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Sanmac 4571

(Hollow bar)

Sanmac 4571 is titanium-stabilized austenitic stainless chromium–nickel–molybdenum steel with improved machinability.

STANDARDS

- ASTM 316 Ti
- UNS S31635
- EN number 1.4571
- EN name X6CrNiMo17-12-2

Product standards
Hollow Bar:
- EN 10216-5*, EN 10294-2, EN 10297-2
- ASTM A312, (ASTM A511)

* The leakage test is deferred to the finished component

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P max.	S max.	Cr	Ni	Mo	Ti
0.03	0.4	1.8	0.045	0.030	17	12.5	2.1	>5xC

FORMS OF SUPPLY

Hollow bar-Finishes, dimensions and tolerances

Hollow bar Sanmac 4571 is stocked in a large number of sizes up to 250 mm outside diameter in the solution-annealed and white-pickled condition. See catalogues S-110-ENG, S-029-ENG or S-02909-ENG.

Dimensions are given as outside and inside diameter with guaranteed component sizes after machining for OD<2.5 X OD.

Outside diameter +2 / -0 %, but minimum +1 / -0 mm

Inside diameter +0 / -2 %, but minimum +0 / -1 mm

Straightness +/-1.5mm/m

Better tolerances can be supplied to special order.

Other forms of supplySolid bar and billet

Steel with improved machinability, Sanmac, is also available in round bar and billet.

Filler metals for welding

The sizes listed below are Sandvik stock standard. The local stocks carry sizes in common demand on the market. For technical information on the filler metals please refer to brochures S-2361-ENG and S-2362-ENG

Wire electrodes and filler wire/rods:

Sandvik 19.12.3.L:0.80, 1.00, 1,20, 1.60, 2.00, 2.40, 3.00, 3.20, 4.00 mm

Sandvik 19.12.3.LSi: 0.80, 1.00, 1,20, 1.60, 2.00, 2.40, 3.00, 3.20, 4.00 mm

Covered electrodes

Sandvik 19.12.3.LR: 1.6, 2.0, 2.5, 3.25, 4.0 mm

Sandvik 19.12.3.LB: 2.0, 2.5, 3.25, 4.0, 5.0 mm

Sandvik 19.12.3.LRHD: 2.5, 3.25, 4.0, 5.0 mm

MECHANICAL PROPERTIES

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)	$A_{2"}$	HRB
MPa	MPa	MPa	%	%	
min.	min.		min.	min.	max.
190	225	490-690	35	35	90

IMPERIAL UNITS

Proof strength		Tensile strength	Elong.		Hardness
$R_{p0.2}$ a c)	$R_{p1.0}$ a c)	R_m c)	A b)	$A_{2"}$	HRB
ksi	ksi	ksi	%	%	
min.	min.		min.	min.	max.
28	33	71-100	35	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= 5.65ÖS_0 where L_0 is the original gauge length and S_0 the original cross-section area.

Impact strength
Due to its austenitic micro structure, Sandvik Sanmac 4571 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

METRIC UNITS

Temperature	Proof strength	
°C	$R_{p0.2}$ c)	$R_{p1.0}$ c)
	MPa	MPa
	min.	min.
50	202	234
100	185	218
150	177	206
200	167	196
250	157	186
300	145	180
350	140	175
400	136	171
450	132	167
500	129	164
550	127	157

IMPERIAL UNITS

Temperature	Proof strength	
°F	$R_{p0.2}$ c)	$R_{p1.0}$ c)
	ksi	ksi
	min.	min.
200	27.0	32.0
400	24.0	28.5
600	21.0	26.0
800	19.5	24.5
1000	18.5	23.5

d) For hollow bar with wall thicknesses greater than 10 mm (0.4 in.) the proof strength values may be slightly lower but still fulfill the requirements according to DIN 17458 and SS 14 23 50.

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	23	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, MEAN VALUES IN TEMPERATURE RANGES ($X10^{-6}$)

Temperature, °C	Per °C	Temperature, °F	Per °F
30-100	16.5	86-200	9
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	19	86-1400	10.5

MODULUS OF ELASTICITY ($X10^{3}$)

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

CORROSION RESISTANCE

General corrosion
Sandvik Sanmac 4571 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.
- E.g. sulphates, sulphides and sulphites
- Caustic environments.

Intergranular corrosion
Sandvik Sanmac 4571 has better resistance to intergranular corrosion than unstabilised steels. The addition of titanium prevents precipitation of chromium carbides in the grain boundaries after prolonged heating in the temperature range 450- 850°C (840-1560°F).

Pitting and crevice corrosion
Resistance to these types of corrosion improves with increasing molybdenum content and Sandvik Sanmac4571 with about 2.1% Mo has substantially higher resistance than steels of type AISI 304/304L.

Stress corrosion cracking
Austenitic stainless steels are susceptible to stress corrosion cracking. This may occur at temperatures above about 60°C (140°F), if the steel is subjected to tensile stresses and at the same time comes into contact with certain solutions, particularly those containing chlorides. 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, Sanmac 2205 or SAF 2507 have higher resistance to stress corrosion cracking than 4571.

Gas corrosion
Sandvik Sanmac 4571 can be used in:

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

Creep behaviour should also be taken into account when using the steel in the creep range. In flue gases containing sulphur, the corrosion resistance is reduced. In such environments these steels 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

Hollow Bar is normally 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

Suitable welding methods for Sandvik Sanmac 4571 are manual metal-arc welding (MMA) with covered electrodes and gas-shielded arc welding with the TIG and MIG methods as first choice. Preheating and post-weld heat treatment is normally not necessary.

Due to the fact that this material is alloyed for improved machinability, there can be higher amounts of surface oxide on the weld bead compared to standard EN 4571 steels. This may lead to arc instability during TIG welding, especially at autogenous welding. Correct setting of the weld current is important. However, when filler metal is used, the weldability is the same as for standard 316Ti steels.

Since this 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 recommendations under "Heat treatment".

Recommendations of filler metal:

TIG (GTAW/141)	19.12.3.L, 19.12.3.LSi, 19.12.3.Nb or 19.12.3.NbSi
MIG (GMAW/131)	19.12.3.L, 19.12.3.LSi, 19.12.3.Nb or 19.12.3.NbSi
MMA (SMAW/111)	19.12.3.LR, 19.12.3.LB, 19.12.3.LRHD or 19.12.3.NbR

APPLICATIONS

Sanmac 4571 is used for a wide range of industrial applications where steels of type ASTM 304/304L have insufficient corrosion resistance. Typical applications are:

- Machined parts for tube and pipe fittings
- Components for valves, pumps, heat exchangers and vessels
- Different tubular shafts in chemical, petrochemical, fertiliser, pulp and paper and power industries as well as in the production of pharmaceuticals, foods and beverages

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.