VDM Metals

A company of ACERINOX

VDM® Alloy 602 MCA

Nicrofer 6025 MCA

Data Sheet No. 4139

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VDM® Alloy 602 MCA

Nicrofer 6025 MCA

VDM® Alloy 602 MCA is a nickel-chromium-iron alloy with additions of aluminum and titanium as well as micro alloying elements zirconium and yttrium. It is normally supplied in solution-annealed condition with a descaled surface.

VDM® Alloy 602 MCA is characterized by:

- Outstanding resistance to oxidation at high temperatures, even under cyclical conditions
- Very good corrosion resistance in carburizing and oxidizing / chlorinating media at high temperatures similar to VDM® Alloy 602 CA
- High creep resistance at elevated temperatures
- Improved workability compared to VDM® Alloy 602 CA

Designations and standards

Standard	Material designation
D	2.4833 – NiCr25FeAlYB

Table 1a – Designations and standards

Product form	DIN
Rod, bar	17742
Sheet, plate	17742
Strip	17742

Table 1b – Designations and standards

Chemical Composition

	Ni	Cr	Fe	C	Mn	Si	Cu	Al	Ti	Y	Zr	P	S	B
Min.	Bal.	24.0	7.0	0.03				1.9	0.10	0.01	0.01			
Max.		27.0	11.0	0.11	0.50	0.50	0.50	2.6	0.20	0.12	0.10	0.020	0.010	0.008

Table 2 – Chemical composition (wt.-%) according to DIN 17742

Physical properties

Density	Melting range
7.97 g/cm^3 at 20 °C 0.288 lb/in^3 at 68 °F	1,364 – 1,397 °C 2,487 – 2,547 °F

Temperature		Specific heat capacity		Thermal conductivity		Modulus of elasticity		Coefficient of thermal expansion		Electrical resistivity	
°C	°F	$\frac{J}{kg \cdot K}$	$\frac{Btu}{lb \cdot °F}$	$\frac{W}{m \cdot K}$	$\frac{Btu\ in}{sq.\ ft \cdot h \cdot °F}$	GPa	10^3 ksi	$\frac{10^{-6}}{K}$	$\frac{10^{-6}}{°F}$	µΩ·cm	$\frac{Ω \cdot circ\ mil}{ft}$
20	68	(450)	(0.108)	(11.0)	(76)	207	30.0	(13.6)	(7.56)	125	752
50	122	460	0.110	11.3	78					125	752
100	212	470	0.112	12.0	83	203	29.4	13.8	7.67	126	758
200	392	490	0.117	13.5	93.6	197	28.6	14.0	7.78	127	764
300	572	500	0.119	15.2	105	190	27.6	14.3	7.94	129	776
400	752	510	0.122	16.9	117	184	26.7	14.7	8.17	131	788
500	932	530	0.127	18.5	128	178	25.8	15.1	8.39	132	794
600	1112	590	0.141	21.9	160	171	24.8	15.2	8.44	133	800
700	1292	600	0.143	22.8	158	164	23.8	15.5	8.61	132	794
800	1472	600	0.143	23.4	164	155	22.5	16.4	9.11	132	794
900	1652	610	0.146	24.1	167	146	21.2	17.1	9.50	132	794
1000	1832	640	0.153	25.6	178	137	19.9	17.7	9.83	133	800
1100	2012	680	0.163	27.8	193	128	18.6	18.3	10.2	133	800
1200	2192	700	0.167	30.1	209			19.0*)	10.6*)		

Table 3 – Typical physical properties at room and elevated temperatures. *) extrapolated

Microstructural properties

VDM® Alloy 602 MCA has a face-centered-cubic structure. The good mechanical properties are driven by carbide precipitation and at temperatures below 800°C (1,472°F), by additional γ' precipitates.

Mechanical properties

The properties in Table 4 are applicable to VDM® Alloy 602 MCA in the solution-annealed condition and indicated size ranges:

- Sheet Metal ≤ 50 mm (≤ 1.97 in)
- Strip ≤ 4 mm (≤ 0.16 in)
- Rods and forgings between 120 mm (4.72 in) and 300 mm (11.81 in)

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

Temperature		Yield strength $R_{p\ 0,2}$		Tensile strength R_m		Elongation A
°C	°F	MPa	ksi	MPa	ksi	%
20	68	250	36.3	640	92.8	35
100	212	220	31.9			
200	392	200	29.0			
300	572	180	26.1			
400	752	170	24.7			
500	932	160	23.2			
600	1112	155	22.5			
700	1292	150	21.8			

Table 4 – Minimum short-term mechanical properties of VDM® Alloy 602 MCA in the solution annealed condition.

ISO V-notch impact strength

Minimum value for V-notch impact strength KV_2 (according to ISO 148-1) at 20 °C in the solution-annealed condition:

≥ 70 Joule

Corrosion resistance

The corrosion resistance of VDM® Alloy 602 MCA is similar to VDM® Alloy 602 CA, which has an oxidation resistance superior to that of VDM® Alloy 601 over the whole temperature range up to 1200°C (2192°F). Even under extreme conditions such as cyclic heating and cooling, VDM® Alloy 602 MCA like VDM® Alloy 602 CA, retains this characteristic, imparted by the tightly adherent layer of aluminum oxide beneath a chromia scale, which is very resistant to spalling. VDM® Alloy 602 MCA has the same good oxidation behavior as VDM® Alloy 602 CA. In comparison, VDM® Alloy 601 has worse oxidation behavior because of its lower aluminum content and hence also a higher mass gain in oxidation experiments.

Furthermore, because of a similar chromium and aluminum content the corrosion resistance of VDM® Alloy 602 MCA in oxidizing, sulfidizing or carburizing environments is similar to VDM® Alloy 602 CA.

For further information please contact VDM.

Applications

VDM® Alloy 602 MCA can be used for a wide range of applications in thermal and petrochemical processes as well in power plant equipment and automotive industry.

Typical applications are:

- Furnace components
- Methanol and ammonia synthesis
- Hydrogen production
- Reformers in chemical and petrochemical industries
- Glow plugs
- Exhaust systems
- Deep drawn parts for high temperature sensors
- Heat exchangers

Fabrication and Heat treatment

VDM® Alloy 602 MCA can be easily hot and cold worked and machined.

Heating
Production pieces must be clean and free from all kinds of contaminants before and during any heating operation. The quality of VDM® Alloy 602 MCA may be impaired if heated in the presence of contaminants such as sulfur, phosphorus, lead and other low-melting-point metals. Sources of such contaminants include marking and temperature-indicating paints and crayons, lubricating grease, fluids and fuels. Fuels must be as low in sulfur as possible. Natural gas should contain less than 0.1 wt.-% sulfur. Liquid fuels with a sulfur content not exceeding 0.5 wt.-% are suitable. Due to their close control of temperature and lack of contamination, thermal treatments in electric furnaces under vacuum or in an inert gas atmosphere are to be preferred. Treatments in an air atmosphere and, alternatively, in gas-fired furnaces are acceptable though, if contaminants are kept at low levels so that a neutral or slightly oxidizing furnace atmosphere is attained. A furnace atmosphere fluctuating between oxidizing and reducing conditions must be avoided as well as direct flame impingement on the metal.

Hot forming
VDM® Alloy 602 MCA may be hot worked in the temperature range 1200 to 900°C (2190 to 1650 °F), followed by water quenching or rapid air cooling. VDM® Alloy 602 MCA has similar to VDM® Alloy 602 CA a reduced ductility between 600°C and 800°C (1112 and 1472°F). Heat treatment after hot working is recommended in order to achieve optimum properties. For heating up, production pieces should be charged into the furnace at maximum working temperature.

Cold forming
For cold working the solution-annealed condition is recommended. The typical elongation at room temperature is larger than the one for VDM® Alloy 602 CA. So cold working is easier. For recommendations about annealing after cold working, stress relaxation cracking and bending see the datasheet of VDM® Alloy 602 CA.

Heat treatment
VDM® Alloy 602 MCA should be used in the solution-annealed condition. A solution-annealing should be performed as high as possible preferred at 1200 °C (2192 °F) to 1220 °C (2228 °F) followed by water quenching or rapid air cooling in air or a protective atmosphere. For any heat treatment the material should be charged into a furnace at maximum annealing temperature observing the precautions concerning cleanliness mentioned earlier under “Heating”.

Descaling and pickling
Oxides of VDM® Alloy 602 MCA and discoloration adjacent to welds are more adherent than on standard stainless steels. Grinding with very fine abrasive belts or discs is recommended. Care should be taken to prevent tarnishing. Before pickling which may be performed in a nitric/hydrofluoric acid mixture the surface oxide layer must be broken up by abrasive blasting, by carefully performed grinding or by pretreatment in a fused salt bath. Particular attention should be paid to the pickling time and temperature.

Machining
VDM® Alloy 602 MCA should preferably be machined in the heat-treated condition. As the alloy is prone to work-hardening, a low cutting speed should be used and the tool should be engaged at all times. Suitable cutter geometries, suitable cutter materials and cut values can be taken from the VDM Metals publication
Working and machining of austenitic special stainless steels and nickel alloys.

Welding information

The qualifications of the welding process are currently under investigation.

For any questions regarding welding, please contact VDM.

Availability

VDM® Alloy 602 MCA is available in the following standard product forms:

Sheet and Plate

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

Delivery condition	Thickness mm (in)	Width mm (in)	Length mm (in)	Piece weight kg (lb)
Hot rolled	3-50 (0.12-1.97)*	≤ 2,500 (98.43)	≤ 12,500 (492.13)	≤ 2.250 (3,858)

Sheets can be manufactured considering the minimum and maximum dimensions
* 2 mm (0.08 in) thickness on request

Strip

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

Thickness mm (in)	Width mm (in)	Coil - inside diameter mm			
0,020-0,15 (0.0007-0.006)	4-230 (0.16-9.055)	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
2-4 (0.08-0.16)	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 and Bar

Delivery condition: Forged, heat treated, descaled or pickled, turned, peeled, ground or polished

Dimensions*	Outer diameter mm (in)	Length mm (in)
General dimensions	6-800 (0.24-31.5)	1,500-12,000 (59.06-472.44)
Material specific dimensions	120-300 (4.72-11.81)	1,500-12,000 (59.06-472.44)

* Further dimensions on request.

Other shapes and dimensions available on request.

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