BÖHLER UDDEHOLM

MATERIALIZING VISIONS

Bohler-Uddeholm D2

COLD WORK TOOL STEEL

General

Bohler-Uddeholm D2 is a high-carbon, high-chromium tool steel alloyed with molybdenum and vanadium characterized by:

- High abrasive wear resistance
- High compressive strength
- Good through-hardening properties
- High stability in hardening
- Good resistance to tempering-back

Typical analysis %	C 1.55	Si 0.3	Mn 0.4	Cr 11.3	Mo 0.8	V 0.8
Standard specification	AISI D2, W.-Nr. 1.2379					
Delivery condition	Soft annealed to approx. 210 HB					
Color code	Yellow/White					

This grade has been manufactured to our internal specification guidelines.

Applications

Bohler-Uddeholm D2 is recommended for tools requiring very high abrasive wear resistance, combined with moderate toughness (shock-resistance). Bohler-Uddeholm D2 can be supplied in various finishes, including the hot-rolled, pre-machined and fine machined condition.

CUTTING

	Material thickness mm	Hardness HRC	
		<180 HRC	>180 HRC
Tools for: Blanking, punching, piercing, cropping, shearing, trimming, clipping	up to 1/8” (3 mm) 1/8”–1/4” (3–6 mm)	60–62 58–60	58–60 54–56
Short, cold shears. Shredding knives for waste plastics. Granulator knives			56–60
Circular shears			58–60
Clipping, trimming tools for forgings		Hot	58–60
		Cold	56–58
Wood milling cutters, reamers, broaches			58–60

FORMING

	Hardness HRC
Tools for: Bending, forming, deep-drawing, rim-rolling, spinning and flow-forming	56–62
Coining dies	56–60
Cold extrusion dies, punches	58–60
Tube- and section forming rolls; plain rolls	56–60
Dies for molding of: Ceramics, bricks, tiles, grinding wheels, tablets, abrasive plastics	58–62
Thread-rolling dies	58–62
Cold-heading tools	56–60
Crushing hammers	56–60
Swaging tools	56–60
Gauges, measuring tools, guide rails, bushes, sleeves, knurling tools, sandblast nozzles	58–62

Properties

PHYSICAL DATA

Hardened and tempered to 62 HRC. Data at room temperature and elevated temperatures.

Temperature	68°F (20°C)	390°F (200°C)	750°F (400°C)
Density lbs/in³ kg/m³	 0.277 7,700	 0.276 7,650	 0.275 7,600
Modulus of elasticity ksi MPa	 30,450 210,000	 29,000 200,000	 26,100 180,000
Coefficient of thermal expansion low temperature tempering per °F from 68°F per °C from 20°C	 – –	 6.8×10^{-6} 12.3×10^{-6}	 – –
high temperature tempering per °F from 68°F per °C from 20°C	 – –	 6.2×10^{-6} 11.2×10^{-6}	 6.7×10^{-6} 12×10^{-6}
Thermal conductivity Btu in/(ft²h°F) W/m °C	 139 20.0	 146 21.00	 159 23.00
Specific heat Btu/lb °F J/kg °C	 0.11 460	 – –	 – –

COMPRESSIVE STRENGTH

Approximate values.

Hardness	Compressive yield strength, $Rc_{0.2}$	
	MPa	ksi
62 HRC	2,200	319
60 HRC	2,150	312
55 HRC	1,900	276
50 HRC	1,650	239

Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 1560°F (850°C). Then cool in the furnace at 20°F (10°C) per hour to 1200°F (650°C), then freely in air.

STRESS RELIEVING

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

HARDENING

Preheating temperature: 1110–1290°F (650–750°C). Austenitizing temperature: 1810–1920°F (990– 1050°C), but usually 1830–1905°F (1000–1040°C).

Temperature		Soaking* time min.	Hardness before tempering
°F	°C		
1,815	990	60	approx. 63 HRC
1,850	1010	45	approx. 64 HRC
1,885	1030	30	approx. 65 HRC

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

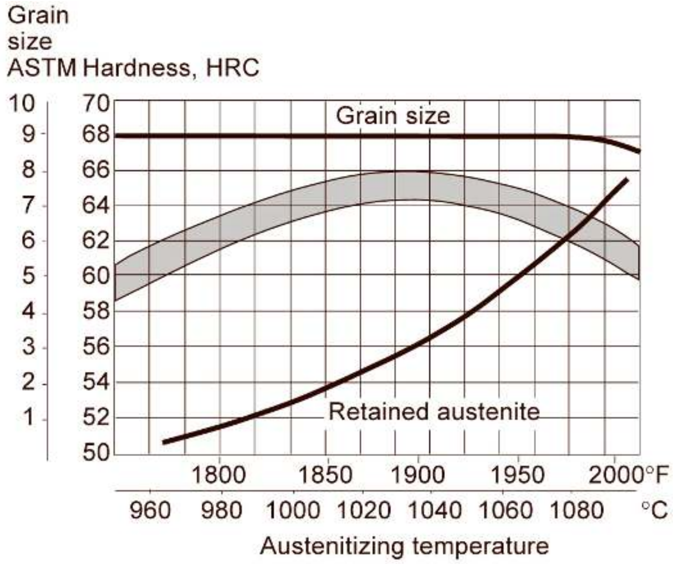
Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

- Oil (Only very simple geometries)
- Vacuum (high speed gas)
- Forced air/gas
- Martempering bath or fluidized bed at 360– 930°F (180–500°C), then cooling in air.

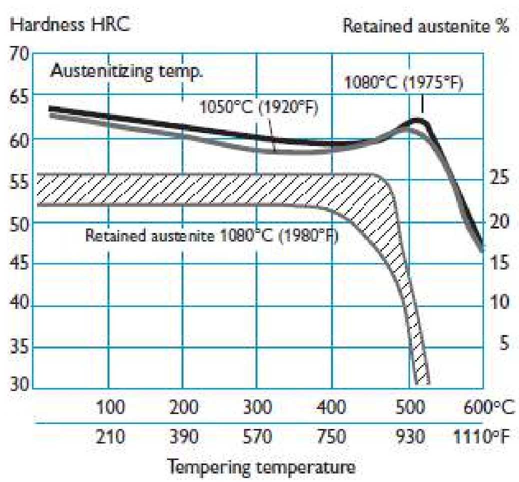
Note: Temper the tool as soon as its temperature reaches 120–160°F (50–70°C). Bohler-Uddeholm D2 typically hardens through in most standard sizes.

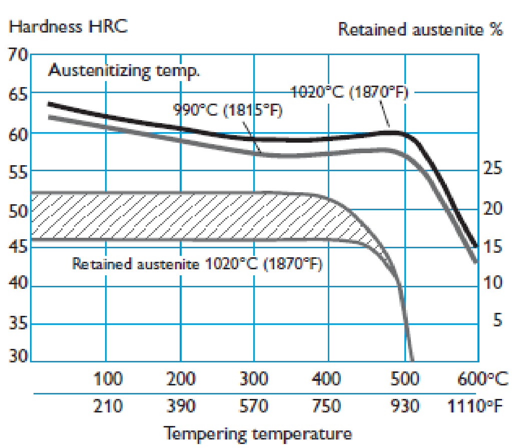
Hardness as a function of austenitizing temperature



TEMPERING

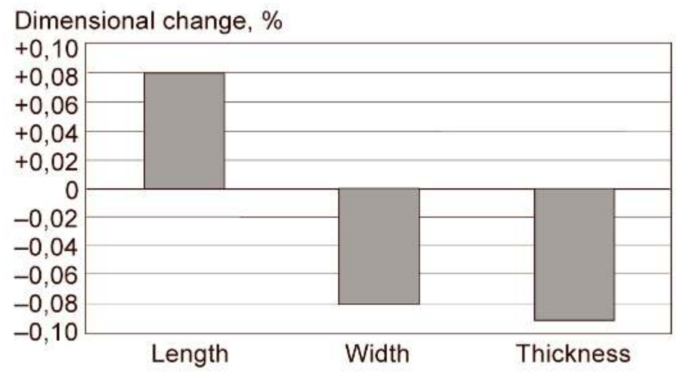
Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with intermediate cooling to room temperature. Lowest tempering temperature 360°F (250°C). Holding time at temperature minimum 2 hours.



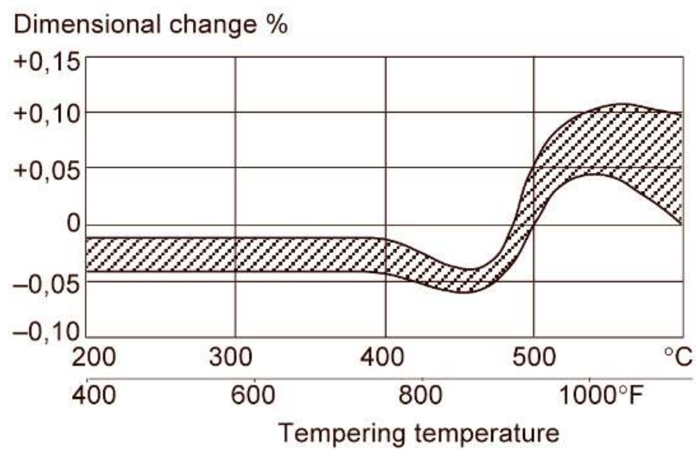


DIMENSIONAL CHANGES DURING HARDENING

Heat treatment: Austenitizing temperature 1870°F (1020°C), 30 minutes, cooling in vacuum equipment with 2 bar nitrogen overpressure.



DIMENSIONAL CHANGES DURING TEMPERING



Note: The dimensional changes on hardening and tempering should be added together. The minimum recommended machining allowance is 0.15% per side assuming that stress relief is performed between rough and semifinish machining, as recommended. If not, machining allowances must be increased accordingly.

SUB-ZERO TREATMENT

Pieces requiring maximum dimensional stability should be sub-zero treated, as volume changes may occur over the course of time. This applies, for example, to measuring tools such as gauges and certain structural components.

Immediately after quenching, the piece should be sub-zero treated to between –95 to –110°F (–70 and –80°C) soaking time 3–4 hours followed by tempering. Sub-zero treatment will give a hardness increase of 1–3 HRC. Avoid intricate shapes as there will be risk of cracking

NITRIDING

Nitriding will give a hard surface layer which is very resistant to wear and erosion, and also increases corrosion resistance. A temperature of 975°F (525°C) gives a surface hardness of approx. 1250 HV1.

Nitriding temperature		Nitriding time	Depth of case, approx.	
°F	°C	hours	in.	mm
975	525	20	0.010	0.25
975	525	30	0.012	0.30
975	525	60	0.014	0.35

Nitrocarburizing at 1060°F (570°C) for 2 hours gives a surface hardness of approx. 950 HV1. The corresponding case depth will be 0.0004”–0.0008” (10–20 μm).

Machining

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

TURNING

Cutting data parameters	Turning with carbide		Turning with high speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) f.p.m. m/min	328–492 100–150	492–200 150–200	40–50 12–15
Feed (f) i.p.r. mm/r	0.008–0.016 0.2–0.4	0.002–0.008 0.05–0.2	0.002–0.012 0.05–0.3
Depth of cut (a_p) inch mm	0.08–0.20 2–6	–0.08 –2	–0.08 –2
Carbide designation US ISO	C2 K15–K20*	C2 K15–K20*	– –

* Use a wear resistant Al_2O_3 coated carbide grade, for example Sandvik Coromant GC 4015 or Seco TP100.

MILLING

Face and square shoulder milling

Cutting data parameters	Milling with carbide		Milling with high speed steel Fine milling
	Rough milling	Fine milling	
Cutting speed (v_c) f.p.m. m/min	330-400 100–120	655–785 200–240	45 14
Feed (f_z) inch/tooth mm/tooth	0.008–0.016 0.2–0.4	0.004–0.008 0.1–0.2	0.004 0.1
Depth of cut (a_p) inch mm	0.08–0.2 2–5	–0.08 –2	–0.08 –2
Carbide designation US ISO	C2 K15*	C2 K15*	

* Use a wear resistant Al_2O_3 coated carbide grade, for example Sandvik Coromant GC 3015 or Seco T15M.

End milling

Cutting data parameters	Type of milling		
	Solide carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) f.p.m. m/min	230–328 70–100	262–360 80–130	40[1)] 12–17[1)]
Feed (f_z) inch/tooth mm/tooth	0.001–0.008[2)] 0.03–0.20[2)]	0.003–0.008[2)] 0.08–0.20[2)]	0.002–0.014[2)] 0.05–0.35[2)]
Carbide designation US ISO	C2 K20	C2 K15-K20[3)]	– –

1) For coated HSS end mill vc ≈ 56 f.p.m. (17 m/min.)
2) Depending on radial depth of cut and cutter diameter.
3) Use a Al_2O_3 coated carbide grade.

DRILLING

High speed steel twist drill

Drill diameter		Cutting speed (v_c)		Feed (f)	
inch	mm	f.p.m.	m/min	i.p.r.	mm/r
–3/16	– 5	30*	10*	0.002–0.006	0.05–0.15
3/16–3/8	5–10	30*	10*	0.006–0.008	0.15–0.20
3/8–5/8	10–15	30*	10*	0.008–0.010	0.20–0.25
5/8–3/4	15–20	30*	10*	0.010–0.014	0.25–0.35

* For coated HSS drill vc 59-66 f.p.m. (12 m/min.)

Carbide drill

Cutting data parameters	Type of drill		
	Indexable index	Solid carbide	Brazed carbide1)
Cutting speed (v_c) f.p.m. m/min	 426–495 130–150	 230–295 70–90	 115–148 35–45
Feed (f) i.p.r. mm/r	 0.002–0.012) 0.05–0.252)	 0.004–0.013) 0.10–0.253)	 0.006–0.014) 0.15–0.254)

1) Drill with internal cooling channels and brazed carbide tip.
2) Feed rate for drill diameter 0.8”–1.6” (20–40 mm)
3) Feed rate for drill diameter 0.2”–0.8” (5–20 mm)
4) Feed rate for drill diameter 0.4”–0.8” (10–20 mm)

GRINDING

General grinding wheel recommendations for Bohler-Uddeholm D2 is given below.

Wheel selection

Type of grinding	Wheel recommendation	
	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	B151 R75 B31) 3SG 46 HVS2)
Face grinding segments	A 24 GV	3SG 36 HVS2) A 36 G V
Cylindrical grinding	A 46 KV	B126 R75 B31) 3SG 60 KVS2) A 60 KV
Internal grinding	A 46 JV	B126 R75 B31) 3SG 60 JVS2) A 60 HV
Profile grinding	A 100 LV	B126 R100 B61) 5SG 80 KVS2) A 120 JV

Electrical-discharge machining–EDM

If EDM is performed in the hardened and tempered condition, the hard brittle white layer must be completely removed through stoning and polishing operations and the tool should then be given an additional temper at appr. 50°F (25°C) below the highest tempering temperature used during the heat treatment process.

Welding

Good results when welding tool steel can be achieved if proper precautions are taken during welding (i.e., elevated working temperature, joint preparation, choice of consumables and welding procedure). If the tool is to be polished or textured, it is necessary to work with an electrode type of matching composition.

Welding method	Working temperature	Consumables	Hardness after welding
MMA (SMAW)	390–480°F 200–250°C	Inconel 625-type UTP 67S Castolin EutecTrode 2 Castolin EutecTrode 6	280 HB 55–58 HRC 56-60 HRC 59-61 HRC
TIG (GTAW)	390–480°F 200–250°C	Inconel 625-type UTPA 73G2 UTPA 67S UTPA 696 CastoTig 45303W	280 HB 53–56 HRC 55–58 HRC 60–64 HRC 60-64 HRC

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