BÖHLER

PLASTIC MOULD STEEL

POWDER METALLURGY

PLASTIC MOULD STEEL

BÖHLER M368
MICROCLEAN®

voestalpine BÖHLER Edelstahl GmbH & Co KG
www.voestalpine.com/bohler-edelstahl

voestalpine
ONE STEP AHEAD.

YOUR BENEFIT

BÖHLER M368 MICROCLEAN is a martensitic chromium steel produced with powder metallurgy. Due to its alloying concept this steel offers **high wear resistance**, **high toughness** and **high corrosion resistance** – the perfect combination for **best application properties**.

- High wear resistance
- High toughness
- High corrosion resistance
- Excellent grindability
- Good polishability
- High dimensional stability

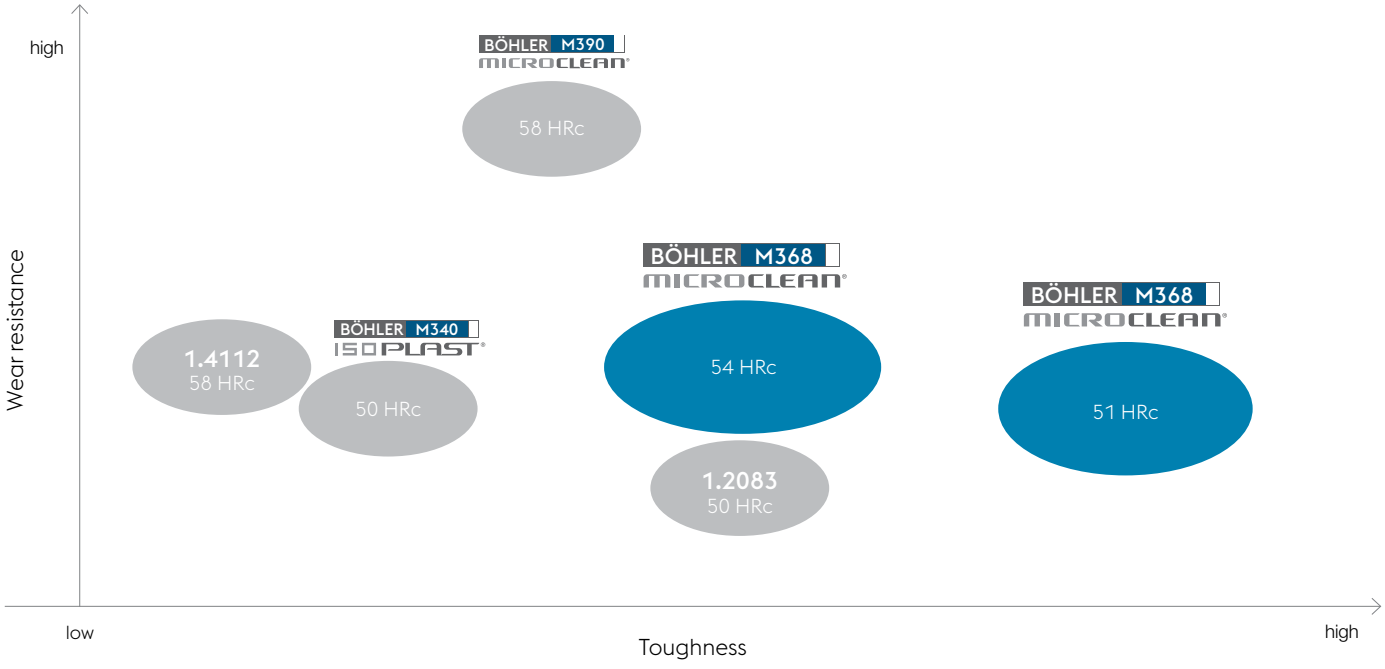
Enable:

- Production of big tools
- Long and consistant tool life
- Reproducibility of production processes
- High precision components

Benefit:

- Increased productivity
- Reduced unit costs

Product positioning



Chemical composition (average %)

C	Si	Mn	Cr	Mo	V	others
0.54	0.45	0.40	17.30	1.10	0.10	+N

patented

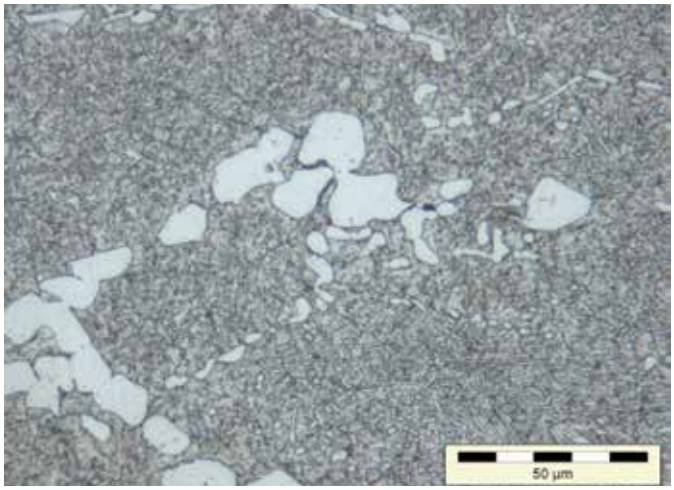
MAXIMUM QUALITY IN USE

for:

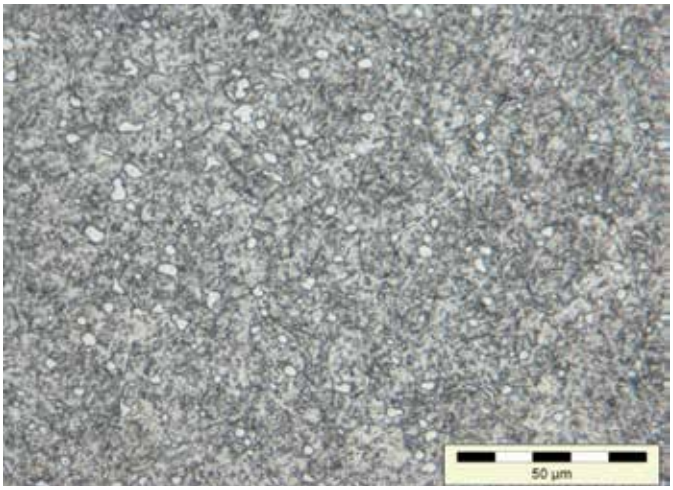
- Mould inserts
- Moulds for the processing of chemically aggressive plastics containing highly abrasive fillers
- Moulds and knives for the food-processing industry
- Moulds for the electronic industry
- Screws for injection moulding machines
- Linings for injection moulding cylinders

IMPRESSIVE HOMOGENEITY

Due to powder metallgurgical production of **BÖHLER M368 MICROCLEAN** a segregation-free microstructure with significantly improved homogeneity in comparison to conventional and ESR-produced standard products like e.g. 1.4112 could be achieved.



Microstructure 1.4112



Microstructure BÖHLER M368 MICROCLEAN

HEAT TREATMENT

DELIVERY CONDITION

Soft annealed **max. 280 HB**

STRESS RELIEVING

» 650 to 700 °C (1200 – 1290 °F)
» After through-heating, soak for 1 to 2 hours in a neutral atmosphere.
» Cool slowly in furnace

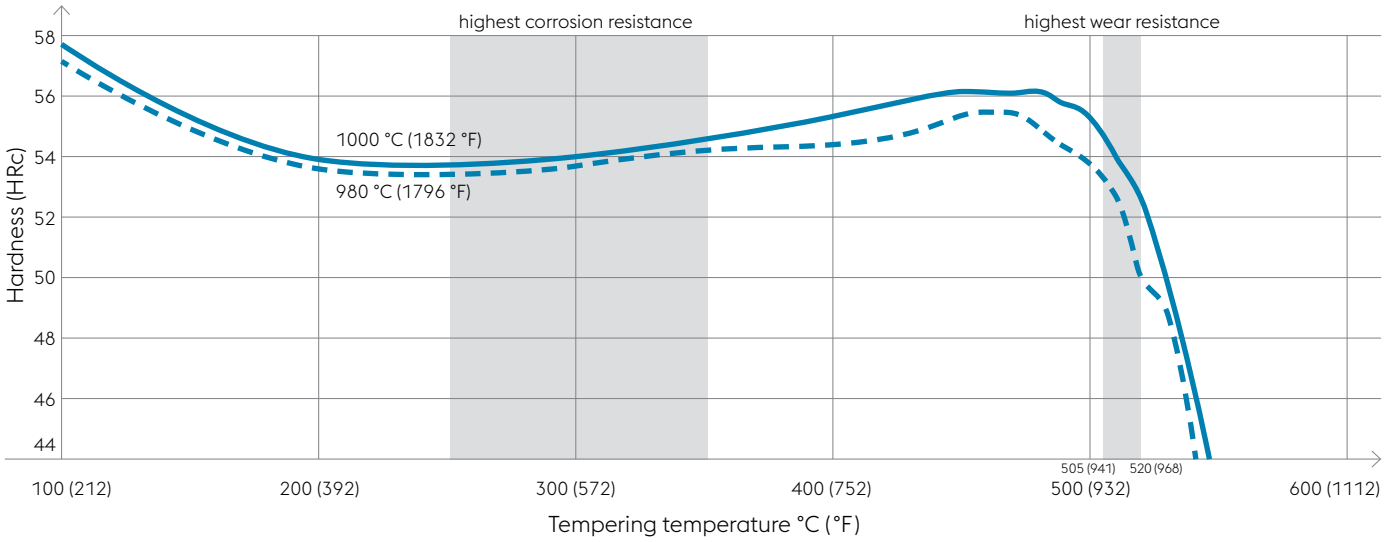
HARDENING

» 980 to 1000 °C (1796 – 1830 °F), N_2
» Following temperature equalisation: 15 – 30 min. holding time
» For big moulds we recommend a low hardening temperature of 980 °C (1796 °F) and a high tempering temperature (505 to 520 °C [941 – 968 °F]).

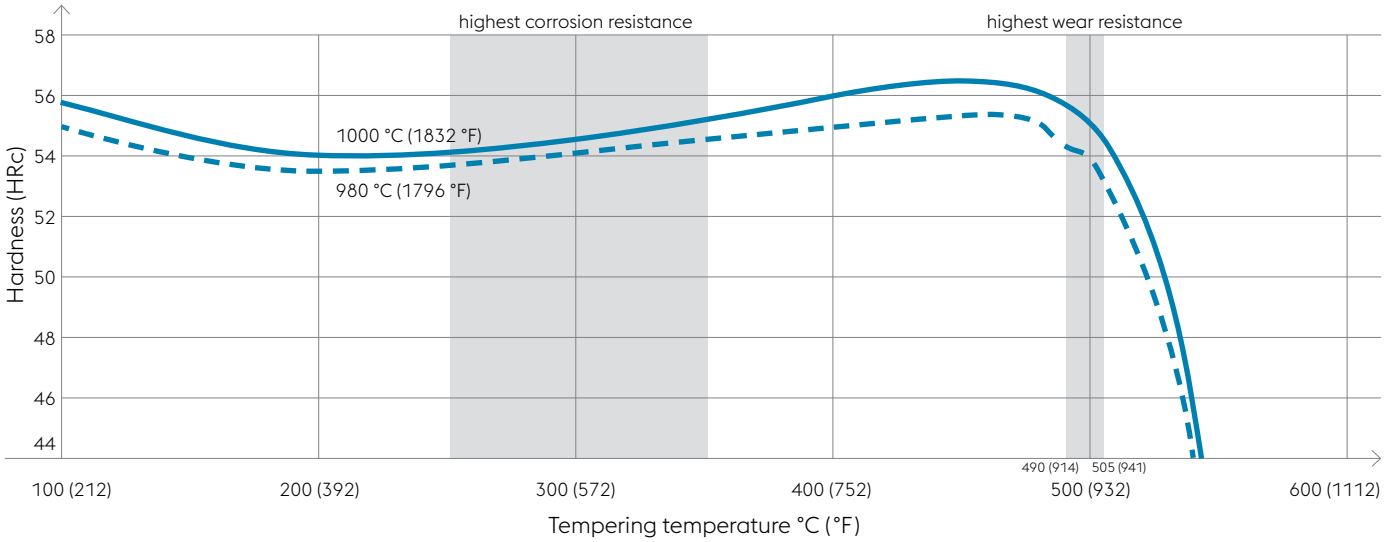
TEMPERING

» Slowly heat to tempering temperature immediately after hardening
» Time in furnace: 1 hour for every 20 mm (0.79 inch) of workpiece thickness but at least 2 hours
» Cool in air
» We recommend that the steel be tempered 3 times.
» We recommend for optimal combination of good corrosion and highest wear-resistance and toughness a tempering temperature between 505 – 520 °C (941 – 968 °F). In this case the corrosionresistance will be suitable for most plastic mould applications.
» We recommend to use, for highest hardness, a tempering temperature between 490 – 505 °C (914 – 941 °F), whereas a subzero-cooling directly after hardening is recommended.
» For highest corrosion-resistance optional a tempering at approx. 300 °C (572 °F) is possible. If additional highest requirements for dimensional stability are necessary, an additional subzero-treatment is recommended.
» Obtainable hardness: 50 – 55 HRc

Tempering chart (no subzero treatment)



Tempering chart (with subzero treatment)

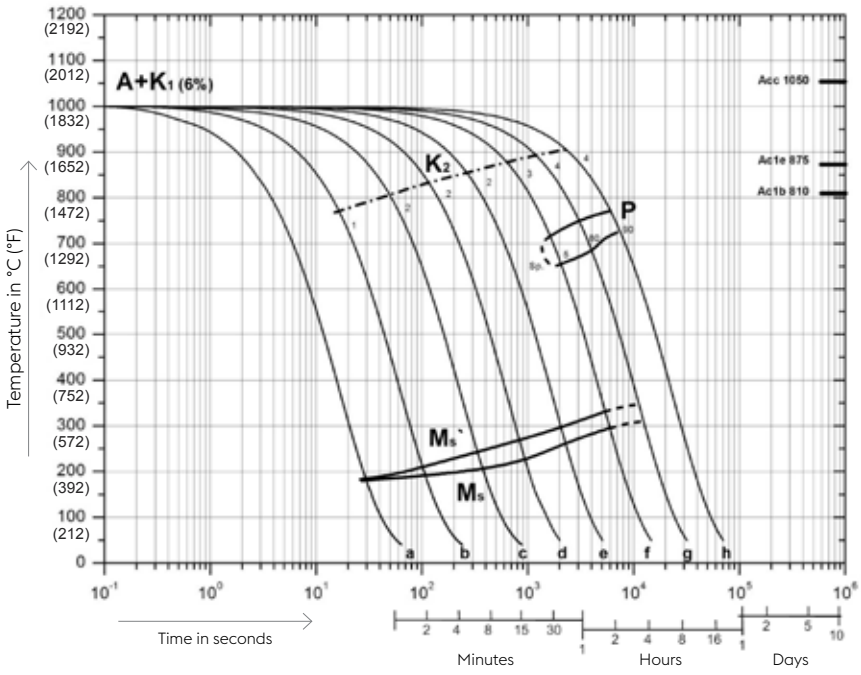


HEAT TREATMENT RECOMMENDATIONS

Continuous cooling CCT curves

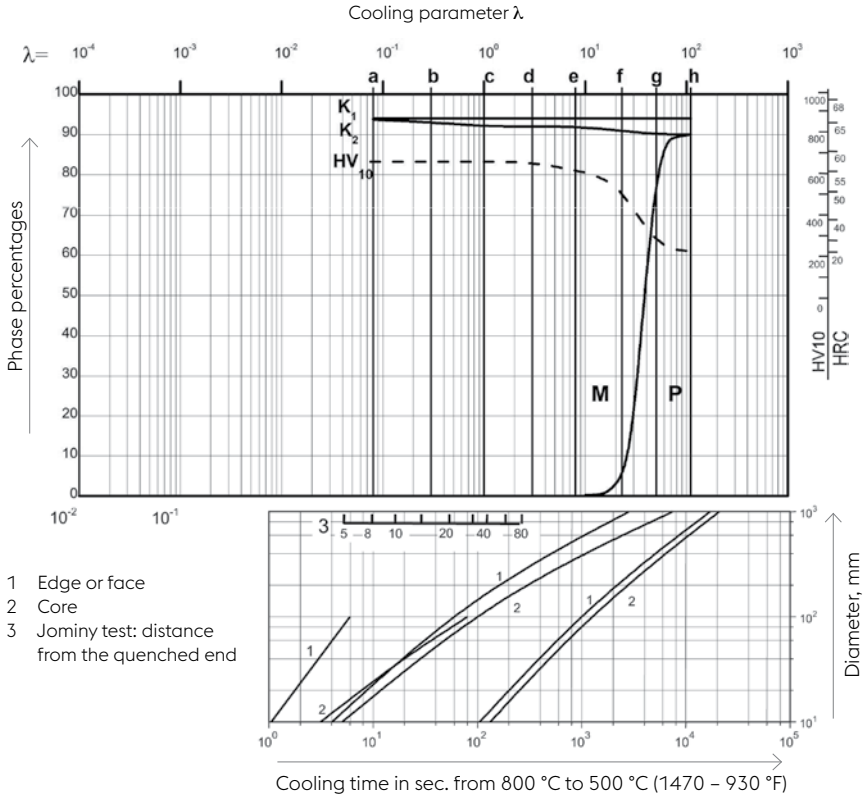
Austenitizing temperature: 1000 °C (1830 °F)
Holding time: 15 minutes
7 ... 60 phase percentages
0.08 ... 110 cooling parameter,
i.e. duration of cooling from
800 – 500° C (1470 – 930 °F)
in s x 10^{-2}

Sample	λ	HV_{10}
a	0.08	660
b	0.30	660
c	1.10	660
d	3.00	660
e	8.00	620
f	23.00	570
g	50.00	235
h	110.00	215



Quantitative phase diagram

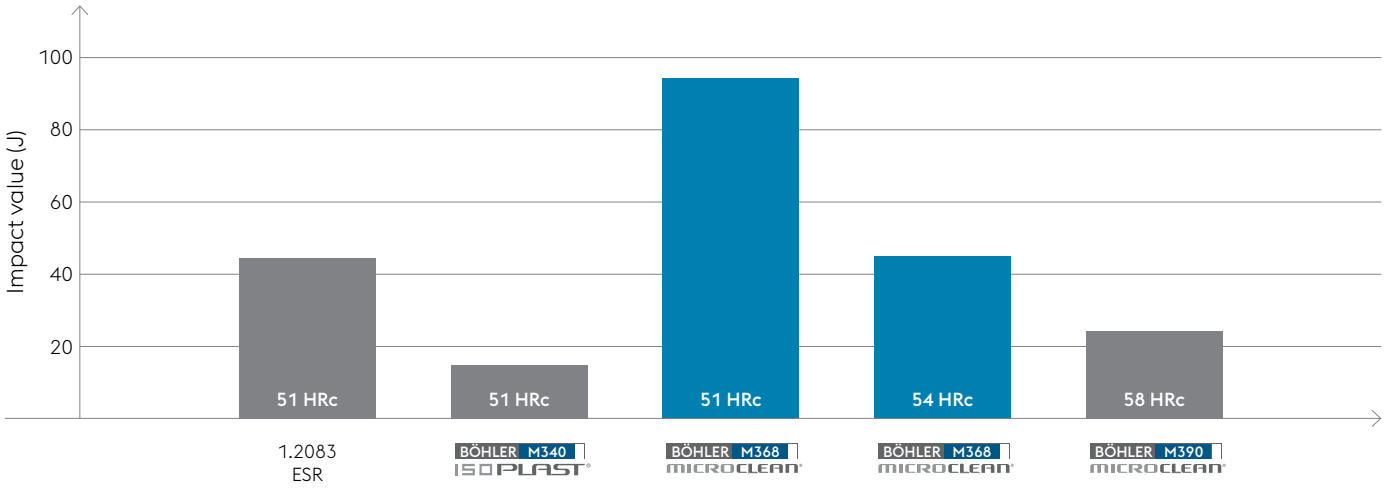
K1	carbides which are not dissolved during austenitization (6%)
K2	start of carbide precipitation during quenching from austenitizing temperature
Ms-Ms'	range of grain boundary martensite
A	Austenite
M	Martensite
P	Perlite



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

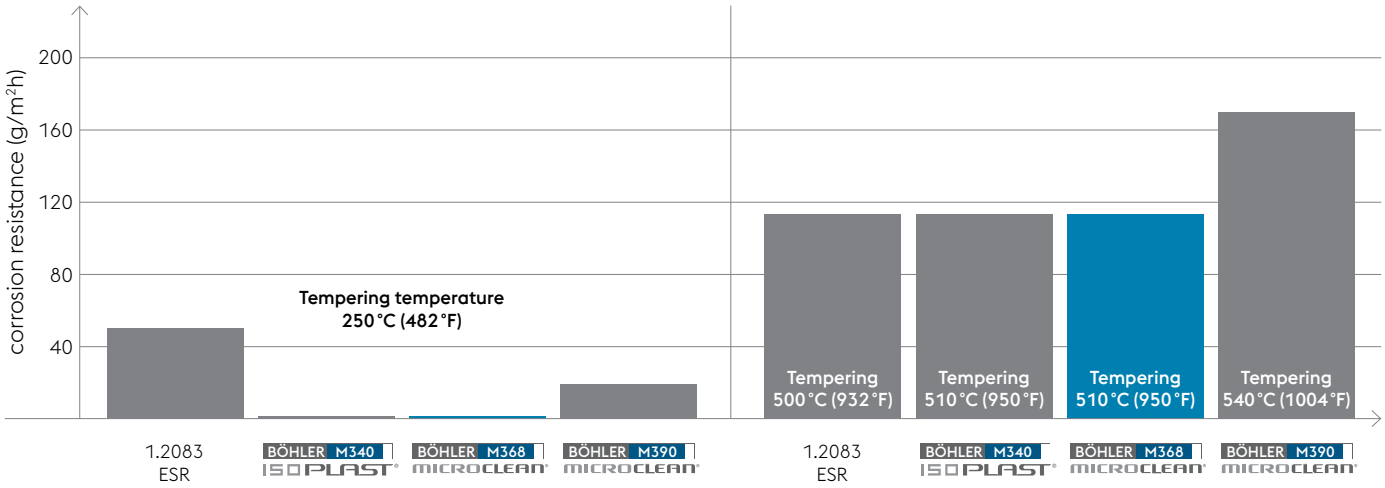
EXCEPTIONAL PROPERTIES

Toughness



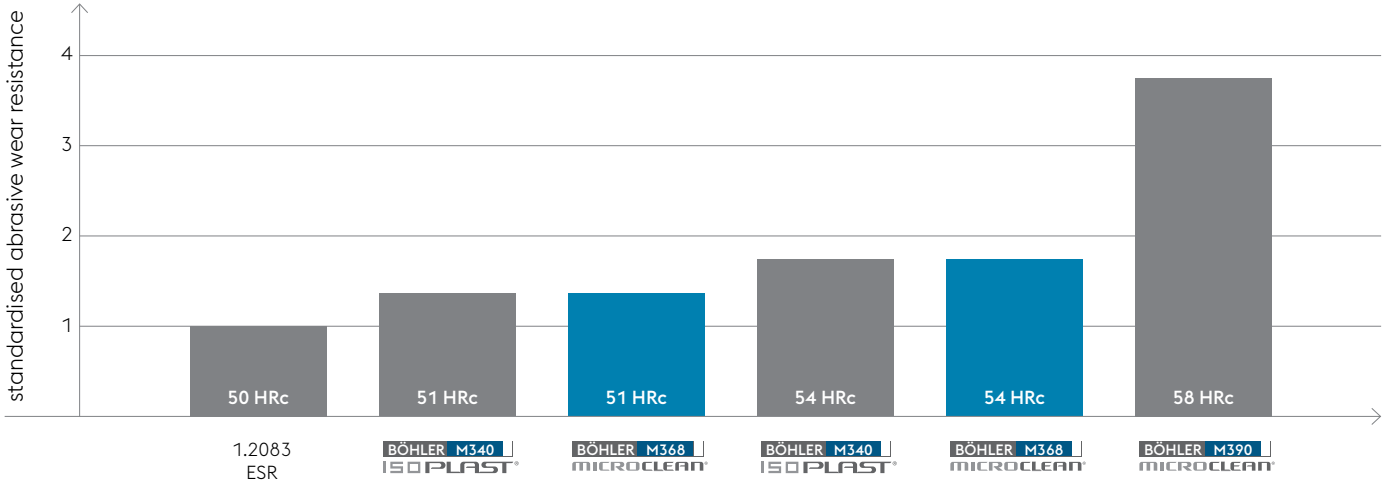
Samples from motherblock 403 x 303 mm, high tempered
Sample size: 10 x 7 x 55 mm (unnotched)

Corrosion resistance (weight loss – test according DIN 50905-2)



For highest corrosion resistance use lower tempering temperatures.
Heat treatment: without subzerocooling
Weight loss test: measured after 24 h with 20 % boiling acetic acid

Wear resistance



Samples from motherblock 403 x 303 mm, high tempered
Small-plate-wear-test
Plastic: Polyamide 66 (PA66), Glass fibre content: 50 wt.%,
Temperature: 300 °C (570 °F)

Sample size: 12 x 15 mm

NUMBERS, FACTS AND DATA

Physical properties

Density at	20 °C 68°F	7.70 kg/dm^3 0.278 lbs/in^3
Specific heat capacity at	20 °C 68°F	460 J/(kg.K) 0.110 Btu/lb °F
Magnetic properties existing		

Thermal conductivity

20 °C	100 °C	200 °C	300 °C	400 °C	500 °C	
22.30	22.80	23.80	24.30	25.0	25.60	W/(m.K)
68 °F	**210 °F**	**390 °F**	**570 °F**	**750 °F**	**930 °F**	
12.92	13.17	13.75	14.08	14.50	14.83	Btu/(ft h °F)

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

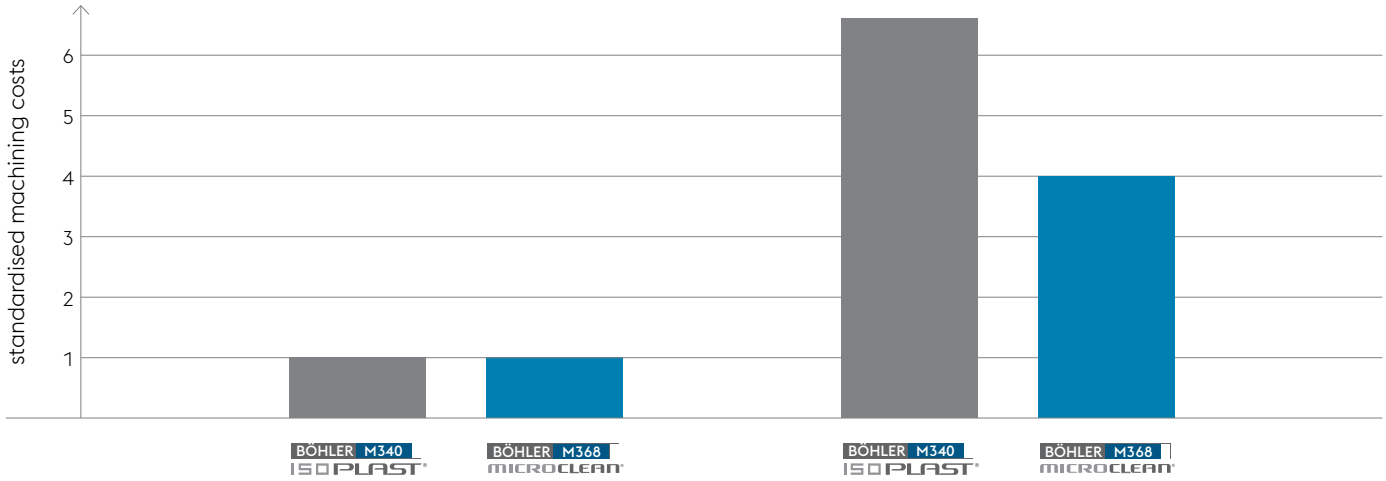
100 °C	200 °C	300 °C	400 °C	500 °C	
10.30	10.82	11.20	11.56	11.87	10^{-6} m/(m.K)
210 °F	**390 °F**	**570 °F**	**750 °F**	**930 °F**	
5.72	6.01	6.22	6.42	6.59	10^{-6} in/(in °F)

Modulus of elasticity

20 °C	100 °C	200 °C	300 °C	400 °C	500 °C	
219	215	209	201	193	183	10^3 N/mm^2
68 °F	**210 °F**	**390 °F**	**570 °F**	**750 °F**	**930 °F**	
31.80	31.20	30.30	29.10	28.00	26.50	10^3 KSI

YOUR COST ADVANTAGE DURING MACHINING

Cost comparison



Rough machining in soft condition (max. 260HB)

End-milling in hard condition (53 HRc)

Tested under real conditions in the machining laboratory, company: PROFACTOR.

Used tools:
Rough machining: Torus cutter V101-05 Depo; v_c = 180 – 220 m/min., 1000 cm^3
End-milling: CC-ball cutter V201-05 Emuge; v_c = 1000 m/min., 1000 cm^2

MACHINING RECOMMENDATIONS

Condition: annealed, figures given are guidelines only

Turning with sintered carbide

Depth of cut (inches)	0.5 – 1 (.02 – .04)	1 – 4 (.04 – .16)	4 – 8 (.16 – .31)
Feed (inches/rev.)	0.1 – 0.2 (.004 – .008)	0.2 – 0.4 (.008 – .016)	0.3 – 0.6 (.012 – .024)
BÖHLERIT grade	SB10, SB20, EB10	SB20, EB10, EB20	SB30, EB20, HB10
ISO grade	P10, P20, M10	P20, M10, M20	P30, M20, K10
Cutting speed v_c (m/min) (f.p.m)			
Indexable inserts **Tool life: 15 min.**	260 – 200 (850 – 655)	200 – 150 (655 – 490)	150 – 110 (490 – 360)
Brazed tools **Tool life: 30 min.**	210 – 170 (690 – 560)	170 – 130 (560 – 425)	140 – 90 (460 – 295)
Coated indexable inserts **BÖHLERIT LC 225 C** **BÖHLERIT LC 235 C**	 bis 260 (850) bis 230 (750)	 bis 220 (720) bis 180 (590)	 bis 150 (490) bis 130 (425)
Rake angle **Clearance angle** **Inclination angle**	12° – 15° 6° – 8° 0°	12° – 15° 6° – 8° 0°	12° – 15° 6° – 8° -4°

Turning with high speed steel

Depth of cut (inches)	0.5 (.02)	3 (.12)	6 (.24)
Feed (inches/rev.)	0.1 (.004)	0.5 (.02)	1.0 (.04)
HSS-grade BÖHLERIT/DIN	S700 / DIN S10-4-3-10		
Cutting speed v_c (m/min) (f.p.m)			
Tool life: 60 min.	55 – 45 (180 – 150)	45 – 35 (150 – 115)	35 – 25 (115 – 80)
Rake angle **Clearance angle** **Inclination angle**	14° – 18° 8° – 10° 0°	14° – 18° 8° – 10° 0°	14° – 18° 8° – 10° 0°

Milling with inserted tooth cutter

Feed (inches/tooth)	up to 0.2 (.008)	0.2 – 0.3 (.008 – .012)
Cutting speed v_c (m/min) (f.p.m)		
BÖHLERIT LW 225	220 – 200 (720 – 655)	140 – 60 (460 – 195)
BÖHLERIT SB40 / ISO P40	100 – 60 (330 – 195)	70 – 40 (230 – 130)
BÖHLERIT LC 444 W	140 – 110 (460 – 360)	–

Drilling with sintered carbide

Drill diameter (inches)	3 – 8 (.12 – .31)	8 – 20 (.31 – .80)	20 – 40 (.80 – 1.6)
Feed (inches/rev.)	0.02 – 0.05 (.001 – .002)	0.05 – 0.12 (.002 – .005)	0.12 – 0.18 (.005 – .007)
BÖHLERIT/ISO grade	HB10 / K10		
Cutting speed v_c (m/min) (f.p.m)	50 – 35 (165 – 115)		
Point angle	115° – 120°	115° – 120°	115° – 120°
Clearance angle	5°	5°	5°

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