SANDVIK 3R12
TUBE AND PIPE, SEAMLESS

DATASHEET

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 standards

- 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*

* Obsolete. Replaced by EN.

Approval

JIS approval for Stainless Steel Tubes

CHEMICAL COMPOSITION (NOMINAL)

Chemical composition (nominal) %

C	Si	Mn	P	S	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.

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.

CORROSION RESISTANCE

General corrosion

Sandvik 3R12 has good resistance in

- Organic acids at moderate temperatures
- Salt solutions, e.g. sulfates, sulfides and sulfites
- Caustic solutions at moderate temperatures

Sandvik 3R12 has better resistance than normal type ASTM TP304 to oxidizing agents, such as nitric acid. Figure 2 shows isocorrosion in nitric acid for Sandvik 3R12.

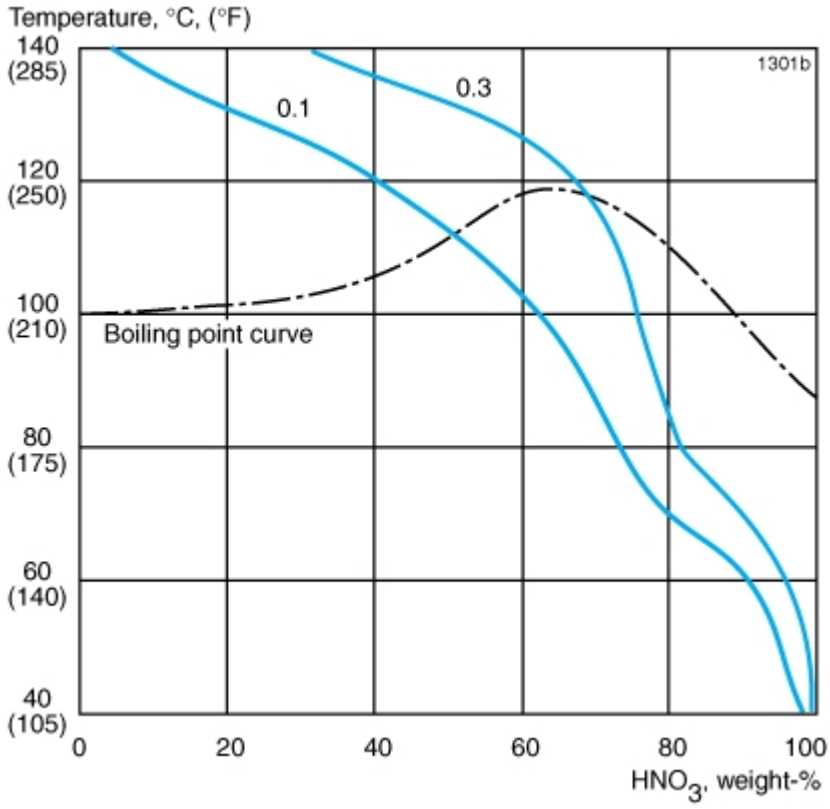

Figure 2. Diagram showing isocorrosion in nitric acid for Sandvik 3R12 at the corrosion rates of 0.1 mm/year (4mpy) and 0.3 mm/year (12 mpy).

Intergranular corrosion

Sandvik 3R12 has a low carbon content and therefore better resistance to intergranular corrosion than steels of type ASTM TP304.

The TTC-diagram, Figure 3, which shows the result of testing for 24 h in boiling Strauss solution (12% sulfuric acid, 6% copper sulfate) 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 5x48 h). A maximum corrosion rate of 0.40 mm/year in the annealed condition and 0.60 mm/year in the sensitized (675°C (1275°F)) condition can be met.

Sandvik 3R12 with its controlled and low impurity level, shows better results than ordinary ASTM TP304L or TP321.

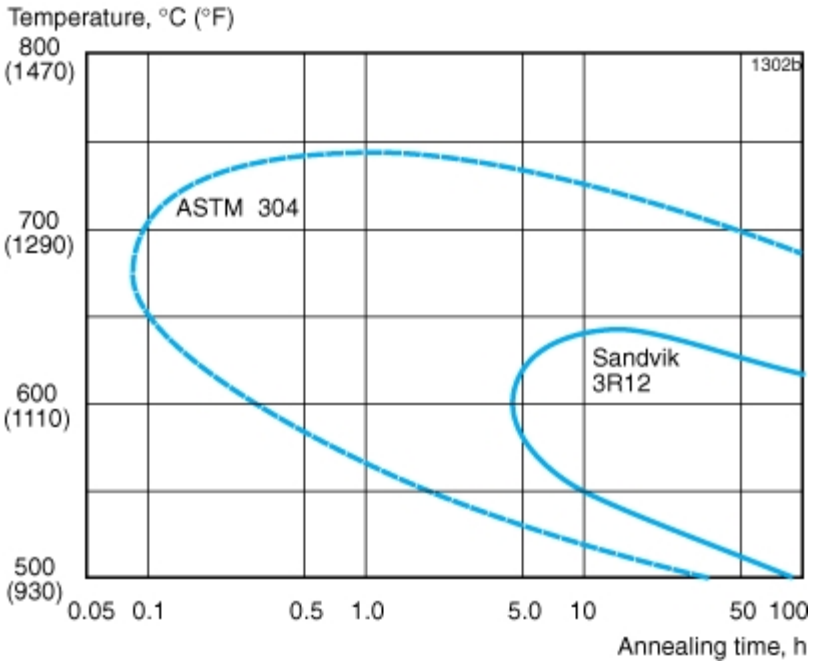

Figure 3. TTC-diagram for Sandvik 3R12 (AISI 304L) and AISI 304.

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 (SCC). 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 (SCC) and pitting.

In applications demanding high resistance to stress corrosion cracking (SCC) we recommend the duplex (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 behavior should also be taken into account when using the Sandvik 3R12 in the creep range.

In flue gases containing sulfur, 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 oxidizing or reducing, i.e. the oxygen content, and whether impurities such as sodium and vanadium are present.

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.

FORMS OF SUPPLY

Seamless tube and pipe in Sandvik 3R12 is supplied in dimensions up to 260 mm (10.2 in.) outside diameter in the solution-annealed and white-pickled condition or solution annealed by a bright-annealing process. U-bent tubes can be supplied on request.

HEAT TREATMENT

Tubes in Sandvik 3R12 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.

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).

Metric units, at 20°C

Proof strength		Tensile strength	Elong.		Hardness
$R_{p0.2}$[a)]	$R_{p1.0}$[a)]	R_m	A[b)]	$A_{2"}$	HRB
MPa	MPa	MPa	%	%	
≥210	≥240	515-680	≥45	≥35	≤90

Imperial units, at 68°F

Proof strength		Tensile strength	Elong.		Hardness
$R_{p0.2}$[a)]	$R_{p1.0}$[a)]	R_m	A[b)]	$A_{2"}$	HRB
ksi	ksi	ksi	%	%	
≥30	≥35	75-99	≥44	≥35	≤90

1 MPa = 1 N/mm²
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 grade fulfils the requirements according to the European standards EN 13445-2 (UFPV-2) ((min. 60 J (44 ft-lb) at -270 ◦C (-455 ◦F)) and EN 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
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

At high temperatures - imperial units

Temperature	Proof strength	
	$R_{p0.2}$	$R_{p1.0}$
°F	ksi	ksi
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
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

Thermal conductivity

Temperature, °C	W/m °C	Temperature, °F	Btu/ft h °F
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, ($x10^{3}$)

WELDING

The weldability of Sandvik 3R12 is good. Welding must be carried out without preheating and subsequent heat treatment is normally not required. Suitable methods of fusion welding are manual metal-arc welding (MMA/SMAW) and gas-shielded arc welding, with the TIG/GTAW method as first choice.

For Sandvik 3R12, heat input of <2.0 kJ/mm and interpass temperature of <150°C (300°F) are recommended.

Recommended filler metals

TIG/GTAW or MIG/GMAW welding

ISO 14343 S 19 9 L / AWS A5.9 ER308L (e.g. Exaton 19.9.L)

MMA/SMAW welding

ISO 3581 E 19 9 L R / AWS A5.4 E308L-17(e.g. Exaton 19.9.LR)

ISO 14343 S 19 9 L / AWS A5.9 ER308L (e.g. Exaton 19.9.L) wire or strip electrodes are recommended for overlay welding of tube sheets and high-pressure vessels in cases where corrosion resistance, equal to that of Sandvik 3R12, is required.

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