Uddeholm
Hotvar®

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".

Edition 4, 09.2011

SS-EN ISO 9001
SS-EN ISO 14001

GENERAL

Uddeholm Hotvar is a high performance molybdenum-vanadium alloyed hot-work tool steel which is characterized by:

- high hot wear resistance
- very good high temperature properties
- high resistance to thermal fatigue
- very good temper resistance
- very good thermal conductivity

Typical analysis %	C 0.55	Si 1.0	Mn 0.8	Cr 2.6	Mo 2.3	V 0.9
Standard specification	None					
Delivery condition	Soft annealed to approx. 210 HB					
Colour code	Red/brown					

IMPROVED TOOLING PERFORMANCE

Uddeholm Hotvar is a specially premium hot work steel developed by Uddeholm to provide a very good performance in tooling up to 650°C. The alloy elements in Uddeholm Hotvar are balanced to give high hot wear resistance and good high temperature properties. Uddeholm Hotvar is manufactured by special techniques.

APPLICATIONS

Uddeholm Hotvar is a hot-work tool steel suitable for applications where hot wear and/or plastic deformation are the dominating failure mechanisms.

Applications and tools of especial interest:

- warm forging, dies and punches
- roll forging, rolling segments
- rock orbital forging, punches and dies
- upset forging, clamping tools
- progressive forging, dies
- axial closed die rolling, top and bottom dies
- cross forming, segments
- hot bending, tools
- hot calibration, tools
- zinc die casting, dies
- Al-tube extrusion

Recommended hardness level is 54–58 HRC. For improving the wear resistance the tools can be plasma nitrided or nitrocarburized.

PROPERTIES

All specimens are taken from the centre of a bar 115 mm Ø (4,5”). Unless otherwise is indicated all specimens were hardened at 1050°C (1920°F), quenched in air and tempered 2 + 2 h at 575°C (1070°F) to a hardness corresponding to 56 HRC.

PHYSICAL DATA

Data at room and elevated temperatures.

Temperature	20°C (68°F)	400°C (750°F)	600°C (1110°F)
Density kg/m³	7 800	7 700	7 600
Density lbs/in³	0.281	0.277	0.274
Modulus of elasticity MPa	210 000	180 000	140 000
Modulus of elasticity psi	30.5×10^6	26.1×10^6	20.3×10^6
Coefficient of thermal expansion per °C from 20°C	–	12.6×10^{-6}	13.2×10^{-6}
Coefficient of thermal expansion per °F from 68°F	–	7.0×10^{-6}	7.3×10^{-6}
Thermal conductivity W/m °C	31	33	33
Thermal conductivity Btu in/(ft²h°F)	215	230	230

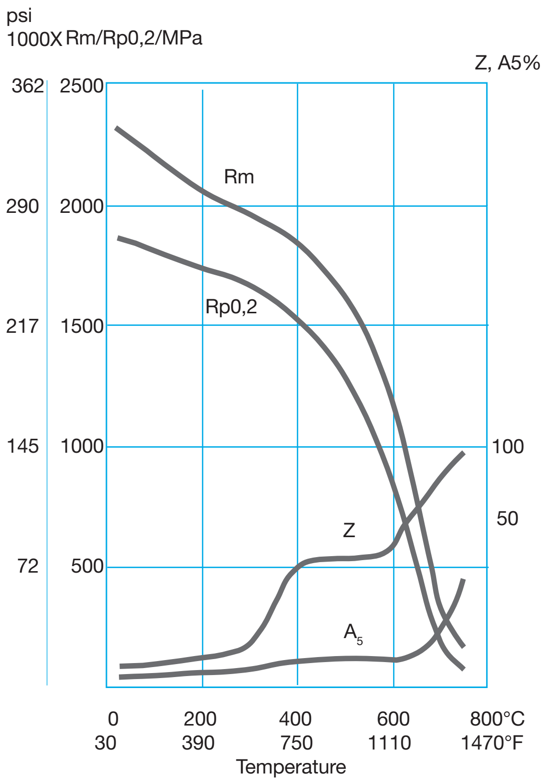
MECHANICAL PROPERTIES

Approximate tensile strength at room temperature.

Hardness	54 HRC	56 HRC	58 HRC
Tensile strength Rm	2 100 MPa 136 tsi 305 000 psi	2 200 MPa 142 tsi 320 000 psi	2 300 MPa 149 tsi 335 000 psi
Yield strength Rp0,2	1 800 MPa 117 tsi 260 000 psi	1 820 MPa 119 tsi 265 000 psi	1 850 MPa 121 tsi 270 000 psi

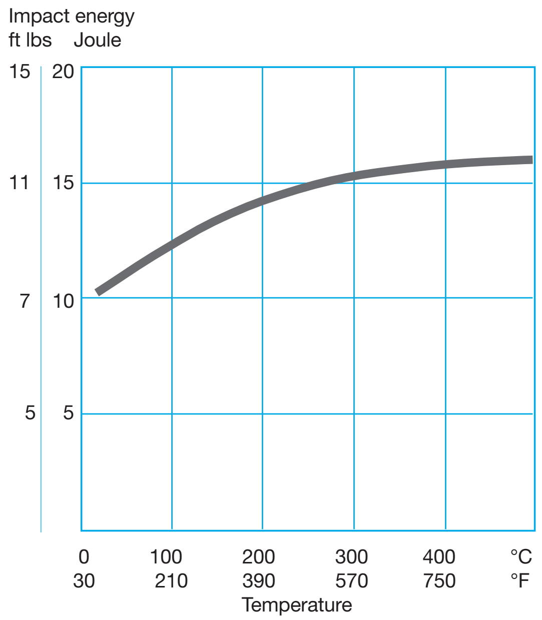
HOT STRENGTH

Hot strength in longitudinal direction.



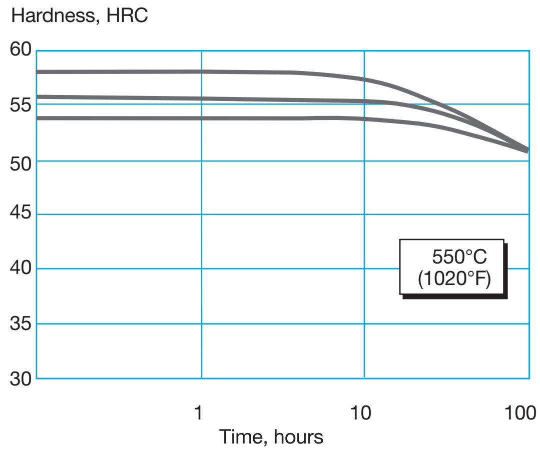
EFFECT OF TESTING TEMPERATURE ON IMPACT ENERGY

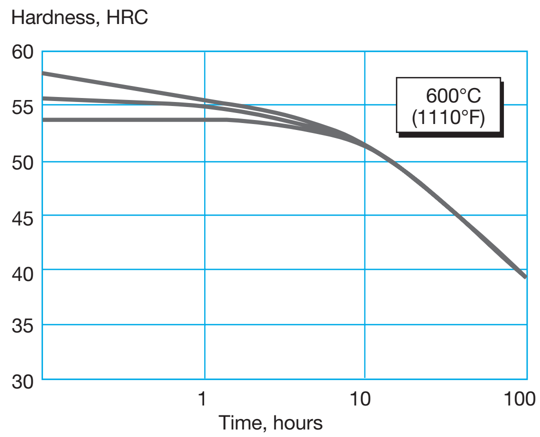
Charpy-V specimens, transverse direction.

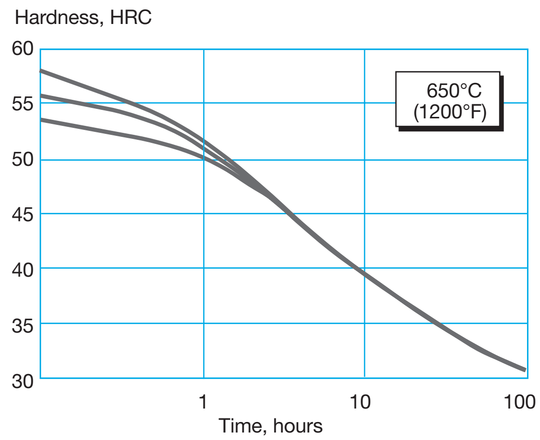


EFFECT OF TIME AT HIGH TEMPERATURE ON HARDNESS

The softening at high temperatures and different holding times are shown below. The specimens have first been hardened and tempered to 54, 56 and 58 HRC.







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 600°C (1110°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 350°C (660°F), then freely in air.

HARDENING

Pre-heating temperature: first step at 480–600°C (895–1110°F), second step at 850 (1560°F).

Austenitizing temperature: 1050–1070°C (1920–1960°F), normally 1050°C (1920°F) but when maximum hardness is required the normally temperature is 1070°C (1960°F).

Temperature °C	Temperature °F	Soaking* time minutes	Hardness before temp. for Ø 25 mm (1") Oil	Hardness before temp. for Ø 25 mm (1") Air
1050	1920	30	61 ±1	59 ±1
1070	1960	20	62 ±1	60 ±1

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

Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

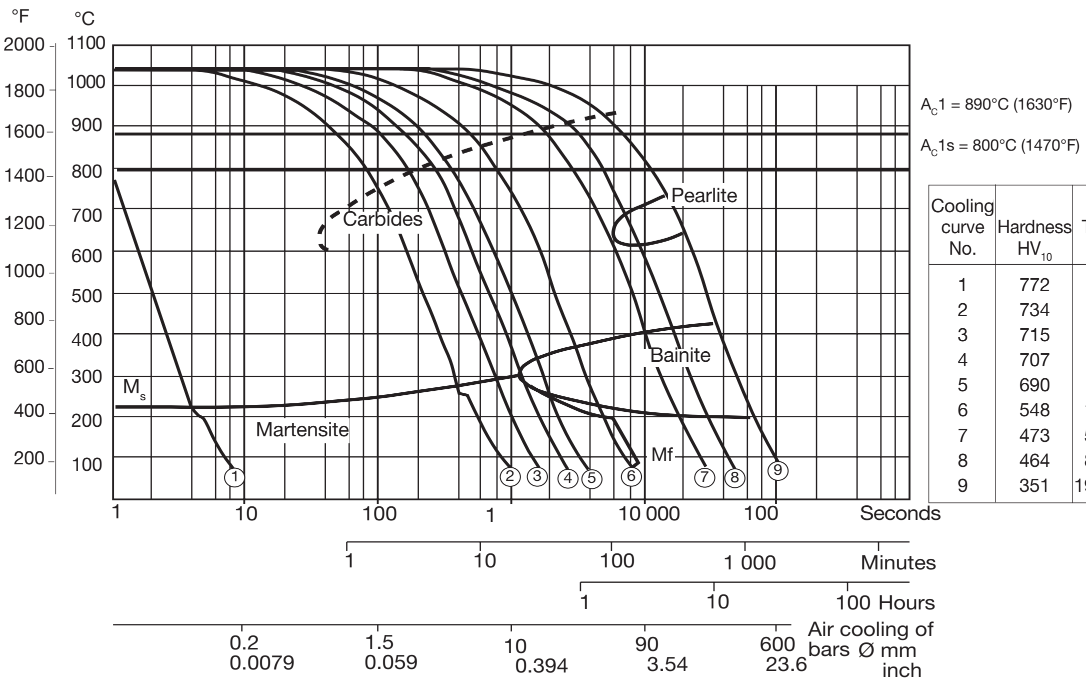
- High speed gas/circulating atmosphere
- Vacuum (high speed gas with sufficient positive pressure)
- Martempering bath or fluidized bed at 450–550°C (840–1020°F)
- Martempering bath or fluidized bed at approx. 180–220°C (360–430°F)
- Warm oil, approx. 80°C (175°F)

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

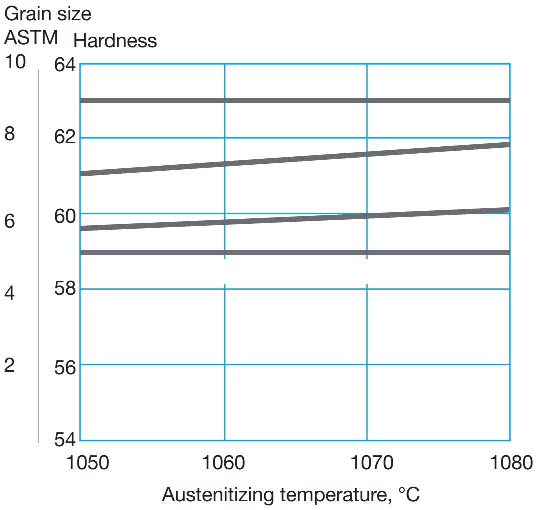
Austenitizing temperature 1050°C (1920°F). Holding time 30 minutes.



Cooling curve No.	Hardness HV_{10}	$T_{800-500}$ (sec)
1	772	1
2	734	140
3	715	280
4	707	450
5	690	630
6	548	1390
7	473	5215
8	464	8360
9	351	19400

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

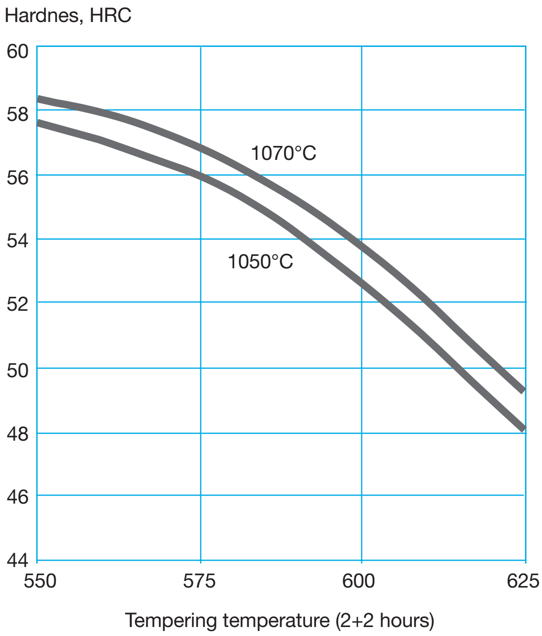
Samples Ø 25 mm (1 inch)



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. Holding time at temperature minimum 2 h.

TEMPERING GRAPH



Tempering at 250°C (485°F), 2 + 2 h gives a hardness o f 56–58 HRC.

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 worse case distortion. It is therefore recommended to always leave enough 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 Hotvar it is recommend to leave a machining allowance of 0.4 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 at least 50°C (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.

Uddeholm Hotvar e can also be nitrocarburized in either gas or salt bath. The surface hardness after nitrocarburizing is about 900 $HV_{0.2}$.

DEPTH OF NITRIDING

Process	Time	Depth mm	Depth inch
Plasma nitriding at 480°C (895°F)	10 30	0.18 0.27	0.0070 0.0106
Nitrocarburizing			
–in gas at 580°C (1075°F)	2.5	0.20	0.0080
–in salt bath at 580°C (1075°F)	1	0.13	0.0050

It should be noted that Uddeholm Hotvar exhibits better nitridability than AISI H13. For this reason, the nitriding times for Uddeholm Hotvar should be shortened in relation to H13, otherwise there is a considerable risk that the case depth will be too great.

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 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.	150–170 490–560	170–190 560–620	20–25 65–80
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	0.5–3 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	Milling with carbide: Rough milling	Milling with carbide: Fine milling
Cutting speed (v_c) m/min f.p.m.	140–200 460–655	260–240 850–785
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	2–5 0.08–0.2	–2 –0.08
Carbide designation ISO US	P20–P40 C6–C5 Coated carbide	P10 C7 Coated carbide or cermet

END MILLING

Cutting data parameters	Type of end mill: Solid carbide	Type of end mill: Carbide indexable insert	Type of end mill: High speed steel
Cutting speed (v_c) m/min f.p.m.	110–150 360–490	120–160 390–520	20–25[1] 65–80[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 high speed steel end mill v_c = 35–40 m/min (115–130 f.p.m.)

[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*	46–50*	0,05–0,15	0,002–0,006
5–10	3/16–3/8	14–16*	46–50*	0,15–0,20	0,006–0,008
10–15	3/8–5/8	14–16*	46–50*	0,20–0,25	0,008–0,010
15–20	5/8–3l4	14–16*	46–50*	0,25–0,35	0,010–0,014

* For coated HSS drill v_c =18–22 m/min. (60–70 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.	160–200 520–655	130–160 425–520	55–60 180–195
Feed (f) mm/r i.p.r.	0.03–0.12[2)] 0.0012–0.005[2)]	0.08–0.20[3)] 0.003–0.008[3)]	0.15–0.25[4)] 0.006–0.010[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”)

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm brochure “Grinding of Tool Steel” and can also be obtained from the grinding wheel manufacturer.

WHEEL RECOMMENDATION

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 GV
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 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

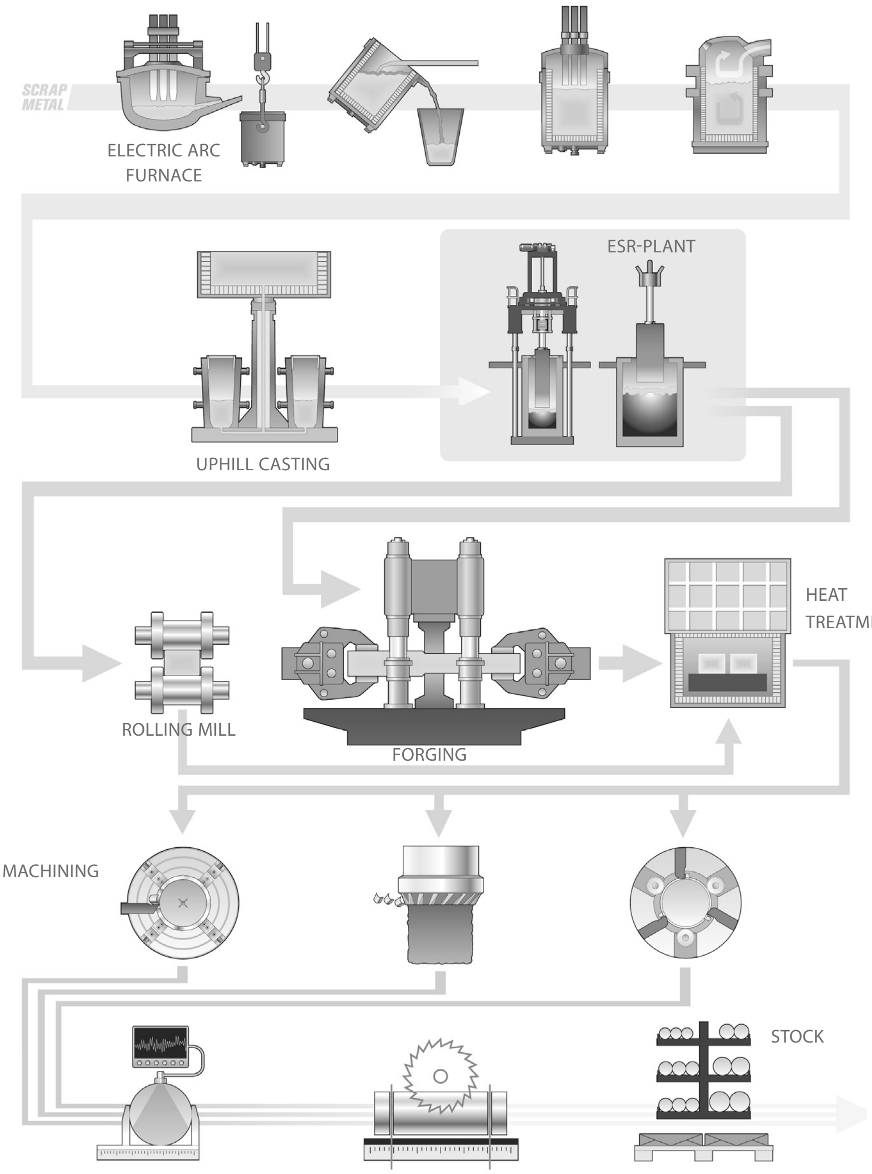
Welding of tool steel can be performed with good results if proper precautions are taken regarding elevated temperature, joint preparation, choice of consumables and welding procedure.

Welding method	TIG	MMA
Working temperature	325–375°C 620–710°F	325–375°C 620–710°F
Filler metal	QRO 90 TIG-WELD	QRO 90 WELD
Hardness after welding	48–53 HRC	48–53 HRC
Heat treatment after welding		
Hardened condition	Temper at 20°C (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 600°C (1110°F) then freely in air.	

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

FURTHER INFORMATION

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



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 degassing 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

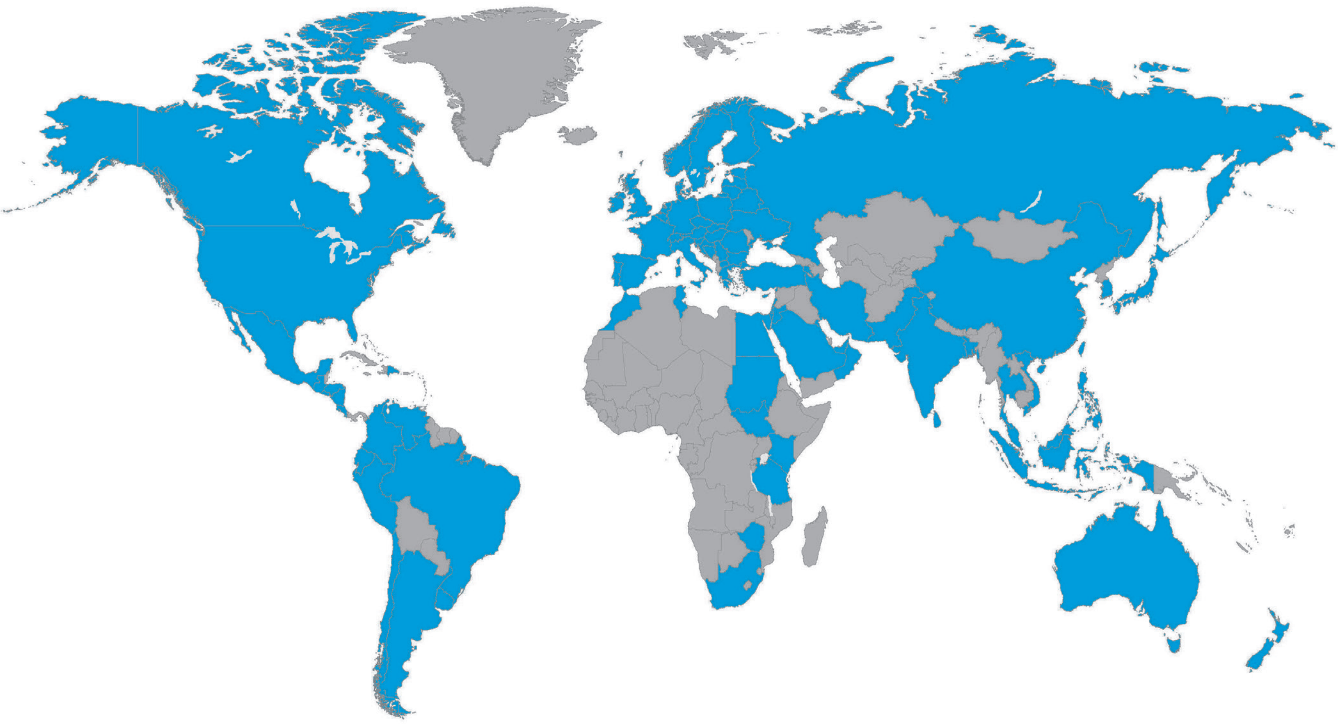
From the ESR plant, the steel goes to the rolling mill or to our forging press to be formed into round or flat bars.

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.



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.

UDDEHOLM 110904

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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