UDDEHOLM VANADIS® 10

UDDEHOLM

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 6, 09.2011
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

UDDEHOLM VANADIS 10

Uddeholm Vanadis 10 is a high vanadium alloyed powder metallurgy tool steel offering a unique combination of an excellent abrasive wear resistance in combination with a good chipping resistance. It is manufactured according to the powder metallurgy process giving a very low amount of non-metallic inclusions.

In tool making Uddeholm Vanadis 10 offers a good machinability and grindability together with a good dimensional stability during heat treatment. It can normally be hardened to 60–65 HRC.

Critical tool steel properties

For good tool performance

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

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

Uddeholm Vanadis 10 is a powder metallurgical cold work tool steel offering a combination of extremely high wear resistance and good toughness.

For toolmaking

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

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

Due to the very carefully balanced alloying and the powder metallurgical manufacturing route, Uddeholm Vanadis 10 has a similar heat treatment procedure to the steel D2. One very big advantage with Uddeholm Vanadis 10 is that the dimensional stability after hardening and tempering is much better than for the conventionally produced high performance cold work steels. This also means that Uddeholm Vanadis 10 is a tool steel which is very suitable for CVD coating.

Applications

Uddeholm Vanadis 10 is especially suitable for very long run tooling where abrasive wear is the dominating problem. Its very good combination of extremely high wear resistance and good toughness also make Uddeholm Vanadis 10 an interesting alternative in applications where tooling made of such materials as cemented carbide tends to chip or crack.

Examples:

- Blanking and forming
- Fine blanking
- Blanking of electrical sheet
- Gasket stamping
- Deep drawing
- Cold forging
- Slitting knives (paper and foil)
- Powder pressing
- Granulator knives
- Extruder screws etc.

General

Uddeholm Vanadis 10 is a chromium-molybdenum-vanadium alloyed steel which is characterized by:

- Extremely high abrasive wear resistance
- High compressive strength
- Very good through-hardening properties
- Good toughness
- Very good stability in hardening
- Good resistance to tempering back

Typical analysis %	C 2.9	Si 0.5	Mn 0.5	Cr 8.0	Mo 1.5	V 9.8
Delivery condition	Soft annealed to approx. 280–310 HB					
Colour code	Green/violet					

Properties

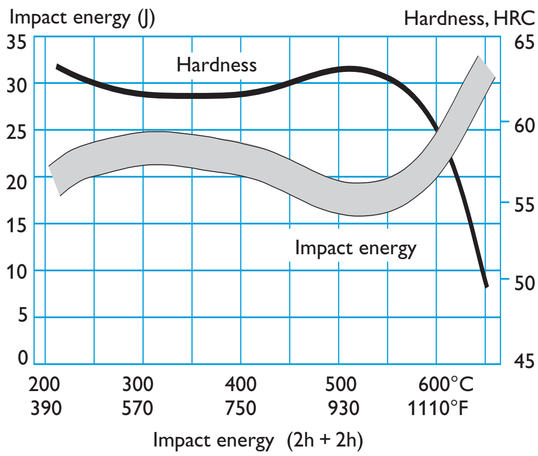
Physical data

Hardened and tempered to 62 HRC.

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density kg/m³ lbs/in³	7 400 0.268	–	–
Modulus of elasticity N/mm² psi	220 000 31.9 x 10^6	210 000 30.4 x 10^6	200 000 29.0 x 10^6
Coefficient of thermal expansion per pro °C ab 20°C °F from 68°F	–	10.7 x 10^{-6} 6.0 x 10^{-6}	11.4 x 10^{-6} 6.3 x 10^{-6}
Thermal conductivity W/m • °C Btu in/(ft² h °F)	–	20 139	22 153
Specific heat J/kg °C Btu/lb °F	460 0.11	–	–

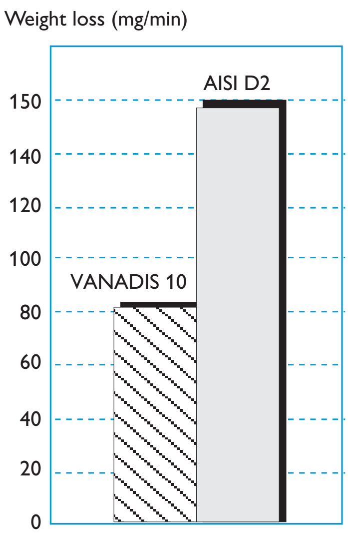
Impact strength

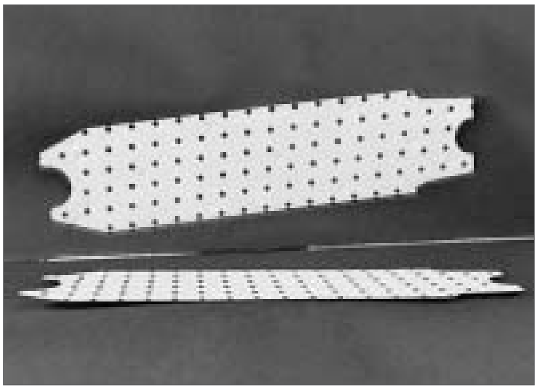
Approximate room temperature impact strength at different tempering temperatures. Specimen size: 7 x 10 x 55 mm (0.27 x 0.40 x 2.2 inches) unnotched. Hardened at 1020°C (1870°F). Quenched in air. Tempered twice.



Wear resistance

Pin on disc test. Disc material: SiC
Uddeholm Vanadis 10 = 62 HRC, D2 = 62 HRC.





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), then freely in air.

Stress relieving

After rough machining the tool should be heated 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: 600–700°C (1110–1290°F)
Austenitizing temperature: 1020–1100°C (1870–2010°F)
Holding time: 30 minutes.

Note: Holding time = time at hardening temperature after the tool is fully heated through. A holding time of less than 30 minutes will result in loss of hardness.

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

Quenching media

- Forced air/gas
- Vacuum furnace (gas overpressure 2–5 bar)
- Martempering bath or fluidized bed at 500–550°C (930–1020°F)
- Martempering bath or fluidized bed at 200–350°C (390–660°F) whereby 350°C (660°F) is preferred.

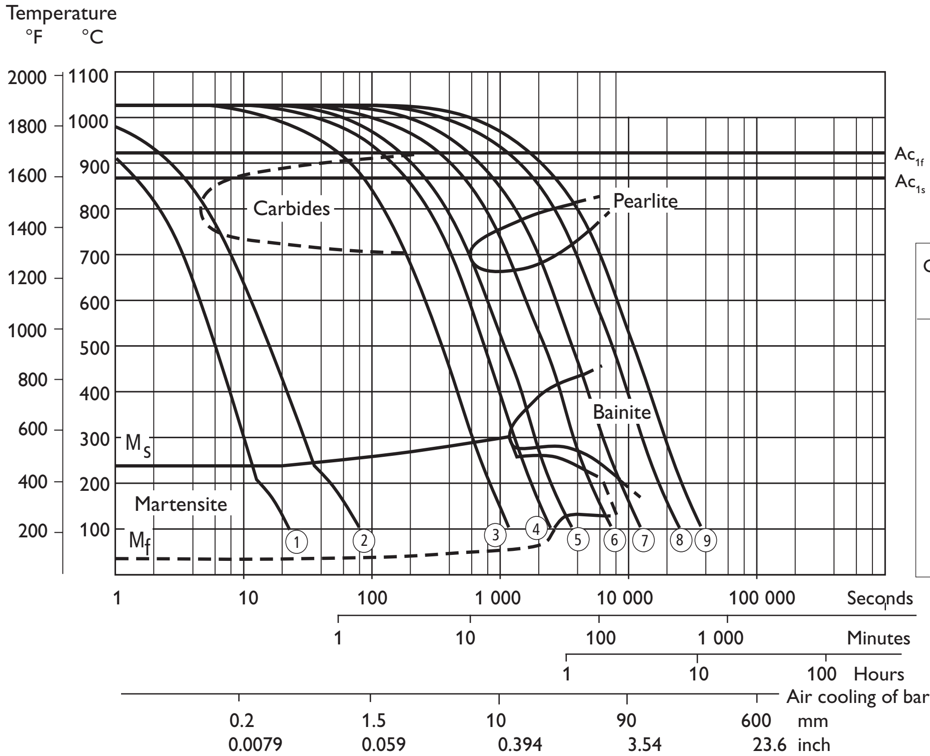
Note 1: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

Note 2: In order to obtain the optimum properties for the tool, the cooling rate should be as fast as is concomitant with acceptable distortion.

Note 3: Tools with sections >50 mm (2") should be quenched in forced air. Quenching in still air will result in loss of hardness.

CCT-GRAPH

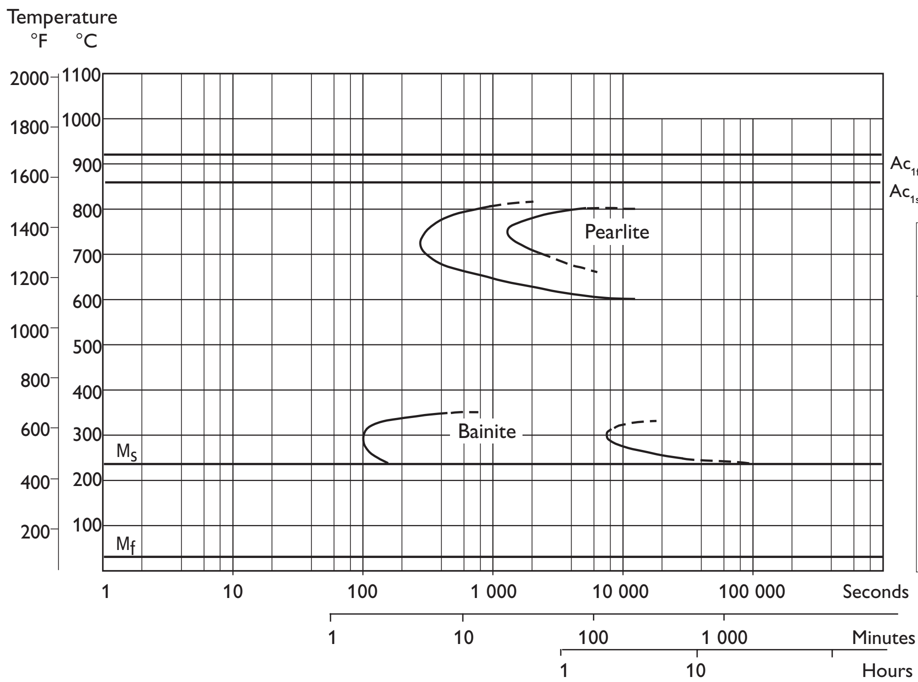
Austenitizing temperature 1020–1060°C (1870–1940°F). Holding time 30 minutes.



Cooling curve No.	Hardness HV 10	$T_{800-500}$ (sec.)
1	890	3,8
2	878	10
3	818	232
4	806	481
5	731	695
6	635	1389
7	509	2318
8	325	4633
9	311	6947

TTT-GRAPH

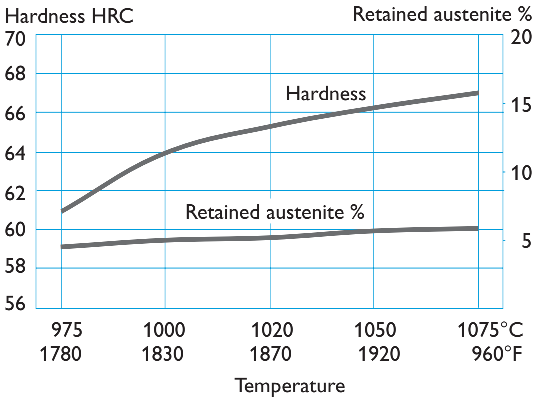
Austenitizing temperature 1020°C (1870°F). Holding time 30 minutes.



Iso-thermal temp. °C	Time hours	Hardness HV10 (approx.)
800	4,5	297
750	18	302
700	1,1	350
675	22	354
650	4	423
600	23	523
500	44	890
425	61	890
400	22,5	890
350	15	858
325	3,5	715
300	7	642
250	22	673

HARDNESS AND RETAINED AUSTENITE AS FUNCTIONS OF AUSTENITIZING TEMPERATURE

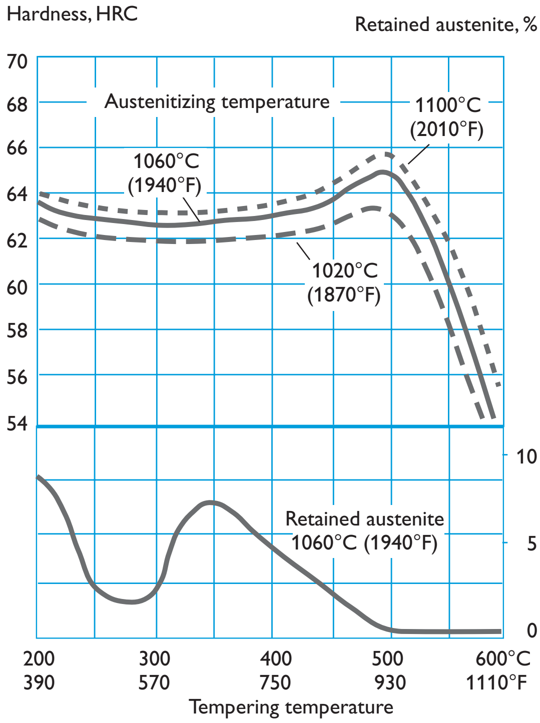
Holding time 30 min. Air-cooling.



Tempering

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with intermediate cooling to room temperature. Lowest tempering temperature 180°C (360°F). Holding time at temperature minimum 2 hours. At a hardening temperature of 1100°C (2010°F) or higher Uddeholm Vanadis 10 should be tempered at minimum 525°C (980°F) in order to reduce the amount of retained austenite

TEMPERING GRAPH

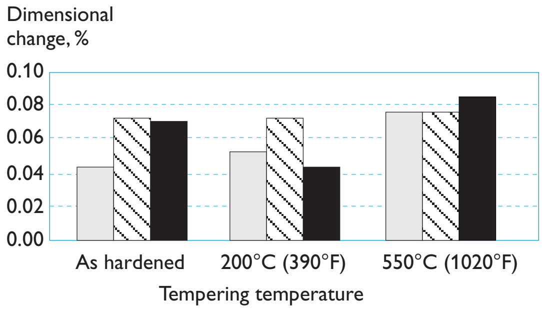


Dimensional changes after tempering

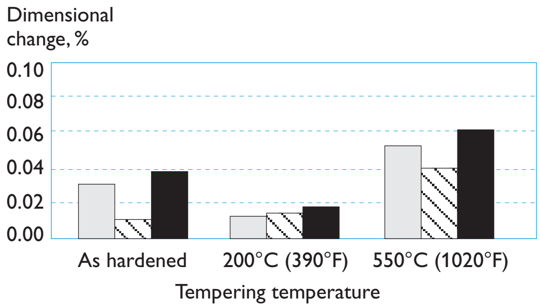
Hardening temperature

980°C 1020°C 1060°C

Specimen size: 65 x 65 x 65 mm (2.5 x 2.5 x 2.5 in.)



Specimen size: 125 x 125 x 25 mm (5 x 5 x 1 in.)



Sub-zero treatment

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

Immediately after quenching, the tool should be sub-zero treated to -70 to -80°C (-95 to -110°F), soaking time 1–3 hours, followed by tempering. The sub-zero treatment leads to a reduction of retained austenite content. This, in turn, will result in a hardness increase of ~1 HRC compared to not sub-zero treated tools if low temperature tempering is used. For high temperature tempered tools there will be no hardness increase and when referencing the normal tempering curves, a 25 to 50°C (45 to 90°F) lower tempering temperature should be chosen to achieve the required hardness.

Tools that are high temperature tempered, even without a sub-zero treatment, will have a low retained austenite content and in most cases, a sufficient dimensional stability. However, for high demands on dimensional stability in service it is also recommended to use a sub-zero treatment in combination with high temperature tempering.

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

Nitriding

Nitriding produces a hard surface layer that increases wear resistance and reduces the tendency towards galling.

High temperature tempered Uddeholm Vanadis 10 is normally tempered at 525°C (980°F). This means that the nitriding temperature used should not exceed 500–525°C (930–980°F). Ion nitriding at a temperature below the tempering temperature used is preferred.

The surface hardness after nitriding is approximately 1250 $HV_{0,2\ kg}$. The thickness of the layer should be chosen to suit the application in question.

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".

Delivery condition: Soft annealed to 280–310 HB

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.	 50–80 160–260	 80–100 260–330	 5–8 16–26
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*	K15*	–

*Use a wear resistant Al_2O_3-coated carbide grade

Drilling

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm	Drill diameter inch	Cutting speed, vc m/min	Cutting speed, vc f.p.m.	Feed (f) mm/r	Feed (f) i.p.r.
–5	–3/16	6–8*	20–26*	0.05–0.15	0.002–0.006
5–10	3/16–3/8	6–8*	20–26*	0.15–0.20	0.006–0.008
10–15	3/8–5/8	6–8*	20–26*	0.20–0.25	0.008–0.010
15–20	5/8–3/4	6–8*	20–26*	0.25–0.35	0.010–0.014

* For coated HSS drill vc 12–14 m/min. (40–45 f.p.m.)

CARBIDE DRILL

Cutting data parameters	Type of drill Indexable insert	Type of drill Solid carbide	Type of drill Carbide tipped[1]
Cutting speed (v_c) m/min. f.p.m.	 70–90 230–295	 40–60 130–200	 20–30 65–100
Feed (f) mm/r 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] 0.006–0.010[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 parameter	Milling with carbide Rough milling	Milling with carbide Fine milling
Cutting speed (v_c) m/min. f.p.m.	 30–50 100–160	 50–70 160–230
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	K15–P15 coated carbide or cermet

END MILLING

Cutting data parameter	Type of mill Solid carbide	Type of mill Carbide indexable insert	Type of mill High speed steel[1]
Cutting speed (v_c) m/min. f.p.m.	30–40 100–130	30–50 100–160	10–14 30–34
Feed (f_z) mm/tooth in/tooth	 0.03–0.20[2] 0.001–0.008	 0.08–0.20[2] 0.003–0.008	 0.05–0.35[2] 0.002–0.05
Carbide designation ISO	–	K 15[3]	–

[1] Uncoated HSS is not recommended
[2] Depending on radial depth of cut and cutter diameter
[3] Use a wear resistant Al_2O_3-coated carbide grade

Grinding

A 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 GV[2]
Face grinding segments	A 36 GV	A 46 GV
Cylindrical grinding	A 60 KV	B151 R75 B3[1] A 60 JV[2]
Internal grinding	A 60 JV	B151 R75 B3[1] A 60 IV
Profile grinding	A 100 IV	B126 R100 B6[1] A 100 JV[2]

[1] If possible, use CBN-wheels for this application
[2] Preferable a wheel type containing sintered Al_2O_3 (seeded gel)

Electrical-discharge machining–EDM

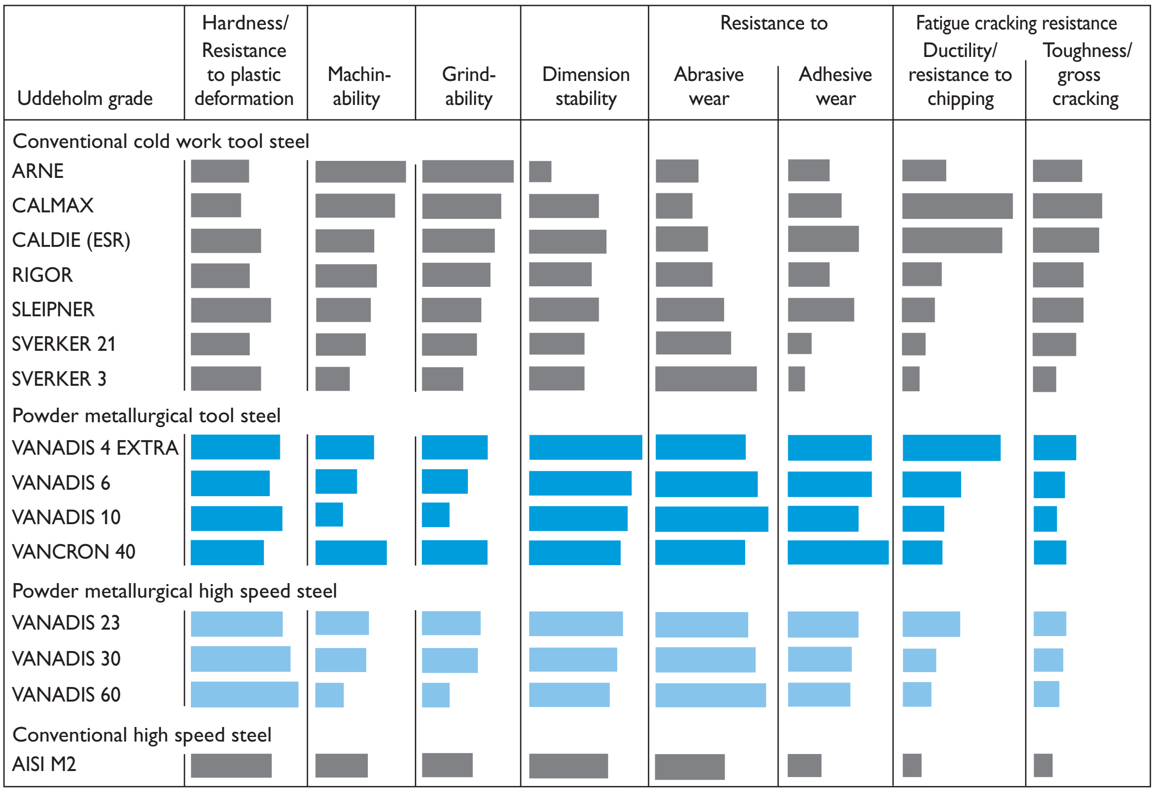
If EDM is performed in the hardened and tempered condition, finish with "fine-sparking", i.e. low current, high frequency.

For optimal performance the EDM'd surface should then be ground/polished and the tool retempered at approx. 25°C (50°F) lower than the original tempering temperature.

When EDM'ing larger sizes or complicated shapes Uddeholm Vanadis 10 should be tempered at high temperatures, above 500°C (930°F).

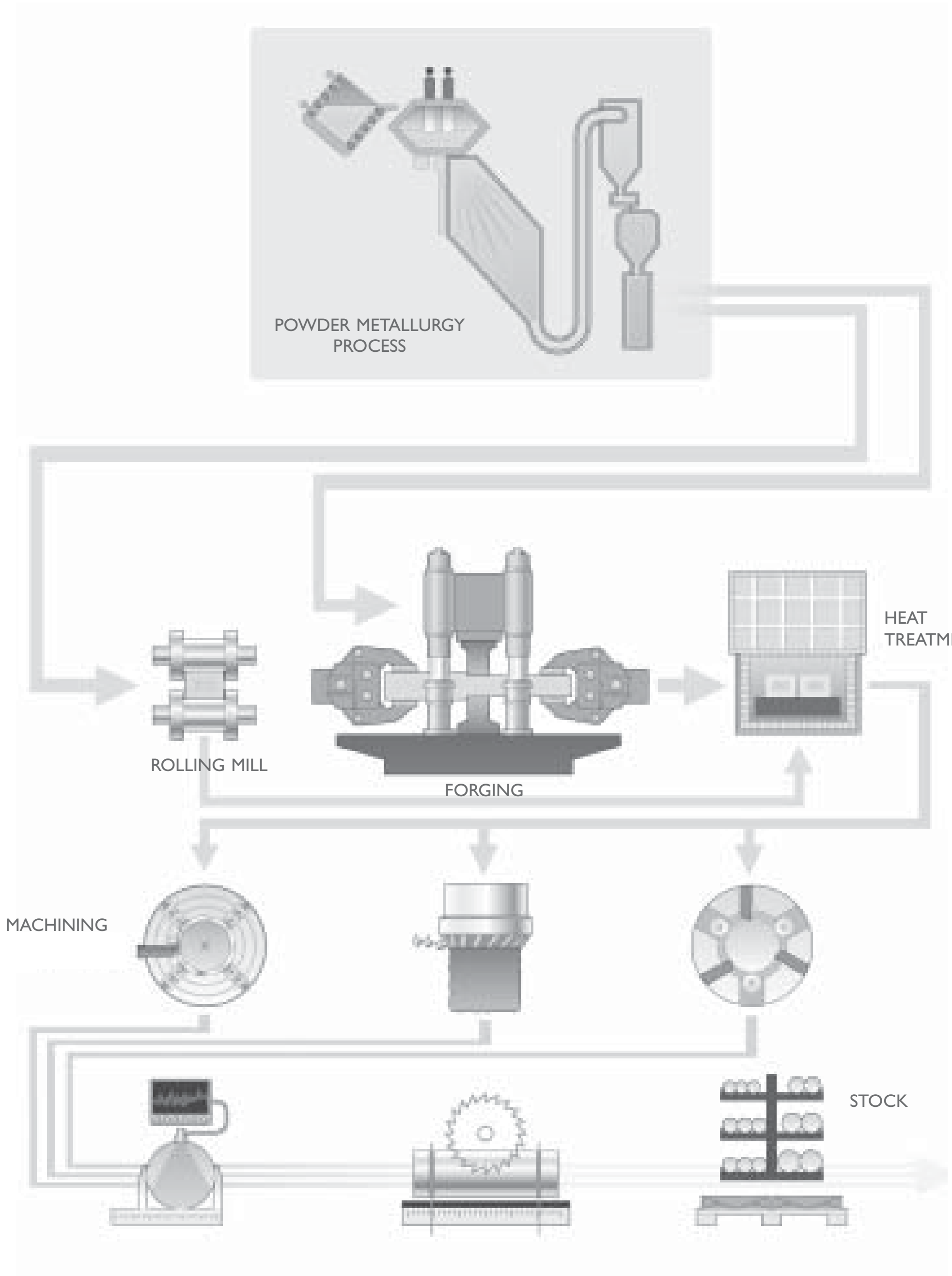
Relative comparison of Uddeholm cold work tool steel

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.



The Powder Metallurgy process

In the powder metallurgy process nitrogen gas is used to atomise the melted steel into small droplets, or grains. Each of these small grains solidifies quickly and there is little time for carbides to grow. These powder grains are then compacted to an ingot in a hot isostatic press (HIP) at high temperature and pressure. The ingot is then rolled or forged to steel bars by conventional methods.

The resulting structure is completely homogeneous steel with randomly distributed small carbides, harmless as sites for crack initiation but still protecting the tool from wear.

Large slag inclusions can take the role as sites for crack initiation instead. Therefore, the powder metallurgical process has been further developed in stages to improve the cleanliness of the steel. Powder steel from Uddeholm Tooling is today of the third generation and is considered the cleanest powder metallurgy tool steel product on the market.

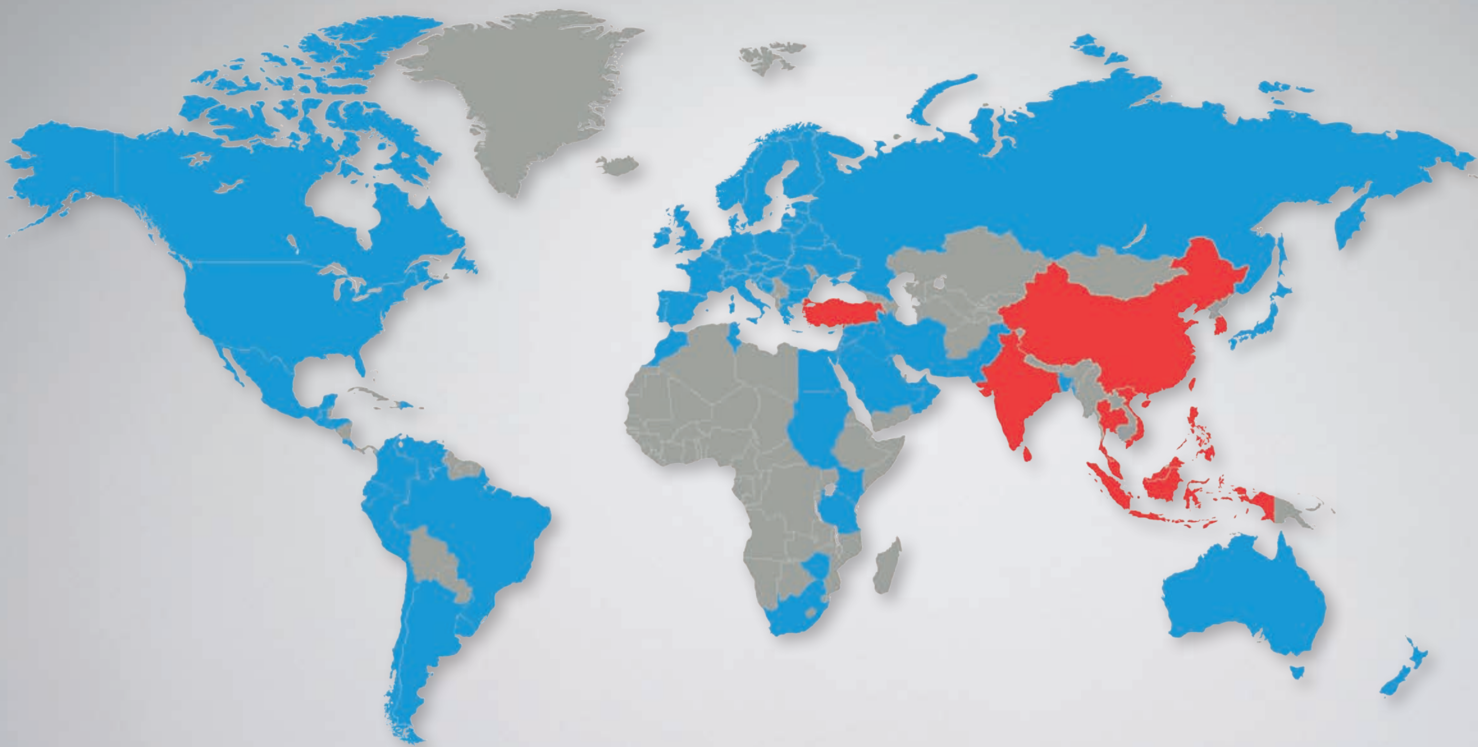
HEAT TREATMENT

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.



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 wholly-owned subsidiary and 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 wholly-owned subsidiary and 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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