Material Data Sheet

Austenitic corrosion resisting steel

Materials Services
Materials Germany

Steel designation	Name	Material No.
	X6CrNiMoTi17-12-2	1.4571 (≈ AISI 316Ti)

Scope

This data sheet applies to hot and cold rolled sheets and strips, semi-finished products, bars/rods, wire and sections as well as seamless and welded pipes/tubes for pressure purpose.

Application

Construction encasement, doors, windows and armatures; offshore modules; cisterns and pipes for chemical tanker; production, warehousing and overland transportation of chemicals, food and beverages; pharmacy, synthetic fiber, paper and textile plants; pressure vessels. The material has good corrosion resistance against chlorides containing media and non-oxidizing acids, due to the Mo-content,
Due to the Ti-alloy, the resistance to **intergranular corrosion** is also guaranteed in the welded condition.

Chemical composition (heat analysis in %)

Product form	C	Si	Mn	P	S	Cr	Mo	Ni	Ti
C, H, P	≤ 0.08	≤ 1.00	≤ 2.00	≤ 0.045	≤ 0.015[1)]	16.50–18.50	2.00–2.50	10.00–13.00	5xC to 0.70
L	≤ 0.08	≤ 1.00	≤ 2.00	≤ 0.045	≤ 0.015[1)]	16.50–18.50	2.00–2.50	10.00–13.00[2)]	5xC to 0.70
T_W	≤ 0.08	≤ 1.00	≤ 2.00	≤ 0.045	≤ 0.015[3)]	16.50–18.50	2.00–2.50	10.00–13.00	5xC to 0.70
T_S	≤ 0.08	≤ 1.00	≤ 2.00	≤ 0.045	≤ 0.015[1)]	16.50–18.50	2.00–2.50	10.00–13.00	5xC to 0.70

C = cold-rolled strip; H = hot-rolled strip; P = hot-rolled sheet; L = semi-finished products, rods, wire and sections; T_W = welded tubes; T_S = seamless tubes

1) A regulated sulfur content of 0.015–0.030 % has to be agreed for products, which have to be processed.

2) If it should be necessary to minimize the content of the delta ferrite, the maximum content of nickel can be raised by 1 %.

3) For tubes, which are welded without filler metals, P + S = max. 0.040 %.

Mechanical properties at room temperature in solution annealed condition

Product form	Thick-ness	0,2 %	1 %	Tensile strength	Elongation		Impact energy (ISO-V)	
		Yield strength					Room temperature ≥ 10 mm thick	
		$R_{p0,2}$	$R_{p1,0}$	R_m	A[1]	A[1]		
	mm	N/mm²		N/mm²	%min	%min	J_{min}	J_{min}
	max.	min.			(longitudinal)	(transverse)	(longitudinal)	(transverse)
C	6	240[3]	270[3]	540 - 690[3]	-	40	-	-
H	12	220[3]	260[3]	540 - 690[3]	-	40	90	60
P	75	220[3]	260[3]	520 - 670[3]	-	40	90	60
L	160	200[4]	235[4]	500 - 700[4]	40	-	100	-
L	250 [2]	200[5]	235[5]	500 - 700[5]	-	30	-	60
T_W	60	190[6]	225[6]	490 - 690[6]	35	30	100	60[8]
T_S[7]	60	190[6]	225[6]	490 - 690[6]	35	30	100	60[8]

[1] gauge length and thickness according to DIN EN
[2] >160 mm
[3] transverse test piece, with product widths < 300 mm longitudinal test piece
[4] longitudinal test piece
[5] transverse test piece
[6] longitudinal test piece, external diameter > 508 mm transverse test piece
[7] hot manufactured
[8] 60 J also at -196 °C

Reference data for some physical properties (for guidance only)

Density at 20 °C	Modulus of elasticity kN/mm² at				Thermal conduc-tivity at 20 °C	Specific thermal capacity at 20 °C	Specific electrical resistivity at 20 °C
kg/dm³	20 °C	200 °C	400 °C	500 °C	W/m K	J/kg K	Ω mm²/m
8.0	200	186	172	165	15	500	0.75

Mean linear thermal expansion coefficient [10^{-6} K^{-1}] between 20 °C and

100 °C	200 °C	300 °C	400 °C	500 °C
16.5	17.5	18.0	18.5	19.0

Guidelines on the temperatures for hot forming and heat treatment[1]

Hot forming		Heat treatment +AT (solution annealed), Microstructure		
Temperature °C	Type of cooling	Temperature °C[2][3][4]	Type of cooling	Microstructure
850 to 1150	air	1030 to 1100	water, air[5]	Austenite with a low content of ferrite

[1] For simulative heat treated test pieces the temperatures for solution annealing have to be agreed.
[2] Solution annealing may be omitted, if the conditions for the hot forming and the concluding cooling are in such a way that the requirements for the mechanical properties of the product can be maintained.
[3] If heat treatment is carried out in a continuous annealing furnace, usually the upper area of the mentioned temperature range is preferred or even exceeded.
[4] For heat treatment within subsequent processing, the lower area of the stated temperature range for solution annealing has to be aspired, as otherwise the mechanical properties could be affected. If the lower limit for the solution annealing temperature was not undercut during hot forming, while repeating annealing a temperature of 980 °C as the lower limit is sufficient.

Processing/Welding

The following welding processes can be used for this steel:

TIG-welding
Arc welding (E)
MAG-welding solid wire
Submerged-arc-welding (SAW)
Laser beam welding

Process	Filler metal			
	similar		higher alloyed	
TIG	Thermanit A Thermanit GE-316L	1.4576 1.4430	Thermanit 19/15 H	1.4455
MAG sold wire	Thermanit A Si Thermanit GE-316L Si	1.4576 1.4430	Thermanit 19/15 H	1.4455
Arc welding (E)	Thermanit A Spezial Thermanit AW Thermanit GE Spezial Thermanit GEW/F Thermanit GEW 316L-17	1.4576 1.4576 1.4430 1.4430 1.4430	Thermanit 19/15 H	1.4455
SAW	Wire	Powder	Wire	Powder
	Thermanit A Thermanit GE – 316 L	Marathon 431 Marathon 213 Marathon 431 Marathon 213	Thermanit 19/15	Marathon 104 Marathon 213
Laser beam welding	see page 3			

When choosing the filler metal, the corrosion stress has to be considered, as well. The use of a higher alloyed filler metal can be necessary because to the cast structure of the weld metal.

A preheating is not necessary for this steel. A heat treatment after welding is normally not usual.

Austenitic steels only have 30% of the thermal conductivity of non-alloyed steels. Their melting point is lower than that of non-alloyed steel, therefore austenitic steels have to be welded with lower heat input than non-alloyed steels. To avoid overheating or burn-thru of thinner sheets, higher welding speed has to be applied.

Copper back-up plates for faster heat reduction are functional, whereas, to avoid cracks in the solder metal, it is not allowed to surface-fuse the copper back-up plate.

This steel has an extensively higher coefficient of thermal expansion as non-alloyed steel. In connection with a worse thermal conductivity, a larger distortion has to be expected.

When welding 1.4571 all procedures, which work against this distortion (e. g. back-step sequence welding, welding alternately on opposite sides with double-V butt weld, with two welders when the components are accordingly large) have to be respected especially. For product thicknesses over 12 mm the double-V butt weld has to be preferred instead of a single-V butt weld. The included angle should be 60°–70°, when using MIG-welding about 50° are enough. An accumulation of weld seams is to be avoided.

Tack welds have to be affixed with relatively shorter distances from each other (significantly shorter than these of non-alloyed steels), in order to prevent strong deformation, shrinking or flaking tack welds. The tacks have to be subsequently ground or at least be free from crater cracks.

1.4571 in connection with austenitic weld metal and too high heat input the tendency to form heat cracks exists. The tendency to form heat cracks can be limited, if the weld metal has a lower content of ferrite (delta ferrite). Contents of ferrite of up to 10 % have a positive effect and do not affect the corrosion resistance in generally. The layers used for welding have to be as thin as possible (stringer bead technique), because a higher cooling speed decreases the tendency to form hot cracks.

A preferably fast cooling has to be aspired while welding as well, to avoid the tendency to intergranular corrosion and embrittlement.

1.4571 is very suitable for **laser beam welding** (weldability A in accordance with DVS sheet 3203, part 3). For a welding groove width smaller than 0.3 mm respectively 0.1 mm product thickness the use of filler metals is not necessary. A similar filler metal can be used for larger welding grooves.
With avoiding oxidation within the seam surface during laser beam welding by applicable backhand welding, e. g. helium as inert gas, the welding seam is as corrosion resistant as the base metal. A hot crack hazard for the welding seam does not exist, when choosing an applicable process.
1.4571 is also suitable for **laser beam fusion cutting** with nitrogen or flame cutting with oxygen. The cut edges only have small heat affected zones and are generally free of micro cracks and thus are well formable. When choosing an suitable process the fusion cut edges can be processed directly. Especially, they can be welded without any further preparation.
When processing only stainless tools like steel brushes, picks/hammer etc. are allowed, in order not to endanger the passivation.
Marking within the welding seam zone with oleigerous pens or temperature indicating crayons is to be avoided.
The high corrosions resistance of this stainless steel is based on the formation of a homogeneous, compact passive layer on the surface. Annealing colors, scale, slag residues, tramp iron, spatters and such like have to be removed, in order to not destroy the passive layer.

For cleaning the surface the processes brushing, grinding, pickling or blasting (iron-free silica sand or glass spheres) can be used. For brushing only stainless steel brushes are to be used. Pickling of the previously brushed seam area is carried out by dipping and spraying. However, pickling pastes or solutions are often used. After pickling a carefull cleaning with water has to be carried out.

Remark

In quenched condition the material might be slightly magnetizable. The magnetizability increases in the case of a high degree of cold forming.

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Reference

DIN EN 10088-2 : 2014-12	Beuth Verlag GmbH, Postfach, D-10772 Berlin
DIN EN 10088-3 : 2014-12	
DIN EN 10216-5 : 2014-03	
DIN EN 10217-7 : 2005-05	
MB 821 "Properties"	Informationsstelle Edelstahl Rostfrei, Postfach 10 22 05, D-40013 Düsseldorf
MB 822 "The converting of stainless steel"	
DVS data sheet 3203, part 3	Verlag für Schweißen und verwandte Verfahren DVS Verlag GmbH, Postfach 10 19 65, D-40010 Düsseldorf
Laser beam electric arc cutting of stainless steels	Thyssen Lasertechnik GmbH, Aachen u. a.
Laser beam – longitudinal welding of profiles of stainless steel	
Welding filler materials	Böhler Schweisstechnik Deutschland GmbH, Hamm

Important Note

Information given in this data sheet about the condition or usability of materials respectively products are no warranty for their properties, but act as a description.

The information, we give on for advice, comply to the experiences of the manufacturer as well as our own. We cannot give warranty for the results of processing and application of the products.