AISI D2
Cold work tool steel

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General

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

- High 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 11.8	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					

Applications

AISI D2 is recommended for tools requiring very high wear resistance, combined with moderate toughness (shock-resistance).

AISI D2 can be supplied in various finishes, including the hot-rolled, pre-machined and fine machined condition.

Cutting	Material thickness	Material Hardness (HB) <180 HRC	Material Hardness (HB) >180 HRC
Tools for: Blanking, fine-blanking, punching, cropping, shearing, trimming, clipping	<1/8" (3 mm)	60–62	58–60
	1/8–1/4" (3–6 mm)	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	HRC
Tools for: Bending, forming, deep-drawing, rim-rolling, spinning and flow-forming	56–62
Coining dies	56–60
Cold extrusion dies,	58–60
punches	56–60
Tube- and section forming rolls; plain rolls	58–62
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 ambient temperature and elevated temperatures.

Temperature	68°F (20°C)	390°F (200°C)	750°F (400°C)
Density			
lbs/in^3	0.277	0.276	0.275
kg/m^3	7 700	7 650	7 600
Coefficient of thermal expansion			
– low temperature tempering			
per °F from 68°F	–	6.8×10^{-6}	–
per °C from 20°C	–	12.3×10^{-6}	–
– high temperature tempering			
per °F from 68°F	–	6.2×10^{-6}	6.7×10^{-6}
per °C from 20°C	–	11.2×10^{-6}	12×10^{-6}
Thermal conductivity			
Btu in/ft^2 h °F	139	146	159
W/m °C	20.0	21.0	23.0
Modulus of elasticity			
ksi	30 450	29 000	26 100
MPa	210 000	200 000	180 000
Specific heat			
Btu/lb°F	0.110	–	–
J/kg °C	460	–	–

COMPRESSIVE STRENGTH

The figures are to be considered as approximate.

Hardness HRC	Compressive yield strength, Rc0.2 ksi	Compressive yield strength, Rc0.2 MPa
62	319	2200
60	312	2150
55	276	1900
50	239	1650

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 °F	Temperature °C	Soaking* time minutes	Hardness before tempering
1815	990	60	approx. 63 HRC
1850	1010	45	approx. 64 HRC
1885	1030	30	approx. 65 HRC

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

Protect the part against decarburization and oxidation during hardening.

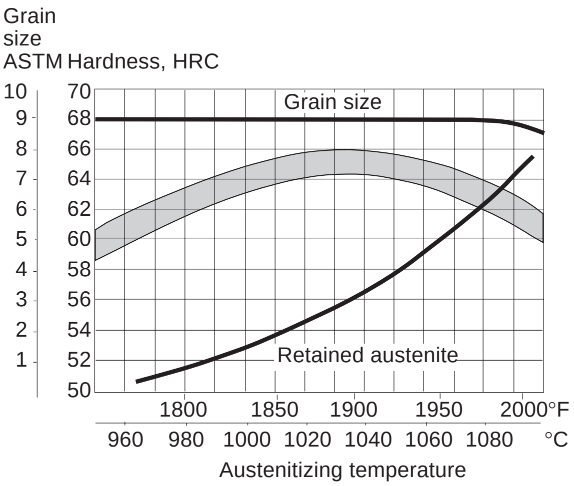
QUENCHING MEDIA

- 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).

AISI D2 hardens through in all standard sizes.

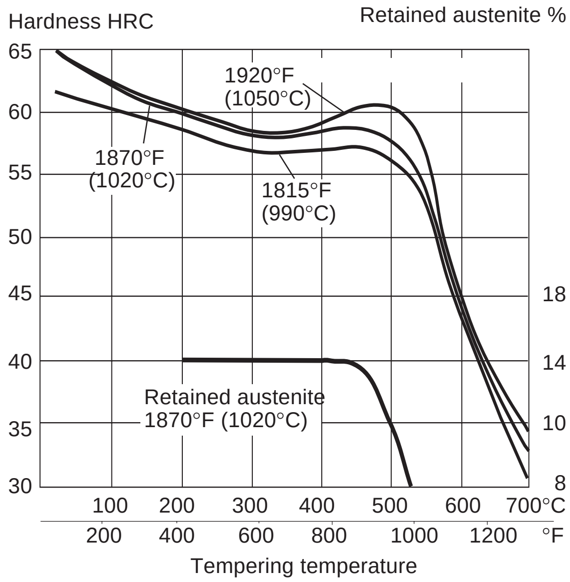
Hardness as a function of austenitizing temperature

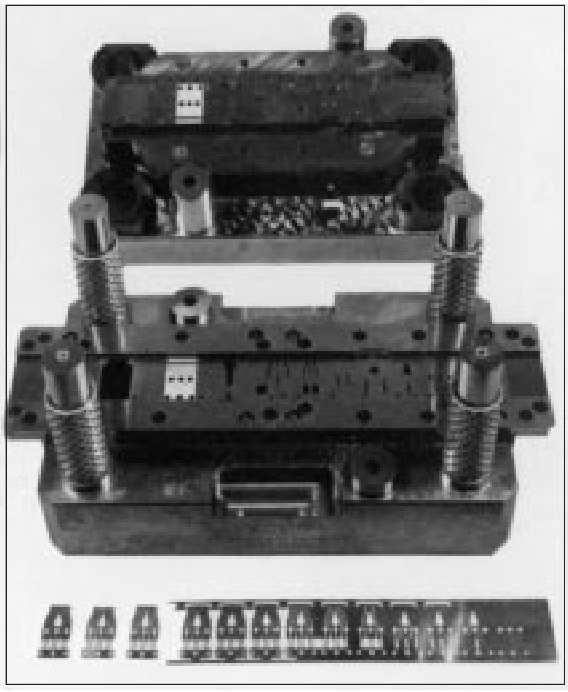


TEMPERING

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 (180° C). Holding time at temperature minimum 2 hours.
High temperature tempering at greater than 950° F (510° C) is recommended if dimensional stability of tooling is critical, if significant wire EDM operations are planned in the hardened state, or if tools are to be coated.

Tempering graph



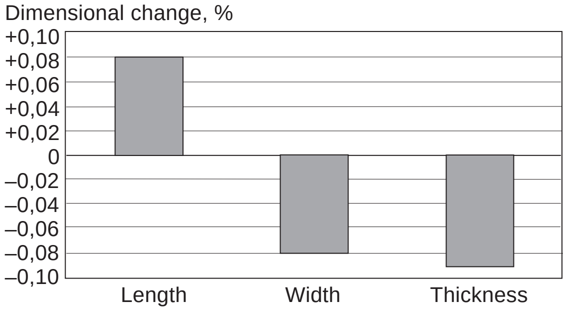


Progressive die made of AISI D2. Long run tooling for blanking of parts in thin sheets.

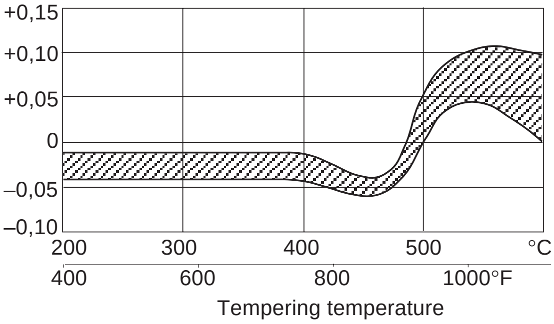
DIMENSIONAL CHANGES DURING HARDENING

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

Sample, 3.15" x 3.15" x 3.15" (80 x 80 x 80 mm).



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.

Sub-zero treatment must always be followed by a series of tempering operations.

NITRIDING AND NITROCARBURIZING

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 HV_1.

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 HV_1. 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.	230–360 70–110	360–500 110–150	50 15
Feed (f) i.p.r. / mm/r	0.012–0.023 0.3–0.6	–0.012 –0.3	–0.012 –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*	C2 K15*	– –

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

DRILLING

High speed steel twist drills

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	30*	10*	0.003–0.008	0.08–0.20
3/16–3/8	5–10	30*	10*	0.008–0.012	0.20–0.30
3/8–5/8	10–15	30*	10*	0.012–0.014	0.30–0.35
5/8–3/4	15–20	30*	10*	0.014–0.016	0.35–0.40

* For coated HSS drill v_c ~45 f.p.m. (14 m/min.)

Carbide drills

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1]
Cutting speed (v_c) f.p.m. / m/min.	400–560 120–170	115 45	145 35
Feed (f) i.p.r. / mm/r	0.002–0.010[2] 0.05–0.25[2]	0.004–0.010[2] 0.10–0.25[2]	0.006–0.010[2] 0.15–0.25[2]

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

MILLING

Face and square shoulder face milling

Cutting data parameters	Milling with carbide		Milling with high speed steel
	Rough milling	Fine milling	Fine milling
Cutting speed (v_c) f.p.m. / m/min.	330–400 100–120	400–460 120–140	45 14
Feed (f_z) in/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		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) f.p.m. / m/min.	80 25	260–430 80–130	40[1] 12[1]
Feed (f_z) in/tooth / mm/tooth	0.001–0.008[2] 0.03–0.2[2]	0.003–0.008[2] 0.08–0.2[2]	0.002–0.014[2] 0.05–0.35[2]
Carbide designation US / ISO	C2 K20	C2 K15[3]	– –

[1] For coated HSS end mill $v_c \approx$ 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.

GRINDING

General grinding wheel recommendation for *AISI D2* is given below. More information can be found in the Uddeholm publication "Grinding of Tool Steel".

Type of grinding	Wheel recommendation	
	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	B151 R75 B3[1] 3SG 46 HVS[2] A 46 GV
Face grinding segments	A 24 GV	3SG 36 HVS[2] A 36 G V
Cylindrical grinding	A 46 LV	B126 R75 B3[1] 3SG 60 KVS[2] A 60 IV
Internal grinding	A 46 JV	B126 R75 B3[1] 3SG 60 JVS[2] A 60 HV
Profile grinding	A 100 LV	B126 R100 B6[1] 5SG 80 KVS[2] A 120 JV

[1] If possible use CBN wheels for this application.
[2] Grinding wheel from Norton Co.

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)	390–485°F 200–250°C	Inconel 625-type UTP 67S	280 HB 55–58 HRC
TIG	390–485°F 200–250°C	Inconel 625-type UTPA 73G2 UTPA 67S UTPA 696	280 HB 53–56 HRC 55–58 HRC 60–64 HRC

Electrical-discharge machining

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 approx. 50°F (25°C) below the previous tempering temperature.

Further information can be obtained from the Uddeholm brochure “EDM of tool steel”.

Further information

Contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels, including the publications “Steels for Cold Work Tooling”.

Relative comparison of Uddeholm cold work tool steel

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS