VDM Metals

A company of ACERINOX

VDM® Alloy C-264

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VDM® Alloy C-264

VDM® Alloy C-264 is a nickel-based super alloy developed by VDM Metals. It was developed specifically for corrosive high-temperature environments, as those found in modern high-performance turbochargers.

VDM® Alloy C-264 is an age-hardenable alloy with an austenitic microstructure. The alloy features a high temperature strength as well as excellent creep resistance at temperatures of up to 950 °C (1,742 °F). VDM® Alloy C-264 is by far superior to similar materials such as VDM® Alloy C-263 (2.4650) in terms of creep resistance especially.

VDM® Alloy C-264 is characterized by:

- Excellent processing properties in solution-annealed condition
- Very good creep strength up to 950 °C (1,742 °F)
- Good oxidation resistance up to approx. 1,050 °C (1,922 °F)
- Good mechanical short and long-term properties, as well as good fatigue strength in age-hardened condition

Designations

Standardization	Material designation
DIN	2.4750
ISO	NiCr25Co20MoTiAl

Table 1 – Designations and standards

Chemical composition

	C	S	Cr	Ni	Mn	Si	Mo	Ti	Nb	Cu	Fe	P	Al	V	Zr	W	Co	B	Al + Ti
Min.	0.04		24.0	bal			5.60	1.50					0.90			0.40	19.0		2.50
Max.	0.08	0.015	26.0		0.60	0.40	6.20	2.00	0.10	0.20	0.70	0.02	1.20	0.50	0.10	0.80	21.0	0.005	3.10

For technical reasons, the material may contain more elements than listed.

Table 2 – Chemical composition (%)

Physical properties

Density	Melting range
8.27 g/cm³ (516 lb/ft³) At 20 °C (68 °F)	1,325– 1,382 °C (2,420 – 2,520 °F)

Temperature		Specific heat capacity		Thermal conductivity		Electrical resistance	Modulus of elasticity		Shear modulus	Coefficient of thermal expansion
° C	° F	$\frac{J}{kg \cdot K}$	$\frac{BTU}{lb \cdot °F}$	$\frac{W}{m \cdot K}$	$\frac{BTU \cdot in}{h \cdot ft^2 \cdot °F}$	µΩ · cm	GPa	10^6 psi	GPa	$\frac{10^{-6}}{°F}$
20	67	414	0.098	9.964	69.1	115	219	31.8	81.9	-
50	122	433	0.103	10.725	74.4	116	-	-	-	-
100	212	457	0.109	11.814	81.9	117	214	31	80.0	6.79
200	392	480	0.115	13.510	93.7	119	208	30.2	77.3	7.16
300	572	495	0.118	14.926	103	121	201	29.2	74.7	7.43
400	752	508	0.121	16.404	114	122	194	28.1	72.2	7.67
500	931	520	0.124	17.589	122	124	188	27.3	69.5	7.86
600	1,112	516	0.123	18.446	128	125	181	26.3	66.7	8.03
700	1,292	607	0.145	23.962	166	125	172	24.9	63.2	7.36
800	1,472	618	0.148	23.845	165	126	163	23.6	59.5	8.65
900	1,652	639	0.153	25.357	176	125	151	21.9	55.0	9.23
950	1,742	650	0.155	26.354	183	125	144	20.9	52.6	-
1,000	1,832	661	0.158	27.371	190	125	139	20.2	50.1	9.72
1,050	1,922	673	0.161	28.418	197	-	134	19.4	48.2	-
1,100	2,012	687	0.164	29.493	204	-	128	18.6	45.9	10.1

Table 3 – Typical physical properties (at room and elevated temperatures)

Microstructural properties

VDM® Alloy C-264 is an age-hardenable alloy with an austenitic microstructure. Beside the main component of nickel, it contains 25% chromium, 20% cobalt, 5.5% molybdenum, 1.7% titanium and 1.1% aluminum. The alloy fea-tures a high temperature strength as well as excellent creep resistance at temperatures of up to 950 °C (1,742 °F). This is achieved by a combination of hardening mechanisms, such as solid solution solidification, carbide hardening and γ' hardening.

VDM® Alloy C-264 is therefore far superior to similar materials such as alloy VDM® C-263 in terms of creep re-sistance especially. This long-term stability is realized through a γ' phase more stable at high temperatures, the main reinforcing phase that can no longer change into the undesired η phase.

Mechanical properties

The following mechanical properties apply to VDM® Alloy C-264 in the age-hardened condition (8 h/800 °C) (8 h/1.472 °F).

Temperature		**Yield strength**		**Tensile strength**		**Elongation at fracture**	**Reduction of area**
		$R_{p\ 0.2}$	**$R_{p\ 0.2}$**	**R_m**	**R_m**	**A_s**	
°C	**°F**	**MPa**	**ksi**	**MPa**	**ksi**	**%**	**%**
20	67	635	92.1	1,026	149	28	15
100	212	572	83	996	144	34	15
200	392	535	77.6	962	140	32	15
300	572	510	74	928	135	31	15
400	752	496	71.9	883	128	40	15
500	932	488	70.8	862	125	37	15
600	1,112	490	71.1	890	129	35	15
650	1,202	506	73.4	936	136	39	15
700	1,292	514	74.5	876	127	33	15
750	1,382	511	74.1	775	112	32	15
800	1,472	422	61.2	642	93.1	30	15
850	1,562	291	42.4	490	71.1	32	
900	1,652	268	38.9	323	46.8	49	
950	1,742	126	18.3	164	23.8	128	
1,000	1,832	82	11.9	115	16.7	77	

Table 4 – Typical mechanical properties at room and elevated temperatures. Hot-rolled strip (thickness 4.8 mm), transverse to the direction of rolling, solution-annealed (SA) + age-hardened (8 h/800°C)

Product form strip Annealing Expansion	Sample position	Duration of hardening	Yield strength		Yield strength		Tensile strength		Elongation at fracture	Uniform elongation
			$Rp_{0.2}$ MPa	$Rp_{0.2}$ ksi	$Rp_{1.0}$ MPa	$Rp_{1.0}$ ksi	R_m MPa	R_m ksi	A_5 %	A_g %
Solution-annealed (SA)	Transverse		364	52,79	399	57.87	800	116	63	55
Age hardening	Transverse	4h/750°C (1,382°F)	600	87,02	616	89.34	1,029	149.24	43	40
Age hardening	Transverse	8h/750°C (1,382°F)	652	94.56	672	97.46	1,076	156.06	40	36
Age hardening	Transverse	4h/800°C (1,472°F)	643	93.26	667	96.74	1,073	155.62	39	35
Age hardening	Transverse	8h/800°C (1,472°F)	653	94.7	681	98.77	1,090	158.1	38	34
Solution-annealed (SA)	Longitudinal		361	52.35	396	57	799	115.88	60	53
Age hardening	Longitudinal	4h/750°C (1,382°F)	596	86.44	612	88.76	1,033	149.82	43	39
Age hardening	Longitudinal	8h/750°C (1,382°F)	650	94.27	667	96.74	1,081	156.78	39	36
Age hardening	Longitudinal	4h/800°C (1,382°F)	641	92.96	664	96.30	1,080	156.64	38	34
Age hardening	Longitudinal	8h/800°C (1,382°F)	652	94.56	680	98.62	1,096	158.96	34	31

Table 5 – Typical mechanical properties at room temperature. Strip (1 mm thickness) in different conditions

Measurements from creep rupture tests in direct comparison: VDM® Alloy C-264 vs. VDM® Alloy C-263

Temperature		Stress		Service life C-264	Service life C-263
°C	°F	MPa	ksi	h	h
730	1,376	400	58	30	-/-
880	1,616	70	10.15	1,503	492
900	1,652	60	8.7	1,424	216
900	1,652	70	10.15	777	55
900	1,652	80	11.6	360	29
920	1,688	70	10.15	203	17
950	1,742	50	7.25	119	-/-
950	1,742	60	8.7	29	17

Table 6 – Creep strength up to rupture; 4.8 mm hot-rolled strip; sample thickness 3 mm; solution-annealed (SA) + age-hardened (4 h/800°C)

Corrosion resistance

VDM® Alloy C-264 is an age-hardenable nickel-chromium-cobalt-molybdenum alloy. Age hardening is realized by means of type γ' precipitated particles, which are achieved by means of admixtures of titanium and aluminum. Besides precipitation hardening, it also contains a high solid solution hardening content, realized by means of the elements chromium, cobalt, molybdenum and tungsten. The high chromium content results in good oxidation resistance as well as a considerable proportion of hardening by means of type $M_{23}C_6$ carbides.

Applications

Based on its outstanding creep resistance and very good oxidation resistance, VDM® Alloy C-264 is used for various components in the hot turbine side of high-performance turbochargers. Due to its excellent workability in the solution-annealed condition, complex and sophisticated components are possible. With a standard elongation at fracture measured in the solution-annealed condition of over 60%, VDM® Alloy C-264 is a deep-drawing material. In the age-hardened condition, VDM® Alloy C-264 also offers a very high elongation at fracture, typically over 35%, giving it good formability.

Typical applications for VDM® Alloy C-264 are:

- Use in components on the hot turbine side of high-performance turbochargers
- Use in components of exhaust systems
- High-temperature seals (C-ring/V-ring or multi-layer gaskets)
- Belleville washers
- Use as deep-drawing material
- Use in powertrain components
- Use as die-forging material

Processing and Heat treatment

VDM® Alloy C-264 can be easily formed both hot and cold and can also be machined.

Heat treatment

VDM® Alloy C-264 is generally used in the age-hardened condition.

The material is usually delivered in the solution-annealed condition. Should solution annealing be necessary anyway, annealing must be performed at 1,150 °C ± 20 °C (2,102 °F ± 68 °F). Depending on the material thickness, immediate water quenching (WQ) or air cooling (AC) may be necessary.
The maximum age-hardened condition achieved after annealing at 800 °C +10/-20 °C (1,472 °F + 50/-68 °F) for 4 to 8 hours. Subsequent air cooling (AC) is sufficient.
Depending on other uses/desired surface conditions, annealing under vacuum or shielding gas is recommended. Solution annealing at 1,150 °C (2,102 °F) in air can result in heat tints or formation of an oxidizing film.
For strip products, the heat treatment can be performed in a continuous furnace at a speed and temperature that is adapted to the strip thickness.

Availability

VDM® Alloy C-264 is available as strip.

The material is usually delivered in the solution-annealed condition. Delivery in the age-hardened condition depends on the material dimensions and is only possible on request.

Strip

Delivery condition: cold rolled, heat treated, pickled or bright annealed

Thickness mm	**Width mm**	**Coil inside diameter mm**			
0.025-0.15 (0.00098 – 0.0059)	4-230 (0.16-9.06)	300	400	500	–
0.15-0.25 (0,0059 – 0.0098)	4-720 (0.16-28.34)	300	400	500	–
0.25-0.6 0.0098 – 0.023)	6-750 (0.24-29.5)	–	400	500	600
0.6-1 0.023 – 0.039)	8-750 (0.32-29.5)	–	400	500	600
1-2	15-750	–	400	500	600

(0.039 – 0.078)	(0.6-29.5)				
2-3 0.078 – 0.11	25-750 (0.98-29.5)	–	400	500	600
Coil sheet – separated from the coil – is available in lengths from 250 to 4,000 mm (9.84 to 157.48 in).					

Publications

The following technical literature has been published about the material VDM® Alloy C-264:

On the evolution of microstructure during creep of a polycrystalline Ni-base Superalloy, H. Sommer, J. Kiese, M. Ersanli, N. de Boer, J. Kloewer, G. Eggeler, presented at Creep 2017, St. Petersburg/Russia, June 19-21, 2017, organized by P. Pafilov and G. Kondzhhaspirov, abstract booklet: ISBN 978-5-7422-5799-8

Strukturbildungsprozesse bei Wärmebehandlungen und beim Kriechen polykristalliner Nickel-Basis-Superlegierungen, H. Sommer, Dissertation, 13.09.2018, Ruhr-Universität Bochum

Design of a new polycrystalline Ni-based superalloy based on Nimonic C-263 for high temperature applications, J. Hunfeld, H. Sommer, J. Kiese, H. Wang, T. Li, C. Somsen, A. Kostka, G. Laplanche, to be published

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