Datasheet updated 2013-05-16 16:11:33 (supersedes all previous editions)

Sandvik 254 SMO

(Tube and pipe, seamless)

Sandvik 254 SMO is a high-alloy austenitic stainless steel developed for use in seawater and other aggressive chloride-bearing media. The steel is characterized by the following properties:

- 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
- EN name X1CrNiMoCuN20-18-7
- W.Nr. 1.4529**
- SS 2378*
- AFNOR Z1 CNDU 20.18.06AZ*

* Obsolete. Replaced by EN.
** Nearest equivalent grade.

Product standards

- Seamless tube and pipe: ASTM A269, A213, A312, NFA 49-217, EN 10216-5
- Welded tube and pipe: ASTM A249, A269 , A312, A358, A409
- Fittings: ASTM A182
- Bar: ASTM A276, A479, EN 10088-3
- Forged products: ASTM A473

Approvals

- UNS S31254 (Sandvik 254 SMO) in the form of seamless pipe has been approved by the American Society of Mechanical Engineers (ASME) for use according to ASME Boiler and Pressure Vessel Code section VIII, div. 1. However, there is no approval for UNS S31254 in the form of seamless tube, but according to the ASME paragraph UG-15 it is allowed to use the design values for seamless pipe according to ASME section VIII, div. 1 also for seamless tube.
- NACE MR 0175 (sulphide stress cracking resistant material for oil field equipment).

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	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

Seamless tube and pipe are supplied in dimensions up to 230 mm (9.06 in.) outside diameter. The delivery condition is either solution annealed and white pickled, or solution annealed in a bright annealing process.

Other forms of supply

- Welded tube and pipe
- Fittings and flanges
- Bar steel
- Forged products
- Cast products

MECHANICAL PROPERTIES

The following figures apply to solution annealed condition seamless tube and pipe.

METRIC UNITS, AT 20°C

Wall thickness	Proof strength		Tensile strength	Elong.		Hardness
	$R_{p0.2}$ a)	$R_{p1.0}$ a)	R_m	A b)	$A_{2"}$	HRB
mm	MPa	MPa	MPa	%	%	
	min.	min.		min.	min.	max.
<5	310	340	675-850	35	35	96
>5	310	340	655-850	35	35	96

1 MPa = 1 N/mm^2

IMPERIAL UNITS, AT 68°F

Wall thickness	Proof strength		Tensile strength	Elong.		Hardness
	$R_{p0.2}$ a)	$R_{p1.0}$ a)	R_m	A b)	$A_{2"}$	HRB
inch	ksi	ksi	ksi	%	%	
	min.	min.		min.	min.	max.
<0.187	45	49	98-123	35	35	96
>0.187	45	49	98-123	35	35	96

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 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). Therefore, the steel should not be exposed to these temperatures for prolonged periods.

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
500	148	180

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
900	22	26

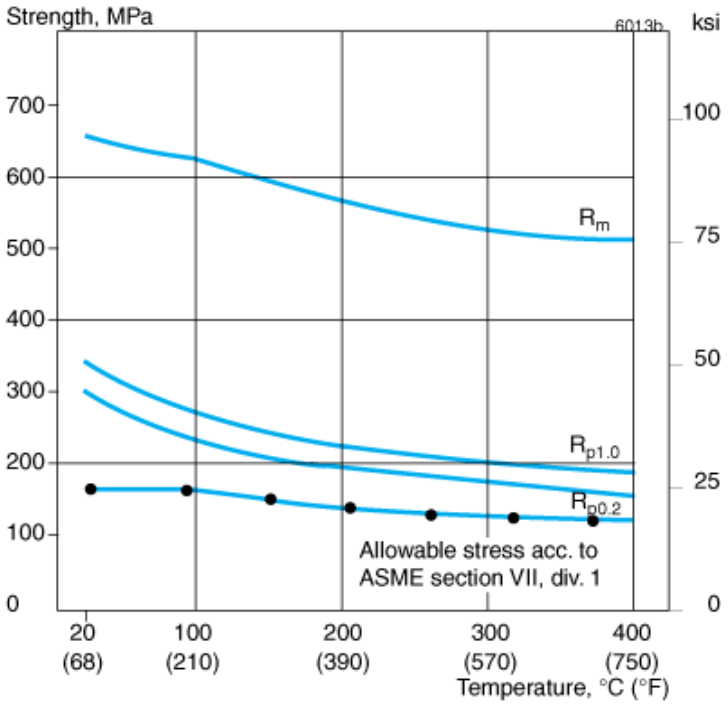

Figure 1. Strength values (min. values) for Sandvik 254SMO and allowable stress according to ASME Boiler and Pressure Vessel Code section VIII, div. 1.

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, MEAN VALUES IN TEMPERATURE RANGES ($X10^6$)

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

MODULUS OF ELASTICITY, ($X10^3$)

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

CORROSION RESISTANCE

In solutions containing halides such as chloride and bromide ions, conventional stainless steels can be readily attacked by local corrosion in the form of pitting corrosion, crevice corrosion or stress corrosion cracking (SCC). In acid environments, the presence of halides also accelerates general corrosion.

General corrosion
In pure sulphuric acid, Sandvik 254 SMO is much more resistant than ASTM TP316, and in naturally aerated sulphuric acid containing chloride ions Sandvik 254 SMO exhibits higher resistance than '904L', see Figure 2.

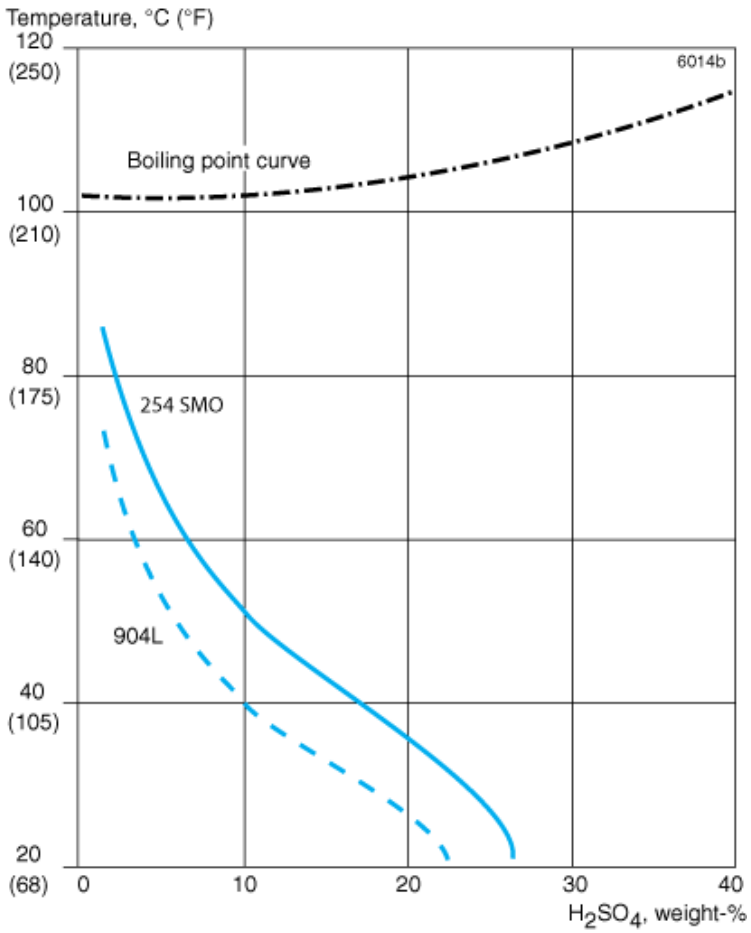

Figure 2. Isocorosion diagram 0.1 mm/year (4mpy) in naturally aerated sulphuric acid containing 2000 ppm chloride ions.

Stress corrosion cracking (SCC)
Ordinary austenitic steels of the ASTM TP304 and TP316 type are prone to stress corrosion cracking (SCC) in chloride-containing solutions at temperatures exceeding about 60°C (140°F). For the austenitic steels, resistance to SCC increases with higher nickel and molybdenum contents. The tables below show the results of two accelerated tests, clearly demonstrating that Sandvik 254 SMO has a very good resistance to SCC.

STRESS COROSION CRACKING TESTS IN BOILING 25% NACL SOLUTION, PH=1.5. U-BEND SPECIMENS.

Grade	Time to failure	Remark
ASTM TP316	<150 h	Pitting
'904L'	No failure (1000 h)	Crevice corrosion
Sandvik 254 SMO	No failure (1000 h)	No attack

STRESS CORROSION CRACKING TESTS. DROP EVAPORATION METHOD*. STRESS: 0.9X$R_{P0.2}$

Grade	Time to failure hours
ASTM TP316	105
'904L'	225
Sandvik 254 SMO	425

* A 0.1 M NaCl solution is allowed to drop slowly onto an electrically heated tensile test specimen at 300 °C (570 °F).

Intergranular corrosion
Sandvik 254 SMO 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, inter-metallic phases can precipitate at the grain boundaries in the temperature range 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
Its high chromium content and particularly the molybdenum content give Sandvik 254 SMO 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 are shown in Figure 3, where it can be seen that Sandvik 254 SMO possesses very good resistance in water containing chlorides. Sandvik 254 SMO is, therefore, a suitable material for use in 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 can be exposed for prolonged periods without suffering crevice corrosion. Figure 4 shows the results of accelerated crevice corrosion tests.

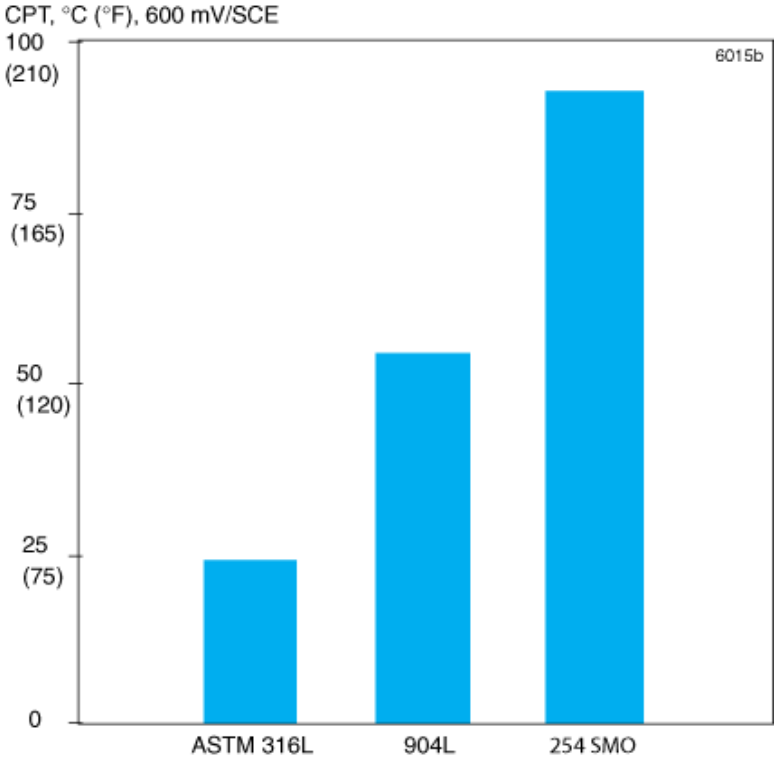

Figure 3. Critical pitting temperature (CPT) in 3% NaCl, 600 mV/SCE.

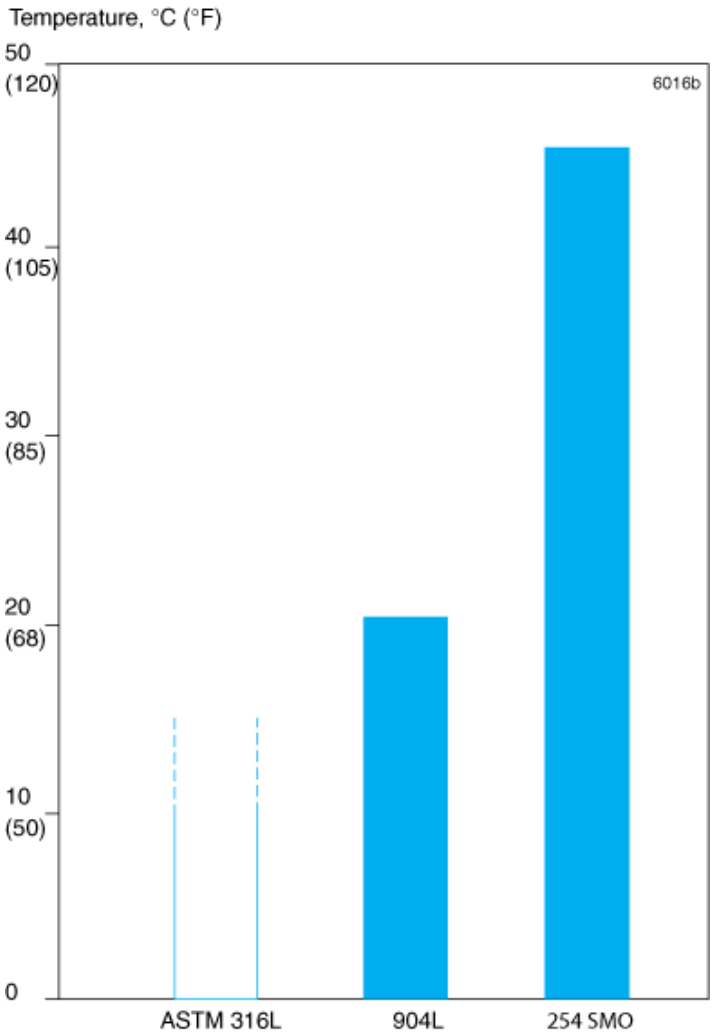

Figure 4. Critical crevice corrosion temperature in $FeCl_3$ for Sandvik 254 SMO, AISI 316L and 904L. According to ASTM G-48.

HEAT TREATMENT

The tubes are delivered in heat treated condition. If additional heat treatment is needed due to further processing the following is recommended.

Solution annealing
1150–1200°C (2100–2190°F), quenching in water. Thin-walled tubes min. 1130°C (2060°F), quenching in air/water.

WELDING

The weldability of Sandvik 254 SMO is good. Welding should be undertaken without preheating, and if correctly performed there will be no need for any subsequent heat treatment. Suitable methods of fusion welding are manual metal-arc welding with covered electrodes and gas-shielded arc welding, mainly by means of the TIG and MIG methods.

Since the material is intended for use under severe 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 maintain the best possible corrosion properties.

The heat input during welding should not exceed 1.5 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 has a very high degree of purity, the risk of this type of cracking is greatly reduced. Backing bars or similar devices of copper alloys must not 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 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 minimized. If, despite these precautions, it is believed that residual stresses may impair the function of the weldment, it is recommended that the entire structure be solution annealed. See under Heat treatment.

In the as-supplied condition, the material has a homogeneous structure. Welding without filler metal leads to structural changes that reduce corrosion resistance. Such welding should be followed by solution annealing in order to ensure that the corrosion properties of the weld metal are equal to those of the parent metal.

Welding wire Sanicro 60 and covered electrodes Sanicro 60 are recommended as filler metal. These filler metals are overalloyed in order to compensate for microsegregation of molybdenum and thereby producing a weld with good corrosion resistance. Dilution from parent material into the weld metal should be kept as low as possible to secure good corrosion resistance. Sanicro 60 is also suitable for welding joints between Sandvik 254 SMO and nickel alloys, other stainless steels or carbon steels.

FABRICATION

Avoid abrasion against copper/copper alloys or other similar metals which, if present in metallic form, can cause cracks during subsequent welding, hot processing or heat treatment.

Bending

The excellent formability of Sandvik 254 SMO permits cold bending to very tight bending radii. Annealing is not normally necessary after cold bending.

Machining

Sandvik 254 SMO is a high alloyed austenitic stainless steel and thus tougher inserts in metal cutting are needed than is the case for lower alloyed austenitic grades. When machining Sandvik 254 SMO considerably lower cutting speeds are recommended compared to the grades Sanmac 304/304L and Sanmac 316/316L, which have improved machinability.

APPLICATIONS

Sandvik 254 SMO is used in the following applications:

- Equipment for handling of seawater, such as, seawater cooling, cooling water pipes, ballast water systems, firefighting systems etc.
- Hydraulic and instrumention tubing
- Equipment in pulp bleaching plants
- Components in gas cleaning systems
- Tanks and pipelines for chemicals with high halide contents

Trademark information: 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.