


FORMVAR



ASSAB 

		REFERENCE STANDARD		
		AISI	WNo.	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 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			
QRO 90 SUPREME	QRO 90 SUPREME			
FORMVAR	FORMVAR			
ASSAB 705		4340	1.6582	SNM8
ASSAB 709		4140	1.7225	SCM4
ASSAB 760		1050	1.1730	S50C

ASSAB is a trademark of ASSAB Pacific Pte Ltd.

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 141223

General

Formvar is a high-performance hot-work tool steel which offers a very good resistance to hot wear and plastic deformation. Formvar is characterised by:

- Good temper resistance
- Good high-temperature strength
- Excellent hardenability
- Good dimensional stability throughout heat treatment and coating operations

Typical analysis %	C 0.35	Si 0.2	Mn 0.5	Cr 5.0	Mo 2.3	V 0.6
Standard specification	None					
Delivery condition	Soft annealed to max. 230 HB					
Colour code	Violet / Yellow-green					

Applications

EXTRUSION

Part	Copper alloys	Aluminium / Magnesium alloys
Dies	-	46 - 52 HRC
Liners, dummy blocks, stems	46 - 52 HRC	44 - 52 HRC

HOT FORGING

Part	Steel / Aluminium
Inserts	46 - 52 HRC

Properties

PHYSICAL PROPERTIES

Hardened and tempered to 44 - 46 HRC.

Temperature	20°C	400°C	600°C
Density kg/m ³	7800	7700	7600
Modulus of elasticity MPa	210 000	180 000	145 000
Coefficient of thermal expansion per °C from 20°C	-	12.7 × 10 ⁻⁶	13.3 × 10 ⁻⁶
Thermal conductivity W/m °C	-	31	32

MECHANICAL PROPERTIES

Tensile properties at room temperature, short transverse direction.

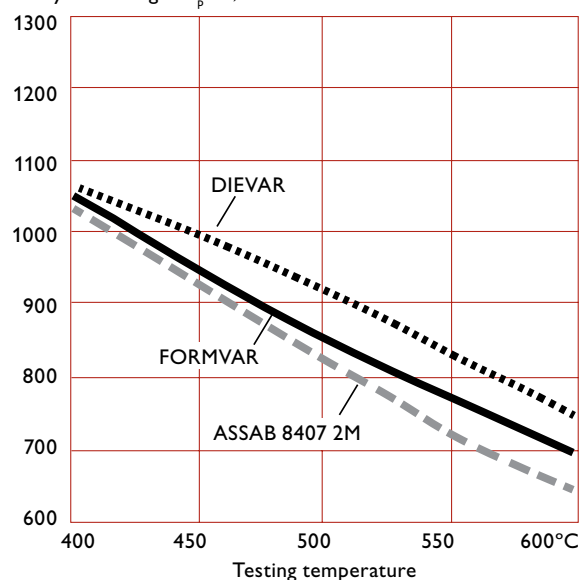
Hardness	44 HRC	48 HRC	52 HRC
Tensile strength R _m	1480 MPa	1640 MPa	1900 MPa
Yield strength R _{p0.2}	1210 MPa	1380 MPa	1560 MPa

Hot yield strength

Austenitising : 1020°C / 30 min.

Tempering : 616°C / 2 x 2h.

Hot yield strength R_{p0.2}, MPa

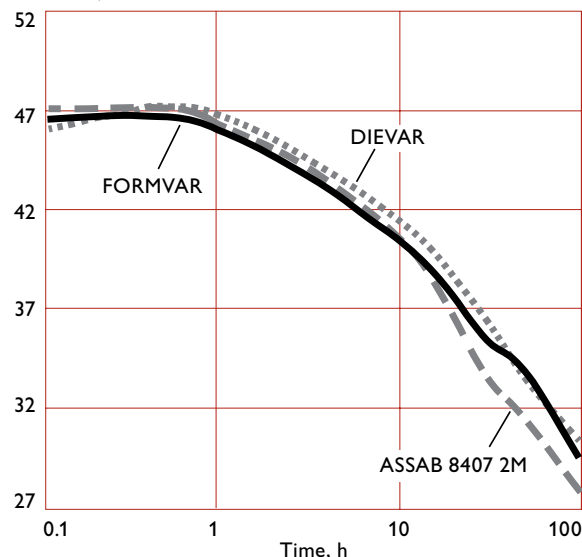


Tempering resistance at 600°C

Austenitising : 1020°C / 30 min.

Tempering : 616°C / 2 x 2h.

Hardness, HRC



Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 850°C. Then cool in furnace at 10°C per hour to 600°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

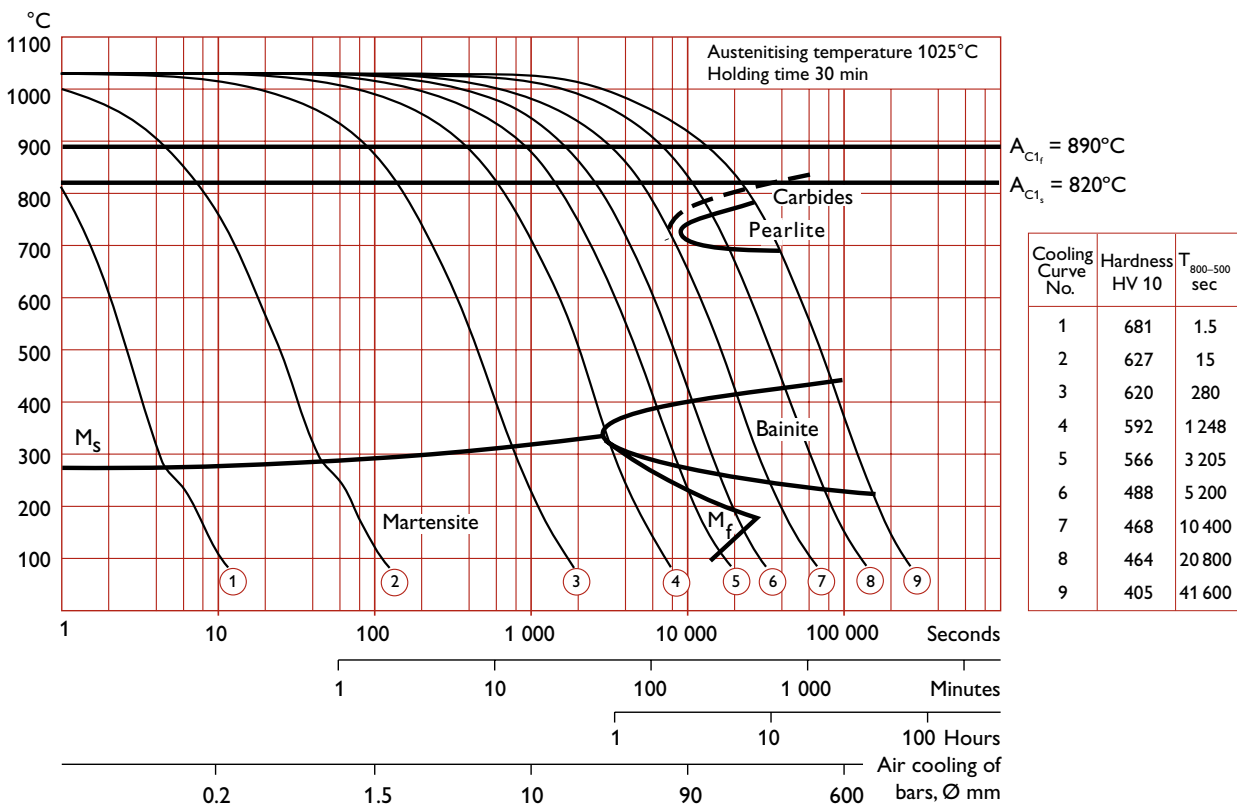
Preheating temperature: 600 - 900°C. Normally a minimum of two preheats, the first in the 600 - 650°C range, and the second in the 820 - 850°C range. When three preheats are used, the second is carried out at 820°C and the third at 900°C.

Austenitising temperature: 1000 - 1030°C.

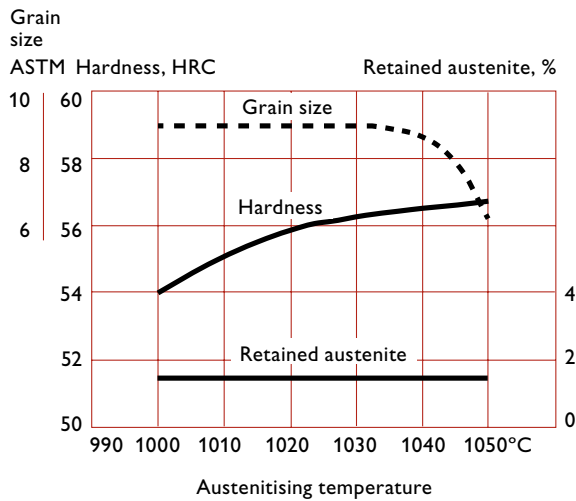


CCT graph

Austenitising temperature 1025°C. Holding time 30 minutes.



Hardness, grain size and retained austenite as functions of austenitising temperature



QUENCHING MEDIA

- High-speed gas/circulating atmosphere
- High-speed gas with sufficient positive pressure quenching in vacuum furnace. An interrupted quench at 320 - 450°C is recommended where distortion control and quench cracking are a concern.
- Martempering bath, salt bath or fluidised bed at 450 - 550°C
- Martempering bath, salt bath or fluidised bed at 180 - 200°C
- Warm oil, approx. 80°C

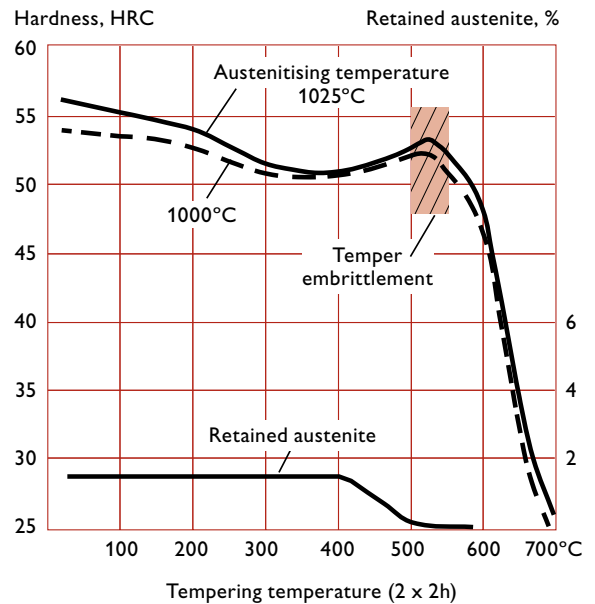
Note 1: Temper the tool as soon as its temperature reaches 50 - 70°C.

TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper minimum twice for forging and extrusion tools and three times for die-casting dies with intermediate cooling to room temperature. Holding time at temperature is minimum 2 hours.

Tempering in the range of 500 - 550°C for the intended final hardness will result in a lower toughness.

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.



Forging die (left) for producing hooks (right). Courtesy: Gunnebo Industries, Sweden.

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 ~160 HB

TURNING

Cutting data parameters	Turning with carbide		Turning with HSS [†]
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min	150 - 200	200 - 250	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 - 2
Carbide designation ISO	P20 - P30 Coated carbide	P10 Coated carbide or cermet	-

[†] High-speed steel

DRILLING

High-speed steel twist drill

Drill diameter mm	Cutting speed (v_c) m/min	Feed (f) mm/r
≤ 5	15 - 20*	0.05 - 0.15
5 - 10	15 - 20*	0.15 - 0.20
10 - 15	15 - 20*	0.20 - 0.25
15 - 20	15 - 20*	0.25 - 0.35

* For coated HSS drill, $v_c \sim 35 - 40$ m/min

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip ¹
Cutting speed (v_c) m/min	180 - 220	120 - 150	60 - 90
Feed (f) mm/r	0.05 - 0.25 ²	0.10 - 0.25 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	130 - 180	180 - 220
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	P20 - P40 Coated carbide	P10 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	130 - 170	120 - 160	25 - 30 ¹
Feed (f) mm/tooth	0.03 - 0.20 ²	0.08 - 0.20 ²	0.05 - 0.35 ²
Carbide designation ISO	-	P20 - P30	-

¹ For coated HSS end mill, $v_c \sim 45 - 50$ m/min

² Depending on radial depth of cut and cutter diameter

GRINDING

Wheel recommendation

Type of grinding	Grinding wheel designation
Face grinding straight wheel	A 46 HV
Face grinding segments	A 24 GV
Cylindrical grinding	A 46 LV
Internal grinding	A 46 JV
Profile grinding	A 100 LV

Machining recommendations

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

Condition: Hardened and tempered to 45±1 HRC

TURNING

Cutting data parameters	Turning with carbide	
	Rough turning	Fine turning
Cutting speed (v_c) m/min	40 - 60	70 - 90
Feed (f) mm/r	0.2 - 0.4	0.05 - 0.2
Depth of cut (a_p) mm	1 - 2	0.5 - 1
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	4 - 6	0.05 - 0.10
5 - 10	4 - 6	0.10 - 0.15
10 - 15	4 - 6	0.15 - 0.20
15 - 20	4 - 6	0.20 - 0.30

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip ¹
Cutting speed (v_c) m/min	60 - 80	60 - 80	40 - 50
Feed (f) mm/r	0.05 - 0.25 ²	0.10 - 0.25 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	50 - 90	90 - 130
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	P20 - P40 Coated carbide	P10 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	60 - 80	70 - 90	5 - 10
Feed (f) mm/tooth	0.03 - 0.20 ¹	0.08 - 0.20 ¹	0.05 - 0.35 ¹
Carbide designation ISO	-	P10 - P20	-

¹ Depending on radial depth of cut and cutter diameter

GRINDING

Wheel recommendation

Type of grinding	Grinding wheel designation
Face grinding straight wheel	A 46 HV
Face grinding segments	A 36 GV
Cylindrical grinding	A 60 KV
Internal grinding	A 60 IV
Profile grinding	A 120 JV

Surface treatment

NITRIDING AND NITROCARBURISING

Nitriding and nitrocarburising result in a hard surface layer which has the potential to improve resistance to wear and soldering, as well as resistance to premature heat checking.

Formvar can be nitrided and nitrocarburised via a plasma, gas, fluidised bed or salt process. Before nitriding, the tool should be hardened and tempered at a temperature at least 25 - 50°C above the nitriding temperature. Otherwise, a permanent loss of core hardness, strength, and/or dimensional tolerances may be experienced.

During nitriding and nitrocarburising, a brittle compound layer, known as the white layer, may be generated. The white layer is very brittle and may result in cracking or spalling when exposed to heavy mechanical or thermal loads. As a general rule, the white layer formation must be avoided.

Nitriding in ammonia gas at 510°C or plasma nitriding at 480°C both result in a surface hardness of approx. 1100 HV_{0.2}.

In general, plasma nitriding is the preferred method because of better control over nitrogen potential. However, careful gas nitriding can give same results.

The surface hardness after nitrocarburising in either gas or salt bath at 580°C is approx. 1100 HV_{0.2}.

Depth of nitriding

Process	Time h	Depth* mm	Hardness HV _{0.2}
Gas nitriding at 510°C	10	0.16	1100
	30	0.22	1100
Plasma nitriding at 480°C	10	0.15	1100
Nitrocarburising	2	in gas at 580°C	0.13
		in salt bath at 580°C	0.08

* Depth of case = distance from surface where hardness is 50 HV_{0.2} over base hardness



Forged crankshafts.



Relative comparison of ASSAB hot-work die steels

QUALITATIVE COMPARISON OF RESISTANCE TO DIFFERENT DIE FAILURES

ASSAB grade	Hot wear	Plastic deformation	Premature cracking	Heat checking
QRO 90 SUPREME	██████████	██████████	██████████	██████████
UNIMAX	██████████	██████████	██████████	██████████
DIEVAR	██████████	██████████	██████████	██████████
ASSAB 8407 SUPREME	██████████	██████████	██████████	██████████
ASSAB 8407 2M	██████████	██████████	██████████	██████████
ALVAR 14	██████████	██████████	██████████	██████████
FORMVAR	██████████	██████████	██████████	██████████



REGIONAL HEAD OFFICE**SINGAPORE**

ASSAB Pacific Ptd 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: +68 431 8897 8922
info.changchun@assab.com

Changzhou*

ASSAB Tooling Technology (Shanghai)
Co., Ltd. - Changzhou Branch
Dalian 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

Jiangxi*

ASSAB Tooling (Dong Guan)
Co., Ltd., Jiangxi Branch
Tel : +86 769 2289 7888
Fax: +86 769 2289 9312
info.jiangxi@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 21 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 0720-1
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. (79223-X)
Tel : +60 3 6189 0022
Fax: +60 3 6189 0044/55
info.kualalumpur@assab.com

Northern Branch

ASSAB Steels (Malaysia) Sdn. Bhd. (79223-X)
Tel : +60 4 507 2020
Fax: +60 4 507 6323
info.penang@assab.com

Southern Branch

ASSAB Steels (Malaysia) Sdn. Bhd. (79223-X)
Tel : +60 7 598 0011
Fax: +60 7 599 4890
info.johor@assab.com

PHILIPPINES

ASSAB Pacific Pte Ltd -
Philippine Branch
Tel : +62 29 539 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

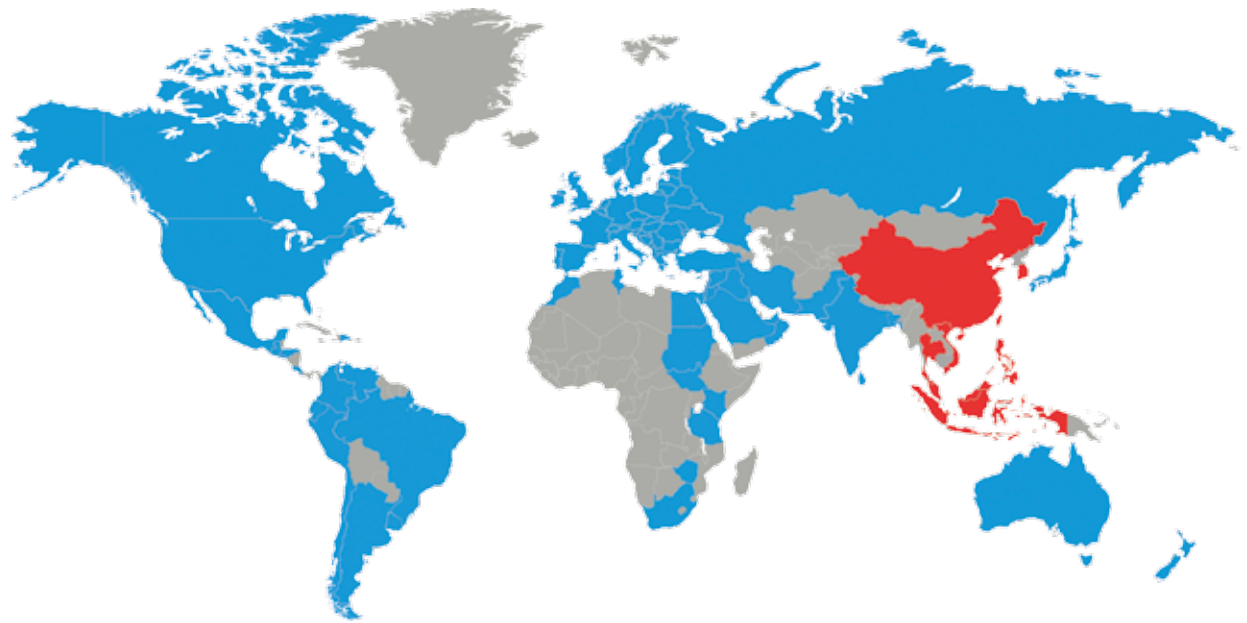
THAILAND

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 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