High Temperature Austenitic Stainless Steel

Steel grades

Outokumpu	EN	ASTM
4948	1.4948	304H
4878	1.4878	321H
153 MA™	1.4818	S30415
4833	1.4833	309S
4828	1.4828	
253 MA®	1.4835	S30815
4845	1.4845	310S
4841	1.4841	314
353 MA®	1.4854	S35315

Characteristic properties

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

Applications

Outokumpu Stainless 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:

- Iron, steel, and non-ferrous industries
- Engineering industry
- Energy conversion plants
- Cement industry

General characteristics

A common feature of Outokumpu Stainless 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.

All steels except EN 1.4948 (i.e., all EN 1.48XX) are included in the European Standard EN 10095 "Heat-resisting steels and nickel alloys". EN 1.4948 is included in EN 10028-7 "Flat products made of steels for pressure purposes – Part 7: Stainless steel". All the above steel grades are also included in ASTM A240.

4948 is a creep-resistant variant of 1.4301, with a standardised minimum carbon content for service at temperatures of up to 800°C in dry air.

4878 is a heat-resistant variant of 1.4541, with a slightly higher maximum carbon content. The recommended maximum service temperature for this steel in dry air is also 800°C. There is also a creep-resistant, boron-alloyed, variant of 1.4541, i.e. 1.4941, which is included in EN 10028-7 and in ASTM A240.

153 MA™ is also a variant of 1.4301, with increased contents of silicon and nitrogen, and microalloyed with rare earth metals (REM). This has raised the maximum service temperature (in dry air) to 1000°C.

4833 and **4828** are standardised high-temperature steels for service at temperatures of up to 950-1000°C in dry air. Utilisation in the temperature range 600-900°C can lead to embrittlement of the material. There is also a creep-resistant variant of 4833, EN 1.4950, which is included in EN 10028-7 and in ASTM A240.

253 MA® is a variant of 1.4828 which has an increased nitrogen content and has been microalloyed with rare earth metals (REM). The most suitable temperature range is 850-1100°C, because structural changes when used between 600 and 850°C can lead to reduced impact toughness at room temperature.

4845 is a standardised high-temperature steel for use at temperatures of up to 1100°C in dry air. This steel is also prone to embrittlement after exposure between 600 and 900°C. There is also a creep-resistant variant of 4845, 1.4951, which is included in EN 10028-7 and in ASTM A240.

4841 is a variant of 1.4845 with an increased content of silicon, which has enhanced the steel's resistance to oxidation/corrosion but also made it more susceptible to embrittlement.

353 MA® is an alloy with a significantly higher nickel content than the other steels. Like 153 MA™ and 253 MA® it has increased contents of silicon and nitrogen, and is microalloyed with rare earth metals (REM). The maximum service temperature in air is 1150°C, but after service at temperatures below ~950°C there is a risk for reduced room temperature impact toughness.

Chemical composition

The chemical composition of a specific steel grade may vary slightly between different national (and international) standards. The required standard will be fully met as specified on the order.

Chemical composition

Table 1

Outokumpu steel name	International steel No		Typical chemical composition %						National steel designations, superseded by EN			
	EN	ASTM/UNS	C max	N	Cr	Ni	Si	Others	BS	DIN	NF	SS
4948	1.4948	304H	0.05	–	18.1	8.3	–	–	304S51	1.4948	Z6 CN 18-09	2333
4878	1.4878	321H	0.05	–	17.3	9.1	–	Ti	321S51	1.4878	Z6 CNT 18-10	2337
153 MA™	1.4818	S30415	0.05	0.15	18.5	9.5	1.3	Ce	–	1.4891	–	2372
4828	1.4828	–	0.04	–	20	12	2	–	–	1.4828	Z17 CNS 20-12	–
4833	1.4833	309S	0.06	–	22.3	12.6	–	–	309S16	1.4833	Z15 CN 23-13	–
253 MA®	1.4835	S30815	0.09	0.17	21	11	1.6	Ce	–	1.4893	–	2368
4841	1.4841	314	0.07	–	25	20	1.7	–	–	1.4841	Z15 CNS 25-20	–
4845	1.4845	310S	0.05	–	25	20	–	–	310S24	1.4845	Z8 CN 25-20	2361
353 MA®	1.4854	S35315	0.05	0.17	25	35	1.3	Ce	–	–	–	–

Microstructure

For most high-temperature alloys, the composition is optimised with regard to strength and/or resistance to corrosion at elevated temperatures.

Diffusion controlled transformations will occur in the material at sufficiently high operating temperatures. The most common type of reaction is the precipitation of non-desirable phases, which, besides lowering the corrosion resistance by consuming beneficial alloying elements (above all chromium), leads to a reduced toughness/ductility of the material – especially at room temperature.

The precipitates are often intermetallic phases such as sigma, chi, and so-called Laves phases.

In 153 MA, 253 MA, and 353 MA, the formation of sigma phase is counteracted by the relatively high contents of nitrogen in the steels (and carbon in 253 MA). Instead, precipitation of carbides and nitrides can occur in the same temperature range, which can result in an equally low impact toughness at room temperature as for intermetallic-embrittled high temperature alloys. Experience and certain laboratory tests have, however, shown that carbide/nitride embrittled steels have a greater ductility when deformation rates are lower, e.g. in tensile and bending tests.

The best steels with regard to embrittlement are 4878, 4948 and 153 MA.

Characteristic temperatures

Table 2

Steel 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
4948	1450 - 1385	800	1150 - 850	1050 - 1110	840 - 900
4878	1440 - 1370	800	1150 - 850	1020 - 1120	840 - 900
153 MA™	1450 - 1370	1000	1150 - 900	1020 - 1120	900
4828	1420 - 1350	1000	1150 - 950	1050 - 1150	1010 - 1040
4833	1420 - 1350	1000	1150 - 950	1050 - 1150	1010 - 1040
253 MA®	1430 - 1350	1100	1150 - 900	1020 - 1120	900
4845	1410 - 1340	1100	1150 - 980	1050 - 1150	1040 - 1070
4841	1400 - 1330	1125	1150 - 980	1050 - 1150	1040 - 1070
353 MA®	1410 - 1360	1150	1150 - 980	1100 - 1150	1010 - 1040

Mechanical properties

Whilst Outokumpu Stainless 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.

Mechanical properties at room temperature (minimum values)

Table 3

Steel grade	Proof strength $R_{p0.2}$ N/mm²	Proof strength $R_{p1.0}$ N/mm²	Tensile strength R_m N/mm²	Elongation %	Hardness max. HB
4948	210	250	510 - 710	45	-
4878	190	230	500 - 720	40	215
153 MA™	290	330	600 - 800	40	210
4828	230	270	550 - 750	30	223
4833	210	250	500 - 700	35	192
253 MA®	310	350	650 - 850	40	210
4845	210	250	500 - 700	35	192
4841	230	270	550 - 750	35	223
353 MA®	300	340	650 - 850	40	210

Elevated temperature tensile properties

At present, no data is available for 353 MA.

Elevated temperature proof strength, $R_{p0,2}$ N/mm², (minimum values) Table 4a

Steel grade	Temperature, °C											
	50	100	150	200	250	300	350	400	450	500	550	600	700
4948	–	157	142	127	117	108	103	98	93	88	83	78	–
4878	–	162	152	142	137	132	127	123	118	113	108	103	–
153 MA™	245	200	–	165	–	150	–	140	–	130	–	120	110
4828	–	140	128	116	108	100	94	91	86	85	84	82	–
4833	–	140	128	116	108	100	94	91	86	85	84	82	–
253 MA®	280	230	–	185	–	170	–	160	–	150	–	140	130
4845	–	140	128	116	108	100	94	91	86	85	84	82	–

Elevated temperature proof strength, $R_{p1,0}$ N/mm², (minimum values) Table 4b

Steel grade	Temperature, °C											
	50	100	150	200	250	300	350	400	450	500	550	600	700
4948	–	191	172	157	147	137	132	127	122	118	113	108	–
4878	–	201	191	181	176	172	167	162	157	152	147	142	–
153 MA™	280	235	–	195	–	180	–	170	–	160	–	150	135
4828	–	185	167	154	146	139	132	126	123	121	118	114	–
4833	–	185	167	154	146	139	132	126	123	121	118	114	–
253 MA®	315	265	–	215	–	200	–	190	–	180	–	170	155
4845	–	185	167	154	146	139	132	126	123	121	118	114	–

Elevated temperature proof strength, R_m N/mm², (minimum values) Table 4c

Steel grade	Temperature, °C											
	50	100	150	200	250	300	350	400	450	500	550	600	700
4948	–	440	410	390	385	375	375	375	370	360	330	300	–
4878	–	410	390	370	360	350	345	340	335	330	320	300	–
153 MA™	570	525	–	485	–	475	–	470	–	435	–	385	300
4828	–	470	450	430	420	410	405	400	385	370	350	320	–
4833	–	470	450	430	420	410	405	400	385	370	350	320	–
253 MA®	630	585	–	545	–	535	–	530	–	495	–	445	360
4845	–	470	450	430	420	410	405	400	385	370	350	320	–

Creep strength

Figure 1 shows the relative creep strength for rupture after 100,000 hours as a function of temperature. Reference steel: 253MA.

It should be noted here that 4948, contrary to the other alloys, is a creep-resistant steel that has been optimised with regard to strength. As an example, it can be mentioned that the creep-resistant variant of 4878, 1.4941, has creep strength values that are 15–20% higher than those for 4948.

For each alloy and temperature, the relative strength has been calculated by dividing the stress value that leads to rupture after 100,000 hours with the corresponding value for 253 MA.

(Diagrams of this type provide a quick and clear presentation of the relative strength of different grades of steel, e.g. 4828, 4833, and 4845 are only half as strong as 253 MA at 800°C, i.e. twice the material thickness is required for "normal" dimensioning.)

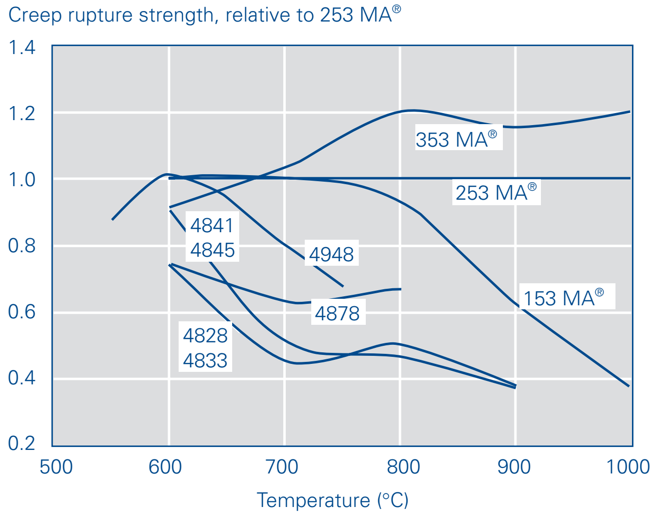

Fig. 1. Relative creep-rupture strength.

Creep rupture strength, $R_{km,10\,000}$ N/mm², (mean values) Table 5a

Steel grade	Temperature, °C												
	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
4948	250	191	132	87	55	34							
4878			142	82	48	27	15						
153 MA™		250	157	98	63	41	25	16	10	6,5	4		
4828			120	70	36	24	18	13	8,5				
4833			120	70	36	24	18	13	8,5				
253 MA®		250	157	98	63	41	27	18	13	9,5	7	5,5	4
4845			130	65	40	26	18	13	8,5				
4841			130	65	40	28	20	14	10				
353 MA®		206	127	82	56	39	28	20	15	11	8	6	4,5

Creep rupture strength, $R_{km,100\,000}$ N/mm², (mean values)

Table 5b

Steel grade	Temperature, °C												
	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
4948	192	140	89	52	28	15							
4878			65	36	22	14	10						
153 MA™		160	88	55	35	22	14	8	5	3	1,7		
4828			65	35	16	10	7,5	5	3				
4833			65	35	16	10	7,5	5	3				
253 MA®		160	88	55	35	22	15	11	8	5,5	4	3	2,3
4845			80	33	18	11	7	4,5	3				
4841			80	33	18	11	7	4,5	3				
353 MA®		129	80	52	36	25	18	13	9,2	6,7	4,8	3,5	2,7

Creep deformation strength, $R_{A1,10\,000}$ N/mm², (mean values)

Table 5c

Steel grade	Temperature, °C												
	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
4948	147	121	94	61	35	24							
4878			85	50	30	17,5	10						
153 MA™		200	126	74	42	25	15	8,5	5	3	1,7		
4828			80	50	25	15,5	10	6	4				
4833			70	47	25	15,5	10	6,5	5				
253 MA®		230	126	74	45	28	19	14	10	7	5	3,5	2,5
4845			90	52	30	17,5	10	6	4				
4841			95	60	35	20	10	6	4				
353 MA®		149	88	54	34	22	15	10,5	8	6	4,5	3,5	2,7

Creep deformation strength, $R_{A1,100\,000}$ N/mm², (mean values)

Table 5d

Steel grade	Temperature, °C												
	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
4948	114	96	74	43	22	11							
4878													
153 MA™		135	80	45	26	15	9	5	3	1,8	1		
4828													
4833													
253 MA®		150	80	45	26	16	11	8	6	4,5	3	2	1,2
4845													
4841													
353 MA®		86	52	33	21	14	9,7	6,9	5,1	3,9	3	2,3	1,8

Physical properties

The physical property values given in the European standard EN 10095 (EN 10028-7 for 4948) are inconsistent and poorly documented. The values below have therefore been extracted from STAHL-EISEN-Werkstoffblatt 310 or from own investigations (153 MA, 253 MA, and 353 MA).
If required, values for these properties at other temperatures can be supplied by Outokumpu Stainless, Avesta Research Centre.

Physical properties Table 6

Steel grade	Density (kg/dm^3)	Young's Modulus (kN/mm^2)			Thermal expansion coefficient (10^{-6}/°C) between 20 °C and			Thermal conductivity (W/m°C)		Heat capacity (J/kg°C)	Electrical resistivity (µΩm)
	20°C	20°C	600°C	1000°C	600°C	800°C	1000°C	20°C	800°C	20°C	20°C
4948	7.93	196	150	120	18.8	19.4	20.0	14.3	26.0	472	0.71
4878	7.92	196	150	–	18.8	19.4	–	13.9	25.8	472	0.74
153 MA™	7.80	200	155	120	18.5	19.0	19.5	15.0	25.5	500	0.84
4828	7.77	196	150	120	18.8	19.4	20.0	12.6	24.7	472	0.87
4833	7.77	196	150	120	18.8	19.4	20.0	12.6	24.7	472	0.87
253 MA®	7.80	200	155	120	18.5	19.0	19.5	15.0	25.5	500	0.84
4845	7.76	196	150	120	18.8	19.4	20.0	11.9	24.3	472	0.96
4841	7.76	196	150	120	18.8	19.4	20.0	11.9	24.8	472	0.96
353 MA®	7.90	190	155	130	16.9	17.5	18.2	11.3	23.0	450	1.00

All these austenitic steels have a greater thermal expansion and a lower thermal conductivity than ferritic stainless steels. This will result in greater thermal stresses when the temperature changes rapidly – thermo-shock – which must be taken into account during design and operation.

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.

As 4878 is a titanium-stabilised grade, it will probably show the best resistance to aqueous corrosion.

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. Below, a number of high-temperature corrosion types are treated. However, industrial environments often contain a mixture of several aggressive compounds, so the choice of material will, as a rule, have to be a compromise.

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 regularly 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 scaling temperatures for our steels are not given in Table 2. Instead, a recommended maximum temperature is given for use in dry air, based on laboratory tests and service experience.Table 2 shows that 353 MA and 4841 have the best oxidation resistance, followed closely by 4845 and 253 MA, see also Figure 2.

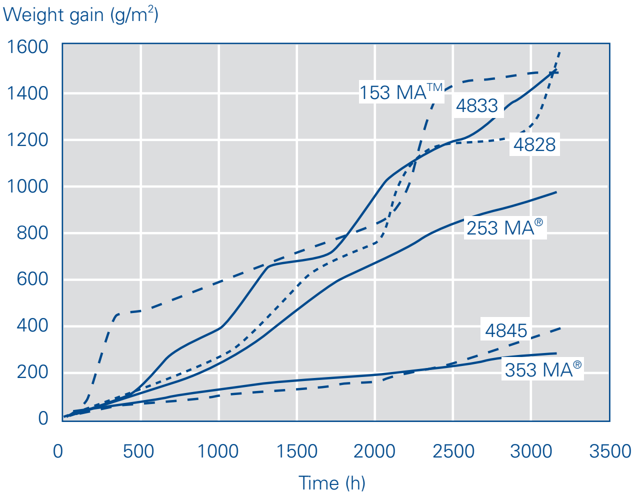

Fig. 2. Long-term oxidation at 1100°C. The specimens were cooled down to room temperature once a week for weighing => 165 h cycles.

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. yttrium, 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.

Molybdenum has a positive effect on corrosion properties at room temperature and moderately elevated temperatures, but can lead to so-called catastrophic oxidation at temperatures exceeding ~750°C.

The reactive element effect is especially favourable under conditions with varying temperatures, where the differences between the thermal expansion/contraction of the metal and the oxide induce stresses in the boundary layer, thereby increasing the risk of scaling. This explains the relatively high oxidation resistance of the MA alloys.

The existence of water vapour in the atmosphere will reduce the resistance to oxidation and thus the maximum service temperature by up to 100°C. Other, more aggressive components in the environment will lead to even greater reductions of the maximum service temperature.

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.

Under so-called reducing conditions, the oxygen activity of the gas can still be sufficiently high to enable the formation of a protective oxide layer, provided that the chromium content of the material is sufficiently high (>25%). If this is not the case, low-melting-point nickel sulphides can be formed instead. Under such circumstances, a nickel-free (or low nickel) material should be selected.

Carbon and nitrogen pick-up

In small amounts, the pick-up of carbon and/or nitrogen can improve certain properties of a material and is therefore used technically to enhance properties such as surface hardness, resistance to wear, and/or fatigue resistance.

However, excessive pick-up of either element has an adverse effect on the material. In addition to the fact that the carbides/nitrides formed have an embrittling effect, they generally have higher chromium contents than the steel itself. The corresponding chromium depletion in the adjoining metal will reduce the oxidation resistance.

The best protection against this type of corrosion is a dense oxide layer, and consequently strong oxide formers, such as chromium and silicon, are beneficial alloying elements.

Aluminium is favourable with regard to carbon pick-up, but the high nitrogen affinity of aluminium causes a significant reduction in the protective effect of the aluminium oxide under strongly nitriding conditions. In certain applications, however, a high carbon and/or nitrogen activity is combined with a low oxygen content, whereby protective oxide layers cannot be formed. Under such conditions, the bulk composition of the material will determine the pick-up resistance. The most advantageous alloying element in this case is nickel, but silicon also has a positive effect.

In certain applications with high carbon activity, low oxygen activity and moderately high temperatures, a type of catastrophic carburisation, referred to as metal dusting, can occur, manifesting itself as a disintegration of the material into particles of graphite, metal, and oxide.

The risk of carbon pick-up increases when the material is subjected to alternating carburisation and oxidising atmospheres. This can occur in carburising furnaces or heat treatment furnaces if there are oil residues on the material being heat treated, or during decoking in the petrochemical industry. Laboratory tests have shown good results for 353 MA.

The risk of nitrogen pick-up is particularly high in furnaces working at high temperatures with oxygen-free gases, consisting of cracked ammonia or other N_2/H_2-mixtures.

Halogens

Gases containing halogens or hydrogen halides are very aggressive to most metallic materials at higher temperatures.

Aluminium, and in particular nickel, appears to increase the resistance to corrosion in most gases containing halogen. Chromium and molybdenum, on the other hand, can have either a positive or a negative effect depending on the composition of the gas.

Molden salts

In certain industrial processes, molten salts are used "deliberately". These salts easily dissolve existing protective oxide layers and can therefore be very aggressive. However, since the conditions are well known and relatively constant, it is possible to keep the effects of corrosion at an acceptable level by accurate process control and optimum materials selection (a high nickel content is often favourable). However, the detrimental effects of undesirable molten salts can be much worse. The most important example of these effects is caused by deposits on the fireside of various heat transfer surfaces. This type of problem is difficult to reduce or solve by materials selection. Instead, modifications should be made in operational conditions and maintenance procedures.

Erosion

Erosion is a very complex phenomenon, in which not only the properties of the construction material but also those of the eroding particles are significant, e.g. hardness, temperature, velocity and angle of impact.

Generally, an adherent, tough, and ductile oxide layer is required for good erosion resistance. In addition, it should be prone to quick and repeated "spontaneous rehealing". In laboratory tests, 353 MA has shown better results than higher-alloyed material, see Figure 3. The reason for this is probably the improved oxide layer due to the REM additions.

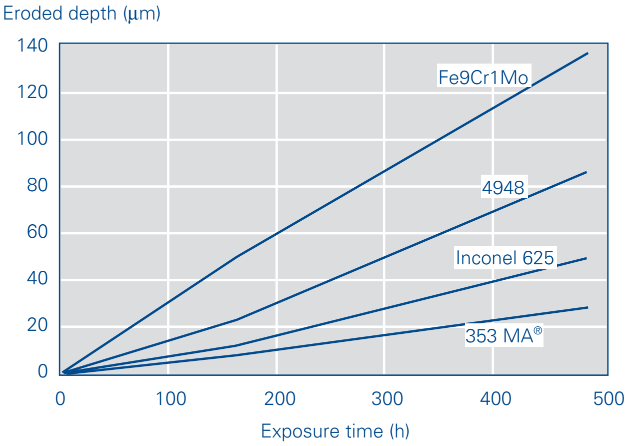

Fig. 3. Results from erosion testing at 550°C.
Source: Rikard Norling, HTC-CTH

Fabrication

Hot and cold forming

Hot working should be carried out within the temperature ranges given in Table 2.

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 refer to the "Machining guidelines for …" series of brochures, which can be obtained on request. Separate leaflets are available for all of the steels but 4828 and 4833. For these, the guidelines for 4845 are probably the most appropriate.

Welding

The steels have good or very good weldability and can be welded using the following methods:

- Shielded metal arc (SMA) welding with covered electrodes.
- Gas shielded welding, e.g., GTA (TIG), plasma arc and GMA (MIG). Pure argon should be used as the shielding gas.
- Submerged arc (SA) welding.

To ensure weld metal properties (e.g. strength, corrosion resistance) equivalent to those of the parent metal, a filler material with an identical 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 detailed information concerning the procedures for welding these steels can be obtained from Avesta Welding AB. In addition to documents covering welding issues of a general nature, more specialist information is available in the brochures entitled "How to weld 253 MA" and "How to weld 353 MA", which are also available on request from the company.

Heat treatment

Heat treatment after hot or cold forming, or welding will often not be needed, because the material will be exposed to high temperatures during service. However, if that is not sufficient, the best option would be a proper solution annealing, with the second best choice being a stress relief annealing. Suitable temperature ranges for both treatments are given in Table 2.

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

Products

Table 7

Hot rolled plate sheet and strip	Dimensions according to Outokumpu Stainless product program.
Cold rolled sheet and strip	Dimensions according to Outokumpu Stainless product program.
Castings	253 MA® is manufactured under licence by Scana Stavanger AS, Norway, Sarralde SA, Spain, Fondinox SpA, Italy, Highland Foundry Lid, Canada, Tiger Machinery & Engineering Services, the Philippines.
Wire rod and drawn wire (other than welding wire)	253 MA® is supplied under licence by Fagersta Stainless AB, Fagersta.
Welded tubes and pipes	Supplied by Outokumpu Stainless Tubular Products AB
Seamless pipe and narrow strip	253 MA® and 353 MA® are manufactured under licence by AB Sandvik Material Technology, Sandviken.
Welding consumables	Supplied by Avesta Welding AB, Avesta.

Material standards

Table 8

EN 10028-7	Flat products for pressure purposes – Stainless steels
EN 10095	Heat resisting steels and nickel alloys
EN 10302	Creep resisting steels and nickel alloys
PrEN 10296-2	Welded steel tubes for mechanical and engineering purposes – Stainless steels
ASTM A167	Stainless and heat-resisting Cr-Ni steel plate/sheet/strip
ASTM A182 / ASME SA-182	Forged or rolled alloy-steel pipe flanges, forged fittings etc for high temperature service
ASTM A213	Seamless ferritic and austenitic alloy-steel boiler, superheater, and heat-exchanger tubes
ASTM A240 / ASME SA-240	Heat-resisting Cr and Cr-Ni stainless steel plate/sheet/strip for pressure purpose
ASTM A249 / ASME SA-249	Welded austenitic steel boiler, superheater, heat exchanger and condenser tubes
ASTM A276	Stainless and heat-resisting steel bars/shapes
ASTM A312 / ASME SA-312	Seamless and welded austenitic stainless steel pipe
ASTM A358 / ASME SA-358	Electric fusion-welded austenitic Cr-Ni alloy steel pipe for high temperature
ASTM A409 / ASME SA-409	Welded large diameter austenitic pipe for corrosive or high-temperature service
ASTM A473	Stainless steel forgings for general use
ASTM A479 / ASME SA-479	Stainless and heat-resisting steel bars and shapes for use in boilers and other pressure vessels

1011EN-GB:3. Centrum Tryck AB, Avesta, Sweden. Nov 2004.

Outokumpu is a dynamic metals and technology group with a clear target to become the number one in stainless steel. Costumers in a wide range of industries use our metal products, technologies and services worldwide. We are dedicated to helping our costumers gain competitive advantage. We call this promise the Outokumpu factor.

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