Uddeholm
Mirrax® ESR

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

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SS-EN ISO 9001
SS-EN ISO 14001

Uddeholm Mirrax® ESR

Uddeholm Mirrax ESR is specially developed and adapted for larger moulds that require corrosion resistance and/or high surface finish.
It is characterized by:

- High hardenability for consistent properties in large dimensions
- Good ductility and toughness for a safe production
- High corrosion resistance for low maintenance requirements
- Excellent polishability for aesthetic quality and function
- Good wear resistance for longer life

Uddeholm Mirrax ESR is also the right choice for larger tools when contamination in production is totally unacceptable: within the medical industry, optical industry and for other high quality transparent articles.

Uddeholm Mirrax ESR is a part of the Uddeholm Stainless Concept.

GENERAL

Demands placed on plastic mould tooling are increasing. Such conditions require mould steel that possess a unique combination of toughness, corrosion resistance and the ability to reach uniform hardness levels throughout large cross sections. Uddeholm Mirrax ESR has proven to be the right choice for these applications.

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

- excellent polishability
- high corrosion resistance
- excellent through-hardening properties
- good ductility and toughness
- good wear resistance

The combination of these properties provides a steel with outstanding production performance. The practical benefits of good corrosion resistance in a plastic mould can be summarized 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 steel), 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 Uddeholm Mirrax ESR, offer the moulder low-maintenance, long-life moulds for the greatest overall tooling economy.

Note! Uddeholm Mirrax ESR is produced using the Electro-Slag-Remelting (ESR) technique. The result is a mould steel with a very low inclusion level providing excellent polishability characteristics.

Typical analysis %	C 0.25	Si 0.35	Mn 0.55	Cr 13.3	Mo 0.35	Ni 1.35	V 0.35	+N
Standard specification	AISI 420 modified							
Delivery condition	Annealed to approx. 250 HB.							
Colour code	Black/Orange with white line across							

APPLICATIONS

Although Uddeholm Mirrax ESR is recommended for all types of moulds, its special properties make it particularly suitable for moulds with the following demands:

- Corrosion/staining resistance, i.e. for moulding of corrosive materials, e.g. PVC, acetates, and for moulds subjected to humid working/storage conditions.
- High surface finish, i.e. for the production of optical parts, such as camera and sunglass lenses, and for medical components, e.g. syringes, analysis vials etc..
- Toughness/ductility, i.e. for complex moulds
- Outstanding through-hardening characteristics i.e. high-hardenability, important for larger moulds.

PROPERTIES

PHYSICAL DATA

Hardened and tempered to 50 HRC. Data at room and elevated temperatures.

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density kg/m^3 lbs/in^3	7 740 0.280	–	–
Modulus of elasticity MPa psi	210 000 30.5 x 10^6	200 000 29 x 10^6	180 000 26.1 x 10^6
Coefficient of thermal expansion /°C from 20°C /°F from 68°F	–	11.1 x 10^{-6} 6.1 x 10^{-6}	11.7 x 10^{-6} 6.7 x 10^{-6}
Thermal conductivity* W/m °C Btu in/(ft^{2}h °F)	–	20 139	24 166
Specific heat J/kg °C Btu/lb °F	460 0,110	–	–

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

TENSILE STRENGTH AT ROOM TEMPERATURE

The tensile strength values are to be considered as only approximate. The test samples have been hardened in air from 1020°C (1870°F) and tempered twice to the given hardness.

All specimens have been taken from a bar with the dimension 407 x 203 mm (16" x 8").

Hardness	50 HRC	45 HRC
Tensile strength Rm MPa psi	 1 780 2.58×10^5	 1 500 2.18×10^5
Yield point Rp0.2 MPa psi	 1 290 1.87×10^5	 1 200 1.74×10^5

IMPACT TOUGHNESS

Uddeholm Mirrax ESR has much higher toughness/ductility compared to other stainless tool steel of W.-Nr. 1.2083/AISI 420 type.

For maximum toughness and ductility use low temperature tempering and for maximum abrasive wear resistance and lower stress level use high temperature tempering.

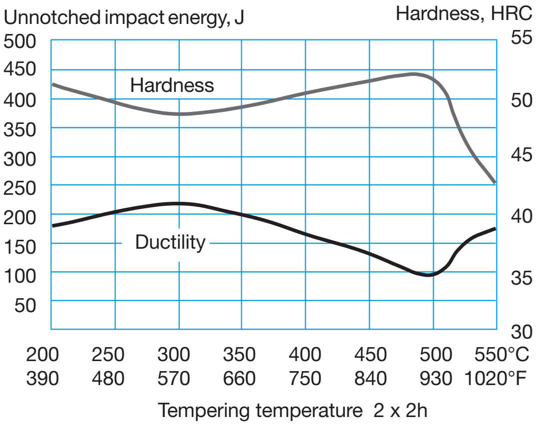
Approximate room temperature impact strength as measured by samples removed from the centre of a forged block, tested in the short transverse direction is shown below.

Original bar dimension: 508 x 306 mm (20" x 12")

Specimen size: 7 x 10 x 55 mm (0.27" x 0.4" x 2.2") unnotched.

Hardened at 1020°C (1870°F) for 30 minutes. Quenched in air. Tempered 2 x 2h.

THE INFLUENCE OF TEMPERING TEMPERATURE ON THE ROOM TEMPERATURE UNNOTCHED IMPACT TOUGHNESS



CORROSION RESISTANCE

A tool made from Uddeholm Mirrax ESR has a very good corrosion resistance and will resist corrosive environments better than other stainless tool steel of the W.-Nr. 1.2083/ AISI 420 type.

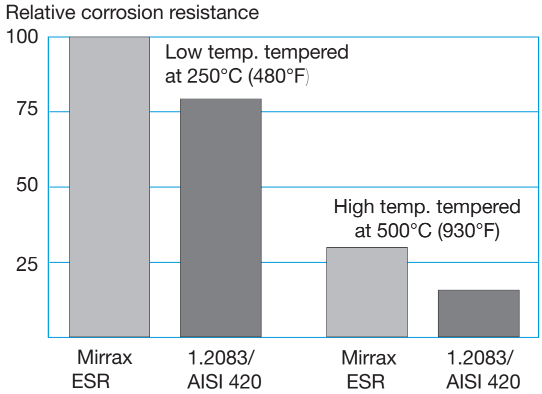
Uddeholm Mirrax ESR shows the best corrosion resistance when tempered at a low temperature and polished to a mirror finish.

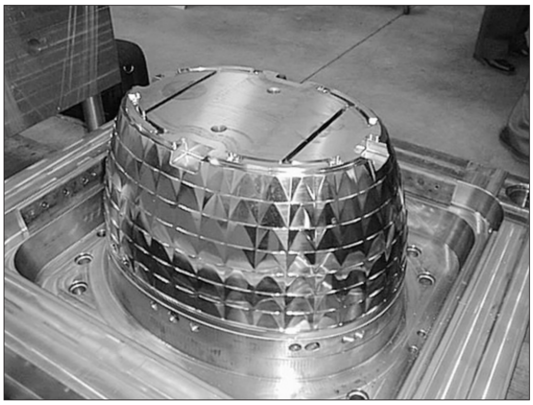
In the graph below values from potentiodynamic polarization curves have been evaluated to show the difference in general corrosion resistance between Uddeholm Mirrax ESR and W.-Nr.1.2083/AISI 420 measured at low- and high temperature tempering.

Specimen size: 20 x 15 x 3 mm (0.8" x 0.6" x 0.1")

Hardened at 1020°C (1870°F) for 30 minutes. Quenched in air. Tempered 2 x 2h.

THE INFLUENCE OF MOULD STEEL AND TEMPERING TEMPERATURE ON CORROSION RESISTANCE





Mould for production of street-light cover.

HEAT TREATMENT

SOFT ANNEALING

Protect the steel and heat through to 740°C (1365°F). Then cool in the furnace at 15°C (30°F) per hour to 550°C (1020°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

Preheating temperature: 600–920°C (1110–1690°F) Normally a minimum of two preheating steps.

Austenitizing temperature: 1000–1025°C (1830–1880°F) but usually 1020°C (1870°F). For very large moulds 1000°C (1830°F) is recommended.

Temperature °C	°F	Holding time* minutes	Hardness before tempering
1020	1870	30	55±2 HRC
1000	1830	30	54±2 HRC

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

Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA AND HARDENABILITY

- Vacuum, cooling in gas with sufficient overpressure
- Fluidized bed or salt bath at 350–500°C (660–930°F) then cool in air blast
- High speed gas/circulating atmosphere

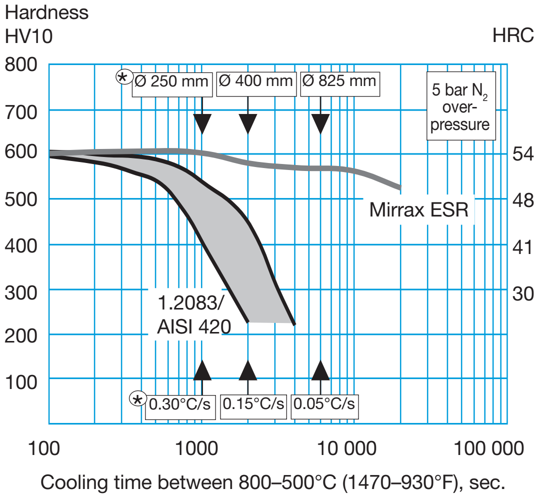
In order to obtain optimum properties, the cooling rate should be as fast as possible while maintaining an acceptable level of distortion. When heating in a vacuum furnace, min. 4–5 bar overpressure is recommended.

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

When hardening larger dimensions of W.-Nr. 1.2083 /AISI 420 type of material, the relatively poor hardenability will provide a low hardness and an undesirable microstructure over the cross section. In some parts of the mould the corrosion resistance and the toughness will be lowered.

Uddeholm Mirrax ESR has a much better hardenability than the W.-Nr. 1.2083/AISI 420 type of material so the high hardness will be retained even in the centre of large dimensions. The very good hardenability will also have a decisive effect on other properties such as toughness and corrosion resistance.

HARDNESS AS A FUNCTION OF COOLING RATE DURING HARDENING



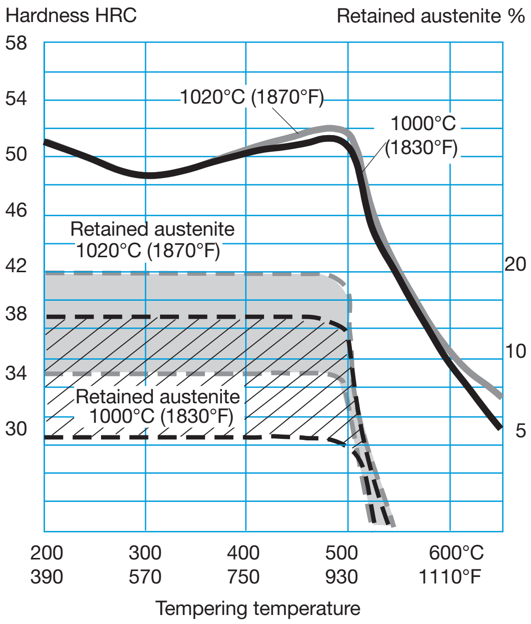
⊛Cooling rate in the centre of the three dimensions is indicated

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 hours.

TEMPERING GRAPH

The tempering curves are approximate.



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.

Note: Tempering at 250–300°C (480–570°F) results in the best combination of toughness, hardness and corrosion resistance. However, for very large moulds and/or a complicated design it is recommended to use a high tempering temperature to reduce the residual stresses to a minimum.

Further information is given in the leaflet “Heat Treatment Recommendations for Uddeholm Mirrax ESR”.

DIMENSIONAL CHANGES

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

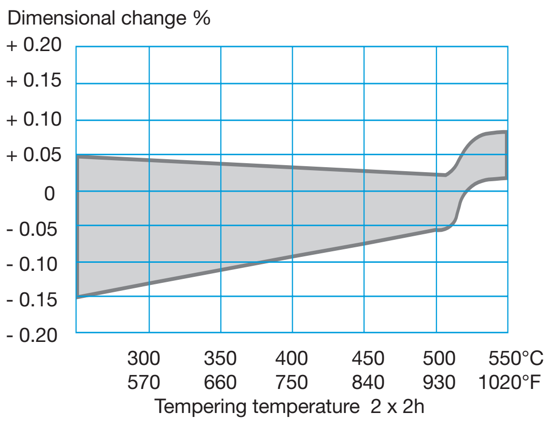
The size and geometry of the tool will also affect distortion and dimensional change. Therefore the tool should always be manufactured with enough machining allowance to compensate for dimensional changes.

Use 0.20% as a guideline for Uddeholm Mirrax ESR provided that a stress relief is performed between rough and semifinished machining as recommended.

Expect shrinkage rather than growth when using low temperature tempering as shown in the graph below.

Dimensional changes were measured for a sample of Uddeholm Mirrax ESR with a size of 100 x 100 x 100 mm (3.9" x 3.9" x 3.9").

Dimensional changes to be expected after hardening from 1000–1020°C (1830–1870°F) and tempered at various temperature. Spread is a result of the different dimensional changes in different directions.



For growth in all directions, tempering at temperatures ≥520°C (≥970°F) is required.

MACHINING RECOMMENDATIONS

The cutting data below are to be considered as guidelines and may require adjustments based on equipment, selection of cutting tools, etc. More information can be found in the Uddeholm publication "Cutting data recommendation".

The recommendations, in following tables, are valid for Uddeholm Mirrax ESR hardness approx. 250 HB.

TURNING

Cutting data parameter	Turning with carbide Rough turning	Fine turning	Turning with HSS* Fine turning
Cutting speed (v_c) m/min f.p.m.	160–210 525–690	210–260 690–850	18–23 59–75
Feed (f) mm/rev i.p.r.	0.2–0.4 0.008–0.016	0.05–0.2 0.002–0.008	0.05–0.3 0.002–0.01
Depth of cut (a_p) mm inch	2–4 0.08–0.16	0.5–2 0.02–0.08	0.5–3 0.02–0.1
Carbide designation ISO US	P20–P30 C6–C5 Coated carbide	P10 C7 Coated carbide or cermet	– –

* HSS = High Speed Steel

MILLING

FACE AND SQUARE SHOULDER MILLING

Cutting data parameter	Milling with carbide Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m.	160–240 525–787	240–280 787–919
Feed (f_z) mm/tooth in/tooth	0.2–0.4 0.008–0.016	0.1–0.2 0.004–0.008
Depth of cut (a_p) mm inch	2–4 0.08–0.16	0.5–2 0.02–0.08
Carbide designation ISO US	P20–P40 C6–C5 Coated carbide	P10–P20 C7–C6 Coated carbide or cermet

END MILLING

Cutting data parameter	Type of end mill Solid carbide	Carbide indexable insert	HSS
Cutting speed (v_c) m/min f.p.m.	120–150 390–500	160–220 525–722	25–30[1] 82–100[1]
Feed (f_z) mm/tooth in/tooth	0.01–0.20[2] 0.0004–0.008[2]	0.06–0.20[2] 0.002–0.008[2]	0.01–0.3[2] 0.0004–0.01[2]
Carbide designation ISO US	– –	P20–P30 C6–C5	– –

[1] For coated HSS end mill v_c = 45–50 m/min. (150–165 f.p.m.)

[2] Depending on radial depth of cut and cutter diameter

DRILLING

HIGH SPEED STEEL TWIST DRILLS

Drill diameter mm	inch	Cutting speed (v_c) m/min	f.p.m.	Feed (f) mm/rev	i.p.r.
–5	–3/16	14–16*	46–52*	0.05–0.15	0.002–0.006
5–10	3/16–3/8	14–16*	46–52*	0.15–0.20	0.006–0.008
10–15	3/8–5/8	14–16*	46–52*	0.20–0.25	0.008–0.010
15–20	5/8–3/4	14–16*	46–52*	0.25–0.30	0.010–0.014

* For coated HSS drill v_c = 22–24 m/min. (72–79 f.p.m.)

CARBIDE DRILL

Cutting data parameter	Type of drill Indexable insert	Solid carbide	Carbide tip[1]
Cutting speed (v_c) m/min f.p.m.	210–230 689–755	80–100 262–328	70–80 230–262
Feed (f) mm/rev i.p.r.	0.03–0.10[2] 0.0012–0.004[2]	0.10–0.25[3] 0.004–0.01[3]	0.15–0.25[3] 0.006–0.01[4]

[1] Drill with replaceable or brazed carbide tip

[2] Feed rate for drill diameter 20–40 mm (0.8"–1.6")

[3] Feed rate for drill diameter 5–20 mm (0.2"–0.8")

[4] Feed rate for drill diameter 10–20 mm (0.4"–0.8")

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm publication "Grinding of tool steel"

Type of grinding	Wheel recommendations Delivery 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 JV
Profile grinding	A 100 KV	A 120 JV

WELDING

Good results when welding tool steel can be achieved if proper techniques are used. Precautions such as preheating, heat treatment, post weld heat treatment, joint preparation, selection of consumables, etc. are required.

For best result after polishing and photo-etching use consumables with a matching chemical composition to the mould steel.

Welding method	TIG
Working temperature	200–250°C (390–480°F)
Welding consumables	MIRRAX TIG-WELD
Hardness after welding	53–56 HRC
Heat treatment after welding:	
Hardened condition	Temper at 10–20°C (50–70°F) below the original tempering temperature.
Delivery condition	Heat treat to 700°C (1290°F) for 5 hours. Then cool freely in air.

LASER WELDING

For laser welding Uddeholm Stavax laser weld rods are available. See the information leaflet "Uddeholm Laser Welding Rods".

Further information is given in the Uddeholm brochure "Welding of Tool Steel" or nearest Uddeholm sales office.

POLISHING

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

A slightly different technique, in comparison with other Uddeholm mould steel, should be used. The main principle is to use smaller steps at the fine-grinding/polishing stages and not to start polishing on too rough of a surface.

It is also important to stop the polishing woperation immediately after the last scratch from the former grit size has been removed.

More detailed information on polishing techniques is given in the brochure "Polishing of tool steel".

PHOTO-ETCHING

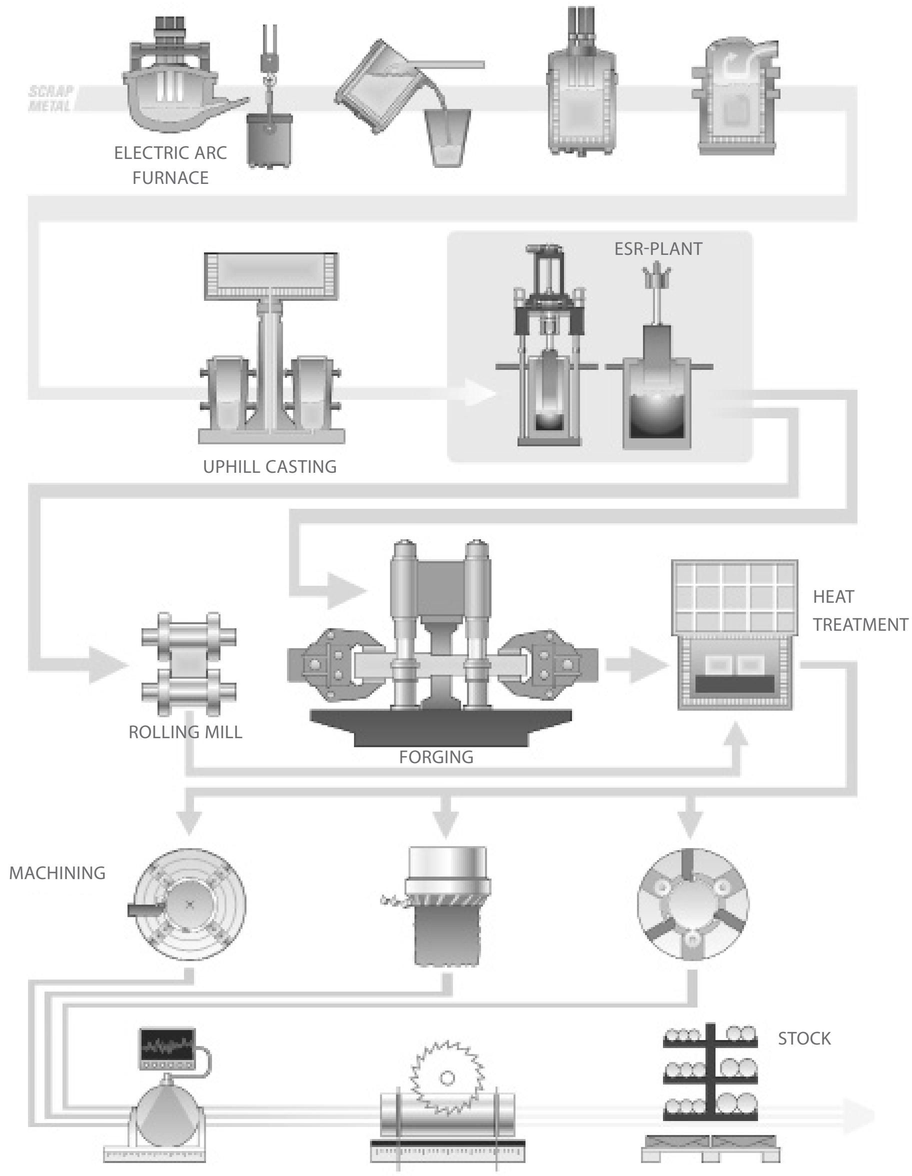
Uddeholm Mirrax ESR has a very low inclusion content and a homogeneous microstructure. The high cleanliness level provides for good photo-etching/texturing characteristics.

The special photo-etching process that might be necessary because of Uddeholm Mirrax ESR's good corrosion resistance is familiar to all the leading photo-etching companies.

Further information is given in the Uddeholm brochure "Photo-etching of tool steel".

FURTHER INFORMATION

Please contact your local Uddeholm office for further information on the selection, heat treatment and application of Uddeholm tool steel, including the publication "Steel for moulds".



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.

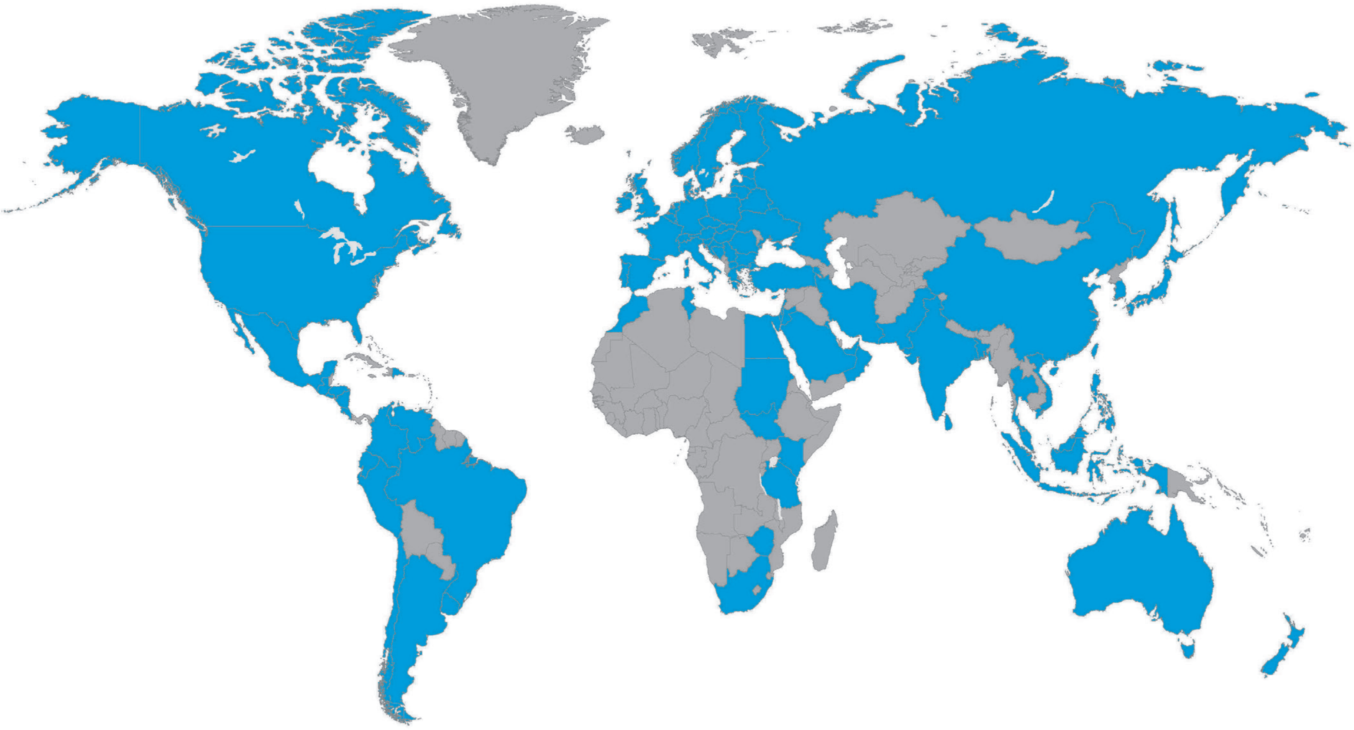
HOT WORKING

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.

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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 secure our position as the world's leading supplier of tooling materials. We act worldwide. For us it is all a matter of trust – in long-term partnerships as well as in developing new products.

For more information, please visit www.uddeholm.com

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