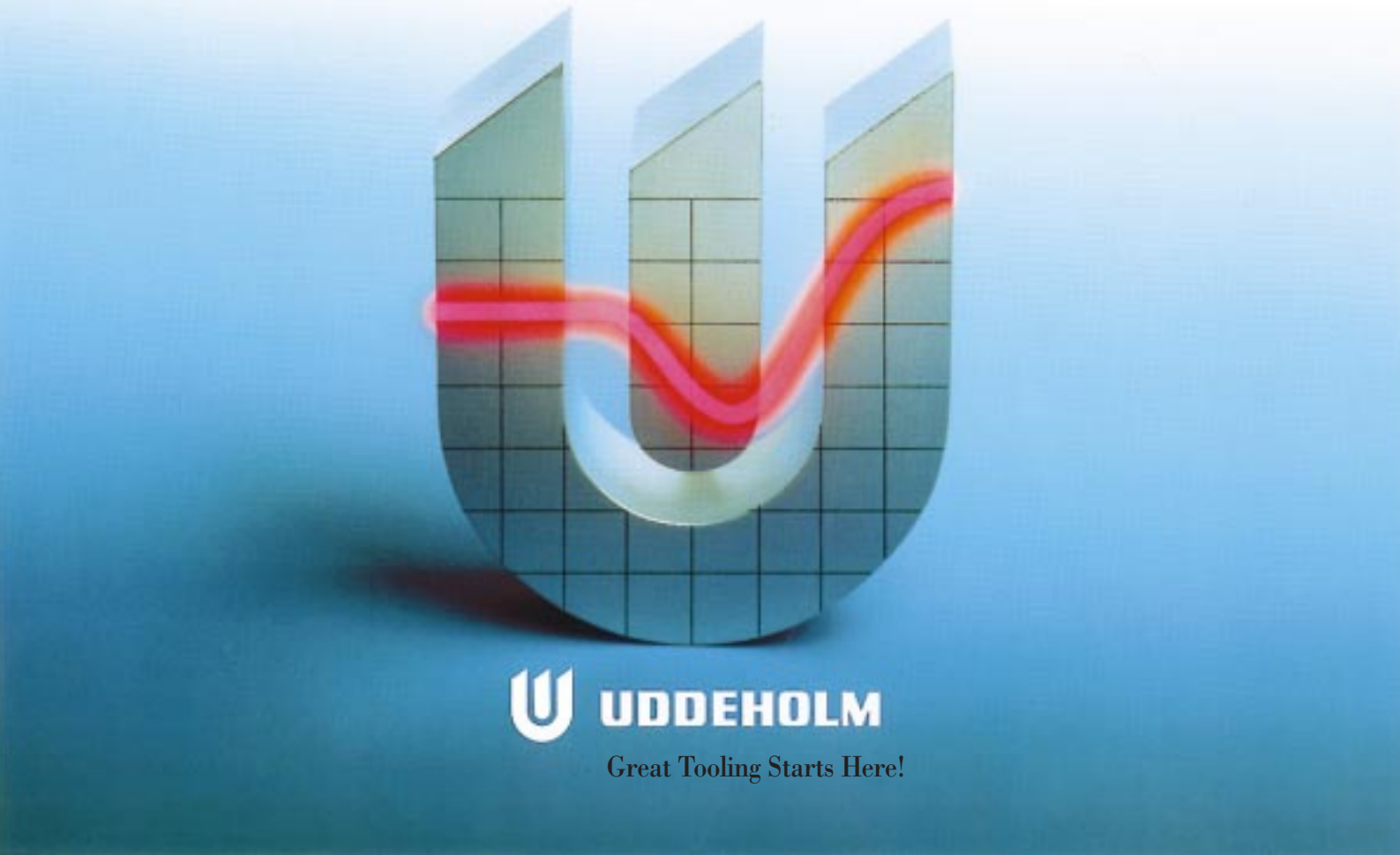
AISI O1
Cold work tool steel



General

AISI O1 general purpose oil-hardening tool steel is a versatile manganese-chromium-tungsten steel suitable for a wide variety of cold-work applications.

Its main characteristics include:

- Good machinability
- Good dimensional stability in hardening
- A good combination of high surface hardness and toughness after hardening and tempering.

These characteristics combine to give a steel suitable for the manufacture of tooling with good tool-life and production economy.

AISI O1 can be supplied in various finishes including hot-rolled, pre-machined, fine-machined and precision ground. It is also available in the form of hollow bar.

Typical analysis %	C 0.95	Mn 1.1	Cr 0.6	W 0.6
Standard specification	AISI O1, W.-Nr. 1.2510			
Delivery condition	Soft annealed approx. 190 HB			
Color code	Yellow			

Applications

Tools for	Material thickness	HRC
Cutting		
Blanking, punching	up to 1/8" (3 mm)	60–62
piercing, cropping,	1/8–1/4" (3–6 mm)	56–60
shearing, trimming	1/4–13/32" (6–10 mm)	54–56
clipping		
Short cold shears		54–60
Clipping and trimming tools for forgings	Hot	58–60
	Cold	56–58
Forming		
Bending, raising, drawing, rim rolling, spinning and flow forming		56–62
Small coining dies		56–60
Gauges, measuring tools		
Turning centres		
Guide bushes, ejector pins, high duty, small/medium drills and taps		
Small gear wheels, pistons, nozzles, cams		58–62

Properties

PHYSICAL DATA

Hardened and tempered to 62 HRC. Data at ambient temperature and elevated temperature.

Temperature	68°F (20°C)	375°F (200°C)	750°F (400°C)
Density			
lbs/in^3	0.282	0.280	0.278
kg/m^3	7 800	7 750	7 700
Modulus of elasticity			
psi	28 x 10^6	27 x 10^6	25 x 10^6
N/mm^2	190 000	185 000	170 000
Coefficient of thermal exp.			
per °F from 68°F	–	6.5 x 10^{-6}	6.3 x 10^{-6}
per °C from 20°C	–	11.7 x 10^{-6}	11.4 x 10^{-6}
Thermal conductivity			
Btu in/ft^2 h °F	222	229	236
W/m °C	32	33	34
Specific heat			
Btu/lb. °F	0.11	–	–
J/kg C	460	–	–

COMPRESSIVE STRENGTH

The figures are to be considered approximate.

	Compressive yield strenght, Rc0.2	
Hardness	N/mm^2	ksi
62 HRC	2200	319
60 HRC	2150	312
55 HRC	1800	261
50 HRC	1350	196

Clipping and edging tool in AISI O1 tool steel to clip and form edge of 0.036" (0.914 mm) thick stainless steel container approx. 10" x 6" x 8" (254 x 152 x 203 mm).

Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 1435° F (780° C). Then cool in the furnace at 27° F (15° 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 (600–700° C)
Austenitizing temperature: 1450–1560° F (790–850° C)

Temperature °F	Temperature °C	Soaking* time minutes	Hardness before tempering
1470	800	30	approx. 65 HRC
1520	825	20	approx. 65 HRC
1560	850	15	approx. 63 HRC

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

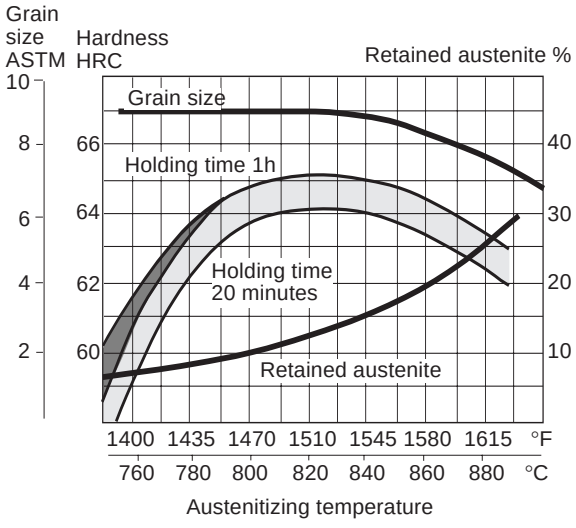
Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

- Oil
- Martempering bath. Temperature 360–435° F (180–225° C), then cooling in air.

Note: Temper the tool as soon as its temperature reaches 120–160° F (50–70° C).

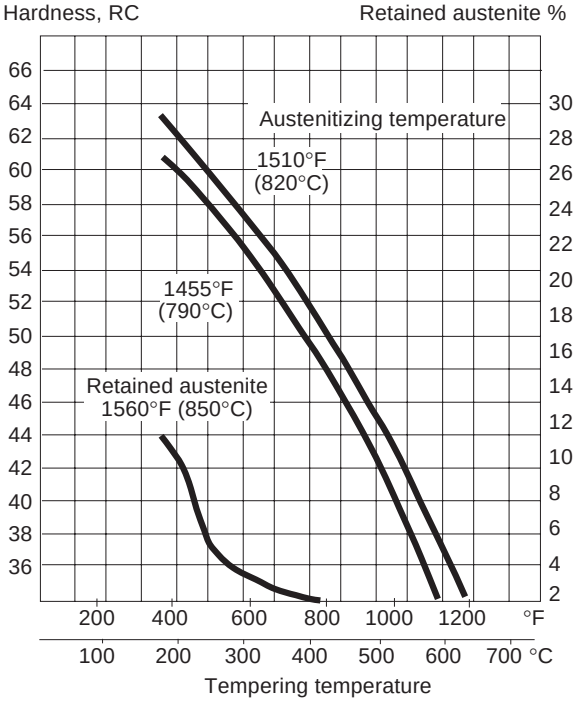
Hardness as a function of hardening temperature.



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 tempering temperature 360° F (180° C). Holding time at temperature minimum 2 hours.

Tempering graph



MARTEMPERING

Tools at austenitizing temperature are immersed in the martempering bath for the time indicated, then cooled in air to not lower than 210° F (100° C). Temper immediately as with oil-quenching.

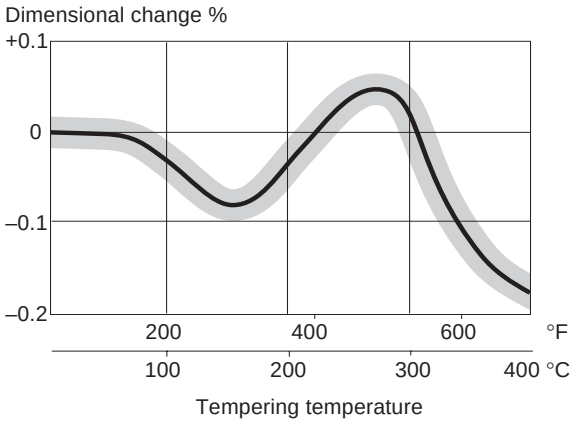
Austenitizing temperature °F	Austenitizing temperature °C	Temp. of martemp. bath °F	Temp. of martemp. bath °C	Holding time in martemp. bath, minutes	Surface hardness prior to tempering (obtained by martempering)
1520	825	435	225	max. 5	64±2 HRC
1520	825	390	200	max. 10	63±2 HRC
1520	825	355	180	max. 20	62±2 HRC
1560	850	435	225	max. 10	62±2 HRC

DIMENSIONAL CHANGES DURING HARDENING

Sample plate, 4" x 4" x 1" (100 x 100 x 25 mm).

	Width %	Length %	Thickness %
Oil hardening from 1530°F (830°C) min.	+0.03	+0.04	–
max.	+0.10	+0.10	+0.02
Martempering from 1530°F (830°C) min.	+0.04	+0.06	–
max.	+0.12	+0.12	+0.02

DIMENSIONAL CHANGES DURING TEMPERING



Note: The dimensional changes on hardening and tempering should be added together. Recommended allowance 0.25%.

SUB-ZERO TREATMENT AND AGING

Pieces requiring maximum dimensional stability should be sub-zero treated and/or artificially aged, as volume changes may occur 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 treated to between –95 to –110° F (–70 and –80° C), soaking time 3–4 hours, followed by tempering or aging. Sub-zero treatment will give a hardness increase of 1–3 HRC. Avoid intricate shapes as there will be risk of cracking.

Aging

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

Machining recommendations

The following tables give machining data for *AISI O1* in soft annealed condition. Hardness 190 HB. The data 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.	460–560	560–730	65
m/min	140–170	170–220	20
Feed (f) i.p.r.	0.012–0.023	–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 Coated carbide	P10 Coated carbide or cermet	–

MILLING

Face and square shoulder 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.	530–660	660–790	80
m/min	160–200	200–240	25
Feed (f_z) in/tooth	0.008–0.016	0.004–0.008	0.004
mm/tooth	0.2–0.4	0.10–0.20	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 Coated carbide	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.	165	400–560	80[1]
m/min	50	120–170	25[1]
Feed (f_z) in/tooth	0.001–0.008[2]	0.003–0.008[2]	0.002–0.014[2]
mm/tooth	0.03–0.2[2]	0.08–0.2[2]	0.05–0.35[2]
Carbide designation US	C2	C6–C5	–
ISO	K20, P40	P20–P30	–

1) *For coated end mills $v_c \approx 115$ f.p.m. (35 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*	16*	0.003–0.008	0.08–0.20
3/16–3/8	5–10	50*	16*	0.008–0.012	0.20–0.30
3/8–5/8	10–15	50*	16*	0.012–0.014	0.30–0.35
5/8–3/4	15–20	50*	16*	0.014–0.016	0.35–0.40

**) For coated HSS drills v_c ~70 f.p.m. (22 m/min.)*

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1]
Cutting speed (v_c) f.p.m.	400–530	200	180
m/min	120–160	60	55
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) *Drills with internal cooling channels and brazed carbide tip.*
2) *Depending on drill diameter.*

GRINDING

General grinding wheel recommendation for *AISI O1* 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 H V	A 46 G V
Face grinding segments	A 24 G V	A 36 G V
Cylindrical grinding	A 46 L V	A 60 J V
Internal grinding	A 46 J V	A 60 I V
Profile grinding	A 100 L V	A 120 J V

Electrical-discharge machining

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

Welding

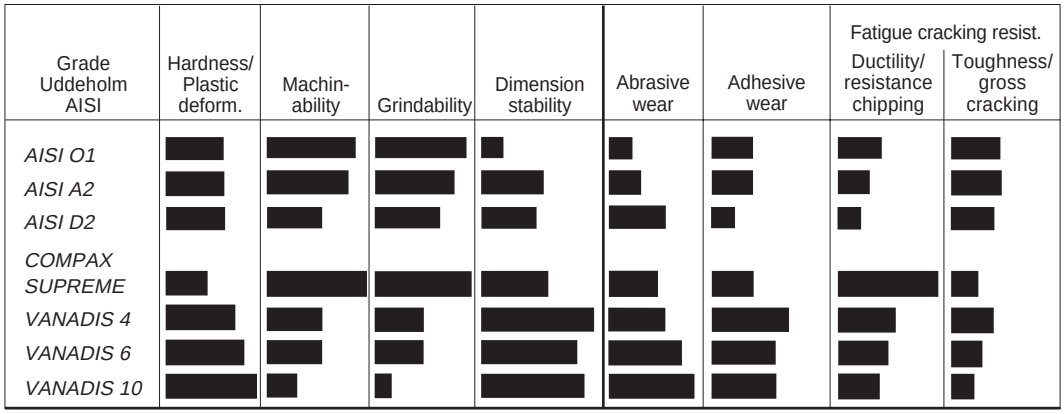
Good results when welding tool steel can be achieved if proper precautions are taken during welding (elevated working temperature, joint preparation, choice of consumables and welding procedure). If the tool is to be polished or photo-etched, it is necessary to work with an electrode type of matching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

Blanking tool made from fine-machined AISI O1 tool steel.

Relative comparison of Uddeholm cold work tool steel

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS



Further information

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels.