Alleima

Sanmac® 4571

Bar

Datasheet

Sanmac® 4571 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

Product standard

- EN 10088-3, EN 10088-5 (dimensions up to 250 mm)
- EN 10272, EN 10222-5, (dimensions ≥ 180 mm), AD-2000-W2
- ASTM A479, ASTM A276
- Chemical composition and mechanical properties acc. to ASTM A182

Approvals

- TÜV AD Merkblatt W0/TRD 100
- Pressure Equipment Directive (2014/68/EU)
- Pre-approval for PMA

Certificate

Status according to EN 10 204/3.1

Chemical composition (nominal)

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo

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Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo
0.03	0.4	1.8	≤0.045	≤0.030	17	11	2.1

Ti=>5xC

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, valves
- Components for pumps

Corrosion resistance

General corrosion

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

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 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 Sanmac SAF™ 2205 or SAF™ 2507 have higher resistance to Stress corrosion cracking than 4571.

Gas corrosion

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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.

Forms of supply

Finishes and dimensions
Sanmac 316Ti bar steel is stocked in a large number of sizes. The standard size range for stock comprises 75-350 mm, see pocket card S-02909.
Round bar is supplied in solution annealed and peel turned condition.
Lengths
Bars are delivered in random lengths of 3-7 m, depending on diameter.
Straightness

Diameter mm	Height of arch, mm/m Typical value
20 - 70	1
> 70	2

Tolerances, mm-sizes

Diameter mm	Tolerances mm
75-95	-0/+1.00
100-285	-0/+1.50
290-350	-0/+2.00

Surface conditions

Surface conditions	Ra, µm Typical value	Size, diameter, mm
Peeled and burnished	1	20-285
Peel turned	2	>285 - 350

Heat treatment

SANMAC® 4571 bars are delivered in solution annealed condition.

Solution annealing

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

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Mechanical properties

Bar steel is tested in delivery 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	≥45	≤215

Imperial units

Proof strength		Tensile strength	Elong.	Contr.	HB
$R_{p0.2}$ a)	$R_{p1.}$ a)	R_m	A b)	Z	
ksi	ksi	ksi	%	%	
≥30.5	≥35.5	75-101.5	≥40	≥45	≤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 strength respectively.
b) Based on L_0 = 5.65 ÖS_0 where L_0 is the original gauge length and S_0 the original cross-section area.

Impact strength

Due to its austenitic microstructure, 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 prEN13445-2(UFPV-2) and EN 10272.

At high temperatures

Metric units

Temperature	Proof strength		Tensile strength
°C	$R_{p.02}$	$R_{p1.0}$	R_m
	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
°F	$R_{p.02}$	$R_{p1.0}$	R_m
	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, 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

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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

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 its machinability, the amount of surface oxides on the welded beads might be higher compared to that of the standard 316Ti steels.

This may lead to arc instability during TIG/GTAW welding, especially welding without filer material. However, the welding behavior of this material is the same as for standard 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)

Hot working

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

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

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Machining

Sanmac is our trademark for the Alleima machinability concept. In SANMAC materials, machinability has been improved without jeopardizing properties such as corrosion resistance and mechanical strength.

The improved machinability is owing to:

- Optimized non-metallic inclusions
- Optimal chemical composition
- Optimized process and production parameters

Detailed recommendations for the choice of tools and cutting data regarding turning, thread cutting, parting/grooving, drilling, milling and sawing are provided in the brochure S-02909-ENG.

The diagram shows the ranges within which data should be chosen in order to obtain a tool life of minimum 10 minutes when machining SANMAC® 4571.

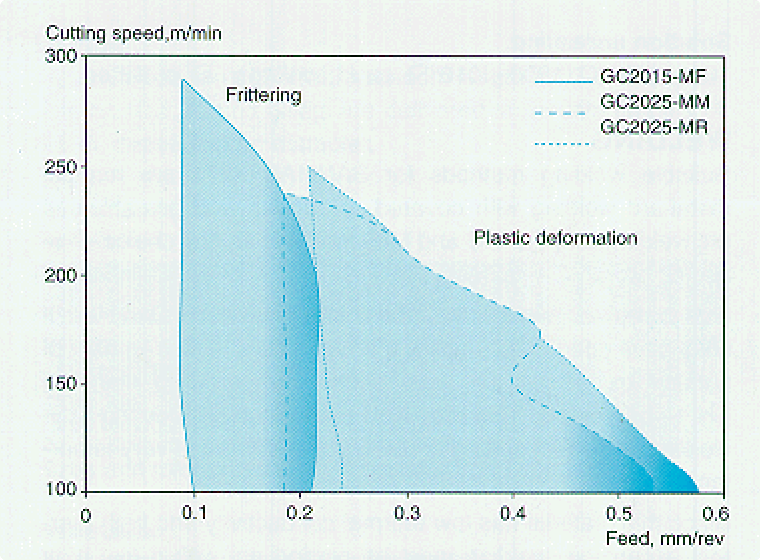

Figure 1. Machining chart SANMAC® 4571.

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, the cutting speeds should be reduced somewhat.

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.

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Turning of SANMAC® 4571

Recommended insert and cutting data (starting values for a tool-life of 15 minutes)

Insert Geometry	Grade	Cutting data Feed	Cutting speed	Application
		mm/rev	m/min	
MF	GC2015	0.15	240	Finishing, copy turning
MM	GC2025	0.25	200	Medium machining
MR	GC2025	0.30	180	Medium-to-rough machining under less stable conditions

Drilling of Sanmac

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.

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	Application
mm/rev	m/min	
0.08-0.22	55	Finishing, copy turning

* The lower value should be selected for smaller diameters

Short hole drilling, diameter 12.7-58 mm

Coromant U-drill, R416.2

Insert Geometry	Grade*	Cutting data Feed	Cutting speed	Application
		mm/rev	m/min	
-53	Central insert GC1020	-	-	-
-53	Peripheral insert GC1020**	0.04-0.18	160	Less stable conditions
-53	Peripheral insert GC3040	0.04-0.18	200	Stable conditions

* Alleima Coromant inserts
** GC1120 for diameters below 17.5 mm

Drilling with high speed steel (HSS) drills

(diameter 1-3 mm)

Cutting data,Feed*	Cutting speed**
mm/rev	m/min
0.03-0.09	10-15

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