VDM Metals

VDM® Alloy 80 A
Nicrofer 7520 Ti

Material Data Sheet No. 4048
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VDM® Alloy 80 A

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VDM® Alloy 80 A is a nickel-chromium alloy that can be age-hardened. The ability to be hardened is achieved by means of admixtures of titanium and aluminum. It can be delivered in a solution-annealed or age-hardened condition. The alloy is generally used in an age-hardened state.

VDM® Alloy 80 A is characterized by:
- Very good corrosion resistance in oxidizing media and good scaling resistance at high temperatures
- High stability and excellent creep resistance at operating temperatures up to 815 °C (1,500 °F)
- High fatigue strength, even under extreme conditions

Designations

Standard	Material designation
EN	2.4952, 2.4631 – NiCr20TiAl
UNS	N07080
AFNOR	NC 20 TA

Standards

Product form	ASTM	BS	ASME	DIN	others
Strip				17742	DIN EN 10302 ISO 6208
Bar	B 637	BS HR 1 BS HR 601	SB 637	17240 17742	DIN EN 10090

Table 1 – Designations and standards

Chemical composition

	Ni	Cr	Fe	S	Si	C	Mn	Ti	Cu	Al	B	Co	P
Min.	65.0	18.0				0.04		1.8		1.0			
Max.		21.0	1.5	0.015	1.0	0.10	1.0	2.7	0.2	1.8	0.008	1,0	0,020
Due to technical reasons the material may contain further chemical elements.													

Table 2 – Chemical composition (%) corresponds to DIN 17742 and ASTM B 637

Physical properties

Density	Melting range	Relative magnetic permeability at 20 °C (68 °F)
8.2 g/cm³ (512 lb/ft³) at 20 °C (68 °F)	1,320-1,370 °C (2,410 – 2,490 °F)	1.001

Temperature		Specific heat capacity		Thermal conductivity		Electrical resistance	Modulus of elasticity		Average lin. Expansion coefficient	
°C	°F	J/kg. °C	BTU/lb°F	W / m · K	Btu · in / sq. ft · h · °F	µΩ · cm	GPa	10^6 ksi	10^{-6} / K	10^{-6} / °F
20	68	460	0.110	11.2	6.47	124	216	31.3	-	-
100	212	469	0.112	12.6	7.28		212	30.7	12.7	7.05
200	392	494	0.118	14.4	8.32		208	30.2	13.3	7.38
300	572	519	0.124	16.1	9.30		202	29.3	13.7	7.61
400	762	548	0.131	17.8	10.3		196	28.4	14.1	7.81
500	932	573	0.137	19.4	11.2		189	27.4	14.4	8.00
600	1,112	599	0.143	20.8	12.0		179	26.0	15.0	8.33
700	1,292	628	0.150	22.3	12.9		161	23.4	15.5	8.61
800	1,472	653	0.156	24.5	14.2		130	18.9	16.2	9.00
900	1,652	678	0.162	26.5	15.3		-	-	17.1	9.50
1,000	1,832	703	0.168	28.4	16.4		-	-	18.1	10.05

Table 3 – Typical physical properties of VDM® Alloy 80 A at room temperature and elevated temperatures

Microstructural properties

VDM® Alloy 80 A is an age-hardenable, austenitic nickel-chromium alloy with admixtures of titanium and aluminum, which retains its strength through the γ'-precipitations ($Ni_3(Al,Ti)$).

Mechanical properties

The following mechanical properties of VDM® Alloy 80 A apply to the described conditions and specifications in the specified semi-finished forms and dimensions (cf. Availability). The properties for larger dimensions must be agreed separately.

Temperature		Yield strength[1] Rp 0.2		Tensile strength[2] Rm		Elongation at fracture A[2]
°C	°F	MPa	ksi	MPa	ksi	%
20	68	600	87.0	930	135	20
100	212	586	85.0			
200	392	568	82.2			
300	572	560	81.2			
400	762	540	78.3			
500	932	520	75.4			
600	1,112	500	72.5			

1) Values according to DIN10302
2) According to ASTM B637

Table 4 – Mechanical short-term properties of solution-annealed VDM® Alloy 80 A at room temperature and elevated temperatures

Temperature		Creep limit $R_{p\,1.0}/10^4$ h		Dreep Limit $R_{p\,1.0}/10^5$ h		Creep rupture strength $R_m/10^4$ h		Creep rupture strength $R_m/10^5$ h	
°C	**°F**	**MPa**	**ksi**	**MPa**	**ksi**	**MPa**	**ksi**	**MPa**	**ksi**
500	932	723	105	640	92.8	745	108	587	85.1
550	1,020	619	89.8	544	78.9	582	84.4	416	60.3
600	1,112	528	76.6	419	60.8	433	62.8	272	39.5
650	1,200	396	57.4	256	37.1	300	43.5	157	22.8
700	1,292	240	34.8	159	23.1	186	27.0	75	10.9
750	1,380	155	22.5	99	14.4	114	16.5	37	5.37
800	1,472	100	14.5	82	11.9	70	10.2	20	2.9

Table 5 – Creep limit and creep strength according to DIN EN 10302

The creep resistance of the material VDM® Alloy 80 A may be influenced by cold deformation after the heat treatment.

Corrosion resistance

VDM® Alloy 80 A has a high resistance to oxidation under cyclic temperature changes. The alloy forms a firmly adhering oxide layer (Cr_2O_3), which protects against progressive corrosion and oxidation attacks. The alloy is resistant to scaling up to 1,000 °C (1,832 °F). The material has proven its resistance to vanadium pentoxide, sodium and sulphur compounds for exhaust valves in engines operated with heavy oil.

Applications

Due to its excellent resistance to creep and due to its high resistance to fatigue at temperatures up to 815 °C (1,500 °F) as well as the very good resistance to oxidation, VDM® Alloy 80 A is used for components such as blades, rings and washers in gas turbines. Additional applications are connecting elements, exhaust valves in combustion engines and other highly stressed components which are used in the aforementioned temperature range, such as brackets for boiler pipes, inserts in castings or high temperature springs.

Fabrication and heat treatment

VDM® Alloy 80 A can be easily formed both hot and cold and can also be machined. However, machines that take account of the mechanical properties are necessary for any processing work.

Heating
It is important that the workpieces are clean and free of any contaminants before and during heat treatment. Sulphur, phosphorus, lead and other low-melting-point metals can result in damage during the heat treatment of VDM® Alloy 80 A. This type of contamination is also contained in marking and temperature display paints or pens, and also in lubricating grease, oils, fuels and similar materials. Fuels must have as low a sulphur content as possible. Natural gas should contain less than 0.1% by weight of sulphur. Heating oil with a maximum sulphur content of 0.5% by weight is also suitable. Electric furnaces are to be preferred due to precise temperature control and lack of contaminants due to fuel. The furnace temperature should be set between neutral and slightly oxidizing and should not change between oxidizing and reducing. The workpieces must not come in direct contact with flames.

Hot forming
VDM® Alloy 80 A can be optimally hot-formed in a temperature range from 1,200 to 1,050 °C (2,190 and 1,920 °F) with subsequent rapid cooling down. For special applications where the endurance strength is more in focus than the creep resistance (e.g. valves), this temperature window should be expanded downwards in order to achieve a fine-grained microstructure. 980 °C (1,796 °F) should not be fallen below. The workpieces are placed in the furnace heated up to hot-forming temperature in order to heat up. Once the temperature has equalized, a retention time of at least 60 minutes for each 100 mm of workpiece thickness should be observed. After this, the workpieces are removed immediately and formed during the stated temperature window. If a temperature of 980 °C (1,800 °F) is fallen below, the workpiece should be heated up as described above, as otherwise it would be too firm for further hot forming. Heat treatment after hot forming is recommended for the optimization of mechanical properties and corrosion resistance.

Cold forming
VDM® Alloy 80 A is ideally cold-formed in the solution-annealed state. The material has a significantly higher work hardening rate than austenitic stainless steels. This must be taken into account during the design and selection of forming

tools and equipment and during the planning of forming processes. Intermediate annealing at 1,040 °C (1,904 °F) followed by a quick cooling down may be necessary at high cold-forming temperatures in order to restore further formability.

Heat treatment

In general, the heat treatment of VDM® Alloy 80 A includes three stages:

- Solution annealing at 1,050 to 1,080 °C (1,922 – 1,976 °F) for 8 hours followed by air cooling.
- Stabilizing annealing at 840 to 860 °C (1,544 – 1,580 °F) for 24 hours followed by air cooling.
- Age hardening annealing at 690 to 710 °C (1,274 – 1,310 °F) for 16 hours followed by air cooling.

The stabilizing annealing is used to specifically eliminate carbides at the grain boundaries. The particularly high-strength increasing γ‘-precipitates are generated during subsequent age hardening. For applications where the endurance strength is in focus instead of the creep resistance (e.g. valves), the solution annealing should occur in the temperature range from 1,010 °C to 1,050 °C (1,850 °F – 1,922 °F) in order to counteract any coarse grain formation that would be detrimental to this application. The mechanical properties can be specifically adjusted in a wide range through variations in the forming and heat treatment parameters. For every heat treatment, the material should be inserted into the furnace already heated up to the annealing temperature and the information mentioned in the chapter "Heating" should be observed.

Descaling and pickling

High-temperature materials develop a protective oxide layer in service. The necessity for descaling should therefore be checked on ordering. Oxides of VDM® Alloy 80 A and discolorations in the area around welds adhere more strongly than in stainless steels. Grinding using extremely fine abrasive belts or grinding discs is recommended. Discolorations caused by grinding (grinding burn) are to be avoided. If pickling is to be carried out, the pickling times (as for all high-temperature materials) should be kept short, because they can otherwise be subject to inter-crystalline corrosion attack. Furthermore, the temperature of the pickling line must be checked. Before pickling in nitric-hydrofluoric acid mixtures, dense oxide layers should be destroyed by blasting or grinding, or pre-treated in salt baths.

Machining

While VDM® Alloy 80 A in the solution-annealed condition is easier to process and the strain on tools is less, better surface quality is achieved in the age-hardened condition. The best results in terms of the surface quality and dimensional accuracy of the finished product are achieved by pre-treatment before hardening and by finishing in the age-hardened condition. For reasons of the increased tendency to work hardening in comparison with low-alloy austenitic stainless steels, a lower cutting speed should be selected and the cutting tool should stay engaged at all times. An adequate chip depth is important in order to cut below a previously formed work-hardened zone.

Availability

VDM® Alloy 80 is available in the following semi-finished forms:

Strip

Delivery condition: cold rolled, heat treated, pickled or bright annealed

Thickness mm (in)	Width mm (in)	Coil-Inside diameter mm (in			
0.025-0.15 (0.00096 – 0.006)	4-230 (0.16 – 9.06)	300 (11.8)	400 (15.7)	500 (19.7)	–
0.15-0.25 (0.006-0.01)	4-720 (0.16-28.34)	300 (11.8)	400 (15.7)	500 (19.7)	–
0.25-0.6 (0.01-0.024)	6-750 (0.24-29.5)	–	400 (15.7)	500 (19.7)	600 (23.06)
0.6-1 (0.024-0.04)	8-750 (0.32-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)
1-2 (0.04-0.08)	15-750 (0.6-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)
2-3 (0.08 – 0.118)	25-750 (0.98-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)
Rolled sheet – separated from the coil- are available in lengths from 250 to 4,000 mm (9,84 to157,48 in) .					

Rod and bar

Delivery condition: forged, rolled, drawn, heat treated, oxidized, descaled or pickled, twisted, peeled, ground or polished

Dimensions	External diameter mm (in)	Length mm (in)
General dimensions	6-800 (0.24 – 31.5)	1,500-12.000 (59.1-472)
Material specific dimensions	10-300 (0.472 – 19.7)	1,500-12.000 (59.1- 472)
Further shapes and dimensions on request		

Wire

Delivery condition: drawn bright, ¼ hard to hard, bright annealed in rings, containers, on spools and headstocks

Drawn Mm (in)	Hot rolled Mm (in)
0.16-10 (0.0063 – 0.394)	5.5-19 (0.0217 – 0.748)

Other shapes and dimensions, such as circular blanks, rings and forgings, can be requested.

Legal notice

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