Uddeholm Sleipner®

UDDEHOLM

This information is based on our present state of knowledge and is intended to provide general notes on our products and their uses. It should not therefore be construed as a warranty of specific properties of the products described or a warranty for fitness for a particular purpose.

Classified according to EU Directive 1999/45/EC
For further information see our "Material Safety Data Sheets".

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SS-EN ISO 9001
SS-EN ISO 14001

Uddeholm Sleipner®

THE CHANGING TOOLING ENVIRONMENT

The tooling environment is changing to adapt to the changing market environment. Lead times are one aspect of this change and they are getting shorter and shorter. This ultimately means that more emphasis has to be placed on tool reliability in service and on time to manufacture the tooling.

The production materials used nowadays are placing more demands on the tools and the tool steels used to manufacture them. For example, advanced high strength steel materials now being used for automotive parts place extra demands on resistance to chipping and cracking, compressive strength and wear resistance.

THE MODERN GENERAL COLD WORK TOOL STEEL

The classical 12 % Cr-steel such as AISI D2 or W.-Nr. 1.2379 are still the backbone of cold work tooling but their limitations are becoming more and more apparent in the changing production environment. Uddeholm Sleipner is a new 8 % Cr-steel from Uddeholms AB. Its property profile has been carefully balanced and the result is a very versatile tool steel which overcomes the limitations of the 12% Cr-steel.

A VERSATILE TOOL STEEL

The property profile of Uddeholm Sleipner is more versatile and superior to that of 12 % Cr-steels. The machinability, grindability and hardenability are much better and it is easier to make small repair welds. This means that Uddeholm Sleipner is the right choice for faster toolmaking. The significantly better chipping resistance also result in better tool performance and easier maintenance.

GENERAL

Uddeholm 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 0.9	Si 0.9	Mn 0.5	Cr 7.8	Mo 2.5	V 0.5
Standard spec.	None					
Delivery condition	Soft annealed to approx. 235 HB					
Colour code	Blue/brown					

APPLICATIONS

Uddeholm 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.

Uddeholm 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 lbs/in^3	 7 730 0.279	 7 680 0.277	 7 620 0.275
Modulus of elasticity MPa ksi	 205 000 297 000	 190 000 276 000	 180 000 261 000
Coefficient of thermal expansion –after low temperature tempering (60 HRC) per °C from 20°C per °F from 68°F –after high temperature tempering per °C from 20°C per °F from 68°F	 – – – –	 12.7 x 10^{-6} 7.1 x 10^{-6} 11.6 x 10^{-6} 6.4 x 10^{-6}	 – – 12.4 x 10^{-6} 6.9 x 10^{-6}
Thermal conductivity W/m •°C Btu in/(ft^2 h °F)	 – –	 20 140	 25 170
Specific heat capacity J/kg °C Btu/lb. °F	 460 0.11	 – –	 – –

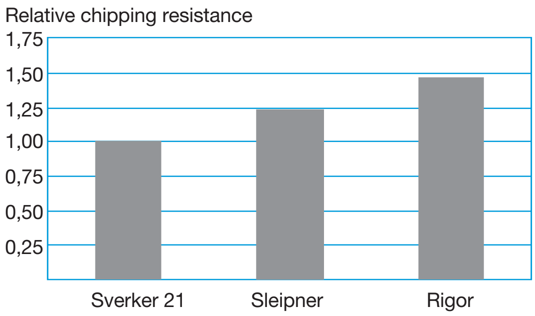
COMPRESSIVE STRENGTH

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

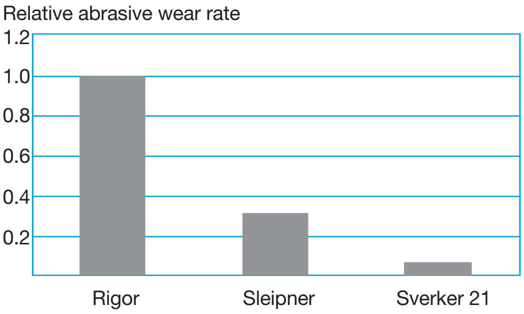
CHIPPING RESISTANCE

Relative chipping resistance for Uddeholm Sverker 21, Uddeholm Sleipner and Uddeholm Rigor at the same hardness level.



ABRASIVE WEAR RESISTANCE

Relative abrasive wear resistance for Uddeholm Sverker 21, Uddeholm Sleipner and Uddeholm 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 hours. Cool slowly to 500°C (930°F) then freely in air.

HARDENING

Preheating temperature: 600–650°C (1110–1200°F) and 850–900°C (1560–1650°F)

Austenitizing temperature: 950–1080°C (1740–1980°F) but usually 1030–1050°C (1890–1920°F).

Holding time: 30 minutes

Note: Holding time = time at hardening temperature after the tool is fully heated through. A holding time of less than recommended time will result in loss of hardness.

Protect the part against decarburization and oxidation during hardening.

Further information can be found in the Uddeholm brochure "Heat treatment of tool steels".

QUENCHING MEDIA

- Vacuum (high speed gas with sufficient overpressure minimum 2 bar)
- Martempering bath or fluidized bed at approx. 200–550°C (390–1020°F)
- Forced air/gas

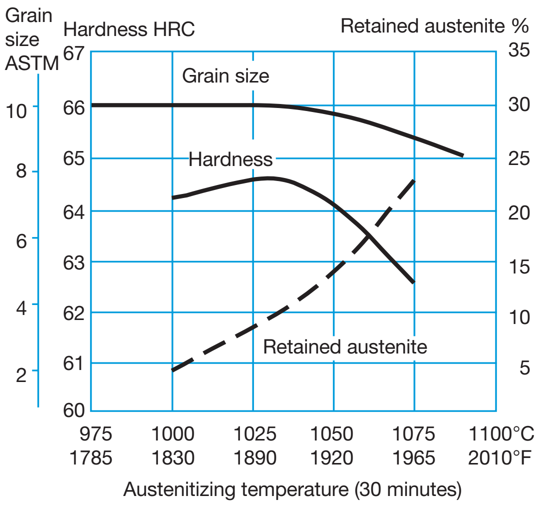
Note: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

In order to obtain the optimum properties for the tool, the cooling rate should be as fast as possible with regards to acceptable distortion.

A slow quench rate will result in loss of hardness compared with the given tempering curves.

Martempering should be followed by forced air cooling if wall thickness is exceeding 50 mm (2").

HARDNESS, RETAINED AUSTENITE AND GRAIN SIZE AS FUNCTION OF AUSTENITIZING TEMPERATURE



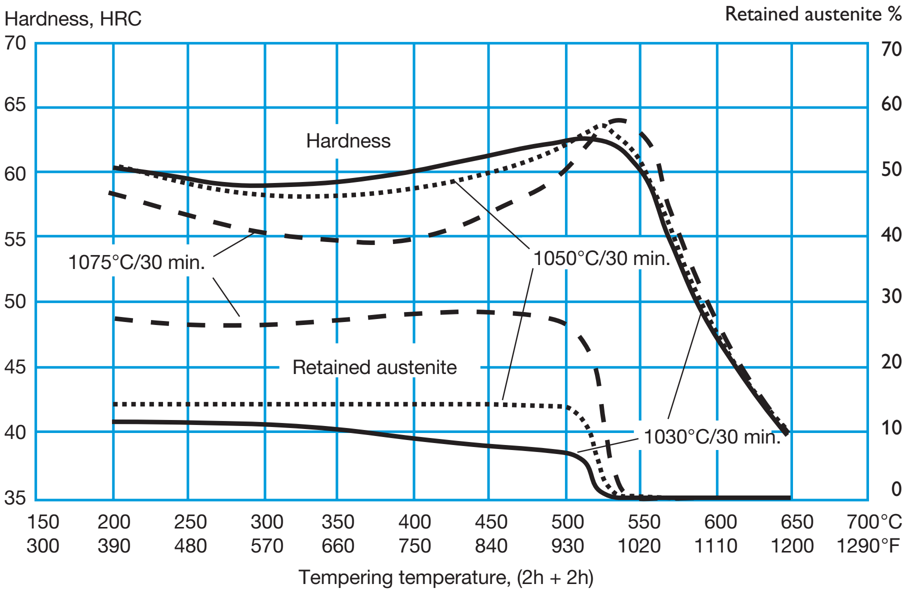
TEMPERING

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.

For highest dimensional stability and ductility, a minimum temperature of 540°C (1000°F) and three tempers is strongly recommended.

Tempering at a lower temperature than 540°C (1000°F) may increase the hardness and compressive strength to some extent but also impair cracking resistance and dimensional stability. However, if lowering the tempering temperature, do not temper below 520°C (970°F).

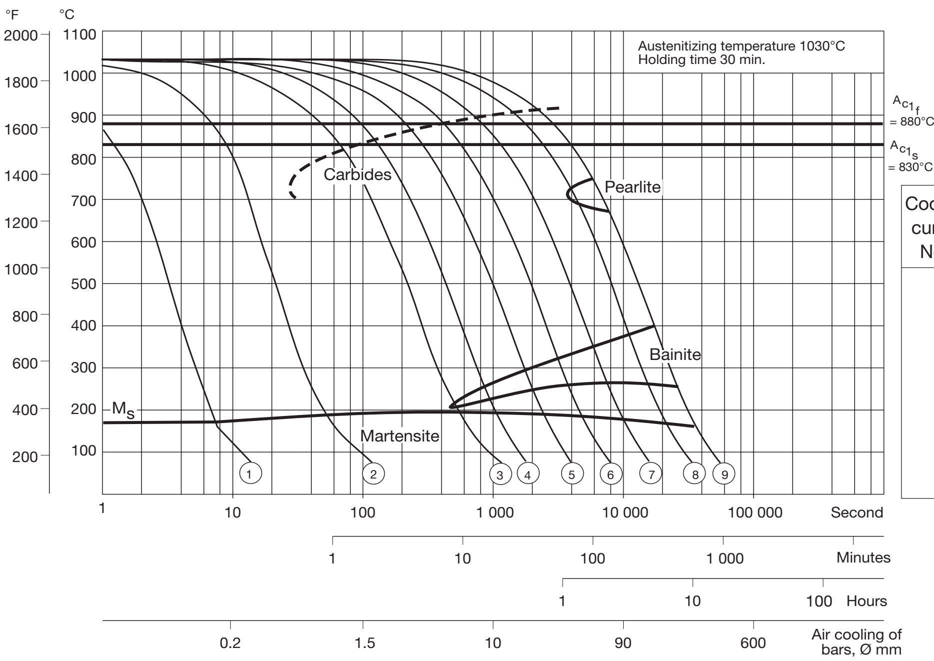
When tempering twice the minimum holding time at temperature is 2 hours. When tempering three times the minimum holding time is 1 hour.



Above tempering curves are obtained after heat treatment of samples with a size of 15 x 15 x 40 mm, cooling in forced air. Lower hardness can be expected after heat treatment of tools and dies due to factors like actual tool size and heat treatment parameters.

CCT-GRAPH

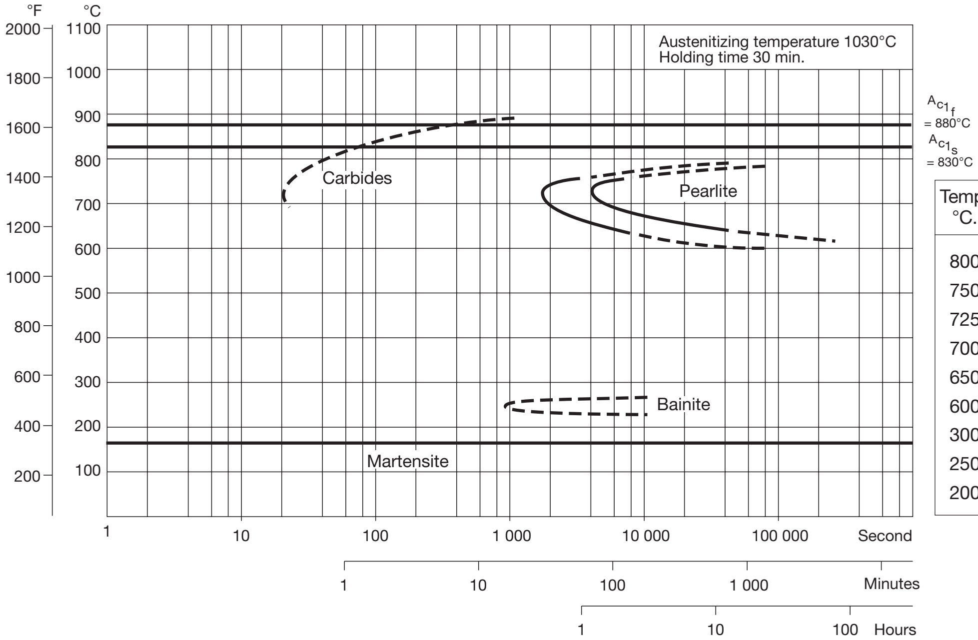
Austenitizing temperature 1030°C (1890°F). Holding time 30 min.



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

TTT-GRAPH

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



Temp. °C.	Time h	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

DIMENSIONAL CHANGES

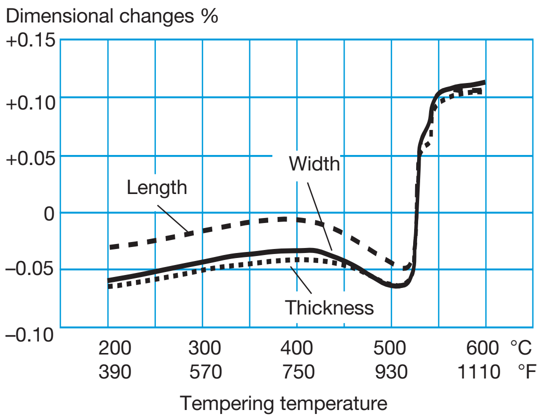
The dimensional changes have been measured after austenitizing and tempering.

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



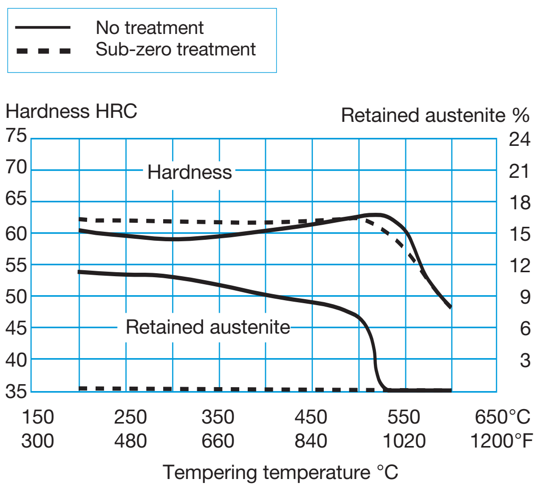
SUB-ZERO TREATMENT

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 steel 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 Uddeholm 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 recommendations”.

The recommendations in following tables are valid for Uddeholm Sleipner in soft annealed condition to approx. 235 HB.

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), 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	–

MILLING

FACE AND SQUARE SHOULDER MILLING

Cutting data parameters	Milling with carbide Rough milling	Milling with carbide 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		
	Solid 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	0.03–0.20[2] 0.001–0.008[2]	0.08–0.20[2] 0.003–0.008[2]	0.05–0.35[2] 0.002–0.014[2]
Carbide designation ISO US	–	P15–P40 C6–C5	–

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

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

* 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	Solid carbide	Carbide tip[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/rev i.p.r	0.05–0.15[2] 0.002–0.006[2]	0.10–0.25[3] 0.004–0.01[3]	0.15–0.25[4] 0.006–0.01[4]

[1] Drill with replaceable or brazed carbide tip
[2] Feed rate for drill diameter 20–40 mm (0.8"–1.6")
[3] Feed rate for drill diameter 5–20 mm (0.2"–0.8")
[4] Feed rate for drill diameter 10–20 mm (0.4"–0.8")

GRINDING

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

Type of grinding	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 JV
Profile grinding	A 100 KV	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 45303W*	60–64 HRC
Caldie Tig-Weld	58–62 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 EutecTrode 2	54–60 HRC
UTP 67S	55–58 HRC
UTP 69	60–64 HRC
Castolin EutecTrode 6	60–64 HRC
Caldie Weld	58–62 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 (480°F)	250°C (480°F)
Max. interpass-temperature	400°C (750°F)	400°C (750°F)

HEAT TREATMENT AFTER WELDING

	Soft annealed	Hardened
Hardness	230 HB	60–62 HRC
Cooling rate	20–40°C/h (40–80°F/h) for the first 2 hours then freely in air	
Heat treatment	Soft anneal Harden Temper	Temper 10–20°C (20–40°F) 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 (1795–1870°F). Cool freely in air.

The hardness at the surface will be 58–62 HRC and 41 HRC (400 HB) at a depth of 3–3.5 mm (0.12–0.14”).

ELECTRICAL-DISCHARGE MACHINING–EDM

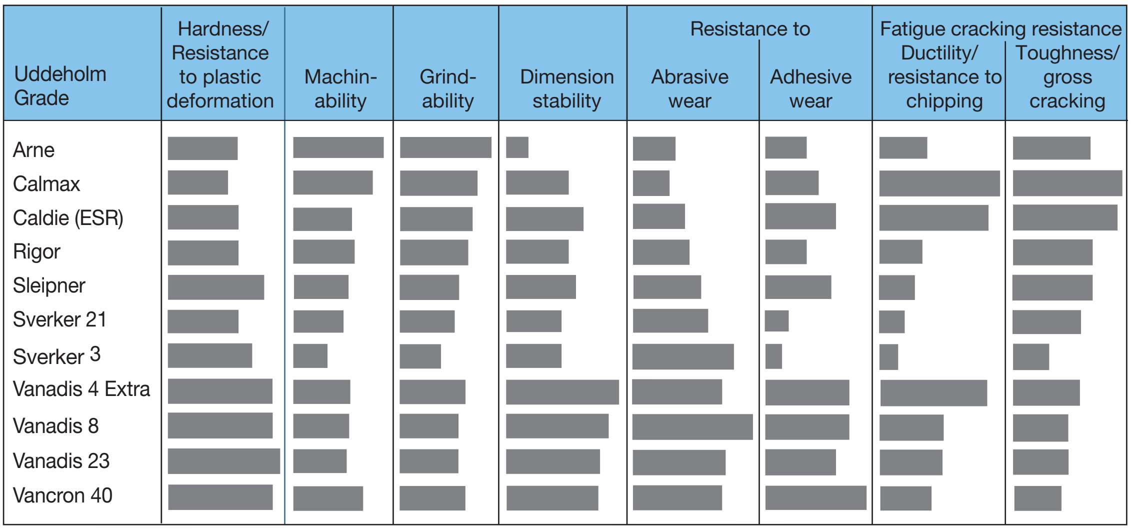
If EDM is performed in the hardened and tempered condition, finish with a fine-sparking, i.e. low current, high frequency.

For optimal performance the EDM’d surface should be ground/polished to completely remove the EDM layer and the tool retempered at approx. 25°C (80°F) below the original tempering temperature.

When EDM’ing larger sizes or complicated shapes Uddeholm Sleipner should be tempered at high temperature, above 500°C (930°F), during the heat treatment to lower the residual stress level and thereby reducing the risk of potential cracking in connection with the EDM .

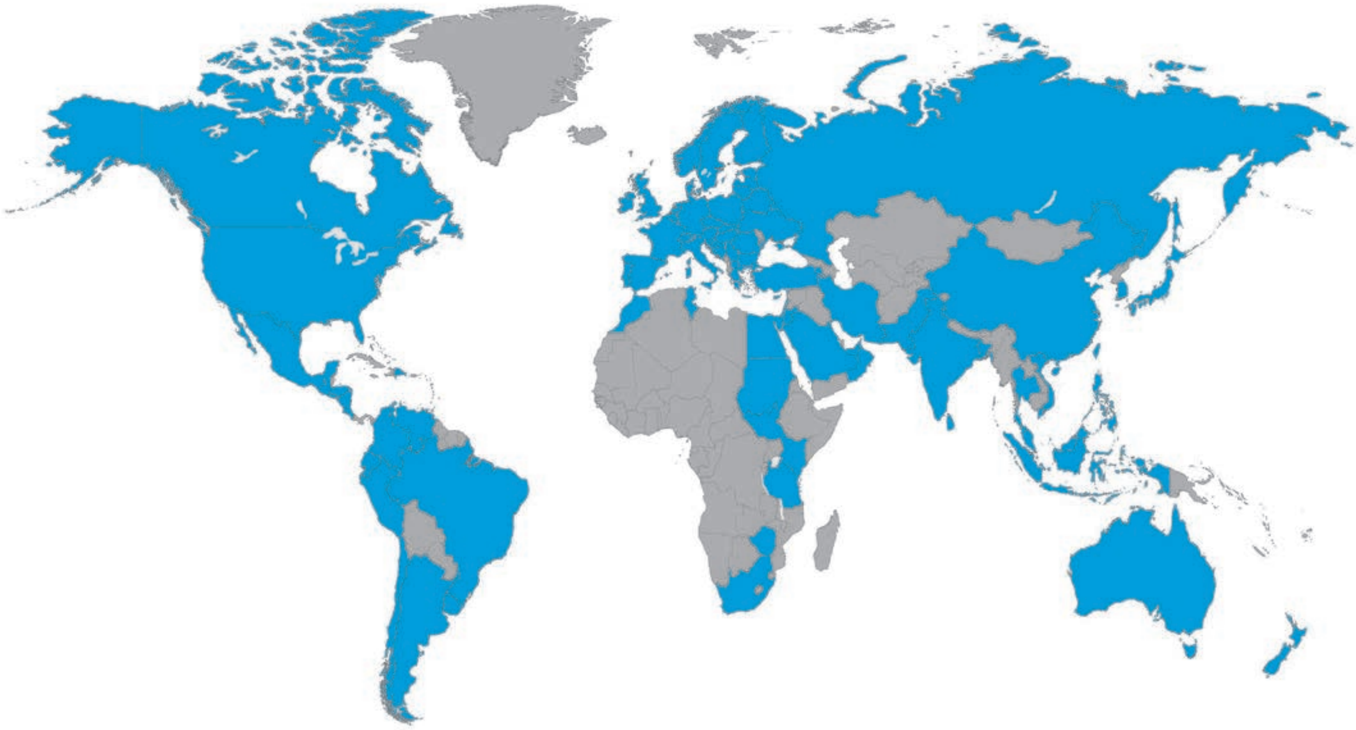
RELATIVE COMPARISON OF UDDEHOLM COLD WORK TOOL STEELS

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.



NETWORK OF EXCELLENCE

Uddeholm is present on every continent. This ensures you high-quality Swedish tool steel and local support wherever you are. We secure our position as the world's leading supplier of tooling materials.

UDDEHOLM

UDDEHOLM 1602. 125 / STROKIRK KNAPPEN 03.2016

Uddeholm is the world's leading supplier of tooling materials. This is a position we have reached by improving our customers' everyday business. Long tradition combined with research and product development equips Uddeholm to solve any tooling problem that may arise. It is a challenging process, but the goal is clear – to be your number one partner and tool steel provider.

Our presence on every continent guarantees you the same high quality wherever you are. We secure our position as the world's leading supplier of tooling materials. We act worldwide. For us it is all a matter of trust – in long-term partnerships as well as in developing new products.

For more information, please visit www.uddeholm.com

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