Uddeholm
Calmax®

UDDEHOLM
a voestalpine company

Uddeholm Calmax®

TOOLING ENVIRONMENT

Many presswork tools used today are still made of standard steel grades of which some of them were developed already around 1930. The poor toughness, flame and induction hardenability of these grades often results in low productivity and high maintenance costs due to unexpected tool failure. Uddeholm Calmax offers due to its higher toughness a higher degree of safety that is essential for better tooling performance and productivity.

PROPERTY PROFILE

Uddeholm Calmax is a tool steel with property profile devoted to safe production, i.e. high chipping and cracking resistance and fairly good wear resistance.

APPLICATIONS

The property profile of Uddeholm Calmax makes it very suitable for low to medium production volume tooling exposed to high stresses.

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".

Edition 9, 05.2021

CERTIFIED
ISO 9001 · OHSAS 18001
ISO 14001 · ISO 50001

GENERAL

Uddeholm Calmax is a chromium molyb-denum-vanadium alloyed steel characterized by:

- High toughness
- Good wear resistance
- Good through hardening properties
- Good dimensional stability in hardening
- Good polishability
- Good weldability

Typical analysis %	C 0.6	Si 0.35	Mn 0.8	Cr 4.5	Mo 0.5	V 0.2
Delivery condition	Soft annealed to approx. 200 HB					
Colour code	White/violet					
Standard specifications	W. -Nr. 1.2358					

APPLICATIONS

The excellent combination of toughness and wear resistance makes Uddeholm Calmax suitable for different applications.

TYPICAL COLD WORK APPLICATIONS

- Blanking and forming
- Heavy duty blanking and forming
- Deep drawing
- Coining
- Cold extrusion
- Rolls
- Shear blades
- Prototype tooling

PLASTIC MOULDING APPLICATIONS

- Long run moulds
- Moulds for reinforced plastics
- Moulds for compression moulding

PROPERTIES

Samples hardened at 960°C/30min and double tempered at 450°C.

PHYSICAL DATA

Temperature	20°C (68°F)	200°C (400°F)	400°C (750°F)
Density kg/m³ lbs/in³	 7 840 0.281	 7 790 0.279	 7 700 0.276
Modulus of elasticity N/mm² Psi	 210 000 30.5 x 10⁶	 200 000 29.0 x 10⁶	 180 000 26.1 x 10⁶
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	– – – –	to 200°C 12.2×10^{-6} to 400°F 6.8×10^{-6}	to 400°C 13.1×10^{-6} to 750°C 7.3×10^{-6}
Thermal conductivity W/m °C Btu in (ft²h°F)	 – –	 24 187	 27 221
Specific heat J/kg°C Btu/lbs°F	 460 0.11	 – –	 – –

COMPRESSIVE STRENGTH

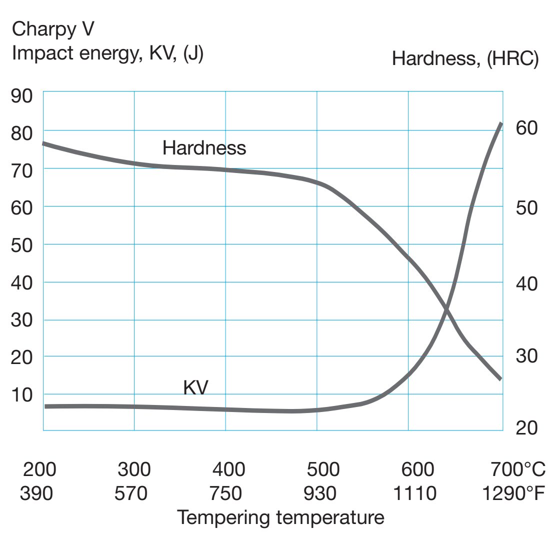
Approximate values at room temperature.

Hardness HRC	Rcm N/mm²	Rc0,2 N/mm²
56	2300	1900
58	2500	2000
60	2700	2100

IMPACT STRENGTH AND HARDNESS

Approximate values at room temperature for different tempering temperatures. Hardened at 960°C (1760°F). Quenched in air. Temp-ered twice.

Bar dimension 315 x 80 mm. Samples from centre of bar in ST (thickness) direction.



HEAT TREATMENT

SOFT ANNEALING

Protect the steel and heat through to 860°C (1580°F), holding time 2h. Cool in furnace 20°C/h to 770°C (35°F/h to 1420°F), then 10°C/h to 650°C (18°F/h to 1200°F) and subsequently freely in air.

STRESS RELIEVING

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

HARDENING

Preheating: 600–750°C (1110–1380°F).

Austenitizing temperature: 950–970°C (1740–1780°F), normally 960°C (1760°F).

Temperature °C	Temperature °F	Holding* time minutes	Hardness before tempering (HRC)
950	1740	30	62
960	1760	30	63
970	1780	30	64

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

Protect the part against decarburization and oxidation during hardening.

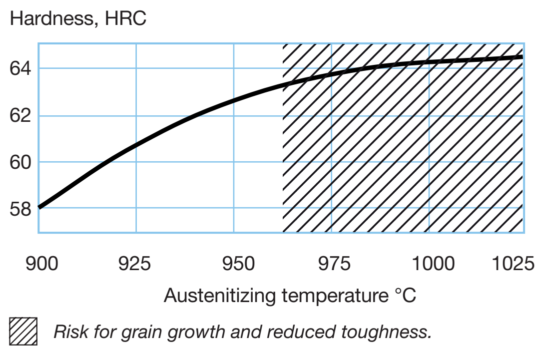
QUENCHING

- Forced air/gas.
- Vacuum furnace with sufficient overpressure.
- Martempering bath or fluidized bed at 200–550°C (320–1020°F) followed by forced air cooling.
- Oil.

Note 1: Quenching in oil gives an increased risk for dimensional changes and cracks.

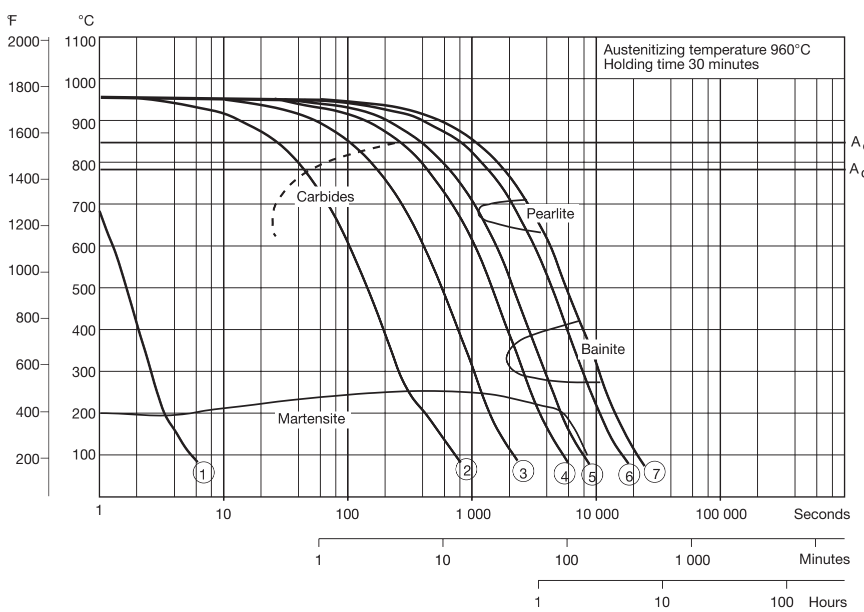
Note 2: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

Hardness and retained austenite as a function of austenitizing temperature.



CCT-GRAPH

Austenitizing temperature 960°C (1760°F). Holding time 30 minutes.

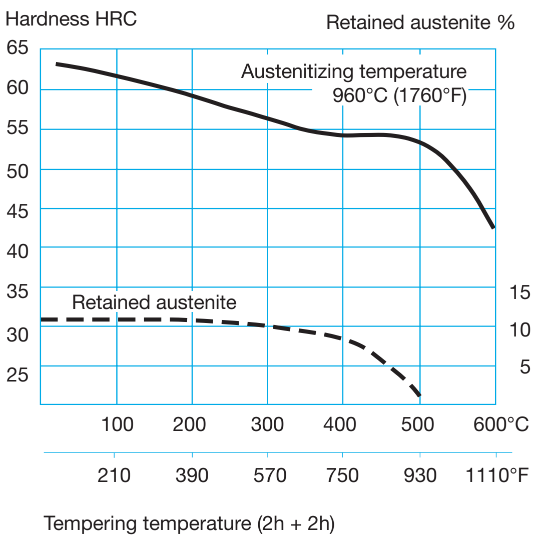


Cooling curve no.	Hardness HV10	T800-500 (sec)
1	820	1
2	762	107
3	743	423
4	734	1071
5	657	1596
6	455	3228
7	413	4292

TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with inter-mediate cooling to room temperature. Lowest tempering temperature 180°C (360°F). Holding time at temperature minimum 2h.

TEMPERING GRAPH

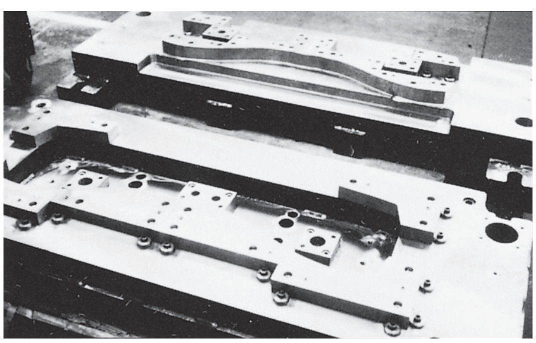


Above tempering curve is obtained after heat treatment of samples with a size of 15 x 15 x 40 mm, cooling in forced air. Lower hardness can be expected after heat treatment of tools and dies due to factors like actual tool size and heat treatment parameters.

DIMENSIONAL CHANGES

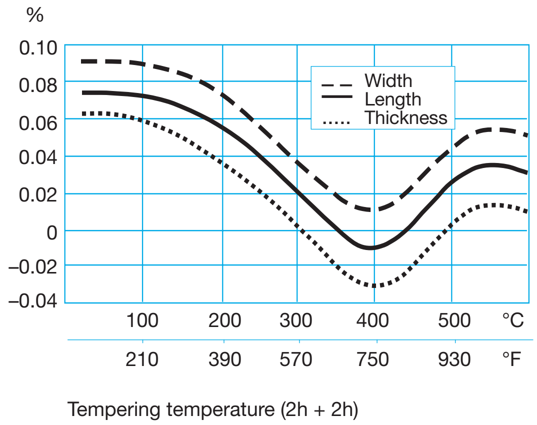
The dimensional changes during hardening and tempering vary depending on temperature, type of equipment and cooling media used during heat treatment.

The size and geometric shape of the tool are also of essential importance. Thus the tool should always be manufactured with enough working allowance to compensate for distor-tion. Use 0,20% as a guideline for Uddeholm Calmax.



Typical blanking die where Uddeholm Calmax could be used because of the high demands on toughness.

An example of dimensional changes for a plate 100 x 100 x 10 mm, hardened and tempered under ideal conditions, is shown in the figure below. Hardening: 960°C (1760°F)/30 min./air.



SURFACE TREATMENT

Some tools are given a surface treatment in order to reduce friction and increase tool wear resistance. The most commonly used treatments are nitriding and surface coating with wear resistant layers of titanium carbide and titanium nitride (CVD, PVD).

Two commonly used nitriding processes are ion nitriding and gas nitriding. Ion nitriding is normally performed at a lower temperature than gas nitriding and is, therefore, the preferred method for Uddeholm Calmax when a substrate hardness of ~54 HRC is required.

Nitriding process	Temp. °C (°F)	Time (h)	Case depth µm	Substrate hardness HRC	Case hardness HV
Ion	465* (870*)	18	200	54	1075
Gas	510* (950*)	12	200	52	1075

* The nitriding temperature used should be 15–25°C (59–77°F) lower than the previously used tempering temperature

A thick case depth considerably reduces the toughness of the tool. The case depth, which can be controlled by the nitriding time, should be selected to suit the application in question.

Uddeholm Calmax can also be CVD coated but the deposition temperature should not exceed 960°C (1760°F). The tool should be re-hardened after being coated.

PVD coatings are usually deposited at temperatures between 200°C (390°F) and 500°C (930°F). If 200°C (390°F) is used, the Uddeholm Calmax substrate hardness will be higher than that obtained at a deposition temperature of 500°C (930°F). However, the adhesion of the coating on the steel is better if a deposition temperature of 500°C (930°F) is used. The PVD deposition temperature should be approx. 20°C (68°F) lower than the previously used tempering temperature.

MACHINING RECOMMENDATIONS

The cutting data below are to be considered as guiding values which must be adapted to existing local condition.

The cutting data recommendations, in following tables, are valid for Uddeholm Calmax in soft annealed condition to approx 200 HB.

TURNING

Cutting data parameters	Rough turning carbide	Fine turning carbide	Fine turning High speed steel
Cutting speed (v_c) m/min f.p.m	150–200 492–656	200–250 656–820	20–25 66–82
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	Drill diameter inch	Cutting speed (v_c) mm	Cutting speed (v_c) inch	Feed (f) mm/r	Feed (f) i.p.r.
–5	–3/16	13–15*	43–49*	0.05–0.10	0.002–0.004
5–10	3/16–3/8	13–15*	43–49*	0.10–0.20	0.004–0.008
10–15	3/8–5/8	13–15*	43–49*	0.20–0.25	0.008–0.010
15–20	5/8–3/4	13–15*	43–49*	0.25–0.30	0.010–0.012

* For coated HSS drill v_c =23–25 m/min. (75–82 f.p.m.)

CARBIDE DRILL

Cutting data parameters	Type of drill: Solid carbide	Indexable insert	Carabide tip[1]
Cutting speed (v_c) m/min f.p.m	120–150 394–492	210–230 689–755	70–100 230–328
Feed (f) mm/r i.p.r	0.10–0.35[2] 0.004–0.014[2]	0.03–0.12[3] 0.001–0.005[3]	0.15–0.40[4] 0.006–0.016[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 SIDE MILLING

Cutting data parameters	Rough milling carbide	Fine milling carbide
Cutting speed (v_c) m/min f.p.m	160–240 525–787	240–280 722–919
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	2–5 0.08–0.20	–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	120–150 394–492	150–200 492–656	40–45[1] 131–148[1]
Feed (f_z) mm/tooth in/tooth	0.006–0.20[2] 0.0002–0.008[2]	0.06–0.20[2] 0.002–0.008[2]	0.01–0.35[2] 0.0004–0.014[2]
Carbide designation ISO US	– –	P15–P40 C6–C5	– –

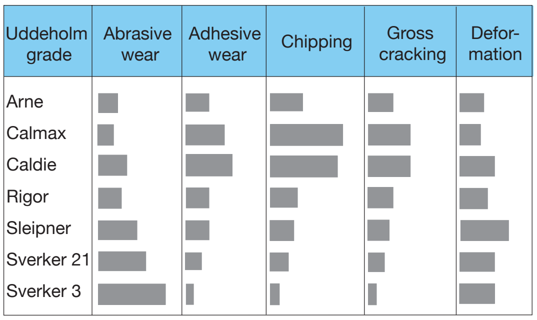
[1] For coated HSS end mill v_c =55–60 m/min. (180–197 f.p.m.).
[2] Depending on radial depth of cut and cutter diameter.

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm brochure "Grinding of Tool Steel".

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 JV
Profile grinding	A 100 LV	A 120 JV

RESISTANCE TO FAILURE MECHANISMS



Cold work product where Uddeholm Calmax would be a good choice for the die.

WELDING

Good results when welding Uddeholm Calmax can be achieved if proper pre-cautions are taken.

1. Always keep the arc length as short as possible. The electrode should be angled at 90° to the joint sides to minimize under cut. In addition, the electrode should be held at an angle of 75–80° to the direction of forward travel.

2. For large repairs, weld the initial layers with a soft weld metal. Make the two first layers with the same electrode diameter and current.

3. Large repair welds should be made at elevated temperature.

4.The joints should be prepared properly.

TIG WELDING RECOMMENDATIONS

Consumables	Hardness as welded	Hardness after rehardening	Preheat temper
UTPA 73G2 UTPA 67S	53–56 HRC 55–58 HRC	51 HRC 52 HRC	200–250°C (390–480°F)
CALMAX/CARMO TIG WELD	58–61 HRC	58–61 HRC	

MMA (SMAW) WELDING RECOMMENDATIONS

Consumables	Hardness as welded	Hardness after rehardening	Preheat temper
UTP 67S	55–58 HRC	52 HRC	200–250°C (390–480°F)
CALMAX/ CARMO WELD	58–61 HRC	58–61 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 860°C (1580°F) in protected atmosphere. Cool in furnace at 10°C/h to 650°C (18°F/h to 1200°F), then freely in air.

Further information on welding of tool steel is given in the Uddeholm brochure "Welding of Tool Steel".

EDM

If spark erosion is performed in the hardened and tempered condition, the tool should be given an additional temper at about 25°C (35°F) lower than previous tempering temperature. Further information is given in the Uddeholm brochure "EDM of Tool Steel".

POLISHING

Uddeholm Calmax has a very homogeneous structure. This coupled with its low content of non metallic inclusions (due to vacuum de-gassing during manufacturing) ensures good surface finish after polishing. Further information is given in the Uddeholm brochure "Polishing Mould Steel".

FURTHER INFORMATION

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

THE CONVENTIONAL 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.

In uphill casting the prepared moulds are filled with a controlled flow of molten steel from the ladle. From this, the steel goes directly to our rolling mill or to the forging press to be formed into round or flat bars.

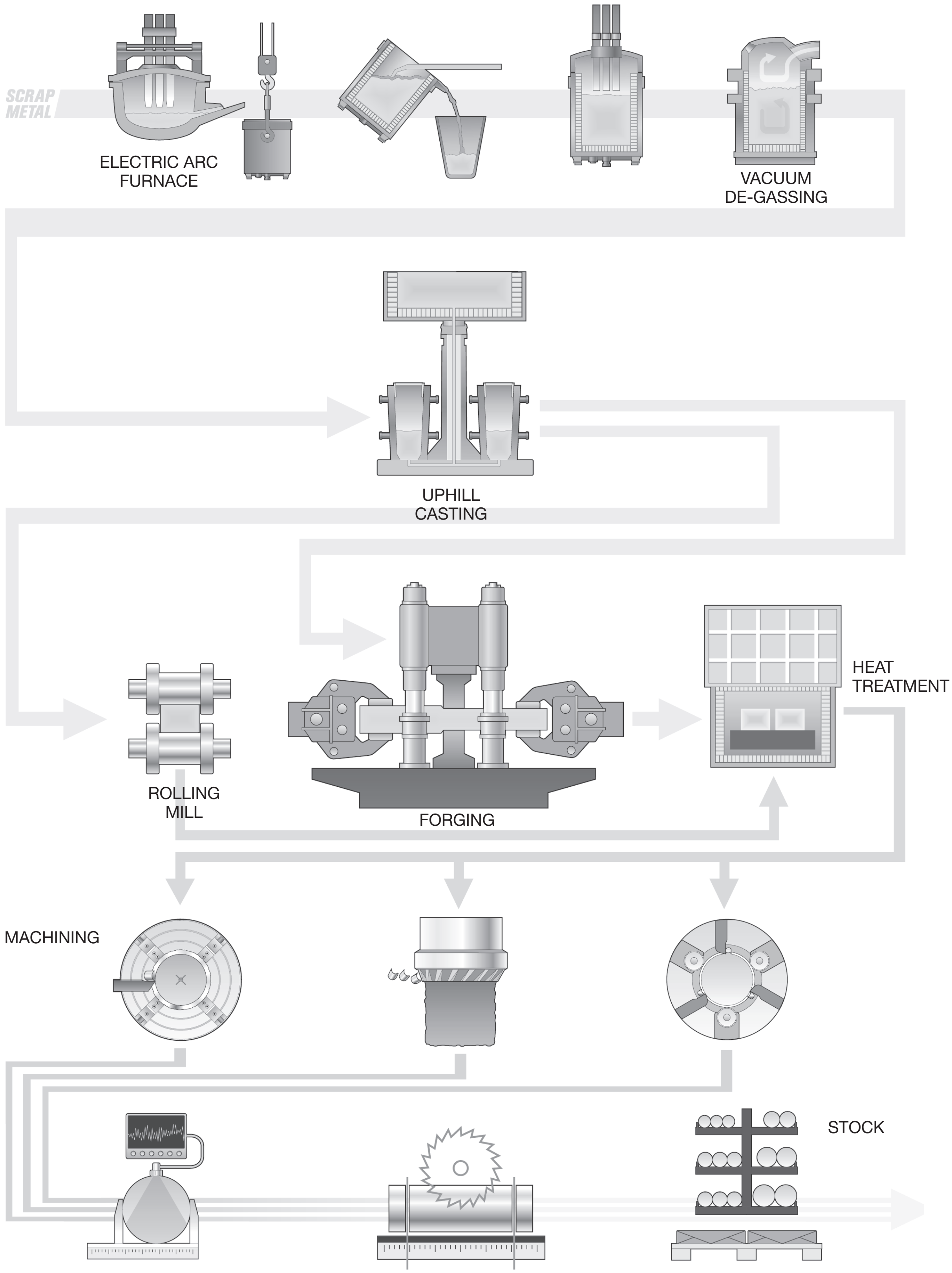
HEAT TREATMENT

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
VACUUM DE-GASSING
UPHILL CASTING
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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