

VDM® Alloy 188
Conicro 4023 W



Conicro 4023 W – alloy 188

Material Data Sheet No. 6001

Edition June 1994

Conicro 4023 W 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.

Conicro 4023 W is characterised by:

- excellent mechanical properties up to 1150 °C (2100 °F)
- good resistance to scaling and oxidation up to 1150 °C (2100 °F)
- good formability and weldability

Designation and standards

Country	Material designation	Specification									
		Chemical composition	Tube and pipe		Sheet and plate	Rod and bar	Strip	Wire	Forgings		
National standards			seamless	welded							
France ANFOR	KCN 22 W				AIR 9165 AIR 9162	AIR 9165 AIR 9161					
Germany DIN VdTUV	W.-Nr. 2.4683 CoCr20NiW										
United Kingdom BS											
USA ASTM ASME AMS ISO	UNS R30188				5608	5772	5608	5801	5772		

Chemical composition (%)

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

Conicro 4023 W – alloy 188

Physical properties

Typical physical properties at room and elevated temperatures.

Density	9.1 g/cm ³	0.33 lb/in ³
Melting temperature	1300–1330 °C	2375–2450 °F
Permeability at 20 °C/68 °F (RT)		1.01
Electrical resistivity	95 μΩ cm	570 $\frac{\Omega \text{ circ mil}}{\text{ft}}$

Temperature T		Specific heat		Thermal conductivity		Modulus of elasticity		Coefficient of thermal expansion between room temperature and T	
°C	°F	J/kg K	$\frac{\text{Btu}}{\text{lb } ^\circ\text{F}}$	W/mK	$\frac{\text{Btu in}}{\text{ft}^2 \text{ h } ^\circ\text{F}}$	kN/mm ²	10 ³ ksi	10 ⁻⁶ /K	$\frac{10^{-6}}{^\circ\text{F}}$
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	

Conicro 4023 W – alloy 188

Mechanical properties

The following properties are applicable to Conicro 4023 W in the solution-treated condition and indicated size ranges.

Form	Dimensions		Tensile strength		0.2 % Yield strength		Elongation A ₅	Brinell hardness max HB
	mm	inches	N/mm ²	ksi	N/mm ²	ksi		
Sheet, strip	≤ 0.5	≤ 0.02					40	
	> 0.5	> 0.02					45	
Plate	≤ 12.5	≤ 0.5	860	125	380	55	40	
Bar	∅ ≤ 100	≤ 4					45	302
Forgings	≤ 75	≤ 3						293

Table 4 - Minimum mechanical properties at room temperature.

Sheet, strip, plate	≤ 0.5	≤ 0.02	620	90	250	36	40
	> 0.5	> 0.02					50

Table 5 - Minimum mechanical properties at 650 °C (1200 °F) after 20 to 30 minutes at testing temperature (according to AMS 5608).

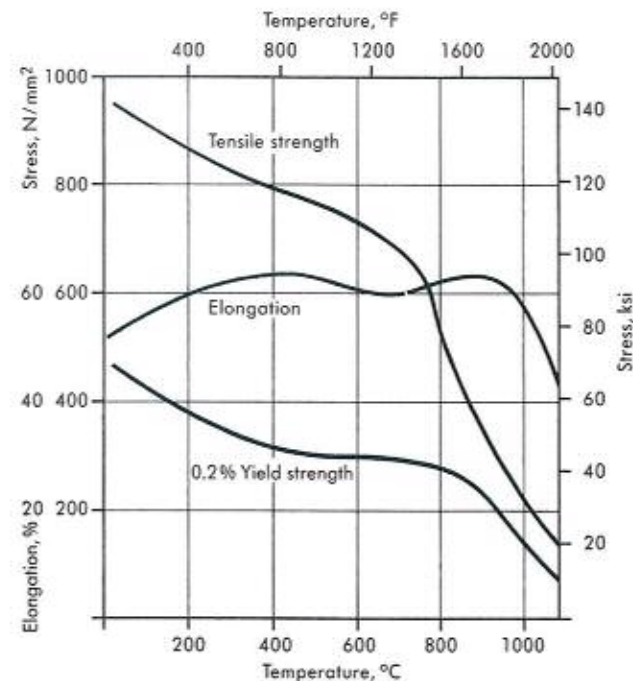


Fig. 1 - Typical short-time properties of solution-treated Conicro 4023 W sheet at room and elevated temperatures.

Specified properties of material outside these size ranges are subject to special enquiry.

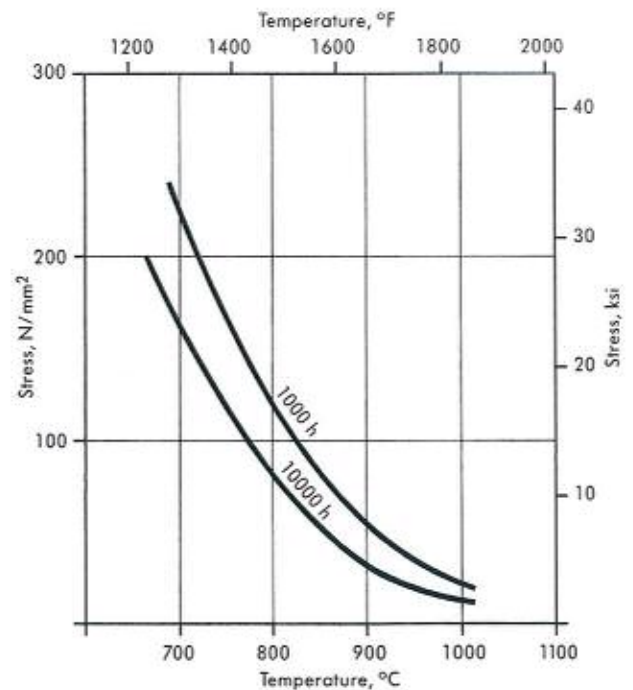


Fig. 2 - Typical creep-rupture properties of solution-treated Conicro 4023 W.

Conicro 4023 W – alloy 188

According to	AIR 9165				AMS 5608		AMS 5772	SNECMA	
Form	Bar	Sheet	Sheet	Sheet	Sheet, strip, plate		Bar	Forgings	
Thickness, diameter	mm	16 ϕ	≤ 5	< 0.8	≥ 0.8	≤ 0.5	> 0.5	–	–
	inches	0.63 ϕ	≤ 0.2	< 0.3	≥ 0.3	≤ 0.02	> 0.02	–	–
Temperature	$^{\circ}\text{C}$	815		925		927		927 1040	
	$^{\circ}\text{F}$	1500		1700		1700		1700 1900	
Time	h	≥ 30			≥ 23			≥ 23	≥ 15
Stress	N/mm ²	155		73	85	62	76	90	83 40
	ksi	22.5		10.6	12.3	8	15	13	12 5.8
Elongation	%	≥ 10		≥ 15	≥ 8	≥ 15		≥ 15	≥ 12

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

Bend properties

Conicro 4023 W 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 (0.05 in)	1.5 x thickness
$> 1.27 < 4.76$ mm	2 x thickness
(> 0.05 in < 0.187 in)	

Metallurgical structure

Conicro 4023 W has a face-centred cubic structure. High-temperature strength is obtained by solid-solution hardening with tungsten and by precipitation of carbides.

Corrosion resistance

Conicro 4023 W exhibits excellent resistance to hot corrosion by sulphidation, and is especially resistant to oxidation up to temperatures of 1150 °C (2100 °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

Conicro 4023 W is used for applications requiring high mechanical properties at high temperatures. Recommended service temperature range is up to 1100 °C (1830 °F).

Typical applications 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

Conicro 4023 W – alloy 188

Fabrication and heat treatment

Conicro 4023 W is readily fabricated by usual industrial procedures. Hot and cold working, however, require high-power machines, owing to the high strength of the material.

The weldability of Conicro 4023 W is excellent. Joining can be performed by all conventional welding processes.

Heating

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

Conicro 4023 W 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 their 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

Conicro 4023 W may be hot-worked in the range 1200 to 1000 °C (2190 to 1830 °F). Cooling should be by water quenching or as fast as possible.

Solution treatment is recommended after hot working to ensure maximum creep resistance.

When the furnace has reached temperature, the material should be soaked for 60 minutes per 100 mm (4 in) of thickness. After soaking for the required time the metal should be withdrawn immediately and worked within the specified range. If the metal temperature falls below the minimum working temperature, it must be reheated.

Cold working

Cold working should be carried out on solution-treated material. Conicro 4023 W has a much higher work-hardening rate than austenitic stainless steel and the forming equipment must be adapted accordingly.

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

Heat treatment

Solution annealing should be carried out in the temperature range 1180 to 1220 °C (2150 to 2230 °F), preferably at about 1190 °C (2175 °F). Water quenching or rapid air cooling, is recommended.

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

Descaling

Oxides of Conicro 4023 W are more adherent than those of stainless steel. Both mechanical and chemical methods of descaling may be applied. Mechanical methods should be avoided which produce either contamination of the metal, or a highly-deformed surface layer.

Before pickling in a nitric/hydrofluoric acid mixture, oxides must be broken up by grit-blasting or by pre-treatment in a fused salt bath.

Machining

Conicro 4023 W should be machined in the solution-treated 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

Conicro 4023 W 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 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.

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	W.-Nr. 2.4683
		CoCr22NiW
		AMS 5801

Availability

Conicro 4023 W is available in all standard mill product forms.

Conicro 4023 W – alloy 188

Technical publications

The following publications concerning Conicro 4023 W may be obtained from Krupp VDM GmbH:

„Korrosion von Nickel, Kobalt und Nickel- und Kobalt-Basislegierungen“

U. Brill, Krupp VDM 1992

We reserve the right to make alterations, especially where necessitated by technical developments or changes in availability.

The information contained in this data sheet, which in any case provides no guarantee of particular characteristics, has been compiled to the best of our knowledge but is given without any obligation on our part.

Our liability is determined solely by the individual contract terms, in particular by our general conditions of sale.

This issue supersedes data sheet no. 6001, edition May 1992.

Edition June 1994: Please ask for the latest edition of this data sheet.

ThyssenKrupp VDM GmbH
Plettenberger Straße 2
58791 Werdohl
Postfach 18 20
58778 Werdohl
Telefon: +49 2392 55-0
Telefax: +49 2392 55-2217
E-Mail: vdm@thyssenkrupp.com
www.thyssenkruppvdm.com

Imprint

Date of publication

June 1994

Publisher

VDM Metals GmbH
Plettenberger Straße 2
58791 Werdohl
Germany

Disclaimer

All information contained in this data sheet are based on the results of research and development work carried out by VDM Metals GmbH, and the data contained in the specifications and standards listed available at the time of printing. The information does not represent a guarantee of specific properties. VDM Metals reserves the right to change information without notice. All information contained in this data sheet is compiled to the best of our knowledge and is provided without liability. Deliveries and services are subject exclusively to the relevant contractual conditions and the General Terms and Conditions issued by VDM Metals GmbH. Use of the most up-to-date version of this data sheet is the responsibility of the customer.

VDM Metals GmbH
Plettenberger Straße 2
58791 Werdohl
Germany

Phone +49 (0) 2392 55-0
Fax +49 (0) 2392 55-2217

vdm@vdm-metals.com
www.vdm-metals.com