

**Uddeholm**  
**Orvar<sup>®</sup> 2**  
**Microdized**

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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.

Classified according to EU Directive 1999/45/EC  
For further information see our "Material Safety Data Sheets".

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## GENERAL

Uddeholm Orvar 2 Microdized is a chromium-molybdenum-vanadium-alloyed steel which is characterized by:

- good resistance to abrasion at both low and high temperatures
- high level of toughness and ductility
- uniform and high level of machinability and polishability
- good high-temperature strength and resistance to thermal fatigue
- excellent through-hardening properties
- very limited distortion during hardening.

|                        |   |           |           |           |           |          |
|------------------------|---|-----------|-----------|-----------|-----------|----------|
| Typical analysis %     | C<br>0.39                               | Si<br>1.0 | Mn<br>0.4 | Cr<br>5.2 | Mo<br>1.4 | V<br>0.9 |
| Standard specification | AISI H13, W.-Nr. 1.2344, EN X40CrMoV5-1 |           |           |           |           |          |
| Delivery condition     | Soft annealed to approx. 180 HB         |           |           |           |           |          |
| Colour code            | Orange/violet                           |           |           |           |           |          |

## APPLICATION

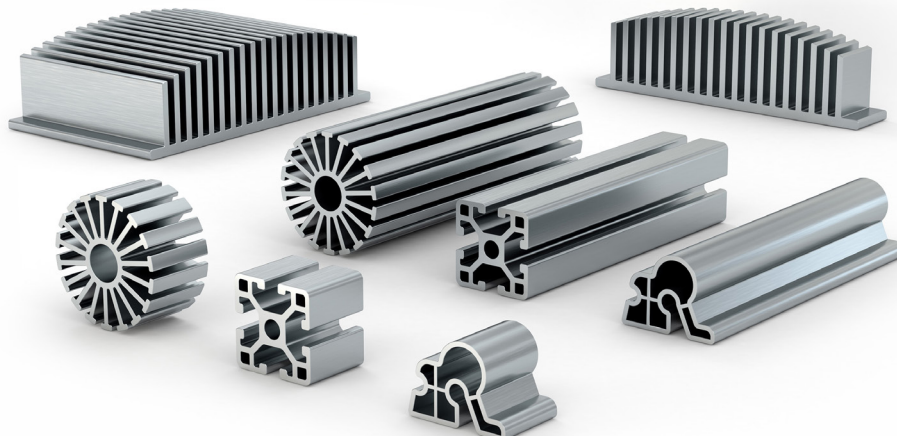
### TOOLS FOR EXTRUSION

| Part  | Aluminium, magnesium alloys, HRC | Copper alloys HRC         | Stainless steel HRC |
|---|----------------------------------|---------------------------|---------------------|
| Dies  | 44-50                            | 43-47                     | 45-50               |
| Backers, die-holders, liners, dummy blocks, stems | 41-50                            | 40-48                     | 40-48               |
| Austenitizing temperature (approx.)               | 1020-1030°C (1870-1885°F)        | 1040-1050°C (1900-1920°F) |                     |

### OTHER APPLICATIONS

| Application                                   | Austenitizing temp. (approx.)  | HRC   |
|---|--|---|
| Severe cold punching, scrap shears            | 1020-1030°C (1870-1885°F)<br>Tempering 250°C (480°F)                               | 50-52   |
| Hot shearing                                  | 1020-1030°C (1870-1885°F)<br>Tempering 250°C (480°F)<br>or 575-600°C (1070-1110°F) | 50-52<br>45-50                                    |
| Shrink rings (e.g. for cemented carbide dies) | 1020-1030°C (1870-1885°F)<br>Tempering 575-620°C (1070-1110°F)                     | 45-50   |
| Wear-resisting parts                          | 1020-1030°C (1870-1885°F)<br>Tempering 575°C (1070°F)<br>Nitriding                 | In core 50-52<br>On surface ~1000 HV <sub>1</sub> |

For applications requiring extreme levels of toughness and ductility e.g. die casting dies, forging dies, the premium grade H13-steel, Uddeholm Orvar Supreme, is recommended.



## PROPERTIES

### PHYSICAL DATA

Unless otherwise is indicated all specimens were hardened 30 minutes at 1025°C (1875°F), quenched in air and tempered 2 + 2 h at 610°C (1130°F). The hardness were 45 ± 1 HRC.

| Temperature   | 20°C<br>(68°F)                    | 400°C<br>(750°F)                                  | 600°C<br>(1110°F)                                 |
|---|-----------------------------------|---|---|
| Density<br>kg/m <sup>3</sup><br>lbs/in <sup>3</sup>                         | 7800<br>0.281                     | 7700<br>0.277                                     | 7600<br>0.274                                     |
| Modulus<br>of elasticity<br>N/mm <sup>2</sup><br>psi                        | 210 000<br>30.5 x 10 <sup>6</sup> | 180 000<br>26.1 x 10 <sup>6</sup>                 | 140 000<br>20.3 x 10 <sup>6</sup>                 |
| Coefficient of<br>thermal expansion<br>per °C from 20°C<br>per °F from 68°F | -<br>-                            | 12.6 x 10 <sup>-6</sup><br>7.0 x 10 <sup>-6</sup> | 13.2 x 10 <sup>-6</sup><br>7.3 x 10 <sup>-6</sup> |
| Thermal<br>conductivity<br>W/m °C<br>Btu in/(ft <sup>2</sup> h°F)           | 25<br>176                         | 29<br>204   | 30<br>211   |

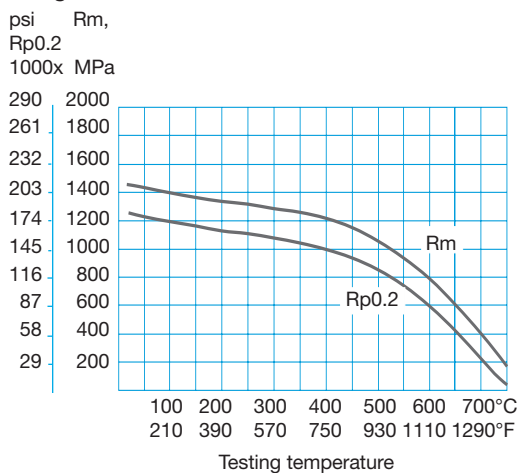
### MECHANICAL PROPERTIES

Approximate tensile strength at room temperature.

| Hardness  | 52 HRC                 | 45 HRC                 |
|---|------------------------|------------------------|
| Tensile strength Rm<br>N/mm <sup>2</sup><br>kp/mm <sup>2</sup><br>psi | 1820<br>185<br>263 000 | 1420<br>145<br>206 000 |
| Yield point Rp0.2<br>N/mm <sup>2</sup><br>kp/mm <sup>2</sup><br>psi   | 1520<br>155<br>220 000 | 1280<br>130<br>185 000 |

### APPROXIMATE STRENGTH AT ELEVATED TEMPERATURES

Longitudinal direction.



## HEAT TREATMENT

### SOFT ANNEALING

Protect the steel and heat through to 850°C (1560°F). Then cool in the furnace at 10°C (20°F) per hour to 650°C (1200°F), then freely in air.

### STRESS RELIEVING

After rough machining the tool should be heated through to 650°C (1200°F), holding time 2 hours. Cool slowly to 500°C (930°F), then freely in air.

### HARDENING

Pre-heating temperature: 600–850°C (1110–1560°F), normally in two pre-heating steps.

Austenitizing temperature: 1020–1050°C (1870–1920°F), normally 1020–1030°C (1870–1885°F).

| Temperature |      | Soaking* time<br>minutes | Hardness before<br>tempering |
|-------------|------|--------------------------|------------------------------|
| °C          | °F   |                          |                              |
| 1025        | 1875 | 30                       | 53±2 HRC                     |
| 1050        | 1920 | 15                       | 54±2 HRC                     |

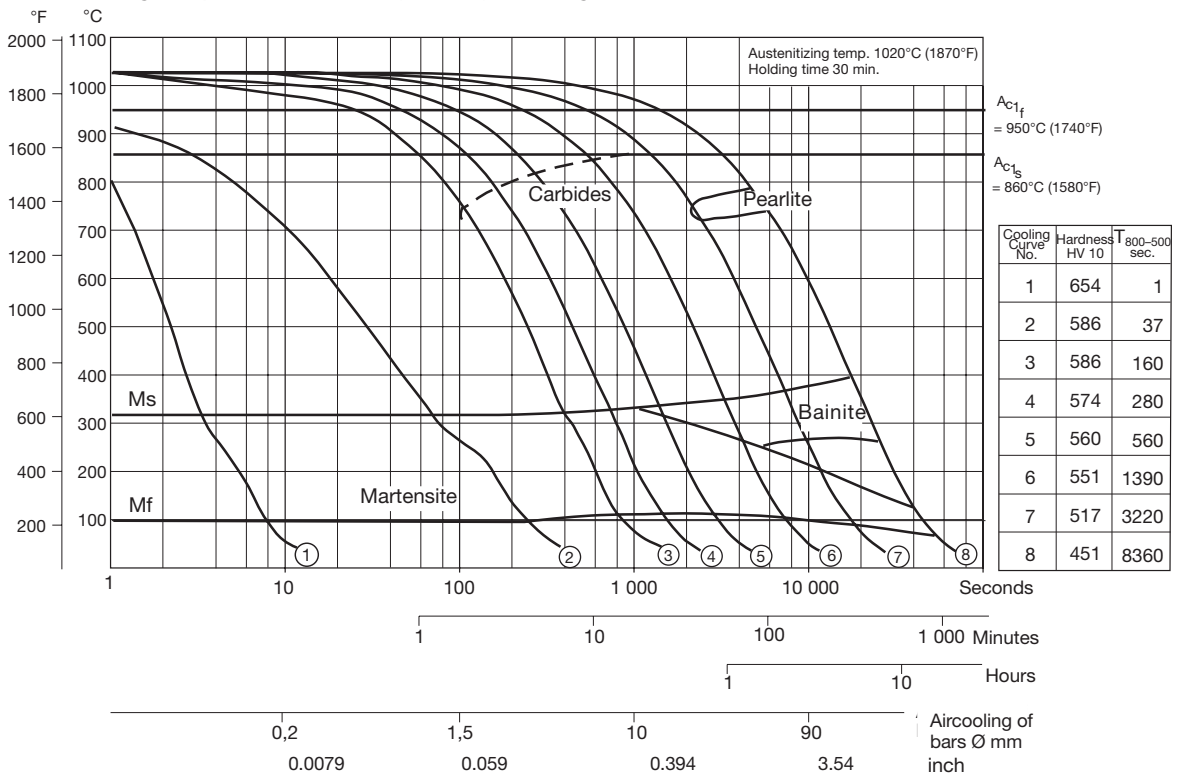
\* Soaking time = time at hardening temperature after the tool is fully heated through

Protect the part against decarburization and oxidation during hardening.



**CCT GRAPH**

Austenitizing temperature 1020°C (1870°F). Holding time 30



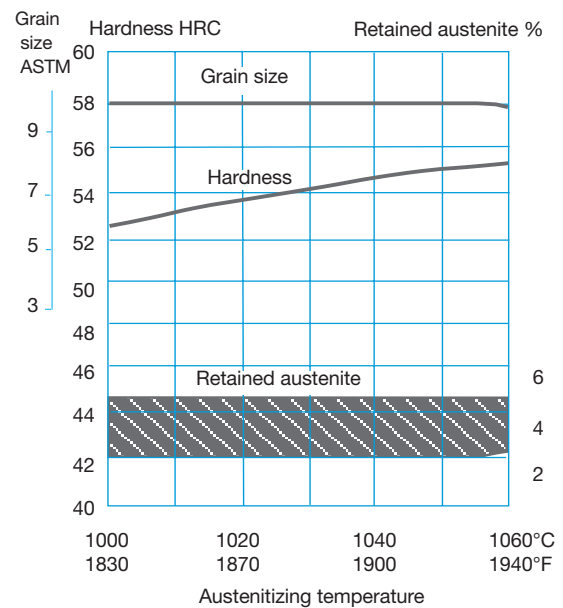
**QUENCHING MEDIA**

- High speed gas/circulating atmosphere
- Vacuum (high speed gas with sufficient positive pressure). An interrupted quench is recommended where distortion control and quench cracking are a concern
- Martempering bath or fluidized bed at 450–550°C (840–1020°F), then cool in air
- Martempering bath or fluidized bed at 180–220°C (360–430°F) then cool in air
- Warm oil

Note 1: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

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.

**HARDNESS, GRAIN SIZE AND RETAINED AUSTENITE AS FUNCTIONS OF AUSTENITIZING TEMPERATURE**

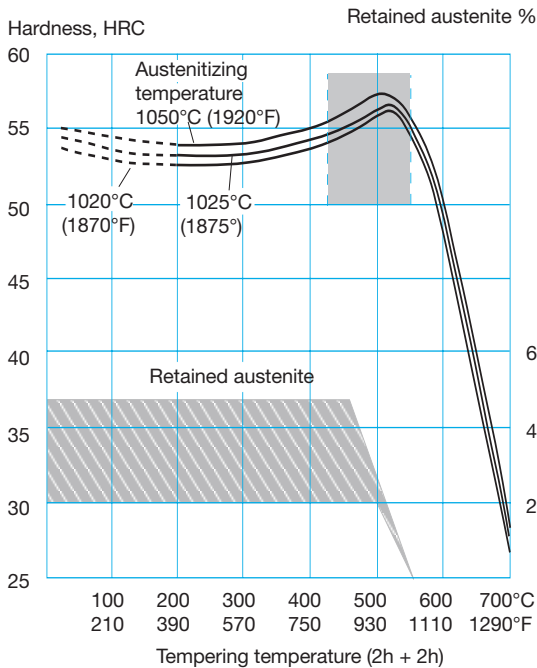


## TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper minimum twice with intermediate cooling to room temperature. Lowest tempering temperature 250°C (480°F). Holding time at temperature minimum 2 h.

To avoid “temper brittleness”, do not temper in the range 425–550°C (800–1020°F), see graph.

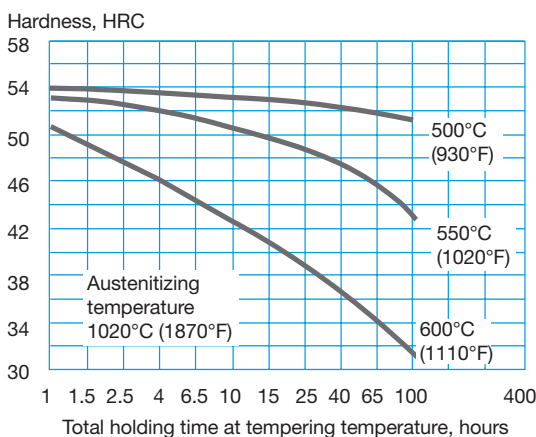
### TEMPERING GRAPH



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.

Tempering within the range 425–550°C (800–1020°F) is not normally recommended due to the reduction in toughness properties.

### EFFECT OF TIME AT TEMPERING TEMPERATURE

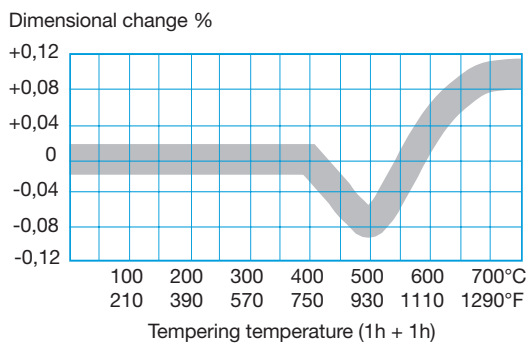


## DIMENSIONAL CHANGES DURING HARDENING

Sample plate, 100 x 100 x 25 mm, 4" x 4" x 1"

|                                   |     | Width % | Length % | Thickness % |
|-----------------------------------|-----|---------|----------|-------------|
| Oil hardened from 1000°C (1870°F) | min | -0.08   | -0.06    | 0.00        |
|                                   | max | -0.15   | -0.16    | +0.30       |
| Air hardened from 1020°C (1870°F) | min | -0.02   | -0.05    | ±0          |
|                                   | max | +0.03   | +0.02    | +0.05       |
| Vac hardened from 1020°C (1870°F) | min | +0.01   | -0.02    | +0.08       |
|                                   | max | +0.02   | -0.04    | +0.12       |

## DIMENSIONAL CHANGES DURING TEMPERING



Note: The dimensional changes in hardening and tempering should be added.

## NITRIDING AND NITROCARBURIZING

Nitriding and nitrocarburizing 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 (45–90°F) above the nitriding temperature.

Nitriding in ammonia gas at 510°C (950°F) or plasma nitriding in a 75% hydrogen/25% nitrogen mixture at 480°C (895°F) both result in a surface hardness of about 1100 HV<sub>0.2</sub>. In general, plasma nitriding is the preferred method because of better control over nitrogen potential; in particular, formation of the so-called white layer, which is not recommended for hot work service, can readily be avoided. However, careful gas nitriding can give perfectly acceptable results.

Uddeholm Orvar 2 Microdized can also be nitrocarburized in either gas or salt bath. The surface hardness after nitrocarburizing is 900–1000 HV<sub>0.2</sub>.

## DEPTH OF NITRIDING

| Process   | Time  | Depth   |
|---|-------|---------|
| Gas nitriding at 510°C  | 10 h  | 0.12 mm |
|   | 30 h  | 0.20 mm |
| Plasma nitriding at 480°C   | 10 h  | 0.12 mm |
|   | 30 h  | 0.18 mm |
| Nitrocarburizing<br>– in gas at at 580°C<br>– in salt bath at 580°C | 2,5 h | 0.11 mm |
|   | 1 h   | 0.06 mm |

Nitriding to case depths >0.3 mm (0.012 inch) is not recommended for hot-work applications. Uddeholm Orvar 2 Microdized can be nitrided in the soft-annealed condition. The hardness and depth of case will, however, be reduced somewhat in this case.

## MACHINING RECOMMENDATIONS

The cutting data below are to be considered as guiding values, which must be adapted to existing local conditions. More information can be found in the Uddeholm publication “Cutting data recommendations”.

*Condition: Soft annealed to approx. 185 HB*

### TURNING

| Cutting data parameters                    | Turning with carbide               |                                       | Turning with high speed steel |
|--|------------------------------------|---------------------------------------|-------------------------------|
|  | Rough turning                      | Fine turning                          | Fine turning                  |
| Cutting speed ( $v_c$ )<br>m/min<br>f.p.m. | 200–250<br>200–250<br>656–820      | 250–300<br>250–300<br>820–984         | 25–30<br>25–30<br>82–98       |
| Feed (f)<br>mm/r<br>i.p.r.                 | 0.2–0.4<br>0.008–0.016             | 0.05–0.2<br>0.002–0.008               | 0.05–0.3<br>0.002–0.01        |
| Depth of cut ( $a_p$ )<br>mm<br>inch       | 2–4<br>0.08–0.16                   | 0.5–2<br>0.02–0.08                    | 0.5–3<br>0.02–0.12            |
| Carbide designation<br>ISO<br>US           | P20–P30<br>C6–C5<br>Coated carbide | P10<br>C7<br>Coated carbide or cermet | –<br>–                        |

## DRILLING

### HIGH SPEED STEEL TWIST DRILL

| Drill diameter |          | Cutting speed, $v_c$ |        | Feed, f   |             |
|----------------|----------|----------------------|--------|-----------|-------------|
| mm             | inch     | m/min                | f.p.m. | mm/r      | i.p.r.      |
| – 5            | –3/16    | 16–18*               | 52–59* | 0.05–0.15 | 0.002–0.006 |
| 5–10           | 3/16–3/8 | 16–18*               | 52–59* | 0.15–0.20 | 0.006–0.008 |
| 10–15          | 3/8–5/8  | 16–18*               | 52–59* | 0.20–0.25 | 0.008–0.010 |
| 15–20          | 5/8–3/4  | 16–18*               | 52–59* | 0.25–0.35 | 0.010–0.014 |

\* For coated HSS drill  $v_c = 28\text{--}30$  m/min. (92–98 f.p.m.)

### CARBIDE DRILL

| Cutting data parameters                    | Type of drill  |  |  |
|--|--|--|--|
|  | Indexable insert                                     | Solid carbide  | Carbide tip <sup>1)</sup>                            |
| Cutting speed ( $v_c$ )<br>m/min<br>f.p.m. | 220–240<br>720–785                                   | 130–160<br>425–525                                   | 80–110<br>260–360                                    |
| Feed (f)<br>mm/r<br>i.p.r.                 | 0.03–0.12 <sup>2)</sup><br>0.001–0.005 <sup>2)</sup> | 0.08–0.20 <sup>3)</sup><br>0.003–0.008 <sup>3)</sup> | 0.15–0.25 <sup>4)</sup><br>0.006–0.010 <sup>4)</sup> |

<sup>1)</sup> Drill with replaceable or brazed carbide tip

<sup>2)</sup> Feed rate for drill diameter 20–40 mm (0.8”–1.6”)

<sup>3)</sup> Feed rate for drill diameter 5–20 mm (0.2”–0.8”)

<sup>4)</sup> Feed rate for drill diameter 10–20 mm (0.4”–0.8”)

## MILLING

### FACE AND SQUARE SHOULDER MILLING

| Cutting data parameters                    | Milling with carbide               |  |
|--|------------------------------------|--|
|  | Rough milling                      | Fine milling                                 |
| Cutting speed ( $v_c$ )<br>m/min<br>f.p.m. | 180–260<br>591–853                 | 260–300<br>853–984                           |
| Feed ( $f_z$ )<br>mm/tooth<br>inch/tooth   | 0.2–0.4<br>0.008–0.016             | 0.1–0.2<br>0.004–0.008                       |
| Depth of cut ( $a_p$ )<br>mm<br>inch       | 2–5<br>0.08–0.2                    | –2<br>–0.08                                  |
| Carbide designation<br>ISO<br>US           | P20–P40<br>C6–C5<br>Coated carbide | P10–P20<br>C6–C7<br>Coated carbide or cermet |

## END MILLING

| Cutting data parameters                    | Type of end mill                                     |  |  |
|--|--|--|--|
|  | Solid carbide  | Carbide indexable insert                             | High speed steel                                     |
| Cutting speed ( $v_c$ )<br>m/min<br>f.p.m. | 160–200<br>525–660                                   | 170–230<br>560–755                                   | 35–40 <sup>1)</sup><br>115–130 <sup>1)</sup>         |
| Feed ( $f_z$ )<br>mm/tooth<br>inch/tooth   | 0.03–0.20 <sup>2)</sup><br>0.001–0.008 <sup>2)</sup> | 0.08–0.20 <sup>2)</sup><br>0.003–0.008 <sup>2)</sup> | 0.05–0.35 <sup>2)</sup><br>0.002–0.014 <sup>2)</sup> |
| Carbide designation ISO                    | –  | P20, P30   | –  |

<sup>1)</sup> For coated HSS end mill  $v_c = 55–60$  m/min. (180–195 f.p.m.)

<sup>2)</sup> Depending on radial depth of cut and cutter diameter

## GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm brochure “Grinding of Tool Steel” and can also be obtained from the grinding wheel manufacturer.

| 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 KV                | A 120 KV           |

## ELECTRICAL-DISCHARGE MACHINING

If spark-erosion is performed in the hardened and tempered condition, the white re-cast layer should be removed mechanically e.g. by grinding or stoning. The tool should then be given an additional temper at approx. 25°C (50°F) below the previous tempering temperature.

## HARD-CHROMIUM PLATING

After plating, parts should be tempered at 180°C (360°F) for 4 hours within 4 hours of plating to avoid the risk of hydrogen embrittlement.

## 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.

| Welding method                | TIG  | MMA                          |
|-------------------------------|--|------------------------------|
| Working temperature           | min. 325°C (min. 620°F)  | min. 325°C (min. 620°F)      |
| Filler metal                  | QRO 90 TIG-WELD<br>DIEVAR TIG-WELD   | QRO 90 WELD<br>UTP 673       |
| Cooling rate                  | 20–40°C/h (35–70°F/h) the first 2–3 h then freely in air.  |                              |
| Hardness after welding        | 48–53 HRC  | 48–53 HRC<br>55–58 HRC (673) |
| Heat treatment after welding: |  |                              |
| Hardened condition            | Temper at 10–20°C (20–35°F) below the original tempering temperature.  |                              |
| Soft annealed condition       | Soft-anneal the material at 850°C (1560°F) in protected atmosphere. Then cool in the furnace at 10°C (20°F) per hour to 650°C (1200°F) then freely in air. |                              |

More detailed information can be found in the Uddeholm brochure “Welding of Tool Steel”.

## POLISHING

Uddeholm Orvar 2 Microdized 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.

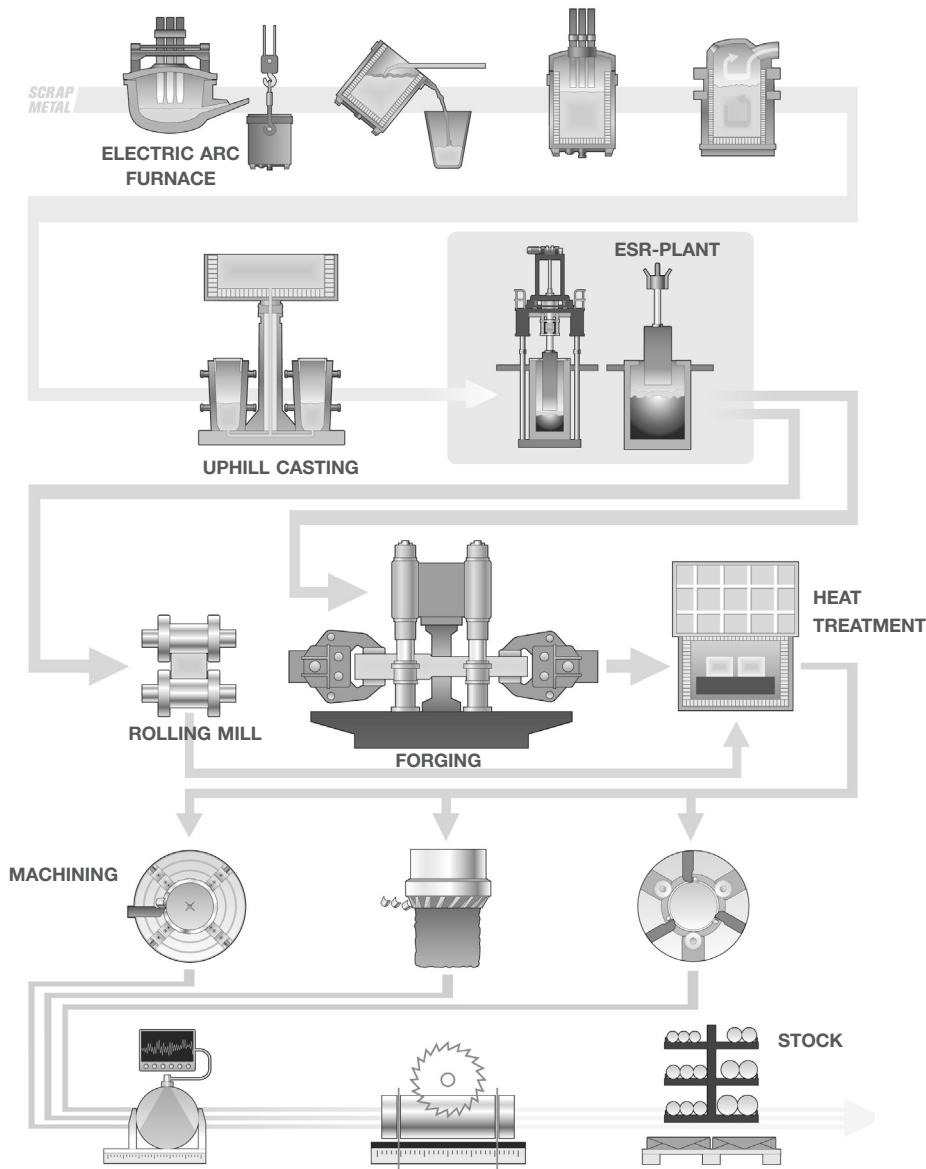


## **PHOTO-ETCHING**

Uddeholm Orvar 2 Microdized is particularly 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 Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steel.



## 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 de-slagging unit removes oxygen-rich slag and after the de-oxidation, alloying and heating of the steel bath are carried out in the ladle furnace. Vacuum degassing removes elements such as hydrogen, nitrogen and sulphur.

### ESR PLANT

In uphill casting the prepared moulds are filled with a controlled flow of molten steel from the ladle.

From this, the steel can go directly to our rolling mill or to the forging press, but also to our ESR furnace where our most sophisticated steel grades are melted once again in an electro slag 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 macro segregation.

Melting under a protective atmosphere gives an even better steel cleanliness.

### HOT WORKING

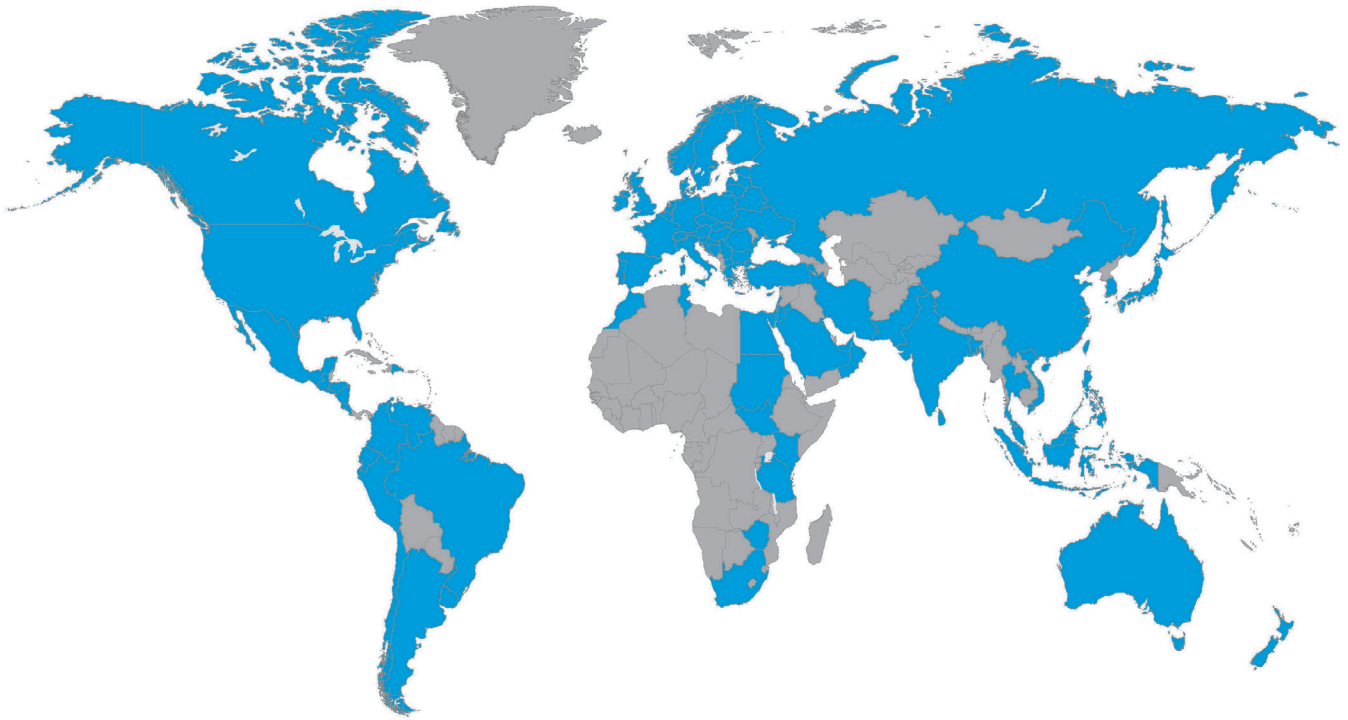
From the ESR plant, the steel goes to the rolling mill or to our forging press to be formed into round or flat bars.

Prior to delivery all of the different bar materials are subjected to a heat treatment operation, either as soft annealing or hardening and tempering. These operations provide the steel with the right balance between hardness and toughness.

### MACHINING

Before the material is finished and put into stock, we also rough machine the bar profiles to required size and exact tolerances. In the lathe machining of large dimensions, the steel bar rotates against a stationary cutting tool. In peeling of smaller dimensions, the cutting tools revolve around the bar.

To safeguard our quality and guarantee the integrity of the tool steel we perform both surface- and ultrasonic inspections on all bars. We then remove the bar ends and any defects found during the inspection.



## **NETWORK OF EXCELLENCE**

Uddeholm is present on every continent. This ensures you high-quality Swedish tool steel and local support wherever you are. We secure our position as the world's leading supplier of tooling materials.

Uddeholm is the world's leading supplier of tooling materials. This is a position we have reached by improving our customers' everyday business. Long tradition combined with research and product development equips Uddeholm to solve any tooling problem that may arise. It is a challenging process, but the goal is clear – to be your number one partner and tool steel provider.

Our presence on every continent guarantees you the same high quality wherever you are. We act worldwide. For us it is all a matter of trust – in long-term partnerships as well as in developing new products. Trust is something you earn, every day.

For more information, please visit [www.uddeholm.com](http://www.uddeholm.com)