UDDEHOLM QRO® 90 SUPREME

UDDEHOLM

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 6, 12.2011
The latest revised edition of this brochure is the English version, which is always published on our website www.uddeholm.com

SS-EN ISO 9001
SS-EN ISO 14001

General

Uddeholm QRO 90 Supreme is a high-performance, chromium-molybdenum-vanadium alloyed hot work tool steel which is characterized by:

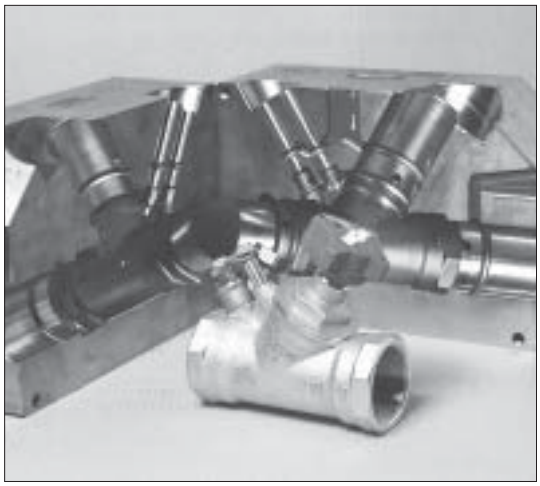
- Excellent high temperature strength and hot hardness
- Very good temper resistance
- Unique resistance to thermal fatigue
- Excellent thermal conductivity
- Good toughness and ductility in longitudinal and transverse directions
- Uniform machinability
- Good heat treatment properties

Typical analysis %	C 0.38	Si 0.30	Mn 0.75	Cr 2.6	Mo 2.25	V 0.9
Standard specification	None.					
Delivery condition	Soft annealed to approx. 180 HB					
Colour code	Orange/light brown					

Improved tooling performance

Uddeholm QRO 90 Supreme is a specially premium hot work steel developed by Uddeholm to provide better performance in high temperature tooling.

The name "supreme" implies that by special manufacturing techniques, including electro-slag remelting the steel attains high purity and good mechanical properties. This together with the optimum balance of alloying elements in Uddeholm QRO 90 Supreme gives a properties profile which is unique among hot work die steel. The combination of high temperature strength, temper resistance and thermal conductivity exhibited by Uddeholm QRO 90 Supreme is unparalleled. Thus Uddeholm QRO 90 Supreme has given improved service life in die casting and extrusion of nonferrous metals and forging and extrusion of steel.



Applications

Die casting dies and associated tooling

Uddeholm QRO 90 Supreme will normally out-perform other standard hot work steel in both aluminium, brass and copper die casting. Its excellent high temperature strength ensures suppression of heat checking and prolonged die life.

Furthermore its high thermal conductivity gives the opportunity to reduce the cycle time and improve productivity.

Uddeholm QRO 90 Supreme can be used for parts where resistance against heat checking, erosion and bending is required. Typical applications are cores, core pins, inserts, small- to medium-sized dies, shot sleeves, moving parts for aluminium, brass and copper die casting.

Extrusion dies and extrusion tooling

In aluminium extrusion Uddeholm QRO 90 Supreme is recommended for dies when the extruded tonnage is likely to exceed the die life for a standard tool steel e.g.:

- Dies for simple profiles to be produced in long series requiring more than one die
- Dies for complicated or thin walled profiles
- Hollow dies
- Dies for difficult-to-extrude alloys

For extrusion tooling components e.g. liners, dummy blocks, mandrels and stems Uddeholm QRO 90 Supreme gives an improved tool life compared to AISI H13 in aluminium and steel extrusion.

In brass and copper extrusion Uddeholm QRO 90 Supreme has given improved tool life for dummy blocks and die holders compared to AISI H13.

Similar improvements have also been made with liners in Uddeholm QRO 90 Supreme for brass extrusion.

Forging dies

Uddeholm QRO 90 Supreme has given many outstanding results for press forging of steel, and brass, particularly in small- and medium-sized dies. The product is also eminently suitable for progressive forging, upset forging, extrusion forging, powder forging and all processes where heavy water cooling is used.

Properties

All specimens are taken from the centre of a 356 x 127 mm (14" x 5") bar. Unless otherwise is indicated all specimens were hardened 30 minutes at 1030°C (1885°F), quenched in air and tempered 2 + 2h at 645°C (1190°F). The hardness were 45 ±1 HRC.

Physical data

Hardened and tempered to 45 HRC.
Data at room and elevated temperatures.

Temperature	20°C (68°F)	400°C (750°F)	600°C (1110°F)
Density kg/m³ lbs/in³	7 800 0.281	7 700 0.277	7 600 0.274
Modulus of elasticity N/mm² psi	210 000 30.5 x 10^6	180 000 26.1 x 10^6	140 000 20.3 x 10^6
Coefficient of thermal expansion per °C from 20°C °F from 68°F	– –	12.6 x 10^{-6} 7.0 x 10^{-6}	13.2 x 10^{-6} 7.3 x 10^{-6}
Thermal conductivity W/m °C Btu in(ft²h°F)	– –	33 230	33 230

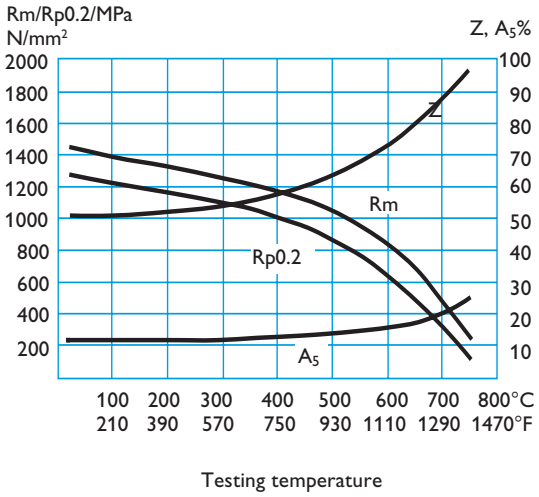
Mechanical properties

Approximate tensile strength at room temperature.

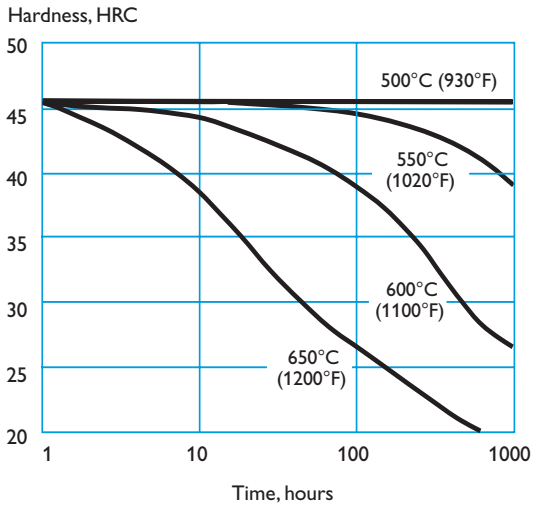
Hardness	48 HRC	45 HRC	40 HRC
Tensile strength R_m	165 kp/mm² 1620 N/mm²	150 kp/mm² 1470 N/mm²	128 kp/mm² 1250 N/mm²
Yield strength Rp0,.	143 kp/mm² 1400 N/mm²	130 kp/mm² 1270 N/mm²	112 kp/mm² 1100 N/mm²

APPROXIMATE STRENGTH AT ELEVATED TEMPERATURES

Longitudinal direction.

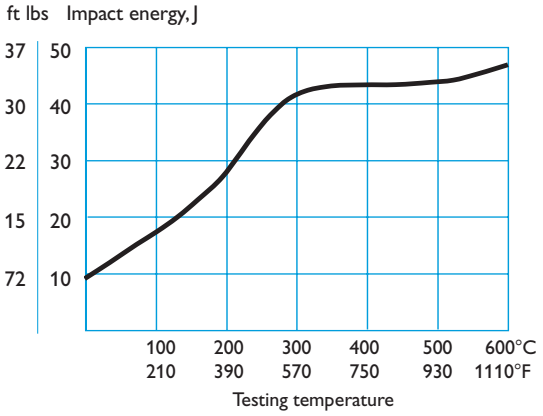


EFFECT OF TIME AT HIGH TEMPERATURES ON HARDNESS



EFFECT OF TESTING TEMPERATURE ON IMPACT ENERGY

Charpy V specimens, short transverse direction.



Heat treatment— general recommendations

Soft annealing

Protect the steel and heat through to 820°C (1500°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

Pre-heating temperature: 600–850°C (1110–1560°F) normally in two pre-heating steps.

Austenitizing temperature: 1020–1050°C (1870–1920°F).

Temperature °C	°F	Soaking* time minutes	Hardness before tempering
1020	1870	30	51±2 HRC
1050	1920	15	52±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

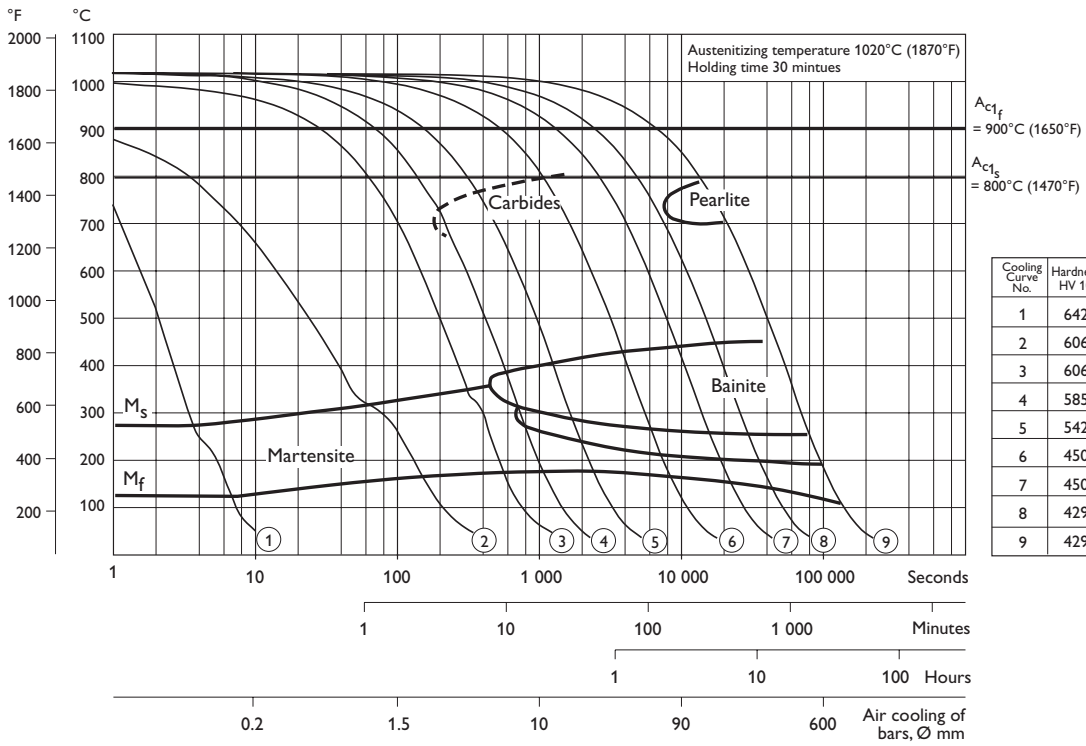
- High speed gas/circulating atmosphere
- Vacuum (high speed gas with sufficient positive pressure). An interrupted quench is recommended
- Martempering bath or fluidized bed at 550°C (1020°F)
- Martempering bath or fluidized bed at 180–220°C (360–430°F)
- Warm oil

Note 1: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

Note 2: In order to obtain the optimum properties for the tool, the cooling rate should be fast but not at a level that gives excessive distortion or cracks.

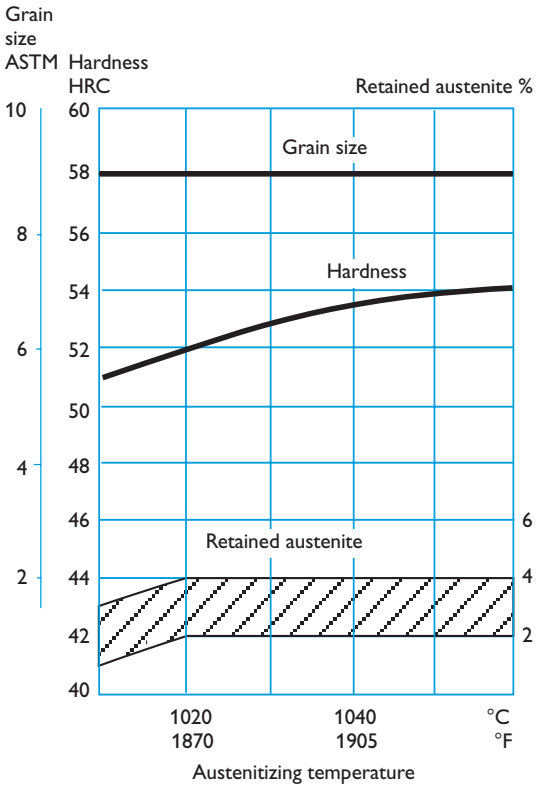
CCT GRAPH

Austenitizing temperature 1870°F (1020°C). Holding time 30 minutes



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ (sec)
1	642	1
2	606	28
3	606	140
4	585	280
5	542	630
6	450	2325
7	450	5215
8	429	11063
9	429	32840

HARDNESS, GRAIN SIZE AND RETAINED AUSTENITE AS FUNCTIONS OF AUSTENITIZING TEMPERATURE



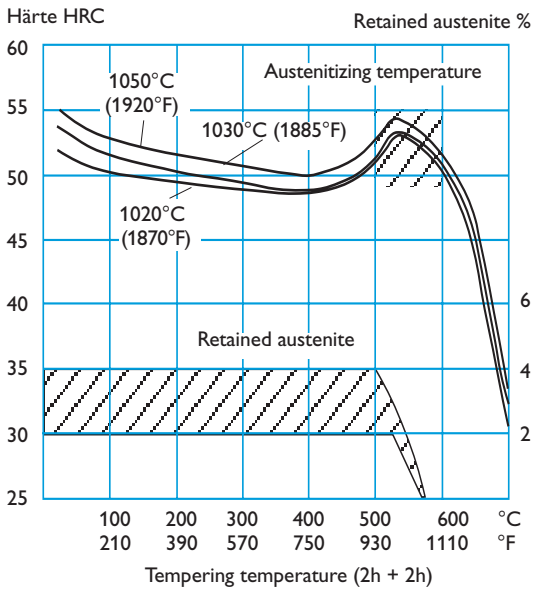
Tempering

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper minimum twice with intermediate cooling to room temperature.

Lowest tempering temperature 600°C (1110°F). Holding time at temperature minimum 2 hours. To avoid "temper brittleness" do not temper in the range 500–600°C (930–1110°F).

TEMPERING GRAPH

Air cooling of specimens 25 x 25 x 40 mm (1" x 1" x 1 1/2"). Larger sections, which contain bainite after hardening, are characterized by a lower initial hardness and displacement of the secondary hardening peak to higher temperatures. During overtempering, however, the curves are more or less identical from about 45 HRC down, irrespective of section size.

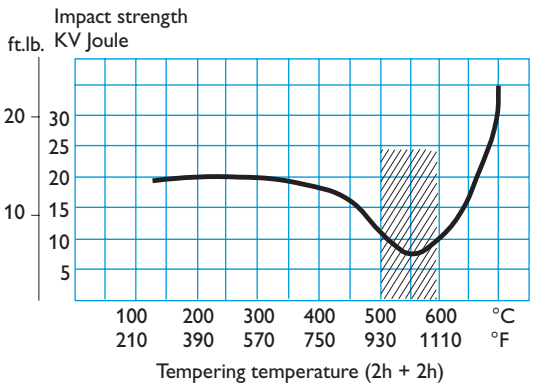


Core pins in Uddeholm QRO 90 HT (prehardened Uddeholm QRO 90 Supreme)

Shot sleeves in Uddeholm QRO 90 Supreme

APPROXIMATE IMPACT STRENGTH AT DIFFERENT TEMPERING TEMPERATURES

Longitudinal specimens, heat treated after machining.



Tempering within the range 500—600°C (930–1110°F) is normally not recommended due to the reduction in toughness properties.

Dimensional changes during hardening and tempering

During hardening and tempering the die is exposed to thermal as well as transformation stresses. This will inevitably result in dimensional changes and in the work case distortion. It is therefore recommended to always leave a machining allowance after machining before the die is hardened and tempered. Normally the size in the largest direction will shrink and the size in the smallest direction might increase but this is also a matter of the die size, the die design as well as the cooling rate after hardening.

For Uddeholm QRO 90 Supreme it is recommended to leave a machining allowance of 0.3 per cent of the dimension in length, width and thickness.

Nitriding and nitrocarburizing

Nitriding and nitrocarburizing result in a hard surface layer which is very resistant to wear and erosion. The nitrided layer is, however, brittle and may crack or spall when exposed to mechanical or thermal shock, the risk increasing with layer thickness. Before nitriding, the tool should be hardened and tempered at a temperature minimum 25–50°C (50–90°F) above the nitriding temperature.

Nitriding in ammonia gas at 510°C (950°F) or plasma nitriding in a 75% hydrogen/25% nitrogen mixture at 480°C (895°F) both result in a surface hardness of about 1000 $HV_{0.2}$. In general, plasma nitriding is the preferred method because of better control over nitrogen potential; in particular, formation of the so-called white layer, which is not recommended for hot-work service, can readily be avoided. However, careful gas nitriding can give perfectly acceptable results.

Uddeholm QRO 90 Supreme can also be nitrocarburized in either gas or salt bath. The surface hardness after nitrocarburizing is 800–900 $HV_{0.2}$.

Depth of nitridig

Process	Time	Depth mm	Depth inch
Gas nitriding at 510°C (950°F)	10 h 30 h	0.16 0.27	0.0063 0.0106
Plasma nitriding at 480°C (895°F)	10h 30 h	0.18 0.27	0.0070 0.0106
Nitrocarburizing – in gas at 580°C (1075°F)	2.5 h	0.20	0.0078
– in salt bath at 580°C (1075°F)	1 h	0.13	0.0051

Nitriding to case depths >0.3 mm (0.012 inch) is not recommended for hot-work applications. It should be noted that Uddeholm QRO 90 Supreme exhibits better nitridability than AISI H13. For this reason, the nitriding times for Uddeholm QRO 90 Supreme should be shortened in relation to H13, otherwise there is considerable risk that the case depth will be too great.

Uddeholm QRO 90 Supreme can be nitrided in the soft annealed condition. The hardness and depth of case will, however, be reduced somewhat in this case.

Die casting die in Uddeholm QRO 90 Supreme.

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 parameters	Turning with carbide		Turning with HSS
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min f.p.m.	200–250 656–820	250–300 820–984	25–30 82–98
Feed (f) mm/rev 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	0.5–2 0.02–0.08
Carbide designation ISO US	P20–P30 C6–C5 Coated carbide	P10–P20 C7–C6 Coated carbide or cermet	– –

Drilling

HIGH SPEED STEEL TWIST DRILL

Drill diameter		Cutting speed, (v_c)		Feed, (f)	
mm	inch	m/min.	f.p.m.	mm/rev	i.p.r.
– 5	–3/16	16–18*	52–59*	0.05–0.15	0.002–0.006
5–10	3/16–3/8	16–18*	52–59*	0.15–0.20	0.006–0.008
10–15	3|8–5|8	16–18*	52–59*	0.20–0.25	0.008–0.010
15–20	5|8–3|4	16–18*	52–59*	0.25–0.30	0.010–0.012

* For coated HSS drill v_c = 28–30 m/min. (92–98 f.p.m.)

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip[1]
Cutting speed, (v_c) m/min f.p.m.	220–240 722–787	130–160 427–525	80–110 262–361
Feed, (f) mm/rev i.p.r.	0.05–0.25[2] 0.002–0.01[2]	0.1–0.25[2] 0.004–0.01[3]	0.15–0.25[2] 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 MILLING

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m.	180–260 590–853	260–300 853–984
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 0.08–0.2	–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		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min f.p.m.	160–200 525–656	170–230 558–755	35–40[1] 115–131[1]
Feed (f_z) mm/tooth inch/tooth	0.03–0.2[2] 0.001–0.008[2]	0.08–0.2[2] 0.003–0.008[2]	0.05–0.35[2] 0.002–0.014[2]
Carbide designation ISO US	– –	P20–P30 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 theUddeholm publication "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 24GV	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

Electrical-discharge machining

If spark-erosion is performed in the hardened and tempered condition, the white re-cast layer should be removed mechanically e.g. by grinding or stoning. The tool should then be given an additional temper at approx. 25°C (50°F) below the previous tempering temperature.

Welding

Welding of tool steel can be performed with good results if proper precautions are taken regarding elevated temperature, joint preparation, choice of consumables and welding procedure.

Welding method	TIG	MMA
Working temperature	325–375°C (620–710°F)	325–375°C (620–710°F)
Filler metals	QRO 90 TIG-WELD	QRO 90 WELD
Post welding cooling	20–40°C/h (35–70°F/h) for the first 2–3 hours and then freely in air.	
Hardness after welding	50–55 HRC	50–55 HRC
Heat treatment after welding		
Hardened condition	Temper at 10–20°C (20–40°F) below the original tempering temperature	
Soft annealed condition	Soft-anneal the material at 820°C (1500°F) in protected atmosphere. Then cool in the furnace at 10°C (20°F) per hour to 650°C (1200°F) then freely in air.	

More detailed information can be found in the Uddeholm brochure "Welding of Tool Steel".

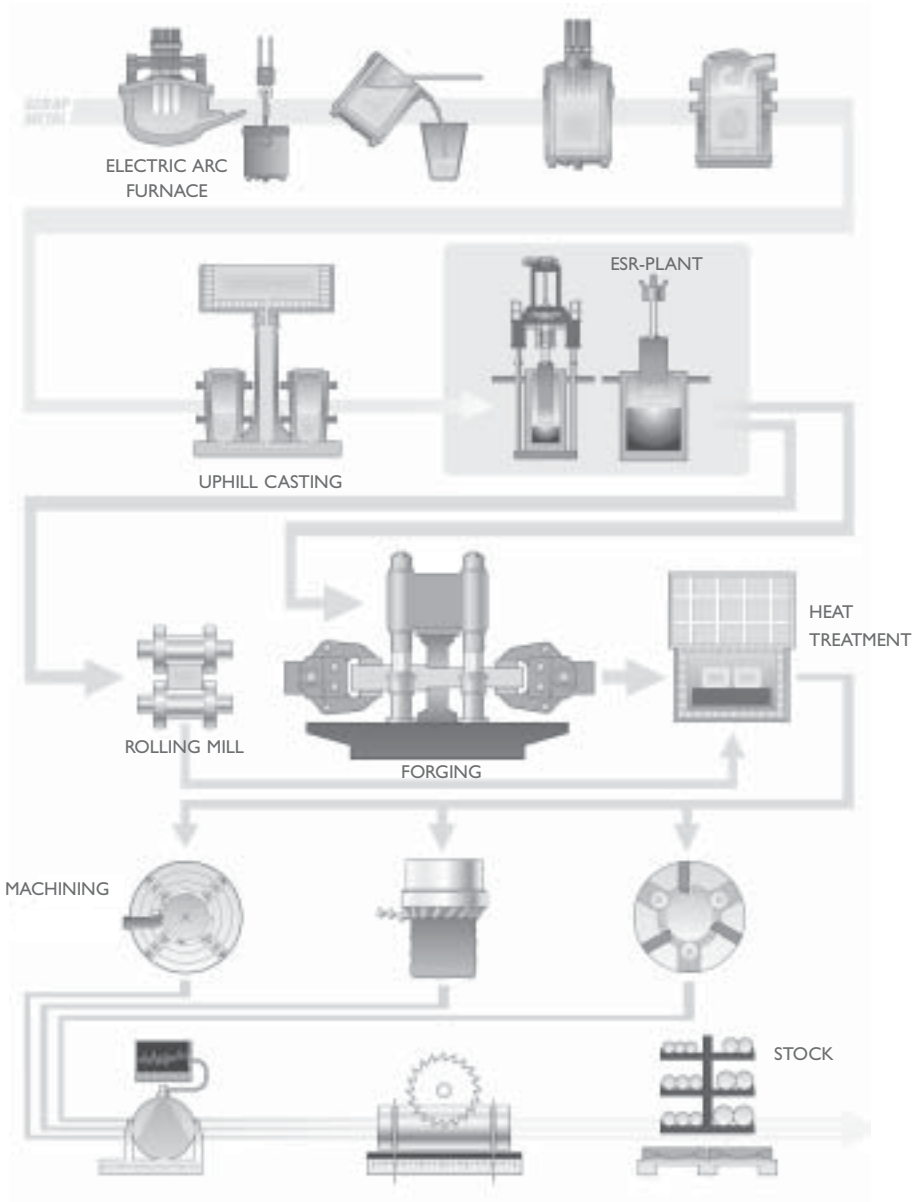
Hard-chromium plating

After plating, parts should be tempered at 180°C (360°F) for 4 hours to avoid the risk of hydrogen embrittlement.

Further information

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

Dummy blocks in Uddeholm QRO 90 Supreme.



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 sulfur.

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.

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 the Asia Pacific area. Together we secure our position as the world's leading supplier of tooling materials.

ASSAB
www.assab.com

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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 the Asia Pacific area. 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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