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Sandvik Bioline 1RK91

(Strip steel)

Sandvik Bioline 1RK91 is a precipitation hardening stainless steel specifically designed for applications requiring high strength combined with good ductility in the final product and high formability in the as-delivered condition. The strength is increased after ageing of the final product.

The characteristics in general can be said to be a combination of properties of ordinary austenitic stainless and low alloyed ferritic steels. For example, elastic modulus, mechanical properties and thermal expansion are comparable to ferritic steels (such as low alloyed carbon steels or chromium steels) while corrosion resistance is more comparable to austenitic stainless steels.

- Excellent mechanical properties; very high tensile strength and hardness levels can be achieved
- Corrosion resistance comparable to ASTM 304L or ASTM 316L depending on condition
- Retained mechanical properties at temperatures up to at least 400°C (750°F)
- Very good relaxation properties
- Good weldability

STANDARDS

- ASTM A693
- UNS S46910

Product standards
- ASTM F899
- ISO 16061

CHEMICAL COMPOSITION (NOMINAL) %

C max	Si max	Mn max	P max	S max	Cr	Ni	Mo	Cu	Ti	Al
0.02	0.5	0.5	0.020	0.005	12	9	4	2.0	0.9	0.4

FORMS OF SUPPLY

The following range of strip thicknesses and widths can be supplied as standard. Other dimensions can be offered on request.

Thickness mm	Width mm	Thickness in.	Width in.
0.015 - 4.00*	2 - 330	0.0006 - 0.158	0.079 - 13

* Depending on requested tensile strength.

The cold-rolled strip can be supplied in coils, bundles, on spools or in cut lengths.

Sandvik Bioline 1RK91 can also be delivered as wire/bar.

MECHANICAL PROPERTIES

The possible ranges for the mechanical properties both in the cold-rolled and aged condition are indicated below.

The strength level after ageing depends on the amount of cold deformation and therefore also on the final dimension.

AT 20°C (68°F)

	Condition	Tensile strength, R_m	Proof strength, $R_{p0.2}$ [a]		
		MPa	ksi	MPa	ksi
Bar	Cold worked	-	-	1100	159
	Aged	1000-2100	145-304	900-1800	130-261
Flat rolled wire	Cold worked	950-1850	138-268	600 - 1800	87 - 261
	Aged	1400-2500	203-363	1200 - 2400	174 - 348
Round wire	Cold worked	950-2150	138-312	-	-
	Aged	1400-3100	203-450	-	-
Strip	Annealed	max 750	max 109	max 350	max 51
	Cold rolled	950-1850	138-268	600-1800	87-261
	Cold rolled + aged	1400-2600	203-377	1200-2500	174-363

1 MPa = 1 N/mm^2
a) $R_{p0.2}$ correspond to 0.2% offset yield strength.

Examples of strength values for the heat treated (aged) condition are shown below. As the true values depend on product form and production route, the exact value for a specific product or application must be determined in each case. Please contact Sandvik for further information.

At elevated temperatures
The values represent testing on material cold worked to a tensile strength of 1650 MPa and subsequently aged at 475°C to 530°C for 4 hours.

Temperature	Tensile strength R_m , MPa				
°C	20	100	200	300	400
Bar form	2000	1900	1770	1630	1510
Wire and strip form	2450	2400	2200	2125	1975

PHYSICAL PROPERTIES

The physical properties of a steel are related to a number of factors, including alloying elements, heat treatment and manufacturing process. The data presented below can generally be used for rough calculations.

Density: 7.9 g/cm^3, 0.29 lb/in^3
Resistivity: cold worked: 0.97 µΩm, aged: 0.83 µΩm

THERMAL CONDUCTIVITY [1)]

Temperature, °C	W/m °C	Temperature, °F	Btu/ft h°F
20	14	68	8
100	16	200	9
200	18	400	10.5
300	20	600	11.5
400	21	700	12

1) For material in heat treated (aged) condition

SPECIFIC HEAT CAPACITY [1)]

Temperature °C	J/kg °C	Temperature °F	Btu/ft h°F
20	455	68	0.11
100	490	200	0.12
200	525	400	0.13
300	560	600	0.14
400	600	700	0.14

1) For material in heat treated (aged) condition

Thermal expansion
Average values in temperature ranges. The steel grade has a coefficient of thermal expansion close to that of carbon steel. This gives it definite design advantages over

normal austenitic stainless steels.

METRIC UNITS [1)]

Grade	Temperature range, °C			
	30-100	30-200	30-300	30-400
Cold worked	11.5	11.5	11.5	11.5
Aged	11.5	12	12	12.5
For comparison:				
Carbon steel (0.2%C)	12.5	13	13.5	14
ASTM 304L	16.5	17.5	18	18

1) ($x10^{-6}$/°C)

IMPERIAL UNITS [1)]

Grade	Temperature range, °F			
	86-200	86-400	86-600	86-700
Cold worked	6.5	6.5	6.5	6.5
Aged	6.5	6.5	7	7
For comparison:				
Carbon steel (0.2%C)	7	7	7.5	7.5
ASTM 304L	9.5	9.5	10	10

1) ($x10^{-6}$/°F)

Modulus of elasticity

The E-modulus depends on dimension and amount of cold deformation in the material. For bar form there is no data available, but for wire and strip E-modulus between 185 - 200 X 10^3 MPa have been achieved.

CORROSION RESISTANCE

Sandvik Bioline 1RK91 has a corrosion resistance comparable to ASTM 304L or ASTM 316L depending on condition and environment.

Pitting and crevice corrosion

The Critical Pitting Temperature (CPT) has been determined using electrochemical CPT testing at 300 mV in NaCl solutions of different concentrations at pH = 6.0, ground test samples (600 µm). All results are average values from six measurements.

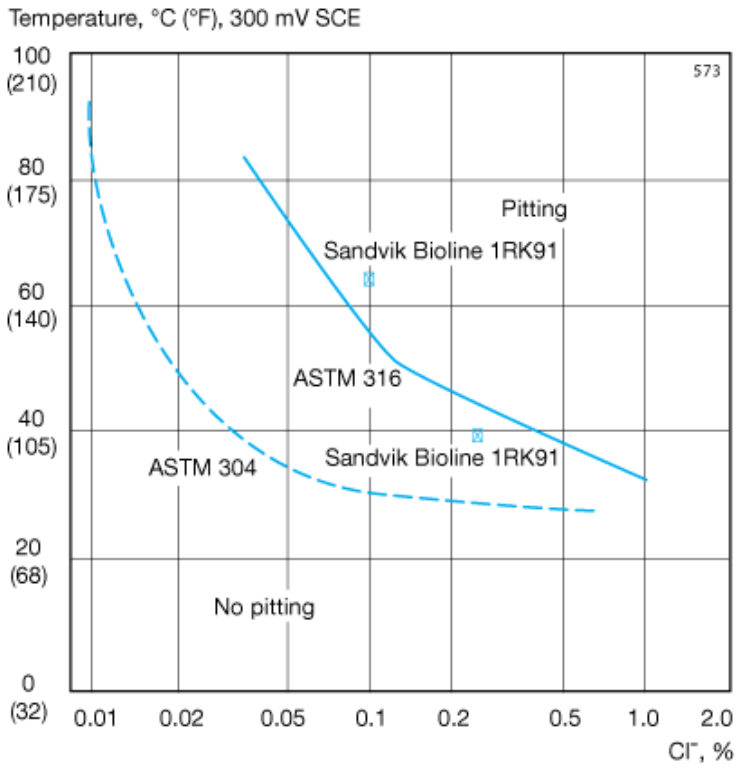

Figure 1. Critical pitting temperatures (CPT) for Sandvik Bioline 1RK91, ASTM 304 and ASTM 316 at varying concentrations of sodium chloride. Potentiostatic determinations at +300 mV SCE, pH = 6.0

General corrosion

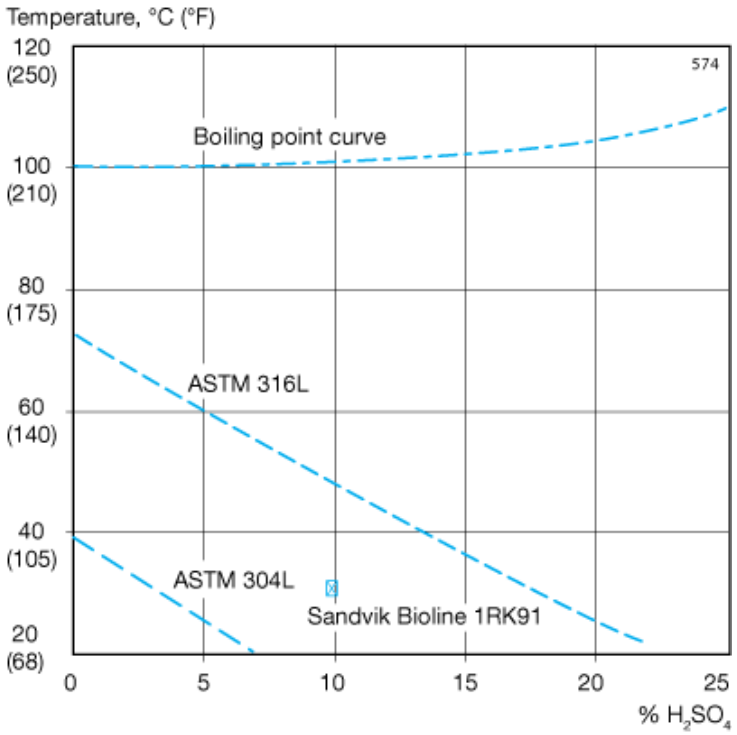

Figure 2. Isocorrosion diagram for Sandvik Bioline 1RK91, ASTM 304L and ASTM 316L in stagnant sulphuric acid. The curves for ASTM 304L and ASTM 316L and the dot for Sandvik Bioline 1RK91 represent a corrosion rate of 0.1 mm/year

HEAT TREATMENT

In the annealed condition, Sandvik Bioline 1RK91 has an austenitic microstructure. To be able to precipitation harden the material and take advantage of the remarkably high ageing (tempering) effect, the matrix has first to be hardened and, thereby, partly transformed to martensite. There are two ways of obtaining the necessary martensitic matrix in Sandvik Bioline 1RK91.

Cold-rolled condition

The most common way, as in other metastable austenitic stainless steels, is to cold roll

the material, whereby deformation martensite is formed. The difference is that the ageing effect is much higher in Sandvik Bioline 1RK91 than in most other stainless steels. For optimum strength, the ageing should be made at 525 °C (977°F) for 1 hour. Some examples of the ageing effect are given in the table.

NOMINAL VALUES AT 20°C (68°F)

Tensile strength MPa		Tensile strength ksi	
Cold rolled	Aged	Cold rolled	Aged
950	1300	138	189
1000	1600	145	232
1200	2000	174	290
1500	2300	218	334
1800	2500	261	363

Annealed condition

With Sandvik Bioline 1RK91 there is another way to obtain a martensitic matrix - by an isothermal treatment at a subzero temperature. This gives an opportunity to use the grade in the soft annealed condition for severe cases of forming and then utilize its ability to still reach a comparably high level of hardness after heat treatment. The required heat treatment cycle and the resulting properties are:

Austenitizing: 1200°C (2190°F) for 5 minutes in a protective atmosphere like argon, hydrogen or vacuum.
Isothermal treatment: -40°C (-40°F) for 24 hours
Ageing: 525°C (997°F) for 1 hour

NOMINAL VALUES AT 20°C (68°F)

Tensile strength MPa		Tensile strength ksi	
Annealed	Heat treated	Annealed	Heat treated
700	1600	102	232

WELDABILITY

The weldability of Sandvik Bioline 1RK91 is good. Suitable welding methods are TIG, MIG and MMA. It can be welded without filler metal (autogenously) using the TIG process, but filler metal is preferable. For TIG and MIG welding, Sandvik 19.12.3.LSi or 19.12.3.L can be used, or if a higher strength is desired, Sandvik 22.8.3.L. For MMA, the corresponding electrodes Sandvik 19.12.3.LR or Sandvik 22.9.3.LR are suitable.

The martensitic content in HAZ of the material decreases after welding resulting in a typical annealed microstructure with an austenitic matrix and a small amount of ferrite. This means that the tensile strength will be lower for the weld compared with the high strength base material. Therefore, welds in Sandvik 1RK91 are not suitable for active parts of a construction, when extremely high strength is required.

APPLICATIONS

In strip form, Sandvik Bioline 1RK91 can be used for hypo-tube application.

In wire form, Sandvik Bioline 1RK91 can be used - depending on the diameter- for surgical suture needles, blood lancets and dental tools (taps, reamers, screw drivers).

DISCLAIMER:
Sandvik is not providing any products or services that are intended or may be construed to be recommending or otherwise advising on, in any manner, the design, suitability, appropriateness or effectiveness, from a medical/biological/safety perspective, of any medical material, instrument and/or medical device.