

DUPLEX 2205

Chemical Composition & Technical Datasheet

UNS S32205 / EN 1.4462 / S31803

GNEE STEEL

Professional Duplex Stainless Steel Supplier

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What is Duplex 2205?

Duplex 2205 (UNS S32205 / EN 1.4462), also known as SAF 2205, is the most widely used grade of duplex stainless steel. It features a two-phase microstructure consisting of approximately equal parts of **ferrite (α)** and **austenite (γ)**, combining the best properties of both ferritic and austenitic stainless steels.

This dual-phase structure gives Duplex 2205 its unique combination of high strength, excellent corrosion resistance, and good toughness — making it a cost-effective alternative to more expensive super-austenitic grades in many applications.

Key Characteristics

■ High Strength

Approximately twice the yield strength of austenitic stainless steels like 316L, enabling thinner, lighter, and more cost-effective designs.

■ Excellent Corrosion Resistance

Superior resistance to pitting, crevice corrosion, stress corrosion cracking (SCC), and general corrosion in chloride-containing environments.

■ Good Weldability

Can be welded by most common methods while maintaining good corrosion resistance and mechanical properties.

■ Cost Effective

Lower nickel content compared to austenitic grades (316L, 904L), offering better price stability and cost advantages.

Designation Standards

Standard	Designation
UNS	S32205 / S31803
EN / DIN	1.4462 (X2CrNiMoN22-5-3)
ASTM / ASME	A240, A790, A789, A923, A276, A479
JIS	SUS329J3L / SUS329J4L
ISO / NACE	ISO 15156-3 / NACE MR0175
Werkstoff	1.4462



Duplex S32205 Seamless Pipe — EN10216-5 / 1.4462

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Chemical Composition

Duplex 2205 has a precisely balanced chemical composition that creates the dual ferritic-austenitic microstructure and delivers its unique combination of properties. High chromium, molybdenum, and nitrogen content provide excellent corrosion resistance, while controlled nickel content stabilizes the austenite phase.

Element	Symbol	Min (%)	Max (%)	Typical (%)
Carbon	C	—	0.030	0.020
Silicon	Si	—	1.00	0.45
Manganese	Mn	—	2.00	1.20
Phosphorus	P	—	0.030	0.025
Sulfur	S	—	0.015	0.002
Chromium	Cr	21.0	23.0	22.0
Nickel	Ni	4.5	6.5	5.5
Molybdenum	Mo	3.0	3.5	3.2
Nitrogen	N	0.14	0.20	0.17
Copper	Cu	—	0.75	0.20
Iron	Fe	—	Balance	Balance

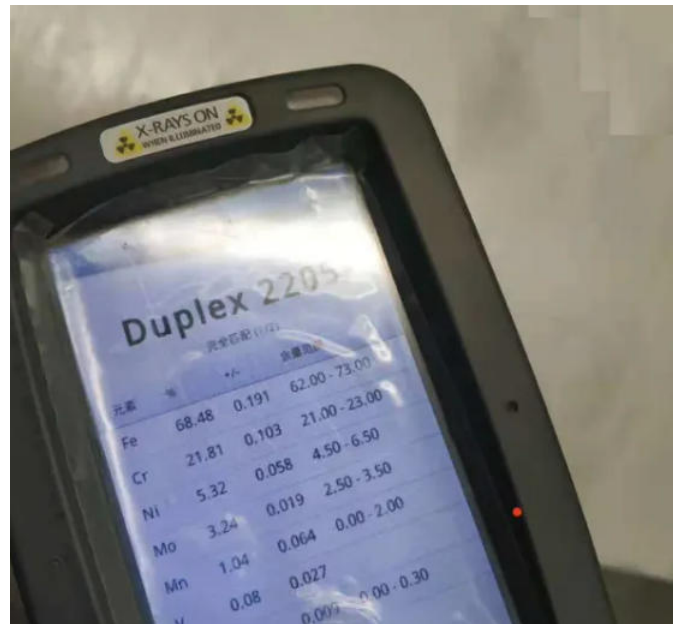
Pitting Resistance Equivalent Number (PREN)

$$\text{PREN} = \% \text{Cr} + 3.3 \times \% \text{Mo} + 16 \times \% \text{N}$$

Typical PREN value for Duplex 2205: **35 – 40**

The PREN value is a widely accepted indicator of a stainless steel's resistance to localized pitting corrosion in chloride environments. Duplex 2205's PREN is significantly higher than 316L (~24) and approaches that of super-austenitic grades.

XRF Composition Analysis



Portable XRF analyzer verifying Duplex 2205 chemical composition

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Mechanical Properties

Duplex 2205 exhibits outstanding mechanical properties, with yield strength approximately twice that of conventional austenitic stainless steels (304/316L). This high strength-to-weight ratio allows for significant material savings in structural and pressure-containing applications.

Property	Symbol	Min. Required	Typical Value	Unit
Yield Strength (0.2%)	Rp0.2	450	550	MPa
Tensile Strength	Rm	655	760	MPa
Elongation (A50)	A	25	40	%
Hardness	HB	—	215	HB
Hardness	HRC	≤ 30	22	HRC
Modulus of Elasticity	E	—	200	GPa
Poisson's Ratio	ν	—	0.30	—
Fatigue Strength	—	—	300	MPa
Impact Energy (V-notch, 20°C)	KV	100	250	J

Temperature Effects

Duplex 2205 maintains good strength at elevated temperatures up to approximately 300°C, and exhibits reasonable toughness down to about -50°C. It is not recommended for cryogenic service below -40°C due to the ferrite phase's ductile-brittle transition behavior.

质量证明书编号 (Certificate No.):202606047					合同号 (Contract No.) :					特种设备制造许可证编号: Manufacture License of Special Equipment:					TS2733007-2027				
产品名称 (commodity): 双相钢不锈钢无缝钢管 DUPLEX SEAMLESS STAINLESS STEEL PIPE					报告日期 (Date of Report): 2026/6/15					ISO9001:证书编号: ISO9001: Certificate No.					20225420340R1M				
产品标准 (Specification): ASTM A790					购买方 (Purchaser):					交货条件 Delivery Condition					固溶酸洗 Annealed,pickling				
钢 号 Grade	炉 号 Heat No.	批 号 Lot No.	规格 Size(mm)	支数 Pieces	重量 Weight (kg)	化 学 成 分 Chemical Constitution (%)													
						C	Si	Mn	P	S	Ni	Cr	Mo	Cu	N	Ti	Nb	Fe	
UNS S31803	FK2601-099	XTD-26053101	168.3*13.0*6000	3	943	0.02	0.449	1.27	0.026	0.001	4.65	22.6	3.06	0.19	0.179	/	/	/	
机械性能 Mechanical properties																			
测试项目 Test Items	屈服点 Yield Point (MPa)	抗拉强度 Tensile Strength (MPa)	延伸率 Elongation A.% (50mm)	硬度值 Hardness (HRC)	铁素体含量 Fe%	压扁试验 Flattening Test	扩口试验 Flaring Test	晶间腐蚀 Corrosion test	水压试验 HT	涡流探伤 ET	超声波探伤 UT								
要求 Requirements	≥450	≥655	≥25%	≤30	ASTM E562	ASTM A1016	ASTM A1016	ASTM A262	ASTM A1016	ASTM E426	ASTM E213								
	503	701	45%	18	47%	合格OK	/	合格OK	合格OK	/	/								
测试结果 Test Results																			
备注 Remark													质量管理部门印章 QC STAMP						
兹确认本证明书所列材料完全按照上述技术的要求进行制造与检验，并满足订货合同规定。 We hereby certify that material described here in has been made and tested completely in accordance with the above specification, and with the requirements of purchase or contract.												制单人 Prepared By		审核人 Approved By					
												陈浩南		张波					

Material Test Certificate (MTC) — actual production test results

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Physical Properties

Property	Value	Unit	Condition
Density	7.80	g/cm³	20°C
Melting Range	1420 – 1460	°C	Solidus – Liquidus
Specific Heat Capacity	450	J/kg·K	20°C
Thermal Conductivity	19	W/m·K	20°C
Thermal Expansion	13.7 × 10 ⁻⁶	m/m·K	20 – 300°C
Electrical Resistivity	0.85	μΩ·m	20°C
Magnetic Permeability	Ferromagnetic	—	Ferritic phase
Poisson's Ratio	0.30	—	20°C

Key Notes

■ Thermal Expansion

Lower coefficient of thermal expansion (~13.7 × 10⁻⁶/°C) compared to austenitic stainless steels (~16 × 10⁻⁶/°C), beneficial for thermal cycling applications.

■ Thermal Conductivity

Higher than austenitic grades (316L ~15 W/m·K), improving heat transfer efficiency.

■ Magnetic Properties

Due to the ferritic phase, Duplex 2205 is ferromagnetic, unlike fully austenitic grades.

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Corrosion Resistance

Duplex 2205 provides excellent corrosion resistance in a wide range of aggressive environments. Its high chromium, molybdenum, and nitrogen content gives it superior resistance to pitting, crevice corrosion, stress corrosion cracking (SCC), and uniform corrosion compared to standard austenitic stainless steels like 316L.

Corrosion Resistance Comparison

Corrosion Type	Duplex 2205	SS 316L	Alloy 904L
Pitting Corrosion	★★★★■	★★■■■	★★★★■
Crevice Corrosion	★★★★■	★★■■■	★★★★■
Stress Corrosion Cracking	★★★★★	★★■■■	★★★ ■■
General Corrosion	★★★★■	★★★ ■■	★★★★★
Intergranular Corrosion	★★★★★	★★★★■	★★★★■
Acid Resistance	★★★★■	★★■■■	★★★★■

Critical Pitting Temperature (CPT)

According to ASTM G48 Method A, the critical pitting temperature of Duplex 2205 is typically **35°C or higher** in 6% FeCl₃ solution — significantly higher than 316L (approximately 5–10°C).

Suitable Environments

- ✓ Seawater and brackish water environments
- ✓ Chloride-containing process streams
- ✓ Flue gas desulfurization (FGD) systems
- ✓ Pulp and paper processing (bleaching, digesters)
- ✓ Chemical processing (acids, alkalis, solvents)
- ✓ Oil and gas production (sour service)
- ✓ Food and beverage processing
- ✓ Desalination plants (RO, MSF)

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Applications

Duplex 2205 is used across a wide range of industries where both high strength and excellent corrosion resistance are required. Its unique combination of properties makes it ideal for demanding applications where standard stainless steels would fail.

Industry	Applications
Oil & Gas	Pipeline systems, separators, heat exchangers, subsea components, process piping, valves, pumps
Chemical Processing	Reactors, storage tanks, heat exchangers, pumps, agitators, piping systems, columns
Desalination	RO pressure vessels, heat exchangers, piping, pumps, evaporators, brine systems
Pulp & Paper	Digester components, bleaching equipment, pumps, piping, recovery boilers, liquor tanks
Power Generation	Flue gas desulfurization (FGD) systems, cooling water systems, heat exchangers, condensers
Food & Beverage Processing	Processing equipment, storage tanks, piping, heat exchangers, fermenters, evaporators
Marine / Shipbuilding	Propeller shafts, rudder stocks, seawater systems, deck equipment, hull structures
Mining & Minerals	Process vessels, piping, pumps, valves, hydrocyclones, flotation cells
Pharmaceutical	Process equipment, reactors, clean-in-place systems, sterile piping
Water Treatment	RO systems, filter housings, piping, valves, pump components, disinfection systems

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Weldability

Duplex 2205 has good weldability and can be welded by most conventional welding processes. However, proper welding procedures are critical to maintain the balanced ferrite-austenite microstructure in the weld and heat-affected zone (HAZ), which is essential for preserving corrosion resistance and mechanical properties.

Welding Processes

- GTAW / TIG — Gas Tungsten Arc Welding
- GMAW / MIG — Gas Metal Arc Welding
- SMAW / MMA — Shielded Metal Arc Welding
- SAW — Submerged Arc Welding
- PAW — Plasma Arc Welding
- FCAW — Flux-Cored Arc Welding
- Resistance Welding

Filler Metals

Process	Filler Metal	UNS No.
GTAW / GMAW	ER2209 (22.8Cr-8.5Ni-3.2Mo-0.17N)	S32209
SMAW	E2209-16 / E2209-17	W32209
SAW	EB2209 + Matching Flux	—

Key Welding Guidelines

- Preheat is generally not required unless thickness > 25mm or ambient temperature < 5°C
- Interpass temperature should be kept below 250°C to avoid excessive ferrite formation
- Use higher heat input than austenitic stainless steels (0.5 – 2.0 kJ/mm recommended)
- Post-weld heat treatment (PWHT) is generally not required for most applications
- For maximum corrosion resistance: solution annealing at 1050 – 1100°C followed by rapid cooling
- Back-purging with argon or nitrogen is recommended for root passes to prevent oxidation

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Strength & Fatigue Resistance

One of the most significant advantages of Duplex 2205 over austenitic stainless steels is its high strength. With a minimum yield strength of 450 MPa (about twice that of 316L), Duplex 2205 allows for thinner wall sections, reduced weight, and significant cost savings in structural and pressure-containing applications.

Strength Comparison (Room Temperature)

Material	Yield Strength (MPa)	Tensile Strength (MPa)	Elongation (%)
Duplex 2205	≥ 450	≥ 655	≥ 25
SS 316L	≥ 170	≥ 485	≥ 40
SS 304L	≥ 170	≥ 485	≥ 40
Super Duplex 2507	≥ 550	≥ 800	≥ 25
Alloy 904L	≥ 220	≥ 490	≥ 35

Fatigue Resistance

Duplex 2205 exhibits excellent fatigue resistance due to its high strength and dual-phase microstructure. The fatigue limit (endurance limit) at 10⁷ cycles is approximately 300 MPa at room temperature — significantly higher than austenitic stainless steels (316L: ~150–200 MPa).

High-Temperature Strength

Duplex 2205 maintains good mechanical properties at elevated temperatures. However, prolonged exposure above 300°C can lead to the formation of harmful intermetallic phases (sigma phase, chi phase, etc.), which reduce both toughness and corrosion resistance. Continuous service temperature is generally limited to 250 – 300°C depending on the application and required design life.

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Machinability & Formability

Machinability

Duplex 2205 is more difficult to machine than standard austenitic stainless steels due to its higher strength and work hardening rate. However, with proper tooling and machining parameters, excellent results can be achieved.

Machining Aspect	Recommendation
Tool Material	Coated carbide (TiAlN/TiCN), Cermet, or CBN for high-speed machining
Cutting Speed	Lower than 316L by 20–30%: 50–100 m/min for carbide tools
Feed Rate	Moderate feed rates to avoid excessive work hardening
Coolant	Adequate coolant supply (emulsion or synthetic) for heat dissipation
Rigidity	Rigid setups to minimize chatter and vibration
Tool Sharpness	Maintain sharp cutting edges to reduce work hardening

Formability

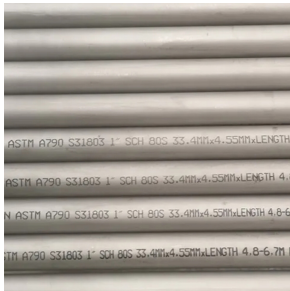
Duplex 2205 has good formability, though not as ductile as austenitic stainless steels. It can be successfully formed by most conventional cold and hot forming processes. The higher yield strength requires greater forming force compared to 304/316L.

- **Cold Forming:** Possible for bending, deep drawing, and roll forming. Higher springback than austenitic steels must be considered.
- **Hot Forming:** Recommended for severe forming operations. Temperature range: 950 – 1150°C. Solution annealing after hot forming is recommended.
- **Bending:** Minimum bend radius of 3–5× thickness for cold bending, depending on thickness and direction.
- **Stretch Forming:** Uniform elongation is about 30–40% at room temperature.

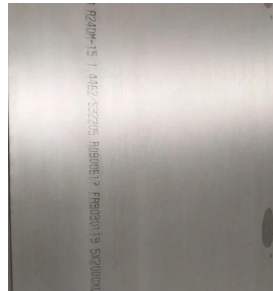
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Products Available from GNEE

GNEE is a professional supplier of Duplex stainless steel products. We supply a comprehensive range of Duplex 2205 (S32205/S31803/1.4462) products in various forms and specifications, sourced from reputable mills including TISCO, Tsingshan, Baosteel, and others. All products are supplied with full Mill Test Certificates (MTC) and quality assurance.



Seamless Pipe (ASTM A790
S31803)



Steel Plate (S32205 / 1.4462)



Round Bar (S32205)

Product Range

Product Type	Standards	Specifications
Seamless Pipe	ASTM A790 / A789 EN 10216-5	OD: 6 – 610 mm WT: 1 – 40 mm Length: up to 12m
Welded Pipe	ASTM A790 / A928 EN 10217-7	OD: 21.3 – 2000 mm WT: 1.5 – 40 mm
Steel Plate / Sheet	ASTM A240 / A480 EN 10088-4	Thickness: 0.5 – 80 mm Width: up to 2000 mm Length: up to 12000 mm
Round Bar / Rod	ASTM A276 / A479 EN 10088-3	Diameter: 6 – 300 mm Length: 3 – 6m (or custom)
Flat Bar / Angle	ASTM A276 EN 10088-3	Custom sizes available
Forged Fittings	ASTM A182 / A815 EN 10222-5	Elbows, tees, reducers, flanges, couplings, etc.
Flanges	ASTM A182 / ASME B16.5 EN 1092-1	Weld Neck, Slip On, Blind, Threaded, Socket Weld
Wire / Wire Rod	ASTM A580 / A313 EN 10088-3	Diameter: 0.5 – 20 mm
U-tube / Coil Tube	ASTM A789 / A803	Custom sizes available

Custom sizes and specifications available upon request. Contact our technical team for specific requirements and quotations.

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Certificates & Quality Assurance

At GNEE, quality is our top priority. All Duplex 2205 products are manufactured in strict accordance with international standards and undergo comprehensive quality inspection before delivery. We provide full traceability from raw material to finished product.

Certificate / Standard	Description
ISO 9001:2015	Quality Management System Certification
ISO 14001	Environmental Management System
PED 97/23/EC	Pressure Equipment Directive (EU)
TÜV / DNV	Third-party inspection and certification
Mill Test Certificate 3.1 / 3.2	EN 10204 certified test reports
NACE MR0175 / ISO 15156	Sour service certification
ASTM A923	Intermetallic phase detection
PMI (Positive Material ID)	100% XRF verification available
Hydrostatic Test	Standard for all pipe products
Eddy Current / Ultrasonic Test	ET / UT testing per applicable standards



TISCO Mill Test Certificate for S32205 Hot Rolled Plate

Quality Control Process

- ✓ Raw Material Inspection & Certificate Verification
- ✓ Chemical Composition Analysis (Spectrometer / OES)

- ✓ Mechanical Property Testing (Tensile, Impact, Hardness)
- ✓ Non-Destructive Testing (UT, ET, PT, MT)
- ✓ Dimensional & Visual Inspection
- ✓ Corrosion Testing (ASTM A262, G48)
- ✓ Microstructure Examination & Ferrite Content Testing
- ✓ Final Inspection & Documentation

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Packaging & Delivery

GNEE provides professional packaging solutions to ensure your Duplex 2205 products arrive in perfect condition. We offer various packaging options to meet different transportation requirements and customer preferences.

Packaging Options

Product	Packaging Method
Pipes / Tubes	Bundled with PVC end caps, woven cloth or plastic film wrap, wooden pallets or cases, seaworthy packaging
Plates / Sheets	On wooden pallets with moisture-proof paper, steel strap binding, PVC film wrapping, edge protectors
Bars / Rods	Steel strap bundled (hexagonal/square), wooden pallets, anti-rust oil coating
Fittings / Flanges	Wooden cases, foam padding, individual wrapping, desiccant for sea transport
Wire / Coil	Spool / coil packaging, plastic wrapping, wooden pallets or reels

Packaging Features

- Rust and corrosion protection during transit
- Mechanical damage prevention (edge protectors, padding)
- Waterproof / moisture-proof packaging for sea freight
- Fumigation-free wooden pallets (ISPM 15 compliant)
- Custom marking and labeling per customer requirements
- End caps for pipe protection
- Individual packing and labeling for easy identification

Marking Information

Each product is clearly marked with: grade, standard, size, heat/lot number, manufacturer logo, and specification. Additional marking available per customer request.

Delivery & Shipping

- **Lead Time:** Standard stock items: 3–7 days; Custom/production orders: 15–45 days
- **Shipping Ports:** Shanghai, Ningbo, Qingdao, Tianjin, Guangzhou (China)
- **Transportation:** Sea freight (FCL/LCL), Air freight, Express courier, Railway (China-Europe)
- **Trade Terms:** EXW, FOB, CIF, CFR, DDP, DAP
- **Payment Terms:** T/T, L/C at sight, Western Union, Trade Assurance

GNEE STEEL

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Your Reliable Partner for Special Steel Solutions

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