VDM Metals

VDM® Alloy 20
Nicrofer 3620 Nb

Material Data Sheet No. 4017
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Nicrofer® 3620 Nb - alloy 20

Nicrofer 3620 Nb is a low carbon, niobium stabilised austentic nickel-iron-chromium alloy with alloying additions of copper and molybdenum.

Nicrofer 3620 Nb is characterized by:

- excellent resistance to sulphuric and phosphoric acids
- good resistance to intergranular corrosion
- very good resistance to chloride-ion induced stress-corrosion cracking
- good resistance to pitting and crevice corrosion
- good mechanical properties at both ambient and elevated temperatures, up to approximately 500 °C (930 °F).

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 DIN VdTÜV-Wbl.	W.-Nr. 2.4660 NiCr20CuMo								
F AFNOR									
UK BS									
USA ASTM ASME ASME Code Case AMS	UNS N08020		B 729	B464 B468 B474 SB464 SB468	B463 SB463	B472 B473 SB473	B463 SB463	B471 B473 B475	B462 SB462
ISO	FeNi35Cr20Cu4Mo2								

Table 1 – Designations and standards.

Chemical composition

	Ni	Cr	Fe	C	Mn	Si	Cu	Mo	Nb+Ta	P	S
min.	32	19.0	bal.				3.0	2.0	8 x C		
max.	38	21.0		0.07	2.0	1.0	4.0	3.0	1.0	0.045	0.035

Table 2 – Chemical composition (wt.-%) acc. to UNS N08020

Physical properties

Density Melting range	8.1 g/cm³	0.29 lb/in.³
Permeability at 20 °C/68 °F (RT)	1380 – 1420 °C	2520 – 2600 °F
	< 1.002	

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	kN/mm²	10³ ksi	10⁻⁶/K	10⁻⁶/°F
20	68	456	0.109	11.5	80	107	644	202	29.3		
93	200		0.111		89		662		28.7		8.3
100	212	466		13.0		110		198		15.0	
200	392	476		14.8		113		192		15.6	
204	400		0.114		103		680		27.8		8.8
300	572	485		16.5		116		185		16.0	
316	600		0.116		117		701		26.7		8.9
400	752	492		18.2		119		179		16.4	
427	800		0.118		130		719		25.7		9.2
500	932	500		19.8		121		172		16.7	
538	1000		0.120		142		734		24.5		9.4
600	1112	508		21.5		123		164		17.1	
649	1200		0.122		154		746		23.2		9.6
700	1292	(515)		(23.0)		(125)		(157)		(17.4)	

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

Nicrofer® 3620 Nb – alloy 20

Mechanical properties

The following mechanical properties are applicable to Nicrofer 3620 Nb – alloy 20 in the stabilized-annealed condition.

Temperature (T)		Yield strength $R_{p0.2}$		Yield strength $R_{p1.0}$		Tensile strength R_m		Elongation A_5	Hardness Brinell
°C	°F	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi	%	HB max.
20	68	240	35	280	40.6	550	80	30	≤ 217
93	200		30.5		35.8		75.6		
100	212	210		250		520		30	
149	300		28.3		34.1		73.2		
150	302	195		235		505		30	
200	392	180		220		495		30	
212	400		26.1		31.9		71.5		
250	482	170		210		480		30	
260	500		24.2		29.9		69.2		
300	572	160		200		470		30	
316	600		22.5		28.3		66.7		

Table 4 – Minimum mechanical properties of Nicrofer 3620 Nb – alloy 20 (plate thickness up to 25 mm [1 in.]).

Temperature		Maximum allowable stress			
°C	°F	N/mm²		ksi	
		1)	2)		2)
38	100			20.0	20.0
93	200			20.0	20.0
100	212	137	138		
149	300			19.8	19.9
200	392	129	134		
204	400			18.7	19.4
260	500			18.2	19.3
300	572	121	132		
316	600			17.5	19.2
343	650			17.4	19.2
371	700			17.3	19.2
399	750			17.0	19.1
400	752	117	131		
427	800			16.8	19.1

[1] values determined by interpolaton [2] conditional stress values (see below)

Table 5 – Maximum allowable stress values in tension according to ASME UNF-23.3, SB 463.

The higher conditional stress values of up to 90 % of the yield strength at temperature may be used for applications in which slightly greater deformation is acceptable. These stresses may result in dimensional changes due to permanent strain and are not recommended for flanges of gasketed joints.

Metallurgical structure

Nicrofer 3620 Nb has a face-centred cubic structure. The balanced chemical composition and optimum annealing temperature promote the formation of niobium carbides and ensure that the corrosion resistance is not impaired by sensitisation.

Corrosion resistance

Nicrofer 3620 Nb has excellent corrosion resistance to sulphuric, phosphoric and organic acids and to aqueous solutions of their salts. Resistance to nitric acid is also good.

Due to the controlled chemical composition, the alloy also has excellent resistance to such forms of corrosion as intergranular corrosion and stress corrosion. The molybdenum content ensures good resistance to pitting and crevice corrosion.

Optimum corrosion resistance can only be obtained if the material is in the correct metallurgical condition and clean.

Applications

Nicrofer 3620 Nb is used in a wide variety of applications up to temperatures of approximately 500 °C (930 °F).

Typical applications are:

- equipment for the manufacture of sulphuric acid and for processes based on sulphuric acid
- extraction columns in the production of amines and the processing of pharmaceuticals
- production of plastics and synthetic fibres
- equipment for food processing to protect against contamination

Fabrication and heat treatment

Nicrofer 3620 Nb is readily fabricated by the usual industrial processes. Hot and cold working, however, require high-power machines, owing to the high strength of the material.

The weldability of Nicrofer 3620 Nb is excellent. Joining can be performed by all the conventional welding processes.

Heating

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

Nicrofer 3620 Nb 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 oxidising and must not fluctuate between oxidising and reducing. Flame impingement on the metal must be avoided.

Hot working

Nicrofer 3620 Nb may be hot-worked in the range 1150 to 900 °C (2100 to 1650 °F). The final hot-working temperature must not exceed 950 °C (1740 °F). Cooling should be by water quenching or as fast as possible.

Annealing after hot working is required to ensure maximum corrosion resistance and an optimum microstructure.

For hot working, the material may be charged into the furnace at maximum working temperature. After soaking for the required time the material should be withdrawn immediately and worked within the specifed range. If the metal temperature falls below the minimum working temperature, it must be reheated.

Cold working

Cold working should be carried out on annealed material. Nicrofer 3620 Nb has a work-hardening rate similar to that of austenitic stainless steel and the forming equipment must be adapted accordingly.

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

After cold reductions of more than 15 %, a final stabilising anneal is required before use.

Heat treatment

Soft or stabilising annealing should be carried out in the temperature range 920 to 960 °C (1690 to 1760 °F), preferably at about 950 °C (1740 °F). Water quenching or rapid air cooling is recommended for thicknesses above about 3 mm (1/8 in.) and is essential for maximum corrosion resistance.

Stress-relief annealing may be performed at temperatures up to 540 °C (1000 °F).

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

Descaling

Oxides of Nicrofer 3620 Nb 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/hydroflouric acid mixture, oxides must be broken up by grit-blasting, fine grinding or by pretreatment in a fused salt bath.

Machining

Nicrofer 3620 Nb should be machined in annealed condition. The alloy's high work-hardening rate should be considered, i.e. only low surface cutting speeds are possible compared with low-alloy standard austenitic stainless steel. Tools should be engaged at all times. Heavy feeds are important in getting below the work-hardened 'skin'.

Joining

Nicrofer 3620 Nb can be welded by all the conventional methods. Proven welding processes are:
GTAW (TIG), GMAW (MIG), Plasma, PHW, SMAW.
Pulsed arc welding is the preferred technique.

Prior to welding, material should be in 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. Sometimes tarnishing can be removed by brushing the joint in the warm condition.

Low heat input is necessary. The interpass temperature should not exceed 120 °C (250 °F).

Neither pre- nor post-weld heat treatment is required.

Nicrofer® 3620 Nb – alloy 20

The following welding products are recommended:

GTAW, GMAW	Nicrofer S 6020	W.-Nr. 2.4831 SG-NiCr21Mo9Nb AWS A5.14 ERNiCrMo-3
		or
	Nicrofer S 5923	W.-Nr. 2.4607 SG-NiCr23Mo16 AWS A5.14 ERNiCrMo-13
SMAW		W.-Nr. 2.4621 EL-NiCr20Mo9Nb AWS A5.11 ENiCrMo-3
		or
		W.-Nr. 2.4609 EL-NiCr22Mo16 AWS A5.11 ENiCrMo-13

Only electrodes which do not result in carbon and silicon pick-up, or which keep it to a minimum, should be used.

For optimum corrosion properties of the weld argon-arc welding, GTAW or GMAW, is preferred.

Availability

Nicrofer 3620 Nb is available in all the standard mill product forms.

Sheet and plate

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

Conditions:
hot or cold rolled (hr, cr),
annealed and pickled

Thickness mm	hr / cr	Width* mm	Length* mm
1.10 – < 1.50	cr	2000	6000
≥ 1.50 – < 6.0	cr	2500	8000
≥ 6.0 – < 10.0	cr	2500	8000
≥ 6.0 – < 10.0	hr	2500	8000
≥ 10.0 – < 20.0	hr	3000	8000
≥ 20.0*	hr		

inches	hr/cr	inches	inches
0.043 – <0.060	cr	80	240
≥ 0.060 – < 1/4	cr	100	320
≥ 1/4 – < 3/8	cr	100	320
≥ 1/4 – < 3/8	hr	100	320
≥ 3/8 – < 3/4	hr	120	320
≥ 3/4*	hr		

*other sizes subject to special enquiry

Forgings

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

Discs and rings

Conditions:
hot rolled or forged,
annealed,
pickled or machined

Product	Weight kg	Thickness mm	OD* mm	ID* mm
Disc	≤ 10000	≤ 300	≤ 3000	–
Ring	≤ 3000	≤ 200	≤ 2500	on request

	lb	inches	inches	inches
Disc	≤ 22000	≤ 12	≤ 120	–
Ring	≤ 6600	≤ 8	≤ 100	on request

*other sizes subject to special enquiry

Rod and bar

Conditions:
forged, rolled, drawn, annealed,
pickled, machined, peeled or ground

Product	forged* mm	rolled* mm	drawn* mm
round d	≤ 300	8 – 75	12 – 76
square a	40 – 300	15 – 100	12 – 65
flat a x b	40 – 80 x 200 – 600	5 – 20 x 120 – 600	10 – 20 x 30 – 80
hexagon s	25 – 80	13 – 50	12 – 60

	inches	inches	inches
round d	≤ 12	0.32 – 3	1/2 – 3
square a	1 5/8 – 12	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
hexagon s	1 – 3 1/8	1/2 – 2	1/2 – 2 3/8

*other sizes subject to special enquiry

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

Thickness mm	Width mm	Coil ID 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, pay-off packs, on spools and spiders

Seamless tube and pipe
Using ThyssenKrupp VDM cast materials seamless tubes and pipes are produced and available from DMV STAINLESS Int. Sales, Tour Neptune, F-92086 Paris, La Défense Cedex (Fax: +33-1-4796 8126; Tel.: +33-1-4796 8128).

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

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