UDDEHOM RIGOR®

UDDEHOLM

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

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The latest revised edition of this brochure is the English version, which is always published on our web site www.uddeholm.com

SS-EN ISO 9001
SS-EN ISO 14001

UDDEHOLM RIGOR

PROPERTIES PROFILE

Uddeholm Rigor is a universal medium alloyed cold work tool steel placed between 12 % Cr-steels and carbon tool steel like AISI 01. The steel has an excellent combination of wear and chipping resistance and a hardenability well suited for modern heat treatment processing. Uddeholm Rigor has also excellent machining and grinding properties.

APPLICATIONS

The properties profile of Uddeholm Rigor combine to give a steel suitable for the manufacture of medium run tooling for applications where a combination of resistance to abrasive wear and chipping is needed. This makes Uddeholm Rigor to a general purpose cold work tool steel.

General

Uddehom Rigor is an air- or oil hardening chromium-molybdenum-vanadium alloyed tool steel characterized by:

- Good machinability
- High stability after hardening
- High compressive strength
- Good hardenability
- Good wear resistance

Typical analysis %	C 1.0	Si 0.3	Mn 0.6	Cr 5.3	Mo 1.1	V 0.2
Standard specification	AISI A2. BA2. W.-Nr. 1.2363. Euro X 100 CrMoV 5					
Delivery condition	Soft annealed to approx. 215 HB					
Colour code	Red/green					

Applications

Uddehom Rigor takes a place in the Uddeholm tool steel range between Uddeholm Arne and Uddeholm Sverker 21, offering an excellent combination of good wear resistance and toughness. It may be regarded, therefore, as a "universal" cold work steel.

For cutting operations the good toughness of Uddehom Rigor gives excellent resistance to chipping of the cutting edge. In many cases tools made from this steel have given better tooling economy than high-carbon, high-chromium steel of the BD3/W.-Nr. 2080 type. Uddehom Rigor has much better machining and grinding properties.

Cutting

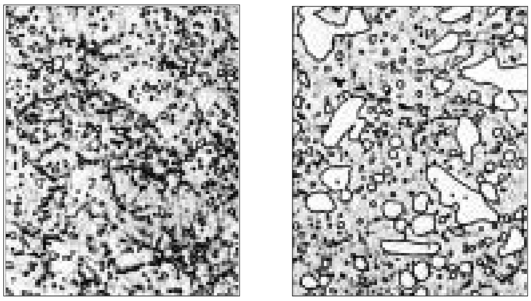
	Material thickness mm	Hardness HRC
Tools for: Blanking, punching, piercing, cropping, shearing, trimming, clipping	up to 3 mm (1/8") 3–6 mm (1/8–1/4") 6–10 mm (1/4–13/32")	60–62 56–60 54–56
Short cold shears Rotary shear blades for plastic waste		56–60
Clipping, trimming tools for forgings	Hot Cold	58–60 56–58

Forming

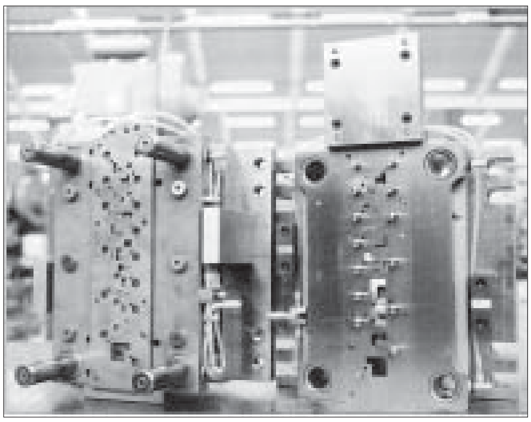
	Hardness HRC
Tools for: Bending, raising, deep-drawing, rim-rolling, spinning and flow-turning	56–62
Coining dies	56–60
Tube- and section forming rolls	58–62
Master hobs for cold hobbing	58–60
Swaging blocks	56–60
Gauges, measuring tools, guide rails bushes, sleeves	58–62
Dies and inserts for moulding tablets, abrasive plastics	58–62

Availability

Uddehom Rigor can be supplied in various finishes, including the hot-rolled, pre-machined and fine-machined condition. It is also available in the form of hollow bar and rings.



Comparison of fine-grained Uddehom Rigor with high-carbon, high-chromium steel of the D3/ W.-Nr. 2080 type.



Properties

Physical data

Hardened and tempered to 62 HRC. Data at room temperature and elevated temperatures.

Temperature	20°C (68°F)	200°C (375°F)	400°C (750°F)
Density kg/m³ lbs/in³	7 750 0.279	7 700 0.277	7 650 0.275
Modulus of elasticity N/mm² psi	190 000 27.5 x 10⁶	185 000 26.9 x 10⁶	170 000 24.6 x 10⁶
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	– –	11.6 x 10⁻⁶ 6.5 x 10⁻⁶	11.3 x 10⁻⁶ 6.3 x 10⁻⁶
Thermal conductivity W/m °C Btu in/(ft²h°F)	26.0 181	27.0 188	28.5 199
Specific heat J/kg °C Btu/lb °F	460 0.11	– –	– –

Compressive strength

Approximate values.

Hardness	Rc0,2 Nmm²	Rc0,2 ksi
62 HRC	2200	319
60 HRC	2150	312
55 HRC	1800	261
50 HRC	1350	196

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

Preheating temperature: 650–750°C (1200–1300°F)

Austenitizing temperature: 925–970°C (1690–1780°F) but usually 940–960°C (1720–1760°F).

Temperature °C	Temperature °F	Soaking* time min.	Hardness before tempering
925	1700	40	approx. 63 HRC
950	1740	30	approx. 64 HRC
970	1780	20	approx. 64 HRC

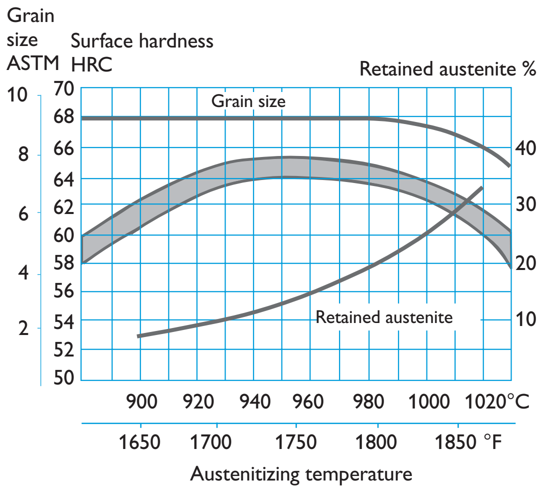
* Soaking time = time at hardening temperature after the tool is fully heated through

Protect the part against decarburization and oxidation during hardening.

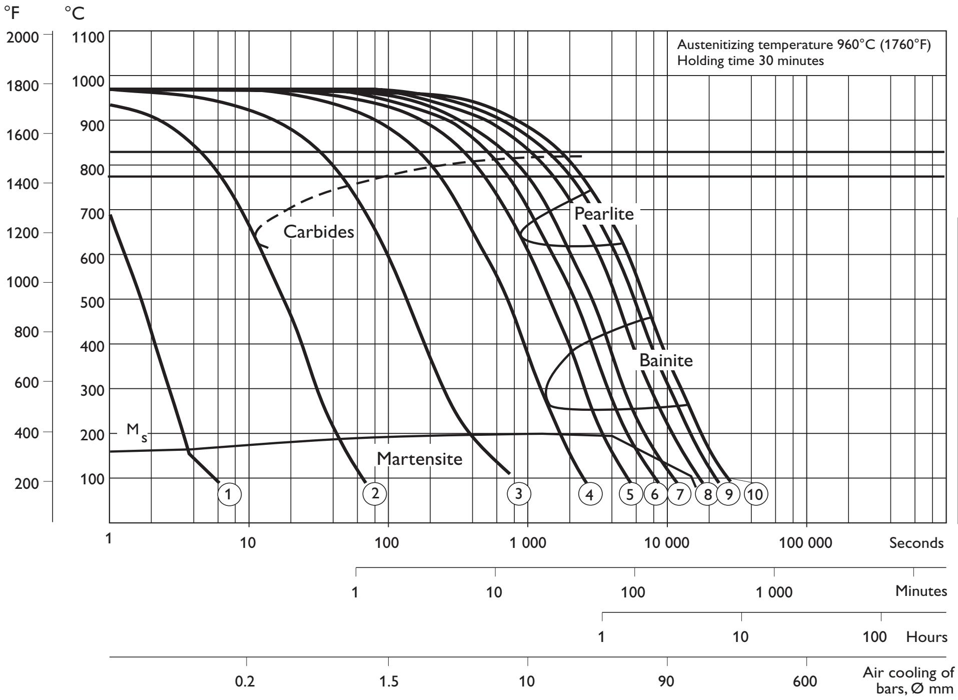
Quenching media

- Martempering bath or fluidized bed at 180–220°C (360–430°F) or 450–550°C (840–1020°F) then cool in air
- Circulating air or atmosphere
- Vacuum furnace with overpressure of gas at cooling
- Oil (only for small and uncomplicated tools)

HARDNESS AS A FUNCTION OF HARDENING TEMPERATURE



CCT GRAPH

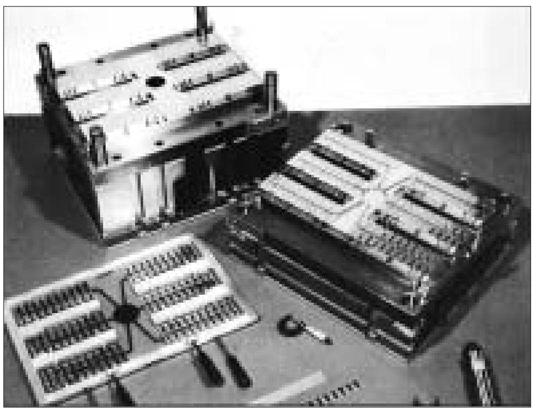


Cooling curve No.	Hardness HV 10	$T_{800-500}$ (sec.)
1	858	1
2	847	13
3	847	100
4	813	502
5	803	1071
6	698	1593
7	585	2138
8	514	3228
9	437	4292
10	387	5228

Tempering

Choose the tempering temperature according to the hardness required by reference to the tempering graph.

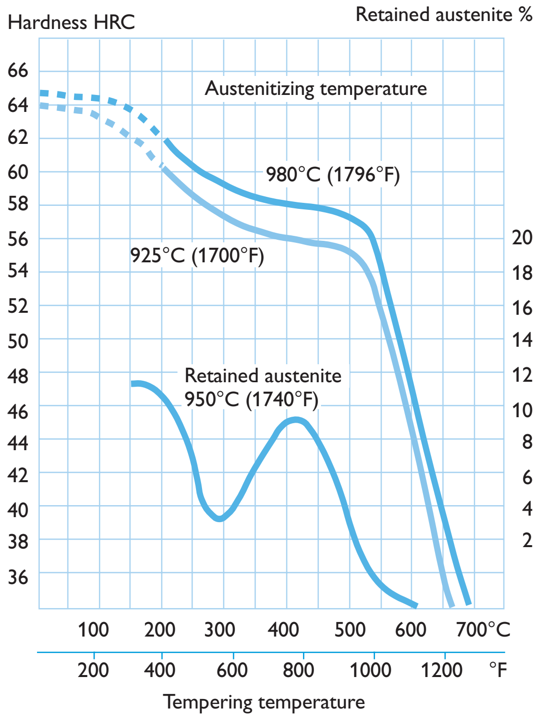
Temper twice with inter-mediate cooling to room temperature. Lowest tempering temperature 180°C (360°F). Holding time at temperature minimum 2 hours.



Transfer mould with Uddehom Rigor inserts to produce encap-sulated electronic components.

TEMPERING GRAPH

The tempering graphs are valid for small samples. The hardness received is also dependent on the tool size

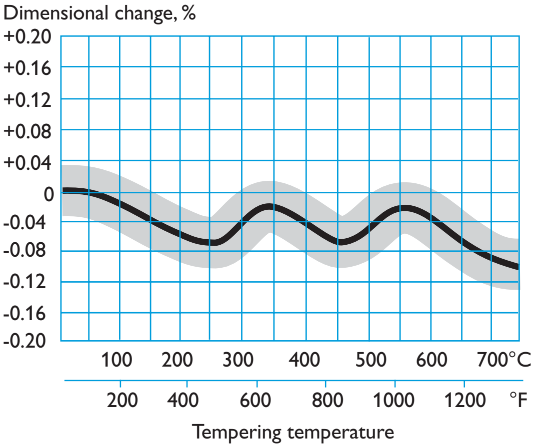


Dimensional changes during hardening

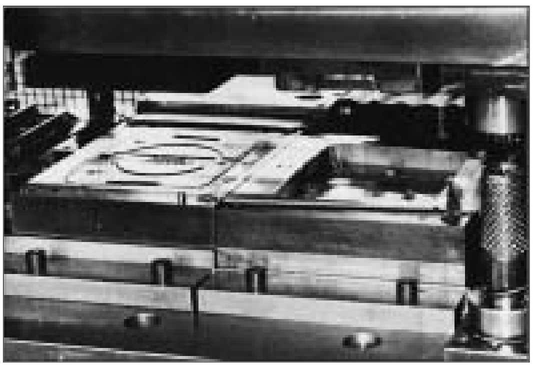
Sample plate, 100 x 100 x 25 mm, 4" x 4" x 1".

		Width %	Length %	Thickness %
Oil hardening from 960°C (1760°F)	min.	–0.10	–0.02	
	max.	–0.05	+0.06	–0.05
Martempering from 960°C (1760°F)	min.	+0.04	+0.06	
	max.	+0.05	+0.08	+0.04
Air hardening from 960°C (1760°F)	min.	+0.08	+0.13	
	max.	+0.14	+0.15	+0.04

Dimensional changes during tempering



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



This tool was made from Uddehom Rigor. 3 million parts were manufactured before the tool was reground.

Sub-zero treatment and aging

Pieces requiring maximum dimensional stability should be sub-zero and/or artificially aged as volume changes may arise in the course of time. This applies, for example, to measuring tools like gauges and certain structural components.

SUB-ZERO TREATMENT

Immediately after quenching, the piece should be sub-zero refrigerated to between -40 and -80°C (between -40 and -110°F) followed by tempering or aging. Sub-zero refrigeration for 2–3 hours will give a hardness increase of 1–3 HRC. Avoid intricate shapes as there is a risk of cracking.

AGEING

Tempering after quenching is replaced by ageing at 110–140°C (230–285°F). Holding time 25–100 hours.

Nitriding

Nitriding will give a hard diffused surface layer which is very resistant to wear and erosion, and also increases corrosion resistance. Nitriding in ammonia gas at a temperature of 525°C (975°F) gives a surface hardness of approx. 1000 HV_1.

Nitriding temperature		Nitriding time	Depth of case, approx.	
°C	°F	hours	mm	in.
525	980	20	0.2	0.008
525	980	30	0.3	0.012
525	980	60	0.4	0.016

2 hours nitrocarburizing treatment at 570°C (1060°F) gives a surface hardness of approx. 900 HV_1. The case depth having this hardness will be 10–20 µm (0.0004–0.0008").

Machining recommendations

The cutting data below, valid for Uddehom Rigor in soft annealed condition, are to be considered as guiding values which must be adapted to existing local conditions.

Turning

Cutting data parameters	Turning with carbide Rough turning	Turning with carbide Fine turning	Turning with high speed steel Fine turning
Cutting speed (v_c) m/min f.p.m.	110–160 360–525	160–210 525–690	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 0.002–0.012
Depth of cut (a_p) mm inch	2–4 0.08–0.16	0.5–2 0.02–0.08	0.5–2 0.02–0.08
Carbide designation ISO US	P20–P30 C6–C5 Coated carbide	P10 C7 Coated carbide or cermet	–

Milling

FACE AND SQUARE SHOULDER MILLING

Cutting data parameters	Milling with carbide Rough milling	Milling with carbide Fine milling
Cutting speed (v_c) m/min f.p.m.	130–200 425–655	200–240 655–785
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	–2 –0.08
Carbide designation ISO US	P20–P40 C6–C5 Coated carbide	P10–P20 C7–C6 Coated carbide or cermet

END MILLING

Cutting data parameters	Type of milling: Solide carbide	Type of milling: Carbide indexable insert	Type of milling: High speed steel
Cutting speed (v_c) m/min f.p.m.	80–120 260–395	120–170 395–560	15–20[1] 50–65[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 US	–	P20–P40 C6–C5	–

[1] For coated HSS end mill v_c = 30–35 m/min. (100–115 f.p.m./min.)

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

Drilling

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm	Drill diameter inch	Cutting speed (v_c) m/min	Cutting speed (v_c) f.p.m.	Feed (f) mm/r	Feed (f) i.p.r.
– 5	–3/16	14–16*	45–50*	0.05–0.15	0.002–0.006
5–10	3/16–3/8	14–16*	45–50*	0.15–0.20	0.006–0.008
10–15	3/8–5/8	14–16*	45–50*	0.20–0.25	0.008–0.010
15–20	5/8–3/4	14–16*	45–50*	0.25–0.35	0.010–0.014

[1] For coated HSS drill v_c = 24–26 m/min. (80–85 f.p.m./min.)

CARBIDE DRILL

Cutting data parameters	Type of drill: Indexable insert	Type of drill: Solid carbide	Type of drill: Brazed carbide[1]
Cutting speed (v_c) m/min f.p.m.	150–170 490–560	80–100 260–330	50–60 165–195
Feed (f) mm/r i.p.r	0.05–0.25[2] 0.002–0.01[2]	0.10–0.25[2] 0.004–0.01[2]	0.15–0.25[2] 0.006–0.01[2]

[1] Drill with replaceable or brazed carbide tip

[2] Depending on drill diameter

Grinding

General grinding wheel recommendation for Uddehom Rigor is given below. More information can be found in the Uddeholm brochure "Grinding of Tool Steel".

Type of grinding	Wheel recommendation: Soft annealed condition	Wheel recommendation: 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 JV

Welding

Good results when welding tool steel can be achieved if proper precautions are taken during welding (elevated working temperature, joint preparation, choice of consumables and welding procedure). If the tool is to be polished or photoetched, it is necessary to work with an electrode type of matching composition.

Welding method	Working temperature	Consumables	Hardness after welding
MMA (SMAW)	200–250°C (390–480°F)	AWS E312 ESAB OK 84.52 UTP 67S Castolin 2 Castolin N 102	300 HB 53–54 HRC 55–58 HRC 54–60 HRC 54–60 HRC
TIG	200–250°C (390–480°F)	AWS ER312 UTPA 67S UTPA 73G2 Castotig 5	300 HB 55–58 HRC 53–56 HRC 60–64 HRC

Electrical-discharge machining–EDM

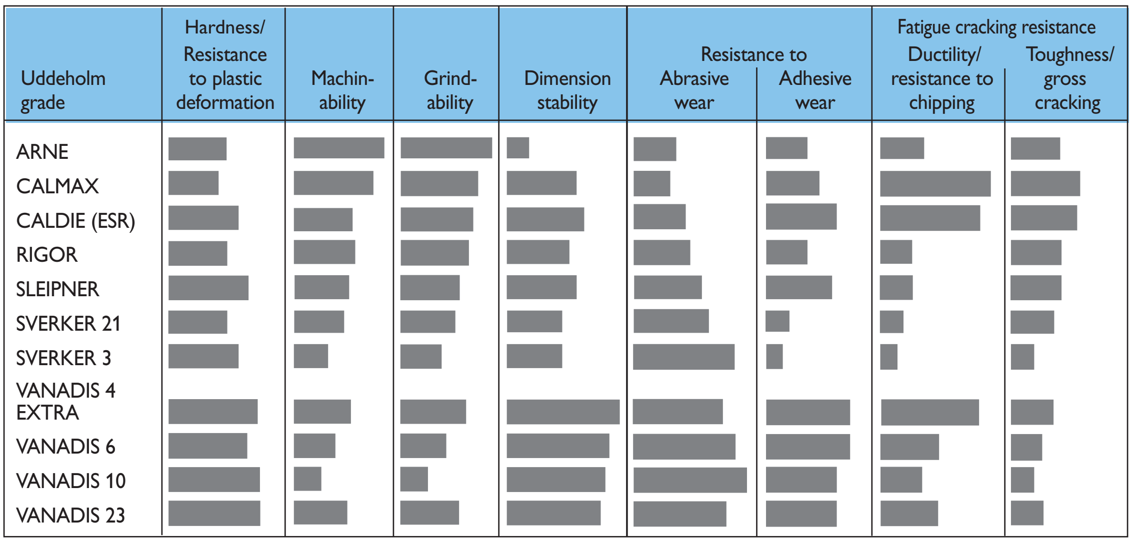
If EDM is performed in the hardened and tempered condition, the tool should then be given an additional temper at about 25°C (50°F) below the previous tempering temperature.

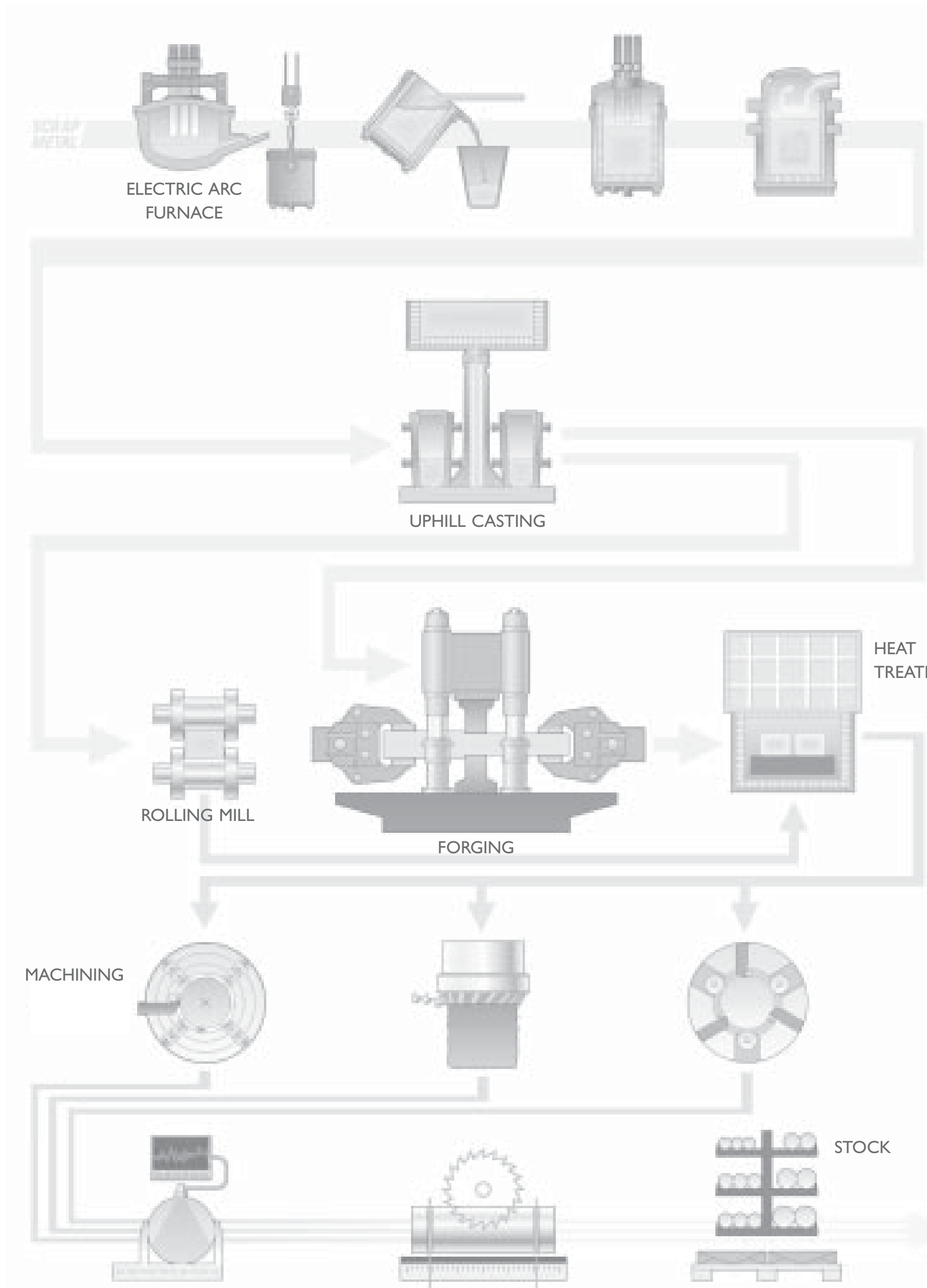
Further information

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

Relative comparison of Uddeholm cold work tool steel

Material properties and resistance to failure mechanisms





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

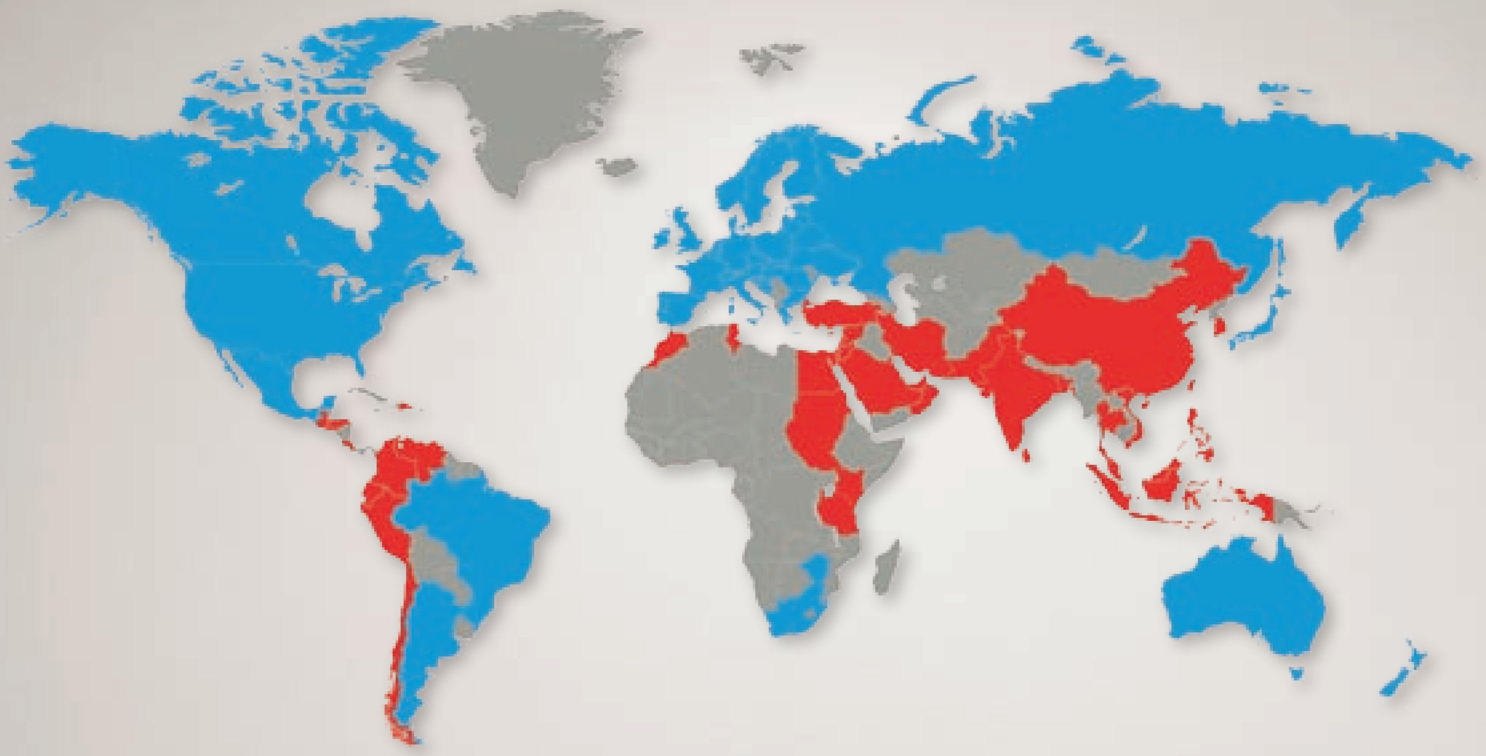
Prior to delivery all of the different bar materials are subjected to a heat treatment operation, either as soft annealing or hardening and tempering. These operations provide the steel with the right balance between hardness and toughness.

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.



Network of excellence

UDDEHOLM is present on every continent. This ensures you high-quality Swedish tool steel and local support wherever you are. ASSAB is our wholly-owned subsidiary and exclusive sales channel, representing Uddeholm in various parts of the world. Together 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. ASSAB is our wholly-owned subsidiary and exclusive sales channel, representing Uddeholm in various parts of the world. Together we secure our position as the world's leading supplier of tooling materials. We act worldwide, so there is always an Uddeholm or ASSAB representative close at hand to give local advice and support. 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, www.assab.com or your local website.

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