

Stainless Steel 2507 (Super Duplex)

Grade 2507 | UNS S32750 | W.Nr. 1.4410 | EN X2CrNiMoN25-7-4

Grade 2507

Grade 2507 is a super duplex (austenitic-ferritic) stainless steel, combining very high mechanical strength with exceptional corrosion resistance. Its duplex microstructure - an approximate 50/50 mix of austenite and ferrite - gives it very high resistance to general corrosion and to pitting and crevice corrosion in high chloride, hot environments, together with excellent resistance to stress corrosion cracking. Like other duplex (ferritic/austenitic) grades the super duplex grades are not suitable for high or low temperature service. 2507 is not recommended for temperatures below -50°C or above +300°C, because of reduced toughness outside this range. The high strength favours applications in pressure vessels and for marine and other shafts. The grade is available as plate, sheet, strip, bar, wire, seamless and welded pipe/tube, forgings and castings.

Corrosion Resistance

Grade 2507 has excellent general corrosion resistance, superior to virtually all other stainless steels. It has high resistance to intergranular corrosion and very high resistance to stress corrosion cracking in both chloride and sulphide environments. A PRE (Pitting Resistance Equivalent) of at least 40 indicates that the material has good pitting and crevice corrosion resistance to warm sea water and other high chloride environments; it is rated as more resistant than grade 904L and approximating that of the 6% Molybdenum "super austenitic" grades. The high chromium, molybdenum and nitrogen content also provides good resistance to organic acids (e.g. formic and acetic acid) and to chloride-bearing inorganic acids such as dilute hydrochloric acid. 2507 is the grade of choice for severe high temperature marine environments and for chemical and petrochemical processing, even including some solutions of strong acids.

Heat Resistance

Although super duplex grades have good high temperature oxidation resistance, like other duplex stainless steels they suffer from embrittlement if held for even short times at temperatures above 300°C (prolonged exposure above 250°C causes microstructural change and a reduction in impact toughness). If grade 2507 becomes embrittled this can only be rectified by a full solution annealing treatment.

Heat Treatment

Solution Treatment (Annealing): heat to 1040-1120°C and cool rapidly in air or by water quenching. Duplex and super duplex grades cannot be hardened by thermal treatment. Annealing in the range 1025-1125°C followed by rapid quenching is typical; the intermetallic sigma phase embrittlement which can form at 600-900°C is eliminated by the full solution anneal.

Welding

2507 is weldable by standard methods, without pre-heat. Consumables over-alloyed with nitrogen and nickel are generally recommended, such as those with ISO designation "25 9 4 L N" (AWS ER2594 / E2594). TIG (GTAW), MIG (GMAW) and all positional manual (MMAW) electrodes are available. Heat input should be within the range 0.5 - 1.5 kJ/mm with a maximum interpass temperature of 150°C. Post weld annealing is essential following autogenous welding, but not otherwise. Nickel-based consumables (e.g. Alloy C22) can also be used to give higher corrosion resisting welds. As for other duplex stainless steels the coefficient of thermal expansion of 2507 is lower than for austenitic grades, reducing distortion and residual stresses.

Machining

The high strength and work-hardening rate of grade 2507 make it more difficult to machine than the standard austenitic grades such as 304. Machining should be carried out with rigid tooling, sharp inserts, positive feed rates and adequate cooling. The grade is magnetic, which can be an aid to workholding. Overheating of the workpiece during machining should be avoided as this may affect corrosion resistance and require re-annealing.

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Fabrication

2507 is a high strength steel, so high forming forces will be required and high spring-back should be anticipated. The ductility of the grade is quite adequate for most operations, but heavy deformation, such as cold forging, is not possible. If more than about 20% cold work is carried out an intermediate solution anneal is required. Hot forging can be carried out in the temperature range 1200 - 1025°C, and hot forming at 1000-1200°C with slow heating to 1000°C. Like other duplex grades 2507 has low hot strength, so may need support during heat treatment or forging. Hot forging should be followed by solution treatment.

Typical Applications

Oil and gas exploration, processing and support systems (offshore platforms, subsea equipment); pollution control including flue gas desulphurisation (FGD); marine and other high chloride environments; seawater desalination plants; chemical processing (pressure vessels, piping, heat exchangers); transport and storage of chemicals; pulp and paper processing; pulp bleaching plants; propeller shafts, rotors and other marine shafts.

Specified Properties

These properties for 2507 are specified for flat rolled product (plate, sheet and coil) in ASTM A240/A240M and for seamless and welded pipe in ASTM A790/A790M, as UNS S32750. Similar but not necessarily identical properties are specified for other products in their respective specifications (e.g. bar in ASTM A276, forgings in ASTM A182, fittings in ASTM A182/A815, seamless tube in ASTM A789).

Composition Specification (%)

Grade		C	Mn	Si	P	S	Cr	Mo	Ni	Cu	N
2507	min.	-	-	-	-	-	24.0	3.0	6.0	-	0.24
	max.	0.030	1.20	0.80	0.035	0.020	26.0	5.0	8.0	0.50	0.32

Composition in percent by weight, per ASTM A240/A240M (flat products) & ASTM A790/A790M (pipe). Iron is the balance.

Mechanical Property Specification

Grade	Tensile Strength (MPa) min.	Yield Strength 0.2% Proof (MPa) min.	Elongation (% in 50mm) min.	Hardness Rockwell C (HR C) max.	Brinell (HB) max.
2507	795	550	15	32	310

Typical values in the annealed condition: tensile strength 850-950 MPa, 0.2% proof stress 650-750 MPa, elongation 25-35%. Charpy V-notch impact energy (longitudinal) 100 J min. at 20°C and typically 80-120 J at -40°C.

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Physical Properties (Typical values in the annealed condition)

Grade	Density (kg/m ³)	Elastic Modulus (GPa)	Mean CTE 0-100°C (µm/m/°C)	Mean CTE 0-315°C (µm/m/°C)	Mean CTE 0-538°C (µm/m/°C)	Thermal Conductivity at 100°C (W/m.K)	Thermal Conductivity at 500°C (W/m.K)	Specific Heat 0-100°C (J/kg.K)	Electrical Resistivity (nΩ.m)
2507	7800	200	13.0	14.0	14.5	15.0	21.0*	460	850

Mean coefficient of thermal expansion: 13.0 µm/m/°C (0-100°C), 14.0 (0-315°C), 14.5 (0-538°C). Thermal conductivity: 14.2 W/m.K at 20°C; 15.0 at 100°C; 18.0 at 300°C; 20.0 at 400°C; *21.0 W/m.K at 500°C (extrapolated). Melting range approx. 1350-1450°C. The grade is magnetic. Sources: Atlas Steels & Sandvik SAF 2507 datasheets (typical values).

Grade Specification Comparison

Grade	UNS No	Euronorm No	Euronorm Name	Swedish SS	Japanese JIS
2507	S32750	1.4410	X2CrNiMoN25-7-4	2328	-

Also specified as: ASTM A182 F53 (forgings), EN 10088-3 X2CrNiMoN25-7-4, GB/T 20878 022Cr25Ni7Mo4N (China), ISO 15510 X2CrNiMoN25-7-4. Related super duplex grade: UNS S32760 (W.Nr. 1.4501, Zeron 100, contains Cu + W), UNS S32550 (1.4507). These comparisons are approximate only.

Possible Alternative Grades

Grade	Why it might be chosen instead of 2507
2205	The lower cost and better availability of 2205 are required, and a lower corrosion resistance and strength can be accepted.
6% Mo	Higher ductility of this austenitic grade is needed, and the much lower strength is acceptable. Corrosion resistance is similar in many environments, but needs to be considered case by case.
Ni Alloys	A corrosion resistance even higher than 2507 is required, and a higher cost is acceptable.

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