Alleima

Sanmac® 304/304L

Billets

Datasheet

Sanmac® 304/304L is an austenitic chromium-nickel steel with improved machinability.

Standards

- ASTM: 304, 304L
- UNS: S30400, S30403
- EN Number: 1.4301, 1.4307
- EN Name: X 5 CrNi 18-10, X 2 CrNi 18-9
- W.Nr.: 1.4301

Product standards

- EN 10088-3
- ASTM A-314

Suitable for the production of flanges etc. according to ASTM A-182 grade F304/304L.

Certificates

Status according to EN 10 204/3.1

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo	Others
≤0.030	0.4	1.3	≤0.040	≤0.030	18.5	9.5	-	-

Applications

Sanmac® 304/304L is used for a wide range of industrial applications.

Industrial categories	Typical applications
Chemical industry	Flanges
Food industry	Valves

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Petrochemical industry	Fittings
Pulp and paper industry	Couplings
Nuclear industry	Rings
	Seals
	Bolts and nuts
	Shafts
	Forgings
	Discs

Corrosion resistance

General corrosion

Sanmac® 304/304L has good resistance in:

- Organic acids at moderate temperatures
- Salt solutions, e.g. sulphates, sulphides and sulphites
- Caustic solutions at moderate temperatures
- Oxidizing acids like nitric acid

Stress corrosion cracking

Austenitic 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. In applications demanding high resistance to stress corrosion cracking, we recommend the austenitic-ferritic steel Sanmac® SAF 2205.

Intergranular corrosion

Sanmac® 304/304L has a low carbon content and, therefore, good resistance to intergranular corrosion.

Pitting and crevice corrosion

The 304/304L grade is relatively low alloyed and, therefore, it may be sensitive to pitting and crevice corrosion, even in solutions of relatively low chloride content. Molybdenum-alloyed steels have better resistance and the resistance improves with an increasing molybdenum content.

Gas corrosion

Sanmac® 304/304L can be used in

- Air up to 850°C (1560°F)
- Steam up to 750°C (1380°F)
- Synthesis gas (ammonia synthesis) up to about 550°C (1020°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, the steel 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**
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

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183, 193	+/-2	max 10

Other products

- Bar and hollow bar (Sanmac®)

Heat treatment

Sanmac® 304/304L billets are delivered in hot worked condition. If another heat treatment is needed after further processing, the following is recommended.

Solution annealing

1040–1100°C (1900–2010°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**	**%**	**%**	
					approx.
≥205	≥230	515-680	≥45	≥50	170

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**	**%**	**%**	
					approx.
≥29.5	≥33.5	74.5-98.5	≥45	≥50	170

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 = 5.65ÖS$_0$, where L_0 is the original gauge length and S_0 the original cross-sectional area.

The **impact energy** (Charpy V) at 20°C (68°F) is min 100 J (74 ft-lb).

At high temperatures

Metric units

Temperature	**Proof strength**	**Tensile strength**

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°C	$R_{p.02}$	$R_{p1.0}$	R_m
	MPa	MPa	MPa
	min.	min.	min.
100	155	190	450
200	127	155	400
300	110	135	380
400	98	125	380
500	92	120	360

Imperial units

Temperature	Proof strength		Tensile strength
°F	$R_{p.02}$	$R_{p1.0}$	R_m
	ksi	ksi	ksi
	min.	min.	min.
200	23.1	28.1	66.1
400	18.3	22.4	57.9
600	15.7	19.3	55.1
800	14.0	17.9	54.3
1000	13.1	17.4	48.9

Physical properties

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

Thermal conductivity

Temperature		Temperature	
°C	W/m °C	°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		Temperature	
°C	J/kg °C	°F	Btu/lb °F

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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		Temperature	
°C	Per °C	°F	Per °F
30-100	16.5	86-200	9.5
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	18.5	86-1400	10.5

Modulus of elasticity, ($x10^{3}$)

Temperature		Temperature	
°C	MPa	°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

Hot working

Hot working should be carried out at a material temperature of 900-1200°C (1650-2190°F), cooling in air or in water. If additional heat treatment is needed, it should be carried out in accordance with the recommendations given for heat treatment.

Welding

The weldability of SANMAC® 304/304L 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. Preheating and post-weld heat treatment are not necessary.

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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 304/304L 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 304/304L steels when welding with filler material.

For SANMAC® 304/304L, heat input of <2.0 kJ/mm and interpass temperature of <150°C (300°F) are recommended.

Recommended filler metals

TIG/GTAW or MIG/GMAW welding

ISO 14343 S 19 9 L / AWS A5.9 ER308L (e.g. Exaton 19.9.L)

MMA/SMAW welding

ISO 3581 E 19 9 L R / AWS A5.4 E308L-17(e.g. Exaton 19.9.LR)

Machining

General

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

The improved machinability is brought about by:

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

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® 304/304L. 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.

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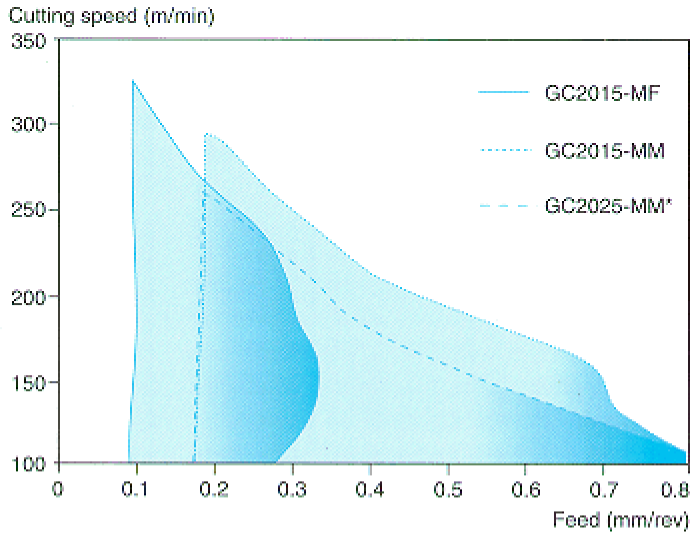

Figure 1. Machining chart for Sanmac 304/304L.

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® 304/304L

Recommended insert and cutting data (starting values)

Insert	Grade	Cutting data, Feed	Cutting speed	Application
Geometry		mm/rev	m/min	
MF	GC2015	0.15	250	Finishing, copy turning
MM	GC2015	0.30	220	Medium machining
MM	GC2025	0.30	190	Medium-to-rough machining under less stable conditions

Drilling Sanmac® 304/304L

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	160

-53	Peripheral insert GC3040**	0.04-0.18	200

* GC1120 for diameters below 17.5 mm
** stable conditions, otherwise use GC1020

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	50

* The lower feed value should be selected for smaller diameter

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 of Sanmac® 304/304L

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)

Roughing Geometry/Grade	Cutting speed m/min	Finishing Geometry/Grade	Cutting speed m/min
MM-2030	185	ML-2030	235

1) Starting values for dry machining

Threading of Sanmac® 304/304L

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 the austenitic materials to work harden, radial infeed is recommended. A generous

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flow of cutting fluid should 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	Grade	Cutting speed
Geometry		**m/min**
All-round	GC1020	160

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 of Sanmac® 304/304L

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® 304/304L, the Sandflex Cobra type 3851 bimetallic band 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.

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