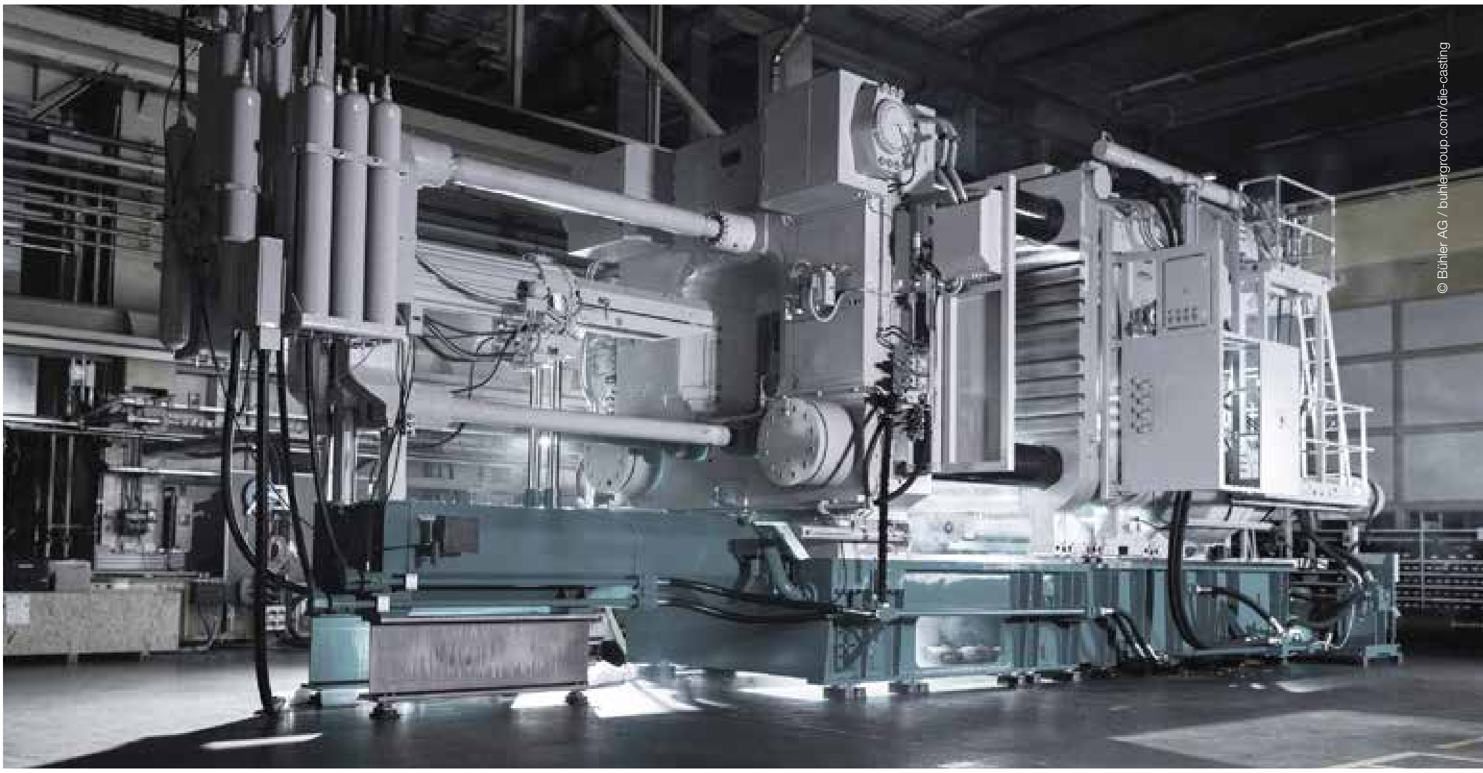
HOT WORK TOOL STEEL

BÖHLER W350 ISOBLOC®

FOR THE HIGHEST STANDARDS

TOOL LOAD

Hot work tool steels applied in hot forming processes such as die casting, forging or extrusion may be damaged on multiple and complex occasions. Damages may arise by collective stress factors combining high mechanical strengths, high temperatures and temperature gradients, whereas the individual stress factors dependent on process type and processing exert variably strong effects on the material.



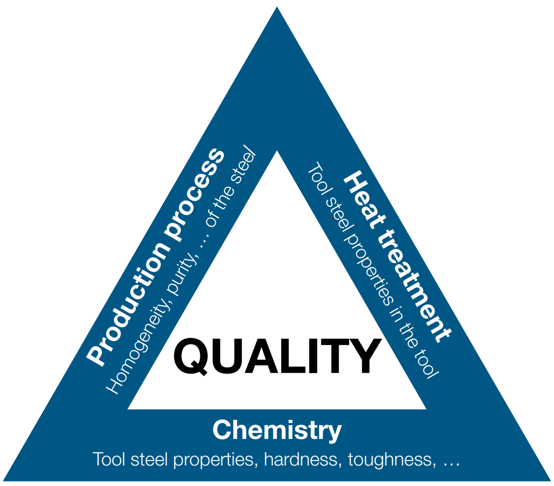
Damage mechanisms	Tool steel properties
Thermal fatigue crack networks	**Hardness**
Erosion	**Strength**
Gross cracking	**Toughness**
Stress cracks	**Ductility**
Chemical attack	**Thermal conductivity**

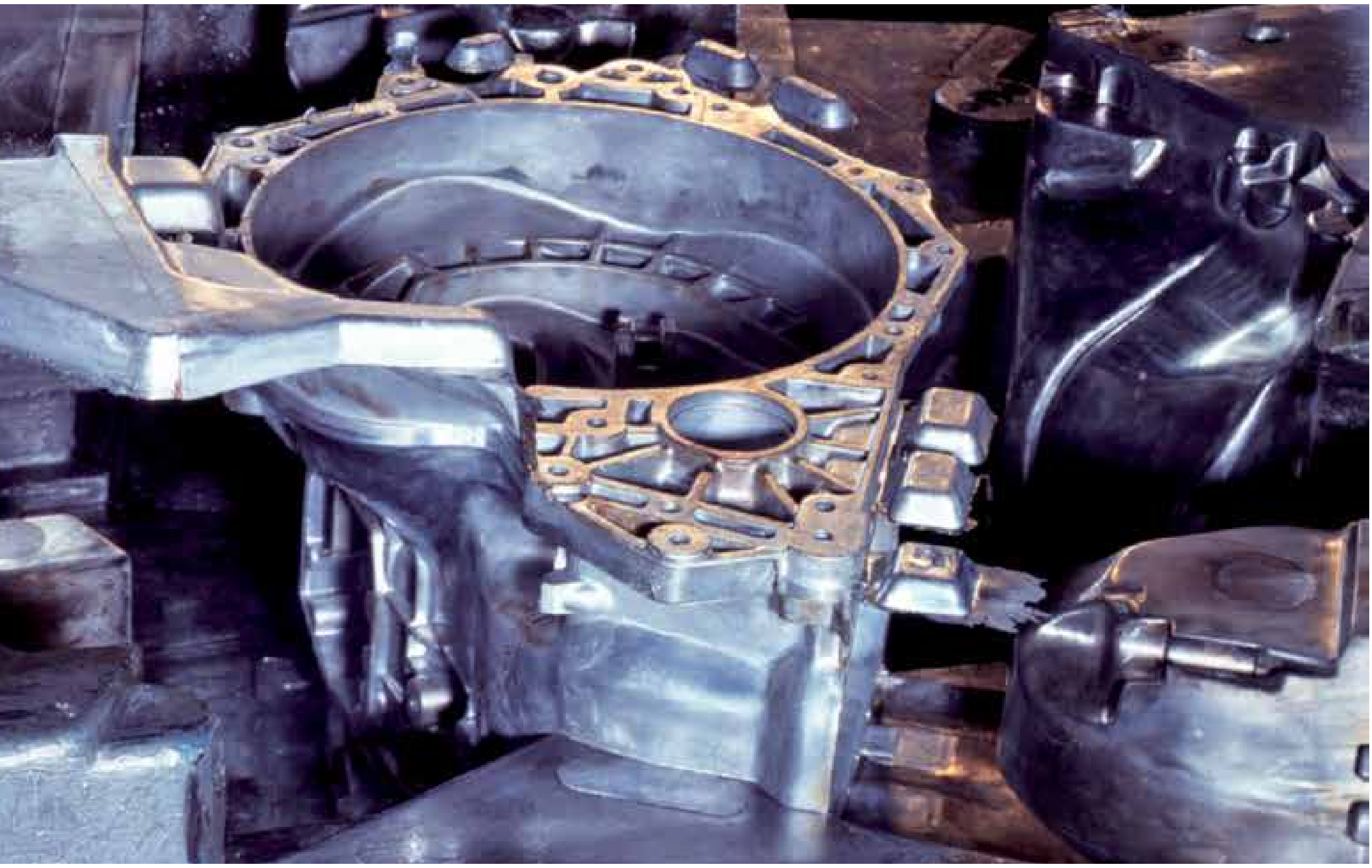
Material hardness, material strength, toughness, ductility and thermal conductivity are vital hot work tool steel properties when it comes to damage mechanisms to be avoided or delayed.

A TOUGH STEEL FOR XXL DIES

There is a fundamental rule: Maximum toughness and ductility are to be striven for in order to avoid gross cracking and to reduce thermal fatigue cracks and stress cracks. Hardness or strength should be selected in such a manner that plastic deformation caused by external stresses and erosion is prevented while aiming towards maximum toughness.

The quality of a tool made of hot work tool steel is defined by its mechanic-technological properties. It largely depends on the metal alloy‘s chemical composition, on the tool material‘s production process (electro slag remelting, vacuum remelting, forging and annealing technologies) and finally on the tool‘s heat treatment.

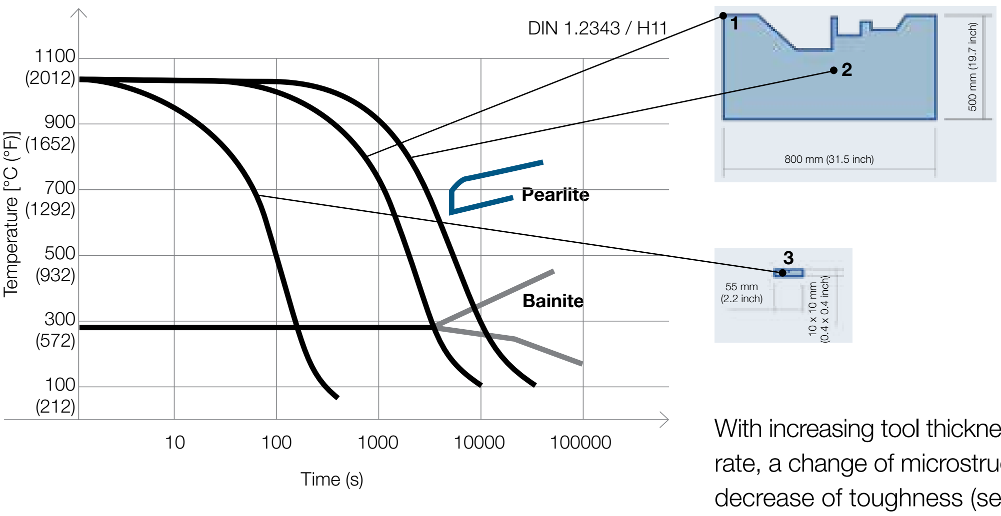




HEAT TREATMENT

In order to achieve high toughness in tools, the cooling speed from the hardening temperature is of major importance during hardening. Cooling speed is primarily dependent on the tool's size.

Cooling chart 2

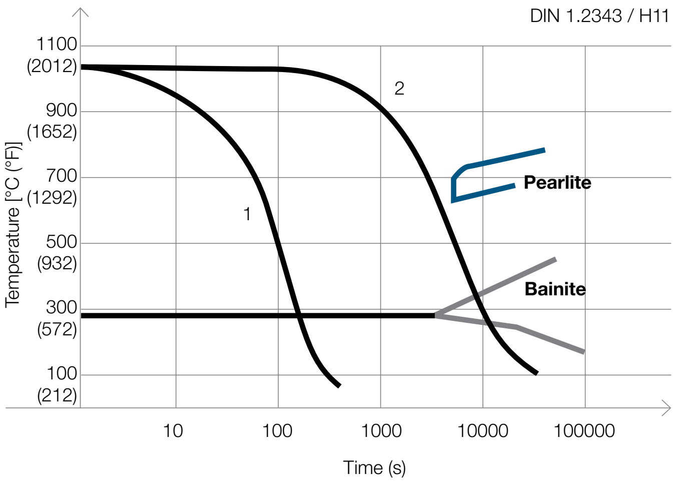


1 Die casting die edge
2 Die casting die core
3 Toughness sample Charpy-V

With increasing tool thickness, resulting in a reduced quenching rate, a change of microstructure occurs, leading to a significant decrease of toughness (see cooling chart 1).

A TOUGH STEEL FOR XXL DIES

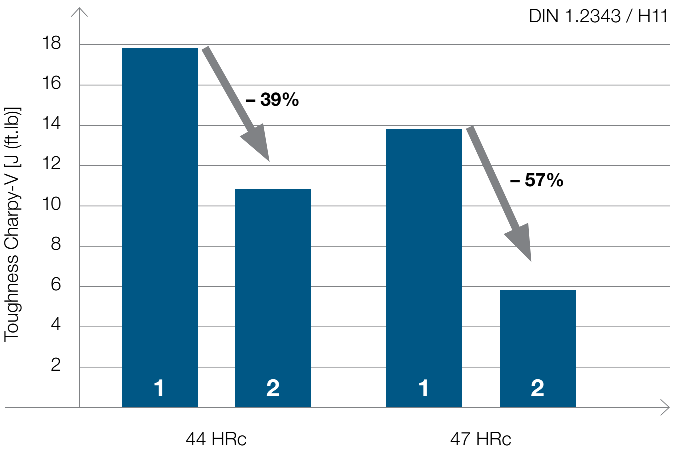
Cooling chart 2



1 Fast quenching of toughness samples Charpy-V
2 Slow quenching of toughness samples Charpy-V

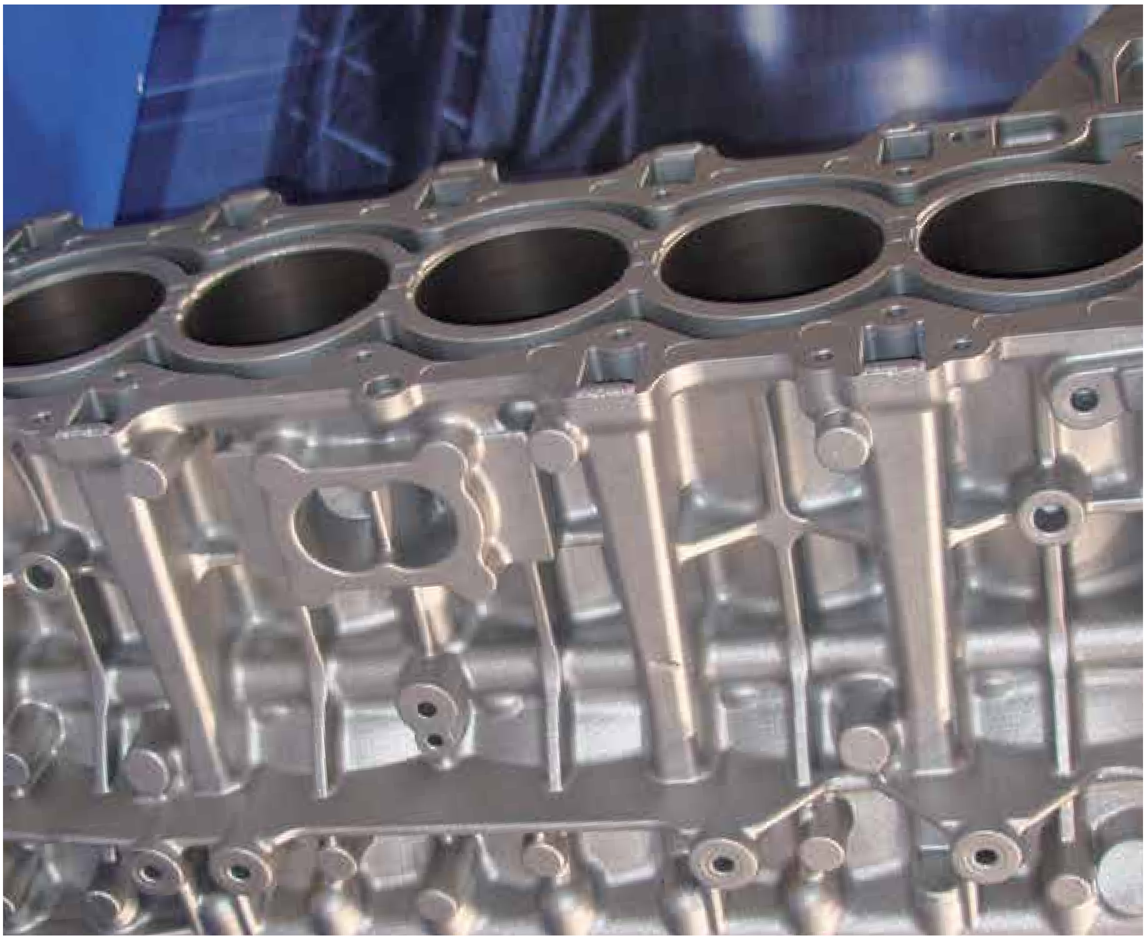
The effects of cooling speed on toughness properties were examined with hot work steel DIN 1.2343 by cooling down notched ISO-V samples at different speeds. Results are shown in the cooling chart 2.

Toughness comparison



1 Fast quenched
2 Slow quenched

The reduced cooling velocity leads to a significant decrease of toughness. If the hardness is increased, the decrease in toughness is even higher.



With the development of **BÖHLER W350 ISOBLOC**, voestalpine BÖHLER Edelstahl allows large tool sizes for the complex loads in hot forming and for effects of heat treating.

A balanced alloy composition ensuring high toughness even in large tools and an improved thermal stability opts for an optimal hardness/strength-toughness/ductility ratio (elongation after fracture and percentage reduction of area after fracture) tailor-fit to every application.

Chemical composition (average %)

C	Si	Mn	Cr	Mo	V	N
0.38	0.20	0.55	5.00	1.75	0.55	def.

Standards

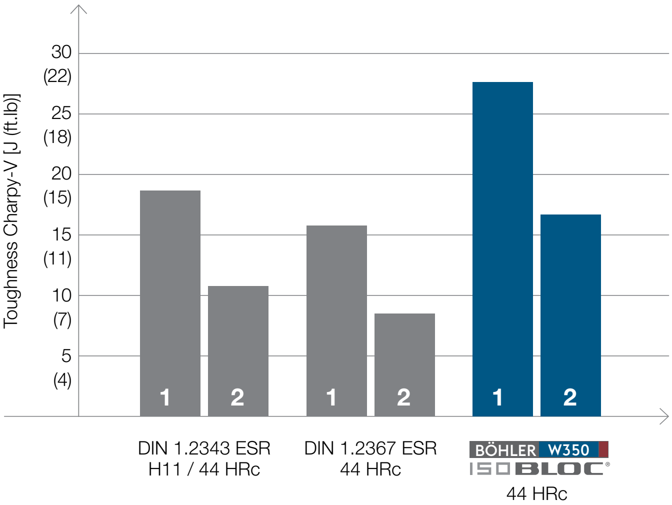
NADCA Grade E

A pressurized remelting process (pressure ESR) coupled with optimized forging technology in three dimensions guarantees a high degree of homogeneity of the mircrostructure and the material properties. A high degree of purity can also be realized.

MECHANICAL PROPERTIES FOR XXL TOUGH

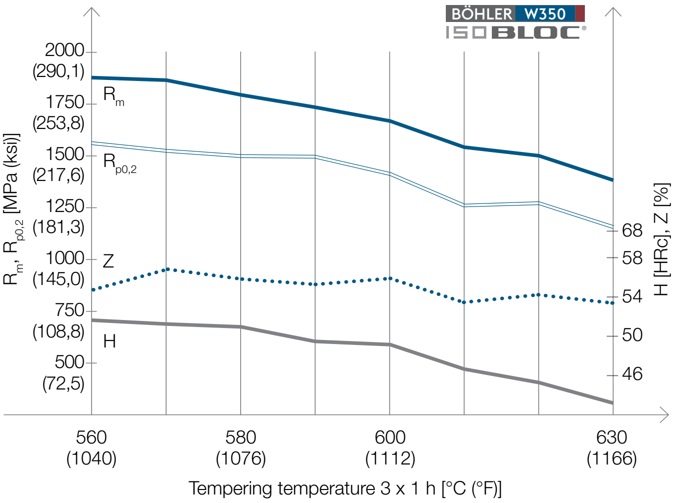
As can be seen in the image below, hot work steel **BÖHLER W350 ISOBLOC** is characterized by a significantly higher level of toughness for a fast and a slow cooling of the hardening temperature compared with standard materials DIN 1.2343 and 1.2367.

Toughness comparison



1 Fast quenched
2 Slow quenched

Mechanical properties



R_m Tensile strength
$R_{p0,2}$ Yield strength
H Hardness
Z Reduction of area

HEAT TREATMENT FOR XXL LIFE TIME

Condition of delivery

- Condition of delivery
  Annealed **max. 205 HB**

HEAT TREATMENT

Annealing

- 800 to 850 °C (1472 to 1562 °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 (1112 °F), further cooling in air.

Stress relieving

- 600 to 650 °C (1112 to 1202 °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

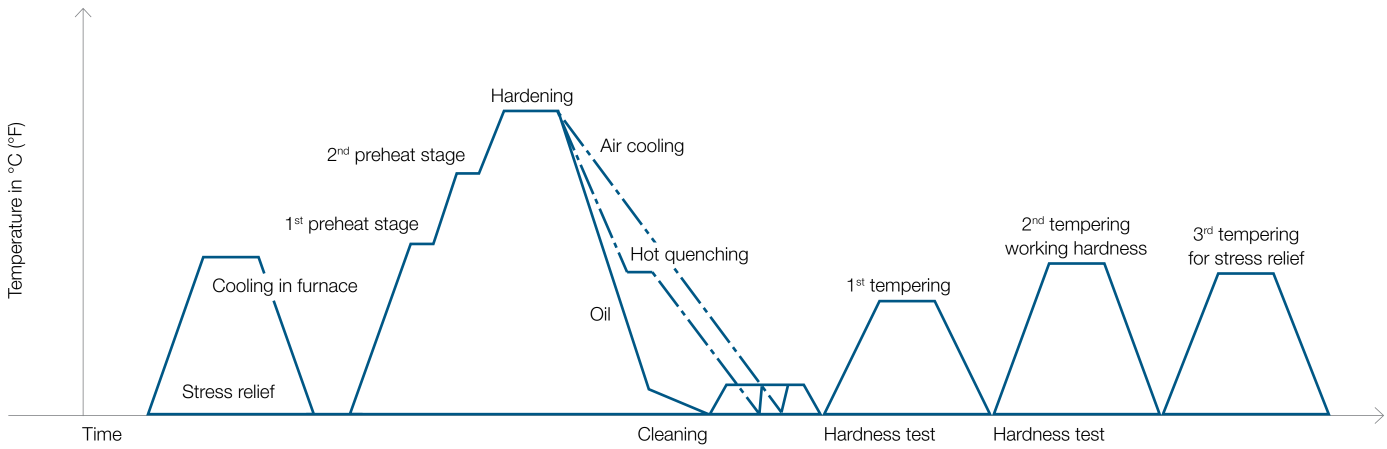
- 1020 °C (1010 °C) [1868 °F (1850 °F)]
- Oil, hot quenching (500 – 550 °C [932 – 1022 °F]), air or vacuum with gas quenching.
- Holding time after temperature equalization: 15 to 30 minutes.

Obtainable hardness:

- 52 – 54 HRC by oil or delayed martensitic hardening,
- 50 – 53 HRC in air or vacuum hardening.

In order to prevent coarsening of the grain, hardening must be carried out at the recommended temperature.
For big dimensions it's recommended to reduce the temperature to 1010 °C (1850 °F).

Heat treatment sequence



HEAT TREATMENT FOR XXL LIFE TIME

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 tempering for stress relieving at temperatures between 30 and 50 °C (85 – 120 °F) below the highest tempering temperature.

SURFACE TREATMENT

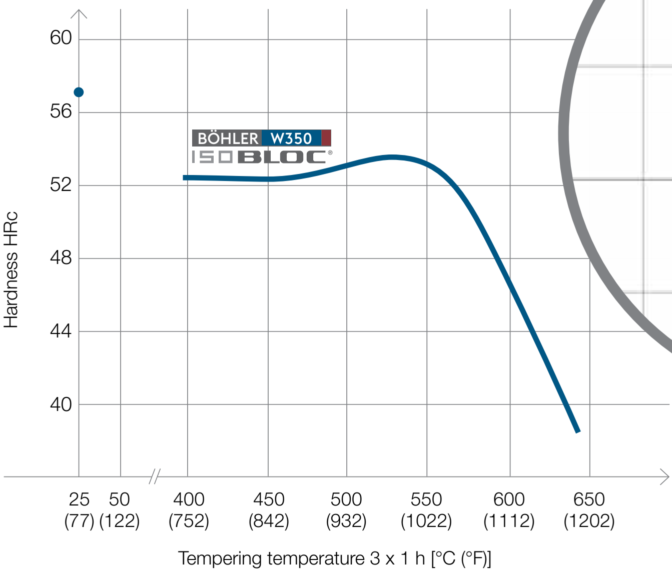
Nitriding

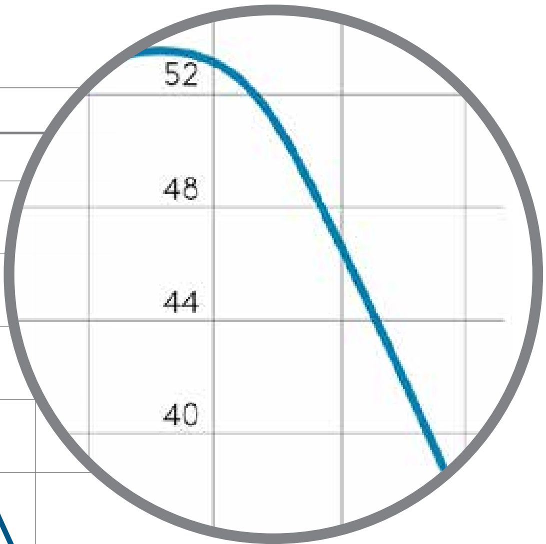
Suited for bath, gas and plasma nitriding.

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.
For further information please take a look to our welding brochure “Welding in tool making“.

Tempering chart





Hardening temperature: 1020 °C (1868 °F)

HEAT TREATMENT FOR XXL TOOLS

Chemical composition (average %)

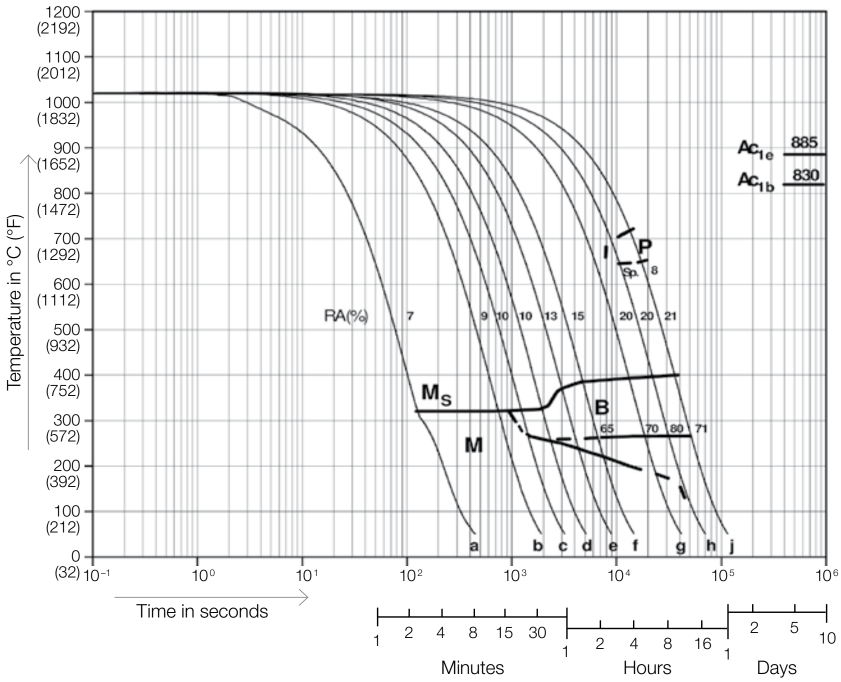
C	Si	Mn	Cr	Mo	V
0.38	0.21	0.50	4.95	1.75	0.53

Continuous cooling CCT curves

Austenitizing temperature: 1020 °C (1868 °F)
Holding time: 15 minutes

HV_{10} Vickers hardness
λ Cooling parameter, i.e. duration of cooling from 800 – 500 °C (1472 – 932 °F) in s x 10^{-2}

Sample	λ	HV10
a	0.50	630
b	3.00	616
c	5.00	606
d	8.00	606
e	14.00	517
f	23.00	478
g	65.00	497
h	110.00	454
j	180.00	459

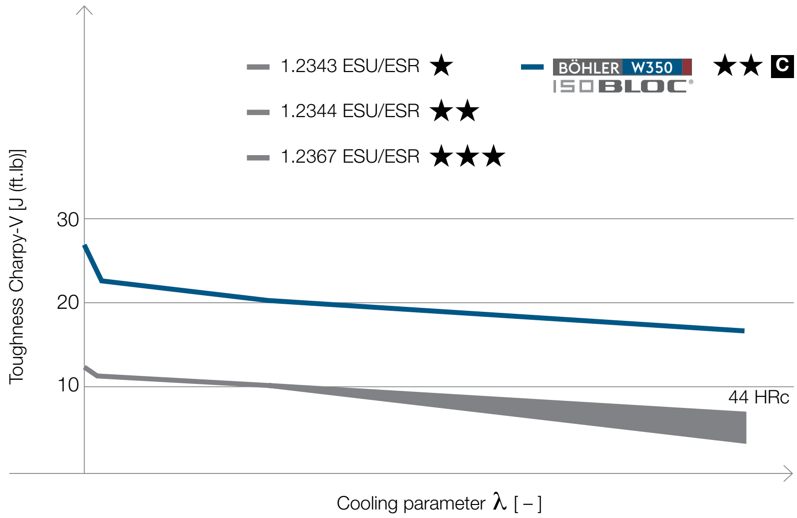


As a basic principle, all of the classic hot work steels display a decrease in toughness as the cooling speed of the quenching temperature is reduced. The new hot work steel **BÖHLER W350 ISOBLOC** was designed in such a way that during a rapid cooling phase with lower cooling parameters, very high toughness values will be able to be achieved and these values are also only marginally reduced when the cooling speed is reduced (higher cooling parameters).

Thermal stability:

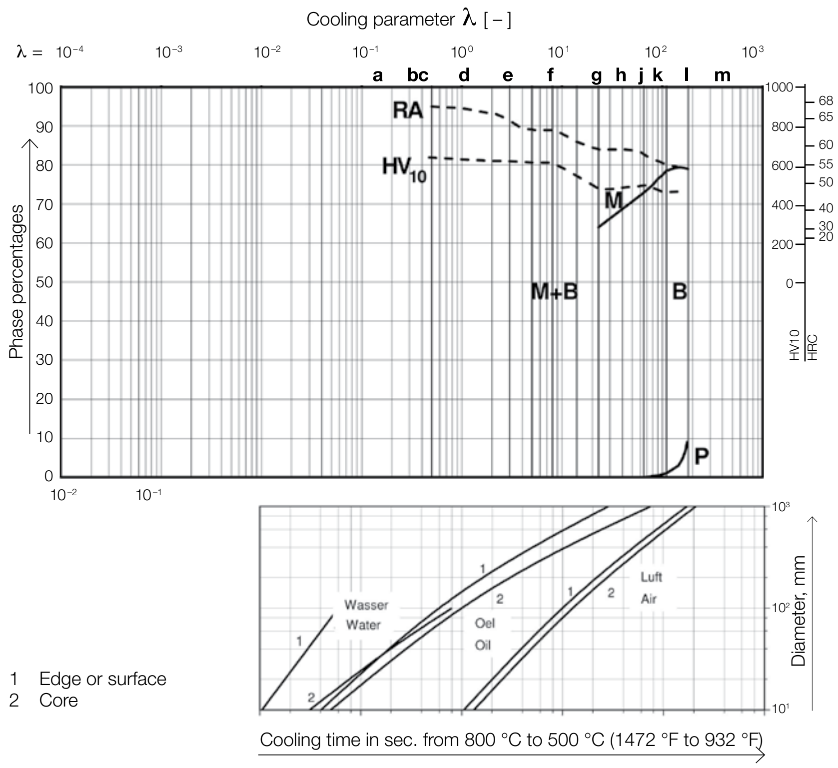
★	standard
★★	improved
★★★	high
C	improved thermal conductivity

Comparison toughness



Quantitative phase diagram

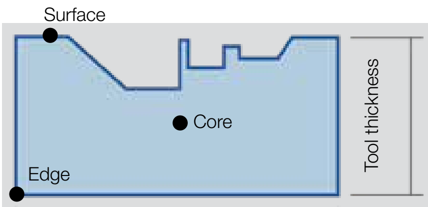
A	Austenite
B	Bainite
K	Carbide
P	Perlite
M	Martensite
RA	Retained austenite
Ms	Martensite start



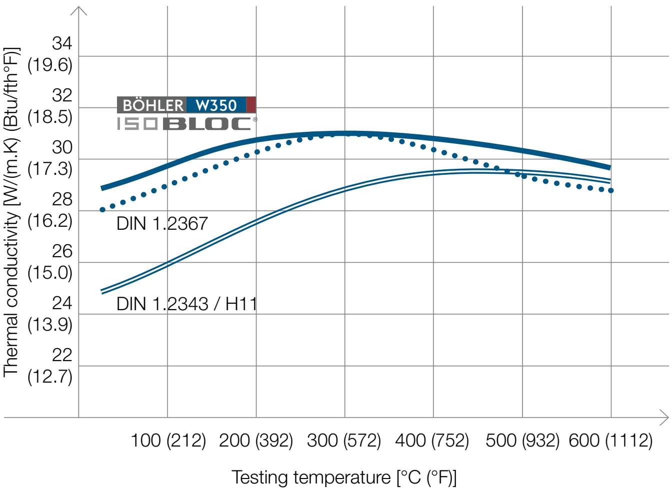
1 Edge or surface
2 Core

PHYSICAL PROPERTIES

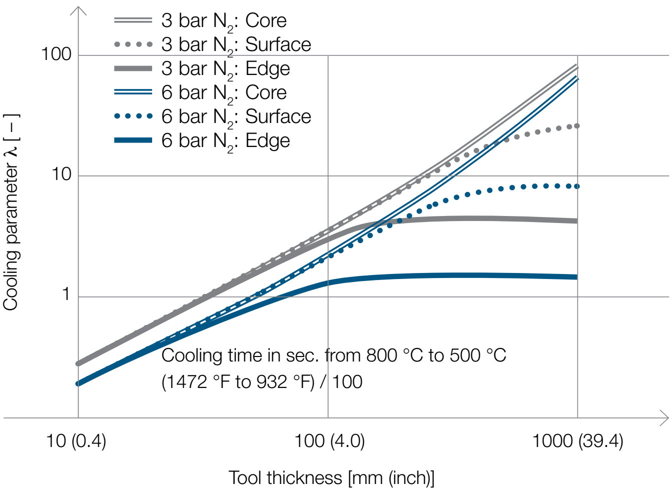
The cooling parameter set during tempering with gas quenching (N_2) is primarily dependent upon the size of the tool and its geometry.



Thermal conductivity



Cooling parameter



Physical properties

Density at	20 °C 68 °F	7.8 kg/dm³ 0.282 lbs/in³
Specific heat capacity at	20 °C 68 °F	455 J/(kg.K) 0.109 Btu/lb°F
Thermal conductivity at	20 °C 68 °F	28.9 W/(m.K) 16.70 Btu/ft h°F
Modulus of elasticity at	20 °C 68 °F	214.3 × 10³ MPa 31.1 x 10³ ksi

Condition: hardened and tempered

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

20 °C	**100 °C**	**200 °C**	**300 °C**	**400 °C**	**500 °C**	**600 °C**	
–	11.45	11.95	12.34	12.69	13.04	13.31	10^{-6} m/(m.K)
68 °F	**212 °F**	**392 °F**	**572 °F**	**752 °F**	**932 °F**	**1112 °F**	
–	6.36	6.64	6.86	7.05	7.24	7.39	10^{-6} in/in°F

Thermal conductivity

20 °C	**100 °C**	**200 °C**	**300 °C**	**400 °C**	**500 °C**	**600 °C**	
28.9	29.8	30.9	31.0	30.7	30.3	29.7	in W/(m.K)
68 °F	**212 °F**	**392 °F**	**572 °F**	**752 °F**	**932 °F**	**1112 °F**	
16.70	17.22	17.85	17.91	17.74	17.51	17.16	Btu/ft h°F

Regarding 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.

Machinability	Tool	Speed	Feed	Depth of cut	Width of cut
Turning	Böhlerit PWLN 2525 M08 / WNMG 060408-BM LC225K	130 v_c m/min	0.40 mm/U	–	–
Rough milling (Ø 25 R 3.5 mm)	Depo M40 NTV Atorn RDHW 0702 MOS	150–240 v_c m/min	0.40 mm/tooth	0.50 mm	17.50 mm
Drilling (Ø 6.8 mm)	Titex VHM Bohrer A3389DPL-6.8	225 v_c m/min	0.18 mm/U	–	–
Deep-hole drilling (Ø 8 mm)	Botek 8x350 K15B Hammond GM08000 A0320 EFHM (Gun Drill)	100 v_c m/min	0.04 mm/U	–	–
Tapping M8	Franken-Emuge B 0503700 0080 MGB	24 v_c m/min	–	–	–

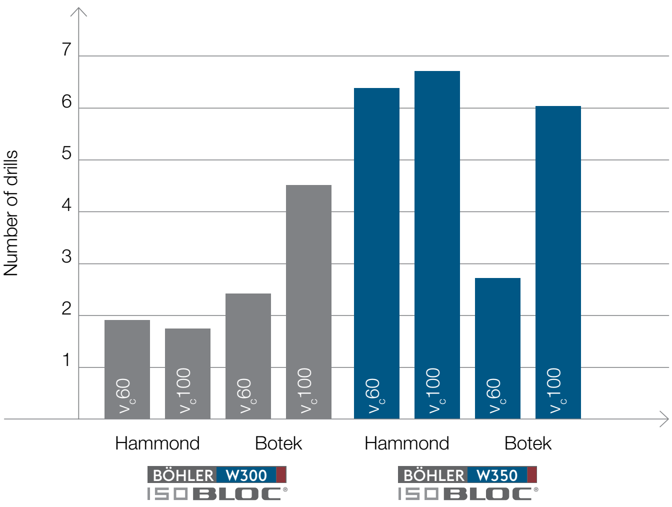
Condition: Soft annealed

Machinability	Tool	Speed	Feed	Depth of cut	Width of cut
Pre-finishing (Ø 12 R 5 mm)	Böhlerit-Kieninger WPB 12-FB-50 LC610Z	290–385 v_c m/min	0.13–0.18 mm/tooth	0.27 mm	1.50 mm
Finishing (Ø 8 mm)	Franken-Emuge 1966A.008	750–1250 v_c m/min	0.05 mm/tooth	0.20 mm	0.20 mm

Condition: hardened and tempered

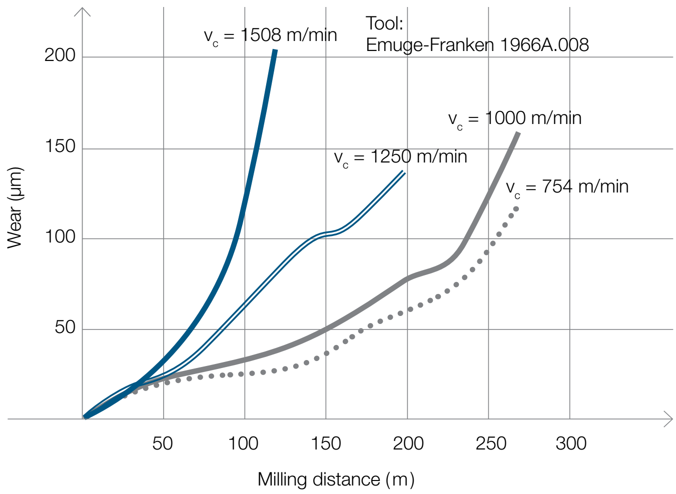
MACHINING RECOMMENDATIONS

Deep-hole drilling: comparative study



The comparative study shows that at deep-hole drilling of **BÖHLER W350 ISOBLOC** espacially at higher cutting speed a higher number of drills could be realized.

Optimization finishing



To optimize the finishing process **BÖHLER W350 ISOBLOC** was tested at different cutting speed and tools. It has shown that the milling distance decreases with increasing cutting speed.

MATERIALS | MACHINING | PVD COATINGS | ADDITIVE

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