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Sandvik 6R44

(Tube and pipe, seamless)

Sandvik 6R44 is an austenitic, niobium-stabilized stainless chromium-nickel steel for use at temperatures up to 850°C (1560°F).

STANDARDS

- ASTM TP347, TP347H
- UNS S34700/S34709
- EN number 1.4550/1.4912
- EN name X6CrNiNb18-10/X7CrNiNb18-10
- W.Nr. 1.4550
- DIN X 6 CrNiNb 18 10
- SS 2338
- AFNOR (Z6CNNb 18.10)
- BS 347S31/347S51

Product standards
Seamless tube and pipe:
- ASTM A213, A269, A312, A376
- EN 10216-5
- BS 3059 Part 2, BS 3605 Part 1, BS 3606
- DIN 17456,17458
- SS 14 23 38

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P max	S max	Cr	Ni	Nb
0.05	0.6	1.7	0.030	0.015	17.5	10	0.7

FORMS OF SUPPLY

Seamless tube and pipe - Finishes and dimensions
Seamless tube and pipe in Sandvik 6R44 is supplied in dimensions up to 260 mm outside diameter in the solution-annealed and white-pickled condition or in the bright annealed condition.

Other forms of supply
- Wire electrodes and filler wire/rods
- Covered electrodes

MECHANICAL PROPERTIES

For tube and pipe with wall thicknesses greater than 10 mm (0.4 in) the proof strength may fall short of the stated values by about 10 MPa (1.4 ksi).

At 20°C (68°F)

Proof strength				Tensile strength		Elong.	Hardness Vickers
$R_{p0.2}$ 1)		$R_{p1.0}$ 1)		R_m	ksi	A 2)	
MPa	ksi	MPa	ksi	MPa		%	
min.	min.	min.	min.			min.	approx.
220	32	250	36	515-690	75-100	40	155

1 MPa = N/mm^2
1) $R_{p0.2}$ and $R_{p1.0}$ correspond to 0.2% offset and 1.0% offset yield strength, respectively.
2) 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 6R44 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

METRIC UNITS

Temperature	Proof strength	
	$R_{p0.2}$	$R_{p1.0}$
°C	MPa	MPa
	min.	min.
50	195	232
100	175	210
150	165	195
200	155	185
250	147	175
300	139	167
350	133	162
400	129	159
450	126	156
500	124	155
550	118	152
600	-	-

IMPERIAL UNITS

Temperature	Proof strength	
	$R_{p0.2}$	$R_{p1.0}$
°F	ksi	ksi
	min.	min.
100	29.2	36.0
200	25.7	30.7
300	24.1	29.7
400	22.3	28.1
500	21.2	25.2
600	19.9	24.1
700	19.0	23.4
800	18.3	22.8
900	18.0	22.2
1000	17.3	22.0
1100	16.8	21.8

CREEP RUPTURE STRENGTH

Temperature		10 000 h		100 000 h	
°C	°F	MPa	ksi	MPa	ksi
		approx.	approx.	approx.	approx.
540	1005	253	36.7	186	27.0
550	1020	237	34.4	172	24.9
580	1075	192	27.8	135	19.6
600	1110	166	24.1	115	16.7
620	1150	142	20.6	97	14.1
650	1202	112	16.2	74	10.7
670	1240	96	13.9	61	8.8
700	1290	74	10.7	48	7.0
800	1470	28	4.1	16	2.3

PHYSICAL PROPERTIES

Density: 7.9 g/cm^3, 0.29 lb/in^3

THERMAL CONDUCTIVITY

Temperature, °C	W/m °C	Temperature, °F	Btu/ft h °F
23	14	73	8
100	15	200	8.5
200	17	400	10
300	18	600	10.5
400	20	800	11.5
500	21	1000	12.5
600	23	1100	13

SPECIFIC HEAT CAPACITY

Temperature, °C	J/kg °C	Temperature, °F	Btu/lb °F
23	485	73	0.11
100	500	200	0.12
200	515	400	0.12
300	525	600	0.13
400	540	800	0.13
500	555	1000	0.13
600	575	1100	0.14

THERMAL EXPANSION [1)]

Temperature, °C	Per °C	Temperature, °F	Per °F
30-100	17	86-200	9.5
30-200	17.5	86-400	9.5
30-300	17.5	86-600	10
30-400	18	86-800	10
30-500	18.5	86-1000	10.5
30-600	18.5	86-1200	10.5
30-700	19	86-1400	10.5
30-800	19.5	86-1600	11
30-900	19.5	86-1800	11
30-1000	20		

1) Mean values in temperature ranges ($x10^{-6}$)

MODULUS OF ELASTICITY [1)]

Temperature, °C	MPa	Temperature, °F	ksi
20	200	68	29.0
100	194	200	28.2
200	186	400	26.9
300	179	600	25.8
400	172	800	24.7
500	165	1000	23.5

1) ($x10^3$)

CORROSION RESISTANCE

Wet corrosion
Sandvik 6R44 is generally used at temperatures above 500°C (930°F), where wet corrosion is not relevant. The stabilisation with niobium gives Sandvik 6R44 good resistance to intergranular corrosion. The steel may be sensitive to pitting and crevice corrosion even in solutions of relatively low chloride content. Austenitic steels are susceptible to stress corrosion cracking. This may occur at temperatures above about 60°C (140°F), if the steel is subject to tensile stresses and at the same time comes into contact with certain solutions, particularly those containing chlorides. Such service conditions should therefore be avoided. Conditions when plants are shut down must also be considered as the condensates which are then formed can develop a chloride content that leads to both stress corrosion cracking and pitting.

Gas corrosion
Sandvik 6R44 can be used in air up to 850°C (1560°F) and in steam up to 750°C (1380°F). It is suitable for use in mild synthesis gas up to about 550°C (1020°F)

Creep behaviour should also be taken into account when using the steel in the creep range.

In flue gases containing sulphur, the corrosion resistance is reduced. In such environments this steel can be used at temperatures up to 600-750°C (1110-1380°F) depending on service conditions. Factors to consider are whether the atmosphere is oxidising or reducing, i.e. the oxygen content, and whether impurities such as sodium and vanadium are present.

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
1000-1100°C (1830-2010°F), 5-20 minutes, rapid cooling in air or water.

WELDING

The weldability of Sandvik 6R44 is good. Suitable welding methods are manual metal-arc welding with covered electrodes and gasshielded 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. See under "Heat treatment".

As filler material for **gas shielded arc welding** we recommend wire electrodes and rods Sandvik 19.9.NbSi or 19.9.Nb. In **manual metal-arc welding** covered electrodes Sandvik 19.9.NbR are recommended.

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. Heat treatment, if any, should take the form of stress relieving or solution annealing, see under "Heat treatment".

Hot bending is carried out at 1100-850°C (2010-1560°F) and should be followed by solution annealing.

APPLICATIONS

Sandvik 6R44 is used for superheater-tubes in steam power plants.

It is also frequently used for cooling tubes in ammonia converters, because of its good resistance to nitrogen absorption and good corrosion resistance.

With its good hot-strength, and good resistance to hydrogen sulphide and intergranular corrosion, Sandvik 6R44 is a suitable material for furnace tubes in refineries. Furnace tubing used in vinyl chloride production is another example of applications in which this steel is often used.

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.