CALMAX

UDDEHOLM CALMAX

ASSAB

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

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CALMAX

The majority of presswork tools used today are manufactured using traditional tool steel such as O1, A2, D2, D3 or D6. These steel offer an apparent adequate wear resistance and their hardness range is suitable for most applications. However, the poor toughness, flame and induction hardenability and weldability of these grades often results in low productivity and high maintenance costs due to unexpected tool failure. The aim of Calmax is to secure an optimal tooling economy, i.e. the lowest tooling costs per part produced.

The pressworking industry has gone through some considerable changes in the last decades. Stainless steel and surface coated strip have been commercialised and high speed presses have been developed. To these technological advances just in time (JIT) manufacture and the moves toward increased productivity and tool life guarantees must be added. The traditional presswork tool steel are still routinely specified and selected but often result in poor tool performance and productivity.

The well balanced properties profile of Calmax is much better matched to modern work materials and manufacturing methods. Calmax offers the high degree of safety which is essential for optimal tooling performance and maximum productivity.

GENERAL

Calmax is a chromium molybdenum-vanadium alloyed steel characterised by:

- High toughness
- Good wear resistance
- Good through hardening properties
- Good dimensional stability in hardening
- Good polishability
- Good weldability

Typical analysis %	C 0.6	Si 0.35	Mn 0.8	Cr 4.5	Mo 0.5	V 0.2
Delivery condition	Soft annealed to approx. 200 HB					
Colour code	White/violet					

APPLICATIONS

The excellent combination of toughness and wear resistance makes Calmax suitable for different applications.

TYPICAL COLD WORK APPLICATIONS

- General blanking and forming
- Heavy duty blanking and forming
- Deep drawing
- Coining
- Cold extrusion dies with complicated geometry
- Rolls
- Shear blades
- Prototype tooling

PLASTIC MOULDING APPLICATIONS

- Long run moulds
- Moulds for reinforced plastics
- Moulds for compression moulding

PROPERTIES

Temperature	20 °C	200 °C	400 °C
Density kg/m³	7 770	7 720	7 650
Modulus of elasticity MPa	194 000	188 000	178 000
Coefficient of thermal expansion per °C from 20 °C	to 100°C 11.7×10^{-6}	to 200°C 12.0×10^{-6}	to 400°C 13.0×10^{-6}
Thermal conductivity W/m°C	-	27	32
Specific heat J/kg°C	455	525	608

COMPRESSIVE STRENGTH

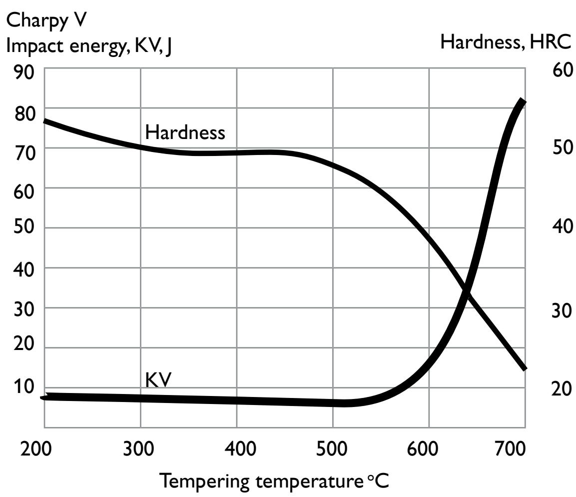
Approximate values at room temperature.

Hardness HRC	Rcm N/mm²	$Rc_{0.2}$ N/mm²
56	2 300	1 900
58	2 500	2 000
60	2 700	2 100

IMPACT STRENGTH AND HARDNESS

Approximate values at room temperature for different tempering temperatures. Hardened at 960°C Quenched in air. Tempered twice.

Bar dimension 315 x 80 mm. Samples from centre of bar in ST (thickness) direction



HEAT TREATMENT

SOFT ANNEALING

Protect the steel and heat through to 860°C, holding time 2 hours. Cool in furnace 20°C/h to 770°C, then 10°C/h to 650°C and subsequently 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: 600 – 750 °C.
Austenitising temperature: 950 - 970 °C, normally 960°C.

Temperature °C	Holding time* minutes	Hardness before tempering HRC
980	30	62
960	30	63
970	30	64

* Holding time = time at austenitising temperature after the tool is fully heated through

Protect the part against decarburisation and oxidation during hardening.

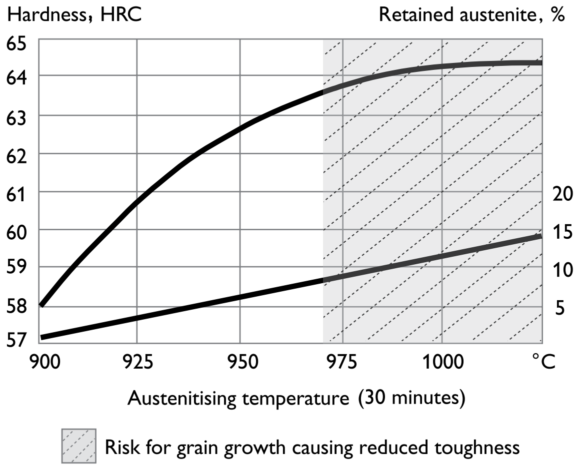
QUENCHING MEDIA

- Forced air/gas
- Vacuum furnace with sufficient overpressure
- Martempering bath or fluidised bed at 200–550°C followed by forced air cooling
- Oil

Note 1: Quenching in oil gives an increased risk for dimensional changes and cracks.

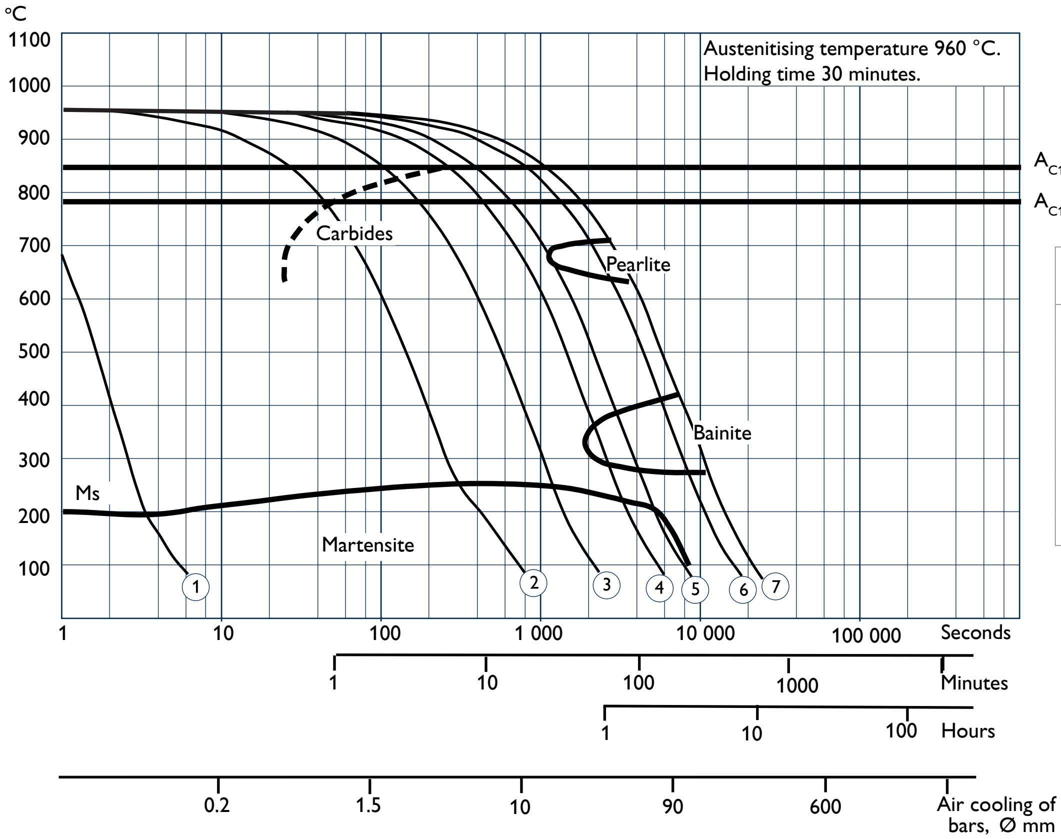
Note 2: Temper the tool as soon as its temperature reaches 50–70°C.

HARDNESS AND RETAINED AUSTENITE AS A FUNCTION OF AUSTENITISING TEMPERATURE



CCT-GRAPH

Austenitising temperature 960 °C. Holding time 30 minutes.

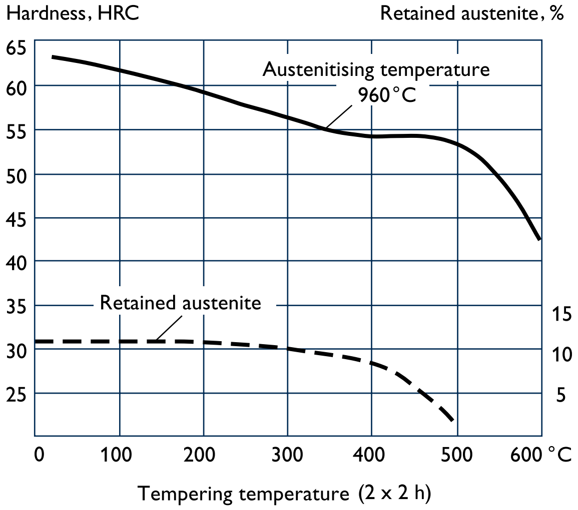


Cooling Curve No.	Hardness HV 10	$T_{800-500}$ sec
1	820	1
2	762	107
3	743	423
4	734	1 071
5	657	1 596
6	455	3 228
7	413	4 292

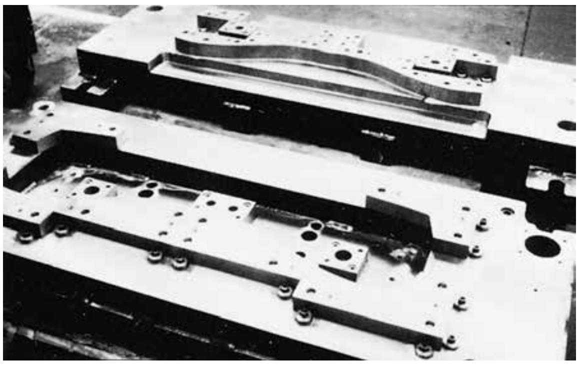
TEMPERING

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.

TEMPERING GRAPH



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.



Typical blanking die where Calmax could be used because of the high demands on toughness.

DIMENSIONAL CHANGES

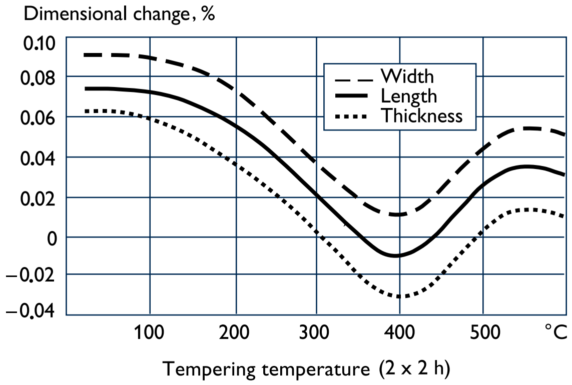
The dimensional changes during hardening and tempering vary depending on temperature, type of equipment and cooling media used during heat treatment.

The size and geometric shape of the tool are also of essential importance. During toolmaking, provide adequate machining allowance to compensate for distortion. Use 0.20% as a guideline for Calmax. Any distortion arising from hardening and tempering can then be adjusted during finish machining.

An example of dimensional changes of a plate, hardened and tempered under ideal conditions, is shown in the graph below.

Heat treatment: Hardening 960°C/30 min., cooling in air and tempering 2 x 2 h at various temperatures

Specimen size: 100 x 100 x 10 mm



SURFACE TREATMENT

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 produced via PVD and CVD.

Two commonly used nitriding processes are ion nitriding and gas nitriding. Ion nitriding is normally performed at a lower temperature than gas nitriding and is, therefore, the preferred method for Calmax when a substrate hardness of ~54 HRC is required.

Process	Temp °C	Time h	Case depth μm	Substrate hardness HRC	Case hardness HV
Ion	465 *	18	200	54	1 075
Gas	510 *	12	200	52	1 075

* The nitriding temperature used should be 15–25°C lower than the previously used tempering emperature.

A thick case depth considerably reduces the toughness of the tool. The case depth, which can be controlled by the nitriding time, should be selected to suit the application in question.

Calmax can also be CVD coated but the deposition temperature should not exceed 960°C. The tool should be re-hardened after being coated.

PVD coatings can be deposited at temperatures between 200°C and 500°C. If 200°C is used, the Calmax substrate hardness will be higher than that obtained at a deposition temperature of 500°C. However, the adhesion of the coating on the steel is better if a deposition temperature of 500°C is used.

The PVD deposition temperature should be approx. 20°C lower than the previously used tempering temperature.

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 Calmax in soft annealed condition to approx. 200 HB.

TURNING

Cutting data parameters	Turning with carbide		Turning with high speed steel Fine turning
	Rough turning	Fine turning	
Cutting speed (v_C), m/min	150 – 200	200 - 250	20 - 25
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	P20 – P30 Coated carbide	P10 Coated carbide or cermet	-

DRILLING

HIGH SPEED STEEL TWIST DRILL

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

* For coated high speed steel drill V_C = 23 - 25 m/min

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip [1]
Cutting speed (v_C), m/min	120 – 150	210 – 230	70 – 100
Feed (f_z) mm/tooth	0.10 – 0.35 [2]	0.08 – 0.12 [3]	0.15 – 0.40 [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 parameter	Turning with carbide	
	Rough milling	Fine milling
Cutting speed (V_C) m/min	160 – 240	240 – 280
Feed (f) mm/tooth	0.2 – 0.4	0.1 – 0.2
Depth of cut (a_p) mm	2 – 5	< 2
Carbide designation ISO	P20 - P40 Coated carbide	P10 - P20 Coated carbide or cermet

END MILLING

Cutting data parameters	Type of end mill		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_C) m/min	120 – 150	150 – 200	40 – 45 [1]
Feed (f_z) mm/tooth	0.006 – 0.20 [2]	0.06 – 0.20 [2]	0.01 – 0.35 [2]
Depth of cut (a_p) mm	-	P15 - P40	-

[1] For coated high speed steel end mill Vc = 55 – 60 m/min
[2] Depending on radial depth of cut and cutter diameter

GRINDING

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

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

WELDING

Good results when welding Calmax can be achieved if proper precautions are taken.

1. Always keep the arc length as short as possible. The electrode should be angled at 90° to the joint sides to minimise under cut. In addition, the electrode should be held at an angle of 75–80° to the direction of forward travel.
2. For large repairs, weld the initial layers with a soft weld metal. Make the two first layers with the same electrode diameter and current.
3. Large repair welds should be made at elevated temperature.
4. The joints should be prepared properly.

TIG WELDING RECOMMENDATIONS

Consumables	Hardness as welded HRC	Hardness after rehardening HRC	Preheat temper °C
UTPA 73G2	53 - 56	51	200 - 250
UTPA 67S	55 - 58	52	
CALMAX/CARMO TIGWELD	58 - 61	58 - 61	

MMA (SMAW) WELDING RECOMMENDATIONS

Consumables	Hardness as welded HRC	Hardness after rehardening HRC	Preheat temper °C
UTPA 67S	55 - 58	52	200 - 250
CALMAX/CARMO TIGWELD	58 - 61	58 - 61	

HEAT TREATMENT AFTER WELDING

HARDENED CONDITION

Temper at 10–20°C below the original tempering temperature.

SOFT ANNEALED CONDITION

Heat through to 860°C in protected atmosphere. Cool in furnace at 10°C/h to 650°C, then freely in air.

Cold work product where Calmax would be a good choice for the die.

ELECTRICAL DISCHARGE MACHINING — EDM

If spark erosion is performed in the hardened and tempered condition, the tool should be given an additional temper at about 25°C lower than previous tempering temperature.

POLISHING

Calmax has a very homogeneous structure. This coupled with its low content of non metallic inclusions (due to vacuum degassing during manufacturing) ensures good surface finish after polishing.

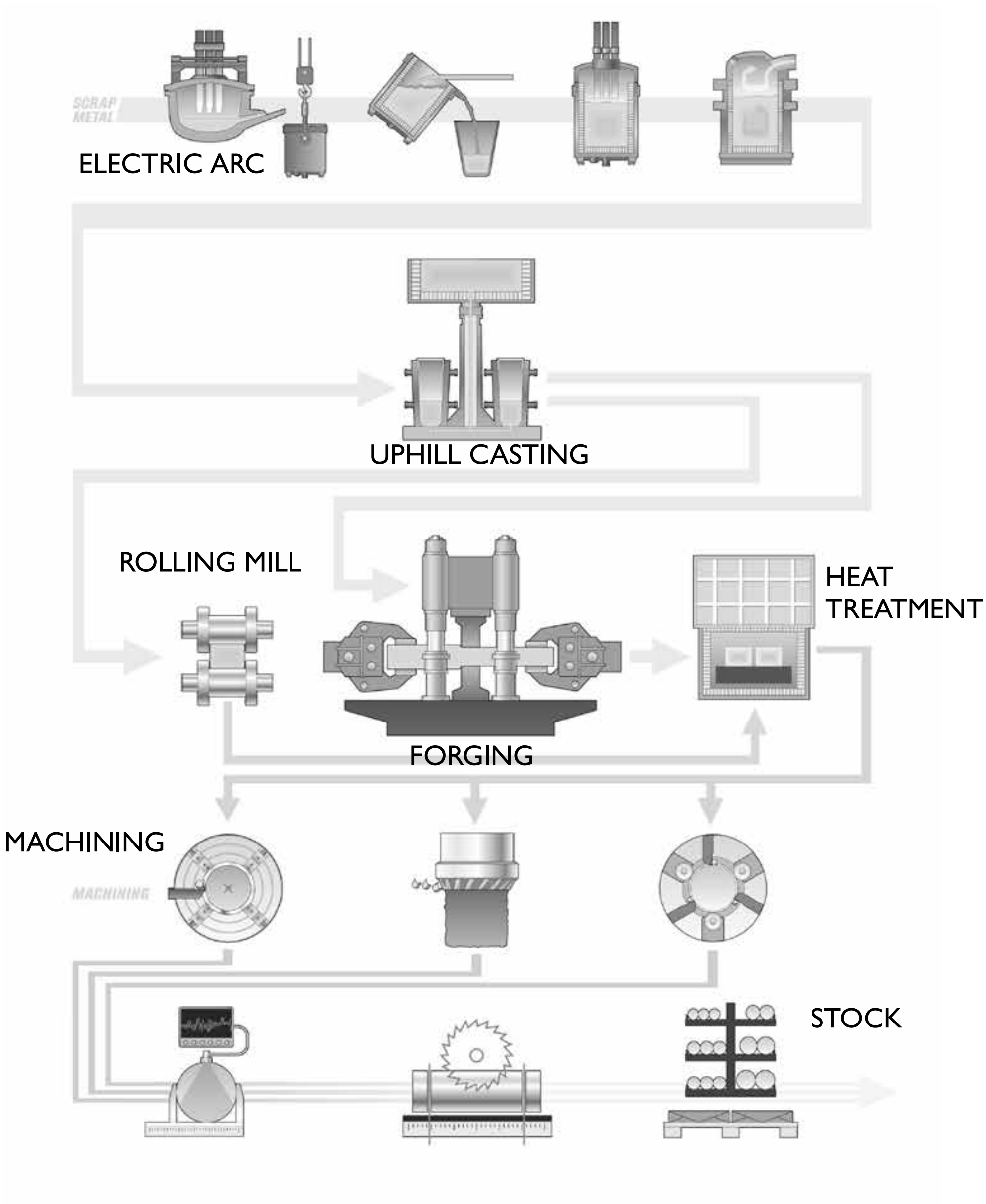
FURTHER INFORMATION

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

RELATIVE COMPARISON OF THE RESISTANCE TO FAILURE 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
ASSAB DF-3								
Calmax								
Caldie (ESR)								
ASSAB 88								
ASSAB XW-42								
ASSAB XW-10								
ASSAB XW-5								
Vanadis 4 Extra*								
Vanadis 8*								
Vancron*								
ASSAB PM 23*								
ASSAB PM 30*								
ASSAB PM 60*								

The longer the bar, the better the resistance.
* ASSAB SuperClean PM tool steel.



THE CONVENTIONAL TOOL STEEL PROCESS

The starting material for our tool steel is carefully selected from high quality recyclable steel. Together with ferroalloys and slag formers, the recyclable steel is melted in an electric arc furnace. The molten steel is then tapped into a ladle.

The de-slagging unit removes oxygen-rich slag and after the de-oxidation, alloying and heating of the steel bath are carried out in the ladle furnace. Vacuum degassing removes elements such as hydrogen, nitrogen and sulphur.

In uphill casting the prepared moulds are filled with a controlled flow of molten steel from the ladle. From this, the steel goes directly to our rolling mill or to the forging press to be formed into round or flat bars.

HEAT TREATMENT

Prior to delivery all of the different bar materials are subjected to a heat treatment operation, either as soft annealing or hardening and tempering. These operations provide the steel with the right balance between hardness and toughness.

MACHINING

Before the material is finished and put into stock, we also rough machine the bar profiles to required size and exact tolerances.

In the lathe machining of large dimensions, the steel bar rotates against a stationary cutting tool. In peeling of smaller dimensions, the cutting tools revolve around the bar.

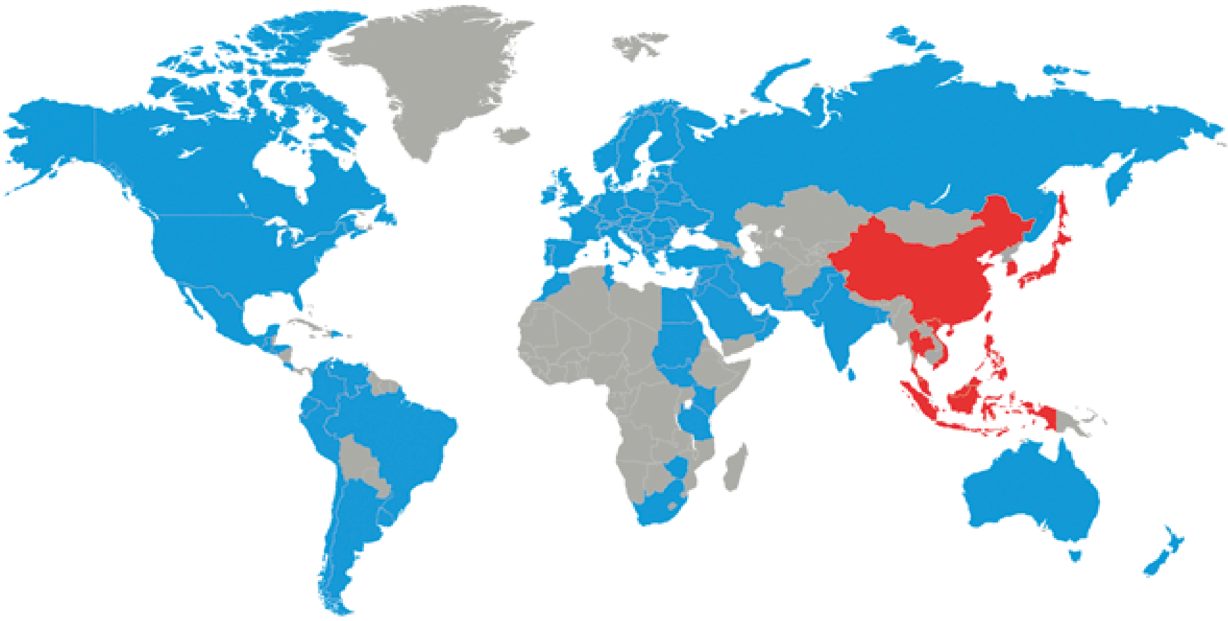
To safeguard our quality and guarantee the integrity of the tool steel we perform both surface - and ultrasonic inspections on all bars. We then remove the bar ends and any defects found during the inspection.

ASSAB

SUPERIOR TOOLING SOLUTIONS

A ONE-STOP SHOP

ASSAB is unmatched as a one-stop product and service provider that offers superior tooling solutions. In addition to the supply of tool steel and other special steel, our range of comprehensive value-added services, such as machining, heat treatment and coating services, span the entire supply chain to ensure convenience, accountability and optimal usage of steel for customers. We are committed to achieving solutions for our customers, with a constant eye on time-to-market and total tooling economy.



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