UNIMAX

Plastic mould steel

COLD WORK | **PLASTIC** MOULDING | **HOT** WORK | **HIGH** PERFORMANCE STEEL

UDDEHOLM

General

Unimax is a chromium-molybdenum-vanadium alloyed tool steel which is characterized by:

- Excellent toughness and ductility in all directions
- Good wear resistance
- Good dimensional stability at heat treatment and in service
- Excellent through-hardening properties
- Good resistance to tempering back
- Good hot strength
- Good thermal fatigue resistance
- Excellent polishability

Typical analysis %	C 0,5	Si 0,2	Mn 0,5	Cr 5,0	Mo 2,3	V 0,5
Standard specification	None					
Delivery condition	Soft annealed to approx. 185 HB					
Colour code	Brown/grey					

Applications

Unimax is suitable for long run production moulds, moulds for reinforced plastics and compression moulding.

Unimax is a problem solver in severe cold work tooling applications such as heavy duty blanking, cold forging and thread rolling, where high chipping resistance is required.

Engineering and hot work applications requiring high hardness and toughness are also an option.

Properties

The properties below are representative of samples which have been taken from the centre of bars with dimensions 396 x 136 mm (15,6"x 5,35"), Ø 125 mm (4,93") and Ø 220 mm (8,67"). Unless otherwise indicated all specimens have been hardened at 1025°C (1875°F), gas quenched in a vacuum furnace and tempered twice at 525°C (975°F) for two hours; yielding a working hardness of 56–58 HRC.

PHYSICAL PROPERTIES

Hardened and tempered to 56–58 HRC

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density, kg/m^3 lbs/in^3	7 790 0,281	–	–
Modulus of elasticity MPa psi	213 000 31,2 x 10^6	192 000 27,8 x 10^6	180 000 26,1 x 10^6
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	– –	11,5 x 10^{-6} 6,3 x 10^{-6}	12,3 x 10^{-6} 6,8 x 10^{-6}
Thermal conductivity W/m °C Btu in/(ft^{2}h°F)	– –	25 174	28 195
Specific heat j/kg°C Btu/lb°F	460 0,11	–	–

MECHANICAL PROPERTIES

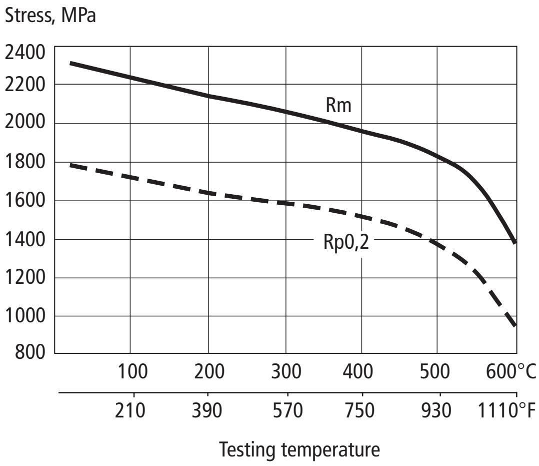
Approx. strength and ductility at room temperature at tensile testing.

Hardness	54 HRC	56 HRC	58 HRC
Yield strength, $R_{p0,2}$	1720 MPa	1780 MPa	1780 MPa
Tensile strength, R_m	2050 MPa	2150 MPa	2510 MPa
Elongation, A_5	9 %	8 %	8 %
Reduction of area, Z	40 %	32 %	28 %

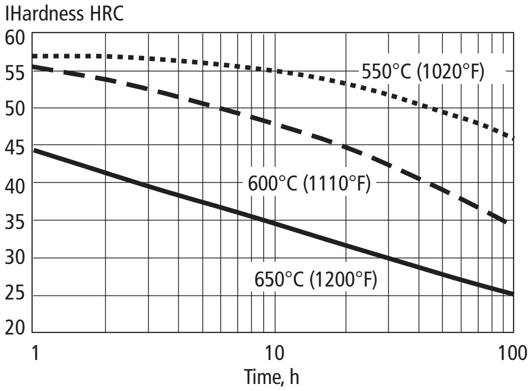
Approximate strength at elevated temperatures

Longitudinal direction.

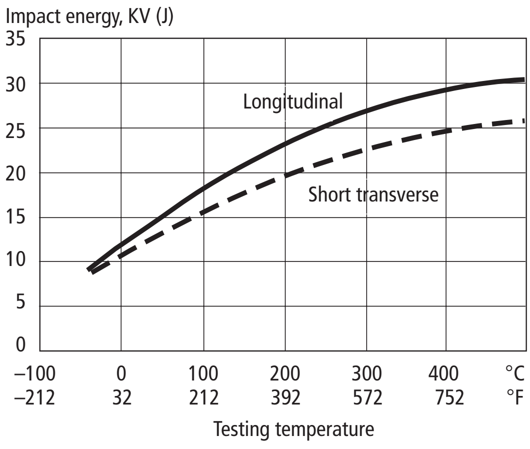
The specimens were hardened from 1025°C (1875°F) and tempered twice at 525°C (975°F) to 58 HRC.



Effect of time at high temperatures on hardness
Initial hardness 57 HRC.



Effect of testing temperature on impact energy
Charpy-V specimens, longitudinal and short transverse direction. Approximate values for specimens from Ø125 mm (4,9") bar.



Heat treatment—general recommendations

SOFT ANNEALING

Protect the steel and heat through to 850°C (1560°F). Then cool in furnace at 10°C (20°F) per hour to 600°C (1110°F), then freely in air.

STRESS RELIEVING

After rough machining the tool should be heated through to 650°C (1200°F), holding time 2 hours. Cool slowly to 500°C (930°F), then freely in air.

HARDENING

Preheating temperature: 600–650°C (1110–1200°F) and 850–900°C (1560–1650°F).

Austenitizing temperature: 1000–1025°C (1830–1875°F), normally 1025°C (1875°F).

Holding time: 30 minutes

Temperature °C	°F	Soaking time minutes	Hardness before tempering
1000	1830	30	61 HRC
1025	1875	30	63 HRC

Soaking time = time at hardening temperature after the tool is fully heated through.

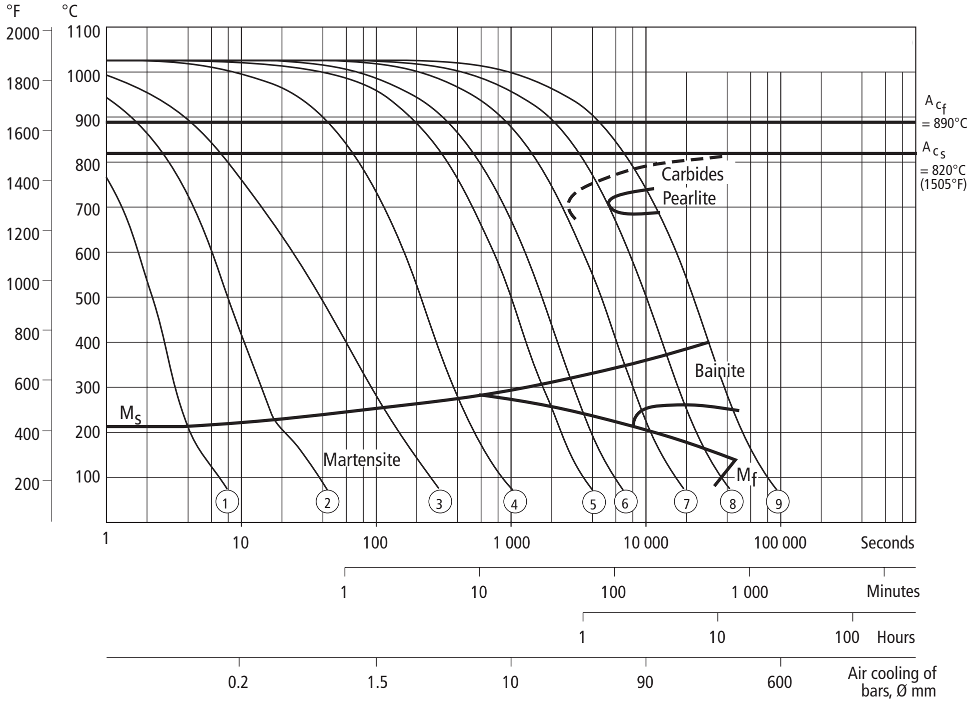
Protect the tool against decarburization and oxidation during austenitizing.

QUENCHING MEDIA

- High speed gas/circulating atmosphere.
- Vacuum furnace (high speed gas with sufficient overpressure).
- Martempering bath, salt bath or fluidized bed at 500–550°C (930–1020°F).
- Martempering bath at 200–350°C (390–660°F).

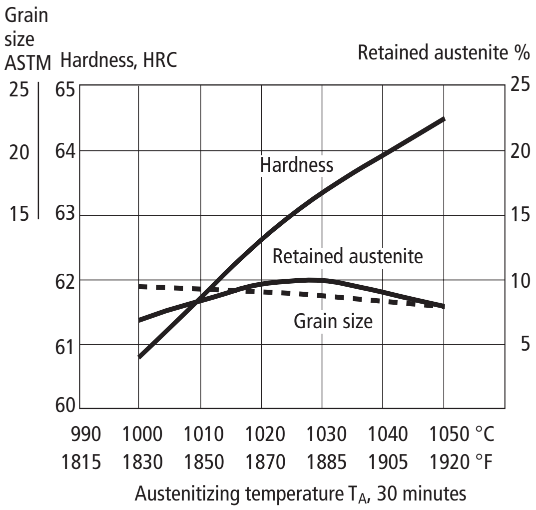
Note: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

CCT graph—Austenitizing temperature 1025°C (1875°F). Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ (sec)
1	835	1
2	819	5
3	798	33
4	782	140
5	724	630
6	712	1064
7	674	2900
8	525	6250
9	476	13850

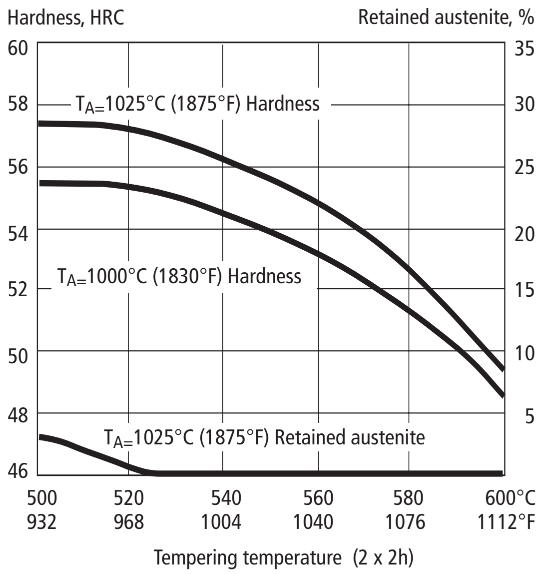
Hardness, grain size and retained austenite as functions of austenitizing temperature



TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph below. Temper at least twice with intermittent cooling to room temperature. The lowest tempering temperature which should be used is 525°C (980°F). The minimum holding time at temperature is 2 hours.

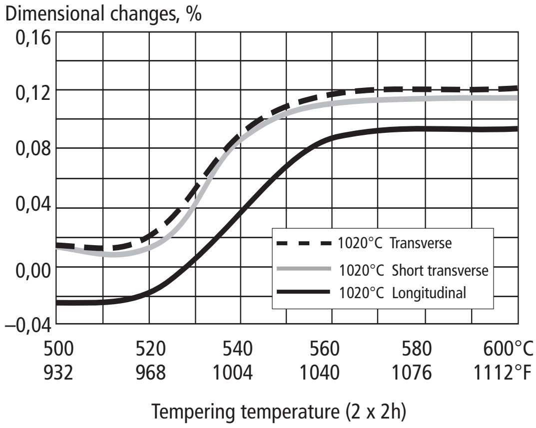
Tempering graph



DIMENSIONAL CHANGES DURING HARDENING AND TEMPERING

The dimensional changes have been measured after austenitizing at 1020°C (1870°F)/30 minutes followed by gas quenching in N_2 at a cooling rate of 1,1°C/second between 800–500°C (1470–930°F) in a cold chamber vacuum furnace.

Specimen size: 100 x 100 x 100 mm (3,9"x 3,9"x 3,9")



Surface treatments

Tool steels may be given a surface treatment in order to reduce friction and increase wear resistance. The most commonly used treatments are nitriding and surface coating with wear resistant layers produced via PVD or CVD.
The high hardness and toughness together with a good dimensional stability makes Unimax suitable as a substrate steel for various surface coatings.

NITRIDING AND NITROCARBURIZING

Nitriding and nitrocarburizing result in a hard surface layer which is very resistant to wear and galling.
The surface hardness after nitriding is approximately 1000–1200 $HV_{0,2kg}$. The thickness of the layer should be chosen to suit the application in question.

PVD

Physical vapour deposition, PVD, is a method for applying wear-resistant surface coating at temperatures between 200–500°C (390–930°F).

CVD

Chemical vapour deposition, CVD, is a method for applying wear-resistant surface coating at a temperature of around 1000°C (1830°F).

Cutting data recommendations

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions.

Condition: Soft annealed to ~185 HB

TURNING

Cutting data parameters	Turning with carbide		Turning with high speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min f.p.m.	150–200 490–655	200–250 655–820	15–20 50–65
Feed (f) mm/r i.p.r.	0,2–0,4 0,008–0,016	0,05–0,2 0,002–0,008	0,05–0,3 0,002–0,012
Depth of cut (a_p) mm inch	2–4 0,08–0,16	0,5–2 0,02–0,08	0,5–2 0,02–0,08
Carbide designation ISO US	P20–P30 C6–C5 Coated carbide	P10 C7 Coated carbide or cermet	– –

MILLING

Face- and square shoulder milling

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m.	120–170 394–558	170–210 558–690
Feed (f_z) mm/tooth inch/tooth	0,2–0,4 0,008–0,016	0,1–0,2 0,004–0,008
Depth of cut (a_p) mm inch	2–4 0,08–0,16	0,5–2 0,02–0,08
Carbide designation ISO US	P20–P40 C6–C5 Coated carbide	P10 C7 Coated carbide or cermet

End milling

Cutting data parameters	Type of milling: Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min	120–150	110–150	20–25[1)]
f.p.m.	390–490	360–490	66–80[1)]
Feed (f_z) mm/tooth	0,01–0,20[2)]	0,06–0,20[2)]	0,01–0,30[2)]
inch/tooth	0,0003–0,008[2)]	0,002–0,008[2)]	0,0003–0,012[2)]
Carbide designation ISO	–	P20–P30	–
US		C6–C5	–

1) For coated HSS end mill v_c 35–40 m/min. (115 –130 f.p.m.).
2) Depending on radial depth of cut and cutter diameter.

DRILLING

High speed steel twist drill

Drill diameter mm	Drill diameter inch	Cutting speed (v_c) m/min	Cutting speed (v_c) f.p.m.	Feed (f) mm/r	Feed (f) i.p.r.
– 5	–3/16	15–20*	49–66*	0,05–0,10	0,002–0,004
5–10	3/16–3/8	15–20*	49–66*	0,10–0,20	0,004–0,008
10–15	3/8–5/8	15–20*	49–66*	0,20–0,30	0,008–0,012
15–20	5/8–3/4	15–20*	49–66*	0,30–0,35	0,012–0,014

1) For coated HSS drill v_c ~35–40 m/min. (115–130 f.p.m.).

Carbide drill

Cutting data parameters	Type of drill: Indexable insert	Solid carbide	Brazed carbide[1)]
Cutting speed (v_c) m/min	180–220	120–150	60–90
f.p.m.	590–720	390–490	195–295
Feed (f) mm/r	0,03–0,10[2)]	0,10–0,25[2)]	0,15–0,25[2)]
i.p.r.	0,001–0,004[2)]	0,004–0,01[2)]	0,006–0,01[2)]

1) Drill with internal cooling channels and brazed carbide tip.
2) Depending on drill diameter.

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm publication "Grinding of Tool Steel".

Recommeded grinding wheels

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 GV
Face grinding segments	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 LV	A 120 KV

Electrical Discharge Machining

Following the EDM process, the applicable die surfaces are covered with a resolidified layer (white layer) and a rehardened and untempered layer, both of which are very brittle and hence detrimental to die performance.

If EDM is used the white layer must be completely removed mechanically by grinding or stoning. After finish-machining the tool should be given an additional temper at approx. 25°C (50°F) below the highest previous tempering temperature.

Further information is given in the Uddeholm brochure "EDM of Tool Steel".

Welding

Welding of die components can be performed, with acceptable results, as long as the proper precautions are taken during the preparation of the joint, the filler material selection, the preheating of the die, the controlled cooling of the die and the post weld heat treatment processes. The following guidelines summarize the most important welding process parameters.

For more detailed information refer to Uddeholm's "Welding of Tool Steel" brochure.

Welding method	TIG	MMA
Preheating temperature	200–250°C (390–480°F)	200–250°C (390–480°F)
Filler material	UTP ADUR600 UTP A73G2	UTP 67S UTP 73G2
Maximum interpass temperature	350°C (660°F)	350°C (660°F)
Post weld cooling	20–40°C/h (45–70°F/h) for the first two hours and then freely in air.	
Hardness after welding	54–60 HRC	55–58 HRC
Post weld heat treatment		
Hardened condition	Temper at 510°C (950°F) for 2 h.	
Soft annealed condition	Soft-anneal according to the "Heat treatment recommendations".	

Further information

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels.

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