Datasheet updated 2012-11-20 15:47:46 (supersedes all previous editions)

Sanmac 2205
(Bar)

Sanmac 2205 is a duplex (austenitic-ferritic) stainless steel with improved machinability. The grade is characterized by:

- Excellent machinability
- High resistance to stress corrosion cracking (SCC) in chloride-bearing environments
- High resistance to stress corrosion cracking (SCC) in environments containing hydrogen sulphide
- High resistance to general corrosion, pitting and crevice corrosion
- High mechanical strength – roughly twice the proof strength of austenitic stainless steels
- Good hot-working properties
- High resistance to erosion corrosion and corrosion fatigue
- Physical properties that offer design advantages
- Good weldability

STANDARDS

- UNS S31803/S32205
- EN number 1.4462
- W.Nr. 1.4462

Product standards

- EN 10088-3, EN 10272, EN 10222-5,
- ASTM A-479, ASTM A-276, MDS D47 Rev. 3
- Analysis and mechanical properties acc. to ASTM A-182

Approvals

Pressure Equipment Directive (97/23/EC)
NORSOK M650 Rev 3, M630 Rev 4, dimensions up to 260 mm.
Pre-approval for PMA

Certificate

Status according to EN 10204/3.1

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cr	Ni	Mo	N
max	max	max	max	max				
0.030	1.0	2.0	0.030	0.015	22.5	5.5	3.2	0.18

FORMS OF SUPPLY

Bar

Finishes and dimensions
Bar steel in grade Sanmac 2205 is stocked in a large number of sizes. The standard size range for stock comprises 20-450 mm, see pocket card S-02909.
Round bar is supplied in the solution annealed and quenched and peel-turned condition.

Lengths
Bars are delivered in random lengths of 3-7 m, depending on diameter.

Straightness

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

Tolerances, mm-sizes

Diameter m m	Tolerances m m
20-35	-0/+0.15
40-45	-0/+0.16
50-70	-0/+0.19
75-95	-0/+1.50
290-350	-0/+2.00
360-450	-0/+3.00

Surface conditions

Surface conditions	Ra, µm Typical value	Size, diameter, mm
Peeled and burnished	1	20-285
Peel turned	2	>285 - 350
Rough machined	5	>350

MECHANICAL PROPERTIES

The following values apply to material in the solution annealed and quenched condition.

Bar with sizes larger than 260 mm may have slightly lower values.

More detailed formation can be supplied on request.

At 20°C (68°F)

METRIC UNITS				
Proof strength		Tensile strength	Elong.	Hardness
$R_{p0.2}$ [a)]	$R_{p1.0}$ [a)]		A [b)]	Brinell
MPa	MPa	MPa	%	
min	min		min	max
450	500	660-860	25	270

IMPERIAL UNITS

Proof strength		Tensile strength	Elong.	Hardness
$R_{p0.2}$ [a)]	$R_{p1.0}$ [a)]		A [b)]	Brinell
ksi	ksi	ksi	%	
min	min		min	max
65	73	96-125	25	270

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 $L_0 = 5.65\sqrt{S}$, where L_0 is the original gauge length and S_0 the original cross-sectional area.

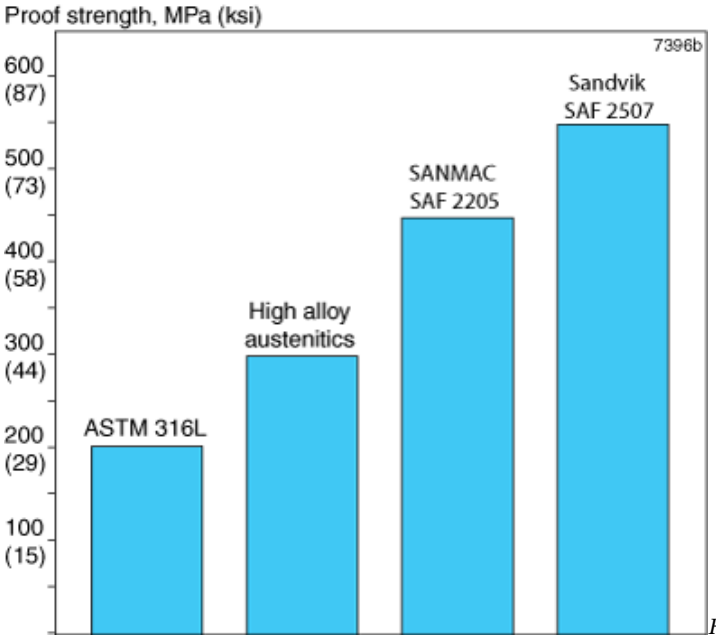

Figure 1. Comparision of proof strength, 0.2% offset, of Sanmac 2205, high alloy austenitics and other grades, for material in the solution-annealed and quenched condition.

Impact strength

Sanmac 2205 possesses good impact strength both at room temperature and at low temperatures. Fig. 2 shows typical impact energy values for Sanmac 2205 bars in different sizes at -50°C (-58°F). The values apply for standard Charpy-V specimens (10 x 10 mm, 0.39 x 0.39 in.) taken in the longitudinal direction of the bar. For dimensions larger than 260 mm (10.2 in.) the impact strength is somewhat lower.

Sanmac 2205 bar stock program guarantees an impact strength of 70 J (52 ft lb) at -50°C (-58°F) for dimensions up to 260 mm (10.2 in.). Over 260 mm (10.2 in.) values only for information.

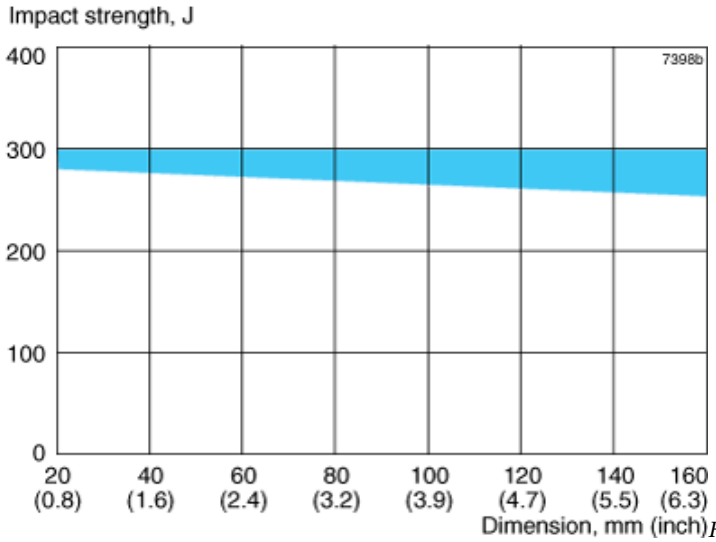

Figure 2. Typical impact strength values for Sanmac 2205 bar at -50°C (-58°F).

At high temperatures

If Sanmac 2205 is exposed for prolonged periods to temperatures exceeding 280 °C (540 °F), the microstructure changes which results in a reduction in impact strength. This effect does not necessarily affect the behaviour of the material at the operating temperature. Contact Sandvik for advice. For pressure vessel applications, 280 °C (540 °F) is required as maximum.

Temp.	Proof Strength	Temp.	Proof Strength
	$R_{p0.2}$		$R_{p0.2}$
°C	MPa	°F	ksi
	min.		min.
100	360	200	52
150	335	300	49
200	315	400	46
250	300	500	44

PHYSICAL PROPERTIES

Density: 7.8 g/cm^3, 0.28 lb/in^3

SPECIFIC HEAT CAPACITY

Temperature, °C	J/(kg °C)	Temperature, °F	Btu/(lb°F)
20	480	68	0.11
100	500	200	0.12
200	530	400	0.13
300	550	600	0.13
400	590	800	0.14

Thermal conductivity

METRIC UNITS

Temperature,°C	20	100	200	300	400
	W/(m °C)				
Sanmac 2205	14	16	17	19	20
AISI 316L	14	15	17	18	20

IMPERIAL UNITS

Temperature, °F	68	200	400	600	800
	Btu/(ft h °F)				
Sanmac 2205	8	9	10	11	12
AISI 316L	8	9	10	10	12

Thermal expansion, mean values in temperature ranges (X10-6)

METRIC UNITS

Temperature, °C	30-100	30-200	30-300	30-400
	Per °C			
Sanmac 2205	13.0	13.5	14.0	14.5
Carbon steel	12.5	13.0	13.5	14.0
AISI 316L	16.5	17.0	17.5	18.0

IMPERIAL UNITS

Temperature, °F	86-200	86-400	86-600	86-800
	Per °F			
Sanmac 2205	7.0	7.5	7.8	8.0
Carbon steel	6.8	7.0	7.5	7.8
AISI 316L	9.0	9.5	9.8	10.0

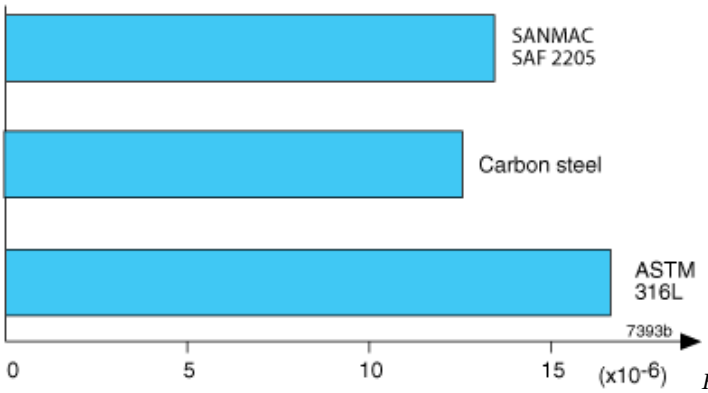

Figure 3. Thermal expansion, per °C (30-100°C.)

SANMAC SAF 2205 has a far lower coefficient of thermal expansion than austenitic stainless steels and can therefore possess certain design advantages.

RESISTIVITY

Temperature, °C	µΩm	Temperature, °F	µΩin.
20	0.74	68	29.1
100	0.85	200	33.1
200	0.96	400	39.8
300	1.00	600	43.3
400	1.10	800	43.3

MODULUS OF ELASTICITY ($X10^3$)

Temperature, °C	MPa	Temperature, °F	ksi
20	200	68	29.0
100	194	200	28.2
200	186	400	27.0
300	180	600	26.2

CORROSION RESISTANCE

General corrosion

In most media, Sanmac 2205 possesses better resistance to general corrosion than steel of type ASTM 316L and ASTM 317L. Impurities that increase corrosivity are often

present in process solutions of acids. If there is a risk of active corrosion, higher-alloyed austenitic stainless steels should be chosen, e.g. Sandvik 2RK65 or Sanicro 28.

Stress corrosion cracking

The standard austenitic steels of the ASTM 304L and ASTM 316L types are prone to stress corrosion cracking (SCC) in chloride-bearing solutions at temperatures above 60°C (140°F). Duplex stainless steels are far less prone to this type of corrosion. Laboratory tests have shown the good resistance to stress corrosion cracking of Sanmac 2205. Results from these tests are presented in fig. 5. The diagram indicates the temperature-chloride range within which Sanmac 2205, the standard steels ASTM 304L and ASTM 316L can be used without a risk of stress corrosion cracking

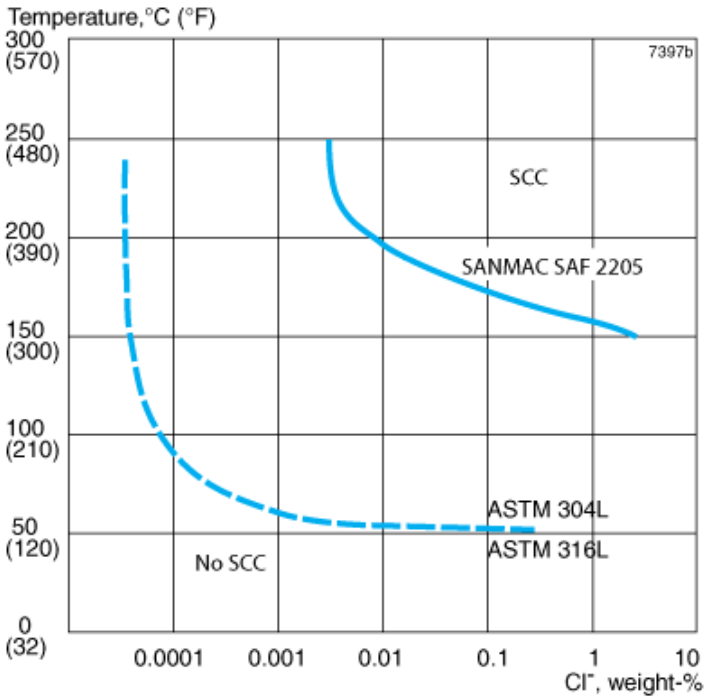

Figure 5.
Resistance to stress corrosion cracking, laboratory results.

In accordance with NACE MR0175/ISO 15156 solution annealed and cold-worked Sanmac 2205 is acceptable for use at any temperature up to 232°C/450°F in sour environments, if the partial pressure of hydrogen sulphide does not exceed 0.3 psi (0.02 bar) and its hardness is not greater than HRC 36. In the solution annealed and liquid quenched condition Sanmac 2205 is acceptable for use at any temperature up to 232°C/450°F in sour environments, if the partial pressure of hydrogen sulphide does not exceed 1.5 psi (0.1 bar). According NACE MR0103 solution annealed and rapid quenched Sanmac 2205, with hardness maximum HRC 28 is acceptable in sour petroleum refining.

Pitting and crevice corrosion

The pitting and crevice corrosion resistance of a steel is determined primarily by its chromium and molybdenum contents, but also by its nitrogen content as well as its slag composition and slag content. A parameter for comparing the resistance of different steels to pitting is the PRE number (Pitting Resistance Equivalent).

CPT ASTM G48 E ASTM 316 15°C
The PRE is defined as, in weight -%:
PRE = % Cr + 3.3 x % Mo +16 x % N

The PRE number for Sanmac 2205 and some compared materials are given in the following table.

Alloy	% Cr	% Mo	% N	PRE
Sanmac 2205	22.5	3.2	0.18	>35
Alloy 825	21.5	3.0	-	31
ASTM 317L	18	3.5	-	30
ASTM 316L	17	2.2	-	24

The ranking given by the PRE number has been confirmed in laboratory tests. Sanmac 2205 can be used at considerably higher temperatures and chloride contents than ASTM 304 and ASTM 316 without pitting occurring. Sanmac 2205 is therefore far more serviceable in chloride-bearing environments than standard 304/316 austenitic steels.

Intergranular corrosion

Sanmac 2205 has a low carbon content and therefore good resistance to intergranular corrosion.

Erosion corrosion

Steels of the ASTM 316 type are attacked by erosion corrosion if exposed to flowing media containing highly abrasive solid particles, e.g. sand, or to media with very high flow velocities. Owing to its combination of high hardness and good corrosion resistance, Sanmac 2205 displays very good resistance under such conditions.

Corrosion fatigue

Sanmac 2205 possesses higher strength and better corrosion resistance than 316/316L austenitic stainless steels. Sanmac 2205 therefore also possesses better fatigue strength under corrosive conditions than such steels.

HEAT TREATMENT

Sanmac 2205 stock program bars are delivered in solution annealed and quenched condition.

Solution annealing

Solution annealing at 1020 – 1100°C (1870 – 2010°F) followed by quenching.

Stress relief heat treatment at 350°C (660°F) for 5 h followed by air cooling

MACHINING

Sanmac 2205 has very good machining properties. In this material machinability has been improved without jeopardising properties such as corrosion resistance and mechanical strength. The non-metallic inclusions in Sanmac steels are of great significance to improved machinability. In addition to sulphides, Sanmac steels contain oxide inclusions, which improve chip breaking and reduce tool wear.

Fig. 6 shows the ranges within which you can choose cutting data to obtain a tool life of 7 minutes in the duplex material Sanmac 2205. The diagram is applicable for short cutting times. For long, continuous cuts, the cutting speeds should be reduced somewhat.

The lowest recommended cutting data 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.
The machining ranges are limited by different wear mechanisms. Once the type of wear has been determined, the cutting data can be optimized with the aid of the diagram.

Recommended insert and cutting data for turning of Sanmac 2205 (starting values)

Insert		Cutting data				Application
Geometry	Grade	Feed		Cutting speed		
		mm/rev.	in./rev.	m/min	ft/min	
MF	GC2025	0.15	0.006	180	590	Finishing
MM	GC2025	0.25	0.010	150	490	Medium machining
MM	GC2035	0.25	0.010	110	360	Rough machining (roughing a low cutting speeds).

Turning in Sanmac 2205 duplex steel is considerably demanding than in the Sanmac austenitic material. This is due mainly to the higher strength of Sanmac 2205, as well as its greater tendency to adhere to the tool.

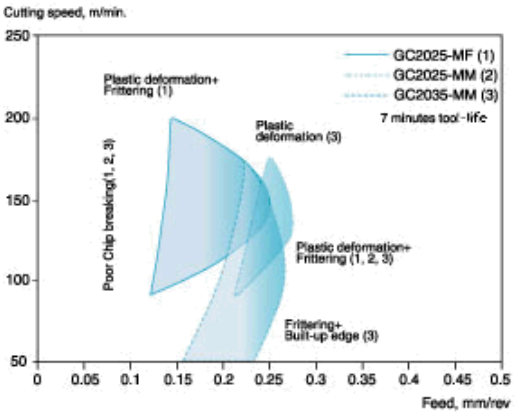

Figure 6. Cutting data recommendations for sandvik Sanmac 2205. GC 2025 and GC 2035 refer to Sandvik Coromant cemented-carbide insert grades.

The machining ranges are limited by different wear mechanisms. Once the type of wear has been determined, the cutting data can be optimized with the aid of the diagram.

WELDING

The weldability of Sanmac 2205 is good. Suitable welding methods are manual metal-arc welding (MMA) with covered electrodes or gas-shielded arc welding. Welding should be undertaken within the heat input range 0.5 – 2.5 kJ/mm. Maxmum interpass temperature is 250°C (482°F). Preheating or post-weld heat treatment is normally not necessary.

Matching filler metals are recommended in order to obtain a weld metal with optimum corrosion resistance and mechanical properties. For gas-shielded arc welding, we recommend Sandvik 22.8.3.L, and for manual metal-arc welding the covered electrode Sandvik 22.9.3.LR. These filler metals can also be used for welding Sanmac 2205 to carbon steels or stainless steels. The covered electrode Sandvik 23.12.2.LR and the welding wire Sandvik 22.15.3.L, both of type AWS 309Mo with low carbon content, can also be used for this purpose.

For welds exposed to especially severe environments, welding with Sandvik SAF 2507 welding consumables is recommended.

Recommendations of filler metal:

TIG (GTAW/141)	Sandvik 25.10.4.L
MIG (GMAW/131)	Sandvik 25.10.4.L
MMA (SMAW/111)	Sandvik 25.10.4.LR

APPLICATIONS

Due to its excellent corrosion properties, Sanmac 2205 is a highly suitable material for service in environments containing chlorides and hydrogen sulphide. The material is suitable for use in production tubing and flowlines for the extraction of oil and gas from sour wells, in refineries and in process solutions contaminated with chlorides. Sanmac 2205 is particularly suitable for heat exchangers where chloride-bearing water or brackish water is used as a cooling medium. The steel is also suitable for use in dilute sulphuric acid solutions and for the handling of organic acids, e.g. acetic acid and mixtures.

- The high strength of Sandvik Sanmac 2205 makes the material an attractive alternative to the austenitic steels in structures subjected to heavy loads.
- The good mechanical and corrosion properties make Sanmac 2205 an economical choice in many applications by reducing the life cycle cost of the equipment.
- The good machining properties make Sanmac 2205 a superior alternative to standard 2205 grades and other duplex grades for applications subjected to all types of machining by extended tool life and possibilities to increase productivity.
