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Sandvik 6R35

(Tube and pipe, seamless)

Sandvik 6R35 is an austenitic, titanium-stabilized stainless chromium-nickel steel. It is suitable for wet-corrosive service but also has good mechanical strength at high temperatures.

STANDARDS

- ASTM TP321, TP321H
- UNS S32100, S32109
- EN number 1.4541, 1.4940
- EN name X6CrNiTi18-10, X7CrNiTi18-10
- W.Nr. 1.4541, 1.4878
- DIN X6CrNiTi 18 10, X12CrNiTi 18 9
- SS 2337
- AFNOR Z6CNT18-10
- BS 321S31, 321S51

Product standards
Seamless tube and pipe
- ASTM A213, A312, A269, A376, (A511)
- EN 10216-5
- BS 3059, 3605, 3606
- DIN 17456, 17458
- SS 14 23 37
- NFA 49-117, 49-217

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P max	S max	Cr	Ni	Ti
0.05	0.5	1.3	0.030	0.030	17.5	10.5	>5xC

FORMS OF SUPPLY

Seamless tube and pipe-Finishes and dimensions
Seamless tube and pipe in Sandvik 6R35 is supplied in dimensions up to 260 mm outside diameter in the solution-annealed and white-pickled condition or solution-annealed in a bright-annealing process.

Hollow bar
Hollow bars are supplied solution-annealed and white-pickled.

Sizes in stock
Seamless tube and pipe
Seamless tube and pipe are stocked in a wide range of sizes according to ISO and ANSI both in hot extruded as well as in the cold finished and annealed condition. Details of our manufacturing and stock programme are given in catalogue S-110-ENG.

Hollow bar
Hollow bar is stocked in large number of sizes. Our standard size range for stock comprises 32-250 mm (1.3-9.8 in.) O.D. See catalogue S-110-ENG.

Filler metal for welding
The sizes listed below are Sandvik stock standard. The local stocks carry sizes in common demand on the market. For technical information on the filler metals please refer to brochures S-2361-ENG and S-2362-ENG.

Welding wire/rod
Sandvik 19.9.NbSi: 0.80, 1.00, 1.20, 1.60 mm diameter
Sandvik 19.9.LSi: 0.80, 1.00, 1.20, 1.60 mm diameter

Covered electrodes
Sandvik 19.9.LR: 1.60, 2.00, 2.50, 3.25, 4.00 mm diameter

MECHANICAL PROPERTIES

At 20°C (68°F)

Proof strength				Tensile strength		Elong.	Hardness
$R_{p0.2}$ [a]		$R_{p1.0}$ [a]		R_m		A [b]	HRB
MPa	ksi	MPa	ksi	MPa	ksi	%	
min	min	min	min			min	max
210	30	240	35	515-690	75-100	35 [c]	90

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.
c) NFA 49-117 and NFA 49–217 with min 45% can be fulfilled.

Impact strength
Due to its austenitic microstructure, Sandvik 6R35 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 prEN 13445-2 (UFPV-2) and prEN 10216-5.

At high temperatures

METRIC UNITS

Temperature	Proof strength [c]	
	$R_{p0.2}$	$R_{p1.0}$
°C	MPa	MPa
	min	min
50	195	230
100	180	210
150	170	195
200	160	185
250	150	180
300	140	175
350	135	170
400	130	165
450	130	165
500	125	160
550	125	160
600	120	155

IMPERIAL UNITS

Temperature	Proof strength [c]	
	$R_{p0.2}$	$R_{p1.0}$
°F	ksi	ksi
	min	min
200	26.0	30.5
400	22.5	26.5
600	19.5	25.0
800	18.5	23.5
1000	17.5	23.0
1100	17.0	22.0

c) For extruded tube and pipe with wall thickness greater than 10 mm (0.4 in.) the proof

strength may fall short of the stated value by 20 MPa (2.9 ksi) at 100°C (200°F) and by 10 MPa (1.4 ksi) in the temperature range 200-600°C (400-1100°F).

CREEP RUPTURE STRENGTH

Temperature		10 000 h		100 000 h	
°C	°F	MPa	ksi	MPa	ksi
		approx.	approx.	approx.	approx.
550	1020	234	34.0	184	26.7
575	1065	175	25.4	126	18.3
600	1110	143	20.7	94	13.6
625	1155	110	16.0	75	10.9
650	1200	90	13.1	58	8.4
675	1245	76	11.0	48	7.0
700	1290	59	8.6	39	5.7
750	1380	29	4.2	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
20	14	68	8
100	15	200	8.5
200	17	400	10
300	19	600	11
400	21	800	12
500	22	1000	13
600	24	1200	14
700	25	1400	15
800	26	1600	16
900	28	1800	16.5
1000	29	2000	17.5
1100	30		

SPECIFIC HEAT CAPACITY

Temperature, °C	J/kg °C	Temperature, °F	Btu/lb °F
20	465	68	0.11
100	490	200	0.12
200	515	400	0.12
300	540	600	0.13
400	560	800	0.14
500	580	1000	0.14
600	595	1200	0.14
700	610	1400	0.15
800	625	1600	0.15
900	640	1800	0.16
1000	650	2000	0.16
1100	665		

THERMAL EXPANSION [1)]

Temperature, °C	Per °C	Temperature, °F	Per °F
30-100	17.5	86-200	9.5
30-200	17.5	86-400	10
30-300	18	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	86-1300	10.5

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

General corrosion
Sandvik 6R35 has with some limitations (nitric acid) the same resistance as the unstabilised steel AISI 304. Consequently, the grades have good resistance to

- Organic acids at moderate temperatures
- Salt solutions, e.g. sulphates, sulphides and sulphites
- Caustic environments at moderate temperatures

Intergranular corrosion
The stabilisation with titanium gives Sandvik 6R35 improved resistance to intergranular corrosion.

Pitting and crevice corrosion
Pitting and crevice corrosion may occur even in solutions of relatively low chloride content. However, the stabilisation with titanium results in a somewhat better resistance than that of AISI 304.

Stress corrosion cracking
Austenitic steels, like 6R35 are susceptible to stress corrosion cracking. This may occur at temperatures above about 60 °C (140 °F), if the material is subjected 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.

In applications demanding high resistance to stress corrosion cracking we recommend the austenitic-ferritic steel Sandvik SAF 2304. See data sheet S-1871-ENG.

Gas corrosion
Sandvik 6R35 can be used in

- Air up to 850°C (1560°F)
- Steam up to 750°C (1380°F)
- Synthesis gas (ammonia synthesis) up to about 550 °C (1020 °F)

Creep 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 normally delivered as described above. If additional heat treatment is needed after further processing the following is recommended.

Solution annealing
Tp 321
1040-1100°C (1905-2010°F), 2-5 min, rapid cooling in air or water.

Tp321H
Stabilisation treatment: 1040-1100°C (1920-2010°F), 2-5 min rapid cooling in air or water. However, annealing above 1100°C (2010°F) may be required in order to meet grain size requirements. This treatment should be followed by a stabilisation treatment.

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

WELDING

The weldability of Sandvik 6R35 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 Sanicro 72. In manual metal-arc welding covered electrodes Sanicro 72 are recommended. For application at temperatures up to 400°C (750°F) also welding wire/rod Sandvik 19.9.NbSi, 19.9.Nb, 19.9.LSi or 19.9.L and covered electrodes Sandvik 19.9.NbR or 19.9.LR 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.

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

MACHINING

Sandvik 6R35 has good machining properties. Detailed recommendations for the choice of tools and cutting data are provided in the printed matter S-1492-ENG.

APPLICATIONS

Good resistance to hydrogen sulphide gas and intergranular corrosion coupled with good high temperature strength make Sandvik 6R35 a suitable material for applications

as tubes in heating furnaces and heat exchangers in sulphurisation and hydro-treating plants. In the petrochemical industry the steel is used in cracking furnaces for the production of ethylene and vinyl chloride. It is also frequently used for heat exchangers and piping in the chemical and petrochemical industries.

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.