Uddeholm Vanadis® 23 SuperClean

UDDEHOLM
a voestalpine company

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.

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

Edition 12, 04.2019

CERTIFIED
ISO 9001 · OHSAS 18001
ISO 14001 · ISO 50001

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 alloy cold work tool steels.

The dimensional stability of Uddeholm Vanadis 23 SuperClean in heat treatment is excellent and predictable compared to conventionally produced high alloy steels. 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.

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.:

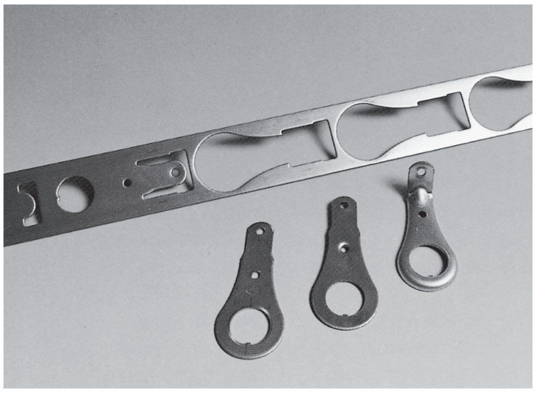
- Blanking of medium to high carbon steel
- Blanking of harder materials such as hardened or cold-rolled strip steel
- Plastics mould tooling subjected to abrasive wear condition
- Plastics processing parts, e.g. feed screws, barrel liners, nozzles, screw tips, non-return check ring valves, pellitizer 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 1.28	Cr 4.2	Mo 5.0	W 6.4	V 3.1
Standard specification	AISI M3:2, (W.-Nr. 1.3395)				
Delivery condition	Soft annealed to approx. 260 HB Drawn max. 320 HB				
Colour code	Violet				



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

PROPERTIES

PHYSICAL DATA

Hardened and tempered condition.

Temperature	20°C (68°F)	400°C (750°F)	600°C (1110°F)
Density kg/m^3 lbs/in^3	7980 0.287	7870 0.283	7805 0.281
Modulus of elasticity MPa ksi	230 000 33×10^3	205 000 30×10^3	184 000 27×10^3
Thermal conductivity W/m•°C Btu in/ft² h °F	24 166	28 194	27 187
Specific heat J/kg °C Btu /lb °F	420 0.10	510 0.12	600 0.14

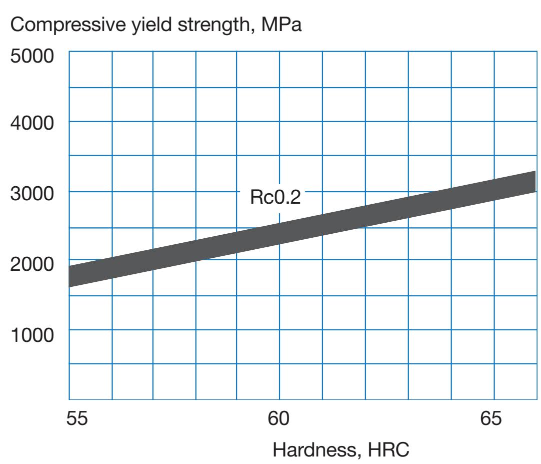
COEFFICIENT OF THERMAL EXPANSION

Temperature range		Coefficient	
°C	°F	°C from 20	°F from 68
20–100	68–212	10.8×10^{-6}	6.0×10^{-6}
20–200	68–392	11.1×10^{-6}	6.2×10^{-6}
20–300	68–572	11.4×10^{-6}	6.3×10^{-6}
20–400	68–752	11.8×10^{-6}	6.6×10^{-6}
20–500	68–932	12.1×10^{-6}	6.7×10^{-6}
20–600	68–1112	12.3×10^{-6}	6.8×10^{-6}

COMPRESSIVE YIELD STRENGTH

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

APROXIMATE COMPRESSIVE YIELD STRENGTH VERSUS HARDNESS AT ROOM TEMPERATURE



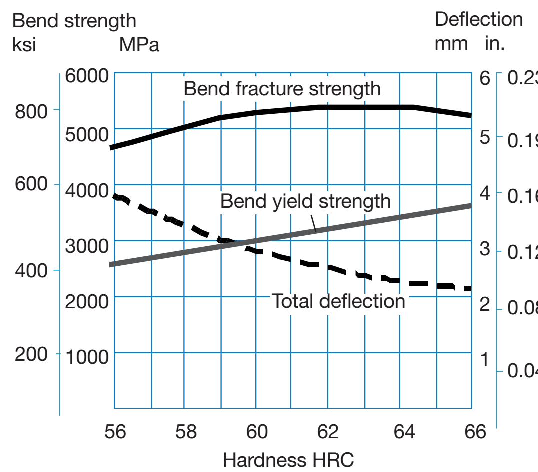
BEND STRENGTH AND DEFLECTION

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

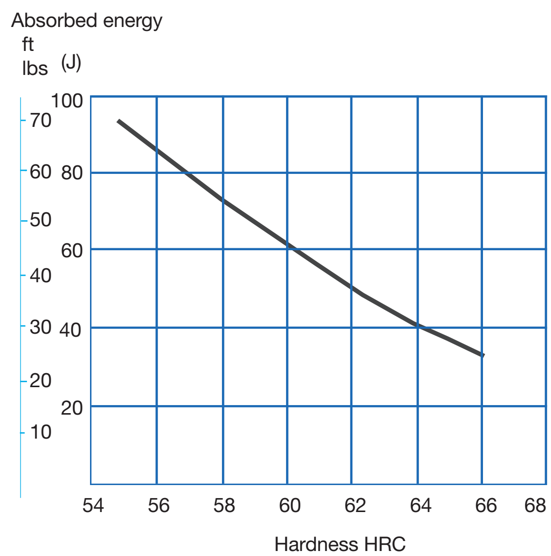
Specimen size: 7 x 10 x 55 mm (0.27" x 0.40" x 2.2")

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.

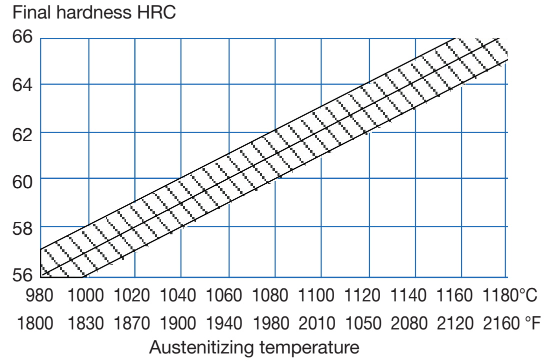
HARDENING

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.

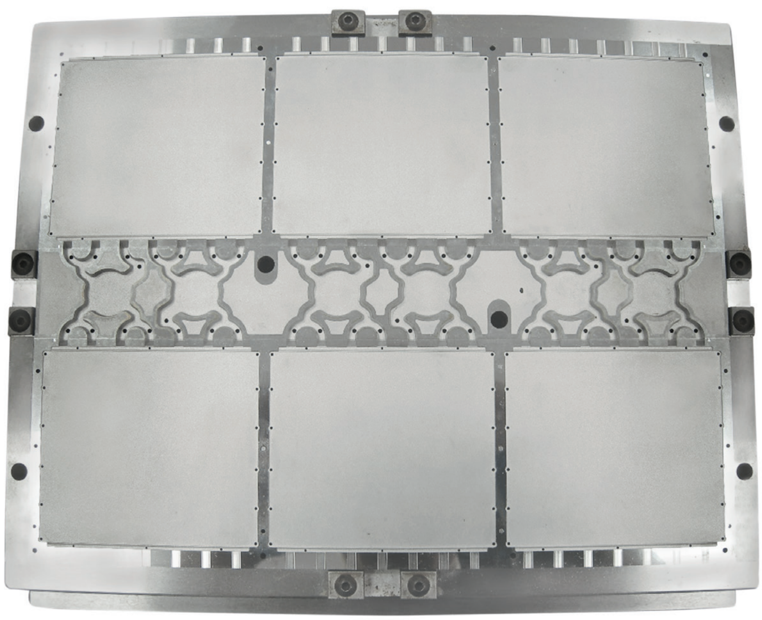
The tool should be protected against decarburization and oxidation during hardening.

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



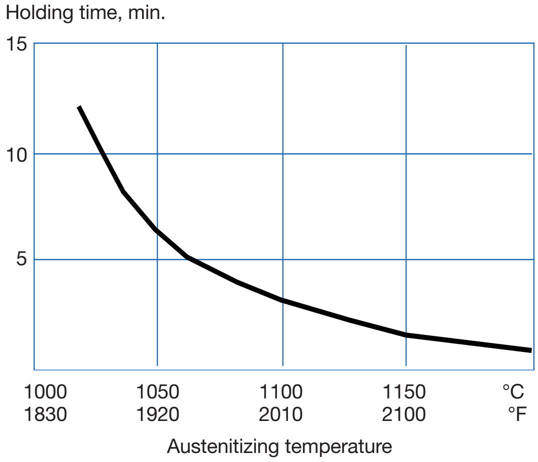
HARDNESS AFTER DIFFERENT HARDENING TEMPERATURES AND TEMPERING 3 TIMES FOR 1 HOUR AT 560°C (1040°F)

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

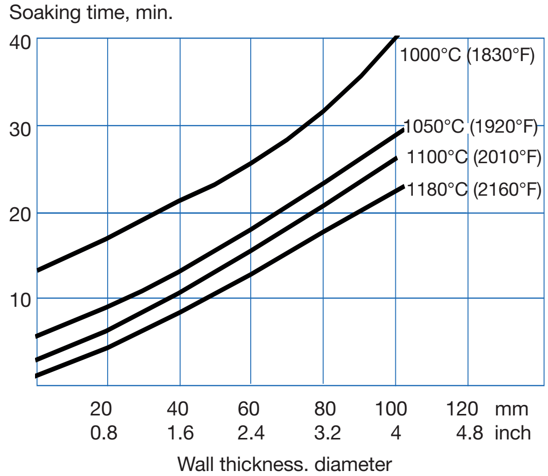


Six cavities IC encapsulation mould.

RECOMMENDED HOLDING TIME, FLUIDIZED BED, VACUUM OR ATMOSPHERE FURNACE



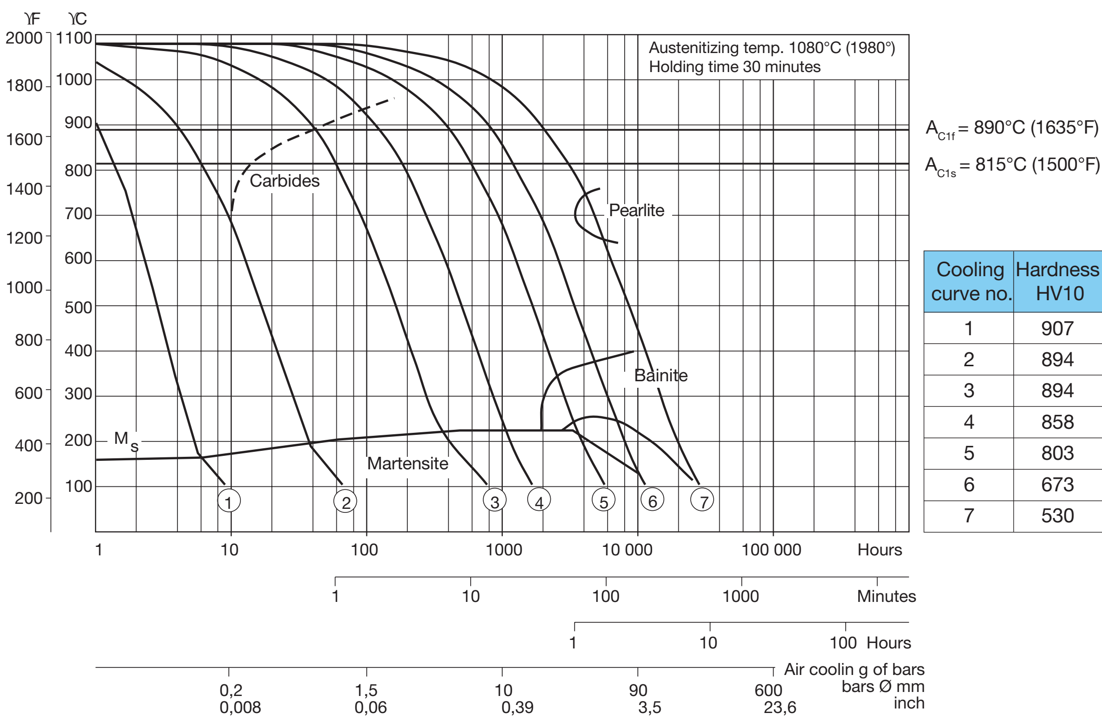
TOTAL SOAKING TIME IN A SALT BATH AFTER PRE-HEATING IN TWO STAGES AT 450°C (840°F) AND 850°C (1560°F)



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.



Cooling curve no.	Hardness HV10	T800-500 (sec)
1	907	1
2	894	10
3	894	104
4	858	313
5	803	1041
6	673	2085
7	530	5211

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 tem-perature. 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 sta-bility 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 h, followed by tempering.

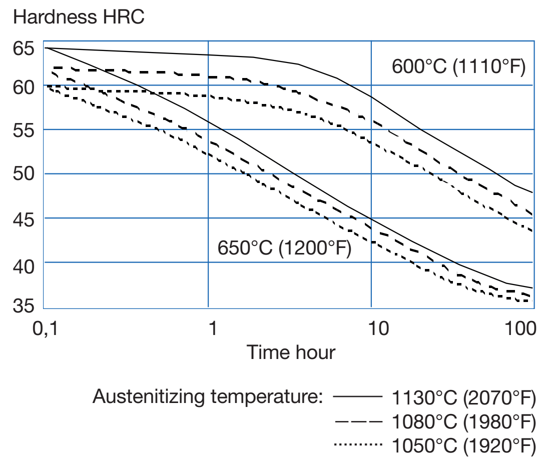
Sub-zero treatment will give a hardness increase of ~1 HRC. Avoid intricate shapes as there will be risk of cracking.

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

HIGH TEMPERATURE PROPERTIES

HARDNESS AS A FUNCTION OF HOLDING TIME AT DIFFERENT WORKING TEMPERATURES

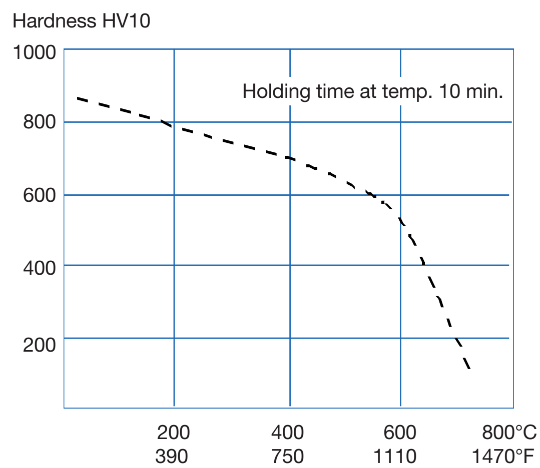
Austenitizing temperature: 1050–1130°C (1920–2070°F). Tempering: 3 x 1 h at 560°C (1040°F).

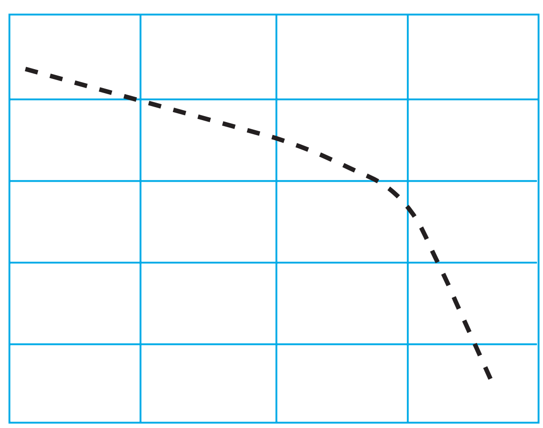


HOT HARDNESS

Austenitizing temperature: 1180°C (2160°F).

Tempering: 3 x 1 h at 560°C (1040°F).

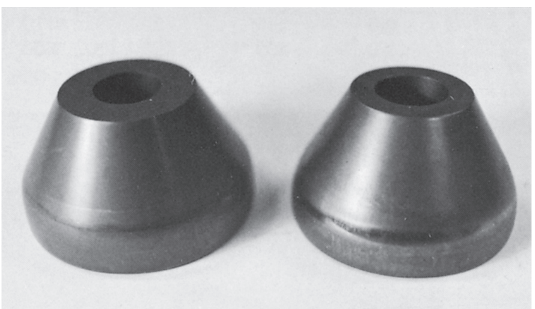




SURFACE TREATMENTS

Some cold work tools are given a surface treatment in order to reduce friction and in-crease 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 harde-ning. This, together with its high strength and toughness, makes Uddeholm Vanadis 23 SuperClean an ideal substrate for high-wear surface coatings.

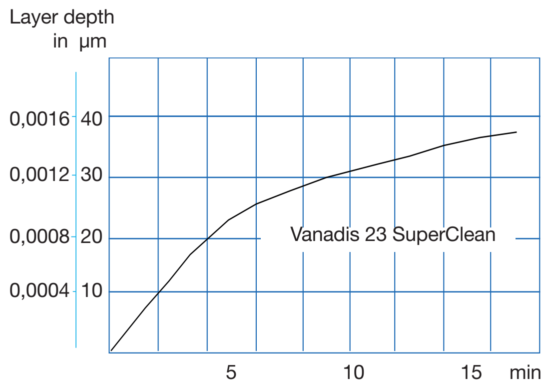


PVD coated tools in Uddeholm Vanadis 23 SuperClean for cold forming of tubes.

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 µm is recommended. This reduces the friction on the envelope surface of punches and has various other advantages.



Depth of nitriding layer
after nitrocarburizing at 570°C (1060°F)

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 Super-Clean 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 vacu-um 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. Further information can be found in the Uddeholm publication "Cutting data recommendations".

Condition: soft annealed to ~260 HB

TURNING

Cutting data parameters	Turning with carbide Rough turning	Turning with carbide Fine turning	Turning with HSS[1] Fine turning
Cutting speed (v_c) m/min f.p.m.	110–160 360–525	160–210 525–690	12–15 40–50
Feed (f) mm/r i.p.r.	0.2–0.4 0.008–0.016	0.05–0.2 0.002–0.008	0.05–0.3 0.002–0.012
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	K20 P10–P20 Coated carbide[2] or cermet[2]	P10 Coated carbide[2] or cermet[2]	–

[1] High speed steel
[2] Use a wear resistant CVD coating

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	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	Type of drill: Solid carbide	Type of drill: Carbide tip[1]
Cutting speed, v_c m/min f.p.m.	120–150 400–490	60–80 200–260	30–40 100–130
Feed, f mm/r i.p.r.	0.05–0.15[5] 0.002–0.006[2]	0.10–0.25[3] 0.004–0.010[3]	0.15–0.25[4] 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	Milling with carbide Fine milling
Cutting speed (v_c) m/min f.p.m.	80–130 260–425	130–160 425–525
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	2–4 0.08–0.16	–12 –0.08
Carbide designation ISO	K20, P20 Coated carbide*	K15, P15 Coated carbide* or cermet*

* Use a wear resistant CVD coating

END MILLING

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

[1] For coated HSS end mill v_c = 14–18 m/min. (46–59 f.p.m.)
[2] Depending on radial depth of cut and cutter diameter
[3] Use a wear resistant CVD coating

GRINDING

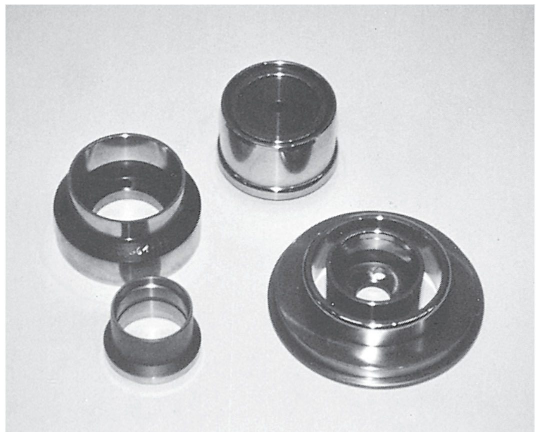
General grinding wheel recommendation is given below. More information can be found in the Uddeholm publication "Grinding of Tool Steel".

Type of grinding	Annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	B151 R50 B3[1] A 46 HV
Face grinding segments	A 36 GV	A 46 GV
Cylindrical grinding	A 60 KV	B151 R50 B3[1] A 60 KV
Internal grinding	A 60 JV	B151 R75 B3[1] A 60 IV
Profile grinding	A 100 IV	B126 R100 B6[1] A 100 JV

[1] If possible use CBN wheels for this application

ELECTRICAL DISCHARGE MACHINING – EDM

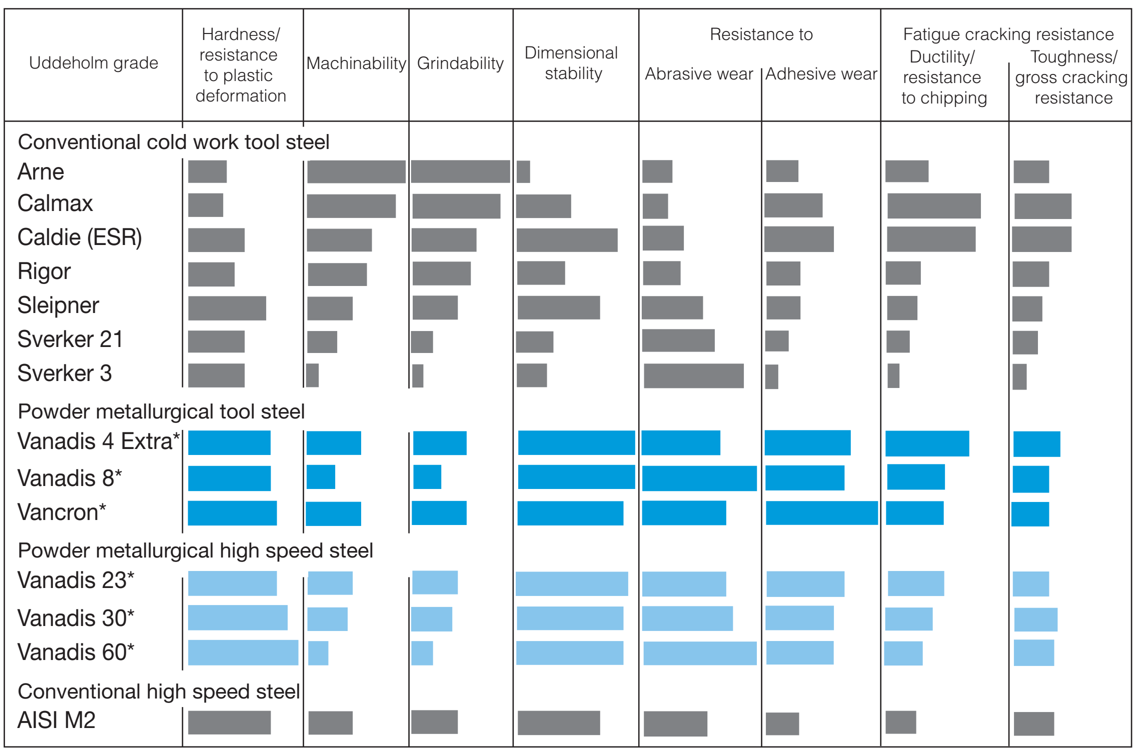
If EDM is performed in the hardened and tempered condition, finish with “fine-sparking”, i.e. low current, high frequency. For optimal performance the EDM’d surface should then be ground/polished and the tool retempered at approx. 535°C (995°F).



Tooling parts for canning industry

RELATIVE COMPARISON OF UDDEHOLM COLD WORK TOOL STEELS

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS



* Uddeholm PM SuperClean tool steels

FURTHER INFORMATION

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steel.

Manufacturing solutions for generations to come

SHAPING THE WORLD®

We are shaping the world together with the global manufacturing industry. Uddeholm manufactures steel that shapes products used in our every day life. We do it sustainably, fair to people and the environment. Enabling us to continue shaping the world – today and for generations to come.

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