Duplex stainless steel offer

DX2304

Chemical composition

Elements	C	Mn	Cr	Ni	Mo	N
%	0.02	1.80	22.80	3.80	0.40	0.13

Typical values
PREN = 26 (Pitting Resistance Equivalent Number - % Cr+3.3x% Mo+16x% N)

European designation [(1)]	American designation [(2)]
X2CrNiN23-4/1.4362	UNS S32304/Type 2304
[(1)] According to EN 10088	[(2)] According to ASTM A240

This grade complies with:

- PED 2014/68/EU (Pressure Equipment Directive)
- CPR 305/2011/EU (Construction Products Regulation / CE marking)
- European Directive 2000/53/EC on end-of-life vehicles and later modifications
- Standard NF A36-711 'Stainless steel intended for use/in contact with foodstuffs, products, and beverages for human and animal consumption (non-packaging steel)'

Key features

- Excellent resistance to general corrosion (comparable to 316L)
- Improved mechanical strength (yield strength twice as high as 304/316 grades) enables properly designed applications to save weight
- Service temperature range: -50°C to 300°C
- Improved stress corrosion resistance compared to 304/316 grades

Applications

- Desalination
- Construction: façades and footbridges
- Flexible tubes
- Oil & Gas industry
- Mining
- Pulp and paper industry
- Pressure vessels
- Caustic solutions
- Organic acids
- Safety panels

Product range

Forms: coils, sheets, strips, and discs
Thicknesses: starting from 0.8 mm and up to 10 mm
Width: up to 2,000 mm (according to thickness)
Finishes: hot and cold rolled

Metallurgical properties

DX2304 grade of stainless steel contains a mix of ferritic (α) and austenitic (γ) phases. This two-phase structure is what gives this alloy 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 also means DX2304 has good resistance to both stress corrosion cracking and intergranular corrosion.

DX2304's chemical analysis is optimized to obtain a typical 50% α -50% γ microstructure after annealing at 950-1,050°C. This ratio, combined with DX2304's low molybdenum content, gives it a better microstructural stability. DX2304 is not meant for continuous use at temperatures above 300°C. Doing so will result in precipitation hardening.

Physical properties

Density	d	kg/dm³	20°C	7.9
Melting temperature	-	°C	-	1,465
Specific heat	c	J/kg.K	20°C	450
Thermal conductivity	k	W/m.K	20°C	14
Mean coefficient of thermal expansion	α	10^{-6}/K	20-200°C 20-400°C	13.5 14
Electric resistivity	ρ	Ω mm²/m	20°C	0.7
Magnetic	-	-	20°C	yes
Young's Modulus	E	GPa	20°C	200

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	1.4462	S32205	800	620	30
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

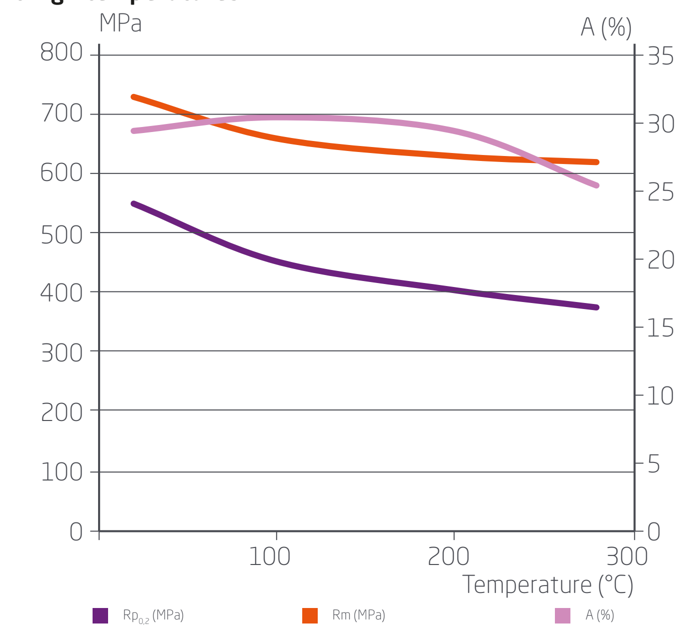
(1) Ultimate Tensile Strength (UTS) / (2) Yield Strength (YS) / (3) Elongation (A)

Typical impact toughness

Temperature (°C)	Kv min.* (J/cm²)
20	150
-40	100

*Kv_2 transversal

At high temperatures



Corrosion resistance

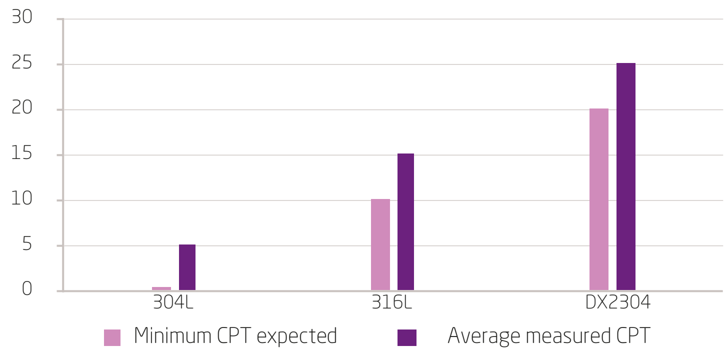
General corrosion

Thanks to its optimized chemical composition, DX2304's general corrosion resistance is similar that of 316/316L.

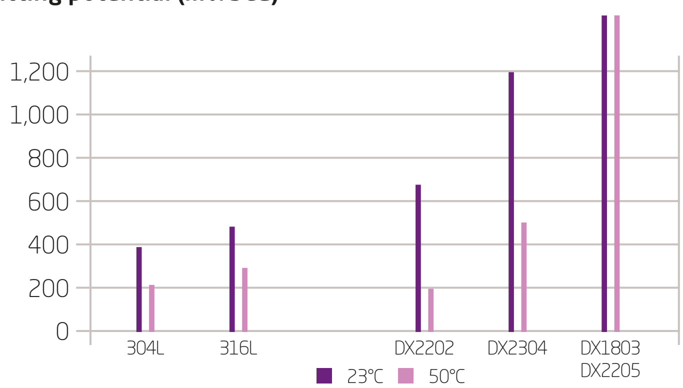
Pitting corrosion

Due to the addition of 23% chromium and 0.1% nitrogen, DX2304 offers much better pitting corrosion resistance than 316L.

Critical Pitting Temperature (°C)



Pitting potential (mV/SCE)



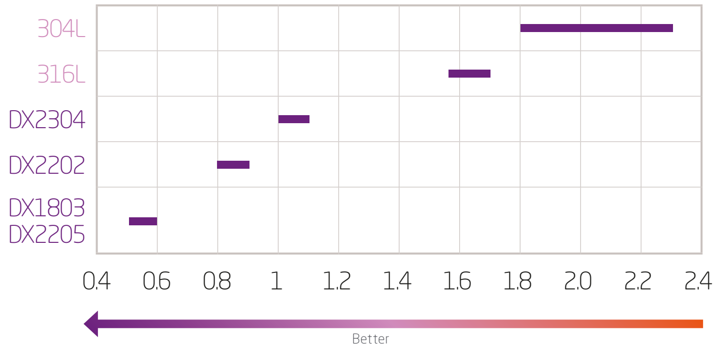
Corrosion resistance (continued)

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 down using grades that contain molybdenum and nickel as both elements are known to decrease the speed of propagation.

Depassivation pH, 2M NaCl, 23°C



Stress corrosion

During stress corrosion resistance tests using chloride-containing aqueous solutions, DX2304 outperforms both 304L and 316L grades. This result can be accredited to DX2304's high chromium and low nickel content - a typical feature of duplex stainless steels.
If DX2304 is not sufficiently resistant for a specific application, we recommend using DX1803 or DX2205 grades.

Intergranular corrosion

Like other duplex stainless steels, DX2304 is resistant to intergranular corrosion and satisfies both the Strauss and Huey tests (according to ASTM A262E and A262C respectively).

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

Forming

This grade can generally be used for forming applications. However, because its yield strength is significantly higher than 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).

Grade	Stretching: Erichsen height* (mm)	Limiting Drawing Ratio* (LDR)
DX2304	9.5	1.95 - 2.0
DX2202	10.5	1.90 - 1.95
DX1803 DX2205	9.5	1.90 - 1.95
304L	11.4	1.90

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

Welding

DX2304's balanced chemical composition limits 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 questions, please don't hesitate to contact the Technical Customer Support Team.

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.
- DX2304'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 (continued)

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 23 7 N L or W 22 9 3 N L [1] ER2209 [2]	G 23 7 N L or G 22 9 3 N L [1] ER2209 [2]	Ar + 2-3% N_2 Ar, Ar+ He
PLASMA	≤ 1.5 mm	> 0.5 mm			Ar + 2-3% N_2 Ar, Ar+ He
MIG		> 0.8 mm		G 23 7 N L or G 22 9 3 N L [1] ER2209 [2]	Ar + 2-3% N_2 + 2% CO_2 or O_2
SAW		> 5 mm		S 23 7 N L or 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

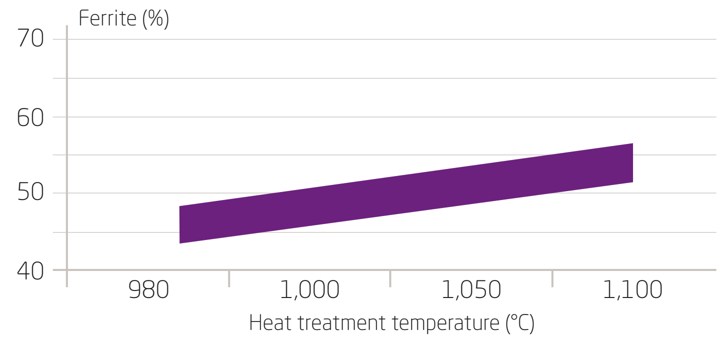
Heat treatment

After hot or cold forming, applying an annealing treatment for a few minutes at a temperature between 950 and 1,050°C, followed by water quenching or rapid air cooling, will restore the structure and eliminate internal stresses. This process will restore corrosion resistance and mechanical properties. Parts must be carefully supported during heating to avoid creep deformation.

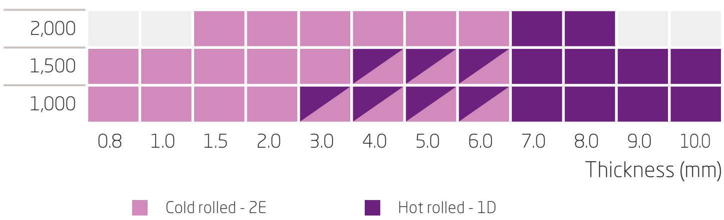
Pickling

The same solutions and pastes used with 304/316 grades can be used for DX2304. However, due to the properties that make DX2304 corrosion resistant, its pickling time will be higher than that of such austenitic grades as 304/316.

- Nitric-Hydrofluoric acid mixture (10% HNO_3 + 2% HF) at ambient temperature or up to 60°C
- Sulfuric-Nitric acid mixture (10% H_2SO_4 + 0.5% HNO_3) at 60°C
- Use descaling pastes for weld areas



Size range



Please contact us about sizes outside this 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