Alleima

Sanmac® 4435

Bar

Datasheet

Sanmac® 4435 is a molybdenum-alloyed (min. 2.5%) austenitic chromium-nickel steel with improved machinability.

Standards

- ASTM: 316L, 316
- UNS: S31603, S31600
- EN Number: 1.4435, 1.4436
- EN Name: X 2 CrNiMo 18-14-3, X 3 CrNiMo 17-13-3
- W.Nr.: 1.4435, 1.4436
- JIS: SUS316, SUS316L

Standards

Product standards

- EN 10088-3, EN 10088-5 (dimensions up to 250 mm)
- EN 10272, EN 10222-5, AD-2000-W2
- ASTM A479, ASTM A276
- Chemical composition and mech.properties acc ASTM A182
- Basler Norm 2-1997

Approval

- TÜV AD-Merkblatt W0/TRD 100
- Pressure Equipment Directive (2014/68/EU)
- JIS Approval for Stainless Steel Bars
- Ü-Zeichen

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Certificate

– Status according to EN 10 204/3.1

Chemical composition (nominal)

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo
≤0.030	0.4	1.7	≤0.040	≤0.025	17.5	12.5	2.6

Applications

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Corrosion resistance

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Forms of supply

Finishes and dimensions

Sanmac® 4435 bar steel is stocked in a large number of sizes. The standard size range for stock comprises 75-350 mm. 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	Height of arch, Typical value
mm	mm/m
20 - 70	1
> 70	2

Tolerances

H12-h15 is valid.

Surface conditions

Surface conditions	Ra, Typical value	Size, diameter
	µm	mm
Peeled and polished	1	20-300
Peel turned	2	>300

Heat treatment

Sanmac® 4435 bar is delivered in solution annealed condition. Billets are delivered in hot-worked condition. If another heat treatment is needed after further processing the following is recommended.

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Solution annealing

1040–1100°C (1900–2010°F), rapid cooling in air or water.

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	%	%	
≥205	≥240	515-690	≥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	%	%	
≥29.5	≥34.5	74.5-100.1	≥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 strength 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-section area.

Impact strength

Due to its austenitic microstructure, SANMAC® 4435 has very good impact strength both at room temperature and at cryogenic temperatures.
Tests have demonstrated that the steel fulfils the requirements according to the European standards prEN 13445-2 (UFPV-2) ((min. 60 J (44 ft-lb) at -270 °C (-455 °F) and EN 10272 (min. 60 J (44 ft-lb) at -196 °C (-320 °F).

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	165	200	420
200	137	165	380
300	119	145	370
400	108	135	-

500	100	128	-

Imperial units

Temperature	Proof strength		Tensile strength
	$R_{p.02}$	$R_{p1.0}$	R_m
°F	ksi	ksi	ksi
	min.	min.	min.
200	23.9	29.0	60.9
400	19.9	23.9	55.1
600	17.3	21.0	53.7
800	15.7	19.6	-
1000	14.5	18.6	-

Physical properties

Density: 8.0 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
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		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

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

Modulus of elasticity [1)]

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

1) $x10^{3}$

Welding

The weldability of Sanmac® 4435 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 316L 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 316L steels when welding with filler material.

For Sanmac® 4435, heat input of <2.0 kJ/mm and interpass temperature of <150°C (300°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 L / AWS A5.9 ER316L (e.g. Exaton 19.12.3.L)

MMA/SMAW welding

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

Hot working

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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 can be find in S-02909-ENG. If priority are given to high production rate in machining Sanmac 316/316L (EN 1.4401/1.4404) is recommended instead of Sanmac® 4435 due to a more suitable chemical composition. Sanmac® 4435 is a machinability improved material with the same reliable machinability as Sanmac® 316/316L (EN 1.4404/1.4404) but with a little shorter expected tool-life.

Turning of Sanmac® 4435

Recommended insert and cutting data (starting values) is available in S-02909-ENG.

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