BÖHLER UDDEHOLM

MATERIALIZING VISIONS

Bohler-Uddeholm M7

HIGH SPEED TOOL STEEL

General

High alloyed, molybdenum high speed steel with good wear resistance and high toughness. This grade has been manufactured to our internal specifications, and audited to meet our guidelines.

Typical analysis %	C 1.02	Si 0.4	Mn 0.3	Cr 3.8	Mo 8.6	V 1.9	W 1.8
Standard specification	AISI M7, DIN/EN 1.3348						
Color code	Gold/White/Yellow						

Applications

Taps, twist drills, reamers, milling tools, broaches, cold extrusion dies.

Hot Forming

FORGING

1650 – 2010°F (900 – 1100°C), afterwards, slow cooling in furnace or blanketed with thermo-insulating material.

Heat treatment

ANNEALING

1420 to 1545°F (770 to 840°C), controlled slow cooling in furnace at 20 to 35°F/hr (10 to 20°C/hr) to approximately 1110°F (600°C), followed by cooling in still air. Hardness after annealing 280 Brinell, maximum.

STRESS RELIEVING

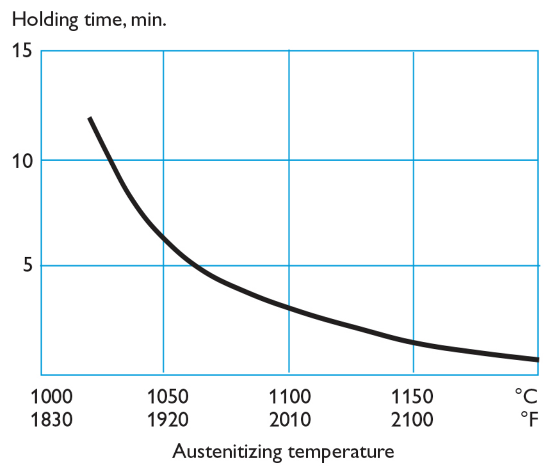
To relieve stresses created by extensive machining or tooling with complex geometries. Heat in a neutral atmosphere for 1 to 2 hours after reaching a temperature of 1110 to 1200°F (600 to 650°C), followed by slow cooling in the furnace.

HARDENING

Hardening temperature of 2000 to 2210°F (1170 to 1210°C); quench in: oil, salt bath at 930 to 1020°F (500 to 550°C), or vacuum. The upper temperature range should be used for parts of simple geometry, the lower range for more complex tooling. For cold work tooling, lower temperatures are of importance for improved toughness.

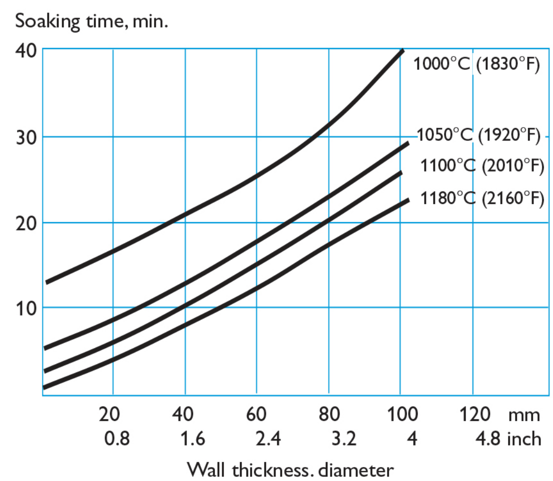
Preheat in multiple steps and equalize surface and core temperatures; for example: Step 1 - 1020°F (550°C), Step 2 – 1560°F (850°C), and Step 3 – 1920°F (1050°C) then to the appropriate hardening temperature. The third preheat is only required for complex geometries.

RECOMMENDED HOLDING TIME, FLUIDIZED BED, VACUUM OR ATMOSPHERE FURNACE

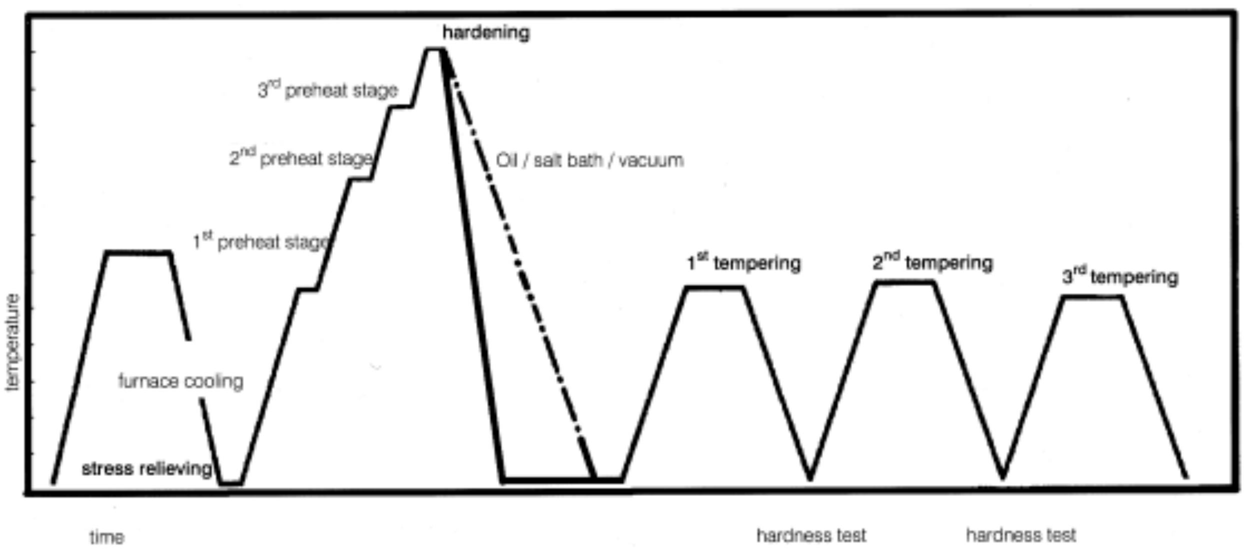


Note: Holding time = time at austenitizing temperature after the tool is fully heated through.

TOTAL SOAKING TIME IN A SALT BATH AFTER PRE-HEATING IN TWO STAGES AT 450°C (840°F) AND 850°C (1560°F)



HEAT TREATMENT SEQUENCE

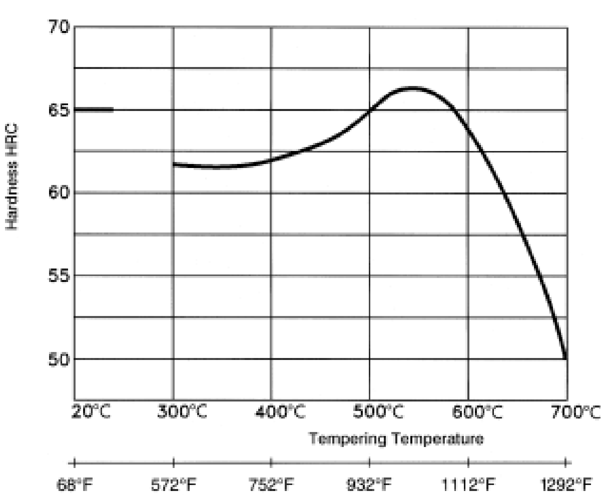


Tempering

Slowly and uniformly heat to the appropriate tempering temperature immediately after the hardening operation. Once the temperature of the tool has been equalized, a soaking period of one hour per inch (25 mm) of workpiece thickness is required, but not less than 2 hours. First and second tempers should be used to reach the desired hardness level, and the third selected for additional stress relief at 85 - 120°F (30 to 50°C) below the highest tempering temperature. Intermittent cooling, in air, between tempers is required for a minimum of 1 hour. Obtainable hardness of 64 to 66 HRC.

TEMPERING CHART

Hardening temperature: 2175°F (1190°C) Specimen size: square cross section 20 mm

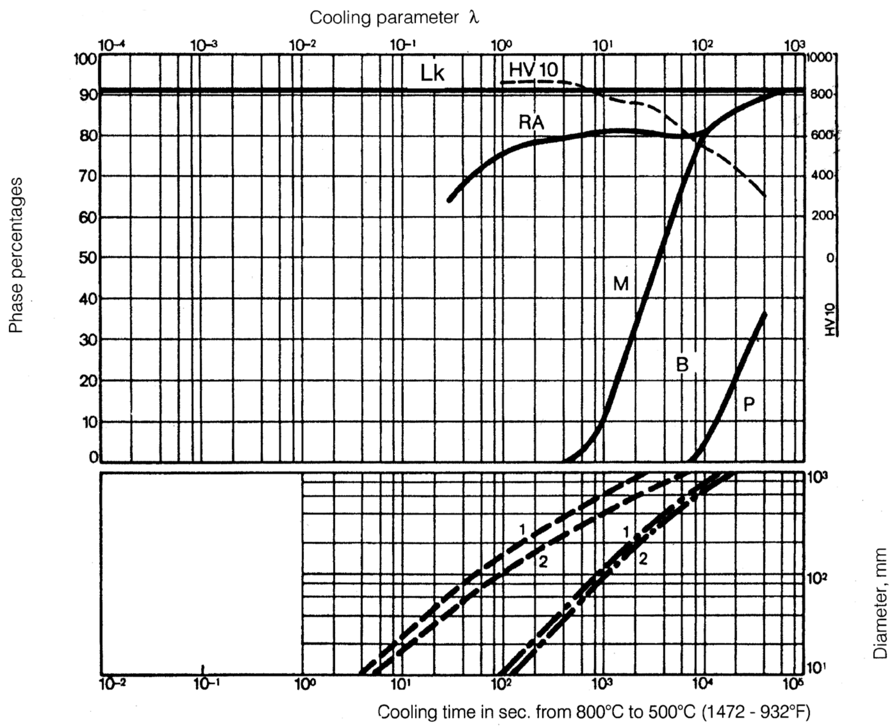


Surface treatment

NITRIDING

Parts made from this steel may be nitrided via the plasma, gas or salt bath processes

Quantitative phase diagram



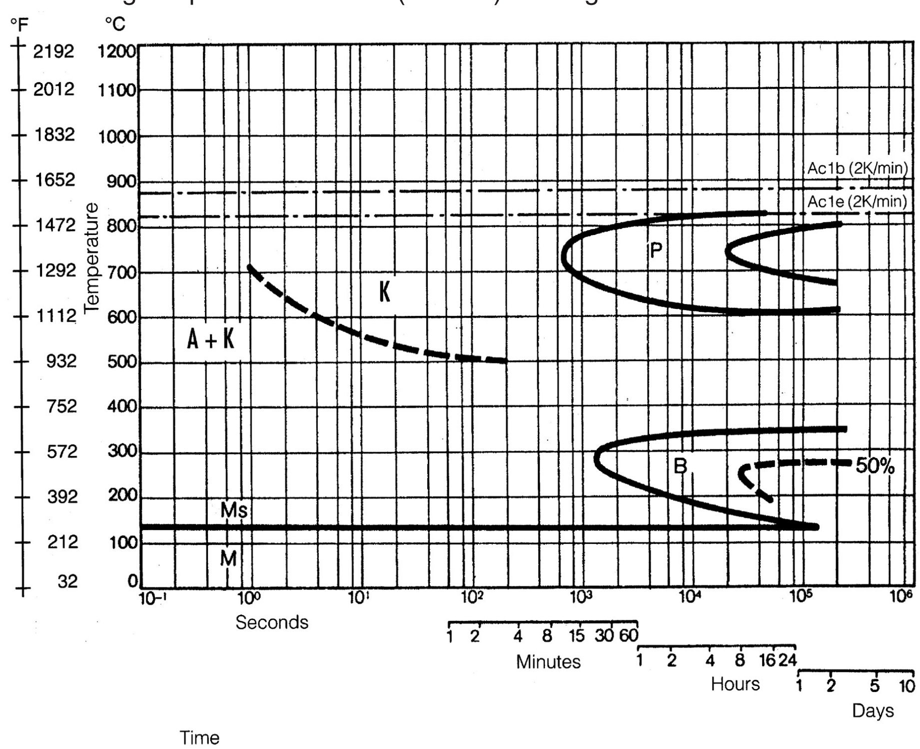
-----Water cooling
- - - Oil cooling
- · - Air cooling
1 ....Edge or face
2 ....Core
3.....Jominy test: distance from end

A.... Austenite
B.... Bainite
M.... Martensite
P.... Pearlite
Lk... Ledeburite carbide
RA.. Retained austenite

Isothermal TTT curves

Typical analysis %	C	Si	Mn	P	S	Cr	Mo	Ni	V	W
	0.96	0.33	0.33	0.021	0.008	3.92	8.79	0.12	2.04	2.09

Austenitizing temperature: 2174°F (1190°C) Holding time: 150 seconds



Properties

PHYSICAL DATA

Temperature	68°F (20°C)
Density lbs/in^3 g/cm^3	130 8.30
Modulus of elasticity psi N/mm^2	31.4×10^6 217×10^3
Thermal conductivity Btu in/(ft^{2}h°F) W/m °C	136 19
Specific heat Btu/lb °F J/kg °C	0.11 460
Electrical Resistivity µohm*in ohm*mm^2/m	25.6 0.65

Thermal expansion between 68°F/ 20°C and...			
Temperature		10^{-6} m/(m*K)	10^{-6} in/in °F
°F	°C		
212	100	11.0	6.2
392	200	11.5	6.5
572	300	11.9	6.7
752	400	12.3	6.9
932	500	12.4	7.0
1112	600	12.5	7.0
1292	700	12.5	7.0

Machining

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

TURNING

Turning with carbide tipped tools

(condition annealed, average values)

<table>
<tr><td>Depth of Cut (a_p)
inches
mm</td><td colspan="2">0.02 to 0.04
0.5 to 1</td><td colspan="2">0.04 to 0.16
1 to 4</td><td colspan="2">0.16 to 0.31
4 to 8</td><td colspan="2">over 0.31
over 8</td></tr>
<tr><td>Feed (f_z)
i.p.r.
mm/rev</td><td colspan="2">0.004 to 0.012
0.1 to 0.3</td><td colspan="2">0.008 to 0.016
0.2 to 0.4</td><td colspan="2">0.012 to 0.024
0.3 to 0.6</td><td colspan="2">0.020 to 0.060
0.5 to 1.5</td></tr>
<tr><td>ISO</td><td colspan="2">P10, P20</td><td colspan="2">P10, P20, M10</td><td colspan="2">P30, M20</td><td colspan="2">P30, P40</td></tr>
<tr><td>Cutting Speed (v_c)
Indexable Carbide Inserts
(edge life 15 min)
f.p.m.
m/min</td><td colspan="2">495 to 690
150 to 210</td><td colspan="2">360 to 525
110 to 160</td><td colspan="2">260 to 360
80 to 110</td><td colspan="2">150 to 230
45 to 70</td></tr>
<tr><td>Cutting Speed (v_c)
Brazed Carbide Tipped Tools
(edge life of 30 min)
f.p.m.
m/min</td><td colspan="2">360 to 490
110 to 150</td><td colspan="2">280 to 440
85 to 135</td><td colspan="2">200 to 295
60 to 90</td><td colspan="2">115 to 230
35 to 70</td></tr>
<tr><td>Hardfaced Indexable
Carbide Inserts
(edge life 15 min)
ISO P20
ISO P35</td><td>f.p.m
to 690
to 460</td><td>m/min
to 210
to 140</td><td>f.p.m.
to 590
to 460</td><td>m/min
to 180
to 140</td><td>f.p.m.
to 430
to 330</td><td>m/min
to 130
to 100</td><td>f.p.m.
to 260
to 200</td><td>m/min
to 80
to 60</td></tr>
<tr><td>Cutting angles for brazed carbide tipped tools
Clearance angle
Rake angle
Angle of inclination</td><td colspan="2">6 to 8°
6 to 12°
0°</td><td colspan="2">6 to 8°
6 to 12°
-4°</td><td colspan="2">6 to 8°
6 to 12°
-4°</td><td colspan="2">6 to 8°
6 to 12°
-4°</td></tr>
</table>

Turning with HSS

(parameters determined using Böhler S700 /1.3207 DIN)			
Depth of Cut (a_p) inches mm	0.02 0.5	0.12 3	0.24 6
Feed (f_z) i.p.r. mm/rev	0.004 0.1	0.016 0.4	0.032 0.8
Cutting Speed (v_c) Indexable Carbide Inserts (edge life 15 min) f.p.m. m/min	65 to 100 20 to 30	50 to 65 15 to 20	33 to 60 10 to 18
Rake angle Clearance angle Angle of inclination	14° 8° -4°	14° 8° -4°	14° 8° -4°

MILLING

Milling with Carbide Tipped Cutters

Feed (f_z)	inch/tooth up to 0.008	mm/tooth up to 0.2	inch/tooth 0.008 to 0.016	mm/tooth 0.2 to 0.4
Cutting Speed (v_c) ISO P25 ISO P40 ISO P35	f.p.m. 330 to 490 200 to 330 280 to 425	m/min 100 to 150 60 to 100 85 to 130	f.p.m. 200 to 360 130 to 230 --	m/min 60 to 110 40 to 70 --

DRILLING

Drilling with Carbide Tipped Tools

Drill Diameter	0.12 to 0.31 inches	3 to 8 mm	0.31 to 0.79 inches	8 to 20 mm	0.79 to 1.57 inches	20 to 40 mm
Feed (f_z)	0.0008 to 0.002 inches	0.02 to 0.05 mm/rev	0.002 to 0.005 inches	0.05 to 0.12 mm/rev	0.005 to 0.007 inches	0.12 to 0.18 mm/rev
ISO - grade	K10		K10		K10	
Cutting Speed (v_c)	115 to 165 f.p.m	35 to 50 m/min	115 to 165 f.p.m.	35 to 50 m/min	115 to 165 f.p.m	35 to 50 m/min
Top angle	115 to 120°		115 to 120°		115 to 120°	
Clearance Angle	5°		5°		5°	

Electrical-discharge machining–EDM

If EDM is performed in the hardened and tempered condition, the tool should then be given stress temper at a temperature that is at least 50°F (25°C) below the lowest tempering temperature.

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