Uddeholm
Stavax® ESR

UDDEHOLM
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Uddeholm Stavax® ESR

Uddeholm Stavax ESR is a premium stainless mould steel for small and medium inserts and cores. Uddeholm Stavax ESR combines corrosion and wear resistance with excellent polishability, good machinability and stability in hardening.

Mould maintenance requirement is reduced by assuring that core and cavity surfaces retain their original finish over extended operating periods. When compared with non stainless mould steel, Uddeholm Stavax ESR offers lower production costs by maintaining rust free cooling channels, assuring consistent cooling and cycle time.

This classic stainless tool steel is the right choice when rust in production is unacceptable and where requirements for good hygiene are high, as within the medical industry, optical industry and for other high quality transparent parts.

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

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

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GENERAL

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

- good corrosion resistance
- excellent polishability
- good wear resistance
- good machinability
- good stability in hardening

The combination of these properties results in a tool steel with outstanding production performance. The practical benefits of good corrosion resistance in a plastics mould can be summarized as follows:

Lower mould maintenance costs

The surface of cavity impressions retain their original finish over extended running periods.

Moulds stored or operated in humid conditions require no special protection.

Lower production costs

Since water cooling channels are unaffected 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 Stavax ESR, offer the moulder low-maintenance, long-life moulds for the greatest overall moulding economy.

Note: Uddeholm Stavax ESR is produced using Electro-Slag-Refining (ESR) technique, resulting in a very low inclusion content.

Typical analysis %	C 0.38	Si 0.9	Mn 0.5	Cr 13.6	V 0.3
Standard specification	AISI 420 modified				
Delivery condition	Soft annealed to approx. 190 HB.				
Colour code	Black/Orange				

APPLICATIONS

Uddeholm Stavax ESR is recommended for all types of moulding tools and 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.
- **Wear resistance,** i.e. for moulding abrasive/filled materials, including injection-moulded thermosetting grades. Uddeholm Stavax ESR is recommended for moulds with long production runs, e.g. disposable cutlery and containers.
- **High surface finish,** i.e. for the production of optical parts, such as camera and sunglasses lenses, and for medical containers, e.g. syringes, analysis phials.

Typof mould	Recommended hardness HRC
Injection mould for: - thermoplastic materials - thermosetting materials	 45-52 45-52
Compression/transfer moulds	45-52
Blow moulds for PVC, PET, etc.	45-52
Extrusion, pultrusion dies	45-52

Uddeholm Stavax ESR core to make disposable polystyrene beakers. Millions of close tolerance mouldings with a very high surface finish have been produced.

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/m³ lbs/in³	7800 0.282	7750 0.280	7700 0.277
Modulus of elasticity N/mm² tsi psi (UK)	210 000 13 600 30.5 x 10⁶	200 000 12 900 29.0 x 10⁶	185 000 12 000 26.8 x 10⁶
Coefficient of thermal expansion /°C from 20°C /°F from 68°F	- -	11.0 x 10⁻⁶ 6.1 x 10⁻⁶	11.4 x 10⁻⁶ 6.3 x 10⁻⁶
Thermal conductivity* W/m °C Btu in/(ft2h °F)	16 110	20 138	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 approximate only. All samples were taken from a bar (in the rolling direction) 25 mm (1") diameter. Hardened in oil from 1025 ±10°C (1880 ±20°F) and tempered twice to the hardness indicated.

Hardness	50 HRC	45 HRC
Tensile strength Rm N/mm² kp/mm² psi	1 780 180 258 000	1 420 145 206 000
Modulus of elasticity N/mm² tsi psi (UK)	1 360 150 197 000	1 280 130 186 000

Corrosion resistance

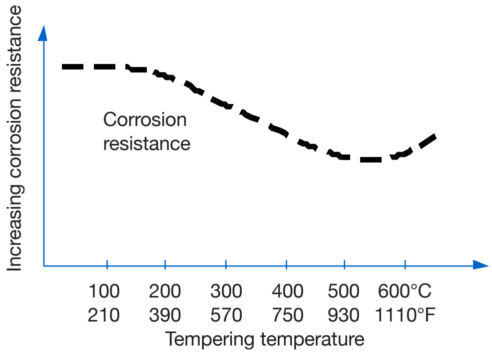
Uddeholm Stavax ESR is resistant to corrosive attack by water, water vapour, weak organic acids, dilute solutions of nitrates, carbonates and other salts.

A tool made from Uddeholm Stavax ESR 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.

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

THE INFLUENCE OF TEMPERING TEMPERATURE ON CORROSION RESISTANCE



HEAT TREATMENT

Soft annealing

Protect the steel and heat through to 890°C (1630°F). Then cool in the furnace at 20°C (40°F) per hour to 850°C (1560°F), then at 10°C (20°F) per hour to 700°C (1290°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: 600–850°C (1110–1560°F).

Austenitizing temperature: 1000–1050°C (1830–1920°F), but usually 1020–1030°C (1870–1885°F).

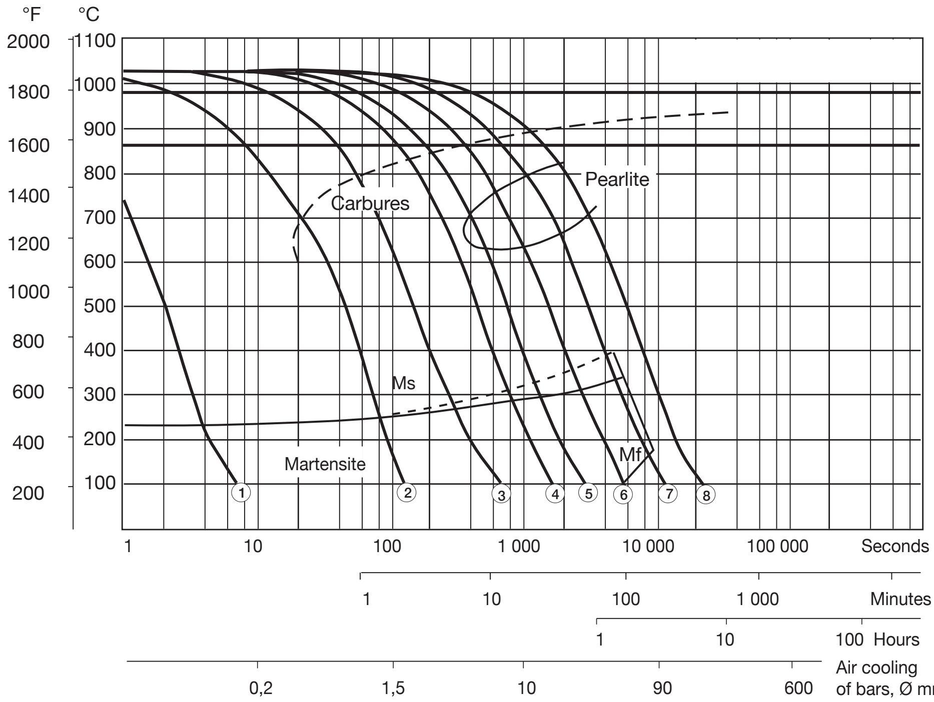
Temperature		Soaking time* minutes	Hardnessbefore tempering
°C	°F		
1020	1870	30	56±2 HRC
1050	1920	30	57±2 HRC

* 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 1030°C (1890°F). Holding time 30 minutes.



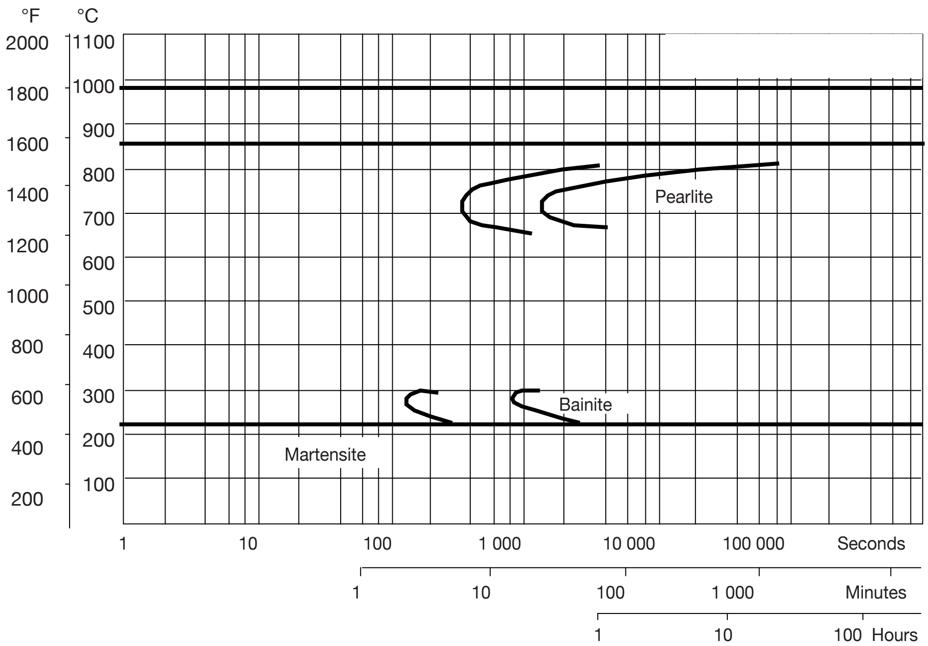
A_{C1f} = 980°C (1800°F)

A_{C1s} = 860°C (1580°F)

Cooling curve no.	Hardness HV10	T800-500 (sec)
1	649	1
2	634	31
3	613	105
4	592	316
5	585	526
6	421	1052
7	274	2101
8	206	4204

TTT-graph

Austenitizing temperature 1030°C (1890°F). Holding time 30 minutes.



A_{C1f} = 980°C (1800°F)

AC1s = 860°C (1580°F)

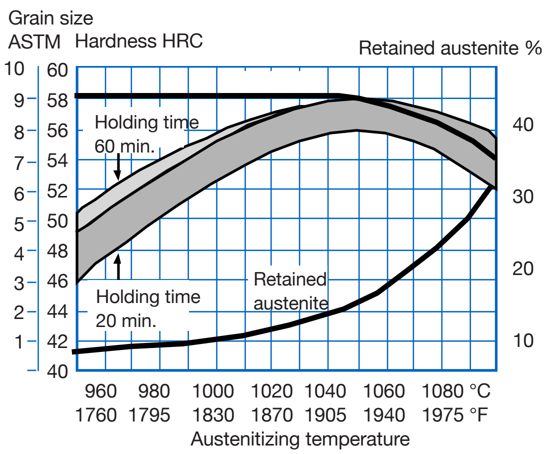
Temp. °C	Time hours	Hardness HV10
800	16.7	173
750	1.8	199
700	0.5	218
650	2.3	240
600	18.3	268
550	18.0	542
500	15.3	613
350	73.6	649
300	7.9	560
275	0.4	606
250	17.2	536

Quenching media

- Fluidized bed or salt bath at 250–550°C (480–1020°F), then cool in air blast
- Vacuum with sufficient positive pressure
- High speed gas/circulating atmosphere

In order to obtain optimum properties, the cooling rate should be as fast as is concomitant with acceptable distortion. When heat treating in a vacuum furnace, a 4–5 bar overpressure is recommended. Temper immediately when the tool reaches 50–70°C (120–160°F).

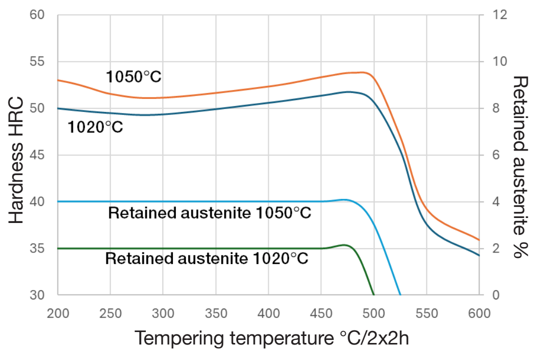
Hardness, grain size and retained austenite as a function of the austenitizing temperature



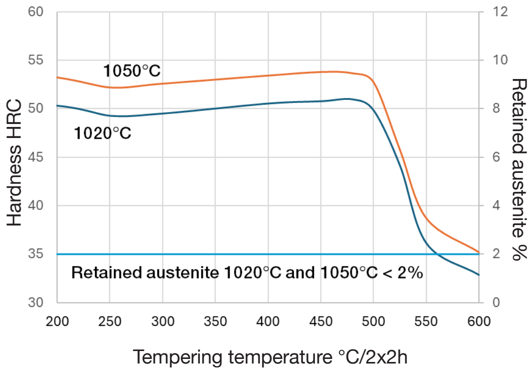
Tempering

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with intermediate cooling to room temperature.

Tempering graph without deep cooling after the quenching



Tempering graph with deep cooling after the quenching (-196°C, -321°F)



The tempering curves are obtained from hardness test of samples taken from the centre of a bar with 100 mm diameter.

Hardening temperature: 1020°C
Quenching over pressure: 5 bar.

Lower hardness can be expected after heat treatment of tools and dies due to factors like actual tool size and heat treatment parameters.

Lowest tempering temperature 250°C (480°F). Holding time at temperature minimum 2 hours.

Note that:

- tempering at 250°C (480°F) is recommended for the best combination of toughness, hardness and corrosion resistance
- the curves are valid for small samples, achieved hardness depends on mould size
- a combination of high austenitizing temperature and low tempering temperature <250°C (<480°F) gives a high stress level in the mould and should be avoided

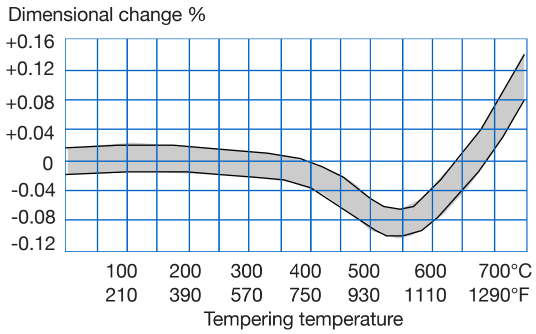
Dimensional changes

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

The size and geometric shape of the tool is also of essential importance. Thus, the tool shall always be manufactured with enough working allowance to compensate for dimensional changes. Use 0.15% as a guideline for Uddeholm Stavax ESR provided that a stress relief is performed between rough and semi-finished machining as recommended.

During tempering

(Note: valid for samples not deep cooled)



During hardening

An example of dimensional changes on a plate, hardened under ideal conditions 100 x 100 x 25 mm (4" x 4" x 1") is shown below.

Hardening from 1020°C (1870°F)		Width %	Length %	Thickness %
Martempered	Min. Max.	+0.02 -0.03	±0 +0.03	-0.04 -
Air hardened	Min. Max.	-0.02 +0.02	±0 -0.03	±0 -
Vacuum hardened	Min. Max.	+0.01 -0.02	±0 +0.01	-0.04 -

Note: Dimensional changes during hardening and tempering should be added together.

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".

Turning

Cutting data parameter	Turning with carbide		Turning with high speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min. f.p.m.	160–210 525–690	210–260 690–850	18–23 60–75
Feed (f) mm/r 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 (ap) 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	P20–P30 Coated carbide	P10 Coated carbide or cermet	-

Drilling

High speed steel twist drills

Drill diameter		Cutting speed (V_c)		Feed (f)	
mm	inch	m/min	f.p.m.	mm/r	i.p.r.
-5	–3/16	12–14*	40–47*	0.05–0.10	0.002–0.004
5-10	3/16–3/8	12–14*	40–47*	0.10–0.20	0.004–0.008
10-15	3/8–5/8	12–14*	40–47*	0.20–0.30	0.008–0.012
15-20	5/8–3/4	12–14*	40–47*	0.30–0.35	0.012–0.014

* For coated HSS drill v_c = 20–22 m/min. (65–70 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.	210–230 690–755	80–100 265–330	70–80 230–265
Feed (f_z) mm/tooth inch/tooth	0.05–0.15[2] 0.002–0.006[2]	0.08–0.20[3] 0.003–0.008[3]	0.15–0.25[4] 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")

Milling

Face and square shoulder face milling

Cutting data parameter	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min. f.p.m.	180–260 600–865	260–300 865–985
Feed (f_z) mm/tooth inch/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	P20–P40 Coated carbide	P10–P20 Coated carbide or cermet

End milling

Cutting data parameter	Type of end mill		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min. f.p.m.	120–150 390–500	170–230 560–755	25–30[1] 85–100[1]
Feed (f_z) mm/tooth inch/tooth	0.01–0.2[2] 0.0004–0.008[2]	0.06–0.2[2] 0.002–0.008[2]	0.01–0.30[2] 0.0004–0.01[2]
Carbide designation ISO	-	P20–P30	-

[1] For coated HSS end mill vc = 45–50 m/min. (150–165 f.p.m.)
[2] 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 publication "Grinding of Tool Steel".

Wheel recommendation		
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 LV	A 120 KV

WELDING

Good results when welding tool steel can be achieved if proper precautions are taken to elevated working temperature, joint preparation, choice of consumables and welding procedure.

For best result after polishing and photo-etching use consumables with the same composition as in the mould.

Welding method	TIG
Working temperature	200–250°C
Welding consumables	STAVAX TIG-WELD
Hardness after welding	54–56 HRC
Heat treatment after welding:	
Hardened condition	Temper at 10–20°C (50–70°F) below the original tempering temperature.
Soft annealed condition	Heat through to 890°C (1630°F) in protected atmosphere. Then cool in the furnace at 20°C (40°F) per hour to 850°C (1560°F), then at 10°C (20°F) per hour to 700°C (1290°F), then freely in air.

Further information is given in the Uddeholm brochure "Welding of Tool Steel".

Laser Welding

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

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

PHOTO-ETCHING

Uddeholm Stavax ESR has a very low content of slag inclusions, making it suitable for photo-etching. The special photo-etching process that might be necessary because of Uddeholm Stavax ESR's good corrosion resistance is familiar to all the leading photo-etching companies. Further information is given in the Uddeholm publication "Photo-etching of tool steel".

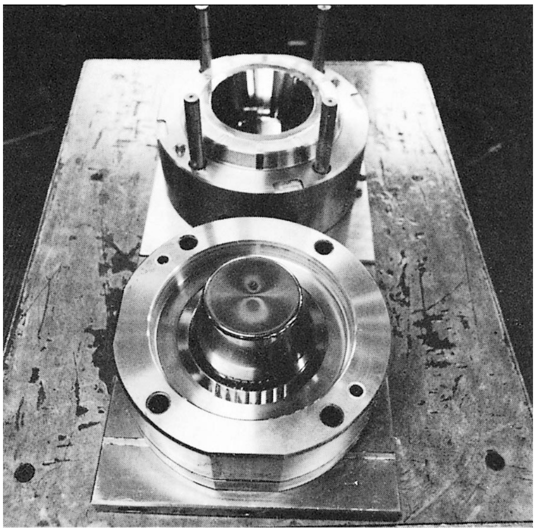
POLISHING

Uddeholm Stavax 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 a surface. It is also important to stop the polishing operation *immediately* the last scratch from the former grain size has been removed.

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



Mould in Uddeholm Stavax ESR for producing clear plastic bowls.

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 de-gassing 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.

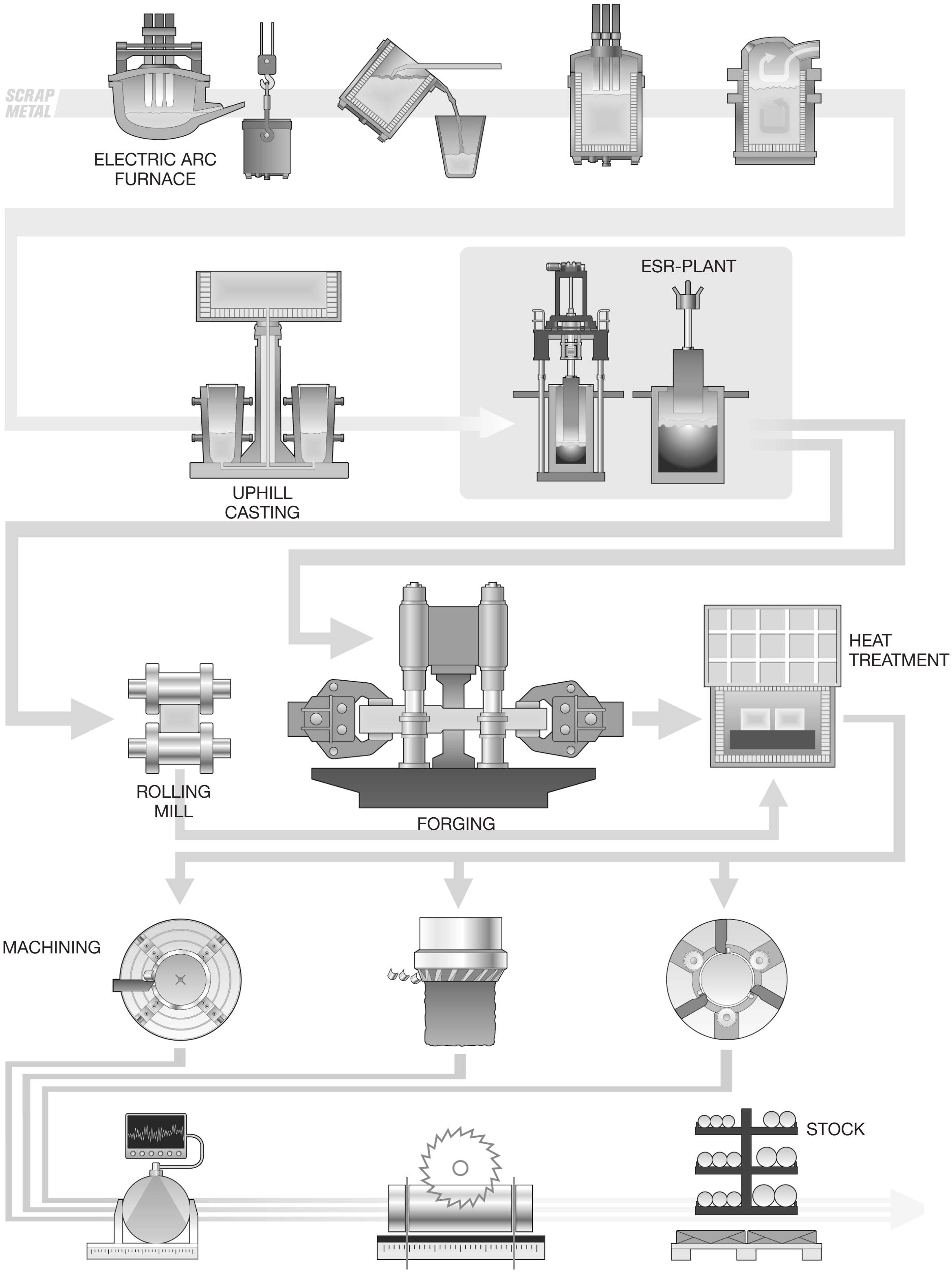
Hot Working

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.


SCRAP METAL
ELECTRIC ARC FURNACE
UPHILL CASTING
ESR-PLANT
ROLLING MILL
FORGING
HEAT TREATMENT
MACHINING
STOCK

Manufacturing solutions for generations to come

SHAPING THE WORLD®

We are shaping the world together with the global manufacturing industry. Uddeholm manufactures steel that shapes products used in our every day life. We do it sustainably, fair to people and the environment. Enabling us to continue shaping the world – today and for generations to come.

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