VDM Metals

A company of ACERINOX

VDM® Alloy 330
Nicrofer 3718

VDM® Alloy DS
Nicrofer 3718 So

Material Data Sheet No. 4102 **Revision 01**
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VDM® Alloy 330/DS

Nicrofer 3718 (So)

VDM® Alloy 330/DS are nickel-iron-chromium solidsolution alloys with the addition of approximately 2% silicon. VDM® Alloy 330 is also available with reduced chromium content in the variant acc. to UNS N08330.

VDM® Alloy 330/DS is characterized by:

- good oxidation and scale resistance
- excellent resistance to carburisation and to alternating carburising and oxidising atmospheres
- good mechanical properties with high strength at elevated temperatures

Designations and standards

Standard	Material designation
EN	1.4864 - X12NiCrSi35-16 (VDM® Alloy 330) 1.4862 - X8NiCrSi38-18 (VDM® Alloy DS)
UNS[1)]	N08330 (VDM® Alloy 330)
AFNOR	Z12NCS35.16 (VDM® Alloy 330) Z12NCS37.18 ((VDM® Alloy DS)

Product form	SEW	DIN EN	BS
Sheet, plate	310/470	10095	3072
Strip	310/470	10095	3073
Rod, bar	310/470	10095	3076
Wire	310/470	10095	3075

Table 1 – Designations and

Chemical composition

	Ni	Cr	Fe	C	Mn	Si	N	P	S
Min.	33,0	15,0	bal.			1,0			
Max.	37,0	17,0		0,15	2,0	2,0	0,11	0,03	0,02

Table 2a – Chemical composition (%) of VDM® Alloy 330 according to 1.4864

	Ni	Cr	Fe	C	Mn	Si	Cu	Ti	P	S
Min.	35,0	17,0	bal.		0,8	1,5				
Max.	39,0	19,0		0,10	1,5	2,5	0,5	0,2	0,03	0,03

Table 2b – Chemical composition (%) of VDM® Alloy DS according 1.4862

Physical properties

Density	Melting range	Relative magnetic permeability at 20 °C (68 °F)
8.0 g/cm³ 0.29 lb/in³	1,330 – 1,400 °C 2,430 – 2,550 °F	1.01

Temperature		Specific heat		Thermal conductivity		Electrical resistivity	Modulus of elasticity		Coefficient of thermal expansion	
°C	°F	J/(kg · K)	Btu/(lb · °F)	W/(m · K)	Btu · in/(sq. ft · h · °F)	µΩ · cm	GPa	10³ ksi	10^{-6}/K	10^{-6}/°F
-100	-148	394					201		13.6	
-73	-100		0.102					28.8		
0	32	467	0.112				196	28.4		
20	68	472	0.113	11.4	79	104	194	28.2		
93	200		0.120		89			27.4		8.3
100	212	501		12.8		107	189		15.1	
200	392	525		14.6		111	183		15.7	
204	400		0.126		102			26.6		8.7
300	572	532		16.3		114	177		16.2	
316	600		0.128		115			25.5		9.0
400	752	555		17.9		117	170		16.6	
427	800		0.134		127			24.4		9.3
500	932	582		19.5		119	163		17.0	
538	1,000		0.142		140			23.2		9.5
600	1,112	604		21.0		122	156		17.4	
649	1,200		0.145		151			22.1		9.8
700	1,292	610		22.6		123	149		17.7	
760	1,400		0.146		164			20.9		10.0
800	1,472	609		24.1		125	141		18.0	
871	1,600		0.146		174			19.8		10.1
900	1,652	615		25.6		127	134		18.3	
982	1,800		0.152		187			.18.7		10.3
1,000	1,832	641		27.0		129	127		18.6	

Table 3 – Typical physical properties at room and elevated temperatures

Microstructural properties

VDM® Alloy 330/DS are solid solution alloys with small amounts of precipitated titanium nitride and carbide as well as carbonitrides in the austenitic matrix.

Mechanical properties

The following mechanical properties apply to VDM® 330/DS in the annealed and solution-treated condition.

Temperature		Yield strength $R_{p\,0.2}$		Yield strength $R_{p\,1.0}$		Tensile strength R_m		Elongation A	Hardness Brinell
°C	°F	MPa	ksi	MPa	ksi	MPa	ksi	%	HB max
20	68	285	41.3	310	45.0	650	94.3	30	210
93	200		39.1		42.8		92.1		
100	212	265		290		630		30	
200	392	240		265		615		30	
204	400		34.8		38.4		89.2		
300	572	220		250		605		30	
316	600		31.2		35.5		87.0		
400	752	210		235		590		30	
427	800		29.7		33.4		84.1		
500	932	200		225		555		30	
538	1000		29.0		31.9		76.9		
600	1112	195		215		480		30	
649	1200		27.6		29.7		60.9		
700	1292	175		190		340		30	
760	1400		21.8		23.2		37.0		
800	1472	135		145		210		30	
871	1600		14.5		16.7		20.3		
900	1652	85		100		120			
982	1800		7.3		8.7		13.0		
1000	1832	48		55		80			

Table 4 – Typical short-time properties at room and elevated temperatures, annealed at 1,020 °C (1,870 °F)

Temperature		Creep strength				Creep rupture strength			
		Rp 1.0/10⁴ h		Rp 1.0/10⁵ h		Rm/10⁴ h		Rm/10⁵ h	
°C	°F	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi	N/mm²	ksi
600	1112	80		40		125		75	
649	1200		7.7		3.6		10.3		6.2
700	1292	35		14		45		25	
760	1400		3.1		1.0		4.1		2.0
800	1472	15		4		20		7	
871	1600		1.1		0.22		1.6		0.52
900	1652	5		1.5		8		3	
982	1800								0.23
1000	1832	(3)				(4)		1.5	

Table 5 – Typical creep properties at elevated temperatures, solution treated at 1,150°C (2,100°F)

Corrosion resistance

The nickel-chromium-iron alloys VDM® Alloy 330/DS containing about 2% silicon are general-purpose heat-resisting materials. They have good oxidation resistance up to about 1000 °C (1850 °F), particularly under cyclic conditions of heating and cooling. They also have excellent resistance to carburisation and are widely used in industry under such conditions. Their resistance to nitrogen-containing atmospheres where oxygen content is low makes them suitable for environments such as cracked ammonia. Due to its higher chromium and silicon contents, VDM® Alloy DS is in every respect superior to the standard VDM® Alloy 330.

Oxidation

VDM® Alloy 330/DS have good oxidation resistance and resist scale formation up to about 1000 °C (1850 °F). Any scale which is formed is tightly adherent, particularly under cyclic conditions of heating and cooling.

Carburisation

The alloys have excellent resistance to carburisation and are therefore widely used in industry under carburising conditi-ons. In an alternating carburising and oxidising atmosphere, excellent resistance is shown to the phenomenon known as “green rot”.

Nitriding

VDM® Alloy 330/DS have good resistance to nitrogen-containing atmospheres where the oxygen content is low, i.e. in cracked ammonia.

Sulphidation

Resistance to sulphidation is better under oxidising than under reducing condition. Sulphide scale has a tendency to flake and spall and does not have the protective action of an oxide scale. It must be pointed out once again that due to the higher chromium and silicon contents, VDM® Alloy DS (1.4862) is superior to the standard material VDM® Alloy 330 (1.4864).

Applications

VDM® Alloy 330/DS find wide application in high-temperature processes like:

- fans operating at high temperatures in carburising furnaces – resisting carburisation
- boxes and baskets used in carburising – resisting carburisation and showing weight savings when compared with cast boxes
- hangers, hooks and conveyor chains used to carry vitreous-enamelled components during firing – resisting oxide spalling so that oxide does not fall on the enamel
- combustion tubes – resisting oxidation to carburisation and alternating oxidising and carburising conditions
- jigs and fixtures used in furnace brazing and wire mesh belts to carry components in heat-treatment processes
- thermocouple sheaths – resisting carburisation and nitriding
- flare-stack tips – resisting alternating conditions
- components handling cracked ammonia

Fabrication and heat treatment

VDM® Alloy 330/DS are formed by established commercial hot and cold working techniques and are joined to themsel-ves or many other metals by common welding processes such as manual metal-arc and TIG.

Heating
It is very important that the workpiece be clean and free from any contaminant before and during heating.
VDM® Alloy 330/DS 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/m^3 maximum, of sulphur. Fuel oils containing no more than 0.5% by mass of sulphur are satisfactory. 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
VDM® Alloy 330/DS may be hot-worked in the range 1150 to 950 °C (2100 to 1740 °F). Cooling should be by water quenching or as fast as possible. Annealing is recommended after hot working to ensure maximum corrosion resistance and optimum structure. The material may be charged into the furnace at maximum working temperature.

Cold working

Cold working should be carried out on annealed material. VDM® Alloy 330/DS have a similar work-hardening rate compared to austenitic stainless steel and the forming equipment must be adapted accordingly. When cold working is performed, interstage annealing may become necessary. After cold reduction of more than 15%, final annealing is required before use, in so far as the creep-strength is important. Bending property and formability is given even with oxidised sheets. Nevertheless the bending radius should be 3 times sheet thickness.

Heat treatment

Annealing should be carried out in the temperature range 1020 to 1120 °C (1870 to 2050 °F). Water quenching is essential for maximum creep resistance. During any heating operation, the precautions outlined earlier regarding cleanliness must be observed.

Descaling

High-temperature alloys form a protecting oxide layer in service. Therefore the necessity of descaling should be checked. Oxides of VDM® Alloy 330/DS and discoloration adjacent to welds, are more adherent than on stainless steels. Grinding with very fine abrasive belts or discs is recommended. If pickling is necessary – as usual with high-temperature alloys – pickling time must be as short as possible. Before pickling in a nitric/hydrofluoric acid mixture, oxides must be broken up by grit-blasting, fine grinding or by pretreatment in a fused salt bath.

Machining

VDM® Alloy 330/DS should be machined in the annealed condition. As the alloys are susceptible to workhardening, a low cutting speed should be used and tools should be engaged at all times. Heavy feeds are important in getting below the work-hardened 'skin'.

Welding information

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

Workplace

A separately located 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. Processing and treatment machines such as shears, punches or rollers must be fitted (felt, cardboard, films) so that the workpiece surfaces cannot be damaged by the pressing in of iron particles through such equipment, as this can lead to corrosion.

Edge preparation

Welding seam preparation should preferably be carried out using mechanical methods through 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

The arc should only be struck in the seam area, such as on the weld edges or on an outlet piece, and not on the component surface. Scaling areas are areas in which corrosion more easily occurs.

Included angle

The different physical behavior of nickel alloys and special stainless steels is generally expressed by lower thermal conductivity and higher thermal expansion compared with carbon steel. This behavior must be taken into account, among other things, by larger root gaps or spacings (2 mm ± 0.5 mm), while the viscous behavior in the molten state means that larger root openings (< 60°) of the individual butt joints must be used to counteract the pronounced shrinkage behavior.

For welding VDM® Alloy DS, however, a root opening angle of 60° is prescribed due to the low viscosity of the weld metal and the low shrinkage - as shown in Figure 1.

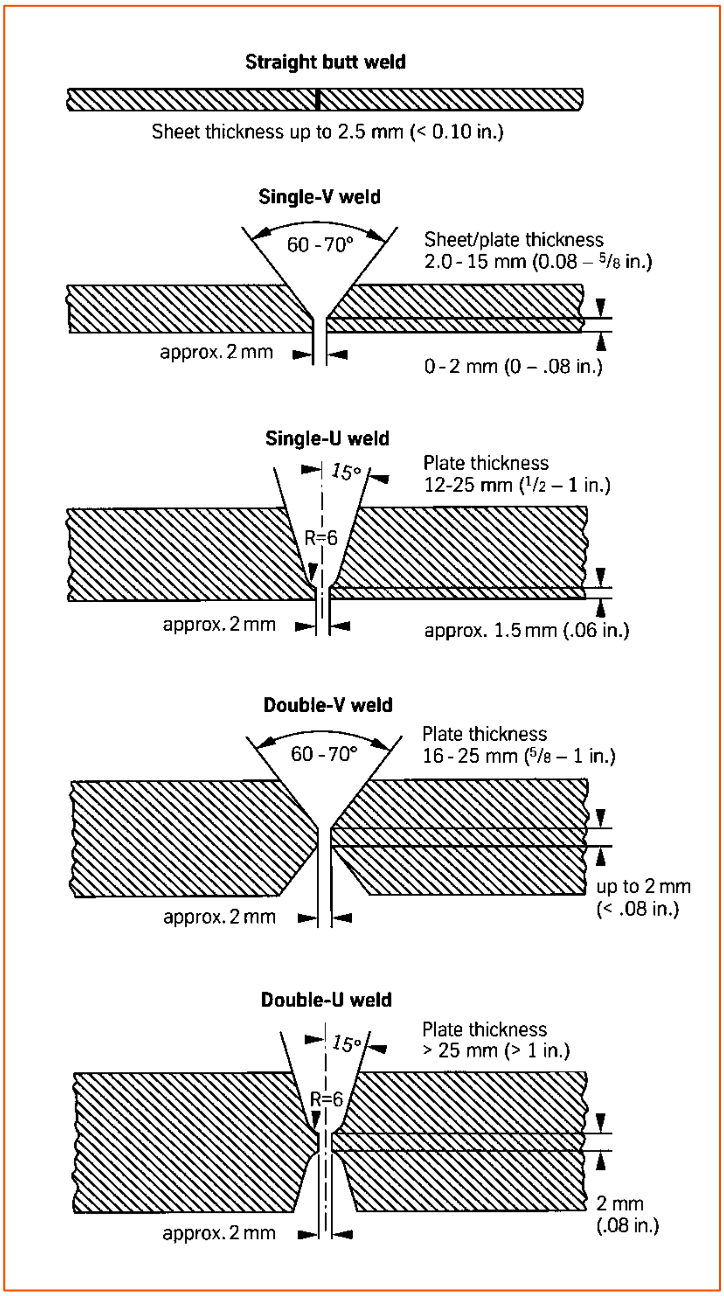

Figure 1 – Seam preparation for welding nickel alloys and special stainless steels

Cleaning

Cleaning of the base metal in the seam area (both sides) and of the filler metal (e.g. welding rod) should be carried out with ACETON. Please do not use trichloroethylene "TRI", perchloroethylene "PER" or carbon tetrachloride "TETRA".

Joining

VDM® Alloy 330/DS can be welded by GTAW, plasma arc and SMAW processes. 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 not exceed 150 °C (300 °F). Neither pre- nor post-weld heat treatment is required.

The following welding products are recommended:

GTAW/Plasma arc	VDM® FM 82 (2.4806) ISO 18274: S Ni 6082 (SG- NiCr20Nb) AWS A 5.14 ERNiCr-3
Rod electrode	VDM® CW 182 (2.4648) EL-NiCr19Nb AWS A 5.14 ENiCr-3

For optimum corrosion resistance argon-arc welding, i.e. GTAW is preferred. VDM® Alloy 330/DS can be welded to a variety of dissimilar metals. In general, the electrodes and filler metals referred to above are used.

Postweld treatment (pickling and brushing)

Pickling, if required or prescribed, is generally the last operation performed on the weldment. In such a case, the work should be carried out by specialized firms. Consultation with our specialists is strongly recommended. If the workmanship is of the highest quality, brushing immediately after welding, i.e. while the metal is still hot, can often produce the desired surface condition, i.e. heat tints can be completely removed. Only fine grinding with clean belts or wheels should be considered, and where possible should be followed by pickling/passivation.

Welding parameters and influences (heat input)

Care should be taken to ensure that the work is performed with a low heat input (see table 6). Attention is also drawn to correct selection of the wire and stick electrode diameters. The welding parameters should be monitored as a matter of principle.

Thickness	Welding technique	Filler material		Root pass[1)]		Intermediate and final passes		Welding speed	Shielding gas	
(mm)		Diameter (mm)	Speed (m/min)	I in (A)	U in (V)	I in (A)	U in (V)	(cm/min)	Type	Rate (l/min)
2.0	Manual GTAW	2.0		70	9			approx. 12	Ar 99.99	8
6.0	Manual GTAW	2.0–2.4		90	10	110	11	approx. 12	Ar 99.99	8
12.0	Manual GTAW	2.4		100	10	110	11	approx.12	Ar 99.99	8
4.0	Plasma arc	1.0–1.2		165	25			approx. 25	Ar 99.99	3
6.0	Plasma arc	1.0–1.2		190–200	25			approx. 25	Ar 99.99	3.5
8.0	SMAW	2.5–3.25		90	10	60–80	approx.			

In all gas-shielded welding operations, ensure adequate back shielding.
These figures are only a guide and are intended to facilitate setting of the welding machines.

Table 6 – Welding parameters

Availability

VDM® Alloy 330/DS are available in all standard mill product forms.

Sheet (for cut-to-length availability, refer to strip)
Delivery condition: hot or cold rolled, heat treated and oxidised or descaled

Condition	Thickness mm	Width mm	Length mm
Cold rolled	1.10 - < 1.50 1.50 - < 3.00	2,000 2,500	8,000 8,000
Cold-/Hot rolled	3.00 - < 7.50	2,500	8,000
Hot rolled	7.50 - ≤ 25.00	2,500	8,000

Strip

Delivery condition: cold rolled, heat treated and oxidised or descaled or bright annealed

Thickness mm	Width mm	Coil – Inside diameter mm			
0.02 ≤ 0.10	4 – 200 (700)[1)]	300	400		
>0.10 ≤ 0.20	4 – 350 (700)[1)]	300	400	500	
>0.20 ≤ 0.25	4 – 700		400	500	600
>0.25 ≤ 0.60	6 – 700		400	500	600
>0.60 ≤ 1.0	8 – 700		400	500	600
>1.0 ≤ 2.0	15 – 700		400	500	600
>2.0 ≤ 3.0	25 – 700		400	500	600

[1)] Widths up to 700 mm need to be requested specifically in the thickness range of 0.02 - ≤ 0.20 mm.

Rod

Delivery condition: forged, rolled, drawn, heat treated and oxidised or descaled, machined, peeled or ground

Product	Forged mm	Rolled mm	Drawn mm
Round (Ø)	≤ 600	8 – 100	12 – 65
Square (a)	40 – 600	15– 280	Not standard
Flat (a x b)	(40 – 80) x (200 – 600)	(5 – 20) x (120 – 600)	(10 – 20) x (30 – 80)
Hexagon (s)	40 – 80	13 – 41	≤ 50

Wire

Delivery condition: bright drawn, ¼ hard to hard bright annealed

0.01 – 12.00 mm diameter

Legal notice

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