VDM Metals

VDM® Alloy X-750
Nicrofer 7016 TiNb

Material Data Sheet No. 4023
December 1988 Edition

Nicrofer® 7016 TiNb – alloy X-750

Nicrofer 7016 TiNb is a precipitation hardenable nickel-chromium-iron alloy containing titanium, niobium and aluminium, exhibiting good corrosion resistance at high and low temperature and high strength up to 820 °C (1500 °F).

It can be delivered in the solution-treated or precipitation-hardened condition.

Nicrofer 7016 TiNb is characterized by:

- high tensile strength up to 600 °C (1100 °F)
- high creep and rupture strength up to 820 °C (1500 °F)
- high oxidation resistance up to 980 °C (1800 °F)
- excellent mechanical properties in cryogenic environments
- good corrosion resistance at high and low temperatures and high resistance to stress corrosion cracking
- good welability by resistance and fusion processes

Designations and standards

Country National standards	Material designation	Specification							
		Chemical composition	Tube and pipe		Sheet and plate	Rod and bar	Strip	Wire	Forgings
			seamless	welded					
D	**W.-Nr. 2.4669** NiCr15Fe7TiAl								
F AFNOR	NC15TNbA								
UK BS									
USA ASTM ASME AMS	UNS N07750		5582		5542 5598	B 637 SB 637 5667 5668 5669 5670 5671 5741 5749	5542 5598	5698 5699	B 637 SB 637 5667 5668 5670 5671 5747 5749
ISO	NiCr15Fe7Ti2Al								

Table 1 – Designations and standards.

Chemical composition

	Ni	Cr	Fe	C	Mn	Si	Cu	Ti	Co	Nb	Al	S
min.	70.0	14.0	5.0					2.25		0.70	0.40	
max.		17.0	9.0	0.08	1.00	0.50	0.50	2.75	(1.0)	1.20	1.00	0.010

Table 2 – Chemical composition (wt.-%).

Physical properties

Density	8.3 g/cm³	0.30 lb/in.³
Melting range	1395– 1430 °C	2540 – 2600 °F
Permeability at 20 °C/68 °F (RT)	1.0035	
Curie temperature age hardned	-125 °C	-193 °F

Temperature (T)		Specific heat		Thermal conductivity		Electrical resistivity		Modulus of elasticity		Coefficient of thermal expansion between room temperature and T	
°C	°F	J / kg K	Btu / lb °F	W / m K	Btu in. / ft² h °F	µ Ω cm	Ω circ mil / ft	kN / mm²	10³ ksi	10⁻⁶ / K	10⁻⁶ / °F
0	32										
20	**68**	430	0.103	12.0	83	121	731	214	31.0		
93	**200**		0.109		89		737		30.0		7.0
100	212	460		13.0		123		206		12.9	
200	392	480		14.1		124		202		13.4	
204	**400**		0.116		98		748		29.2		7.1
300	572	500		17.3		126		196		14.0	
316	**600**		0.120		109		760		28.3		7.5
400	752	520		17.9		127		190		14.5	
427	**800**		0.125		120		770		27.4		7.8
500	932	535		18.5		129		185		14.8	
538	**1000**		0.130		131		783		26.7		8.1
600	1112	560		19.9		131		180		15.4	
649	**1200**		0.137		143		786		25.5		8.4
700	1292	600		21.5		130		171		16.3	
760	**1400**		0.151		154		775		24.0		8.8
800	1472	660		22.8		128		161		17.1	
871	**1600**		0.171		164		761		22.1		9.3
900	1652	750		24.0		125		149		17.8	
982	**1800**				173				20.0		9.8
1000	1832			25.3				135			

Table 3 – Typical physical properties at room temperature (or as indicated).

AMS No.	Heat-treatment No.	Form	Dimensions mm
5542	5	Strip	< 0.25
			0.25 – < 0.60
			≥ 0.60
		Sheet	0.25 – 0.60
			> 0.60 – 3.20
			> 3.20 – 6.35
		Plate	4.75 – 100
5598	2	Strip	< 0.25
			0.25 – < 0.60
			≥ 0.60
		Sheet	0.25 – 0.60
			> 0.60 – 3.20
			> 3.20 – 6.35
		Plate	4.75 – 100
5667	4	Bar, forging	≤ 100
			> 100
5668	1	Ring, bar, forging	≤ 250
5669	2	Bar	< 60
			60 – < 100
			≥ 100
5670	2	Bar, forging, ring	< 60
			60 – < 100
			≥ 100
5671	2	Bar, forging, ring	≤ 60 long transv.
			> 60 – 100 long transv.
			> 100
5747	2	Bar, forging, ring	< 60
			60 – < 100
			≥ 100
5582	5	Tubing	< 3.20 OD ≤ 0.4 s
			≥ 3.20 OD > 0.4 s
5698	8	Spring wire	≤ 0.60
			> 0.60 – 12.7
5699	see right	Wire	> 0.3 – 6.35 round square
			> 6.35 – 10.6
			> 10.6 – 15.9

Table 4a – Minimum mechanical properties at room temperature, metric values.

Nicrofer® 7016 TiNb – alloy X-750

Mechanical properties
The following properties are applicable to Nicrofer 7016 TiNb in the hot and cold formed, solution-treated or solution-treated and precipitation-hardened condition, and the indicated size ranges. Material outside these size ranges (see availability) with agreed properties are subject to special enquiry.

Annealed					Precipitation hardened				
Tensile strength N/mm²	0.2 % Yield strength N/mm²	Elongation A_5 %	Brinell hardness HB	Grain size µm	Tensile strength N/mm²	0.2 % Yield strength N/mm²	Elongation A_5 %	Reduction of area Z %	Brinell hardness HB
965				as agreed	1035				
895		20		≤ 152	1070				> 300
as agreed		as agreed					15		
965		30							
895	415	40		≤ 152	1140	725	20		> 315
895	450								
					1070	690	20		
965				as agreed	1070				
930		18		≤ 64	1100		12		> 300
as agreed									
930	515	30							
930	515	35		≤ 64	1170	795	18		> 315
				as agreed	1100	725	18		> 300
			≤ 300		1140	725	20	25	300 – 360
					1100	690	15	17	
					860	550	8	8	260 – 340
					975				
					1170	795	18	25	315 – 400
							15	20	
					as agreed				
					1170	795	18	18	300 – 400
							15	15	
					as agreed	as agreed			
					1170	795	18	18	300 – 400
					1140	760	15	15	
					1170	795	15	15	
					1100	725	12	12	
					as agreed	as agreed			
			≤ 320		1170	795	18	18	300 – 380
							15	15	
as agreed									
965	550	30/35		≤ 152	1070	690	15/20		
< 1035					> 1070				
900 – 1140					> 1140				

As recieved	After heat treatment	
Tensile strength N/mm²	No. 9 Tensile strength N/mm²	No. 1 Tensile strength N/mm²
1310	1520	1035
1210		
1100	1380	1000
	1240	

Mechanical properties
The following properties are applicable to Nicrofer 7016 TiNb in the hot and cold formed, solution-treated or solution-treated and precipitation-hardened condition, and the indicated size ranges. Material outside these size ranges (see availability) with agreed properties are subject to special enquiry.

AMS No.	Heat-treatment No.	Form	Dimensions mm	Annealed: Tensile strength N/mm²	Annealed: 0.2 % Yield strength N/mm²	Annealed: Elongation A_5 %	Annealed: Brinell hardness HB	Annealed: Grain size µm	Precipitation hardened: Tensile strength N/mm²	Precipitation hardened: 0.2 % Yield strength N/mm²	Precipitation hardened: Elongation A_5 %	Precipitation hardened: Reduction of area Z %	Precipitation hardened: Brinell hardness HB
5542	5	Strip	< 0.25	965				as agreed	1035				> 300
			0.25 – < 0.60	895		20		≤ 152	1070				
			≥ 0.60	as agreed		as agreed					15		
		Sheet	0.25 – 0.60	965		30							
			> 0.60 – 3.20	895	415	40		≤ 152	1140	725	20		> 315
			> 3.20 – 6.35	895	450								
		Plate	4.75 – 100						1070	690	20		
5598	2	Strip	< 0.25	965				as agreed	1070				
			0.25 – < 0.60	930		18		≤ 64	1100		12		> 300
			≥ 0.60	as agreed									
		Sheet	0.25 – 0.60	930	515	30							
			> 0.60 – 3.20	930	515	35		≤ 64	1170	795	18		> 315
			> 3.20 – 6.35										
		Plate	4.75 – 100					as agreed	1100	725	18		> 300
5667	4	Bar, forging	≤ 100				≤ 300		1140	725	20	25	300 – 360
			> 100						1100	690	15	17	
5668	1	Ring, bar, forging	≤ 250						860	550	8	8	260 – 340
									975				
5669	2	Bar	< 60						1170	795	18	25	315 – 400
			60 – < 100								15	20	
			≥ 100						as agreed				
5670	2	Bar, forging, ring	< 60						1170	795	18	18	300 – 400
			60 – < 100								15	15	
			≥ 100						as agreed	as agreed			
5671	2	Bar, forging, ring	≤ 60 long						1170	795	18	18	300 – 400
			≤ 60 transv.						1140	760	15	15	
			> 60 – 100 long						1170	795	15	15	
			> 60 – 100 transv.						1100	725	12	12	
			> 100						as agreed	as agreed			
5747	2	Bar, forging, ring	< 60				≤ 320		1170	795	18	18	300 – 380
			60 – < 100								15	15	
			≥ 100										
5582	5	Tubing	< 3.20 OD ≤ 0.4 s	as agreed									
			≥ 3.20 OD > 0.4 s	965	550	30/35		≤ 152	1070	690	15/20		
5698	8	Spring wire	≤ 0.60	< 1035					> 1070				
			> 0.60 – 12.7	900 – 1140					> 1140				

				As recieved		After heat treatment		
				Tensile strength N/mm²		No. 9 Tensile strength N/mm²		No. 1 Tensile strength N/mm²
5699	see right	Wire	> 0.3 – 6.35 round	1310		1520		1035
			square	1210				
			> 6.35 – 10.6	1100		1380		1000
			> 10.6 – 15.9			1240		

Table 4a – Minimum mechanical properties at room temperature, metric values.

AMS No.	Heat-treatment No.	Form	Dimensions inches	Tensile strength ksi	0.2 % Yield strength ksi	Annealed Elongation A_5 %	Brinell hardness HB	Grain size ASTM No.
5542	5	Strip	< 0.010	140				as agreed
			0.010 – < 0.025	130		20		
			≥ 0.025	as agreed		as agreed		
		Sheet	0.010 – 0.024	140		30		
			> 0.024 – 0.125	130	60	40		
			> 0.125 – 0.250	130	65			
		Plate	0.187 – 4.0					
5598	2	Strip	< 0.010	140				as agreed
			0.010 – < 0.025	135		18		
			≥ 0.025	as agreed				
		Sheet	0.010 – 0.024	135	75	30		
			> 0.024 – 0.125	135	75	35		
			> 0.125 – 0.250					
		Plate	0.187 – 4.0					as agreed
5667	4	Bar, forging	≤ 4.0				≤ 300	
			> 4.0					
5668	1	Ring, bar, forging	≤ 10.0					
5669	2	Bar	< 2.50					
			2.50 – < 4.0					
			≥ 4.0					
5670	2	Bar, forging, ring	< 2.50					
			2.50 – < 4.0					
			≥ 4.0					
5671	2	Bar, forging, ring	≤ 2.50 long.					
			≤ 2.50 transv.					
			2.50 – 4.0 long.					
			2.50 – 4.0 transv.					
			> 4.0					
5747	2	Bar, forging, ring	< 2.50				≤ 320	
			2.50 – < 4.0					
			≥ 4.0					
5582	5	Tubing	< 0.125 OD ≤ 0.015 s	as agreed				
			≥ 0.125 OD > 0.015 s	140	80	30/35		
5698	8	Spring wire	≤ 0.025	< 150				
			> 0.025 – 0.50	130 – 165				
				As received Tensile strength ksi				
5699	see right	Wire	0.012 – 0.250 round	190				
			square	175				
			> 0.250 – 0.418	160				
			> 0.418 – 0.625					

Table 4b – Minimum mechanical properties at room temperature, imperial values.

Precipitation hardened				
Tensile strength ksi	0.2 % Yield strength ksi	Elongation A_5 %	Reduction of area Z %	Brinell hardness HB
150				
155		15		> 300
165	105	20		> 315
155	100	20		
155				
160		12		> 300
170	115	18		> 315
160	105	18		> 300
165	105	20	25	300 – 360
160	100	15	17	
125	80	8	8	260 – 340
140				
170	115	18	25	315 – 400
		15	20	
as agreed				
170	115	18	18	300 – 400
		15	15	
as agreed	as agreed			
170	115	18	18	300 – 400
165	110	15	15	
170	115	15	15	
160	105	12	12	
as agreed	as agreed			
170	115	18	18	300 – 380
		15	15	
155	100			
> 155				
> 165				

After heat treatment	
No. 9 Tensile strength ksi	No. 1 Tensile strength ksi
220	150
200	145
180	

AMS No.	Heat-treatment No.	Form	Dimensions inches	Annealed: Tensile strength ksi	Annealed: 0.2 % Yield strength ksi	Annealed: Elongation A_5 %	Annealed: Brinell hardness HB	Annealed: Grain size ASTM No.	Precipitation hardened: Tensile strength ksi	Precipitation hardened: 0.2 % Yield strength ksi	Precipitation hardened: Elongation A_5 %	Precipitation hardened: Reduction of area Z %	Precipitation hardened: Brinell hardness HB
5542	5	Strip	< 0.010	140				as agreed	150				> 300
			0.010 – < 0.025	130		20			155		15		
			≥ 0.025	as agreed		as agreed							
		Sheet	0.010 – 0.024	140		30			165	105	20		> 315
			> 0.024 – 0.125	130	60	40							
			> 0.125 – 0.250	130	65								
		Plate	0.187 – 4.0						155	100	20		
5598	2	Strip	< 0.010	140				as agreed	155				
			0.010 – < 0.025	135		18			160		12		> 300
			≥ 0.025	as agreed									
		Sheet	0.010 – 0.024	135	75	30			170	115	18		> 315
			> 0.024 – 0.125	135	75	35							
			> 0.125 – 0.250										
		Plate	0.187 – 4.0					as agreed	160	105	18		> 300
5667	4	Bar, forging	≤ 4.0				≤ 300		165	105	20	25	300 – 360
			> 4.0						160	100	15	17	
5668	1	Ring, bar, forging	≤ 10.0						125	80	8	8	260 – 340
									140				
5669	2	Bar	< 2.50						170	115	18	25	315 – 400
			2.50 – < 4.0								15	20	
			≥ 4.0						as agreed				
5670	2	Bar, forging, ring	< 2.50						170	115	18	18	300 – 400
			2.50 – < 4.0								15	15	
			≥ 4.0						as agreed	as agreed			
5671	2	Bar, forging, ring	≤ 2.50 long.						170	115	18	18	300 – 400
			transv.						165	110	15	15	
			2.50 – 4.0 long.						170	115	15	15	
			transv.						160	105	12	12	
			> 4.0						as agreed	as agreed			
5747	2	Bar, forging, ring	< 2.50				≤ 320		170	115	18	18	300 – 380
			2.50 – < 4.0								15	15	
			≥ 4.0										
5582	5	Tubing	< 0.125 OD ≤ 0.015 s	as agreed									
			≥ 0.125 OD > 0.015 s	140	80	30/35			155	100			
5698	8	Spring wire	≤ 0.025	< 150					> 155				
			> 0.025 – 0.50	130 – 165					> 165				

				As received	After heat treatment		
					No. 9		No. 1
				Tensile strength ksi	Tensile strength ksi		Tensile strength ksi
5699	see right	Wire	0.012 – 0.250 round	190	220		150
			square	175			
			> 0.250 – 0.418	160	200		145
			> 0.418 – 0.625		180		

Table 4b – Minimum mechanical properties at room temperature, imperial values.

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Bending test for sheet in the solution-treated condition without cracking:

equal to the thickness up to 1.27 mm (0.05 in.)
of twice the thickness > 1.27 to 6.35 mm (> 0.05 to 0.250 in.)

Form	Heat treat-ment	Testing temperature		Tensile strength		0.2 % Yield strength		Elong. A_5	Stress rupture values Stress		Time	Elong. A_5	acc. to
		C°	°F	N/mm²	ksi	N/mm²	ksi	%	N/mm²	ksi	h	%	
Bar, forg., ring	1	730	1350						360	52.5	23	≥ 5	AMS 5668
Bar, forgings	1	730	1350						310	45	100	≥ 5	ASTM-B 637
Forgings	1	820	1500						260	38	100	≥ 5	
Rod, bar	0	820	1500						260	38	100	≥ 5	
Tubing	5	705	1300	1070	155	690	100	15/20					AMS 5582
Tubing	5	730	1350						310	45	≥ 23		
Sheet	5	705	1300	1140	165	725	105	20					AMS 5542
Plate				1070	155	690	100	20					
Strip				1070	155	690	100	15					

Table 5 – Minimum mechanical properties at elevated temperatures after precipitation hardening.

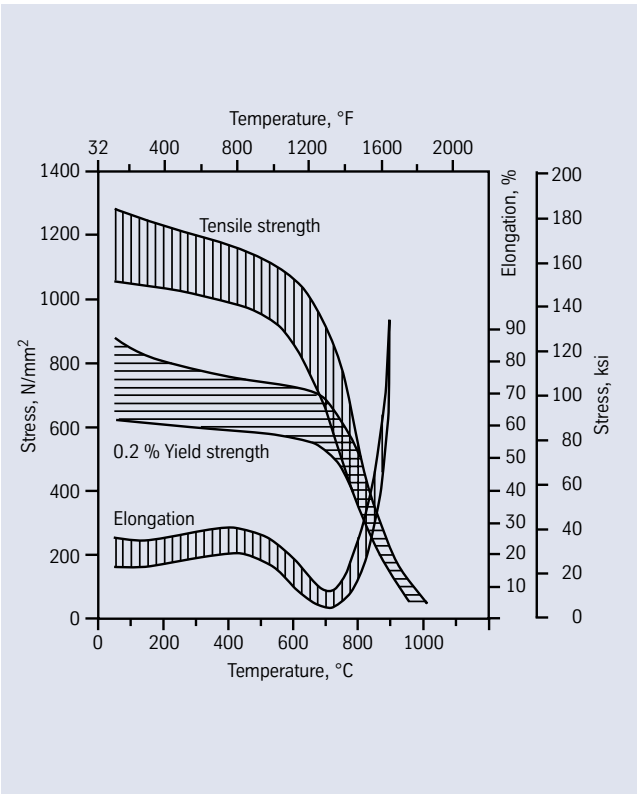

Fig. 1 – Typical short-time properties of different precipitation-hardened products at elevated temperatures.

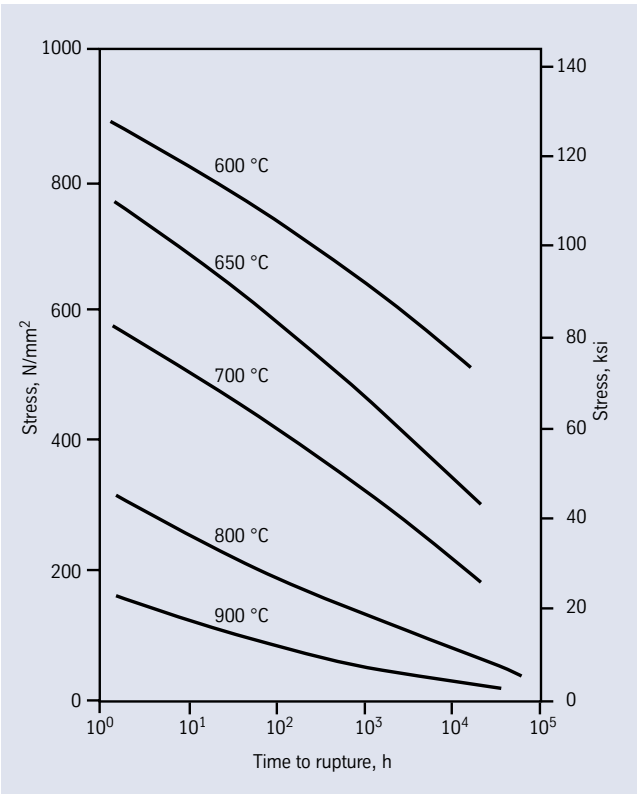

Fig. 2 – Typical high-temperature creep-rupture strength of bars after heat treatment No. 1.

Metallurgical structure
Nicrofer 7016 TiNb has an austenitic structure. The excellent mechanical strength results from precipitation hardening of the matrix gamma phase (γ) by formation of gamma prime (γ') phase together with some carbides. By a double ageing heat treatment a dublex gamma prime (γ') structure is formed. Several heat treatments are in use and are described in a special section, see Fig. 3 and Table 6 (°C) and Table 7 (°F).

Corrosion resistance
Nicrofer 7016 TiNb shows excellent general corrosion resistance at high and low temperatures and high resistance to stress-corrosion cracking. Oxidation resistance up to 980 °C (1800 °F) is remarkably high.

Applications
Due to its high temperature strength up to 820 °C (1500 °F) and its excellent corrosion resistance, Nicrofer 7016 TiNb finds a wide range of applications; for example:

- industrial and aircraft turbines
- rockets
- cryogenic purposes
- pressure vessels
- extrusion and forming tools
- nuclear reactors
- springs, bellows and bolts

Fabrication and heat treatment
Nicrofer 7016 TiNb can be hot and cold formed, joined and machined. Suitable equipment and forming in the solution treated condition are advantageous.

Heating
It is very important that the workpiece be clean and free from any contaminant before and during heating.

Nicrofer 7016 TiNb may become embrittled if heated in the presence of contaminants such as sulphur, phosphorus, lead and other low-melting-point metals. Sources of contamination include marking and temperature-indicating paints and crayons, lubricating grease and fluids, and fuels. Fuels must be low in sulphur; e.g. natural and liquefied petroleum gases should contain less than 0.1 % by mass and town gas 0.25 g/m³ maximum of sulphur. Fuel oils containing no more than 0.5 % by mass of sulphur are satisfactory.

Electric furnaces are desirable due to close control of temperature and freedom from contamination. Gas-fired furnaces are acceptable if impurities are at low levels.

The furnace atmosphere should be neutral to slightly reducing and must not fluctuate between oxidizing and reducing. Flame impingement on the metal must be avoided.

Hot working
Nicrofer 7016 TiNb may be hot-worked in the range 980 to 1200 °C (1800 to 2200 °F). Cooling should be by water quenching or as fast as possible. Localised reheating is not recommended.

Annealing after hot working is recommended to ensure maximum corrosion resistance.

For hot working, the material may be charged into the furnace at maximum working temperature.

During the final hot working with min. 20 % reduction the temperature must not exceed 1100 °C (2000 °F) to ensure high mechanical properties.

Cold working
Cold working should be carried out on solution-annealed material. Nicrofer 7016 TiNb has a much higher work-hardening rate than austenitic stainless steel and the forming equipment must be designed accordingly.

When cold working is performed, interstage annealing may become necessary.

Heat treatment
Various solution and ageing treatments are used to produce required properties. Long ageing times are necessary to develop optimum mechanical properties in Nicrofer 7016 TiNb.

For service up to 600 °C (1100 °F) with high tensile strength, direct ageing after forming or annealing is usual.

For optimum long-time properties, high creep and rupture strength and good oxidation resistance, a solution treatment followed by double ageing is recommended.

Typical heat-treatment combinations are given in Fig. 3, Table 6 (°C) and Table 7 (°F).

During any heating operation, the precautions outlined earlier regarding cleanlines must be observed.

Descaling
Oxides of Nicrofer 7016 TiNb and discoloration adjacent to welds, are more adherent than on stainless steels. Grinding with very fine abrasive belts or discs is recommended.

Before pickling in a nitric/hydrofluoric acid mixture, oxides must be broken up by grit-blasting or by pretreatment in a fused salt bath.

Machining
Nicrofer 7016TiNb should be machined in the annealed condition. The alloy's high work-hardening rate should be considered, i.e. only low surface cutting speeds are possible compared with low-alloyed standard austenitic stainless steel. Tools should be engaged at all times. Heavy feeds are important in getting below the work-hardened 'skin'.

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Joining

The precipitation-hardening alloy Nicrofer 7016 TiNb can be welded by all conventional processes, including gas tungsten-arc (GTAW/TIG), gas metal-arc (GMAW/MIG) and shielded metal-arc welding (SMAW/MMA). Low heat input is necessary.

Prior to welding, material should be in the annealed condition, clean and free from scale, grease, marking paints etc. A zone approximately 25 mm (1 in.) wide on each side of the joint should be ground to bright metal.

Interpass temperature should be 80 to max. 120 °C (175 to 250 °F).

Nicrofer 7016 TiNb should be annealed or solution treated prior to welding. A post-weld heat treatment is required before ageing.

For TIG and MIG welding the use of Nicrofer S 7020 alloy electrodes (W.-Nr. 2.4806, SG-NiCr20Nb, AWS A 5.14 ERNiCrFe-7), is mandatory.

For shielded metal-arc welding (MMA) the corresponding covered electrode (W.-Nr. 2.4648, EL-NiCr19Nb) is recommended.

For optimum corrosion resistance argon-arc welding, i.e. GTAW is preferred.

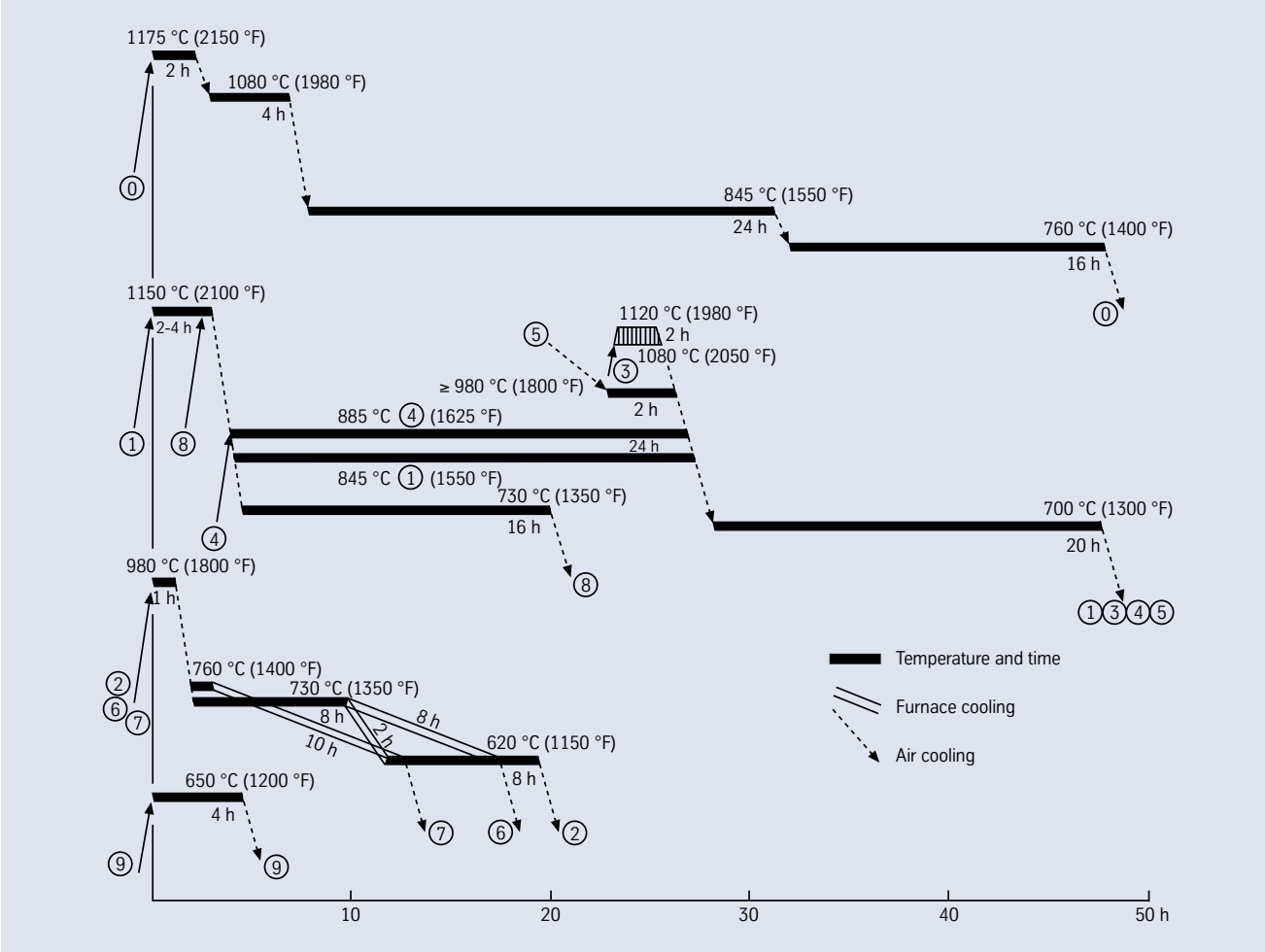

Fig. 3 – Heat-treatment combinations.

No.	anneal	solution	equalise	stabilise	precipitation harden	according to	
						ASTM	AMS
0	1175 °C 2h AC	1080 °C 4h AC		845 °C 24h AC	760 °C 16h AC	B 637	–
1		1150 °C 2 – 4h AC		845 °C 24h AC	700 °C 20h AC	B 637	5668
3		1080 – 1120 °C 2h AC			700 °C 20h AC	B 637	–
4			885 °C 24h AC		700 °C 20h AC	–	5667
5	≥ 980 °C				700 °C 20h AC	–	5542 5582
8		1150 °C 15’			730 °C 16h AC	–	5698
2		980 °C ~ 1h AC			730 °C 8h FC 2h to 620 °C 8h AC	B 637	5598 5669
6		980 °C 1h AC			730 °C 8h FC 10h to 620 °C AC	–	5670 5671 5747
7		980 °C 1h AC			760 °C 1h FC 10h to 620 °C AC	–	–
9					650 °C 4h	–	5699

Table 6 – Heat-treatment combinations Nos. 0 – 9 (C°).

No.	anneal	solution	equalise	stabilise	precipitation harden	according to	
						ASTM	AMS
0	2150 °F 2h AC	1980 °F 4h AC		1550 °F 24h AC	1400 °F 16h AC	B 637	–
1		2100 °F 2 – 4h AC		1550 °F 24h AC	1300 °F 20h AC	B 637	5668
3		1980 – 2050 °F 2h AC			1300 °F 20h AC	B 637	–
4			1625 °F 24h AC		1300 °F 20h AC	–	5667
5	≥ 1800 °F				1300 °F 20h AC	–	5542 5582
8		2100 °F 15’			1350 °F 16h AC	–	5698
2		1800 °F ~ 1h AC			1350 °F 8h FC 2h to 1150 °F 8h AC	B 637	5598 5669
6		1800 °F 1h AC			1350 °F 8h FC 10h to 1150 °F AC	–	5670 5671 5747
7		1800 °F 1h AC			1400 °F 1h FC 10h to 1150 °F AC	–	–
9					1200 °F 4h	–	5699

Table 7 – Heat-treatment combinations Nos. 0 – 9 (F°).

Nicrofer® 7016 TiNb – alloy X-750

Availability

Nicrofer 7016 TiNb is available in the following standard mill product forms.

Sheet and plate

(for cut-to-length availability, refer to strip)

Conditions:
hot or cold rolled (hr, cr),
solution treated or precipitation hardened and pickled

Thickness mm	hr / cr	Width* mm	Length* mm
≥ 1.20 – < 1.50	cr	2000	6000
≥ 1.50 – < 6.0	cr	2000	5000
≥ 6.0 – < 10.0	cr	2000	4000**
≥ 6.0 – < 10.0	hr	2000	4000**
≥ 10.0 – < 20.0	hr	2000	2500**
≥ 20.0*	hr		

inches		inches	inches
≥ 0.047 – < 0.060	cr	80	240
≥ 0.060 – < 1/4	cr	80	240
≥ 1/4 – < 3/8	cr	80	160**
≥ 1/4 – < 3/8	hr	80	160**
≥ 3/8 – < 3/4	hr	80	100**
≥ 3/4*	hr		

*larger sizes subject to special enquiry
**depending on piece weight

Discs and rings

Conditions:
hot rolled or forged,
solution treated or precipitation hardened,
pickled or machined

Product	Weight kg	Thickness mm	O. D.* mm	I. D. mm
Disc	≤ 2000	≤ 130	≤ 2000	–
Ring	≤ 2000	≤ 200	≤ 2500	on request

	lb	inches	inches	inches
Disc	≤ 4400	≤ 5	≤ 80	–
Ring	≤ 4400	≤ 8	≤ 100	on request

*larger sizes subject to special enquiry

Rod and bar

Conditions:
forged, rolled, drawn,
solution treated or precipitation hardened,
pickled, machined, peeled or ground

Product	forged* mm	rolled* mm	drawn* mm
round d	≤ 200	15 – 75	12 – 65
square a	40 – 200	15 – 100	12 – 65
flat a x b	40 – 80 x 200 – 600	5 – 20 x 120 – 600	10 – 20 x 30 – 80
hexagonal s	40 – 80	13 – 50	12 – 60

	inches	inches	inches
round d	≤ 8	5/8 – 3	1/2 – 2 1/2
square a	1 5/8 – 8	5/8 – 4	1/2 – 2 1/2
flat a x b	1 5/8 – 3 1/8 x 8 – 24	3/16 – 3/4 x 5 – 24	3/8 – 3/4 x 1 1/4 – 3 1/8
hexagonal s	1 5/8 – 3 1/8	1/2 – 2	1/2 – 2 3/8

*larger sizes subject to special enquiry

Forgings

Shapes other than discs, rings, rod and bar are subject to special enquiry.

Strip*
Conditions:
cold rolled,
solution treated and pickled or bright annealed**

Thickness mm	Width mm	Coil i. d. mm				
0.04 – ≤ 0.10	30 – 120	100	300			
> 0.10 – ≤ 0.20	4 – 200		300	400		
> 0.20 – ≤ 0.25	4 – 400		300	400		
> 0.25 – ≤ 0.60	5 – 635		300	400		
> 0.60 – ≤ 1.0	8 – 635			400	500	
> 1.0 – ≤ 2.0	15 – 635			400	500	600
> 2.0 – 3.0	25 – 635			400	500	600

inches	inches	inches				
0.0016 – ≤ 0.004	1.20 – 5	4	12			
> 0.004 – ≤ 0.008	0.16 – 8		12	16		
> 0.008 – ≤ 0.010	0.16 – 16		12	16		
> 0.010 – ≤ 0.024	0.20 – 25		12	16		
> 0.024 – ≤ 0.04	0.32 – 25			16	20	
> 0.04 – ≤ 0.08	0.60 – 25			16	20	24
> 0.08 – 0.12	1.0 – 25			16	20	24

*cut-to-length available in lengths from 500 to 3000 mm (20 to 120 in.)
**maximum thickness 3.0 mm (1/8 in.)

Wire
Conditions:
bright drawn, 1/4 hard to hard
bright annealed

Dimensions:
0.01 – 12.7 mm (0.0004 – 1/2 in.) diameter
in coils, pail-packs, on spools and spiders

Welding filler metals
Suitable welding rods and wire are available in standard sizes.

Seamless tube and pipe
Using ThyssenKrupp VDM cast materials seamless tubes and pipes are produced and available from DMV STAINLESS SAS, Tour Neptune, F-92086 Paris, La Défense Cedex (Fax: +33-1-4796 8141; Tel.: +33-1-4796 8140; E-mail: dmv-hq@dmv-stainless.com).

Welded tube and pipe
Welded tubes and pipes are obtainable from qualified manufacturers using ThyssenKrupp VDM semi-fabricated products.

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