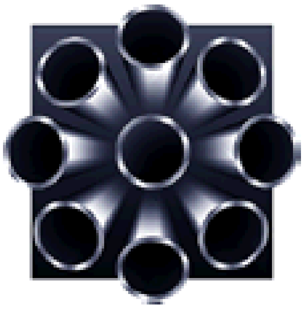

SANDVIK

Seamless tube

Sandvik 3R60

S-1826-ENG May 2000 • Cancels all previous editions

Sandvik 3R60 is an austenitic chromium-nickel steel with minimum 2.5% molybdenum and a low carbon content.
Sandvik 3R60 is also supplied in a variant for the urea industry, Sandvik 3R60 Urea Grade. See data sheet S-1843-ENG.

CHEMICAL COMPOSITION (NOMINAL), %

C max.	Si	Mn	P max.	S max.	Cr	Ni	Mo
0.030	0.4	1.7	0.040	0.015	17.5	13	2.6

STANDARDS

Type of steel

- ASTM TP316L, TP316
- AISI 316L, 316
- UNS S31603, S31600
- EN 1.4435[a)], 1.4436[a)]
- EN name X 2 CrNiMo 18-14-3[a)], X 3 CrNiMo 17-13-3[a)]
- W.-Nr. 1.4435, 1.4436
- DIN X 2 CrNiMo 18 14 3, X 5 CrNiMo 17 13 3
- SS 2353, 2343
- AFNOR Z2 CND 17.13
- BS 316S13
- JIS SUS316LTP, 316TP; SUS316LTB, 316TB

Product standards

- ASTM A213; A269 and A312
- EN 10088[a)]
- DIN 17456; 17458
- SS 14 23 53, 14 23 43
- NFA 49-117[b)]; 49-217[b)]
- BS 3605; BS 3606
- JIS G3459; JIS G3463

Approval

- JIS approval no. SE9402 for stainless steel tubes

FORMS OF SUPPLY

Seamless tube and pipe – Finishes and dimensions

Seamless tube and pipe in Sandvik 3R60 is supplied in dimensions up to 260 mm outside diameter. The delivery conditions is either solution annealed and white pickled, or solution annealed in a bright anneling process

Other forms of supply

We can also deliver other product forms from stock in a grade corresponding to type 316L mainly:

- Welded tube and pipe
- Fittings and flanges
- Bar steel
- Filler metal for welding

Sizes in stock

Seamless tubes are stocked in a wide range of sizes according to ISO. Heat exchanger and instrumentation tubes are also stocked in BWG- and SWG-sizes. Hollow bar is stocked in a large number of sizes as SANMAC 316L (see data sheet S-1841-ENG).

Details of our manufacturing programme are given in catalogue S-110-ENG.

MECHANICAL PROPERTIES

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

At 20°C

Metric units

Proof strength $R_{p0.2}$[a)] MPa min.	$R_{p1.0}$[a)] MPa min.	Tensile strength R_m MPa	Elong. A[d)] % min.	Elong. $A_{2"}$ %	Hardness HRB max.
220	250	515–690	40[c)]	35	90

At 68°F

Imperial units

Proof strength $R_{p0.2}$[a)] ksi min.	$R_{p1.0}$[a)] ksi min.	Tensile strength R_m ksi	Elong. A[b)] % min.	Elong. $A_{2"}$ %	Hardness HRB max.
32	36	75–100	40[c)]	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 $\sqrt{S0}$ where L0 is the original gauge length and S0 the original cross-section area.

c) NFA 49-117, 49-217 with min 45% can be fulfilled on request.

The impact strength (Charpy V) at -60 °C (-75 °F) is min. 150 J (110 ft-lb).

[a)] *Valid for sheet/plate, strip, semifinished products, bars, rods and sections for general purposes (not for pressure purposes).*

[b)] *Mo content 2.00–2.40%.*

At high temperatures

Metric units

Temperature °C	Proof strength $R_{p0.2}$ MPa min	$R_{p1.0}$ MPa min
50	200	230
100	180	215
150	165	195
200	150	180
250	140	170
300	135	160
350	130	155
400	125	150
450	120	145
500	120	145
550	115	140
600	110	135

Imperial units

Temperature °F	Proof strength $R_{p0.2}$ ksi min	$R_{p1.0}$ ksi min
200	26	31
400	21	26
600	19	23
800	18	21
1000	17	20

Creep strength

Temperature		Creep-rupture strength (ISO-values)			
		10 000h		100 000h	
°C	°F	MPa approx.	ksi approx.	MPa approx	ksi approx.
550	1020	255	37.0	177	25.7
575	1065	214	31.0	137	19.9
600	1110	172	24.9	108	15.7
625	1155	137	19.9	86	12.5
650	1200	108	15.7	64	9.3
675	1245	83	12.0	46	6.7
700	1290	64	9.3	33	4.8
725	1335	49	7.1	25	3.6
750	1380	37	5.4	18	2.6

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	14	68	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
20	485	68	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, mean values in temperature ranges (x10^{-6})

Temperature °C	Per °C	Temperature °F	Per °F
30–100	16.5	86–200	9.5
30–200	17	86–400	9.5
30–300	17.5	86–600	10
30–400	18	86–800	10
30–500	18	86–1000	10
30–600	18.5	86–1200	10.5
30–700	18.5	86–1400	10.5

Modulus of elasticity, (x10^3)

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

CORROSION RESISTANCE

General corrosion

Sandvik 3R60 has good resistance in

- organic acids at high concentrations and moderate temperatures.
- inorganic acids, e.g. phosphoric and sulphuric acids, at moderate concentrations and temperatures. The steel can also be used in sulphuric acid of concentrations above 90% at low temperature.
- salt solutions, e.g. sulphates, sulphides and sulphites.
- caustic environments.

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 lead to both stress corrosion cracking and pitting. In applications demanding high resistance to stress corrosion cracking, austenitic-ferritic steels, such as Sandvik SAF 2304 or SAF 2205 are recommended. See data sheets S-1871-ENG and S-1874-ENG.

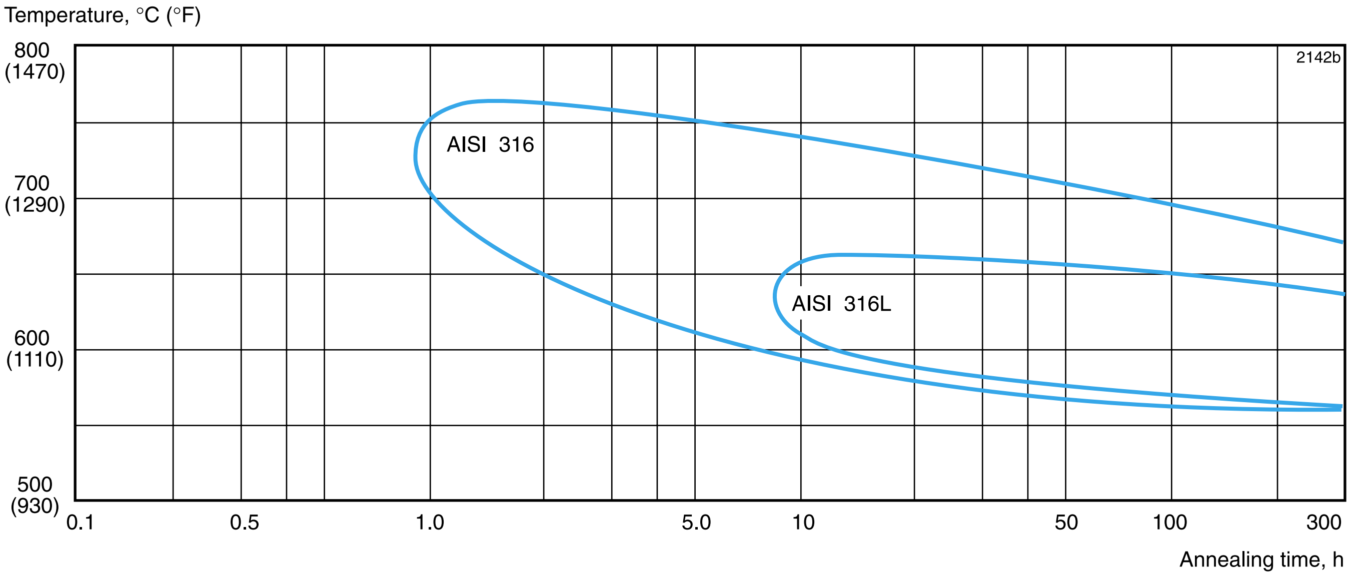

Figure 1. TTC-diagram for Sandvik 3R60 (AISI 316L) and AISI 316.

Intergranular corrosion

Sandvik 3R60 has a low carbon content and therefore better resistance to intergranular corrosion than steels of type AISI 316.

The TTC-diagram, Figure 1, shows the result of corrosion testing for 24 hours in boiling Strauss solution (12% sulphuric acid, 6% copper sulphate). The resistance to grain boundary attack is much better for AISI 316L than for AISI 316. This is an advantage in complicated welding operations.

Pitting and crevice corrosion

Resistance to these types of corrosion improves with increasing molybdenum content. Sandvik 3R60, containing about 2.6% Mo, has substantially higher resistance to attack than steels of type AISI 304 and also better resistance than ordinary AISI 316/316L steels with 2.1% Mo.

Gas corrosion

Sandvik 3R60 can be used in

- air up to 850°C (1560°F)
- steam up to 750°C (1380°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 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 3R60 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 should be stress relieved. See under “Heat treatment”.

As filler metals for gas-shielded arc welding we recommend wire electrodes and rods Sandvik 19.12.3.L,19.12.3.LSi. In shielded metal-arc welding (SMAW) covered electrodes Sandvik 19.12.3.LR, 19.12.3.LRV or 19.12.3.LRHD are recommended. If flux cored arc welding is preferred, the electrodes 19.12.3.LT or 19.12.3.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 3R60 is used for a wide range of industrial applications where steels of type AISI 304 and 304L have insufficient corrosion resistance. Typical examples are: heat exchangers, condensers, pipelines, cooling and heating coils in the chemical, petro-chemical, pulp and paper and food industries.

FURTHER INFORMATION

Our datasheets and substantial technical information about our grades and products are available on the Sandvik Steel web-site www.steel.sandvik.com.

The following printed matter can be ordered via the web-site or from our nearest Sandvik office.

S-1821-ENG	Sandvik SANMAC 316L (Data sheet)
S-110-ENG	Sandvik, pipe-tube-hollow bar seamless standard programme
S-1131-ENG	Sandvik stainless fitting and flanges – Santrade stock programme
S-1492-ENG	Stainless hollow bar (pocket card)
S-029-ENG	Stainless steels and cutting tools for better machining
S-2361-ENG	Stainless wire electrodes and filler wire / rods
S-2362-ENG	Stainless covered electrodes for joining surfacing
S-2366-ENG	Stainless welding consumables for surfacing – Strip and wire electrodes

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.

SANDVIK

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