

## Duplex Stainless Steel

# DX2202

### Chemical Composition

| Elements | C    | Mn   | Cr    | Ni   | Mo   | N    |
|----------|------|------|-------|------|------|------|
| %        | 0.02 | 1.30 | 23.00 | 2.50 | 0.30 | 0.21 |

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

| European designation <sup>(1)</sup>  | American designation <sup>(2)</sup>   |
|--------------------------------------|---------------------------------------|
| X2CrNiN22-2/1.4062                   | UNS S32202/Type 2202                  |
| <sup>(1)</sup> According to EN 10088 | <sup>(2)</sup> According to ASTM A240 |

This 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)
- > 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

- > Good general resistance to corrosion, comparable to 304L at elevated temperature and to 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 and footbridges)
- > Drinking water systems
- > Desalination systems
- > Pulp and paper industry (tanks, cladding used in paper machines)
- > Oil tanks
- > Juice tanks
- > Automotive structures
- > Domestic water heaters

### Product Range

**Forms:** coils, sheets, strips, and discs

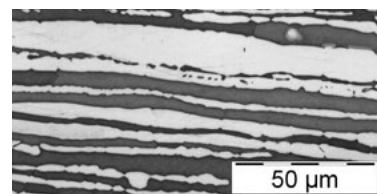
**Thicknesses:** starting from 0.8 mm and up to 12.7 mm

**Width:** up to 2,000 mm (according to thickness)

**Finishes:** hot and cold rolled

### Metallurgical Properties

DX2202 grade of stainless steel contains a mix of ferritic ( $\alpha$ ) and austenitic ( $\gamma$ ) 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 DX2202 has good resistance to both stress corrosion cracking and intergranular corrosion.



DX2202 microstructure (dark areas represent ferritic phase)

DX2202 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  $\alpha'$  phase, possibly accompanied by other embrittling phases. This phenomenon, commonly referred to as 475°C embrittlement, is not unique to DX2202 but is encountered with all ferritic structures.

## Physical Properties

|                                       |   |                      |                      |            |
|---------------------------------------|---|----------------------|----------------------|------------|
| Density                               | d | kg/dm <sup>3</sup>   | 20°C                 | 7.9        |
| Melting temperature                   | - | °C                   | -                    | 1,470      |
| Specific heat                         | c | J/kg.K               | 20°C                 | 490        |
| Thermal conductivity                  | k | W/m.K                | 20°C                 | 15         |
| Mean coefficient of thermal expansion | α | 10 <sup>-6</sup> /K  | 20-200°C<br>20-400°C | 13.5<br>14 |
| Electric resistivity                  | ρ | Ω mm <sup>2</sup> /m | -                    | 0.7        |
| 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 | R <sub>m</sub> <sup>(1)</sup><br>(MPa) | R <sub>p0.2</sub> <sup>(2)</sup><br>(MPa) | A <sup>(3)</sup><br>% |
|---------------|----------------------|-----------------|--|---|-----------------------|
| <b>DX2202</b> | <b>1.4062</b>        | <b>S32202</b>   | <b>710</b>                             | <b>530</b>                                | <b>30</b>             |
| 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/mm<sup>2</sup> / Typical values

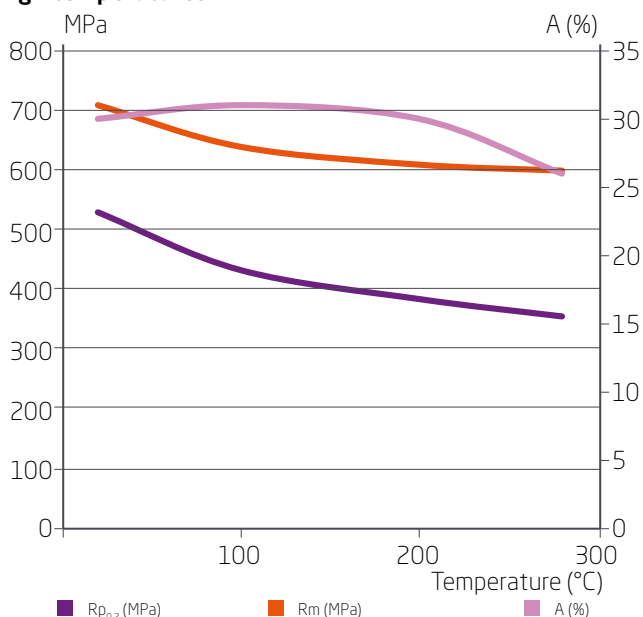
<sup>(1)</sup> Ultimate Tensile Strength (UTS) / <sup>(2)</sup> Yield Strength (YS) / <sup>(3)</sup> Elongation (A)

### Typical impact toughness

| Temperature<br>(°C) | Kv min.*<br>(J/cm <sup>2</sup> ) |
|---------------------|----------------------------------|
| 20                  | 150                              |
| -40                 | 100                              |

\*Kv<sub>2</sub> transversal

### At high temperatures



## Corrosion Resistance

### General corrosion

DX2202 is designed to replace 304 and 304L in most critical applications.

Although DX2202 offers better resistance to pure sulphuric acid than 304L, its resistance level is lower than that of DX2304 and 316L.

DX2202 can also be used in combination with nitric acid.

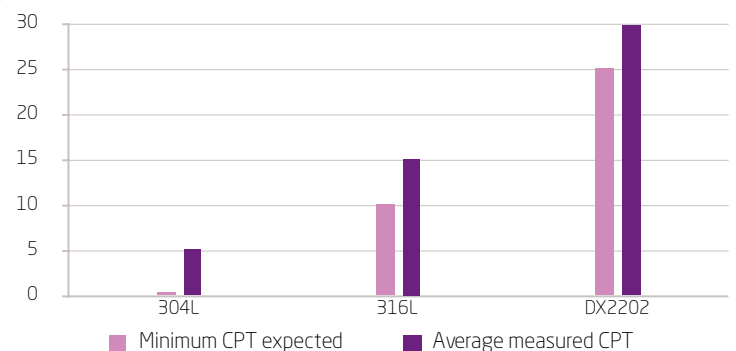
### Pitting corrosion

Generally speaking, DX2202 offers at least the same level of pitting corrosion resistance as 304L. Depending on the environment, DX2202 has a pitting corrosion resistance comparable to that of 316L.

For example, in the case of drinking water systems, the pitting potential is even slightly higher than that of 304L and 316L.

In other environments, such as those rich in sodium chloride, and at different temperatures, DX2202 has a corrosion resistance that is at least comparable to that of 304L, but slightly lower than that of 316L.

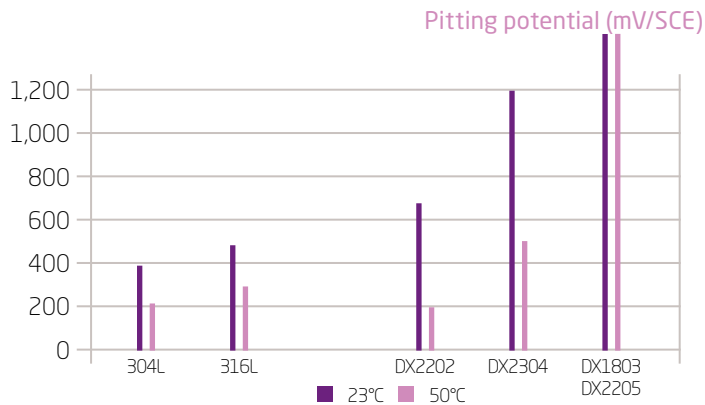
### Critical Pitting Temperature (°C)



## Corrosion Resistance (continued)

### Intergranular corrosion

Like other duplex stainless steels, DX2202 is resistant to intergranular corrosion and satisfies both the Strauss and Huey tests (according to ASTM A262E and A262C respectively).

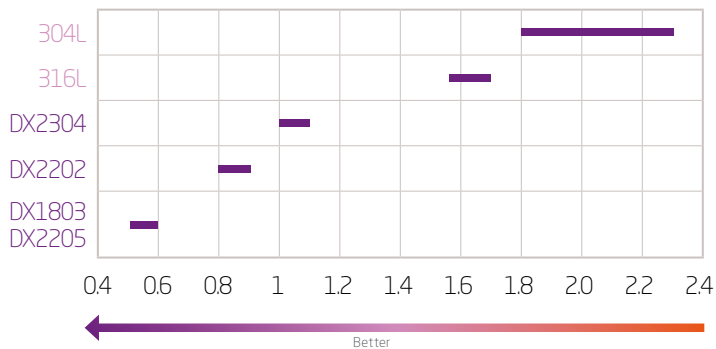


### Crevice corrosion

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



### Atmospheric corrosion resistance

We are currently testing DX2202's atmospheric corrosion resistance.

Although testing is ongoing, initial results place the grade between 304L and 316L. These tests also indicate that this grade is not suitable for use in marine environments.

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

## Forming

### Cold forming

DX2202 is well-suited for cold forming. However, an intermediate full-annealing heat treatment (1,040 - 1,080°C) must be applied whenever cold working deformation exceeds 20%. Such heat treatment is also recommended when cold deformation exceeds 10%. Applying the heat treatment after the last cold forming pass will restore the material's mechanical properties.

### Bending

Compared to 304L, a minimum bending radius must be applied to DX2202. This is due to its higher mechanical properties and lower elongation to rupture. The minimum bending radius must always be at least three times the thickness of the base material and four times the thickness whenever welded assembly is used.

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

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

## Welding

DX2202'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 any 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.
- > DX2202'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.

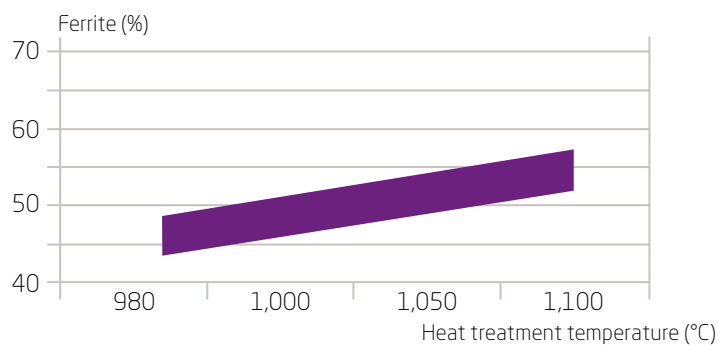
## Welding (continued)

| Welding process           | No filler material  | With filler metal   |  |  | Shielding gas<br>Backing gas                                    |
|---------------------------|---------------------|---------------------|--|--|---|
|                           | Typical thicknesses | Typical thicknesses | Filler material  |  |   |
|                           |                     |                     | Rod  | Wire   |   |
| Resistance:<br>spot, seam | ≤ 2 mm              |                     |  |  |   |
| TIG                       | ≤ 1.5 mm            | > 0.5 mm            | W 23 7 N L or W 22 9 3 N L <sup>(1)</sup><br>ER2209 <sup>(2)</sup> | G 23 7 N L or G 22 9 3 N L <sup>(1)</sup><br>ER2209 <sup>(2)</sup> | Ar + 2-3% N <sub>2</sub><br>Ar, Ar+ He                          |
| PLASMA                    | ≤ 1.5 mm            | > 0.5 mm            |  |  | Ar + 2-3% N <sub>2</sub><br>Ar, Ar+ He                          |
| MIG                       |                     | > 0.8 mm            |  | G 23 7 N L or G 22 9 3 N L <sup>(1)</sup><br>ER2209 <sup>(2)</sup> | Ar + 2-3% N <sub>2</sub> + 2% CO <sub>2</sub> or O <sub>2</sub> |
| SAW                       |                     | > 5 mm              |  | S 23 7 N L or S 22 9 3 N L <sup>(1)</sup><br>ER2209 <sup>(2)</sup> |   |
| SMAW                      |                     | Repairs             | E 22 9 3 N L R <sup>(1)</sup><br>ER2209 <sup>(2)</sup>             |  |   |
| Laser                     | ≤ 5 mm              |                     |  |  | N <sub>2</sub> (Ar or He possible)                              |

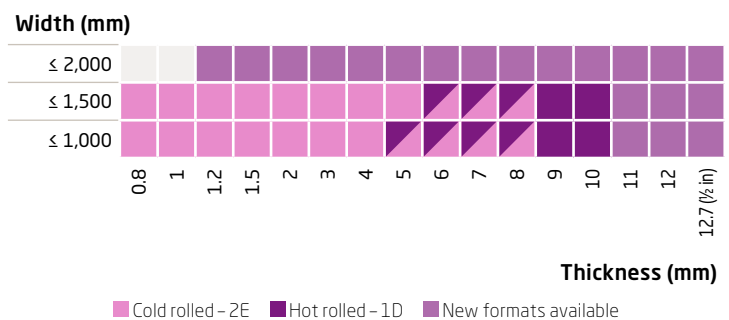
<sup>(1)</sup> EN ISO 14343 - <sup>(2)</sup> AWS 5.9

## Heat Treatment

After cold forming, applying an annealing treatment for a few minutes at 1,040 ±60°C, followed by water quenching or rapid air cooling, will restore the structure and eliminate internal stresses.



## Size Range



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Aperam Stainless Europe