outokumpu
high performance stainless steel

Therma 4724

EN 1.4724

General characteristics

Low-alloyed ferritic heat resisting grade with improved scaling resistance. Uncritical regarding embrittlement at service temperatures. Applied for e.g. furnace equipment, thermal boiler components, grids, burner nozzles, conveying parts, thermowells. The high temperature (HT) ferritic stainless steels complement Outokumpu austenitic heat and creep portfolio. The main alloying element in the ferritic grades is chromium. Its positive effect on the scaling resistance is enhanced by silicon and aluminium. The characteristic properties are excellent resistance to oxidising and reducing sulphur containing atmospheres, good resistance to oxidation and high thermal conductivity with low thermal expansion.
4713 does not form brittle phases but should only be exposed to moderately corrosive atmospheres owing to its low chromium content.
4724 is a truly stainless high temperature grade with 13% chromium. It is not critical in terms of embrittlement. 4742 shows better scaling resistance than 4724 and can be subjected to reducing sulphur environments without risk. It is subject to 475°C embrittlement and grain coarsening at temperatures above 950°C. σ-phase may form after long time exposures to temperatures around 650°C.
4762 - with the highest chromium content- is the most resistant to reducing sulphurous gases. It is susceptible to the same embrittlement phenomena as 4742 whilst σ-phase forms during long exposures in the range 600°C to 800°C.

Characteristic temperatures

The characteristic temperatures for the different grades are shown in the table below.

Steel grade	Maximum service temperature in dry air,ºC	Hot forming[1],ºC	Annealing[2],ºC
4713	800	1100-750	750-800
4724	850	1100-750	800-850
4742	1000	1100-750	800-850
4762	1150	1100-750	800-850

Typical applications

Outokumpu Stainless ferritic high temperature steels are mostly used in high temperature applications with sulphurous atmospheres and/or low tensile loads such as for installations within:

- Furnace equipment
- Thermal boiler components
- Grids
- Burner nozzles
- Conveying parts
- Thermowells
- Chemical industry (drums)
- Power industry (coal burners)
- Metalworking industry (heat treatment boxes)

[1] Cooling still air [2] Cooling forced air or water

Creep strength

Creep properties of 47XX, $R_{p0,1}$ N/mm^2 (mean values) are shown in the table below.

Time,h	Temperature				
	500	600	700	800	900
1 000	80	27.5	8.5	3.7	1.8
10 000	50	17.5	4.7	2.1	1.0

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	1.20-3.00	30-1250	1.20-3.00	350-1250
2BB	Bright-pickled	0.50-3.50	30-1500	0.50-3.50	600-1500
2C	Cold rolled, heat treated	0.80-4.00	30-1500	0.80-4.00	600-1500
2D	Cold rolled, heat treated, pickled	0.50-4.00	30-1500	0.50-4.00	600-1500
2E	Cold rolled, heat treated, mech. desc. pickled	0.50-4.00	30-1500	0.50-4.00	600-1500
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	0.05-1.50	3-649		

Continous hot rolled products, available dimensions (mm)

Surface finish		Coil / Strip		Plate / Sheet	
		Thickness	Width	Thickness	Width
1C	Hot rolled, heat treated, not descaled	3.50-6.00	50-1530		
1D	Hot rolled, heat treated, pickled	4.00-6.00	50-1250	4.00-6.00	350-1250
1U	Black hot rolled	3.50-6.00	50-1530		

Chemical composition

The chemical composition is given in the table below.

The chemical composition is given as % by weight.

	C	Mn	Cr	Ni	Mo	N	Other
Typical	**0.07**		**12.5**				**Si:1.0 Al:0.9**
EN 10095	≤0.12	≤1.00	12.00-14.00				Si:0.70-1.40

Corrosion resistance

Oxidation

In oxidising environments, a protective oxide layer is likely to be formed on the metallic surface. If the layer is tight and adherent, it can prevent other aggressive elements in the environment from attacking and reacting with the steel. However, the layer can grow in thickness due to constant oxidation. The resulting porous layer will allow the gas to penetrate through to the base material through pores or cracks. Silicon and aluminum are both beneficial for oxidation resistance. Low thermal expansion and high thermal conductivity of the ferritic base material reduce changes in volume and thus spalling of the protective layer.

Sulphur attacks

As a rule, ferrites perform better than austenites in oxidising and reducing sulphurous atmospheres. SO_2 or H_2S are possible compounds in sulphur containing process gases or fuels. In terms of resistance to carburisation, austenitic grades show more favorable results than ferritic ones due to their high Ni-content. Formation of chromium carbides or chromium nitrides, respectively, embrittles the material. Additionally, the surrounding matrix becomes chromium depleted and thus less able to form an oxide layer, which consequently reduces the scaling resistance of the material. Silicon has a beneficial effect on both carbon and nitrogen pick-up. Aluminum is only favorable in terms of carburisation. The high nitrogen affinity of aluminum results in aluminum nitrides retarding formation of a protective alumina and leading to premature failure of the material.

Molten metals

In molten metals, Nickel is the most susceptible element to dissolution. Austenitic material is bound to fail when e.g. molten copper penetrates the grain boundaries. HT ferrites - on the other hand - are expected to show good compatibility with molten copper. Final resistance will, of course, depend on the composition of the molten metal.
For more information, see Outokumpu Corrosion Handbook.

Pitting corrosion resistance		Crevice corrosion resistance
PRE	CPT	CCT
13		

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

Mechanical properties

Mechanical properties at room temperature are shown in the table below.

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)	**480**	**510**	**600**					

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)								

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)	**340**	**370**	**515**	**30**				
EN 10095	≥ 250		450 - 650					

[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 10095.

	Modulus of	Thermal exp. at	Thermal	Thermal	Electrical	

Density kg/dm^3	elasticity GPa	100 °C 10^{-6}/°C	conductivity W/m°C	capacity J/kg°C	resistance µΩm	Magnetizable
7.7		10,5	21	500	0.75	Yes

Fabrication

Hot forming

Hot working should be carried out within the temperature ranges given under the headline Characteristic temperatures earlier in this datasheet.

Formability/Machining

Generally, ferrites are difficult to form in the cold condition. They are formable at room temperature when sheets are no thicker than 3 mm; 4713 even 6 mm. Thicker 4713 and 4724 plates must be preheated and formed within the temperature range 250 - 300°C. 4742 and 4762 should even be heated up to 800 - 900°C to avoid formation of any brittle phases. Generally, the minimum radius for bending deformation can be taken as “double thickness”. Machining is considered to be less problematic due to their low strain hardening rates.

Welding

The same precautions as for carbon steels are normally required. Preheating of the joints to 200-300°C is necessary for plates thicker than 3 mm. Due to grain growth in the heat affected zone, the heat input should be minimised. Gas shielded welding methods such as GTA (TIG), plasma arc and GMA (MIG) are preferred. Pure argon should be used as the shielding gas. Matching filler material has detrimental effect on the ductility why austenitic welding consumables, e.g. 307, 309 or 310 are recommended. If the weld will be exposed to a sulphurous environment, overlay welding with the matching ferritic filler will be necessary.

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 Ferritic Stainless Steel
Datasheet describing Outokumpu ferritic grades for use in high temperature applications.

Standards & approvals

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

Standard	Designation
EN 10095	1.4724

Contacts & Enquiries

Contact your nearest sales office

www.outokumpu.com/contacts

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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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