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Sandvik 254 SMO (ESR)

(Billets)

Sandvik 254 SMO* (ESR) is a high-alloy austenitic stainless steel developed for use in seawater and other aggressive chloride-bearing media. The steel is electroslag remelted which gives a cleaner material free from segregations. The grade is characterized by:

- Excellent resistance to pitting and crevice corrosion
- High resistance to general corrosion
- High resistance to stress corrosion cracking
- Higher strength than conventional austenitic stainless steels
- Good weldability

STANDARDS

- UNS S31254
- EN number 1.4547
- SS 2378

Product standards
EN 10088-3

Suitable for production of flanges etc. according to ASTM A182 Grade F44.

Certificates
Status according to EN 10 204 3.1

CHEMICAL COMPOSITION

C max	Si max	Mn max	P max	S max	Cr	Ni	Mo	N	Cu
0.020	0.80	1.00	0.030	0.010	20	18	6.1	0.20	0.7

FORMS OF SUPPLY

Sizes and tolerances
Round-cornered square, as well as round billets, are produced in a wide range of sizes according to the following tables. Larger sizes offered on request.

Surface conditions
Square billets
Unground, spot ground or fully ground condition.

Round billets
Peel turned or black condition.

SQUARE BILLETS

Size mm	Tolerance mm	Length m
80	+/-2	4 - 6.3
100, 114, 126, 140, 150	+/-3	4 - 6.3
160, 180, 195, 200	+/-4	4 - 6.3
>200 - 350	+/-5	3 - 5.3

Sizes and tolerances apply to the rolled/forged condition.

PEEL TURNED ROUND BILLETS

Size	Tolerance	Length
mm	mm	m
75 - 200 (5 mm interval)	+/-1	max 10
>200 - 450	+/-3	3 - 8

UNGROUND ROUND BILLETS

Size	Tolerance	Length
mm	mm	m
77 - 112 (5 mm interval)	+/-2	max 10
124, 134	+/-2	max 10
127, 147, 157	+/-2	max 10
142, 152, 163	+/-2	max 10
168, 178, 188	+/-2	max 10
183, 193	+/-2	max 10

Other products
Mostly supplied in non-ESR condition

- Welded tube and pipe
- Seamless tube and pipe
- Fittings and flanges

MECHANICAL PROPERTIES

For billets testing is performed on separately solution annealed and quenched test pieces.

The following figures apply to material in the solution annealed condition.

At 20°C (68°F)

METRIC UNITS

Proof strength		Tensile strength	Elong	Hardness
$R_{p0.2}$[a]	$R_{p1.0}$[a]	R_m	A[b]	Brinell
MPa	MPa	MPa	%	
min.	min.		min.	max.
310	340	675-850	35	260

IMPERIAL UNITS

Proof strength		Tensile strength	Elong.	Hardness
$R_{p0.2}$[a]	$R_{p1.0}$[a]	R_m	A[b]	Brinell
ksi	ksi	ksi	%	
min.	min.		min.	max.
45	49	98-123	35	260

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 $L_0 = 5.65 \sqrt{S_0}$ where L_0 is the original gauge length and S_0 the original cross-section area.

Impact strength
Due to its austenitic microstructure, Sandvik 254 SMO/ESR has very good impact strength both at room temperature and at cryogenic temperatures.
Tests have demonstrated that the steel fulfils the requirements (60 J (44 ft-lb) at -196 °C (-320 °F)) according to the European standards EN 13445-2 (UFPV-2) and EN 10216-5.

At high temperatures
Intermetallic phases are precipitated within the temperature range of 600-1000°C (1110-1830°F). The steel should therefore not be exposed to these temperatures for prolonged periods. Minimum proof strenght properties at high temperatures are based on datasheets seamless tubes and pipe. Since the tubes have thin walls the values should only be used as indicative values for billets.

METRIC UNITS

Temperature	Proof strength	
°C	$R_{p0.2}$	$R_{p1.0}$
	MPa	MPa
	min.	min.
100	230	270
200	190	225
300	170	200
400	160	190

IMPERIAL UNITS

Temperature	Proof strength	
°F	$R_{p0.2}$	$R_{p1.0}$
	ksi	ksi
	min.	min.
200	34	40
400	27	32
600	24	29
700	24	28

PHYSICAL PROPERTIES

Density: 8.0 g/cm^3, 0.29 lb/in^3

THERMAL CONDUCTIVITY

Temperature, °C	W/m °C	Temperature, °F	Btu/ft h °F
20	10	68	6
100	12	200	7
200	14	400	8
300	16	600	9.5
400	18	800	10.5
500	20	1000	11.5
600	21	1200	12.5
700	23	1300	13

SPECIFIC HEAT CAPACITY

Temperature, °C	J/kg °C	Temperature, °F	Btu/ft h °F
20	485	68	0.12
100	510	200	0.12
200	535	400	0.13
300	565	600	0.14
400	585	800	0.14
500	600	1000	0.14
600	615	1200	0.15
700	625	1400	0.15

THERMAL EXPANSION [1)]

Temperature, °C	Per °C	Temperature, °F	Per °F
30-100	16	86-200	9
30-200	16	86-400	9
30-300	16.5	86-600	9
30-400	16.5	86-800	9.5
30-500	17	86-1000	9.5
30-600	17	86-1200	9.5
30-700	17.5	86-1300	10

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

MODULUS OF ELASTICITY [1)]

Temperature, °C	MPa	Temperature, °F	ksi
20	195	68	28.3
100	190	200	27.6
200	182	400	27.5
300	174	600	25.1
400	166	800	23.8
500	158	1000	22.5

1) ($x10^3$)

CORROSION RESISTANCE

Stress corrosion cracking (SCC)
Ordinary austenitic steels of the AISI 304 and 316 types are prone to stress corrosion cracking in chloride-containing solutions at temperatures exceeding about 60°C (140°F). For austenitic steels, resistance to SCC increases with increasing nickel and molybdenum contents. The tables below give the results of two accelerated tests, showing that Sandvik 254 SMO has very good resistance to SCC.

Stress corrosion cracking tests in boiling 25% NaCL solution, pH=1.5. U-bend specimens.

Steel	Time to failure	Remark
AISI 316	<150 h	Pitting
904L	No failure (1000 h)	Crevice corrosion
254 SMO	No failure (1000 h)	No attack

Intergranular corrosion
Sandvik 254 SMO/ESR has a very low carbon content. This means that there is very little risk of carbide precipitation during heating, for example, when welding. The steel passes the Strauss test (ASTM A262, practice E) even after sensitizing for one hour at 600-1000°C (1110-1830°F).

However, due to the high alloying content of the steel, intermetallic phases can precipitate at the grain boundaries in the temperature range at 600-1000°C (1110-1830°F). These precipitations do not involve any risk of intergranular corrosion in the environments in which the steel is intended to be used. Thus, welding can be carried out without any risk of intergranular corrosion.

Pitting corrosion
The high chromium content and particularly the molybdenum content give Sandvik 254 SMO/ESR excellent resistance to pitting and crevice corrosion.

The high nitrogen content also improves pitting resistance. The results of laboratory determination of the critical pitting temperature (CPT) in 3 % NaCl shows that Sandvik 254 SMO/ESR has a far greater CPT than 904L and it possesses very good resistance in water containing chlorides. Sandvik 254 SMO/ESR is, therefore, a suitable material for use in, for example, seawater.

Crevice corrosion
The weak point of conventional stainless steels is their limited resistance to crevice corrosion. In seawater, for example, there is a considerably greater risk of crevice corrosion under gaskets, deposits or fouling. Tests in natural seawater at 60°C (140°F) have shown that Sandvik 254 SMO/ESR can be exposed for prolonged periods, without suffering crevice corrosion.

For further information regarding corrosion resistance of Sandvik 254 SMO, please see the data sheet Seamless tube and pipe - Sandvik 254 SMO. The data should be considered in the knowledge that it may not be applicable for thick sections, such as forgings.

HOT WORKING

Hot working should be carried out at a material temperature of 950-1200°C (1740-2190°F). Hot working of Sandvik 254 SMO/ESR should be followed by rapid cooling in air or water. Subsequent heat treatment should be carried out in accordance with the recommendations given for heat treatment.

HEAT TREATMENT

Billets are delivered in the hot worked condition. The following heat treatment is recommended.

Solution annealing
1150-1200°C (2100-2190°F), followed by quenching in water.

WELDING

The weldability of Sandvik 254 SMO/ESR is good. Preheating and post-weld heat treatment are normally not recommended. Suitable methods of fusion welding are manual metal-arc with covered electrodes and gas shielded arc welding, mainly by means of the TIG and MIG/MAG methods.

Since the material is intended for use under severely corrosive conditions, welding must be carried out with care, and followed by thorough cleaning to ensure that the weld metal and the heat affected zone will have as good corrosion properties as possible. Degreasing of the weld area with acetone or alcohol is recommended, in order to avoid porosity and fissuring.

The heat input during welding should not exceed 1.0 kJ/mm, and in multi-pass welding, the interpass temperature should not exceed 100°C (210°F). A stringer bead welding technique should be used.

The welding of fully austenitic steels usually entails a risk of hot cracking in the weld metal, particularly if the weldment is under constraint. However, since Sandvik 254 SMO/ESR has a very high degree of purity, the risk of this type of cracking is greatly reduced. Backing bars and similar devices of copper alloys, however, cannot be used, since copper penetration into the grain boundaries in stainless steel can lead to cracking.

In common with all austenitic stainless steels, Sandvik 254 SMO/ESR has low thermal conductivity and high thermal expansion. For this reason, welding should be carefully planned in advance so that distortion of the welded joint can be minimised. If, despite these precautions, it is believed that residual stresses may impair the function of the weldment, it is recommended that the entire structure is solution annealed. See under Heat treatment.

Sanicro 60 wire and electrodes are recommended as filler metal. This filler metal is overalloyed and produces a weld that has better corrosion properties than the parent metal. Sanicro 60 is also suitable for welding joints between Sandvik 254 SMO/ESR and nickel alloys, other stainless steels or carbon steels.

MACHINING

Machining Sandvik 254 SMO/ESR, as with other stainless steels, requires an adjustment

to tooling data and machining method, in order to achieve satisfactory results. Compared to Sanmac 316/316L, the cutting speed must be reduced by approximately 55-60% when turning Sandvik 254 SMO/ESR with coated, cemented carbide tools. Much the same applies to other operations. Feeds should only be reduced slightly and with care.

Detailed recommendations for the choice of tools and cutting data are provided in the data sheet for Sanmac 316/316L.

APPLICATIONS

Sandvik 254 SMO is used in the following applications:

- Equipment for handling seawater - for example, heat exchangers, cooling water systems, ballast water systems, firefighting systems etc.
- Equipment in pulp bleaching plants.
- Components in gas cleaning systems.

Industrial categories	Typical applications
Chemical industry	Flanges
Petrochemical industry	Valves
Pulp and paper industry	Fittings
Oil and gas industry	Couplings
	Rings
	Seals
	Bolts and nuts
	Shafts
	Forgings
	Discs

* 254 SMO is a trademark owned by Outokumpu OY.

DISCLAIMER:
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. This datasheet is only valid for Sandvik materials.