Technical Data Sheet

ATI 600™

Nickel-base Alloy

(UNS N06600)

INTRODUCTION

ATI 600™ alloy (UNS Designation N06600) is a nickel-chromium alloy designed for use from cryogenic to elevated temperatures in the range of 2000°F (1093°C). ATI 600™ alloy is non-magnetic and readily weldable.

The alloy is used in a variety of corrosion resistant applications. The high nickel content of the alloy provides a level of resistance to reducing environments, while the chromium content of the material provides resistance to weaker oxidizing environments. The high nickel content of the material provides exceptional resistance to chloride stress corrosion cracking.

The forming properties of the ATI 600™ alloy are similar to those of stable austenitic stainless steels.

PRODUCT FORMS

ATI 600™ alloy is available in plate, sheet, and strip and long product forms. The alloy is supplied in the annealed conditions generally specified. Sheet and strip can be provided in the various temper conditions specified. Plate can be supplied in the "as rolled" condition.

SPECIFICATIONS & CERTIFICATES

The following widely published specifications are applicable to the ATI 600™ alloy.

Product Form	Specification			
	ASTM	ASME	AMS	MIL
Plate, Sheet and Strip	B168	SB-168	5540	MIL-N-23228
Pipe and Tubing	B167 B516 B517	SB-167 SB-516 SB-517	5580	MIL-DTL-23227
Condenser Tubing	B163	SB-163		DTL
Rod, Bar and Forgings	B166	SB-163	5665	MIL-23229
Wire	B166	SB-166	5687	

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TYPICAL ANALYSIS

Element	Percentage by Weight
Carbon	0.05 max.
Manganese	0.25 max.
Sulfur	0.002 max.
Silicon	0.20 max.
Chromium	15.5
Nickel + Cobalt	Balance
Iron	8.0
Copper	0.10

PHYSICAL PROPERTIES

Density
0.304 lb./in^3
8.42 g/cm^3

Specific Gravity
8.42

Magnetic Permeability
<1.02

Specific Heat
32-212°F 0.11 Btu/lb-°F
(0-100°C) 460 Joules/kg•K

Linear Coefficient of Thermal Expansion

Average for Range °F (°C)		Mean Linear Coefficient of Thermal Expansion	
°F	°C	10-6/°F	10-6/°C
70-200	21-93	6.9	12.4
70-400	21-204	7.3	13.1
70-600	21-316	7.6	13.7
70-800	21-427	7.9	14.2
70-1000	21-538	8.1	14.6
70-1200	21-649	8.4	15.1
70-1400	21-760	8.7	15.7

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Thermal Conductivity

Temperature		Thermal Conductivity	
°F	°C	Btu-ft/h-ft^2-°F	W/m•K
70	21	8.6	14.8
200	93	8.9	15.4
400	204	9.9	17.1
600	316	10.8	18.7
800	427	11.9	20.6
1000	538	13.0	22.5

Elastic Modulus, Modulus of Rigidity, and Poisson's Ratio

Temperature		Elastic Modulus (E)		Modulus of Rigidity (G)		Poisson's Ratio
°F	°C	10^6 psi	GPa	10^6 psi	GP	
70	21	30	207	11	76	0.29

CORROSION RESISTANCE

The high nickel content of ATI 600™ alloy provides good resistance to moderate levels of reducing conditions. The nickel content of the alloy renders the alloy extremely resistant to chloride stress corrosion cracking. ATI 600™ alloy is used in solutions of magnesium chloride.

Similarly, the chromium content of ATI 600™ alloy provides resistance to weak oxidizing environments. In this respect, ATI 600™ alloy is an improvement over ATI 200™ alloy (commercially pure nickel). In strong oxidizing solutions like hot, concentrated nitric acid, the ATI 600™ alloy has poor resistance.

The ATI 600™ alloy is relatively unattacked by the majority of neutral and alkaline salt solutions. The ATI 600™ alloy is used in some caustic environments.

The ATI 600™ alloy resists steam and mixtures of steam, air and carbon dioxide. The alloy has excellent oxidation resistance to about 2100°F (1149°C). The nickel content of the alloy renders it subject to attack at elevated temperatures in sulfur containing atmospheres, however.

MECHANICAL PROPERTIES

Room temperature mechanical properties of the ATI 600™ alloy are shown below. The material is in the annealed condition.

0.2% Offset Yield Strength		Ultimate Tensile Strength		Elongation
psi	(MPa)	psi	MPa	% in 2" (51 mm)
37,000	(255)	93,000	640	45

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Short-time Elevated Temperature Tensile Properties

The following table illustrates the short time tensile properties of the ATI 600™ alloy at temperatures above room temperature. Low temperature properties are added for comparison.

Test Temperature		0.2% Offset Yield Strenght		Ultimate Tensile Strength		Elongation %
°F	°C	psi	MPa	psi	MPa	
-110	-79	42,400	292	106,450	734	64
600	316	31,000	213	90,500	624	46
800	427	29,500	203	88,500	610	49
1000	528	28,500	197	84,000	579	47
1200	649	26,500	183	65,000	448	39
1400	760	17,000	117	27,500	190	46
1600	871	9,000	62	15,000	103	80
1800	982	4,000	28	7,500	52	118

IMPACT RESISTANCE

ATI 600™ alloy shows excellent toughness even at subzero temperatures. The following are typical results for standard size Charpy V-Notch impact specimens machined from plate.

Testing Temp.		Charpy Impact Energy, ft-lb (Joules)					
°F	°C	Annealed		As Hot Rolled		Cold Rolled	
-100	-73	180	(244)	180	(244)	-	-
70	21	180	(244)	180	(244)	155	(210)
1000	538	160	(217)	160	(217)	-	-

CREEP AND STRESS RUPTURE PROPERTIES

Typical stress rupture properties of ATI 600™ alloy are presented below in comparison to some other materials. The data indicate that the ATI 600™ alloy has modest load carrying ability in the temperature range in which creep and stress rupture are design criteria.

Testing Temperature		Alloy	Stress, psi (MPa) to Produce Rupture in					
°F	°C		10 hr		100 hr		1000 hr	
1000	538	304 600 A-286	- 74,000 100,000	- (510) (690)	43,000 50,000 95,000	(297) (345) (655)	34,000 34,000 88,000	(234) (234) (607)
1200	649	304 600 800	- 34,000 40,000	- (234) (276)	23,000 23,000 32,000	(159) (159) (221)	16,000 14,500 21,000	(110) (100) (145)
1350	732	600 A-286	20,000 49,000	(138) (338)	13,500 35,000	(93) (241)	9,200 21,000	(63) (145)

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COLD FORMING

ATI 600™ alloy 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 ATI 600™ alloy 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 not considered detrimental to the properties of the material.

WELDABILITY

The ATI 600™ alloy 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 ATI 600™ alloy to itself and other materials. Since the alloy forms a tightly adhering oxide, which can be removed only by grinding, inert gas shielding is desirable.

HEAT TREATMENT

The ATI 600™ alloy 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. Softening begins at 1600°F (871°C) and can be conducted to about 2100°F (1149°C). At temperatures of 1800°F (982°C) or higher, grain growth will occur rapidly. However, very short time at 1900°F (1038°C) may be used to soften the material without producing undue grain growth. Slow cooling or quenching produces approximately the same hardness in ATI 600™ alloy.

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