ASSAB 88

UDDEHOLM
SLEIPNER

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 150216

ASSAB 88

THE CHANGING TOOLING ENVIRONMENT

The tooling environment is changing to suit the changing market environment. Lead times are one aspect of this change and they are getting shorter and shorter. This ultimately means that there is more emphasis regarding on time delivery to manufacture the tooling, and tool reliability in service.

The production materials used nowadays are placing more demands on the tools and the tool steels used to manufacture them. For example, advanced high strength steel sheet materials now being used for automotive parts place extra demands on resistance to chipping and cracking, compressive strength and wear resistance.

THE MODERN GENERAL COLD WORK TOOL STEEL

The classical 12% Cr-steels such as AISI D2 or WNr. 1.2379 are still the backbone of cold work tooling, but their limitations are becoming more and more apparent in the changing production environment.

ASSAB 88 is a new 8% Cr-steel from Uddeholm Tooling, our steel mill in Sweden. Its properties profile has been carefully balanced, and the result is a very versatile tool steel which overcomes the limitations of the 12% Cr-steels.

A VERSATILE TOOL STEEL

The properties profile of ASSAB 88 is more versatile and superior to that of 12% Cr-steels. The machinability, grindability and hardenability are much better, and it is easier to make small repair welds. This means that ASSAB 88 is the right choice for faster toolmaking, better tool performance and easier maintenance.

General

ASSAB 88 is a chromium-molybdenum-vanadium alloyed tool steel which is characterised by:

- Good wear resistance
- Good chipping resistance
- High compressive strength
- High hardness (>60 HRC) after high temperature tempering
- Good through-hardening properties
- Good dimensional stability during hardening
- Good resistance to tempering back
- Good WEDM properties
- Good machinability and grindability

Typical analysis %	C 0.9	Si 0.9	Mn 0.5	Cr 7.8	Mo 2.5	V 0.5
Standard spec.	None					
Delivery condition	Soft annealed to approx. 235 HB					
Colour code	Blue / Brown					

Applications

ASSAB 88 is a general purpose steel for cold work tooling. It has a mixed-abrasive wear profile and a good resistance to chipping. Furthermore, a high hardness (>60 HRC) can be obtained after high temperature tempering. This means that surface treatments such as nitriding or PVD can be made on a high strength substrate. It also means that big blocks and complicated shapes with >60 HRC hardness can be wire EDM'd with a much reduced risk of cracking.

ASSAB 88 is recommended for medium run tooling applications, where a resistance to mixed or abrasive wear and a good resistance to chipping are required.

TYPICAL APPLICATIONS

- Blanking and fine blanking
- Shearing
- Forming
- Coining
- Cold forging
- Cold extrusion
- Thread rolling
- Drawing and deep drawing

Properties

PHYSICAL DATA

Hardened and tempered to 62 HRC.

Temperature	20°C	200°C	400°C
Density kg/m³	7 730	7 680	7 620
Modulus of elasticity MPa	205 000	190 000	180 000
Coefficient of thermal expansion - low tempered* per °C from 20°C - high tempered* per °C from 20°C	 - -	 12.7×10^{-6} 11.6×10^{-6}	 - 12.4×10^{-6}
Thermal conductivity W/m °C	-	20	25
Specific heat J/kg °C	460	-	-

* Low tempered ~200°C, high tempered ~550°C

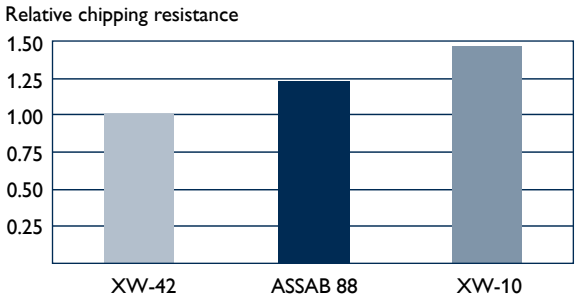
COMPRESSIVE STRENGTH

Approximate compressive strength at room temperature.

Hardness HRC	Compressive yield strength $R_{c0.2}$ (MPa)
50	1 700
55	2 050
60	2 350
62	2 500
64	2 650

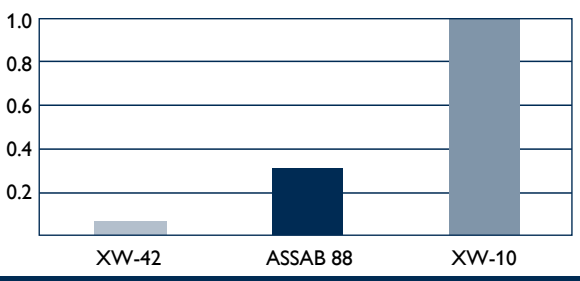
CHIPPING RESISTANCE

Relative chipping resistance for XW-42, ASSAB 88 and XW-10 at the same hardness level.



ABRASIVE WEAR RESISTANCE

Relative abrasive wear resistance for XW-42, ASSAB 88 and XW-10 at the same hardness level (low value means better wear resistance).



Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 850°C. Then cool in the furnace at 10°C per hour to 650°C, then freely in air.

STRESS RELIEVING

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

HARDENING

Preheating temperature: 650–750°C.

Austenitising temperature: 950–1080°C, but usually 1030–1050°C.

Holding time: 30 minutes

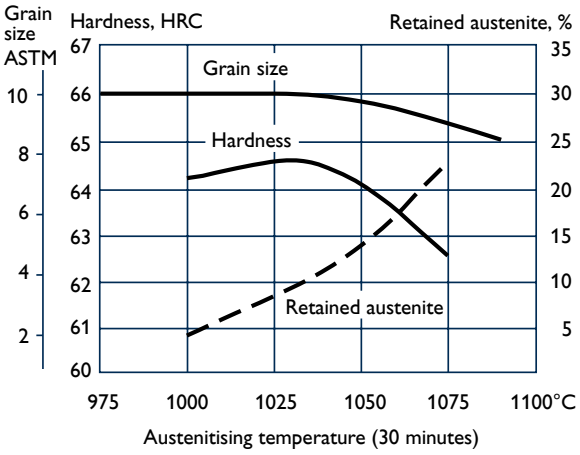
Protect the part against decarburisation and oxidation during hardening.

QUENCHING MEDIA

- Forced gas/circulating atmosphere
- Vacuum (high speed gas with sufficient overpressure)
- Martempering bath or fluidised bed at 500–550°C
- Martempering bath or fluidised bed at approx. 200–350°C
- Warm oil, approx. 80°C (only very simple geometries)

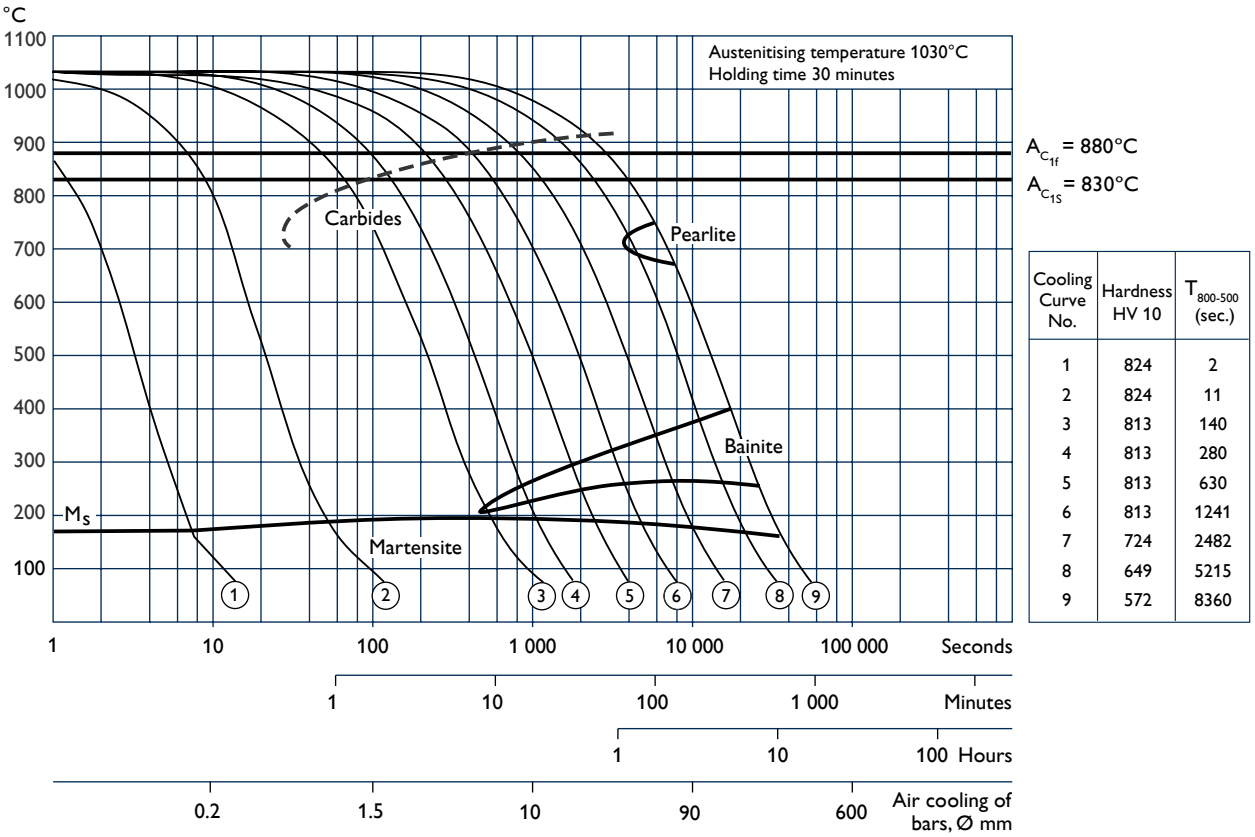
Note: Temper the tool as soon as its temperature reaches 50–70°C.

Hardness, retained austenite and grain size as function of austenising temperature



CCT graph

Austenitising temperature 1030°C. Holding time 30 minutes.

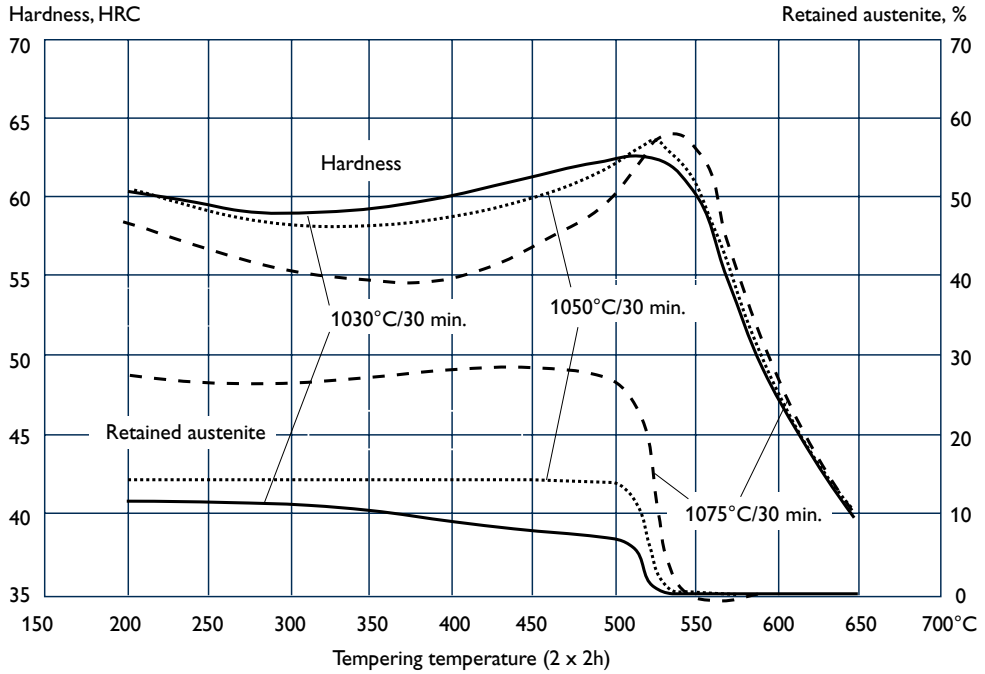


Cooling Curve No.	Hardness HV 10	$T_{800-500}$ (sec.)
1	824	2
2	824	11
3	813	140
4	813	280
5	813	630
6	813	1241
7	724	2482
8	649	5215
9	572	8360

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. The lowest tempering temperature which should be used is 180°C. The minimum holding time at temperature is 2 hours.



DIMENSIONAL CHANGES

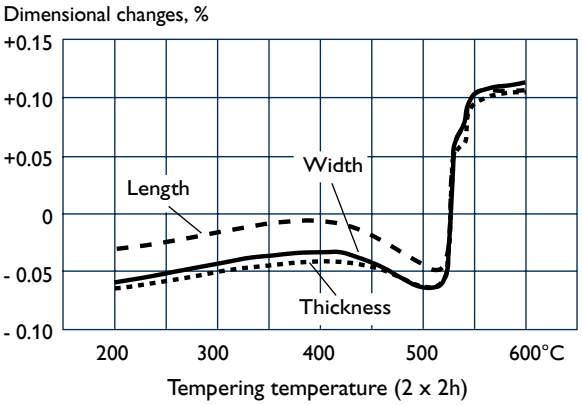
The dimensional changes have been measured after austenitising and tempering.

Austenitising: 1030°C/30 min, cooling in vacuum furnace at 0.75°C/s between 800°C and 500°C

Tempering: 2 x 2 h at various temperatures

Specimen size: 100 x 100 x 100 mm

Dimensional changes as function of tempering temperature



SUB-ZERO TREATMENT

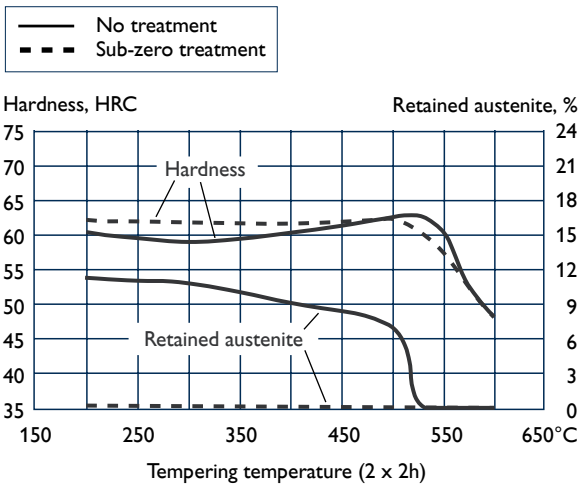
Pieces requiring maximum dimensional stability in service should be sub-zero treated.

Sub-zero treatment reduces the amount of retained austenite and changes the hardness as shown in the diagram below.

Austenitising: 1030°C /30 min

Tempering: 2 x 2 h at various temperatures

Hardness and retained austenite as function of tempering temperature and sub-zero treatment



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 ~235 HB

TURNING

Cutting data parameters	Turning with carbide		Turning with HSS†
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min	100 - 150	150 - 200	17 - 22
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	K10, P15 Coated carbide	-

† *High speed steel*

DRILLING

High speed steel twist drill

Drill diameter mm	Cutting speed (v_c) m/min	Feed (f) mm/r
≤ 5	13 - 18*	0.05 - 0.10
5 - 10	13 - 18*	0.10 - 0.20
10 - 15	13 - 18*	0.20 - 0.25
15 - 20	13 - 18*	0.25 - 0.30

* *For coated HSS drill, v_c ~ 25–35 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	45 - 55
Feed (f) mm/r	0.05 - 0.15[2]	0.10 - 0.25[2]	0.15 - 0.25[2]

[1] *Drill with replacable or brazed carbide 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	110 - 180	180 - 220
Feed (f_z) mm/tooth	0.2 - 0.4	0.1 - 0.2
Depth of cut (a_p) mm	2 - 5	≤ 2
Carbide designation ISO	K20, P20 Coated carbide	P10 - P20 Coated carbide

End milling

Cutting data parameters	Type of milling		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min	80 - 120	100 - 140	13 - 18[1]
Feed (f) mm/tooth	0.03 - 0.20[2]	0.08 - 0.20[2]	0.05 - 0.35[2]
Carbide designation ISO	-	P15-P40	-

[1] *For coated HSS end mill, v_c ~ 30–35 m/min*
[2] *Depending on radial depth of cut and cutter diameter*

GRINDING

Wheel recommendation

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 JV
Profile grinding	A 100 KV	A 120 JV

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. 25°C lower than the original tempering temperature.

When EDM'ing larger sizes or complicated shapes, ASSAB 88 should be tempered at high temperatures, above 500°C.

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 or CVD.

The high hardness and good resistance to chipping together with a good dimensional stability make ASSAB 88 suitable as a substrate steel for various surface coatings.

NITRIDING AND NITROCARBURISING

Nitriding and nitrocarburising result in a hard surface layer which is very resistant to wear and galling. The surface hardness after nitriding is approximately 1100 $HV_{0.2kg}$. The thickness of the layer should be chosen to suit the application in question.

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 are separately hardened and tempered in a vacuum furnace after surface treatment.

FLAME HARDENING

Use oxy-acetylene equipment with a capacity of 800–1250 l/h. Oxygen pressure 2.5 bars, acetylene pressure 1.5 bar. Adjust to give neutral flame.

Temperature: 980–1020°C. Cool freely in air.

The hardness at the surface will be 58–62 HRC and 41 HRC (400 HB) at a depth of 3–3.5 mm.

Welding

Good results when welding tool steel can be achieved if proper precautions are taken during the welding operation.

- The joints should be prepared properly.
- Repair welds should be made at elevated temperature. Make the two first layers with the same electrode diameter and/or current.
- Always keep the arc length as short as possible. The electrode should be angled at 90° to the joint sides to minimise undercut. In addition, the electrode should be held at an angle of 75–80° to the direction of forward travel.
- For large repairs, weld the initial layers with a soft filler material (buffering layer).

Welding method	TIG	MMA
Preheating temp.[1]	250°C	250°C
Filler material	Type AWS ER 312 (buffering layers) UTP A696 CastoTIG 5[3] CALDIE TIG-WELD	Type AWS E 312 (buffering layers) UTP 69 Castolin 6 CALDIE WELD
Maximum interpass temp.[2]	400°C	400°C
Postweld cooling	20 - 40°C/h for the first two hours and then freely in air < 70°C	
Hardness after welding	Type AWS ER 312 (buffering layers) 300 HB Other filler materials 58 - 64 HRC	Type AWS E 312 (buffering layers) 300 HB Other filler materials 58 - 64 HRC
Heat treatment after welding		
Hardened condition	Temper 10-20°C below the original tempering temperature.	
Soft annealed condition	Soft anneal according to the "Heat treatment" recommendation.	

[1] *Preheating temperature must be established throughout the tool and must be maintained for the entire welding process, to prevent weld cracking. For hardened and tempered tool, the actual preheat temperature used is typically lower than the original tempering temperature to prevent a drop in hardness.*

[2] *The temperature of the tool in the weld area immediately before the second and subsequent pass of a multiple pass weld. When exceeded, there is a risk of distortion of the tool or soft zones around the weld.*

[3] *Should not be used for more than 4 layers because of the increased risk of cracking.*

Relative comparsion 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								

Further information

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

Case study

MICROCHIPPING AND WEAR RESISTANCE

Component : VCM plate
Tooling type : Fine blanking die
Tooling size : 45 x 250 x 320 mm
Heat treatment : 1030°C/45 min., vacuum 4 bars N_2, 540°C/2x2h, 400°C/2.5h to 59-60 HRC
Work material : 2.7 mm thick AISI 1010 (50-56 HRB)

Tool Steel	AISI D2 / WNr. 1.2379 / SKD 11	ASSAB 88
Hardness	60 HRC	59-60 HRC
Surface Treatment	None	None
No. of Parts Produced	100 000 - 200 000	> 786 941
Failure Mode	Microchipping and wear	Did not fail
Comment	—	Test was terminated because the required number of parts had been produced.

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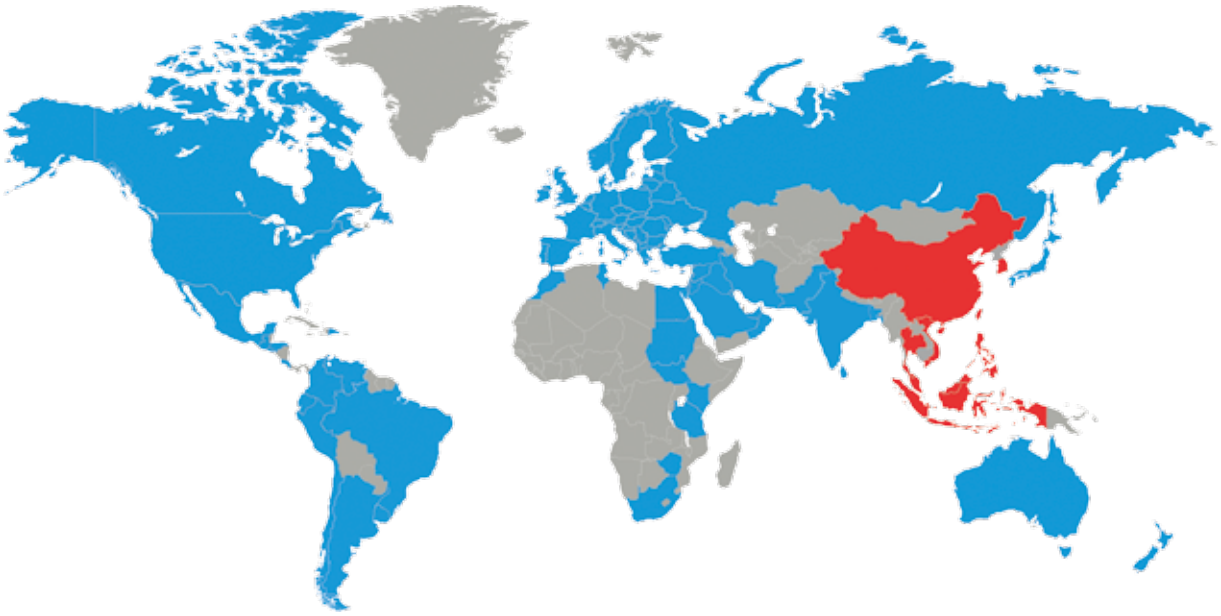

Choosing the right steel is of vital importance. ASSAB engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the best treatment for each application. ASSAB not only supplies steel products with superior quality, we offer state-of-the-art machining, heat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

ASSAB and Uddeholm are present on every continent. This ensures you that high-quality tool steels 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

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