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<td>ORVAR 2M</td>
<td>H13</td>
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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 140919
General

Vanadis 10 SuperClean is a high vanadium alloyed powder metallurgical (PM) tool steel offering a unique combination of an excellent abrasive wear resistance in combination with a good chipping resistance.

Vanadis 10 SuperClean is characterised by:
- Extremely high abrasive wear resistance
- High compressive strength
- Very good through-hardening properties
- Good toughness
- Very good stability during hardening
- Good resistance to tempering back

<table>
<thead>
<tr>
<th>Typical analysis %</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
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<td>Standard specification</td>
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<td>Delivery condition</td>
<td>Soft annealed to approx. 280 - 310 HB</td>
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<td>Colour code</td>
<td>Green / Violet</td>
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Due to the very carefully balanced alloying and the powder metallurgical manufacturing route, Vanadis 10 SuperClean has a similar heat treatment procedure to the steel D2. One very big advantage with Vanadis 10 SuperClean is that the dimensional stability after hardening and tempering is much better than for the conventionally produced high performance cold work steels. This also means that Vanadis 10 SuperClean is a tool steel which is very suitable for CVD coating.

Applications

Vanadis 10 SuperClean is especially suitable for very long run tooling where abrasive wear is the dominating problem. Its very good combination of extremely high wear resistance and good toughness also makes Vanadis 10 SuperClean an interesting alternative in applications where tooling made of carbide tends to chip or crack.

Typical Applications
- Blanking and forming
- Fine blanking
- Blanking of electrical sheet
- Gasket stamping
- Deep drawing
- Cold forging
- Slitting knives (paper and foil)
- Powder pressing
- Granulator knives
- Extruder screws etc.

Properties

PHYSICAL PROPERTIES
Hardened and tempered to 62 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>7 400</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Modulus of elasticity MPa</td>
<td>220 000</td>
<td>210 000</td>
<td>200 000</td>
</tr>
<tr>
<td>Coefficient of thermal expansion per °C from 20°C</td>
<td>–</td>
<td>10.7 x 10⁻⁴</td>
<td>11.4 x 10⁻⁴</td>
</tr>
<tr>
<td>Thermal conductivity W/m °C</td>
<td>–</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Specific heat J/kg °C</td>
<td>460</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

IMPACT STRENGTH

The effect of tempering temperature on unnotched impact strength at room temperature.
Specimen size: 7 x 10 x 55 mm
Specimen type: Unnotched
Heat treatment: Hardened at 1020°C. Quenched in air. Tempered twice.

WEAR RESISTANCE

Test method: Pin-on-disc test
Disc material: SiC

Weight loss, mg/min
Heat treatment

**SOFT ANNEALING**
Protect the steel and heat through to 900°C. Cool in the furnace at 10°C per hour to 750°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: 550 - 850°C
- Austenitising temperature: 1020 - 1100°C

*Holding time: 30 minutes*

Holding time = Time at hardening temperature after the tool is fully heated through. A holding time of less than 30 minutes will result in loss of hardness.

*Protects the parts against decarburisation and oxidation during hardening.*

**QUENCHING MEDIA**
- \( \text{N}_2 \) with sufficient overpressure quenching in vacuum furnace
- Martempering bath or fluidised bed at 500 - 550°C
- Martempering bath or fluidised bed at 200 - 350°C whereby 350°C is preferred
- Forced air/gas

*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 as fast as possible while maintaining an acceptable level of distortion.*

*Note 3: Tools with sections >50 mm should not be quenched in still air as it will result in loss of hardness.*

**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 temperature is 2 hours. At a hardening temperature of 1100°C or higher, Vanadis 10 SuperClean should be tempered at minimum 525°C in order to reduce the amount of retained austenite.

**Hardness and retained austenite as functions of austenitising temperature**

*Holding time 30 min. Air-cooling.*

**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.
VANADIS 10 SuperClean

Sub-Zero Treatment

Tools requiring maximum dimensional stability in service can be sub-zero treated as follows:

Immediately after quenching, the piece should be sub-zero treated, followed by tempering. Vanadis 10 SuperClean is commonly sub-zero treated between -150°C and -196°C for 1 - 3 hours, although occasionally -70°C to -80°C are used due to constraints of the sub-zero medium and equipment available. The sub-zero treatment leads to a reduction of retained austenite content. This, in turn, will result in a hardness increase of ~1 HRC compared to non sub-zero treated tools if low temperature tempering is used.

Tools that are high-temperature tempered, even without a sub-zero treatment, will have a low retained austenite content and in most cases, a sufficient dimensional stability. However, for high demands on dimensional stability in service, it is recommended to use a sub-zero treatment in combination with high-temperature tempering.

CCT graph

Austenitising temperature 1020 - 1060°C. Holding time 30 minutes.

Dimentional Changes After Tempering

<table>
<thead>
<tr>
<th>Hardening temperature</th>
<th>980°C</th>
<th>1020°C</th>
<th>1060°C</th>
</tr>
</thead>
</table>

Specimen size: 65 x 65 x 65 mm

<table>
<thead>
<tr>
<th>Dimensional change, %</th>
<th>As hardened</th>
<th>200°C</th>
<th>550°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.02</td>
<td>0.04</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Specimen size: 125 x 125 x 25 mm

<table>
<thead>
<tr>
<th>Dimensional change, %</th>
<th>As hardened</th>
<th>200°C</th>
<th>550°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.02</td>
<td>0.04</td>
<td>0.08</td>
</tr>
</tbody>
</table>
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 280 - 310 HB**

### TURNING

<table>
<thead>
<tr>
<th>Cutting data parameters</th>
<th>Turning with carbide</th>
<th>Turning with HSS</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>50 - 80</td>
<td>80 - 100</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_d) mm</td>
<td>2 - 4</td>
<td>0.5 - 2</td>
</tr>
<tr>
<td>Carbide designation ISO</td>
<td>K20 Coated carbide*</td>
<td>K15 Coated carbide*</td>
</tr>
</tbody>
</table>

* 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>≤ 5</td>
<td>6 - 8'</td>
<td>0.05 - 0.15</td>
</tr>
<tr>
<td>5 - 10</td>
<td>6 - 8'</td>
<td>0.15 - 0.20</td>
</tr>
<tr>
<td>10 - 15</td>
<td>6 - 8'</td>
<td>0.20 - 0.25</td>
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<tr>
<td>15 - 20</td>
<td>6 - 8'</td>
<td>0.25 - 0.35</td>
</tr>
</tbody>
</table>

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

### MILLING

**Face and square shoulder milling**

<table>
<thead>
<tr>
<th>Cutting data parameters</th>
<th>Milling with carbide</th>
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<tbody>
<tr>
<td></td>
<td>Rough milling</td>
</tr>
<tr>
<td>Cutting speed (v_c) m/min</td>
<td>30 - 50</td>
</tr>
<tr>
<td>Feed (f) mm/tooth</td>
<td>0.2 - 0.4</td>
</tr>
<tr>
<td>Depth of cut (a_d) mm</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Carbide designation ISO</td>
<td>K20 - P20 Coated carbide*</td>
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* Use a CVD coating

### END MILLING

<table>
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<th>Cutting data parameter</th>
<th>Type of end mill</th>
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<tr>
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<tr>
<td>Cutting speed (v_c) m/min</td>
<td>30 - 40</td>
</tr>
<tr>
<td>Feed (f) mm/tooth</td>
<td>0.03 - 0.20²</td>
</tr>
<tr>
<td>Carbide designation ISO</td>
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</tr>
</tbody>
</table>

1 Uncased HSS is not recommended

2 Depending on radial depth of cut and cutter diameter

3 Use a CVD coating

### GRINDING

**Wheel recommendation**

<table>
<thead>
<tr>
<th>Type of grinding</th>
<th>Soft-annealed condition</th>
<th>Hardened condition</th>
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<tbody>
<tr>
<td>Face grinding straight wheel</td>
<td>A 46 HV</td>
<td>B151 R50 B3¹ A 46 GVD²</td>
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<tr>
<td>Face grinding segments</td>
<td>A 36 GV</td>
<td>A 46 GV</td>
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<tr>
<td>Cylindrical grinding</td>
<td>A 60 KV</td>
<td>B151 R75 B3¹ A 60 JV²</td>
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<tr>
<td>Internal grinding</td>
<td>A 60 JV</td>
<td>B151 R75 B3¹ A 60 IV</td>
</tr>
<tr>
<td>Profile grinding</td>
<td>A 100 IV</td>
<td>B126 R100 B6¹ A 100 JV²</td>
</tr>
</tbody>
</table>

1 If possible, use CBN wheels for this application

2 Preferably a wheel type containing sintered \(\text{Al}_2\text{O}_3\) (seeded gel)
Electrical discharge machining

If EDM is performed in the hardened and tempered condition, finish with “fine-sparking”, i.e., low current, high frequency. For optimal performance, the following precautionary measures are recommended:

- The surface layer affected by EDM should be removed by polishing or stoning; or
- The tool retempered at approx. 25°C lower than the original tempering temperature; or
- A combination of the two precautionary measures mentioned above.

When EDM’ing larger sizes or complicated shapes, Vanadis 10 Super-Clean should be high-temperature tempered.

Surface treatment

NITRIDING

Nitriding produces a hard surface layer that increases wear resistance and reduces the tendency towards galling.

If high-temperature tempered, Vanadis 10 Super-Clean is normally tempered at 525°C or above. This means that the nitriding temperature used should not exceed 500 - 525°C. Ion nitriding at a temperature below the tempering temperature used is preferred.

The surface hardness after nitriding is approximately 1250 HV0.2 kg. The thickness of the layer should be chosen to suit the application in question.

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

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<th>ASSAB grade</th>
<th>Hardness/Resistance to plastic deformation</th>
<th>Machinability</th>
<th>Grindability</th>
<th>Dimension stability</th>
<th>Resistance to Abrasive wear</th>
<th>Adhesive wear</th>
<th>Fatigue cracking resistance</th>
<th>Ductility/resistance to chipping</th>
<th>Toughness/gross cracking</th>
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</tbody>
</table>
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