Stainless Europe

ArcelorMittal

Grade DX2202

Duplex stainless steel

Chemical Composition

Elements	C	Mn	Cr	Ni	Mo	N
%	0.025	1.30	23.00	2.50	<0.30	0.20

Typical values
ArcelorMittal Industeel - Ugitech EP06290991 patent under registration

European designation	American designation
X2CrNiN22-2 / 1.4062(1)	UNS 32202 / Type 2202

(1) According to EN 10088

This grade complies with

- Stainless Europe Material Safety Data Sheet n°1 (European Directive 2001/58/EC).
- European Directive 2000/53/EC on end-of-life vehicles and later modifications.
- Standard NFA36 711 "Stainless steel intended for use in contact with foodstuffs, products and beverages for human and animal consumption (non packaging steel)"
- French Decree No.92-631 dated 8 July 1992 and Regulation No. 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food (and repealing Directives 80/590/EECand 89/109/EEC).
- French regulatory paper dated 13 January 1976 relating to materials and articles made of stainless steel in contact with foodstuffs.

General Characteristics

The principal features of **DX2202** are:

- Good general resistance to corrosion, comparable to 18-9L (1.4307, Type 304L) at elevated temperature and to 18-11ML (1.4404, Type 316L) at room temperature
- Improved mechanical strength
- Service temperature range: -50 °C to 300°C
- Improved stress corrosion resistance compared to 304

Applications

- Construction (crash barriers, food bridges)
- Potable water systems
- Desalination
- Pulp and paper industry (tanks, cladding of paper machines)
- Oil tanks
- Juice tanks
- Automotive structure

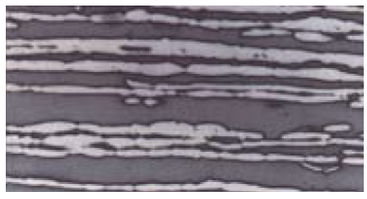
Product range

Forms: sheets, blanks, strips
Thicknesses: from 0.7 up to 10 mm
Width: up to 2000 mm according to thickness
Finishes: hot rolled, cold rolled

Metallurgical properties

The grade DX2202 is a stainless steel of the austenitic-ferritic group, whose structure is composed of a mix of ferritic (α) and austenitic (γ) phases. The two-phase structure of the alloy makes it possible to obtain elevated yield strength values whilst still maintaining sufficient ductility. The hardening is provided by the ferritic phase, whereas the austenitic lattice enables to preserve both ductility and toughness.

The mixed structure gives our **DX2202** a good resistance to stress corrosion cracking and makes it insensitive to intergranular corrosion.



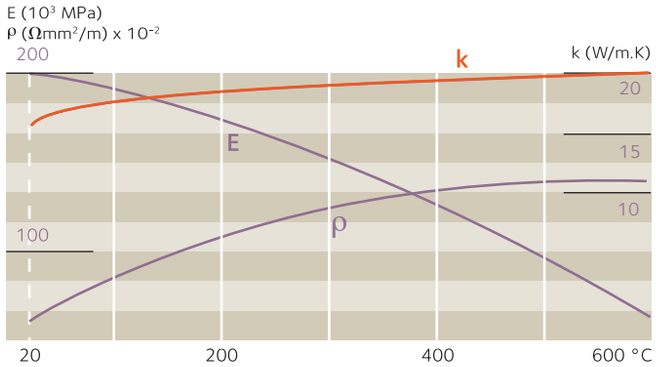
Microstructure of the 22-02 (dark areas represent the ferritic phase)

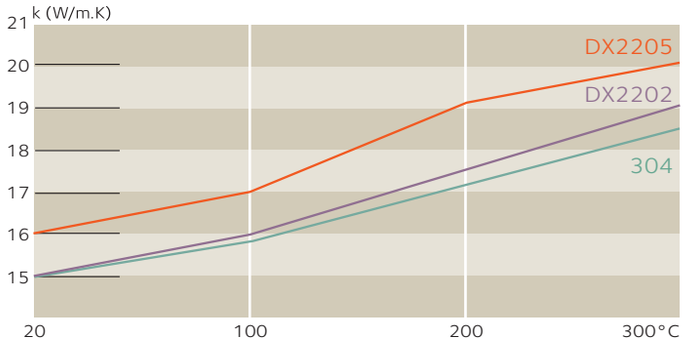
Continuous use of our **DX2202** at temperatures above 300°C is not recommended for the following reason: Between 350 and 550°C there is a loss of ductility by embrittlement of the ferritic phase due to the formation of the so-called α' phase, possibly accompanied by other embrittling phases; this is a classical phenomenon encountered with ferritic structure, more commonly referred to as "475°C embrittlement".

Physical Properties

Cold rolled and annealed sheet

Density	ρ	kg/dm³	20°C	7.8
Melting temperature		°C		1480
Specific Heat	C	J/kg.K	20°C	480
Thermal condctivity	K	W/m.K	20°C	15
Mean coefficient of thermal expansion	α	10^{-6} / K	20 -100°C 20 -200°C 20 -300°C	9.5 11.5 12
Electrical resistivity	ρ	Ω.mm²/m		0.70
Magnetic				Yes
Young's Modulus	E	MPa. 10³	20°C	200
Shear Modulus	G	MPa. 10³	20°C	75





Mechanical properties

In annealed condition at 20°C
According to EN 10002-1 (July 2001), test piece perpendicular to rolling direction.

Test piece:
Length = 80mm (thickness < 3mm)
Length = 5.65mm √So (thickness ≥ 3mm)

Grade designation	European designation	ASTM A240	R_m (1) (MPa)	$R_{P0,2}$ (MPa)	A(3) %
DX2202	1.4062	2202	750	550	31
DX2304	1.4362	2304	730	550	30
18-11ML	1.4401/4404	316/316L	620	310	48
K45	1.4621	445 (a)	510	360	29
18-9E	1.4301	304	670	320	50

1 MPa = 1 N/mm² *Typical Values

(1) Ultimate Tensile Strength (UTS). (2) Yield Strength (YS). (3) Elongation (A). (a) Common designation

At elevated temperatures

Temperature	20°C	100°C	200°C	280°C
$R_{P0,2}$(MPa)	550	430	380	350
R_m(MPa)	750	640	610	600
A (%)	31	31	30	26

Typical impact strength

Temperature (°C)	Kv min.* (J)
20	100
-50	50

*Kv transversal, HRAP 5mm

Corrosion resistance

General corrosion resistance

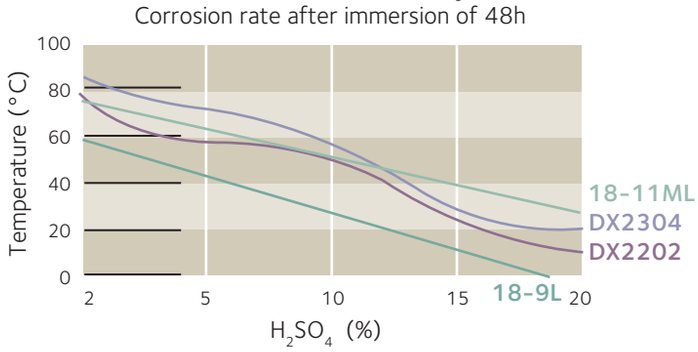
DX2202 has been designed to replace the 18-9E/18-9L (1.4301/1.4307, Type 304/304L) in most applications that are critical for the 18-9E/18-9L. Pure sulfuric acid is an example where its resistance is better than that of 18-9L but lower than that of DX2304 (1.4362, Type 2304) and 18-11ML (1.4404, Type 316L).

DX2202 can also be used in combination with nitric acid.

Pitting corrosion resistance

Generally speaking, the **DX2202** has at least the same level of pitting corrosion resistance as the 18-9L (1.4307, Type 304L). Depending on the environment, the pitting corrosion resistance of the **DX2202** can be compared with the resistance of the 18-11ML (1.4404, Type 316L). This is the case in potable water where the pitting potential is even slightly higher than the 18-9L and the 18-11ML.

ISO corrosion curves 0.2mm/year.
Corrosion rate after immersion of 48h



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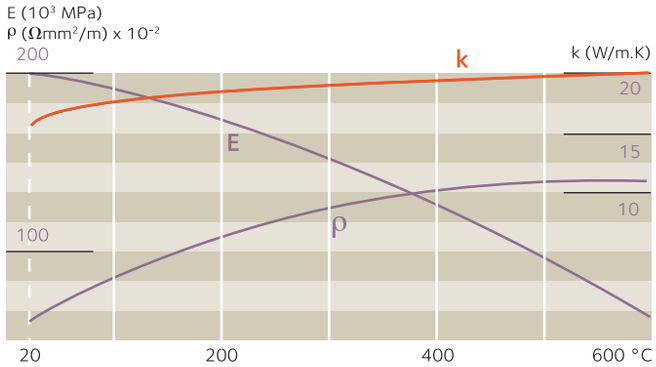

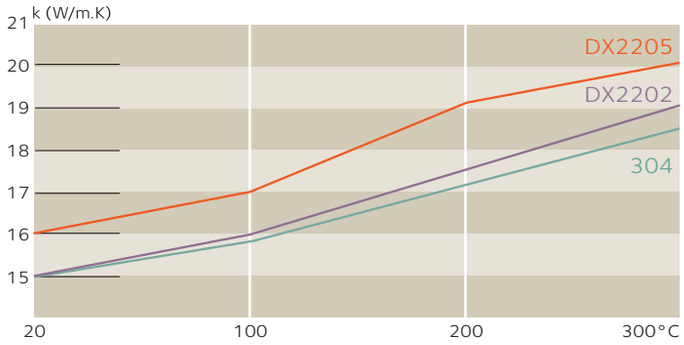

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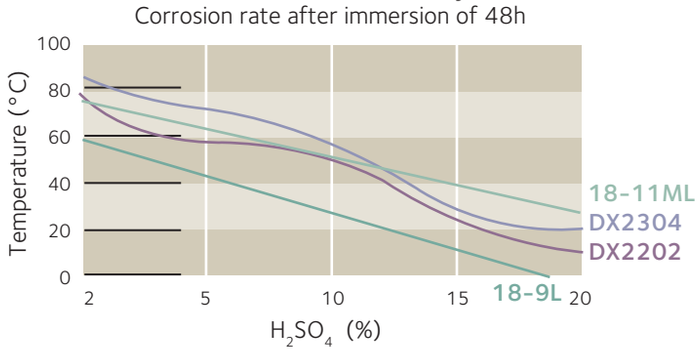
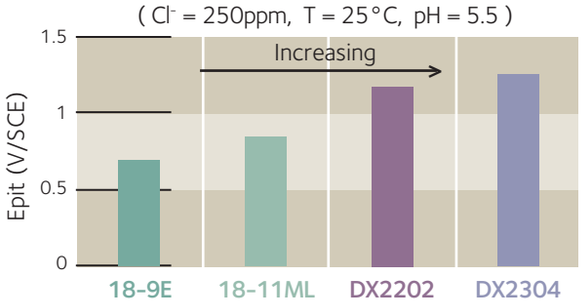
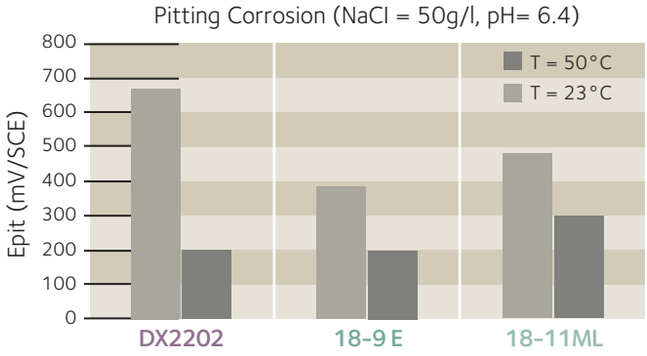


In other environments though, for example environments rich of sodium chloride at different temperature, the **DX2202** corrosion resistance is at least at the same level as that of 18-9L (1.4307, Type 304L) but slightly inferior to that of 18-11ML.

Pitting potential in potable water
(Cl^- = 250ppm, T = 25°C, pH = 5.5)



Pitting Corrosion (NaCl = 50g/l, pH= 6.4)

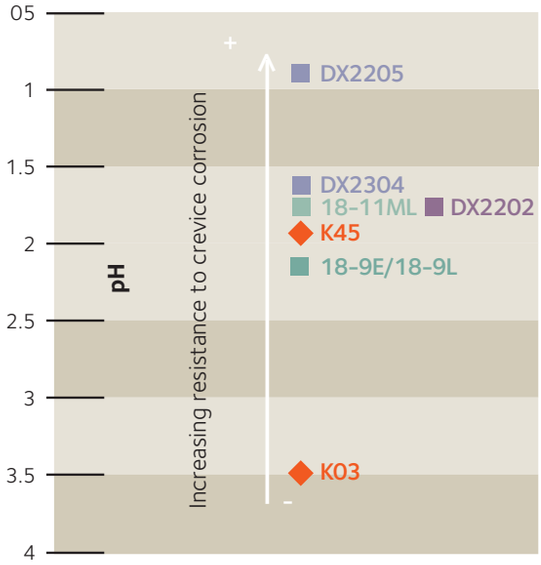


Intergranular corrosion resistance
The **DX2202** is resistant to intergranular corrosion like other duplex stainless steels and is conform to the requirements of following standards :

- Strauss test according to ASTM A262E
- HUEY test according to ASTM A262C

Crevice Corrosion
Crevice corrosion is a type of corrosion that can be divided in two stages. During the first stage, the initiation, an incubation period is needed before sufficient chloride accumulation and acidification lead to depassivation within the crevice region.
A depassivation pH can be defined as the critical condition for passivity breakdown.
The propagation is the second stage and is involved in the dissolution of metal. To slow down this stage, molybdenum and nickel containing grades are to be preferred since both these elements have a positive effect on decreasing the speed of propagation.

Depassivation pH in a deaerated NaCl 2M environment at 23°C



Erosion corrosion
Our grade **DX2202** has better erosion corrosion resistance than other stainless steels such as K10 (1.4000, Type 410S), K03 (1.4003) and 18-9E (1.4301, Type304).

Fatigue corrosion
DX2202 has better fatigue corrosion resistance than 18-9L (1.4307, Type 304L). Still, a careful design of critical parts, like avoiding angles or shape irregularities, is essential to make use of these better fatigue properties.

Atmospheric corrosion resistance
Tests are in progress at various locations to check the atmospheric corrosion resistance of our **DX2202**.
The initial results situate this grade between 18-9L (1.4307, Type 304L) and 18-11ML (1.4404, Type 316L) and show that the use of this grade in marine atmospheres is not recommended.
More information about the test results are available from our technical customer support department.

Forming

Hot forming
DX2202 can be hot formed after heating to temperatures between 950°C and 1100°C.
If forming is finished above 950°C and cooling (air or water) is fast enough, a final heat treatment can be avoided.

When hot forming is applied to blanks welded with weld mold 2209 or 2304, a new heat treatment at 1050°C followed by rapid cooling (air or water) is required. During heating, parts must be supported carefully to avoid creep deformation.

Cold forming
Our grade **DX2202** is suited to be cold formed as well.

When the cold working deformation exceeds 20%, an intermediate full annealing heat treatment (1040/1080°C) must be applied. Such heat treatment is also recommended after the last cold forming pass, if cold deformation exceeds 10%, in order to restore the mechanical properties.

Bending
Compared to the 18-9L (1.4307, Type 304L) a minimum bending radius must be applied due to the higher mechanical properties and lower elongation to rupture.
The minimum bending radius must be at least 3 times the thickness of the base material and 4 times the thickness of the welded assembly.

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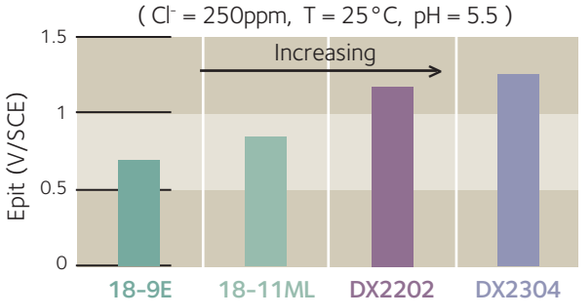

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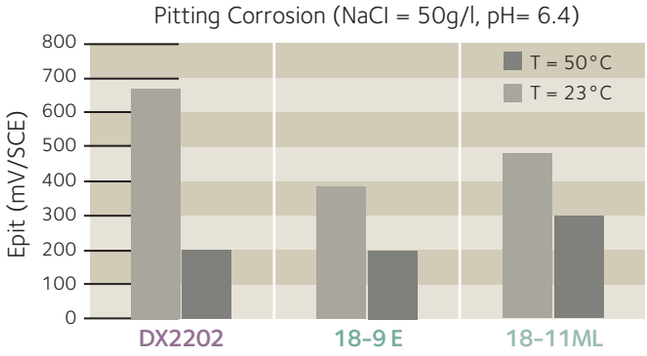

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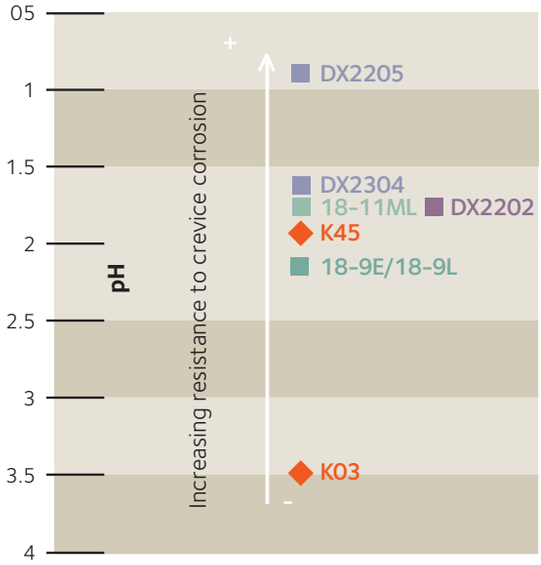

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Welding

The chemical composition of our **DX2202** has been balanced to limit structural changes in the heat affected zone. Therefore there is no need to control minimal welding heat inputs. Neither preheating nor postheating is required. Maximal interpass temperature of 150°C is advised.

Welding process	No filler metal	With filler metal			Shielding gas
	Typical thickness	Thicknesses	Filler metal		
			Rod	Wire	
Resistance: Spot, Seam	< 2 mm < 2 mm				
TIG	< 1.5 mm	> 0.5 mm	W 22 9 3 N L (1) ER2209 (2)		Ar* Ar+ He
PLASMA	< 1.5 mm	> 0.5 mm	W 22 9 3 N L (1) ER2209 (2)		Ar* Ar+ He
MIG		> 0.8 mm		G 22 9 3 N L (1) ER2209 (2)	Argon + 2 % CO_2 Argon + 2 % CO_2 + Helium
S.A.W		> 2 mm		S 22 9 3 N L (1) ER2209 (2)	
Electrode		Repairs	E 22 9 3 N L R		
Laser	< 5 mm				He + N_2

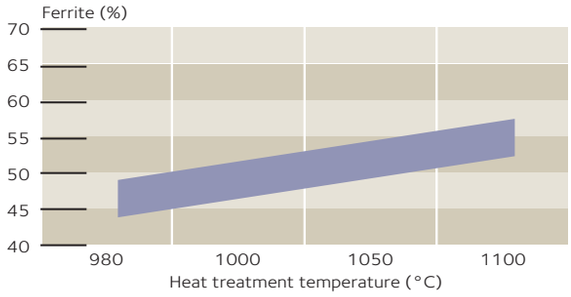
(1) EN ISO 14343 (2) AWS 5.9

* For TIG and MIG with duplex filler metal, and especially for TIG without filler metal, the addition of nitrogen in the shielding gas is recommended to preserve the corrosion resistance in the melting zone (Ar +3%N).

Heat treatment and finishing

Heat treatment

After cold forming, an annealing treatment of a couple of minutes at 1040 +/- 60°C, followed by water quenching or rapid air cooling restores the structure and eliminates internal stresses.



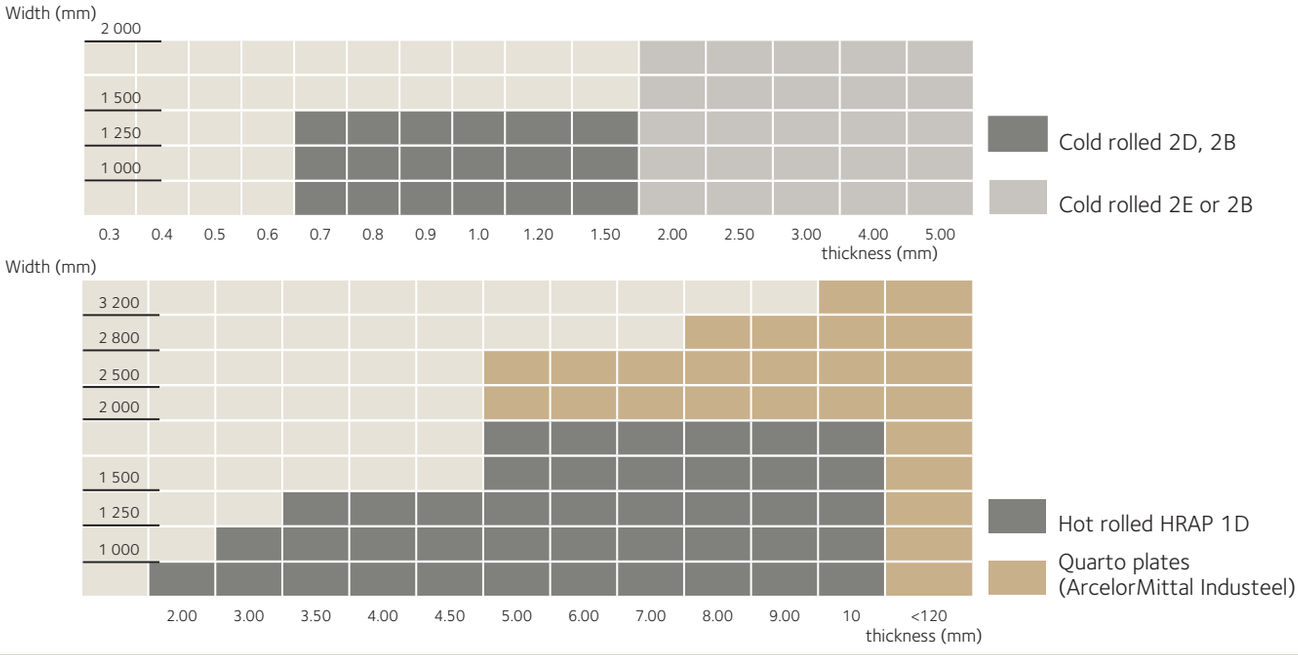
Cooling

The effect of the cooling rate is shown in following table:

Speed (°C/h)	Precipitation	Ferrite Hardness (HV_{10})
2000	no	223
1000	no	223
500	no	224
200	no	228
50	yes	233

Air cooling is acceptable for thicknesses up to 50mm (but faster cooling rates are preferred).

Size range



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