Alleima

Sanmac® 4571

Billets

Datasheet

Sanmac® 4571, 1.4571/316Ti, is a titanium-stabilized, molybdenum-alloyed austenitic chromium-nickel steel with improved machinability.

Standards

- ASTM: 316Ti
- UNS: S31635
- EN Number: 1.4571
- W.Nr.: 1.4571
- DIN: X 6 CrNiMoTi 17 12 2

Product standards

- EN 10088-3
- ASTM A-314

Suitable for the production of flanges etc. according to AD-2000-W2.

Certificates

Status according to EN 10 204/3.1

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo	Others
0.03	0.4	1.8	≤0.045	≤0.030	17	11	2.1	Ti>5x(C+N)

Applications

Sanmac® 4571 is used for a wide range of industrial applications, where steels of type AISI 304/304L have insufficient corrosion resistance.

Industrial categories	Typical applications

Datasheet last updated 2024-02-09 13:29:35 (supersedes all previous editions)

Chemical industry	Flanges
Food industry	Valves
Petrochemical industry	Fittings
Pulp and paper industry	Couplings
Nuclear industry	Rings
	Seals
	Bolts and nuts
	Shafts
	Forgings
	Discs

Corrosion resistance

General corrosion

Sanmac® 4571 has good resistance in:

- Organic acids at high concentrations and temperatures
- Inorganic acids, e.g. phosphoric and sulphuric acids, at moderate concentrations and temperatures. The steel can also be used in sulphuric acid with concentrations above 90% at low temperature.
- Salt solutions, e.g. sulphates, sulphides and sulphites
- Austic environments

Intergranular corrosion

Sanmac® 4571 has better resistance to intergranular corrosion than unstabilized 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 an increasing molybdenum content and Sanmac® 4571, 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®, SAF 2205™ or SAF 2507®, are recommended. See data sheets S-1871-ENG, S-1874-ENG and S-1875-ENG.

Gas corrosion

Sanmac® 4571 can be used in:

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

Creep behavior should also be taken into account when using the steel in the creep range. In flue gases containing sulphur, 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 oxidizing or reducing, i.e. the oxygen content, and whether impurities, such as sodium and vanadium, are present.

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

Datasheet last updated 2024-02-09 13:29:35 (supersedes all previous editions)

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

- Seamless tube and pipe (Sanmac®)
- Hollow bar (Sanmac®)

Heat treatment

Sanmac® 4571 billets are delivered in the hot worked condition and not solution annealed.

Any heat treatment after further processing should be performed according to the following recommendation.

Solution annealing

Material temperature 1060-1070°C (1940-1960°F), rapid cooling in air or water.

Mechanical properties

Testing is performed on separately solution annealed and quenched test pieces. The following figures apply to material in the solution annealed and quenched condition.

At 20°C (68°F)

Metric units

Proof strength		Tensile strength	Elong.	Contr.	HB
$R_{p0.2}$ a)	$R_{p1.0}$ a)	R_m	A b)	Z	
MPa	MPa	MPa	%	%	
≥210	≥245	515-700	≥40	≥50	≤215

Imperial units

Proof strength		Tensile strength	Elong.	Contr.	HB
$R_{p0.2}$ a)	$R_{p1.0}$ a)	R_m	A b)	Z	
ksi	ksi	ksi	%	%	
≥30.5	≥35.5	75-101.5	≥40	≥50	≤215

1 MPa = 1 N/mm^2
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-sectional

Datasheet last updated 2024-02-09 13:29:35 (supersedes all previous editions)

area.

Impact strength

Due to its austenitic microstructure, Sanmac® 4571 has very good impact strength both at room temperature and at cryogenic temperatures.

Tests on bar have demonstrated that the steel fulfils the requirements (60 J (44 ft-lb) at -196 °C (-320 °F)), according to the European standards EN13445-2(UFPV-2) and EN 10272.

At high temperatures

Metric units

Temperature	Proof strength		Tensile strength
	$R_{p.02}$	$R_{p1.0}$	R_m
°C	MPa	MPa	MPa
	min.	min.	min.
100	185	215	440
200	165	192	390
300	145	175	375
400	135	164	375
500	129	158	360

Imperial units

Temperature	Proof strength		Tensile strength
	$R_{p.02}$	$R_{p1.0}$	R_m
°F	ksi	ksi	ksi
	min.	min.	min.
200	26.8	31.2	63.8
400	23.9	27.8	56.6
600	21.0	25.4	54.4
800	19.6	23.8	54.4
1000	18.7	22.9	52.2

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	21	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 1)

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

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

Modulus of elasticity 1)

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

Datasheet last updated 2024-02-09 13:29:35 (supersedes all previous editions)

1) (x10^3)

Hot working

A suitable hot working temperature is 1220-1260°C (2230-2300°F). The temperature used should not decrease below 900°C (1650°F).

Hot working of Sanmac® 4571 should be followed by rapid cooling in water or in air. If any additional heat treatment is used, this should be carried out in accordance with the recommendations given for heat treatment.

Welding

The weldability of Sanmac® 4571 is good. 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.

Since this material is alloyed in such a way to improve machinability, the amount of surface oxides on the welded beads might be higher compared to standard 1.4571/316Ti steels. This may lead to arc instability during TIG/GTAW welding, especially welding without filler material. However, the welding behavior of this material is the same as for standard 1.4571/316Ti steels when welding with filler material.

For Sanmac® 4571, heat input of <1.5 kJ/mm and interpass temperature of <100°C (210°F) are recommended. Preheating and post-weld heat treatment are normally not necessary.

Recommended filler metals

TIG/GTAW or MIG/GMAW welding

ISO 14343 S 19 12 3 Nb / AWS A5.9 ER318 (e.g. Exaton 19.12.3.Nb)

ISO 14343 S 19 12 3 L / AWS A5.9 ER316L (e.g. Exaton 19.12.3.L)

MMA/SMAW welding

ISO 3581 E 19 12 3 Nb R / AWS A5.4 E318-16

ISO 3581 E 19 12 3 L R / AWS A5.4 E316L-17(e.g. Exaton 19.12.3.LR)

12 3 Nb / AWS A5.9 ER318 (e.g. Exaton 19.12.3.Nb)

ISO 14343 S 19 12 3 L / AWS A5.9 ER316L (e.g. Exaton 19.12.3.L)

MMA/SMAW welding

ISO 3581 E 19 12 3 Nb R / AWS A5.4 E318-16

ISO 3581 E 19 12 3 L R / AWS A5.4 E316L-17(e.g. Exaton 19.12.3.LR)

Machining

General

In Sanmac® materials, machinability has been improved without jeopardizing properties, such as corrosion resistance and mechanical strength.

Improved machinability is brought about by:

- Optimized non-metallic inclusions
- Optimum chemical composition

Datasheet last updated 2024-02-09 13:29:35 (supersedes all previous editions)

– Optimized process and production parameters

Detailed recommendations for the choice of tools and cutting data, for turning, thread cutting, parting/grooving, drilling, milling and sawing, are provided in the brochure S-029-ENG.

Machining chart

The diagram shows the ranges, within which data should be chosen in order to obtain a tool life of 10 minutes minimum, when machining the austenitic Sanmac® 4571. The ranges are limited in the event of low feeds, because of unacceptable chip breaking. In the case of high cutting speeds, plastic deformation is the most dominant cause of failure. When feed increases and the cutting speed falls, edge frittering (chipping) increases significantly. The diagram is applicable for short cutting times. For long, continuous cuts, cutting speeds should be reduced.

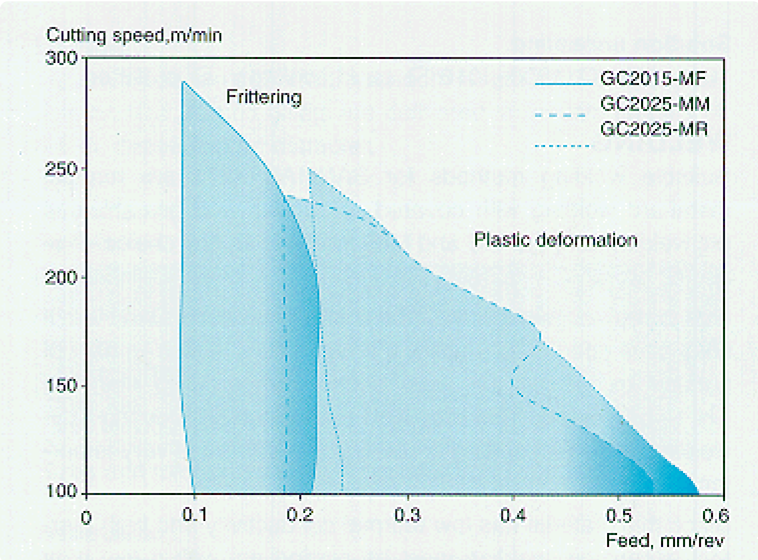

Figure 1. Machining chart for Sanmac 4571.

Figure 1. Machining chart for Sanmac® 4541.

The lowest recommended cutting speed is determined by the tendency of the material to stick to the insert (built-up edge), although the integrity of insert clamping and the stability of the machine are also of great significance.

It is important to conclude, which wear mechanism is active, in order to optimize cutting data with the aid of the diagram.

Turning Sanmac® 4571

Recommended insert and cutting data (starting values)

Insert Geometry	Grade	Cutting data Feed	Cutting speed	Application
		mm/rev.	m/min	
MF	GC2015 0.15		240	Finishing, copy turning
MM	GC20250.25		210	Medium machining
MR	GC20250.30		180	Medium-to-rough machining under less stable conditions

Datasheet last updated 2024-02-09 13:29:35 (supersedes all previous editions)

Drilling Sanmac® 4571

The recommended methods for drilling give the most cost effective results for the respective diameter ranges. When producing holes with diameters larger than 58 mm, short hole drilling is used up to 58 mm, followed by internal turning, up to the desired diameter. Cutting data for internal turning should be chosen in accordance with the turning recommendations. The recommendations for drilling are applicable for a tool life of 30 minutes.

Short hole drilling, diameter 12.7 - 58 mm

Coromant U-drill, R416.2

Insert Geometry	Grade	Cutting data, Feed	Cutting speed
		mm/rev.	m/min
-53	Central insert GC1020	-	-
-53	Peripheral insert GC1020*	0.04-0.18	150
-53	Peripheral insert GFC3040**	0.04-0.18	200

* GC1120 for diameters below 17.5 mm
** stable conditions, otherwise use GC1020 and cutting speed 180 m/min

Drilling with Alleima Coromant Delta C drill, diameter 3 - 12.7 mm

Code R415.5. Grade GC1220
(diameter range 3 - 20 mm)

Cutting data, Feed*	Cutting speed
mm/rev.	m/min
0.08-0.22	40

* The lower feed value should be selected for smaller diameters.

Drilling with high speed steel (HSS) drill

(diameter 1-3 mm)

Cutting data, Feed*	Cutting speed**
mm/rev.	m/min
0.03-0.09	8-15

* The lower feed value should be selected for smaller diameters
** The higher cutting speed should be selected for coated drills

Milling Sanmac® 4571

Use of optimum cutting data means that milling can be carried out at cutting speeds above those where there is a risk of built-up edge formation. Dry milling results in long tool life. If coolant is needed (e.g. when the surface cannot be reached in the dry condition), the cutting speed must be reduced by approximately 40-60% to prevent tool wear due to increased thermal load on the inserts.

Milling with CoroMill cutters 1)

Datasheet last updated 2024-02-09 13:29:35 (supersedes all previous editions)

Roughing Geometry/Grade	Cutting speed	Finishing Geometry/Grade	Cutting speed
	m/min		m/min
MM-2030	180	ML-2030	225

1) Starting values for dry machining

Threading Sanmac® 4571

Indexable inserts can be used for external thread cutting of all diameters. Threading with screw-cutting dies or die heads is economical only for small diameters. For internal threading with short and normal cutting lengths, thread cutting with indexable inserts is recommended above a hole diameter of 12 mm. For long cutting lengths, thread cutting with indexable inserts is recommended for hole diameters above 20 mm.

Thread turning

Due to the tendency of austenitic materials to work harden, radial infeed is recommended. A generous flow of cutting fluid should also be used, partly to obtain a reliable process and partly to guide the chip. The recommendations apply to a tool life of 30 minutes.

Insert Geometry	Grade	Cutting speed
		m/min
All-round	GC1020	150

Thread tapping

Compared with uncoated threading taps, coated threading taps can improve productivity by up to 100%. For the advantages of coated threading taps to be realized, a generous flow of cooling fluid must be used. The recommendations apply to a tool life of 30 minutes.

Cutting speed
m/min
4-15

The higher range of cutting data should be chosen for coated threading taps

Sawing Sanmac® 4571

Cutting with bandsaws or cold saws gives the best cutting economy. If the demand for surface smoothness is great, circular sawing is preferable.

Band sawing gives high productivity, is flexible and incurs low investment costs.

When band sawing Sanmac® 4571, the Sandflex Cobra type 3851 bimetallic bandsaw blades, which is available from Bahco Group (formerly Sandvik Saws and Tools), is recommended.

Tooth spacing should be selected according to the dimensions of the material to be cut, and stated in TPI (the number of teeth per in.). The TPI should be reduced for thicker dimensions. For a bar dimension of D = 150 mm, 2/3 TPI or 1/2 TPI is recommended.

Cutting speed
m/min

45-50

Feed is regulated to obtain a good chip form.

Datasheet last updated 2024-02-09 13:29:35 (supersedes all previous editions)