

Therma 4828

EN 1.4828

General characteristics

Austenitic grade with improved oxidation resistance. Commonly used for furnace equipment (esp. supporting parts), annealing and hardening boxes, air heaters.

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.

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:

- Furnace equipment (esp. supporting parts)
- Annealing and hardening boxes
- Air heaters
- 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
2B	Cold rolled, heat treated, pickled, skin passed	0.30-3.00	30-1250	0.30-3.00	350-1250
2BB	Bright-pickled	0.30-3.50	30-1500	0.30-3.50	600-1500
2C	Cold rolled, heat treated	1.00-3.00	30-1500	1.00-3.00	600-1500
2D	Cold rolled, heat treated, pickled	0.30-3.50	30-1500	0.30-3.50	600-1500
2E	Cold rolled, heat treated, mech. desc. pickled	0.50-6.35	30-2040	0.50-6.35	300-2040
2G	Ground	0.30-3.00	30-1500	0.30-3.00	600-1500
2J	Brushed or dull polished	0.30-3.00	30-1500	0.30-3.00	600-1500
2R	Cold rolled, bright annealed	0.05-3.00	3-1500	0.30-3.00	350-1500

Continuous hot rolled products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
1C	Hot rolled, heat treated, not descaled	2.00-10.00	50-1550		

1D	Hot rolled, heat treated, pickled	4.00-12.70	50-2040	4.00-12.70	300-2040
1G	Ground	2.00-3.00	750-1350	2.00-3.00	750-1350
1U	Black hot rolled	2.00-10.00	50-1550		

Quarto plate products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
1C	Hot rolled, heat treated, not descaled			6.00-50.00	400-3000
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 mass.

	C	Mn	Cr	Ni	Mo	N	Other
Typical	0.05		19.3	11.2			Si:1.9
EN 10095	≤0.20	≤2.00	19.00-21.00	11.00-13.00		≤0.11	Si:1.50-2.50

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 the rate 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. titanium, 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
19		

PRE Pitting Resistant Equivalent calculated using the formula: $PRE = \%Cr + 3.3 \times \%Mo + 16 \times \%N$

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

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)	300	330	650					
EN 10095	≥ 230	≥ 270	550 - 750	≥ 30				

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)	325	370	630	59			82	
EN 10095	≥ 230	≥ 270	550 - 750	≥ 30				

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)	270	310	610	55				
EN 10095	≥ 230	≥ 270	550 - 750	≥ 30				

¹⁾Elongation according to EN standard:

A₈₀ for thickness below 3 mm.

A for thickness = 3 mm.

Elongation according to ASTM standard A₂ or A₅₀.

Physical properties

Data according to EN 10088

Density	Modulus of elasticity	Thermal exp. at 100 °C	Thermal conductivity	Thermal capacity	Electrical resistance	Magnetizable
kg/dm ³	GPa	10 ⁻⁶ /°C	W/m°C	J/kg°C	μΩm	
7.9	196	16,5	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

The steels have good or very good weldability. To ensure weld metal properties (e.g. strength, corrosion resistance) equivalent to those of the parent metal, a filler material with a matching composition should preferably be used. 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.

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.

Stainless steels in waste and biomass power plant applications

R. Pettersson. A. Bergquist. J. Flyg. B. Beckers.

Standards & approvals

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

Standard	Designation
EN 10095	1.4828

Contacts & Enquiries

Contact your nearest sales office

www.outokumpu.com/contacts

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