Specification Sheet: 2205 (UNS S32205/S31803) EN 1.4462

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 properties 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 erosion 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 competitive when compared to 316L or 317L.

Alloy 2205 is particularly suitable for applications covering the -50°F/+600°F temperature range. Temperatures outside 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

EURONORM.. 1.4462 X2CrNiMoN 22.5.3

AFNOR............ Z3 CrNi 22.05 AZ

DIN.................. W. Nr 1.4462

Corrosion Resistance

General Corrosion

Because of its high chromium (22%), molybdenum (3%) and nitrogen (0.18%) contents, the corrosion resistance properties of 2205 are superior to that of 316L or 317L in most environments.

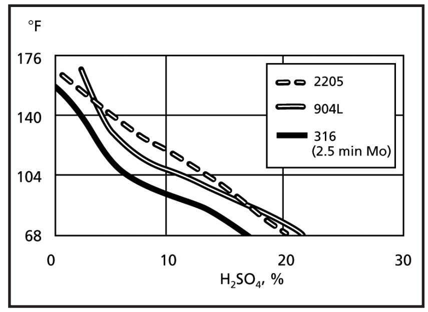
Localized Corrosion Resistance

The chromium, molybdenum and nitrogen in 2205 also provide excellent 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 cracking resistance of stainless steels.

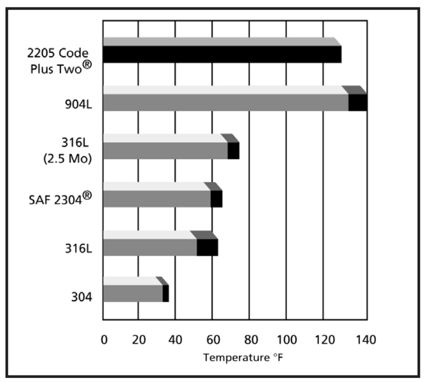
Chloride stress corrosion cracking of austenitic stainless steels can occur when the necessary conditions of temperature, tensile stress, oxygen and chlorides are present. Since these conditions are not easily controlled, stress corrosion cracking has often been a barrier to utilizing 304L, 316L or 317L.



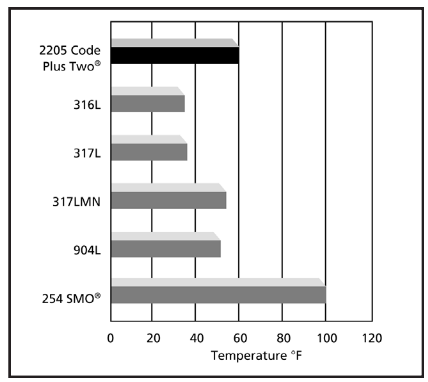
Isocorrosion Curves 4 mpy (0.1 mm/yr), in sulfuric acid solution containing 2000 ppm chloride.

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



Critical Crevice Corrosion Temperature (CCT) in 10% $FeCl_3 \bullet 6H_2O$

General Corrosion in Wet Process Phosphoric Acids

Grade	Corrosion Rate, ipy Solution A, 140°F	Corrosion Rate, ipy Solution B, 120°F
2205	**3.1**	**3.9**
316L	>200	>200
904L	47	6.3

Composition, wt %

P_2O_5	HCl	HF	H_2SO_4	Fe_2O_3	Al_2O_3	SiO_2	CaO	MgO
Sol A 54.0	0.06	1.1	4.1	0.27	0.17	0.10	0.20	0.70
Sol B 27.5	0.34	1.3	1.72	0.4	0.01	0.3	0.02	—

Stress Corrosion Cracking Resistance

Grade	Boiling 42% $MgCl_2$	Wick Test	Boiling 25% NaCl
2205	**F**	**P**	**P**
254 SMO®	F	P	P
Type 316L	F	F	F
Type 317L	F	F	F
Alloy 904L	F	P or F	P or F
Alloy 20	F	P	P

(P=Pass, F=Fail)

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Chemical Analysis

Typical Values (Weight %)

C	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 %] ≥ 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/in^3	0.278	—	—	—
Modulus of Elasticity	psi x 10^6	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 ft°F	8.7	9.2	9.8	10.4
Heat Capacity	Btu/lb/°F	0.112	0.119	0.127	0.134
Electrical Resistivity	Ωin x 10^{-6}	33.5	35.4	37.4	39.4

Structure

The chemical analysis of 2205 is optimized to obtain a typical 50 α / 50 γ 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 intermetallic 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 forming 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 combination 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 working 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 solution annealing and stress relieving. Stress relief treatments at any lower temperature carry the risk of precipitation of detrimental intermetallic or nonmetallic phases.

Machinability

With high-speed steel tooling, 2205 may be machined at the same feeds and speeds as type 316L. When carbide tooling is used, cutting speeds should be reduced by about 20% relative to the speeds for type 316L. Powerful machines and rigid mounting of tools and parts are essential.

Welding

Alloy 2205 possesses good weldability. The goal of welding 2205 is that the weld metal and heat-affected zone (HAZ) retain the corrosion resistance, 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 nonmetallic phases.

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

NOTE

This technical data and information represents our best knowledge at the time of printing. However, it may be subject to some slight variations 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.