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Sandvik 3R65

(Tube and pipe, seamless)

Sandvik 3R65 is a molybdenum-alloyed austenitic stainless chromium-nickel steel with a low carbon content.

STANDARDS

- ASTM TP316L, TP316
- UNS S31603, S31600
- EN number 1.4404, 1.4401
- EN name X2CrNiMo17-12-2, X5CrNiMo17-12-2
- W.Nr. 1.4404, 1.4401
- DIN X 2 CrNiMo 17 13 2, X 5 CrNiMo 17 12 2
- SS 2348
- AFNOR Z 2 CND 17.12, Z 6 CND 17.11
- BS 316S11

Product standards

- ASTM A213, A269, A312
- EN 10216-5
- BS 3605, BS 3606
- DIN 17456, 17458
- NFA 49-117, 49-217
- SS 14 23 48

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cr	Ni	Mo
max			max	max			
0.030	0.4	1.7	0.040	0.015	17	11.5	2.1

FORMS OF SUPPLY

Seamless tube and pipe- Finishes and dimensions
Seamless tube and pipe in 3R65 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
We can also deliver other product forms from stock in a grade corresponding to 316L mainly:

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

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 2 (1.4 ksi).

At 20°C

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.
220	250	515-690	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.
32	35	75-100	45	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 ÖS_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 3R65 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

Temperature	Proof strength	
°C	$R_{p0.2}$	$R_{p1.0}$
	MPa	MPa
	min.	min.
50	200	230
100	180	215
150	165	195
200	150	180
250	140	170
300	130	160
350	120	150
400	115	145
450	115	145
500	110	140
550	110	140
600	95	120

IMPERIAL UNITS

Temperature	Proof strength	
°F	$R_{p0.2}$	$R_{p1.0}$
	ksi	ksi
	min.	min.
200	27	32
400	22	26
600	18	24
800	17	21
1000	16	20

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 [1)]

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

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 3R65 has good resistance to:

- Organic acids at high concentrations and temperatures, with the exception of formic acid and acids with corrosive contaminants
- Inorganic acids, e.g. phosphoric acid, at moderate concentrations and temperatures, and sulphuric acid below 20% at moderate 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

Intergranular corrosion
Sandvik 3R65 has a low carbon content and therefore better resistance to intergranular corrosion than other steels of type AISI 316.
Pitting and crevice corrosion
Resistance of these types of corrosion improves with molybdenum content. Sandvik 3R65 has substantially higher resistance to attack than steels of type AISI 304.

Stress corrosion cracking
Austenitic steels are susceptible to stress corrosion cracking. Stress corrosion cracking may occur if the steel is simultaneously exposed to the following:
- Tensile stresses
- Certain solutions, particularly those containing chlorides
- Temperatures above 60°C (140°F)

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, austenitic-ferritic steels, e.g. Sandvik SAF 2304 or SAF 2205 are recommended. See data sheets S-1871-ENG and S-1874-ENG.
Gas corrosion
Sandvik 3R65 can be used in

- Air up to 850°C (1560°C)
- Steam up to 750°C (1380°F)

In flue gases containing sulphur, the corrosion resistance is reduced. In such environments Sandvik 3R65 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), 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 weldablity of Sandvik 3R65 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 19.12.3.L, 19.12.3.LSi or, when a ferritic-free weld metal is required, 25.22.2.LMn. In **manual metal-arc welding** covered electrodes Sandvik 19.12.3.LR or 19.12.3.LRHD are recommended and as a ferrite free alternative 25.22.2.LMnB.

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.

MACHINING

Sandvik 3R65 has good machining properties. Tool and cutting data recommendations

are the same as for steel 3R60 in brochure S-1462-ENG.

APPLICATIONS

Sandvik 3R65 is used in a wide variety of industrial applications. Typical examples are heat exchangers, condensers, pipelines, cooling and heating coils in the chemical, petrochemical, pulp and paper and food 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.