

Type 2507 UNS S32750

Design Features

- Very high strength
- High resistance to pitting, crevice, and general corrosion
- Very high resistance to chloride stress corrosion cracking
- Lower coefficient of thermal expansion than austenitic stainless steels
- Higher thermal conductivity than austenitic stainless steels

Applications

- Oil and Gas Industry Equipment
- Offshore Platforms
- Heat exchangers
- Process and service water systems
- Fire-fighting systems
- Injection and ballast water systems
- Chemical Process Industries
- Heat exchangers
- Vessels
- Piping
- Desalination Plants
- High pressure RO-plant and seawater piping
- Mechanical and Structural Components
- High strength, corrosion-resistant parts
- Power Industry FGD Systems, Utility and Industrial Scrubber Systems
- Absorber towers, ducting, piping

Product Forms Available

- Plate
- Sheet and KBR Wide Sheet
- Billet and Bar
- Pipe and Tubing
- Welding Consumables

General Characteristics

Outokumpu Stainless 2507 was designed for demanding applications which require exceptional strength and corrosion resistance, such as chemical

Specifications

S32750 (wrought products)

	ASTM	ASME
Plate, Sheet, Strip	A 240, A 480	SA-240, SA-480
Bar, Billet	A 479	SA-479
Pipe and Tubing	A 789, A 790, A 928	SA-789, SA-790
Fittings, Forgings	A 182, A 815	SA-182, SA-815
ASME/ANSI B16.34 for A 182, A 240, A 479, A 789, A 790		
ASME Section VIII, Division 1 Code Case 2047		
NACE MR0175		
EN 10088		

process, petrochemical, and seawater equipment. As a duplex (ferritic-austenitic) stainless steel, Outokumpu Stainless 2507 combines the most desirable characteristics of both ferritic and austenitic steels.

The duplex microstructure gives this grade high strength, excellent resistance to chloride stress corrosion cracking, high thermal conductivity, and a low coefficient of thermal expansion. In addition, Outokumpu Stainless 2507's high chromium, molybdenum, and nitrogen levels provide excellent resistance to pitting, crevice, and general corrosion. The impact strength is also high.

Composition, wt. pct.

Table 1

Element	Typical Outokumpu Stainless 2507	ASTM S32750
Carbon	0.020	0.030 max
Chromium	25.0	24.0-26.0
Nickel	7.0	6.0-8.0
Molybdenum	4.0	3.0-5.0
Nitrogen	0.27	0.24-0.32
Manganese	0.50	1.20 max
Phosphorus	0.030	0.035 max
Sulfur	0.001	0.020 max
Silicon	0.30	0.80 max
Iron	Balance	Balance

Outokumpu Stainless 2507 is suitable for most typical stainless steel forming operations and has good weldability. Shielded metal arc (SMAW), gas tungsten arc (GTAW), plasma arc (PAW), flux cored wire (FCW), and submerged arc welding (SAW) have all been shown to be satisfactory joining methods.

When solution annealed at 1925°F minimum and water quenched, 2507 contains 30–50% ferrite. The balance of the microstructure is austenite. The typical chemical composition is shown in Table 1.

Mechanical and Physical Properties

Outokumpu Stainless 2507 combines high tensile and impact strength with a low coefficient of thermal expansion and high thermal conductivity. These properties are suitable for many structural and mechanical components. The low, ambient, and elevated temperature mechanical properties of 2507 sheet and plate are shown in Tables 2 through 4. All of the test data shown are for samples in the annealed and quenched condition. Physical property data can be found in Table 5.

Mechanical Properties

Table 2

Ultimate Tensile Strength, ksi	116 min.
0.2% Offset Yield Strength, ksi	80 min.
1% Offset Yield Strength, ksi	91 min.
Elongation in 2 inches, %	15 min.
Hardness, Rockwell C	32 max.
Impact Energy, ft-lbs	74 min.

Low Temperature Impact Properties

Table 3

Temperature °F	RT	32	-4	-40	-76	-112	-148	-320
Ft-lbs	162	162	155	140	110	44	30	7

Elevated Temperature Tensile Properties

Table 4

Temperature °F	68	212	302	392	482
0.2% Offset Yield Strength, ksi	80	65	61	58	55
Ultimate Tensile Strength, ksi	116	101	98	95	94

Outokumpu Stainless 2507 is not recommended for applications which require long exposures to temperatures in excess of 570°F because of the increased risk of a reduction in toughness. The data listed in this brochure are typical for wrought products and should not be regarded as a maximum or minimum value unless specifically stated.

Corrosion Resistance

Intergranular Corrosion

Outokumpu Stainless 2507's low carbon content greatly lowers the risk of carbide precipitation at the grain boundaries during heat treatment; therefore, the alloy is highly resistant to carbide-related intergranular corrosion.

General Corrosion

The high chromium and molybdenum content of Outokumpu Stainless 2507 make it extremely resistant to uniform corrosion by organic acids like formic and acetic acid. Outokumpu Stainless 2507 also provides excellent resistance to inorganic acids, especially those containing chlorides. Table 6 contains data generated in accordance with the testing procedures of the Materials Testing Institute of the Chemical Process Industries (MTI). These tests show the temperature levels necessary to produce a corrosion rate of 5 mpy in a variety of corrosive environments.

In dilute sulfuric acid contaminated with chloride ions 2507 has better corrosion resistance than 904L, which is a highly alloyed austenitic steel grade specially designed to resist pure sulfuric acid; this is shown in Figure 1.

Stainless steel of type 17-12-2.5 cannot be used in hydrochloric acid due to the risk of localized and uniform corrosion. However, as

Physical Properties

Table 5

Density	lb/in ³	0.28
Modulus of Elasticity	psi x 10 ⁶	29
Coefficient of Thermal Expansion 68–212°F/ °F	x 10 ⁻⁶ /°F	7.2
Thermal Conductivity	Btu/h ft°F	8.7
Heat Capacity	Btu/lb°F	0.12
Electrical Resistivity	Ω-in x 10 ⁻⁶	31.5

Lowest Temperature (°F) at Which the Corrosion Rate Exceeds 5 mpy

Table 6

Corrosion Environment	654 SMO®	254 SMO®	904L	Type 316L (2.7 Mo)	Type 304	2507	2205 Code Plus Two®	2304
0.2% Hydrochloric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
1% Hydrochloric Acid	203	158	122	86	86p	>Boiling	185	131
10% Sulfuric Acid	158	140	140	122	—	167	140	149
60% Sulfuric Acid	104	104	185	<54	—	<57	<59	<<55
96% Sulfuric Acid	86	68	95	113	—	86	77	59
85% Phosphoric Acid	194	230	248	203	176	203	194	203
10% Nitric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
65% Nitric Acid	221	212	212	212	212	230	221	203
80% Acetic Acid	>Boiling	>Boiling	>Boiling	>Boiling	212p	>Boiling	>Boiling	>Boiling
50% Formic Acid	158	212	212p	104	≤50	194	194	59
50% Sodium Hydroxide	275	239	Boiling	194	185	230	194	203
83% Phosphoric Acid + 2% Hydrofluoric Acid	185	194	248	149	113	140	122	95
60% Nitric Acid + 2% Hydrochloric Acid	>140	140	>140	>140	>140	>140	>140	>140
50% Acetic Acid + 50% Acetic Anhydride	>Boiling	>Boiling	>Boiling	248	>Boiling	230	212	194
1% Hydrochloric Acid + 0.3% Ferric Chloride	>Boiling, p	203ps	140ps	77p	68p	203ps	113ps	68p
10% Sulfuric Acid + 2000ppm Cl ⁻ + N ₂	149	104	131	77	—	122	95	<55
10% Sulfuric Acid + 2000ppm Cl ⁻ + SO ₂	167	140	122	<<59p	—	104	<59	<<50
WPA1, High Cl ⁻ Content	203	176	122	≤50	<<50	203	113	86
WPA2, High F ⁻ Content	176	140	95	≤50	<<50	167	140	95

ps = pitting can occur
ps = pitting/crevice corrosion can occur

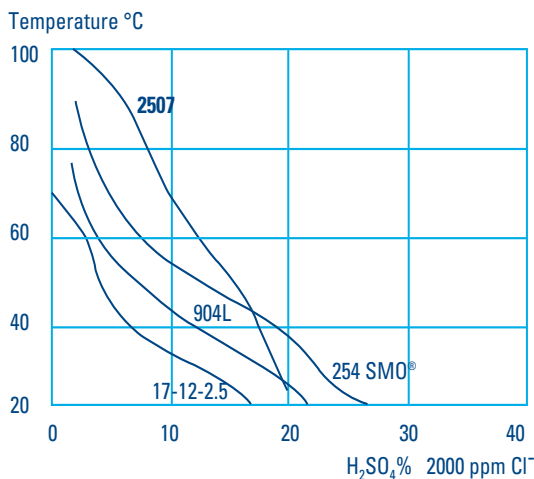
WPA	P ₂ O ₅	Cl ⁻	F ⁻	H ₂ SO ₄	Fe ₂ O ₃	Al ₂ O ₃	SiO ₂	CaO	MgO
1	54	0.20	0.50	4.0	0.30	0.20	0.10	0.20	0.70
2	54	0.02	2.0	4.0	0.30	0.20	0.10	0.20	0.70

illustrated in Figure 2, 2507 can be used in dilute hydrochloric acid. Pitting need not be a risk in the

zone below the borderline in this figure, but crevices must be avoided.

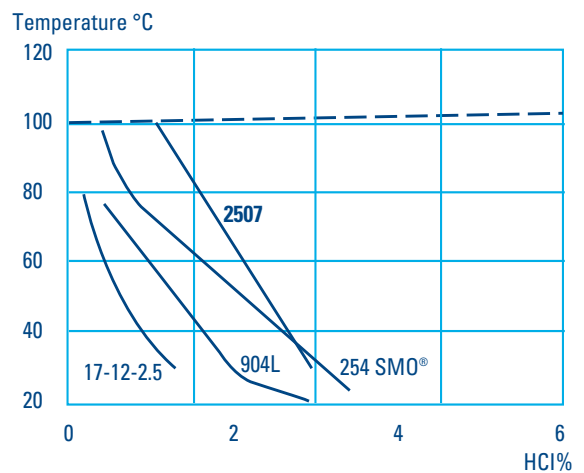
Isocorrosion Curves, 0.1 mm/year, in sulfuric acid with an addition of 2000 ppm chloride ions

Figure 1



Isocorrosion Curves, 0.1 mm/year, in hydrochloric acid. Broken line curve represents boiling point

Figure 2



Pitting Corrosion

Different testing methods can be used to establish the pitting resistance of steels in chloride-containing solutions. The data in Figure 3 were measured by an electrochemical technique based on ASTM G 61 but with a special test cell developed by Outokumpu Stainless. This test measures the critical pitting temperature (CPT) above which pitting is indicated.

With standard ASTM G 61 test equipment, crevice corrosion of the specimen holder can adversely affect the test. The Outokumpu Stainless cell eliminates this problem providing more accurate test results. The critical pitting temperatures (CPT) of several high-performance steels in a 1M sodium chloride solution were determined using this test. The results illustrate the excellent resistance of Outokumpu Stainless 2507 to pitting corrosion. The normal data spread for each grade is indicated by the dark gray portion of the bar.

Crevice Corrosion

The presence of crevices, almost unavoidable in practical constructions and operations, make stainless steels more susceptible to corrosion in chloride environments. Outokumpu Stainless 2507 is highly resistant to crevice corrosion. The

critical crevice corrosion temperature of Outokumpu Stainless 2507 and several other high-performance stainless steels are shown in Figure 4. The tests were conducted in a 10% FeCl₃ solution in accordance with the MTI's Manual Number 3, Corrosion Test Methods. PTFE multiple crevice washers were used with a torque of 0.21 ft. lbs.

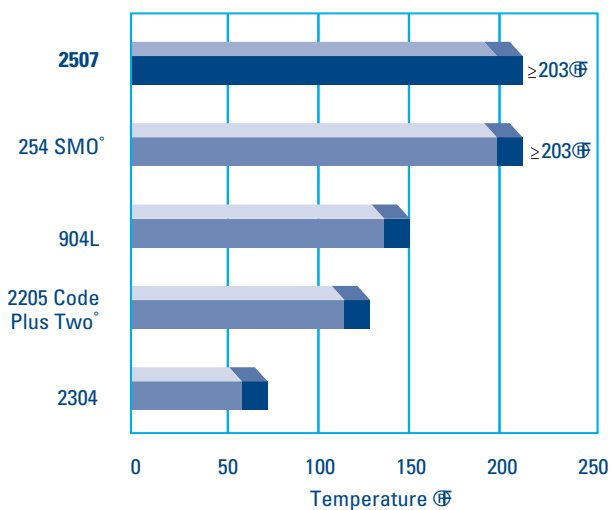
Stress Corrosion Cracking

The duplex structure of Outokumpu Stainless 2507 provides excellent resistance to chloride stress corrosion cracking (SCC). The drop evaporation test, which simulates the condensation/evaporation cycle found in many applications where stress corrosion cracking is a problem, was used to compare the stress corrosion cracking resistance of several high-performance stainless steels.

In accordance with MTI-5, a dilute sodium chloride solution is slowly dripped onto an electrically heated specimen which is simultaneously subjected to tensile stress. The applied stresses are gradually increased in increments of 20% until they are 90% of the material's yield strength at 392°F. The test is run for up to 500 hours and measures the minimum stress required for failure. The results can be found in Table 7.

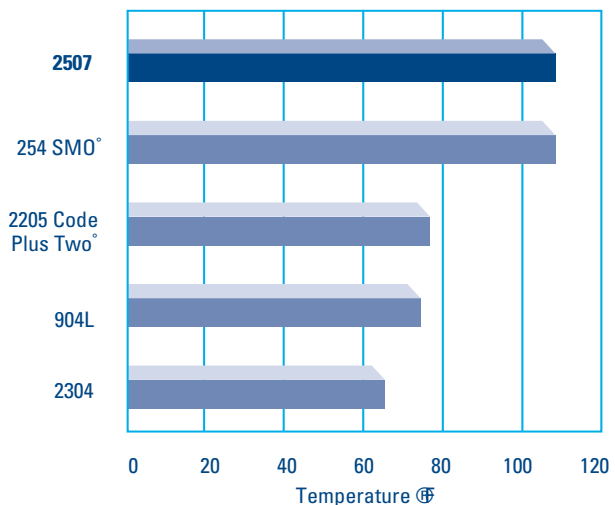
Critical Pitting Temperature (CPT) range for various alloys in 1M NaCl

Figure 3



Critical Crevice Corrosion Temperature (CCT) for various alloys in 10% FeCl₃

Figure 4



Duplex stainless steels, especially 2205, have been used in some sour gas applications where hydrogen sulfide can cause sulfide stress corrosion. Because of its higher alloy content, Outokumpu Stainless 2507 is superior to 2205, in corrosion resistance and strength. Outokumpu Stainless 2507 is especially useful in offshore oil and gas applications and in wells with either naturally high brine levels or where brine has been injected to enhance recovery.

**Fabrication
Cold Forming**

Most of the common stainless steel forming methods can be used for cold working Outokumpu Stainless 2507. The alloy has a higher yield strength and lower ductility than the austenitic steels so fabricators may find that higher forming forces, increased radius of bending, and increased allowance for springback are necessary. Deep drawing, stretch forming, and similar processes are more difficult to perform on Outokumpu Stainless 2507 than on an austenitic stainless steel. When forming requires more than 10% cold deformation, a solution anneal and quench are recommended.

Hot Forming

Outokumpu Stainless 2507 should be hot worked between 1875°F and 2250°F. This should be followed by a solution anneal at 1925°F minimum and a rapid air or water quench.

**Drop Evaporation Test
for SCC**

Table 7

Outokumpu Stainless Grade	Min. Stress for SCC, (ksi)	% of Typical 0.2% Y.S. (at 392°F)	Hours to Failure
2507	54	90	>500, 415
2205 Code Plus Two®	33	50	360, >500
904L	28	90	230, 348
254 SMO®	>32	>90	>500, >500

Heat Treatment

Outokumpu Stainless 2507 should be solution annealed and quenched after either hot or cold forming. Solution annealing should be done at a minimum of 1925°F. Annealing should be followed immediately by a rapid air or water quench. To obtain maximum corrosion resistance, heat treated products should be pickled and rinsed.

Welding

Outokumpu Stainless 2507 possesses good weldability and can be joined to itself or other materials by shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW), plasma arc welding (PAW), flux cored wire (FCW), or submerged arc welding (SAW). Outokumpu Stainless 2507/P100 filler metal is suggested when welding Outokumpu Stainless 2507 because it will produce the appropriate duplex weld structure.

As with any joining process, it is important that the surfaces be cleansed immediately before welding. Preheating of Outokumpu Stainless 2507 is not necessary except to prevent condensation on cold metal. The interpass weld temperature should not exceed 300°F or the weld integrity can be adversely affected. The root should be shielded with argon or 90% N₂/10% H₂ purging gas for maximum corrosion resistance. The latter provides better corrosion resistance.

If welding is to be done on only one surface and post weld cleaning is not possible, GTAW is suggested for root passes. GTAW or PAW should not be done without a filler metal unless post weld clean up is possible. A heat input of 5-38 kJ/in. should be used for SMAW or GTAW. A heat input of about 50kJ/in. can be used for SAW.

Welding Consumables

Outokumpu Stainless provides coated electrodes; wires for GTAW, GMAW, FCW, and SAW; and welding fluxes, all of which have been formulated to produce excellent results. For these products, call our welding unit at 1-800-441-7343.

Technical Support

Outokumpu Stainless, Inc. assists users and fabricators in the selection, qualification, installation, operation, and maintenance of 2507 duplex stainless steel. Technical personnel, supported by the research laboratory of Outokumpu Stainless, can draw on years of field experience with 2507 to help you make the technically and economically correct materials decision.

Outokumpu Stainless is prepared to discuss individual applications and to provide data and experience as a basis for selection and application of 2507.

Outokumpu Stainless works closely with its distributors to ensure timely availability of 2507 in the forms, sizes, and quantities required by the user. For assistance with technical questions and to obtain top quality 2507, call Outokumpu Stainless, Inc. at 1-800-833-8703.

8 Type 2507

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Outokumpu Stainless is a core business within Outokumpu, a dynamic metals and technology group operating worldwide and marketing its metals, metal products, technology and services to customers in a wide range of industries.

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