THG 2000

High-strength special steel
with good machining properties for demanding applications

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

UDDEHOLM

General

THG 2000 is a chromium-molybdenum-vanadium-alloy steel developed for such applications as indexable insert drill and milling cutter bodies.
THG 2000 is available in soft annealed and prehardened condition.
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 a normal tool steel, 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 0,39	Si 1,0	Mn 0,4	Cr 5,3	Mo 1,3	V 0,9
Delivery condition	Soft annealed to approx. 185 HB Prehardened 39–43 HRC					
Colour code	Yellow/violet – soft annealed Violet/grey – prehardened					

Applications

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.
Examples of applications are:

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

Indexable insert drills, manufactured from THG 2000.

Properties

PHYSICAL DATA

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

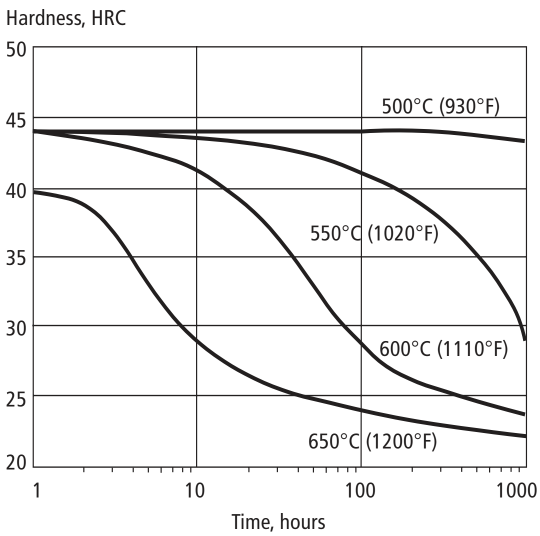
Temperature	20°C (68°F)	400°C (750°F)	600°C (1110°F)
Density			
kg/m³	7800	7700	7600
lbs/in³	0,281	0,277	0,274
Modulus of elasticity			
N/mm²	210 000	180 000	140 000
psi	$30,3 \times 10^6$	$26,1 \times 10^6$	$20,3 \times 10^6$
Coefficient of thermal expansion			
per °C from 20°C	–	$12,6 \times 10^{-6}$	$13,2 \times 10^{-6}$
per °F from 68°F	–	$7,0 \times 10^{-6}$	$7,3 \times 10^{-6}$
Coefficient of thermal conductivity			
W/m °C	–	29	30
Btu in/(ft²h°F)	–	204	211

MECHANICAL PROPERTIES

Approximate tensile strength at room temperature.

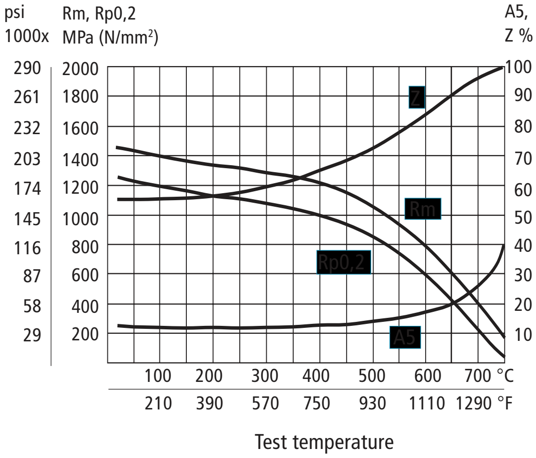
Hardness	52 HRC	45 HRC
Ultimate tensile strength, Rm		
N/mm²	1820	1420
kp/mm²	185	145
tsi	117	92
psi	263 000	206 000
Yield strength, Rp0,2		
N/mm²	1520	1280
kp/mm²	155	130
tsi	98	83
psi	220 000	185 000

Effect of hardening time on hardness at elevated temperatures



Strength at elevated temperatures

Longitudinal direction.



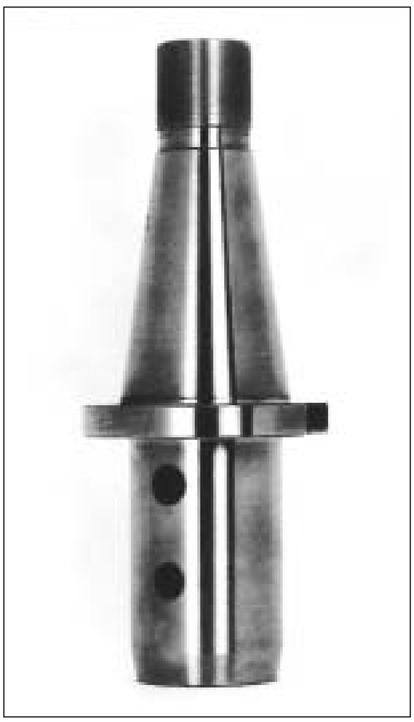
Heat treatment

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 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.



A tool holder for an end mill made of THG 2000.

HARDENING

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

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

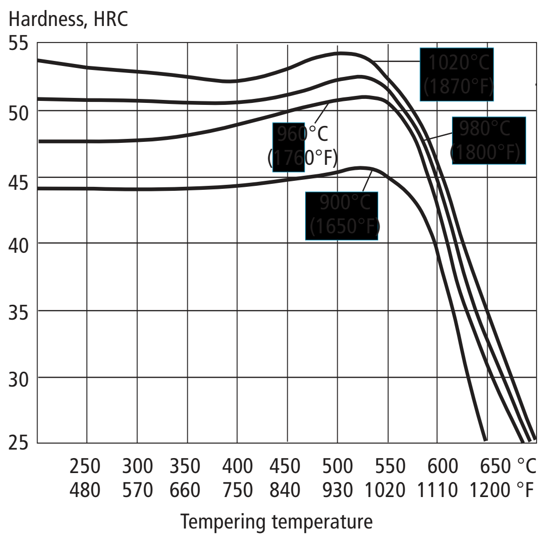
- Circulating air or atmosphere
- Vacuum furnace (with sufficient positive pressure)
- Martempering bath or fluidized bed at 180–220°C (350–430°F), or at 450–550°C (840–1020°F), followed by cooling in air
- Hot oil 60–70°C (140–160°F).

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



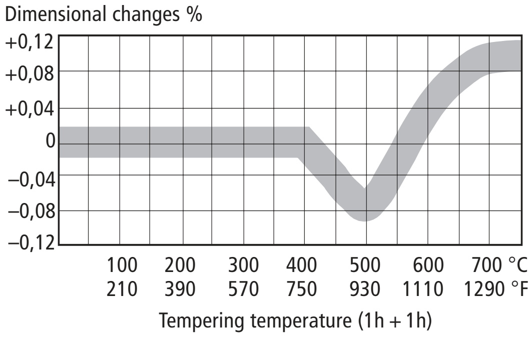
Tempering within the range 425–525°C (800–980°F) is not normally recommended, due to the fact that toughness properties are degraded in this temperature range.

DIMENSIONAL CHANGES DURING HARDENING

Test plate size 100 x 100 x 25 mm

	Width %	Length %	Thickness %
Oil-hardened from 1020°C (1868°F) min.	–0,08	–0,06	0,00
max.	–0,15	–0,16	+0,30
Air-hardened from 1020°C (1868°F) min.	–0,02	–0,05	–
max.	+0,03	+0,02	+0,05
Vacuum-hardened from 1020°C (1868°F) min.	+0,01	–0,02	+0,08
max.	+0,02	–0,04	+0,12

DIMENSIONAL CHANGES DURING TEMPERING



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

CASE HARDENING

Case hardening increases the surface hardness and wear resistance of the steel, increases its resistance to bending and twisting and improves the fatigue strength.

THG 2000 can be case hardened as follows:
Carburization temperature: 900°C (1650°F)
Austenitizing temperature: 980°C (1795°F)
Cooling: in air or oil
Tempering: 250°C (480°F) twice, or 525°C (980°F) twice.
Surface hardness: 58 ±3 HRC.

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 $HV_{0,2}$. 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.
THG 2000 can also be nitro-carburized in gas or salt baths, to produce a surface hardness of 900–1000 $HV_{0,2}$.

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)	2,5	0,11	0,004
– in salt bath at 580°C (1076°F)	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.
THG 2000 can also be nitrided in the soft-annealed condition, although its hardness and case depth will be somewhat reduced.

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

Cutting data recommendations

The cutting data below for 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
	Rough turning	Fine 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
Tool grade	P10–P15 Coated carbide	P10 Coated carbide or cermet	–

DRILLING

High speed steel twist drill

Drill diameter Ø mm	Drill diameter Ø 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	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 = 35 m/min. (115 f.p.m).*

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1]
Cutting speed, (v_c) m/min f.p.m.	 220–240 725–790	 130–160 430–530	 80–110 265–360
Feed (f) mm/r i.p.r.	 0,06–0,15[2] 0,002–0,006	 0,08–0,30[2] 0,003–0,012	 0,15–0,25[2] 0,006–0,01

[1] Drill with internal cooling channels and brazed carbide tip.
[2] 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.	 200–260 660–860	 260–300 860–990
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
Tool grade	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.	 150–200 495–660	 160–210 530–690	 40–45[1] 130–148
Feed (f_z) mm/tooth inch/tooth	 0,03–0,20[2] 0,0012–0,008	 0,08–0,20[2] 0,003–0,008	 0,05–0,35[2] 0,002–0,014
Tool grade	"Micrograin" Coated carbide	P20–P30 Coated carbide	–

[1] For coated HSS end mill v_c = 50–60 m/min. (165–200 f.p.m.)
[2] Depending on radial depth of cut and cutter diameter.

Cutting data recommendations for THG 2000 in prehardened condition 39–43 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
Tool grade	P10–P15 Coated carbide	P10 Coated carbide or cermet or mixed carbide

DRILLING

TiCN-coated high speed steel 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	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	0,008–0,01
15–20	5/8–3/4	10–15	33–50	0,25–0,30	0,01–0,012

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

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1]
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[2] 0,002–0,004	 0,05–0,15[2] 0,002–0,006	 0,10–0,15[2] 0,004–0,006

[1] Drill with internal cooling channels and brazed carbide tip.
[2] 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
Tool grade	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 26–33
Feed (f_z) mm/tooth inch/tooth	 0,03–0,15[1] 0,0012–0,006	 0,08–0,15[1] 0,003–0,006	 0,05–0,20[1] 0,002–0,008
Tool grade	"Micrograin" Coated carbide	P15–P30 Coated carbide	TiCN-coated HSS mill

[1] Depending on radial depth of cut and cutter diameter.

GRINDING

A general grinding wheel recommendations is given below. More information can be found in the Uddeholm brochure "Grinding of Tool Steel".

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 JV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 LV	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.

Welding

Welding of 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
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 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 steels.

The combination of good high-temperature strength, wear resistance and good machining properties make THG 2000 suitable for use as rolls in continuous casting machines.

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