

# **VDM® Alloy 800**

## **Nicrofer 3220**

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VDM® Alloy 800 is an austenitic iron-nickel-chromium alloy. VDM® Alloy 800 is characterized by:

- Good corrosion and heat resistance
- Good mechanical properties at low and elevated temperatures up to 800 °C (1,472 °F)
- Good resistance to oxidizing, reducing and nitriding conditions
- Good workability

It is recommended to use VDM® Alloy 800 L if resistance to wet corrosion is required as a main application feature. The solution-annealed version VDM® Alloy 800 H is recommended for application temperatures above 600 °C (1,112 °F).

### Designations

Standard	Material designation
EN	1.4876 – X10NiCrAlTi32-20
UNS	N08800
UK	NA15

### Standards

Product form	VdTÜV	ASTM	ASME	SEW	DIN EN	others
Sheet, plate	412	B 409 A 240	SB 409 SA 240	470	10028-7 10302 10095	
Strip		B 409 A 240	SB 409	400	10028-7 10088-1 10095	SAE AMS 5871 ISO 6208
Rod, bar	412	B 408 B 564	SB 408 SB 564	470	10302 10095	NACE MR 0175/ISO15156
Wire						DIN EN 10095

Table 1 – Designations and Standards

# Chemical composition

	C	S	Cr	Ni	Mn	Si	Ti	Cu	Fe	P	Al
Min.			19.0	30.0	0.5	0.20	0.20		41.0		0.20
Max.	0.1	0.01	21.5	32.0	1.0	0.60	0.50	0.50	47.0	0.015	0.40

Table 2 – Typical chemical composition (%)

# Physical properties

Density	Melting range	Relative magnetic permeability at 20 °C (68°F)
8,0 g/cm <sup>3</sup> (500 lb/ft <sup>3</sup> ) at 20 °C (68 °F)	1.350-1.400 °C (2,460-2,550 °F)	1.01

Temperature		Specific heat capacity		Thermal conductivity		Electrical resistance	Modulus of elasticity		Average linear expansion coefficient	
°C	°F	J kg · K	Btu · in sq. ft · h · °F	W m · K	Btu · in sq. ft · h · °F	μΩ · cm	GPa	10 <sup>3</sup> ksi	10 <sup>-6</sup> K	10 <sup>-6</sup> °F
20	68	443 <sup>1)</sup>	0.106 <sup>1)</sup>	12,4 <sup>1)</sup>	7.16 <sup>1)</sup>	101	194	28,1		
100	212	457	0.109	13,7	7.92	104	189	27,4	14.1	7.8
200	392	474	0.113	15,3	8.84	108	183	26,5	14.6	8.1
300	572	492	0.118	17,0	9.82	112	177	25,7	14.9	8.2
400	752	512	0.122	18,9	10.9	115	170	24,7	15.2	8.4
500	932	548	0.131	21,4	12.4	118	163	23,6	15.5	8.6
600	1,112	578	0.138	23,6	13.6	120	156	22,6	15.9	8.8
700	1,292	588	0.14	24,7 <sup>2)</sup>	14.3 <sup>2)</sup>	122	149	21,6	16.4	9.1
800	1,472	598	0.143	25,8	14.9	124	141	20,5	17.0	9.4
900	1,652	602	0.144	26,7	15.4	126	134	19,4	17.4	9.6
1.000	1,832	613	0.146	28,0	16.2	127	127	18,4	17.8	9.8
1.100	2,012	628	0.15	29,6	17.1	128 <sup>1)</sup>	120 <sup>1)</sup>	17,4	18.3	10.1
1.200	2,192	634	0.151	30,6	17.7	129 <sup>1)</sup>	113 <sup>1)</sup>	16,4	18.7	10.3

<sup>1)</sup> Values are extrapolated

<sup>2)</sup> Values are interpolated

Table 3 - Typical physical properties of VDM® Alloy 800 at room temperature and elevated temperatures

# Microstructural properties

VDM® Alloy 800 is an austenitic solid solution alloy which precipitates carbides and  $\gamma'$  phase during high-temperature ageing.

# Mechanical properties

The following properties at room and elevated temperatures apply in the solution-annealed condition and for the specified dimensions. The properties for larger dimensions must be agreed separately. The values are valid for longitudinal and transverse test samples.

Temperature		Yield strength <sup>1)</sup>		Yield strength <sup>1)</sup>		Tensile strength <sup>2)</sup>		Elongation
		$R_{p\ 0.2}$		$R_{p\ 1.0}$		$R_m$		A
°C	°F	MPa	ksi	MPa	ksi	MPa	ksi	%
20	68	210	30.5	240	34.8	500	72.5	30
100	212	185	26.8	205	29.7	425	61.6	
200	392	160	23.2	180	26.1	400	58.0	
300	572	145	21.0	165	23.9	390	56.6	
400	762	130	18.9	150	21.8	380	55.1	
500	932	125	18.1	145	21.0	360	52.2	
550	1022	115	16.7	135	19.6	300	43.5	

<sup>1)</sup> Minimum values according to VdTÜV data sheet 412

<sup>2)</sup> Values >100 °C/212 °F are for information only

Table 4 – Mechanical short-term properties of the soft annealed VDM® Alloy 800 at room and elevated temperatures

Product form	Dimensions		Yield strength		Yield strength		Tensile strength		Elongation
	mm	in	$R_{p\ 0.2}$	$R_{p\ 1.0}$	$R_{p\ 0.2}$	$R_{p\ 1.0}$	$R_m$	$R_m$	A
			MPa	ksi	MPa	ksi	MPa	ksi	%
Sheet, plate, strip, soft annealed	≤ 50	≤ 1.97	≥ 210	≥ 30.5	≥ 240	≥ 34.8	≥ 500	≥ 72.5	≥ 30
Rod, bar, solution annealed	≤ 160	≤ 6.3	≥ 210	≥ 30.5	≥ 240	≥ 34.8	≥ 500	≥ 72.5	≥ 30

Table 5 – Mechanical short-term properties at room temperature, minimum values according to VdTÜV data sheet 412

## ISO V-notch impact toughness

Transverse: Average value, room temperature: ≥ 100 J/cm<sup>2</sup>

Longitudinal: Average value, room temperature: ≥ 200 J/cm<sup>2</sup>

Average values of 3 samples at room temperature according to VdTÜV data sheet 412

# Corrosion resistance

VDM® Alloy 800 is resistant to many corrosive media. For wet corrosion, the increased nickel content of this alloy results in good resistance to stress cracking corrosion. The elevated chromium content increases the resistance to pitting and crevice corrosion. The alloy shows good resistance in nitric acid and organic acids, but only limited resistance to sulfuric and hydrochloric acid. Pitting corrosion may occur in halogen-containing acids. The material shows good resistance in oxidizing and reducing saline solutions. It is also resistant in fresh water and steam as well as mixtures of steam, air and carbon dioxide. At elevated temperatures, VDM® Alloy 800 exhibits excellent resistance in oxidizing and carburizing atmospheres as well as in alternating oxidizing and carburizing atmospheres. The resistance to hydrogen, nitrogen and sulfuric gases is good, whereby it is better under oxidizing conditions than under reducing conditions.

# Applications

Typical fields of application for VDM® Alloy 800 are:

- Heating element sheaths
- Acetic anhydride cracking furnaces

VDM® Alloy 800 shall be used in the soft-annealed condition up to 600 °C (1,112 °F). The solution-annealed version VDM® Alloy 800 H shall be considered for application temperatures above 600 °C (1,112°F).

# Fabrication and heat treatment

VDM® Alloy 800 can be easily formed both hot and cold and can also be readily machined.

## Heating

It is important that the workpieces are clean and free of any contaminants before and during heat treatment. Sulfur, phosphorus, lead and other low-melting-point metals can result in material damage during the heat treatment. This type of contamination is also contained in marking and temperature display colors or paints, and also in lubricating grease, oils, fuels and similar materials. The sulfur content of fuels must be as low as possible. Natural gas should contain less than 0.1% by weight of sulfur. Heating oil with a maximum sulfur 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 working**

VDM® Alloy 800 can be hot-formed at a temperature range of between 1,200 and 900 °C (2,192-1,652 °F) with subsequent rapid cooling down in water or in air, whereby the temperature range from 760 to 540 °C (1,400-1,004 °F) must be passed through quickly. Hot bending is performed between 1,150 and 1,000 °C (2,102-1,832 °F). For preheating, the workpieces may be placed in the furnace which has already been preheated to the maximum hot forming temperature. The workpieces should be retained in the furnace for around 60 minutes per 100 mm of thickness once the furnace has reached its temperature again. After this, the workpiece should be removed from the furnace immediately and formed within the temperature interval stated above, whereby reheating is necessary once the temperature reaches 900 °C (1,652 °F). Heat treatment after hot-working is recommended for the achievement of optimal corrosion properties and microstructure.

**Cold working**

VDM® Alloy 800 is easily cold-shaped. However, it has a slightly higher work-hardening than carbon steel. 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 is necessary during cold working.

**Heat treatment**

VDM® Alloy 800 is used in the soft-annealed condition in applications whose operating temperatures are below approximately 600 °C (1,112 °F). The annealing should be performed at temperatures of 920 to 980 °C (1688-1796 °F), preferably at about 950 °C (1,742 °F). The retention time during annealing depends on the semi-finished product thickness and can be calculated as follows:

- For thicknesses  $d \leq 10$  mm (0.39 in), the retention time is  $t = d * 3$  min/mm
- For thickness  $d = 10 - 20$  mm (0.39 - 0.79 in), the retention time is  $t = 30$  min +  $(d - 10)$  mm \* 2 min/mm
- For thickness  $d > 20$  mm (0.79 in), the retention time is  $t = 50$  min +  $(d - 20)$  mm \* 1 min/mm

The retention time commences with material temperature equalization; longer times are generally considerably less critical than retention times that are too short. Cooling should be accelerated with water to achieve optimum corrosion properties. Fast air cooling can also be carried out at thicknesses below approx. 3 mm. The material must be placed in a furnace that has been heated up to the maximum annealing temperature before any heat treatment.

For strip and wire products, the heat treatment can be performed in a continuous furnace at a speed and temperature that is adapted to the material thickness. The cleanliness requirements listed under "Heating" must be observed.

**Descaling and pickling**

Oxides of VDM® Alloy 800 and tempering colors in the area around welds adhere more strongly than in stainless steels. Grinding using extremely fine abrasive belts or grinding discs is recommended. It is imperative that grinding burns are avoided. Before pickling in nitric-hydrofluoric acid mixtures, the oxide layers should be destroyed by abrasive blasting or fine grinding, or pre-treated in molten salts. The pickling baths used should be carefully monitored with regard to concentration and temperature.

**Machining**

Machining of VDM® Alloy 800 should take place in an annealed condition. Because of the elevated tendency toward work hardening in comparison with low-alloy austenitic stainless steels, a low cutting speed and a feed level that is not too high should be selected and the cutting tool should be engaged at all times. An adequate depth of cut is important in order to cut below the previously formed strain-hardened zone. Optimum heat dissipation through the use of large quantities of suitable preferably aqueous lubricants has considerable influence on a stable machining process.

# Welding information

When welding nickel alloys and special stainless steels, the following information should be taken into account:

## **Workplace**

A workplace, which is specifically separated from areas in which C-steel is being processed, must be provided. Maximum cleanliness is required, and drafts should be avoided during gas-shielded welding.

## **Auxiliary equipment and clothing**

Clean fine leather gloves and clean working clothes must be used.

## **Tools and machines**

Tools that have been used for other materials may not be used for nickel alloys and stainless steels. Only stainless steel brushes may be used. Machines such as shears, punches or rollers must be fitted (e.g. with felt, cardboard, films) so that the workpiece surfaces cannot be damaged by such equipment due to pressed-in iron particles as this can lead to corrosion.

## **Welding edge preparation**

Welding edge preparation should preferably be carried out using mechanical methods such as lathing, milling or planing. Abrasive waterjet cutting or plasma cutting is also possible. In the latter case, however, the cut edge (seam flank) must be cleanly reworked. Careful grinding without overheating is also permissible.

## **Striking the arc**

Striking may only take place in the seam area, such as on the weld edges or on an outlet piece, and not on the component surface. Striking points are places that may be more susceptible to corrosion.

## **Included angle**

Compared to C-steels, nickel alloys and special stainless steels exhibit lower heat conductivity and greater heat expansion. Larger root gaps and web spacing (1 to 3 mm/ 0,039 to 0,118 in) are required to live up to these properties. Due to the viscosity of the welding material (compared to standard austenites) and the tendency to shrink, opening angles of 60 to 70° – as shown in Figure 1 – have to be provided for butt welds.

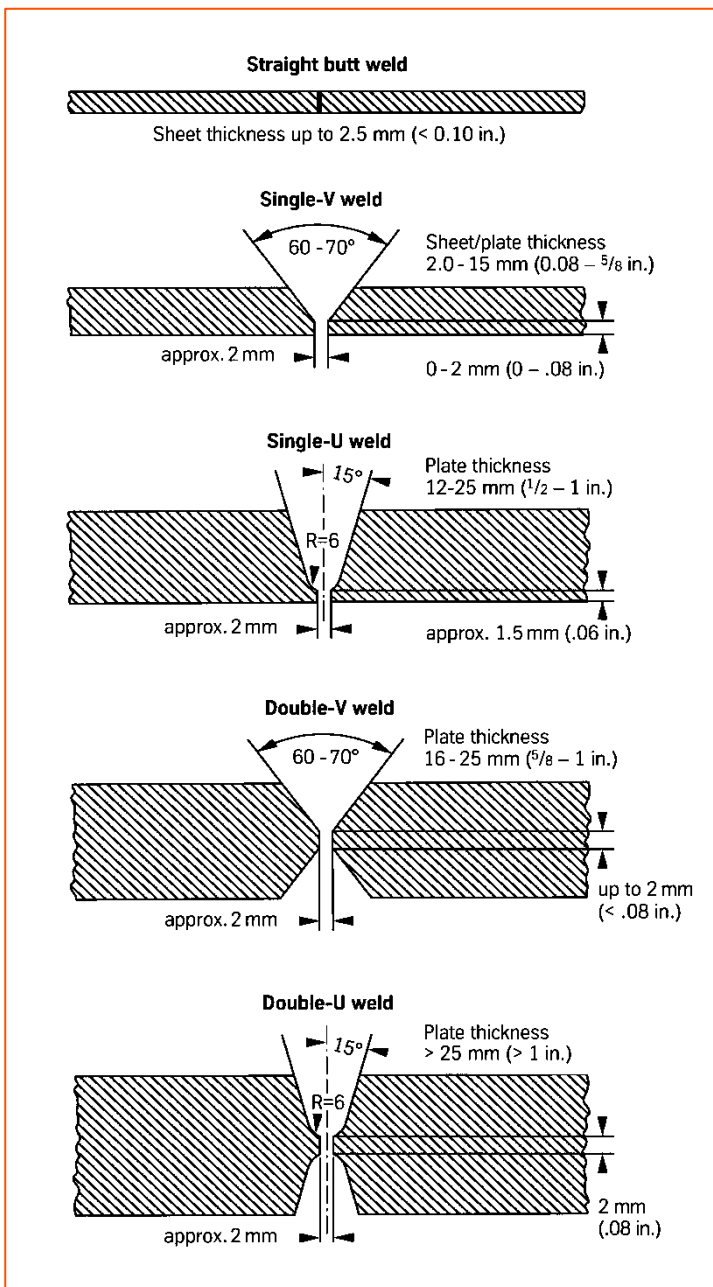


Figure 6 – Seam preparation for welding nickel alloys and special stainless steels

### Cleaning

Cleaning of the base material in the seam area (both sides) and the welding filler (e.g. welding rod) should be carried out using acetone.

### Filler material

The use of the following fillers is recommended for TIG and MAG welding methods:

VDM® FM 82 (W-no. 2.4806)

UNS N06082 AWS A5.14 ERNiCr-3

DIN EN ISO 18274 S Ni 6082 (NiCr20Mn3Nb)

or



VDM® FM 625 (W.-no. 2.4831)  
UNS N06625  
DIN EN ISO 18274: S Ni 6625; NiCr22Mo9Nb

The use of coated electrodes is possible.

#### **Welding parameters and influences**

Care should be taken that the work is performed with a deliberately chosen, low heat input as indicated in Table 6 by way of example. The stringer bead technique is recommended. The interpass temperature should not exceed 120 °C (248 °F). The welding parameters should be monitored as a matter of principle.

Heat input Q can be calculated as follows:

$$Q = \frac{U \cdot I \cdot 60}{v \cdot 1.000} \left( \frac{\text{kJ}}{\text{cm}} \right)$$

U = arc voltage, volts

I = welding current strength, amperes

v = welding speed, cm/min.

#### **Post-treatment**

If the work is performed well, brushing immediately after welding, i.e. while still warm, and without additional pickling, will result in the desired surface condition. In other words, annealing colors can be removed completely. Pickling, if required or specified, should generally be the last operation in the welding process. The information contained in the section entitled "descaling and pickling" must be observed. Heat treatments are normally not required either before or after welding.

Thickness (mm) / (in)	Welding process	Filler metal		Root pass <sup>1)</sup>		Intermediate and final passes		Welding speed (cm/min.)	Shielding gas type	
		Diameter (mm) (in)	Speed (m/min.)	I in (A)	U in (V)	I in (A)	U in (V)		Art	Quantity Gas rate (l/min.)
3 (0,118 in)	Manual TIG	2 (0,0787 in)	-	90	10	110-120	11	10-15	I1, R1 mit max. 3% H2	8-10
6 (0,236 in)	Manual TIG	2-2,4 (0,0787- 0,0945 in)	-	100-110	10	120-130	12	10-15	I1, R1 mit max. 3% H2	8-10
8 (0,315 in)	Manual TIG	2,4 (0,0945 in)	-	110-120	11	130-140	12	10-15	I1, R1 mit max. 3% H2	8-10
3 (0,118 in)	Autom. TIG HD <sup>2)</sup>	0,8 - 1,2 (0,0315- 0,0472 in)	1 – 2,5	-	-	150	10	25	I1, R1 mit max. 3% H2	15-20
5 (0,197 in)	Autom. TIG HD <sup>2)</sup>	0,8 – 1,2 (0,0315- 0,0472 in)	1,4	-	-	150	10	25	I1, R1 mit max. 3% H2	15-20
4 (0,157 in)	Plasma <sup>3)</sup>	1 - 1,2 (0,0394- 0,0472 in)	1	165	25	-	-	25	I1, R1 mit max. 3% H2	30
6 (0,236 in)	Plasma <sup>3)</sup>	1 - 1,2 (0,0394- 0,0472 in)	1	190 - 200	25	-	-	30	I1, R1 mit max. 3% H2	30
≥ 12 (≥ 0,472 in)	SAW	1,6 (0,063 in)	-	-	-	250	28	44 - 55	-	-
8 (0,315 in)	MIG/MAG <sup>4)</sup>	1 (0,0394 in)	8	-	-	140-160	25-28	25-35	I1, R1 mit max. 3% H2	18 – 20
≥ 10 (≥ 0,394 in)	MIG/MAG <sup>4)</sup>	1,2 (0,0472 in)	5	-	-	150-180	28-32	35-50	I1, R1 mit max. 3% H2	18 – 20

<sup>1)</sup> It must be ensured that there is sufficient root protection, for example using Ar 4.6, for all inert gas welding processes.

<sup>2)</sup> The root pass should be welded manually (see manual TIG).

<sup>3)</sup> Recommended plasma gas Ar 4.6 / rate 3.0 to 3.5 l/min

<sup>4)</sup> For MAG welding the use of multicomponent inert gases is recommended.

Section energy kJ/cm:

Autom. TIG max. 6; manual TIG, MIG/MAG manual, autom. max. 8; Plasma max. 10

Figures are for guidance only and are intended to facilitate setting of the welding machines.

Table 6 – Welding parameters

# Availability

VDM® Alloy 800 is available in the following semi-finished forms:

## Sheet

Delivery condition: Hot or cold-rolled, heat-treated, de-scaled or pickled

Condition	Thickness mm (in)	Width mm (in)	Length mm (in)	Weight Kg (lb)
Cold-rolled	1-7 (0.04-0.28)	≤ 2,500 (98.4)	≤ 12,500 (492.13)	
Hot-rolled*	3-80 (0.118-3.15)	≤ 2,500 (98.4)	≤ 12,500 (492.13)	≤ 2,250 (4.960)

\* Sheets of 2mm (0,08 in) thickness are available on request

## Strip

Delivery condition: Cold-rolled, heat-treated, pickled or bright annealed

Thickness mm (in)	Width mm (in)	Coil-inside diameter mm (in)			
0,02-0,15 (0.0008-0.006)	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 (23.6)
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)
2-3,5 (0,08-0.138)	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 – 4.000 mm (9.84 to 157.48 in).

## Rod and bar

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

Dimensions*	Outside diameter Mm (in)	Length Mm (in)
General dimensions	6-800 (0.24-31.5)	1.500-12.000 (59.06-472)
Material specific dimensions	12-500 (0.472-19.7)	1.500-12.000 (59.06-472)

\*Further 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 (0.006-0.04)	5,5-19 (0.22-0.75)

Other shapes and dimensions such as circular blanks, rings, seamless or longitudinal-welded tubes and pipes or forgings are subject to special enquiry.

# Legal notice

23 November 2020

## **Publisher**

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