COLUMBUS STAINLESS
[Pty] Ltd

Technical Brochure

HEAT RESISTING AUSTENITIC STAINLESS STEELS

Adding Stainless Quality to life

www.columbusstainless.co.za

Introduction

The heat resisting austenitics are highly alloyed stainless steel used for their excellent oxidation resistance, high temperature strength and creep resistance in high temperature applications. They are tough and ductile and can be readily fabricated and machined.

309S-1.4833 has very good oxidation resistance and this is improved even further with **309S Si 1.4828**, which has a higher silicon content.

The 309S types have a lower nickel content compared to the 310S types and this improves their resistance to hydrogen sulphide (H2S) attack at high temperatures.

The 309S types are low carbon grades and are recommended for applications where sensitisation and subsequent corrosion by high temperature gasses or condensates during shutdown may pose a problem.

The 309S types are used, for example, in applications such as furnace parts, fire box sheets, high temperature containers, catalytic converters, exhaust systems, etc.

The **310S** types have higher chromium and nickel contents to enable them to resist oxidation in continuous service at temperatures up to 1 200°C provided reducing sulphur gases are not present.

The higher silicon content in **310S Si-1.4841** improves this oxidiation resistance even further.

In intermittent high temperature service, the 310S types can be used at temperatures up to 1 030°C as they resist scaling and have a relatively low coefficient of expansion differential between the metal and the scale. These stainless steels have superior resistance to both the 304 types and the 309S types in carburising and reducing environments.

The 310S types are used in applications such as furnace parts, muffles, radiant tubes, ammonia converters, etc.

Product range

The latest revision of the Product Catalogue should be consulted, as the product range is subject to change without notice.

The Product Catalogue is available from the Technical Department or can be found at www.columbusstainless.co.za

Specifications and tolerances

Columbus Stainless (Pty) Ltd supplies the heat resisting austenitics to ASTM A167, ASTM A240, ASME SA240, and EN 10095.

Columbus Stainless (Pty) Ltd normally supplies material to the following tolerances:

HOT ROLLED

ASTM A480M
ISO 9444 - material processed as coil
ISO 18286 - material processed as plate
ASTM A480/ASTM A480M
ASME SA480/ASME SA480M

ISO 18286
ISO 9444-2
EN 10051
EN 10029
IS 6911

COLD ROLLED

ASTM A480M
ISO 9445
ASTM A480/ASTM A480M
ASME SA480/ASME SA480M
ISO 9445-2
IS 6911

Other spefications and tolerances may be available on request. Further information is available in the Product Catalogue, which can be obtained from the Technical Department or can be found at www.columbusstainless.co.za

Further information

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Disclaimer

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Chemical composition

In accordance with ASTM A240, ASTM A167, EN 10088-2 and EN 10095, as applicable.

Grade	C	Si	Mn	P	S	N	Cr	Ni
309S-1.4833	0.08	0.75	2.0	0.045	0.015	0.11	22.0 24.0	12.0 14.0
309S Si-1.4828	0.20	1.50 2.50	2.0	0.045	0.015	0.11	19.0 21.0	11.0 13.0
310S-1.4845	0.08	0.75	2.0	0.045	0.015	0.11	24.0 26.0	19.0 22.0
310S Si-1.4841	0.20	1.50 2.50	2.0	0.045	0.015	0.11	24.0 26.0	19.0 22.0

- Compositions are ranges or maximum values.

Mechanical properties

In accordance with ASTM A240, ASTM A167, EN 10088-2 and EN 10095, as applicable.

Grade	R_m (MPa)	$Rp_{0.2}$ (MPa)	$Rp_{1.0}$ (MPa)	El (%)	Max BHN
309S-1.4833	515 700	210	250	40	192
309S Si-1.4828	550 750	230	270	30	223
310S-1.4845	515 700	210	250	40	192
310S Si-1.4841	550 750	230	270	30	223

- Minimum values, unless max or range is indicated.
- The table assumes certification to ASTM A167, ASTM A240, EN 10088-2 and EN 10095, where applicable.

PROPERTIES AT ELEVATED TEMPERATURES

The properties quoted below are typical of annealed 309S, and 310S steels. These values are given as a guideline only, and should not be used for design purposes.

Short time elevated temperature tensile strength (MPa)

Grade	100°C	200°C	300°C	400°C	500°C	600°C	700°C	800°C	900°C	1 000°C	1 100°C
309S	580	570	560	520	465	390	300	210	130	65	25
310S	600	590	570	530	475	405	315	225	140	80	45

Short time elevated temperature 0.2% proof stress (MPa)

Grade	100°C	200°C	300°C	400°C	500°C	600°C	700°C	800°C
309S	265	240	225	210	190	170	150	130
310S	265	250	225	200	175	155	130	110

Short time elevated temperature elongation (%)

Grade	100°C	200°C	300°C	400°C	500°C	600°C	700°C	800°C	900°C	1 000°C	1 100°C
309S	47	46	44	42	39	37	36	37	43	53	72
310S	41	40	38	35	32	31	33	38	45	53	57

Maximum recommended service temperature

Grade	Continuous (°C)	Intermittent (°C)
309S types	1 100	980
310S types	1 200	1 030

- In oxidising conditions.

PROPERTIES AT ELEVATED TEMPERATURES (CONTINUED)

Creep and creep rupture properties

	Stress (MPa) to produce 1% strain				Stress (MPa) to produce rupture			
Temperature (°C)	10 000 hours		100 000 hours		1 000 hours		10 000 hours	
	309S	310S	309S	310S	309S	310S	309S	310S
450	210	180	145	115				
500	140	145	95	95	375		340	
550	100	115	65	75	270	240	230	205
600	70	85	45	60	190	150	160	130
650	45	55	30	40	130	90	100	75
700	30	35	15	25	80	60	55	50
750	15	20	10	15	50	45	35	35
800	10	10	5	10	35	35	20	25
850	5	5		5	20	25	15	20

Physical properties

The values given below are for 20°C, unless otherwise stated.

		309S types	310S types
Density (kg/m^3)		7 900	7 900
Modulus of elasticity in tension (GPa)		200	200
Modulus of elasticity in torsion (GPa)		70	70
Specific heat capacity (J/kg K)		500	500
Thermal conductivity at	100°C (W/m K)	15.6	14.2
	500°C (W/m K)	18.7	18.5
Electrical resistivity (x10^{-9} Ω m)		780	780
Mean coefficient of thermal expansion from	0 to 100°C (x10^{-6} K^{-1})	15.9	15.0
	0 to 300°C (x10^{-6} K^{-1})	16.6	16.2
	0 to 500°C (x10^{-6} K^{-1})	17.2	17.0
	0 to 700°C (x10^{-6} K^{-1})	18.3	17.8
	0 to 1 000°C (x10^{-6} K^{-1})	19.5	18.9
Melting range (°C)		1 400	1 400
		1 450	1 450
Relative permeability		1.02	1.02

- These grades remain non-magnetic even after cold working.

Thermal processing and fabrication

ANNEALING

Annealing of the heat resisting austenitics is achieved by heating to between 1 030°C and 1 150°C for 60 minutes per 25mm thickness (2.5min/mm) followed by water quenching. Annealing will ensure that any carbide precipitates are taken back into solution.

HOT WORKING

The heat resisting austenitics can be forged, hot headed and upset satisfactorily. Uniform heating of the steel in the range of 1 150°C to 1 250°C is required. The finishing temperature should not be below 950°C. Forgings should be cooled rapidly in air or water.

COLD WORKING

The heat resisting austenitics can be deep drawn, stamped, headed and upset without difficulty. Since austenitic stainless steels work harden, severe cold forming operations should be followed by annealing.

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Thermal processing and fabrication (continued)

MACHINING

Like all the austenitic stainless steels, this alloy group machines with a rough and stringy swarf. Rigidly supported tools with as heavy a cut as possible should be used to prevent glazing.

WELDING

The heat resisting austenitics can be satisfactorily welded and brazed by all methods, giving a tough weld. Welding procedures for the 310S types have to be selected with care in order to avoid hot cracking due to the fully austenitic weld microstructure obtained from using matching filler metals.

Corrosion resistance

The heat resisting austenitics are not usually used in aqueous conditions, but are usually used in high temperature gaseous environments. The following aspects of this dry corrosion are pertinent.

OXIDATION RESISTANCE

In many processes, isothermal (constant temperature) conditions are not maintained and process temperatures vary. Expansion differences between the base metal and the scale during heating and cooling can cause cracking and spalling of the protective scale. This allows the oxidising media to attack the exposed metal surface. The high chromium and nickel content of the heat resisting austenitics provides good resistance to high temperature oxidation. The spalling resistance is greatly improved with the higher nickel contents of the 310S types because nickel reduces the expansion differential between the scale and the base metal.

EFFECT OF ATMOSPHERE

The presence of water vapour increases the corrosion rate. However, the increased nickel and chromium contents of the heat resisting austenitics provide good resistance to moist air at temperatures in excess of 980°C. They also have good scaling resistance to carbon dioxide and can be used at temperatures similar to those quoted for service in air.

SULPHUR VAPOUR

Sulphur vapour readily attacks the austenitic grades. Typical corrosion rates for various stainless steels after 1 300 hours exposure to flowing sulphur vapour at 570°C are shown alongside.

Grade	Corrosion Rate (mm/yr)
310S types	0.48
309S types	0.57
304 types	0.69
316L types	0.79
321	1.39

HYDROGEN SULPHIDE

The rate of corrosion in hydrogen sulphide depends on concentration, temperature, pressure and permeability of the scale. The presence of chromium in the steel helps to stabilise the scale and slow the diffusion process. At high pressure and temperature when hydrogen is present, the attack is more severe and alloys such as the 309S types are more suited to these conditions.

FLUE GASES

It is extremely difficult to generalise corrosion rates in flue and process gases since gas composition and temperature may vary considerably within the same process unit.

Combustion gases normally contain sulphur compounds, as sulphur dioxide is present as an oxidising gas, along with carbon dioxide, nitrogen, carbon monoxide and excess oxygen. Protective oxides are generally formed and depending on exact conditions, the corrosion rate may be similar or slightly greater than for service in air.

Reducing flue gases contain varying amounts of hydrogen sulphide, hydrogen, carbon monoxide, carbon dioxide and nitrogen. The corrosion rates encountered in these environments are sensitive to hydrogen sulphide content and temperature, and satisfactory material selection often necessitates service testing. The high nickel content of the 310S types may be deleterious in some instances due to sulphidation, in which case, the 309S types may be the preferred material.

CARBURISATION

High chromium and nickel contents result in a slower diffusion rate of carbon into the steel. The heat resisting austenitics therefore have good resistance to carburising atmospheres.

AMMONIA

The high nickel content of the 310S types ensures a good resistance to ammonia atmospheres at high temperatures. Typical corrosion rates for 310S types in an ammonia converter containing 5-6% NH_3 after 30 000 hours at 500°C, are in the region of 0,003mm/yr.

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