



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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The latest revised edition of this brochure is the English version, which is always published on our web site [www.uddeholm.com](http://www.uddeholm.com)



SS-EN ISO 9001  
SS-EN ISO 14001

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## UDDEHOLM THG 2000

Reliable and efficient steel is essential for good results. The same goes for achieving high productivity and high availability. When choosing the right steel many parameters must be considered, however, by using superior steel your productivity can be greatly improved. With excellent machinability and very good dimension stability during hardening, you will spend less time to finish your product, this makes it easier to meet your deadline.

Uddeholm THG 2000 is a steel grade which provides several benefits in applications with high demands on mechanical properties in combination with excellent machinability.

### SUPERIOR MACHINABILITY

Superior machinability will give you the advantage of shorter machining time. In turn this means that it will be easier for you to meet your customers demands on delivery time. You will also benefit from lower cutting tool cost and increased availability of your machines. The excellent machinability will be most evident when drilling and tapping of small holes.

### GOOD MECHANICAL PROPERTIES IN HIGH TEMPERATURES

Uddeholm THG 2000 is a high strength special steel, intended for applications with severe demands on mechanical properties of the material. It will also be an excellent choice for products where good high-temperature strength and resistance to thermal fatigue is required. Uddeholm THG 2000 has also very good resistance to abrasion at both low and high temperatures.

### UDDEHOLM HIGH PERFORMANCE STEEL FOR SHAFTS

Used in hardened condition, Uddeholm THG 2000 is an extremely strong and tough steel. This means excellent results with shafts that last up to four times longer than other traditional steel.

## General

Uddeholm THG 2000 is a high-strength special steel, intended for applications with severe demands on the mechanical properties of the material, while also requiring good machinability. Its main features are:

- Good resistance to abrasion at both low and high temperatures
- Good toughness and ductility
- Good high-temperature strength and resistance to thermal fatigue
- Good through-hardening characteristics and suitability for air hardening
- Very little distortion during hardening

Compared with similar steel grades the machinability is improved, which facilitates such operations as drilling and tapping small holes. It is particularly suitable for induction-hardening, and can also be given a PVD coating without reducing the hardness of the tool.

Typical analysis %	C	Si	Mn	Cr	Mo	V
	0.39	0.5	0.4	5.3	1.3	0.9
Delivery condition	Soft annealed to approx. 185 HB Prehardened – on demand					
Colour code	Yellow/violet – soft annealed Violet/grey – prehardened					

## Applications

- Indexable insert drills and milling cutters
- Milling chucks and tool tapers
- Highly stressed drive shafts and transmission parts
- Rolls in continuous casting machines
- Clamp jaws
- Conveyor rollers for carrying hot parts



Indexable insert drills, manufactured from Uddeholm THG 2000.

## Properties

### Physical data

Hardened and tempered to 45 HRC.

Data at room temperature and at elevated temperatures.

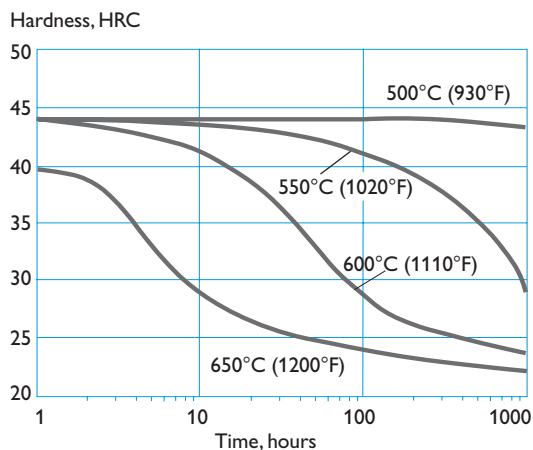
Temperature	20°C (68°F)	400°C (750°F)	600°C (1110°F)
Density kg/m <sup>3</sup> lbs/in <sup>3</sup>	7 800 0.281	7 700 0.277	7 600 0.274
Modulus of elasticity N/mm <sup>2</sup> psi	210 000 30.3 × 10 <sup>6</sup>	180 000 26.1 × 10 <sup>6</sup>	140 000 20.3 × 10 <sup>6</sup>
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	– –	12.6 × 10 <sup>-6</sup> 7.0 × 10 <sup>-6</sup>	13.2 × 10 <sup>-6</sup> 7.3 × 10 <sup>-6</sup>
Coefficient of thermal conductivity W/m °C Btu in/(ft <sup>2</sup> h °F)	– –	29 204	30 211

### Mechanical properties

Approximate tensile strength at room temperature.

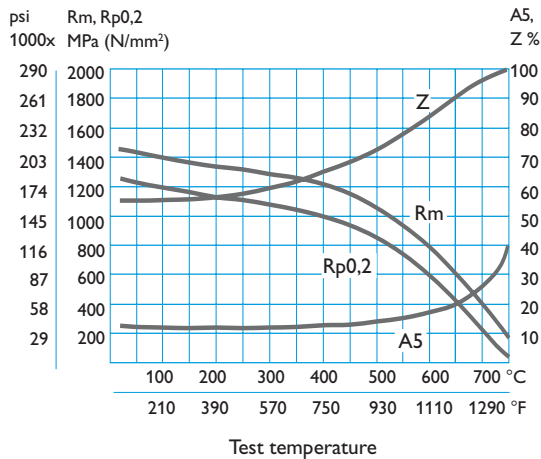
Hardness	52 HRC	45 HRC	39 HRC
Ultimate tensile strength, R <sub>m</sub> N/mm <sup>2</sup> kp/mm <sup>2</sup> tsi psi	1 820 185 117 263 000	1 420 145 92 206 000	1 230 125 79 178 000
Yield strength, R <sub>p0.2</sub> N/mm <sup>2</sup> kp/mm <sup>2</sup> tsi psi	1 520 155 98 220 000	1 280 130 83 185 000	1 050 107 68 152 000

### EFFECT OF HOLDING TIME ON HARDNESS AT ELEVATED TEMPERATURES



**STRENGTH AT ELEVATED TEMPERATURES**

Longitudinal direction.



**Heat treatment**

**Soft annealing**

Protect the steel against decarburization and heat it through to 850°C (1560°F). Allow it to cool in the furnace at a rate of 10°C (20°F) per hour to 650°C (1200°F), and then freely in air.

**Stress relieving**

After rough machining it is recommended to do a stress relieving, the part shall then be heated through to 650°C (1200°F), and held at this temperature for two hours. Cool slowly to 500°C (930°F), and then freely in air.

**Hardening**

Preheating temperature: 600–850°C (1110–1560°F).  
Austenitizing temperature: 900–1030°C (1650–1890°F), normally 1020°C (1870°F).

Temperature		Soaking time* minutes	Hardness before tempering
°C	°F		
900	1650	45	44 ± 3 HRC
920	1690	45	46 ± 3 HRC
940	1720	45	47 ± 3 HRC
960	1760	45	48 ± 3 HRC
980	1800	45	50 ± 3 HRC
1000	1830	45	52 ± 3 HRC
1020	1870	30	53 ± 3 HRC

\* Soaking time = time at specified temperature after the part is fully heated through

Protect the part from decarburization during hardening.

**Quenching media**

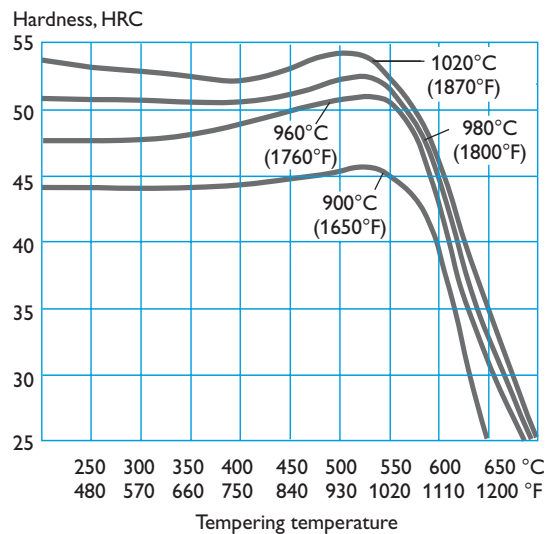
- Circulating air or atmosphere
- Vacuum furnace (with sufficient positive pressure)
- Martempering bath or fluidized bed at 180–220°C (350–430°F), or at 450–550°C (840–1020°F), followed by cooling in air
- Hot oil 60–70°C (140–160°F).

Note: Temper the part as soon as its temperature has fallen to 50–70°C (120–160°F).

**Tempering**

Choose the tempering temperature to suit the hardness required by reference to the diagram below. Temper twice, with intermediate cooling to room temperature. The minimum tempering temperature is 180°C (360°F). The holding time at the relevant temperature shall be at least 2 hours.

TEMPERING GRAPH



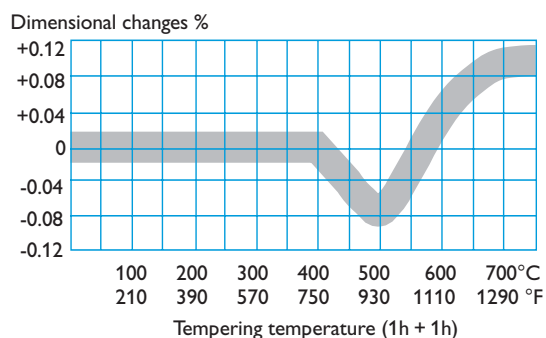
Tempering within the range 425–525°C (800–980°F) is not normally recommended, due to the fact that toughness properties are degraded in this temperature range.

## Dimensional changes during hardening

Test plate size 100 x 100 x 25 mm

	Width %	Length %	Thickness %
Oil-hardened from 1020°C (1868°F) min. max.	-0.08 -0.15	-0.06 -0.16	0.00 +0.30
Air-hardened from 1020°C (1868°F) min. max.	-0.02 +0.03	-0.05 +0.02	- +0.05
Vacuum-hardened from 1020°C (1868°F) min. max.	+0.01 +0.02	-0.02 -0.04	+0.08 +0.12

## Dimensional changes during tempering



Note: The dimensional changes occurring during hardening and tempering are cumulative.

## Case hardening

The intention with the case hardening is to obtain a tough core and a hard wear resistance surface. The core will achieve a hardness of 50 ±2 HRC and the surface a hardness of 60 ±2 HRC.

Final grinding operations, in order to achieve correct dimensions, should be performed as a last operation after case hardening.

### PRE-OXIDATION

Pre-oxidation is done in order to avoid uneven carburization.

If different furnaces are used for pre-oxidation and carburization, the part has to be transferred between the furnaces as quick as possible.

Per-oxidation 850°C (1560°F). Slow heating in air. Holding time 2 hours ±10 minutes.

Carburizing temperature: 900°C (1650°F) ±10°C (50°F). Carbon potential ~0,75. Holding time approx. 16 hours. Time is set due to requested case hardened depth.

Austenitizing temperature: 980°C (1795°F) ±10°C (50°F). Holding time 30 minutes ± 5 minutes. Cool in circulating air.

Tempering temperature: 260°C (500°F) ±10°C (50°F). Holding time 2 x 1 hour.

Carburizing time	Case hardening depth approx.	
	mm	inch
2 hours	~0.35	~0.014
4 hours	~0.65	~0.025
16 hours	~1.30	~0.051

Use a mild carburization material.

## Nitriding

Nitriding produces a hard surface layer which is very resistant to wear and erosion. However, the nitrided layer is brittle and can crack or spall if exposed to mechanical or thermal shock, with the risk increasing with layer thickness. Before nitriding, the part must be hardened and tempered at a temperature at least 50°C (90°F) above the nitriding temperature.

Nitriding in ammonia at 510°C (950°F), or plasma nitriding at 480°C (896°F) in a 25% nitrogen— 75% hydrogen mixture, can both produce a surface hardness of about 1100 HV<sub>0.2</sub>. In general, plasma nitriding is to be preferred, as it provides better control of the nitrogen potential. In particular, it avoids formation of the “white layer”, although gas nitriding can give perfectly acceptable results.

Uddeholm THG 2000 can also be nitro-carburized in gas or salt baths, to produce a surface hardness of 900–1000 HV<sub>0.2</sub>.



### NITRIDING DEPTH

Process	Time hours	Nitriding depth	
		mm	inch
Gas nitriding at 510°C (950°F)	10	0.12	0.005
	30	0.20	0.008
Plasma nitriding at 480°C (896°F)	10	0.12	0.005
	30	0.18	0.007
Nitrocarburizing – in gas at 580°C (1076°F) – in salt bath at 580°C (1076°F)	2.5	0.11	0.004
	1	0.06	0.002

Nitriding to case depths more than 0,3 mm (0,012 inch) is not recommended for components intended for high-temperature applications. Uddeholm THG 2000 can also be nitrided in the soft-annealed condition, although its hardness and case depth will be somewhat reduced.

## Cutting data recommendations

The cutting data below for Uddeholm THG 2000 should be regarded as guide values, which should be modified in the light of experience to suit specific local conditions. For more detailed information, see Uddeholm brochure “Cutting data recommendations”.

*Soft annealed condition: ~185 HB*

### Turning

Cutting data parameters	Turning with carbide		Turning with high speed steel Fine turning
	Rough turning	Fine turning	
Cutting speed ( $v_c$ ) m/min f.p.m.	210–260 690–860	260–310 860–1020	30–35 100–115
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	P10–P15 Coated carbide	P10 Coated carbide or cermet	–

## Drilling

### HIGH SPEED STEEL TWIST DRILL

Drill diameter Ø		Cutting speed ( $v_c$ )		Feed (f)	
mm	inch	m/min	f.p.m.	mm/r	i.p.r.
–5	–3/16	25–30*	82–100*	0,08–0,20	0,003–0,008
5–10	3/16–3/8	25–30*	82–100*	0,20–0,30	0,008–0,012
10–15	3/8–5/8	25–30*	82–100*	0,30–0,35	0,012–0,014
15–20	5/8–3/4	25–30*	82–100*	0,35–0,40	0,014–0,016

\* For coated HSS drill  $v_c = 30–35$  m/min. (100–115 f.p.m)

### CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip <sup>1)</sup>
Cutting speed ( $v_c$ ) m/min f.p.m.	230–250 755–820	140–170 460–560	90–120 295–390
Feed (f) mm/r i.p.r.	0,06–0,15 <sup>2)</sup> 0,002–0,006 <sup>2)</sup>	0,08–0,30 <sup>2)</sup> 0,003–0,012 <sup>2)</sup>	0,15–0,25 <sup>2)</sup> 0,006–0,01 <sup>2)</sup>

<sup>1)</sup> Drill with replaceable or brazed carbide tip

<sup>2)</sup> Depending on drill diameter

## Milling

### FACE AND SQUARE SHOULDER MILLING

Cutting data parameter	Milling with carbide	
	Rough milling	Fine milling
Cutting speed ( $v_c$ ) m/min f.p.m.	190–270 620–885	270–310 885–1020
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	P20–P40 Coated carbide	P10–P20 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.	170–210 560–690	180–240 590–790	40–45 <sup>1)</sup> 130–148
Feed ( $f_z$ ) mm/tooth inch/tooth	0,03–0,20 <sup>2)</sup> 0,0012–0,008	0,08–0,20 <sup>2)</sup> 0,003–0,008	0,05–0,35 <sup>2)</sup> 0,002–0,014
Carbide designation ISO	“Micrograin” Coated carbide	P20–P30 Coated carbide	–

<sup>1)</sup> For coated HSS end mill  $v_c = 55–65$  m/min. (180–213 f.p.m.)

<sup>2)</sup> Depending on radial depth of cut and cutter diameter

*Cutting data recommendations for Uddeholm THG 2000 in prehardened condition ~45 HRC*

**Turning**

Cutting data parameters	Turning with carbide	
	Rough turning	Fine turning
Cutting speed ( $v_c$ ) m/min f.p.m.	60–80 200–260	80–100 260–330
Feed (f) mm/r i.p.r.	0.2–0.4 0.008–0.016	0.05–0.2 0.002–0.008
Depth of cut ( $a_p$ ) mm inch	2–4 0.08–0.16	0.5–2 0.02–0.08
Carbide designation ISO	P10–P15 Coated carbide	P10 Coated carbide or cermet or mixed carbide

**Drilling**

**TICN-COATED HIGH SPEED STEEL DRILL**

Drill diameter $\varnothing$		Cutting speed ( $v_c$ )		Feed (f)	
mm	inch	m/min	f.p.m.	mm/r	i.p.r.
–5	–3/16	10–15	33–50	0,03–0,15	0,001–0,006
5–10	3/16–3/8	10–15	33–50	0,15–0,20	0,006–0,008
10–15	3/8–5/8	10–15	33–50	0,20–0,25	0,008–0,010
15–20	5/8–3/4	10–15	33–50	0,25–0,30	0,010–0,012



A transmission part manufactured from Uddeholm THG 2000, hardened to 45 HRC.

**CARBIDE DRILL**

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip <sup>1)</sup>
Cutting speed ( $v_c$ ) m/min f.p.m.	90–110 300–360	80–100 260–330	50–60 165–200
Feed (f) mm/r i.p.r.	0,05–0,10 <sup>2)</sup> 0,002–0,004 <sup>2)</sup>	0,05–0,15 <sup>2)</sup> 0,002–0,006 <sup>2)</sup>	0,10–0,15 <sup>2)</sup> 0,004–0,006 <sup>2)</sup>

<sup>1)</sup> Drill with replaceable or brazed carbide tip  
<sup>2)</sup> Depending on drill diameter

**Milling**

**FACE AND SQUARE SHOULDER MILLING**

Cutting data parameter	Milling with carbide	
	Rough milling	Fine milling
Cutting speed ( $v_c$ ) m/min f.p.m.	40–50 130–165	50–70 165–230
Feed ( $f_z$ ) mm/tooth inch/tooth	0.15–0.25 0.006–0.01	0.10–0.20 0.004–0.008
Depth of cut ( $a_p$ ) mm inch	2–4 0.08–0.16	–2 –0.08
Carbide designation ISO	P20–P40 Uncoated carbide	P10–P20 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.	80–100 260–330	80–100 260–330	8–10 <sup>2)</sup> 26–33 <sup>2)</sup>
Feed ( $f_z$ ) mm/tooth inch/tooth	0.03–0.15 <sup>1)</sup> 0.0012–0.006	0.08–0.15 <sup>1)</sup> 0.003–0.006	0.05–0.20 <sup>1)</sup> 0.002–0.008
Carbide designation ISO	"Micrograin" Coated carbide	P15–P30 Coated carbide	TiCN-coated HSS mill

<sup>1)</sup> Depending on radial depth of cut and cutter diameter  
<sup>2)</sup> For coated HSS end mill  $v_c = 10–15$  m/min. (33–49 f.p.m.)

## 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	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 JV
Profile grinding	A 100 KV	A 120 JV

## Electrical-discharge machining, EDM

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.

## Hard-chromium plating

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



Uddeholm THG 2000 is a suitable material for various types of milling cutter bodies.

## Welding

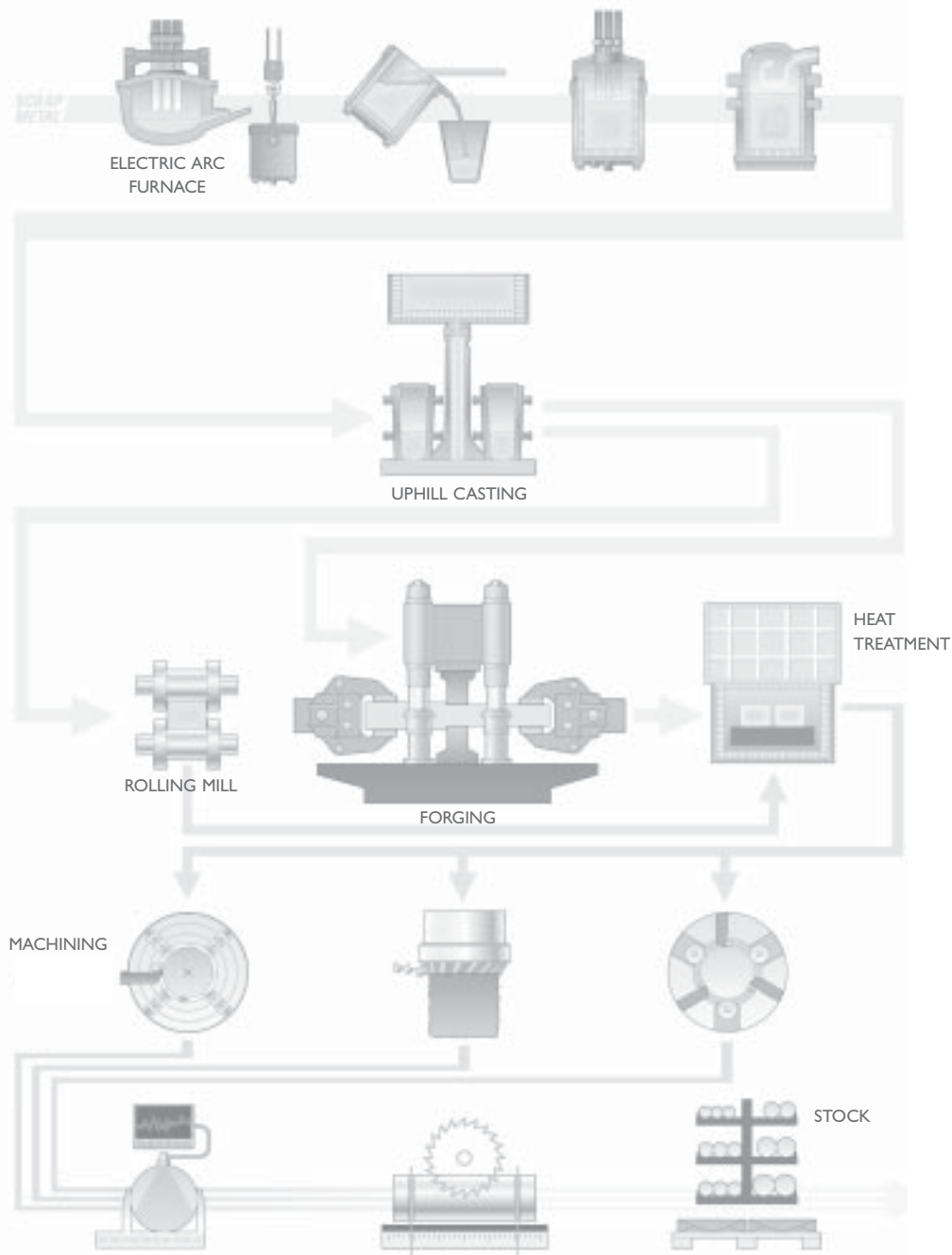
Welding of Uddeholm THG 2000 can be performed with good results if proper precautions are taken regarding elevated temperature, joint preparation, choice of consumables and welding procedure.

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	48–51 HRC	48–51 HRC
<i>Heat treatment after welding</i>		
Hardened condition	Temper at 20°C (40°F) below the original tempering temperature.	
Soft annealed condition	Soft-anneal the material at 850°C (1560°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".

## Further information

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



## 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-sludging 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. ASSAB is our wholly-owned subsidiary and exclusive sales channel, representing Uddeholm in various parts of the world. Together we secure our position as the world's leading supplier of tooling materials.

