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<th>AISI</th>
<th>WNr.</th>
<th>JIS</th>
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<tr>
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<td>ARNE</td>
<td>O1</td>
<td>1.2510</td>
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<td>ASSAB 88</td>
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<tr>
<td>ASSAB PM 23 SUPERCLEAN</td>
<td>VANADIS 23 SUPERCLEAN</td>
<td>(M3:2)</td>
<td>1.3395</td>
<td>SKH 53</td>
</tr>
<tr>
<td>ASSAB PM 30 SUPERCLEAN</td>
<td>VANADIS 30 SUPERCLEAN</td>
<td>(M3:2 + Co)</td>
<td>1.3294</td>
<td>SKH 40</td>
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<tr>
<td>ASSAB PM 60 SUPERCLEAN</td>
<td>VANADIS 60 SUPERCLEAN</td>
<td></td>
<td>(1.3292)</td>
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<tr>
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</tr>
<tr>
<td>ASSAB 618</td>
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<td>P20 Mod.</td>
<td>1.2738</td>
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<tr>
<td>ASSAB 618 HH</td>
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<td>1.2738</td>
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<td>P20 Mod.</td>
<td>1.2738 Mod.</td>
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<td>420 Mod.</td>
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<tr>
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<td>VIDAR 1 ESR</td>
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<td>1.2343</td>
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<tr>
<td>RAMAX HH</td>
<td>RAMAX HH</td>
<td></td>
<td>420 F Mod.</td>
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<td>ASSAB MM40</td>
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<td>ALVAR 14</td>
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<td>1.2714</td>
<td>SKT 4</td>
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<td>ASSAB 2714</td>
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<td>1.2714</td>
<td>SKT 4</td>
</tr>
<tr>
<td>ASSAB 8407 2M</td>
<td>ORVAR 2M</td>
<td>H13</td>
<td>1.2344</td>
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<td>ORVAR SUPREME</td>
<td>H13 Premium</td>
<td>1.2344 ESR</td>
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<td>DIEVAR</td>
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<td>HOTVAR</td>
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<tr>
<td>QRO 90 SUPREME</td>
<td>QRO 90 SUPREME</td>
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<td>ASSAB 705</td>
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<td>1.6582</td>
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<td>ASSAB 709</td>
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<td>4140</td>
<td>1.7225</td>
<td>SCM4</td>
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<td>ASSAB 760</td>
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<td>1050</td>
<td>1.1730</td>
<td>S50C</td>
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</table>

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 D140714
POLMAX

FOR EXTREME SURFACE FINISH REQUIREMENTS

Two specialised remelting steps of electroslag (ESR) and vacuum arc (VAR) remelting are used to produce Polmax to ensure that it meet the most extreme demands on polishability in plastic mould steels. The combination of these two remelting processes greatly reduces the amount of segregation/banding and non-metallic inclusions, which results in a mould steel with homogeneous microstructure and a very high microcleanliness level. These are two extremely important properties that make Polmax stands out as one the cleanest steels available. Thus, Polmax offers unparalleled polishability. This high performance grade achieves surface finishes that go well beyond what can be achieved by most other tool steels.

Polmax is specifically engineered for cavities, cores, inserts and a broad range of product applications that demand superior surface finish. Examples include optical, medical and CD/DVD applications.

Polmax 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

The rapid development in the high-tech area is putting higher and higher demands on the tool steel. Surface finishes, which have not been possible to achieve with ordinary tool steels, are required. For these extreme requirements, Polmax is the right choice.

New processes have been developed to meet the increased demands on surface finish. For Polmax, methods like ESR (Electroslag Remelting) and VAR (Vacuum Arc Remelting) are used in order to reduce inclusion levels to minimum amounts.

Polmax possesses the following properties:
- Excellent polishability
- Good corrosion resistance
- Good wear resistance
- Good machinability
- Good dimensional stability during heat treatment

Properties

PHYSICAL PROPERTIES

Hardened and tempered to 52 HRC.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>20°C</th>
<th>200°C</th>
<th>400°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density kg/m³</td>
<td>7 800</td>
<td>7 750</td>
<td>7 700</td>
</tr>
<tr>
<td>Modulus of elasticity MPa</td>
<td>200 000</td>
<td>190 000</td>
<td>180 000</td>
</tr>
<tr>
<td>Coefficient of thermal expansion per °C from 20°C</td>
<td>-</td>
<td>11.0 x 10⁻⁴</td>
<td>11.4 x 10⁻⁴</td>
</tr>
<tr>
<td>Thermal conductivity W/m °C</td>
<td>19</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Specific heat J/kg °C</td>
<td>460</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

TENSILE STRENGTH

The strength values are to be considered as approximate. The test samples have been hardened in oil from 1025°C and tempered twice to 52 HRC.

<table>
<thead>
<tr>
<th></th>
<th>2050 MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, Rm</td>
<td></td>
</tr>
<tr>
<td>Yield strength, Rp0.2</td>
<td>1610 MPa</td>
</tr>
</tbody>
</table>

CORROSION RESISTANCE

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

A tool made from Polmax 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.

Polmax shows the best corrosion resistance when tempered at about 250°C and polished to a mirror finish.
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*
*Austenising temperature: 1000–1050°C, but usually 1020–1030°C.*

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Soaking time minutes</th>
<th>Hardness before tempering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1020</td>
<td>30</td>
<td>56±2 HRC</td>
</tr>
<tr>
<td>1050</td>
<td>30</td>
<td>57±2 HRC</td>
</tr>
</tbody>
</table>

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

Protect the tool against decarburisation and oxidation during austenitising.

**QUENCHING MEDIA**
- Vacuum furnace with sufficient overpressure
- High speed gas/circulating atmosphere
- Martempering bath at 250–550°C, then cool in air
- Warm oil (60–80°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.

**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.

For the best combination of toughness, hardness, corrosion resistance and dimension stability during use, the following heat treatment cycle is recommended.

Sub-zero cooling is only required when demands on dimension stability during use are very high. Received hardness: 52–54 HRC.
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**

<table>
<thead>
<tr>
<th>Cutting data parameters</th>
<th>Turning with carbide</th>
<th>Turning with HSS(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rough turning</td>
<td>Fine turning</td>
</tr>
<tr>
<td>Cutting speed ((v_c)) m/min</td>
<td>160 - 210</td>
<td>210 - 260</td>
</tr>
<tr>
<td>Feed ((f)) mm/r</td>
<td>0.2 - 0.4</td>
<td>0.05 - 0.2</td>
</tr>
<tr>
<td>Depth of cut ((a_p)) mm</td>
<td>2 - 4</td>
<td>0.5 - 2</td>
</tr>
<tr>
<td>Carbide designation ISO</td>
<td>P20 - P30</td>
<td>Coated carbide or cement</td>
</tr>
</tbody>
</table>

\(^1\) High speed steel

**DRILLING**

High speed steel twist drill

<table>
<thead>
<tr>
<th>Drill diameter mm</th>
<th>Cutting speed ((v_c)) m/min</th>
<th>Feed ((f)) mm/r</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\leq 5)</td>
<td>12 - 14(^1)</td>
<td>0.05 - 0.10</td>
</tr>
<tr>
<td>5 - 10</td>
<td>12 - 14(^1)</td>
<td>0.10 - 0.20</td>
</tr>
<tr>
<td>10 - 15</td>
<td>12 - 14(^1)</td>
<td>0.20 - 0.30</td>
</tr>
<tr>
<td>15 - 20</td>
<td>12 - 14(^1)</td>
<td>0.30 - 0.35</td>
</tr>
</tbody>
</table>

\(^1\) For coated HSS drill, \(v_c\approx 20–22\) m/min

**MILLING**

Face and square shoulder milling

<table>
<thead>
<tr>
<th>Cutting data parameters</th>
<th>Milling with carbide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rough milling</td>
</tr>
<tr>
<td>Cutting speed ((v_c)) m/min</td>
<td>180 - 260</td>
</tr>
<tr>
<td>Feed ((f)) mm/tooth</td>
<td>0.2 - 0.4</td>
</tr>
<tr>
<td>Depth of cut ((a_p)) mm</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Carbide designation ISO</td>
<td>P20 - P40</td>
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</table>

End milling

<table>
<thead>
<tr>
<th>Cutting data parameters</th>
<th>Type of milling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Solid carbide</td>
</tr>
<tr>
<td>Cutting speed ((v_c)) m/min</td>
<td>120 - 150</td>
</tr>
<tr>
<td>Feed ((f)) mm/tooth</td>
<td>0.01 - 0.02(^2)</td>
</tr>
<tr>
<td>Carbide designation ISO</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^1\) For coated HSS drill, \(v_c\approx 45–50\) m/min

**GRINDING**

Wheel recommendation

<table>
<thead>
<tr>
<th>Type of grinding</th>
<th>Soft annealed condition</th>
<th>Hardened condition</th>
</tr>
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<tbody>
<tr>
<td>Face grinding straight wheel</td>
<td>A 46 HV</td>
<td>A 46 HV</td>
</tr>
<tr>
<td>Face grinding segments</td>
<td>A 24 GV</td>
<td>A 36 GV</td>
</tr>
<tr>
<td>Cylindrical grinding</td>
<td>A 46 LV</td>
<td>A 60 KV</td>
</tr>
<tr>
<td>Internal grinding</td>
<td>A 46 JV</td>
<td>A 60 IV</td>
</tr>
<tr>
<td>Profile grinding</td>
<td>A 100 LV</td>
<td>A 120 KV</td>
</tr>
</tbody>
</table>

1 Depending on drill diameter
Polishing

Polmax has extremely good polishability in the hardened and tempered condition.

A slightly different technique is needed when polishing corrosion-resistant tool steel compared with conventional tool steel. The main principle is to use smaller steps at the fine grinding and polishing stages, try to grind to as fine surface as possible before starting the polishing operation. It is also important to stop the polishing operation immediately, after the last scratch from the former grain size has been removed.

PRACTICAL HINTS

- Polishing should be carried out in dust- and draught-free places. Hard dust particles can easily contaminate the abrasive and ruin an almost finished surface.

- Each polishing tool should be used for only one paste grade and kept in dust-proof container.

- The polishing tools gradually become “impregnated” and improve with use.

- Hands and workpiece should be cleaned carefully between each change of paste grade, the workpiece with a grease solvent and the hands with soap.

- Paste should be applied to the polishing tool in manual polishing, while in machine polishing, the paste should be applied to the workpiece.

- The finer the grain size, the less thinning liquid.

- Polishing pressure should be adjusted to the hardness of the polishing tool and the grade of the paste. For the finest grain sizes, the pressure should only be the weight of the polishing tool.

- Heavy material removal requires hard polishing tools and coarse paste.

- Finish polishing of plastic moulds should be carried out in the release direction.

- Polishing should start in the corners, edges and fillets or the difficult parts of the mould.

- Be careful with sharp corners and edges, so they are not rounded off. Preferably use hard polishing tools.

Quality

To ensure Polmax fulfils the high demands on cleanliness to obtain good polishability, each bar is individually tested.

Chemical composition, soft annealed hardness and microcleanliness of each bar are tested at Uddeholm Tooling, our steel mill in Sweden.

Microcleanliness is rated according to ASTM E 45 Method A, a well established standard method taking into consideration the amount of sulphides, oxides, silicates and globular inclusions.

Maximum inclusion level approved, according to ASTM E 45 Method A, Plate I–r

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td>T</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>H</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>T</td>
<td>0.5</td>
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Further information

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

Cleanliness in every step of the polishing operation is of such great importance that it can not be over-emphasised.
Relative comparison of ASSAB plastic mould steels

<table>
<thead>
<tr>
<th>ASSAB grade</th>
<th>Plastic deformation</th>
<th>Cracking</th>
<th>Wear</th>
<th>Corrosion</th>
<th>Polishability</th>
<th>Thermal conductivity</th>
<th>Machinability</th>
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<tbody>
<tr>
<td>ASSAB 618</td>
<td></td>
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<td>ASSAB 718 HH</td>
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<td>NIMAX</td>
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<td>MIRRA X ES R</td>
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<tr>
<td>ASSAB 8407 SUPREME</td>
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<tr>
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<tr>
<td>ELMAX</td>
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</tr>
</tbody>
</table>
Double Remelting 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.

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

| Pressure Electroslag Remelting (PESR) | Vacuum Arc Remelting (VAR) |

REMELTING PLANT

As Polmax is our cleanest steel, it goes to our remelting plant, where it goes through two separate remelting processes of electroslag (ESR) and vacuum arc (VAR) remelting.

The ESR process involves remelting a consumable electrode immersed in an overheated slag bath. Steel refining is achieved by chemical reaction with the liquid slag. Controlled solidification in the steel bath results in an ingot with very low sulphur level and reduced non-metallic inclusions by chemical reaction with the processing slag. Melting in a protective atmosphere or pressure electroslag remelting (PESR) gives an even better cleanliness of the steel.

Like ESR, the VAR process involves remelting a consumable electrode, but the refining or remelting process occurs under vacuum. The benefits of remelting under vacuum include better removal of dissolved gases and oxide inclusions, as well as reduction of segregation.

In short, the combination of two separate refining/remelting processes are utilised to produce a mould steel with the highest level of cleanliness to meet the most extreme demands on polishability.

From the remelting plant, our double remelted steels go to the rolling mill or to our forging press to be formed into round or flat bars, and undergo similar remaining processes and inspection such as heat treatment, machining, control and inspection, and warehousing just like the rest of our other steel grades.
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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 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