HOT WORK TOOL STEEL

BÖHLER W400
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 homogenous 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 W400 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 W400 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
- Very high thermal stability

APPLICATION

- Die casting
- Plastic moulds
- Gravity / low pressure casting
- Forging
- Rapid forging presses
- Extrusion
- General cold work applications
- Industrial knife
- Tool holder
- Mechanical engineering applications

Chemical composition (Average in %)

C	Si	Mn	Cr	Mo	V
0.38	0.20	0.30	5.00	1.30	0.50

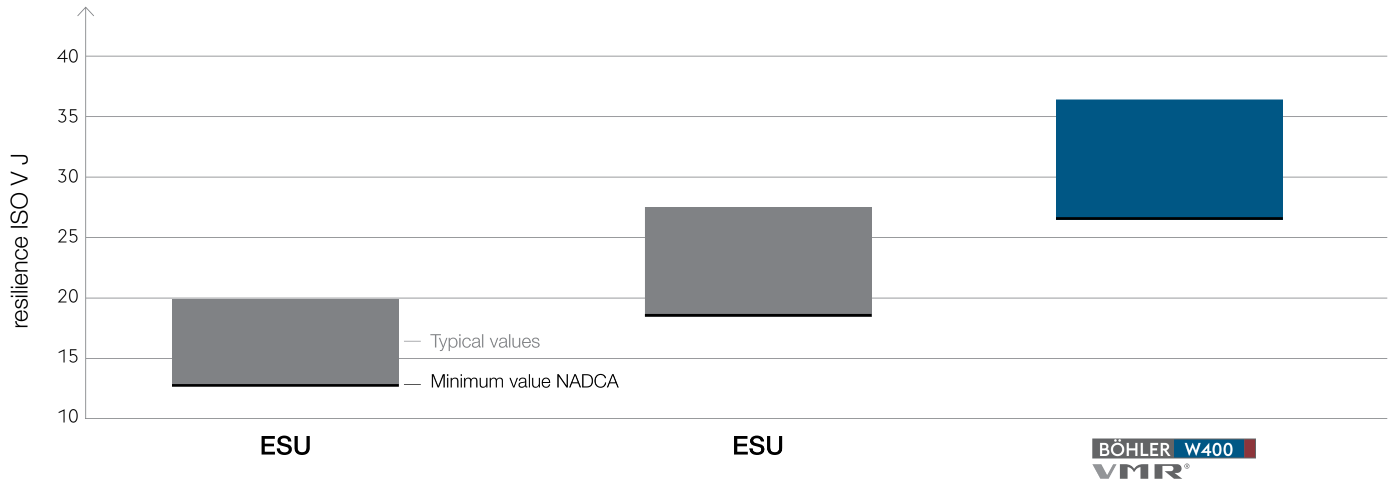
Standards

DIN /EN	BS	UNE	AISI	UNS	ANFOR	UNI	JIS	GOST	NADCA
1.2340 X36CrMoV5-1	~ BH11	~ F5317 ~ X37CrMoSiV5	~ H11	~ T20811	Z36CDV5 ~ Z38CDV5	~ X37CrMoV5-1KU	~ SKD6	~ 4Ch5MFS	Grade E Type E 1810

EXCEPTIONAL TOUGHNESS DUE TO SPECIAL MANUFACTURING TECHNOLOGY

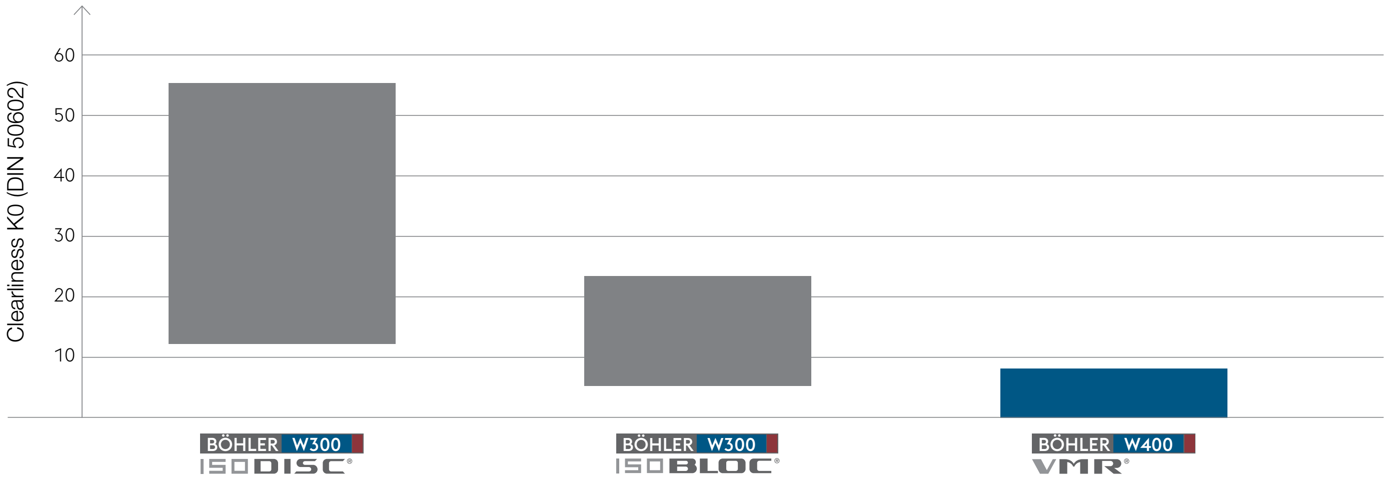
A comparison of different grades and production routes used in die casting shows, that a material with high homogeneity, high isotropy and high microcleanliness also has the highest levels of toughness. One of the best methods of measuring the toughness is in an impact bending test.

The tests are performed on single heat treated notched specimens with hardness 44 – 46 HRC. The exact specimen location and test procedure are defined in NADCA #207. The following diagram shows the minimum and typical values for single heat treated specimens according to NADCA #207.



The summary of the micro-cleanliness levels of various qualities manufactured by different routes shows that BÖHLER W400 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

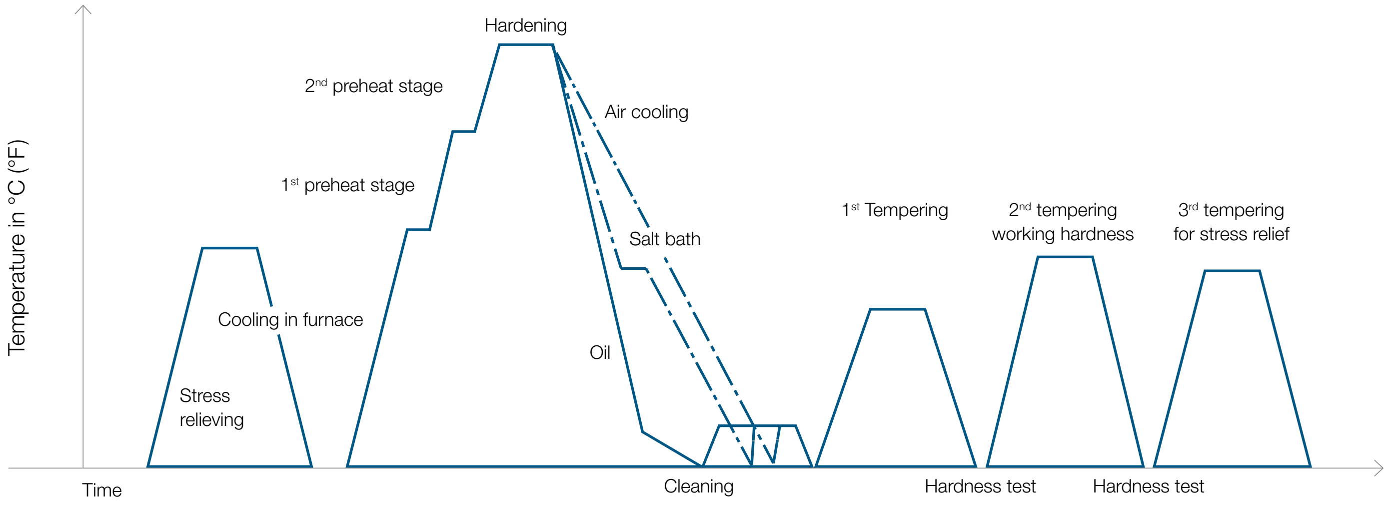
Annealed max. 205 HB

HEAT TREATMENT

Annealing:

» 800 to 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 to 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

» 980 to 990 °C (1795 °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:

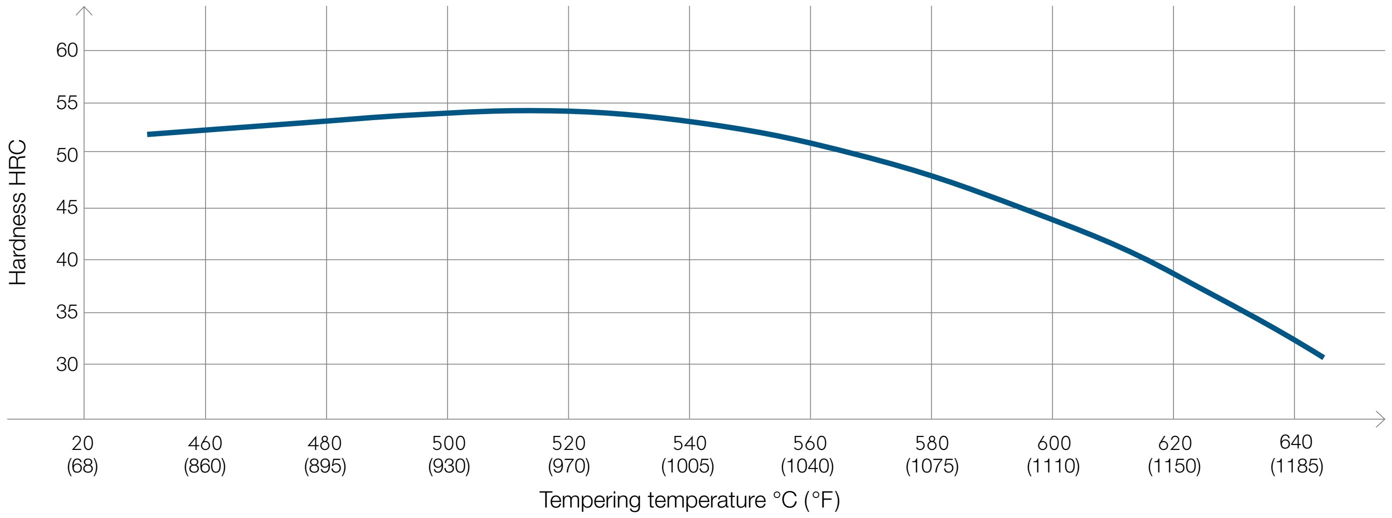
Slow heating to tempering temperature immediately after hardening/time in furnace 1 hour for each 20 mm (0.79 inch) of workpiece thickness but at least 2 hours/cooling in air. It is recommended to temper at least twice. A third tempering cycle for the purpose of stress relieving may be advantageous.

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: 990 °C (1815 °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.

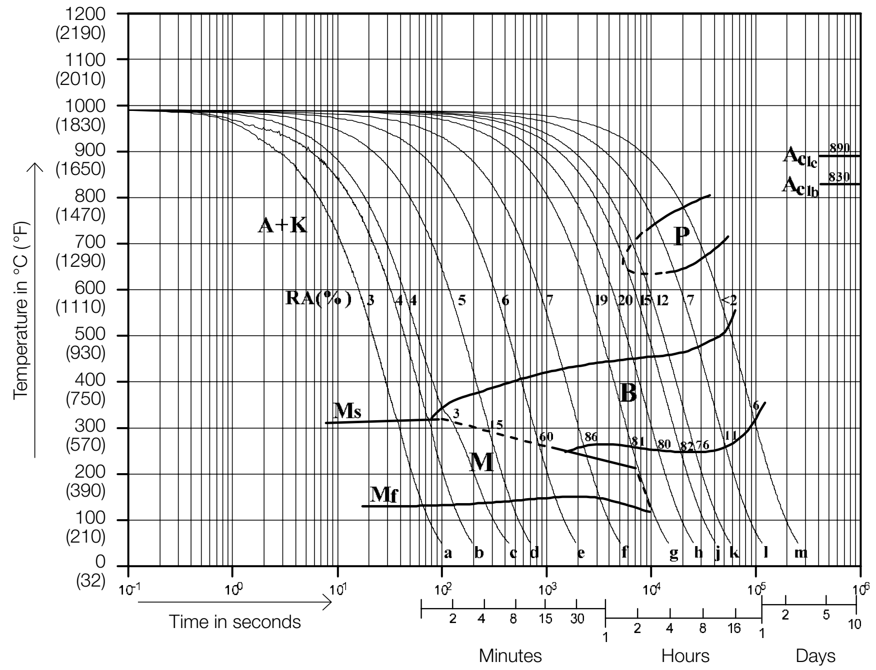
Chemical composition (average %)

C	Si	Mn	Cr	Mo	V
0.38	0.20	0.30	5.00	1.30	0.50

Continuous cooling CCT curves

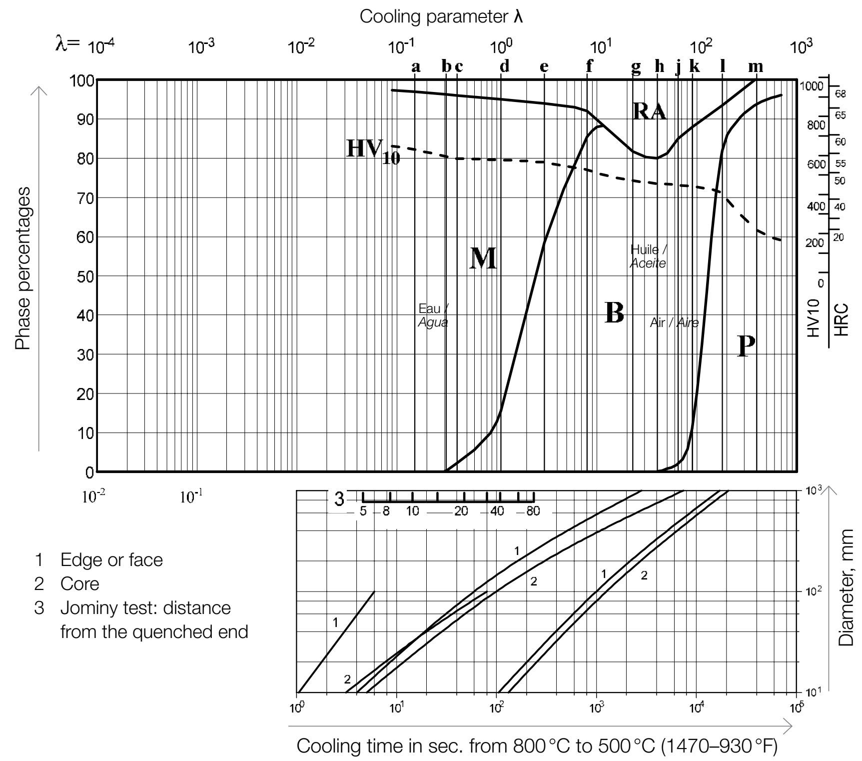
Austenitizing temperature: 990 °C (1815 °F)
Holding time: 15 minutes
647 ... 226 phase percentages 500
0.15 ... 400 cooling parameter, i.e. duration of cooling from 800 – 500 °C (1470 – 930 °F) in s x 10^{-2}

Sample	λ	HV_{10}
a	0.15	647
b	0.31	619
c	0.40	590
d	1.1	595
e	3.0	582
f	8.0	546
g	23.0	478
h	40.0	462
j	65.0	462
k	90.0	454
l	180.0	434
m	400.0	226



Quantitative phase diagram

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



MACHINING RECOMMENDATIONS

Type of machining*		Tool material¹	Cutting speed	Feed mm/rev.	Depth of cut	Working with
Turning	Pre-roughing	P35[1]	80 m/min (260 f.p.m)	1.0 (0.0039 inch/rev.)	14 mm (0.55 inch)	cooling lubricant
	Roughing	P25[1]	120 m/min (395 f.p.m)	0.8 (0.0031 inch/rev.)	8 mm (0.31 inch)	cooling lubricant
	Roughing	P15[1]	180 m/min (590 f.p.m)	0.3 (0.0012 inch/rev.)	2 mm (0.08 inch)	cooling lubricant
Milling	Roughing	P25[1]	120 m/min (395 f.p.m)	0.15 mm (0.0006 inch) tooth	5 mm (0.20 inch)	dry/compressed air
	Finishing	P25[1]	140 m/min (460 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]	100 m/min (330 f.p.m)	0.17 (0.0007 inch/rev.)	–	cooling lubricant
	D = 20 – 40 mm (0.8 – 1.6 inch)	P25[1]	100 m/min (330 f.p.m)	0.12 (0.0005 inch/rev.)	–	cooling lubricant
	D = 0 – 20 mm (0 – 0.8 inch)	K20	70 m/min (230 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	330 m/min (1080 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	360 m/min (1180 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	400 m/min (1310 f.p.m)	0.12 mm (0.0005 inch) tooth	0.15 mm (0.006 inch)	oil-mist

**) For a working hardness of approx. 50 HRc

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

Physical properties

Density at	20 °C (68 °F)	7.80 kg/dm³
	500 °C (930 °F)	7.64 kg/dm³
	600 °C (1110 °F)	7.60 kg/dm³
Specific heat at	20 °C (68 °F)	470 J/(kg.K) (110 Btu/lb °F)
	500 °C (930 °F)	670 J/(kg.K) (131 Btu/lb °F)
	600 °C (1110 °F)	740 J/(kg.K) (141 Btu/lb °F)
Electrical resistivity at	20 °C (68 °F)	0.52 Ohm.mm²/m (0.87 x 10^{-3} Ohm circular-mil per ft)
	500 °C (930 °F)	0.86 Ohm.mm²/m (1.43 x 10^{-3} Ohm circular-mil per ft)
	600 °C (1110 °F)	0.96 Ohm.mm²/m (1.60 x 10^{-3} Ohm circular-mil per ft)
Modulus of elasticity at	20 °C (68 °F)	211 GPa (30.6 x 10^6 psi)
	500 °C (930 °F)	178 GPa (25.8 x 10^6 psi)
	600 °C (1110 °F)	167 GPa (24.2 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	
11.00	11.17	11.93	12.68	13.98	14.34	10^{-6} m/(m.K)
212 °F	**392 °F**	**572 °F**	**752 °F**	**932 °F**	**1110 °F**	
6.10	6.20	6.60	7.00	7.80	8.00	10^{-6} in/in °F

Thermal conductivity at

100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	
32.10	32.60	32.80	32.60	32.10	30.50	in W/(m.K)
212 °F	**392 °F**	**572 °F**	**752 °F**	**932 °F**	**1110 °F**	
18.50	18.80	19.00	18.80	18.50	17.60	Btu/in/ft² 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.

MATERIALS | MACHINING | PVD COATINGS | ADDITIVE

EDRO

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