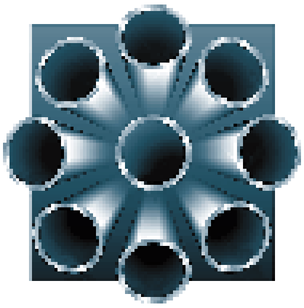

Seamless tube

Sandvik 253 MA

SANDVIK Steel

S-1743-ENG March 1999 • Cancels all previous editions

Sandvik 253 MA¨ is an austenitic chromium-nickel steel alloyed with nitrogen and rare earth metals. The grade is characterised by:

- *high creep strength*
- *very good resistance to isothermal and, above all, cyclic oxidation*
- *very good resistance to combustion gases*
- *very good resistance to carburisation*
- *good structural stability at high temperatures*
- *good weldability*

The grade can be used at temperatures up to about 1150°C (2100°F).

CHEMICAL COMPOSITION (NOMINAL), %

C	Si	Mn max.	P max.	S max.	Cr	Ni	N	Ce*
0.08	1.6	0.8	0.040	0.030	21	11	0.17	0.05

* To cerium should be added the quantity of other rare earth metals, because the addition takes the form of misch metal containing about 50% Ce.

STANDARDS

Type of steel

- UNS S30815
- EN 1.4835 [a)]
- W.-Nr. (1.4893), (1.4828 Mod.) [b)]
- SS 2368
- DIN (X 8 CrNiSiN 21 11)

Product standards

- ASTM A213, A312
- SS 14 23 68

Approvals

Approved for use in ASME Boiler and Pressure Vessel Code, Section VIII, div. 1 and Section I, Code Case 2033-1
ASME B31.1, Case 162

FORMS OF SUPPLY, FINISHES AND DIMENSIONS

Seamless tube and pipe in 253 MA are supplied in dimensions up to 260 mm outside diameter in the solution annealed and white-pickled condition or in the bright annealed condition.

a) Preliminary (pr EN 10095)
b) SEW 470
253 MA® is a trademark owned by Avesta Sheffield AB

Other forms of supply

Welded tube and pipe

Welded tube and pipe are supplied on request

Strip

253 MA strip can be supplied solution-annealed and pickled, brigth-annealed or cold-rolled to the mechanical properties required.

Size range

width max	370 mm (14.6 inch)
thickness	0.05-3.0 mm (0.002-0.12 inch)

Fittings
Wire electrodes and filler wire / rods
Covered electrodes
Wire, drawn or ground
Bar steel
Plate, sheet and wide strip

SIZES IN STOCK

253 MA is stocked in over 20 schedule sizes ranging from 3/8" to 6". Data concerning sizes and finishes are obtainable on request from your nearest Sandvik office.

Welding consumables

Welding wire and wire electrodes Sandvik 22.12.HT in the following diameters: 0.80, 1.20, 2.00, 2.40 and 3.20 mm.

Covered electrodes Sandvik 22.123.HTR in the diameters: 2.5, 3.25 and 4.0 mm (3/22, 1/8 and 5/32 inch).

MECHANICAL PROPERTIES

At 20°C (68°F)

Metric units

Proof strength $R_{p0.2}$[a)] MPa min.	$R_{p1.0}$[a)] MPa min.	Tensile strength R_m MPa	Elong. A[b)] % min.	$A_{2"}$ % min.	Hardness Vickers approx.
310	345	650–850	40	35	190

Imperial units

Proof strength $R_{p0.2}$[a)] ksi min.	$R_{p1.0}$[a)] ksi min.	Tensile strength R_m ksi	Elong. A[b)] % min.	$A_{2"}$ % min.	Hardness Vickers approx.
45	50	94-123	40	35	190

1 MPa = 1 N/mm²

a) *$R_{p0.2}$ and $R_{p1.0}$ correspond to 0.2% offset and 1.0% offset yield strength, respectively.*

b) *Based on $L_0 = 5.65\sqrt{S_0}$, where L_0 is the original gauge length and S_0 the original cross-section area.*

§At high temperatures

Metric units

Temperature °C	Proof strength $R_{p0.2}$ MPa min.	$R_{p1.0}$ MPa min.	Tensile strength R_m MPa min.
100	225	265	550
200	180	215	475
300	170	200	440
400	160	190	425
500	150	180	400
600	140	165	340

Imperial units

Temperature °F min.	Proof strength $R_{p0.2}$ ksi min.	$R_{p1.0}$ ksi min.	Tensile strength R_m ksi approx.
200	33.5	39.0	80.5
400	26.0	31.0	68.5
600	24.5	28.5	63.6
800	23.0	27.5	61.0
1000	21.0	25.5	55.0
1200	19.5	23.0	46.5

Creep strength

The creep and creep-rupture strength values correspond to values evaluated by the Swedish Institute for Metals Research to be included in Swedish Standard. The evaluation is based on data submitted by AB Sandvik Steel and Avesta Sheffield AB and tests made by the Swedish Institute for Metals Research. The values apply to tube and pipe, sheet and plate and bar steel. The somewhat higher values given in parentheses apply to Sandvik seamless tube and pipe only. The basic values have been determined by testing at intervals of 100 degrees Celcius, as well as at 750°C (1380°F), under uniaxial stress and with a constant load. The mean values in the tables below have been evaluated from the test results with the aid of linear regression of the logarithmic relation between stress and time. This evaluation has also provided the basis of interpolation and extrapolation of temperatures and times.

The temperature above which the calculation is based on creep-rupture strength instead of $R_{p0.2}$ proof strength can be read off from Fig. 1. For 253 MA this temperature is about 550°C (1020°F).

Fig. 2 shows the relation between nominal stress and minimum creep rate, measured during testing under constant load.

Metric units

Temperature °C	Creep strength 1% 10 000 h MPa	Creep strength 1% 100 000 h MPa	Creep rupture strength 10 000 h MPa		Creep rupture strength 100 000 h MPa	
525	-	-	-		162	
550	-	-	-		128	
575	-	-	167		102	
600	117	70	138		82	
625	93	55	112		64	
650	75	42	94		52	
675	59	32	76		43	
700	46	25	62		33	
725	38	20	50		27	
750	31	16	41		22	
775	25	13	33		18	
800	20	11	27	(28)	15	(16)
825	17	9.4	22	(23)	12	(14)
850	14	8.0	18	(20)	10	(12)
875	12	6.7	15	(17)	8.8	(10)
900	10	5.7	13	(14)	7.5	(8.4)
925	8.5	4.8	11	(12)	6.6	(7.2)
950	7.3	4.0	9.6	(10.5)	5.7	(6.3)
975	6.3	3.5	8.2	(9.0)	5.0	(5.8)
1000	5.4	3.0	7.0	(7.8)	4.3	(4.9)
1025	–	–	6.2	(6.6)	3.8	
1050	–	–	5.5	(5.7)	3.3	
1075	–	–	4.9		3.0	
1100	–	–	4.3		2.6	

Imperial units

Temperature °F	Creep strength 1% 10 000 h ksi	Creep strength 1% 100 000 h ksi	Creep rupture strength 10 000 h ksi		Creep rupture strength 100 000 h ksi	
1000	–	–	–		20.9	
1050	–	–	–		16.1	
1100	–	–	21.2		12.6	
1150	13.9	8.3	17.1		9.7	
1200	10.9	6.1	13.8		7.5	
1250	8.4	4.5	10.7		5.9	
1300	6.5	3.5	8.6		4.6	
1350	5.1	2.8	6.8		3.8	
1400	4.1	2.2	5.5		2.9	
1450	3.2	1.7	4.3	(4.4)	2.5	
1500	2.6	1.42	3.4	(3.6)	1.9	(2.1)
1550	2.2	1.19	2.7	(3.0)	1.5	(1.8)
1600	1.7	0.99	2.2	(2.5)	1.25	(1.5)
1650	1.45	0.81	1.9	(2.0)	1.07	(1.26)
1700	1.23	0.68	1.6	(1.7)	0.93	(1.04)
1750	1.04	0.58	1.33	(1.46)	0.80	(0.88)
1800	0.87	0.49	1.13	(1.23)	0.70	(0.75)
1850	-	-	0.96	(1.03)	0.59	(0.68)
1900	-	-	0.84	(0.88)	0.51	
1950	-	-	0.75	(0.77)	0.45	
2000	-	-	0.67		0.39	

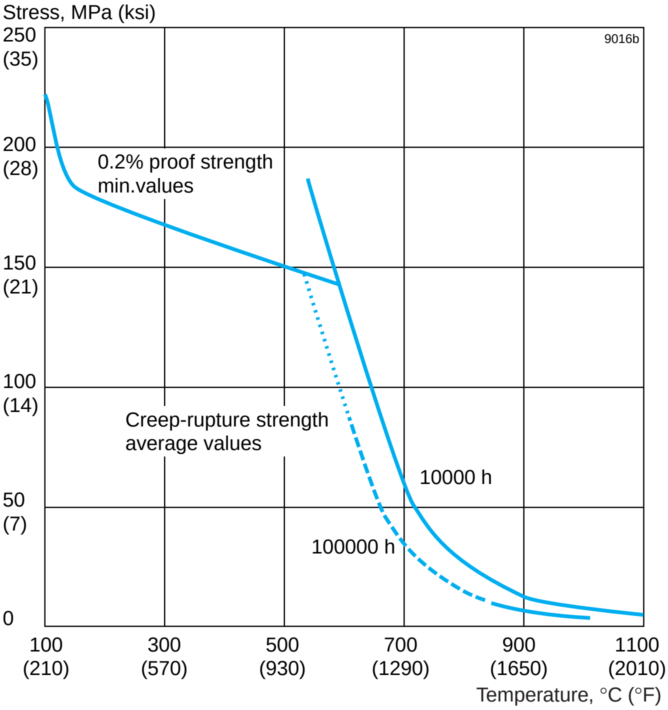

Fig. 1 Proof strength $R_{p0.2}$ and creep-rupture strength at 10 000 and 100 000 h.

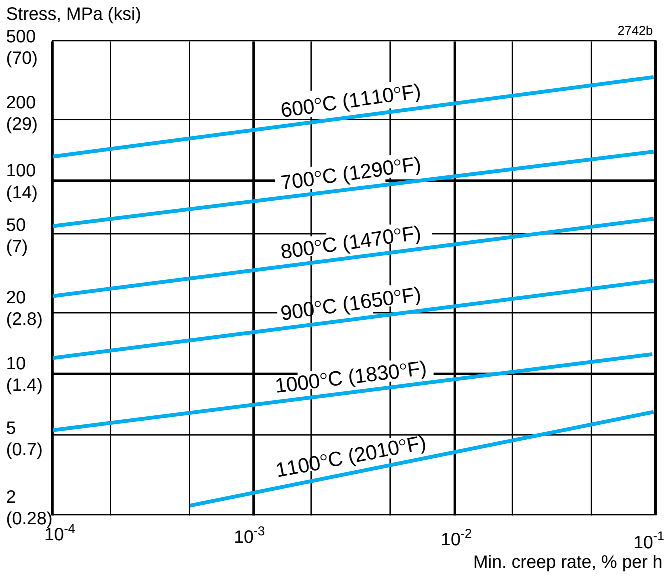

Fig. 2 Relation between nominal stress and minimum creep rate at 600 –1100°C (1110–2010°F).

PHYSICAL PROPERTIES

Density, 7.8 g/cm³, 0.28 lb/in³

Relative magnetic permeability
(typical value) 1.003

Thermal conductivity

Temperature °C	W/m °C	Temperature °F	Btu/ft h °F
20	13	68	7.5
100	15	200	8.5
200	16	400	9.5
300	18	600	10.5
400	20	800	11.5
500	21	1000	12.5
600	23	1200	13.5
700	24	1400	14.5
800	25	1600	15
900	26	1800	16
1000	28	2000	17
1100	29		

Specific heat capacity

Temperature °C	J/kg °C	Temperature °F	Btu/lb °F
20	490	68	0.12
100	515	200	0.12
200	540	400	0.13
300	565	600	0.14
400	580	800	0.14
500	600	1000	0.15
600	615	1200	0.15
700	630	1400	0.15
800	645	1600	0.16
900	655	1800	0.16
1000	665	2000	0.16
1100	680		

Thermal expansion, mean values in temperature ranges ($x10^{-6}$)

Temperature °C	Per °C	Temperature °F	Per °F
30-100	16.5	86-200	9.5
30-200	17	86-400	9.5
30-300	17	86-600	9.5
30-400	17.5	86-800	10
30-500	18	86-1000	10
30-600	18	86-1200	10
30-700	18.5	86-1400	10.5
30-800	19	86-1600	10.5
30-900	19	86-1800	11
30-1000	19.5		

Resistivity

Temperature °C	μΩm	Temperature °F	μΩinch
20	0.84	68	33.1
100	0.93	200	36.3
200	1.03	400	40.7
300	1.13	600	45.0
400	1.22	800	48.7
500	1.29	1000	51.7
600	1.37	1200	54.3
700	1.39	1400	55.7
800	1.43	1600	56.6
900	1.44	1800	57.0
1000	1.45		

Modulus of elasticity, ($x10^3$)

Temperature °C	MPa	Temperature °F	ksi
20	200	68	28.5
200	185	400	27.0
400	170	800	24.0
600	155	1200	21.5
800	135	1400	20.0
1000	120	1800	17.5

CORROSION RESISTANCE

Air

253 MA has very high resistance to oxidation, especially at cyclically varied temperatures; see Figs. 3 and 4. The service temperature in air should not exceed about 1150°C (2100°F).

Isothermal oxidation at 1150°C (2100°F) for 100 h results in a corrosion rate of about 0.3 mm/year (13 mpy), and exposure at the same temperature for 1000 h causes about 0.2 mm/year (9 mpy).

Cyclic oxidation at 1150°C for 5 x 24 h with cooling to room temperature every 24 hours gives a corrosion rate of less than 1.1 mm/year (43 mpy), which is insignificantly greater than the corrosion rate at 1000°C (1830°F).

Cyclic oxidation testing for 1000 h (15 min. at the testing temperature and 5 min. at room temperature, making a total of 3000 cycles) places heavy demands on the elasticity and adhesive capacity of the oxide. The test results in Fig. 4 show that the resistance of 253 MA in such difficult conditions is superior to that of both AISI 310 and W.-Nr. 1.4828 (AISI 309). The very good properties of this grade in cyclic conditions have been achieved by adding rare earth metals and silicon.

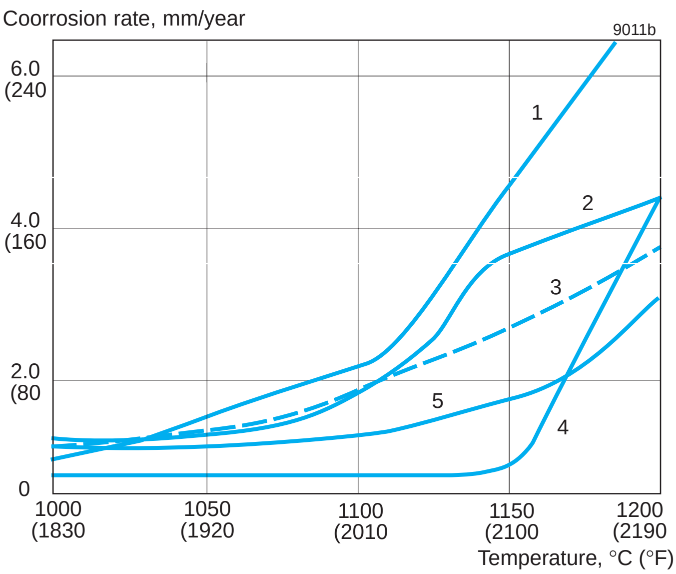

Fig. 3 Oxidation in air during cyclic testing 5x24 h with cooling to room temperature every 24 h. Comparison of 253 MA with four other high-temperature materials.

1 = W.-Nr. 1.4828 (AISI 309) — *4 = 253 MA*

2 = AISI 446 — *5 = Alloy 800 H*

= AISI 310

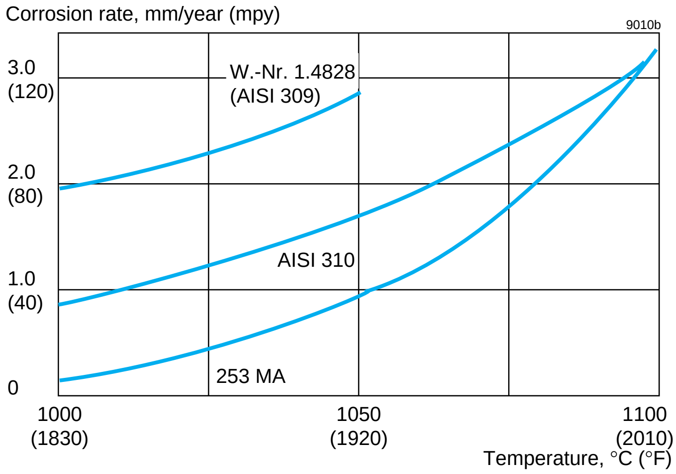

Fig. 4 Oxidation in air during 1000 h cyclic exposure. The cycles comprise 15 min. at the testing temperature and 5 min at room temperature. The curves represent averages.

Carburising atmosphere

Carburisation can occur when a material comes into contact with hot gases of high carbon activity, e.g. hydrocarbons. The degree of carburisation depends on the composition of the material and on the carbon and oxygen content of the gas.

Thanks to the relatively high chromium content and the addition of silicon and rare earth metals a protective oxide is easily formed on the surface of 253 MA. The carburisation resistance is therefore good. Fig. 5 shows carburisation after 500 h at different temperatures in a mixture of about 10% methane and about 90% argon containing 0.5% oxygen. As can be seen, 253 MA is less prone to carburisation at high temperatures in these conditions than AISI 310 and Alloy 800H.

In alternately oxidising and carburising atmospheres and carburising slags 253 MA is slightly more prone to carburisation than steels of higher chromium and/or nickel content.

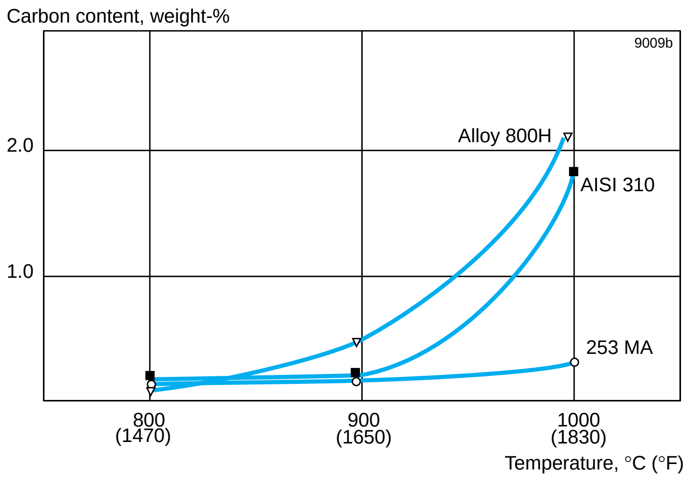

Fig. 5 Carburisation of a cylindrical test piece at 0.5 mm (0.02 inch) distance from the surface after testing for 500 h at different temperatures in about 10% CH_4 + about 90% Ar + 0.5% O_2 .

Other gaseous atmospheres

The ferritic structure of 4C54 gives it good resistance in baths In addition to its very good oxidation resistance in air, 253 MA is also highly resistant to other atmospheres. The highly protective oxide layer makes it possible for this steel to be used at high temperatures in atmospheres containing sulphur and other aggressive compounds. 253 MA is more resistant than the higher-alloyed 25Cr/20Ni steels to combustion gas attacks in cyclic conditions. It has an equivalent resistance, compared to the same grades, in conditions which are virtually isothermal.

253 MA can also be used in nitrogen-containing atmospheres provided that the gas contains enough oxygen to form a protective oxide layer. In gas shields containing little or no oxygen the resistance of 253 MA is inferior to that of Alloy 800H and 25Cr/20Ni steels as illustrated in Fig. 6. Thus 243 MA is not recommended to be used in muffle tubes using cracked ammonia gas.

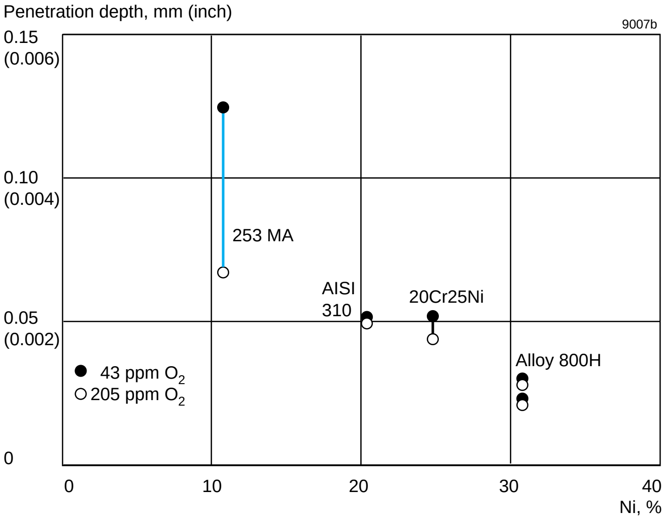

Fig. 6 Testing for 400 h at 825°C (1515°F) in nitrogen containing 43 and 205 ppm O_2, respectively

Salt and metal melts

Compared with ordinary austenitic stainless steels, 253 MA has good resistance to cyanide melts and neutral salt melts and also to metal melts, e.g. lead, at high temperatures. Its resistance to metal melts is to a great extent determined by the oxygen content of the melt. As with other alloyed steels, corrosion is greatest at the surface of the metal bath.

Wet corrosion

253MA is not generally used in conditions requiring great resistance to wet corrosion. The steel is, however, somewhat more resistant than AISI 304 to stress corrosion cracking in chloride-bearing aqueous solutions. Its resistance is more or less the same as that of AISI 316.

Structural stability

Because 253MA contains less chromium, and because of the nitrogen addition, it is less prone to sigma phase embrittlement than 25Cr/20Ni steels, see Fig. 7.

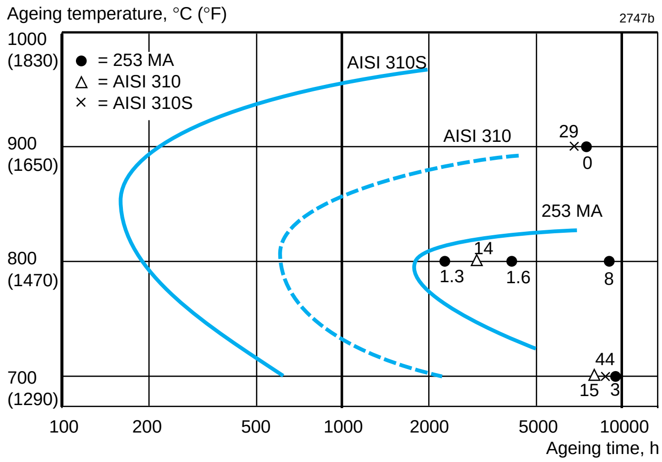

Fig. 7 Time-Temperature-Transformation (TTT) diagram showing incipient sigma phase formation curves. No sigma phase is formed in the steel to the left of the curves. The figures at the measuring points refer to sigma phase percentage by volume.

HEAT TREATMENT

The tubes are delivered in heat treated condition. If another heat treatment is needed after further processing the following is recommended:

Stress relieving

850-950°C (1560-1740°F), 10-15 minutes, cooling in air

Solution annealing

1050-1150°C (1920-2100°F), 5-20 minutes, rapid cooling in air or water.

WELDING

The weldability of 253MA is good. Suitable welding methods are manual metal-arc welding with covered electrodes and gas-shielded arc welding with the TIG and MIG methods as first choice. Preheating and post-weld heat treatment are not normally necessary.

Since the material has low thermal conductivity and high thermal expansion welding must be carried out with a low heat input and with welding plans well thought out in advance so that the deformation of the welded joint can be kept under control. If, despite these precautions, it is foreseen that the residual stresses might impair the function of the weldment, we recommend that the entire structure be stress-relieved.

As filler metal for gas-shielded arc welding we recommend wire electrodes and rods Sandvik 22.12.HT. In manual metal-arc welding covered electrodes Sandvik 22.12.HTR are recommended. The composition of these filler metals is designed to yield a weld metal whose creep strength and oxidation resistance will correspond to those of the parent metal.

Data concerning the creep strength of weld metal and welds are obtainable on request.

BENDING

Annealing after cold bending is not normally necessary, but this point must be decided with regard to the degree of bending and the operating conditions. However, if cold bending has exceeded 10-20%, we recommend solution annealing for tubes that are to be used at temperatures above about 800°C (1450°F) and when the highest possible creep strength is required in the bent tube.

Hot bending is carried out at 1100-850°C (2050-1560°F) and should be followed by solution annealing.

APPLICATIONS

The high creep strength of 253 MA, coupled with its excellent oxidation resistance and its good resistance to carburisation in constantly carburising gas, makes it a very suitable material for purposes for which 18/8 steels lack the necessary resistance to oxidation and carburisation and stainless chromium steels have insufficient creep strength and structural stability. What is more, 253 MA can very well take the place of higher-alloyed materials such as 25Cr/20Ni steels and Alloy 800H, or even Alloy 600 in certain cases.

253 MA has come to be extensively used in the metallurgical industry and in the petrochemical and power industries. Applications include the following:

tubes in waste-heat recovery systems in metallurgical industry, e.g. recuperators

- tubes in heat treatment furnaces, e.g. radiation tubes, thermocouple protection tubes, burner components, furnace rollers
- tubes for injection of pulverised coal in blast furnaces
- tubing for fluidised-bed combustion plants
- furnace tubes for mud incineration plants
- tubes for carbon black process gas coolers/air heaters
- tubes for the glass and cement industries
- styrene reactor tubes
- EDC cracking tubes
- convection tubes in ethylene cracking
- air preheater tubes in sulphuric acid gas converters

FURTHER INFORMATION

The following printed matter can be ordered from your nearest Sandvik office

S-130-ENG "Sandvik stainless high temperature grades"

S-56-14-ENG "Sandvik 253 MA (UNS 30815) - the problem solver for high-temperature applications "

Recommendations are for guidance only, and the suitability of a material for a specific application can be confirmed only when we know the actual service conditions. Continuous development may necessitate changes in technical data without notice.

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