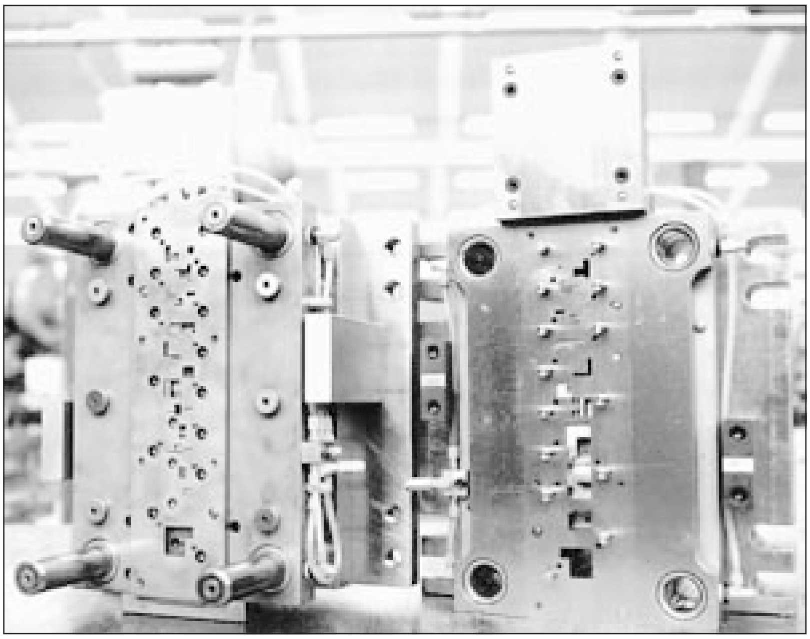


AISI A2
Cold work tool steel

UDDEHOLM
Great Tooling Starts Here!

General

AISI 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, W.-Nr. 1.2363					
Delivery condition	Soft annealed to approx. 215 HB					
Color code	Red/green					

Applications

AISI A2 takes a place in the Uddeholm 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 good toughness of *AISI A2* gives excellent resistance to chipping of the cutting edge. In many cases tools made from this steel have given better tooling economy than high-carbon, high-chromium steels of the D3/W.-Nr. 2080 type. *AISI A2* has much better machining and grinding properties.

CUTTING

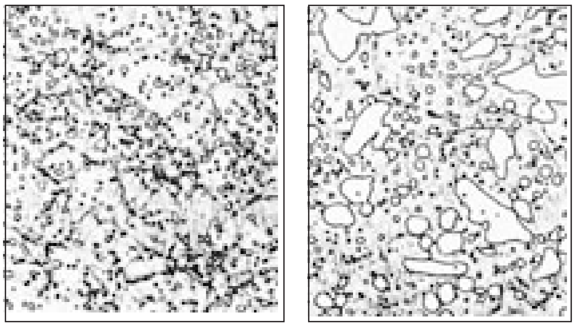
	Material thickness mm	Hardness HRC
Tools for: Blanking, punching, piercing, cropping, shearing, trimming, clipping	up to 1/8" (3 mm) 1/8–1/4" (3–6 mm) 1/4–13/32" (6–10 mm)	60–62 56–60 54–56
Short cold shears Rotary shear blades for plastic waste		56–60
Clipping, trimming tools for forgings	Hot Cold	58–60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

FORMING

	Hardness HRC
Tools for: Bending, raising, 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 bushes, sleeves	58–62
Dies and inserts for molding tablets, abrasive plastics	58–62

Availability

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



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

Properties

PHYSICAL DATA

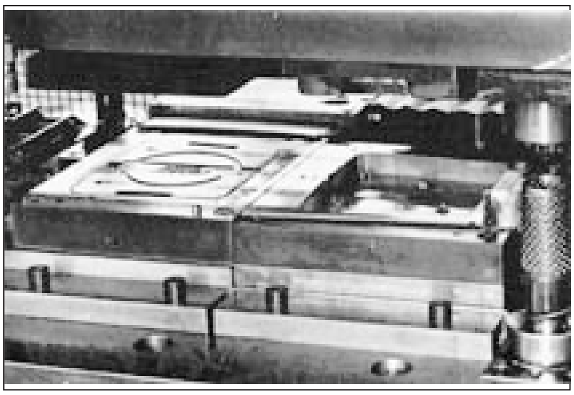
Hardened and tempered to 62 HRC. Data at room temperature and elevated temperatures.

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	 27.5×10^6 190 000	 26.9×10^6 185 000	 24.6×10^6 170 000
Coefficient of thermal expansion per °F from 68°F per °C from 20°C	 – –	 6.5×10^{-6} 11.6×10^{-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, Rc0.2 N/mm²	ksi
62 HRC	2200	319
60 HRC	2150	312
55 HRC	1800	261
50 HRC	1350	196



This tool was made from AISI A2. 3 million parts were manufactured before the tool was reground.

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	°C	Soaking* time min.	Hardness before tempering
1700	925	40	approx. 63 HRC
1740	950	30	approx. 64 HRC
1780	970	20	approx. 64 HRC

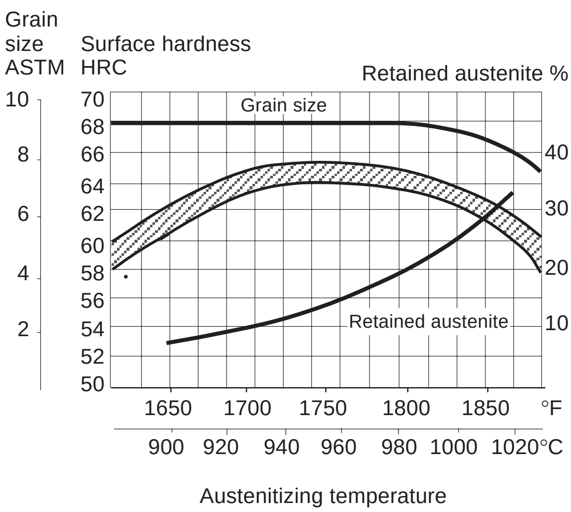
** Soaking time = time at hardening temperature after the tool is fully heated through.*

Protect the part against decarburization and oxidation during hardening.

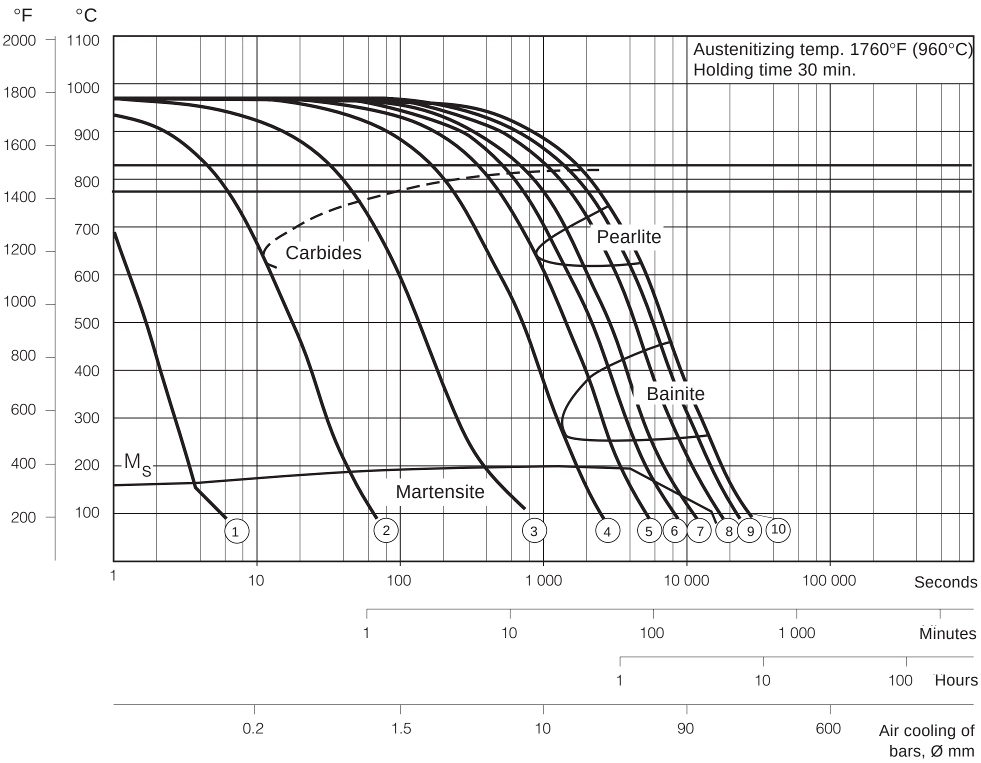
QUENCHING MEDIA

- 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.



CCT graph

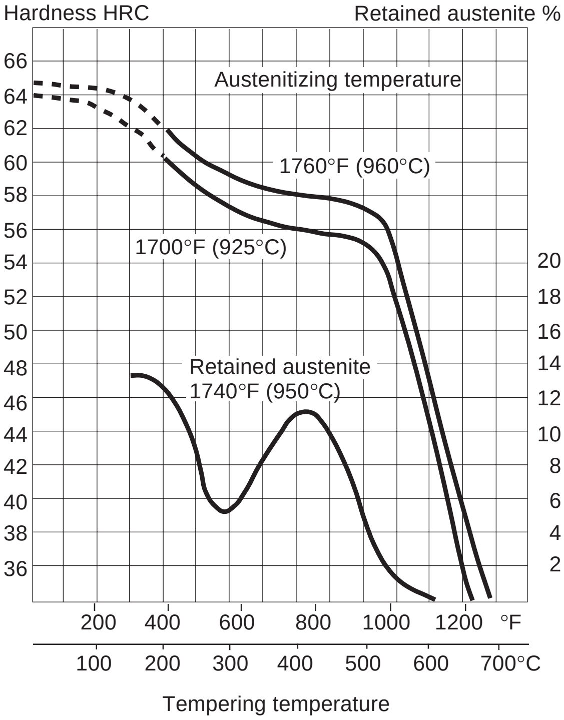


Cooling curve No.	Hardness HV 10	$T_{800-500}$ (sec.)
1	858	1
2	847	13
3	847	100
4	813	502
5	803	1071
6	698	1593
7	585	2138
8	514	3228
9	437	4292
10	387	5228

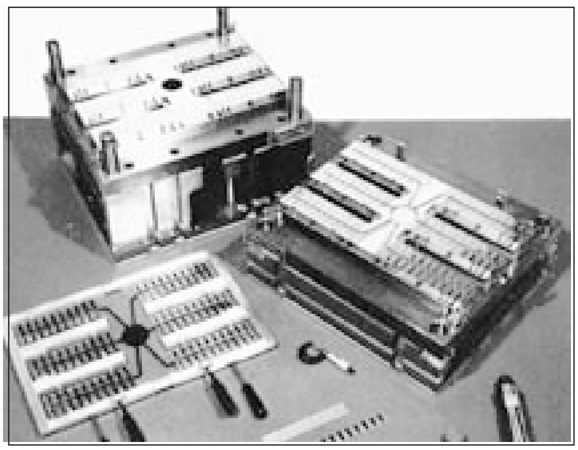
Note:
$T_{800-500}$ = cooling time between 1472–932°F (800–500°C)

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 (180°C). Holding time at temperature minimum 2 hours.



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



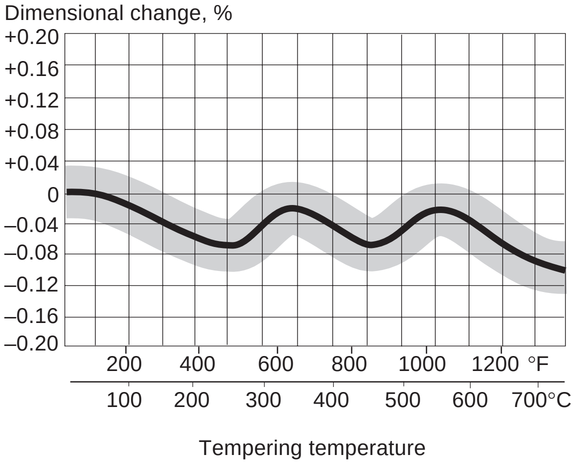
Transfer mold with AISI A2 inserts to produce encapsulated electronic components.

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. / max.	–0.10 –0.05	–0.02 +0.06	±0 –0.05
Martempering from 1760°F (960°C) min. / max.	+0.04 +0.05	+0.06 +0.08	±0 +0.04
Air hardening from 1760°F (960°C) min. / max.	+0.08 +0.14	+0.13 +0.15	±0 +0.04

DIMENSIONAL CHANGES DURING TEMPERING



Note: The dimensional changes on hardening and tempering should be added together.

SUB-ZERO TREATMENT AND AGING

Pieces requiring maximum dimensional stability should be sub-zero and/or artificially aged as volume changes may arise in the course of time. This applies, for example, to measuring tools like gauges and certain structural components.

Sub-zero treatment

Immediately after quenching, the piece should be sub-zero refrigerated to between –40 and –110°F (–40 and –80°C) followed by tempering or aging. Sub-zero refrigeration for 2–3 hours will give a hardness increase of 1–3 HRC. Avoid intricate shapes as there is a risk of cracking.

Aging

Tempering after quenching is replaced by aging at 230–285°F (110–140°C). Holding time 25–100 hours.

NITRIDING

Nitriding will give 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 HV_1.

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

2 hours nitrocarburizing treatment at 1060°F (570°C) gives a surface hardness of approx. 900 HV_1. The case depth having this hardness will be 0.0004–0.0008" (10–20 µm).

Machining

The cutting data below, valid for *AISI 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 Rough turning	Turning with carbide Fine turning	Turning with high speed steel Fine turning
Cutting speed (v_c) f.p.m.	335–500	500–665	65
m/min	100–150	150–200	20
Feed(f) i.p.r.	0.01–0.024	–0.01	–0.01
mm/r	0.3–0.6	–0.3	–0.3
Depth of cut (a_p) inch	0.08–0.24	–0.08	–0.08
mm	2–6	–2	–2
Carbide designation US	C6–C5	C7	–
ISO	P20–P30	P10	–
	Coated carbide	Coated carbide or cermet	

MILLING

Face and square shoulder milling

Cutting data parameters	Milling with carbide Rough milling	Milling with carbide Fine milling	Milling with high speed steel Fine milling
Cutting speed (v_c) f.p.m.	365–465	465–600	60
m/min	110–140	140–180	18
Feed (f_z) inch/tooth	0.008–0.016	0.004–0.008	–0.004
mm/tooth	0.2–0.4	0.1–0.2	0.1
Depth of cut (a_p) inch	0.08–0.2	–0.08	–0.08
mm	2–5	–2	–2
Carbide designation US	C6–C5	C7–C6	
ISO	P20–P40	P10–P20	–
	Coated carbide	Coated carbide or cermet	

End milling

Cutting data parameters	Type of milling: Solide carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) f.p.m.	165	400–565	60[1]
m/min	50	120–170	18[1]
Feed (f_z) inch/tooth	0.001–0.008[2]	0.003–0.008[2]	0.002–0.014[2]
mm/tooth	0.03–0.20[2]	0.08–0.20[2]	0.05–0.35[2]
Carbide designation US	C2	C6–C5	–
ISO	K20	P20–P40	–

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

DRILLING

High speed steel twist drill

Drill diameter inch	Drill diameter mm	Cutting speed (v_c) f.p.m.	Cutting speed (v_c) m/min	Feed (f) i.p.r.	Feed (f) mm/r
–3/16	– 5	50*	15*	0.003–0.008	0.08–0.20
3/16–3/8	5–10	50*	15*	0.008–0.012	0.20–0.30
3/8–5/8	10–15	50*	15*	0.012–0.014	0.30–0.35
5/8–3/4	15–20	50*	15*	0.014–0.016	0.35–0.40

[1] *For coated HSS drill v_c ~70 f.p.m./min. (21 m/min.)*

Carbide drill

Cutting data parameters	Type of drill: Indexable insert	Solide carbide	Brazed carbide[1]
Cutting speed (v_c) f.p.m.	400–565	200	165
m/min	120–170	60	50
Feed (f) i.p.r.	0.002–0.01[2]	0.004–0.01[2]	0.006–0.01[2]
mm/r	0.05–0.25[2]	0.10–0.25[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 recommendation for *AISI A2* is given below. More information can be found in the Uddeholm brochure "Grinding of Tool Steel".

Wheel selection

Type of grinding	Wheel recommendation 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 JV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 LV	A 120 JV

Electrical-discharge machining–EDM

If EDM is performed in the hardened and tempered condition, the tool should then be given an additional temper at about 50°F (25°C) below the previous tempering temperature.

Welding

Good results when welding tool steel can be achieved if proper precautions are taken during welding (elevated working temperature, joint preparation, choice of consumables and welding procedure). If the tool is to be polished or photo-etched, 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 UTP 67S	300 HB 55–58 HRC
TIG	390–480°F (200–250°C)	AWS ER312 UTPA 67S UTPA 73G2	300 HB 55–58 HRC 53–56 HRC

Further information

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels, including the publication "Steels for Cold Work Tooling" (English edition).

Relative comparison of Uddeholm cold work tool steel

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS