Zapp 1RK91/9.9910GA Datasheet
Medical Wire

zapp

Zapp is certified according to ISO 9001

Zapp 1RK91/9.9910GA 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 AISI 304L or AISI 316L depending on condition
- Retained mechanical properties at temperatures up to at least 400 °C (750 °F)
- Very good relaxation properties
- Good weldability

Standards

- UNS: S46910

Product standards:

- ASTM F899
- ISO 16061

Applications

In strip form Zapp 1RK91/9.9910GA can be used for hypo-tube applications.

In wire form Zapp 1RK91/9.9910GA can be used – depending on the diameter– for surgical suture needles, blood lancets and dental tools (taps, reamers, screw drivers).

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Ti	Al
≤ 0.02	≤ 0.5	≤ 0.5	≤ 0.020	≤ 0.005	12.0	9.0	4.0	2.0	0.9	0.4

Forms of supply

Wire in Zapp 1RK91/9.9910GA can be supplied with surface finishes according to the table.

Surface finishes	Size range, mm (in.)
Coated	0.30 - 10.00 (0.012 - 0.4)
Bright drawn	0.10 - 1.50 (0.004 - 0.059)
Straightened and ground	0.60 - 12.00 (0.024 - 0.47)

The following forms of supply are available:

- Coils with weights up to 150 kg
- Various types of spools with wire weights up to 500 kg
- Straightened lengths up to 4 m

Sizes and tolerances

The diameter tolerance is normally D2 for drawn wire and h8 for ground bars. Tighter tolerances can be offered on request.

Sizes and tolerances for wire

Dimension		Diameter tolerance, ±		Ovality, max	
mm	in.	mm	in-	mm	in.
0.10 - 0.125	0.004 - 0.005	0.004	0.00016	-	-
> 0.125 - 0.25	> 0.005 - 0.010	0.005	0.00020	0.003	0.00012
> 0.25 - 0.50	> 0.010 - 0.020	0.007	0.00028	0.004	0.00016
> 0.50 - 1.00	> 0.020 - 0.039	0.009	0.00035	0.005	0.00020
> 1.00 - 1.60	> 0.039 - 0.063	0.011	0.00043	0.006	0.00024
> 1.60 - 2.50	> 0.063 - 0.098	0.014	0.00070	0.008	0.00032
> 2.50 - 6.00	> 0.098 - 0.236	-	-	-	-

Sizes and tolerances for bar in the straightened and ground condition

Diameter min.	Diameter tolerance
mm (in.)	-
0.6 (0.024")	h8

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	-	-	1,100	159
	Aged	1,000 - 2,100	145 - 304	900 - 1,800	130 - 261
Round wire	Cold worked	900 - 2,150	131 - 312	-	-
	Aged	1,400 - 3,100	203 - 450	-	-

1 MPa = 1 N/mm²

a) Rp0,2 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 Zapp for further information.

At elevated temperatures

The values represent testing on material cold worked to a tensile strength of 1,650 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 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/cm³, 0.29 lb/in³
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	8.0
100	16	200	9.0
200	18	400	10.5
300	20	600	11.5
400	21	700	12.0

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	12.0	12.0	12.5
For comparison:				
Carbon steel (0.2 % C)	12.5	13.0	13.5	14.0
AISI 304L	16.5	17.5	18.0	18.0

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	7.0
For comparison:				
Carbon steel (0.2 % C)	7.0	7.0	7.5	7.5
AISI 304L	9.5	9.5	10.0	10.0

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 E-modul between 185 - 200 X 10 MPa have been achieved.

Corrosion resistance

Zapp 1RK91/9.9910GA has a corrosion resistance comparable to AISI 304L or AISI 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.

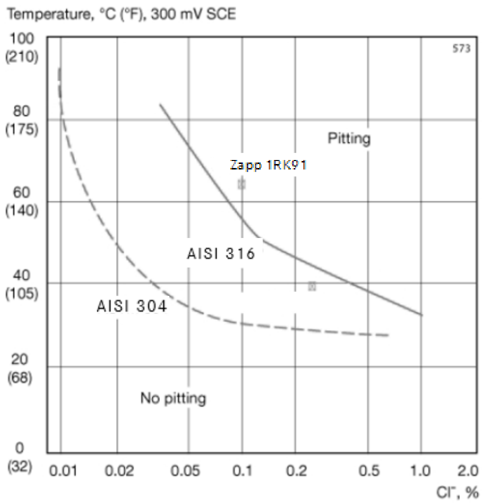

Figure 1. Critical pitting temperatures (CPT) for Zapp 1RK91/9.9910GA, AISI 304 and AISI 316 at varying concentrations of sodium chloride. Potentiostatic determinations at +300 mV SCE, pH = 6.0.

General corrosion

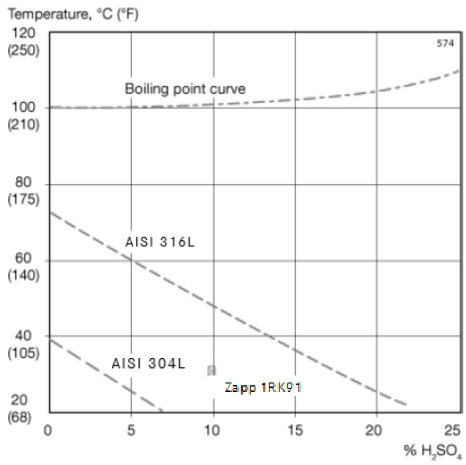

Figure 2. Iso corrosion diagram for Zapp 1RK91/9.9910GA, AISI 304L and AISI 316L in stagnant sulphuric acid. The curves for AISI 304L and AISI 316L and the dot for Zapp 1RK91/9.9910GA represent a corrosion rate of 0.1 mm/year

Heat treatment

Zapp 1RK91/9.9910GA was originally developed for applications requiring ultra-high strength in combination with good fracture toughness. In the annealed condition, Zapp 1RK91/9.9910GA 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. Strength increases dramatically for wire following heat treatment at a temperature of approximately 475 °C (885 °F), at which point precipitation occurs in the martensitic matrix.

This heat treatment is called ageing or tempering and is best carried out on the final product. This takes advantage of the good formability of the material in the as delivered condition.

For wire in Zapp 1RK91/9.9910GA, optimum ageing is made at 475 °C (885 °F) for 4 hours. Examples of the ageing effect on tensile strength are given below.

Tensile strength

MPa	MPa	ksi	ksi
Cold worked	Aged	Cold worked	Aged
950	1,300	135	189
1,000	1,600	145	232
1,200	2,000	174	290
1,500	2,300	218	334
1,800	2,600	261	377

Weldability

The weldability of Zapp 1RK91/9.9910GA 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, 19.12.3.LSi or 19.12.3.L can be used, or if a higher strength is desired, 22.8.3.L. For MMA, the corresponding electrodes 19.12.3.LR or 22.9.3.LR are suitable.

The martensitic content in HAZ of the material decreeses 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 Zapp 1RK91/9.9910GA are not suitable for active parts of a construction, when extremely high strength is required.

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