Duplex Stainless Steel

DX1803/DX2205

Chemical Composition

Elements (%)	C	Mn	Cr	Ni	Mo	N
DX1803	0.02	1.8	22.1	5	2.9	0.17
DX2205	0.02	1.8	22.8	5.5	3.1	0.17

Typical values
PREN = 33 for DX1803 and PREN = 35 for DX2205
(Pitting Resistance Equivalent Number - % Cr+3.3x% Mo+16x% N)

European designation [1]	American designation [2]
X2CrNiMoN22-5-3/1.4462	UNS S31803
	UNS S32205

[1] According to EN 10088 [2] According to ASTM A240

These grades comply with:

- Aperam Stainless Europe - Safety Information Sheet for Stainless Steel
- European directive 2000/53/EC on end-of-life vehicles and later modifications
- PED 2014/68/EU (Pressure Equipment Directive)
- CPR 305/2011/EU (Construction Products Regulation / CE marking)
- NF A36-711 standard "Stainless Steel intended for use in contact with foodstuffs, products and beverages for human and animal consumption (non packaging steel)"
- ISO 15156-3 / NACE MR 0175
- ISO 17945 / NACE MR 0103
- Norsok M650 (MDS D45)

Key Features

- Excellent corrosion resistance, with a minimum PREN value of 33 for DX1803 and 35 for DX2205
- Yield strength twice as high as Type 304
- Service temperature range: -50°C to 300°C

Applications

- Equipment and piping for the chemical industry, Oil & Gas industries and desalination plants
- Heat exchangers

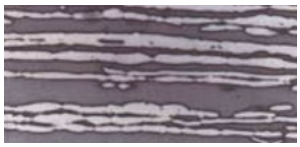
Product Range

Forms: coils, sheets, strips, and discs
Thicknesses: starting from 0.8 mm and up to 12.7 mm
Width: up to 2,000 mm (according to thickness)
Finishes: hot and cold rolled

Metallurgical Properties

DX1803/DX2205 grades of stainless steel contain a mix of ferritic (α) and austenitic (γ) phases. This two-phase structure is what gives these alloys an elevated yield strength while maintaining sufficient ductility. The ferritic phase provides the strengthening while the austenitic lattice enables ductility and toughness.

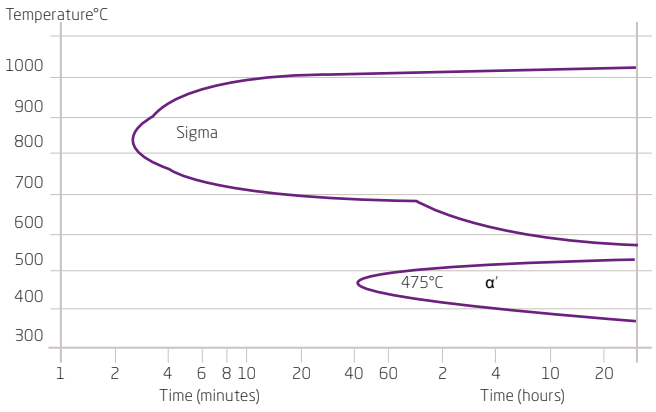
This mixed structure means DX1803/DX2205 have good resistance to stress corrosion cracking and are insensitive to intergranular corrosion, while their high chromium and molybdenum content ensures their resistance against pitting and uniform corrosion.



Microstructure of DX1803/DX2205 (dark areas represent the ferritic phase)

DX1803/DX2205 is not meant for continuous use at temperatures above 300°C:

- Use in temperatures ranging from 350 - 550°C will result in the ferritic phase losing ductility. This is due to the formation of the so-called α' phase, possibly accompanied by other embrittling phases. Commonly referred to as 475°C embrittlement, this phenomenon is common to ferritic stainless steels
- Due to the material's high chromium and molybdenum content, use in temperatures between 600 and 950°C will result in embrittling Sigma phase precipitation.



Physical Properties

Density	d	kg/dm³	20°C	7.9
Melting temperature	-	°C	-	1,430
Specific heat	c	J/kg.K	20°C	460
Thermal conductivity	k	W/m.K	20°C	13.5
Mean coefficient of thermal expansion*	α	10^{-6}/K	20-200°C 20-400°C	14.0 14.5
Electric resistivity	ρ	Ω mm²/m	20°C	0.8
Magnetic	-	-	-	yes
Young's modulus	E	GPa	20°C	200

*Thermal expansion 25% lower than that of 316, comparable with carbon steel

Mechanical Properties

In annealed condition at 20°C

According to ISO 6892-1, transverse direction
Gauge length: 50 mm

Grade	European designation	UNS designation	Rm (1) (MPa)	$Rp_{0.2}$ (2) (MPa)	A (3) %
DX2202	1.4062	S32202	710	530	30
DX2304	1.4362	S32304	730	550	30
DX1803	**1.4462**	**S31803**	**800**	**620**	**30**
DX2205		**S32205**			
DX2507	1.4410	S32750	910	680	30
316L	1.4401/4404	S31603	620	300	52
304L	1.4307	S30403	650	300	54

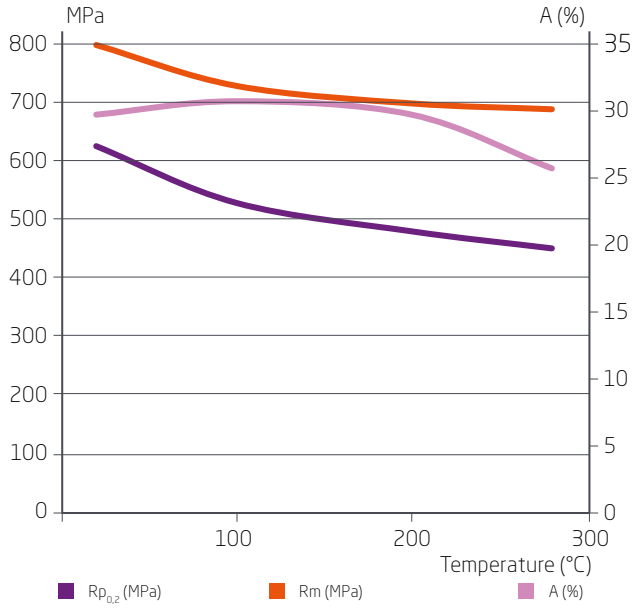
1 MPa= 1 N/mm² / Typical values
(1) Ultimate Tensile Strength (UTS) / (2) Yield Strength (YS) / (3) Elongation (A)

Typical impact toughness

Temperature (°C)	Kv min.* (J/cm²)
20	250
-40	200

*Kv_2 transversal

At high temperatures



Corrosion Resistance

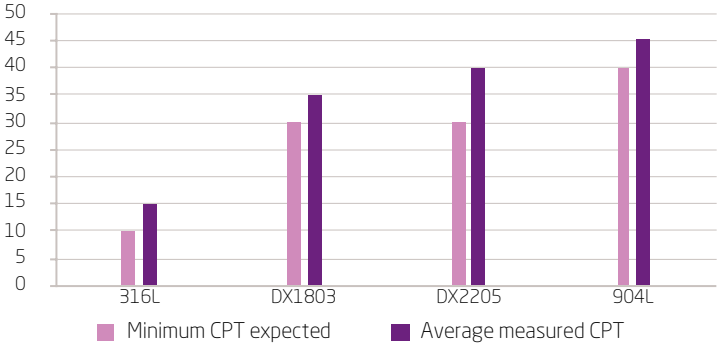
General corrosion

This grade is particularly well-suited for use in severe corrosion conditions, where it can replace highly alloyed austenitic stainless steels.

Pitting corrosion

Given their higher chromium, molybdenum and nitrogen contents, DX1803 /DX2205 exhibit very good resistance against pitting corrosion. Their performances are superior to that of 316L. A stainless steel's pitting corrosion resistance ranking is generally established using the PREN (Pitting Resistance Equivalent Number = %Cr + 3.3*%Mo + 16*%N) formula. DX2205's value typically lies around 35.7, compared to 24.1 for Type 316 and 26 for DX2304.

Critical Pitting Temperature (°C)



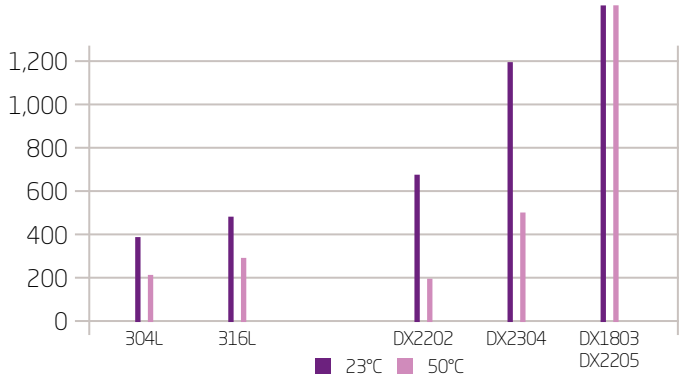
Intergranular corrosion

Like other duplex stainless steels, DX1803/DX2205 are resistant to intergranular corrosion and satisfy both the Strauss and Huey tests (according to ASTM A262E and A262C respectively).

Stress corrosion cracking

Thanks to their dual phase structure, DX1803/DX2205 have a very low sensitivity to stress corrosion cracking and demonstrate adequate resistance in acid gas environments (CO_2 + H_2S).

Pitting potential (mV/SCE)

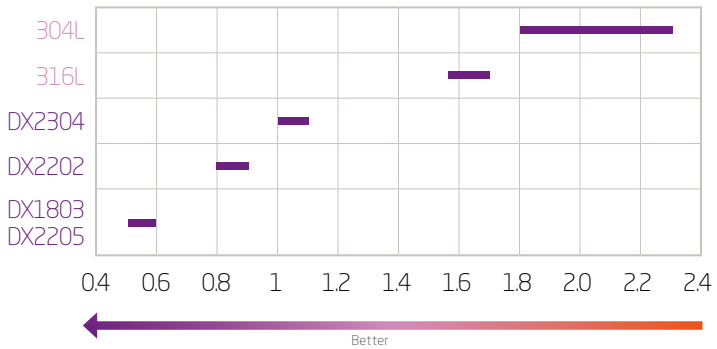


Crevice corrosion

Crevice corrosion occurs in two stages. During the first stage (initiation), chloride accumulates and acidification begins. This eventually causes depassivation within the crevice region. A depassivation pH is the critical condition for passivity breakdown.

The metal begins to dissolve during the second stage (propagation). This process can be slowed using grades that contain molybdenum and nickel as both elements are known to decrease the speed of propagation.

Depassivation pH, 2M NaCl, 23°C



For more information about our corrosion testing results, please contact the Technical Customer Support Team.

Forming

These grades can generally be used for forming applications. However, because their yield strength is about double that of Type 304, the use of presses or section rolling equipment with suitable power is required. The aptitude for stretch forming is determined by the dome height of the Erichsen test, whereas deep drawing ability is defined by the Limiting Drawing Ratio (LDR).

Bending

For thicknesses below 0.8 mm, a minimum bending radius of 0.5 x the thickness is recommended. For heavier gauges, the bending radius must be at least 1.5 x the thickness.

Grade	Stretching: Erichsen height* (mm)	Limiting Drawing Ratio* (LDR)
DX1803 DX2205	9.5	1.9 - 1.95
DX2202	10.5	1.9 - 1.95
DX2304	9.5	1.95 - 2.0
304L	11.4	1.9

* Typical values - Erichsen test: hemispherical punch (diam. 20 mm), LDR: cylindrical punch (diam. 33 mm)

Welding

DX1803/DX2205's chemical compositions are balanced to limit microstructural changes in the heat affected zone. When welding without filler material, solidification is fully ferritic. This is followed by austenite formation during further cooling. If cooling is too rapid, excess ferrite may result. Thus, one must always select the right welding parameters, (i.e. energy, filler metal, shielding gas) to control ferrite fraction in both the fusion and heat affected zones. Welding conditions also depend on the thickness of the material and on the welding equipment being used. If you have any questions, please don't hesitate to contact the Technical Customer Support Team.

Welding (continued)

Our recommendations

- Use both shielding and backing gases.
- Use nitrogen whenever welding without filler metal. In other cases, adapt nitrogen use to the selected filler metal.
- DX1803/DX2205's austenitic-ferritic structure eliminates the risk of hot cracking. However, if welded under improper conditions, it may become sensitive to cold cracking. To avoid such risks, a non-hydrogenated gas must be used for welding and all filler materials must be correctly dried (temperature above 250°C in most cases).
- Pre- or post-welding heat treatment is not recommended as improper conditions may lead to intermetallic phase precipitation.
- For multipass welding, a maximum interpass temperature of 150°C is advised. This will prevent the formation of deleterious phases.
- Pickling and passivation will result in better corrosion resistance.

Welding process	No filler material	With filler metal			Shielding gas Backing gas
	Typical thicknesses	Typical thicknesses	Filler material		
			Rod	Wire	
Resistance: spot, seam	≤ 2 mm				
TIG	≤ 1.5 mm	> 0.5 mm	W 22 9 3 N L [1] ER2209 [2]	G 22 9 3 N L [1] ER2209 [2]	Ar + 2-3% N_2 Ar, Ar+ He
PLASMA	≤ 1.5 mm	> 0.5 mm		P 22 9 3 N L [1] ER2209 [2]	Ar + 2-3% N_2 Ar, Ar+ He
MIG		> 0.8 mm		G 22 9 3 N L [1] ER2209 [2]	Ar + 2-3% N_2 + 2% CO_2 or O_2
SAW		> 5 mm		S 22 9 3 N L [1] ER2209 [2]	
SMAW		Repairs	E 22 9 3 N L R [1] ER2209 [2]		
Laser	≤ 5 mm				N_2 (Ar or He possible)

[1] EN ISO 14343 [2] AWS 5.9

Heat Treatment and Finishing

Heat treatment

After cold forming, applying an annealing treatment for a few minutes at 1,050 ±25°C, followed by air cooling, will restore the structure and eliminate internal stresses. After heat treatment, pickling, followed by passivation, must be carried out.

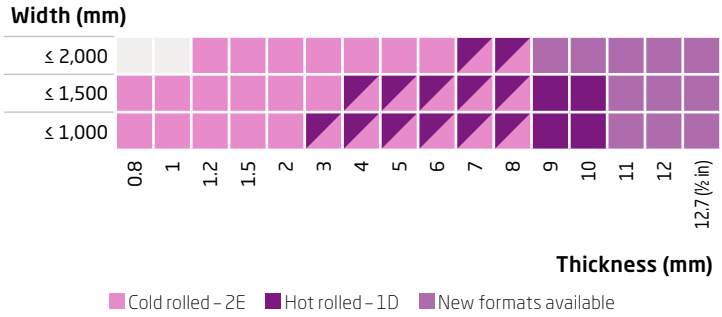
Pickling

By acid mix (20% HNO_3 + 2% HF) at room temperature or at 60°C. By sulphuric-nitric bath (10% H_2SO_4 + 0.5% HNO_3) at room temperature or at 60°C. Use pickling pastes for welds.

Passivation

Nitric acid bath (10 – 25%) at 20°C. Use passivating pastes for welds.

Size Range



These grades are also available in heavy plates delivered by Aperam South America:

- Thicknesses: starting from 14 and up to 40 mm
- Width: up to 1,300 mm

Please contact us about sizes outside this range.

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