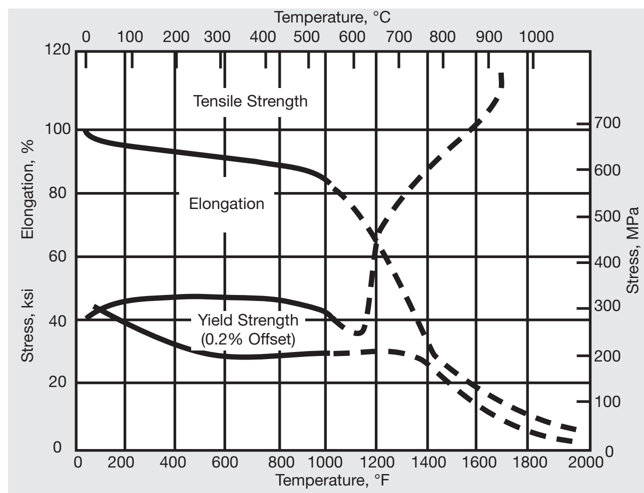

Figure 1. High-temperature tensile properties of annealed bar. ——— Indicates the typical usage range.

Corrosion Resistance

The outstanding attribute of INCOLOY alloy 825 is its high level of corrosion resistance. In both reducing and oxidize environments, the alloy resists general corrosion, pitting, crevice corrosion, intergranular corrosion, and stress-corrosion cracking. Some environments in which INCOLOY alloy 825 is particularly useful are sulfuric acid, phosphoric acid, sulfur-containing flue gases, sour gas and oil wells, and sea water.

For details on the corrosion resistance of alloy 825, contact any Special Metals office or check our website, www.specialmetals.com.

Fabrication

Annealing temperatures are critical in maintaining the high degree of corrosion resistance for which INCOLOY alloy 825 was designed. For this reason, material leaving the mill has been carefully processed to provide maximum corrosion resistance. Therefore, during subsequent working, interstage and final anneals should be limited to the 1700 to 1800°F (930-980°C) range, consistent with selected time and prior cold work. The optimum temperature for stabilization is considered to be 1725°F (940°C) whereas 1800°F (980°C) provides the optimum combination of softness and fine grain structure for deep-drawing temper without sacrificing corrosion resistance. Quenching is usually not necessary for parts of thin cross section such as those from sheet, strip and wire, but rapid cooling may be desired to avoid sensitization in heavier sections.

Prior to any heat treatment, normal precautions should be taken to remove all lubricants, shop soil and markings which could induce intergranular attack and embrittlement.

General procedures for heating, as well as for pickling, are available from Special Metals or on our website, www.specialmetals.com.

Hot and Cold Forming

The hot-working range for INCOLOY alloy 825 is 1600 to 2150°F (870 to 1180°C). For optimum corrosion resistance, final hot working should be done at temperatures between 1600 and 1800°F (870 and 980°C).

Cooling after hot working should be air cool or faster. Heavy sections may become sensitized during cooling from the hot-working temperature, and therefore be subject to intergranular corrosion in certain media. A stabilizing anneal (see above) restores resistance to corrosion. If material is to be welded or subjected to further thermal treatment and subsequently exposed to an environment that may cause intergranular corrosion, the stabilizing anneal should be performed regardless of cooling rate from the hot-working temperature.

Cold-forming properties and practices are essentially the same for INCOLOY alloy 825 as for INCONEL alloy 600. Although work-hardening rate is somewhat less than for the common grades of austenitic stainless steels, it is still relatively high. Forming equipment should be well powered and strongly built to compensate for the increase in yield strength with plastic deformation.

Additional information on hot and cold forming can be obtained by contacting Special Metals or visiting our website, www.specialmetals.com.

Machining

All standard machining operations are readily performed on INCOLOY alloy 825. The alloy normally has optimum machining characteristics in the annealed temper. Tooling and procedures described for Group C alloys should be used; contact Special Metals for details or visit our website, www.specialmetals.com.

Joining

INCOLOY alloy 825 has good weldability by all conventional processes. For most applications, INCONEL® Welding Electrode 112 for shielded metal-arc welding and INCONEL Filler Metal 625 for gas-shielded processes are used. For applications that require highest resistance to corrosion, INCO-WELD® Welding Electrode 686CPT® and INCO-WELD Filler Metal 686CPT are used. Information on surface preparation, joint design, and welding technique can be obtained on the Special Metals Corporation website, www.specialmetals.com, or by calling any Special Metals office.

Available Products and Specifications

INCOLOY Alloy 825 is designated as UNS N08825 and Werkstoff Number 2.4858. It is listed in NACE MR0175 for oil and gas service. Alloy 825 is available as pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Rod, Bar, Wire and Forging Stock - BS 3076NA16, ASTM B 425, ASTM B 564, ASME SB 425, ASME SB 564, ASME Code Case N-572, DIN 17752, DIN 17754, VdTÜV 432, ISO 9723, ISO 9724, ISO 9725

Plate, Sheet and Strip - BS 3072NA16, BS 3073NA16, ASTM B 424, ASTM B 906, ASME SB 424, ASME SB 906, DIN 17750, VdTÜV 432, ISO 6208

Pipe and Tube - BS 3074NA16, ASTM B 163, ASTM B 423, ASTM B 704, ASTM B 705, ASTM B 751, ASTM B 775, ASTM B 829, ASME SB 163, ASME SB 423, ASME SB 704, ASME SB 705, ASME SB 751, ASME SB 775, ASME SB 829, ASME Code Case 1936, DIN 17751, VdTÜV 432, ISO 6207

Others - ASTM B 366, ASME SB 366, DIN 17744

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