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Alloyed steel with specified elevated temperature properties

Material Data Sheet

Steel Designation:	Name	Material No.
	16Mo3	**1.5415**

Scope

This data sheet applies for flat products made of steel for pressure purposes, seamless and welded steel tubes with circular diameter for pressure purposes.

Application

16Mo3 is particularly suitable for pipe material for boiler, superheater tubes, hot steam pipes and collector pipes, stove tubes and conduits, heat exchanger and for purposes of the petroleum-refining industry. He can be used in continuous operation up to about 530 °C wall temperature.

Chemical composition (Heat analysis in %)[1)]

Product form	C	Si	Mn	P	S	Al_{total}	N	Cr	Cu	Mo	Ni
C,P,H	0,12-0,20	≤ 0,35	0,40-0,90	≤ 0,025	≤ 0,010	[2)]	≤ 0,012	≤ 0,30	≤ 0,30[3)]	0,25-0,35	≤ 0,30
T_S	0,12-0,20	≤ 0,35	0,40-0,90	≤ 0,025	≤ 0,020	≤ 0,040	≤ 0,012	≤ 0,30	≤ 0,30[4)]	0,25-0,35	≤ 0,30
T_W	0,12-0,20	≤ 0,35	0,40-0,90	≤ 0,025	≤ 0,020	≤ 0,040	-	≤ 0,30	≤ 0,30[4)]	0,25-0,35	≤ 0,30

C = cold-rolled sheet ; H = hot-rolled sheet ; P = hot-rolled plate ; T_S = seamless tubes ; T_W = welded tubes

1) Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser exept for finishing the cast. All appropriate measures shall be taken to prevent the addition from scrap or other materials used in steelmaking of these elements which may affect the mechanical properties and usability.

2) The Al content of the cast shall be determined and given in the inspection document.

3) A lower maximum copper content and/or a maximum sum of copper and tin content, e.g. Cu + 6Sn ≤ 0,33 %, may be agreed upon at the time of enquiry and order, e.g. with regard to hot formability for the grades where only a maximum copper content is specified.

4) Option 2: *In order to faciliate subsequent forming operations, an agreed maximum copper content lower than indicated and an agreed specified maximum tin content shall apply.*

Mechanical properties at room temperature (transverse test pieces)

Product	Usual Deliver condition	Product thickness mm above	Product thickness mm up to	Yield strength R_{eH} N/mm² min.	Tensile strength R_m N/mm²	Elongation A % min.	Impact energy KV J min.
C, H, P	+N[2)]		16	275	440 - 590	22	31
		16	40	270			
		40	60	260			
		60	100	240	430 - 580		
		100	150	220	420 - 570		
		150	250	210	410 - 570		

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(fortgesetzt)

Product	Usual Delivery condition	Wall thickness mm		Upper yield or proof strength R_{eH} or $R_{p0,2}$	Tensile strength R_m	Elongation A		Impact energy[5] KV	
		over	up to	N/mm² min.	N/mm²	% min.		J min.	
T_S	+N[2]		16	280	450 - 600	22[3]	20[4]	40[3][6]	27[4][6]
		16	40	270					
		40	60	260					
		60	100	-					
T_W[1]	+N[2]		16	280	450 - 600	22	20	40[3]	27[4]

1) for T up to 16 mm
2) normalized
3) longitudinal test piece
4) transverse test piece
5) to be demonstrated,if Option 4 and/or 5 is/are determined, if foot note f applies.
6) Option 4: *The impact energy has to be demonstrated.*

Minimum values of the 0.2% yield strength at elevated temperatures

Product	Product / Wall thickness mm		0.2 % Yield strength at a temperature in °C						
	over	up to	200	250	300	350	400	450	500
			N/mm² min.						
C, H, P		16	233	213	194	175	159	147	141
	16	40	228	209	190	172	156	145	139
	40	60	215	200	170	160	150	145	140
	60	100	200	185	165	155	145	140	135
	100	150	190	175	155	145	140	135	130
	150	250	178	163	148	134	121	113	108
T_S		60	224	205	173	159	156	150	146
T_W		16	224	205	173	159	156	-	-

Reference data of strength values for 1 % (plastic) creep strain and creep rupture (informative)

Tempe-rature	Strength of 1 % (plastic) creep strain[1] for		Creep rupture strength[2] for							
	10 000 h	100 000 h	10 000 h		100 000 h		200 000 h		250 000 h	
°C	N/mm²	N/mm²	N/mm²		N/mm²		N/mm²		N/mm²	
	C, H, P	C, H, P	C, H, P	T_S	C, H, P	T_S	C, H, P	T_S	C, H, P	T_S
450	216	167	298	298	239	236	217	218	-	210
460	199	146	273	273	208	205	188	188	-	179
470	182	126	247	247	178	176	159	158	-	148
480	166	107	222	221	148	149	130	129	-	122
490	149	89	196	196	123	124	105	105	-	98

(continued)

Tempe-rature	Strength of 1 % (plastic) creep strain[1] for		Creep rupture strength[2] for							
	10 000 h	100 000 h	10 000 h		100 000 h		200 000 h		250 000 h	
°C	N/mm²	N/mm²	N/mm²		N/mm²		N/mm²		N/mm²	
500	132	73	171	171	101	102	84	84	-	78
510	115	59	147	148	91	83	69	67	-	63
520	99	46	125	125	66	65	55	53	-	50
530	84	36	102	104	53	51	45	42	-	38
540	-	-	-	84	-	40	-	34	-	-
550	-	-	-	64	-	32	-	25	-	-

1) Stress related to the out put cross-section, which leads after 10 000 or 100 000 h to a permanent elongation of 1 %.
2) Stress related to the out put cross-section, which leads after 10 0000, 100 000, 200 000 or 250 000 h to breakage.

Reference data on some physical properties (for guidance only)

Density at 20 °C	Modulus of elastivity kN/mm² at				Thermal conductivity at 20 °C	spec. thermal capacity at 20 °C	spec. electrical resistivity at 20 °C
kg/dm³	20 °C	300 °C	400 °C	500 °C	W/m K	J/kg K	Ω mm²/m
7,85	210	185	175	165	42,5	482	0,13

Linear coefficient of thermal expansion 10^{-6} K^{-1} between 20 °C and

100 °C	200 °C	300 °C	400 °C	500 °C
11,1	12,1	12,9	13,5	13,9

Guidelines for temperatures for hot forming and heat treatment

Hot forming		Heat treatment (normalizing), Microstructure		
Temperature °C	Type of cooling	Temperature °C	Type of cooling	Microstructure
1150 - 850	Air	890 - 950[1]	Air	Ferrite/Perlite

1) When normalizing, after the required temperatures have been attained over the whole cross-section, no further holding is necessary and should be generally avoided.
In certain cases, tempering at 590 – 650°C may be necessary.

Processing / Welding

Standard welding processes for this steel grade are:

TIG-welding
MAG-welding massive wire
Arc welding (E)
Submerged arc welding (SAW)

Process	**Filler metal**	
TIG	Union I Mo	
MAG massive wire	Union I Mo	
MAG cored wire	Union MV Mo	
Arc welding (E)	Phönix SH Schwarz 3TR Phönix SH Schwarz 3K	
SAW	Wire	Powder
	Union S 2 Mo Union S 3 Mo	UV 420 TT UV 420 TT

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This steel can be welded within all thickness ranges according to afore mentioned welding processes considering the general rules of technology by hand and automatically welding. Work pieces have to be preheated on 200 °C at thicknesses > 10 mm.
As filler metal for this steel the mentioned electrodes and wires are recommended.
After welding, for work pieces which depend on the technical rules for pressure equipment, a heat treatment particularly has to be specified. In all other cases stress relieving anneal has to be performed.
When flame cutting larger wall thicknesses the cutting zone should be preheated on approx. 200 °C.

Remark
The material is magnetizable.

References
ThyssenKrupp
DIN EN 10028-2:2009-09
DIN EN 10216-2:2007-10
DIN EN 10217-2:2005-04

Important Hint
Information given in this data sheet about property or applicability of materials respective products is no assurance of characteristics but serve for description.
Information, with which we like to advise you, relate to the experience of the producers and our own. Warranty for the results of the treatment and application of the products cannot be granted.