Uddeholm
Polmax®

UDDEHOLM
a voestalpine company

Uddeholm Polmax®

FOR EXTREME SURFACE FINISH REQUIREMENTS

To meet the most extreme demands on polishability in plastic mould steels, Uddeholm Polmax stands out as one of the cleanest steels available. Thus it offers unparalleled polishability. This high performance grade achieves surface finishes that go well beyond what can be achieved by most other tool steels.

Uddeholm Polmax is also resistant to most corrosion attacks.

Uddeholm Polmax is specifically engineered for cavities, cores, inserts and a broad range of product applications that demand superior surface finish. Examples include optical and medical applications.

Uddeholm Polmax is a part of the Uddeholm Stainless Concept.

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

The rapid development in the high-tech area is putting higher and higher demands on the tool steel. Surface finishes, which have not been possible to achieve with ordinary tool steels, are required. For these extreme requirements Uddeholm Polmax is the right choice.

For Uddeholm Polmax methods like ESR (Electro Slag Remelting) and VAR (Vacuum Arc Remelting) are used in order to reduce inclusion levels to minimum amounts.

Characteristics found in Uddeholm Polmax:

- Excellent polishability
- Good corrosion resistance
- Good wear resistance
- Good machinability
- Good stability in hardening

Typical analysis %	C 0,38	Si 0,9	Mn 0,5	Cr 13,6	V 0,3
Delivery condition	Soft annealed to approx. 200 HB				
Colour code	Green/black				

APPLICATIONS

Examples on applications where extreme surface finishes are required:

- Lens moulds
- Moulds for medical applications
- Moulds for optical applications
- Moulds for analysis phials

PROPERTIES

PHYSICAL DATA

Hardened and tempered to 52 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
Coefficient of thermal expansion per °C from 20° per °F from 68°F	– –	11,0 x 10^{-6} 6,1 x 10^{-6}	11,4 x 10^{-6} 6,4 x 10^{-6}
Thermal conductivity W/m °C Btu in/ft^2 h °F	16 110	20 138	24 166
Modulus of elasticity N/mm^2 psi	200 000 29,0 x 10^6	190 000 27,6 x 10^6	180 000 26,1 x 10^{-6}
Specific heat J/kg °C Btu/lb°F	460 0,110	– –	– –

STRENGTH OF MATERIAL

The strength values are to be considered as approximate. The test samples have been hardened in oil from 1025°C (1875°F) and tempered twice to 52 HRC.

Tensile strength, Rm	2050 N/mm^2 300 000 psi
Yield point, Rp0,2	1610 N/mm^2 234 000 psi

CORROSION RESISTANCE

Uddeholm Polmax is resistant to corrosive attack by water, water vapour, weak organic acids, dilute solutions of nitrates, carbonates and other salts.

A tool made from Uddeholm Polmax will have good resistance to rusting and staining due to humid working and storage conditions and when moulding corrosive plastics under normal production conditions.

Uddeholm Polmax shows the best corrosion resistance when tempered at about 250°C (480°F) and polished to a mirror finish.

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 (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: 600–850°C (1110–1560°F)

Austenitizing temperature: 1000–1050°C (1830–1920°F) but usually 1020–1030°C (1870–1885°F)

Temperature °C	°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

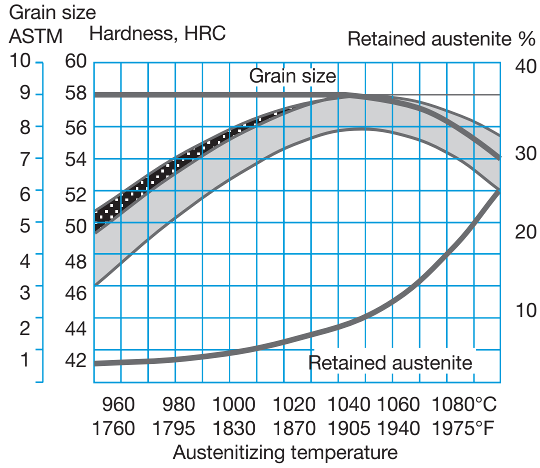
Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

- 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 vacuum 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

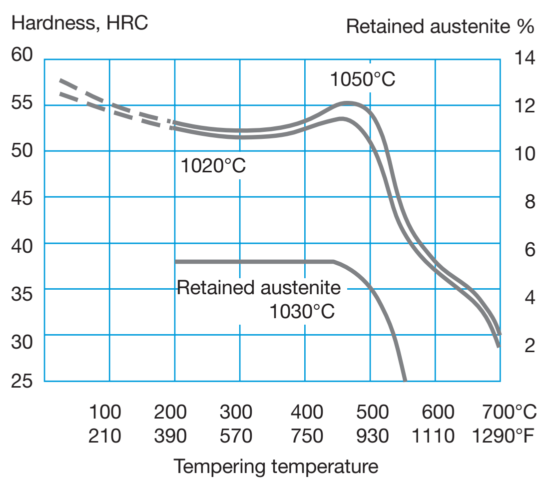


TEMPERING

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). Holding time at tem-perature minimum 2 hours.

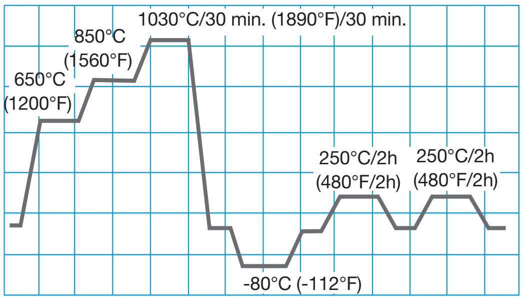
TEMPERING GRAPH



Note that:

- tempering at 250°C (480°F) is recommended for the best combination of toughness, hardness and corrosion resistance
- above curves are valid for small samples, achieved hardness depends on mould size
- 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

For maximum hardness and best combination of toughness, corrosion resistance and dimension stability during use, following heat treatment cycle is recommended.



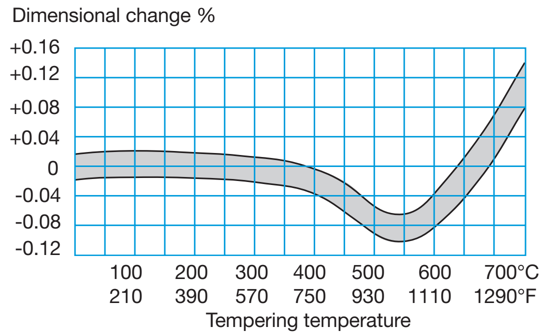
Subzero cooling is only required when demands on dimension stability during use are very high. Received hardness: 52–54 HRC.

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 Uddeholm Polmax provided that a stress relief is performed between rough and semi-finished 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 %
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.

Head-up display.

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".

TURNING

Cutting data parameter	Turning with carbide		Turning with high speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (vc) m/min. f.p.m.	160–210 525–690	210–260 690–850	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 (ap) mm inch	2–4 0.08–0.16	0.5–2 0.02–0.08	0.5–3 0.02–0.1
Carbide designation ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	–

DRILLING

HIGH SPEED STEEL TWIST DRILLS

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*	40–47*	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	Carbide tip[1]
Cutting speed, (v_c) m/min f.p.m.	210–230 690–755	80–100 265–330	70–80 230–265
Feed, (f) mm/r i.p.r.	0.05–0.15[2] 0.002–0.006[2]	0.08–0.20[3] 0.003–0.008[3]	0.15–0.25[4] 0.006–0.01[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 FACE MILLING

Cutting data parameter	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min. f.p.m.	180–260 600–865	260–300 865–985
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	0.5–2 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 (vc) m/min. f.p.m.	120–150 390–500	170–230 560–755	25–30[1] 85–100[1]
Feed (fz) mm/tooth inch/tooth	0.01–0.2[2] 0.0004–0.008[2]	0.06–0.2[2] 0.002–0.008[2]	0.01–0.30[2] 0.0004–0.01[2]
Carbide designation ISO	–	P20–P30	–

[1] For coated HSS end mill vc = 45–50 m/min. (150–165 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 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

POLISHING

Uddeholm Polmax has extremely good polishability in the hardened and tempered condition.

A slightly different technique is needed when polishing corrosion resistant tool steel compared with conventional tool steel. The main principle is to use smaller steps at the fine-grinding/polishing stages and try to grind to as fine surface as possible before starting the polishing operation. It is also important to stop the polishing operation immediately the last scratch from the former grain size has been removed.

PRACTICAL HINTS

- Polishing should be carried out in dust- and draught-free places. Hard dust particles can easily contaminate the abrasive and ruin an almost finished surface.
- Each polishing tool should be used for **only one** paste grade and kept in dust-proof container.
- The polishing tools gradually become “impregnated” and improve with use.
- Hands and workpiece should be cleaned carefully between each change of paste grade, the work-piece with a grease solvent and the hands with soap.
- Paste should be applied to the polishing tool in manual polishing, while in machine polishing, the paste should be applied to the work-piece.
- The finer the grain size, the less thinning liquid.
- Polishing pressure should be adjusted to the hardness of the polishing tool and the grade of the paste. For the finest grain sizes, the pressure should only be the weight of the polishing tool.
- Heavy material removal requires hard polishing tools and coarse paste.
- Finish polishing of plastic moulds should be carried out in the release direction.
- Polishing should start in the corners, edges and fillets or the difficult parts of the mould.
- Be careful with sharp corners and edges, so they are not rounded off. Preferably use hard polishing tools.

Cleanliness in every step of the polishing operation is of such great importance that it can not be over-emphasized.

PHOTO-ETCHING

Uddeholm Polmax 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 Uddeholm Polmax’s good corrosion resistance is familiar to all the leading photo-etching companies. Further information is given in the Uddeholm publication “Photo-etching of tool steel”.

FURTHER INFORMATION

Please contact your local Uddeholm office for further in formation on the selection, heat treatment, application and availability of Uddeholm tool steels.

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.

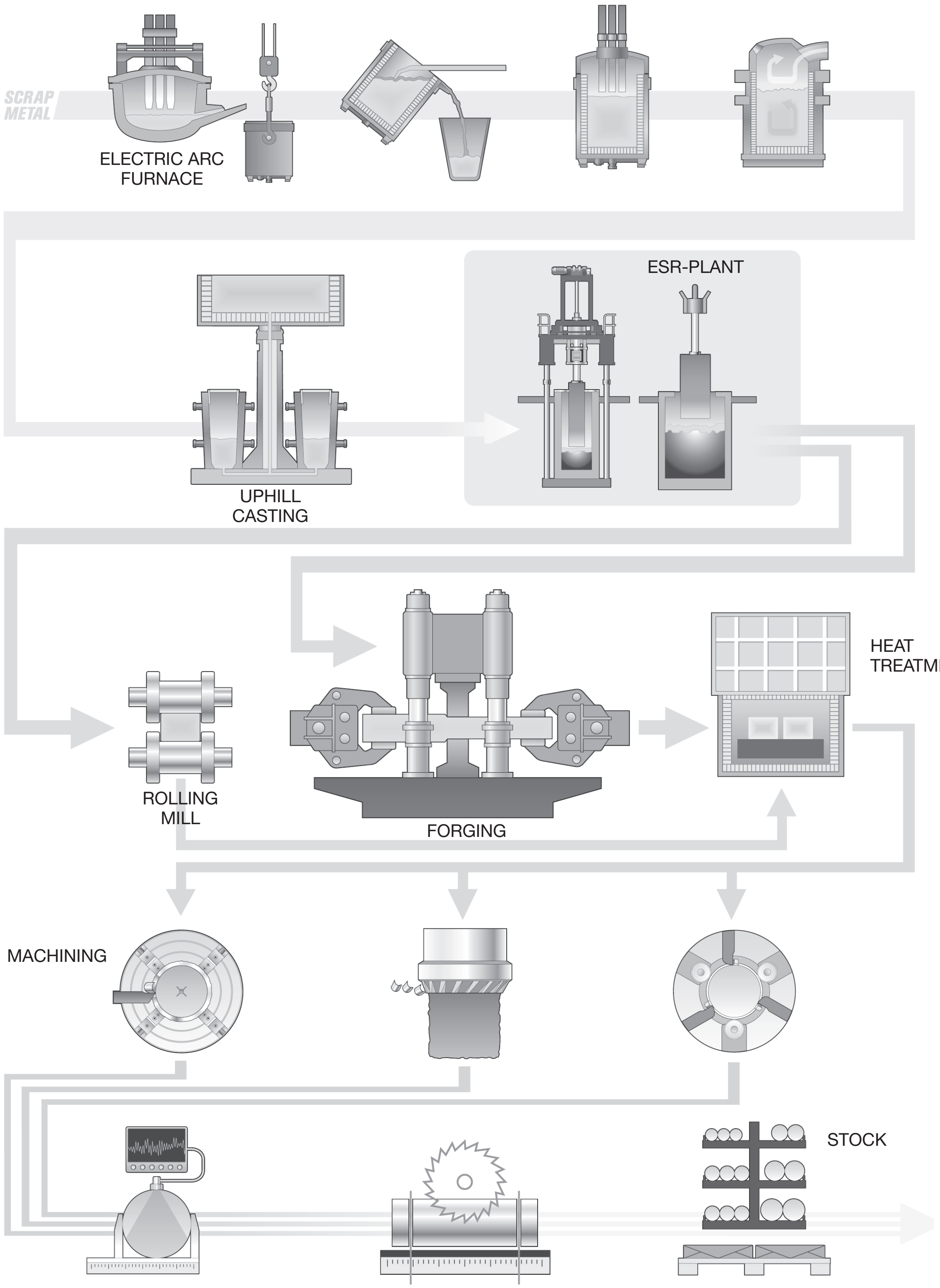
HOT WORKING

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
ESR-PLANT
UPHILL
CASTING
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.