Duplex Stainless Steel

DX2507

Chemical Composition

Elements	C	Cr	Ni	Mo	N
%	<0.025	25.8	6.7	3.5	0.26

Typical values
PREN ≥ 41 (Pitting Resistance Equivalent Number – % Cr+3.3x% Mo+16x% N)

Aperam high quality superduplex stainless steels are characterized by a high PREN (minimum 41%) and the ability to meet the most demanding applications. Superduplex DX2507 with high-PREN is available on demand.

European designation [1]	American designation [2]
X2CrNiMoN25-7-4/ 1.4410	UNS S32750/Type 2507
[1] According to EN 10088-1	[2] According to ASTM A240

These grade complies 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)
- 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 M630 (MDS D55)

Key Features

- **High mechanical properties:** DX2507 has twice the yield strength of austenitic grades, equivalent to that of high strength carbon steel construction grades.
- **High corrosion resistance:** Although comparable to 6% Mo superaustenitic stainless steels, DX2507 offers better resistance to stress corrosion cracking. Superduplex also has a higher localized corrosion resistance than 825 nickel based alloys.
- **Cost efficient material selection:**
  - Optimal material selection, in regards to cost and corrosion risk
  - Optimized design (weight saving, easier erection)
  - Attractive life cycle costs (durability, limited maintenance)

Applications

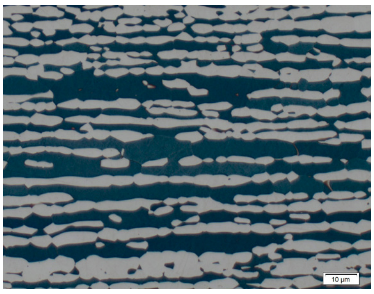
- Seawater desalination: sea water pipes
- Upstream Oil & Gas: flexibles and pipes for offshore wells, umbilicals – Norsok M630 (MDS D55)
- Pollution control
- Chemical processing: pressure vessels and heat exchangers
- Wastewater treatment for all industries: storage tanks, concentrators
- Geothermal applications: heat exchangers

Product Range

Forms: coils, sheets and strips
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

Our DX2507 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. DX2507's chemical composition is designed to target a 50% α / 50% γ microstructure after annealing at 1,040-1,120°C and followed by water cooling.



Example of DX2507 microstructure (ferrite in grey, austenite in white) – no intermetallic phases detected.

DX2507 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. This phenomenon, commonly referred to as 475°C embrittlement, is not unique to DX2507 but is encountered with all ferritic structures.

The different fabrication steps used by Aperam's facilities allow DX2507 to obtain optimal microstructure and close control of the segregation at mid-thickness, thus preventing detrimental intermetallic phase precipitations.

Physical Properties

Density	d	kg/dm³	20°C	7.9
Melting temperature	-	°C	-	1,445
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

Mechanical Properties

In annealed condition at 20°C

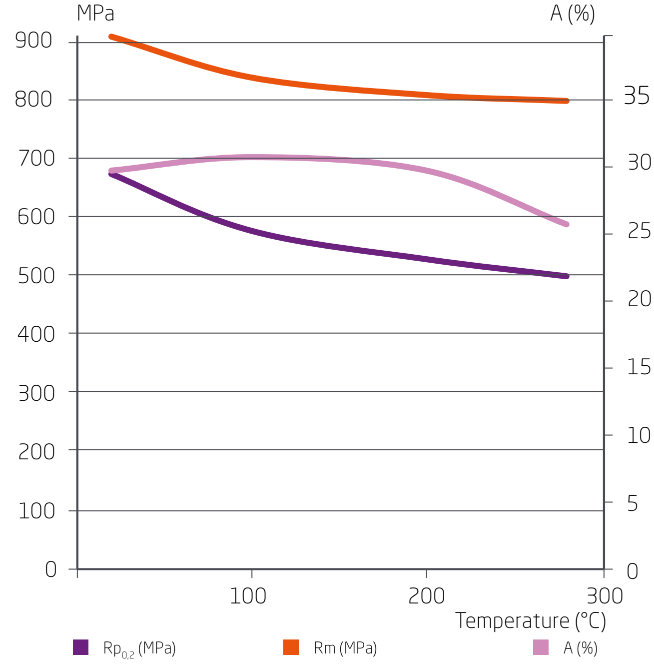
According to ISO 6892-1, transverse direction. Gauge length: 50 mm

Grade	European designation	UNS designation	Rm [1] (MPa)	$Rp_{0.2}$ [2] (MPa)	A [3] %
DX2101	1.4162	S32101	740	550	32
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)

At high temperatures



Typical impact toughness

Temperature (°C)	Kv min.* (J)
20	200
-40	150

*Kv_2 transversal

Corrosion Resistance

Uniform corrosion

Thanks to its high chromium content, DX2507 has a uniform corrosion resistance similar to that of 6% Mo grades.

Intergranular corrosion

Duplex stainless steels exhibit high intergranular corrosion resistance - the result of having a low carbon and high chromium content and the addition of nitrogen.
Like other duplex stainless steels, DX2507 is resistant to intergranular corrosion and satisfies both the Strauss and Huey tests (according to ASTM A262E and A262C respectively).

Pitting corrosion

DX2507's 25.8% chromium, 3.5% Molybdenum and 0.26% nitrogen content means the grade has a pitting corrosion resistance as high as some 6% Mo stainless steels and even higher than some nickel based alloys. To compare relative corrosion resistance, ASTM G48E Critical Pitting Temperatures (CPT) are plotted on the following graph:

Critical Pitting Temperature (°C)

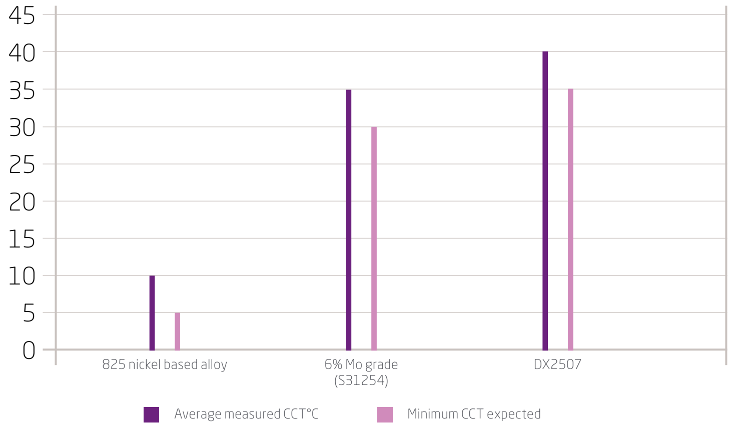
as determined by ASTM G48E

Crevice Corrosion

To compare relative corrosion resistance, ASTM G48F Critical Crevice Temperatures (CCT) are plotted on the following graph:

Critical Crevice Temperature (°C)

as determined by ASTM G48F

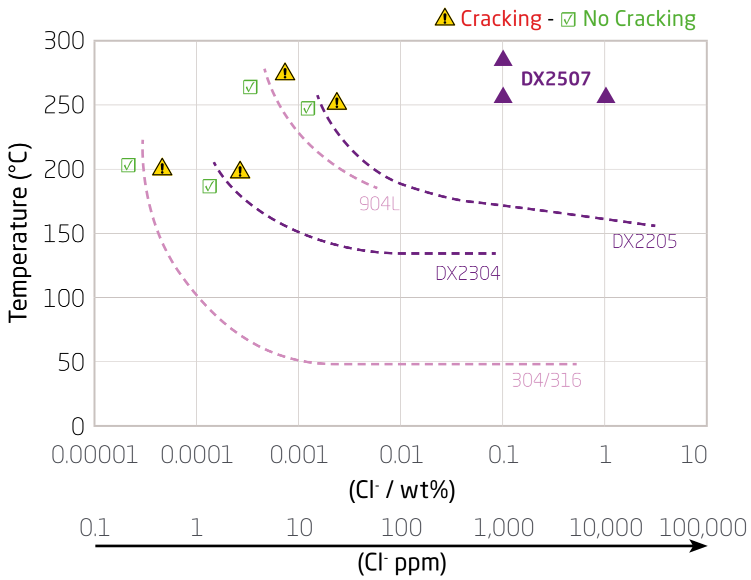


Stress corrosion cracking

Stress Corrosion Cracking (SCC) is a degradation mechanism induced by the combination of three main factors:

- Corrosive environment (aggressiveness of the media)
- Stress on the material (internal stress from fabrication, in-service applied stress, design selection)
- Material's susceptibility (corrosion resistance, microstructure, mechanical properties)

Duplex, and particularly superduplex, are more resistant to stress corrosion cracking than austenitic grades. DX2507 is no exception, exhibiting excellent resistance to chloride-induced SCC. This is illustrated by the following graph. Note that there is no sign of SCC up to 1,000 ppm Cl /250°C and 10,000 ppm Cl /250°C.



In accordance with ISO 15156/NACE MR 0175, solution annealed and liquid quenched wrought DX2507 is suitable for use in Oil & Gas production sour environments at temperatures up to 450°F (232°C), so long as the partial pressure of hydrogen sulphide does not exceed 3 psi (0.20 bar).

DX2507, with a maximum hardness of 32 HRC, and when solution annealed and rapidly cooled, in accordance with NACE MR0103, is suitable for use in sour petroleum refining applications.

Hydrogen Induced Stress Cracking (HISC)

Hydrogen Induced Stress Cracking (HISC) is a failure phenomenon induced by the combination of:

- The presence of hydrogen (e.g. from cathodic protection)
- Stress (loading, notch effect)
- Material (microstructure, mechanical properties)

HISC may occur when hydrogen diffuses into the metal. Hydrogen diffuses much faster in the ferrite phase than in the austenite phase. Therefore, ferritic steels and ferrite containing steels (e.g. duplex stainless steels) are more susceptible to HISC than austenitic stainless steels. High mechanical stress increases the hydrogen diffusion rate, crack initiation and propagation in the material, thus increasing the risk of HISC. In superduplex stainless steels, cracks tend to propagate in the embrittled ferrite phase and arrest at the ferrite-austenite phase boundaries. Susceptibility to HISC significantly increases with increasing austenite spacing. Coarse-grained microstructures are therefore more susceptible, and DNV RP-F112 recommends a maximal austenite spacing of 30 µm.

Thanks to the metallurgical process used to produce hot and cold rolled coils, DX2507 exhibits a fine microstructure and a narrow austenite spacing. Less than 5 µm is a typical value.

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

Forming

This grade can be used for forming applications. However, because its yield strength is significantly higher than that of austenitic grades, the use of presses or section rolling equipment with suitable power is required.

DX2507 tolerates severe cold forming conditions, even with high mechanical properties and limited elongation when compared to austenitic stainless steels.

A bending test is commonly used to evaluate a steel's forming ability. The minimal bending radius is equals to the thickness of the base metal and is 4 times the thickness of the weld.

When the plastic strain exceeds 10% after cold forming, construction code may require the use of heat treatment to restore both corrosion and ductility properties.

In the case of hot forming, heat treatment must be performed.

Welding

DX2507 can be welded using conventional welding processes. To achieve optimal phase balance and properties for the welded joint, appropriate welding parameters must be selected (e.g. welding preparation, shielding and backing gases, filler metals, welding heat input).
General recommendations can be summarized as follows:

Low welding heat input	Moderate welding heat input	High welding heat input
Limits austenite formation in Heat Affected Zone and Weld Metal => higher ferrite content	Balance between microstructure, weld properties and welding condition Interpass temperature at 100°C to limit deleterious precipitation	Allow austenite formation in Heat Affected Zone and Weld Metal => lower ferrite content Risk of intermetallic phase precipitation
Risk of embrittlement in service conditions where hydrogen is present and ferrite content is too high		No risk of hot cracking due to the ferrite solidification

The use of a nitrogen-containing shielding gas is strongly recommended, particularly when no filler metal is used.
The following table illustrates different welding conditions for different welding processes:

Welding process	No filler material	With filler material			Shielding gas Backing gas
	Typical thicknesses	Typical thicknesses	Filler material: Rod	Filler material: Wire	
Resistance: spot, seam	≤ 2 mm				
TIG	≤ 1.5 mm	> 0.5 mm	W 25 9 4 N L [1] ER 25 9 4 L [2]	G 25 9 4 N L [1] ER 25 9 4 L [2]	Ar + 2-3% N_2 (+He)
PLASMA	≤ 1.5 mm	> 0.5 mm	W 25 9 4 N L [1] ER 25 9 4 L [2]	G 25 9 4 N L [1] ER 25 9 4 L [2]	Ar + 2-3% N_2 (+He)
MIG		> 0.8 mm		G 25 9 4 N L [1] ER 25 9 4 L [2]	Ar + 2-3% N_2 + 2% CO_2 or O_2
SAW		> 5 mm		25 9 4 N L [1] ER 25 9 4 L [2]	
FCAW		> 5 mm		25 9 4 N [4] E2553 [2]	Ar + CO_2, CO_2
SMAW		Repairs	E 25 9 4 N L [3] E 2594 [2]		
Laser	≤ 5 mm				N_2 (Ar or He possible)

[1] EN ISO 14343 / [2] AWS 5.9 / 5.4 / [3] EN 1600 / [4] EN 12073

Although pure nitrogen or 90% N_2 + 10% H_2 can be used as backing gas, the use of pure argon or Ar + 2-3% N_2 is more common.
Pre- or post-heating are not useful for duplex grades. Thanks to its high resistance to stress corrosion cracking, post-welding heat treatment is not necessary. In fact, improper conditions could lead to intermetallic phase precipitation.

When welding without filler metal and/or without adding nitrogen in the shielding gas, additional heat treatment is often recommended. When required or needed after welding, it is advised to only use solution annealing with water cooling.
Better corrosion resistance is achieved when the weld is pickled and passivated.

Heat Treatment and Finishing

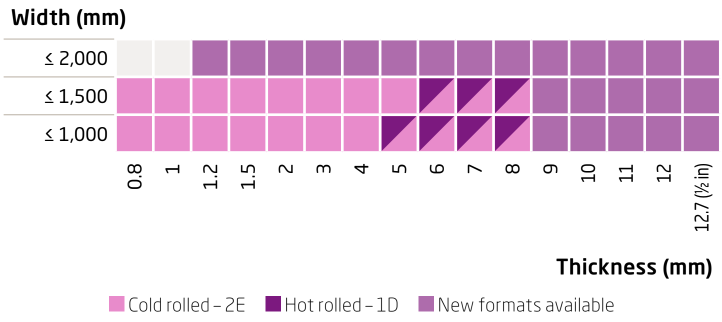
Heat Treatment

After forming, restoration heat treatment may be required. The optimal heat treatment for superduplex stainless steel is solution annealing (1,040 – 1,120°C) followed by rapid cooling (water or air quenching) to avoid σ phase precipitation.
Special attention must be paid to supporting pieces during heating to avoid creep deformation.

Pickling and passivation

The surface of stainless steel is oxidized after welding or heat treatment. However, mechanical cleaning such as brushing, grinding, polishing or blasting, will only partially restore the stainless steel's properties. Maximal corrosion resistance is obtained after pickling and passivation.
Pickling is applied to remove surface oxides, such as weld heat tint or heat treatment scale, and is typically carried out with nitric/hydrofluoric acid solutions.
Due to its high chromium content, it is somewhat harder to remove the heat tint from a duplex grade than from an austenitic grade. A longer exposure to pickling products or to a higher temperature may be required.
Chemical passivation treatments are used to clean the surface of such contamination, as free iron and accelerate the formation of a protective passive film. Stainless steels are typically passivated using nitric acid solutions. It's recommended to use passivation treatments after such fabrication processes such as rolling, bending, blasting, and machining.

Size Range



Please contact us about sizes outside this range.