



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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The latest revised edition of this brochure is the English version,  
which is always published on our web site [www.uddeholm.com](http://www.uddeholm.com)



SS-EN ISO 9001  
SS-EN ISO 14001

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## 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                               | 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

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<br>(68°F)     | 200°C<br>(390°F)                                  | 400°C<br>(750°F)                                  |
|---|--------------------|---|---|
| Density<br>kg/m <sup>3</sup><br>lbs/in <sup>3</sup>   | 7 730<br>0.279     | 7 680<br>0.277                                    | 7 620<br>0.275                                    |
| Modulus of elasticity<br>MPa<br>ksi   | 205 000<br>297 000 | 190 000<br>276 000                                | 180 000<br>261 000                                |
| Coefficient of thermal expansion<br>—after low temperature tempering (60 HRC)<br>per °C from 20°C<br>per °F from 68°F | —                  | 12.7 × 10 <sup>-6</sup><br>7.1 × 10 <sup>-6</sup> | —   |
|   | —                  | —   | —   |
| —after high temperature tempering<br>per °C from 20°C<br>per °F from 68°F   | —                  | 11.6 × 10 <sup>-6</sup><br>6.4 × 10 <sup>-6</sup> | 12.4 × 10 <sup>-6</sup><br>6.9 × 10 <sup>-6</sup> |
|   | —                  | —   | —   |
| Thermal conductivity<br>W/m · °C<br>Btu in/(ft <sup>2</sup> h °F)   | —                  | 20<br>140   | 25<br>170   |
|   | —                  | —   | —   |
| Specific heat capacity<br>J/kg · °C<br>Btu/lb. °F   | 460<br>0.11        | —<br>—  | —<br>—  |
|   | —                  | —   | —   |

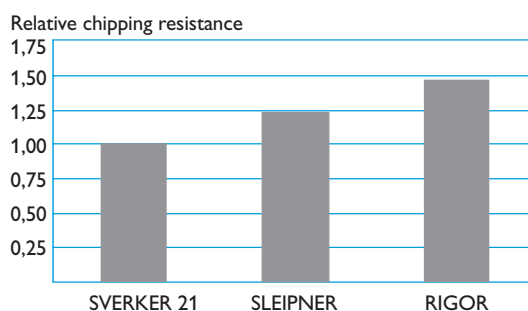
### Compressive strength

The figures should be considered as approximate.

| Hardness<br>HRC | Compressive yield strength R <sub>c0,2</sub> |     |
|-----------------|--|-----|
|                 | MPa  | ksi |
| 50              | 1 700  | 250 |
| 55              | 2 050  | 300 |
| 60              | 2 350  | 340 |
| 62              | 2 500  | 360 |
| 64              | 2 650  | 380 |

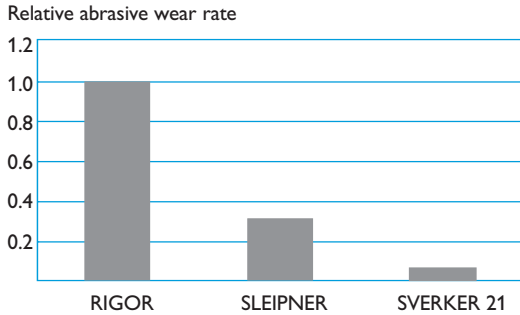
### Chipping resistance

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:* 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 minutes

*Protect the part against decarburization and oxidation during hardening.*

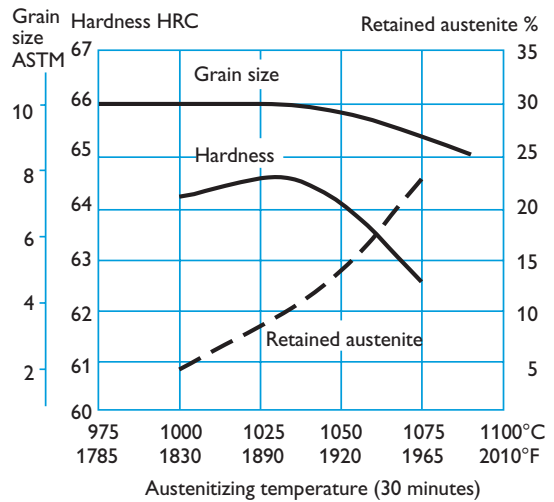


### Quenching media

- 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)

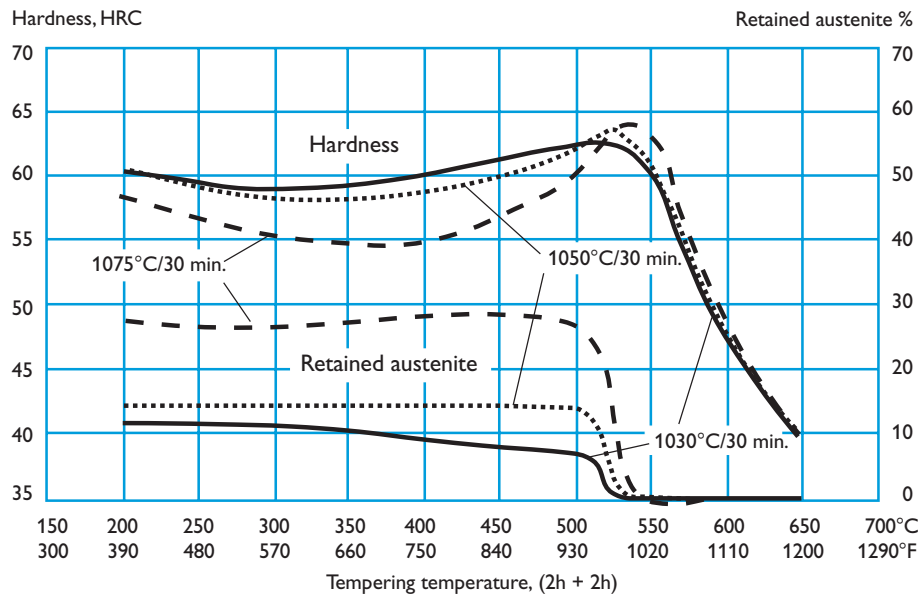
*Note:* Temper the tool as soon as its temperature reaches 50–70°C (120–160°F)

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



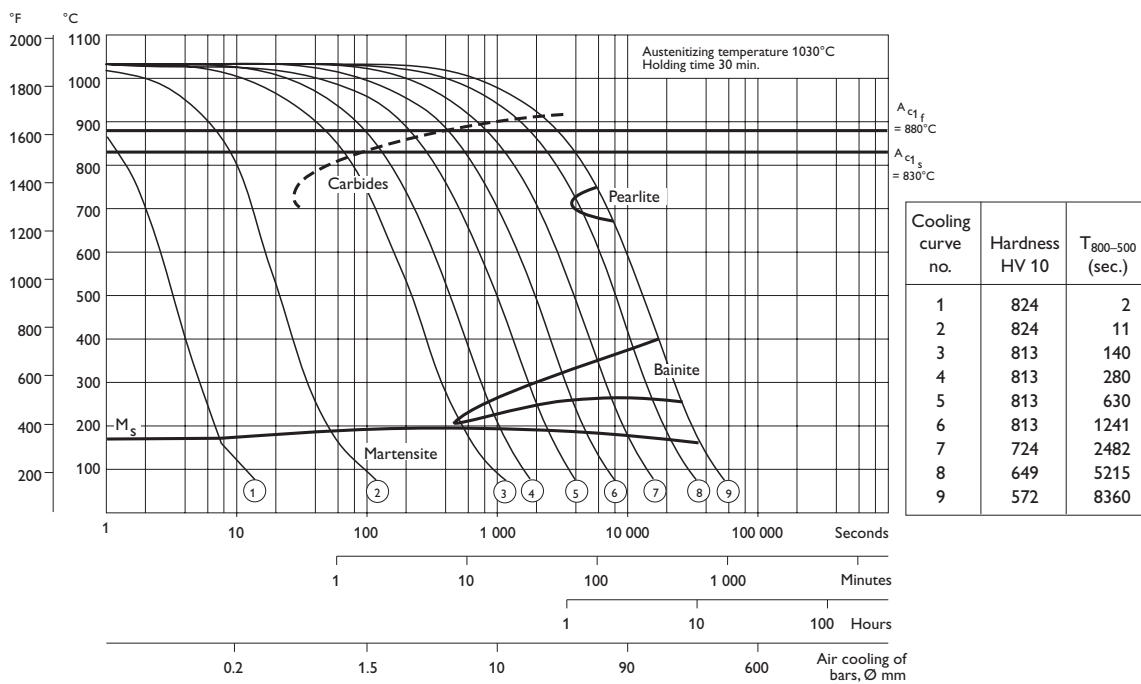
## Tempering

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 hours.



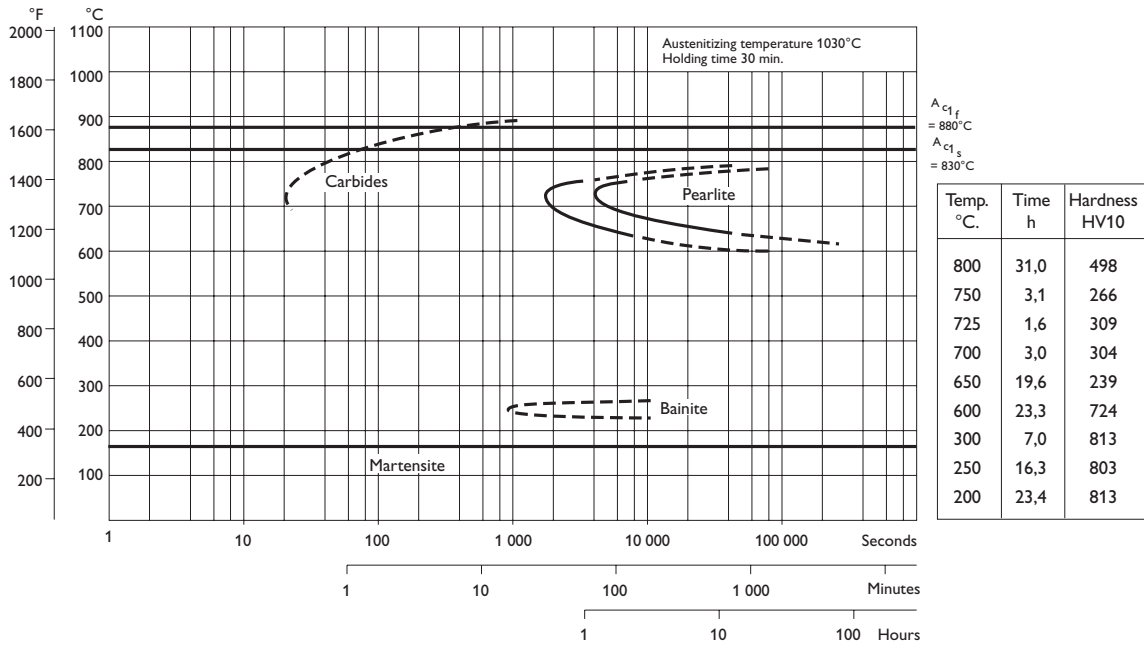
## CCT-GRAPH

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



TTT-GRAPH

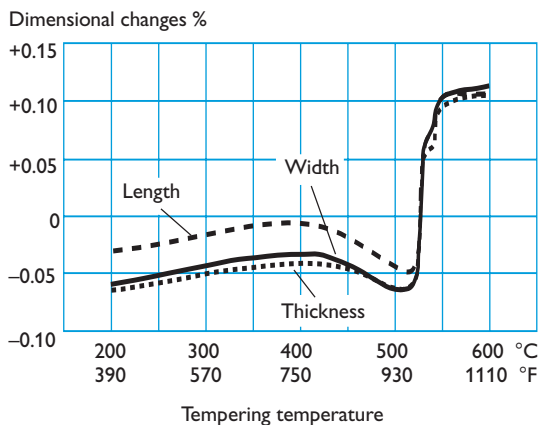
Austenitizing temperature 1030°C (1890°F). Holding time 30 min.



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



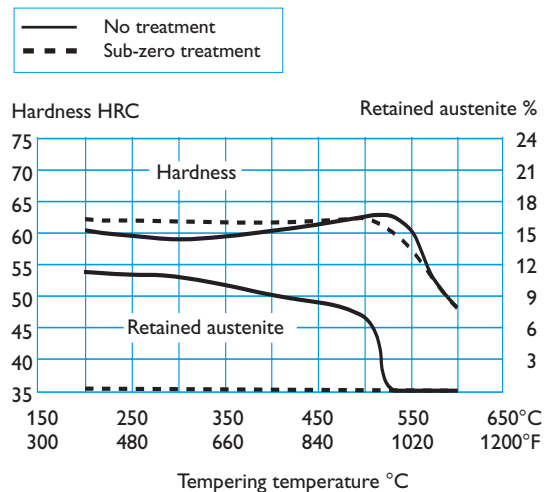
Sub-zero treatment

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<sub>0,2kg</sub>. 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                |                                      | Turning with high speed steel |
|---|-------------------------------------|--------------------------------------|-------------------------------|
|   | Rough turning                       | Fine turning                         | Fine turning                  |
| Cutting speed (v <sub>c</sub> ), m/min.<br>f.p.m. | 100–150<br>328–492                  | 150–200<br>492–656                   | 17–22<br>56–72                |
| Feed, (f)<br>mm/rev<br>i.p.r.                     | 0.2–0.4<br>0.008–0.016              | 0.05–0.2<br>0.002–0.008              | 0.05–0.3<br>0.002–0.01        |
| Depth of cut, (a <sub>p</sub> )<br>mm<br>inch     | 2–4<br>0.08–0.16                    | 0.5–2<br>0.02–0.08                   | 0.5–3<br>0.02–0.12            |
| Carbide designation<br>ISO<br>US                  | K20, P20<br>C2–C6<br>Coated carbide | K10, P15<br>C3, C7<br>Coated carbide | –                             |

### Milling

#### FACE AND SQUARE SHOULDER MILLING

| Cutting data parameters                            | Milling with carbide                 |                                    |
|--|--------------------------------------|------------------------------------|
|  | Rough milling                        | Fine milling                       |
| Cutting speed (v <sub>c</sub> )<br>m/min<br>f.p.m. | 110–180<br>360–590                   | 180–220<br>590–722                 |
| Feed (f <sub>z</sub> )<br>mm/tooth<br>inch/tooth   | 0.2–0.4<br>0.008–0.016               | 0.1–0.2<br>0.004–0.008             |
| Depth of cut (a <sub>p</sub> )<br>mm<br>inch       | 2–5<br>0.08–0.2                      | –2<br>–0.08                        |
| Carbide designation<br>ISO<br>US                   | K20, P20<br>C2, C6<br>Coated carbide | P10–P20<br>C3–C7<br>Coated carbide |



END MILLING

| Cutting data parameters                            | Type of milling                                      |  |  |
|--|--|--|--|
|  | Solid carbide  | Carbide indexable insert                             | High speed steel                                     |
| Cutting speed (v <sub>c</sub> )<br>m/min<br>f.p.m. | 80–120<br>262–394                                    | 100–140<br>328–460                                   | 13–18 <sup>1)</sup><br>43–59 <sup>1)</sup>           |
| Feed (f <sub>c</sub> )<br>mm/tooth<br>inch/tooth   | 0.03–0.20 <sup>2)</sup><br>0.001–0.008 <sup>2)</sup> | 0.08–0.20 <sup>2)</sup><br>0.003–0.008 <sup>2)</sup> | 0.05–0.35 <sup>2)</sup><br>0.002–0.014 <sup>2)</sup> |
| Carbide designation<br>ISO<br>US                   | –  | P15–P40<br>C6–C5                                     | –  |

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

Drilling

HIGH SPEED STEEL TWIST DRILL

| Drill diameter |          | Cutting speed (v <sub>c</sub> ) |        | 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<sub>c</sub> 25–35 m/min. (82–115 f.p.m./min.)

CARBIDE DRILL

| Cutting data parameters                            | Type of drill  |   |   |
|--|--|---|---|
|  | Indexable insert                                     | Solid carbide                                       | Carbide tip <sup>1)</sup>                           |
| Cutting speed (v <sub>c</sub> )<br>m/min<br>f.p.m. | 140–160<br>460–525                                   | 80–100<br>262–328                                   | 45–55<br>148–180                                    |
| Feed (f)<br>mm/r<br>i.p.r.                         | 0.05–0.15 <sup>2)</sup><br>0.002–0.006 <sup>2)</sup> | 0.10–0.25 <sup>3)</sup><br>0.004–0.01 <sup>3)</sup> | 0.15–0.25 <sup>4)</sup><br>0.006–0.01 <sup>4)</sup> |

<sup>1)</sup> Drill with replaceable or brazed carbide tip  
<sup>2)</sup> Feed rate for drill diameter 20–40 mm (0.8”–1.6”)  
<sup>3)</sup> Feed rate for drill diameter 5–20 mm (0.2”–0.8”)  
<sup>4)</sup> 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 than 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<br>Harden<br>Temper                                | Temper<br>10–20°C (20–40°F)<br>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.

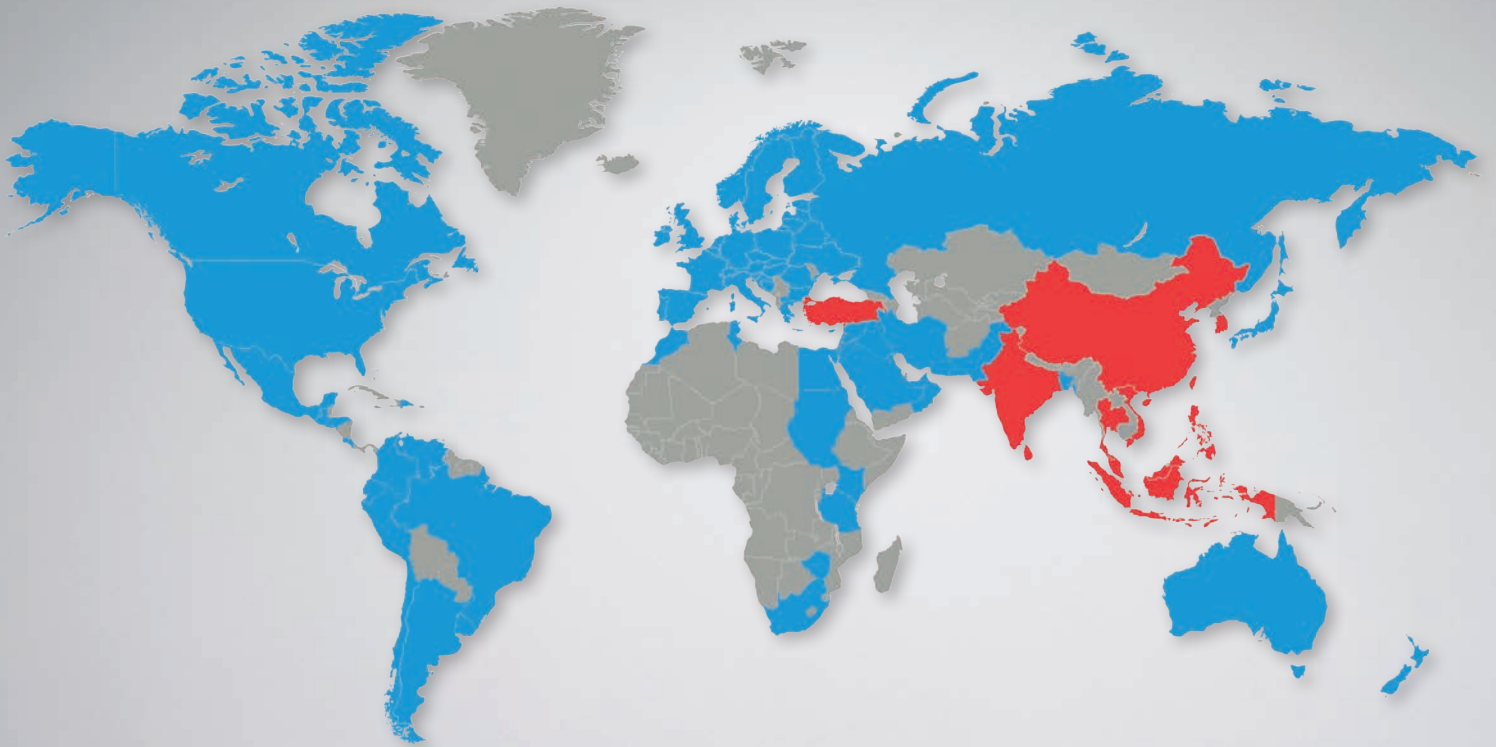
## Relative comparison of Uddeholm cold work tool steel

Material properties and resistance to failure mechanisms

| Uddeholm grade  | Hardness/<br>Resistance to plastic deformation | Machinability | Grindability | Dimension stability | Resistance to |               | Fatigue cracking resistance          |                              |
|-----------------|--|---------------|--------------|---------------------|---------------|---------------|--------------------------------------|------------------------------|
|                 |  |               |              |                     | Abrasive wear | Adhesive wear | Ductility/<br>resistance to chipping | Toughness/<br>gross cracking |
| ARNE            | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| CALMAX          | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| CALDIE (ESR)    | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| RIGOR           | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| SLEIPNER        | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| SVERKER 21      | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| SVERKER 3       | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| VANADIS 4 EXTRA | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| VANADIS 6       | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| VANADIS 10      | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| VANADIS 23      | █  | █             | █            | █                   | █             | █             | █                                    | █                            |
| VANCRON 40      | █  | █             | █            | █                   | █             | █             | █                                    | █                            |

### 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. ASSAB is our wholly-owned subsidiary and exclusive sales channel, representing Uddeholm in the Asia Pacific area. Together we secure our position as the world's leading supplier of tooling materials.

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. ASSAB is our wholly-owned subsidiary and exclusive sales channel, representing Uddeholm in the Asia Pacific area. Together we secure our position as the world's leading supplier of tooling materials. We act worldwide, so there is always an Uddeholm or ASSAB representative close at hand to give local advice and support. For us it is all a matter of trust – in long-term partnerships as well as in developing new products. Trust is something you earn, every day.

For more information, please visit [www.uddeholm.com](http://www.uddeholm.com), [www.assab.com](http://www.assab.com) or your local website.

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