

ASSAB PM 60 SuperClean

Uddeholm Vanadis 60 SuperClean

ASSAB
SuperClean



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 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			
ASSAB 705		4340	1.6582	SNM8
ASSAB 709		4140	1.7225	SCM4
ASSAB 760		1050	1.1730	S50C

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The information contained herein is based on our present state of knowledge and is intended to provide general notes on our products and their uses. It should not therefore be construed as a warranty of specific properties of the products described or a warranty for fitness for a particular purpose. Each user of ASSAB products is responsible for making its own determination as to the suitability of ASSAB products and services.

Edition 140101

General

ASSAB PM 60 SuperClean is a high alloyed powder metallurgical (PM) high speed steel characterised by:

- Highest wear resistance
- Maximum compressive strength
- Good through-hardening properties
- Good toughness
- Good dimensional stability during heat treatment
- Very good temper resistance

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 to max. 340 HB					
Colour code	Gold					

ASSAB PM 60 SuperClean could be hardened to a very high hardness and compressive strength. ASSAB PM 60 SuperClean has the same good dimensional stability, like other PM grades, during heat treatment. Its toughness is very good despite its very high alloy content. The machinability is lower compared with lower alloyed high speed steel. The grindability of ASSAB PM 60 SuperClean is equal to or better than other high alloyed high speed steel, but somewhat lower than that of ASSAB PM 30 SuperClean. ASSAB PM 60 SuperClean has a very high hot hardness.

Applications

ASSAB PM 60 SuperClean is a cobalt alloyed high performance PM high speed steel. The cobalt addition of approx. 10.5% has a positive influence on the high temperature properties (i.e., hot hardness and temper resistance), compressive strength and modulus of elasticity. ASSAB PM 60 SuperClean contains a high volume of very small, very hard, uniformly distributed carbides due to its high carbon content coupled with a large amount of carbides forming elements (i.e., chromium, molybdenum, tungsten and vanadium). The small carbides in ASSAB PM 60 SuperClean are harmless as sites for crack initiation and offer a very good protection against wear.

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.

Typical applications of ASSAB PM 60 SuperClean include blanking thin, abrasive materials such as electrical sheets and gasket materials, and it is a good choice to replace carbide that tends to chip or crack.

Properties

PHYSICAL PROPERTIES

Temperature	20°C	400°C	600°C
Density ¹ kg/m ³	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 Soft annealed condition

² Hardened and tempered condition

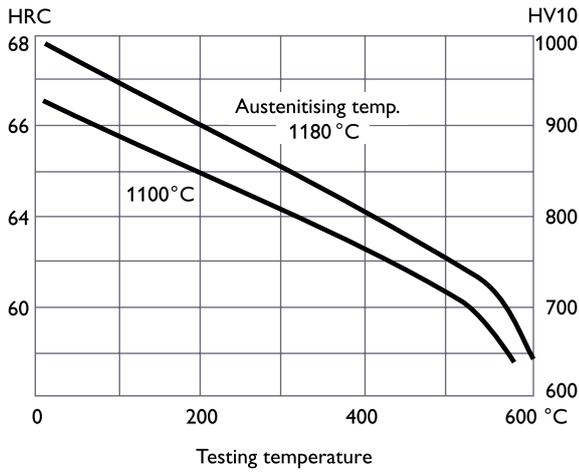
COEFFICIENT OF THERMAL EXPANSION IN DIFFERENT TEMPERATURE INTERVALS

Hardened and tempered condition.

Temperature range	Coefficient (°C ⁻¹)
20 - 100°C	9.6 × 10 ⁻⁶
20 - 200°C	9.8 × 10 ⁻⁶
20 - 300°C	10.1 × 10 ⁻⁶
20 - 400°C	10.4 × 10 ⁻⁶
20 - 500°C	10.7 × 10 ⁻⁶
20 - 550°C	10.8 × 10 ⁻⁶

HIGH TEMPERATURE PROPERTIES

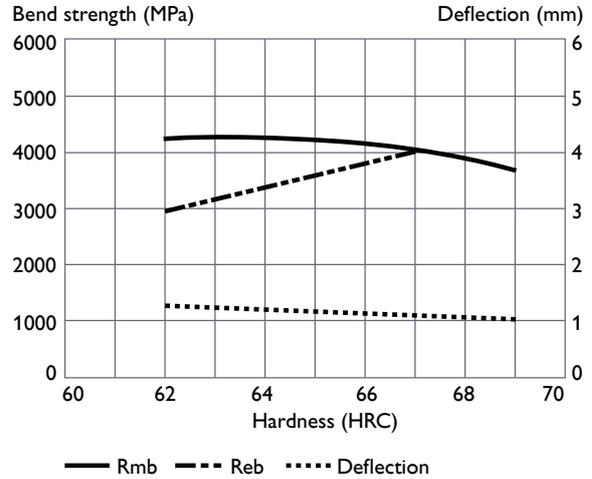
Hot hardness



BENDING STRENGTH

Four-point bend testing.

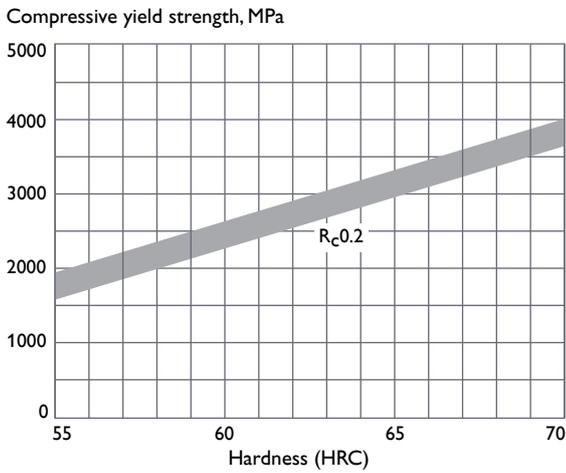
Original dimension: 6 mm Ø
 Specimen size: 5 mm Ø
 Tempering: 3 x 1 h at 560 °C



COMPRESSIVE YIELD STRENGTH

Specimen: Hourglass shaped with 10mm Ø waist

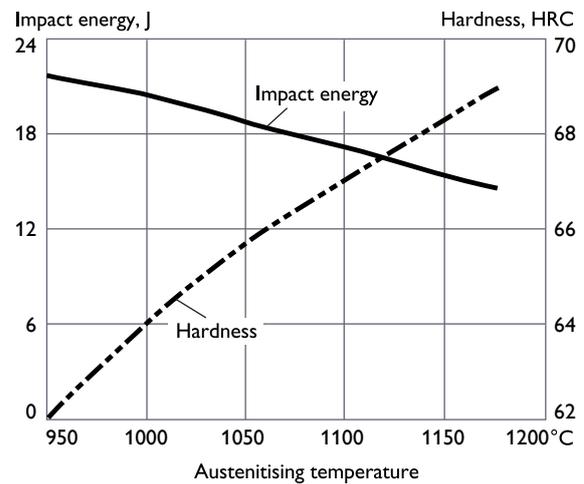
Approximate compressive yield strength versus hardness at room temperature



IMPACT STRENGTH

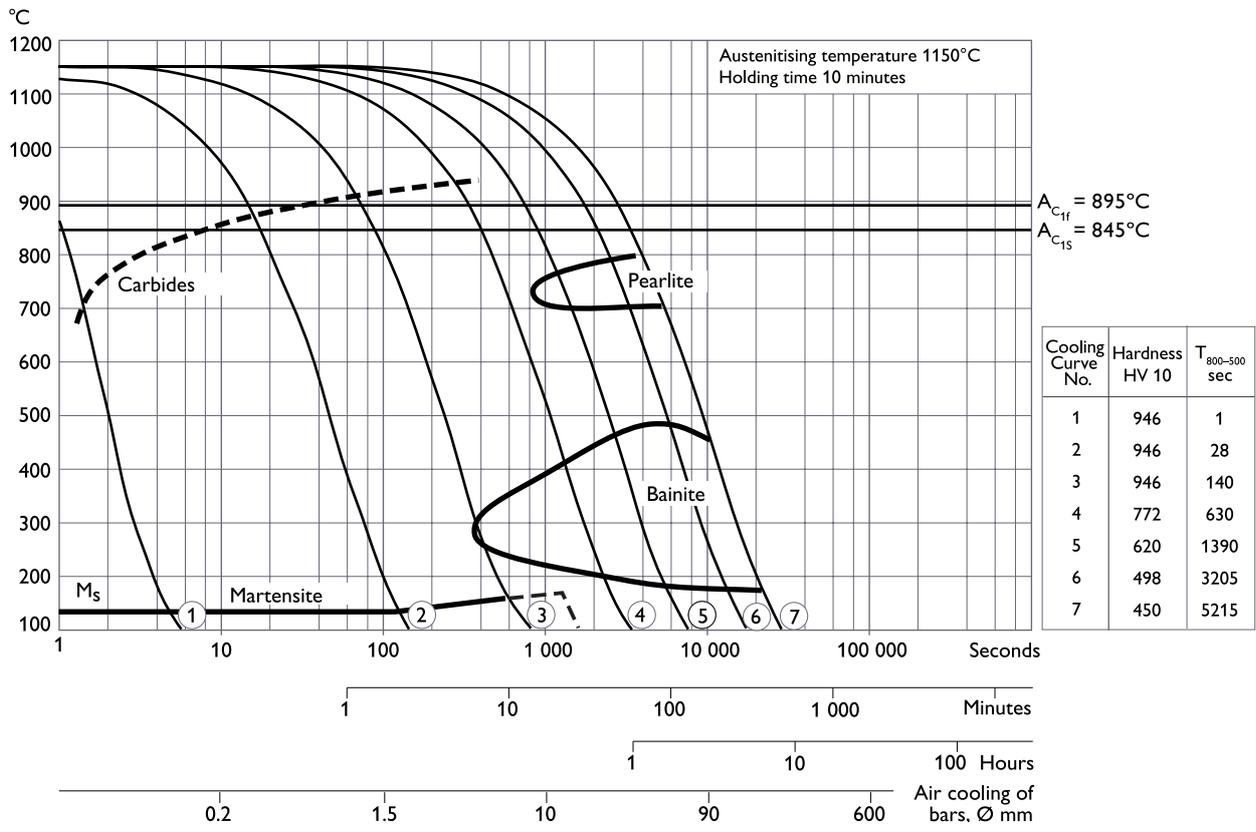
Approximate room temperature impact strength at different hardness levels.

Original dimensions: 9 x 12 mm
 Specimen size: 7 x 10 x 55 mm
 Specimen type: Unnotched
 Tempering: 3 x 1 h at 560 °C



CCT graph

Austenitising temperature 1150°C. Holding time 10 minutes.



Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 850 - 900°C. Cool in the furnace at 10°C/h to 700°C, then freely in air.

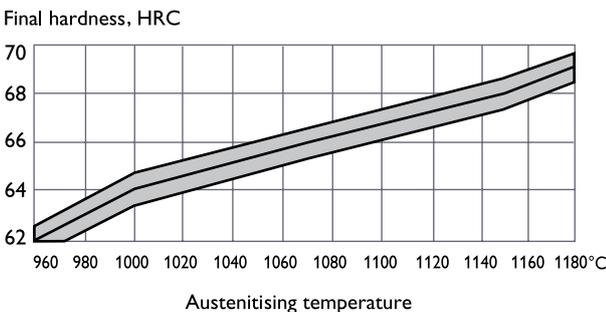
STRESS RELIEVING

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

Preheating temperature: 450 - 500°C and 850 - 900°C
 Austenitising temperature: 1100 - 1180°C, according to the desired final hardness, see diagram below
 The tool should be protected against decarburisation and oxidation during hardening.

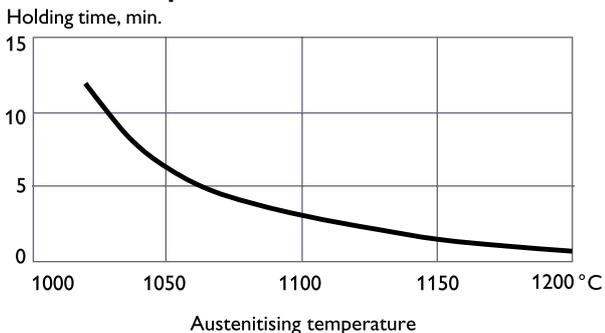
Hardness after tempering 3 times for 1 hour at 560°C



Hardness obtained after hardening at different austenitising temperatures and tempering 3 times for 1 hour at 560°C

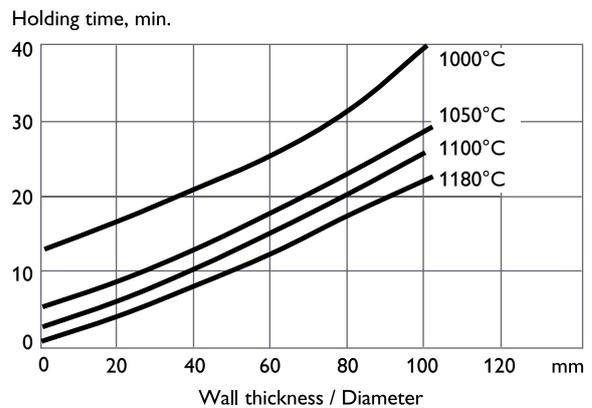
Hardness HRC	Austenitising temp. °C
62	960
64	1000
66	1070
68	1150
69	1180

Recommended holding time, vacuum, fluidised bed or atmosphere furnace



Holding time = Time at austenitising 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.

Total soaking time in a salt bath after preheating in two stages at 450°C and 850°C



QUENCHING MEDIA

- Vacuum furnace with high speed gas at sufficient overpressure (≥2 bar)
- Martempering bath at approx. 540°C
- Forced air / gas

Note 1: Quenching should be continued until the temperature of the tool reaches approx. 50°C. The tool should then be tempered immediately.

Note 2: For applications where maximum toughness is required, use a martempering bath or a furnace with sufficient overpressure.

TEMPERING

Tempering should always be carried out at 560°C irrespective of the austenitising temperature. Temper three times for at least 1 hour each 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% to +0.13%

SUB-ZERO TREATMENT

Parts requiring maximum dimensional stability should be sub-zero treated. Immediately after quenching, the piece should be sub-zero treated, followed by tempering. ASSAB PM 60 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. 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.

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 ~320 HB

TURNING

Cutting data parameters	Turning with carbide		Turning with HSS [†]
	Rough turning	Fine turning	Fine turning
Cutting speed (v _c) m/min	60 - 90	90 - 110	6 - 10
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, P10 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	6 - 8*	0.05 - 0.15
5 - 10	6 - 8*	0.15 - 0.2
10 - 15	6 - 8*	0.2 - 0.25
15 - 20	6 - 8*	0.25 - 0.35

* For coated HSS drill, v_c = 12 - 14 m/min

Carbide drill

Cutting data parameters	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/r	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 parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v _c) m/min	40 - 60	60 - 80
Feed (f _z) 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*

* Use a CVD coating

End milling

Cutting data parameters	Type of end mill		
	Solid carbide	Carbide indexable insert	High speed steel ¹
Cutting speed (v _c) m/min	30 - 40	40 - 60	10 - 15
Feed (f _z) mm/tooth	0.01 - 0.2 ²	0.06 - 0.2 ²	0.01 - 0.3 ²
Carbide designation ISO	-	K15, P10 - P20 Coated carbide ³ or cermet ³	-

¹ A coated HSS end mill
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 36 GV	B151 R50 B3 ¹ A 46 GV ²
Cylindrical grinding	A 60 KV	B151 R50 B3 ¹ A 60 KV ²
Internal grinding	A 60 JV	B151 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 Al₂O₃ (seeded gel)

Electrical discharge machining

If EDM is performed in the hardened and tempered condition, the EDM'd surface is covered with a resolidified layer (white layer) and a rehardened and untempered layer, both of which are very brittle and hence detrimental to the tool performance.

When a profile is produced by EDM, it is recommended to finish with "fine-sparking", i.e., low current, high frequency. For optimal performance, the EDM'd surface should be ground/polished to remove the white layer completely. The tool should then be retempered at approx. 535°C.

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	██████	██████	██████	██████	██████	██	██	██

REGIONAL HEAD OFFICE**SINGAPORE**

ASSAB Pacific Pte Ltd
Tel : +65 6534 5600
Fax : +65 6534 0655
info@assab.com
www.assab.com

CHINA**Beijing**

ASSAB Tooling (Beijing) Co., Ltd.
Tel : +86 10 6786 5588
Fax : +86 10 6786 2988
info.beijing@assab.com

Changchun*

ASSAB Tooling (Beijing) Co., Ltd.,
Dalian Branch
Tel : +86 431 8897 8922
Fax : +86 431 8897 8922
info.changchun@assab.com

Changzhou*

ASSAB Tooling Technology (Shanghai)
Co., Ltd. - Changzhou Branch
Tel : +86 519 8188 0008
Fax : +86 519 8510 2820
info.changzhou@assab.com

Chongqing

ASSAB Tooling Technology
(Chongqing) Co., Ltd.
Tel : +86 23 6745 5698
Fax : +86 23 6745 5699
info.chongqing@assab.com

Dalian

ASSAB Tooling (Beijing) Co., Ltd.,
Dalian Branch
Tel : +86 411 8761 8080
Fax : +86 411 8761 9595
info.dalian@assab.com

Dongguan

ASSAB Tooling (Dong Guan)
Co., Ltd.
Tel : +86 769 2289 7888
Fax : +86 769 2289 9312
info.dongguan@assab.com

Guangzhou*

ASSAB Tooling (Dong Guan)
Co., Ltd., Guangzhou Branch
Tel : +86 020 3482 8891
Fax : +86 020 3482 5329
info.guangzhou@assab.com

Hong Kong*

ASSAB Steels (HK) Ltd.
Tel : +852 2487 1991
Fax : +852 2489 0938
info.hongkong@assab.com

Hunan*

ASSAB Tooling (Dong Guan)
Co., Ltd., Hunan Branch
Tel : +86 731 8452 3986
Fax : +86 731 8452 3986
info.hunan@assab.com

Ningbo

ASSAB Tooling Technology
(Ningbo) Co., Ltd.
Tel : +86 574 8680 7188
Fax : +86 574 8680 7166
info.ningbo@assab.com

Qingdao

ASSAB Tooling (Qingdao)
Co., Ltd.
Tel : +86 532 8752 9999
Fax : +86 532 8752 9588
info.qingdao@assab.com

Shanghai

ASSAB Tooling Technology
(Shanghai) Co., Ltd.
Tel : +86 21 2416 9688
Fax : +86 21 5442 4244
info.shanghai@assab.com

Suzhou*

ASSAB Tooling Technology (Shanghai)
Co., Ltd. - Suzhou Branch
Tel : +86 512 6900 0161
Fax : +86 512 6252 9227
info.suzhou@assab.com

Tianjin*

ASSAB Tooling (Beijing) Co., Ltd.,
Tianjin Branch
Tel : +86 22 2370 7808
Fax : +86 22 2370 7806
info.tianjin@assab.com

Wuhan

ASSAB Tooling Technology
(Shanghai) Co., Ltd., Wuhan Branch
Tel : +86 27 6930 0156
Fax : +86 27 6934 6326
info.wuhan@assab.com

Xiamen

ASSAB Tooling (Xiamen) Co., Ltd.
Tel : +86 592 562 4678
Fax : +86 592 568 3703
info.xiamen@assab.com

Xi'an*

ASSAB Tooling (Beijing) Co., Ltd.,
Xi'an Branch
Tel : +86 29 8525 5139
Fax : +86 29 8526 2080
info.xian@assab.com

Yantai*

ASSAB Tooling (Qingdao) Co., Ltd.
Tel : +86 535 693 4100
Fax : +86 535 693 4200
info.yantai@assab.com

INDONESIA**Jakarta - Head Office**

PT. ASSAB Steels Indonesia
Tel : +62 21 461 1314
Fax : +62 21 461 1306/
+62 21 461 1309
info.jakarta@assab.com

Bandung*

PT. ASSAB Steels Indonesia
Tel : +62 22 5234 017
Fax : +62 22 5234 020
info.bandung@assab.com

Cikarang*

PT. ASSAB Steels Indonesia
Tel : +62 21 461 1314
Fax : +62 21 461 1306/
+62 21 461 1309
info.cikarang@assab.com

Medan*

PT. ASSAB Steels Indonesia
Tel : +62 61 8477 935
Fax : +62 61 8477 936
info.medan@assab.com

Semarang*

PT. ASSAB Steels Indonesia
Tel : +62 24 7071 2574/
+62 24 7658 4803
Fax : +62 24 674 7145
info.semarang@assab.com

Surabaya

PT. ASSAB Steels Indonesia
Tel : +62 31 849 9606
Fax : +62 31 843 2040
info.surabaya@assab.com

Tangerang*

PT. ASSAB Steels Indonesia
Tel : +62 21 5316 0795
Fax : +62 21 5316 0794
info.tangerang@assab.com

JAPAN**Tokyo - Head Office***

Bohler-Uddeholm KK
Tel : +81 3 5226 3771
Fax : +81 3 5226 6110
info@bohler-uddeholm.jp

Fukuroi

Bohler-Uddeholm KK
Tel : +81 538 43 9240
Fax : +81 538 43 9244
info@bohler-uddeholm.jp

Nagoya*

Bohler-Uddeholm KK
Tel : +81 52 979 5081
Fax : +81 52 933 6461
info@bohler-uddeholm.jp

Osaka*

Bohler-Uddeholm KK
Tel : +81 6 6307 7621
Fax : +81 6 6307 7627
info@bohler-uddeholm.jp

KOREA**Incheon - Head Office**

ASSAB Steels (Korea) Co., Ltd.
Tel : +82 32 821 4300
Fax : +82 32 821 3311
info.korea@assab.com

Busan

ASSAB Steels (Korea) Co., Ltd.
Tel : +82 51 831 3315
Fax : +82 51 831 3319
info.korea@assab.com

Daegu

ASSAB Steels (Korea) Co., Ltd.
Tel : +82 53 384 3315
Fax : +82 53 384 3317
info.korea@assab.com

MALAYSIA**Kuala Lumpur - Head Office**

ASSAB Steels (Malaysia) Sdn. Bhd.
Tel : +60 3 6189 0022
Fax : +60 3 6189 0044/55
info.kualalumpur@assab.com

Northern Branch

ASSAB Steels (Malaysia) Sdn. Bhd.
Tel : +60 4 507 2020
Fax : +60 4 507 6323
info.penang@assab.com

Southern Branch

ASSAB Steels (Malaysia) Sdn. Bhd.
Tel : +60 7 598 0011
Fax : +60 7 599 4890
info.johor@assab.com

PHILIPPINES**Laguna**

ASSAB Pacific Pte Ltd -
Philippine Branch
Tel : +63 49 539 0441 to 0442
Fax : +63 49 539 1075
info.philippines@assab.com

SINGAPORE

ASSAB Steels Singapore (Pte) Ltd
Tel : +65 6862 2200
Fax : +65 6862 0162
info.singapore@assab.com

TAIWAN**Taipei - Head Office**

ASSAB Steels Taiwan Co., Ltd.
Tel : +886 2 2299 2849
Fax : +886 2 2299 0147
info.taipei@assab.com

Kaoshiung

ASSAB Steels Taiwan Co., Ltd.
Tel : +886 7 624 6600
Fax : +886 7 624 0012
info.kaoshiung@assab.com

Nantou

ASSAB Steels Taiwan Co., Ltd.
Tel : +886 49 225 1702
Fax : +886 49 225 3173
info.nantou@assab.com

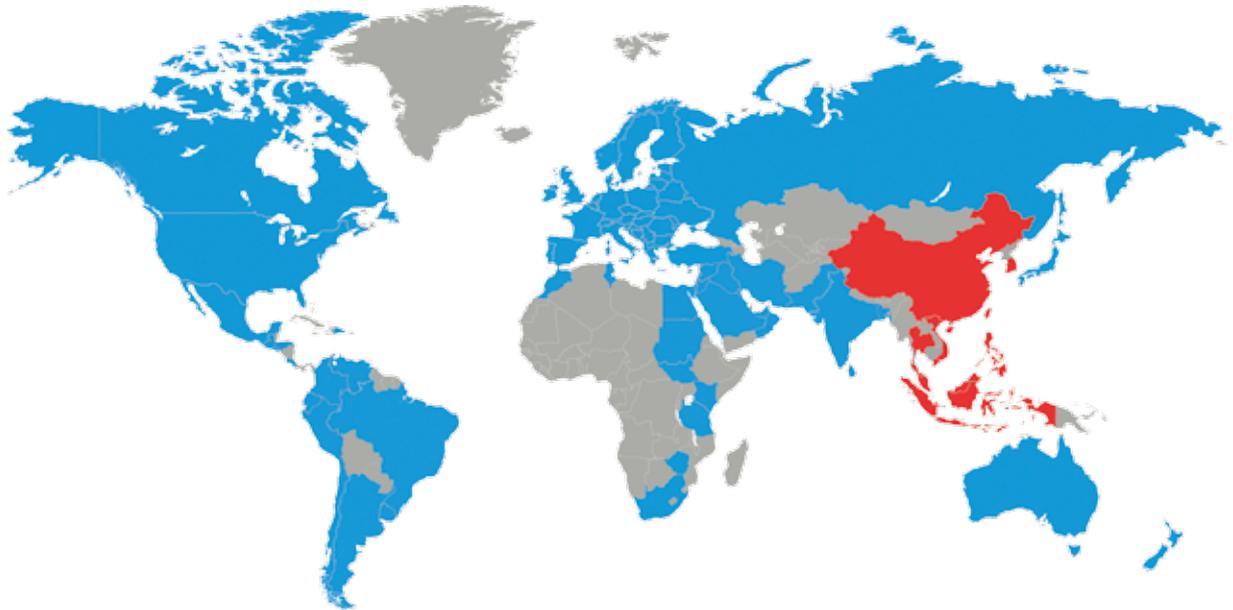
THAILAND

ASSAB Steels (Thailand) Ltd
Tel : +66 2 757 5017
Fax : +66 2 385 5943
info.thailand@assab.com

VIETNAM

ASSAB Steels (Vietnam) Co. Ltd
Tel : +84 61 8899 099
Fax : +84 61 8899 191
info.vietnam@assab.com

* Sales office



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 the 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 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