outokumpu
high performance stainless steel

Therma 310S/4845

EN 1.4845, ASTM TYPE 310S / UNS S31008

General characteristics

Austenitic heat resisting 4845 grade with very good oxidation resistance. This grade 4845 belongs to austenitic chromium-nickel stainless steel grades. A specific feature for 4845 grade is high chromium and high nickel contents, which make this grade suitable for use in high temperatures. A common feature of Outokumpu high temperature steels is that they are designed primarily for use at temperatures exceeding ~550 °C, i.e. in the temperature range where creep strength as a rule is the dimensioning factor and where HT corrosion occurs. Optimising steels for high temperatures has meant that their resistance to aqueous corrosion has been limited. All steels are austenitic, resulting in relatively high creep strength values.

Characteristic properties
- Good resistance to oxidation
- Good resistance to high-temperature corrosion
- Good mechanical strength at elevated temperatures

Typical applications

Outokumpu high temperature steels can be and have been used in a number of applications where the temperature exceeds 550°C, e.g. for equipment and components within:
- Industrial furnace equipment
- Oil industry equipment
- Heat treatment baskets
- Heat exchanges
- Steam boilers and thermowells
- Iron, steel, and non-ferrous industries
- Engineering industry
- Energy conversion plants
- Cement industry

Products & dimensions

Cold rolled products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
2BB	Bright-pickled	0.50-3.00	30-1500	0.50-3.00	600-1500
2C	Cold rolled, heat treated	0.80-3.00	30-1500	0.80-3.00	600-1500
2D	Cold rolled, heat treated, pickled	0.50-3.00	30-1500	0.50-3.00	600-1500
2E	Cold rolled, heat treated, mech. desc. pickled	0.50-7.92	30-2070	0.50-4.00	300-2070
2G	Ground	0.50-3.00	30-1500	0.50-3.00	600-1500
2J	Brushed or dull polished	0.50-3.00	30-1500	0.50-3.00	600-1500
2R	Cold rolled, bright annealed	0.05-6.00	3-1500	0.50-3.00	350-1500

Continous hot rolled products, available dimensions (mm)

Surface finish		Coil / Strip Thickness	Width	Plate / Sheet Thickness	Width
1C	Hot rolled, heat treated, not descaled	2.50-10.00	50-1530		
1D	Hot rolled, heat treated, pickled	2.70-12.70	50-2070	3.00-12.70	300-2070
1E	Hot rolled, heat treated, mech. desc.	2.16-4.76	36-1520	2.16-4.76	400-1500
1U	Black hot rolled	2.50-10.00	50-1530		

Quarto plate products, available dimensions (mm)

Surface finish		Coil / Strip Thickness	Width	Plate / Sheet Thickness	Width
1D	Hot rolled, heat treated, pickled			6.00-50.00	400-3000

Chemical composition

Typical chemical composition is given in the table below. The chemical composition is given as % by weight.

	C	Mn	Cr	Ni	Mo	N	Other
Typical	**0.05**		**25.5**	**19.1**			
ASME II A SA-240	≤0.08	≤2.00	24.0-26.0	19.0-22.0			
ASTM A240	0.04-0.10	≤2.00	24.0-26.0	19.0-22.0			
ASTM A240	≤0.08	≤2.00	24.0-26.0	19.0-22.0			
EN 10095	≤0.10	≤2.00	24.00-26.00	19.00-22.00		≤0.11	
IS 6911	≤0.25	≤2.0	24.0-26.0	18.0-21.0	≤0.70		
IS 6911	≤0.08	≤2.00	24.0-26.0	19.0-22.0	≤0.70		

Corrosion resistance

Aqueous corrosion

Since most high-temperature materials are optimised with regard to strength and corrosion resistance at elevated temperatures, their resistance to electrochemical low-temperature corrosion may be less satisfactory. Components made of high-temperature material should therefore be designed and operated so that acid condensates are not formed, or at least so that any such condensates are drained away.

High-temperature corrosion

The resistance of a material to high-temperature corrosion is in many cases dependent on its ability to form a protective oxide layer. In a reducing atmosphere, when such a layer cannot be created (or maintained), the corrosion resistance of the material will be determined by the alloy content of the material.

Oxidation

When a material is exposed to an oxidising environment at elevated temperatures, a more or less protective oxide layer will be formed on its surface. Even if oxidation is seldom the primary cause of high-temperature corrosion failures, the oxidation behaviour is important, because the properties of the oxide layer will determine the resistance to attack by other aggressive elements in the environment.The oxide growth rate increases with increasing temperature until therate of oxidation becomes unacceptably high or until the oxide layer begins to crack and spall off, i.e. the scaling temperature is reached. The alloying elements that are most beneficial for oxidation resistance are chromium, silicon, and aluminium. A positive effect has also been achieved with small additions of so-called (re)active elements, e.g. ttrium, hafnium, rare earth metals (REM, e.g. Ce and La). These affect the oxide growth so that the formed layer will be thinner, tougher, and more adherent and thus more protective.

Sulphur attacks

Various sulphur compounds are often present in flue gases and other process gases. As a rule, they have a very detrimental effect on the useful life of the exposed components. Sulphides can nucleate and grow due to kinetic effects even under conditions where only oxides would form from a thermodynamic point of view. In existing oxide layers, attacks can occur in pores and cracks. It is therefore essential that the material is able to form a thin, tough, and adherent oxide layer. This requires a high chromium content and preferably also additions of silicon, aluminium, and/or reactive elements.

Pitting corrosion resistance		Crevice corrosion resistance
PRE	CPT	CCT
26		

PRE Pitting Resistant Equivalent calculated using the formula: PRE = %Cr + 3.3 x %Mo + 16 x %N
CPT Corrosion Pitting Temperature as measured in the Avesta Cell (ASTM G 150), in a 1M NaCl solution (35,000 ppm or mg/l chloride ions).
CCT Critical Crevice Corrosion Temperature is the critical crevice corrosion temperature which is obtained by laboratory tests according to ASTM G 48 Method F

For more information see Outokumpu Corrosion Handbook or contact Outokumpu.

Mechanical properties

Whilst Outokumpu high temperature steels are mainly optimised for oxidation and high temperature corrosion resistance, they also have good mechanical properties, partly due to their austenitic structure and partly due to certain alloying elements. Design values are usually based on minimum proof strength values for constructions used at temperatures up to around 550°C. For higher temperatures, mean creep strength values are used.

Cold rolled coil and sheet	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical (thickness 1 mm)	**280**	**320**	**590**	**60**				
ASME II A SA-240	≥ 205		≥ 515				≤ 217	
ASTM A240	≥ 205		≥ 515				≤ 217	
ASTM A240	≥ 205		≥ 515			≤ 95HRB	≤ 217	
EN 10095	≥ 210	≥ 250	500 - 700	≥ 33				
IS 6911	≥ 210		≥ 490			≤ 95HRB	≤ 217	
IS 6911	≥ 205		≥ 515			≤ 95HRB	≤ 217	

Hot rolled coil and sheet	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical (thickness 4 mm)	**290**	**330**	**590**	**47**			**83**	
ASME II A SA-240	≥ 205		≥ 515				≤ 217	
ASTM A240	≥ 205		≥ 515				≤ 217	
ASTM A240	≥ 205		≥ 515				≤ 217	
EN 10095	≥ 210	≥ 250	500 - 700	≥ 35				
IS 6911	≥ 210		≥ 490			≤ 95HRB	≤ 217	
IS 6911	≥ 205		≥ 515			≤ 95HRB	≤ 217	

Hot rolled quarto plate	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV
Typical (thickness 15 mm)	**240**	**310**	**600**	**50**				
ASME II A SA-240	≥ 205		≥ 515			≤ 95HRB	≤ 217	
ASTM A240	≥ 205		≥ 515			≤ 95HRB	≤ 217	
ASTM A240	≥ 205		≥ 515			≤ 95HRB	≤ 217	
EN 10095	≥ 210	≥ 250	500 - 700	≥ 35				
IS 6911	≥ 210		≥ 490			≤ 95HRB	≤ 217	
IS 6911	≥ 205		≥ 515			≤ 95HRB	≤ 217	

Wire rod	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	Elongation[1)] %	Impact strength J	Rockwell	HB	HV

Typical	270	310	600	50				

[1)]Elongation according to EN standard:
A_{80} for thickness below 3 mm.
A for thickness = 3 mm.
Elongation according to ASTM standard $A_{2"}$ or A_{50}.

Physical properties

Data according to EN 10088

Density kg/dm^3	Modulus of elasticity GPa	Thermal exp. at 100 °C 10^{-6}/°C	Thermal conductivity W/m°C	Thermal capacity J/kg°C	Electrical resistance µΩm	Magnetizable
7.9	196	15,5	15	500	0.85	No

Fabrication

Like other austenitic steels, heat-resistant steels can also be formed in cold condition. However, as a result of their relatively high nitrogen content, the mechanical strength of certain steels is higher and consequently greater deformation forces will be required.
Machining
The relatively high hardness of austenitic steels and their ability to strain harden must be taken into consideration in connection with machining. For more detailed data on machining, please contact Outokumpu, Avesta Research Centre.
Welding
High temperature constructions are frequently exposed to thermal fatigue due to variations of temperature. For this reason it is very important to design the welded joint without notches. Furthermore it is important that welds have oxidation resistance and creep strength compatible with the parent material.
To ensure weld metal properties (e.g. strength, corrosion resistance) equivalent to those of the parent metal, a filler metal with a matching composition should preferably be used. Recommended filler metal is 25 20. In some cases, however, a differing composition may improve e.g. weldability or structural stability. Gas shielded welding has resulted in the best creep properties for welds. 4845 is a fully austenitic steel and susceptible to hot cracking. Due to this, the heat input should be limited to maximum 1,0 kJ/mm. For this reason SAW should be avoided. The use of filler and a basic flux/coating will reduce the risk of hot cracking.
When welding heat resistant stainless steel to carbon steels, 23Cr 12Ni filler can be used. Nickel-based filler may be a better alternative if there is a high risk of loss of strength in the HAZ of the carbon steel. The reason is that if carbon in the construction steel may diffuse into the low carbon weld metal, the HAZ in the carbon steel well lose strength.
Repair welding of exposed and damaged high temperature equipment is easily performed with MMA. Before welding, it is important to remove all magnetic areas close to the weld joint since these may contain embrittling phases. Machining or grinding is suitable methods.

More detailed information concerning welding procedures can be obtained from the Outokumpu Welding Handbook, available from our sales offices.

More information

A number of publications regarding this steel grade are available for downloading from our web page. The downloads can be found under Products/Useful Tools Online/Publications. Below are a few publications that might be of interest.

High Temperature Austenitic Stainless Steel
Material datasheet presenting the properties for Outokumpu austenitic grades suitable for high temperature applications

Acom 2010 Ed:2
Materials performance in simulated waste combustion environments
R. Pettersson. J. Flyg. P. Viklund.
High temperature corrosion under simulated biomass deposit conditions
R. Pettersson. J. Flyg. P. Viklund.

Standards & approvals

The most commonly used international product standards are given in the table below.

Standard	Designation
ASME SA-240M Code Sect. II. Part A	TYPE 310S / UNS S31008
ASTM A240/A240M	TYPE 310S / UNS S31008; TYPE 310S / UNS S31008
EN 10095	1.4845
IS 6911, AMENDMENT NO. 2	ISS 310; ISS 310S

Contacts & Enquiries

Contact your nearest sales office

www.outokumpu.com/contacts

Working towards forever.

We work with our customers and partners to create long lasting solutions for the tools of modern life and the world's most critical problems: Clean energy, clean water and efficient infrastructure. Because we believe in a world that lasts forever.

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