Uddeholm Orvar® 2 Microdized

UDDEHOLM
a voestalpine company

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

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CERTIFIED
ISO 9001 · OHSAS 18001
ISO 14001 · ISO 50001

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 0.39	Si 1.0	Mn 0.4	Cr 5.2	Mo 1.4	V 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

Aluminium, Part	Copper magnesium alloys, HRC	Stainless alloys HRC	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)	

PLASTIC MOULDING APPLICATIONS

Part	Austenitizing temp. (approx.)	HRC
Injection moulds Compression/ transfer moulds	1020–1030°C (1870–1885°F) or 550–580°C (1020–1080°F)	48–50

OTHER APPLICATIONS

Application	Austenitizing temp. (approx.)	HRC
Severe cold punching, scrap shears	1020–1030°C (1870–1885°F) Tempering 250°C (480°F)	50–52
Hot shearing	1020–1030°C (1870–1885°F) Tempering 250°C (480°F) or 575–600°C (1070–1110°F)	50–52 45–50
Shrink rings (e.g. for cemented carbide dies)	1020–1030°C (1870–1885°F) Tempering 575–620°C (1070–1110°F)	45–50
Wear-resisting parts	1020–1030°C (1870–1885°F) Tempering 575°C (1070°F) Nitriding	In core 50–52 On surface ~1000 HV_1

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

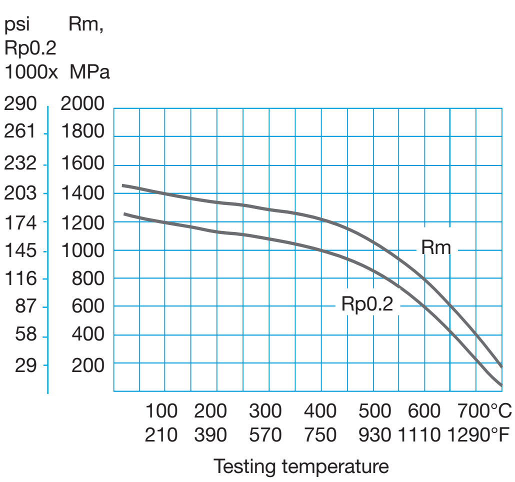
MECHANICAL PROPERTIES

Approximate tensile strength at room temperature.

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

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).

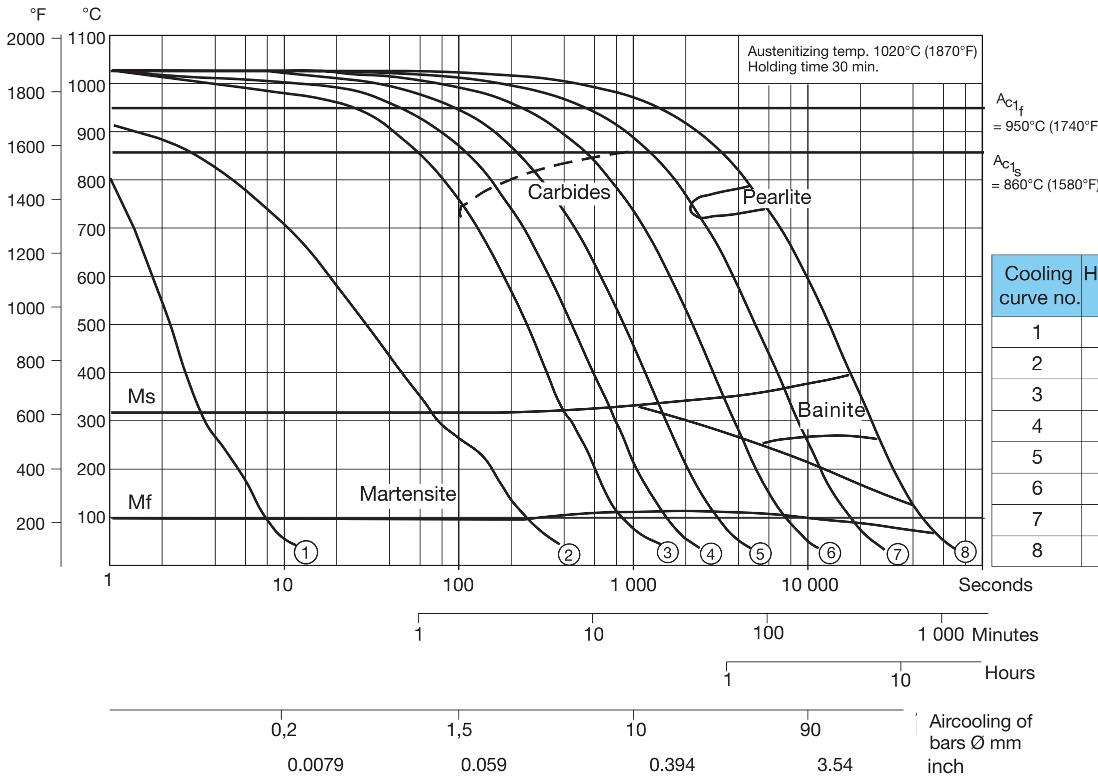
Temperature °C	Temperature °F	Soaking* time minutes	Hardness before tempering
1025	1875	30	53±2 HRC
1050	1920	15	54±2 HRC

* 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



Cooling curve no.	Hardness HV10	T800-500 (sec)
1	654	1
2	586	37
3	586	160
4	574	280
5	560	560
6	551	1390
7	517	3220
8	451	8360

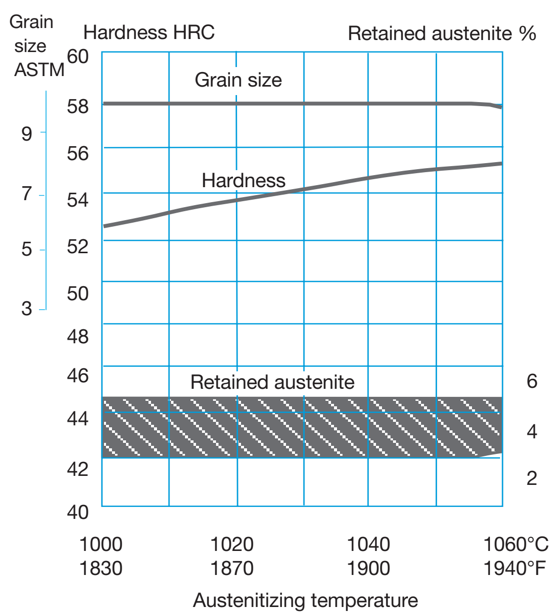
QUENCHING MEDIA

- 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

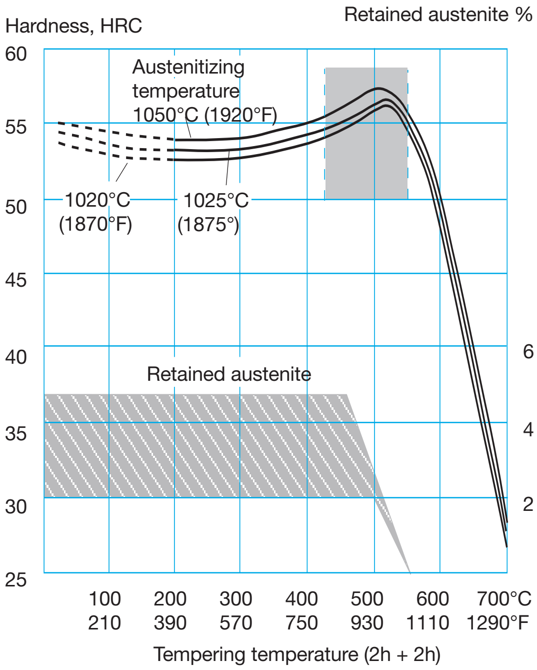


TEMPERING

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.

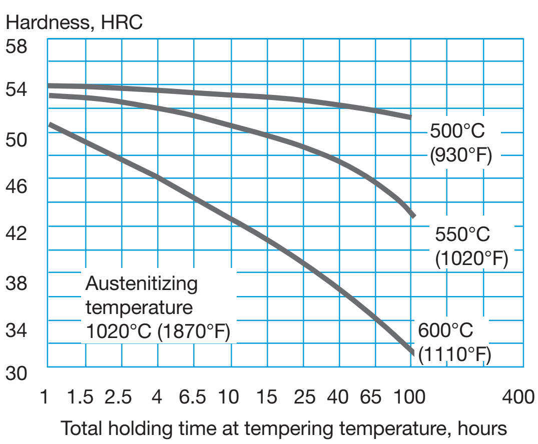
TEMPERING GRAPH



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

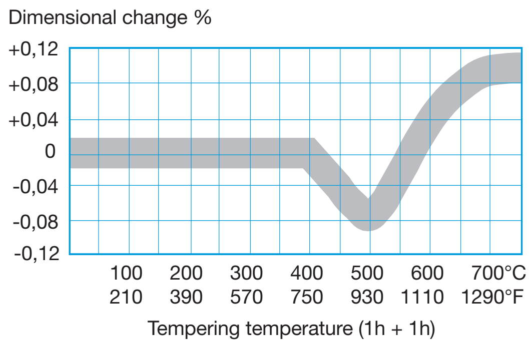


DIMENSIONAL CHANGES DURING HARDENING

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

		Width %	Length %	Thickness %
Oil hardened from 1000°C (1870°F)	min max	–0.08 –0.15	–0.06 –0.16	0.00 +0.30
Air hardened from 1020°C (1870°F)	min max	–0.02 +0.03	–0.05 +0.02	±0 +0.05
Vac hardened from 1020°C (1870°F)	min max	+0.01 +0.02	–0.02 –0.04	+0.08 +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 tem-pered 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 $HV_{0.2}$. 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 re-com-mended 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 $HV_{0.2}$.

DEPTH OF NITRIDING

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

Nitriding to case depths >0.3 mm (0.012 inch) is not recommended for hot-work applica-tions. 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

Turning with Cutting data parameters	Turning carbide Rough turning	 Fine turning	with high speed steel Fine turning
Cutting speed (v_c) m/min f.p.m.	200–250 200–250 656–820	250–300 250–300 820–984	25–30 25–30 82–98
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 (a_p) mm inch	2–4 0.08–0.16	0.5–2 0.02–0.08	0.5–3 0.02–0.12
Carbide designation ISO US	P20–P30 C6–C5 Coated carbide	P10 C7 Coated carbide or cermet	– –

DRILLING

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm	inch	Cutting speed, v_c m/min	f.p.m.	Feed, f 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 = 28–30 m/min. (92–98 f.p.m.)

CARBIDE DRILL

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

Milling with carbide Cutting data parameters	Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m.	180–260 591–853	260–300 853–984
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	2–5 0.08–0.2	–2 –0.08
Carbide designation ISO US	P20–P40 C6–C5 Coated carbide	P10–P20 C6–C7 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) m/min f.p.m.	160–200 525–660	170–230 560–755	35–40[1] 115–130[1]
Feed (f_z) mm/tooth inch/tooth	0.03–0.20[2] 0.001–0.008[2]	0.08–0.20[2] 0.003–0.008[2]	0.05–0.35[2] 0.002–0.014[2]
Carbide designation ISO	–	P20, P30	–

1) For coated HSS end mill v_c = 55–60 m/min. (180–195 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 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 – EDM

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 DIEVAR TIG-WELD	QRO 90 WELD 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 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 con-sistent 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 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.

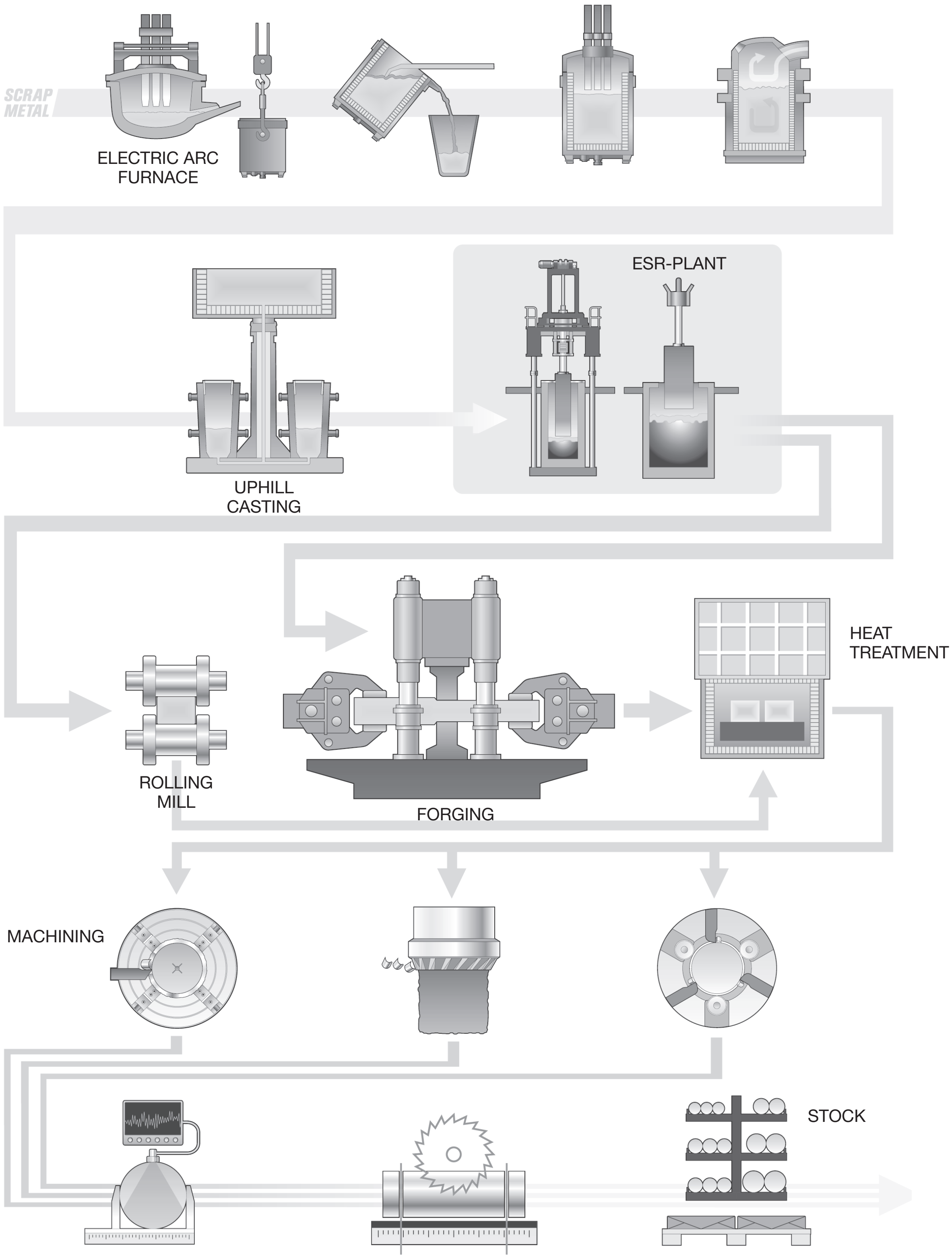
HOT WORKING

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
HEAT TREATMENT
ROLLING MILL
FORGING
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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