VDM Metals

A company of ACERINOX

VDM® Alloy 188
Conicro 4023 W

Material Data Sheet No. 6001 **Revision 01**
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Conicro 4023 W

VDM® Alloy 188 is a high-temperature, heat resistant, cobalt-base alloy with equal contents of nickel and chromium, a high tungsten content and a controlled lanthanum addition.

VDM® Alloy 188 is characterized by:

- Excellent mechanical properties up to 1,150 °C (2,100 °F)
- Good resistance to scaling and oxidation up to 1,150 °C (2,100 °F)
- Good formability and weldability

Designations and standards

Standard	Material designation
DIN EN	2.4683 – CoCr20NiW
UNS	R30188

Product form	AMS
Sheet, plate	5608
Strip	5608
Rod, bar	5772
Wire	5801

Table 1 – Designations and standards

Chemical composition

	Ni	Cr	Fe	C	Mn	Si	Co	W	Al	La	P	S	B
Min.	20.0	20.0		0.05		0.2	bal.	13.0		0.02			
Max.	24.0	24.0	3.0	0.15	1.25	0.4		16.0	0.20	0.12	0.015	0.015	0.01

Table 2 – Chemical composition (%)

Physical properties

Density	Melting range	Relative magnetic permeability at 20 °C (68 °F)	Electrical resistivity
9.1 g/cm3 0.33 lb/in3	1,300-1,330°C 2,375-2,450°F	1.01	95 µΩ · cm

Temperature		Specific heat		Thermal conductivity		Modulus of elasticity		Coefficient of thermal expansion	
°C	°F	J / kg · K	Btu / lb · °F	W / m · K	Btu · in / sq. ft · h · °F	GPa	10^3 ksi	10^{-6} / K	10^{-6} / °F
0	32								
20	68	405	0.097	10.2	71	222	32.2		
93	200		0.101		84		31.8		6.6
100	212	425		12.2		218		11.9	
200	392	445		14.3		213		12.6	
204	400		0.106		99		30.9		7.0
300	572	465		15.9		207		13.2	
316	600		0.112		112		29.9		7.4
400	752	485		17.5		201		13.8	
427	800		0.117		125		28.9		7.8
500	932	505		19.2		194		14.5	
538	1000		0.122		137		27.7		8.2
600	1112	525		20.9		184		15.2	
649	1200		0.128		151		26.4		8.6
700	1292	540		22.7		179		15.8	
760	1400		0.132		166		25.1		9.0
800	1472	560		24.6		170		16.5	
871	1600		0.138		179		23.8		9.4
900	1652	575		26.3		161		17.2	
982	1800		0.141		192		22.3		9.9
1000	1832	590		27.9		152		17.9	
1093	2000		0.144		204		20.7		10.3
1100	2012	605		29.5		143		18.5	

Table 3 – Typical physical properties at room and elevated temperatures

Microstructural properties

VDM® Alloy 188 has a face-centred cubic structure. High-temperature strength is obtained by solid-solution hardening with tungsten and by precipitation of carbides.

Mechanical properties

The following mechanical properties apply to VDM® Alloy 188 in the solution-treated condition and indicated size ranges.

Form	Dimensions		Yield strength $R_{p\,0.2}$		Tensile strength R_m		Elongation A	Hardness Brinell
	mm	in	MPa	ksi	MPa	ksi	%	HB max
Plate	≤ 12.5	≤ 0.5	380	55	860	125	40	
Sheet, strip, (plate*)	≤ 0.5	≤ 0.02	250*	36*	620*	90*	40	
	> 0.5	> 0.02					45 (50*)	
Rod, bar	≤ 100	≤ 4					45	302
Forgings	≤ 75	≤ 3					45	293

*Minimum mechanical properties at 650°C (1200°F) after 20 to 30 minutes at testing temperature (acc. To AMS 5608)

Table 4 – Minimum mechanical properties at room temperature.

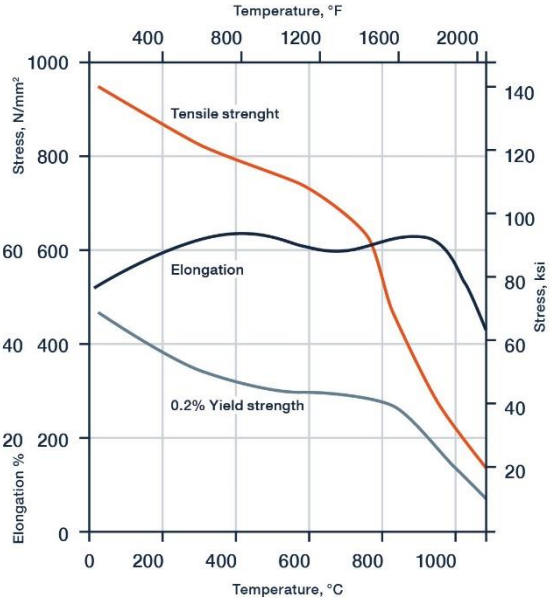

Fig.1 – Typical short-time properties of solution-treated VDM® Alloy 188 sheet at room and elevated temperatures.

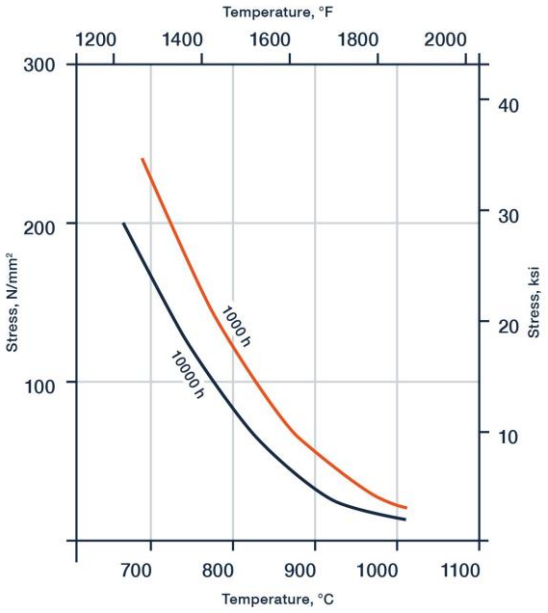

Fig.2 – Typical creep-rupture properties of solution-treated VDM® Alloy 188.

According to		**AMS 5608**		**AMS 5772**	
Form		Sheet, strip, plate		Bar	Forgings
Thickness, diameter	mm	≤ 0.5	> 0.5		
	in	≤ 0.02	> 0.02		
Temperature	°C	927			927
	°F	1,700			1,700
Time	h	≥ 23			≥ 23
Stress	N/mm²	62	76	90	83
	Ksi	8	15	13	12
Elongation	%	≥ 8	≥ 15		≥ 15

Table 6 – Specified stess-rupture requirements at given temperature.

Bend properties

VDM® Alloy 188 sheet in the solution-treated condition can be bent through an angle of 180° over the following diameter mandrels:

Sheet Thickness	**Mandrel diameter**
≤ 1.27 mm (0.05in)	1.5 x thickness
> 1.27 < 4.76 mm (> 0.05 < 0.187 in)	2 x thickness

Corrosion resistance

VDM® Alloy 188 exhibits excellent resistance to hot corrosion by sulphidation, and is especially resistant to oxidation up to temperatures of 1,150 °C (2,100 °F), under both static and cyclic conditions, even under high gas velocities. This corrosion resistance, combined with good mechanical properties, make this alloy suitable for many high-temperature applications.

Applications

VDM® Alloy 188 is used for applications requiring high mechanical properties at high temperatures. Recommended service temperature range is up to 1,100 °C (1,830 °F).

Typical fields of application for VDM® Alloy 188 are:

- Components for industrial and aircraft gas turbines, including combustion cans, housings, turbine rings, afterburners, casings and ducts
- Air heaters
- Furnace muffles, rolls and radiant tubes
- High-temperature heat exchangers, valves and springs

Fabrication and heat treatment

VDM® Alloy 188 can be easily formed both hot and cold and can also be machined. The weldability of VDM® Alloy 188 is excellent. Joining can be performed by all conventional welding processes.

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 damage during the heat treatment of the material. This type of contamination is also contained in marking and temperature-indicating paints or pens as well as 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 and town gas 0.025g/m^3 maximum, 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 forming

VDM® Alloy 188 should be hot-formed in a temperature range of 1,200 to 1,000 °C (2,190 to 1,830 °F) with subsequent rapid cooling in water or in air. For heating up, workpieces should be placed in a furnace that has been heated up to the maximum hot-forming temperature (solution annealing temperature). Once the furnace has reached its temperature again, the workpieces should remain in the furnace for around 60 minutes per 100 mm (3.94 in) of thickness. After this, they should be removed from the furnace immediately and formed within the temperature range stated above. If the metal temperature falls below the minimum working temperature, it must be reheated.

Cold forming
Cold working should be carried out on solution-treated material. VDM® Alloy 188 has a significantly higher work hardening rate than other widely used austenitic stainless steels and the forming equipment must be adapted accordingly.
When cold working is performed, interstage annealing may become necessary.

Heat treatment
Solution annealing should take place at temperatures between 1,180 and 1,220 °C (2,150 and 2,230 °F), preferably at about 1,190 °C (2,175 °C). Water quenching or rapid air cooling, is recommend.
During any heating operation, the precautions outlined earlier regarding cleanliness must be observed.

Descaling and pickling
Oxides of VDM® Alloy 188 and discoloration adjacent to welds are more adherent than on stainless steels. Grinding using extremely fine abrasive belts or grinding discs is recommended. It is imperative that grinding burns be avoided. Before pickling in nitric-hydrofluoric acid mixtures, the oxide layers should be destroyed by abrasive blasting or fine grinding, or pre-treated in in a fused salt bath. The pickling baths used should be carefully monitored with regard to concentration and temperature.

Machining
VDM® Alloy 188 should be machined in the heat-treated condition. Because of the considerably 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

VDM® Alloy 188 can be welded by gas tungsten-arc (GTAW/TIG) welding. Pulsed arc welding is the preferred technique. Prior to welding, material should be in the solution-treated condition, clean and free form scale, grease, marking paints etc. A zone approximately 25mm (1in) wide on each side of the joint should be ground to bright metal.
Low heat input is necessary. Interpass temperature should not exceed 120°C (250°F). Neither pre- nor post-weld heat treatment is required.

The following welding products are recommended:

GTAW/GMAW	Conicro S 4023	2.4683 CoCr22NiW AMS 5801

Availability

VDM® Alloy 188 is available in all standard mill product forms.

Plate, sheet

Delivery condition: Hot or cold rolled, annealed, de-scaled resp. pickled

Condition	Thickness mm (in)	Width mm (in)	Length mm (in)	Piece weight kg
Cold rolled	1 – 7 (0.04 – 0.28)	1,000 – 2,500 (39.4 – 98.43)	≤ 12,500 (492.13)	
Hot rolled	3 – 100 (0.12 – 3.94)[1)]	1,000 – 2,500 (39.4 – 98.43)	≤ 12,500 (492.13)	≤ 2,700 (106.3)[2)]

[1)] 2 mm thickness on request
[2)] Piece weights up to 4,500 kg on request

Strip

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

Thickness mm (in)	Width mm (in)	Coil – inside diameter mm			
0.02 – 0.15 (0.0008 – 0.006)	4 – 230 (0.16 – 9.06)	300	400	500	–
0.15 – 0.25 (0.006 – 0.01)	4 – 720 (0.16 – 28.34)	300	400	500	–
0.25 – 0.6 (0.01 – 0.024)	6 – 750 (0.24 – 29.5)	–	400	500	600
0.6 – 1 (0.024 – 0.04)	8 – 750 (0.32 – 29.5)	–	400	500	600
1 – 2 (0.04 – 0.08)	15 – 750 (0.6 – 29.5)	–	400	500	600
2 – 3 (0.08 – 0.12)	25 – 750 (0.98 – 29.5)	–	400	500	600

Rolled sheet – separated from the coil – are available in lengths from 250 to 4,000 mm (9.84 to 157.48 in).

Rod

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

Condition	Outside diameter mm (in)	Length mm (in)
Rolled, drawn	6 – 125 (0.24 – 31.5)	≤ 12,000 (472.44)
Forged	125 – 600 (0.47 – 23.62)	≤ 7,500 (295.28)

Wire

Delivery condition: bright drawn, 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 – 0.4)	5.5 – 19 (0.22 – 0.75)

Legal notice

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