VDM Metals

A company of ACERINOX

VDM® Alloy C-263
Nicrofer 5120 CoTi

Material Data Sheet No. 4020 **Revision 01**
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VDM® Alloy C-263

Nicrofer 5120 CoTi

VDM® Alloy C-263 is a high-temperature precipitation-hardening creep-resisting nickel-chromium-cobalt-molybdenum alloy developed by Rolls-Royce. It is ususally supplied in the high-temperature annealed condition and is recommended for service temperatures up to 850 °C (1,560 °F).

VDM® Alloy C-263 is characterized by:

- Excellent resistance to oxidation and scaling up to 1,000 °C (1,800 °F)
- Good mechanical properties and excellent creep values at elevated temperatures
- Good weldability without susceptibility to post-weld heat treatment cracking
- Improved wear characteristics

Designations and standards

Standard	Material designation
DIN EN	2.4650 – NiCo20Cr20MoTi
UNS	N07263
ISO	NiCo20Cr20Mo5Ti2Al

Product form	AMS
Sheet, plate	5872
Strip	5872
Rod, bar	5886

Table 1 – Designations and standards

Chemical composition

	Ni	Cr	Fe	C	Mn	Si	Cu	Mo	Co	Al	Ti	Al+Ti	P	S	B	Pb*	Ag*	Zr*
Min.	bal.	19.0		0.04				5.6	19.0	0.3	1.9	2.4						
Max.		21.0	0.7	0.08	0.6	0.4	0.2	6.1	21.0	0.6	2.4	2.8	0.015	0.007	0.005	0.002	0.0005	0.02

*determination only if requested

Table 2 – Chemical composition (%)

Physical properties

Density	Melting range	Relative magnetic permeability at 20 °C (68 °F)
8.4 g/cm³	1,300 – 1,360 °C	< 1.001
0.30 lb/in³	2,370 – 2,480 °F	

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
0	32	422	0.1000	11.6	81	115	223	32.3		
20	68	426	0.102	11.7	81	115	222	32.3		
93	200		0.106		89			31.6		6.0
100	212	447		13.0		117	218		10.7	
200	392	472		14.7		118	212		12.0	
204	400		0.113		102			30.6		6.7
300	572	497		16.3		120	206		12.5	
316	600		0.119		115			29.6		7.0
400	752	523		18.0		122	198		13.0	
427	800		0.126		128			28.4		7.3
500	932	548		19.7		124	192		13.5	
538	1000		0.133		141			27.2		7.6
600	1112	573		21.4		126	184		14.1	
649	1200		0.139		154			25.9		8.0
700	1292	598		23.0		126	176		14.9	
760	1400		0.146		167			24.3		8.5
800	1472	624		24.7		125	165		15.9	
871	1600		0.153		181			22.6		9.2
900	1652	649		26.8		124	153		17.2	
982	1800		0.159		196			20.8		9.9
1000	1832	674		28.5		124	143		18.2	

Table 3 – Typical physical properties at room and elevated temperatures

Microstructural properties

The high-temperature strength of VDM® Alloy C-263 is obtained by two strengthening mechanismus. The cobalt and molybdenum additions give solid-solution strengthening. The aluminum and titanium additions form precipitates of the γ'phases Ni_3 (Al, Ti) on age-hardening.

The cobalt addition also increases the solubility of γ' above 1100 °C (2010 °F), thus facilitating hot working despite the high aluminium and titanium contents. Boron and zirconium also improve creep rupture properties.

In the fully heat-treated condition, the microstructure of of VDM® Alloy C-263 shows fine discontinuous precipitates of carbides ($M_{23}C_6$) at the grain boundaries.

Continuous $M_{23}C_6$ films must be avoided, as this can lead to poor ductility and hot trearing during welding. Correct solution treatment will avoid this effect.

Mechanical properties

The following mechanical properties apply to VDM® Alloy C-263 in the indicated size ranges (see availability). Specified properties of material outside these size ranges are subject to special enquiry.

A. Hot or cold-rolled sheet, solution treated and descaled

Hardness max. 250 HB

Bending (parallel to the rolling direction) 180°
≤ 1.27 mm ≤ 0.050 in. factor 1
> 1.27 to 4.75 mm > 0.050 to 0.187 in. factor 2

Grain size
hot-rolled sheet ≤ 127 µm ASTM No. 3
cold-rolled sheet ≤ 190 µm ASTM No.

B. Hot or cold-formed, solution treated, precipitation-hardened and descaled

After precipitation hardening the product will meet the following properties at 780 ± 2 °C (1435 ± 3 °F) after 20 min. at temperature:

Tensile strength R_m	≥ 540 N/mm²	≥ 78.5 ksi
Yield strength $R_{p\ 0.2}$	≥ 400 N/mm²	≥ 58.5 ksi
Elongation A5	≥ 15 %	
Creep strength	under continuous stress of 120 N/mm² /17 ksi for 50 hours total plastic strain ≤ 0.1 %.	

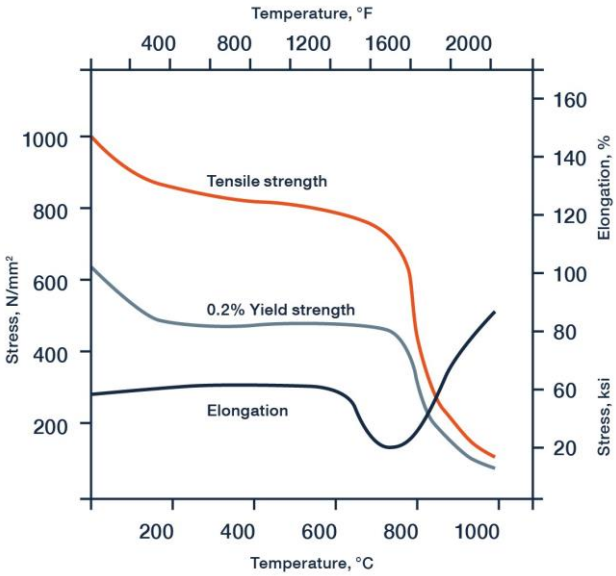

Figure 1 – Typical short-time properties of solution-treated and precipitation-hardened VDM® Alloy C-263 sheet and plate at room and elevated temperatures.

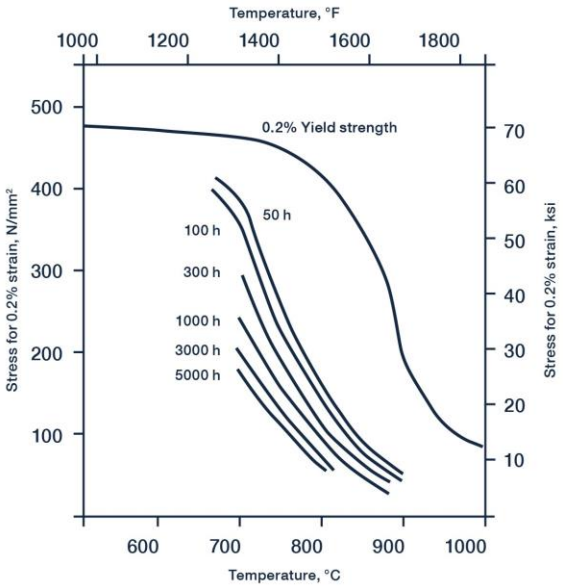

Figure 2 – 0.2 % total plastic strain data for solution-treated and age hardened cold-rolled sheet.

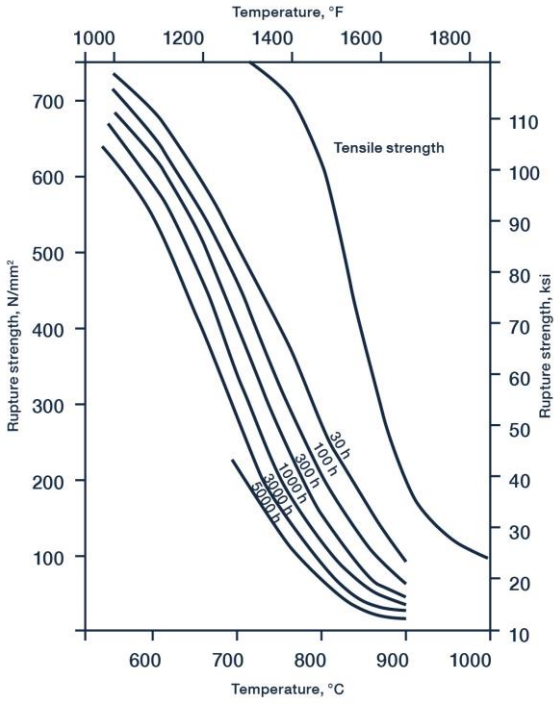

Figure 3 – Creep rupture values of solution-treated and age hardened cold-rolled sheet.

Corrosion resistance

VDM® Alloy C-263 shows excellent oxidation resistance up to 1,000 °C (1,830 °F).

Applications

Due to its high-temperature corrosion resistance and excellent high-temperature strength up to 815 °C (1,500 °F), combined with ease of fabrication and weldability, VDM® Alloy C-263 finds wide application in high-temperature service, especially in aircraft and industrial gas turbines. Examples are combustion chambers, exhaust cones and rings.

Fabrication and heat treatment

VDM® Alloy C-263 is readily fabricated by usual industrial procedures.

Heating
It is very important that the workpiece be clean and free from any contaminant before and during heating.
Nicrofer 5120 CoTi 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 sulphur are satisfactory.

Electric furnaces are desirable due to 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 oxidizing and must not fluctuate between oxidising and reducing. Flame impingement on the metal must be avoided.

Hot forming
VDM® Alloy C-263 may be hot-worked in the range 1,170 to 950 °C (2,140 to 1,740 °F). Cooling should be by water quenching or as fast as possible. During the final hot working operation, the temperature must not exceed 1,120 °C (2,050 °F).

Solution treatment is recommended after hot working to ensure optimum properties. For hot working, the material may be charged into the furnace at maximum working temperature.

Cold forming

Cold working should be carried out on solution-treated material. Nicrofer 5120 CoTi 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.

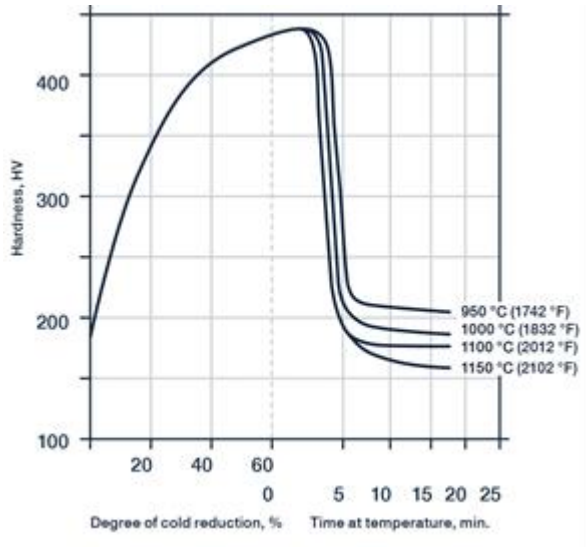

Figure 4 – Influence of cold working and subsequent annealing on the hardness of cold-rolled sheet (1.0 to 1.5 mm/0.04 to 0.06 in.)

Heat treatment

Solution treatment should be carried out at 1,150 ± 10 °C (2,100 ± 15 °F), sheet and plate 5 to 15 min. WQ or AC, rod and bar 0.5 to 2.5 h WQ to hardness of max. 230 HB.

Intermediate softening between cold-forming processes at 1,080 ± 10 °C (1,980 ± 15 °F), 4 to 6 min., AC.

Diffusion annealing of welding seams at 1,150 °C (2,100 °F) 1 h AC.

Precipitation heat treatment should be carried out at 800 ± 15 °C (1,475 ± 25 °F), ageing time at temperature 8 hours ± 0.5 h, AC to hardness of min. 275 HV.

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

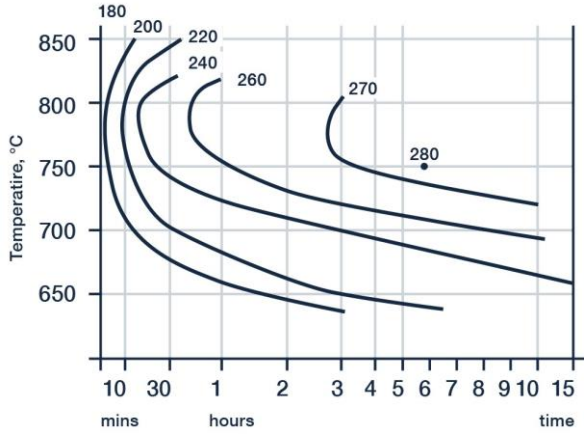

Figure 5 – Effect of ageing time and temperature on hardness (HV) of solution-treated sheet material with initial hardness HV 30 – 180

Descaling and pickling
Oxides of VDM® Alloy C-263 and discoloration adjacent to welds, are more adherent than on stainless steels. Grinding with very fine abrasive belts or discs is recommended. Before pickling in a nitric/hydrofluoric acid mixture, oxides must be broken up by grit-blasting or by pretreatment in a fused salt bath.

Machining
VDM® Alloy C-263 should be machined in the annealed condition. The alloy's high work-hardening rate should be considered; i.e. only low surface cutting speeds are possible compared with low-alloyed standard austenitic stainless steel. Tools should be engaged at all times. Heavy feeds are important in getting below the work-hardened 'skin'.

Welding information

The precipitation-hardening VDM® Alloy C-263 is suitable for the fabrication of complex welded structures, and can be repair-welded. Weld ductility, ease of fabrication and high strength are the main advantages of this quaternary alloying system.

VDM® Alloy C-263 can be welded by conventional processes as gas tungsten-arc (TIG/GTAW), plasma, laser, and electronbeam welding; heavier wall thicknesses can be welded with MIG pulsed-arc welding.

Matching material or the following welding products are recommended:

TIG/MIG-PA

VDM® FM C-263 (2.4650)
DIN EN ISO 18274: S Ni 7263 (NiCo20Cr20MoTi)
BS 2901 NA38

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 ot the joint should be ground to bright metal. Low heat input is necessary. Interpass temperature should not exceed 100 °C (210 °F). VDM® Alloy C-263 is not susceptible to post-weld heat treatment cracking, due to the very low ageing rate which permits stress relief to take place prior to precipitation of γ'-phase. It is also free from heat-affected-zone cracking.

Availability

VDM® Alloy C-263 is available in the following standard 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

22.07.2021

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