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Sanmac 2205

(Hollow 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
- EN name X2CrNiMoN22-5-3

Product standards

EN 10216-5, EN 10297-2, EN 10294-2

ASTM A790

Approvals

- Approved by the American Society of Mechanical Engineers (ASME) for use in accordance with ASME Boiler and Pressure Vessel Code, section VIII, div. 1 and section VIII, div. 2, Case 2067-2
- NACE MR 0175 (sulphide stress cracking resistant material for oil field equipment)

CHEMICAL COMPOSITION (NOMINAL) %

C max.	Si max.	Mn max.	P max.	S max.	Cr	Ni	Mo	N
0.030	1.0	2.0	0.030	0.015	22.5	4.5	3.2	0.17

FORMS OF SUPPLY

Hollow bar-Finishes, dimensions and tolerances

Hollow bar Sanmac 2205 is stocked in a large number of sizes up to 250 mm outside diameter in the solution-annealed and white-pickled condition. Contact us for more information.

Dimensions are given as outside and inside diameter with guaranteed component sizes after machining.
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 on special order.

Other forms of supply

Bar

Sanmac 2205 is also available as solid bar.

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 contact Sandvik Steel.

Wire electrodes and filler wire/rods:
Sandvik 22.8.3.L: 0.80, 1.00, 1,20, 1.60, 2.00, 2.40, 3.00, 3.20, 4.00 mm
Sandvik 25.10.4.L: 0.08, 1.00, 1.20, 1.60, 2.00, 2.40, 3.00, 3.20, 4.00 mm

Covered electrodes
Sandvik 22.9.3.LR: 1.6, 2.0, 2.5, 3.25, 4.0 mm
Sandvik 25.10.4.LR: 2.0, 2.5, 3.25, 4.0, 5.0 mm

Other Sandvik SAF 2205 products

- Seamless tube and pipe
- Welded tube and pipe
- Fittings and flanges
- Strip electrodes and flux for surfacing
- Strip, annealed or cold-rolled to different degrees of hardness
- Plate, sheet and wide strip

MECHANICAL PROPERTIES

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

At 20°C (68°F)

Hollow bar with a wall thickness max. 20 mm (0.79 in.)

METRIC UNITS

Proof strength		Tensile strength	Elong.		Hardness
$R_{p0.2}$[a]	$R_{p1.0}$[a]	R_m	A[b]	$A_{2"}$	HRC
MPa	MPa	MPa	%	%	
min.	min.		min.	min.	max.
450	500	680-880	25	25	28

IMPERIAL UNITS

Proof strength		Tensile strength	Elong.		Hardness
$R_{p0.2}$[a]	$R_{p1.0}$[a]	R_m	A[b]	$A_{2"}$	HRC
ksi	ksi	ksi	%	%	
min.	min.		min.	min.	max.
65	73	99-128	25	25	28

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
Sanmac 2205 possesses good impact strength both at room temperature and at low temperatures.

At high temperatures
If Sanmac 2205 is exposed for prolonged periods to temperatures exceeding 280°C (540°F), the micro structure changes which results in a reduction in impact strength. This effect does not necessarily affect the behaviour of the material at the operating temperature. For example, heat exchanger tubes may be used at higher temperatures without any problems. Contact Sandvik for advice.

For pressure vessel applications, 280°C (540°F) is required as maximum according to VdTÜV-Wb 418.

Hollow bar with wall thickness max. 20 mm (0.79 in.)

METRIC UNITS

Temperature	Proof strength		Tensile strength
°C	$R_{p0.2}$	$R_{p1.0}$	R_m
	MPa	MPa	MPa
	min.	min.	min.
100	370	420	630
150	345	385	600
200	330	360	580
250	320	350	570
300	310	340	560

IMPERIAL UNITS

Temperature	Proof strength		Tensile strength
°F	$R_{p0.2}$	$R_{p1.0}$	R_m
	ksi	ksi	ksi
	min.	min.	min.
200	54.0	61.5	92.0
300	50.5	55.5	87.0
400	48.0	52.0	84.0
500	46.0	50.0	82.5
600	44.5	49.0	81.0

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
ASTM 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
ASTM 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	8.0	8.0
Carbon steel	6.8	7.0	7.5	7.8
ASTM 316L	9.0	9.5	9.8	10.0

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

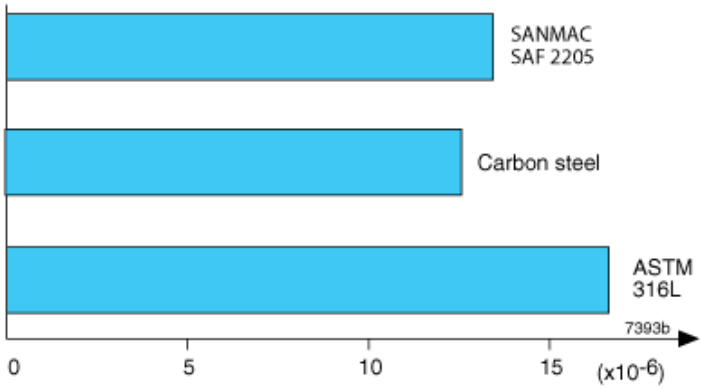

Figure 2. Thermal expansion per °C (30-100°C).

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 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. 3. 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.

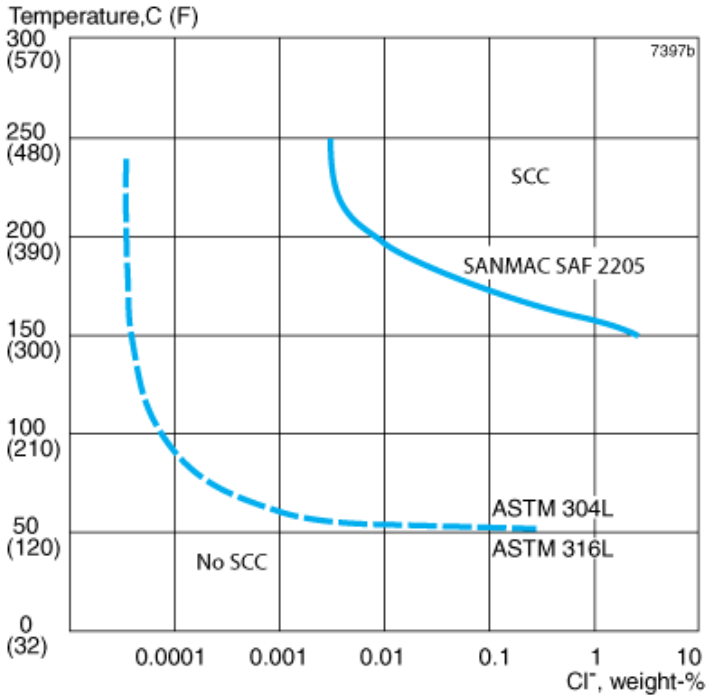

Figure 3. Resistance to stress corrosion cracking (SCC) in neutral chloride sloutions with an oxygen content of 8 ppm. Laboratory results for Sanmac 2205 of constant load specimens loaded to the proof strength at the test temperature.

In accordance with NACE MR0175/ISO 15156 solution annealed and cold-worked Sandvik 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 Sandvik 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 Sandvik SAF 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	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 type austenitic stainless steels. Sanmac 2205 therefore also possesses better fatigue strength under corrosive conditions than such steels.

HEAT TREATMENT

Hollow bar is normally delivered in heat treated condition. In the solution annealed condition Sanmac 2205 has an austenitic-ferritic microstructure, which is free from grain-boundary carbides and intermetallic phases.

The ferrite content is 40 – 60%.

If additional heat treatment is needed after further processing the following, is recommended.

Solution annealing
1020–1100°C (1870–2010 °F), rapid cooling in air or water.

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

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.