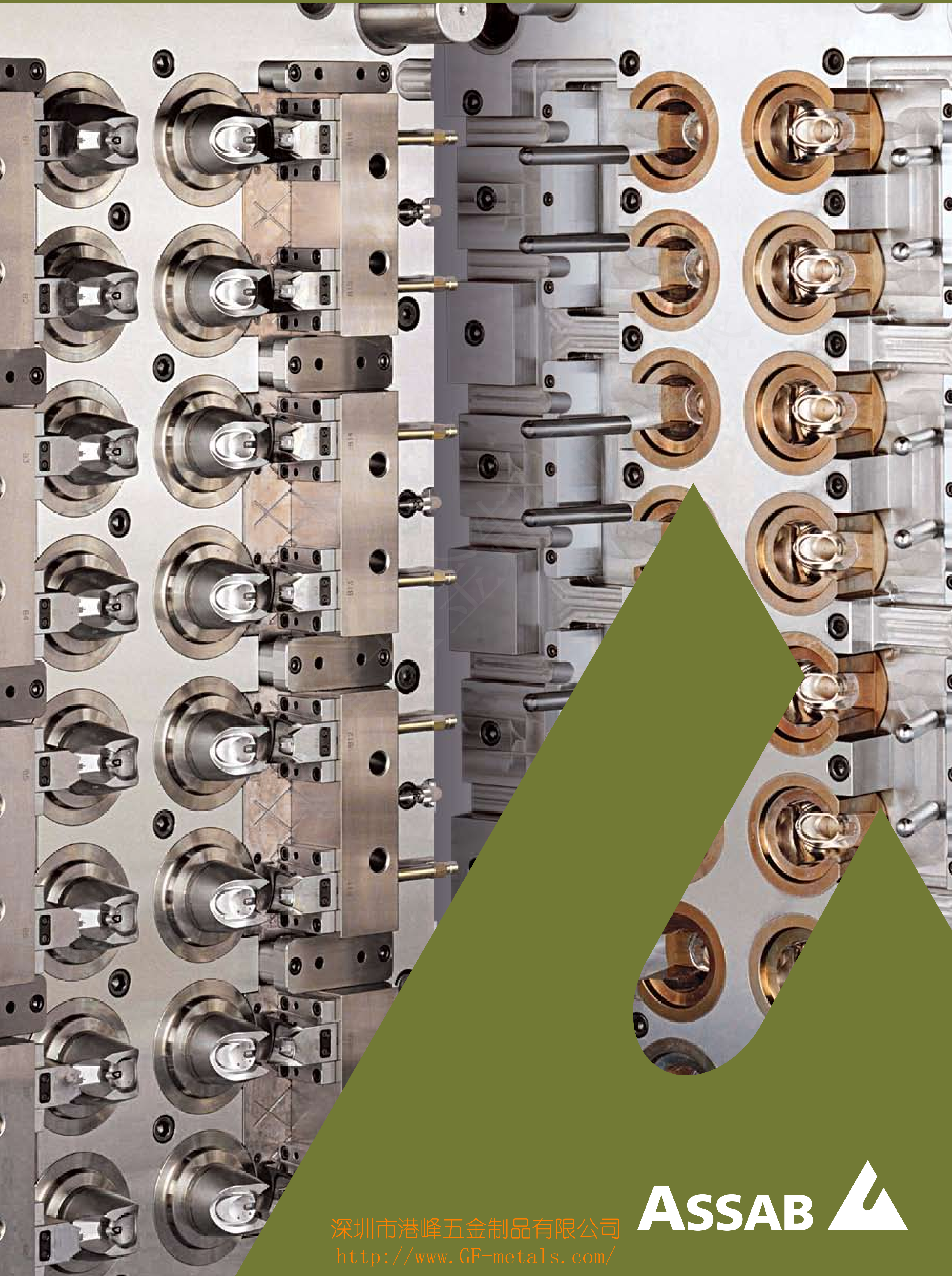
STAVAX ESR

UDDEHOLM
STAVAX ESR



ASSAB

ASSAB	UDDEHOLM	REFERENCE STANDARD		
		AISI	DIN	JIS
DF-2	ARNE	O1	1.2510	SKS 3
DF-3		O1	1.2510	SKS 3
XW-5	SVERKER 3	D6 (D3)	(1.2436)	(SKD 2)
XW-10	RIGOR	A2	1.2363	SKD 12
XW-41	SVERKER 21	D2	1.2379	SKD 11
XW-42		D2	1.2379	SKD 11
CARMO	CARMO			
CALMAX	CALMAX			
CALDIE	CALDIE			
ASSAB 88	SLEIPNER			
ASP 23	VANADIS 23	(M3:2)	1.3344	SKH 53
ASP 30	VANADIS 30	M3:2 + Co	1.3244	SKH 40
ASP 60	VANADIS 60		1.3241	
VANADIS 4 EXTRA	VANADIS 4 EXTRA			
VANADIS 6	VANADIS 6			
VANADIS 10	VANADIS 10			
VACRON 40	VANCRON 40			
618		P20 Mod.	1.2738	
618 HH		P20 Mod.	1.2738	
618 T		P20 Mod.	1.2738 Mod.	
718 SUPREME	IMPAX SUPREME	P20 Mod.	1.2738	
718 HH	IMPAX HH	P20 Mod.	1.2738	
NIMAX	NIMAX			
UNIMAX	UNIMAX			
CORRAX	CORRAX			
STAVAX ESR	STAVAX ESR	420 Mod.	1.2083 ESR	SUS 420J2
MIRRAX ESR	MIRRAX ESR	420 Mod.		
POLMAX	POLMAX			
ELMAX	ELMAX			
RAMAX LH	RAMAX LH	420 F Mod.		
RAMAX HH	RAMAX HH	420 F Mod.		
ROYALLOY				
PRODAX				
PT18	MOLDMAX SC			
MMXL	MOLDMAX XL			
MM40	MOLDMAX HH			
ALVAR 14	ALVAR 14		1.2714	SKT 4
8407 2M	ORVAR 2M	H13	1.2344	SKD 61
8407 SUPREME	ORVAR SUPREME	H13 Premium	1.2344 ESR	SKD 61
DIEVAR	DIEVAR			
HOTVAR	HOTVAR			
QRO 90 SUPREME	QRO 90 SUPREME			
705		4340	1.6582	SNCM8
709		4140	1.7225	SCM4
760		1050	1.1730	S50C

This information 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.

Edition 081112

STAVAX ESR

The plastic product is only as good as the surface finish of the mould steel in which the product is formed. The presence of non-metallic inclusions and segregation within the steel, limit the polishability of the mould steel. Thanks to the electroslag remelting (ESR) process that is utilised to produce Stavax ESR, this steel is capable of being polished to a very high surface finish. The ESR process is an additional step during the steelmaking, which ensures very clean steel with low sulphur content (0.003% max.) and non-metallic inclusions.

Stavax ESR is an excellent choice for small and medium inserts and cores.

- **Properties**
  Stavax ESR combines corrosion and wear resistance with excellent polishability, and offers good machinability.
- **Advantages**
  Clean and homogeneous mould steel improves polishability, photoetchability and texture.
- **Benefits**
  Reduce mould maintenance as the mould made of Stavax ESR maintains its original surface finish over a long period of production.

  When compared with non-stainless mould steels, Stavax ESR offers lower production costs through clean cooling channels that assure uniform cooling and consistent cycle times.

  Especially suitable for applications within the medical industry, optical industry and for other high quality transparent parts when rust in production is unacceptable and where requirements for good hygiene are high.

Stavax ESR is a product within the ASSAB Stainless Concept.

The Stainless Concept is our own programme of metallurgically balanced stainless grades that has been specially developed and continually expanded to meet the needs of today's fast-changing plastic moulding industry. The problems are well known: rust problems with moulds, surface that need repolishing, cooling channels that have to be redrilled, and parts that rust together. Choosing the right product within our Stainless Concept, which can be used individually or in combination to produce the highest quality tooling for the full range of moulding applications, will minimise the problems above.

General

Stavax ESR is a premium grade stainless tool steel with the following properties:

- good corrosion resistance
- excellent polishability
- good wear resistance
- good machinability
- good dimensional stability during heat treatment

The combination of these properties provides a steel with outstanding production performance. The practical benefits of good corrosion resistance of a plastic mould can be summarised as follows:

- **Lower mould maintenance costs**
  The surface of cavity impressions retain their original finish over an extended service life. Moulds stored or operated in humid conditions require no special protection.
- **Lower production costs**
  Since cooling channels are less likely to be affected by corrosion (unlike conventional mould steels), heat transfer characteristics, and therefore cooling efficiency, are constant throughout the mould life, ensuring consistent cycle times.

These benefits, coupled with the high wear resistance of Stavax ESR, offer the moulder low-maintenance, long-life moulds for the greatest overall tooling economy.

Note: Stavax ESR is produced using the Electroslag Remelting (ESR) technique. The result is a mould steel with a very low inclusion level providing excellent polishability characteristics.

Typical analysis %	C 0.38	Si 0.9	Mn 0.5	Cr 13.6	V 0.3
Standard specification	AISI 420 modified, WNr. 1.2083 ESR, SUS 420J2				
Delivery condition	Soft annealed to approx. 200 HB				
Colour code	Black / Orange				

Stavax ESR core to make disposable polystyrene beakers. Millions of close tolerance mouldings with a very high surface finish have been produced.

Applications

Whilst Stavax ESR is recommended for all types of moulding tools, its special properties make it particularly suitable for moulds with the following demands:

- **Corrosion/staining resistance**
  Moulding of corrosive plastics, e.g., PVC, acetates, and for moulds subjected to humid working/storage conditions.
- **Wear resistance**
  Moulding abrasive/ filled materials, including injection moulded thermosetting grades. Stavax ESR is recommended for moulds with long production runs, e.g., disposable cutlery and containers.
- **High surface finish**
  Production of optical parts, e.g., camera and sunglass lenses. Moulding of medical components, e.g., syringes and analysis vials.

Stavax ESR is the right choice for lens mould with extreme demand on polishability.

Type of mould	Recommended hardness HRC
Injection moulds for thermoplastics	45-52
Injection moulds for thermosetting plastics	45-52
Compression / transfer moulds	50-52
Blow moulds for PVC, PET etc.	45-52
Extrusion, pultrusion dies	45-52

Properties

PHYSICAL DATA

Hardened and tempered to 50 HRC.

Temperature	20°C	200°C	400°C
Density kg/m^3	7800	7750	7700
Modulus of elasticity MPa	200 000	190 000	180 000
Coefficient of thermal expansion per °C from 20°C	-	11.0×10^{-6}	11.4×10^{-6}
Thermal conductivity W/m °C	19	20	24
Specific heat J/kg °C	460	-	-

**Thermal conductivity is very difficult to measure. The scatter can be as high as ±15%*

Stavax ESR is a desirable choice for the medical industry, which operates in "clean room" environments, and cannot accept any rust on the moulds.

TENSILE STRENGTH

The tensile strength values are to be considered as approximate only. All samples were taken from a bar (in the rolling direction) with 25 mm diameter. Hardened in oil from 1025 ±10°C and tempered twice to the indicated hardness.

Hardness	50 HRC	45 HRC
Tensile strength, R_m	1780 MPa	1420 MPa
Yield strength, $R_{p0.2}$	1460 MPa	1280 MPa

Stavax ESR is especially suitable for moulding application requiring good hygiene such as clear plastic beer mug made of SAN copolymer.

CORROSION RESISTANCE

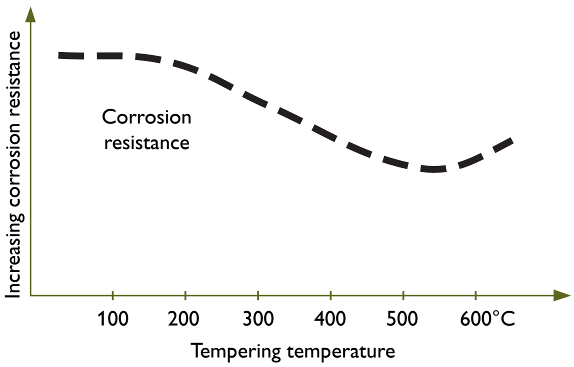
Stavax ESR is resistant to corrosive attack by water, water vapour, weak organic acids, dilute solutions of nitrates, carbonates and other salts.

A tool made from Stavax ESR will have good resistance to rusting and staining due to humid working and storage conditions, and when moulding corrosive plastics under normal production conditions.

Note: Special protectants are not recommended during mould storage. Many protectants are chloride based and may attack the passive oxide film, resulting in pitting corrosion. Tools should be thoroughly cleaned and dried prior to storage.

Stavax ESR shows the best corrosion resistance when tempered at low temperature and polished to a mirror finish.

The influence of tempering temperature on corrosion resistance



Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 890°C. Then cool in the furnace at 20°C per hour to 850°C, then at 10°C per hour to 700°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

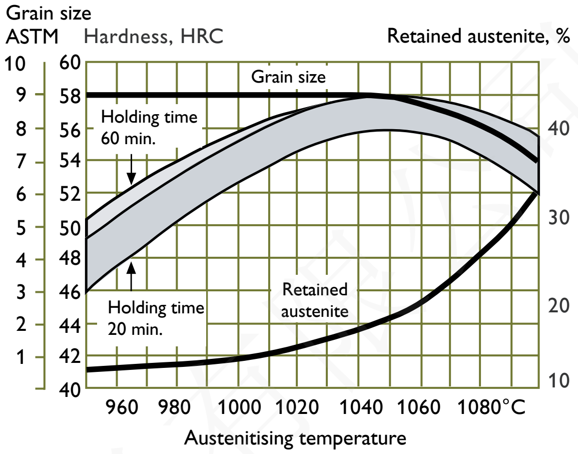
Preheating temperature: 600–850°C.
Austenitising temperature: 1000–1050°C, but usually 1020°C–1030°C.

Temperature °C	Soaking time minutes	Hardness before tempering
1020	30	56±2 HRC
1050	30	57±2 HRC

Soaking time = time at hardening temperature after the tool is fully heated through.

Protect the tool against decarburisation and oxidation during austenitising.

Hardness, grain size and retained austenite as a function of austenitising temperature



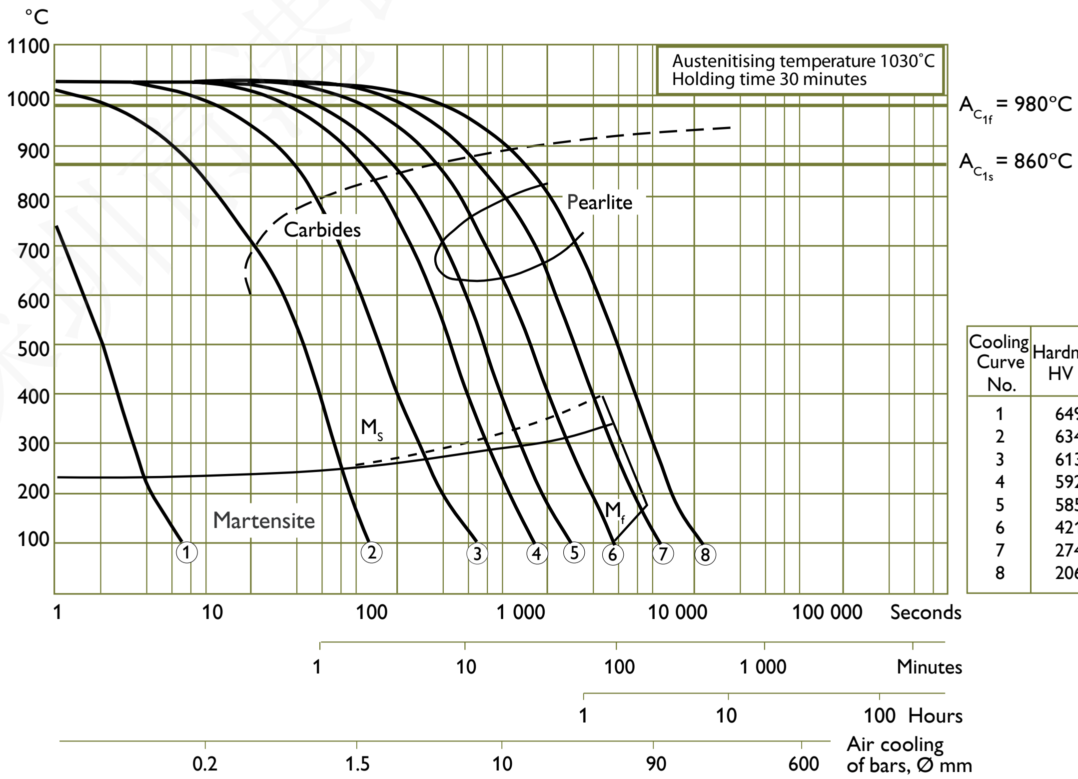
QUENCHING MEDIA

- Vacuum with sufficient positive pressure
- High speed gas/circulating atmosphere
- Fluidised bed or salt bath at 250–550°C, then cool in air blast
- Warm oil, approx. 80°C

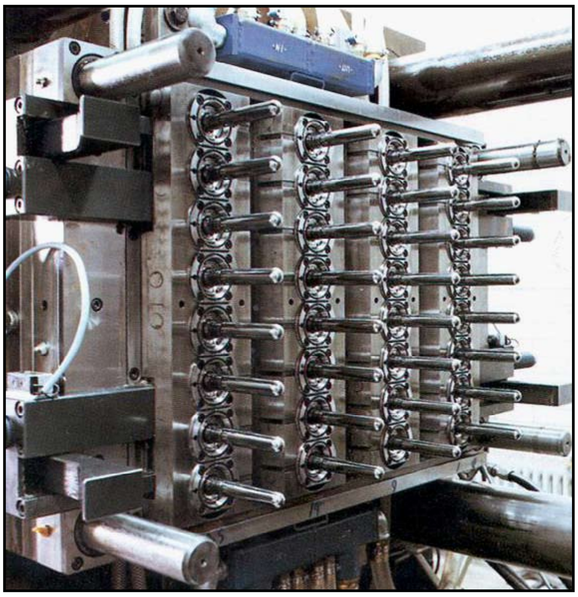
In order to obtain optimum properties for the tool, the cooling rate should be fast, but not at a rate that gives excessive distortion or crack. When heat treating in a vacuum furnace, a minimum of 4–5 bars overpressure is recommended. Temper immediately when the tool reaches 50–70°C.

CCT graph

Austenitising temperature 1030°C. Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ sec.
1	649	1
2	634	31
3	613	105
4	592	316
5	585	526
6	421	1052
7	274	2101
8	206	4204



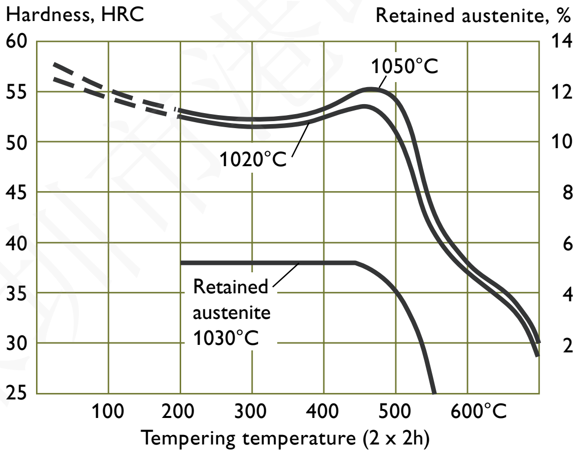
A preform mould made of Stavax ESR.

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 preferred tempering temperature is 250°C minimum. On exceptional occasion, the lowest temperature of 180°C is used for small simple inserts that require a hardness of 52-54 HRC.

Tempering graph



Note: The curves as shown in the tempering graph are valid for small samples. Actual hardness achieved after hardening and tempering depends on the mould size.

Tempering at 250°C is recommended for the best combination of toughness, hardness and corrosion resistance.

A combination of high austenitising temperature and low tempering temperature <250°C gives a high stress level in the mould, and should be avoided.

DIMENSIONAL CHANGES

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

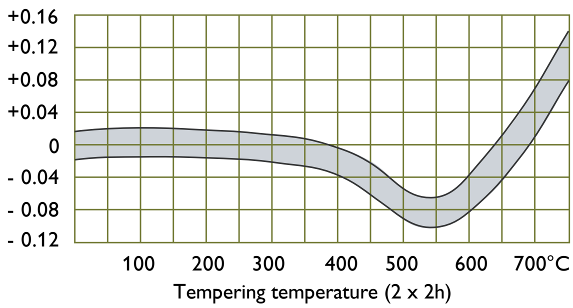
The size and geomety of the tool are also of essential importance. Thus, the tool shall always be manufactured with enough working allowance to compensate for dimensional changes. Use 0.15% as a guideline for Stavax ESR provided that a stress relief is performed between rough and semi-finish machining as recommended.

Dimensional changes during hardening

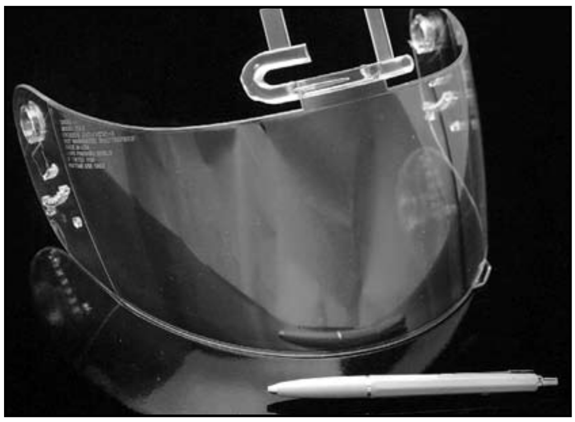
An example of dimensional changes on a plate, hardened under ideal conditions 100 x 100 x 25 mm is shown below.

Hardening from 1020°C		Width %	Length %	Thickness %
Martempered	Min. Max.	+0.02 -0.03	±0 +0.03	-0.04 -
Air hardened	Min. Max.	-0.02 +0.02	±0 -0.03	±0 -
Vacuum hardened	Min. Max.	+0.01 -0.02	±0 +0.01	-0.04 -

Dimensional changes during tempering



Note: Dimensional changes during hardening and tempering should be added together.



Motorcycle helmet lens made of polycarbonate was initially moulded using AISI 420, but was later moulded using Stavax ESR due to the very severe demands on polishability.

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 ~200 HB

TURNING

Cutting data parameters	Turning with carbide		Turning with HSS†
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min	160 - 210	210 - 260	18 - 23
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	P20 - P30 Coated carbide	P10 Coated carbide or cement	-

† High speed steel

DRILLING

High speed steel twist drill

Drill diameter mm	Cutting speed (v_c) m/min	Feed (f) mm/r
≤ 5	12 - 14*	0.05 - 0.10
5 - 10	12 - 14*	0.10 - 0.20
10 - 15	12 - 14*	0.20 - 0.30
15 - 20	12 - 14*	0.30 - 0.35

** For coated HSS drill, v_c = 20–22 m/min*

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip
Cutting speed (v_c) m/min	210 - 230	80 - 100	70 - 80
Feed (f) mm/r	0.03 - 0.10[1]	0.10 - 0.25[1]	0.15 - 0.25[1]

[1] 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	180 - 260	260 - 300
Feed (f_z) mm/tooth	0.2 - 0.4	0.1 - 0.2
Depth of cut (a_p) mm	2 - 4	0.5 - 2
Carbide designation ISO	P20 - P40 Coated carbide	P10 - P20 Coated carbide or cermet

End milling

Cutting data parameters	Type of milling		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min	120 - 150	170 - 230	25 - 30[1]
Feed (f_z) mm/tooth	0.01 - 0.02[2]	0.06 - 0.2[2]	0.01 - 0.30[2]
Carbide designation ISO	-	P20 - P30	-

[1] For coated HSS end mill, v_c ~ 45–50 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 IV
Profile grinding	A 100 LV	A 120 KV

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. 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. 25°C below the highest previous tempering temperature.

Welding

There is a general tendency for tool steel to crack after welding. When welding is required, take proper precautions with regards to joint preparation, filler material selection, preheating, welding procedure and post weld heat treatment to ensure good welding results.

For best result after polishing and photo-etching, use the recommended filler materials as shown in the table below.

Welding method	TIG	MMA
Preheating temperature[1]	200 - 250°C (soft annealed ~200 HB) 200°C (hardened 56 HRC) 250°C (hardened 52 HRC)	
Filler material	STAVAX TIG-WELD	STAVAX WELD
Maximum interpass temperature[2]	400°C (soft annealed ~200 HB) 350°C (hardened 56 HRC) 400°C (hardened 52 HRC)	
Postweld cooling	20 - 40°C/h for the first two hours and then freely in air	
Hardness after welding	54 - 56 HRC	
Heat treatment after welding		
Hardened condition	Temper at 10-20°C below the orginial tempering temperature.	
Soft annealed condition	Heat through to 890°C in protected atmoshpere. Then cool in the furnace at 20°C per hour to 850°C, then at 10°C per hour to 700°C, then freely in air.	

[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.

Polishing

Stavax ESR has a very good polishability in the hardened and tempered condition.

A slightly different technique, in comparison with other ASSAB mould steels, should be used. The main principle is to use smaller steps at the fine grinding and polishing stages, and not to start polishing on too rough a surface. It is also important to stop the polishing operation immediately, after the last scratch from the former grain size has been removed.

More detailed information on polishing techniques is given in the brochure "Polishing of Tool Steel".

Photo-etching

Stavax ESR has a very low content of slag inclusions, making it suitable for photoetching. The special photo-etching process that might be necessary because of Stavax ESR's good corrosion resistance is familiar to all the leading photo-etching companies.

Further information

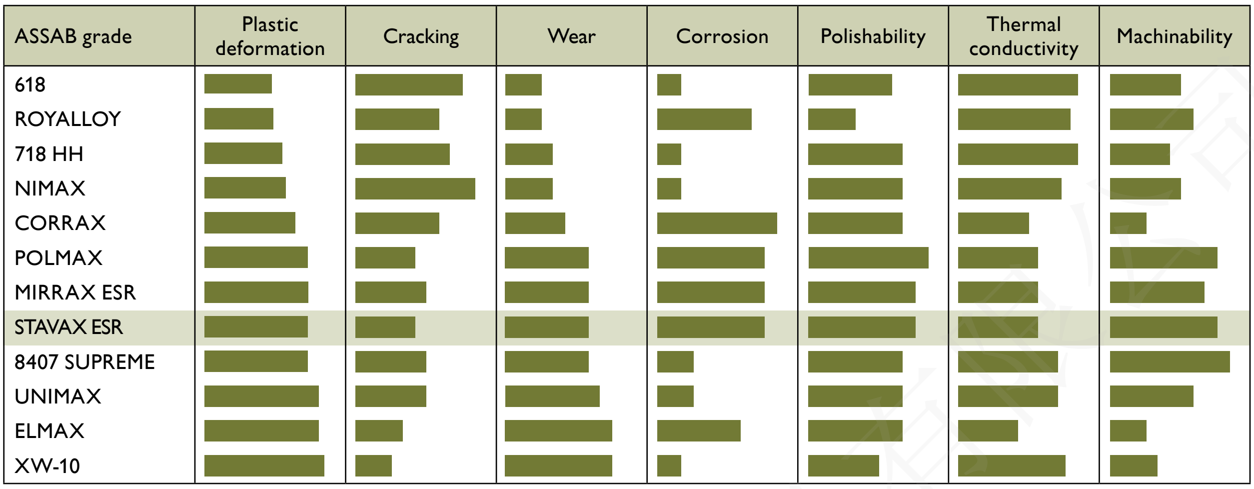
For further information, i.e., steel selection, heat treatment, application and availability, please contact our ASSAB office* nearest to you.

*See back cover page

A clean steel with very good polishability gives the final medical product an excellent surface finish.

Relative comparison of ASSAB plastic mould steels

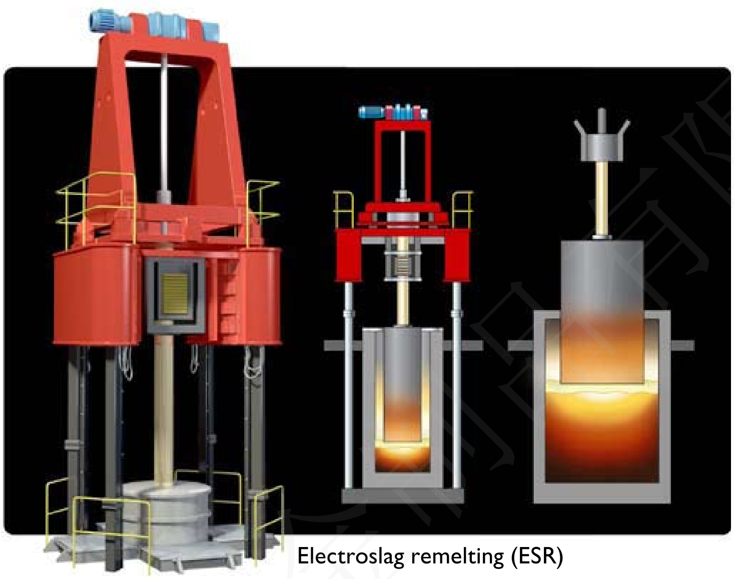
RESISTANCE TO FAILURE MECHANISMS AND CRITICAL MOULD STEEL PROPERTIES



The ESR 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 deslagging unit removes oxygen-rich slag. Then deoxidation, alloying and heating of the steel bath are carried out in the ladle furnace. Vacuum degassing removes elements such as hydrogen, nitrogen and sulphur.



Electroslag remelting (ESR)

ESR PLANT

In uphill casting, a controlled flow of molten steel from the ladle filled the prepared moulds, and solidifies into ingots.

Subsequently, the steel can go directly to our rolling mill or to the forging press. Our premium steel grades go to our ESR furnace, where they are melted once again in an electroslag remelting process. This is done by melting a consumable electrode immersed in an overheated slag bath. Controlled solidification in the steel bath results in an ingot of high homogeneity, thereby removing macrosegregation. Melting under a protective atmosphere gives an even better steel cleanliness.

HOT WORKING

From the ESR plant, the steel goes to the rolling mill or to our forging press to be formed into round or flat bars.

Prior to delivery, all bar materials are heat treated to either soft annealed condition, or hardened and tempered condition.

MACHINING

Before putting into stock, flat bar profiles are machined to the required size and exact tolerance. Whilst larger round dimensions are turned in lathe, where the steel bars rotate against a stationary cutting tool. Peeling is performed on smaller round dimensions via cutting tools that revolve around the bars for removal of surface defects.

To safeguard the quality and integrity of our tool steels, we perform surface inspection and ultrasonic testing on all bars. We then cut off and discard the bar ends and any defects that are found during inspection.

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Jalan Perindustrial Bukit Minyak 7
Kawasan Perindustrial Bukit Minyak
14000 Bukit Mertajam
SPT Penang, Malaysia
Tel : 60 4 507 2020
Fax : 60 4 507 6323

Johor*
No. 8 Jalan Pesiaran Teknologi
Taman Teknologi Johor
81400 Senai
Johor, Malaysia
Tel : 60 7 598 0011
Fax : 60 7 599 4890

Other offices in Ipoh, Malacca and Puchong.

PHILIPPINES

Laguna*
ASSAB Pacific Pte. Ltd.
Philippine Branch
Blk 2 Lot 4, Interstar corner Solid Streets
Laguna International Industrial Park (LIIP)
Mamplasan, Biñan, Laguna
4024 Philippines
Tel : 63 49 539 0458 / 59 / 60
Fax : 63 49 539 1075

Another office in Cebu.

SINGAPORE*

ASSAB Steels Singapore (Pte.) Ltd.
18 Penjuru Close
Singapore 608616
Tel : 65 6862 2200
Fax : 65 6862 0162

TAIWAN

Taipei*
ASSAB Steels Taiwan Co., Ltd.
No. 112, Wu Kung 1st Rd.
Wu Ku Industry Zone
Taipei 248-87, Taiwan (R.O.C.)
Tel : 886 2 2299 2849
Fax : 886 2 2299 0147 / 2348

Kaoshiung*
No. 1, Bangong West 3rd Rd.
Gangshan Industrial Zone
Kaohsiung 820-59, Taiwan (R.O.C.)
Tel : 886 7 624 6600
Fax : 886 7 624 0012 / 16

Nantou*
No. 10, Industry South 5th Rd.
Nan Kang Industry Zone
Nantou 540-66, Taiwan (R.O.C.)
Tel : 886 49 225 1702
Fax : 886 49 225 3173

THAILAND*

ASSAB Steels (Thailand) Ltd.
9/8 Soi Theedinthai, Taeparak Road,
Bangplee, Samutprakarn 10540
Thailand
Tel : 66 2 385 5937
66 2 757 5017
Fax : 66 2 385 5936
66 2 385 5943

VIETNAM*

Cam Steel Trading Co., Ltd.
90/8, Block 5
Tan Thoi Nhat Ward, District 12
Ho Chi Minh City, Vietnam
Tel : 84 8 5920 920
Fax : 84 8 7190 555

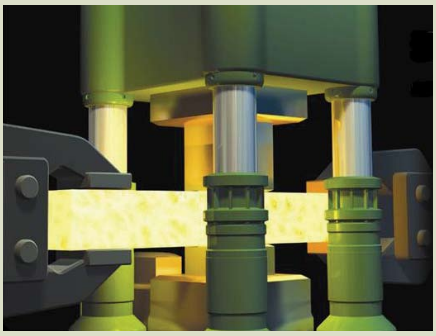
* Sales office with warehouse and/or value added services
† Sales office only

ASSAB TOOL STEELS have been in Asia since 1945. Our customers associate ASSAB brand with tooling materials that are high in quality and consistency.

The ASSAB sales companies and distributors offer you well assorted stocks in a number of places covering the Asia Pacific region. To further shorten the lead time, ASSAB will mill, grind, drill and even wire-cut the tool steel to meet your requirements. ASSAB also provides state-of-the-art vacuum heat treatment services to enhance the steel properties.

Our engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the best treament for each application. We always carry out material examinations at our local mini laboratories and at the central laboratory in Sweden.

Our steel mill in Sweden, Uddeholm Tooling, is one of the few steelworks in the world that is dedicated to the manufacture of tool steels only. Uddeholm Tooling is certified to ISO 9001 and ISO 14001.



Our forging press is one of the most modern of its kind in the world.

Besides tool steels, the ASSAB services for tool makers include:

- Welding electrodes for repair welding of tools
- High strength aluminium for tooling purposes
- Copper alloys (e.g., beryllium copper) for inserts in moulds
- Alloy machinery steels
- Cold rolled strip steels for saws, compressor valves, coater blades, etc
- High Performance Steels (HPS)
- Granshot