INCONEL 625 TECHNICAL DATA

Type Analysis

Element	Min	Max
Carbon	--	0.10
Nickel	Bal.	
Chromium	20.0	23.0
Iron	--	5.00
Silicon	--	0.50
Manganese	--	0.50
Sulfur	--	0.015
Phosphorus	--	0.015
Molybdenum	8.00	10.0
Titanium	--	0.40
Cobalt	--	1.00
Columbium + Tantalum	3.15	4.15
Aluminum	--	0.40

Description

Alloy 625 is a nonmagnetic , corrosion - and oxidation-resistant, nickel-based alloy. Its outstanding strength and toughness in the temperature range cryogenic to 2000°F (1093°C) are derived primarily from the solid solution effects of the refractory metals, columbium and molybdenum, in a nickel-chromium matrix. The alloy has excellent fatigue strength and stress-corrosion cracking resistance to chloride ions. Some typical applications for alloy 625 have included heat shields, furnace hardware, gas turbine engine ducting, combustion liners and spray bars, chemical plant hardware, and special seawater applications.

Corrosion Resistance

Alloy 625 has withstood many corrosive environments. In alkaline, salt water, fresh water, neutral salts, and in the air, almost no attack occurs. The nickel and chromium provide resistance to oxidizing environments. Nickel and molybdenum provide for resistance to nonoxidizing atmospheres. Pitting and crevice corrosion are prevented by molybdenum. Niobium stabilizes the alloy against sensitization during welding. Chloride stress-corrosion cracking resistance is excellent. The alloy resists scaling and oxidation at high temperatures.

Pickling

Sodium hydride baths are necessary to descale this alloy. After the sodium hydride treatment, the material should be immersed in a sulfuric acid bath 165°F (74°C) for approximately 3 minutes. A 25-minute immersion in a nitric-hydrofluoric bath 145°F (63°C) is then necessary. Rinse. Sulfuric solution: 16% by weight, H_2SO_4. Nitric solution: 8% HNO_3 by weight and 3% HF by weight. Acid etching for macro-inspection-expose material electrolytically to a 3-to-1 HCl to HNO_3 solution, saturated with $CuCl_2$ at a current density of 0.645 amp/in^2 (25.4 A/m)

Physical Properties

Physical Property	°C	Metric Units	°F	British Units
Density	22	8.44 g/cubic cm	72	0.305 lb/cubic in.
Electrical Resistivity	23 100 200 300 400 500 600	1.26 microhm-m 1.27 1.28 1.29 1.30 1.31 1.32	74 212 392 572 752 932 1112	49.6 microhm-in. 50.0 50.4 50.8 51.2 51.6 52.0
Mean Coefficient of Thermal Expansion	20-204 20-316 20-427 20-538 20-649 20-760 20-871 20-982	13.1 x 10(-6)m/m-°C 13.5 13.9 14.4 15.1 15.7 16.6 17.3	68-400 68-600 68-800 68-1000 68-1200 68-1400 68-1600 68-1800	7.3 microinches/in.-°F 7.5 7.7 8.0 8.4 8.7 9.2 9.6
Thermal Conductivity	23 100 200 300 400 500 600	9.8 W/M-°C 11.4 13.4 15.5 17.6 19.6 21.3	74 212 392 572 752 932 1112	68 Btu-in./ft^2.-hr.-°F 79 93 108 122 136 148
Specific Heat	0 100 200 300 400 500 600	429 J/kg-°C 446 463 480 496 513 560	32 212 392 572 752 932 1112	0.102 Btu/lb-°F 0.107 0.111 0.115 0.118 0.123 0.134

Average Dynamic Modulus of Elasticity *

Form	Condition	Test Temp., F(C)	Average Dynamic Modulus of Elasticity, psi x 10(6) (MPa)
Plate, 3/8 in. (9.5 mm) thick	Annealed at 1925°F (1052°C), rapid cooled	Room 200 (93) 400 (204) 600 (316) 800 (427) 1000 (538) 1200 (649) 1400 (760) 1600 (871) 1800 (982)	30.2 (208,000) 29.2 (201,000) 28.8 (199,000) 27.7 (191,000) 26.7 (184,000) 25.6 (176,000) 24.3 (168,000) 22.8 (157,000) 21.2 (146,000) 18.7 (129,000)

* Average of five tests at each temperature.

Mechanical Properties

Average Impact Strength, Plate *

Aging Temperature, F (C)	Aging Time, hrs.	Average Charpy V-Notch Impact Strength,	
		ft. lbs.	**J**
Annealed**	--	81	110
1200 (649)	1000 4000 8000 16000	11 8 5 4	15 11 7 5
1400 (760)	1000 4000 8000 16000	5 4 5 4	7 5 7 5
1600 (871)	1000 4000 8000 16000	12 11 15 14	16 15 20 19

*Average of four tests on 1/2-in. (12.7mm) plate from a single heat.
**1875F (1024C), rapid cooled.

Average Hardness and Tensile Data, Room Temperature

Condition	Form	Ultimate Tensile Strength, ksi (MPa)	Yield Strength at 0.2% offset,ksi (MPa)	Elongation in 2" percent	Hardness, Rockwell
Annealed at 1925°F (1052°C), rapid cooled	Sheet 0.014-0.063" thick	132.0 (910)	67.9 (468)	47	B94
Annealed at 1925°F (1052°C), rapid cooled	Sheet,* 0.0.78-0.155" thick	131.5 (907)	67.4 (465)	45	B97
Annealed at 1925°F (1052°C), rapid cooled	Plate,*** 1/4" 1/2" 3/4" 1.00" 1-1/2" 1-3/4"	132.0 (910) 130.0 (896) 132.3 (912) 127.2 (877) 127.3 (878) 128.0 (883)	65.5 (452) 67.0 (462) 80.0 (552) 75.3 (519) 73.7 (508) 66.0 (455)	46 44 44 42 43 44	B94 B98 B98 B97 B97 C20

*Based on average of 146 tests
**Based on average of 67 tests.
***Based on average of 4 or less tests.

Aged Hardness, Room Temperature*

Form	Aging Temperature, F (C)	Aging Tme, hrs.	Hardness, Rockwell A
Plate, 1/2 in. (12.7 mm) thick	Annealed**	--	58
	1200 (649)	1000 4000 8000	68 68 68
	1400 (760)	1000 4000 8000	65 66 65
	1600 (871)	1000 4000 8000	60 60 60

*Single tests from a single heat.
**1875F (1024C), rapid cooled.

Average Tensile Data, Room Temperature*

Form	Aging Temperature, F (C)	Aging Tme, hrs.	Ultimate Tensile Strength, Ksi (MPa)	Yield Strength at 0.2% offset, Ksi (MPa)	Elongation in 2 in., (50.8 mm), percent
Plate, 1/2 in. (12.7 mm) thick	Annealed**	--	127.7 (880)	66.2 (456)	46
	1200 (649)	1000 4000 8000 16000	165.0 (1138) 163.6 (1128) 164.2 (1132) 165.4 (1140)	122.3 (843) 117.9 (813) 117.8 (812) 118.5 (817)	28 24 18 12
	1400 (760)	1000 4000 8000 16000	142.9 (985) 145.5 (1003) 142.6 (983) 140.4 (968)	95.5 (658) 104.1 (718) 97.4 (672) 96.1 (663)	17 12 13 12
	1600 (871)	1000 4000 8000 16000	130.0 (896) 130.0 (896) 127.0 (876) 128.4 (885)	68.3 (471) 66.4 (458) 63.7 (439) 63.4 (437)	30 29 26 32

*Average of three tests from a single heat.
**1875F (1024C), rapid cooled.

Average Tensile Data, Sheet*

Test Temperature, °F(°C)	Ultimate Tensile Strength, ksi (MPa)	Yield Strength at 0.2% offset,ksi (MPa)	Elongation in 2" percent
Room	138.8 (957)	72.0 (496)	38
200	133.3 (919)	67.3 (464)	41
400	129.4 (892)	62.2 (429)	44
600	125.6 (866)	59.5 (410)	45
800	122.2 (843)	59.2 (408)	45
1000	119.9 (827)	58.8 (405)	46
1200	119.6 (825)	57.0 (393)	47
1400	88.4 (609)	55.3 (381)	70
1600	52.1 (359)	34.9 (241)	69
1800	25.0 (172)	10.8 (75)	108
2000	13.3 (92)	6.1 (42)	89

*Annealed at 1925°F (1052°C), rapid cooled.

Average Rupture Data, Sheet*

Test Temperature, °F(°C)	Average Rupture Strength, ksi (MPa) for Time Indicated		
	10 hrs	100 hrs	1000 hrs
1200 (649) 1400 (760) 1600 (871)	82 (565) 36 (248) 12 (83)	71 (490) 27 (186) 6.7 (46)	60 (414) 20 (138)** 3.7 (26)**

*Annealed at 1925°F (1052°C), rapid cooled.
**Extrapolated

Heat Treatment

Alloy 625 has three basic heat treatments:
(1)High Solution Anneal - 2000/2200°F (1093/1204°C), air quench or faster.
(2)Low Solution Anneal - 1700/1900°F (927/1038°C), air quench or faster.
(3)Stress Relieve - 1650°F (899°C), air quench.
The time at the above temperatures depends on volume and section thickness. Strip, for example, would require shorter times than large sections. Temperatures for treatments No. 1 and 2 are generally held for 1/2 to 1 hour, 1 to 4 hours for treatment No. 3.
Treatment No. 1 is not commonly used for applications below 1500°F (816°C). It is generally used above 1500°F and where resistance to creep is important. The high solution anneal is also used to develop the maximum softness for mild processing operations such as cold rolling or drawing.
Treatment No. 2 is the used treatment and develops an optimum combination of tensile and rupture properties from ambient temperatures to 1900°F (1038°C). Ductility and toughness at cryogenic temperatures are also very good.
Treatment No. 3 is recommended for application below 1200°F (649°C) when maximum fatigue, hardness, tensile and yield strength properties are desired. Ductility and toughness at cryogenic temperatures are excellent. When a fine grain size is desired for fatigue, tensile and yield strengths up to 1500°F (816°C), treatment No. 3 is sometimes used.

Workability

Hot Working
Hot working may done at 2100°F (1149°C) maximum furnace temperature. Care should be exercised to avoid frictional heat build-up which can result in overheating, exceeding 2100°F (1149°C). Alloy 625 becomes very stiff at temperatures below 1850°F (1010°C). Work pieces that fall below this temperature should be reheated. Uniform reductions are recommended to avoid the formation of a duplex grain structure. Approximately 15/20% reduction is recommended for finishing.

Cold Forming
Alloy 625 can be cold formed by standards methods. When the material becomes too stiff from cold working, ductility can be restored by process anneal.

Machineability
Low cutting speeds, rigid tools and work piece, heavy equipment, ample coolant and positive feeds are general recommendations.

High-Speed Cutting Tools for Lathe Turning Operations

Angle	Roughing	Finishing
Back rake	0°	8°
Positive side rake		14-18°
End clearance	6°	8°
End cutting edge	6°	25°
Side cutting edge	--	Up to 45°

Cutting Speeds for High-Speed Steels

Operation	Speed		Feed	
	sfpm	m/s	ipr	mm/rev
Turning	12-20	0.06/.010	0.010	0.25
Drilling (.500"/12.70mm)	10-12	0.05/0.06	0.006/0.010	0.15/0.25
Tapping	5-10	0.03/0.05	--	--
Milling	10-20	0.05/0.10	--	--
Reaming	8-10	0.04/0.05	--	--