Uddeholm Carmo®

UDDEHOLM
a voestalpine company

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".

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CERTIFIED
ISO 9001 · OHSAS 18001
ISO 14001 · ISO 50001

Uddeholm Carmo®

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 limited performance of these grades often results in low productivity and high maintenance costs. Uddeholm Carmo offers due to its higher toughness a robust solution for better tooling performance and productivity.

PROPERTY PROFILE

Uddeholm Carmo is a prehardened steel where even the largest dimensions show a very uniform hardness profile. Uddeholm Carmo has better toughness, flame, laser and induction hardenability and better weldability compared with standard steel grades used in press work tools.

APPLICATIONS

Uddeholm Carmo is a steel grade wich has been developed in close cooperation with the automotive industry. Its properties have been balanced to give one universal tool steel for car body dies instead of several different grades wich are normally used.

GENERAL

Carmo is a high-strength, surface- and through hardening steel delivered prehardened to 240–270 HB.

The steel can be surface hardened without water cooling. The hardened and tempered matrix is a good base for the surface hardened layer.

The steel can be easily repair welded.

Typical analysis %	C 0.6	Si 0.35	Mn 0.8	Cr 4.5	Mo 0.5	V 0.2
Delivery condition	Prehardened to 240–270 HB					
Colour code	Red/violet					
Standard specifications	W. -Nr. 1.2358					

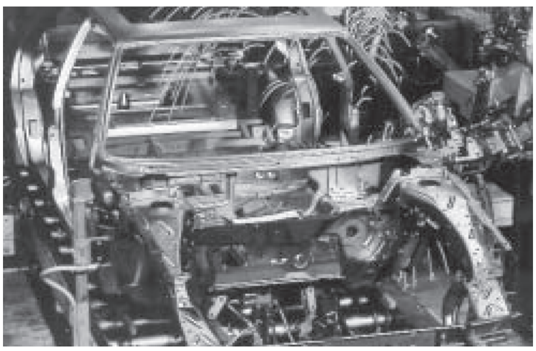
APPLICATIONS

Carmo is a cold work tool steel which has been developed together with the automotive industry. Its property profile has been balanced to give one universal tool steel for car body dies instead of the several steel grades (surface hardening and through hardening grades) which are normally used.

The steel can be used in the surface hardened or in the through-hardened condition for blanking and forming of both car body parts (thin sheet) or structural parts (thicker sheet).

TYPICAL COLD WORK APPLICATIONS

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



PROPERTIES

PHYSICAL DATA

Values for delivery condition.

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density kg/m^3 lbs/in^3	7780 0,281	7730 0,279	7660 0,277
Modulus of elasticity MPa Psi	204 000 29,6 x 10^6	196 000 28,4 x 10^6	185 000 26,8 x 10^6
Coefficient of thermal expansion 1/ °C 1/ °F	– –	12,3 x 10^{-6} 6,8 x 10^{-6}	13,3 x 10^{-6} 7,4 x 10^{-6}
Specific heat J/kg °C Btu/lbs °F	460 0,11	– –	– –

MECHANICAL PROPERTIESÁ

Typical values at room temperature, 270 HB.

Tensile strength Rm N/mm^2	870
Yield point Rp0,2 N/mm^2	670
Elongation A_5 %	15
Reduction of area Z %	50

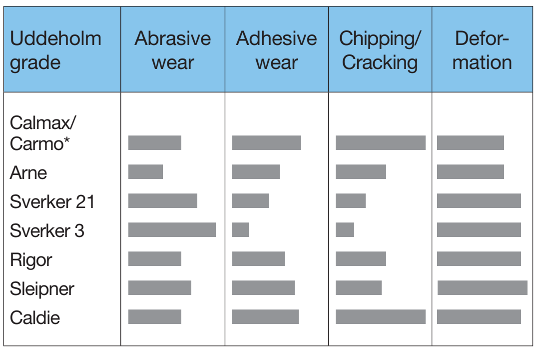
OTHER IMPORTANT PROPERTIES

Total tooling economy, i.e. minimizing the total cost incurred in running the tool—including down-time and maintenance—is important in presswork operations. It is of particular importance in the automotive industry where very large, automated press-lines are operating to a just-in-time concept. This puts very special requirements on the steels used for the tooling:

- high toughness for maximum safety in operation
- good machining properties
- easy maintenance to minimize press downtime.

These requirements are fully met by Carmo. The toughness of Carmo is much better than for the steel types A2 and D2. Repair welding of Carmo is easy.

RESISTANCE TO FAILURE MECHANISMS



** Carmo in the through hardened condition.*

HEAT TREATMENT

STRESS RELIEVING

Temperature: 550–650°C (1020–1200°F). Holding time: 2h. Cooling in furnace to 500°C (930°F), then in air.

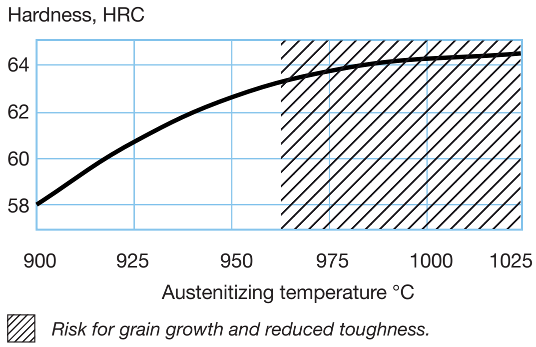
HARDENING

For through hardening following temperatures and times are recommended:

- Pre-heating temperature: 600–700°C (1110–1290°F).
- Austenitizing temperature: 950–970°C (1740–1780°F), normally 960°C (1760°F).
- Holding time: 30–45 minutes.

The tool should be protected against decarburization during hardening.

Hardness as a function of austenitizing temperature.



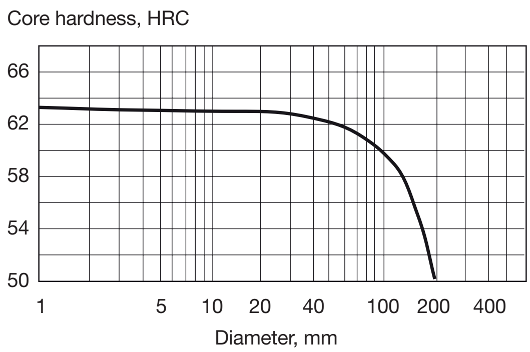
QUENCHING

- 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 tempera ture reaches 50–70°C (120–160°F).

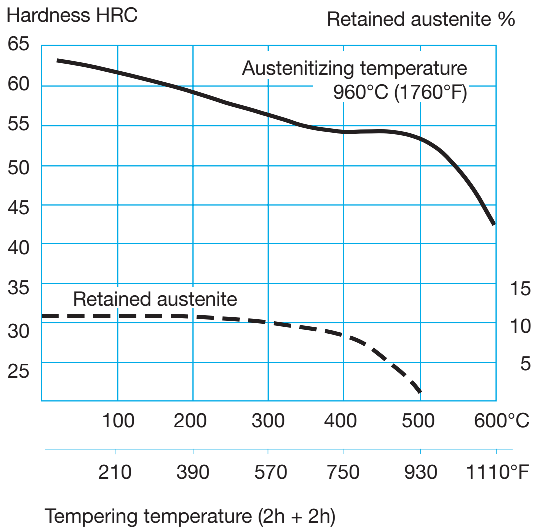
Core hardness as a function of diameter for air cooling.



TEMPERING

The tempering temperature for the required hardness may be determined by means of the tempering graph. Temper twice. Lowest tempering temperature 200°C (390°F). Holding time at temperature minimum 2 hours.

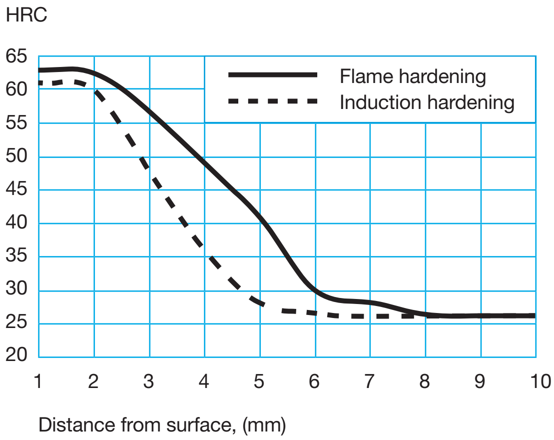
TEMPERING GRAPH



SURFACE HARDENING

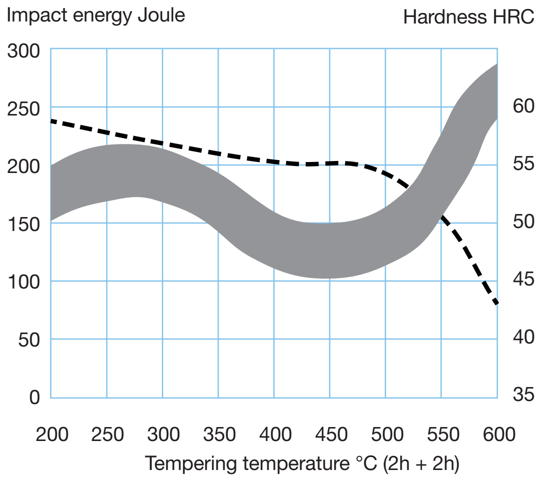
The steel can be surface hardened without water cooling to a hardness of 58–62 HRC. Depending on type of surface hardening the hardness depth can vary between 2–5 mm.

Typical hardness profiles after surface hardening from 960°C.



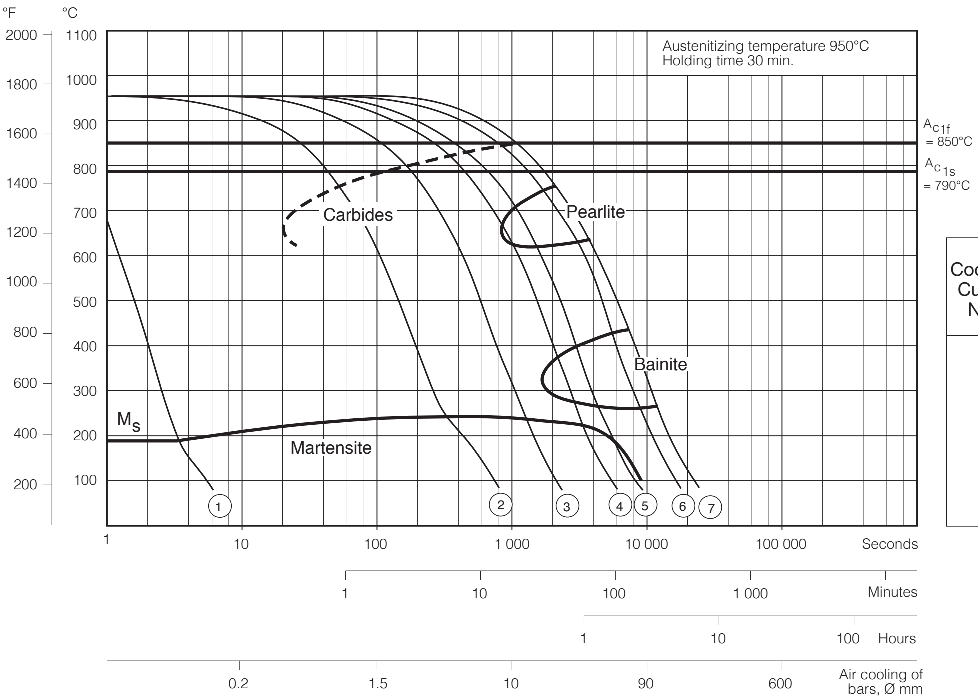
IMPACT STRENGTH

Room temperature. Specimen size: 7 x 10 x 55 mm unnotched. Hardened at 960°C (1760°F). Quenched in air. Tempered twice.



CCT-GRAPH

Austenitizing temperature 950°C (1760°F). Holding time 30 minutes.



Cooling Curve No.	Hard-ness HV10	$T_{800-500}$ sec.
1	814	1
2	782	107
3	752	423
4	720	1071
5	596	1596
6	427	3228
7	372	4292

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 Carmo in prehardened condition to approx 250 HB.

TURNING

Cutting data parameters	Rough turning carbide	Fine turning carbide	Turning with high speed steel Fine turning
Cutting speed (v_c) m/min f.p.m.	130–180 425–590	180–230 590–755	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 (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	– –

MILLING

FACE AND SQUARE SHOULDER MILLING

Cutting data parameters	Rough milling carbide	Fine milling carbide
Cutting speed (v_c) m/min f.p.m.	140–230 460–755	230–270 755–885
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 0.08–0.20	–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.	110–140 360–460	130–180 425–590	25–30[1)] 82–100[1)]
Feed (f_z) mm/tooth inch/tooth	0.006–0.20[2)] 0.001–0.008[2)]	0.08–0.20[2)] 0.003–0.008[2)]	0.01–0.35[2)] 0.002–0.014[2)]
Carbide designation ISO US	– –	P20–P40 C6–C5 Coated carbide	– –

[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 DRILL

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*	40–46*	0.05-0.15	0.002-0.006
5–10	3/16–3/8	12–14*	40–46*	0.15-0.25	0.006-0.01
10–15	3/8–5/8	12–14*	40–46*	0.25-0.30	0.01-0.012
15–20	5/8–3/4	12–14*	40–46*	0.30-0.35	0.012-0.014

** For coated HSS drills v_c = 22–24 m/min. (72–80 f.p.m.).*

CARBIDE DRILL

Cutting data parameters	Type of end drill		
	Indexable insert	Solid carbide	Carbide tip[1)]
Cutting speed (v_c) m/min f.p.m.	200–220 655–720	110–140 360–460	60–80 200–260
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)]	0.01–0.25[4)] 0.006– 0.01[4)]

[1)] *Drill with replaceable or braced 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 brochure "Grinding of Tool Steel".

Type of grinding	Prehardened condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 36 GV	A 36 GV
Cylindrical grinding	A 60 LV	A 60 KV
Internal grinding	A 60 JV	A 60 JV
Profile grinding	A 120 LV	A 120 JV

FLAME-HARDENING

Use an oxy-acetylene burner for 1250–2500 l/h with a normal flame.

Temperature: 950 ±30°C (1740 ±50°F). Hardness: surface 58 ±2 HRC, at a depth of 3–4 mm 400 $HV_{10\,kg}$.

A temperature guide for judgement of the right flame hardening temperature can be obtained from your local Uddeholm office.

WELDING RECOMMENDATIONS

GENERAL

When cold work steels are welded, there is always a risk of cracking in the weld metal and/ or in the heat affected zone (HAZ). However, cracking can be avoided by using a proper welding technique and the right consumables. Wrought material is always easier to weld than castings because it has a higher toughness.

In general, the following is valid:

- Always keep the arc length as short as possible. The coated electrode should be angled at 90° to the joint sides to avoid undercut. In addition, the electrode should be held at an angle of 75–80° to the direction of forward travel.
- Larger repair welds must be made at elevated temperature. The temperature of the workpiece should be held as constant as possible during welding. The best way to keep the tool at constant temperature during welding is to use an insulated box with thermostatically regulated electrical heating elements inside the walls.
- The first two layers should always be welded with the same heat input and with a small diameter electrode (max 3,25 Ø electrode for MMA or max 120A for TIG welding).
- First of all, the parent metal is clad in using an appropriate number of runs. All other runs should then be made up on top of pre-existing weld metal except in those cases where soft metal electrodes of the type 29/9 are used. When a soft weld metal is used, a space of 3 mm must be left below the finished surface so that the hard facing electrode can be used to give the right surface hardness on the welded tool.
- For large weld repairs, the parent metal should be coated with a soft weld metal of the 29/9 type (i.e. 29% Cr, 9% Ni electrodes AWS ER 312 or AWS E312), which gives a tougher weld metal with lower hardness.
- The choice of electrode for welding depends on the hardness required in the weld metal (see table below).
- In order to obtain the required hardness (as given in the table below), the weld should be built up with at least 3 layers plus an additional layer which is ground off after welding has been completed. When welding tool steels, the last layer should always be ground off.
- It should be noted that differences between expected and achieved hardness in the weld metal normally depend on how the grinding of the last layer has been carried out. Grinding should always be carried out before the temperature in the tool sinks too much. If the grinding is too rough so that the weld becomes red hot, microcracks will appear in the weld metal.
- The following heat treatment cycle is recommended for large weld repairs:

1. Pre-heat the tool to 200–250°C (390–480°F). Keep that temperature during the whole welding operation.
2. Let the tool cool slowly after welding to <70°C (<160°F).
3. Temper the tool at a temperature 25°C (50°F) below previously used preheating temperature, or at 200°C (390°F).

JOINT PREPARATION

The importance of careful joint preparation cannot be over-emphasized. Cracks should be ground out so that the joint bottom is rounded and the sides of the joint slope at an angle of at least 30° to the vertical. The width of the joint bottom should be at least 1 mm greater than the electrode diameter (including the coating) which is used. Further recommendations on welding of tool steels can be found in the Uddeholm brochure “Welding of Tool Steel”.

TIG Welding Consumables for wrought Carmo

Condition of material	Consumables	Hardness as welded	Preheating[1] temperature
Hardened Pre-hardened	UTPA 651[2] UTPA 73G2 UTPA 67S UTPA 696 CALMAX/ CARMO TIG-WELD[3]	240 HB 53–56 HRC 55–58 HRC 60–64 HRC 58–61 HRC	200–250°C (390–480°F)

MMA (SMAW) Consumables for wrought Carmo

Condition of material	Consumables	Hardness as welded	Preheating[1] temperature
Hardened Pre-hardened	Avesta P7[4] UTP 65D[4] UTP 67S UTP 73G2 CALMAX/ CARMO WELD[3]	ca 270 HB ca 250 HB 55–58 HRC 55–58 HRC 58–61 HRC	200–250°C (390–480°F)

Remarks:

[1] The tool should cool slowly after welding.

[2] TIG rods of the type AWS ER 312.

[3] Calmax/Carmo TIG-Weld/Weld consumables corresponds to the chemical composition of Carmo/Calmax, i.e. similar heat treatment respons.

[4] MMA-Consumables of the type AWS E 312.

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.

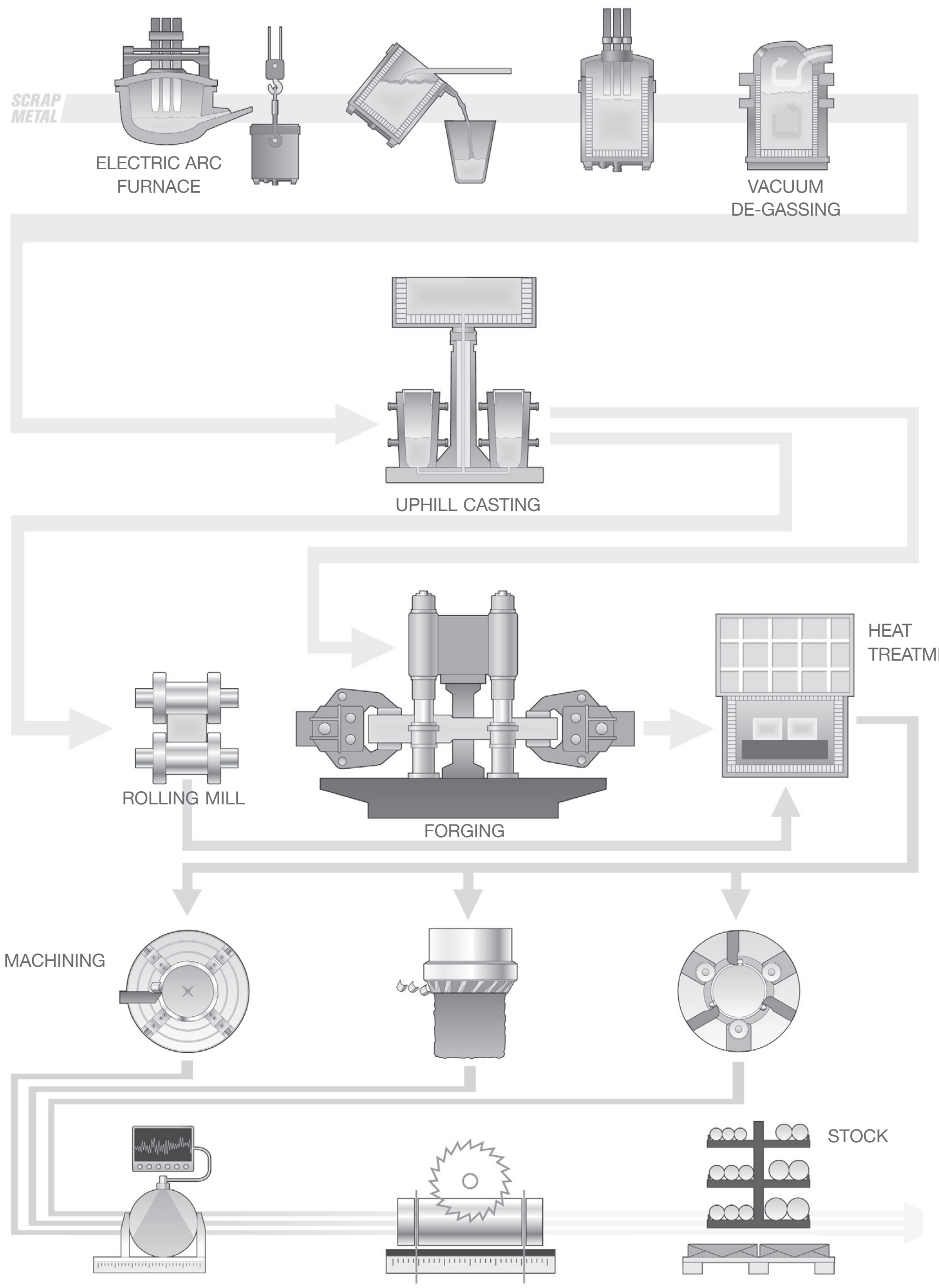
POLISHING

Uddeholm Calmax has a very homogeneous structure. This coupled with its low content of non metallic inclusions (due to vacuum degassing 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 de-gassing 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

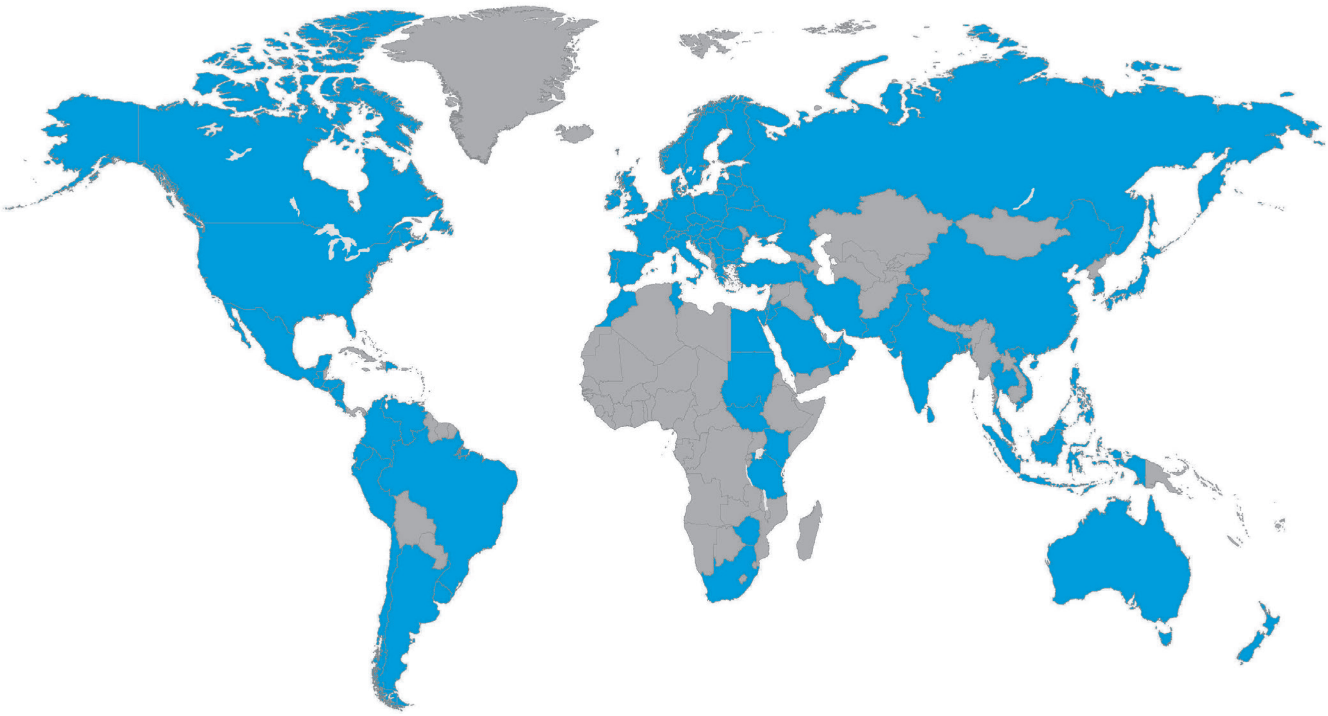
Prior to delivery all of the different bar materials are subjected to a heat treatment operation, either as soft annealing or hardening and tempering. These operations provide the steel with the right balance between hardness and toughness.

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. 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 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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