Technical Data Sheet

ATI 444™

Stainless Steel: Ferritic

(UNS S44400)

INTRODUCTION

ATI 444™ alloy is a low carbon and low nitrogen ferritic stainless steel containing 18% chromium, 2% molybdenum. The alloy is stabilized with additions of columbium and titanium for resistance to intergranular corrosion. One big advantage of the ATI 444 alloy over austenitic stainless steels, such as 304 and 316 alloys, is the practical immunity of the ATI 444 alloy to chloride stress corrosion cracking (SCC).

The alloy's enhanced resistance to pitting and crevice corrosion combined with its good general corrosion resistance to a multitude of environments makes it an excellent choose for a wide range of applications. Some of the more common applications include heat exchanger tubing, food processing equipment, and hot water tanks. The alloy's resistance to hot corrosion combined with its good creep resistance makes it an excellent choice for automotive exhaust applications.

COMPOSITION

Element	Weight%	ASTM* Specification
Chromium	18.2	17.5 - 19.5
Molybdenum	1.90	1.75 - 2.50
Nickel	< 0.5	1.00 max
Manganese	0.30	1.00 max
Phosphorus	<0.03	0.040 max
Sulfur	<0.002	0.030 max
Silicon	0.45	1.00 max
Carbon	0.013	0.025 max
Nitrogen	0.015	0.035 max
Columbium	0.27	---
Titanium	0.13	---
Columbium plus Titanium	0.40	0.2 + 4(C+N)min 0.8 max
Iron	bal.	bal.

SPECIFICATIONS & CERTIFICATES

The ATI 444 alloy is designated as UNS S44400 in ASTM specifications A240, A268, and A276. The alloy is also covered by ASME Specifications SA 240 and SA 268 and is listed in Section II, Part D for Section VIII, Division 1 use to a maximum temperature of 650°F.

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PHYSICAL PROPERTIES

ATI 444 alloy is a single phase ferritic (body centered cubic) stainless steel at all temperatures up to the melting point. The alloy can not be hardened by heat treatment. The physical properties of the alloy are similar to other ferritic stainless steels. It has a higher thermal conductivity and lower coefficient of thermal expansion than austenitic alloys, such as type 304 and 316 stainless steels.

Property	Value	Units
Density at 72°F (22°C)	7.75 0.280	g/cm^3 lb/in^3
Thermal Conductivity at 212 °F (100°C)	12.4 21.4	BTU/hr•ft•°F W/m•K
Thermal Expansion coefficient at 68-392°F (20-200°C)	5.7 10.3	µ in/in/°F µ m/m/°C
Specific Heat	0.107 447	BTU/lb/°F J/Kg•K

CORROSION RESISTANCE

General Corrosion Resistance

The combination of 18% chromium and 2% molybdenum provides ATI 444 alloy with very good resistance to a wide range of corrosive media. The general corrosion rates for ATI 444, ATI 304, and ATI 316 alloys measured in various test solutions are presented in the following table.

	Corrosion Rate (mils per year)[1]		
Boiling Solution	**AL 444™**	**ATI 304™**	**ATI 316™**
65% Nitric Acid	18	8.4	41.3
20% Acetic Acid	0.1	0.12	<0.1
45% Formic Acid	27.1	64.1	18.2
1% Hydrochloric Acid	1.7	88.3	226
10% Oxalic Acid	101	46.5	51.4
20% Phosphoric Acid	2.3	2.6	0.2
10% Sulfamic Acid	>1000	127	83.4
10% Sulfuric Acid	>1000	446	636
50% Sodium Hydroxide	293	183	123

(1) Results are the average of five 48-hour test periods.

Stress Corrosion Cracking Resistance

The ATI 444 alloy is practically immune to chloride stress corrosion cracking. The following table compares the cracking resistance of the ATI 444 alloy to conventional austenitic stainless steels in standard boiling test solutions. This testing was performed with U-bend specimens prepared in accordance with ASTM G30. The "pass" designation indicates that no cracking was observed during a 1000-hour exposure period. The "fail" designation indicates that samples did exhibit cracking during the test exposure. As shown ATI 444 alloy resists cracking in all test solutions while the austenitic alloys exhibit cracking in all three boiling solutions.

Alloy	42% $MgCl_2$	33% LiCl	26%NaCl
AL 444™	Pass	Pass	Pass
ATI 304™	Fail	Fail	Fail
ATI 316™	Fail	Fail	Fail

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Pitting and Crevice Corrosion Resistance

The chromium and molybdenum content of the ATI 444 alloy provides increased resistance to pitting and crevice corrosion. One method of evaluating the relative pitting resistance of an alloy is to measure the "pitting potential" using cyclic potentiodynamic polarization measurements. The following table summarizes the pitting potentials for ATI 444, ATI 304, and ATI 316 alloys. The more positive the potential the more resistant the material to initiating localized chloride attack.

Alloy	Pitting Potential* Volts vs. Saturated Calomel Electrode
AL 444™	0.58
Type 304	0.35
Type 316	0.56

Test Solution – 1000ppm Cl^- from NaCl, pH=5, Temperature=25°C

Alloy	Solution - 200 ppm NaOCl Wt. Loss (g/cm^2) - Comments	Solution - 5.25% NaOCL Wt. Loss (g/cm^2) - Comments
ATI 304™	0.001 - Crevice Corrosion 0.001 - Crevice Corrosion	0.0013 - Crevice Corrosion 0.0011 - Crevice Corrosion
ATI 316™	0.000 - No Evidence of Attack <0.001 - Crevice Corrosion	0.0009 - Crevice Corrosion 0.0010 - Crevice Corrosion
AL 444™	0.000 - No Evidence of Attack 0.000 - Crevice Corrosion	0.0007 - Crevice Corrosion 0.0001 - Crevice Corrosion

Test Solution – 1000ppm Cl- from NaCl, pH=5, Temperature=25°C

The relative crevice corrosion resistance of the ATI 304, ATI 316, and ATI 444 alloys is presented in the above table. The alloys were tested in sodium hypochlorite solutions using duplicate specimens prepared in accordance with the ASTM G48 Practice B specification. Specimens were exposed for 96 hours at a test temperature of 160°F.

Integranular Corrosion Resistance

The relatively low levels of carbon and nitrogen combined with the addition of titanium and columbium stabilizers provide enhanced resistance to intergranular corrosion. ATI 444 alloy demonstrates no evidence of intergranular corrosion after exposure to the Cu-$CuSO_4$-16% H_2SO_4 test (ASTM A262 Practice E).

The alloy specification requires that the (%Ti + %Cb) be equal to 0.20 + 4(%C + %N) minimum and 0.80 maximum. This composition was developed to provide intergranular corrosion resistance in the as-welded condition. No post-weld heat treatment is required to restore corrosion performance.

Property	Typical Value	ASTM A249
Yield Strength 0.2% offset	50 ksi 345 MPa	40 ksi* 275 MPa*
Ultimate Tensile Strength	75 ksi 517 MPa	60 ksi* 415 MPa*
Elongation in 2" (51 mm)	30%	20%*
Hardness	80 HRB	217 Brinell** 96 HRB**

* minimum, ** maximum

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WELDABILITY

The ATI 444 alloy can be welded satisfactorily by a wide range of welding practices. However, it is essential that welding procedures minimize the pickup of oxygen, carbon, and nitrogen, in order to maintain the corrosion resistance and ductility of the alloy. Therefore, gasshielded processes are recommended. Argon shielding gas is preferred and the shielding gas should not contain hydrogen or nitrogen.

The ATI 444 alloy has been satisfactorily welded using TIG processes, both autogenously and with matching filler metal. The alloy has been welded using MIG processes with matching filler metal or low carbon austenitic stainless steel filler. The use of low carbon Ni-base wires has also been shown to produce acceptable welds. The ATI 444 alloy can be welded to other ferritic stainless steels, carbon steel, austenitic stainless steels and Ni-base alloys.

PRODUCT FORMS

ATI 444 ferritic stainless steel is available in sheet, plate and strip from ATI.

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