

# 2205 (UNS S32205/S31803) EN 1.4462 duplex stainless steel

### A 22Cr-3Mo Stainless Steel

Alloy 2205 is a 22% Chromium, 3% Molybdenum, 5-6% Nickel, nitrogen alloyed duplex stainless steel with high general, localized and stress corrosion resistance proper-ties in addition to high strength and excellent impact toughness.

Alloy 2205 provides pitting and crevice corrosion resistance superior to 316L or 317L austenitic stainless steels in almost all corrosive media. It also has high corrosion and ero-sion fatigue properties as well as lower thermal expansion and higher thermal conductivity than austenitic.

The yield strength is about twice that of austenitic stainless steels. This allows a designer to save weight and makes the alloy more cost competi-tive when compared to 316L or 317L. Alloy 2205 is particularly suitable for applications covering the -50°F/+600°F temperature range. Temperatures out-side this range may be considered but need some restrictions, particularly for welded structures.

## Applications

Pressure vessels, tanks, piping, and heat exchangers in the chemcal processing industry Piping, tubing, and heat exchangers for the handling of gas and oil Effluent scrubbing systems Pulp and paper industry digesters, bleaching equipment, and stock-handling systems Rotors, fans, shafts, and press rolls requiring combined strength and corrosion resistance Cargo tanks for ships and trucks Food processing equipment Biofuels plants

### **Standards**

ASTM/ASME... A240 UNS S32205/S31803, 2205 EURONORM... 1.4462 X2CrNiMoN22.5.3 AFNOR...... Z3 CrNi 22.05 AZ DIN...... W. Nr 1.4462

### **Corrosion Resistance**

General Corrosion Because of its high chromium

(22%), molybdenum (3%) and nitro-gen (0.18%) contents, the corrosion resistance properties of 2205 are superior to that of 316L or 317L in most environments.

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#### **Localized Corrosion Resistance**

The chromium, molybdenum and nitrogen in 2205 also provide excel-lent resistance to pitting and crevice corrosion even in very oxidizing and acidic solutions.

## **Stress Corrosion Resistance**

The duplex microstructure is known to improve the stress corrosion crack-ing resistance of stainless steels. Chloride stress corrosion cracking of austenitic stainless steels can occur when the necessary conditions of temperature, tensile stress, oxygen and chlorides are present. Since these conditions are not easily controlled, stress corrosion cracking has often been a barrier to utilizing 304L, 316L or 317L.

## **Corrosion Fatigue Resistance**

Alloy 2205 combines high strength and high corrosion resistance to produce high corrosion fatigue strength. Applications in which processing equipment is subject to both an aggressively corrosive environment and to cycle loading can benefit from the properties of 2205.





Critical Pitting Temperature in 1M NaCl Measured using the AvestaPolarit Pitting Cell



General Corrosion in Wet Process Phosphoric Acids									
Grade		Corrosion Rate, ipy							
		Solution A, 140°F			Solu	Solution B, 120°F			
2205			3.1			3.9	3.9		
316L			>200				>200		
904L			47				6.3		
Composition, wt %									
P2O5	HCI	HF	H2SO4	Fe2O3	Al2O3	SiO2	CaO	MgO	
Sol A	0.06	1 1	4.1	0.27	0.17	0.10	0.20	0.70	
54.0	0.00	1.1	4.1	0.27	0.17	0.10	0.20	0.70	
Sol B	0.34	1.3	1.72	0.4	0.01	0.3	0.02		

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27	.5								
Stress Corrosion Cracking Resistance									
Grade		Boiling Wick		k	Boiling				
			42% MgCl2		Test		25% NaCl		
2205		F		Р		F	þ		
254 SMO®		F		Р		F	þ		
	Т	ype 316I		F		F		I	7
	Т	ype 317I		F		F		I	7
	Α	lloy 904	Ĺ	F		P or	F	Ро	r F
	1	Alloy 20		F		Р		I	þ

(P=Pass, F=Fail)

## **Chemical Analysis**

Typical Values (Weight %)

С	Cr	Ni	Mo	N	Others		
0.020	22.1	5.6	3.1	0.18	S = 0.001		
$PREN = [Cr \%] + 3.3 [Mo \%] + 16 [N \%] \ge 34$							

## **Mechanical Properties**

Mechanical Properties at Room Temperature

ASTM A 240	Typical	
Yield Strength (0.2%), ksi	65 min.	74
Tensile Strength, ksi	90 min.	105
Elongation, %	25 min.	30
Hardness HB	293 max.	256

Tensile Properties at Elevated Temperatures

Temperature °F	122	212	392	572
Yield Strength (0.2%), ksi	60	52	45	41
Tensile Strength, ksi	96	90	83	81

### **Physical Properties**

Temperature °F		68	212	392	572
Density	lb/in3	0.278		_	
Modulus of Elasticity	psi x 106	27.6	26.1	25.4	24.9
Linear Expansion (68°F-T)	10-6/°F		7.5	7.8	8.1
Thermal Conductivity	Btu∕h ft⁰F	8.7	9.2	9.8	10.4
Heat Capacity	Btu/lb/ºF	0.112	0.119	0.127	0.134
Electrical Resistivity	Ωin x 10-6	33.5	35.4	37.4	39.4

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### Structure

The chemical analysis of 2205 is optimized to obtain a typical 50  $\alpha$  / 50  $\gamma$  microstructure after solution annealing treatment at 1040°/1080°C (1900°/1922°F).

Heat treatments performed above 2000°F may result in an increase of ferrite content.

Like all duplex stainless steels, 2205 is susceptible to precipitation of inter-metallic phases, usually referred to as sigma phase. Intermetallic phases precipitate in the range of 1300°F to 1800°F, with the most rapid precipitation occurring at about 1600°F. Thus, it is prudent to have 2205 pass a test for the absence of intermetallic phases, such as those in ASTM A 923.

## Processing

## Hot Forming

Forming below 600°F is recommended whenever possible. When hot form-ing is required, the workpiece should be heated uniformly and worked in the range of 1750° to 2250°F. Alloy 2205 is quite soft at these temperatures and is readily formed. Above this range, 2205 is subject to hot tearing. Immediately below this range, the austenite becomes substantially stronger than the ferrite and may cause cracking, a particular danger to "cold" edges. Below 1700°F there can be rapid formation of intermetallic phases because of the combina-tion of temperature and deformation. Whenever hot forming is done, it should be followed by a full solution anneal at 1900°F minimum and rapid quench 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 1900°F minimum, followed by rapid cooling or water quenching.

### Cold Forming

Alloy 2205 is readily sheared and cold formed on equipment suited to work-ing stainless steels. However, because of the high strength and rapid work hardening of 2205, forces substantially higher than those for austenitic steels

are required to cold form 2205. Also because of the high strength, a somewhat larger allowance must be made for springback.

### Heat Treatment

Alloy 2205 should be annealed at 1900°F minimum, followed by rapid cooling, ideally by water quenching. This treatment applies to both solu-tion annealing and stress relieving.

Stress relief treatments at any lower temperature carry the risk of precipi-tation of detrimental intermetallic or nonmetallic phases.

### Machinability

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With high-speed steel tooling, 2205 may be machined at the same feeds and speeds as type 316L. When car-bide tooling is used, cutting speeds should be reduced by about 20% relative to the speeds for type 316L.

Powerful machines and rigid mount-ing of tools and parts are essential.

## Welding

Alloy 2205 possesses good weld-ability. The goal of welding 2205 is that the weld metal and heat-affected zone (HAZ) retain the corrosion resis-tance, strength, and toughness of the base metal. The welding of 2205 is not difficult, but it is necessary to design welding procedures that lead to a favorable phase balance after welding and will avoid precipitation of detrimental intermetallic or nonmetal-lic phases.

2205 can be welded by: GTAW (TIG); GMAW (MIG); SMAW ("stick" electrode); SAW; FCW; and PAW.

## NOTE

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This technical data and information repre-sents our best knowledge at the time of printing. However, it may be subject to some slight varia-tions due to our ongoing research program on corrosion resistant grades.

We, therefore, suggest that information be verified at time of inquiry or order. Furthermore, in service, real conditions are specific for each application. The data presented here is only for the purpose of description and may only be considered as guarantees when our Company has given formal written approval.

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