# UDDEHOLM
# VANCRON® 40 SUPERCLEAN

UDDEHOLM

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Uddeholm Vancron 40 SuperClean is a nitrided powder tool steel, which means that a "surface coating" is already integrated into the finished tooling material. The result is a tool surface with very low friction that reduces galling or sticking of the material.

Uddeholm Vancron 40 SuperClean offers the possibility of eliminating time- and cost-consuming surface coatings like CVD, PVD or TD. This is achieved already in the manufacturing process of Uddeholm Vancron 40 SuperClean by introducing an extra nitriding operation.

Benefits for the tool user include improved and consistent quality of the manufactured parts, especially regarding the surfaces. More reliable delivery time and higher utilization of the production equipment are also benefits, with fewer disturbances and interruptions in production. Further improvements include simplified maintenance, which can often be made in-house as no surface coating is required; and as well, total tool life is increased.

The tool maker can produce a high quality tool that does not require any surface coating, which means a shorter delivery time and freedom to make adjustments after the heat treatment.

In total this means that the product quality will be uniform from the first part produced to the last and that a tool manufactured in Uddeholm Vancron 40 SuperClean will make it easier for you to keep your promises!





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

Edition 10, Revised 01.2014, not printed
The latest revised edition of this brochure is the English version, which is always published on our web site www.uddeholm.com

SS-EN ISO 9001
SS-EN ISO 14001

# Critical tool steel properties

## For good tool performance

In many cold work applications tools are surface coated in order to prevent galling and adhesive wear.

Furthermore it is important to have the correct hardness for the applications as well as a sufficient ductility and toughness in order to prevent premature failure due to chipping/ crack formation.

Uddeholm Vancron 40 SuperClean is a nitrided powder metallurgical tool steel offering an excellent combination of galling resistance and adhesive wear resistance.

## For tool making

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

Tool making 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 tool making.

The powder manufacturing route used for Uddeholm Vancron 40 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 Vancron 40 SuperClean in heat treatment is good and predictable compared to conventionally produced high alloy steel.

Uddeholm Vancron 40 SuperClean is designed to be used without surface coating as it contains a high amount of low friction vanadium rich nitrides in the matrix.

# Applications

Uddeholm Vancron 40 SuperClean is a cold work tool steel with an excellent galling/adhesive wear profile, which makes the steel ideal for severe production conditions and/or long run production in applications where surface coated tool steel is needed. The work materials in these applications are often soft/adherent materials such as austenitic and ferritic stainless steel, mild steel, copper, aluminium, etc.

Uddeholm Vancron 40 SuperClean should be used in cold work applications where the predominant failure mechanisms are adhesive wear or galling.

Typical applications are:

- Blanking and forming
- Cold extrusion
- Deep drawing
- Powder pressing
- An alternative to tooling when coatings and cemented carbide used to be the only solution

# General

Uddeholm Vancron 40 SuperClean is a Cr-Mo-W-V-N alloyed cold work tool steel, which is characterized by

- Very high adhesive wear resistance
- Very high galling resistance
- Good chipping and cracking resistance
- High compressive strength
- Good through hardening properties
- Good dimensional stability in hardening
- Very good resistance to tempering back
- Good WEDM properties

| Typical analysis % | C 1.1 | N 1.8 | Si 0.5 | Mn 0.4 | Cr 4.5 | Mo 3.2 | W 3.7 | V 8.5 |
|---|---|---|---|---|---|---|---|---|
| Standard specification | None | | | | | | | |
| Delivery condition | Soft annealed to approx. 300 HB | | | | | | | |
| Colour code | Gold/ Dark blue | | | | | | | |

# Properties

## Physical data

After hardening and tempering to 61 HRC

| Temperature | 20°C (68°F) | 200°C (390°F) | 400°C (750°F) |
|---|---|---|---|
| Density<br>kg/m³<br>lbs/in³ | 7 700<br>0.278 | – | – |
| Modulus of elasticity<br>MPa<br>psi | 236 000<br>35.2 x $10^6$ | 227 000<br>32.9 x $10^6$ | 213 000<br>30.9 x $10^6$ |
| Coefficient of thermal expansion per<br>°C from 20°C<br>°F from 68°F | – | 11.1 x $10^{-6}$<br>6.1 x $10^{-6}$ | 11.9 x $10^{-6}$<br>6.6 x $10^{-6}$ |
| Thermal conductivity<br>W/m •°C<br>Btu in/ft² h °F | – | 21 ±2<br>145 ±14 | 25 ±0.5<br>173 ±3 |
| Specific heat<br>J/kg °C<br>Btu /lb °F | 460<br>0.11 | – | – |

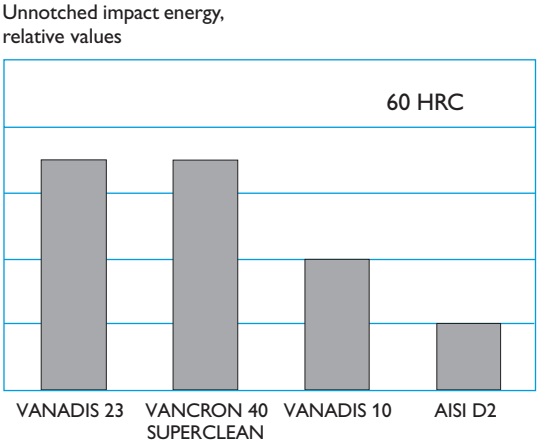
## Compressive strength

Approximately compressive strength vs. hardness is shown in the table below.

| Hardness HRC | Compressive yield strength Rc0.2 (MPa) |
|---|---|
| 58 | 2200 |
| 60 | 2500 |
| 62 | 2700 |
| 64 | 3000 |

## Unnotched impact energy

Unnotched impact energy for Uddeholm Vanadis 23, Uddeholm Vancron 40 SuperClean, Uddeholm Vanadis 10, and AISI D2 is shown below.




# Heat treatment

## Soft annealing

Protect the steel and heat through to 900°C (1650°F). Then cool in the furnace at 10°C/h (20°F/h) to 650°C (1200°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

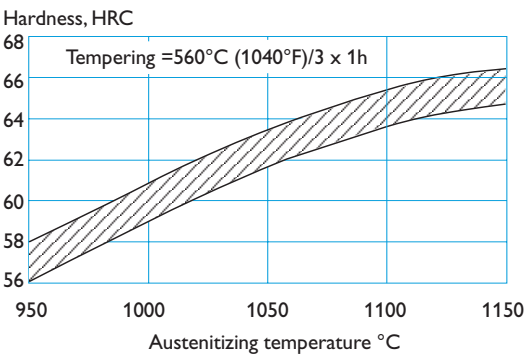
The hardenability for Uddeholm Vancron 40 SuperClean is equivalent to Uddeholm Vanadis 23, which ensures good through hardening properties at quenching in salt bath or gas quenching in vacuum furnace.

*Pre-heating in two stages:* 600–650°C (1110–1200°F) and 850–900°C (1560–1650°F).
*Austenitizing temperature:* 950–1150°C (1740–2100°F) normally 1020°C (1870°F).
*Holding time:* 30 minutes (10 minutes at 1100°C (2010°F) and above.

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

In some cases denitriding should also be considered. To avoid loss of nitrogen, which may lower the surface hardness, a minimum of 10 mbar and up to 3–400 mbar nitrogen overpressure is recommended during hardening. Alternatively the machining allowance could be increased.

Uddeholm Vancron 40 SuperClean can be heat treated to give a wide range of hardness. To achieve a hardness between 58–65 HRC the austenitizing temperature is varied in the range 950–1150°C (1740–2100°F). The recommended austenitizing temperature is 1020°C

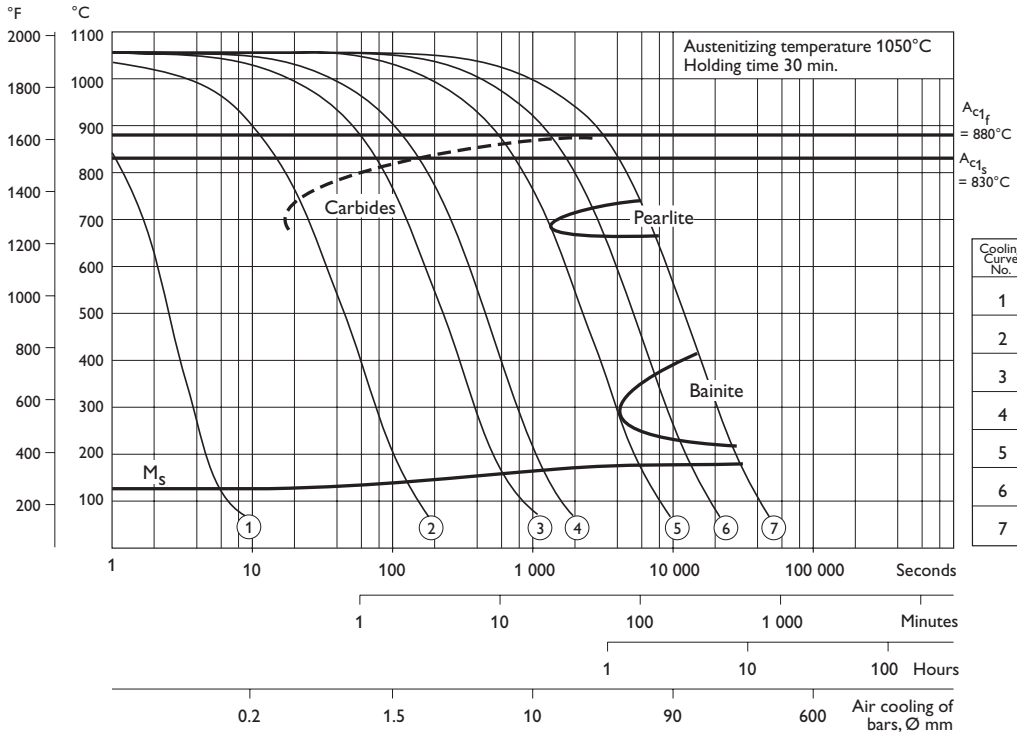


(1865°F) with 30 minutes holding time followed by quenching and tempering at 560°C (1040°F)/
3 x 1 h resulting in a hardness of 60–62 HRC.

In order to avoid a too low working hardness it is recommended to austenitize at a higher hardening temperature than normal and if the hardness will be too high temper down the hardness to the right hardness level.

## CCT-GRAPH (CONTINUOUS COOLING)

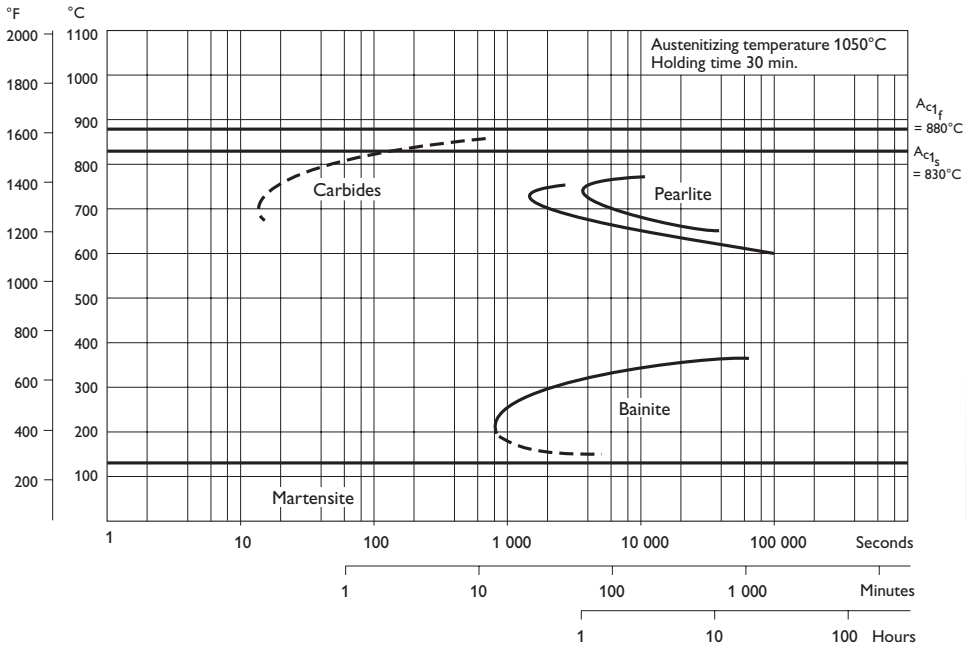
Austenitizing temperature 1050°C (1920°F). Holding time 30 minutes.




| Cooling Curve No. | Hardness HV 10 | $T_{800-500}$ (sec) |
|---|---|---|
| 1 | 882 | 1 |
| 2 | 882 | 28 |
| 3 | 882 | 140 |
| 4 | 882 | 280 |
| 5 | 882 | 1390 |
| 6 | 762 | 3205 |
| 7 | 493 | 7320 |

## TTT-GRAPH (ISOTHERMAL TRANSFORMATION)

Austenitizing temperature 1050°C (1920°F). Holding time 30 minutes.




| Temp. °C | Time hours | Hardn. HV 10 |
|---|---|---|
| 750 | 4,9 | 354 |
| 725 | 1,6 | 383 |
| 700 | 14,1 | 383 |
| 650 | 14,5 | 433 |
| 600 | 63,3 | 613 |
| 400 | 8,1 | 946 |
| 350 | 6,5 | 657 |
| 300 | 7,7 | 620 |
| 250 | 2,0 | 933 |
| 200 | 20,1 | 858 |

## 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.

*Note 3:* We always recommend a sub-zero treatment when a hardening temperature above 1100°C (2100°F) has been used, see details in the paragraph to the right.

## 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 3% after this tempering cycle.

## Dimensional changes

Dimensional changes after hardening and tempering.
*Heat treatment:* austenitizing between 950–1100°C (1740–2010°F)/30 minutes and tempering 3 x 1 h at 560°C (1040°F).
*Specimen size:* 50 x 50 x 50 mm (2" x 2" x 2") and 100 x 40 x 20 mm (4" x 1,5" x 1").
*Dimensional changes:* growth in length, width and thickness +0.04% to +0.20%.

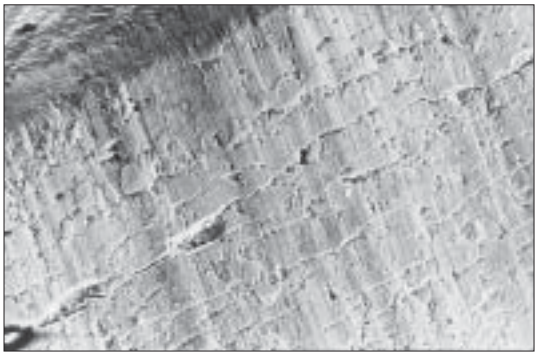
## Sub-zero treatment

Tools requiring maximum dimension stability in service can be sub-zero treated as follows:

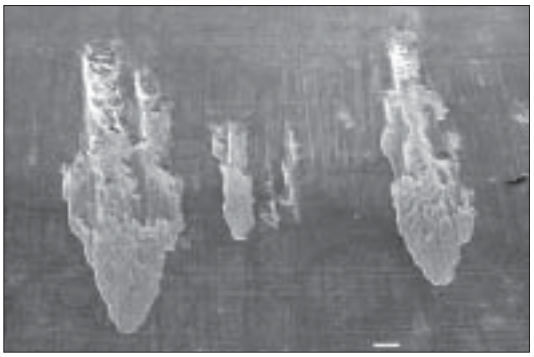
For the highest requirements on dimensional stability sub-zero treatment in liquid nitrogen is recommended after quenching and after each tempering at 560°C.

In less critical cases the tool should be sub-zero treated immediately after quenching to at least -70°C (-95°F), soaking time 1–3 h, followed by tempering at 560°C (1040°F) 1 hour x three times.

The sub-zero treatment leads to a reduction of the retained austenite content. For a high hardening temperature, > 1100°C (2010°F), we always recommend sub-zero treatment followed by four temperings at 560°C (1040°F) 1 hour, in order to reduce the retained austenite and improve the dimensional stability.



Adhesive wear.



Galling.

# Surface treatments

*Note:* Uddeholm Vancron 40 SuperClean is designed to be used without surface coating as it contains a high amount of nitrogen and has already a form of internal surface coating.

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).

If extremely good resistance to galling is required in severe forming operations, Uddeholm Vancron 40 SuperClean can be surface coated like other PM steels. Recommended treatment is PVD with Ti(C, N) or TiAlN.

## Nitriding

A brief immersion in a special salt bath to produce a nitrided diffusion zone of 2–20 µm 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 Vancron 40 SuperClean is high temperature tempered at 560°C (1040°F) there is no danger of dimensional changes during PVD coating.

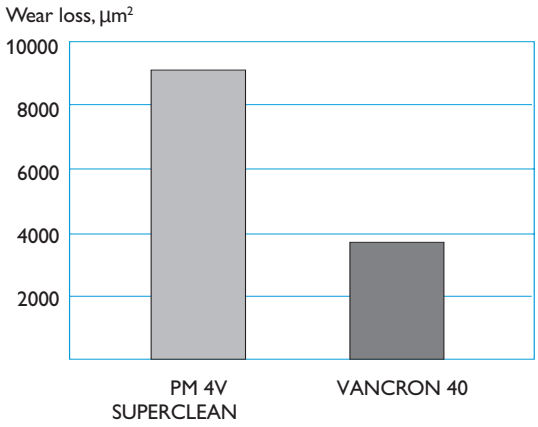
## CVD

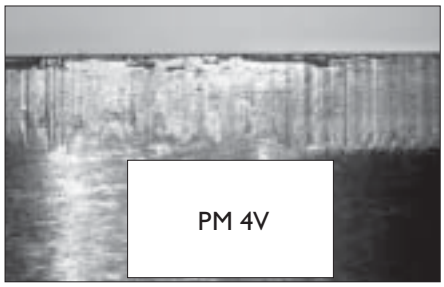
Chemical vapour deposition, CVD, is used for applying wear resistant surface coatings at a temperature of around 1000°C (1830°F). It is recommended that the tools should be separately hardened and tempered in a vacuum furnace after surface treatment.

## Wear resistance

ADHESIVE WEAR

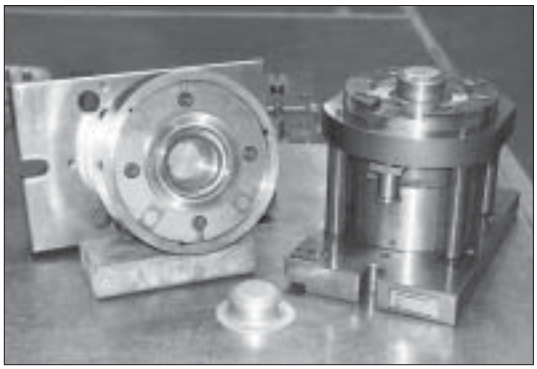
Wear resistance comparison.
*Component:* laboratory test strip.
*Tool type:* blanking punch.
*Tool dimension:* 10 x 40 mm.
*Work material:* 18/8 stainless steel SS 2331 1 mm thick.




## Tribological properties—Case Study

Cold forming die for producing a part of stainless steel for pump housing.
Courtesy: Grundfos A/S, Denmark.



RESULTS

| Uddeholm Steel / Surface coating | VANADIS 23 Uncoated | VANADIS 10 Uncoated | VANCRON 40 SUPERCLEAN Uncoated |
|---|---|---|---|
| Part Produced | 83 000 | 1 900 000 | >18 000 000 |
| Hardness HRC | 62 | | 64 |
| Failure mechanism | Galling | | Still running |

| Uddeholm Steel / Surface coating | VANADIS 23 Salt bath nitriding | PVD TiN | CVD TiC/TiN |
|---|---|---|---|
| Part Produced | 160 000 | 130 000 | 2 000 000 |
| Hardness HRC | 62 | | |
| Failure mechanism | Galling | | Delamination |

# Cutting data recommendations

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

Further information can be found in the Uddeholm publication "Cutting data recommendations".

## Turning

| Cutting data parameters | Turning with carbide: Rough turning | Turning with carbide: Fine turning | Turning with HSS: Fine turning |
|---|---|---|---|
| Cutting speed ($v_c$) m/min<br>f.p.m. | 110–160<br>361–525 | 160–200<br>525–660 | 20–25<br>22–83 |
| Feed (f) 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 ($a_p$) 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* Coated carbide | K15* Coated carbide or cermet | – |

* Use a wear resistant $Al_2O_3$ coated carbide grade

## Drilling

HIGH SPEED STEEL TWIST DRILL

| Drill diameter mm | Drill diameter inch | Cutting speed $v_c$ m/min. | Cutting speed $v_c$ f.p.m. | Feed f mm/r | Feed f i.p.r. |
|---|---|---|---|---|---|
| – 5 | –3/16 | 12–14* | 40–46* | 0.05–0.10 | 0.002–0.004 |
| 5–10 | 3/16–3/8 | 12–14* | 40–46* | 0.10–0.20 | 0.004–0.008 |
| 10–15 | 3/8–5/8 | 12–14* | 40–46* | 0.20–0.25 | 0.008–0.010 |
| 15–20 | 5/8–3/4 | 12–14* | 40–46* | 0.25–0.35 | 0.010–0.014 |

* For coated HSS drill $v_c$ = 22–24 m/min. (72–79 f.p.m.)

CARBIDE DRILL

| Cutting data parameters | Type of drill: Indexable insert | Type of drill: Solid carbide | Type of drill: Brazed carbide[1] |
|---|---|---|---|
| Cutting speed, $v_c$ m/min<br>f.p.m. | 140–160<br>462–528 | 80–100<br>264–330 | 50–60<br>165–197 |
| Feed, f mm/r<br>i.p.r. | 0.05–0.15[2]<br>0.002–0.006[2] | 0.10–0.25[2]<br>0.004–0.010[3] | 0.15–0.25[2]<br>0.006–0.010[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")

## 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. | 80–100<br>262–330 | 100–120<br>330–396 |
| 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 | –2<br>–0.08 |
| Carbide designation ISO | K20*<br>Coated carbide | K15*<br>Coated carbide or cermet |

* Use a wear resistant $Al_2O_3$ coated carbide grade

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>132–164 | 70–90<br>230–297 | 12–15[1]<br>40–50[1] |
| Feed ($f_z$)<br>mm/tooth<br>inch/tooth | 0.01–0.2[2]<br>0.0004–0.008[2] | 0.06–0.2[2]<br>0.002–0.008[2] | 0.01–0.3[2]<br>0.0004–0.012[2] |
| Carbide designation ISO | – | K15[3] | – |

[1] For coated HSS end mill $v_c$ = 20–30 m/min. (66–99 f.p.m.)
[2] Depending on radial depth of cut and cutter diameter
[3] Use a wear resistant $Al_2O_3$ coated carbide grade

## 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[1]<br>A 46 HV |
| Face grinding segments | A 36 GV | A 46 GV |
| Cylindrical grinding | A 60 KV | B151 R50 B3[1]<br>A 60 KV |
| Internal grinding | A 60 JV | B151 R75 B3[1]<br>A 60 IV |
| Profile grinding | A 100 IV | B126 R100 B6[1]<br>A 100 JV |

[1] If possible use CBN wheels for this application

# Electrical-discharge machining, EDM

Tools of Uddeholm Vancron 40 SuperClean can be produced with Electrical Discharge Machining (EDM) as long as the EDM layer is carefully removed. Fine grinding and polishing, and retempering the tool at approx. 535°C (995°F) is recommended.

Due to the extremely high nitrogen content in the steel, there are some general recommendations to be followed

## Power settings

A coarse pass with high power can result in release of nitrogen from the steel causing pitting.

As a general rule of thumb the EDM'ing of Uddeholm Vancron 40 SuperClean should be done with medium or fine passes using lower power setting.

## Flushing

N-alloyed PM steels put higher demands on the flushing conditions. The On/Off time ratio shouldbe low, i.e. shorter On time and longer Off time.

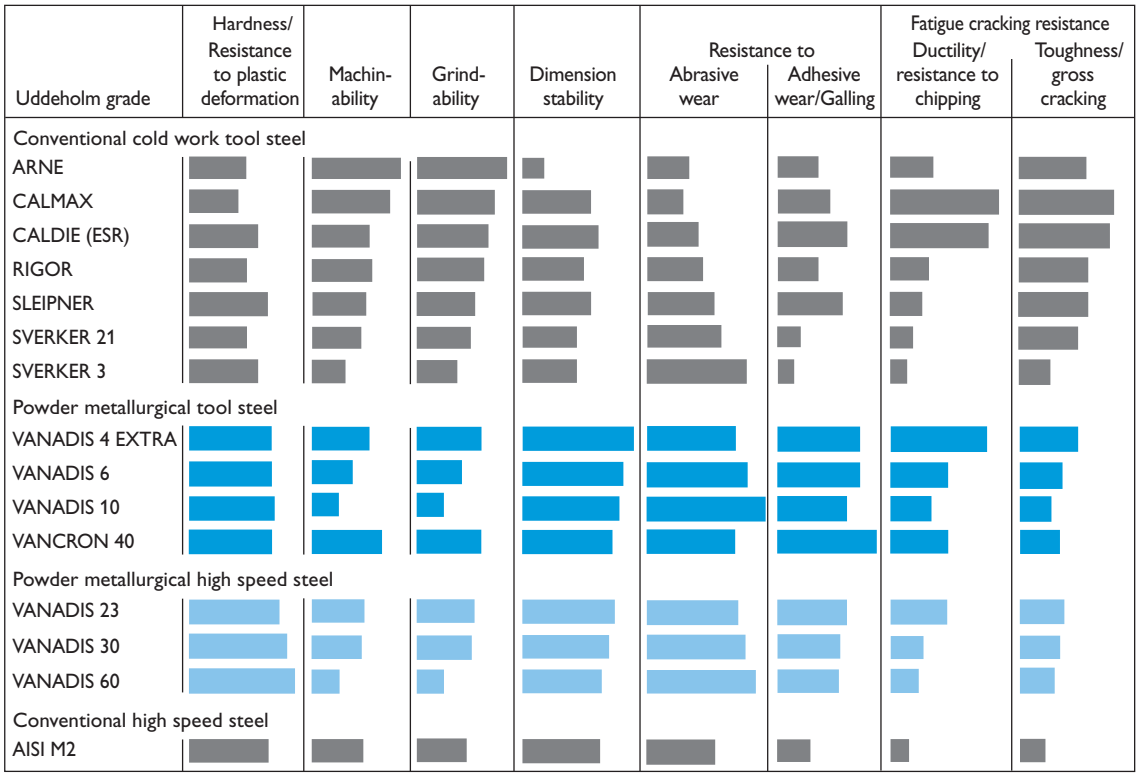
A general rule of thumb is that Off time should be twice the On time. When possible, use flushing through the electrode or through holes in the work piece. Higher viscosity of the dielectric liquid is also preferable due to better transportation of removed particles (can also give shorter EDM time and better surface finish).

## Electrodes

For rough EDM operations graphite electrodes are recommended, preferably of high quality (small grain size, and/or Cu impregnated). A switched polarity might reduce sticking on electrode if that happens. For fine EDM use Cu or W/Cu electrodes. When Graphite electrodes must be used in fine EDM, high quality (small grain size, and/or Cu impregnated) is recommended.

# 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. For more information, please visit www.uddeholm.com

# 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.

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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, www.assab.com or your local website.

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