VANADIS 4 EXTRA SUPERCLEAN

UDDEHOLM VANADIS 4 EXTRA SUPERCLEAN

ASSAB	UDDEHOLM a voestalpine company	REFERENCE STANDARD		
		AISI	WNr.	JIS
ASSAB DF-3	ARNE	O1	1.2510	SKS 3
ASSAB XW-10	RIGOR	A2	1.2363	SKD 12
ASSAB XW-42	SVERKER 21	D2	1.2379	(SKD 11)
CALMAX / CARMO	CALMAX / CARMO		1.2358	
VIKING	VIKING / CHIPPER		(1.2631)	
CALDIE	CALDIE			
ASSAB 88	SLEIPNER			
ASSAB PM 23 SUPERCLEAN	VANADIS 23 SUPERCLEAN	(M3:2)	1.3395	(SKH 53)
ASSAB PM 30 SUPERCLEAN	VANADIS 30 SUPERCLEAN	(M3:2 + Co)	1.3294	SKH 40
ASSAB PM 60 SUPERCLEAN	VANADIS 60 SUPERCLEAN		(1.3292)	
VANADIS 4 EXTRA SUPERCLEAN	VANADIS 4 EXTRA SUPERCLEAN			
VANADIS 8 SUPERCLEAN	VANADIS 8 SUPERCLEAN			
VANCRON SUPERCLEAN	VANCRON SUPERCLEAN			
ELMAX SUPERCLEAN	ELMAX SUPERCLEAN			
VANAX SUPERCLEAN	VANAX SUPERCLEAN			
ASSAB 518		P20	1.2311	
ASSAB 618 T		(P20)	(1.2738)	
ASSAB 618 / 618 HH		(P20)	1.2738	
ASSAB 718 SUPREME / HH	IMPAX SUPREME / HH	(P20)	1.2738	
NIMAX / NIMAX ESR	NIMAX / NIMAX ESR			
VIDAR 1 ESR	VIDAR 1 ESR	H11	1.2343	SKD 6
UNIMAX	UNIMAX			
CORRAX	CORRAX			
ASSAB 2083		420	1.2083	SUS 420J2
STAVAX ESR	STAVAX ESR	(420)	(1.2083)	(SUS 420J2)
MIRRAX ESR	MIRRAX ESR	(420)		
MIRRAX 40	MIRRAX 40	(420)		
TYRAX ESR	TYRAX ESR			
POLMAX	POLMAX	(420)	(1.2083)	(SUS 420J2)
RAMAX HH	RAMAX HH	(420 F)		
ROYALLOY	ROYALLOY	(420 F)		
COOLMOULD	COOLMOULD			
ASSAB 2714			1.2714	SKT 4
ASSAB 2344		H13	1.2344	SKD 61
ASSAB 8407 2M	ORVAR 2M	H13	1.2344	SKD 61
ASSAB 8407 SUPREME	ORVAR SUPREME	H13 Premium	1.2344	SKD 61
DIEVAR	DIEVAR			
QRO 90 SUPREME	QRO 90 SUPREME			
FORMVAR	FORMVAR			

( ) - modified grade

Edition 20191113

Vanadis 4 Extra SuperClean

CONSISTENT TOOL PERFORMANCE — LONG AND RELIABLE TOOL LIFE

With an increased demand for just in time deliveries (JIT) and shorter lead time, it is of utmost importance that the tool life is predictable with a long and reliable performance. This is also a prerequisite to reduce, your down time, cost for tool maintenance and optimise machine utilisation.

This gives an optimal tooling economy and a competitive production cost. Vanadis 4 Extra SuperClean properties offer very good combination of wear resistance and ductility. This makes it possible for consistent tool performance for demanding cold work applications such as blanking and forming of austenitic stainless steel and Advanced High Strength Steel (AHSS) where a combination of abrasive, adhesive or mixed wear resistance is needed in combination with resistance to chipping and cracking.

MACHINABILITY

The tool making process is a very important link in the tooling sequence. In order to achieve a long and reliable tool performance the quality of the tool in terms of surface finish is extremely important. Vanadis 4 Extra SuperClean offers a very good machinability and grindability compared to other high alloyed PM - tool steel, giving the best conditions for an excellent tool quality. This is the result of the well balanced chemistry and the SuperClean production route.

CRITICAL TOOL STEEL PROPERTIES

FOR GOOD TOOL PERFORMANCE

- Correct hardness for the application
- High wear resistance
- High ductility

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

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

FOR TOOLMAKING

- Machinability
- Heat treatment
- Dimensional stability during heat treatment

Toolmaking with highly alloyed tool steel has traditionally created problems with machining and heat treatment when compared with lower alloyed grades, this then often leads to increased toolmaking costs.

Due to our carefully balanced alloying and the powder metallurgical manufacturing process, Vanadis 4 Extra SuperClean, has better machinability than the tool steel grade AISI D2.

One major advantage with Vanadis 4 Extra SuperClean is that the dimensional stability after hardening and tempering is much better than for all known high performance cold work tool steel. This means, for example, that Vanadis 4 ExtraSuperClean is a tool steel which is very suitablefor CVD coating.

GENERAL

Vanadis 4 SuperClean is a chromium-molybdenum-vanadium alloyed steel which is characterised by:

- Very good ductility
- High abrasive-adhesive wear resistance
- High compressive strength
- Good dimensional stability during heat treatment and in services
- Very good through-hardening properties
- Good temper back resistance
- Good machinability and grindability

Typical analysis %	C 1.4	Si 0.4	Mn 0.4	Cr 4.7	Mo 3.5	V 3.7
Delivery condition	Soft annealed to approx. 230 HB					
Colour code	Green/white with a black line across					

APPLICATIONS

Vanadis 4 Extra SuperClean is especially suitable for applications where adhesive wear and/or chipping are the dominating failure mechanisms, i.e.

- with soft/adherent materials such as austenitic stainless steel, mild steel, copper, aluminium, etc. as work material
- with thicker work material
- high strength work materials

Vanadis 4 Extra SuperClean is however also very suitable for blanking and forming of Advanced High Strength Steels, these materials place high demands on the tool steel regarding abrasive wear resistance and ductility.

Examples:

- Blanking and forming
- Fine blanking
- Cold extrusion tooling
- Powder pressing
- Deep drawing
- Knives
- Substrate steel for surface coating

PROPERTIES

PHYSICAL DATA

Hardened and tempered to 60 HRC.

Temperature	20°C	200°C	400°C
Density kg/m³	7 700	-	-
Modulus of elasticity MPa	206 000	200 000	185 000
Coefficient of thermal expansion /°C from 20°C	-	10.8 x 10^{-6}	11.6 x 10^{-6}
Thermal conductivity W/m°C	-	30	30
Specific heat J/kg°C	460	-	

COEFFICIENT OF THERMAL EXPANSION

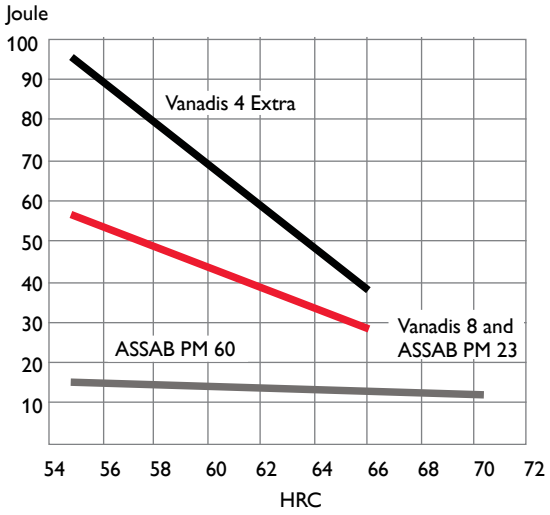
Temperature range, °C	Coefficient, °C from 20
20 - 100	11.0 x 10^{-6}
20 - 200	11.3 x 10^{-6}
20 - 300	11.7 x 10^{-6}
20 - 400	12.1 x 10^{-6}
20 - 500	12.4 x 10^{-6}

IMPACT STRENGTH

Approximate room temperature impact strength as a function of hardness is shown below.
Original bar dimension: Ø 105 mm, samples are taken from the centre and tested in the transverse direction.
Specimen size: 7 x 10 x 55 mm unnotched.
Hardened between 940°C and 1150°C. Holding time 30 minutes up to 1100°C, over 1100°C 15 minutes. Quenched in air. Tempered 2 x 2h between 525°C and 570°C.

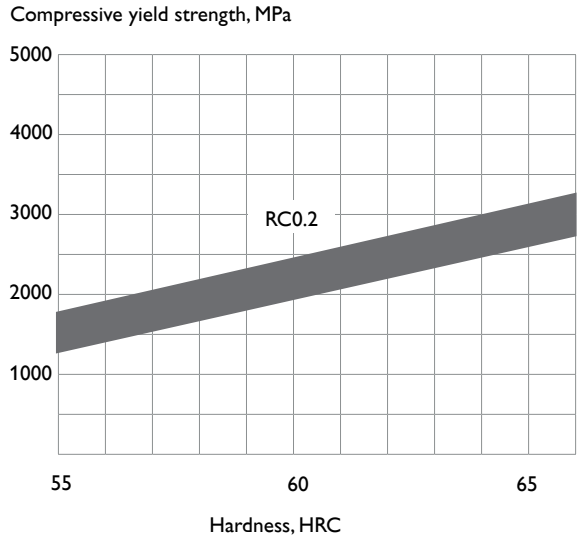
DUCTILITY

Impact test, unnotched, CR2 (thickness direction).
The impact strengths shown in the graph up to the right, are average values. Vanadis 8 SuperClean and ASSAB PM 23 SuperClean have a similar impact strength.



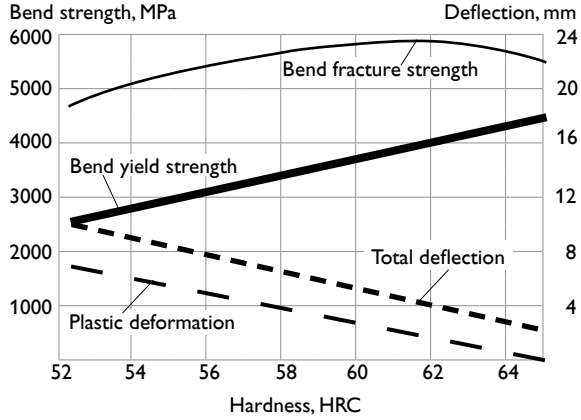
COMPRESSIVE YIELD STRENGTH

Approximate compressive yield strength versus hardness at room temperature.



BEND STRENGTH AND DEFLECTION

Four-point bend testing
Specimen size: 5 mm
Loading rate: 5 mm/min
Austenitising temperature: 990 - 1180°C
Tempering: 3 x 1 h at 560°C



HEAT TREATMENT

SOFT ANNEALING

Protect the steel and heat through to 900°C. Cool in the furnace at 10°C per hour to 750°C, then freely in air.

STRESS RELIEVING

After rough machining the tool should be heated through to 650°C, holding time 2 hours. Cool slowly to 500°C, then freely in air.

HARDENING

Pre-heating temperature: First preheating at 600 – 650°C and second at 850 – 900°C

Austenitising temperature: 940 – 1180°C, normally 1020°C.

- For large sections, i.e. >70 mm use 1060°C.
- For the very best wear resistance use 1100-1180°C.

Soaking time: 30 min. for hardening temperatures up to 1100°C (2010°F), 15 min. for temperatures higher than 1100°C (2010°F).

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

Protect the tool against decarburisation and oxidation during hardening.

QUENCHING MEDIA

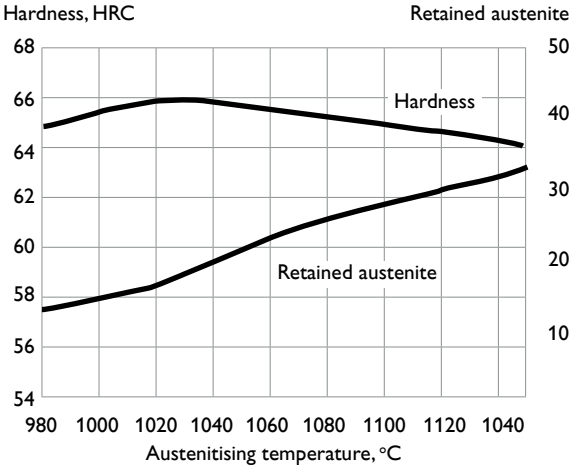
- Vacuum (high speed gas at sufficient overpressure, minimum 2 bar)
- Martempering bath or fluidised bed at 200–550°C
- Forced air/gas

Note: Temper the tool as soon as its temperature reaches 50–70°C. In order to obtain the optimum properties for the tool, the cooling rate should be as fast as possible with regards to acceptable distortion.

A slow quench rate will result in loss of hardness compared with the given tempering curves.

Martempering should be followed by forced air cooling if wall thickness is exceeding 50 mm.

HARDNESS AND RETAINED AUSTENITE AS A FUNCTION OF AUSTENITISING TEMPERATURE



Bumper for passenger car, blanking tools made by Vanadis 4 Extra SuperClean.
Sheet material strength 1000 MPa, thickness 2 mm.
Courtesy of Essa Palau, Barcelona, Spain.

TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper at least twice with intermediate cooling to room temperature.

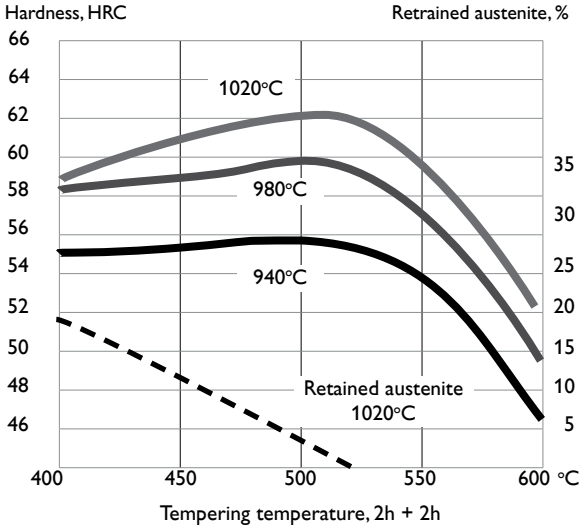
For highest dimensional stability and ductility, a minimum temperature of 540°C and three tempers is strongly recommended.

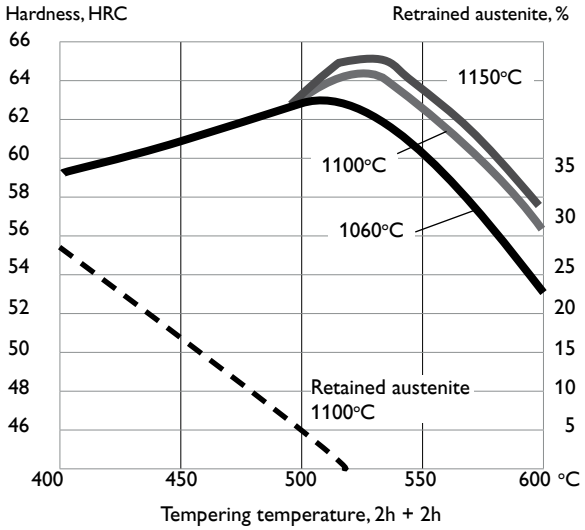
Tempering at a lower temperature than 540°C may increase the hardness and compressive strength to some extent but also impair cracking resistance and dimensional stability. However, if lowering the tempering temperature, do not temper below 520°C.

When tempering twice the minimum holding time at temperature is 2 hours. When tempering three times the minimum holding time is 1 hour.

The tempering curves are obtained after heat treatment of samples with a size of 15 x 15 x 40 mm, cooling in forced air. Lower hardness can be expected after heat treatment of tools and dies due to factors like actual tool size and heat treatment parameters.

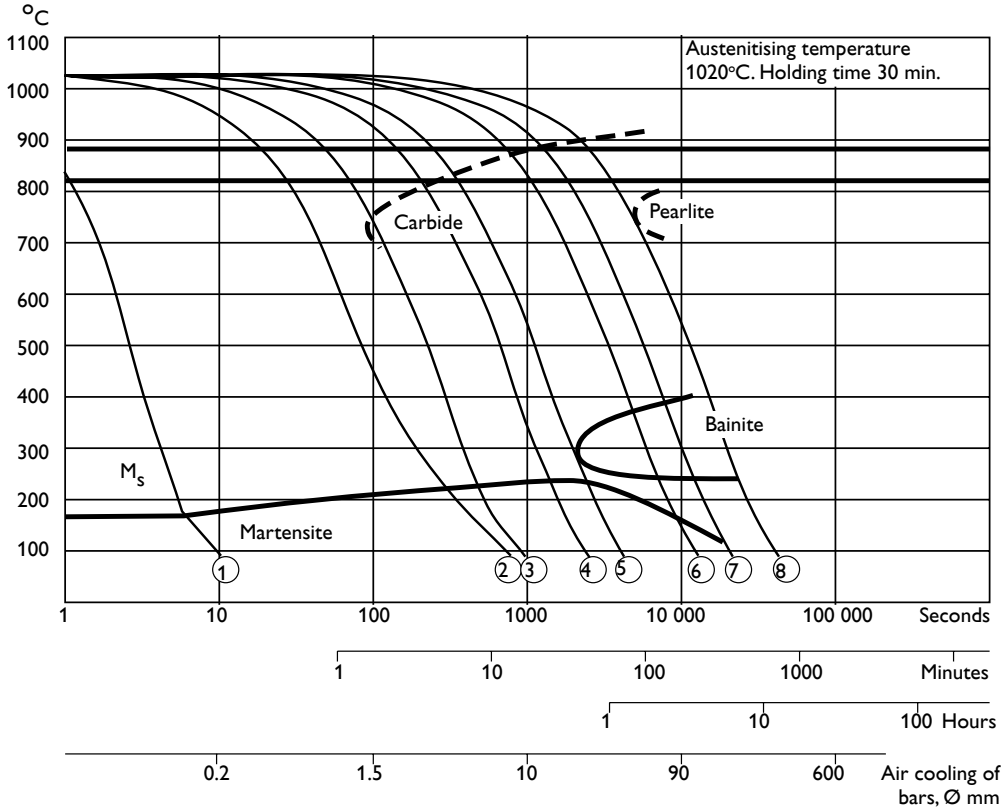
TEMPERING GRAPH





CCT-GRAPH

Austenitising temperature 1020°C. Holding time 30 minutes.



A_{c1_f} = 880°C

A_{c1_s} = 815°C

Cooling Curve No.	Hardness HV10	T 800-500 (sec)
1	858	1
2	858	53
3	858	139
4	858	415
5	858	700
6	649	2077
7	548	3500
8	519	7000

DIMENSIONAL CHANGES DURING HARDENING AND TEMPERING

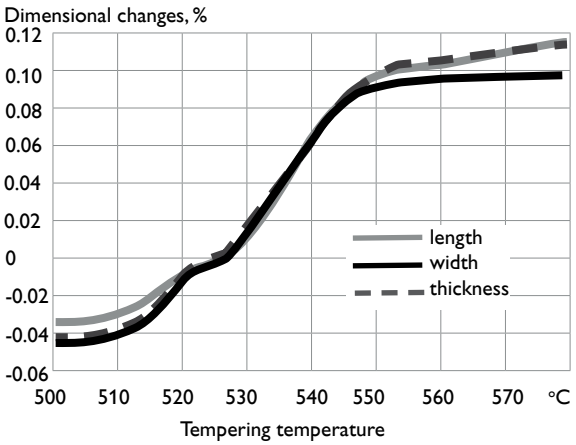
Dimensional changes have been measured after hardening and tempering.

Austenitizing: 1020°C/30 min., cooling in vacuum furnace at 1.1°C/sec. between 800°C and 500°C.

Tempering: 2 x 2 h at various temperatures

Sample size: 80 x 80 x 80 mm

DIMENSIONAL CHANGES DURING HARDENING AND TEMPERING IN LENGTH, WIDTH AND THICKNESS DIRECTION



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, soaking time 3– 4 hours, followed by tempering.

The tempering temperature should be lowered 25°C in order to get the desired hardness when a high temperature temper is performed.

Avoid intricate shapes as there will be risk of cracking.

SURFACE TREATMENT

Some cold work tool steel are given a surface treatment in order to reduce friction and increase wear resistance. The most commonly used treatments are nitriding and surface coating with wear resistant layers produced via PVD and CVD.

The high hardness and toughness together with a good dimensional stability makes Vanadis 4 Extra SuperClean ideal as a substrate steel for various surface coatings.

NITRIDING

Nitriding gives a hard surface layer that is resistant to wear and erosion.

Vanadis 4 Extra SuperClean is normally high Temperature tempered at around 540°C. This means that the nitriding temperature used should not exceed 525°C. Ion nitriding at a temperature below the tempering temperature used is preferred.

The surface hardness after nitriding is approximately 1150 $HV_{0.2\ kg}$. The thickness of the layer should be chosen to suit the application in question.

For blanking and punching the recommended case depth is 10–20 µm and for forming tools it can be up to max. 30 µm.

PVD

Physical vapour deposition, PVD, is a method of applying a wear resistant coating at temperatures between 200–500°C.

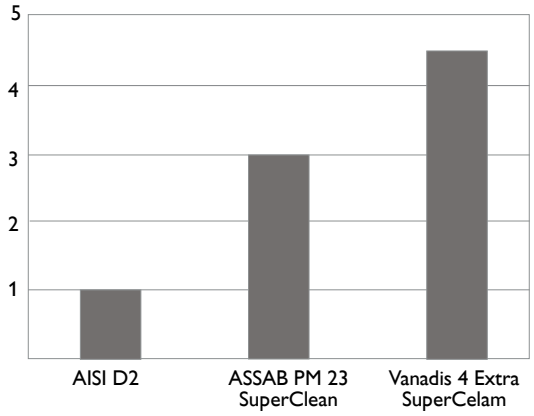
CVD

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

MACHINABILITY

Relative machinability and grindability for AISI D2, ASSAB PM 23 SuperClean and Vanadis 4 Extra SuperClean. High value indicates good machinability/ grindability.

Relative machinability/grindability, (1=worse 5=best)



MACHINING RECOMMENDATIONS

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

The recommendations, in following tables, are valid for Vanadis 4 Extra SuperClean in soft annealed condition to ~230 HB.

TURNING

Cutting data parameter	Turning with carbide		Turning with high speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (V_c) m/min	120 – 170	170 – 220	15 – 20
Feed (f) mm/rev	0.2 – 0.4	0.05 – 0.2	0.05 – 0.3
Depth of cut (a_p) mm	2 – 4	0.5 – 2	0.5 – 3
Carbide designation ISO	K20 *, P20	K15 *, P15	-

* Use a wear resistance CVD-coating

MILLING

FACE AND SQUARE SHOULDER MILLING

Cutting data parameter	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (V_c) m/min	110 - 150	150 – 200
Feed (f) mm/tooth	0.2 – 0.4	0.1 – 0.2
Depth of cut (a_p) mm	2 – 4	≤ 2
Carbide designation ISO	K20, P20 Coated carbide * or cermet *	K15, P15 Coated carbide * or cermet *

* Use a wear resistant CVD coating

END MILLING

Cutting data parameter	Type of end mill		
	Solid carbide	Carbide indexable insert	High speed steel [1]
Cutting speed (V_c) m/min	60 – 80	110 – 160	8 – 12
Feed. (f) mm/tooth	0.03 – 0.20 [2]	0.08 – 0.20 [2]	0.05 – 0.35 [2]
Carbide designation ISO	–	K15 [3] Coated carbide or cermet	–

[1] For coated HSS end mill v_c = 18 – 24 m/min.
[2] Depending on radial depth of cut and cutter diameter
[3] Use a wear resistant CVD coating

DRILLING

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm	Cutting speed (Vc) m/min	Feed (f) mm/rev
≤ 5	12 – 14 *	0.05 – 0.15
5–10	12 – 14 *	0.15 – 0.25
10–15	12 – 14 *	0.25 – 0.30
15–20	12 – 14 *	0.30 – 0.35

* For coated HSS drill v_c = 22–24 m/min.

CARBIDE DRILL

Cutting data parameter	Type of drill		
	Indexable insert	Solid carbide	Carbide tip [1]
Cutting speed (V_c) m/min	140 – 160	80 – 100	50 – 60
Feed. (f) mm/rev	0.05 – 0.15 [2]	0.08 – 0.20 [3]	0.15 – 0.25 [4]

[1] Drill with replaceable or brazed carbide tip
[2] Feed rate for drill diameter 20 – 40 mm
[3] Feed rate for drill diameter 5 – 20 mm
[4] Feed rate for drill diameter 10 – 20 mm

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the "Grinding of tool steel" brochure.

Type of grinding	Annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	B151 R50 B3 [1] A 46 HV [2]
Face grinding segments	A 24 GV	A 46 FV [2]
Cylindrical grinding	A 60 KV	B151 R75 B3 [1] A60 KV [2]
Internal grinding	A 60 JV	R151 R75 B3 [1] A 60 KV [2]
Profile grinding	A 100 LV	B126 R100 B6 [1] A 80 JV [2]

[1] If possible use CBN wheels for this application
[2] Grinding wheels containing ceramic Al_2O_3 type is recommended

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 lower than the original tempering temperature.

When EDM'ing larger sizes or complicated shapes Vanadis 4 Extra SuperClean should be tempered at high temperatures, above 540°C.

RELATIVE COMPARISON OF ASSAB COLD WORK TOOL STEEL

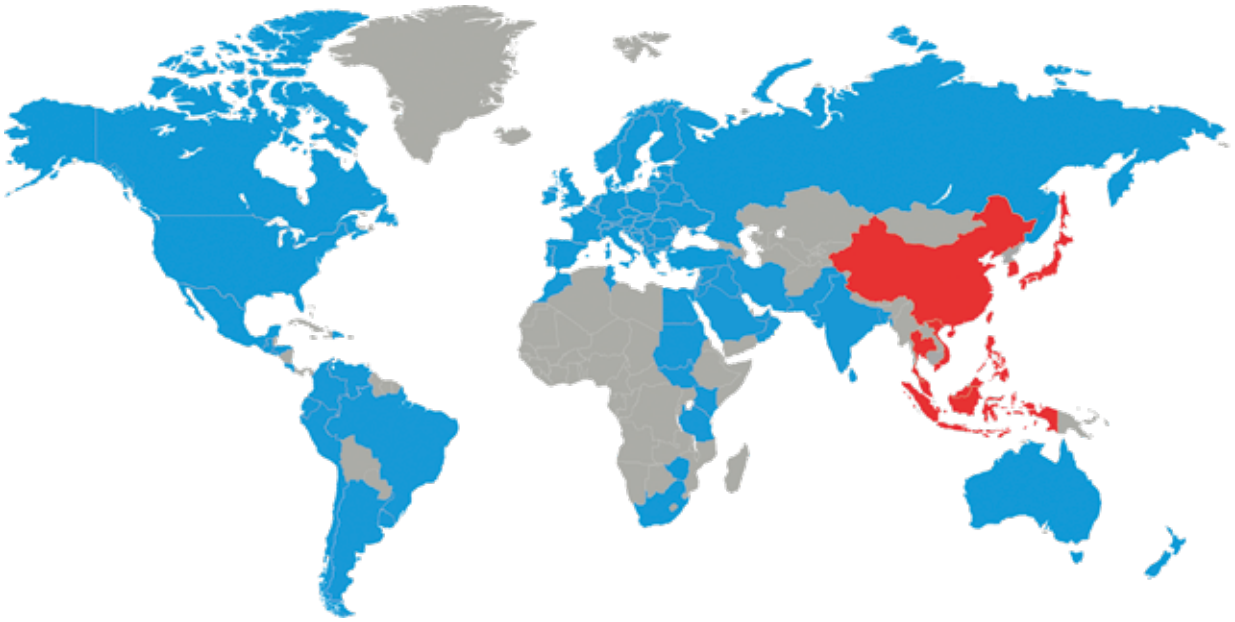
MATERIAL PROPERTIES AND RESISTANCE TO FAILLURE MECHANISMS

ASSAB Grade	Hardness/ Resistance to plastic deformation	Machinability	Grindability	Dimension stability	Resistance to		Fatigue cracking resistance	
					Abrasive wear	Adhesive wear/Galling	Ductility/ resistance to chipping	Toughness/ gross cracking
Conventional cold work tool steel								
ASSAB DF-3								
ASSAB XW-5								
ASSAB XW-10								
ASSAB XW-42								
Calmax								
Caldie (ESR)								
ASSAB 88								
Powder metallurgical tool steel								
Vanadis 4 Extra*								
Vanadis 8*								
Vancron*								
Powder metallurgical high speed steel								
ASSAB PM 23*								
ASSAB PM 30*								
ASSAB PM 60*								
Conventional high speed steel								
ASSAB M2								

* ASSAB PM SuperClean Tool Steel

FURTHER INFORMATION

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



Choosing the right steel is of vital importance. ASSAB engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the best treatment for each application. ASSAB not only supplies steel products with superior quality, we offer state-of-the-art machining, heat treatment and surface treatment services to enhance steel properties to meet your requirement in the shortest lead time. Using a holistic approach as a one-stop solution provider, we are more than just another tool steel supplier.

ASSAB and Uddeholm are present on every continent. This ensures you that high quality tool steel and local support are available wherever you are. Together we secure our position as the world's leading supplier of tooling materials.

For more information, please visit www.assab.com

UDDEHOLM
a voestalpine company

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