253 MA®

EN 1.4835
UNS S30815

C 0.09	Si 1.7	Cr 21	Ni 11	Others N, Ce

Design Features

The chemical composition of 253 MAis balanced to provide optimum properties in the temperature range 850–1100°C.

- **Excellent resistance to oxidation; scaling temperature 1150°C.**
- **Excellent creep deformation resistance and rupture strength.**
- **Very good high temperature corrosion and erosion resistance in most atmospheres.**
- **Relatively high proof and tensile strength at elevated temperatures.**
- **Good formability and weldability; acceptable machinability.**

Applications

• SINTERING PLANTS

Grids, wind boxes, burners, fans, etc.

• BLAST FURNACE PLANTS

Charging pipes for pulverized coal, circulation fans, piping, expansion bellows, recuperators for blast furnace gas, and parts of coking ovens exposed to heat.

• STEEL MELTING, SMELTERS, AND CONTINUOUS CASTING PLANTS

Extraction hoods, flue gas ducts, dampers, doors, bridges, and preheaters for scrap and ladles.

• ROLLING MILLS (HEATING FURNACES)

Furnace rollers, slide-rails, walking beams, framework, edge reinforcements for doors, etc.

• HEAT TREATMENT FURNACES AND ACCESSORIES

Muffles, retorts, fans, heat exchangers, furnace hearths, conveyors, radiant tubes, electric heater elements, anchor bolts and fasteners for refractory materials, fixtures for brazing work, trays and baskets, thermocouple sheathing, etc.

• MINERAL PREPARATION AND CEMENT PRODUCTION

Feeding and discharging systems in preheaters, rotary kilns and coolers; pipes, burner shields, burners, grate plates, flap valves, ring segments, refractory anchors, etc.

General Characteristics

Avesta Sheffield 253 MAis an austenitic heat resisting stainless steel designed for service in the temperature range 850–1100°C for applications where high creep strength and good corrosion resistance are important.

In addition to the alloying elements chromium and nickel, this grade contains small amounts of rare earth metals (REM), which significantly improve the resistance to oxidation. Nitrogen is added to improve the creep properties and to make the steel fully austenitic. In spite of its relatively low levels of chromium and nickel, this grade offers high temperature properties which are equivalent to those of more highly alloyed steels and nickel base alloys.

Chemical Composition

The chemical composition of specific steel grades may vary slightly between different national product standards. The required standard will be fully met as specified on the order.

Table 1

International steel numbers		Avesta Sheffield	Typical composition %						National steel designations, superseded by EN		
EN	ASTM	steel name	C	N	Cr	Ni	Si	Others	BS	DIN	SS
1.4878	321H	18-10Ti	0.05	–	17.5	9.5	–	Ti	321S51	1.4878	2337
1.4828	–	20-12Si	0.04	–	20	12	2.0	–	–	1.4828	–
1.4833	309S	23-13	0.06	–	22.5	12.5	–	–	309S16	1.4833	–
1.4845	310S	25-20	0.05	–	25	20	–	–	310S24	1.4845	2361
1.4818	S30415	153 MA™	0.05	0.15	18.5	9.5	1.3	Ce	–	–	2372
1.4835	**S30815**	**253 MA®**	**0.09**	**0.17**	**21**	**11**	**1.7**	**Ce**	**–**	**–**	**2368**
1.4854	S35315	353 MA®	0.05	0.15	25	35	1.3	Ce	–	–	–
			$C_{max.}$								
1.4864	–	Alloy 1.4864*	0.15	–	16	35	1.5	–	–	1.4864	–
–	N08330	Alloy 330*	0.05	–	19	35	1.0	–	–	–	–
–	–	Alloy DS*	0.08	–	18	37	2.3	–	–	–	–
1.4876	N08800	Alloy 800*	0.12	–	21	32	0.5	Ti, Al	–	1.4876	–
2.4851	N06601	Alloy 601*	0.10	–	23	60	0.3	Al	–	2.4851	–

*These alloys are not produced within the Avesta Sheffield Group.

INFORMATION 9834:2 SUPERSEDES INF.9728

Structure

Most high temperature alloys are prone to embrittlement at room temperature after exposure at 550–850°C. This is generally caused by precipitation of intermetallic phases, e.g. sigma, chi, and Laves phases. For 253 MA, however, the higher carbon and nitrogen contents reduce the tendency of such precipitations, although exposure in the same temperature range will give rise to intergranular precipitation of carbides and nitrides. This will give aged 253 MA an impact toughness equal to that of other high temperature alloys. On the other hand, the tensile and bending ductilities will be considerably higher than those of alloys embrittled by intermetallic phases.

TEMPERATURE CHARACTERISTICS *Table 2*

	Temp.°C
Solidification range	1430 –1350
Scaling temperature	1150
Hot forming	1150 –900
Quench annealing	1020 –1120
Stress relief annnealing (min. 0.5 h)	900
Pressure vessel application	830 –1100

Mechanical Properties

The proof strength and the ultimate tensile strength values of 253 MAare high at all temperatures. Mechanical properties are listed in Tables 3–5. Avesta Sheffield is using EN 10095 data when applicable. Data refers to transverse specimens from sheet and plate with a thickness of up to 30 mm. Figure 1 shows that the creep strength of 253 MA at temperatures above 700°C is about twice that of competing high temperature grades of type 20-12Si, 23-13 and 25-20.

Design values are usually based on proof strength values for constructions used at temperatures up to about 550°C. For higher temperatures, creep strength values are applied.

MECHANICAL PROPERTIES *Table 3*

Minimum values			20°C
Proof strength	$R_{p0.2}$	N/mm²	310
	$R_{p1.0}$	N/mm²	350
Tensile strength	R_m	N/mm²	650
Elongation	A_5	%	40
Hardness	HB	max	210

STRENGTH AT ELEVATED TEMPERATURES (MINIMUM VALUES) *Table 4*

		50	100	200	300	400°C
$R_{p0.2}$	N/mm²	280	230	185	170	160
$R_{p1.0}$	N/mm²	315	265	215	200	190
R_m	N/mm²	630	585	545	535	530
		500	600	700	800	900°C
$R_{p0.2}$	N/mm²	150	140	130	-	-
$R_{p1.0}$	N/mm²	180	170	155	-	-
R_m	N/mm²	495	445	360	(260)	(150)

CREEP STRENGTH (MEAN VALUES) *Table 5*

N/mm²	600	700	800	900	1000	1100°C
Creep strain						
$R_{A\ 1/10,000}$	126	45	19	10	(5)	(2.5)
$R_{A\ 1/100,000}$	80	26	11	6	(3)	(1.2)
Creep rupture						
$R_{km\ 10,000}$	157	63	27	13	(7)	(4)
$R_{km\ 100,000}$	88	35	15	8	(4)	(2.3)

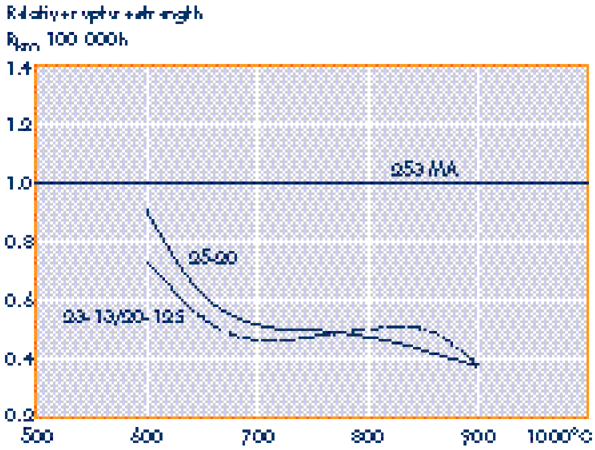

Fig. 1. Relative 100,000 h creep rupture strength for some steel grades at various temperatures. Reference alloy: 253 MA.

Physical Properties

Table 6

Typical values		20	600	800	1000°C
Density	g/cm³	7.8	7.6	7.5	7.4
Modulus of elasticity	kN/mm²	200	155	135	120
Linear expansion	(20–T)x10⁻⁶/°C	17*	18.5	19	19.5
Thermal conductivity	W/m°C	15	22.5	25.5	29
Heat capacity	J/kg°C	500	600	630	660
Electrical resistivity	nΩm	850	1370	1430	1450

* = 20–100°C

Wet Corrosion

253 MAis designed for applications exposed to hot gas corrosion only. The high carbon and nitrogen contents of the alloy make it susceptible to sensitization and intergranular corrosion in wet environments. Components made of 253 MAshould therefore be designed and operated so that the formation of acid condensates is inhibited.

High Temperature Corrosion

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

OXIDATION

253 MAhas a very high resistance to oxidation. This is due to the high chromium and silicon contents of the alloy and the REM addition, resulting in a slow oxide growth rate (see Figure 2). The oxide layer, which is thin and ductile, adheres firmly to the underlying alloy surface. Consequently, the resistance to spalling at cyclic temperature variations is improved. Another effect of the oxide scale characteristics is the good resistance of the alloy to erosion.

In order to determine the scaling temperature under intermittent conditions, Avesta Sheffield uses a 45 h oxidation test. During this period the specimen is first heated and then air cooled to room temperature five times. The scaling temperature is defined as the lowest of the following:

- the temperature which results in a weight increase of 1.0 g/m^2 h
- the temperature that is 50°C below the temperature which results in a weight increase of 2.0 g/m^2 h

The scaling temperature in air for 253 MAis 1150°C (see Figure 3). This value is equivalent to that shown by type 25-20 and 100°C higher than the values shown by type 20-12Si and 23-13. Due to the rather short testing time, the recommended maximum service temperature for 253 MA is 50°C lower than the evaluated scaling temperature, i.e. 1100°C.

SULPHUR ATTACK

Sulphur and sulphur compounds, often present in combustion gases as well as in various process gases, will have an adverse effect on the performance of heat resisting alloys.

High chromium and silicon contents increase an alloy's resistance to sulphur attack, especially under oxidizing conditions. However, when the atmosphere is reducing and no protective oxide can be formed, alloys with a high nickel content should be avoided. This is especially true for high nickel (> 50%), low chromium (≤ 20%) alloys. A chromium content above 25% in alloys containing nickel will increase their resistance to sulphur attack.

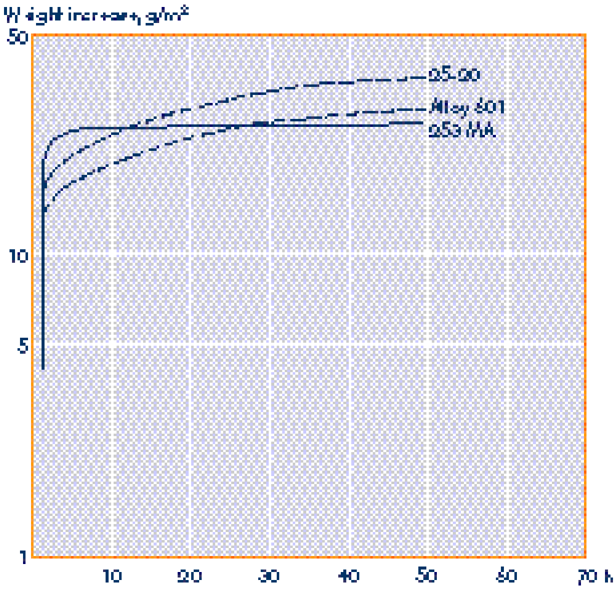

Fig. 2. Weight increase for 253 MAduring isothermal oxidation, 1200°C.

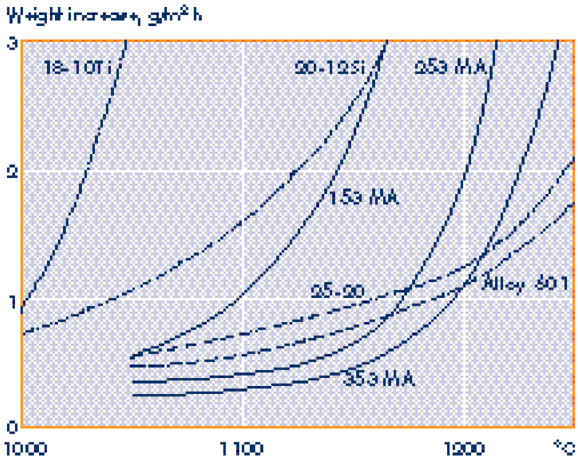

Fig. 3. Weight increase for 253 MAand some other alloys after intermittent oxidation, 45 h.

Thanks to the relatively low nickel content of 253 MA and its ability to form a protective oxide layer, this alloy performs very well under sulphidizing conditions, even if there are only traces of oxygen in the atmosphere.

CARBON AND NITROGEN PICK-UP

In small amounts, both carbon and nitrogen can improve the mechanical properties of a material. However, excessive pick-up of either element will lead to embrittlement and reduced oxidation resistance – both caused by the precipitation of chromium carbides and/or nitrides in the grain boundaries. The resulting depletion of chromium in the structure will reduce the ability of the material to restore a damaged oxide layer. As a result, the material will be more susceptible to attacks from other aggressive compounds in the environment. Heat resistant alloys are particularly exposed to the risk of carbon pick-up when subjected to fluctuating carburizing and oxidizing atmospheres. This may be the case in carburizing furnaces or when oil residues are present on heat treated material.

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

The resistance of an alloy to carbon and nitrogen pick-up can be improved by increasing the nickel content. In oxidizing environments, strong oxide formers such as chromium and silicon (and aluminium in carburizing but not nitriding atmospheres) are beneficial.

Service experience and some limited laboratory tests have thus shown that the ability of 253 MAto form a very protective oxide layer results in a resistance to carbon and nitrogen pick-up, which is equal or even superior to that of higher alloyed grades.

Under reducing conditions (often found e.g. in the petrochemical industry) an alloy with a higher nickel and/or silicon content must be selected.

Fabrication

HOT AND COLD FORMING

Hot working should be performed in the temperature range 1150–900°C. Quench annealing is generally not required since the material will be exposed to high temperatures when in operation.

Like other austenitic steels, the material can be formed in cold condition. Due to its relatively high nitrogen content, the mechanical strength of 253 MA is higher and larger deformation forces are therefore required.

MACHINING

The relatively high hardness of 253 MAand its tendency to strain-harden must be taken into account in connection with machining. For further information on machining data, see “Machining guidelines for 253 MA” which can be obtained on request.

WELDING

253 MAhas very good weldability and can be welded using the following methods:

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

Filler metal of type Avesta 253 MAis recommended for both covered electrodes and welding wire. This ensures a weld metal with properties equivalent to those of the parent material. Gas shielded welding ensures optimum creep resistance in the weld metal.

Alternatively, Avesta 309 may be used in cases where a somewhat lower creep strength and oxidation resistance are acceptable. Further information on the creep properties of weldments can be obtained from the R&D Department of Avesta Sheffield.

Typical values for the chemical composition of the weld metal are shown in Table 7.

WELD METAL (TYPICAL VALUES)

Table 7

	C	Si	Mn	Cr	Ni	N	Oth.
Avesta 253 MA							
Cov. electrode	0.06	1.5	0.8	22	10.5	0.18	REM*
Wire	0.08	1.6	0.5	21	10	0.17	REM*
Avesta 309							
Cov. electrode	0.05	0.8	1.0	24	13.5	–	–

* Rare Earth Metals

More detailed welding instructions are given in a special brochure entitled “How to weld 253 MA” which is available from Avesta Welding AB, tel. +46 226 815 00 or telefax +46 226 815 75.

Products

HOT ROLLED PLATE

Dimensions according to Avesta Sheffield's manufacturing programme.

COLD ROLLED SHEET, PLATE AND COIL

Dimensions according to Avesta Sheffield's manufacturing programme.

BAR AND FORGINGS

Delivered by Avesta Valbruna AB, Karlstad, Sweden.

CASTINGS

Manufactured under licence by Scana Stavanger AS, Norway, Sarralde SA, Spain, Fondinox SpA, Italy, Highland Foundry Ltd, Canada, Tiger Machinery & Industrial Corporation, Philippines.

WIRE ROD AND DRAWN WIRE

(other than welding wire)
Delivered under licence by Fagersta Stainless AB, Fagersta, Sweden.

WELDED STAINLESS TUBES AND PIPES

Delivered by AST(Avesta Sandvik Tube AB), Sweden.

SEAMLESS PIPE AND TUBE, NARROW STRIP

Manufactured under licence by AB Sandvik Steel, Sandviken, Sweden.

WELDING CONSUMABLES

Delivered by Avesta Welding AB, Avesta, Sweden.

PRODUCT STANDARDS

EN 10095
Heat resisting steels and nickel alloys.
(Implementation 1998/99).

ASTM A182/ASME SA-182
Forged or rolled alloy-steel pipe flanges, forged fittings, and valves and parts 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 chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels

ASTM A249/ASME SA-249
Welded austenitic steel boiler, superheater, heat-exchanger, and condenser tubes

ASTM A276
Stainless and heat-resisting steel bars and shapes

ASTM A312/ASME SA-312
Seamless and welded austenitic stainless steel pipes

ASTM A358/ASME SA-358
Electric-fusion-welded austenitic chromium-nickel alloy steel pipe for high-temperature service

ASTM A409/ASME SA-409
Welded large diameter austenitic pipe for corrosive or high-temperature service

ASTM A473
Stainless and heat-resisting steel forgings

ASTM A479/ASME SA-479
Stainless and heat-resisting steel bars and shapes for use in boilers and other pressure vessels

ASTM A813
Single or double-welded austenitic stainless steel pipe

ASTM A814
Cold-worked welded austenitic stainless steel pipe

ASME VIII/Div. 1
Rules for construction of pressure vessels

Vd TÜV
Pressure vessel use applied from case to case.

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