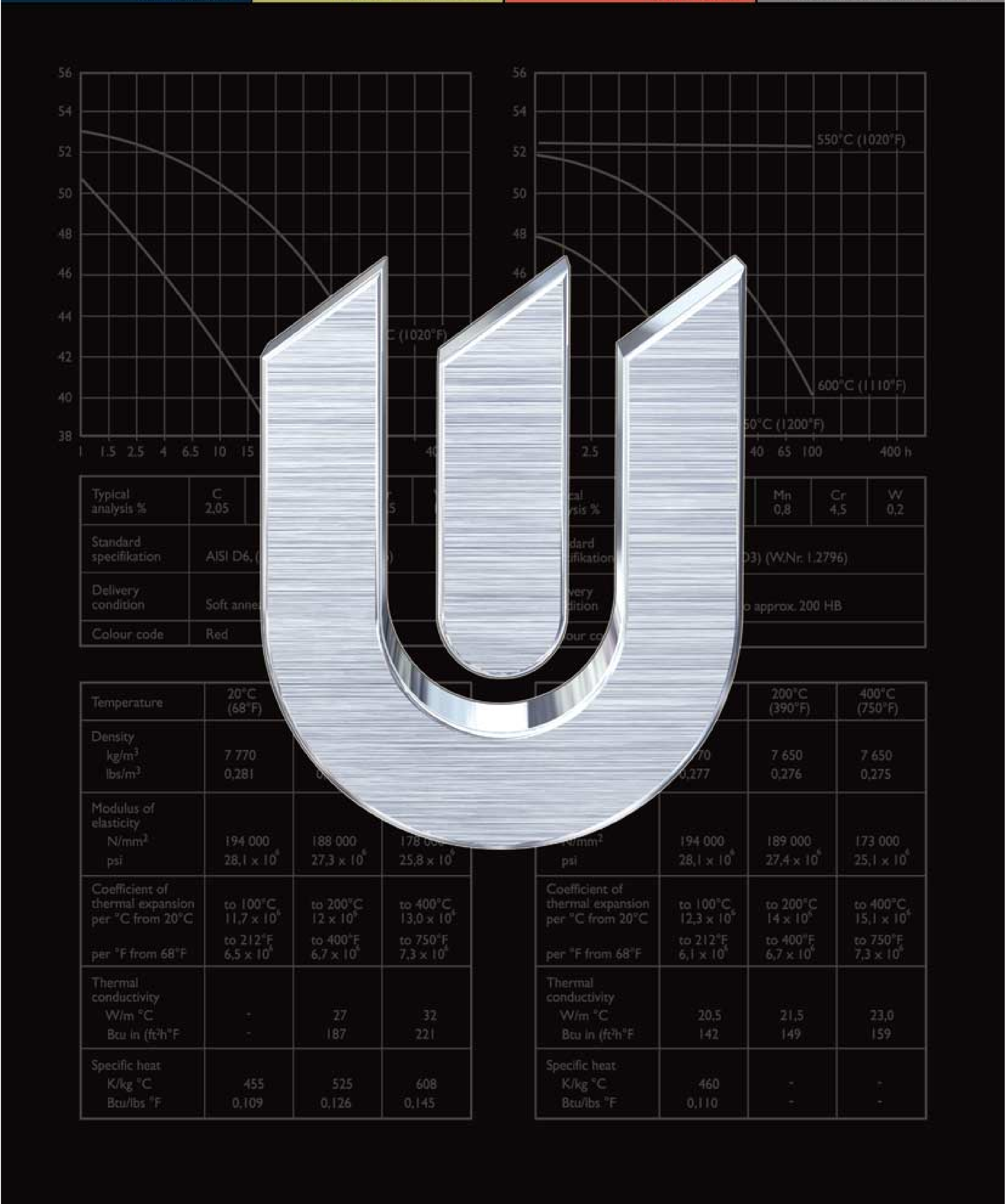
VANADIS 10–SuperClean™

High performance powder metallurgical cold work tool steel

COLD WORK | **PLASTIC** MOULDING | **HOT** WORK | **HIGH** PERFORMANCE STEEL



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.

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

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, *VANADIS 10* has a similar heat treatment procedure to the steel D2. One very big advantage with *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 *VANADIS 10* is a tool steel which is very suitable for CVD coating.

Applications

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 *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

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

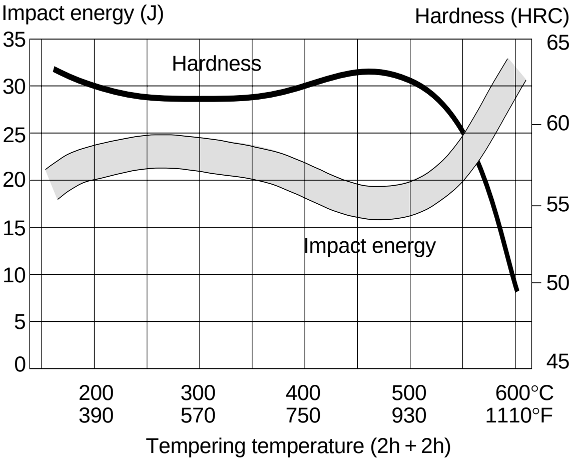
PHYSICAL DATA

Hardened and tempered to 62 HRC.

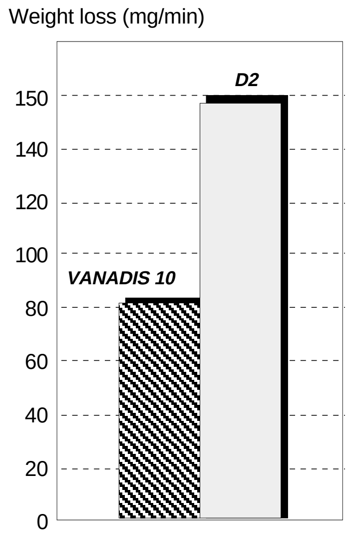
Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density kg/m³ lbs/in³	7 400 0,268	—	—
Modulus of elasticity N/mm² psi	220 000 $31,9 \times 10^6$	210 000 $30,4 \times 10^6$	200 000 $29,0 \times 10^6$
Coefficient of thermal expansion per °C from 20°C °F from 68°F	—	$10,7 \times 10^{-6}$ $6,0 \times 10^{-6}$	$11,4 \times 10^{-6}$ $6,3 \times 10^{-6}$
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") unnochted. Hardened at 1020°C (1870°F). Quenched in air. Tempered twice.



WEAR RESISTANCE



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

Typical application area for VANADIS 10: high volume production of electrical components.

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 mins.

N.B. 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.

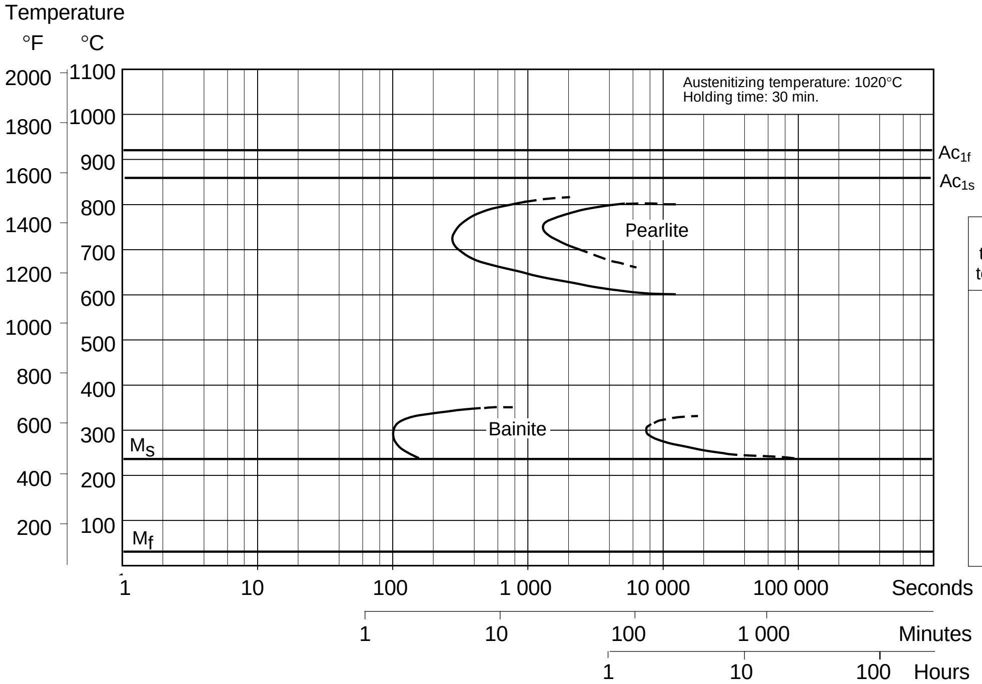
Note 1: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

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.

TTT-graph

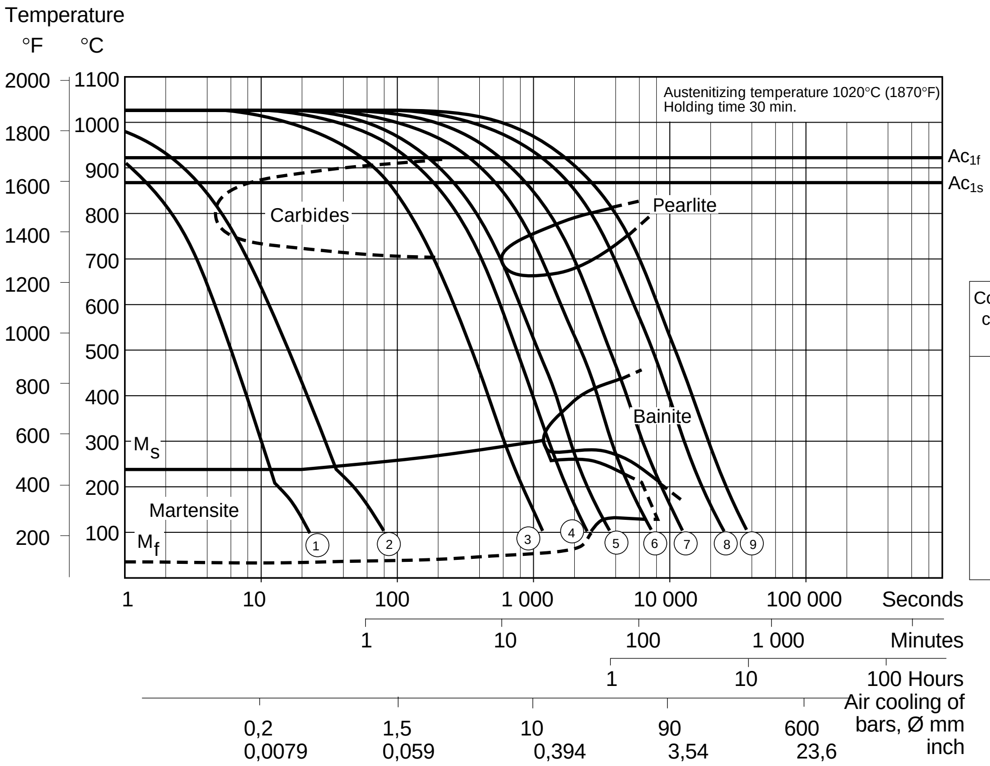
Austenitizing temperature 1020°C (1870°F). Holding time 30 minutes.



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

CCT-graph

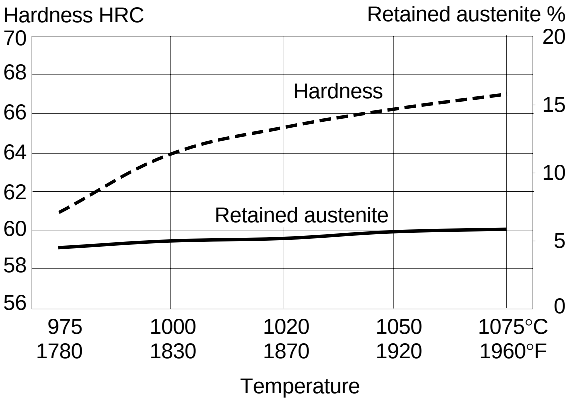
Austenitizing temperature 1020–1060°C (1870–1940°F). Holding time 30 minutes.



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

Hardness and retained austenite as functions of austenitizing temperature.

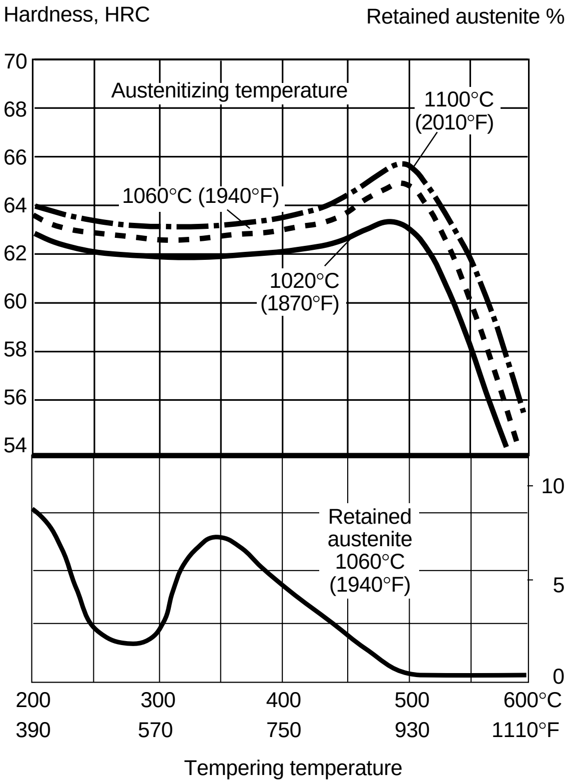
Holding time 30 min. Air-cooling.



TEMPERING

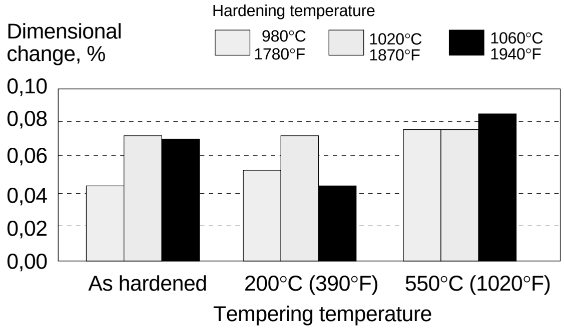
Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with intermediate cooling to room temperature. Lowest tempering temperature 180° C (360° F). Holding time at temperature minimum 2 hours. At a hardening temperature of 1100° C (2010°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

Tempering graph

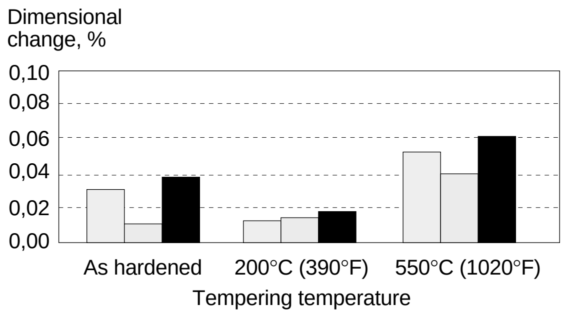


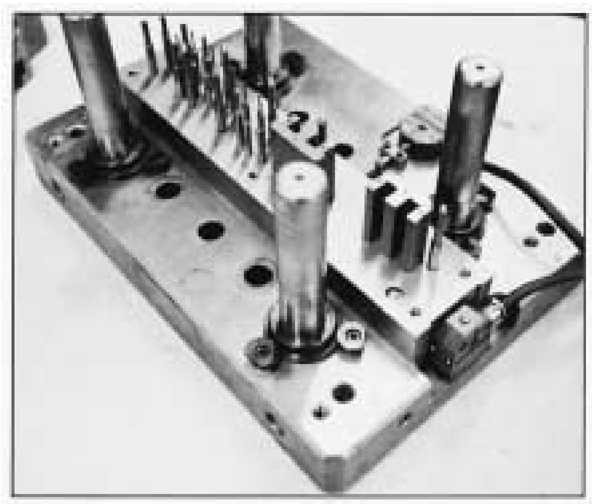
DIMENSIONAL CHANGES AFTER HARDENING AND TEMPERING

Specimen size: 65 x 65 x 65 mm (2,5" x 2,5" x 2,5")



Specimen size: 125 x 125 x 25 mm (5" x 5" x 1")





Typical application for VANADIS 10. Tool for blanking and forming eletcrical strip.

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 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.

NITRIDING

Nitriding produces a hard surface layer that increases wear resistance and reduces the tendency towards galling.
If high temperature tempered *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.

Machining recommendations

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

TURNING

Cutting data parameters	Turning with carbide: Rough turning	Turning with carbide: Fine turning	Turning with high speed steel
Cutting speed (v_c) m/min.	40–70	70–130	10
f.p.m.	130–230	230–430	33
Feed (f) mm/r	0,3–0,6	–0,3	–0,3
i.p.r.	0,01–0,024	–0,01	–0,01
Depth of cut (a_p) mm	2–6	–2	–2
inch	0,08–0,24	–0,08	–0,08
Carbide designation ISO	K15*	K15*	–

Use a wear resistant Al_2O_3-coated carbide grade, e.g. Sandvik Coromant GC 3015 or SECO TP05.

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	8*	26*	0,08–0,20	0,003–0,008
5–10	3/16–3/8	8*	26*	0,20–0,30	0,008–0,012
10–15	3/8–5/8	8*	26*	0,30–0,35	0,012–0,014
15–20	5/8–3/4	8*	26*	0,35–0,40	0,014–0,016

** For coated HSS drill $v_c \approx$ 10 m/min. (30 f.p.m.).*

Carbide drill

Cutting data parameters	Type of drill: Indexable insert	Solid carbide	Carbide tipped coolant-fed[1]
Cutting speed (v_c) m/min.	80–130	35	25
f.p.m.	260–430	115	85
Feed (f) mm/r	0,05–0,25[2]	0,10–0,25[2]	0,15–0,25[2]
i.p.r.	0,002–0,01	0,004–0,01	0,006–0,01

[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	Milling with high speed steel
Cutting speed (v_c) m/min.	40–80	80–110	8
f.p.m.	130–200	260–360	26
Feed (f_z) mm/tooth	0,2–0,4	0,1–0,2	0,1
in/tooth	0,008–0,016	0,004–0,008	0,004
Depth of cut (a_p) mm	2–5	–2	–2
inch	0,08–0,20	–0,08	–0,08
Carbide designation ISO	K15*	K15*	–

**Use a wear resistant Al_2O_3 coated carbide grade, e.g. Sandvik Coromant GC 3015 or SECO T10M.*

End milling

Cutting data parameters	Type of end mill: Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min.	20	50–80	8[1]
f.p.m.	65	165–265	26[1]
Feed (f_z) mm/tooth	0,03–0,20[2]	0,08–0,20[2]	0,05–0,35[2]
in/tooth	0,001–0,008[2]	0,003–0,008[2]	0,002–0,014[2]
Carbide designation ISO	K 20	K 15[3]	–

[1] For coated HSS end mill $v_c \approx$10 m/min (33 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

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	Annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	B107 R75 B3[1)] 3SG 46 GVS[2)] C 46 GV
Face grinding segments	A 24 GV	3SG 46 FVSPF[2)] A 46 FV
Cylindrical grinding	A 60 JV	B126 R75 B3[1)] 5SG 70 IVS[2)] C 60 IV
Internal grinding	A 46 JV	B107 R75 B3[1)] 3SG 60 JVS[2)] C 60 HV
Profile grinding	A 100 LV	B107 R100 V[1)] 5SG 80 JVS[2)] C 120 HV

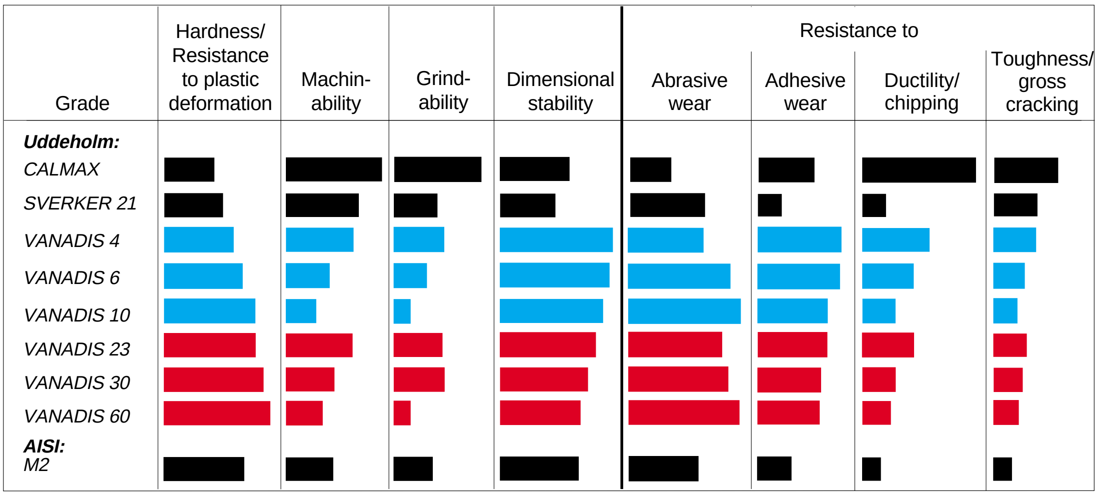
[1)] If possible, use CBN-wheels for this application.
[2)] Grinding wheel from Norton Co.

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 re-tempered at approx. 25°C (50°F) lower than the original tempering temperature.
When EDM’ing larger sizes or complicated shapes *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



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