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Sandvik Nanoflex

(Wire)

Sandvik Nanoflex is a precipitation hardening stainless steel specifically designed for applications requiring high strength combined with good ductility in the final product. The grade is characterized by high formability in the as-delivered condition and its 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. This means that properties such as elastic modulus, mechanical properties and thermal expansion are comparable to ferritic steels (such as low alloyed carbon steels or chromium steels) while properties such as 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)

STANDARDS

- UNS S46910

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

Simplified chemical composition for external use:

Alloying elements of more than 1%. Approximate values.

Cr	Ni	Mo	Cu	Ti
12	9	4	2	1

SIZE RANGE AND TOLERANCES

Surface finish	Size range, mm (in.)
Coated	0.40 - 6.00 (0.016 - 0.24)
Diamond drawn (bright)	0.10 - 2.50 (0.004 - 0.098)

SPOOLS

Dimension mm	Spool no	Wire weight in.		kg
0.10 - 0.290		0.0039 - 0.0114	7	3
>0.161 - 1,60		0.0063 - 0.0630	23	max 16

COILS METRIC UNITS

Dimension mm	Wire weight kg
1.60 - 1.80	max 20
>1.80 - 2.50	max 60
>2.50 - 6.00	max 100

In exceptional cases, spools or coils of lower weight than given in the above tables can be included in a delivery.

Tolerances
The diameter tolerance is normally D2. The wire can also be supplied with tolerance grade D1 and D3.

METRIC UNITS

Dimension mm	Ovality mm max	Diameter tolerance mm +/-
0.10 - 0.125	-	0.004
>0.125 - 0.25	0.003	0.005
>0.25 - 0.50	0.004	0.007
>0.50 - 1.00	0.005	0.009
>1.00 - 1.60	0.006	0.011
>1.60 - 2.50	0.008	0.014
>2.50 - 4.00	-	0.018
>4.00 - 6.00	-	0.022

IMPERIAL UNITS

Dimension in.	Ovality in. max	Diameter tolerance in.
0.004 - 0.005	-	0.00016
>0.005 - 0.010	0.00012	0.00020
>0.010 - 0.020	0.00016	0.00028
>0.020 - 0.039	0.00020	0.00035
>0.039 - 0.063	0.00024	0.00043
>0.063 - 0.098	0.00032	0.00070
>0.098 - 0.236	-	0.00087

FORMS OF SUPPLY

The material is delivered in lots and forms adapted to the customer's requirements:

- in coils with weights up to 150 kgs
- on various types of spools with wire weights up to 1 000 kgs
- in straightened lengths up to 4 m

PHYSICAL PROPERTIES

Density, g/cm^3 (lb/in^3): 7.9 (0.29)

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 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 aged condition

Thermal expansion
Mean values in temperature ranges ($x10^{-6}$)

The material has a coefficient of thermal expansion close to that of carbon steel. This gives it definite design advantages over normal austenitic stainless steels. The values given in the table are average values in the temperature ranges.

METRIC UNITS 1)

Temperature, °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
Carbon steel (0,2 %C)	12.5	13	13.5	14
Aisi 304L	16.5	17.5	18	18

1) $x10^{-6}$/°C

IMPERIAL UNITS 1)

Temperature, °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
Carbon steel (0,2 %C)	7	7	7.5	7.5
Aisi 304L	9.5	9.5	10	10

1) $x10^{-6}$/°F

Modulus of elasticity

The E-modulus is dependant on dimension, condition, direction and amount of cold reduction of the material. The data below have been achieved by tensile testing at 20°C (68°F) of cold rolled strips along the rolling direction and they are typical values only. At ageing an increase of the E-modulus with 15 - 20 $x10^3$ MPa can be expected.

Tensile strength			
MPa	E($x10^3$) MPa	ksi	E ($x10^3$) ksi
1000	185	145	26.8
1200	180	174	261
1450	185	210	26.8
1850	190	268	27.6

MECHANICAL PROPERTIES

The possible ranges for the mechanical properties both in 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 dimension.

For more information regarding ageing, click here.

AT 20°C (68°F)

Condition	Proof strength, $R_{p0.2}$ [a)]		Tensile strength, R_m	
	MPa	ksi	MPa	ksi
Flat rolled wire				
Cold worked	600 - 1800	87 - 261	950-1850	138-268
Aged	1200 - 2400	174 - 348	1400-2500	203-363
Round wire				
Cold worked	-	-	950-2150	138-312
Aged	-	-	1400-3000	203-436

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

At elevated temperatures

The values represents testing on material cold worked to 1650 MPa and subsequently aged at 475°C for 4 hours.

Temperature	Tensile strength, R_m	
°C (°F)	MPa	ksi
20 (68)	2450	356
100 (200)	2400	348
200 (400)	2200	319
300 (600)	2125	308
400 (700)	1975	287

CORROSION RESISTANCE

The material has a corrosion resistance comparable to AISI 304L or AISI 316L depending on condition and environment.

Pitting and crevice corrosion

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

Pitting corrosion

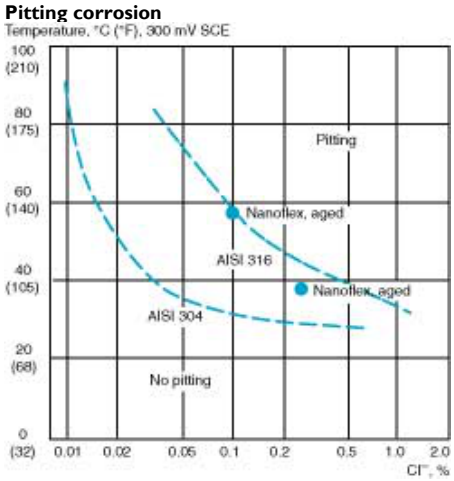

Figure 1: Critical pitting temperatures (CPT) for Sandvik Nanoflex, AISI 304 and AISI 316 at varying concentrations of sodium chloride. Pontiostatic determinations at +300 mV (SCE), pH= 6.0

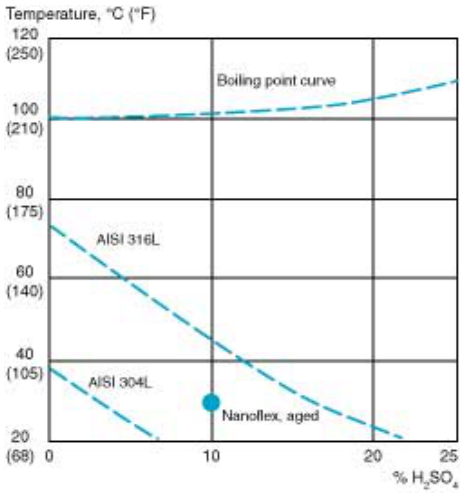

Figure 2: Isocorrosion diagram for Sandvik Nanoflex, AISI 304L and 316L in stagnant sulphuric acid. The curves for AISI 304L and 316L and the dot for Sandvik Nanoflex represents a corrosion rate of 0.1 mm/year.

HEAT TREATMENT

The material was developed for applications requiring ultra-high strength in combination with good fracture toughness. The strength is increased remarkably at a heat treatment in the temperature range of 400 - 450°C (750- 840°F), whereby precipitation occurs in the martensitic matrix. This heat treatment is called ageing or tempering and it is preferably made on the final product, to first take advantage of the good formability in as delivered condition.

The optimum ageing is made at 475°C (885°F) for 4 hours. Some examples of the ageing effect on the tensile strength is given below.

Tensile strength, MPa		Tensile strength, ksi	
Cold worked	Aged	Cold worked	Aged
950	1300	135	189
1000	1600	145	232
1200	2000	174	290
1500	2300	218	334
1800	2500	261	363

WELDABILITY

The weldability 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 the material are not suitable for active parts of a construction, when extremely high strength is required.

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.