



## UDDEHOLM VANADIS® 23 SUPERCLEAN

Uddeholm Vanadis 23 SuperClean is a high alloyed powder metallurgical high speed steel corresponding to AISI M3:2 with a very good abrasive wear resistance in combination with a high compressive strength. It is suitable for demanding cold work applications like blanking of harder materials like carbon steel or cold rolled strip steel and for cutting tools.

The machinability and grindability are superior than for conventional high speed steel and so is the dimensional stability after heat treatment. The superclean powder metallurgy process ensures that the cleanliness is on a high level with a low amount of non-metallic inclusions.

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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

## Critical tool steel properties for

### Good tool performance

- Correct hardness for the application
- High wear resistance
- High toughness to prevent premature failure due to chipping/crack formation

High wear resistance is often associated with low toughness and vice-versa. However, in many cases both high wear resistance and toughness are essential for optimal tooling performance.

Uddeholm Vanadis 23 SuperClean is a powder metallurgical tool steel offering an excellent combination of wear resistance and toughness.

### Toolmaking

- Machinability
- Heat treatment
- Grinding
- Dimensional stability in heat treatment
- Surface treatment

Toolmaking with highly alloyed tool steel means that machining and heat treatment are often more of a problem than with the lower alloy grades. This can, of course, raise the cost of toolmaking.

The powder manufacturing route used for Uddeholm Vanadis 23 SuperClean means that its machinability is superior to that of similar conventionally produced grades and some highly alloyed cold work tool steel.

The dimensional stability of Uddeholm Vanadis 23 SuperClean in heat treatment is excellent and predictable compared to conventionally produced high alloy steel. This, coupled with its high hardness, good toughness and high temperature tempering, means that Uddeholm Vanadis 23 SuperClean is very suitable for surface coating, in particular for PVD.

Stainless steel fastener stamped with a Uddeholm Vanadis 23 SuperClean die and Uddeholm Vanadis 4 Extra SuperCleran punch

## Applications

Uddeholm Vanadis 23 SuperClean is especially suitable for blanking and forming of thinner work materials where a mixed (abrasive–adhesive) or abrasive type of wear is encountered and where the risk for plastic deformation of the working surfaces of the tool is high, e.g.:

- Blanking of medium to high carbon steel
- Blanking of harder materials such as hardened or cold-rolled strip steel
- Plastics mould tooling subjected to abrasive wear condition
- Plastics processing parts, e.g. feed screws, barrel liners, nozzles, screw tips, non-return check ring valves, pelletizer blades, granulator knives

## General

Uddeholm Vanadis 23 SuperClean is a chromium-molybdenum-tungsten-vanadium alloyed high speed steel which is characterized by:

- High wear resistance (abrasive profile)
- High compressive strength
- Very good through-hardening properties
- Good toughness
- Very good dimensional stability on heat treatment
- Very good temper resistance

|                        |  |           |           |          |          |
|------------------------|--|-----------|-----------|----------|----------|
| Typical analysis %     | C<br>1.28  | Cr<br>4.2 | Mo<br>5.0 | W<br>6.4 | V<br>3.1 |
| Standard specification | AISI (M3:2), W.-Nr. 1.3395                           |           |           |          |          |
| Delivery condition     | Soft annealed to approx. 260 HB<br>Drawn max. 320 HB |           |           |          |          |
| Colour code            | Violet   |           |           |          |          |



# Properties

## Physical data

Hardened and tempered condition.

| Temperature   | 20°C<br>(68°F)                  | 400°C<br>(750°F)                | 600°C<br>(1110°F)               |
|---|---------------------------------|---------------------------------|---------------------------------|
| Density<br>kg/m <sup>3</sup><br>lbs/in <sup>3</sup>           | 7980<br>0.287                   | 7870<br>0.283                   | 7805<br>0.281                   |
| Modulus of elasticity<br>MPa<br>ksi                           | 230 000<br>33 x 10 <sup>3</sup> | 205 000<br>30 x 10 <sup>3</sup> | 184 000<br>27 x 10 <sup>3</sup> |
| Thermal conductivity<br>W/m·°C<br>Btu in/ft <sup>2</sup> h °F | 24<br>166                       | 28<br>194                       | 27<br>187                       |
| Specific heat<br>J/kg °C<br>Btu /lb °F                        | 420<br>0.10                     | 510<br>0.12                     | 600<br>0.14                     |

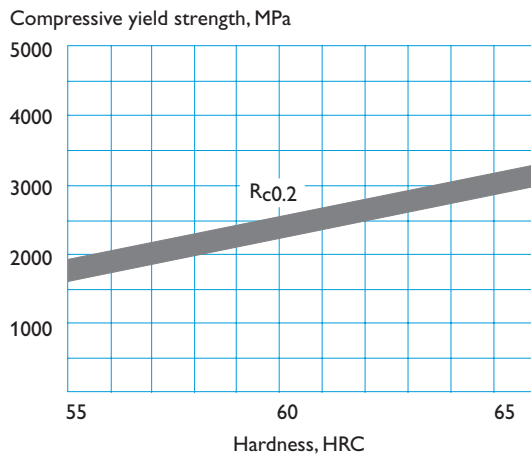
## COEFFICIENT OF THERMAL EXPANSION

| Temperature range |         | Coefficient             |                        |
|-------------------|---------|-------------------------|------------------------|
| °C                | °F      | °C from 20              | °F from 68             |
| 20–100            | 68–212  | 10.8 x 10 <sup>-6</sup> | 6.0 x 10 <sup>-6</sup> |
| 20–200            | 68–392  | 11.1 x 10 <sup>-6</sup> | 6.2 x 10 <sup>-6</sup> |
| 20–300            | 68–572  | 11.4 x 10 <sup>-6</sup> | 6.3 x 10 <sup>-6</sup> |
| 20–400            | 68–752  | 11.8 x 10 <sup>-6</sup> | 6.6 x 10 <sup>-6</sup> |
| 20–500            | 68–932  | 12.1 x 10 <sup>-6</sup> | 6.7 x 10 <sup>-6</sup> |
| 20–600            | 68–1112 | 12.3 x 10 <sup>-6</sup> | 6.8 x 10 <sup>-6</sup> |

## compressive yield strength

Specimen: Hourglass shaped with 10 mm (0.39") Ø waist

APROXIMATE COMPRESSIVE YIELD STRENGTH VERSUS HARDNESS AT ROOM TEMPERATURE.



## Bend strength and deflection

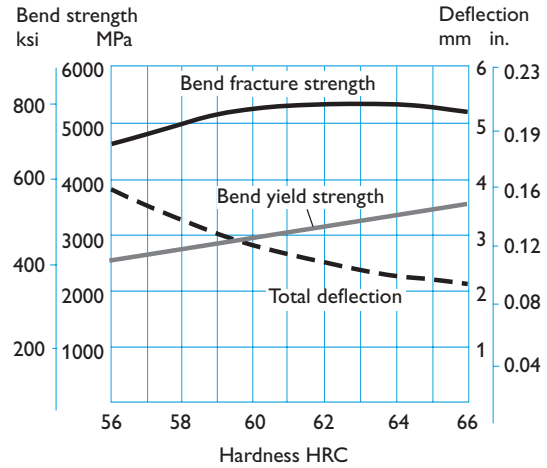
Four-point bend testing.

Specimen size: 5 mm (0.2") Ø

Loading rate: 5 mm/min. (0.2"/min.)

Austenitizing temperature: 990–1180°C (1810–2160°F)

Tempering: 3 x 1 h at 560°C (1040°F)



## Impact strength

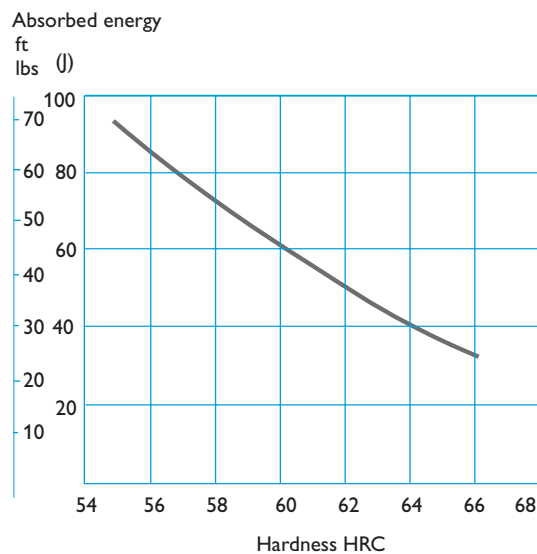
Specimen size: 7 x 10 x 55 mm (0.27" x 0.40" x 2.2")

Specimen type: unnotched

Tempering: 3 x 1 h at 560°C (1040°F)

Longitudinal direction.

APPROXIMATE ROOM TEMPERATURE IMPACT STRENGTH AT DIFFERENT HARDNESS LEVELS.



## Heat treatment

### Soft annealing

Protect the steel and heat through to 850–900°C (1560–1650°F). Then cool in the furnace at 10°C/h (20°F/h) to 700°C (1290°F), then freely in air.

### Stress relieving

After rough machining the tool should be heated through to 600–700°C (1110–1290°F), holding time 2 hours. Cool slowly to 500°C (930°F), then freely in air.

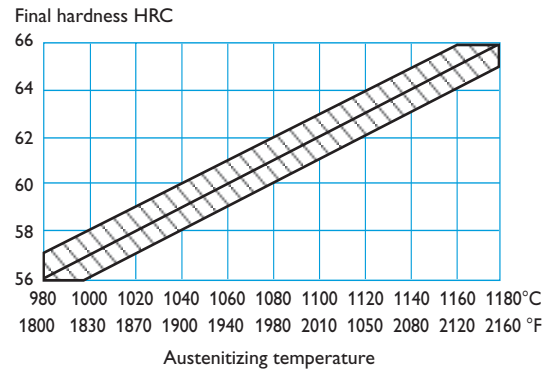
### Hardening

*Pre-heating temperature:* 450–500°C (840–930°F) and 850–900°C (1560–1650°F).

*Austenitizing temperature:* 1050–1180°C (1920–2160°F) according to the desired final hardness, see diagram below.

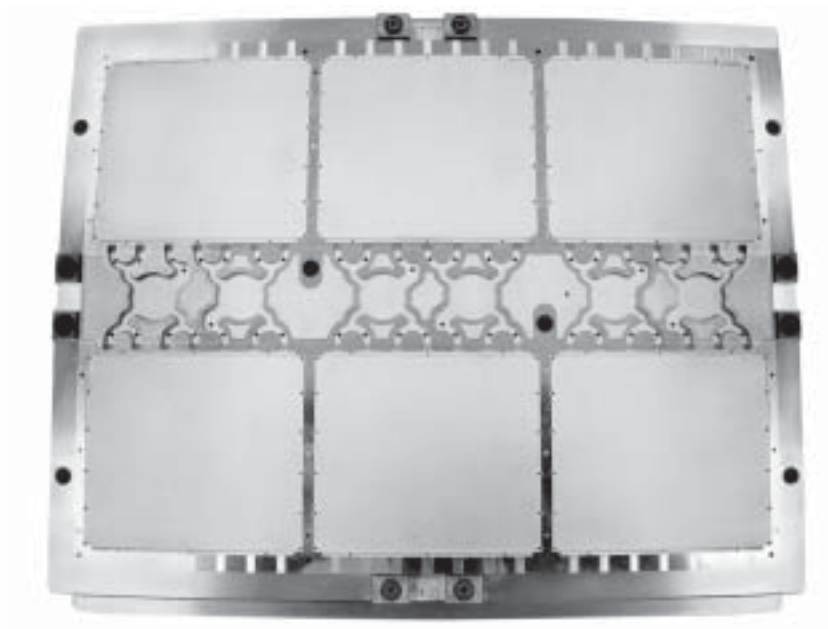
*The tool should be protected against decarburization and oxidation during hardening.*

### HARDNESS AFTER TEMPERING 3 TIMES FOR 1 HOUR AT 560°C (1040°F)



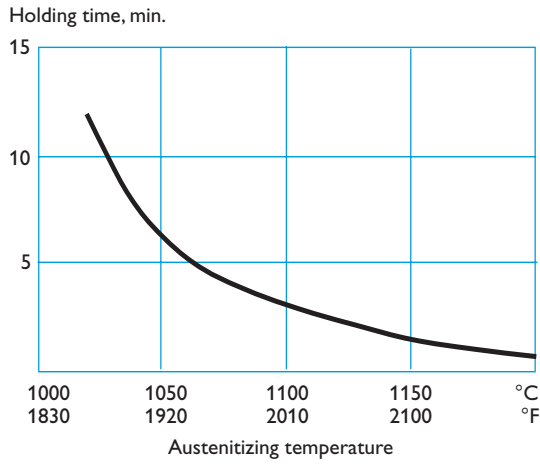
### HARDNESS AFTER DIFFERENT HARDENING TEMPERATURES AND TEMPERING 3 TIMES FOR 1 HOUR AT 560°C (1040°F).

| HRC | °C   | °F   |
|-----|------|------|
| 58  | 1020 | 1868 |
| 60  | 1060 | 1940 |
| 62  | 1100 | 2012 |
| 64  | 1140 | 2084 |
| 66  | 1180 | 2120 |

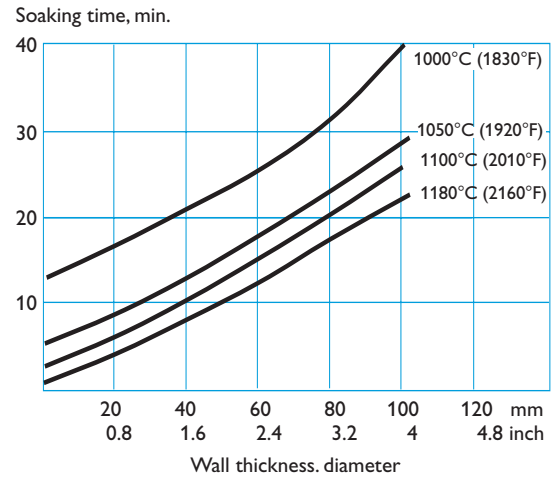


Six cavities IC encapsulation mould.

RECOMMENDED HOLDING TIME, FLUIDIZED BED, VACUUM OR ATMOSPHERE FURNACE



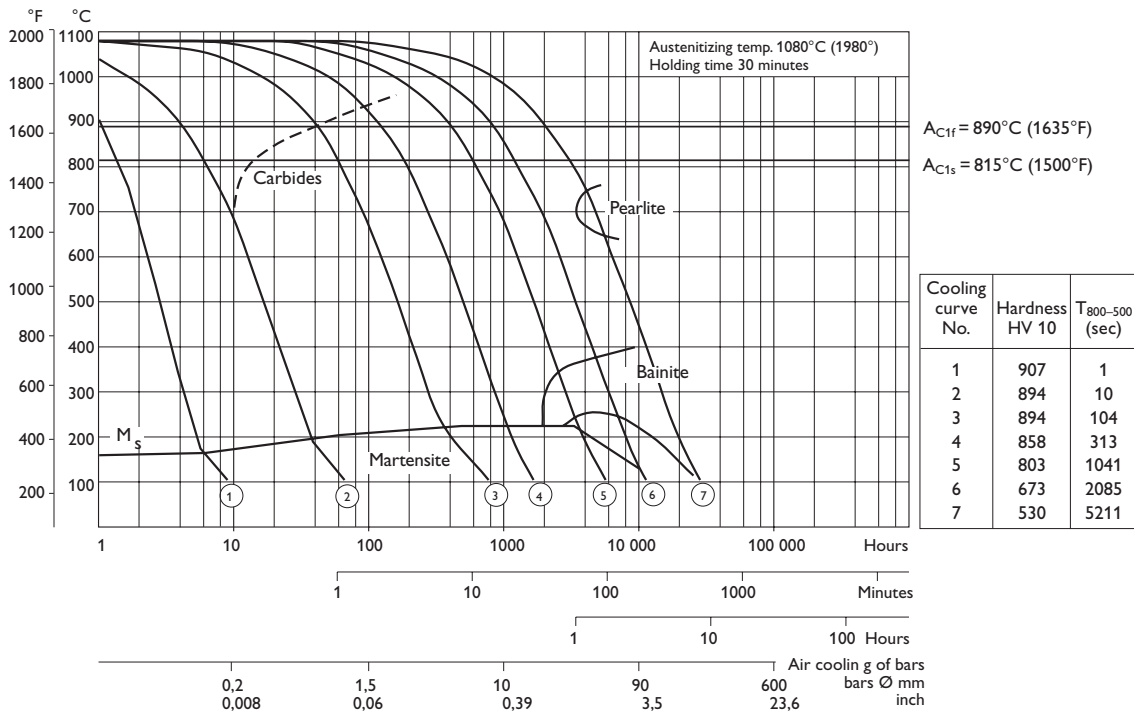
TOTAL SOAKING TIME IN A SALT BATH AFTER PRE-HEATING IN TWO STAGES AT 450°C (840°F) AND 850°C (1560°F)



**Note:** Holding time = time at austenitizing temperature after the tool is fully heated through. A holding time that is less than the recommendation mentioned above, will result in loss of hardness.

CCT-GRAPH (CONTINUOUS COOLING).

Austenitizing temperature 1080°C (1980°F). Holding time 30 minutes.



## Quenching media

- Vacuum furnace with high speed gas at sufficient overpressure (2–5 bar)
- Martempering bath or fluidized bed at approx. 550°C (1020°F)
- Forced air/gas

*Note 1:* Quenching should be continued until the temperature of the tool reaches approx. 50°C (120°F). The tool should then be tempered immediately.

*Note 2:* For applications where maximum toughness is required use a martempering bath or a furnace with sufficient overpressure.

## Tempering

For cold work applications tempering should always be carried out at 560°C (1040°F) irrespective of the austenitizing temperature. Temper three times for one hour at full temperature. The tool should be cooled to room temperature between the tempers. The retained austenite content will be less than 1% after this tempering cycle.

## Dimensional changes

Dimensional changes after hardening and tempering.

*Heat treatment:* Austenitizing between 1050–1130°C (1920–2070°F) and tempering 3 x 1 h at 560°C (1040°F).

*Specimen size:* 80 x 80 x 80 mm (3" x 3" x 3") and 100 x 100 x 25 mm (4" x 4" x 1").

*Dimensional changes:* growth in length, width and thickness +0,03% – +0,13%.

## Sub-zero treatment

Pieces requiring maximum dimensional stability can be sub-zero treated as follows:

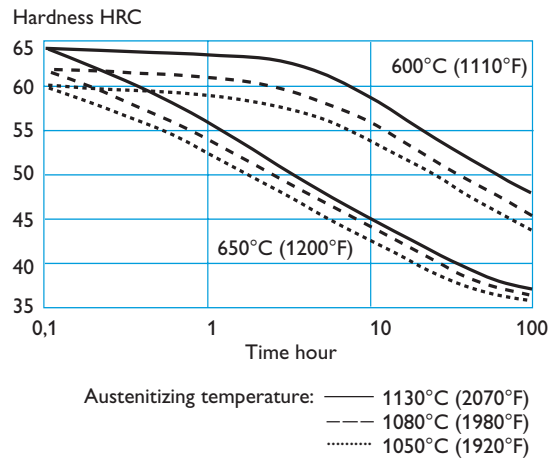
Immediately after quenching the piece should be sub-zero treated to between -70 to -80°C (-95 and -110°F), soaking time 1–3 hours, followed by tempering.

Sub-zero treatment will give a hardness increase of ~1 HRC. Avoid intricate shapes as there will be risk of cracking.

## High temperature properties

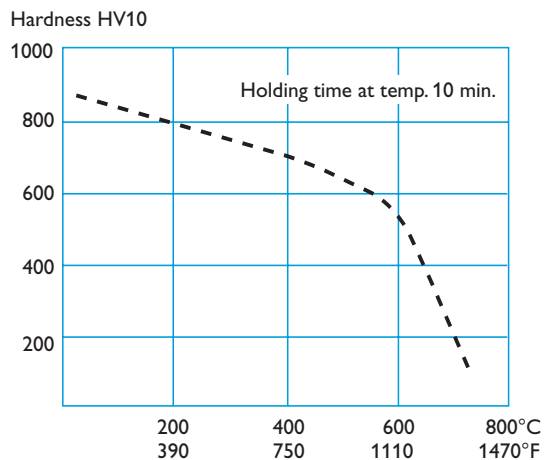
HARDNESS AS A FUNCTION OF HOLDING TIME AT DIFFERENT WORKING TEMPERATURES

Austenitizing temperature: 1050–1130°C (1920–2070°F). Tempering: 3 x 1 h at 560°C (1040°F).



## HOT HARDNESS

Austenitizing temperature: 1180°C (2160°F). Tempering: 3 x 1 h at 560°C (1040°F).



Stainless steel fastener stamped with a Uddeholm Vanadis 23 SuperClean die and Uddeholm Vanadis 4 Extra SuperClean punch

## Surface treatments

Some cold work tools are given a surface treatment in order to reduce friction and increase tool wear resistance. The most commonly used treatments are nitriding and surface coating with wear resistant layers of titanium carbide and titanium nitride (CVD, PVD).

Uddeholm Vanadis 23 SuperClean have been found to be particularly suitable for titanium carbide and titanium nitride coatings. The uniform carbide distribution in Uddeholm Vanadis 23 SuperClean facilitates bonding of the coating and reduces the spread of dimensional changes resulting from hardening. This, together with its high strength and toughness, makes Uddeholm Vanadis 23 SuperClean an ideal substrate for high-wear surface coatings.



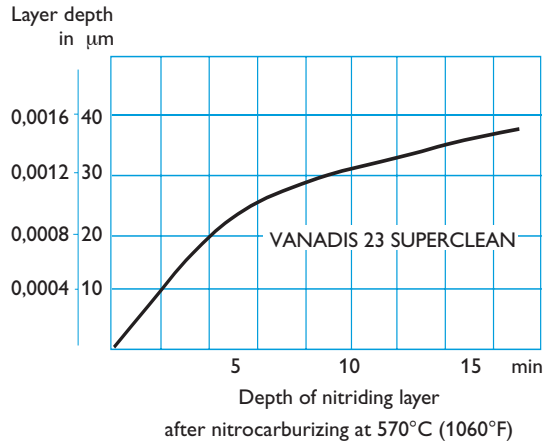
PVD coated tools in Uddeholm Vanadis 23 SuperClean for cold forming of tubes



Punches manufactured by LN's Mekaniska Verkstads AB in Sweden. Uddeholm Vanadis 23 SuperClean is a perfect steel for this application

## Nitriding

A brief immersion in a special salt bath to produce a nitrided diffusion zone of 2–20  $\mu\text{m}$  is recommended. This reduces the friction on the envelope surface of punches and has various other advantages.



## PVD

Physical vapour deposition, PVD, is a method of applying a wear-resistant coating at temperatures between 200–500°C (390–930°F). As Uddeholm Vanadis 23 SuperClean is high temperature tempered at 560°C (1040°F) there is no danger of dimensional changes during PVD coating.

## 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 should be separately hardened and tempered in a vacuum furnace after surface treatment.



## Cutting data recommendations

The cutting data below are to be considered as guiding values which must be adapted to existing local condition.

Condition: soft annealed to ~260 HB

### Turning

| Cutting data parameters                    | Turning with carbide  |  | Turning with HSS <sup>1)</sup><br>Fine turning |
|--|---|--|--|
|  | Rough turning   | Fine turning   |  |
| Cutting speed ( $v_c$ )<br>m/min<br>f.p.m. | 110–160<br>360–525  | 160–210<br>525–690   | 12–15<br>40–50                                 |
| Feed ( $f$ )<br>mm/r<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>0.002–0.012                        |
| Depth of cut ( $a_p$ )<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 ISO                    | K20<br>P10–P20<br>Coated carbide <sup>2)</sup><br>or cermet <sup>2)</sup> | P10<br>Coated carbide <sup>2)</sup><br>or cermet <sup>2)</sup> | –  |

<sup>1)</sup> High speed steel

<sup>2)</sup> Use a wear resistant CVD coating

### Drilling

#### HIGH SPEED STEEL TWIST DRILL

| Drill diameter |          | Cutting speed $v_c$ |        | Feed $f$  |             |
|----------------|----------|---------------------|--------|-----------|-------------|
| mm             | inch     | m/min.              | f.p.m. | mm/r      | i.p.r.      |
| – 5            | –3/16    | 10–12*              | 33–39* | 0.05–0.10 | 0.002–0.004 |
| 5–10           | 3/16–3/8 | 10–12*              | 33–39* | 0.10–0.20 | 0.004–0.008 |
| 10–15          | 3/8–5/8  | 10–12*              | 33–39* | 0.20–0.25 | 0.008–0.010 |
| 15–20          | 5/8–3/4  | 10–12*              | 33–39* | 0.25–0.35 | 0.010–0.014 |

\* For TiCN coated HSS drill  $v_c = 16–18$  m/min. (52–59 f.p.m.)

#### CARBIDE DRILL

| Cutting data parameters                 | Type of drill  |  |  |
|---|--|--|--|
|   | Indexable insert                                     | Solid carbide  | Carbide tip <sup>1)</sup>                            |
| Cutting speed, $v_c$<br>m/min<br>f.p.m. | 120–150<br>400–490                                   | 60–80<br>200–260                                     | 30–40<br>100–130                                     |
| Feed, $f$<br>mm/r<br>i.p.r.             | 0.05–0.15 <sup>5)</sup><br>0.002–0.006 <sup>2)</sup> | 0.10–0.25 <sup>3)</sup><br>0.004–0.010 <sup>3)</sup> | 0.15–0.25 <sup>4)</sup><br>0.006–0.010 <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”)

### Milling

#### FACE AND SQUARE SHOULDER MILLING

| Cutting data parameters                    | Milling with carbide        |   |
|--|-----------------------------|---|
|  | Rough milling               | Fine milling                              |
| Cutting speed ( $v_c$ )<br>m/min<br>f.p.m. | 80–130<br>260–425           | 130–160<br>425–525                        |
| Feed ( $f_z$ )<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 ( $a_p$ )<br>mm<br>inch       | 2–4<br>0.08–0.16            | –12<br>–0.08                              |
| Carbide designation ISO                    | K20, P20<br>Coated carbide* | K15, P15<br>Coated carbide*<br>or cermet* |

\* Use a wear resistant CVD coating

#### END MILLING

| Cutting data parameters                    | Type of mill   |   |  |
|--|--|---|--|
|  | Solid carbide  | Carbide indexable insert  | High speed steel                                     |
| Cutting speed ( $v_c$ )<br>m/min<br>f.p.m. | 40–50<br>130–165                                     | 90–110<br>295–360   | 5–8 <sup>1)</sup><br>16–26 <sup>1)</sup>             |
| Feed ( $f_z$ )<br>mm/tooth<br>inch/tooth   | 0.01–0.2 <sup>2)</sup><br>0.0004–0.008 <sup>2)</sup> | 0.06–0.2 <sup>2)</sup><br>0.002–0.008 <sup>2)</sup>                       | 0.01–0.3 <sup>3)</sup><br>0.0004–0.012 <sup>2)</sup> |
| Carbide designation ISO                    | –  | K15<br>P10–P20<br>Coated carbide <sup>3)</sup><br>or cermet <sup>3)</sup> | –  |

<sup>1)</sup> For coated HSS end mill  $v_c = 14–18$  m/min. (46–59 f.p.m.)

<sup>2)</sup> Depending on radial depth of cut and cutter diameter

<sup>3)</sup> Use a wear resistant CVD coating

### Grinding

General grinding wheel recommendation is given below. More information can be found in the Uddeholm publication “Grinding of Tool Steel”.

| Type of grinding             | Annealed condition | Hardened condition                     |
|------------------------------|--------------------|--|
| Face grinding straight wheel | A 46 HV            | B151 R50 B3 <sup>1)</sup><br>A 46 HV   |
| Face grinding segments       | A 36 GV            | A 46 GV                                |
| Cylindrical grinding         | A 60 KV            | B151 R50 B3 <sup>1)</sup><br>A 60 KV   |
| Internal grinding            | A 60 JV            | B151 R75 B3 <sup>1)</sup><br>A 60 IV   |
| Profile grinding             | A 100 IV           | B126 R100 B6 <sup>1)</sup><br>A 100 JV |

<sup>1)</sup> If possible use CBN wheels for this application

## Electrical-discharge machining

If EDM is performed in the hardened and tempered condition, finish with “fine-sparking”, i.e. low current, high frequency. For optimal performance the EDM’d surface should then be ground/polished and the tool retempered at approx. 535°C (995°F).



Tooling parts for canning industry

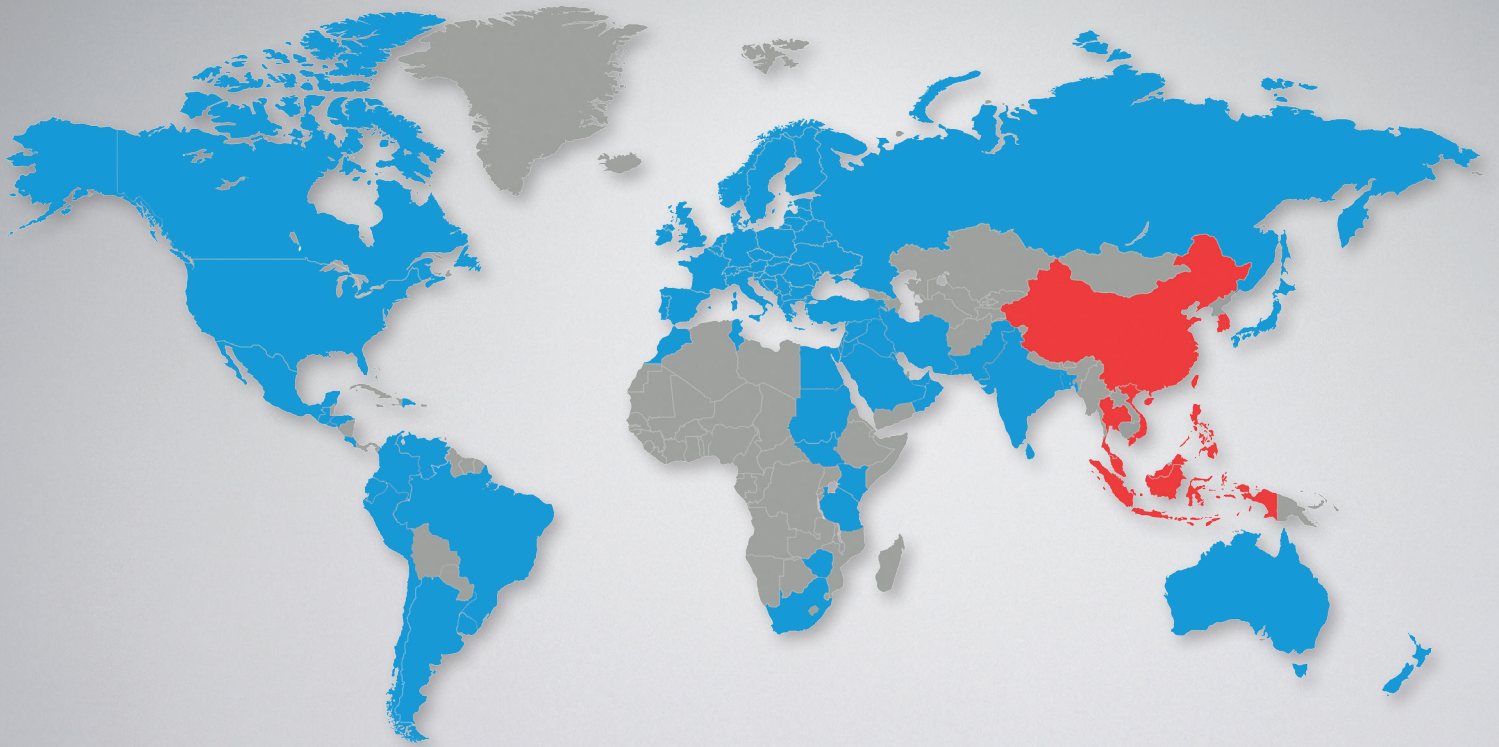
## Relative comparison of Uddeholm cold work tool steel

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 |
| Conventional cold work tool steel     |  |               |              |                     |               |               |                                      |                              |
| ARNE                                  | ██████   | ██████        | ██████       | ██                  | ██            | ██            | ██                                   | ██████                       |
| CALMAX                                | ██████   | ██████        | ██████       | ██████              | ██            | ██████        | ██████                               | ██████                       |
| CALDIE (ESR)                          | ██████   | ██████        | ██████       | ██████              | ██            | ██████        | ██████                               | ██████                       |
| RIGOR                                 | ██████   | ██████        | ██████       | ██████              | ██            | ██            | ██                                   | ██████                       |
| SLEIPNER                              | ██████   | ██████        | ██████       | ██████              | ██████        | ██████        | ██                                   | ██████                       |
| SVERKER 21                            | ██████   | ██            | ██           | ██                  | ██████        | ██            | ██                                   | ██████                       |
| SVERKER 3                             | ██████   | ██            | ██           | ██                  | ██████        | ██            | ██                                   | ██                           |
| Powder metallurgical tool steel       |  |               |              |                     |               |               |                                      |                              |
| VANADIS 4 EXTRA                       | ██████   | ██████        | ██████       | ██████              | ██████        | ██████        | ██████                               | ██████                       |
| VANADIS 6                             | ██████   | ██            | ██           | ██████              | ██████        | ██████        | ██                                   | ██                           |
| VANADIS 10                            | ██████   | ██            | ██           | ██████              | ██████        | ██████        | ██                                   | ██                           |
| VANCRON 40                            | ██████   | ██████        | ██████       | ██████              | ██████        | ██████        | ██████                               | ██████                       |
| Powder metallurgical high speed steel |  |               |              |                     |               |               |                                      |                              |
| VANADIS 23                            | ██████   | ██            | ██           | ██████              | ██████        | ██████        | ██                                   | ██                           |
| VANADIS 30                            | ██████   | ██            | ██           | ██████              | ██████        | ██████        | ██                                   | ██                           |
| VANADIS 60                            | ██████   | ██            | ██           | ██████              | ██████        | ██████        | ██                                   | ██                           |
| Conventional high speed steel         |  |               |              |                     |               |               |                                      |                              |
| AISI M2                               | ██████   | ██            | ██           | ██████              | ██████        | ██            | ██                                   | ██                           |

## 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 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 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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