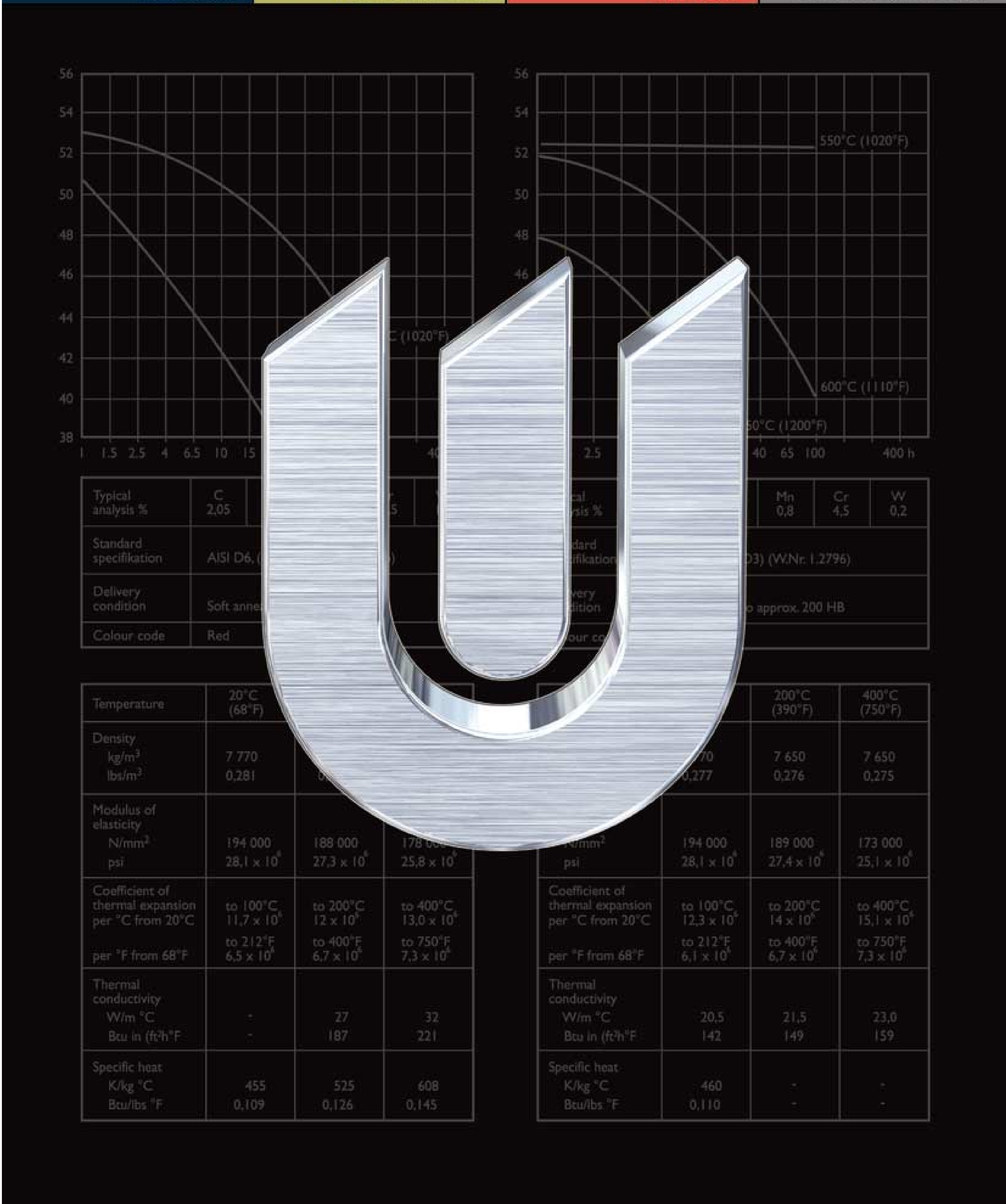
SLEIPNER

Cold work tool steel

COLD WORK | **PLASTIC** MOULDING | **HOT** WORK | **HIGH** PERFORMANCE STEEL



General

SLEIPNER is a chromium-molybdenum-vanadium alloyed tool steel which is characterised by:

- Good wear resistance
- Good chipping resistance
- High compressive strength
- High hardness (>60 HRC) after high temperature tempering
- Good through-hardening properties
- Good stability in hardening
- Good resistance to tempering back
- Good WEDM properties
- Good machinability and grindability
- Good surface treatment properties.

Typical analysis %	C	Si	Mn	Cr	Mo	V
	0,9	0,9	0,5	7,8	2,5	0,5
Standard spec.	None					
Delivery condition	Soft annealed to approx. 235 HB					
Colour code	Blue/brown					

Applications

SLEIPNER is a general purpose steel for cold work tooling. It has a mixed-abrasive wear profile and a good resistance to chipping. Furthermore a high hardness (>60 HRC) can be obtained after high temperature tempering. This means that surface treatments such as nitriding or PVD can be made on a high strength substrate. Also, it means that complicated shapes with hardness levels >60 HRC can be wire EDM'd from blocks with relatively thick cross-sections with a much reduced risk of cracking.

SLEIPNER is recommended for medium run tooling applications where a resistance to mixed or abrasive wear and a good resistance to chipping are required.

Examples:

- Blanking and fine blanking
- Shearing
- Forming
- Coining
- Cold forging
- Cold extrusion
- Thread rolling
- Drawing and deep drawing
- Powder pressing

Properties

PHYSICAL DATA

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

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density			
kg/m^3	7 730	7 680	7 620
lbs/in^3	0,279	0,277	0,275
Modulus of elasticity			
MPa	205 000	190 000	180 000
ksi	297 000	276 000	261 000
Coefficient of thermal expansion			
–after low temperature tempering (60 HRC)			
per °C from 20°C	–	$12,7 \times 10^{-6}$	–
per °F from 68°F	–	$7,1 \times 10^{-6}$	–
–after high temperature tempering			
per °C from 20°C	–	$11,6 \times 10^{-6}$	$12,4 \times 10^{-6}$
per °F from 68°F	–	$6,4 \times 10^{-6}$	$6,9 \times 10^{-6}$
Thermal conductivity			
W/m•°C	–	20	25
Btu in/(ft^2 h °F)	–	140	170
Specific heat			
J/kg C	460	–	–
Btu/lb. °F	0,11	–	–

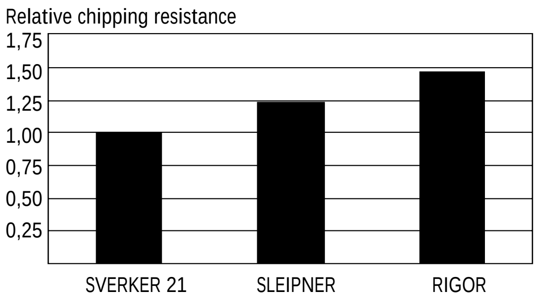
COMPRESSIVE STRENGTH

The figures should be considered as approximate.

Hardness HRC	Compressive yield strength $R_{c0,2}$ MPa	ksi
50	1 700	250
55	2 050	300
60	2 350	340
62	2 500	360
64	2 650	380

CHIPPING RESISTANCE

Relative chipping resistance for *SVERKER 21, SLEIPNER* and *RIGOR* at the same hardness level.



ABRASIVE WEAR RESISTANCE

Relative abrasive wear resistance for *SVERKER 21 SLEIPNER* and *RIGOR* at the same hardness level (low value means better wear resistance).

Heat treatment

SOFT ANNEALING

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

STRESS RELIEVING

After rough machining the tool should be heated through to 650°C (1200°F) and held for 2 h. Cool slowly to 500°C (930°F) then freely in air.

HARDENING

Preheating temperature: 650–750°C (1200–1380°F)
Austenitizing temperature: 950–1080°C (1740–1980°F) but usually 1030–1050°C (1890–1920°F)
Holding time: 30 min

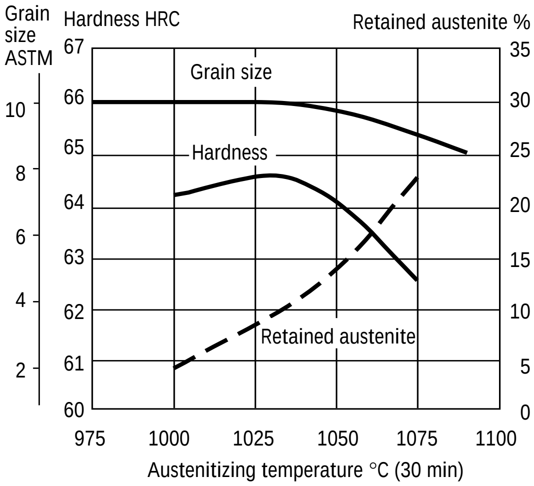
Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

- Forced gas/circulating atmosphere
- Vacuum (high speed gas with sufficient overpressure)
- Martempering bath or fluidized bed at 500–550°C (930–1020°F)
- Martempering bath or fluidized bed at approx. 200–350°C (390–660°F)
- Oil (only very simple geometries)

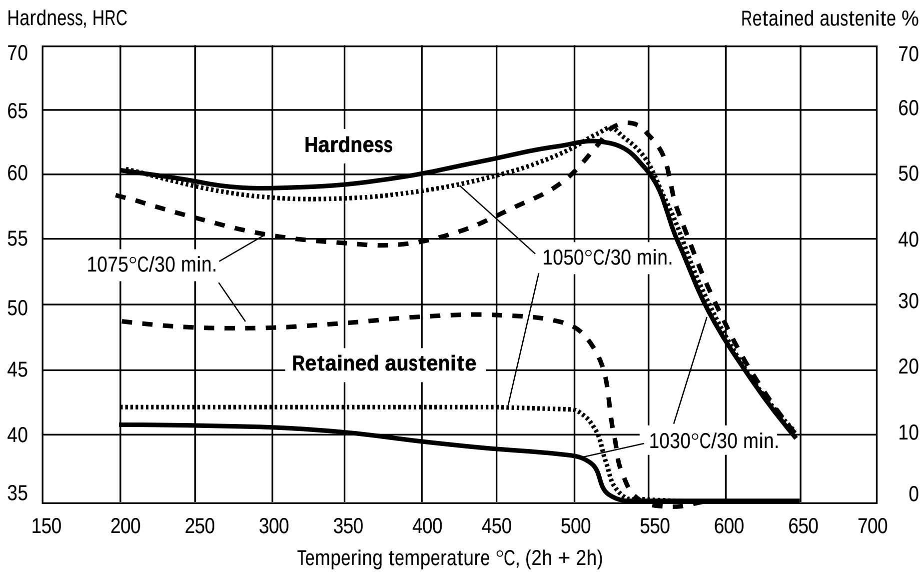
Note: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F)

Hardness, retained austenite and grain size as function of austenitizing temperature



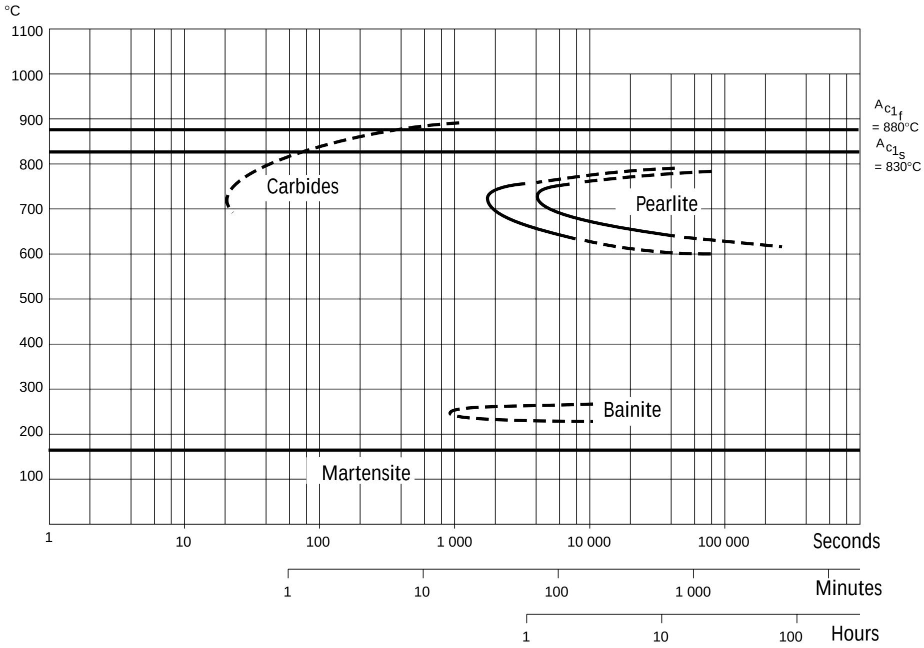
TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper at least twice with intermediate cooling to room temperature. The lowest tempering temperature which should be used is 180°C (360°F). The minimum holding time at temperature is 2 h.



TTT-graph

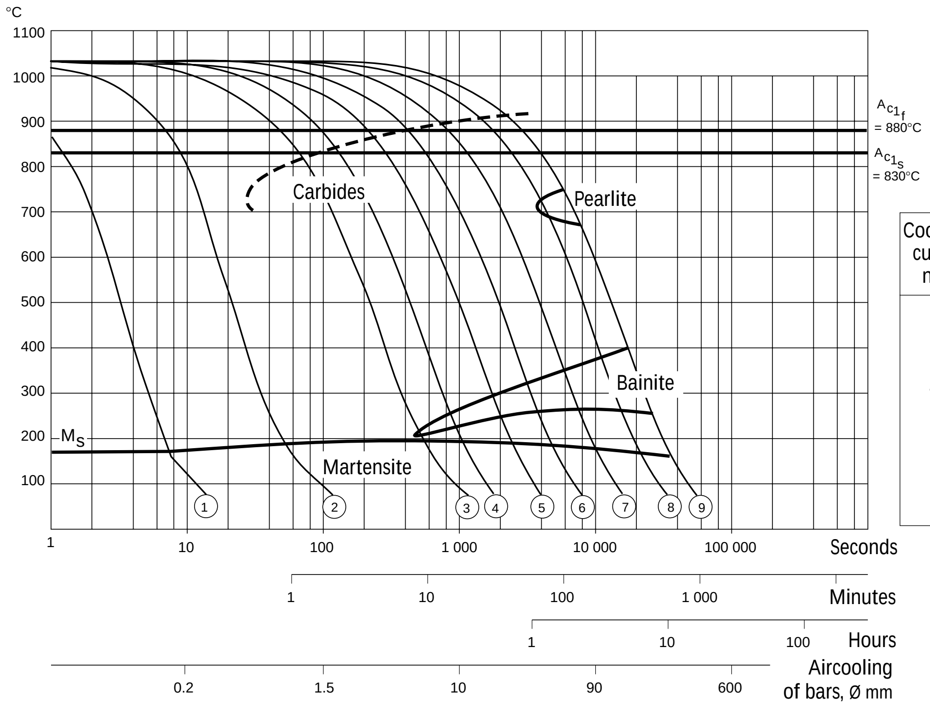
Austenitizing temperature 1030°C (1890°F). Holding time 30 min.



Temp. °C.	Time h2	Hardness HV10
800	31,0	498
750	3,1	266
725	1,6	309
700	3,0	304
650	19,6	239
600	23,3	724
300	7,0	813
250	16,3	803
200	23,4	813

CCT-graph

Austenitizing temperature 1030°C (1890°F). Holding time 30 min.



Cooling curve no.	Hardness HV 10	*$T_{800-500}$ (sec.)
1	824	2
2	824	11
3	813	140
4	813	280
5	813	630
6	813	1241
7	724	2482
8	649	5215
9	572	8360

DIMENSIONAL CHANGES

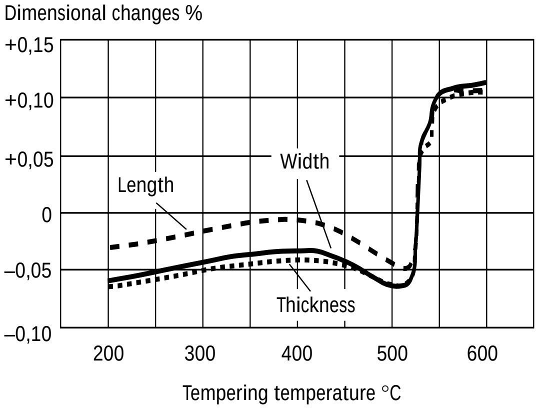
The dimensional changes have been measured after austenitizing and tempering.

Austenitizing: 1030°C (1890°F)/30 min, cooling in vacuum furnace at 0,75°C/s (1,35°F/s) between 800°C (1470°F) and 500°C (930°F)

Tempering: 2 x 2 h at various temperatures

Specimen size: 100 x 100 x 100 mm

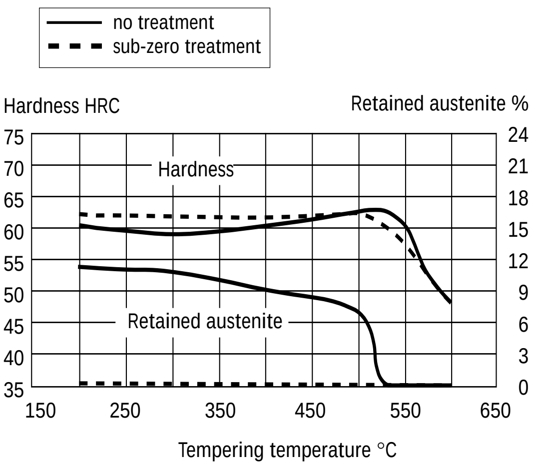
Dimensional changes as function of tempering temperature



SUB-ZERO TREATMENT

Pieces requiring maximum dimensional stability in service should be sub-zero treated. Sub-zero treatment reduces the amount of retained austenite and changes the hardness as shown in the diagram below:
Austenitizing: 1030°C (1890°F)/30 min
Tempering: 2 x 2 h at various temperatures

Hardness and retained austenite as function of tempering temperature and sub-zero treatment



Surface treatments

Some cold work tool steels are given a surface treatment in order to reduce friction and increase wear resistance. The most commonly used treatments are nitriding and surface coating with wear resistant layers produced via PVD or CVD.

The high hardness and good resistance to chipping together with a good dimensional stability make *SLEIPNER* suitable as a substrate steel for various surface coatings.

NITRIDING AND NITROCARBURIZING

Nitriding and nitrocarburizing result in a hard surface layer which is very resistant to wear and galling. The surface hardness after nitriding is approximately 1100 $HV_{0,2kg}$. The thickness of the layer should be chosen to suit the application in question.

PVD

Physical vapour deposition, PVD, is a method of applying a wear-resistant coating at temperatures between 200–500°C (390–930°F).

CVD

Chemical vapour deposition, CVD, is used for applying wear-resistant surface coatings at a temperature of around 1000°C (1830°F). It is recommended that the tools are separately hardened and tempered in a vacuum furnace after surface treatment.

Machining recommendations

The cutting data below are to be considered as guide values which must be adapted to existing local conditions.
More information can be found in the Uddeholm publication ”Cutting data recommendation”.

Condition: Soft annealed to approx. 235 HB.

TURNING

Cutting data parameters	Turning with carbide		Turning with high speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min. f.p.m.	 100–150 328–492	 150–200 492–656	 17–22 56–72
Feed, (f) mm/rev i.p.r.	 0,2–0,4 0,008–0,016	 0,05–0,2 0,002–0,008	 0,05–0,3 0,002–0,01
Depth of cut, (a_p) mm inch	 2–4 0,08–0,16	 0,5–2 0,02–0,08	 0,5–3 0,02–0,12
Carbide designation ISO US	 K20, P20 C2–C6 Coated carbide	 K10, P15 C3, C7 Coated carbide	 – –

DRILLING

High speed steel twist drill

Drill diameter		Cutting speed (v_c)		Feed (f)	
mm	inch	m/min	f.p.m.	mm/rev	i.p.r.
– 5	–3/16	13–18*	43–59*	0,05–0,10	0,002–0,004
5–10	3/16–3/8	13–18*	43–59*	0,10–0,20	0,004–0,008
10–15	3/8–5/8	13–18*	43–59*	0,20–0,25	0,008–0,010
15–20	5/8–3/4	13–18*	43–59*	0,25–0,30	0,010–0,012

1) For coated HSS drill v_c 25–35 m/min. (82–115 f.p.m./min.)

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solide carbide	Brazed carbide[1)]
Cutting speed (v_c) m/min f.p.m.	 140–160 460–525	 80–100 262–328	 45–55 148–180
Feed (f) mm/r i.p.r	 0,05–0,15[2)] 0,002–0,006[2)]	 0,10–0,25[2)] 0,004–0,01[2)]	 0,15–0,25[2)] 0,006–0,01[2)]

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

MILLING

Face and square shoulder milling

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m.	 110–180 360–590	 180–220 590–722
Feed (f_z) mm/tooth inch/tooth	 0,2–0,4 0,008–0,016	 0,1–0,2 0,004–0,008
Depth of cut (a_p) mm inch	 2–5 0,08–0,2	 –2 –0,08
Carbide designation ISO US	 K20, P20 C2, C6 Coated carbide	 P10–P20 C3–C7 Coated carbide

End milling

Cutting data parameters	Type of milling		
	Solide carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min f.p.m.	 80–120 262–394	 100–140 328–460	 13–18[1)] 43–59[1)]
Feed (f_z) mm/tooth inch/tooth	 0,006–0,20[2)] 0,0002–0,008[2)]	 0,06–0,20[2)] 0,002–0,008[2)]	 0,01–0,35[2)] 0,0004–0,014[2)]
Carbide designation ISO US	 K10, P40 C3, C5	 P15–P40 C6–C5	 – –

1) For coated HSS end mill v_c 30–35 m/min. (98–115 f.p.m. min.)
2) Depending on radial depth of cut and cutter diameter.

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm publication ”Grinding of tool steel”.

Wheel grinding

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

Welding

Good results when welding tool steel can be achieved if proper precautions are taken during the welding operation.

- The joints should be prepared properly.
- Repair welds should be made at elevated temperature. Make the two first layers with the same electrode diameter and/or current.
- Always keep the arc length as short as possible. The electrode should be angled at 90° to the joint sides to minimize undercut. In addition, the electrode should be held at an angle of 75–80° to the direction of forward travel.
- For large repairs, weld the initial layers with a soft filler material (buffering layer)

FILLER MATERIAL

TIG Welding consumables

Filler Material	Hardness after welding
Type AWS ER312	300 HB (for buffering layers)
UTP A67S	55–58 HRC
UTP A696	60–64 HRC
CastoTig 5*	60–64 HRC

** Should not be used for more then 4 layers because of the increased risk of cracking*

MMA (SMAW) Welding consumables

Filler Material	Hardness after welding
Type AWS E312	300 HB (for buffering layers)
CASTOLIN 2	54–60 HRC
UTP 67S	55–58 HRC
UTP 69	60–64 HRC
CASTOLIN 6	60–64 HRC

PREHEATING TEMPERATURE

The temperature of the tool during the entire welding process should be maintained at an even level.

	Soft annealed	Hardened
Hardness	230 HB	60–62 HRC
Preheating temperature	250°C	250°C
Max. interpass-temperature	400°C	400°C

HEAT TREATMENT AFTER WELDING

	Soft annealed	Hardened
Hardness	230 HB	60–62 HRC
Cooling rate	20–40°C/h for the first 2 hours then freely in air	
Heat treatment	Soft anneal Harden Temper	Temper 10–20°C below the latest tempering temperature

More information on welding of tool steel can be found in the Uddeholm publication ”Welding of Tool Steel”.

Flame hardening

Use oxy-acetylene equipment with a capacity of 800–1250 l/h. Oxygen pressure 2,5 bar, acetylene pressure 1,5 bar. Adjust to give neutral flame.

Temperature: 980–1020°C. Cool freely in air.

The hardness at sthe surface will be 58–62 HRC and 41 HRC (400 HB) at a depth of 3–3,5 mm.

Electrical-discharge machining–EDM

If EDM is performed in the hardened and tempered condition, finish with a fine-sparking, i.e. low current, high frequency.

For optimal performance the EDM’d surface should be ground/polished and the tool re-tempered at approx. 25°C (80°F) lower than the original tempering temprature.

When EDM’ ing larger sizes or complicated shapes *SLEIPNER* should be tempered at high temperature, above 500°C (930°F).

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 steel.