ALLOY 825

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 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 ALLOY 020.

Physical Constants and Thermal Properties
Some physical constants for 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.

Mechanical Properties
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. (19mm) 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).
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.

Corrosion Resistance
The outstanding attribute of 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 ALLOY 825 is particularly useful are sulfuric acid, phosphoric acid, sulfurcontaining flue gases, sour gas and oil wells, and sea water.

Fabrication
ALLOY 825 products are heat treated during manufacturing at the mill to develop the optimum combination of stabilization, corrosion resistance, mechanical properties, and formability. To maintain these properties during fabrication, subsequent anneals should be performed between 1700 to 1800°F (930 to 980°C) followed by rapid air cooling or water quenching. Heat treatment in the lower end of the range is acceptable for stabilization. However, annealing at temperatures in the higher end of this range may be preferred for softness and grain structure for forming and deep-drawing while maintaining corrosion resistance. Quenching is usually not necessary for parts of thin cross section (e.g., sheet, strip and wire), but may be desired to avoid sensitization in products of heavier cross section. General procedures for heating, forming, pickling, and finishing are found in the SMC bulletin "Fabricating". Welding, brazing, and soldering techniques are discussed in "Joining".

Hot and Cold Forming
The hot-working range for 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 ALLOY 825 as for 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.

Machining
All standard machining operations are readily performed on ALLOY 825. The alloy normally has optimum machining characteristics in the annealed temper. Tooling and procedures described for Group C alloys should be used.

Welding
ALLOY 825 has good weldability by all conventional processes.

Table 1 - Limiting Chemical Composition, % of 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.

Table 2 - Physical Constants

Density, lb/in³	0.294
Mg/m³	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/ft²•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.

Table 4 - Modulus of Elasticity (Hot Rolled and Annealed Plate)

Temperature	Young's Modulus	Shear Modulus	Poisson's Ratio
°F	10^3 ksi	10^3 ksi	
100	28.3	11.0	0.29
200	27.9	10.9	0.28
300	27.5	10.7	0.29
400	27.1	10.4	0.30
500	26.6	10.2	0.30
600	26.1	10.1	0.29
700	25.5	10.0	0.28
800	25.0	9.8	0.28
900	24.5	9.5	0.29
1000	24.0	9.2	0.30
1100	23.6	8.9	0.33
1200	23.0	8.6	0.34
1300	22.3	8.2	0.35
1400	21.3	7.9	0.35
1500	20.3	7.6	0.34
1600	19.5	7.3	0.34
1700	18.5	6.9	0.34
1800	17.5	6.5	0.34
Temperature	Young's Modulus	Shear Modulus	Poisson's Ratio
°C	GPa	GPa	
20	196	76	0.29
100	192	75	0.28
200	187	72	0.30
300	181	70	0.29
400	174	68	0.28
500	168	65	0.29
600	162	61	0.33
700	154	57	0.35
800	142	53	0.34
900	131	49	0.34
1000	118	44	0.34

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.

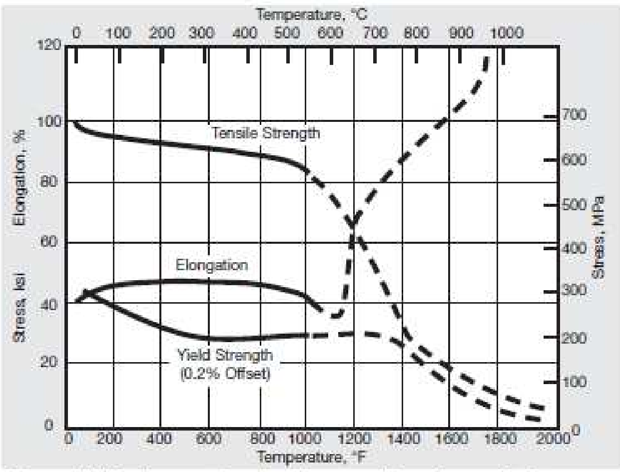

Figure 1. High-temperature tensile properties of annealed bar.
——— Indicates the typical usage range.

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