VANADIS 4 EXTRA SuperClean

Uddeholm Vanadis 4 Extra SuperClean

ASSAB
SuperClean

ASSAB

ASSAB	UDDEHOLM	REFERENCE STANDARD		
		AISI	WNr.	JIS
ASSAB DF-2	ARNE	O1	(1.2510)	(SKS 3)
ASSAB DF-3		O1	(1.2510)	(SKS 3)
ASSAB XW-5	SVERKER 3	D6 (D3)	(1.2436)	(SKD 2)
ASSAB XW-10	RIGOR	A2	1.2363	SKD 12
ASSAB XW-41	SVERKER 21	D2	1.2379	SKD 11
ASSAB XW-42		D2	1.2379	SKD 11
CARMO	CARMO		1.2358	
CALMAX	CALMAX		1.2358	
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 6 SUPERCLEAN	VANADIS 6 SUPERCLEAN			
VANADIS 10 SUPERCLEAN	VANADIS 10 SUPERCLEAN			
VANCRON 40 SUPERCLEAN	VANCRON 40 SUPERCLEAN			
ELMAX SUPERCLEAN	ELMAX SUPERCLEAN			
ASSAB 518		P20	1.2311	
ASSAB 618		P20 Mod.	1.2738	
ASSAB 618 HH		P20 Mod.	1.2738	
ASSAB 618 T		P20 Mod.	1.2738 Mod.	
ASSAB 718 SUPREME	IMPAX SUPREME	P20 Mod.	1.2738	
ASSAB 718 HH	IMPAX HH	P20 Mod.	1.2738	
NIMAX	NIMAX			
MIRRAX 40	MIRRAX 40	420 Mod.		
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 Mod.	1.2083 ESR	SUS 420J2
MIRRAX ESR	MIRRAX ESR	420 Mod.		
POLMAX	POLMAX			
RAMAX HH	RAMAX HH	420 F Mod.		
ROYALLOY	ROYALLOY			
PRODAX				
ASSAB PT18				
ASSAB MMXL				
ASSAB MM40				
ALVAR 14	ALVAR 14		1.2714	SKT 4
ASSAB 2714			1.2714	SKT 4
ASSAB 8407 2M	ORVAR 2M	H13	1.2344	SKD 61
ASSAB 8407 SUPREME	ORVAR SUPREME	H13 Premium	1.2344 ESR	SKD 61
DIEVAR	DIEVAR			
HOTVAR	HOTVAR			
QRO 90 SUPREME	QRO 90 SUPREME			
FORMVAR	FORMVAR			
ASSAB 705		4340	1.6582	SNCM8
ASSAB 709		4140	1.7225	SCM4
ASSAB 760		1050	1.1730	S50C

Edition 140919

VANADIS 4 EXTRA SuperClean

CONSISTENT TOOL PERFORMANCE WITH LONG AND RELIABLE TOOL LIFE

With an increased demand for just-in-time (JIT) deliveries and shorter lead time, it is of utmost importance that the tool life is predictable and with a long and reliable performance. Good performance is also necessary in order to reduce your down time and cost for tool maintenance, as well as to optimise machine utilisation. Such reduction and optimisation lead to an optimal tooling economy and a competitive production cost.

Vanadis 4 Extra SuperClean properties offer extremely 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 steels and advanced high-strength steels (AHSS) where a combination of abrasive, adhesive or mixed wear resistance is needed together with resistance to chipping and cracking for long-production runs, with less tooling maintenance.

MACHINABILITY

The toolmaking 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 with other highly alloyed powder metallurgical tool steels, resulting in the best conditions for an excellent tool quality. This is due to the well balanced chemistry of Vanadis 4 Extra SuperClean and the SuperClean process that is utilised for its production.

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 ductility 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 steels 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 steels. This means that Vanadis 4 Extra SuperClean is a tool steel which is very suitable for CVD coating.

General

Vanadis 4 Extra 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 service
- Very good through-hardening properties
- Good temper-back resistance
- Good machinability and grindability

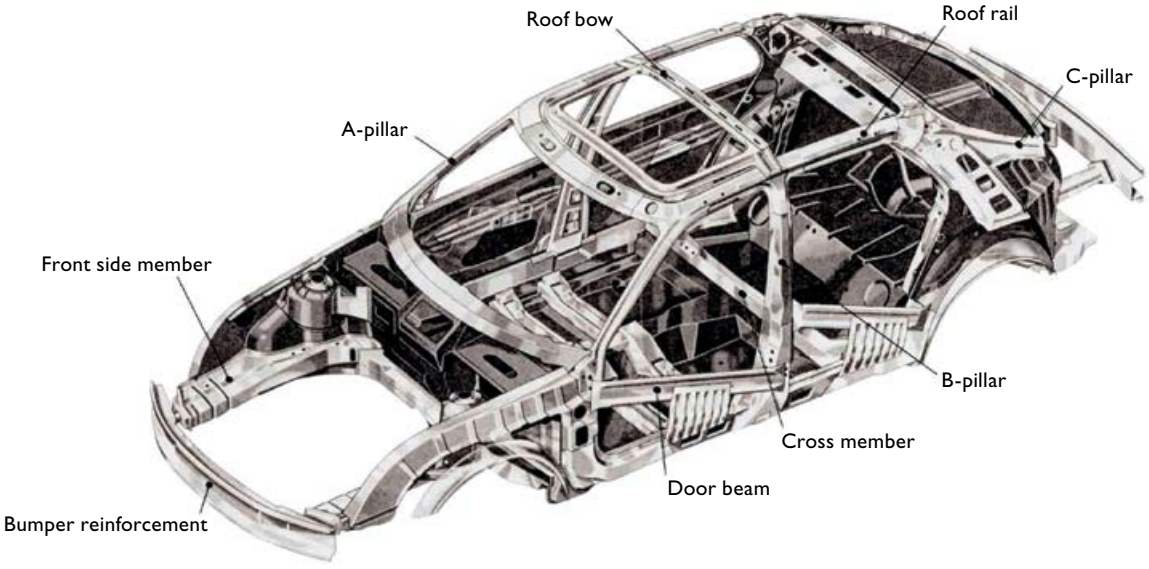
Typical analysis %	C 1.4	Si 0.4	Mn 0.4	Cr 4.7	Mo 3.5	V 3.7
Standard spec.	None					
Delivery condition	Soft-annealed to approx. 230 HB					
Colour code	Green / White with black line across					

Applications

Vanadis 4 Extra SuperClean is especially suitable for applications where adhesive wear and/or chipping are the dominant failure mechanisms. For examples:

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

Vanadis 4 Extra SuperClean is also very suitable for blanking and forming of Ultra High Strength Steel Sheets. These materials place high demands on the tool steel regarding abrasive wear resistance and ductility.



Vanadis 4 Extra SuperClean is very suitable for blanking and forming of Ultra High Strength Steel Sheets into automotive structural parts.

TYPICAL APPLICATIONS

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

IMPACT STRENGTH

Approximate room temperature unnotched 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.

Properties

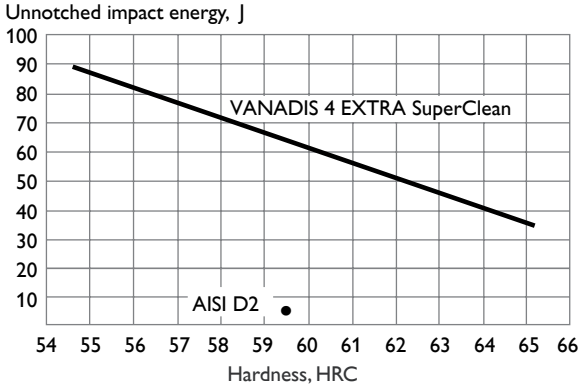
PHYSICAL DATA

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
Thermal conductivity W/m °C	-	30	30
Specific heat J/kg °C	460	-	-

Unnotched impact strength (ductility)

The difference in ductility between Vanadis 4 Extra SuperClean and AISI D2 at different hardness levels.



COEFFICIENT OF THERMAL EXPANSION IN DIFFERENT TEMPERATURE INTERVALS

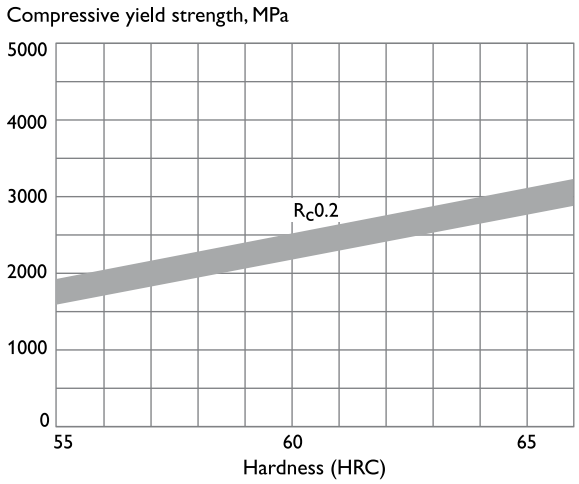
Hardened and tempered condition.

Temperature range	Coefficient (°C^{-1})
20 - 100°C	11.0 x 10^{-6}
20 - 200°C	11.3 x 10^{-6}
20 - 300°C	11.7 x 10^{-6}
20 - 400°C	12.1 x 10^{-6}
20 - 500°C	12.4 x 10^{-6}

COMPRESSIVE YIELD STRENGTH

Specimen: Hourglass shaped with 10mm Ø waist

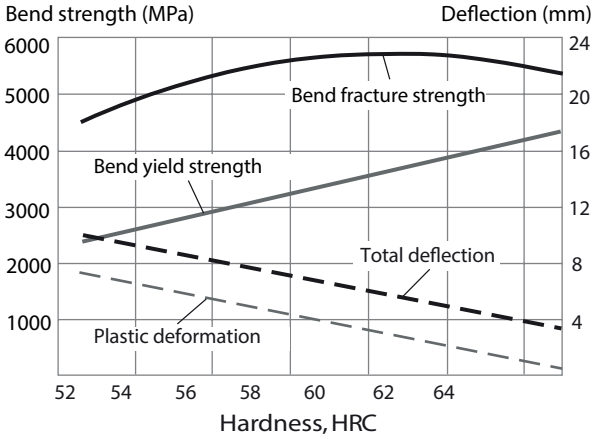
Approximate compressive yield strength versus hardness at room temperature

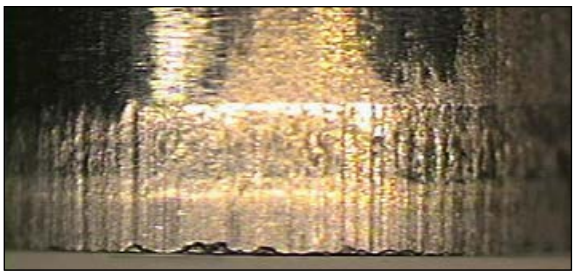


BENDING STRENGTH

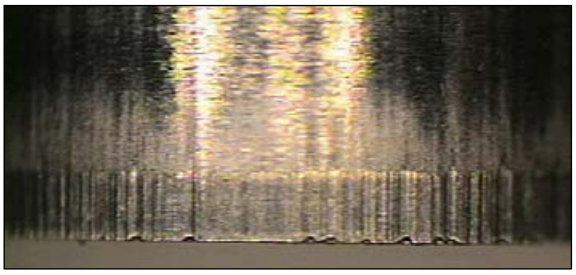
Four-point bend testing.

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

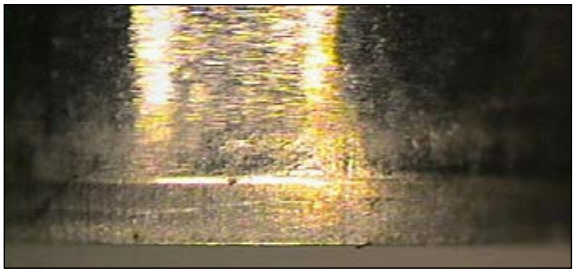




SKD11 / AISI D2 / WNr. 1.2379 (57 HRC)



ASSAB 88 (61 HRC)



VANADIS 4 EXTRA SuperClean (62 HRC)

Punches used for blanking 1.8 mm thick high-strength steels (1200 MPa), after 50,000 press strokes.

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

Preheating temperature: 550 - 850°C.

Austenitising temperature: 940 - 1150°C. Normally 1020°C. For large sections >70 mm, use 1060°C or above. For the very best wear resistance, use 1100 - 1150°C.

Holding time: 30 min. up to 1100°C, 15 min. above 1100°C.

Holding time = time at hardening temperature after the tool is fully heated through. A holding time that is less than the recommendation mentioned above, will result in loss of hardness.

Protect the part against decarburisation and oxidation during hardening. Hardening in a vacuum furnace is reccommended.

QUENCHING MEDIA

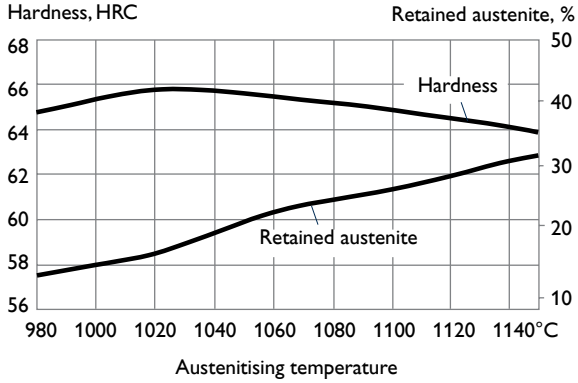
- N_2 with sufficient overpressure quenching in vacuum furnace
- Martempering bath or fluidised bed at 500 - 550°C
- Martempering bath or fluidised bed at 200 - 350°C

Note 1: Temper the tool as soon as its temperature reaches 50 - 70°C.

Note 2: In order to obtain the optimum properties for the tool, the cooling rate should be as fast as possible while maintaining an acceptable level of distortion.

Note 3: Martempering should be followed by forced air cooling if wall thickness exceeds 70 mm.

Hardness and retained austenite as a function of austenising temperature



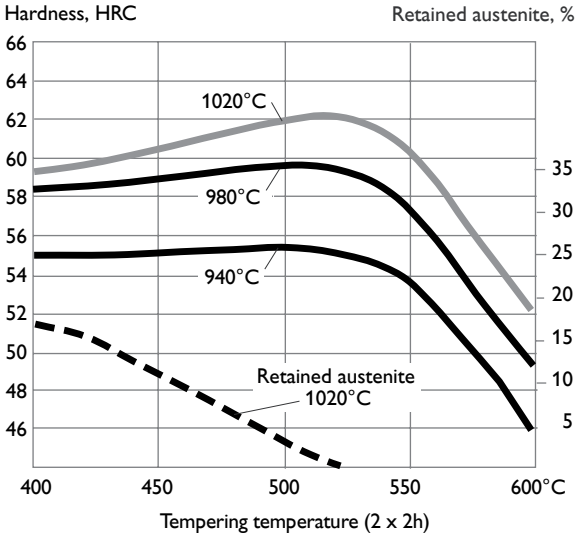
TEMPERING

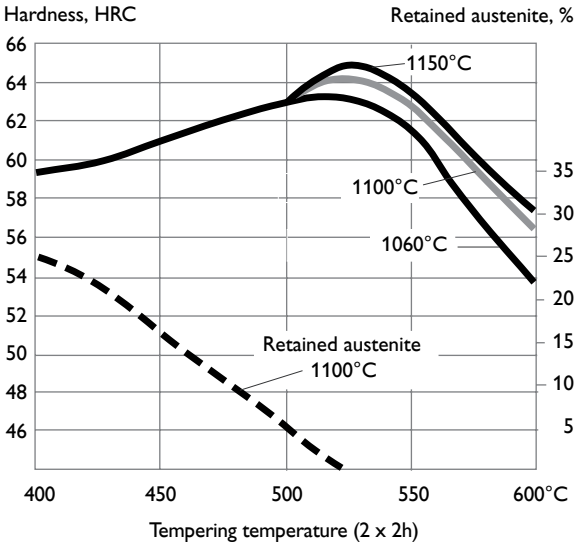
The tempering temperature can be selected according to the hardness required by reference to the tempering graphs below.

Temper at least twice with intermediate cooling to room temperature. The lowest tempering temperature which should be used is 520°C. The minimum holding time at temperature is 2 hours.

In order not to reduce the toughness and to avoid a high content of retained austenite, do not temper below 520°C.

Tempering graphs





Above 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.

DIMENSIONAL CHANGES

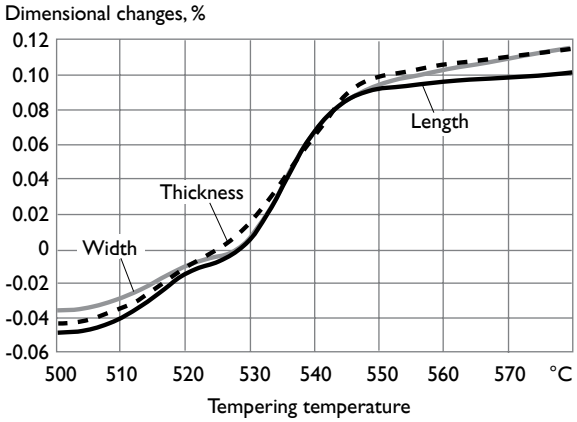
Dimensional changes have been measured after hardening and tempering.

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

Tempering: 2 x 2 h at various temperatures

Sample size: 80 x 80 x 80 mm

Dimensional changes as function of tempering temperature



SUB-ZERO TREATMENT

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

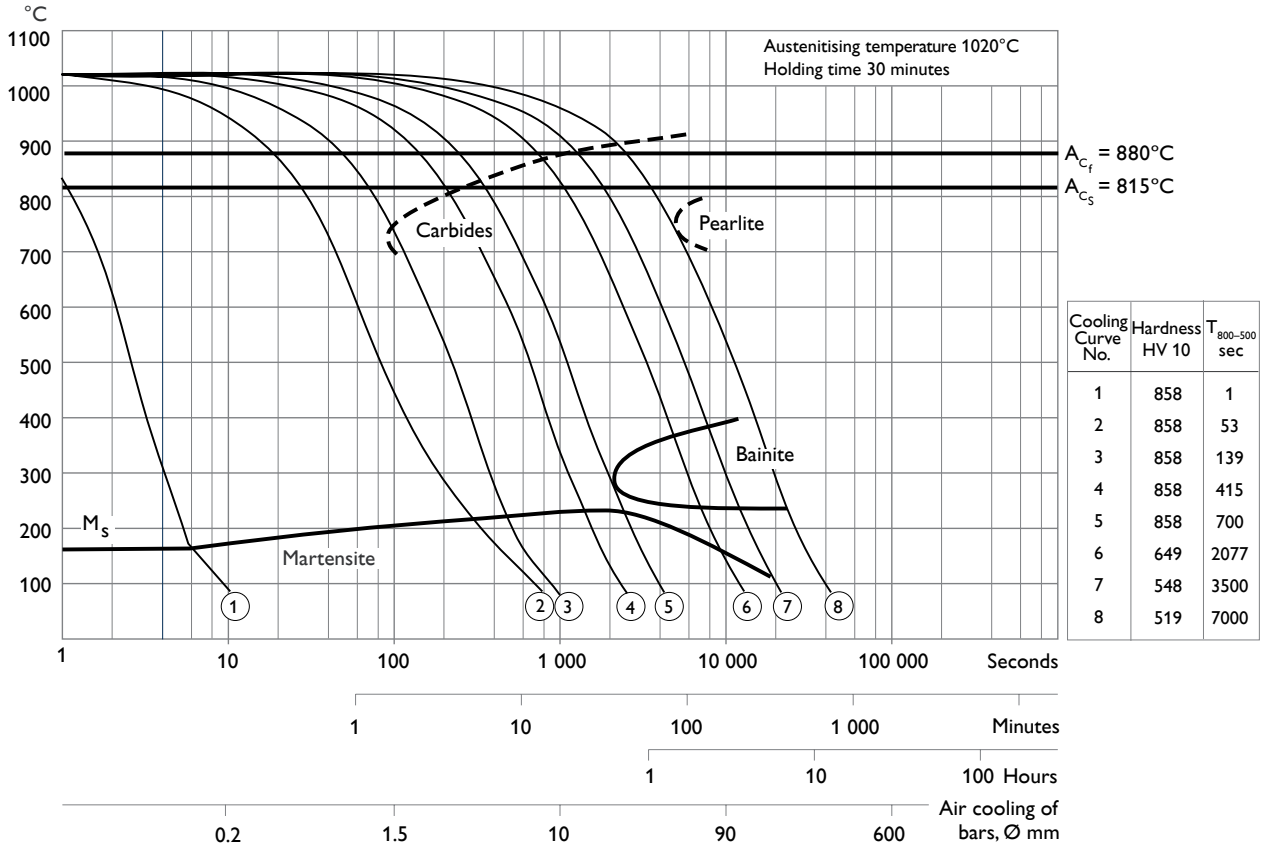
Immediately after quenching, the piece should be sub-zero treated followed by tempering. Vanadis 4 Extra SuperClean is commonly sub-zero treated between -150°C and -196°C, although occasionally -70°C to -80°C are used due to constraints of the sub-zero medium and equipment available. Soaking time 1 - 3 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.

CCT graph

Austenitising temperature 1020°C. Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ 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

Machining recommendations

The cutting data below are to be considered as guiding values and as starting points for developing your own best practice.

Condition: Soft-annealed condition ~230 HB

TURNING

Cutting data parameters	Turning with carbide		Turning with HSS†
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min	120 - 170	170 - 220	15 - 20
Feed (f) mm/r	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 Coated carbide* or cermet*	K15, P15 Coated carbide* or cermet*	-

† *High-speed steel*
* *Use a CVD coating*

DRILLING

High-speed steel twist drill

Drill diameter mm	Cutting speed (v_c) m/min	Feed (f) mm/r
≤ 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 parameters	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/r	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*

MILLING

Face and square shoulder milling

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min	110 - 150	150 - 200
Feed (f_z) 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 CVD coating*

End milling

Cutting data parameters	Type of milling		
	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 Coated carbide[3] or cermet[3]	-

[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 CVD coating*

GRINDING

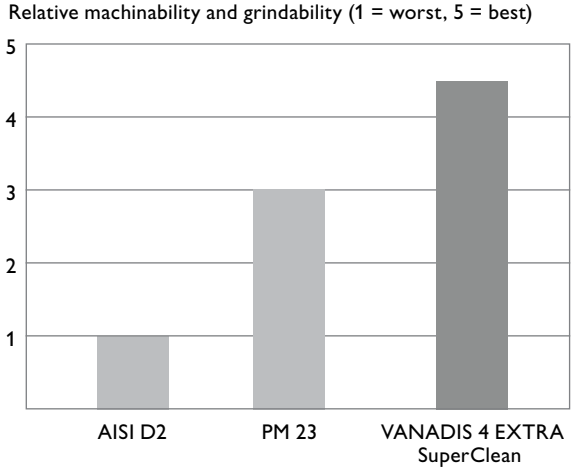
Wheel recommendation

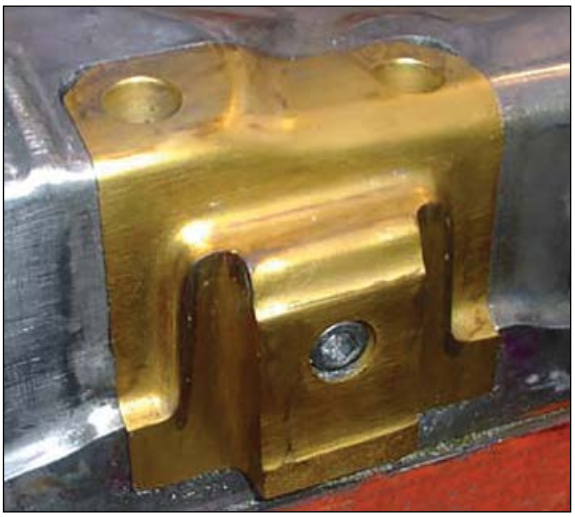
Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	B151 R50 B3[1] A 46 HV[2]
Face grinding segments	A 24 GV	A 46 FV[2]
Cylindrical grinding	A 60 KV	B151 R75 B3[1] A 60 KV[2]
Internal grinding	A 60 JV	B151 R75 B3[1] A 60 KV[2]
Profile grinding	A 100 LV	B126 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*

Machinability

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





PVD coated trimming dies for high strength steels used to make automotive parts.

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 following precautionary measures are recommended:

- The surface layer affected by EDM should be removed by polishing or stoning; or
- The tool retempered at approx. 25°C lower than the original tempering temperature; or
- A combination of the two precautionary measures mentioned above.

When EDM'ing larger sizes or complicated shapes, Vanadis 4 Extra SuperClean should be high-temperature tempered.

Surface treatment

Some cold-work tool steels 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 525°C. This means that the nitriding temperature used should not exceed 500 - 525°C. Ion nitriding at a temperature below the tempering temperature used is preferred. The surface hardness after nitriding is approximately 1150 $HV_{0.2kg}$.

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 whereas for forming tools, the case depth 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.

Further information

For further information, i.e., steel selection, heat treatment, application and availability, please contact our ASSAB office nearest to you.

Relative comparison of ASSAB cold-work tool steels

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS

ASSAB grade	Hardness/ Resistance to plastic deformation	Machinability	Grindability	Dimension stability	Resistance to		Fatigue cracking resistance	
					Abrasive wear	Adhesive wear	Ductility/ resistance to chipping	Toughness/ gross cracking
ASSAB DF-3								
CALMAX								
CALDIE (ESR)								
ASSAB XW-10								
ASSAB 88								
ASSAB XW-42								
ASSAB XW-5								
VANADIS 4 EXTRA								
VANADIS 10								
VANCRON 40								
ASSAB PM 23								
ASSAB PM 30								
ASSAB PM 60								
AISI M2								

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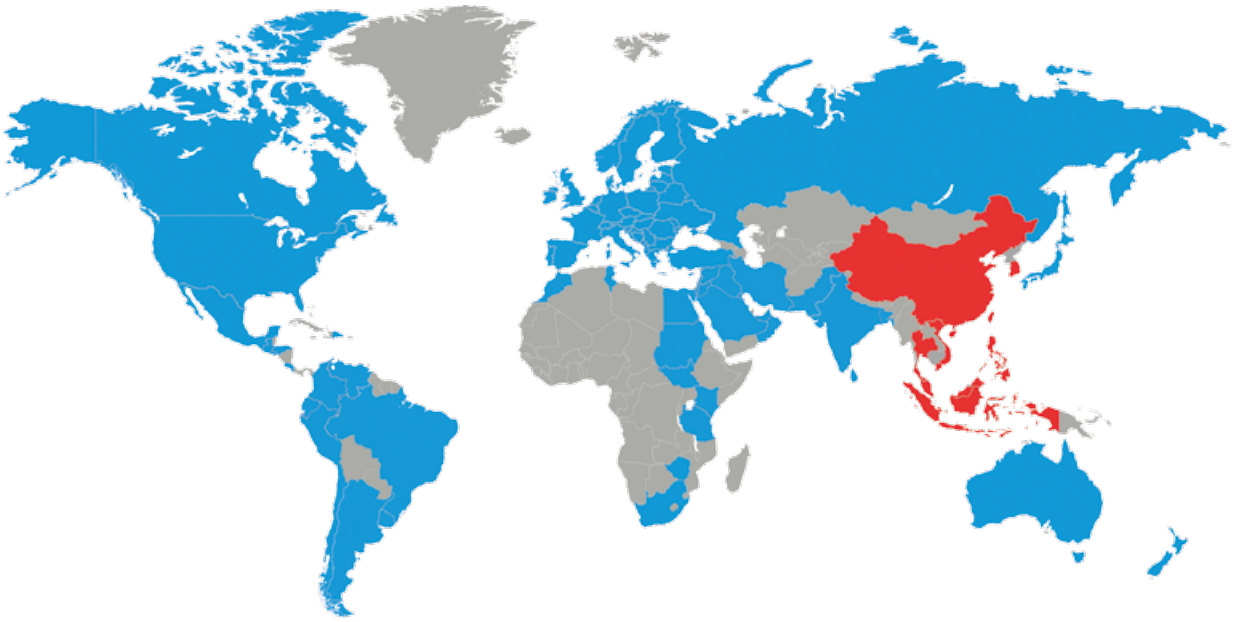

Choosing the right steel is of vital importance. ASSAB engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the best treatment for each application. ASSAB not only supplies steel products with superior quality, we offer state-of-the-art machining, heat 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.

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