Uddeholm
Vanadis® 4 Extra SuperClean

UDDEHOLM
a voestalpine company

Uddeholm Vanadis® 4 Extra SuperClean

CONSISTENT TOOL PERFORMANCE — LONG AND RELIABLE TOOL LIFE

With an increased demand for just in time deliveries (JIT) and shorter lead time, it is of utmost importance that the tool life is predictable with a long and reliable performance. This is also a prerequisite to reduce, your down time, cost for tool maintenance and optimize machine utilization. This gives an optimal tooling economy and a competitive production cost.

Uddeholm Vanadis 4 Extra SuperClean properties offer very good combination of wear resistance and ductility. This makes it possible for consistent tool performance for demanding cold work applications such as blanking and forming of austenitic stainless steel and Advanced High Strength Steel (AHSS) where a combination of abrasive, adhesive or mixed wear resistance is needed in combination with resistance to chipping and cracking.

MACHINABILITY

The tool making process is a very important link in the tooling sequence. In order to achieve a long and reliable tool performance the quality of the tool in terms of surface finish is extremely important. Uddeholm Vanadis 4 Extra SuperClean offers a very good machinability and grindability compared to other high alloyed PM- tool steel, giving the best conditions for an excellent tool quality. This is the result of the well balanced chemistry and the SuperClean production route.

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".

Edition 15, 01.2022

CERTIFIED
ISO 9001 · OHSAS 18001
ISO 14001 · ISO 50001

CRITICAL TOOL STEEL PARAMETERS

FOR GOOD TOOL PERFORMANCE

- Correct hardness for the application
- High wear resistance
- High ductility

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

Uddeholm Vanadis 4 Extra SuperClean is a powder metallurgical cold work tool steel offering an extremely good combination of wear resistance and ductility for high performance tools.

FOR TOOLMAKING

- Machinability
- Heat treatment
- Dimensional stability during heat treatment

Toolmaking with highly alloyed tool steel has traditionally created problems with machining and heat treatment when compared with lower alloyed grades, this then often leads to increased toolmaking costs.

Due to our carefully balanced alloying and the powder metallurgical manufacturing process, Uddeholm Vanadis 4 Extra SuperClean has better machinability than the tool steel grade AISI D2.

One major advantage with Uddeholm Vanadis 4 Extra SuperClean is that the dimensional stability after hardening and tempering is much better than for all known high performance cold work tool steel. This means, for example, that Uddeholm Vanadis 4 Extra SuperClean is a tool steel which is very suitable for CVD coating.

GENERAL

Uddeholm Vanadis 4 Extra SuperClean is a chromium-molybdenum-vanadium alloyed steel which is characterized by:

- Very good ductility
- High abrasive-adhesive wear resistance
- High compressive strength
- Good dimensional stability during heat treatment and in service
- Very good through-hardening properties
- Good temper back resistance
- Good machinability and grindability

Typical analysis %	C 1.4	Si 0.4	Mn 0.4	Cr 4.7	Mo 3.5	V 3.7
Delivery condition	Soft annealed to approx. 230 HB					
Colour code	Green/white with a black line across					

APPLICATIONS

Uddeholm Vanadis 4 Extra SuperClean is especially suitable for applications where adhesive wear and/or chipping are the dominating failure mechanisms, i.e.

- with soft/adherent materials such as austenitic stainless steel, mild steel, copper, aluminium, etc. as work material
- with thicker work material
- high strength work materials

Uddeholm Vanadis 4 Extra SuperClean is however also very suitable for blanking and forming of Advanced High Strength Steels, these materials place high demands on the tool steel regarding abrasive wear resistance and ductility.

Examples:

- Blanking and forming
- Fine blanking
- Cold extrusion tooling
- Powder pressing
- Deep drawing
- Knives
- Substrate steel for surface coating

PROPERTIES

PHYSICAL DATA

Hardened and tempered to 60 HRC.

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density kg/m³ lbs/in³	 7 700 0.278	 – –	 – –
Modulus of elasticity N/mm² psi	 206 000 29.8×10^6	 200 000 29.0×10^6	 185 000 26.8×10^6
Thermal conductivity W/m • °C Btu in/(ft² h °F)	 – –	 30 210	 30 210
Specific heat J/kg °C Btu/lb °F	 460 0.11	 – –	 – –

COEFFICIENT OF THERMAL EXPANSION

Temperature range		Coefficient	
°C	°F	°C from 20	°F from 68
20–100	68–212	11.0×10^{-6}	6.1×10^{-6}
20–200	68–392	11.3×10^{-6}	6.3×10^{-6}
20–300	68–572	11.7×10^{-6}	6.5×10^{-6}
20–400	68–752	12.1×10^{-6}	6.7×10^{-6}
20–500	68–932	12.4×10^{-6}	6.9×10^{-6}

IMPACT STRENGTH

Approximate room temperature impact strength as a function of hardness is shown below.

Original bar dimension: Ø 105 mm, samples are taken from the centre and tested in the transverse direction.

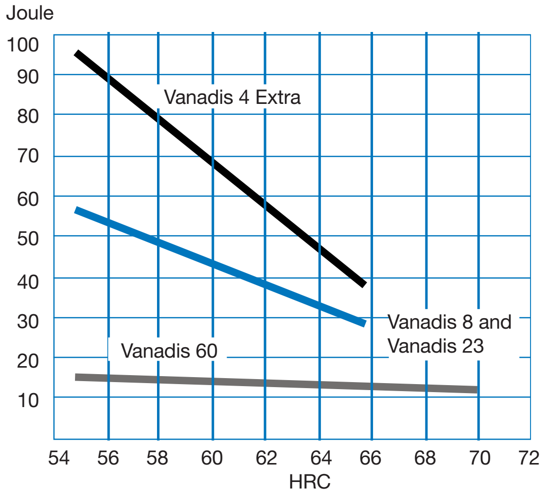
Specimen size: 7 x 10 x 55 mm (0.27 x 0.40 x 2.2”) unnotched.

Hardened between 940°C (1725°F) and 1150°C (2100°F). Holding time 30 minutes up to 1100°C (2010°F), over 1100°C (2010°F) 15 minutes. Quenched in air. Tempered 2 x 2h between 525°C (980°F) and 570°C (1060°F).

DUCTILITY

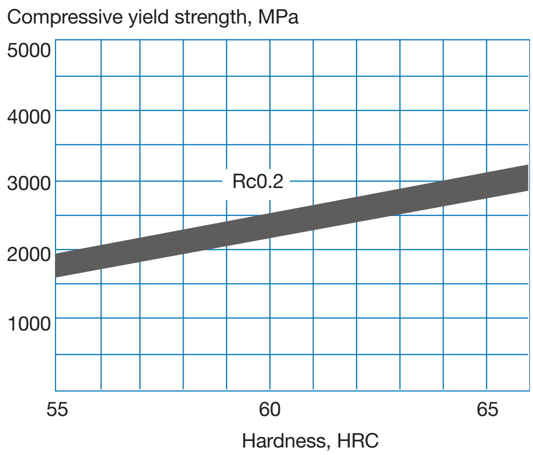
Impact test, unnotched, CR2 (thickness direction).

The impact strengths shown in the graph up to the right, are average values. Vanadis 8 SuperClean and Vanadis 23 SuperClean have a similar impact strength.



COMPRESSIVE YIELD STRENGTH

Approximate compressive yield strength versus hardness at room temperature.



BEND STRENGTH AND DEFLECTION

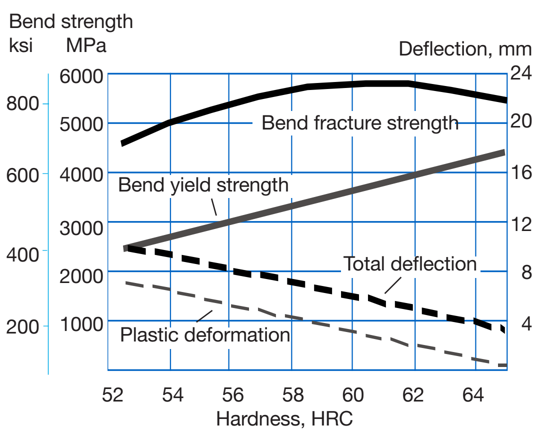
Four-point bend testing.

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)



HEAT TREATMENT

SOFT ANNEALING

Protect the steel and heat through to 900°C (1650°F). Cool in the furnace at 10°C (20°F) per hour to 750°C (1380°F), th en freely in air.

STRESS RELIEVING

After rough machining the tool should be eated through to 650°C (1200°F), holding time 2 hours. Cool slowly to 500°C (930°F), then freely in air.

HARDENING

Pre-heating temperature: First pre-heating at 600–650°C (1110–1200°F) and second at 850–900°C (1560–1650°F)

Austenitizing temperature: 940–1180°C (1725–2160°F), normally 1020°C (1870°F).

- For large sections, i.e. >70 mm (2.75”) use 1060°C (1940°F).
- For the very best wear resistance use 1100–1180°C (2010–2160°F).

Soaking time: 30 min. for hardening temperatures up to 1100°C (2010°F), 15 min. for temperatures higher than 1100°C (2010°F).

Note: Soaking 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 tool 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 at sufficient overpressure, minimum 2 bar)
- Martempering bath or fluidized bed at 200–550°C (390–1020°F)
- Forced air/gas

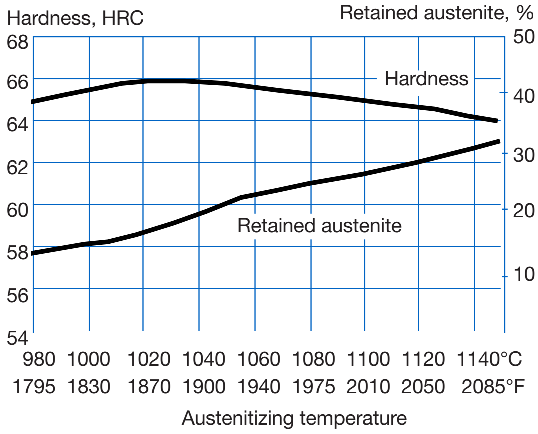
Note: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

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 AND RETAINED AUSTENITE AS A FUNCTION OF AUSTENITIZING TEMPERATURE



Bumper for passenger car, blanking tools made by Uddeholm Vanadis 4 Extra SuperClean.
Sheet material strength 1000 MPa, thickness 2 mm (0.08”).
Courtesy of Essa Palau, Barcelona, Spain.

TEMPERING

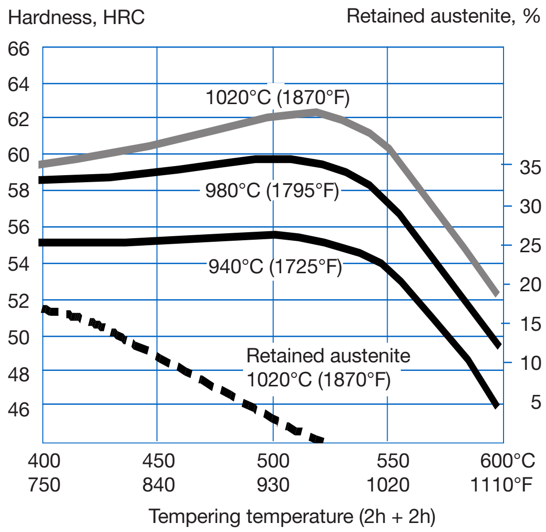
Choose the tempering temperature according to the hardness required by reference to the tempering graphs. Temper at least twice with intermediate cooling to room temperature.

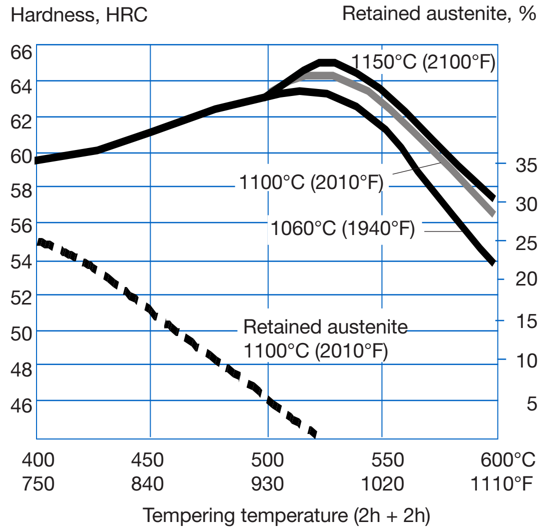
For highest dimensional stability and ductility, a minimum temperature of 540°C (1000°F) and three tempers is strongly recommended.

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.

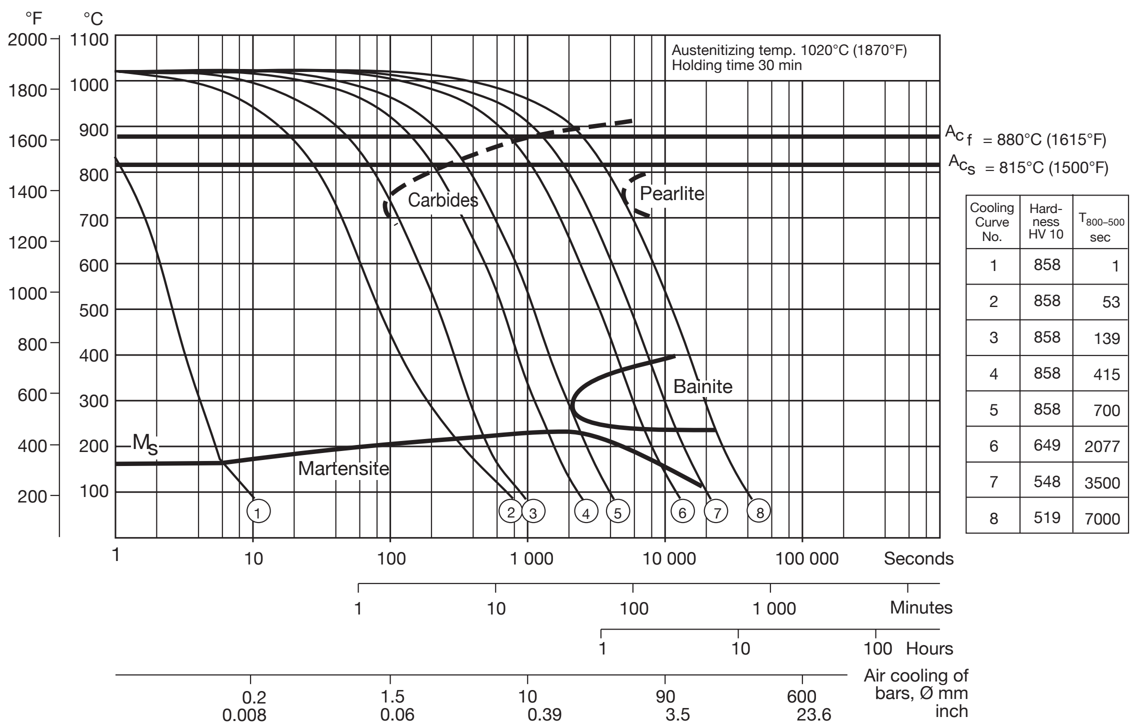
The tempering curves, in the two graphs, are obtained after heat treatment of samples with a size of 15 x 15 x 40 mm, cooling in forced air. Lower hardness can be expected after heat treatment of tools and dies due to factors like actual tool size and heat treatment parameters.





CCT GRAPH

Austenitizing temperature 1020°C (1870°F). Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ sec
1	858	1
2	858	53
3	858	139
4	858	415
5	858	700
6	649	2077
7	548	3500
8	519	7000

DIMENSIONAL CHANGES DURING HARDENING AND TEMPERING

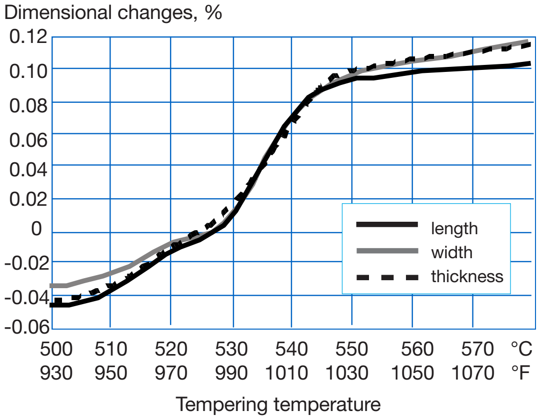
Dimensional changes have been measured after hardening and tempering.

Austenitizing: 1020°C/30 min. (1870°F/30 min.), cooling in vacuum furnace at 1.1°C/sec. (2°F/sec.) between 800°C (1470°F) and 500°C (930°F).

Tempering: 2 x 2 h at various temperatures

Sample size: 80 x 80 x 80 mm (3.15" x 3.15" x 3.15")

DIMENSIONAL CHANGES DURING HARDENING AND TEMPERING IN LENGTH, WIDTH AND THICKNESS DIRECTION



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 and -80°C (-95 to -110°F), soaking time 3–4 hours, followed by tempering.

The tempering temperature should be lowered 25°C (50°F) in order to get the desired hardness when a high temperature temper is performed.

Avoid intricate shapes as there will be risk of cracking.

SURFACE TREATMENT

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 and CVD.

The high hardness and toughness together with a good dimensional stability makes Uddeholm Vanadis 4 Extra SuperClean ideal as a substrate steel for various surface coatings.

NITRIDING

Nitriding gives a hard surface layer that is resistant to wear and erosion.

Uddeholm Vanadis 4 Extra SuperClean is normally high temperature tempered at around 540°C (1000°F). This means that the nitriding temperature used should not exceed 525°C (980°F). Ion nitriding at a temperature below the tempering temperature used is preferred. The surface hardness after nitriding is approximately 1150 $HV_{0,2\ kg}$.

The thickness of the layer should be chosen to suit the application in question.

For blanking and punching the recommended case depth is 10–20 µm and for forming tools it can be up to max. 30 µm.

PVD

Physical vapour deposition, PVD, is a method of applying a wear resistant coating at temperatures between 200–500°C (390–930°F).

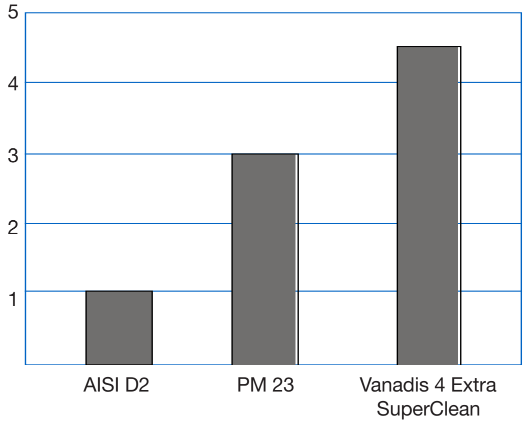
CVD

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

MACHINABILITY

Relative machinability and grindability for AISI D2, PM 23 and Uddeholm Vanadis 4 Extra SuperClean. High value indicates good machinability/grindability.

Relative machinability/grindability, (1=worse 5=best)



MACHINING RECOMMENDATIONS

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

The recommendations, in following tables, are valid for Uddeholm Vanadis 4 Extra SuperClean in soft annealed condition to ~230 HB.

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. f.p.m.	120–170 395–560	170–220 560–720	15–20 50–65
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 0.002–0.012
Depth of cut (a_p) mm inch	2–4 0.08–0.16	0.5–2 0.02–0.08	0.5–3 0.02–0.08
Carbide designation ISO	K20*, P20* or cermet*	K15*, P15* or cermet*	–

* Use a wear resistance CVD-coating

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.	110–150 360–490	150–200 490–655
Feed (f_z) mm/tooth in/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	– 2 – 0.08
Carbide designation ISO	K20, P20 Coated carbide* or cermet*	K15, P15 Coated carbide* or cermet*

* Use a wear resistant CVD coating

END MILLING

Cutting data parameters	Type of milling: Solid carbide	Type of milling: Carbide indexable insert	Type of milling: High speed steel[1]
Cutting speed (v_c) m/min. f.p.m.	60–80 200–260	110–160 360–525	8–12 26–40
Feed (f_z) mm/tooth in/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	–	K15[3] Coated carbide or cermet[3]	–

1) For coated HSS end mill v_c = 18–24 m/min. (60–80 f.p.m.)
2) Depending on radial depth of cut and cutter diameter
3) 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/rev	Feed (f) i.p.r.
–5	–3/16	12–14*	40–46*	0.05–0.15	0.002–0.006
5–10	3/16–3/8	12–14*	40–46*	0.15–0.25	0.006–0.010
10–15	3/8 –5/8	12–14*	40–46*	0.25–0.30	0.010–0.012
15–20	5/8 –3/4	12–14*	40–46*	0.30–0.35	0.012–0.014

* For coated HSS drills v_c = 22–24 m/min. (72–80 f.p.m.)

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	80–100 260–330	50–60 165–200
Feed (f) mm/rev i.p.r.	0.05–0.15[2] 0.002–0.006[2]	0.08–0.20[3] 0.003–0.008[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”.

WHEEL RECOMMENDATION

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	B151 R50 B3[1] A 46 HV[2]
Face grinding segments	A 24 GV	A46 FV[2]
Cylindrical grinding	A 60 KV	B151 R75 B3[1] A 60 KV[2]
Internal grinding	A 60 JV	B151 R75 B3[1] A 60 KV[2]
Profile grinding	A 100 LV	B126 R100 B6[1] A 80 JV[2]

[1] If possible use CBN wheels for this application
[2] Grinding wheels containing ceramic Al_2O_3 type is recommended

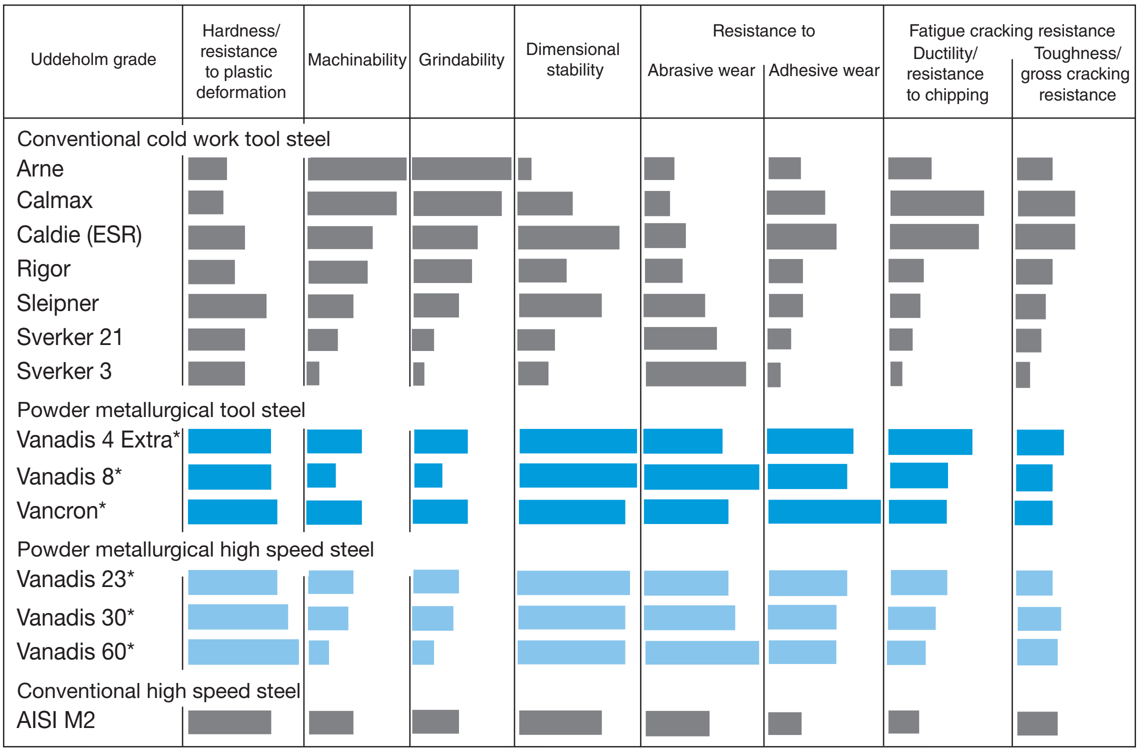
ELECTRICAL DISCHARGE MACHINING - EDM

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. 25°C (45°F) lower than the original tempering temperature.

When EDM’ing larger sizes or complicated shapes Uddeholm Vanadis 4 Extra SuperClean should be tempered at high temperatures, above 540°C (1000°F).

RELATIVE COMPARISON OF UDDEHOLM COLD WORK TOOL STEEL

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS



* Uddeholm PM SuperClean tool steels

ELECTRON BEAM MELTING AND LASER METAL DEPOSITION

Uddeholm Vanadis 4 Extra is also available as powder for processing by Electron Beam Melting (EBM) and Laser Metal Deposition (LMD). This powder has the same chemical composition as the PM material.

POWDER CHARACTERISTICS

SHAPE AND DENSITY – TYPICAL VALUES

Sphericity, $SPHT_3$	0.93
Aspect ratio, b/l_3	0.90
Apparent density, g/cm^3	4.4
Tap density, g/cm^3	5.0
True density, g/cm^3	7.7

PARTICLE SIZE DISTRIBUTION – TYPICAL VALUES

D10, µm	D50, µm	D90, µm
55	80	120

	Hardness, HRC	Unnotched Impact Toughness, J	Modulus of elasticity, N/mm^2
EBM Processed Uddeholm Vanadis 4 Extra	64	20	225

After EBM processing is the following heat treatment recommended:

Solution annealing 1100°C (2012°F) for 30 minutes.
Tempering 540°C (1004°F) 4 times for 1 hour
The physical and mechanical properties of the EBM processed material is the same as for the PM material except for the data below:

LASER METAL DEPOSITION (LMD)

For LMD processing Vanadis 4 Extra can be cladded up to ~3-4 layers at RT on a prehardened base material, such as AISI H13 or P20.

For cladding of more layers on more complex geometries, or when using a higher alloyed base material, such as AISI A2, D2 or S7, preheating at ~300°C is necessary to reduce the risk of cracking.

Tempering at 535-550°C 2x2h after cladding will give a surface hardness of ~900-930 HV_{10}.

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

Since 1668 we have been providing a wide range of innovative cutting-edge solutions for our customers in demanding segments. Our dedicated employees work in almost ninety countries and together we deliver improved competitiveness to clients worldwide. Welcome to Uddeholm.