ASSAB PM 60 SUPERCLEAN

UDDEHOLM VANADIS 60 SUPERCLEAN

ASSAB	UDDEHOLM	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 / 718 HH	IMPAX SUPREME / IMPAX 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)
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 20210505

ASSAB PM 60 SuperClean

ASSAB PM 60 SuperClean is a high alloyed powder metallurgical high speed steel suitable for very demanding cold work applications and for cutting tools. The high carbon and alloying content, Co, Mo, W and V, gives an extremely high compressive strength, 69 HRC, combined with a very good abrasive wear resistance.

For cutting tool applications ASSAB PM 60 SuperClean offers a unique combination of high wear resistance, hot hardness and good toughness compared to all other HSS.

The PM process ensures a good machinability and grindability together with a good dimensional stability during heat treatment.

APPLICATIONS

ASSAB PM 60 SuperClean is a high alloyed high performance PM high speed steel with an addition of cobalt.

ASSAB PM 60 SuperClean is particularly suitable for cold work tooling where highest wear resistance and highest compressive strength are required at the same time.

GENERAL

ASSAB PM 60 SuperClean is a W-Mo-V-Co alloyed PM high speed steel characterised by:

- High wear resistance
- Maximum compressive strength
- Good through hardening properties
- Good toughness
- Good dimensional stability on heat treatment

Typical analysis %	C 2.3	Cr 4.2	Mo 7.0	W 6.5	V 6.5	Co 10.5
Standard specification	~W.-Nr. 1.3292					
Delivery condition	Soft annealed, max. 340 HB					

ASSAB PM 60 SuperClean is a super highly alloyed PM high speed steel with a high cobalt and vanadium content.

PROPERTIES

PHYSICAL DATA

ASSAB PM 60 SuperClean could be hardened to a very high hardness and compressive strength. ASSAB PM 60 SuperClean has further the same good dimensional stability during heat treatment as the other ASSAB PM SuperClean grades. The toughness despite the very high alloying content is very good. The machinability is lower compared to lower alloyed HSS. The grindability of ASSAB PM 60 SuperClean is equal or better than other high alloyed HSS, but somewhat lower than for ASSAB PM 30 SuperClean. ASSAB PM 60 SuperClean has a very high hot hardness.

Temperature	20°C	400°C	600°C
Density [1] kg/m³	7 960	7 860	7 810
Modulus of elasticity [2] MPa	250 000	222 000	200 000
Thermal conductivity [2] W/m°C	21	25	24
Specific heat [2] J/kg°C	420	510	600

[1] = for the soft annealed condition.
[2] = for the hardened and tempered condition.

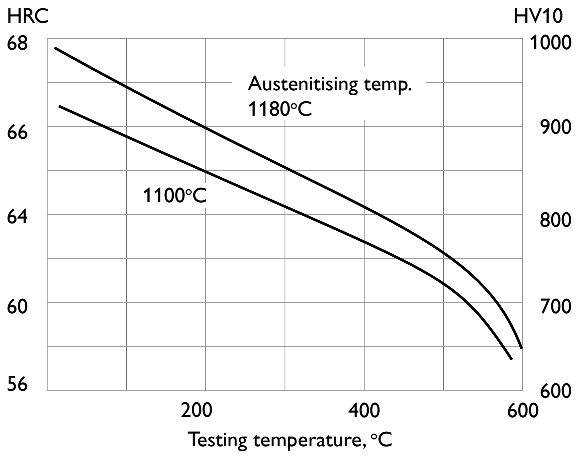
COEFFICIENT OF THERMAL EXPANSION

Hardened and tempered condition

Temperature range, °C	Coefficient, °C from 20
20 - 100	9.6×10^{-6}
20 - 200	9.8×10^{-6}
20 - 300	10.1×10^{-6}
20 - 400	10.4×10^{-6}
20 - 500	10.7×10^{-6}
20 - 550	10.8×10^{-6}

HIGH TEMPERATURE PROPERTIES

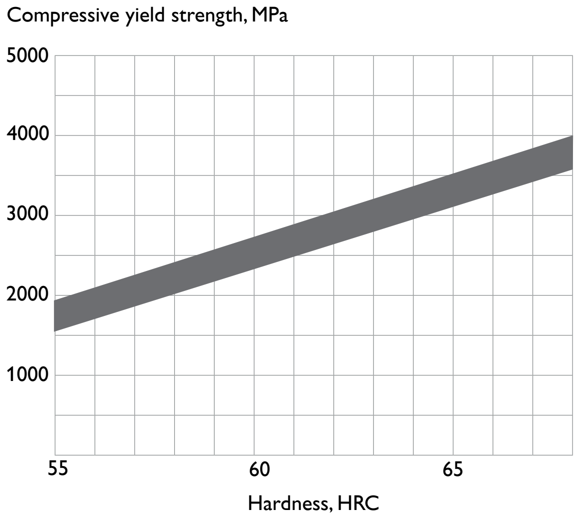
ASSAB PM 60 SUPERCLEAN HOT HARDNESS



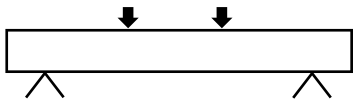
COMPRESSIVE YIELD STRENGTH

Specimen: Hourglass shaped with 10 mm Ø waist

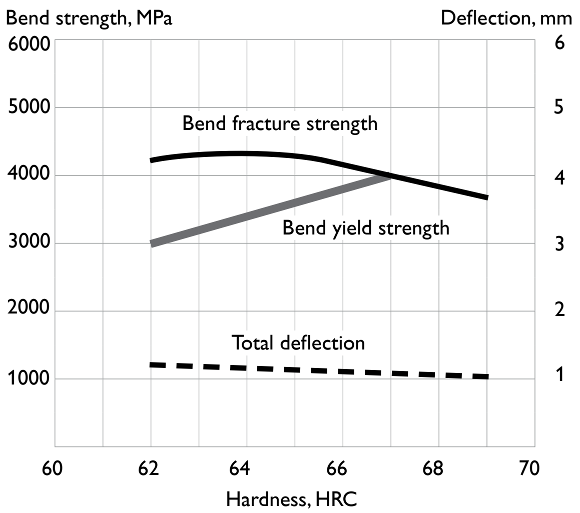
APPROXIMATE COMPRESSIVE YIELD STRENGTH VERSUS HARDNESS AT ROOM TEMPERATURE



BEND STRENGTH AND DEFLECTION



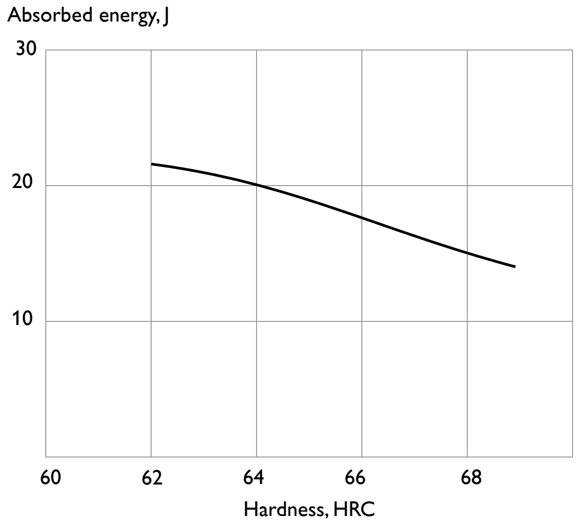
Four-point bend testing
Specimen size: 5 mm Ø
Loading rate: 5 mm/min
Austenitising temperature: 1100–1210°C
Tempering: 3 x 1 h at 560°C, air cooling to room temperature.



IMPACT STRENGTH

Specimen size: 7 x 10 x 55 mm
Specimen type: Unnotched
Tempering: 3 x 1 h at 560°C

APPROXIMATE ROOM TEMPERATURE IMPACT STRENGTH AT DIFFERENT HARDNESS LEVELS



HEAT TREATMENT

SOFT ANNEALING

Protect the steel and heat through to 850–900°C. Then cool in the furnace at 10°C per hour to 700°C, then freely in air.

STRESS RELIEVING

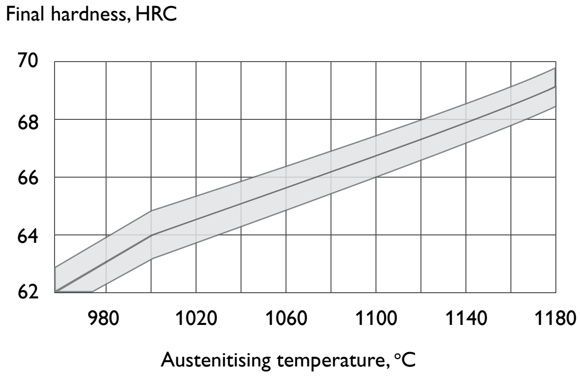
After rough machining the tool should be heated through to 600–700°C, holding time 2 hours. Cool slowly to 500°C, then freely in air.

HARDENING

Pre-heating temperature: 450–500°C and 850–900°C

Austenitising temperature: 1100–1180°C, according to the desired final hardness.
The tool should be protected against decarburisation and oxidation during hardening.

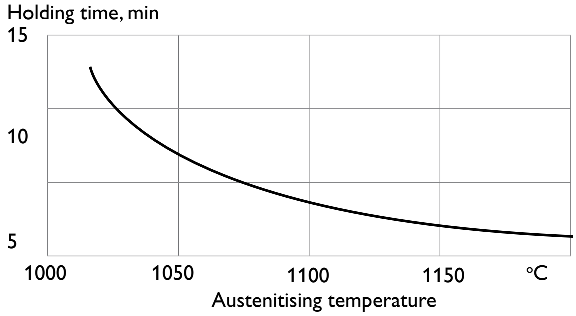
HARDNESS AFTER TEMPERING 3 TIMES FOR 1 HOUR AT 560°C



Hardness for different austenitising temperatures after tempering 3 times for one hour at 560°C ± 1 HRC.

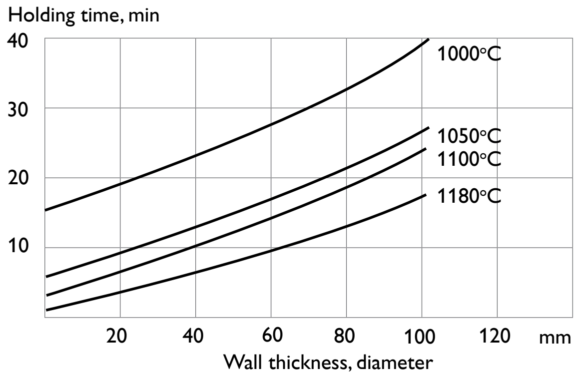
Hardness, HRC	Austenitising temperature °C
62	960
64	1000
66	1070
68	1150
69	1180

RECOMMENDED HOLDING TIME



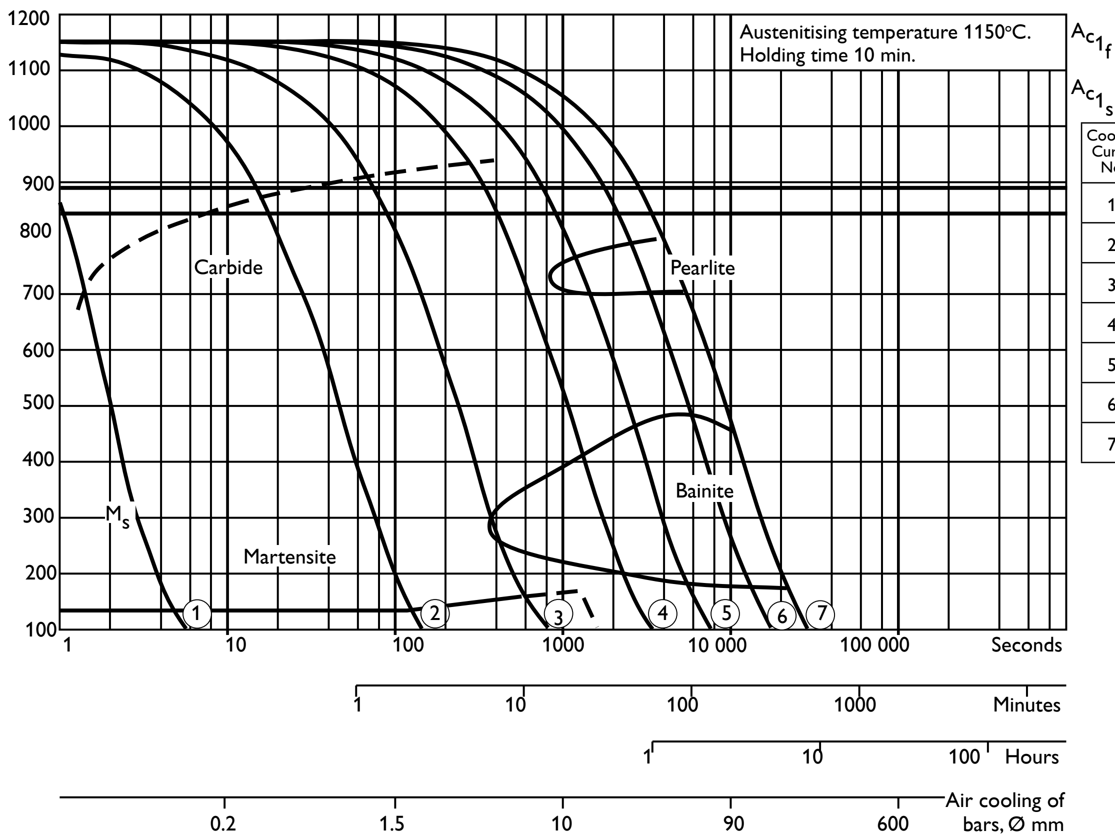
Note: Holding time = time at austenitising temperature after the tool is fully heated through.

TOTAL SOAKING TIME IN A SALT BATH AFTER PRE-HEATING IN TWO STAGES AT 450°C AND 850°C



CCT-GRAPH (CONTINUOUS COOLING)

Austenitising temperature 1150°C. Holding time 10 minutes.



Cooling Curve No.	Hardness HV10	$T_{800-500}$ (sec)
1	946	1
2	946	28
3	946	140
4	772	630
5	620	1390
6	498	3205
7	450	5215

QUENCHING MEDIA

- Vacuum furnace with high speed gas at sufficient overpressure.
- Martempering bath or fluidised bed at approx. 540°C.

Note 1 : Quenching should be continued until the temperature of the tool reaches approx. 25°C. The tool should then be tempered immediately.

Note 2 : In order to obtain a high toughness, the cooling speed in the core should be at least 10°C/sec. This is valid for cooling from the austenitising temperature down to approx. 540°C. After temperature equalisation between the surface and core, the cooling rate of approx. 5°C/sec. can be used. The above cooling cycle results in less distortion and residual stresses.

TEMPERING

Tempering should always be carried out at 560°C 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 and tempering 3 x 1 h at 560°C.

Specimen size: 80 x 80 x 80 mm and 100 x 100 x 25 mm.

Dimensional changes: growth in length, width and thickness +0.03% – +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 followed by tempering.

ASSAB PM 60 SuperClean is commonly sub-zero treated between -150 and -196°C although occasionally -70 to -80°C are used due to constraints of the sub-zero medium and equipment available. A treatment time of 1–3 hours at temperature will give a hardness increase of 1–3 HRC.

Avoid intricate shapes as there is a risk of cracking.

CUTTING DATA RECOMMENDATIONS

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

Condition: soft annealed to ~320 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	60 – 90	90 – 110	6 – 10
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 Coated carbide* or cermet*	K15, P10 Coated carbide* or cermet*	-

* Preferably a wear resistant CVD coated carbide grade

DRILLING

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm	Cutting speed (Vc) m/min	Feed (f) mm/rev
≤ 5	6 – 8*	0.05 – 0.15
5–10	6 – 8*	0.15 – 0.20
10–15	6 – 8*	0.20 – 0.25
15–20	6 – 8*	0.25 – 0.35

* For coated high speed steel drill v_c = 12–14 m/min.

CARBIDE DRILL

Cutting data parameter	Type of drill		
	Indexable insert	Solid carbide	Carbide tip [1]
Cutting speed (V_C) m/min	80 – 100	40 – 60	20 – 30
Feed. (f) mm/rev	0.08 – 0.14 [2]	0.10 – 0.15 [3]	0.10 – 0.20 [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	40 – 60	60 – 80
Feed (f) mm/tooth	0.2 – 0.3	0.1 – 0.2
Depth of cut (a_P) mm	2 – 4	1 – 2
Carbide designation ISO	K20, P20 Coated carbide*	K15, P10 Coated carbide* or cermet*

* Preferably a wear resistant CVD coated carbide grade

END MILLING

Cutting data parameter	Type of end mill		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (V_C) m/min	30 – 40	40 – 60	10 – 14 [1]
Feed. (f) mm/tooth	0.01 – 0.2 [2]	0.06 – 0.20 [2]	0.01 – 0.3 [2]
Carbide designation ISO	–	K15, P10–P20 Coated carbide [3] or cermet [3]	–

[1] A coated high speed steel end mill
[2] Depending on radial depth of cut and cutter diameter
[3] Preferably a wear resistant CVD coated carbide grade

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 36 GV	B151 R50 B3[1] A46 GV [2]
Cylindrical grinding	A 60 KV	B151 R50 B3[1] A60 KV [2]
Internal grinding	A 60 JV	R151 R75 B3[1] A 60 IV [2]
Profile grinding	A 100 IV	B126 R100 B6[1] A 120 JV [2]

[1] If possible, use CBN-wheels for this application

[2] Preferably a wheel type containing sintered Al_2O_3 (seeded gel)

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.

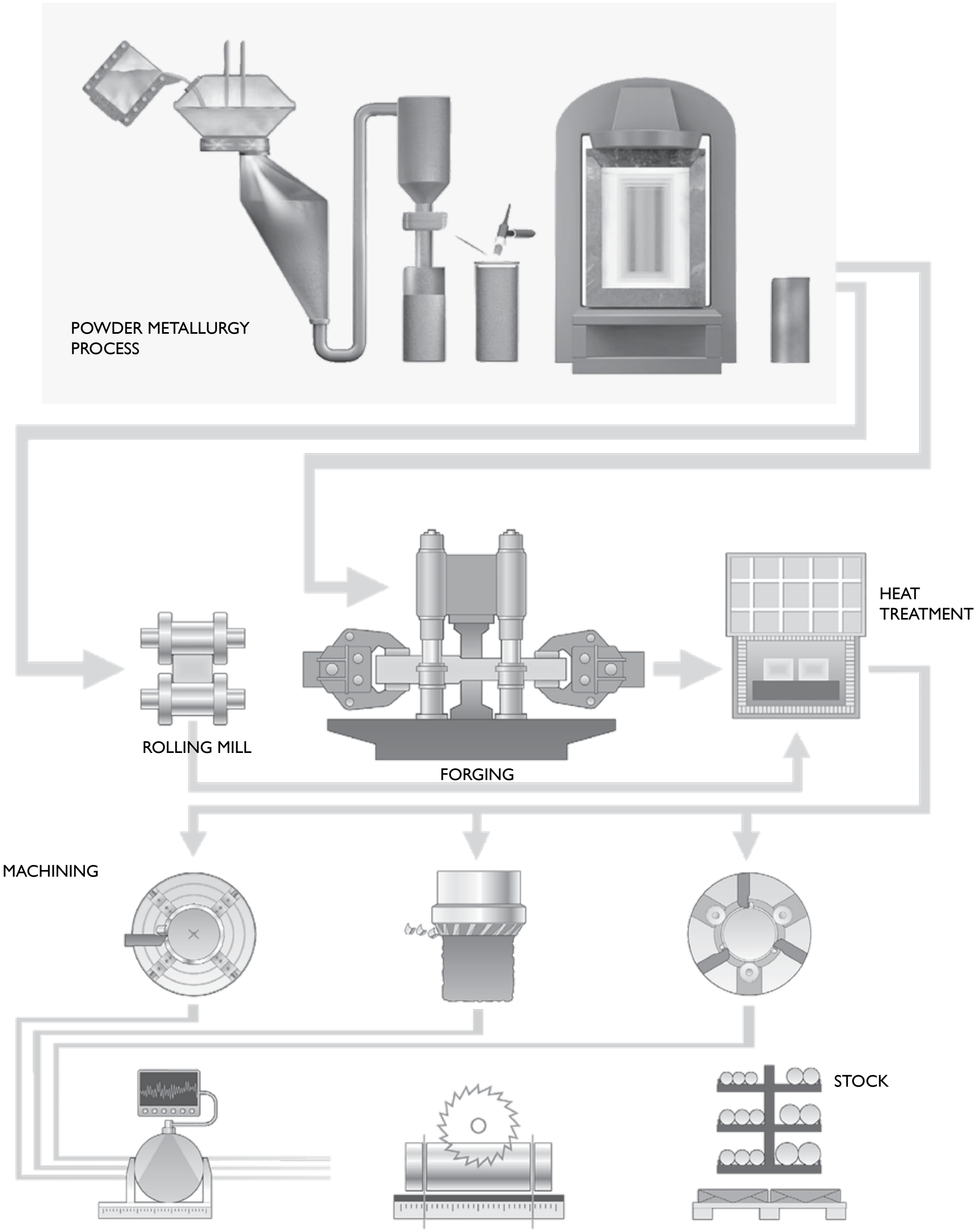
FURTHER INFORMATION

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

RELATIVE COMPARISON OF ASSAB COLD WORK TOOL STEEL

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS

* ASSAB PM SuperClean Tool Steel


POWDER METALLURGY PROCESS
HEAT TREATMENT
ROLLING MILL
FORGING
MACHINING
STOCK

THE POWDER METALLURGY PROCESS

In the powder metallurgy process nitrogen gas is used to atomise the melted steel into small droplets, or grains. Each of these small grains solidifies quickly and there is littletime for carbides to grow. These powder grains are then compacted to an ingot in a hot isostatic press (HIP) at high temperature and pressure. The ingot is then rolled or forged to steel bars by conventional methods.

The resulting structure is completely homogeneous steel with randomly distributed small carbides, harmless as sites for crack initiation but still protecting the tool from wear.

Large slag inclusions can take the role as sites for crack initiation instead. Therefore, the powder metallurgical process has been further developed in stages to improve the cleanliness of the steel. Powder steel from ASSAB is today of the third generation and is considered the cleanest powder metallurgy tool steel product on the market.

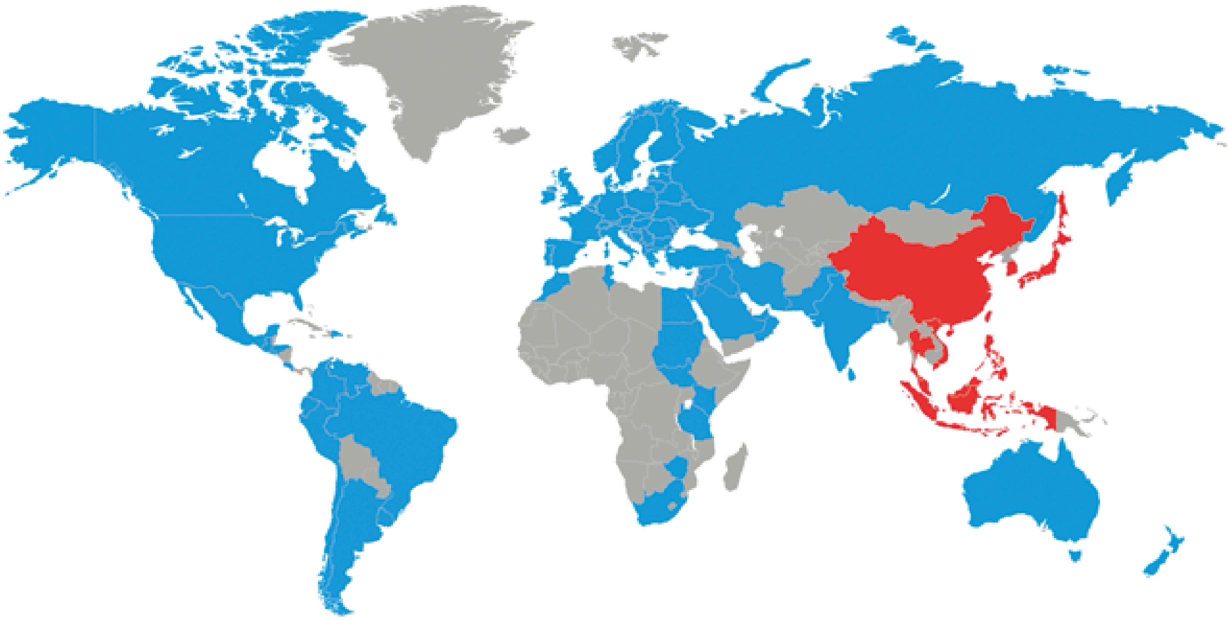
HEAT TREATMENT

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.



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