BÖHLER UDDEHOLM

MATERIALIZING VISIONS

Bohler-Uddeholm A2

COLD WORK TOOL STEEL

General

Bohler-Uddeholm A2 is an air or oil hardening chromium-molybdenum-vanadium alloyed tool steel characterized by:

- Good machinability
- High stability after hardening
- High compressive strength
- Good hardenability
- Good wear resistance

Typical analysis %	C 1.0	Si 0.3	Mn 0.6	Cr 5.3	Mo 1.1	V 0.2
Standard specification	AISI A2, BA2, W.-Nr. 1.2363					
Delivery condition	Soft annealed to approx. 215 HB					
Color code	Red/green					

This grade has been manufactured to our internal specifications, and audited to meet our guidelines.

Applications

Bohler-Uddeholm A2 takes a place in the tool steel range between AISI O1 and AISI D2, offering an excellent combination of good wear resistance and toughness. It may be regarded, therefore, as a "universal" cold work steel. For cutting operations the Bohler-Uddeholm A2 provides good resistance to chipping of the cutting edge. In many cases tools made from this steel have shown better tooling economy than high-carbon, high-chromium steels of the D3/ W.-Nr. 2080 type. In addition, Bohler-Uddeholm A2 has much better machining and grinding properties.

CUTTING

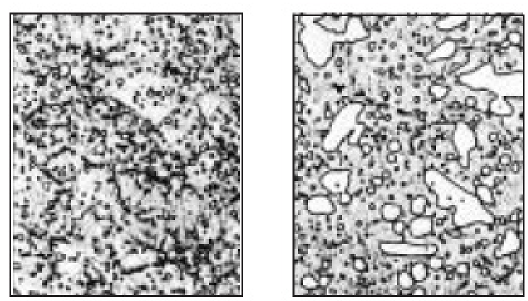
	Material thickness mm	Hardness HRC
Tools for: Blanking, punching, piercing, cropping, shearing, trimming, clipping	up to 1/8" (3 mm) 1/8-1/4" (3-6 mm) 1/4-13/32" (6-10 mm)	60-62 56-60 54-56
Short cold shears and Rotary shear blades for plastic waste		56-60
Trimming tools for forgings	Hot Cold	58-60 56-58

FORMING

	Hardness HRC
Tools for: Bending, forming, deep-drawing, rim-rolling, spinning and flow-turning	56-62
Coining dies	56-60
Tube- and section forming rolls	58-62
Master hobs for cold hobbing	58-60
Swaging blocks	56-60
Gauges, measuring tools, guide rails bushings, sleeves	58-62
Dies and inserts for molding tablets, abrasive plastics	58-62

Availability

Bohler-Uddeholm A2 can be supplied in various conditions, including hot-rolled, pre-machined and fine-machined. It is also available in the form of hollow bar and rings.



Comparison of fine-grained Bohler-Uddeholm A2 with high-carbon, high-chromium steel of the D3/W.-Nr. 2080 type.

Properties

PHYSICAL DATA

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

Temperature	68°F (20°C)	375°F (200°C)	750°F (400°C)
Density lbs/in³ kg/m³	0.279 7,750	0.277 7,700	0.275 7,650
Modulus of elasticity psi N/mm²	27.5 x 10^6 190,000	26.9 x 10^6 185,000	24.6 x 10^6 170,000
Coefficient of thermal expansion per °F from 68°F per °C from 20°C	– –	6.5 x 10^{-6} 11.6 x 10^{-6}	– –
Thermal conductivity Btu in/(ft²h°F) W/m °C	181 26.0	188 27.0	199 28.5
Specific heat Btu/lb °F J/kg °C	0.11 460	– –	– –

COMPRESSIVE STRENGTH

Approximate values.

Hardness	Compressive yield strength, $Rc_{0.2}$	
	N/mm²	ksi
62 HRC	2,200	319
60 HRC	2,150	312
55 HRC	1,800	261
50 HRC	1,350	196

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: 1200–1380°F (650-750°C). Austenitizing temperature: 1700 –1780°F (925–970°C), but usually 1720–1760°F (940–960°C).

Temperature °F	Temperature °C	Soaking* time min.	Hardness before tempering
1,700	925	40	approx. 63 HRC
1,740	950	30	approx. 64 HRC
1,780	970	20	approx. 64 HRC

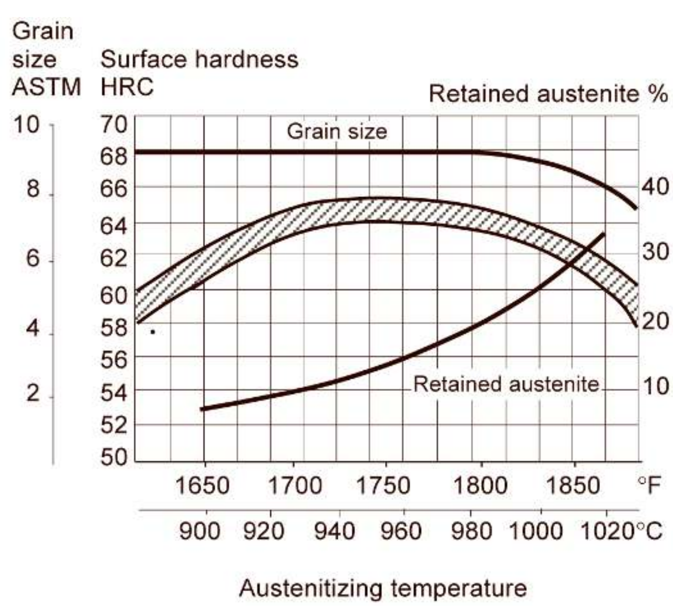
* Soaking time = time at hardening temperature after the tool is fully heated through.

Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

- Martempering bath or fluidized bed at 360–430°F (180–220°C) or 840–1020°F (450–550°C) then cool in air
- Circulating air or atmosphere
- Vacuum furnace with overpressure of gas at cooling
- Oil (only for small and uncomplicated tools).

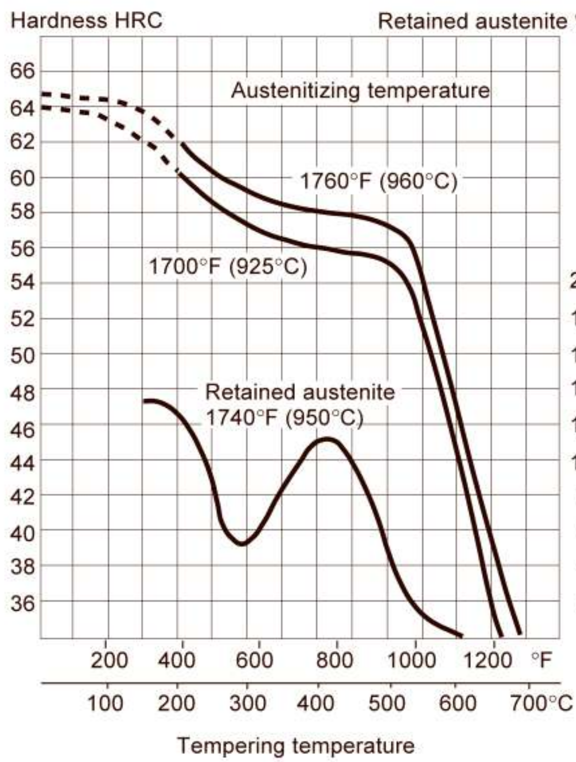
Hardness as a function of hardening temperature



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 recommended tempering temperature 480°F (250°C). Holding time at temperature minimum 2 hours.

The tempering graphs are valid for small samples. The hardness received is also dependent on the tool size samples.

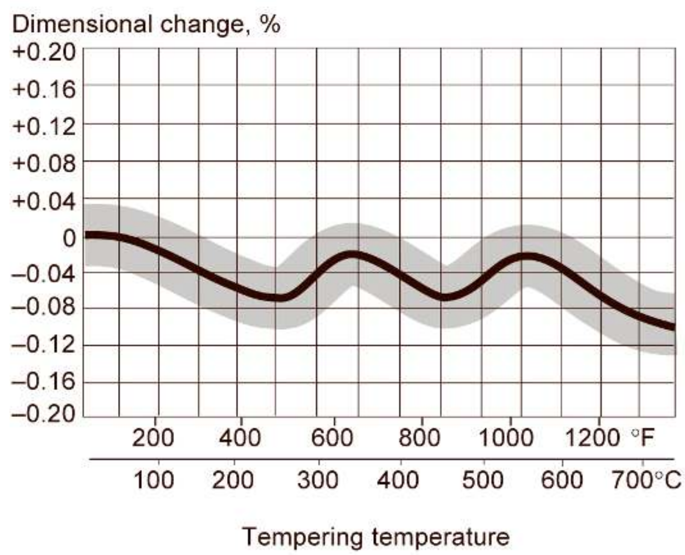


DIMENSIONAL CHANGES DURING HARDENING

Sample plate, 4” x 4” x 1”, 100 x 100 x 25 mm.

	Width %	Length %	Thickness %
Oil hardening from 1760°F (960°C) min.	-0.10	-0.02	±0
max.	-0.05	+0.06	-0.05
Martempering from 1760°F (960°C) min.	+0.04	+0.06	±0
max.	+0.05	+0.08	+0.04
Air hardening from 1760°F (960°C) min.	+0.08	+0.13	±0
max.	+0.14	+0.15	+0.04

DIMENSIONAL CHANGES DURING TEMPERING



SUB-ZERO TREATMENT

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

Sub-zero treatment

Immediately after quenching, the piece should be cooled to sub-zero temperatures between –40 and –110°F (–40 and –80°C) followed by tempering. Sub-zero cooling for 2–3 hours will provide a hardness increase of 1–3 HRC. Avoid intricate shapes as there is a risk of cracking. Alternatively, sub-zero treatment can be done between first and second tempers. This will have less effect, but safer with respect to risk cracking.

NITRIDING

Nitriding will create a hard, diffused surface layer which is very resistant to wear and erosion, and also increases corrosion resistance. Nitriding in ammonia gas at a temperature of 975°F (525°C) gives a surface hardness of approx. 1000 HV1.

Nitriding temperature		Nitriding time	Depth of case, approx.	
°F	°C	hours	in.	mm
980	525	20	0.008	0.2
980	525	30	0.012	0.3
980	525	60	0.016	0.4

Two hours nitrocarburizing treatment at 1060°F (570°C) gives a surface hardness of approx. 900 HV1. The case depth at this hardness level will be 0.0004–0.0008” (10–20 µm).

Machining

The cutting data below, valid for Bohler-Uddeholm A2 in soft annealed condition, 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	360-525 110-160	525-690 160-210	60-75 18-23
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	0.08-0.16 2-4	0.02-0.08 0.5-2	0.02-0.08 0.5-2
Carbide designation US ISO	C6-C5 P20-P30 Coated carbide	C7 P10 Coated carbide or cermet	– –

MILLING

Face and square shoulder milling

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) f.p.m. m/min	425-655 130-200	655-785 200-240
Feed (f_z) inch/tooth mm/tooth	0.008-0.016 0.2-0.4	0.004-0.008 0.1-0.2
Depth of cut (a_p) inch mm	0.08-0.16 2-4	-0.08 -2
Carbide designation US ISO	C6-C5 P20-P40 Coated carbide	C7-C6 P10-P20 Coated carbide or cermet

End milling

Cutting data parameters	Type of milling		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) f.p.m. m/min	260-395 80-120	395-560 120-170	50-65[1)] 15-20[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	– –	C6–C5 P20–P40	– –

1)For coated HSS end mill v_c ~80 f.p.m. (24 m/min.)
2)Depending on radial depth of cut and cutter diameter.

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	45-50*	14-16*	0.003-0.008	0.08-0.20
3/16-3/8	5-10	45-50*	14-16*	0.008-0.012	0.20-0.30
3/8-5/8	10-15	45-50*	14-16*	0.012-0.014	0.30-0.35
5/8-3/4	15-20	45-50*	14-16*	0.014-0.016	0.35-0.40

*)For coated HSS drill v_c 80-85 f.p.m. (24-26 m/min.)

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1)]
Cutting speed (v_c) f.p.m. m/min	490-560 150-170	260-330 80-100	165-195 50-60
Feed (f) i.p.r. mm/r	0.002-0.01[2)] 0.05-0.25[2)]	0.004-0.01[2)] 0.10-0.25[2)]	0.006-0.01[2)] 0.15-0.25[2)]

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

GRINDING

General grinding wheel recommendations for Bohler-Uddeholm A2 is given below.

Wheel selection

Type of grinding	Wheel recommendation	
	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
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 KV	A 120 JV

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.

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	AWS E312 ESAB OK 84.52 UTP 67S Castolin EutecTrode 2 Castolin EutecTrode N102	300 HB 53-54 HRC 55-58 HRC 54-60 HRC 54-60 HRC
TIG (GTAW)	390-480°F 200-250°C	AWS ER312 UTPA 67S UTPA 73G2 Casto Tig 45303 W	300 HB 55–58 HRC 53–56 HRC 60-64 HRC

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