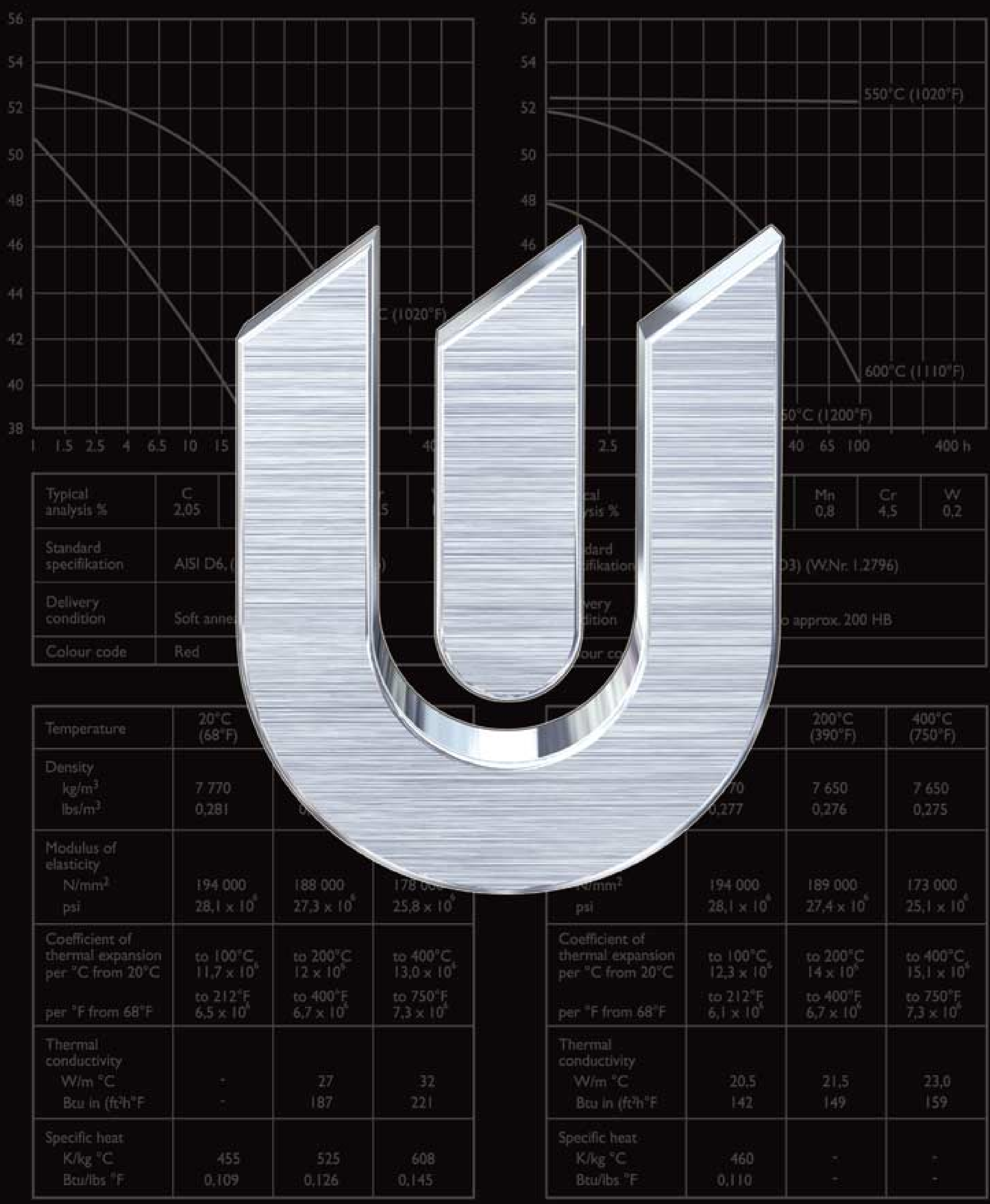
STAVAX ESR

Stainless mould steel

COLD WORK | PLASTIC MOULDING | HOT WORK | HIGH PERFORMANCE STEEL



General

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

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

The combination of these properties gives a 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 steels), 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 *STAVAX ESR,* offer the moulder low-maintenance, long-life moulds for the greatest overall moulding economy.

Note! *STAVAX ESR* is produced using the 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. 200 HB.				
Colour code	Orange/black				

Applications

Whilst *STAVAX ESR* is recommended for all types of moulding tools, 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. *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.

Type of mould	Recommended hardness HRC
Injection mould for:	
thermoplastic materials	45–54
thermosetting materials	45–54
Compression/transfer moulds	50–54
Blow moulds for PVC, PET, etc.	45–54
Extrusion, pultrusion dies	45–54

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/m^3 lbs/in^3	7 800 0,282	7 750 0,280	7 700 0,277
Modulus of elasticity N/mm^2 tsi psi	200 000 12 900 29,0 x 10^6	190 000 12 300 27,6 x 10^6	180 000 11 600 26,1 x 10^6
Coefficient of thermal expansion /°C from 20°C /°F from 68°F	– –	11,0 x 10^{-6} 6,0 x 10^{-6}	11,4 x 10^{-6} 6,5 x 10^{-6}
Thermal conductivity* W/m °C Btu in/(ft^{2}h °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 R_m N/mm^2 kp/mm^2 tsi psi	1 780 180 114 256 000	1 420 145 92 206 000
Yield point $R_{p0,2}$ N/mm^2 kp/mm^2 tsi psi	1 460 150 95 213 000	1 280 130 83 185 000

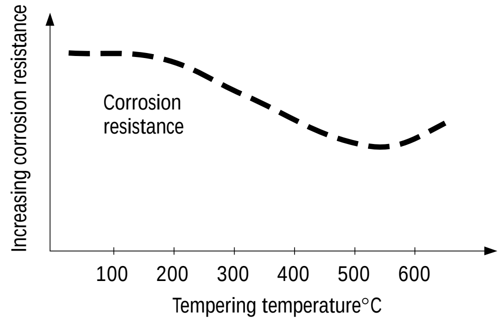
CORROSION RESISTANCE

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 *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.

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.

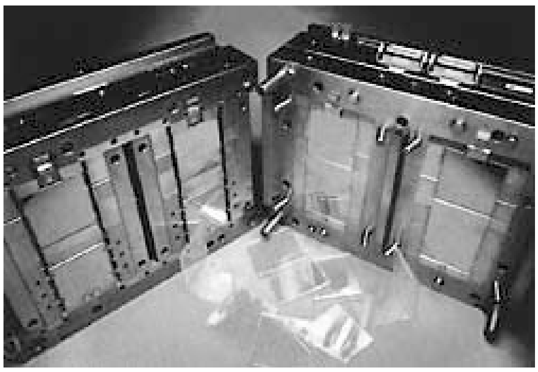
HARDENING

Preheating temperature: 600–850°C (1110–1560°F)
Austenitizing temperature: 1020–1050°C (1870–1920°F), but usually 1020°C–1030°C (1870–1885°F).

Temperature °C	Temperature °F	Soaking time* minutes	Hardness before tempering
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.

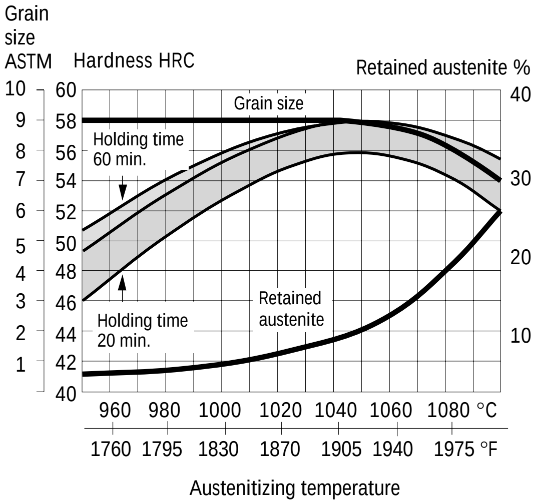


QUENCHING MEDIA

- Oil
- 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 vaccuum furnace, a 4–5 bar overpressure is recommended. Temper immediately when the tool reaches 50–70°C (120–160°F).

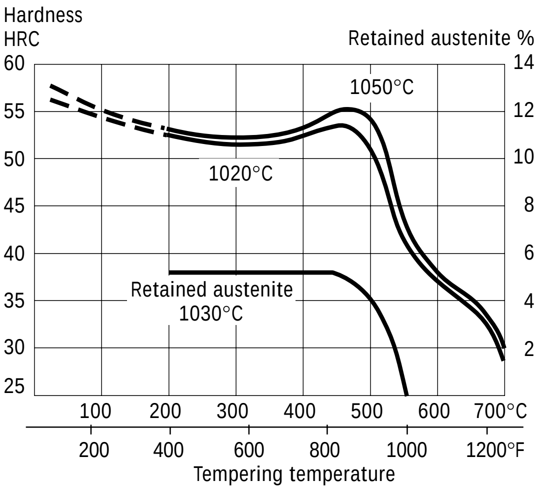
Hardness, grain size and retained austenite as a function of the austenitizing temperature.



TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with intermediate cooling to room temperature. Lowest tempering temperature 180°C (360°F) for small simple inserts, but 250°C (480°F) is the preferred minimum. Holding time at temperature minimum 2 hours.

Tempering graph



Note: 1. Tempering at 250°C (480°F) is recommended for the best combination of toughness, hardness and corrosion resistance.

Note: 2. Above curves are valid for small samples. Achieved hardness depends on mould size.

Note: 3. 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.

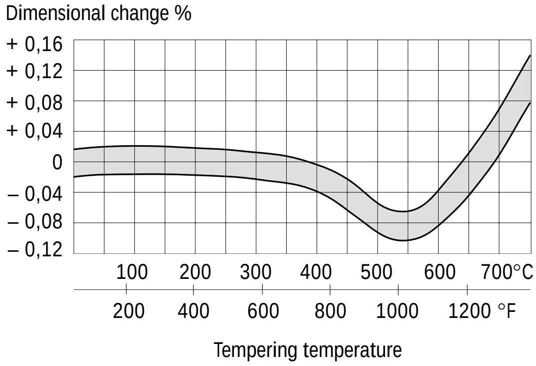
DIMENSIONAL CHANGES

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 *STAVAX ESR* provided that a stress relief is performed between roguh and semifinished machining as recommended.

During tempering



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 %
Oil hardened	Min. Max.	+ 0,02 – 0,05	+ 0,02 – 0,03	+ 0,04 –
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 Recommendation”.

TURNING

Cutting data parameter	Turning with carbide Rough turning	Turning with carbide Fine turning	Turning with high speed steel Fine turning
Cutting speed (v_c) m/min	160–210	210–260	18–23
f.p.m.	525–690	690–850	60–75
Feed (f) mm/r	0,2–0,4	0,05–0,2	0,05–0,3
i.p.r.	0,008–0,016	0,002–0,008	0,002–0,01
Depth of cut (a_p) mm	2–4	0,5–2	0,5–3
inch	0,08–0,16	0,02–0,08	0,02–0,1
Carbide designation ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	–

MILLING

Face and square shoulder face milling

Cutting data parameter	Milling with carbide Rough milling	Milling with carbide Fine milling
Cutting speed (v_c) m/min	180–260	260–330
f.p.m.	600–865	865–1080
Feed (f_z) mm/tooth	0,2–0,4	0,1–0,2
in/tooth	0,008–0,016	0,004–0,008
Depth of cut (a_p) mm	2–4	0,5–2
inch	0,08–0,16	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	120–150	170–230	25–30[1]
f.p.m.	390–500	560–755	85–100
Feed (f_z) mm/tooth	0,01–0,20[2]	0,06–0,20[2]	0,01–0,3[2]
in/tooth	0,0004–0,008	0,002–0,008	0,0004–0,01
Carbide designation ISO	–	P20–P30	–

[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 drills

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	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	Brazed carbide[1]
Cutting speed, (v_c) m/min	210–230	80–100	70–80
f.p.m.	690–755	265–330	230–265
Feed, (f) mm/giro	0,03–0,10[2]	0,10–0,25[2]	0,15–0,25[2]
i.p.r.	0,0012–0,004	0,004–0,01	0,006–0,01

[1] Drills with internal cooling channels and brazed carbide tip
[2] Depending on drill diameter

GRINDING

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

Type of grinding	Wheel recommendation: 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.

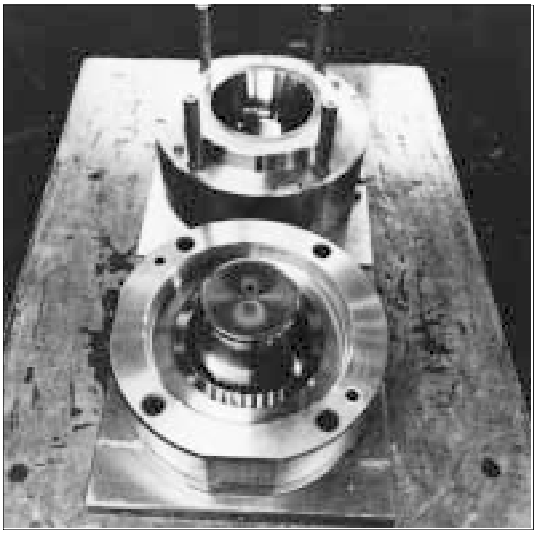
Welding method	TIG	MMA
Working temperature	200–250°C	200–250°C
Welding consumables	STAVAX TIG-WELD	STAVAX WELD
Hardness after welding	54–56 HRC	54–56 HRC
Heat treatment after welding:		
Hardened condition	Temper at 10–20°C (50–70°F) below the original tempering temperature.	
Soft annealed condition	Heat 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”.

Photo-etching

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 *STAVAX ESR’s* good corrosion resistance is familiar to all the leading photo-etching companies.

Further information is given in the Uddeholm booklet “Photo-etching of tool steel”.



Mould in STAVAX ESR for producing clear plastic bowls.

Polishing

STAVAX ESR has a very good polishability in the hardened and tempered condition.

A slightly different technique, in comparison with other Uddeholm mould steels, 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 steels, including the publication “Steel for moulds”.