UDDEHOLM VANADIS® 23

SUPERCLEAN³

UDDEHOLM

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

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

For tool making

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

Tool making with highly alloyed tool steels 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 Vanadis 23 means that its machinability is superior to that of similar conventionally produced grades and some highly alloyed cold work tool steels.

The dimensional stability of Uddeholm Vanadis 23 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 is very suitable for surface coating, in particular for PVD.

Applications

Uddeholm Vanadis 23 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 steels
- Blanking of harder materials such as hardened or cold-rolled strip steels
- 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 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. 1.3344)				
Delivery condition	Soft annealed to approx. 260 HB				
Colour code	Violet				

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

Properties

Physical data

Hardened and tempered condition.

Temperature	20°C (68°F)	400°C (750°F)	600°C (1110°F)
Density kg/m³ lbs/in³	7980 0,287	7870 0,283	7805 0,281
Modulus of elasticity MPa ksi	230 000 33 x 10³	205 000 30 x 10³	184 000 27 x 10³
Coefficient of thermal expansion per °C from 20°C °F from 68°F	– –	12,1 x 10⁻⁶ 6,7 x 10⁻⁶	12,7 x 10⁻⁶ 7,0 x 10⁻⁶
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

Impact strength

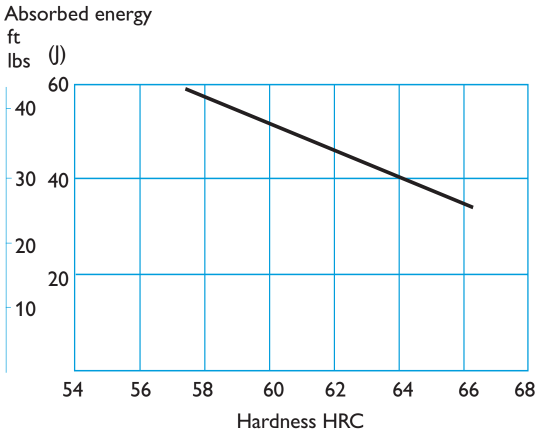
Approximate room temperature impact strength at different hardness levels.

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.



Bending strength and deflection

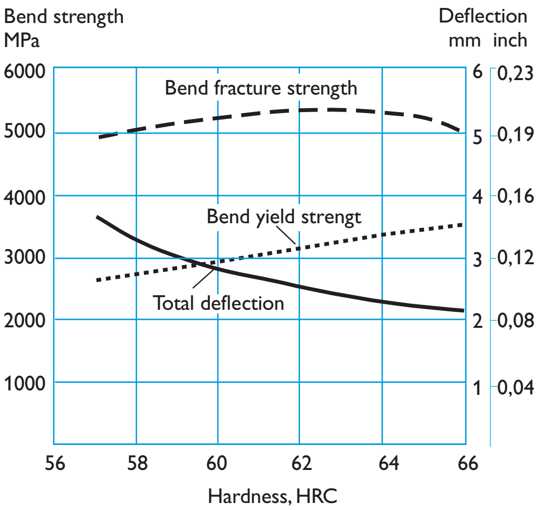
Four-point bend testing.

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).



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

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.

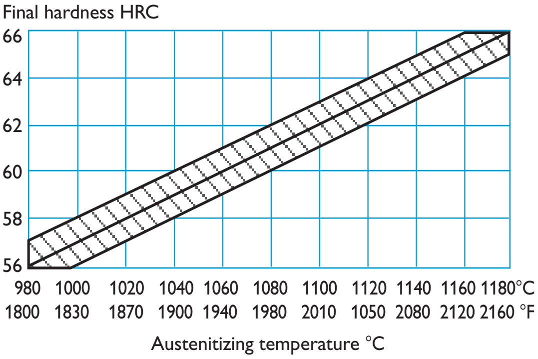
Stress relieving

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.

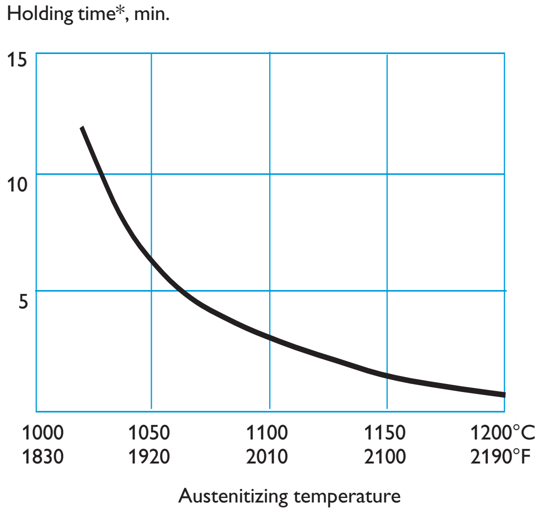
The tool should be protected against decarburization and oxidation during hardening.



Hardness after different hardening temperatures and tempering 3 times for 1 hour at 560°C (1040°F).

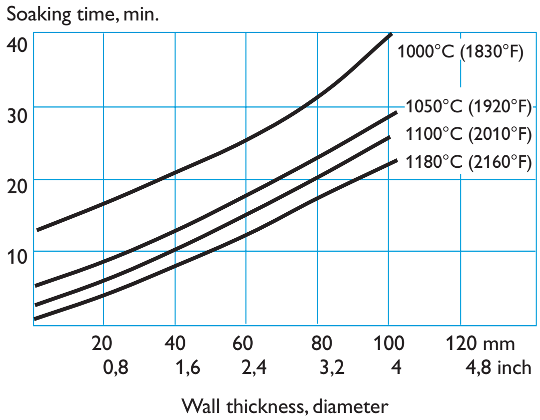
HRC	°C	°F
58	1020	1868
60	1060	1940
62	1100	2012
64	1140	2084
66	1180	2120

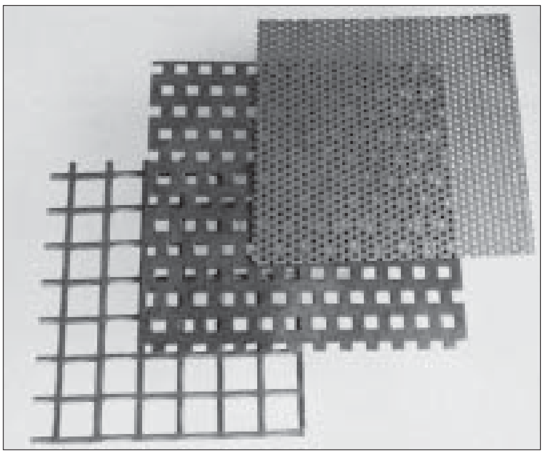
RECOMMENDED HOLDING TIME, FLUIDIZED BED, VACUUM OR ATMOSPHERE FURNACE



* Holding time = time at austenitizing temperature after the tool is fully heated through

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

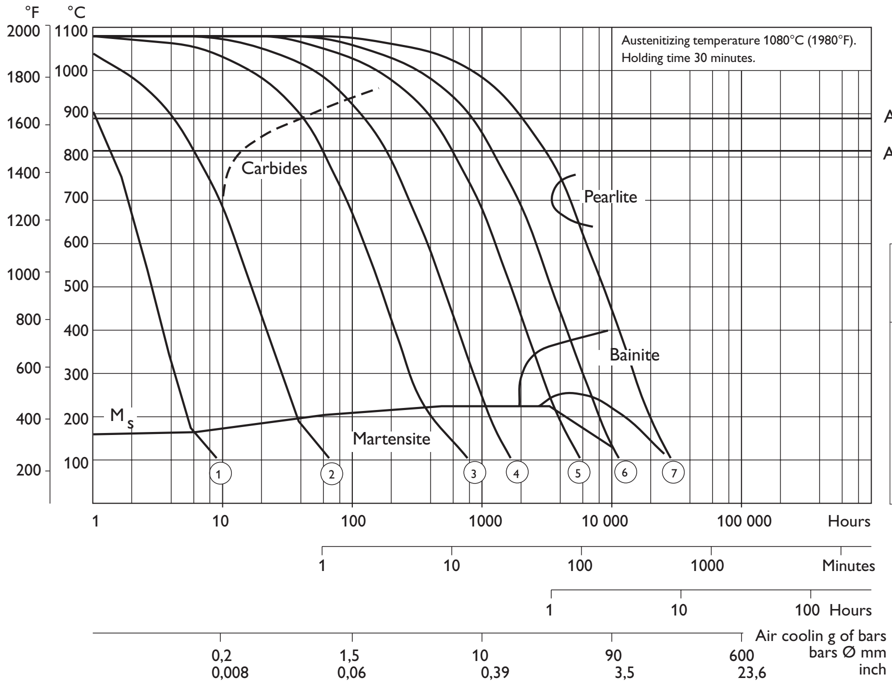




Punched plate.

CCT-GRAPH (CONTINUOUS COOLING).

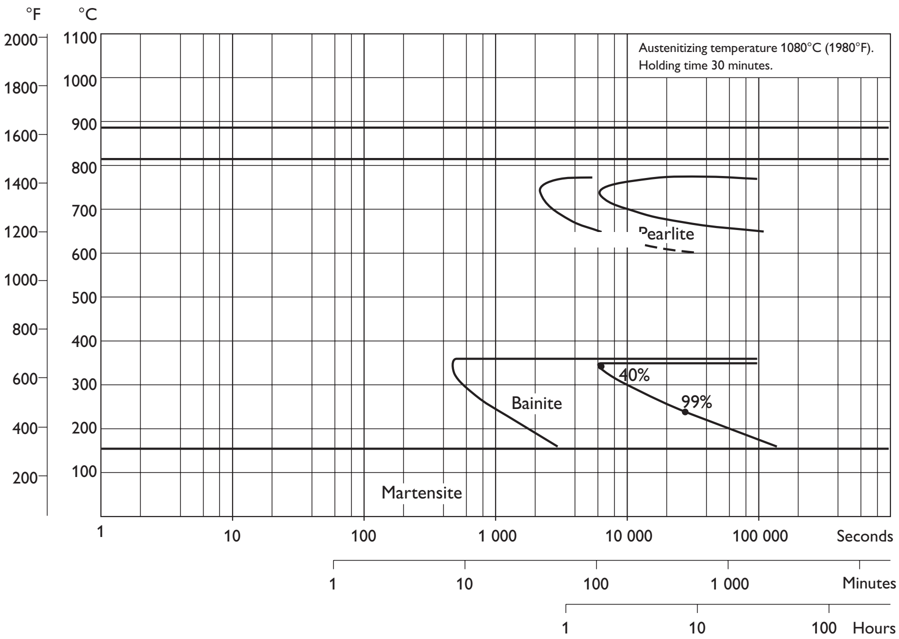
Austenitizing temperature 1080°C (1980°F). Holding time 30 minutes.



Cooling curve N°	Hardness HV 10	$T_{800-500}$ (sec.)
1	907	1
2	894	10
3	894	104
4	858	313
5	803	1041
6	673	2085
7	530	5211

TTT-GRAPH (ISOTHERMAL TRANSFORMATION).

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



Temp. °C	Time hours	Hardness HV 10
775	16,9	276
750	2,5	363
725	2,2	370
700	4,5	380
650	70,7	370
600	17,7	813
400	23,0	907
375	23,3	907
350	2,1	649
300	2,7	613
250	22,5	665
200	25,8	707

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:

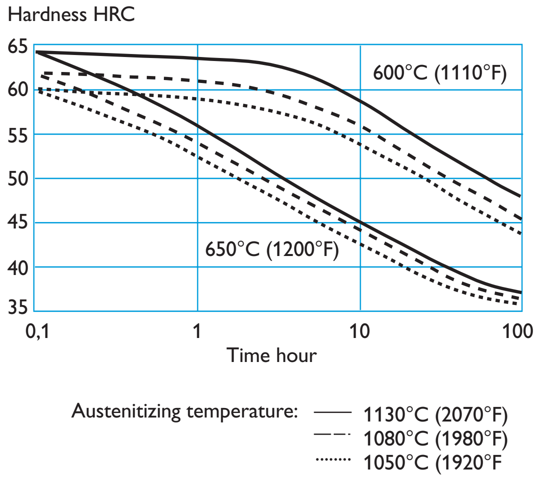
Immediately after quenching the piece should be sub-zero treated to between -70 to -80°C (-95 and -110°F), soaking time 1–3 hours, followed by tempering.

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

High temperature properties

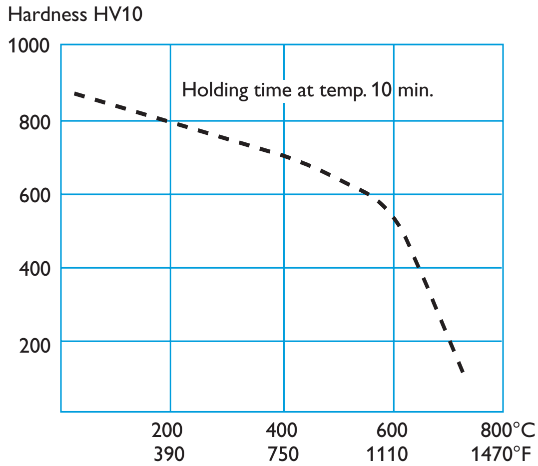
HARDNESS AS A FUNCTION OF HOLDING TIME AT DIFFERENT WORKING TEMPERATURES

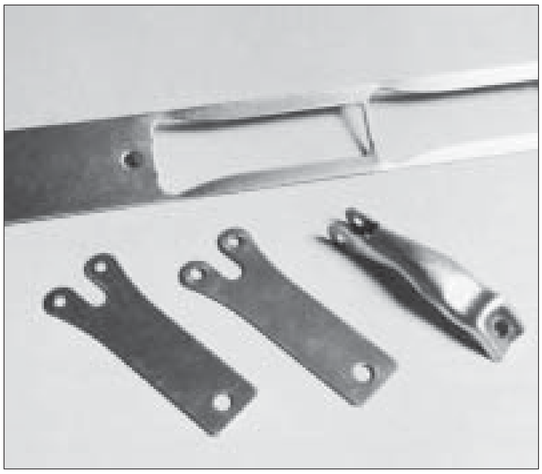
Austenitizing temperature: 1050–1130°C (1920–2070°F). Tempering: 3 x 1 h at 560°C (1040°F).



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 die and Uddeholm Vanadis 4 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).

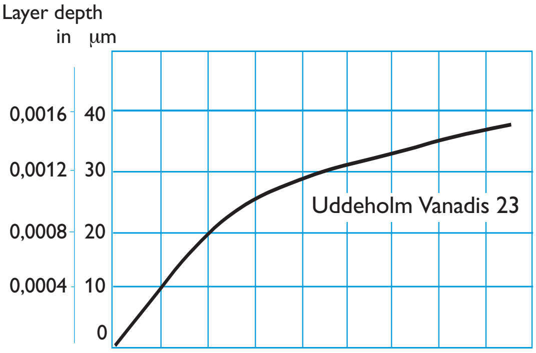
Uddeholm Vanadis 23 has been found to be particularly suitable for titanium carbide and titanium nitride coatings. The uniform carbide distribution in Uddeholm Vanadis 23 facilitates bonding of the coating and reduces the spread of dimensional changes resulting from hardening. This, together with its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

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

Tooling parts for canning industry.

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 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.

Turning

Cutting data parameter	Turning with carbide Rough turning	Turning with carbide Fine turning	Turning with high speed steel 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 (ap) 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	P10–P20* Coated carbide	P10* Coated carbide or cermet	–

* Use a wear resistant Al_2O_3 coated carbide grade

Drilling

HIGH SPEED STEEL TWIST DRILL

Drill diameter, Ø mm	Drill diameter, Ø 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 Brazed carbide[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[2] 0,002–0,006[2]	0,10–0,25[2] 0,004–0,010[2]	0,15–0,25[2] 0,006–0,010[2]

[1] Drill with internal cooling channels and brazed carbide tip
[2] Depending on drill diameter

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	–2 –0,08
Carbide designation ISO	K20* Coated carbide	K15* Coated carbide

* Use a wear resistant Al_2O_3 coated carbide grade

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
Feed (fz) mm/tooth inch/tooth	0,01–0,2[2] 0,0004–0,008	0,06–0,2[2] 0,002–0,008	0,01–0,3[2] 0,0004–0,012
Carbide designation ISO	–	K15[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 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] 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

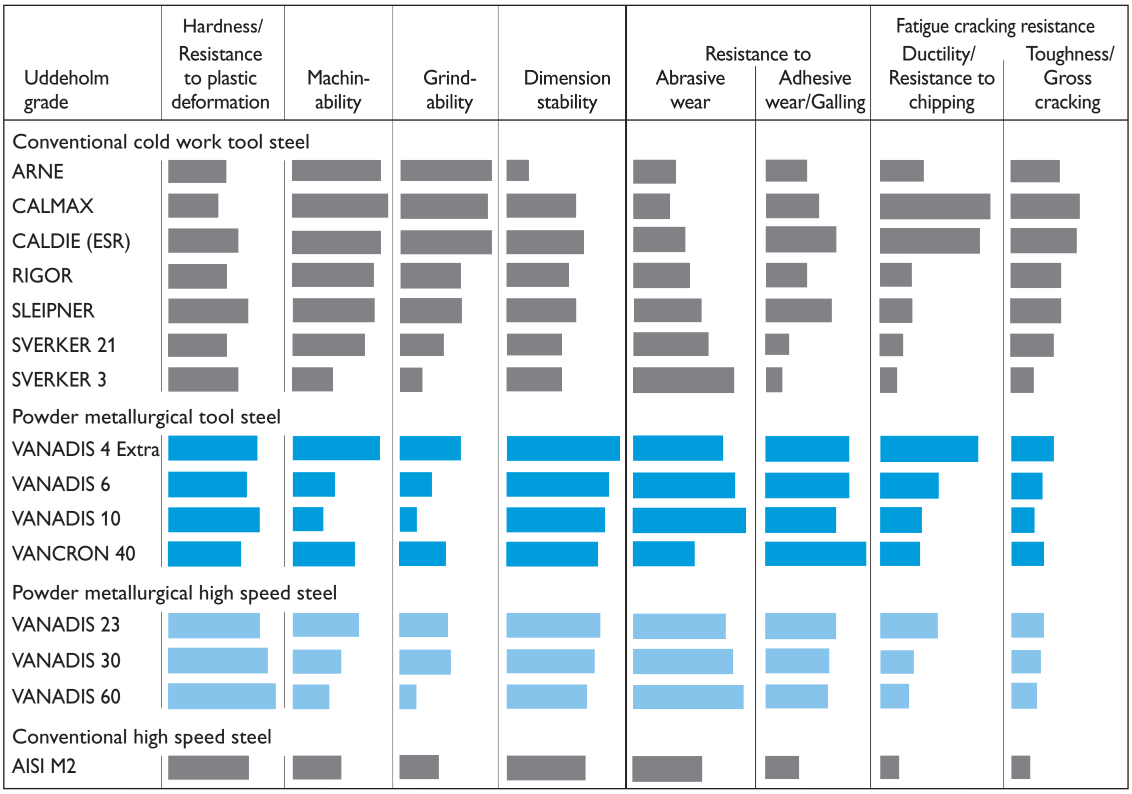
If EDM is performed in the hardened and tempered condition, finish with "fine-sparking", i.e. low current, high frequency. For optimal performance the EDM'd surface should then be ground/polished and the tool retempered at approx. 535°C (995°F).

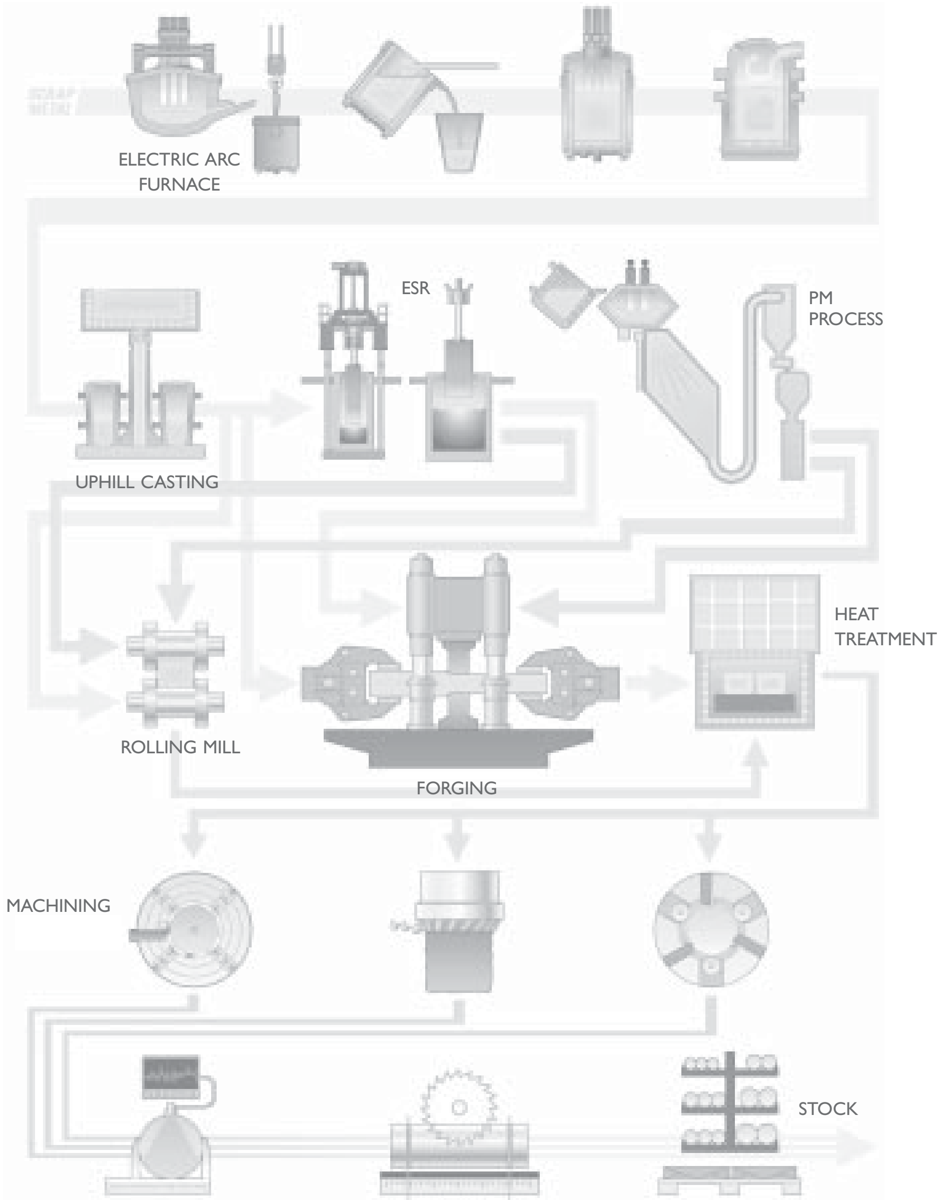
Further information

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

Relative comparison of Uddeholm cold work tool steel

Material properties and resistance to failure mechanisms





The Tool Steel Process

The starting material for our tool steel is carefully selected from high quality recyclable steel. Together with ferroalloys and slag formers, the recyclable steel is melted in an electric arc furnace. The molten steel is then tapped into a ladle.

The de-slagging unit removes oxygen-rich slag and after the de-oxidation, alloying and heating of the steel bath are carried out in the ladle furnace. Vacuum degassing removes elements such as hydrogen, nitrogen and sulphur.

ESR PLANT

In uphill casting the prepared moulds are filled with a controlled flow of molten steel from the ladle. From this, the steel can go directly to our rolling mill or to the forging press, but also to our ESR furnace where our most sophisticated steel grades are melted once again in an electro slag remelting process. This is done by melting a consumable electrode immersed in an overheated slag bath. Controlled solidification in the steel bath results in an ingot of high homogeneity, thereby removing macro segregation. Melting under a protective atmosphere gives an even better steel cleanliness.

HOT WORKING

From the ESR plant, the steel goes to the rolling mill or to our forging press to be formed into round or flat bars.

Similar to our ESR steel, the other high quality steel grades, including the powder metal steels and spray formed steels, go to the rolling mill or the forging press. Prior to delivery all of the different bar materials are subjected to a heat treatment operation, either as soft annealing or hardening and tempering. These operations provide the steel with the right balance between hardness and toughness.

MACHINING

Before the material is finished and put into stock, we also rough machine the bar profiles to required size and exact tolerances. In the lathe machining of large dimensions, the steel bar rotates against a stationary cutting tool. In peeling of smaller dimensions, the cutting tools revolve around the bar.

To safeguard our quality and guarantee the integrity of the tool steel we perform both surface- and ultrasonic inspections on all bars. We then remove the bar ends and any defects found during the inspection.

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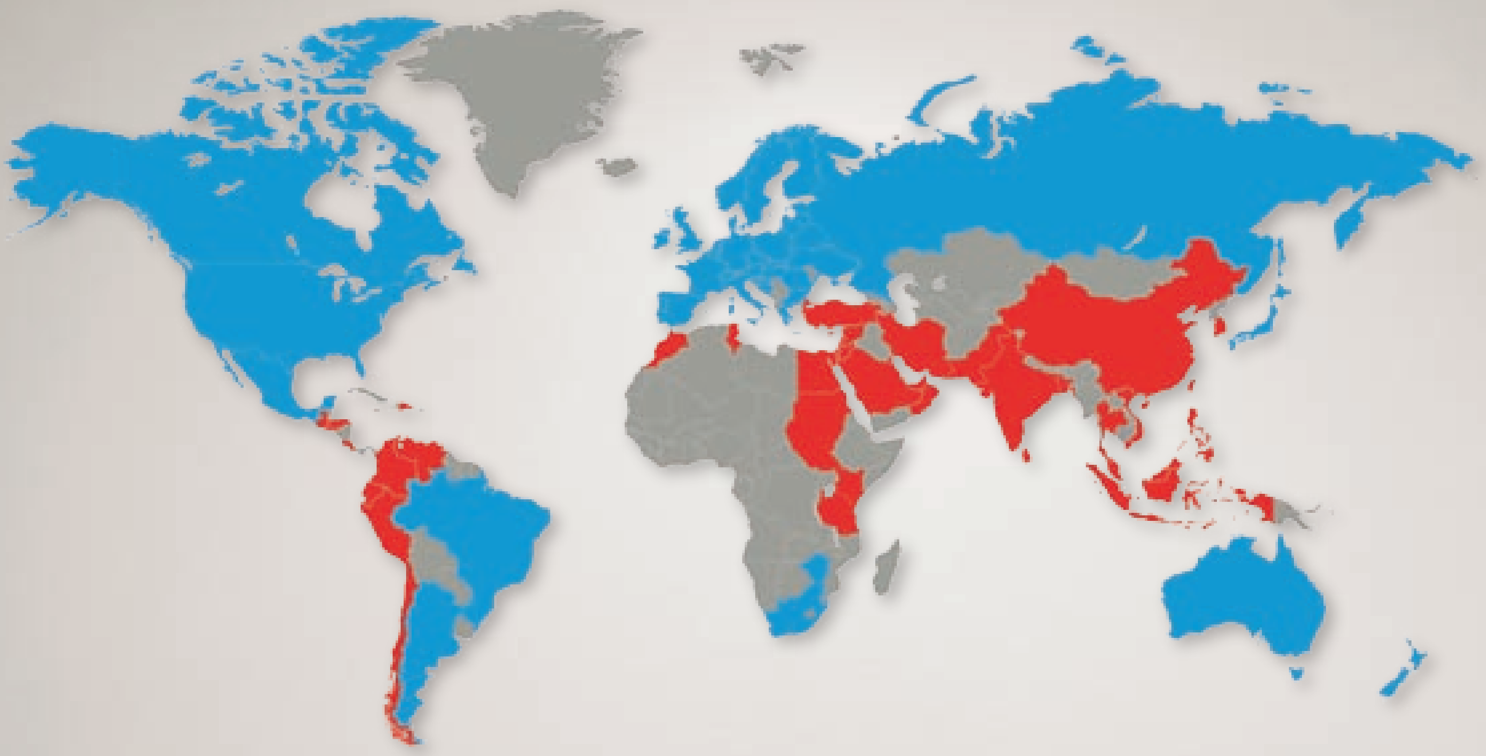

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