New Castle
Stainless Plate, LLC

Superduplex 2507

UNS S32750

General properties

New Castle 2507 was designed for demanding applications that require exceptional strength and corrosion resistance, such as chemical process, petrochemical, and seawater equipment. As a duplex (ferritic-austenitic) stainless steel, New Castle 2507 combines the most desirable characteristics of both ferritic and austenitic steels.

Solution annealed 2507 plate from New Castle contains nearly equivalent amounts of ferrite and austenite, and the typical chemical composition is shown in Table 1. 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, New Castle 2507's high chromium, molybdenum, and nitrogen levels provide excellent resistance to pitting, crevice, and general corrosion.

Plate Product Sizes

Plate product is available up to 3 inches thick and up to 120 inches wide depending on the thickness.

Mechanical and Physical Properties

New Castle 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 mechanical properties of New Castle 2507 plate at various temperatures 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.

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
- Vessels
- Desalination plants
- Mechanical and structural components
- High strength, corrosion-resistant parts
- Power industry FGD systems, utility and industrial scrubber systems

Chemical Composition (wt%) *Table 1*

	C	Mn	Cr	Ni	Mo	N	Other
Typical	0.02	0.5	25.0	7.0	4.0	0.27	
UNS S32750	≤0.030	≤1.20	24.0-26.0	6.0-8.0	3.0-5.0	...0.24-0.32	

New Castle 2507 is not recommended for applications which require long exposures to temperatures in excess of 570°F because of the increased risk of alpha prime precipitation and 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

New Castle 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 contents of New Castle 2507 make it extremely resistant to uniform corrosion by organic acids like formic and acetic acid. New Castle 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.

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

In dilute sulfuric acid contaminated with chloride ions New Castle 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.

Type 316L stainless steel cannot be used in hydrochloric acid due to the risk of localized and uniform corrosion. However, as 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.

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 as described in ASTM G150.. This test measures the critical pitting temperature (CPT) above which pitting is indicated.

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 New Castle 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. New Castle 2507 is highly resistant to crevice corrosion. The critical crevice corrosion temperature of New Castle 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.

Pitting Corrosion

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

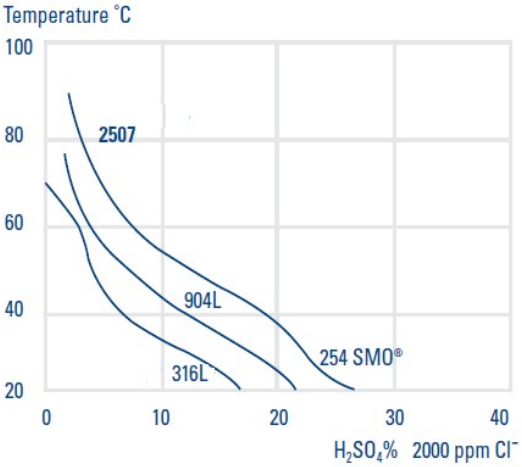
Corrosion Environment	654 SMO®	254 SMO®	904L	Type 316L (2.7 Mo)	Type 304	Outokumpu 2507	2205 Code Plus Two®	Outokumpu 2304
0.2% Hydrochloric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	**>Boiling**	>Boiling	>Boiling
1% Hydrochloric Acid	203	158	122	86	86p	**>Boiling**	185	131
10% Sulfuric Acid	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_2O_5	Cl^-	F^-	H_2SO_4	Fe_2O_3	Al_2O_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

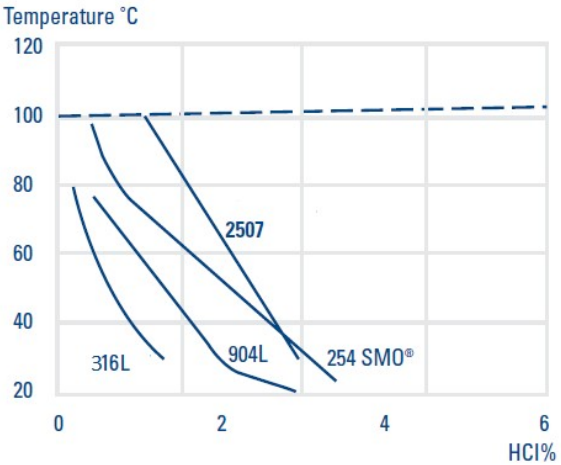
Isocorrosion Curves, 0.1 mm/year, in sulfuric acid with an addition of 2000 ppm chloride ions

Figure 1



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

Figure 2



Stress Corrosion Cracking

The duplex structure of New Castle 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.

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, New Castle 2507 is superior to 2205 both in corrosion resistance and strength. New Castle 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 New Castle 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 New Castle 2507 than on an austenitic stainless steel. When forming requires more than 10% cold deformation, a solution anneal and quench are recommended.

Hot Forming

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

Heat Treatment

New Castle 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 acid pickled and rinsed.

Welding

New Castle 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). E/ER 2594 filler metal is suggested when welding New Castle 2507 because it will produce the appropriate duplex weld structure.

As with any joining process, it is important that the surfaces be cleaned immediately before welding. Preheating of New Castle 2507 is not necessary except to prevent condensation on cold metal. The interpass weld temperature should not exceed 200°F or the weld integrity can be adversely affected. The root should be shielded with argon or 98% argon/2% N2 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 solution annealing after welding is possible. A heat input of 5-38 kJ/in. should be used for SMAW, GTAW, GMAW, and a heat input up to 50kJ/in. can be used for SAW.

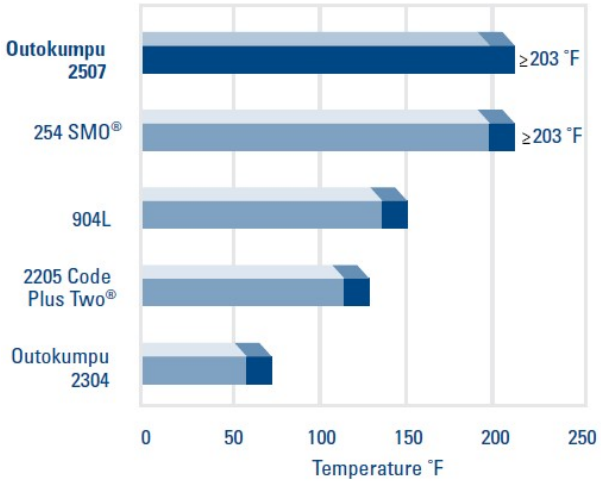
Drop Evaporation Test for SCC

Table 7

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

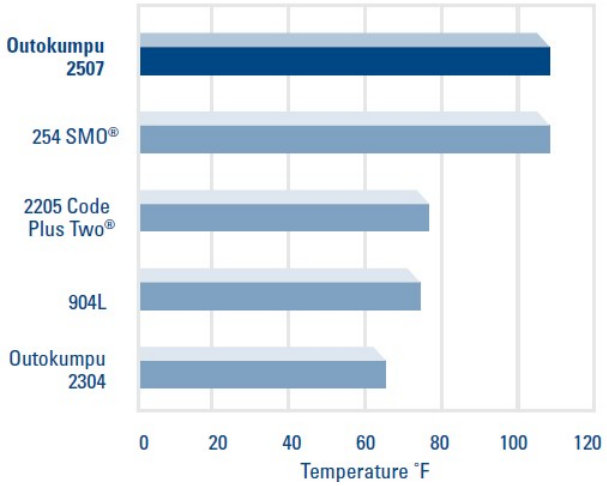
Critical Pitting Temperature (CPT) range for various alloys in 1M NaCl

Figure 3



Critical Crevice Corrosion Temperature (CCT) for various alloys in 10% $FeCl_3$

Figure 4



Technical Support

New Castle assists end users and fabricators in the selection, qualification, installation, operation, and maintenance of New Castle 2507 duplex stainless steel. New Castle is prepared to discuss individual applications and to provide data and experience as a basis for selection and application of New Castle 2507.

New Castle works closely with its distributors to ensure timely availability of New Castle 2507 in the sizes, and quantities required by the end user. For assistance with technical questions and to obtain top quality New Castle 2507, call New Castle at 1-800-349-0023.

New Castle

Stainless Plate, LLC