SANDVIK 2RK65™ BILLETS

DATASHEET

Sandvik 2RK65™ ('904L') is a high-alloy austenitic stainless steel intended for use under severe corrosion conditions within the process industry. The material is characterized by:

- Very good resistance to attack in acidic environments, e.g. sulphuric, phosphoric and acetic acid
- Very good resistance to pitting in neutral chloride-bearing solutions
- Much better resistance to crevice corrosion than steels of the ASTM 304 and ASTM 316 types
- Very good resistance to stress corrosion cracking
- Good weldability

STANDARDS

- ASTM: '904L'
- UNS: N08904
- EN Number: 1.4539
- EN Name: X1NiCrMoCu25-20-5
- W.Nr.: 1.4539
- DIN: X1 NiCrMoCu25 20 5
- SS: 2562
- AFNOR: Z2NCDU25-20
- BS: 904S13

Product standards

EN 10088-3
Suitable for the production of flanges etc. according to ASTM A182 Grade F904L.

Certificates

Status according to EN 10 204 3.1

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cr	Ni	Mo	Others
≤0.020	0.4	1.8	≤0.025	≤0.015	19.5	24.5	4.1	Cu=1.5

APPLICATIONS

Sandvik 2RK65™ is a multi-purpose material for use under severe corrosion conditions. This has been proven both by laboratory tests and by extensive operational experience with the steel.

Typical applications for Sandvik 2RK65™ are found in oil refineries and within the chemical and petrochemical

industry.

Sandvik 2RK65™ is also used within the pulp and paper, mineral and metallurgical and food industries, in seawater cooling and in many other fields.

The grade is an excellent alternative to standard austenitic stainless steels in heat exchangers using high temperature water with chloride contamination.

Industrial categories	Typical applications
Chemical industry	Flanges
Oil refineries	Valves
Petrochemical industry	Fittings
Pulp and paper industry	Couplings
Food industry	Rings
Mineral industry	Seals
Metallurgical industry	Bolts and nuts
	Shafts
	Forgings
	Discs
	Pigtails and headers

CORROSION RESISTANCE

General corrosion

Because of the high contents of nickel, chromium and molybdenum the resistance to general corrosion is above that of AISI 316L.

Pitting and crevice corrosion

The high chromium and molybdenum contents of this steel make its resistance to pitting and crevice corrosion superior to AISI 316L.

Stress corrosion cracking

Ordinary austenitic steels of the AISI 304 and AISI 316 types are susceptible to stress corrosion cracking in chloride-bearing solutions at temperatures above about 60°C (140°F). At high temperatures, above about 100°C, chloride contents as low as in the ppm-range (10^{-4} %) are sufficient to cause stress corrosion cracking in these steels. A nickel content of 25%, as is the case for Sandvik 2RK65™, is sufficient to provide very good resistance under working conditions.

For further information regarding corrosion resistance of Sandvik 2RK65™, please see the data sheet - Seamless tube and pipe - Sandvik 2RK65™. The data should be considered in the knowledge that it may not be applicable for thick sections, such as forgings.

FORMS OF SUPPLY

Sizes and tolerances

Round-cornered square, as well as round billets, are produced in a wide range of sizes according to the following tables.
Larger sizes offered on request.

Surface conditions

Square billets

Unground, spot ground or fully ground condition.

Round billets
Peel turned or black condition.

Square billets

Size	Tolerance	Length
mm	mm	m
80	+/-2	4 - 6.3
100, 114, 126, 140, 150	+/-3	4 - 6.3
160, 180, 195, 200	+/-4	4 - 6.3
>200 - 350	+/-5	3 - 5.3

Sizes and tolerances apply to the rolled/forged condition.

Peel turned round billets

Size	Tolerance	Length
mm	mm	m
75 - 200 (5 mm interval)	+/-1	max 10
>200 - 450	+/-3	3 - 8

Unground round billets

Size	Tolerance	Length
mm	mm	m
77 - 112 (5 mm interval)	+/-2	max 10
124, 134	+/-2	max 10
127, 147, 157	+/-2	max 10
142, 152, 163	+/-2	max 10
168, 178, 188	+/-2	max 10
183, 193	+/-2	max 10

Other products
- Welded tube and pipe
- Seamless tube and pipe
- Strip, annealed or cold-rolled to different degrees of hardness

HEAT TREATMENT
Billets are delivered in the hot worked condition. The following heat treatment is recommended.

Solution annealing
1050-1150°C (1920-2100°F), followed by quenching in water.

MECHANICAL PROPERTIES
Testing is performed on separately solution annealed and quenched test pieces.

The following figures apply to material in the solution annealed condition.

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)]	Brinell
MPa	MPa	MPa	%	
≥230	≥250	530-720	≥40	≤230

Imperial units

Proof strength		Tensile strength	Elong	Hardness
$R_{p0.2}$[a)]	$R_{p1.0}$[a)]	R_m	A[b)]	Brinell
ksi	ksi	ksi	%	
≥33	≥36	77-104	≥40	≤230

1 MPa = 1 N/mm²
a) $R_{p0.2}$ and $R_{p1.0}$ correspond to 0.2% offset and 1.0% offset yield strengths, 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 2RK65™ 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 EN 13445-2 (UFPV-2) and EN 10216-5.

At high temperatures

The steel should not be exposed to temperatures above about 550 °C (1020 °F) for prolonged periods, since this leads to precipitation of intermetallic phases, which can have an adverse effect on both the mechanical properties and the corrosion resistance of the steel. Minimum proof strength properties at high temperatures are based on datasheets seamless tubes and pipe. Since the tubes have thin walls the values should only be used as indicative values for billets.

Metric units

Temperature	Proof strength	
	$R_{p0.2}$	$R_{p1.0}$
°C	MPa	MPa
	min.	min.
100	176	205
200	155	185
300	136	165
400	125	155

Imperial units

Temperature	Proof strength	
	$R_{p0.2}$	$R_{p1.0}$
°F	ksi	ksi
	min.	min.
200	26.1	30.3
400	22.4	26.7
600	19.5	23.7

Imperial units

Temperature	Proof strength	
	$R_{p0.2}$	$R_{p1.0}$
°F	ksi	ksi
	min.	min.
700	18.6	22.9

PHYSICAL PROPERTIES

Density: 8.0 g/cm³, 0.29 lb/in³

Thermal conductivity

Temperature, °C	W/(m °C)	Temperature, °F	Btu/(ft h °F)
20	12	68	7
100	14	200	8
200	16	400	9
300	18	600	10.5
400	20	800	11.5
500	22	1000	13
600	23	1200	14
700	25	1300	14.5

Specific heat capacity

Temperature, °C	J/(kg °C)	Temperature, °F	Btu/(lb °F)
20	460	68	0.11
100	485	200	0.12
200	515	400	0.12
300	545	600	0.13
400	570	800	0.14
500	590	1000	0.14
600	605	1200	0.15
700	615	1300	0.15

Thermal expansion, **mean values in temperature ranges ($x10^{-6}$)**

Temperature, °C	Per °C	Temperature, °F	Per °F
30-100	15.5	86-200	8.5
30-200	16	86-400	9
30-300	16.5	86-600	9
30-400	17	86-800	9.5
30-500	17	86-1000	9.5
30-600	17.5	86-1200	9.5
30-700	17.5	86-1300	10

Resistivity

Temperature, °C	µΩm	Temperature, °F	µΩin.
20	0.94	68	37.0
100	0.99	200	38.8
200	1.07	400	42.2
300	1.13	600	44.6
400	1.15	800	45.5
500	1.17	1000	45.8
600	1.15	1200	45.9
700	1.18	1300	46.5

Modulus of elasticity **(x10³)**

Temperature, °C	MPa	Temperature, °F	ksi
20	195	68	28.5
100	190	200	27.5
200	182	400	26.5
300	174	600	25
400	166	800	24
500	158	1000	22.5

HOT WORKING

Hot working should be carried out at a material temperature of 900-1200°C (1650-2190°F). Hot working of Sandvik 2RK65™ should be followed by rapid cooling in air or water. Subsequent heat treatment should be carried out in accordance with the recommendations given for heat treatment.

WELDING

The weldability of Sandvik 2RK65™ is good. Welding must be carried out without preheating, and normally there is no need for any subsequent heat treatment. 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 2RK65™, heat-input of <1.0 kJ/mm and interpass temperature of <100°C (210°F) are recommended. A string bead welding technique should be used.

Recommended filler metals

TIG/GTAW or MIG/GMAW welding

ISO 14343 S 20 25 5 Cu L/ AWS A5.9 ER385 (e.g. Exaton 20.25.5.LCu)

MMA/SMAW welding

ISO 3581 E 20 25 5 Cu N L R/ AWS A5.4 E385-16 (e.g. Exaton 20.25.5.LCuR)

MACHINING

The machining of Sandvik 2RK65™, as with other stainless steels, requires an adjustment to, tooling data and machining method, in order to achieve satisfactory results. Compared to Sanmac® 316/316L, the cutting speed must be reduced by approximately 40-45%, when turning Sandvik 2RK65™ with coated, cemented carbide tools. Much the same applies to other operations. Feeds should only be reduced slightly and with care.

Detailed recommendations for the choice of tools and cutting data are provided in the data sheet for Sanmac® 316/316L.

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