JACQUET

ALLOY 2205 DATA SHEET

UNS S32205, EN 1.4462 / UNS S31803

GENERAL PROPERTIES

Alloy 2205 (UNS designations S32205/S31803) is a 22 % chromium, 3 % molybdenum, 5-6 % nickel, nitrogen alloyed duplex stainless steel. Duplex stainless steels are neither fully austenitic like 304 stainless, nor fully ferritic, like 430 stainless. **Alloy 2205**, when heat treated properly, has a microstructure that has nearly equal proportions of austenite and ferrite phases. This provides **Alloy 2205** with superior resistance to stress corrosion cracking as well as improved resistance to crevice corrosion and general corrosion environments as compared with T304 and T316 Stainless Steels.

The duplex structure of **Alloy 2205** results in a yield strength that is around twice that of austenitic stainless steels. This allows engineers to save weight by using lighter gage materials without compromising structural integrity which in turn, makes the alloy extremely cost effective.

Alloy **Alloy 2205** is well suited for environments in the -50 °F to +600 °F temperature range. It is also highly suitable for service in environments containing chlorides and hydrogen sulfide, such as marine environments and the oil and gas extraction industry, the pulp and paper industry, the mining industry, oil and gas production, and heat exchangers for use in environments containing chlorides or brackish water as the cooling medium.

APPLICATIONS

- Pressure vessels, tanks and piping systems for the Chemical Process Industry;
- Piping, tubing and heat exchangers for the Oil and Gas Industry;
- Digesters, liquor tanks and bleaching equipment for the Pulp and Paper Industry;
- Rotors, fans, shafts and rolls in environments requiring high strength and high corrosion resistance;
- Tanks for ships and trucks;
- Food processing equipment;
- Biofuel plants.

STANDARDS

Product form	Specifications					
	ASTM	ASME	EN	Euronorm	AFNOR	DIN
Plate sheet and Strip	A240	SA240	10028-7	1.4462X2CrNi MoN22.5.3	Z3CrNi 22.05AZ	W.Nr 1.4462
Seamless, Pipe and Tubing	A790/A928	SA790	10028-7	1.4462X2CrNi MoN22.5.3	Z3CrNi 22.05AZ	W.Nr 1.4462
Rod, Bar and Wire	A270/A789	SA789	10028-7	1.4462X2CrNi MoN22.5.3	Z3CrNi 22.05AZ	W.Nr 1.4462
Forgings and Rings	A182/A276 A479	SA182/SA276 SA479	10028-7	1.4462X2CrNi MoN22.5.3	Z3CrNi 22.05AZ	W.Nr 1.4462

ALLOY 2205

CHEMICAL COMPOSITION

Grade	C	Mn	Si	Cr	Ni	Mo	P	S	N	Fe
S31803	0.030 max	2.00 max	1.00 max	21.00→23.00	4.50→6.50	2.50→3.50	0.030 max	0.020 max	0.08→0.20	Balance
S32205	0.030 max	2.00 max	1.00 max	21.00→23.00	4.50→6.50	2.50→3.50	0.030 max	0.020 max	0.14→0.20	Balance

MECHANICAL PROPERTIES

////ANNEALED MATERIAL TYPICAL ROOM TEMPERATURE

	Yield Strength 0.2% offset		Ultimate Tensile Strength		Elongation	
Grade	psi	MPa	psi	MPa	% to 2" (51 mm)	Hardness
S31803	65 000	450	90 000	620	25.0	31 Rc (293 HBN) max
S32205	65 000	450	95 000	655	25.0	31 Rc (293 HBN) max

//// The Duplex structure of **Alloy 2205** gives it considerably higher strength that **T316L** stainless steel. This allows the use of lighter sections of material without any sacrifice in structural performance. The following chart compares the mechanical properties of **Alloy 2205** to other corrosion resistant alloys.

////SPECIFIED TENSILE PROPERTIES PER ASTM A240

Alloy	Ultimate Tensile Strength Ksi minimum	Yield Strength Ksi minimum	Hardness maximum
2205	95	65	31 Rc
AI2003	95	65	31 Rc
T316L Stainless Steel	75	30	95 Rb
T317L Stainless Steel	75	30	95 Rb
T317LMN Stainless Steel	80	35	96 Rb
904L	71	31	90 Rb
20	80	35	95 Rb
AI-6Xn	95	45	100 Rb

////ASME BOILER & PRESSURE VESSEL CODE, SECTION VIII, DIVISION 1, ALLOWABLE STRESS VALUES, KSI

Alloy	200 °F	300 °F	400 °F	500 °F	600 °F
2205	25.7	24.8	23.9	23.3	23.1
AI2003	26.3	24.8	24.5	24.5	24.5
T316L Stainless Steel	20.0	20.0	19.3	18.0	17.0
T317L Stainless Steel	17.0	15.2	14.0	31.1	12.5
904L	16.7	15.1	13.8	12.7	11.9
20	20.6	19.7	18.9	18.2	17.7
AI-6Xn	26.2	23.8	21.9	20.5	19.4

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////ELEVATED TEMPERATURE FATIGUE RESISTANCE

Temperature		Yield Strength 2 % Offset		Tensile Strength		Elongation
°F	°C	Ksi	Mpa	Ksi	Mpa	in 2"
200	93	30.2	208	75.2	518	39.5
400	204	26.0	179	66.0	455	28.0
600	316	23.1	159	64.2	443	26.0
800	427	21.2	146	62.7	433	25.0
1000	538	21.0	145	61.3	423	23.0
1200	649	21.1	146	54.4	375	19.5
1400	760	21.1	146	37.9	261	23.0
1600	871	16.2	112	22.5	155	48.0
1800	982	8.0	55	11.3	78	41.0

PHYSICAL PROPERTIES

Density

0.283 **lb/in**^{3}

7.82 **g/cm**^{3}

Magnetic Permeability

1.02

Thermal Conductivity

212 **°F**	8.4 **Btu/hr-°F**
100 **°C**	14.6 **W/m-°K**

Thermal Expansion Coefficient

68→212 **°F**	7.2 **µ in/in/°F**
68→392 **°F**	7.5 **µ in/in/°F**
68→572 **°F**	7.8 **µ in/in/°F**
20→100 **°C**	13.0 **µ m/m/°C**
20→200 **°C**	13.5 **µ m/m/°C**
20→300 **°C**	14.0 **µ m/m/°C**

Elastic modulus

72 **°F**	29.0 10^6 **Psi**
22 **°C**	200 **GPa**

Poisson's Ratio

0.2

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CORROSION RESISTANCE

////GENERAL CORROSION RESISTANCE

Alloy 2205 is resistant to dilute reducing acids and moderate to high concentrations of oxidizing acids. The alloy is resistant to low concentrations of organic acids, but should be used with caution in higher concentrations at elevated temperatures.

	Corrosion Rate in MPY (mm/a)			
Test Solution	T316 Stainless Steel		Alloy 2205	
Boiling	Base Metal	Welded Sample*	Base metal	Welded Sample*
20 % **Acetic Acid**	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)
45 % **Formic Acid**	23.4 (0.60)	20.9 (0.53)	0.5 (0.01)	0.5 (0.01)
1 % **Hydrochloric Acid**	1.0 (0.02)	63.6 (1.61)	0.8 (0.02)	0.6 (0.02)
65 % **Nitric**	22.3 (0.56)	18.4 (0.46)	20.6 (0.52)	19.3 (0.49)
10 % **Oxalic Acid**	48.2 (1.22)	44.5 (1.13)	7.8 (0.20)	5.1 (0.13)
20 % **Phosphoric Acid**	0.6 (0.20)	1.08 (0.03)	0.8 (0.02)	1.2 (0.03)
10 % **Sodium Bisulfate**	71.6 (1.82)	56.2 (1.43)	25.4 (0.65)	19.9 (0.51)
50 % **Sodium Hydroxide**	77.6 (1.97)	88.4 (2.17)	23.9 (0.61)	22.6 (0.57)
10 % **Sulfamic Acid**	124.0 (3.15)	119.0 (3.03)	22.0 (0.56)	17.4 (0.44)
10 % **Sulfuric Acid**	635.0 (16.1)	658.0 (16.7)	206.0 (5.23)	200.0 (5.08)
Ferric Sulfate/ 50 % **Sulfuric Acid (A** 262 **B)**	26.0 (0.66)	23.3 (0.59)	19.9 (0.51)	17.6 (0.45)

*Autogenous welds, not heat treated

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////CHLORIDE STRESS CORROSION RESISTANCE

The duplex nature of **Alloy 2205** prodives it with substantially greater resistance to Chlorice Stress Corrosion Cracking over **T304L**, **T316L** and **T317L** Stainless Steel.

	Chloride Stress Corrosion Resistance (Boiling)		
Alloy	42 % $MgCl_2$	33 % LiCi	26 % NaCl
Austenitic T304L (8 % Ni)	**Failed (20 hours)**	**Failed (96 hours)**	**Failed (850 hours)**
Ferritic T439 (0.1 % Ni)	**Passed (2 000 hours)**	**Passed (2 000 hours)**	**Passed (2 000 hours)**
Duplex Alloy 2205 (5 % Ni)	**Failed (89 hours)**	**Passed (1 000 hours)**	**Passed (1 000 hours)**
Duplex Alloy 2205 (5 % Ni) Welded	**Failed (89 hours)**	**Passed (1 000 hours)**	**Passed (1 000 hours)**

*Failed indicates failure by chloride stress corrosion cracking in the time span noted.

////ONSET OF CREVICE CORROSION

Crevice Corrosion Data in 10 % Ferric Chloride	
Alloy	**Temperature °F(°C)**
T316 Stainless steel	27 (-3)
T317 Stainless steel	35 (2)
Alloy 2205	69 (20)
E-Brite®	75 (24)
AL-6XN®	113 (45)
Alloy 625	113 (45)
AL 29-4C®	125 (52)

////ELECTROCHEMICAL PITTING CORROSION

Electrochemical Pitting Corrosion in 1 M Sodium Chloride Solution	
Alloy	**Temperature °F(°C)**
T316 Stainless steel	64 (18)
E-Brite®	97 (36)
904L	120 (49)
Alloy 2205	120 (49)
T317LXN Stainless steel	132 (56)
AL-6XN®	194 (90)

Electrochemical Pitting Corrosion in 0.1 M Sodium Chloride Solution	
Alloy	**Temperature °F(°C)**
T304 Stainless steel	77 (25)
T317 Stainless steel	82 (28)
Type 444 Stainless steel	61 (16)
Alloy 2205	144 (62)

MACHINABILITY //

////With standard, high-speed steel tooling, **Alloy 2205** can be machined at the same feeds and speeds as **T316L stainless steel**. When carbide tooling is used, cutting speeds should be reduced by approximately 20 % relative to the speeds for **T316L stainless steel**. Powerful equipment and rigid mounting of tools and parts are necessary

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HEAT TREATMENT

Alloy 2205 should be annealed at 1 900 °F minimum followed by rapid cooling, preferably by water quenching. This treatment applies to both solution annealing and stress annealing. Stress relief treatments at any lower temperatures carry the risk of precipitation of detrimental intermetallic or nonmetallic phases.

FORMING

HOT FORMING

Forming **Alloy 2205** below 600 °F is recommended whenever possible. When hot forming is required, the metal should be heated uniformly and worked in the range of 1 750 °F to 2 250 °F. The metal is very soft at these temperature ranges and is easily formed. Above this range, **Alloy 2205** is susceptible to hot tearing. Whenever hot forming is done, it should be followed by a full solution anneal at 1 900 °F minimum followed by rapid quenching to restore phase balance, toughness, and corrosion resistance. Stress relieving is not required or recommended, however, if it must be performed, the material should receive a full solution anneal at 1 900 °F minimum followed by rapid cooling or water quenching.

COLD FORMING

Alloy 2205 is easily sheared and cold formed on equipment suitable for working stainless steels. However, due to the high strength and rapid work hardening of **Alloy 2205**, forces substantially higher than those for austenitic stainless steels are required to cold form it. Also, due to the high strength, a somewhat larger allowance must be made for “spring back”.

WELDING

Alloy 2205 can be readily welded. The desired result of welding **Alloy 2205** is that the weld metal and the heat-affected (HAZ) retain the corrosion resistance, strength and toughness of the base metal. The actual welding of **Alloy 2205** is not difficult but it is necessary to design welding procedures that lead to a favorable phase balance after welding and one which will avoid precipitation of detrimental intermetallic or nonmetallic phases.

Alloy 2205 can be welded by GTAW (TIG), GMAW (MIG), SMAW (“stick” electrodes), SAW, FCW and PAW methods.