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Sandvik 253 MA

(Tube and pipe, seamless)

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

- High creep strength
- Very good resistance to isothermal and, particularly, cyclic oxidation
- Good structural stability at high temperatures
- Good weldability
- The grade can be used at temperatures up to about 1150°C (2100°F)

STANDARDS

- UNS S30815
- EN number 1.4835
- W.Nr. (1.4893)/(1.4828mod)
- SS 2368

Product standards

- ASTM A213, A312
- EN 10297-2
- SS 14 23 68

Approvals

Approved for use in ASME Boiler and Pressure Vessel Code, Section I, III and VIII, Div. 1 (SA-182, SA-213, SA-240, SA-249 SA-312 and SA-479).

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, since the the additive takes the form of misch metal containing about 50% Ce.

FORMS OF SUPPLY

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

Stock sizes
Sandvik 253 MA is stocked in schedule sizes ranging from outside diameter 3/8" to 6" outside diameter. Additional data concerning sizes and finishes is available on request from your nearest Sandvik office.

Other forms of supply
- Fittings
- Wire electrodes

The forms of supply below can be supplied on request:

- Welded tube and pipe
- Strip
- Covered electrodes
- Wire, drawn or ground
- Bar steel
- Plate, sheet and wide strip

Welding consumables
Welding wire and wire electrodes, grade Sandvik 22.12.HT: 0.80, 1.20, 2.00, 2.40 and 3.20 mm diameters.

Covered electrodes, grade Sandvik 22.12.HTR:
2.5, 3.25 and 4.0 mm (3/22, 1/8 and 5/32 in.) diameters.

MECHANICAL PROPERTIES

At 20°C (68°F)

METRIC UNITS

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

IMPERIAL UNITS

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

1 MPa = 1 N/mm^2
a) $R_{p0.2}$ and $R_{p1.0}$ correspond to 0.2% offset and 1.0% offset yield strength, respectively.
b) Based on $L_0 = 5.65$ ÖS_0 where L_0 is the original gauge length and S_0 the original cross-section area

At high temperatures

METRIC UNITS

Temperature	Proof strength		Tensile strength
°C	$R_{p.02}$	$R_{p1.0}$	R_m
	MPa	MPa	MPa
	min.	min.	min.
100	225	265	550
200	189	215	475
300	170	200	440
400	160	190	425
500	150	180	400
600	140	165	340

IMPERIAL UNITS

Temperature	Proof strength		Tensile strength
°F	$R_{p.02}$	$R_{p1.0}$	R_m
	ksi	ksi	ksi
	min.	min.	min.
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 for inclusion in the Swedish Standard. The evaluation is based on data submitted by AB Sandvik Materials Technology and Outokumpu Stainless and tests made by the Swedish Institute for Metals Research. The values apply to tube, pipe, sheet, plate and bar steel. The 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 and 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 relationship between stress and time. This evaluation has also provided the basis of interpolation and extrapolation of temperatures and times. The temperature above which design calculations are based on creep rupture strength instead of $R_{p0.2}$ proof strength, can be read off from Fig. 1. For Sandvik 253 MA this temperature is about 550°C (1020°F). Fig. 2 shows the relationship between nominal stress and minimum creep rate, measured during testing under constant load.

METRIC UNITS

Temperature	Creep strength 1%		Creep rupturestrength	
°C	10 000 h	100 000 h	10 000 h	100 000 h
	MPa	MPa	MPa	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	37	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	Creep strength 1%		Creep rupturestrength	
°F	10 000 h	100 000 h	10 000 h	100 000 h
	ksi	ksi	ksi	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	3.6	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(1.03)	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

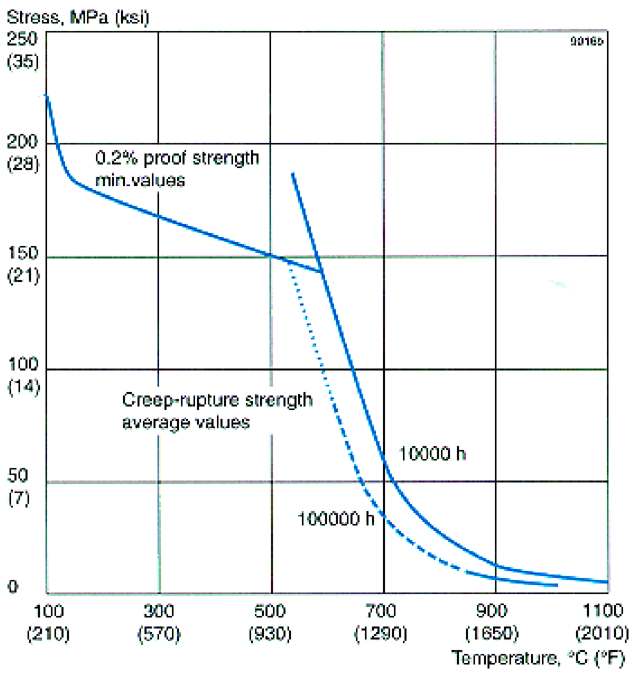

Fig. 1. Proof strength Rp0.2 and creep tupture strength at 10 000 and 100 000 h.

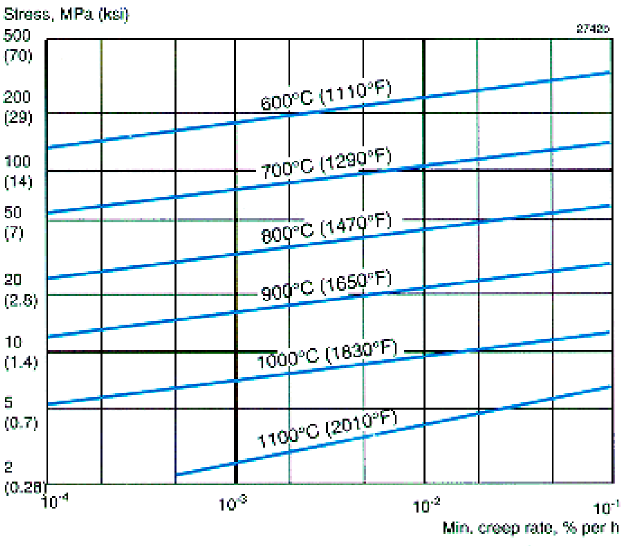

Fig. 2 Relationship between nominal stress and minimum creep rate at 600 –1100°C (1110–2010°F).

PHYSICAL PROPERTIES

Density: 7.8 g/cm^3, 0.28 lb/in^3

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	14	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/ft h °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 [1)]

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		

1) mean values in temperature ranges ($x10^6$)

RESISTIVITY

Temperature, °C	μΩm	Temperature, °F	μΩin.
20	0.84	68	33.2
100	0.91	200	35.4
200	0.97	400	38.1
300	1.02	600	40.3
400	1.07	800	42.3
500	1.11	1000	44.1
600	1.15	1200	45.7
700	1.18	1400	47.1
800	1.21	1600	48.2
900	1.23	1800	49.2
1000	1.26	2000	50.5
1100	1.29		

MODULUS OF ELASTICITY [1)]

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

1) ($x10^3$)

CORROSION RESISTANCE

Air
Sandvik 253 MA has very high resistance to oxidation, especially at cyclically varying 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 (2100°F) 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 only marginally 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 Sandvik 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.

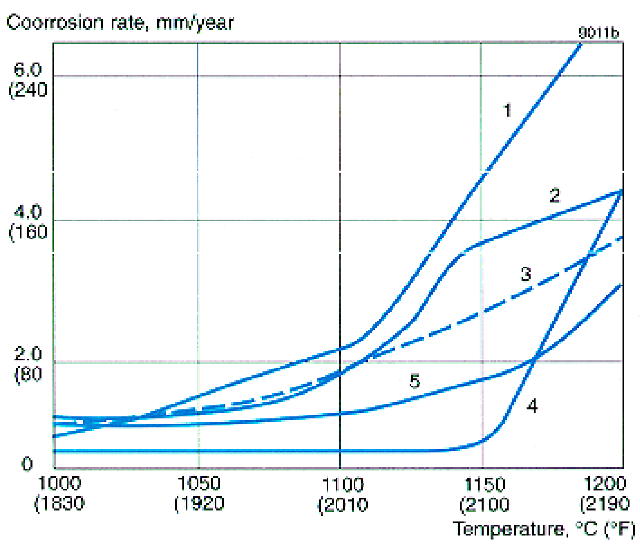

Figure 3. Oxidation in air during cyclic testing 5x24 h with cooling to room temperature every 24 h. Comparison of Sandvik 253 MA with four other high temperature materials.
1 = W.-Nr. 1.4828 (AISI 309)
2 = AISI 446
3 = AISI 310
4 = Sandvik 253 MA
5 = Alloy 800 H

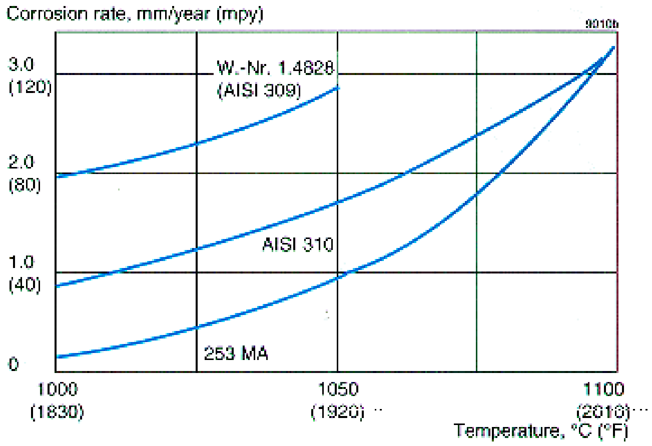

Figure 4. Oxidation in air during 1000 h cyclic exposure. The cycles comprise 15 min. at the testing temperature and 5 min at room temperature. The curves represent averages.

Carburizing atmosphere
Carburization can occur when a material comes into contact with hot gases with high carbon activity, e.g. hydrocarbons. The degree of carburization depends on the composition of the material and on the carbon and oxygen contents 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 Sandvik 253 MA material. Carburization resistance is, therefore, good. Fig. 5 shows carburization 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, Sandvik 253 MA is less prone to carburization at high temperatures in these conditions than AISI 310 and Alloy 800H.

In alternately oxidizing and carburizing atmospheres and carburizing slags, Sandvik 253 MA is slightly more prone to carburization than steels of higher chromium and/or nickel content.

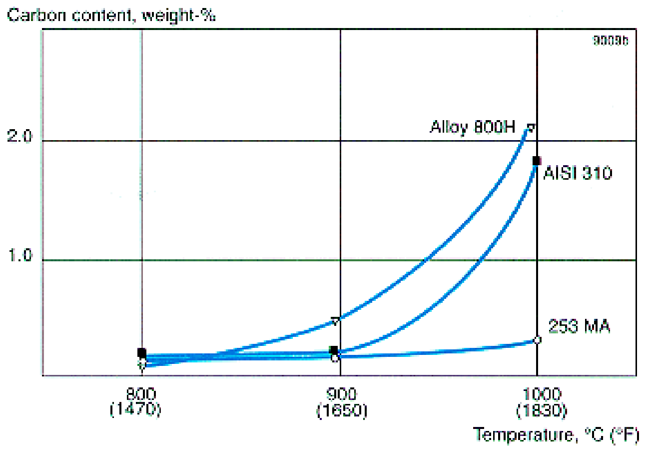

Figure 5. Carburization of a cylindrical test piece at 0.5 mm (0.02 in.) distance from the surface after testing for 500 h at different temperatures in about 10% CH_4 + about 90% Ar + 0.5% O_2 .

Other gaseous atmospheres
In addition to its very good oxidation resistance in air, Sandvik 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. Sandvik 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. Sandvik 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 Sandvik 253 MA is inferior to that of Alloy 800H and 25Cr/20Ni steels as illustrated in Fig. 6. Thus, the grade is not recommended for use in muffle tubes using cracked ammonia gas.

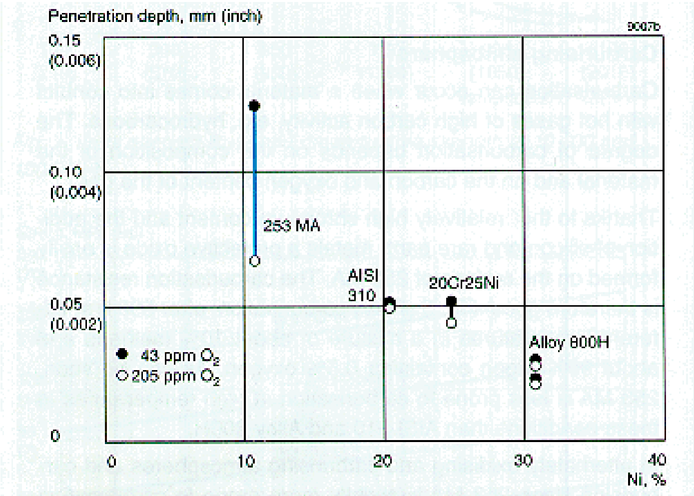

Figure 6. Testing for 400 h at 825°C (1515°F) in nitrogen containing 43 and 205 ppm O_2 , respectively.

Salt and metal melts

Compared with ordinary austenitic stainless steels, Sandvik 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

Sandvik 253 MA is not generally used in conditions requiring great resistance to wet corrosion. The steel is, however, slightly 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 Sandvik 253 MA contains less chromium, and because of the addition of nitrogen it is less prone to sigma phase embrittlement than 25Cr/20Ni steels. See Fig. 7.

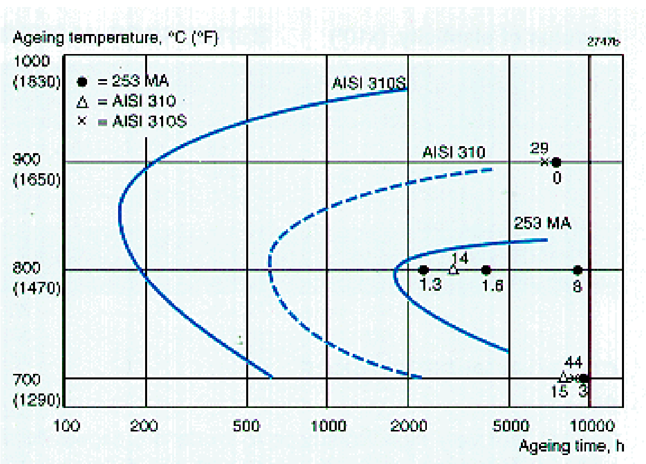

Figure 7. Time-Temperature- Transformation (TTT) diagram showing 1% sigma phase formation curves. The figures at the measuring points refer to sigma phase percentages by volume.

HEAT TREATMENT

Tubes are delivered in the 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 Sandvik 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 should be carried out with a low heat input and with welding plans well thought out in advance, so that 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 is stress relieved.

As filler metal for **gas shielded arc welding** we recommend Sandvik 22.12.HT wire electrodes and rods. When using gas metal-arc welding (MIG/MAG), pulsed arc and an inert shielding gas like pure argon or an argon helium mix is suggested. In **manual metal-arc welding,** Sandvik 22.12.HTR covered electrodes 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 is available on request.

BENDING

Annealing after cold bending is not normally necessary, but this should be reviewed depending on the degree of bending and the operating conditions.

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

APPLICATIONS

The high creep strength of Sandvik 253 MA, coupled with its excellent oxidation resistance and its good resistance to carburization in constantly carburizing gas, makes it a very suitable material for end uses in which 18/8 steels lack the necessary resistance to oxidation and carburization.

Stainless chromium steels have insufficient creep strength and structural stability. Furthermore, Sandvik 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.

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

- Tubes in waste heat recovery systems in the 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 pulverized coal in blast furnaces
- Tubing for fluidized-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
- Muffle tubes in continuous wire annealing furnaces

* 253 MA is a trademark owned by Outokumpu OY.