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Sandvik 3R12

(Tube and pipe, seamless)

Sandvik 3R12 is an austenitic stainless chromium-nickel steel with a low carbon content.

STANDARDS

- ASTM TP304L, TP304
- UNS S30403, S30400
- EN number 1.4306, 1.4301
- W.Nr. 1.4306, 1.4301
- DIN X 2 CrNi 19 11, X 5 CrNi 18 10
- SS 2352, 2333
- AFNOR Z 2 CN 18.10
- BS 304S31, 304S11
- JIS SUS304L, SUS304LTB, SUS304TP

Product standard

Seamless tube and pipe
ASTM A213, A269 and A312
JIS G3459
JIS G3463
EN 10216-5
BS 3605, 3606
DIN 17456, 17458
NFA 49-117, 49-217
SS 14 23 52, 14 23 33

Approval

JIS approval for Stainless Steel Tubes

CHEMICAL COMPOSITION (NOMINAL) %

C max	Si	Mn	P max.	S max.	Cr	Ni
0.030	0.5	1.3	0.030	0.015	18.5	10

Subject to agreement, material with extra low Co content can be supplied.

FORMS OF SUPPLY

Seamless tube and pipe
Tube and pipe are delivered in the solution annealed and white-pickled condition or in the bright-annealed condition The size range can be seen from Fig. 1. U-tubes can be delivered on request.

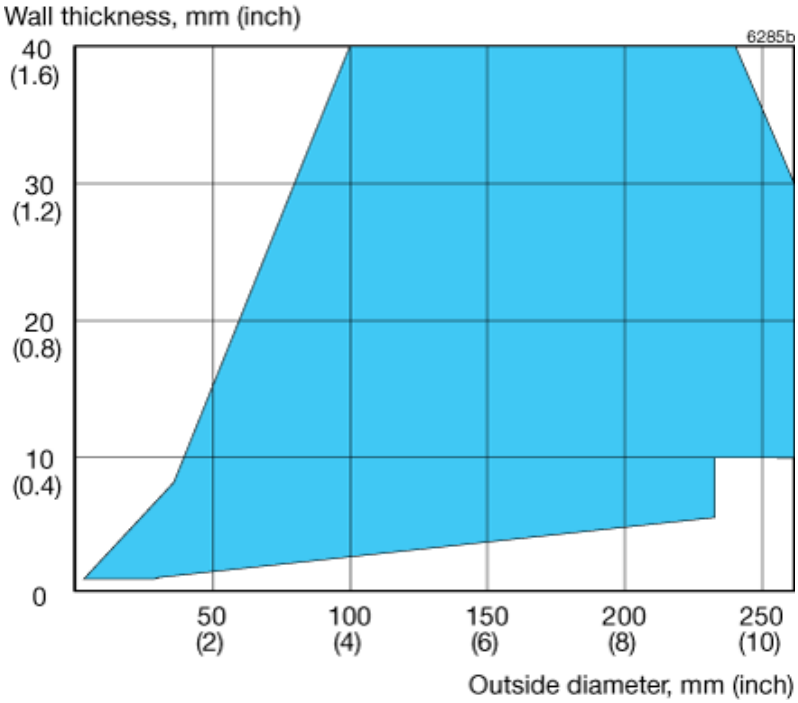

Figure 1. Principal size range for seamless tube and pipe.

MECHANICAL PROPERTIES

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

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)]	$A_{2"}$	HRB
MPa	MPa	MPa	%	%	
min.	min.		min.	min.	max.
210	240	515-680	45	35	90

AT 68°F IMPERIAL UNITS

Proof strength		Tensile strength	Elong.		Hardness
$R_{p0.2}$ [a)]	$R_{p1.0}$ [a)]	R_m	A [b)]	$A_{2"}$	HRB
ksi	ksi	ksi	%	%	
min.	min.		min.	min.	max.
30	35	75-99	44	35	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.

Impact strength

Due to its austenitic microstructure, Sandvik 3R12 has very good impact strength both at room temperature and at cryogenic temperatures.

Tests have demonstrated that the steel fulfils the requirements according to the European standards prEN 13445-2 (UFPV-2) ((min. 60 J (44 ft-lb) at -270 °C (-455 °F)) and prEN 10216-5 (min. 60 J (44 ft-lb) at -196 °C (-320°F).

AT HIGH TEMPERATURES - METRIC UNITS

Temperature	Proof strength	
	$R_{p0.2}$	$R_{p1.0}$
°C	MPa	MPa
	min.	min.
50	190	215
100	165	190
150	150	175
200	140	165
250	130	155
300	125	150
350	120	145
400	115	140
450	110	135
500	105	130
550	100	125
600	95	120

AT HIGH TEMPERATURES - IMPERIAL UNITS

Temperature	Proof strength	
	$R_{p0.2}$	$R_{p1.0}$
°F	ksi	ksi
	min.	min.
200	24	28
400	20	24
600	18	22
800	16	20
1000	15	18

CREEP-RUPTURE STRENGTH (ISO-VALUES)

Temperature		10 000 h		100 000 h	
°C	°F	MPa	ksi	MPa	ksi
		approx.	approx.	approx.	approx.
550	1020	195	28.3	115	16.6
575	1065	147	21.3	93	13.5
600	1110	122	17.6	74	10.7
625	1155	100	14.5	58	8.4
650	1200	79	11.5	45	6.5
675	1245	64	9.2	33	4.8
700	1290	48	7.0	23	3.3

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	15	68	8.5
100	16	200	9.5
200	18	400	10.5
300	20	600	12
400	22	800	13
500	23	1000	14
600	25	1200	15
700	26	1300	15

SPECIFIC HEAT CAPACITY

Temperature, °C	J/kg °C	Temperature, °F	Btu/lb °F
20	475	68	0.11
100	500	200	0.12
200	530	400	0.13
300	560	600	0.13
400	580	800	0.14
500	600	1000	0.14
600	615	1200	0.15
700	625	1300	0.15

THERMAL EXPANSION [1)]

Temperature, °C	Per °C	Temperature, °F	Per °F
30-100	16.5	86-200	9
30-200	17	86-400	9.5
30-300	17.5	86-600	10
30-400	18	86-800	10
30-500	18.5	86-1000	10
30-600	18.5	86-1200	10.5
30-700	19	86-1400	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) Modulus of elasticity, ($x10^3$)

CORROSION RESISTANCE

General corrosion
Sandvik 3R12 has good resistance in

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

Sandvik 3R12 has better resistance than normal type AISI 304 to oxidising agents, such as nitric acid. Figure 2 shows isocorrosion in nitric acid for Sandvik 3R12.

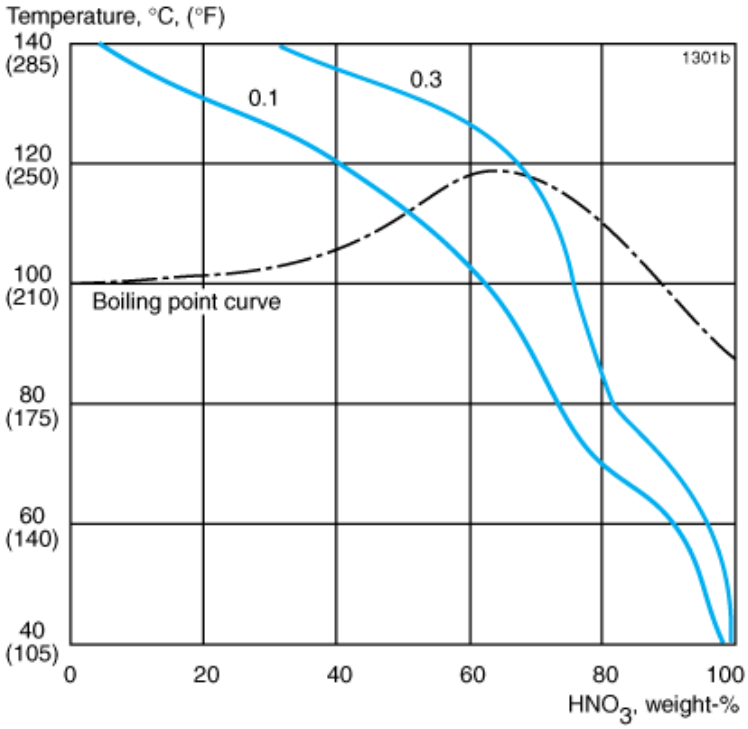

Figure 2. Diagram showing isocorosion in nitric acid for Sandvik 3R12 at the corrosion rates of 0.1 mm/year (4mpy) and 0.3 mm/year (12 mpy).

Intergranular corrosion
Sandvik 3R12 has a low carbon content and therefore better resistance to intergranular corrosion than steels of type AISI 304.

The TTC-diagram, Figure 3, which shows the result of testing for 24 hour in boiling Strauss solution (12% sulphuric acid, 6% copper sulphate) confirms the superior resistance of Sandvik 3R12. This is an advantage in complicated welding operations.

The good resistance against intergranular attack of Sandvik 3R12 is also demonstrated in the Huey test (boiling in 65% nitric acid for 5x48h). A maximum corrosion rate of 0.40 mm/year in the annealed condition and 0.60 mm/year in the sensitised (675°C (1275°F)) condition can be met.

Sandvik 3R12 with its controlled and low impurity level, shows better results than ordinary AISI 304L or 321.

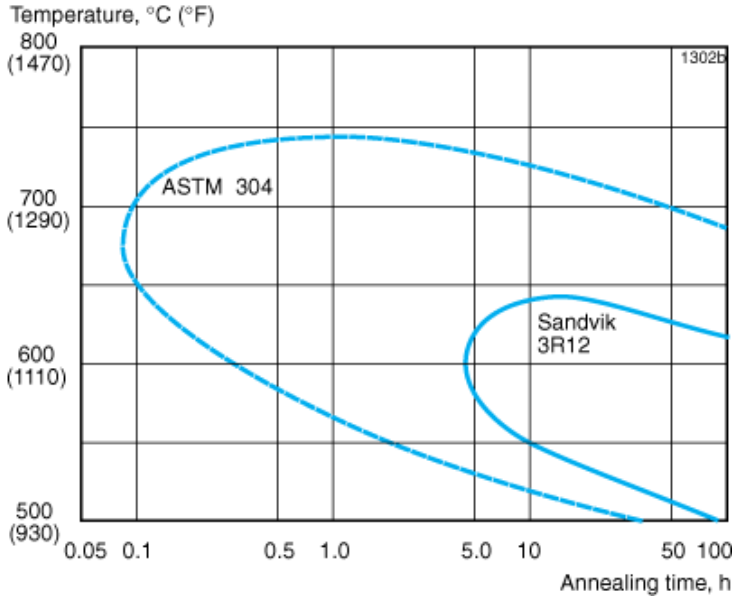

Figure 3. TTC-diagram for Sandvik 3R12 (AISI 304L) and AISI 304.

Pitting and crevice corrosion
The steel may be sensitive to pitting and crevice corrosion even in solutions of relatively low chloride content. Molybdenum-alloyed steels have better resistance improves with increasing molybdenum content.

Stress corrosion cracking
Austenitic steels are susceptible to stress corrosion cracking. This may occur at temperatures above about 60°C (140°F) if the steel 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 conditions 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.

Gas corrosion
Sandvik 3R12 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 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 the 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 in heat treated condition. If additional heat treatment is needed after further processing the following is recommended.

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

Solution annealing
1000-1100°C (1830-2010°F), rapid cooling in air or water.

WELDING

The weldability of Sandvik 3R12 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. See under Heat treatment.

As filler material for **gas-shielded arc welding** we recommend wire electrodes and rods Sandvik 19.9.L or 19.9.LSi. In **manual metal-arc welding** covered electrodes Sandvik 19.9.LR or 19.9.LRHD are recommended. If flux cored arc welding is preferred, electrodes Sandvik 19.9.LT or 19.9.LVT should be used.

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 3R12 is used for a wide range of industrial applications. Typical examples are: heat exchangers, condensers, pipelines, cooling and heating coils in the chemical, petrochemical, fertilizer, pulp and paper and nuclear power industries, as well as in the production of pharmaceuticals, foods and beverages.