

 **BÖHLER**

EDRO



HOT WORK
TOOL STEEL

HOT WORK TOOL STEEL

BÖHLER W403
VMR®

SERVICE LIFE INCREASE THROUGH HIGHER WORKING HARDNESS

The most important factors, among others, which can result in a lowering of production costs are a long tool life and low maintenance and stand still costs. This is achieved in practice by using tool materials which, for example, are highly homogeneous and have a high micro-cleanliness, causing a significant delay in the onset of heat checking.

In addition, tool life can be dramatically increased in some applications by taking advantage of high thermal stability or inherent toughness. Along with longer tool life, using these modified tool materials gives users numerous supplementary benefits arising from the following factors:

- » Less tools
- » Fewer tool changes
- » Lower repair costs
- » Longer cycle times between tool repairs

Material properties

BÖHLER grade	High temperature strength	High temperature toughness (small tool)	Toughness in tool (big tool)	Machinability
BÖHLER W300 ISODISC®	★★	★★★	★★	★★★★★
BÖHLER W300 ISOBLOC®	★★	★★★★	★★★	★★★★★
BÖHLER W302 ISODISC®	★★★	★★★	★★	★★★★★
BÖHLER W302 ISOBLOC®	★★★	★★★★	★★★	★★★★★
BÖHLER W303 ISODISC®	★★★★	★★★	★★	★★★★★
BÖHLER W350 ISOBLOC®	★★★	★★★★	★★★★	★★★★★
BÖHLER W360 ISOBLOC®	★★★★★	★★★★	★★★	★★★★★
BÖHLER W400 VMR®	★★	★★★★★	★★★	★★★★
BÖHLER W403 VMR®	★★★★	★★★★	★★★	★★★★

ISODISC: Conventional quality with special heat treatment.
ISOBLOC: ESR grade with special heat treatment.

QUALITY CHARACTERISTICS

The outstanding properties of BÖHLER's tool steel W403 VMR are dependant not only on a modified chemical composition, but also on the following technologically optimised production steps:

- » Selection of highly clean raw materials for melting
- » Remelting under vacuum (VMR)
- » Optimised diffusion annealing and structural treatment
- » Final, special heat treatment for an excellent annealed condition

PROPERTIES

Due to the balanced combination of a modified chemical composition and an optimised processing route, optimum material properties have been achieved in BÖHLER W403 VMR:

- » Good macro- and microstructure with lowest levels of segregation
- » Lowest gas contents
- » Lowest levels of unwanted trace elements
- » Excellent homogeneity and isotropy
- » Highest degree of cleanliness
- » Good toughness
- » Best polishability
- » Best heat checking resistance (resistance to thermal fatigue)
- » Very high thermal stability

APPLICATION

- » Die casting
- » Plastic moulds
- » Gravity / low pressure die casting
- » Forging
- » Fast forge pressing
- » Extrusion
- » General Cold Work applications
- » Industrial knives
- » Tool holder
- » Mechanical engineering applications

Chemical composition (average in %)

C	Si	Mn	Cr	Mo	V
0.38	0.20	0.25	5.00	2.80	0.65

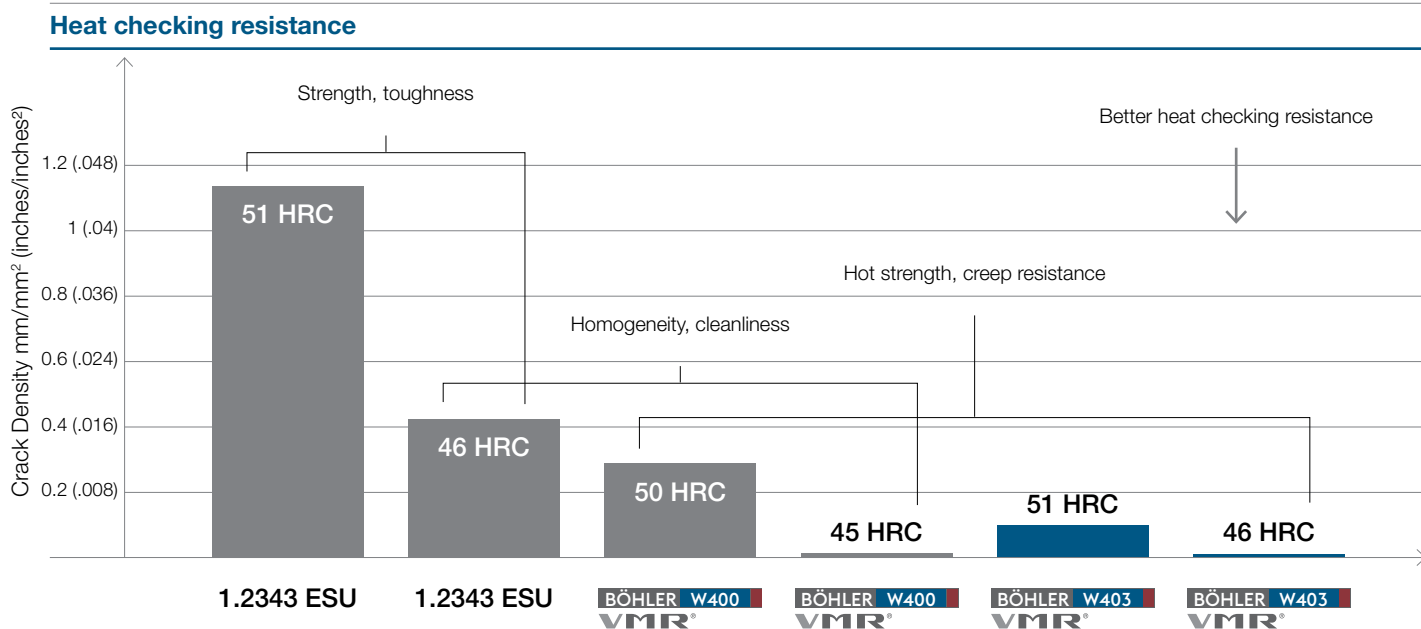
Standards

DIN /EN	AFNOR	NADCA
~ 1.2367 ~ X38CrMoV5-3	~ Z38CDV5-3	Grade C Type C1885

Analysis: patent protected steel

SPECIAL MANUFACTURING TECHNOLOGY YIELDS OUTSTANDING HEAT CHECKING RESISTANCE

A comparison of various high-grade hot work steels shows that the alloy composition of BÖHLER W403 VMR steel in combination with vacuum melt technology yields the best heat checking resistance or thermal fatigue strength. This has been confirmed by numerous practical application cases as well as scientific methods, including laser pulse tests.

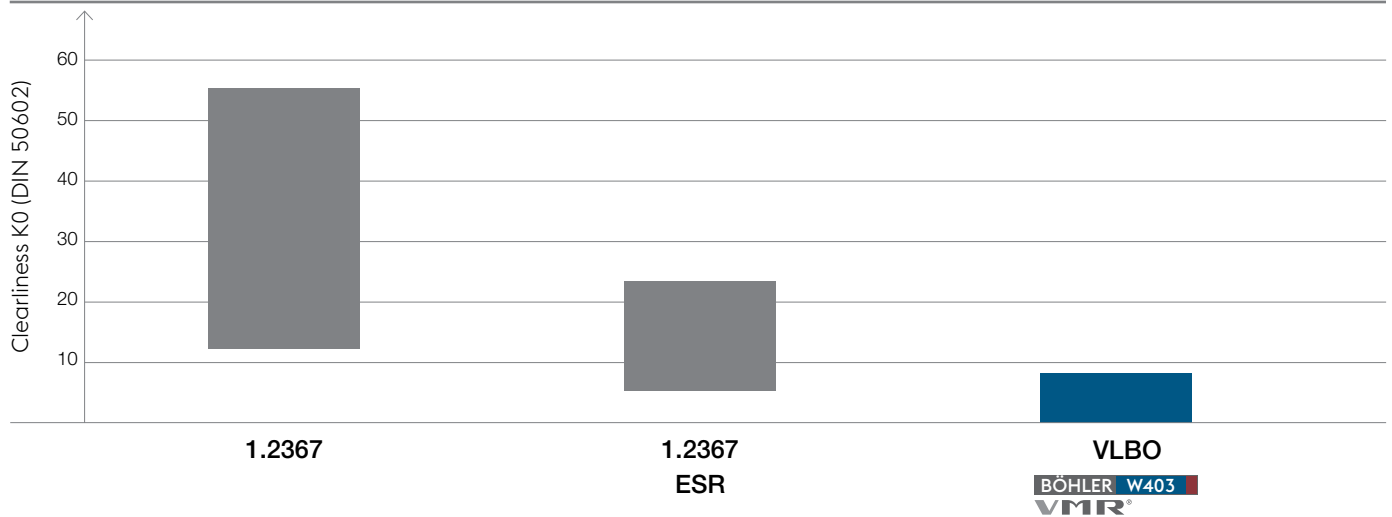


Crack density in laser pulse tests with various materials and annealing states:

- » Pulse energie: 1,444 J
- » Pulse cycle: 2/5/2 ... sek.
- » Background temperature: 580 – 600 °C (1076 °F – 1110 °F)
- » Background: 180 °C (356 °F)

The overview of the micro-cleanliness levels of various qualities manufactured by different routes shows that BÖHLER W403 VMR has a micro-cleanliness level comparable to that which is generally only demanded by the aerospace industry.

Micro-cleanliness and microstructure



CONDITION OF DELIVERY

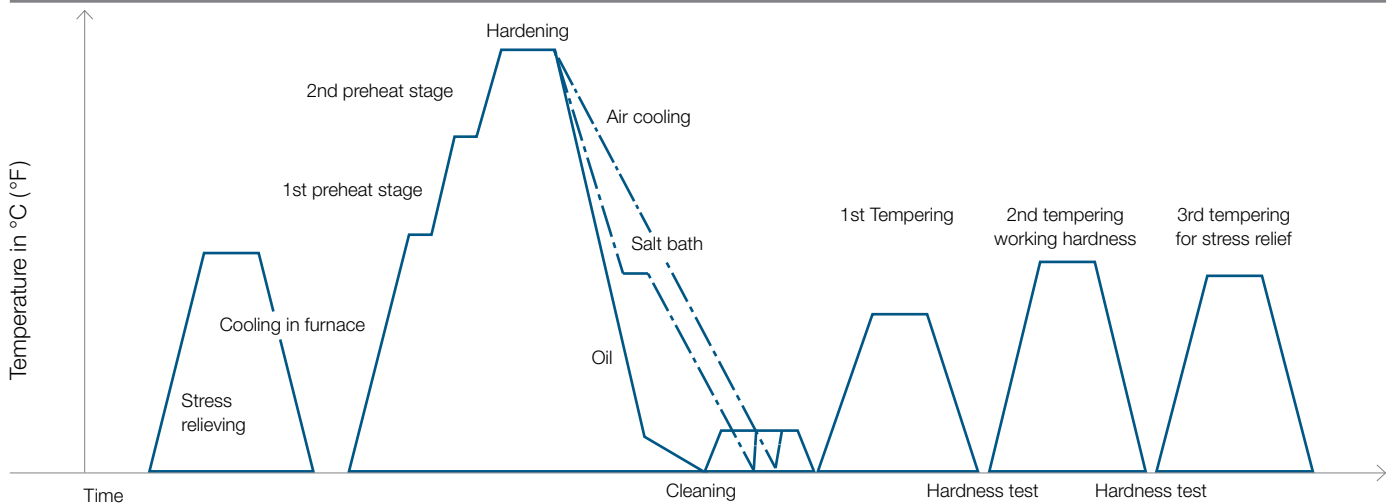
Annealed max. 205 HB

HEAT TREATMENT

Annealing:

- » 800 bis 850 °C (1470 to 1560 °F)
- » Slow controlled cooling in furnace at a rate of 10 to 20 °C/hr (50 to 68 °F/hr) down to approx. 600 °C (1110 °F), further cooling in air

Heat treatment sequence



STRESS RELIEVING

- » 600 bis 650 °C (1110 to 1200 °F)
- » Slow cooling in furnace
- » To relieve stresses caused by extensive machining, or for complex shapes
- » Soak for 1 – 2 hours after temperature equalisation (in neutral atmosphere)

HARDENING

- » 1020 bis 1030 °C (1870 to 1885 °F)
- » Oil, salt bath (500–550 °C [930 – 1020 °F]), air or vacuum with gas quenching
- » Holding time after temperature equalization: 15 to 30 minutes

Obtainable hardness:

- » 52 – 54 HRC in oil or salt bath hardening
- » 50 – 53 HRC in air or vacuum hardening

Note: If higher hardening temperatures are used, there is a risk of coarsening of the grain.

Tempering:

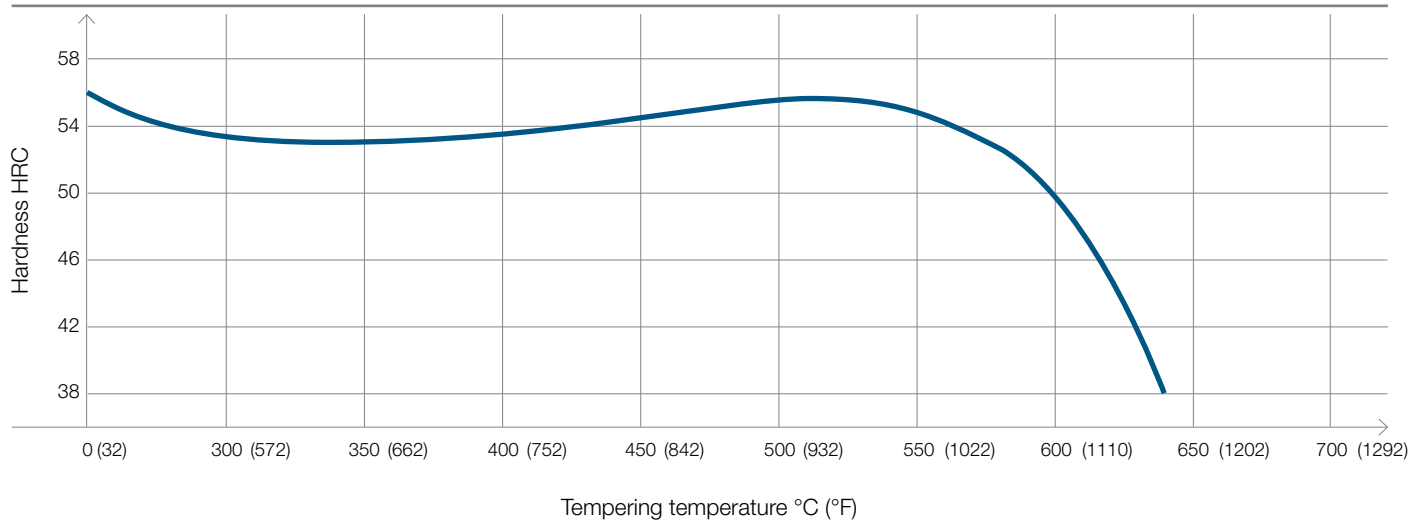
Slow heating to tempering temperature immediately after hardening/time in furnace 1 hour for each 20 mm (0.79 inch) of workpiece thickness but at least 2 hours/cooling in air. It is recommended to temper at least twice. A third tempering cycle for the purpose of stress relieving may be advantageous.

1st tempering approx. 30 °C (85 °F) above maximum secondary hardness.

2nd tempering to desired working hardness. The tempering chart shows average tempered hardness values.

3rd for stress relieving at a temperature 30 to 50 °C (85 – 120 °F) below highest tempering temperature.

Tempering chart



Hardening temperature: 1030 °C (1886 °F)
Specimen size: square 20 mm (0.79 inch)

SURFACE TREATMENT

Nitriding:

Suited for bath, gas and plasma nitriding.

Repair welding:

There is a general tendency for tool steels to develop cracks after welding. If welding cannot be avoided, the instructions of the appropriate welding electrode manufacturer should be sought and followed.

Chemical composition (average %)

C	Si	Mn	Cr	Mo	V
0.38	0.20	0.25	5.00	2.80	0.65

Continuous cooling CCT curves

Austenitizing temperature: 1025 °C (1880 °F)

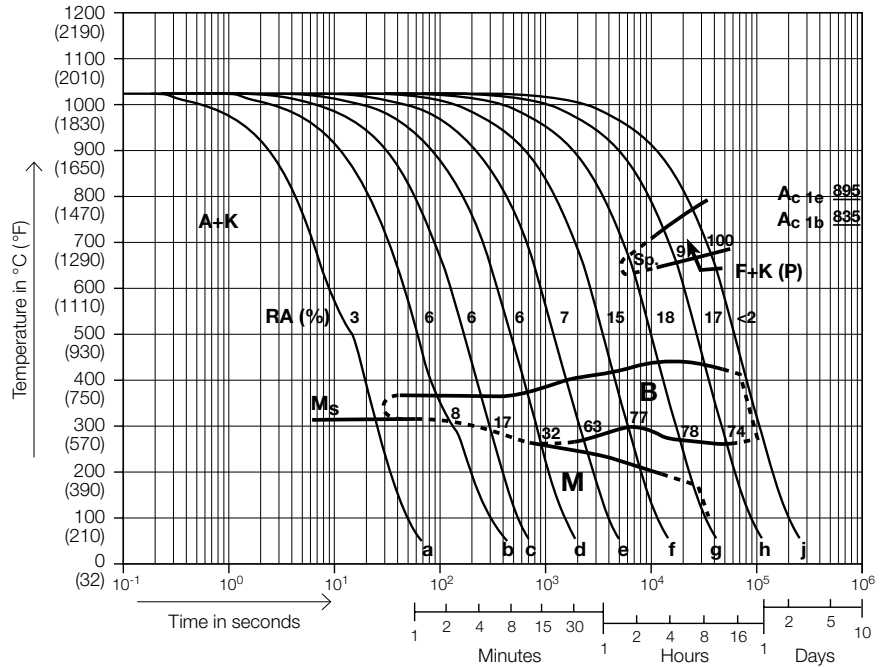
Holding time: 15 minutes

686 ... 234 Vickers hardness

1 ... 100 phase percentages

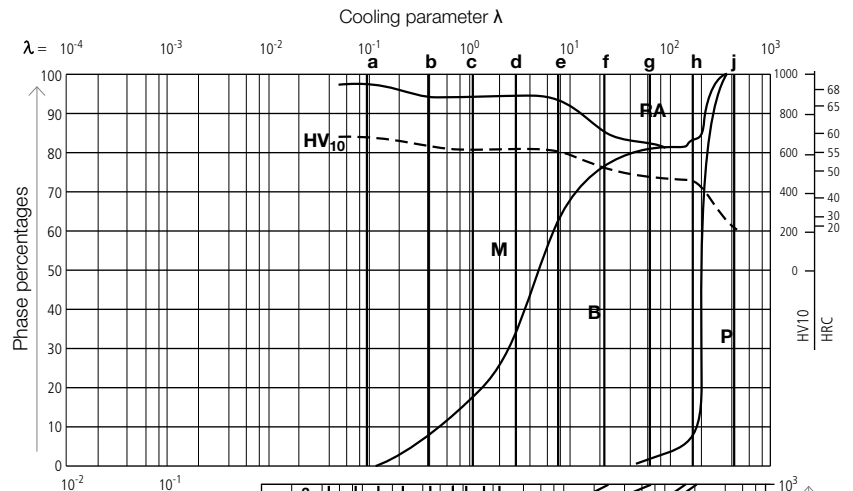
0,1 ... 400 cooling parameter, i.e. duration of cooling from 800 – 500 °C (1470 – 930 °F) in $s \times 10^{-2}$

Sample	λ	HV ₁₀
a	0.1	686
b	0.4	643
c	1.1	619
d	3.0	624
e	8.0	615
f	23.0	529
g	65.0	494
h	180.0	465
j	400.0	234

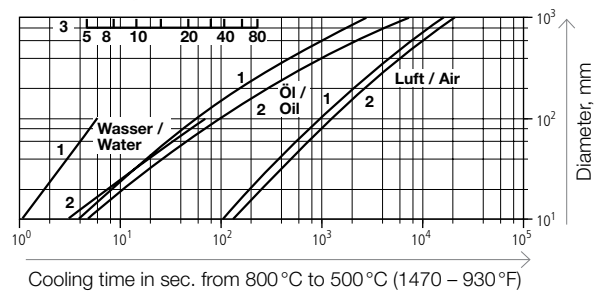


Quantitative phase diagram

- A Austenite
- B Bainite
- F Ferrite
- K Carbide
- M Martensite
- P Perlite
- RA Retained austenite



- 1 Edge or face
- 2 Core
- 3 Jominy test: distance from the quenched end



MACHINING RECOMMENDATIONS

Type of machining*		Tool material ¹⁾	Cutting speed	Feed mm/rev.	Depth of cut	Working with
Turning	Pre-roughing	P35 ¹⁾	60 m/min (195 f.p.m)	1.0 (0.0039 inch/rev.)	14 mm (0.55 inch)	cooling lubricant
	Roughing	P25 ¹⁾	90 m/min (295 f.p.m)	0.8 (0.0031 inch/rev.)	8 mm (0.31 inch)	cooling lubricant
	Roughing	P15 ¹⁾	140 m/min (460 f.p.m)	0.3 (0.0012 inch/rev.)	2 mm (0.08 inch)	cooling lubricant
Milling	Roughing	P25 ¹⁾	90 m/min (295 f.p.m)	0.15 mm (0.0006 inch) tooth	5 mm (0.20 inch)	dry/compressed air
	Finishing	P25 ¹⁾	110 m/min (360 f.p.m)	0.10 mm (0.0004 inch) tooth	1 mm (0.04 inch)	dry/compressed air
Drilling	D = 40 – 80 mm (1.6 – 3.2 inch)	P25 ¹⁾	80 m/min (45 f.p.m)	0.17 (0.0007 inch/rev.)	–	cooling lubricant
	D = 20 – 40 mm (0.8 – 1.6 inch)	P25 ¹⁾	80 m/min (260 f.p.m)	0.12 (0.0005 inch/rev.)	–	cooling lubricant
	D = 0 – 20 mm (0 – 0.8 inch)	K20	50 m/min (165 f.p.m)	0.10 (0.0004 inch/rev.)	–	cooling lubricant

^{*)} for annealed material

¹⁾ Tools with multi-layer coating

High Speed Cutting**	Tool	Cutting Speed	Feed	Depth of cut	Lubricant
Roughing	Milling cutter with indexable inserts d = 15 / r = 3.5	450 m/min (1475 f.p.m)	0.2 mm (0.0008 inch) tooth	0.4 mm (0.016 inch)	dry
Pre-finishing	Solid carbide milling cutter (TiAlN) d8	400 m/min (1310 f.p.m)	0.2 mm (0.0008 inch) tooth	0.5 mm (0.020 inch)	oil-mist
Finishing	Solid carbide milling cutter (TiAlN) d6	420 m/min (1380 f.p.m)	0.12 mm (0.0005 inch) tooth	0.15 mm (0.006 inch)	oil-mist

^{**) For a working hardness of approx. 45 HRc}

Optimum machining parameters can only be obtained in consultation with the appropriate machine tool manufacturer.

Physical properties

Density at	20 °C (68 °F)	7.85 kg/dm ³ (0.284 lbs/in ³)
	500 °C (930 °F)	7.69 kg/dm ³ (0.278 lbs/in ³)
	600 °C (1110 °F)	7.66 kg/dm ³ (0.277 lbs/in ³)
Specific heat at	20 °C (68 °F)	470 J/(kg.K) (112 Btu/lb °F)
	500 °C (930 °F)	670 J/(kg.K) (160 Btu/lb °F)
	600 °C (1110 °F)	740 J/(kg.K) (177 Btu/lb °F)
Modulus of elasticity at	20 °C (68 °F)	211.4 GPa (30.6 x 10 ⁶ psi)
	500 °C (930 °F)	177.7 GPa (25.8 x 10 ⁶ psi)
	600 °C (1110 °F)	166.2 GPa (24.1 x 10 ⁶ psi)

Condition: hardened and tempered (average values)

Thermal expansion between 20 °C (68 °F) and ... °C (°F)

100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	
10.63	10.83	12.00	12.92	14.13	14.34	10 ⁻⁶ m/(m.K)
212 °F	392 °F	572 °F	752 °F	932 °F	1110 °F	
5.90	6.00	6.70	7.20	7.90	8.00	10 ⁻⁶ in/in °F

Thermal conductivity at

20 °C	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	
29.80	31.50	32.40	32.60	32.10	30.90	30.10	in W/(m.K)
68 °F	212 °F	392 °F	572 °F	752 °F	932 °F	1110 °F	
17.20	18.20	18.70	18.80	18.60	17.90	17.40	Btu/in/ft ² h°F

As regards applications and processing steps that are not expressly mentioned in this product description/data sheet, the customer shall in each individual case be required to consult us.

The data contained in this brochure is merely for general information and therefore shall not be binding on the company. We may be bound only through a contract explicitly stipulating such data as binding. Measurement data are laboratory values and can deviate from practical analyses. The manufacture of our products does not involve the use of substances detrimental to health or to the ozone layer.

MATERIALS | MACHINING | PVD COATINGS | ADDITIVE

EDRO

(888) 368-3376 | INFO@EDRO.COM | EDRO.COM