outokumpu
high performance stainless steel

Therma
High service temperatures

Outokumpu Therma Alloy 800/800H/800HT

Outokumpu Therma range datasheet

General characteristics

The Therma range contains heat-resisting stainless steels and alloys for use in applications with high service temperatures normally > 550 °C/1020 °F.

Outokumpu Therma Alloy 800/800H/800HT is a series of high-temperature alloys design for high creep strength, resistance to carburization, oxidation, and other types of high-temperature corrosion. Therma Alloy 800 series (EN 1.4876/1.4958/1.4959, UNS N08800/N08810/N08811) are stabilized austenitic alloys with high Nickel and Chromium content as well as controlled additions of Carbon, Titanium and Aluminum. Additionally, grain size is controlled for improved creep strength properties.

Designations.

Table 1

Outokumpu grade	ASTM/ASME B409/SB409	ASTM/ASME A240/SA240	EN 10088-1	EN 10095	EN 10028-7	EN 10302
Therma Alloy 800	N08800	N08800	1.4876	1.4876	–	–
Therma Alloy 800H	N08810	N08810	1.4958	1.4876	1.4958*	1.4958
Therma Alloy 800HT	N08811	N08811	1.4959	1.4876	1.4959*	1.4959

*) Only listed as Hot rolled plate.

Therma Alloy 800 has:

- Good mechanical properties at low temperatures and elevated temperatures up to 800 °C.
- Good corrosion and heat resistance.
- Good resistance to oxidizing, reducing and nitriding conditions.

Therma Alloy 800H/800HT has:

- Good to excellent creep strength properties.
- Good resistance to oxidizing, reducing and nitriding conditions.
- Therma Alloy 800H has high microstructural stability also when exposed to intermediate service temperatures, 560–760 °C, thanks to controlled Al + Ti (0.4–0.7 wt%) content.
- For operating temperature above 700 °C Therma Alloy 800HT provides excellent creep strength by controlling the Al + Ti content to 0.85–1.20 wt%.
- Therma Alloy 800H and 800HT has a controlled grain size for increased creep strength properties.

Typical applications:

- General high-temperature service
- Steam/hydrocarbon reformers
- Ethylene pyrolysis
- Acetic anhydride cracking furnaces
- Heat exchangers
- Heating element sheaths
- High temperature process equipment

Microstructure

Outokumpu Therma Alloy 800 series have an austenitic microstructure. The titanium stabilization together with the high carbon content provides high metallurgical stability and increased high-temperature properties. Titanium nitrides, titanium carbides, and chromium carbides are normally present in the alloys' microstructure.

Generally, for operating temperatures above 600 °C Therma alloy 800H or 800HT are recommended. For continuous operating temperature at, or repeatedly lowered to, intermediate service temperatures 560–760 °C Therma Alloy 800H is recommended. At intermediate service temperature Therma Alloy 800HT is prone to precipitation of gamma prime (γ') associated with reduced ductility.

Chemical composition

Chemical composition. Table 2

Outokumpu grade		C	Cr	Ni	Si	Al	Ti	Al + Ti	Other
Therma Alloy 800	Min.	–	19	30	–	0.2	0.2	–	–
	Max.	0.1	22	32	0.7	0.6	0.6	–	–
Therma Alloy 800H	Min.	0.05	19	30	–	0.2	0.2	0.4	–
	Max.	0.08	22	32	0.7	0.5	0.5	0.7	–
Therma Alloy 800HT	Min.	0.06	19	30	–	0.25	0.25	0.85	–
	Max.	0.1	22	32	0.7	0.6	0.6	1.2	–
Therma 253MA	Typical	0.09	21	11	1.6	–	–	–	0.05Ce, 0.17N
Therma 310S	Typical	0.05	25.5	19.1	–	–	–	–	–

Mechanical properties

Mechanical properties at 20°C, according the standards. Table 3

Outokumpu grade	UNS/EN		ASTM/ASME B409/SB409	ASTM/ASME A240/SA240	EN 10095	EN 10028-7	EN 10302
Therma Alloy 800	N08800/ 1.4876	Min. $R_{p0.2}$, MPa (ksi)	205 (30)	205 (30)	170	–	–
		Min. $R_{p1.0}$, MPa (ksi)	–	–	192	–	–
		Min. R_m, MPa (ksi)	520 (75)	520 (75)	450–680	–	–
		Min. A (%)	30	30	30	–	–
Therma Alloy 800H	N08810/ 1.4876 / 1.4958	Min. $R_{p0.2}$, MPa (ksi)	170 (25)	170 (25)	170	170	170
		Min. $R_{p1.0}$, MPa (ksi)	–	–	192	200	
		Min. R_m, MPa (ksi)	450 (65)	450 (65)	450–680	500–750	500–750
		Min. A (%)	30	30	30	30	30
Therma Alloy 800HT	N08811/ 1.4876/ 1.4959	Min. $R_{p0.2}$, MPa (ksi)	170 (25)	170 (25)	170	170	170
		Min. $R_{p1.0}$, MPa (ksi)	–	–	192	200	–
		Min. R_m, MPa (ksi)	450 (65)	450 (65)	450–680	500–750	500–750
		Min. A (%)	30	30	30	30	30

Creep rupture strength $R_{km\ 10,000}$ (MPa mean values) according to EN 10095.

Table 4

Outokumpu grade	Temperature, °C												
	500	550 [1]	600	650 [2]	700	750 [2]	800	850 [2]	900	950 [2]	1000	1050 [2]	1100
Therma Alloy 800H	290	225	140	97	69	–	–	–	–	–	–	–	–
Therma Alloy 800HT	–	–	–	–	73	51	35	24	17	11	7.5	–	–
Therma 310S	–	–	130	65	40	26	18	13	8.5	–	–	–	–
Therma 253 MA	–	250	157	98	63	41	27	18	13	9.5	7	5.5	4

[1] Values according to EN 10028-7. [2] Own data.

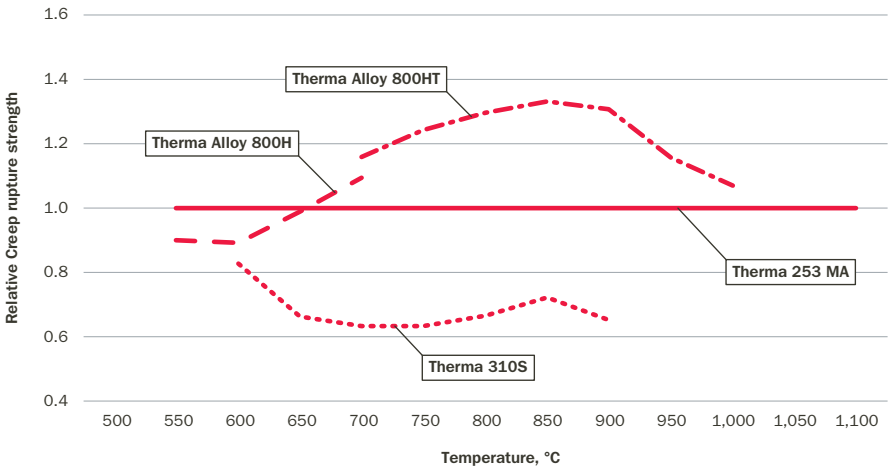

Fig. 1. Relative creep rupture strength 10,000 h, normalized to Therma 253 MA.

Creep rupture strength $R_{km\ 100,000}$ (MPa mean values) according to EN 10095.

Table 5

Outokumpu grade	Temperature, °C												
	500	550 [2]	600	650 [2]	700	750 [2]	800	850 [2]	900	950 [2]	1000	1050 [2]	1100
Therma Alloy 800H [1]	215	160	95	63	44	–	–	–	–	–	–	–	–
Therma Alloy 800HT [1]	–	–	–	–	45	30	20	14	9	5	3	–	–
Therma 310S	–	–	80	33	18	11	7	4.5	3	–	–	–	–
Therma 253 MA	–	160	88	55	35	22	15	11	8	5.5	4	3	2.3

[1] Values according to EN 10028-7. [2] Own data.

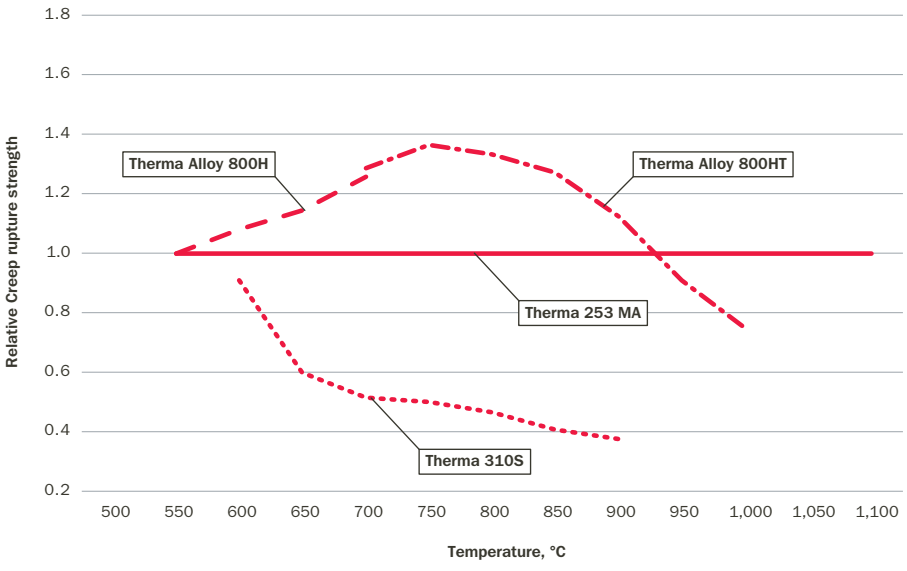

Fig. 2. Relative creep rupture strength 100,000 h, normalized to Therma 253 MA.

High-temperature corrosion

Therma Alloy 800H and 800HT

Outokumpu alloys Therma Alloy 800H and 800HT are designed with controlled carbon, aluminium and titanium content as well as controlled solution annealing treatment for optimum creep strength required in various high temperature industrial applications. Alloy 800H and 800HT have superior properties linked to their refined chemical compositions. Their high nickel content enhances the alloys resistance against carburisation. These alloys are also resistant to oxidation and sulfidation, owing to their high chromium content which develops a protective oxide surface but also due to the addition of iron, which greatly decreases the risks of internal oxidation often responsible for embrittlement in nickel-chromium alloys.

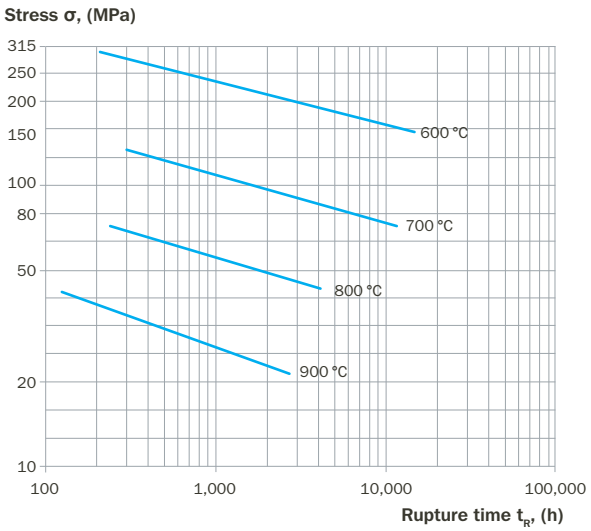

Fig. 3. Creep rupture stength of 3 mm sheet of Therma Alloy 800H.

Physical properties

The physical property values given for the austenitic grades in the European standard EN 10095 are inconsistent and poorly documented. The values below have therefore been extracted from STAHL-EISEN-Werkstoffblatt 310 or from own investigations (Therma 253 MA). Values for these properties at other temperatures can be supplied by Outokumpu, Avesta Research Centre, on request.

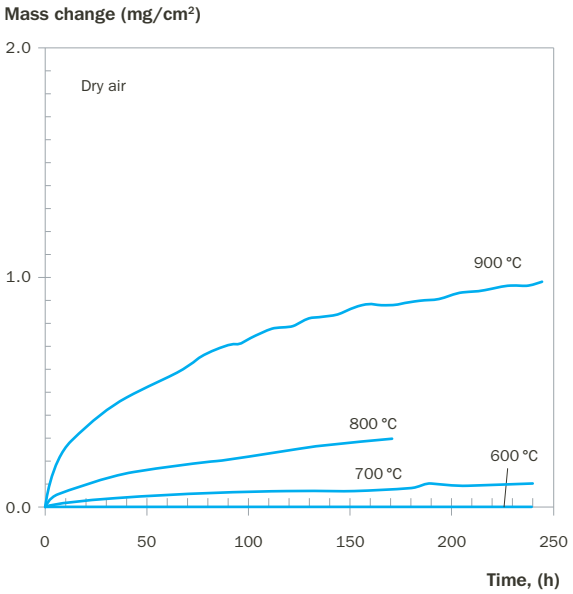

Fig. 4. Iso-thermal oxidation of Therma Alloy 800H in dry air.

Table 6

Metric

Outokumpu name	Density [kg/dm³]	Modulus of elasticity at 20 °C [GPa]			Coefficient of thermal expansion 20–100 °C [10⁻⁶/K]			Thermal conductivity at 20 °C [W/(m x K)]			Thermal capacity [J/(kg x K)]	Electrical resistivity [Ω x mm²/m]
	20 °C	20 °C	600 °C	1000 °C	600 °C	800 °C	1000 °C	20 °C	500 °C	800 °C	20 °C	20 °C
Therma 253 MA	7.80	200	155	120	18.5	19.0	19.5	15.0	–	25.6	500	0.84
Therma 310S/4845	7.80	196	150	120	18.8	19.4	20.0	11.9	–	24.3	472	0.96
Therma Alloy 800 *)	8	—	–	–	17	17.5	18.5	12	17	–	550	1.0
Therma Alloy 800H *)	8	200	155	125	17.5	18.3	19.0	12	–	–	460	0.99
Therma Alloy 800HT *)	8	200	155	125	17.5	18.3	19.0	12	–	–	460	0.99

*) Values according to EN 10028-7

Fabrication

Forming and Heat treatment

Austenitic stainless steels can be readily cold formed by all standard methods. Like other austenitic stainless steels, heat-resisting steels can be formed in the hot or cold condition.

The hot forming of Therma Alloy 800, 800H and 800HT normally performed in the temperature range 870–1200 °C. No hot working should be done between 650–870 °C, to avoid γ' precipitates. The grades are subject to some carbide precipitation in the 540–760 °C temperature range and should be rapidly cooled through that range when sensitization is a concern.

After hot working cooling should be performed by forced air or faster. Heavy sections may become sensitized during cooling from the hot-working temperature, and therefore be subject to intergranular corrosion in certain media.

Heat treatment after hot or cold forming, or welding, will often not be necessary because the material will be exposed to high temperatures during service. Solution annealing for Alloy 800H and 800HT is normally performed at 1120–1220 °C to achieve a large grain size and excellent creep properties. Retention time required depends on the workpiece thickness. Alloy 800 can be solution annealing at 1000–1100 °C.

Components in which the material has become embrittled during service will benefit from a rejuvenating solution anneal before any maintenance work – for example, straightening or repair welding is carried out.

Welding

The weldability of the Therma Alloy 800/800H/800HT is good with all conventional welding processes. Some of the details that require attention are:

1. Cleanliness. It is important that the weld joint surfaces are clean before welding. The surface should be free from oxide films, grease, dirt, oil etc. It is especially important to remove the oxide films because their high melting point makes them difficult to melt and can lead to defects.
2. In common with other nickel base alloys, the fluidity of molten weld metal is low leading to a sluggish weld pool which does not wet out easily. The weld penetration is less for comparable weld settings. To compensate for this, the edge preparation should have a larger bevel angle, narrower root face and wider root opening.
3. In common with austenitic stainless steels, the Therma Alloy 800 series has low thermal conductivity and high coefficient of thermal expansion. Welding procedures should be selected to minimize welding distortion and residual stress.

Table 8 shows the recommended consumables for the welding of Therma Alloy 800 series.

Characteristic temperatures.

Table 7

Outokumpu grade	Solidification range, °C	Maximum service temperature in dry air, °C	Hot forming, °C	Solution annealing, °C	Stress relief annealing (min. 0.5 h), °C
Therma Alloy 800	1400–1300	–	1200–870	1000–1100	870
Therma Alloy 800H	1400–1300	1,100	1200–870	1150–1220	870
Therma Alloy 800HT	1400–1300	1,100	1200–870	1150–1220	870
Therma 253MA	1450–1350	1,150	1150–900	1020–1120	900
Therma 310S	1410–1340	1,050	1150–980	1050–1150	1040–1070

Recommended welding consumables for the welding of Therma Alloy 800 series.

Table 8

Base Material/ Consumable	For service temp. (°C)	Alloy	Group No. in ISO 15608 *)	AWS A5.11	Covered electrode ISO 14172	
					Alloy Symbol	
					Number	Chemical symbol
Therma Alloy 800/800H/800HT			45			
MMA/SMAW	≤800	WE 182	43	E NiCrFe-3	E Ni 6182	NiCr15Fe6Mn
	> 800	WE 117	46	E NiCrCoMo-1	E Ni 6117	NiCr22Co12Mo
Consumable	**For service temp. (°C)**	**Alloy**	**Group No. in ISO 15608**	**AWS A5.14**	**Solid wire ISO 18274**	
					Number	**Chemical symbol**
GTAW/GMAW	≤ 800	FM82	43	ER NiCr-3	Ni 6082	NiCr20Mn3Nb
	> 800	617	46	ER NiCrMoCo-1	Ni 6617	NiCr22Co12Mo9

*) The group number as per ISO 15608 can be used as an input for the tables in ISO 15614 to decide the range of material groupings for which a given welding procedure qualification is valid.

When single figures are given, they refer to the mid-level in the range.

Products

Outokumpu Therma Alloy 800, 800H and 800HT are available as cold rolled strip, sheet and plate, and as hot rolled sheet and plate. Currently in coil widths up to 1,500 mm in thickness range 0.4 mm to 8 mm, plate widths up to 2,500 mm in thickness range 8 mm to 80 mm.

Special requirements.

Table 9

	Special Grain Size Requirements		
Standard	ASTM/ASME B409/SB409	ASTM/ASME A240/SA240	EN 10028-7
Therma Alloy 800H	ASTM No. 5 or coarser.	ASTM No. 7 or coarser.	–
Therma Alloy 800HT	ASTM No. 5 or coarser.	ASTM No. 7 or coarser.	EN ISO 643 shall be 1 to 5.

Contacts and enquiries

Contact us

Our experts are ready to help you choose the best stainless steel product for your next project.

www.outokumpu.com/contact

Own notes

Working towards a world that lasts 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.

outokumpu classic			outokumpu pro					
Moda	Core	Supra	Forta	Ultra	Dura	Therma	Prodec	Deco
Mildly corrosive environments	Corrosive environments	Highly corrosive environments	Duplex & other high strength	Extremely corrosive environments	High hardness	High service temperatures	Improved machinability	Special surfaces

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