



Duplex 2205

(UNS S32205 / UNS S31803 / 1.4462)

2205 duplex stainless steel is the most mainstream and widely adopted duplex grade, accounting for around 60% of global duplex stainless steel consumption. It is nitrogen & molybdenum alloyed dual-phase stainless steel, with balanced microstructure of roughly 50% austenite and 50% ferrite after proper solution annealing. This alloy integrates core strengths of ferritic and austenitic stainless steels: high mechanical strength, outstanding chloride corrosion resistance, and reliable stress corrosion cracking resistance. Its overall corrosion performance matches grade 904L, and outperforms standard 316L & 317L austenitic stainless steels. The yield strength is nearly double that of regular austenitic stainless grades, which allows thinner wall design for pressure-bearing equipment and cuts long-term material cost.

Standard operating temperature window: -50°C to 300°C . Service above 300°C will trigger material embrittlement; temperature below -50°C leads to declined low-temperature ductility, so out-of-range service is not recommended.



Chemical Composition (Mass Fraction, %)

Element	C	Mn	Si	P	S	Cr	Mo	Ni	N
2205 Duplex	≤0.030	≤2.00	≤1.00	≤0.030	≤0.020	22.0–23.0	3.0–3.5	4.5–6.5	0.14–0.20

Mandatory Mechanical Properties (National Standard Requirement)

Item	Standard Value
Minimum Tensile Strength	655 MPa
Minimum 0.2% Offset Yield Strength	485 MPa
Minimum Elongation	25%
Maximum Hardness	30 HRC

Equivalent Material Grades

Standard System	Grade Mark
UNS	S32205, S31803
DIN / Werkstoff Nr.	1.4462
EN Standard	X2CrNiMoN 22-5-3
JIS	SUS 329J3L
GB National Standard	00Cr23Ni5Mo3N



Core Material Advantages

1. Ultra-high yield strength: Around twice the yield strength of 304, 316L austenitic stainless steel, enables lightweight structural design and reduces material weight & cost for pressure vessels, piping and equipment.
2. Superior localized corrosion resistance: Excellent resistance to pitting, crevice corrosion, intergranular corrosion, erosion corrosion and corrosion fatigue in chloride-rich media.
3. Strong anti-SCC performance: Resists stress corrosion cracking under chloride and hydrogen sulfide containing environments, far better than conventional austenitic grades.
4. Balanced low-temperature toughness: Better ductility than ferritic & martensitic stainless steel at sub-zero temperature, stable service down to -50°C.
5. Good weldability: Compatible with all mainstream welding processes, low thermal expansion minimizes welding distortion and residual stress.
6. Comparable seawater resistance to 904L, cost more competitive than high-alloy austenitic stainless steel in marine & offshore projects.

Corrosion Resistance Performance

- General corrosion: Outperforms 316L and 317L in most acidic, saline and industrial process media.
- Pitting & crevice corrosion: High PREN value (~35), reliable service in brackish water, seawater and chloride-contaminated process liquid.
- Stress Corrosion Cracking (SCC): Immune to chloride-induced SCC up to 150°C; excellent anti-SCC performance in sour oil & gas media with H₂S.
- Erosion & corrosion fatigue: Suitable for fluid conveying equipment with high flow velocity and solid particle scouring.

Heat Treatment Guide

- Solution annealing temperature range: 1020°C ~ 1100°C
- Cooling requirement: Rapid water or air quenching after holding to maintain balanced austenite-ferrite dual phase structure.
- Hardening note: Cannot be hardened via heat treatment; work hardening occurs under cold forming operations.
- High temperature limit: Long-term service above 300°C will cause material embrittlement and sharp drop of impact toughness.

Machining & Fabrication Features

Machining Performance

- Poor machinability compared with 304; recommended cutting speed is about 20% lower than 304 stainless steel.
- High strength and hardness lead to faster tool wear; rigid machine equipment and dedicated cutting tools are required for stable processing.

Cold Forming & Bending

- Lower ductility than austenitic stainless grades; cold heading is not feasible without intermediate annealing.
- Bending and forming need heavy-duty forming equipment to overcome high yield strength.
- Surface is prone to scratches and abrasion during processing; protective covering is required to avoid surface damage that weakens corrosion resistance.

Product Forms & Corresponding Industrial Standards

Product Form	Executed Standards
Seamless Tube	EN 10216-5, NFA 49-217, ASTM A789 / SA789
Welded & Seamless Pipe	ASTM A790 / SA790
Plate, Sheet & Strip	ASTM A240 / SB240, ASTM A480, EN 10088-2
Bar & Section Shapes	ASTM A276, A479, EN 10088-3
Forged Billets, Flanges, Valves & Pipe Fittings	ASTM A182, A815, EN 10088-3

Typical Industrial Applications

- Oil & gas upstream & downstream: Offshore platform equipment, sour well pipelines, flowlines, separators, heat exchangers
- Chemical processing industry: Reaction vessels, scrubbers, acid & salt storage tanks, process piping
- Marine & coastal engineering: Seawater heat exchangers, desalination equipment, marine pump bodies, underwater piping
- Pulp & paper mills: Digester tanks, liquor storage vessels, paper machine components
- Wastewater treatment: Chloride-rich sewage treatment tanks, aeration piping
- General heavy industry: High-strength pressure vessels, structural components exposed to corrosive atmosphere



Limitations & Disadvantages

1. Higher production & processing cost: Contains high nickel, molybdenum precious alloy elements; complex smelting and heat treatment raise overall material cost, less competitive for cost-sensitive low-corrosion projects.
2. Limited forming capacity: Lower plasticity than austenitic stainless steel, cold forming operations require intermediate annealing and heavy-duty equipment.
3. Strict welding control: Improper gas protection, excessive interpass temperature or unfitted filler metal causes phase separation, reducing mechanical strength and corrosion resistance of weld joints.
4. Narrow service temperature range: Long-term use over 300°C leads to embrittlement; low-temperature ductility declines sharply below -50°C.
5. Surface vulnerability: Susceptible to scratch and abrasion during transportation & fabrication; damaged surface film accelerates local corrosion, requiring strict surface protection and regular maintenance.

Comparison: 2205 Duplex VS 316L Austenitic Stainless Steel

Chemical Difference

- 2205: 22–23% Cr, 3.0–3.5% Mo, 4.5–6.5% Ni, 0.14–0.20% N, dual ferrite-austenite microstructure
- 316L: 16–18% Cr, 2.0–3.0% Mo, 10–14% Ni, low carbon single austenite phase, no nitrogen alloying

Performance Gap

1. Corrosion resistance: 2205 far exceeds 316L under high chloride, seawater, H₂S sour media; 316L suffers severe pitting & SCC in concentrated chloride environments.
2. Mechanical strength: 2205 yield strength is nearly double 316L, supporting lightweight design for pressure components.
3. Fabrication: 316L features excellent ductility, easy cold bending & deep drawing; 2205 needs higher forming tonnage and extra annealing for complex cold forming.
4. Price: 2205 raw material and processing cost are higher than 316L.

Selection Guidance

Choose 2205 duplex stainless steel if your project meets any of the below conditions:

- Long-term exposure to seawater, brackish water or high-concentration chloride solutions
- Service media containing hydrogen sulfide (sour oil & gas, chemical waste liquid)
- Equipment requiring high mechanical strength and thin-wall lightweight design
- Process environments prone to pitting, crevice corrosion and stress corrosion cracking
- Applications where 304 / 316L austenitic stainless steel suffers premature corrosion failure



Do not select 2205 for:

- Continuous service temperature above 300°C or below -50°C
- Mass cold stamping, deep drawing and mass cold heading production
- Low-corrosion indoor environments with strict cost control requirements

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