ASSAB ASP 23

High performance powder metallurgical cold work tool steel

ASSAB

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 ductility and vice-versa. However, for optimal tool performance both high wear resistance and ductility are essential in many cases.

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

TOOLMAKING

- Machinability
- Heat treatment
- 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 alloyed grades. This can, of course, raise the cost of toolmaking.

The powder manufacting route used for *ASP 23* means that its machinability is superior to that of conventionally produced grades with similar analysis and some highly alloyed cold work tool steels.

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

Applications

ASP 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 surface of the tool is high. For examples:

- 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 proccessing parts, e.g. feed screws, barrel liners, nozzles, screw tips, non-return check ring valves, pellitiser blades, granulator knives.

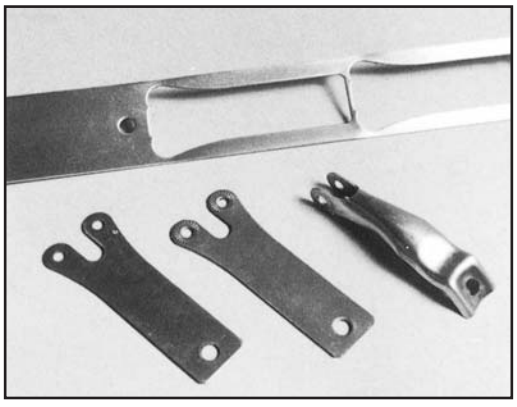
General

ASP 23 is a chromium-molybdenum-tungsten-vanadium alloyed high speed steel which is characterised 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, JIS SKH53				
Delivery condition	Soft annealed to approx. 260* HB				
Colour code	Violet				

** For drawn material, max. 300 HB.*



Stainless steel fastener blanked with an ASP 23 die and VANADIS 4 punch.

Properties

PHYSICAL DATA

Hardened and tempered condition.

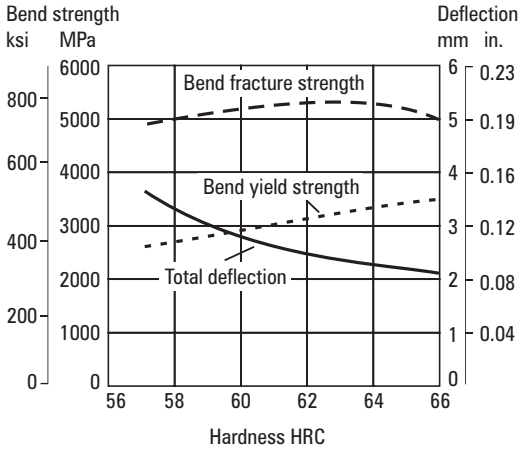
Temperature	20°C (70°F)	400°C (750°F)	600°C (1110°F)
Density			
kg/m³	7 980	7 870	7 805
lb/in³	0.287	0.283	0.281
Modulus of elasticity			
MPa	230 000	205 000	184 000
ksi	33 x 10³	30 x 10³	27 x 10³
Thermal conductivity			
W/m °C	24	28	27
Btu in/ft²h°F	165	194	187
Specific heat			
J/kg °C	420	510	600
Btu/lb°F	0.10	0.12	0.14

COEFFICIENT OF THERMAL EXPANSION IN DIFFERENT TEMPERATURE INTERVALS

Temperature range	Coefficient
20 – 100°C	10.8 x 10^{-6}
20 – 200°C	11.1 x 10^{-6}
20 – 220°C	11.3 x 10^{-6}
20 – 240°C	11.3 x 10^{-6}
20 – 260°C	11.5 x 10^{-6}
20 – 280°C	11.6 x 10^{-6}
20 – 300°C	11.7 x 10^{-6}
20 – 400°C	12.1 x 10^{-6}
–	–
100 – 200°C	11.4 x 10^{-6}
200 – 300°C	12.7 x 10^{-6}
300 – 400°C	13.3 x 10^{-6}
400 – 500°C	13.6 x 10^{-6}

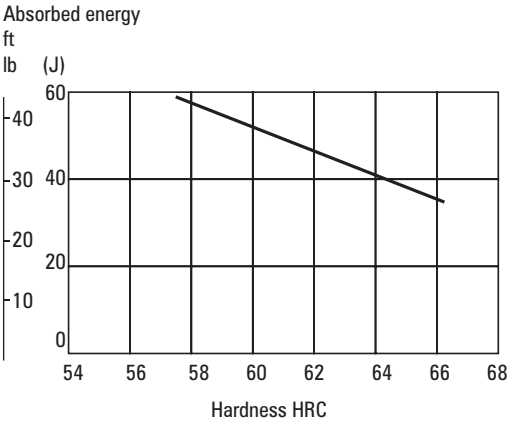
BENDING STRENGTH AND DEFLECTION

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



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.



Screwbolt forged in an ASP 23 tool.

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

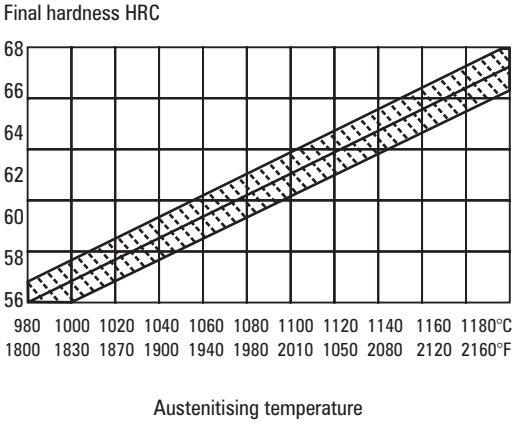
Afte rough machining the tool should be heated through to 600-700°C (1110-1290°F), holding time 2 hours. Cool slowly to 500C (930°F), freely in air.

HARDENING

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

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

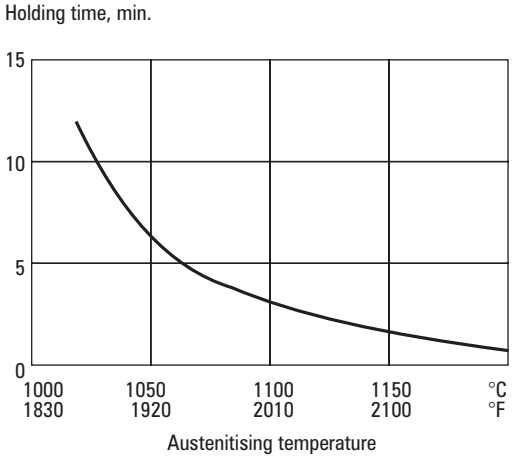
The tool should be protected against decarburisation and oxidation during hardening.



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

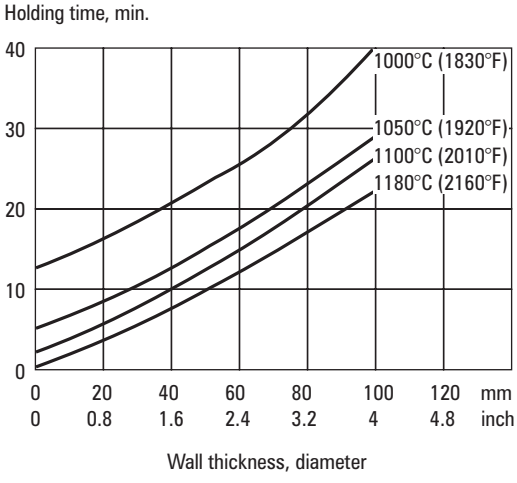
HRC	°C	°F
58	1020	1868
60	1060	1940
62	1100	2012
64	1140	2084
66	1180	2160

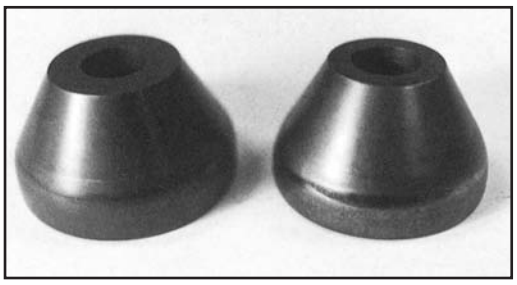
Recommended holding time, fluidised bed, vacuum or atmosphere furnace.



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

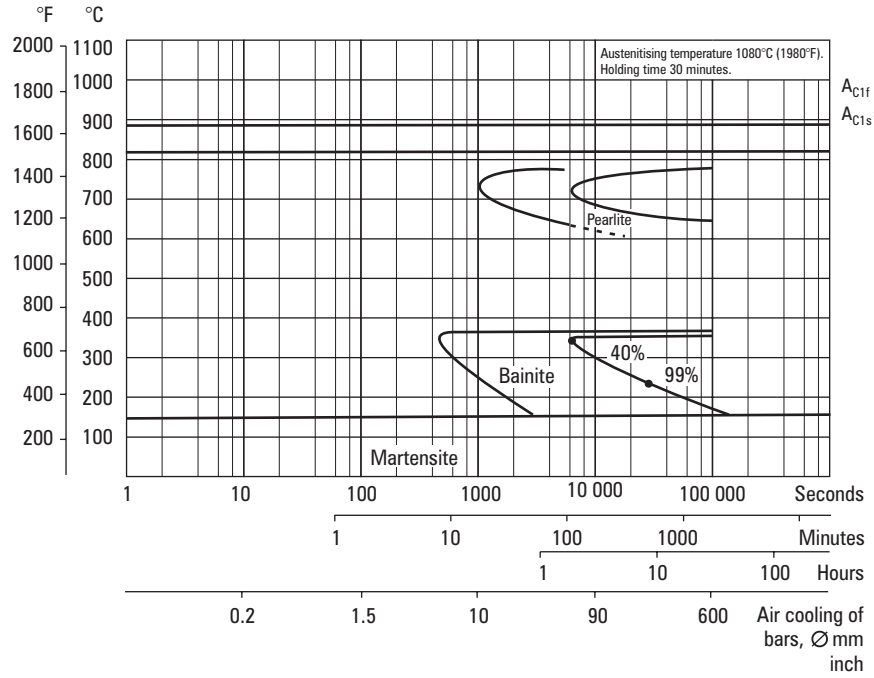
Total soaking time in a salt bath after pre-heating in two stages at 450°C (840°F) and 850°C (1560°F).





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

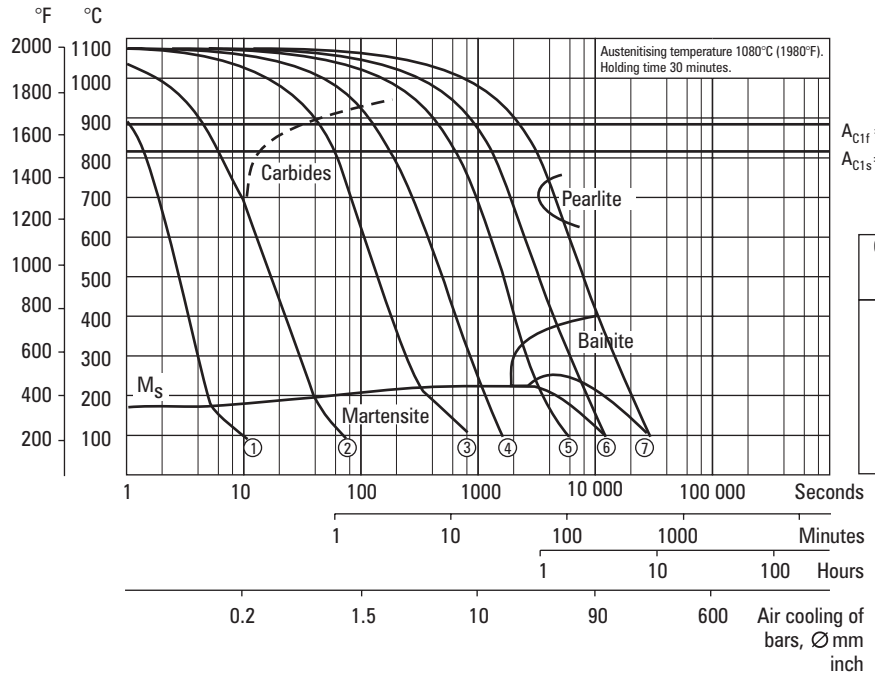
TTT-graph (isothermal transformation).
Austenitising temperature 1080°C (1980°F). Holding time 30 minutes.



A_{C1f} = 890°C (1635°F)
A_{C1s} = 815°C (1500°F)

Temp. °C	Time hours	Hardness HV10
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).
Austenitising temperature 1080°C (1980°F). Holding time 30 minutes.



A_{C1f} = 890°C (1635°F)
A_{C1s} = 815°C (1500°F)

Cooling curve No.	Hardness HV 10	$T_{800\text{-}500}$ (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 fluidised 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

Tempering should always be carried out at 560°C (1040°F) irrespective of the austenitising 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: Austenitising 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% to +0.13%.

SUB-ZERO TREATMENT

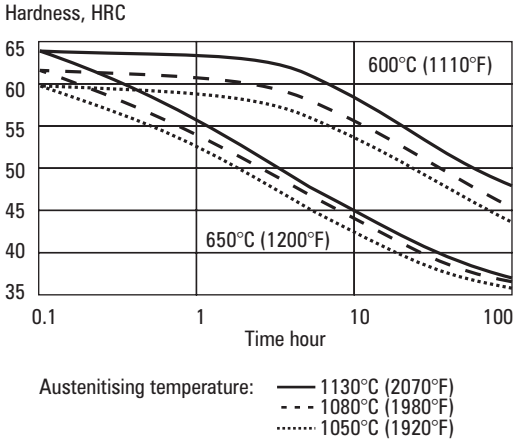
Pieces requiring maximum dimensional stability can be sub-zero treated as follows:

Immediately after quenching the piece should be sub-zero treated to between -70 to -800°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
TEMPERING RESISTANCE

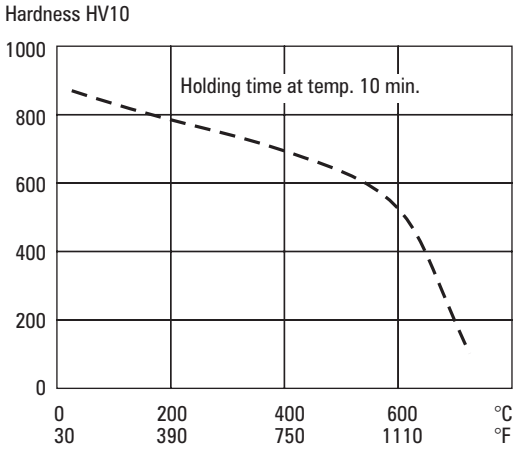
Hardness as a function of holding time at different working temperatures.

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



Hot hardness

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



Tooling parts for canning industry.

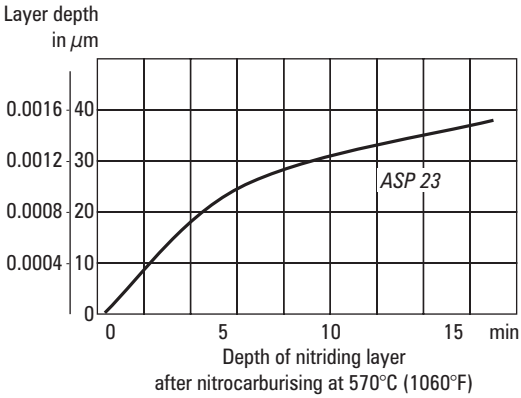
Surface treatments

The most commonly used treatments are nitriding and surface coating with wear-resistant layers of titanium carbide and titanium (CVD, PVD).

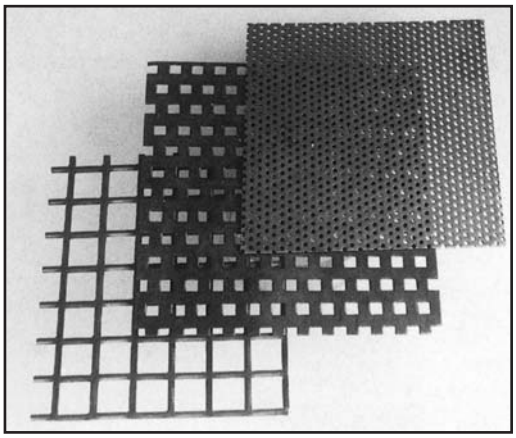
ASP 23 have been found to be particularly suitable for titanium carbide and titanium nitride coatings. The uniform carbide distribution in ASP23 facilitates bonding of the coating and reduces the spread of dimensional changes resulting from hardening. This, together with its high strength and toughness, makes *ASP 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 nitrocarburising at 570°C (1060°F)



Punched plate.

PVD

Physical vapour deposition, PVD, is a method of applying a wear-resistant coating at temperatures between 200-500°C (390-930°F). As *ASP 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 guidelines and as starting point for evaluating your own best practice.

Condition: Soft annealed to approx. 260 HB

TURNING

Cutting data parameters	Turning with carbide		Turning with HSS
	Rough turning	Fine turning	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, (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* Coated carbide	K15* Coated carbide or cermet	–

** Use a wear resistant $Al_2 0_3$ coated carbide.*

DRILLING

High speed steels twist drill

Drill diameter		Cutting speed (v_c)		Feed (f)	
mm	inch	m/min	f.p.m.	mm/r	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 - 0.012
15-20	5/8 - 3/4	10 - 12*	33- 39*	0.25 - 0.30	0.012 - 0.014

** For coated HSS drill, v_c = 16 - 18 m/min. (52 - 59 f.p.m.)*

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1]
Cutting speed, (v_c) m/min f.p.m.	120 - 150 394 - 490	60 - 80 197 - 260	30 - 40 98 -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 - 0.01[2]	0.15 - 0.25[2] 0.006 - 0.01[2]

1) Drill with internal cooling channels and brazed tip.
2) Depending on drill diameter.

MILLING

Face and square shoulder milling

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed, (v_c) m/min f.p.m.	80 - 130 260 - 435	130 - 160 435 - 535
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 $Al_2 0_3$ coated carbide.*

End milling

Cutting data parameters	Type of end mill		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed, (v_c) m/min f.p.m.	40 - 50 130 - 164	90 - 110 295 - 365	5 - 8[1] 16 - 26[1]
Feed, (f_z) mm/tooth in/tooth	0.01 - 0.2[2] 0.004 - 0.008[2]	0.06 - 0.2[2] 0.002 - 0.008[2]	0.01 - 0.3[2] 0.0004 - 0.012[2]
Carbide designation ISO	–	K15*	–

1) For coated HSS, v_c = 12 - 16 m/min. (39 -52 f.p.m.)
2) Depending on radial depth of cut and cutter diameter.
3) Use a wear resistant $Al_2 0_3$ coated carbide.

GRINDING

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

Wheel recommendation

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).

Relative comparison of ASSAB cold work tool steel

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS

ASSAB grade	Hardness/ Resistance to plastic deformation	Machin-ability	Grind-ability	Dimension stability	Resistance to		Fatigue cracking resistance	
					Abrasive wear	Adhesive wear	Ductility/ resistance to chipping	Toughness/ gross cracking
DF-3								
CALMAX								
ASSAB 88								
XW-42								
XW-5								
VANADIS 4								
VANADIS 6								
VANADIS 10								
ASP 23								
ASP 30								
ASP 60								
AISI M:2								

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* *Sales office with warehouse and/or value added services.*

† *Sales office only.*

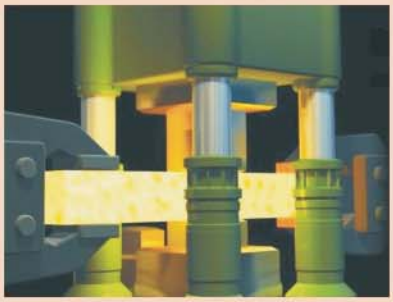
ASSAB TOOL STEELS have been in Asia for more than 60 years. Our customers associate ASSAB brand with tooling materials that are high in quality and consistency.

The ASSAB sales companies and distributors offer you well assorted stocks in a number of places covering the Asia Pacific region.

Besides providing you with the right tool steel for every type of tool, we can help you with machine service and heat treatment.

Our engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the best treatment for each application. We also carry out material examinations at our local mini laboratories, and at the central laboratory in Sweden.

Our steel mill in Sweden, Uddeholm Tooling, is one of the few steelworks in the world that is dedicated to the manufacture of tool steels only. Uddeholm Tooling is certified to **ISO 9001** and **ISO 14001**.



Our forging press is one of the most modern of it's kind in the world.

Besides tool steels, the ASSAB services for tool makers include:

- ☐ Welding electrodes for repair welding of tools.
- ☐ High strength aluminium for tooling purposes.
- ☐ Copper alloys (e.g. beryllium copper) for inserts in moulds.
- ☐ Alloy machinery steels.
- ☐ Cold rolled strip steels for saws, compressor valves, coater blades, etc.
- ☐ High Performance Steels (HPS)

ASSAB
ASSAB PACIFIC GROUP

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