JACQUET

ALLOY 601 DATA SHEET

UNS N06601

GENERAL PROPERTIES

Alloy 601 (UNS designation N06601) is a nickel-chromium alloy designed for use in high temperature applications. Compared to **Alloy 600** (UNS designation N06600), **Alloy 601** has increased chromium as well as the addition of aluminum which forms a tough oxide scale at elevated temperatures which gives the alloy excellent resistance to oxidation through 2200 °F under cyclic conditions. The alloy has good resistance to stress corrosion cracking. The alloy is not recommended for use in reducing or sulfur environments.

The alloy is used extensively in heat treating applications, industrial furnaces, gas turbine components, and in petrochemical and pollution control equipment and systems.

APPLICATIONS

- Heat treating baskets, trays and fixtures;
- Radiant tubes, supports, return bends, muffles and retorts;
- Combustor components and catalyst grid supports in equipment for nitric acid production;
- Superheater tube supports and grid supports and ash handling systems in the power generation field;
- Turbine engine igniters and combustion can liners, diffuser assemblies and containment rings.

STANDARDS

Product form	Specifications			
	ASTM	ASME	AMS	Military
Plate sheet and Strip	B168		5870	
Seamless, Pipe and Tubing	B167			
Rod, Bar and Wire	B166			
Forgings and Rings			5715	

CHEMICAL COMPOSITION

C	Mn	S	Si	Cr	Ni	Fe	Cu
0.10 max	1.50 max	0.015 max	0.50 max	21.00→25.00	58.00→63.00	Balance	1.00 max

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MECHANICAL PROPERTIES

Room temperature mechanical properties of Alloy 601 are shown below. The material is in the annealed condition.

Yield Strength 0.2% offset		Ultimate Tensile Strength		Elongation
psi	MPa	psi	MPa	% to 2" (51 mm)
64 000	440	115 000	790	45

SHORT TIME ELEVATED TEMPERATURE TENSILE PROPERTIES

The following table illustrates the short time tensile properties of Alloy 601 at temperatures above room temperature.

Test temperature		Yield Strength 0.2% Offset		Ultimate Tensile Strength		Elongation
°F	°C	psi	MPa	psi	MPa	% in 2"
400	204	60 000	415	109 000	750	45
800	427	52 000	360	102 000	705	44
1 000	538	48 000	330	90 000	620	44
1 200	649	41 000	280	60 000	415	45
1 400	760	26 000	180	43 000	235	70
1 600	871	15 000	105	18 000	125	120

PHYSICAL PROPERTIES

Density

0.291 **lb/in³**

8.05 **g/cm³**

Magnetic Permeability

1.02

Specific Heat

32→212 **°F** 0.11 **Btu/lb-°F**

0→100 **°C** 460 **J/kg-°K**

Specific Gravity

8.05

Curie Temperature

< −320 **°F**

< −196 **°C**

Melting Range

2374→2494 **°F**

1301→1368 **°C**

THERMAL PROPERTIES

Temperature		Electrical Resistivity		Thermal Conductivity		Coefficient of Expansion		Specific Heat	
°F	°C	ohm-circ mil/ft	μ Ω-m	Btu-in/ft²-hr-°F	W/m-°C	10⁻⁶ in/in/°F	mm/m/°C	Btu/lb-°F	J/kg-°C
70	20	710	1.180	78	11.2	–	–	0.107	448
200	100	716	1.192	87	12.7	7.60	13.75	0.112	469
400	200	727	1.207	100	14.3	8.01	14.36	0.119	498
600	300	735	1.220	113	16.0	8.11	14.58	0.126	523
800	400	741	1.229	126	17.7	8.30	14.83	0.133	548
1 000	500	747	1.239	139	19.5	8.50	15.19	0.140	578
1 200	600	751	1.247	153	21.0	8.87	15.62	0.147	603
1 400	700	751	1.249	165	22.8	9.19	16.11	0.155	632
1 600	800	754	1.249	178	24.4	9.51	16.67	0.162	657
1 800	900	758	1.259	190	26.1	9.82	17.24	0.169	686
2 000	1 000	763	1.262	203	27.8	10.18	17.82	0.176	712

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MODULUS OF ELASTICITY AND POISSON'S RATIO

Temperature		Modulus of Elasticity				Poisson's ratio
		10^6		GPa		
°F	°C	Tension	Torsion	Tension	Torsion	
70	20	29.95	11.77	206.5	81.2	0.272
200	100	29.42	11.49	202.4	79.2	0.278
400	200	28.50	11.10	196.8	76.5	0.286
600	300	27.59	10.67	191.2	73.8	0.296
800	400	26.57	10.21	184.8	71.2	0.299
1000	500	25.43	9.68	178.2	68.1	0.308
1200	600	24.12	9.05	170.8	64.3	0.327
1400	700	22.48	8.32	161.3	60.2	0.340
1600	800	20.54	7.52	150.2	55.6	0.350
1800	900	18.43	6.63	137.9	50.3	0.370
2000	1000	16.20	5.68	124.7	44.7	0.395

IMPACT STRENGTH

The effect of high temperature exposure compared to room temperature

Temperature		Time/hrs	Charpy V-Notch Impact Strength	
°F	°C		ft/lb	J
80	27	–	180	244
1000	540	100	86	117
		400	89	121
		1000	89	121
1100	590	100	88	119
		300	92	125
		1000	93	126
1200	650	100	93	126
		300	90	122
		1000	94	127
1300	700	100	95	129
1400	760	146	105	142
1500	820	159	117	159
1600	870	103	117	159

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TYPICAL STRESS RUPTURE PROPERTIES

Alloy 601 offers excellent creep/stress rupture properties which make the alloy suitable for extended service in very high temperature environments. It's resistance to oxidation and other forms of high temperature corrosion make it the alloy of choice in these severe applications.

Temperature		Stress, psi (MPa) to produce rupture in		Stress, psi (MPa) to produce % of creep/hr			
°F	°C	100 hr	1 000 hr	0.0001 % hr	0.001 % hr	0.01 % hr	0.10 % hr
1 000	540	70 000 (500)	55 000 (400)	42 000 (290)	52 000 (380)	60 500 (450)	–
1 100	595	50 000 (350)	40 100 (300)	28 000 (190)	38 000 (275)	48 000 (370)	–
1 200	650	38 000 (280)	28 000 (185)	10 900 (145)	24 000 (155)	30 000 (190)	40 000 (300)
1 300	705	20 000 (150)	15 000 (90)	7 100 (50)	10 000 (70)	15 000 (100)	19 000 (140)
1 400	760	14 500 (90)	9 000 (60)	4 000 (30)	6 000 (42)	8 000 (58)	10 350 (80)
1 500	815	9 900 (69)	6 200 (42)	2 800 (19)	4 000 (30)	6 000 (42)	8 600 (63)
1 600	870	7 000 (50)	4 100 (30)	2 000 (14)	3 000 (22)	4 200 (30)	6 100 (42)
1 800	980	3 600 (26)	2 500 (14)	780 (5.7)	1 250 (8)	1 900 (11)	2 900 (20)
2 000	1 095	1 700 (10)	1 000 (7)	350 (3)	650 (4)	940 (6.5)	1 450 (9)
2 100	1 150	1 400 (8)	800 (5)	–	–	–	–

OXIDATION RESISTANCE

Alloy 601 has excellent resistance to oxidation and scaling in high temperature environments. The protective oxide layer formed by the addition of aluminium at elevated temperatures allows the alloy to perform with very little weight loss in cyclic applications at temperatures through 2 300 °F.

CORROSION RESISTANCE

The high nickel and chromium composition of **Alloy 601** not only help to give it superior high temperature performance but also bive the alloy excellent resistance to many wet corrosive environments. In these types of applications, the performance of **Alloy 601** is similar to that of **Alloy 600**. **Alloy 601** has excellent resistance to nitric acid, low concentrations of phosphoric acid, sodium hydroxide solutions and sea water. The alloy is not resistant to hydrochloric and hydrofluoric acid environments.

Because of the alloys high nickel content, it is extremely resistant to chloride-ion stress-corrosion crackin in most environments.

HEAT TREATMENT

Alloy 601 is not hardenable by heat treatment. The alloy can only be strengthened by cold working. Annealing is conducted to soften the material after cold working operations. As with other nickel based alloys, **Alloy 601** must be clean before any heat treating is attempted. Softening begins at 1 600 °F (871 °C). At temperatures of 1 850 °F (1010 °C) or higher, grain growth will occur rapidly.

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COLD FORMING

////**Alloy 601** exhibits the excellent cold forming characteristics normally associated with chromium-nickel stainless steels. The high nickel content prevents the austenite to martensite transformation which can occur when **Alloys 301** or **304** stainless steels are cold formed. The alloy has a lower work hardening rate than **Alloys 301** or **304** and can be used in multiple draw forming operations where relatively large amounts of deformation occur between anneals.

////If a high temperature anneal is conducted on the **Alloy 601** to produce a relatively large grain size for elevated temperature properties, extensive forming produces a visibly undulated surface called “orange peel”. This surface characteristic is produced by the large grain size and is usually considered detrimental to the properties of the material.

WELDING

////**Alloy 601** can be joined by the standard resistance and fusion welding processes used for the stainless steels. A number of welding rods and wires are commercially available for joining **Alloy 601** to itself and other materials. Since the aluminum in the alloy forms a tightly adhering oxide, which can be removed only by grinding, inert gas shielding is desirable.