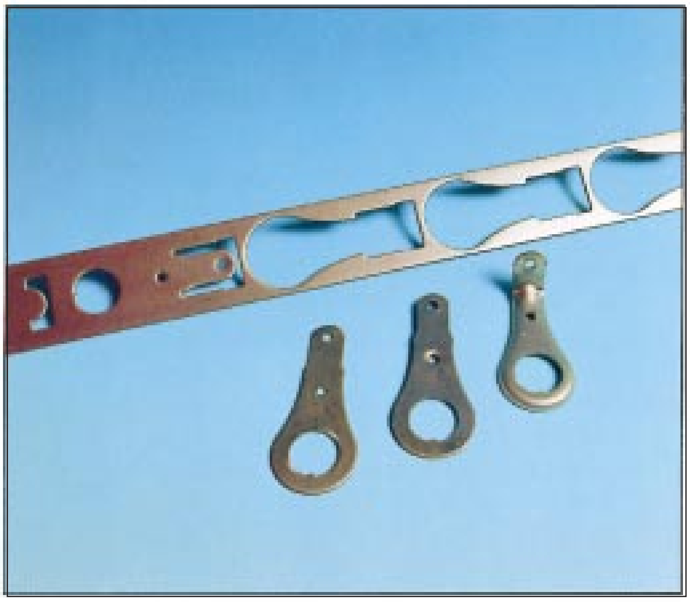


VANADIS 23 – SuperClean™
High performance powder metallurgical cold work tool steel

UDDEHOLM

Great Tooling Starts Here!

Cover:
Stainless steel fastener stamped with a VANADIS 23 die and VANADIS 4 punch.

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.

VANADIS 23 is a powder metallurgical tool steel offering an excellent combination of wear resistance and toughness.

TOOLMAKING

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

Toolmaking 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 toolmaking.

The powder manufacturing route used for *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 *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 *VANADIS 23* is very suitable for surface coating, in particular for PVD.

Applications

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 mold tooling subjected to abrasive wear conditions
- Plastics processing parts, e.g. feed screws, barrel liners, nozzles, screw tips, non-return check ring valves, pellitizer blades, granulator knives.

General

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				
Delivery condition	Soft annealed to approx. 260 Brinell				
Color code	Violet				

Tooling parts for canning industry.

Properties

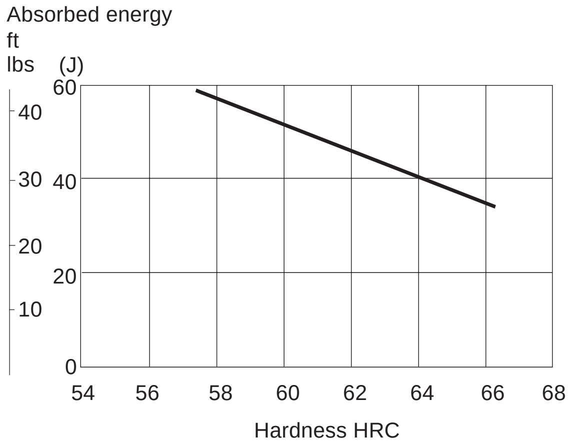
PHYSICAL DATA

Hardened and tempered condition.

Temperature	70°F (20°C)	750°F (400°C)	1110°F (600°C)
Density			
lbs/in³	0.287	0.283	0.281
kg/m³	7980	7870	7805
Modulus of elasticity			
ksi	33 x 10³	30 x 10³	27 x 10³
MPa	230 000	205 000	184 000
Coefficient of thermal expansion per			
°F from 68°F	–	6.7 x 10^{-6}	7.0 x 10^{-6}
°C from 20°C	–	12.1 x 10^{-6}	12.7 x 10^{-6}
Thermal conductivity			
Btu in/ft² h°F	166	194	187
W/m•°C	24	28	27
Specific heat			
Btu /lb °F	0.10	0.12	0.14
J/kg °C	420	510	600

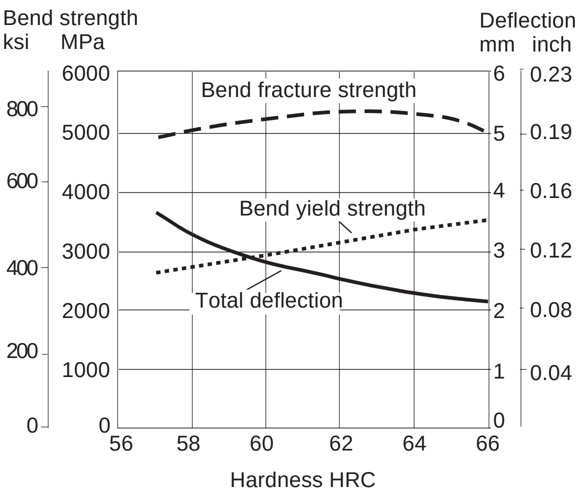
IMPACT STRENGTH

Approximate room temperature impact strength at different hardness levels.
Specimen size: 0.27" x 0.40" x 2.2" (7 x 10 x 55 mm)
Specimen type: unnotched.
Tempering: 3 x 1 h at 1040° F (560° C).
Longitudinal direction.



BENDING STRENGTH AND DEFLECTION

Four-point bend testing.
Specimen size: 0.2" (5 mm) Ø.
Loading rate: 0.2"/min. (5 mm/min.). Austenitizing temperature: 1810–2160° F (990–1180° C).
Tempering: 3 x 1 h at 1040° F (560° C).



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

Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 1560–1650° F (850–900° C). Then cool in the furnace at 20° F/h (10° C/h) to 1290° F (700° C), then freely in air.

STRESS RELIEVING

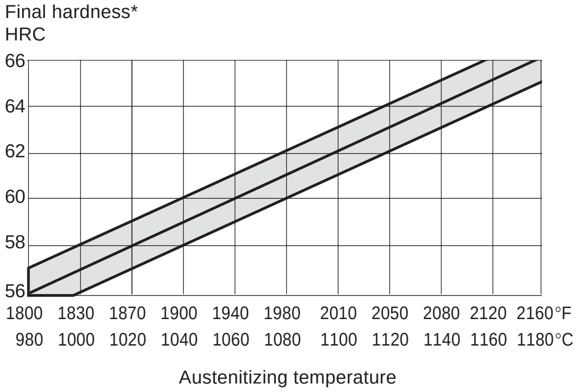
After rough machining the tool should be heated through to 1110–1290° F (600–700° C), holding time 2 hours. Cool slowly to 930° F (500° C), then freely in air.

HARDENING

Pre-heating temperature: 840–930° F (450–500° C) and 1560–1650° F (850–900° C).

Austenitizing temperature: 1920–2160° F (1050–1180° C) according to the desired final hardness, see diagram below.

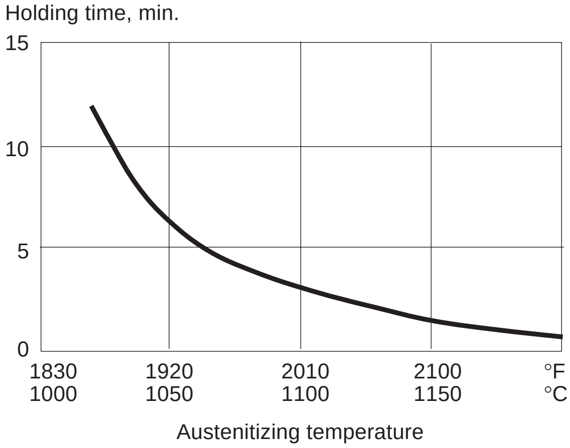
The tool should be protected against decarburization and oxidation during hardening.



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

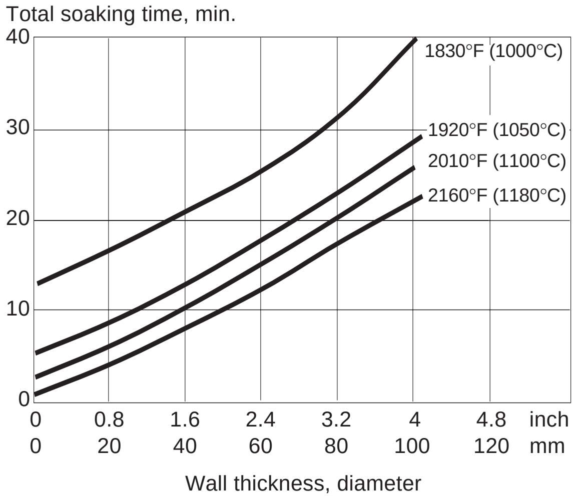
HRC	°F	°C
58	1868	1020
60	1940	1060
62	2012	1100
64	2084	1140
66	2120	1160

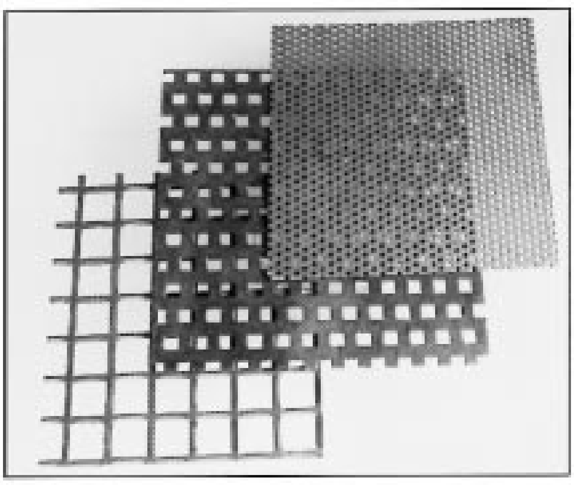
Recommended holding time, fluidized bed, vacuum or atmosphere furnace



Note: Holding time = time at austenitizing temperature after the tool is fully heated through.

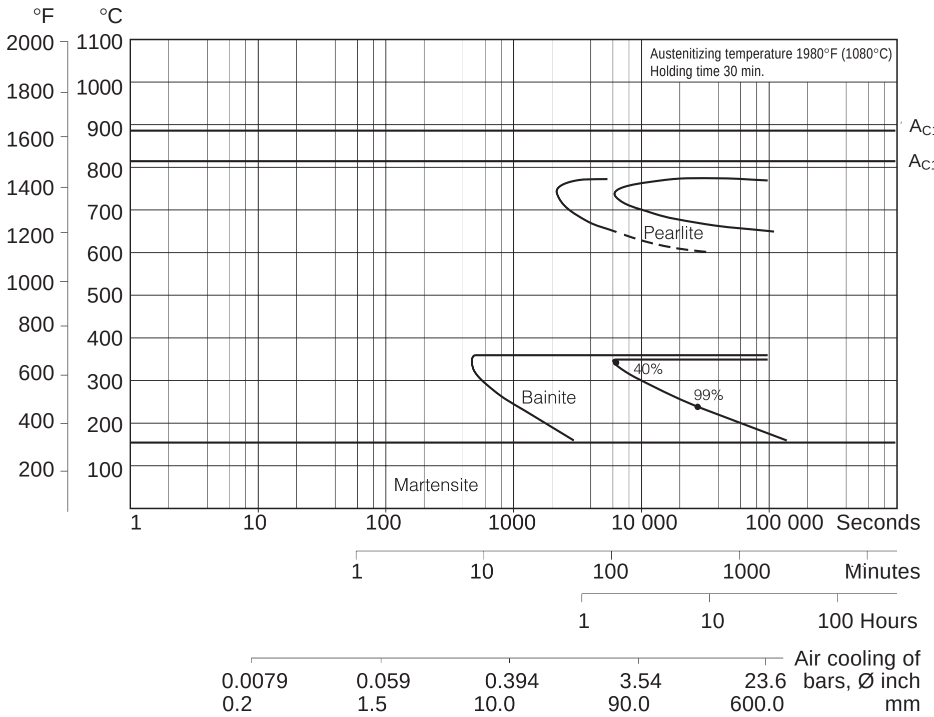
Total soaking time in a salt bath after pre-heating in two stages at 840°F (450°C) and 1560°F (850°C).





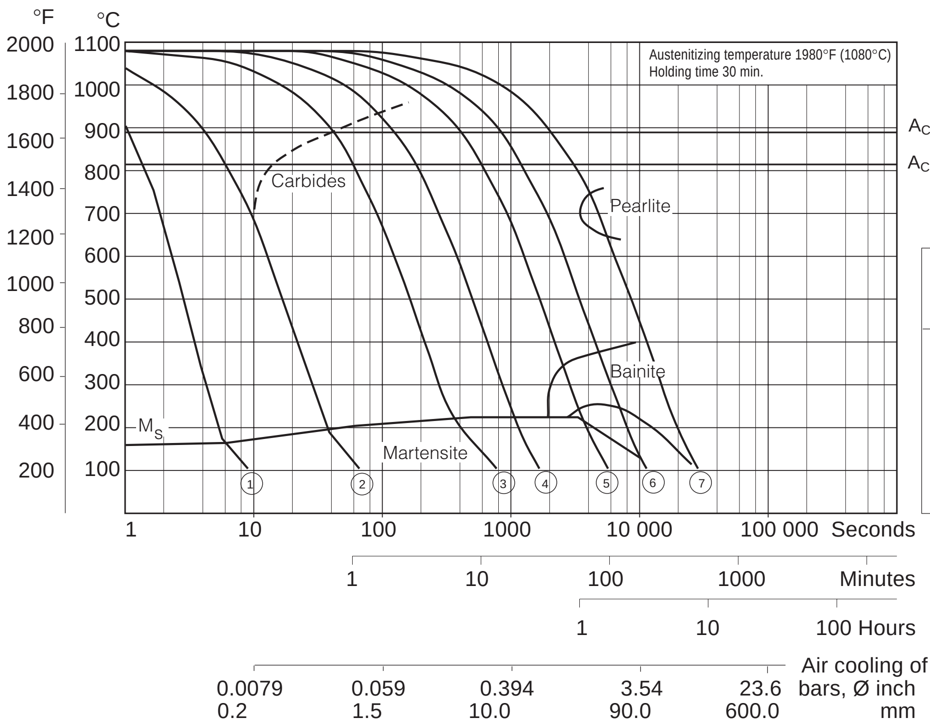
Punched plate.

TTT-graph (isothermal transformation).
Austenitizing temperature 1980° F (1080° C). 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

CCT-graph (continuous cooling).
Austenitizing temperature 1980° F (1080° C). Holding time 30 minutes.



Cooling curve No.	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

QUENCHING MEDIA

- Vacuum furnace with high speed gas at sufficient overpressure (2–5 bar)
- Martempering bath or fluidized bed at approx. 1020° F (550° C)
- Forced air/gas.

Note 1: Quenching should be continued until the temperature of the tool reaches approx. 120° F (50° C). 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 1040° F (560° C) 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 1920–2070° F (1050–1130° C) and tempering 3 x 1 h at 1040° F (560° C).
Specimen size: 3" x 3" x 3" (80 x 80 x 80 mm) and 4" x 4" x 1" (100 x 100 x 25 mm).
Dimensional changes: growth in length, width and thickness +0.03% – +0.13%.

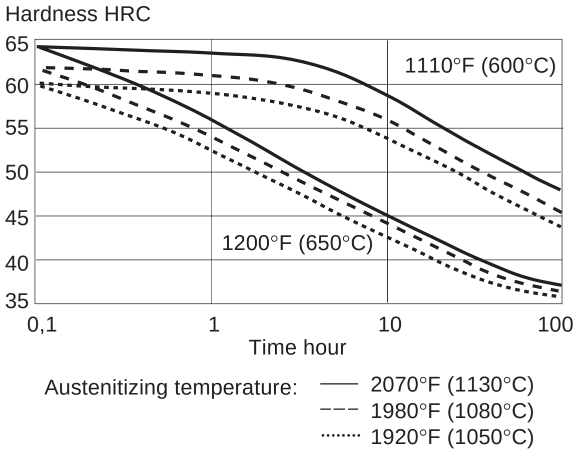
SUB-ZERO TREATMENT

Pieces requiring maximum dimensional stability can be sub-zero treated as follows:
Immediately after quenching the piece should be sub-zero treated to between –95 and –110° F (–70 to –80° C), soaking time 1–3 hours, followed by tempering. Subzero treatment will give a hardness increase of ~1 HRC. Avoid intricate shapes as there will be risk of cracking.

HIGH TEMPERATURE PROPERTIES
TEMPERING RESISTANCE

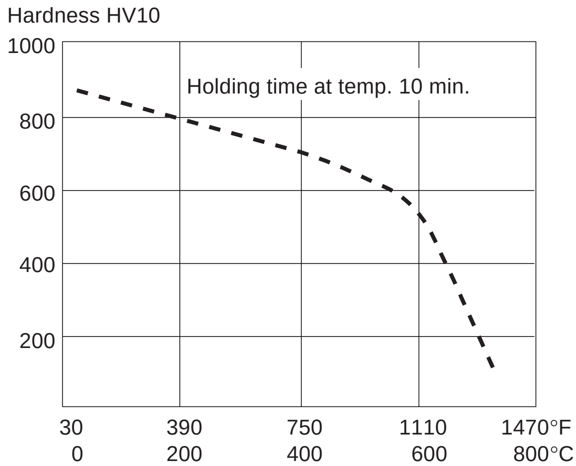
Hardness as a function of holding time at different working temperatures.

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



Hot hardness

Austenitizing temperature: 2160° F (1180° C).
Tempering: 3 x 1 h at 1040° F (560° C).



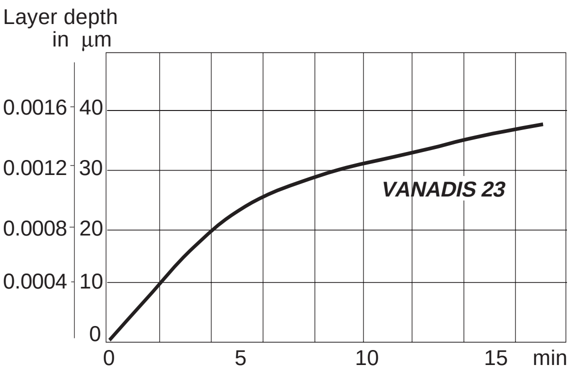
Stainless steel fastener stamped with a VANADIS 23 die and VANADIS 4 punch.

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).
VANADIS 23 have been found to be particularly suitable for titanium carbide and titanium nitride coatings. The uniform carbide distribution in *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 *VANADIS 23* an ideal substrate for high-wear surface coatings.

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 1060°F (570°C)

PVD coated tools in VANADIS 23 for cold forming of tubes.

PVD

Physical vapor deposition, PVD, is a method of applying a wear-resistant coating at temperatures between 390–930° F (200–500° C). As *VANADIS 23* is high temperature tempered at 1040° F (560° C) there is no danger of dimensional changes during PVD coating.

CVD

Chemical vapor deposition, CVD, is used for applying wear-resistant surface coatings at a temperature of around 1830° F (1000° C). It is recommended that the tools should be separately hardened and tempered in a vacuum furnace after surface treatment.

Machining recommendations

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

TURNING

Cutting data parameters	Turning with carbide		Turning with HSS
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) f.p.m.	400–500	500–565	50
m/min	120–150	150–170	15
Feed (f) i.p.r.	0.008–0.016	0.002–0.008	0.002–0.012
mm/r	0.2–0.4	0.05–0.2	0.05–0.3
Depth of cut (a_p) inch	0.08–0.16	0.02–0.08	0.02–0.12
mm	2–4	0.5–2	0.5–3
Carbide designation US	C7–C6*	C7*	–
ISO	P10–P20*	P10*	–

** Use a wear resistant coated carbide grade, for example Sandvik Coromant GC4015 or SECO TP100.*

DRILLING

High speed steel twist drills

Drill diameter inch	Drill diameter mm	Cutting speed v_c f.p.m.	Cutting speed v_c m/min.	Feed f i.p.r.	Feed f mm/r
–3/16	– 5	27–47*	8–14*	0.002–0.006	0.05–0.15
3/16–3/8	5–10	27–47*	8–14*	0.006–0.010	0.15–0.25
3/8–5/8	10–15	27–47*	8–14*	0.010–0.014	0.25–0.35
5/8–3/4	15–20	27–47*	8–14*	0.014–0.016	0.35–0.40

**For TiCN coated HSS drill v_c ~ 83–100 f.p.m. (25–30 m/min.)*

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1)]
Cutting speed, v_c f.p.m.	350–435	135	117
m/min	110–130	40	35
Feed, f i.p.r.	0.003–0.006[2)]	0.004–0.006[2)]	0.004–0.008[2)]
mm/r	0.08–0.15[2)]	0.10–0.15[2)]	0.10–0.20[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		Milling with HSS
	Rough milling	Fine milling	Fine milling
Cutting speed (v_c) f.p.m.	335–435	435–535	40
m/min	100–130	130–160	12
Feed (f_z) inch/tooth	0.008–0.012	0.004–0.008	0.004
mm/tooth	0.2–0.3	0.1–0.2	0.1
Depth of cut (a_p) inch	0.08–0.16	0.04–0.08	0.04–0.08
mm	2–4	1–2	1–2
Carbide designation US	C3*	C3*	–
ISO	K15*	K15*	–

** Use a wear resistant coated carbide grade, for example Sandvik Coromant GC3015 or SECO T15M.*

End milling

Cutting data parameters	Type of mill		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) f.p.m.	150–185	365–465	40[1)]
m/min	45–55	110–140	12[1)]
Feed (f_z) inch/tooth	0.0004–0.008[2)]	0.002–0.008[2)]	0.0004–0.012[2)]
mm/tooth	0.01–0.2[2)]	0.06–0.2[2)]	0.01–0.3[2)]
Carbide designation US	C2	C3[3)]	–
ISO	K20	P25[3)]	–

[1)] For coated HSS end mill v_c ~83–100 f.p.m. (25–30 m/min.).
[2)] Depending on radial depth of cut and cutter diameter.
[3)] Coated carbide.

GRINDING

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

Wheel selection

Type of grinding	Annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	B151 R75 B3[1)] 3SG 46 HVS[2)] A 46 GV
Face grinding segments	A 24GV	3SG 36 HVS[2)] A 36 HV
Cylindrical grinding	A 60 JV	B126 R75 B3[1)] 3SG 60 KVS[2)] A 60 IV
Internal grinding	A 46 JV	B126 R75 B3[1)] 3SG 60 JVS[2)] A 60 HV
Profile grinding	A 100 LV	B107 R100 B6[1)] 5SG 80 KVS[2)] A 120 JV

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

Electrical-discharge machining

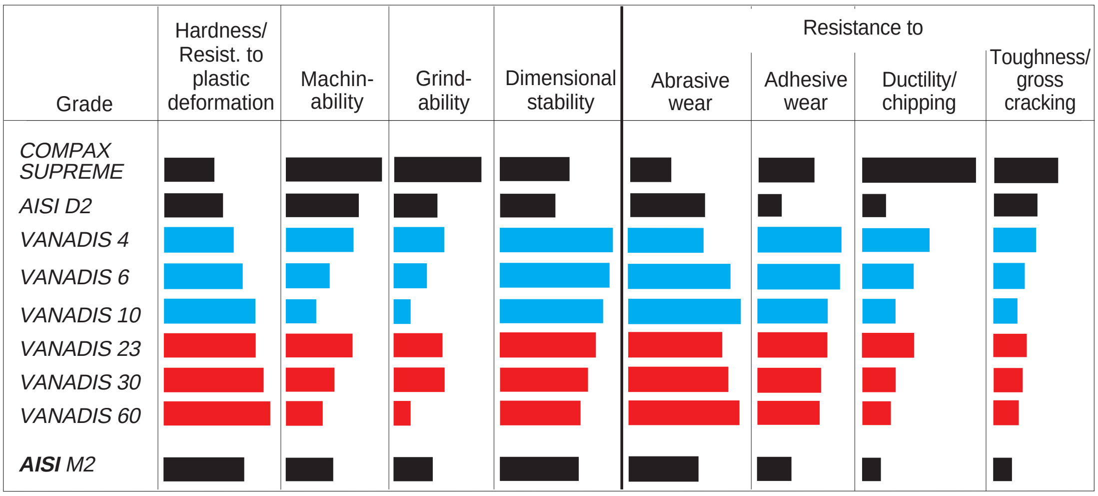
If EDM is performed in the hardened and tempered condition, finish with “fine-sparking”, i.e. low current, high frequency. For optimal performance the EDM’d surface should then be ground/ polished and the tool retempered at approx. 995°F (535°C).

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



Inget påtryck