### ASSAB DF-3
- ARNE
- **AISI**: O1
- **WNr.**: 1.2510
- **JIS**: SKS 3

### ASSAB XW-5
- SVERKER 3
- **AISI**: D6 (D3)
- **WNr.**: 1.2436
- **JIS**: SKD 2

### ASSAB XW-10
- RIGOR
- **AISI**: A2
- **WNr.**: 1.2363
- **JIS**: SKD 12

### ASSAB XW-42
- SVERKER 21
- **AISI**: D2
- **WNr.**: 1.2379
- **JIS**: SKD 11

### CALMAX / CARMO
- **AISI**: CALMAX / CARMO
- **WNr.**: 1.2358

### VIKING
- **AISI**: VIKING / CHIPPER
- **WNr.**: (1.2631)

### CALDIE
- **AISI**: CALDIE

### ASSAB 88
- **AISI**: SLEIPNER

### ASSAB PM 23 SUPERCLEAN
- VANADIS 23 SUPERCLEAN
- **AISI**: (M3:2)
- **WNr.**: 1.3395
- **JIS**: SKH 53

### ASSAB PM 30 SUPERCLEAN
- VANADIS 30 SUPERCLEAN
- **AISI**: (M3:2 + Co)
- **WNr.**: 1.3294
- **JIS**: SKH 40

### ASSAB PM 60 SUPERCLEAN
- VANADIS 60 SUPERCLEAN
- **AISI**: (1.3292)

### VANADIS 4 EXTRA SUPERCLEAN
- VANADIS 4 EXTRA SUPERCLEAN

### VANADIS 8 SUPERCLEAN
- VANADIS 8 SUPERCLEAN

### VANCRON SUPERCLEAN
- VANCRON SUPERCLEAN

### ELMAX SUPERCLEAN
- ELMAX SUPERCLEAN

### ASSAB 518
- **AISI**: P20
- **WNr.**: 1.2311

### ASSAB 618 T
- **AISI**: (P20)
- **WNr.**: (1.2738)

### ASSAB 618 / 618 HH
- **AISI**: (P20)
- **WNr.**: (1.2738)

### ASSAB 718 SUPREME / HH
- IMPAX SUPREME / HH
- **AISI**: (P20)
- **WNr.**: 1.2738

### NIMAX
- **AISI**: NIMAX

### NIMAX ESR
- **AISI**: NIMAX ESR

### VIDAR 1 ESR
- **AISI**: VIDAR 1 ESR
- **WNr.**: H11
- **WNr.**: 1.2343
- **JIS**: SKD 6

### UNIMAX
- **AISI**: UNIMAX

### CORRAX
- **AISI**: CORRAX
- **WNr.**: 420
- **WNr.**: 1.2083
- **JIS**: SUS 420J2

### STAVAX ESR
- **AISI**: STAVAX ESR
- **WNr.**: (420)
- **WNr.**: (1.2083)
- **JIS**: (SUS 420J2)

### MIRRAX ESR
- **AISI**: MIRRAX ESR
- **WNr.**: (420)

### MIRRAX 40
- **AISI**: MIRRAX 40
- **WNr.**: (420)

### POLOMAX
- **AISI**: POLOMAX
- **WNr.**: (420)
- **WNr.**: (1.2083)
- **JIS**: (SUS 420J2)

### RAMAX HH
- **AISI**: RAMAX HH
- **WNr.**: (420 F)

### ROYALLOY
- **AISI**: ROYALLOY
- **WNr.**: (420 F)

### COOLMOULD
- **AISI**: COOLMOULD

### ASSAB 2714
- **AISI**: 1.2714
- **JIS**: SKT 4

### ASSAB 2344
- **AISI**: H13
- **WNr.**: 1.2344
- **JIS**: SKD 61

### ASSAB 8407 2M
- **AISI**: ORVAR 2M
- **WNr.**: H13
- **WNr.**: 1.2344
- **JIS**: SKD 61

### ASSAB 8407 SUPREME
- **AISI**: ORVAR SUPREME
- **WNr.**: H13 Premium
- **WNr.**: 1.2344
- **JIS**: SKD 61

### DIEVAR
- **AISI**: DIEVAR

### QRO 90 SUPREME
- **AISI**: QRO 90 SUPREME

### FORMVAR
- **AISI**: FORMVAR

---

( ) - modified grade

ASSAB is a trademark of voestalpine High Performance Metals 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 therefore not 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 20190328
GENERAL

ASSAB 2344 is a chromium-molybdenumvanadium-alloyed tool steel which is characterised by:

- Good resistance to abrasion at both low and high temperatures
- High level of toughness and ductility
- Good machinability and polishability
- Good high-temperature strength and resistance to thermal fatigue
- Excellent through-hardening properties
- Very limited distortion during hardening

<table>
<thead>
<tr>
<th>Typical analysis %</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard specification</td>
<td>0.39</td>
<td>1.1</td>
<td>0.4</td>
<td>5.2</td>
<td>1.4</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Delivery condition: Soft annealed to approx. 205 HB.

Colour code: Orange / Violet

APPLICATIONS

PLASTIC MOULDING

<table>
<thead>
<tr>
<th>Part</th>
<th>Austenitising and tempering temperature</th>
<th>HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injection moulds, Compression/transfer moulds</td>
<td>Austenitising 1020 - 1030°C</td>
<td>50 – 52</td>
</tr>
<tr>
<td>Tempering 250 °C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EXTRUSION

<table>
<thead>
<tr>
<th>Part</th>
<th>Aluminium, magnesium alloys, HRC</th>
<th>Copper alloys HRC</th>
<th>Stainless steels HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dies</td>
<td>44 - 50</td>
<td>43 - 47</td>
<td>45 - 50</td>
</tr>
<tr>
<td>Backers, die holders, liners, dummy blocks, stems</td>
<td>41 - 50</td>
<td>40 - 48</td>
<td>40 - 48</td>
</tr>
<tr>
<td>Austenitising temperature</td>
<td>1020 - 1030°C</td>
<td>1040 - 1050°C</td>
<td></td>
</tr>
</tbody>
</table>

DIE CASTING

<table>
<thead>
<tr>
<th>Part</th>
<th>Tin, lead zinc alloys HRC</th>
<th>Aluminium magnesium alloys, HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dies</td>
<td>46 - 50</td>
<td>42 - 48</td>
</tr>
<tr>
<td>Fixed inserts, cores</td>
<td>46 - 52</td>
<td>44 - 48</td>
</tr>
<tr>
<td>Sprue parts</td>
<td>48 - 52</td>
<td>46 - 48</td>
</tr>
<tr>
<td>Nozzles</td>
<td>35 - 42</td>
<td>42 - 48</td>
</tr>
<tr>
<td>Ejector pins (nitried)</td>
<td>46 - 50</td>
<td>46 - 50</td>
</tr>
<tr>
<td>Plunger, short-sleeve (normally nitried)</td>
<td>42 - 46</td>
<td>42 - 48</td>
</tr>
<tr>
<td>Austenitising temp.</td>
<td>1020 - 1030°C</td>
<td></td>
</tr>
</tbody>
</table>

OTHER APPLICATIONS

<table>
<thead>
<tr>
<th>Application</th>
<th>Austenitising and tempering temperature</th>
<th>HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe cold punching, scrap shears</td>
<td>Austenitising 1020 - 1030 °C</td>
<td>50 - 52</td>
</tr>
<tr>
<td>Tempering 250 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot Shearing</td>
<td>Austenitising 1020 - 1030°C</td>
<td>50 - 52</td>
</tr>
<tr>
<td>Tempering 250°C</td>
<td>45 - 50</td>
<td></td>
</tr>
<tr>
<td>Shrink rings (e.g. for cemented carbide dies)</td>
<td>Austenitising 1020 - 1030°C</td>
<td>45 - 50</td>
</tr>
<tr>
<td>Tempering 575°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wear resisting parts</td>
<td>Austenitising 1020 - 1030°C</td>
<td>Core</td>
</tr>
<tr>
<td>Tempering 575°C</td>
<td>50 - 52</td>
<td></td>
</tr>
<tr>
<td>Nitriding</td>
<td>Surface</td>
<td>~1000HV</td>
</tr>
</tbody>
</table>

Other applications also include forming dies, die inserts, and tools for the manufacture of screws, nuts, rivets and bolts.
PROPERTIES

PHYSICAL DATA

Unless otherwise indicated, all specimens were hardened 30 minutes at 1025°C, quenched in air and tempered 2 + 2 h at 610°C. The hardness were 45 ± 1 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>7 700</td>
<td>7 600</td>
</tr>
<tr>
<td>Modulus of elasticity N/mm²</td>
<td>215 000</td>
<td>180 000</td>
<td>165 000</td>
</tr>
<tr>
<td>Coefficient of thermal expansion °C from 20°C</td>
<td>-</td>
<td>12.5 x 10⁻⁶</td>
<td>13.0 x 10⁻⁶</td>
</tr>
<tr>
<td>Thermal conductivity W/m °C</td>
<td>24</td>
<td>28</td>
<td>28</td>
</tr>
</tbody>
</table>

MECHANICAL PROPERTIES

Heat treated 1600 N/mm² (48 - 49 HRC)
Heat treated 1200 N/mm² (38 - 39 HRC)
1 .... Tensile strength N/mm²
2 .... 0.2% proof stress N/mm²
3 .... Reduction of area %
HEAT TREATMENT

SOFT ANNEALING
Protect the steel and heat through to 750 - 800°C. Then cool in the furnace at 10 - 20°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 - 850°C, normally in two preheating steps.
Austenitising temperature: 1020 - 1050°C, normally 1020 - 1030°C.

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Soaking time, minutes</th>
<th>Hardness before tempering, HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1025</td>
<td>30</td>
<td>53 ± 2</td>
</tr>
<tr>
<td>1050</td>
<td>15</td>
<td>54 ± 2</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 hardening.

QUENCHING MEDIA
- High-speed gas/circulating atmosphere
- High-speed gas with sufficient positive pressure quenching in vacuum furnace. Interrupted quench is recommended for distortion control, or when quench cracking is a concern.
- Martempering bath or fluidised bed at 450 - 550°C, then cool in air
- Martempering bath or fluidised bed at approx. 180 - 220°C then cool in air
- Warm oil

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

Note 2: In order to obtain the optimum properties for the tool, the cooling rate should be fast, but not at a level that gives excessive distortion or cracks.

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 lowest tempering temperature which should be used is 180°C. The minimum holding time at tempering temperature is 2 hours. To avoid “temper brittleness”, do not temper in the range 425 - 550°C, see graph.

TEMPERING GRAPH

Tempering within the range 425 - 550°C is normally not recommended due to the reduction in toughness properties.

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 ~185 HB

TURNING

<table>
<thead>
<tr>
<th>Cutting data parameters</th>
<th>Turning with carbide</th>
<th>Turning with High speed steel</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>200 – 250</td>
<td>250 – 300</td>
</tr>
<tr>
<td>Feed (f), mm/rev</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 Coated carbide</td>
<td>P10 Coated carbide or cermet</td>
</tr>
</tbody>
</table>
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>≤ 5</td>
<td>16 – 18 e</td>
<td>0.05 – 0.15</td>
</tr>
<tr>
<td>5 – 10</td>
<td>16 – 18 e</td>
<td>0.15 – 0.20</td>
</tr>
<tr>
<td>10 – 15</td>
<td>16 – 18 e</td>
<td>0.20 – 0.25</td>
</tr>
<tr>
<td>15 – 20</td>
<td>16 – 18 e</td>
<td>0.25 – 0.35</td>
</tr>
</tbody>
</table>

For coated HSS drill v_c = 28 – 30 m/min.

CARBIDE DRILL

<table>
<thead>
<tr>
<th>Cutting data parameters</th>
<th>Type of drill</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Indexable insert</td>
</tr>
<tr>
<td>Cutting speed (v_c), m/min</td>
<td>220 – 240</td>
</tr>
<tr>
<td>Feed (f), mm/r</td>
<td>0.03 – 0.10 2)</td>
</tr>
</tbody>
</table>

1) Drill with replaceable or brazed carbide tip
2) Depending on drill diameter

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 – 5</td>
</tr>
<tr>
<td>Carbide designation ISO</td>
<td>P20 – P40 Coated carbide</td>
</tr>
</tbody>
</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>160 – 200</td>
</tr>
<tr>
<td>Feed (f), mm/tooth</td>
<td>0.03 – 0.20 2)</td>
</tr>
<tr>
<td>Carbide designation ISO</td>
<td>–</td>
</tr>
</tbody>
</table>

1) For coated HSS end mill, vc = 55 – 60 m/min
2) Depending on radial depth of cut and cutter diameter

SURFACE TREATMENT

NITRIDING AND NITROCARBURISING

Nitriding and nitrocarburising result in a hard surface layer which is very resistant to wear and erosion. The nitrided layer is, however, brittle and may crack or spall when exposed to mechanical or thermal shock, the risk increasing with layer thickness. Before nitriding, the tool should be hardened and tempered at a temperature at least 25 - 50°C above the nitriding temperature.

Nitriding in ammonia gas at 510°C, or plasma nitriding in a 75% hydrogen/25% nitrogen mixture at 480°C, both result in a surface hardness of about 1100 HV0.2. In general, plasma nitriding is the preferred method because of better control over nitrogen potential. Particularly, plasma nitriding can readily avoid the formation of so-called white layer, which is not recommended for hot work service. However, careful gas nitriding can give perfectly acceptable results.

ASSAB 2344 can also be nitrocarburised in either gas or salt bath. The surface hardness after nitrocarburising is 900 - 1000 HV0.2.

DEPTH OF NITRIDING

<table>
<thead>
<tr>
<th>Process</th>
<th>Time, h</th>
<th>Depth, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas nitriding at 510°C</td>
<td>10</td>
<td>0.12</td>
</tr>
<tr>
<td>Plasma nitriding at 480°C</td>
<td>10</td>
<td>0.12</td>
</tr>
<tr>
<td>Nitrocarburising - in gas at 580°C</td>
<td>2.5</td>
<td>0.11</td>
</tr>
<tr>
<td>- in salt bath at 580°C</td>
<td>1</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Nitriding to case depths >0.3 mm is not recommended for hot-work applications.

ASSAB 2344 can be nitrided in the soft-annealed condition. The hardness and depth of case will, however, be reduced somewhat in this case.
**WELDING**

Welding of tool steel can be performed with good results if proper precautions are taken regarding elevated temperature, joint preparation, choice of consumables and welding procedure. The following guidelines summarise the most important welding process parameters.

<table>
<thead>
<tr>
<th>Welding method</th>
<th>TIG</th>
<th>MMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working temperature</td>
<td>325 - 375 °C</td>
<td>325 - 375 °C</td>
</tr>
<tr>
<td>Filler metals</td>
<td>QRO 90 TIG Weld</td>
<td>QRO 90 Weld</td>
</tr>
<tr>
<td></td>
<td>DIEVAR TIG Weld</td>
<td>UTP A 673</td>
</tr>
<tr>
<td></td>
<td>UTP A 673</td>
<td></td>
</tr>
<tr>
<td>Cooling rate</td>
<td>20 - 40 °C/h for the first 2 - 3 hours and then freely in air.</td>
<td></td>
</tr>
<tr>
<td>Hardness after welding</td>
<td>QRO 90 TIG-WELD</td>
<td>QRO 90 TIG-WELD</td>
</tr>
<tr>
<td></td>
<td>DIEVAR TIG-WELD</td>
<td>48 - 53 HRC</td>
</tr>
<tr>
<td></td>
<td>UTP A 673</td>
<td>UTP A 673</td>
</tr>
<tr>
<td></td>
<td>57 - 60 HRC</td>
<td>55 - 58 HRC</td>
</tr>
<tr>
<td>Heat treatment after welding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardened condition</td>
<td>Temper at 25°C below the original tempering temperature.</td>
<td></td>
</tr>
<tr>
<td>Soft annealed condition</td>
<td>Soft anneal according to the &quot;Heat treatment&quot; recommendation.</td>
<td></td>
</tr>
</tbody>
</table>

**HARD CHROME PLATING**

After plating, parts should be tempered at 180°C for 4 hours, within 4 hours of plating, to avoid the risk of hydrogen embrittlement.

**ELECTRICAL DISCHARGE MACHINING — EDM**

If spark-erosion is performed in the hardened and tempered condition, the white re-cast layer should be removed mechanically by grinding or stoning.

The tool should then be given an additional temper at approx. 25°C below the previous tempering temperature.

**POLISHING**

ASSAB 2344 exhibits good polishability in the hardened and tempered condition. Polishing after grinding can be effected using aluminium oxide or diamond paste.

**TYPICAL PROCEDURE**

1. Rough grinding to 180 - 320 grain size using a wheel or stone.
2. Fine grinding with abrasive paper or powder, down to 400 - 800 grain size.
3. Polish with diamond paste grade 15 (15μm grain size) using a polishing tool of soft wood or fibre.
4. Polish with diamond paste 8-6-3 (8-6-3μm grain size) using a polishing tool of soft wood or fibre.
5. When demands on surface finish are high, grade 1 (1μm grain size) diamond paste can be used for final polishing with a fibre polishing pad.

**PHOTO-ETCHING**

ASSAB 2344 is suitable for texturing by the photo-etching method. Its high level of homogeneity and low sulphur content ensures accurate and consistent pattern reproduction.

**FURTHER INFORMATION**

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