

# GRANE

Tool and mould steel

COLD WORK

PLASTIC MOULDING

HOT WORK

HIGH PERFORMANCE STEEL



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.

## General

Grane is a Chromium-Nickel-Molydenum-alloyed steel which is characterized by

- high toughness
- high hardness
- good stability in hardening
- high resistance to wear
- good polishing properties
- good machinability.

Typical analysis %	C 0,55	Si 0,3	Mn 0,5	Cr 1,0	Ni 3,0	Mo 0,3
Standard specification	(AISI L6)					
Delivery condition	Soft annealed to approx. 230 HB.					
Colour code	Orange/White					

## Applications

The excellent combination of toughness and wear resistance offered by Grane enables it to be used for a great many tooling applications, both hot and cold. It is widely used for moulds in the plastics industry and for a variety of heavy-duty tools exposed to severe pressure, shock loading or bending stresses.

The relatively high hardness (max. 56 HRC) obtainable with Grane, makes it especially suitable for long-life moulding tools, which also require a good level of toughness.

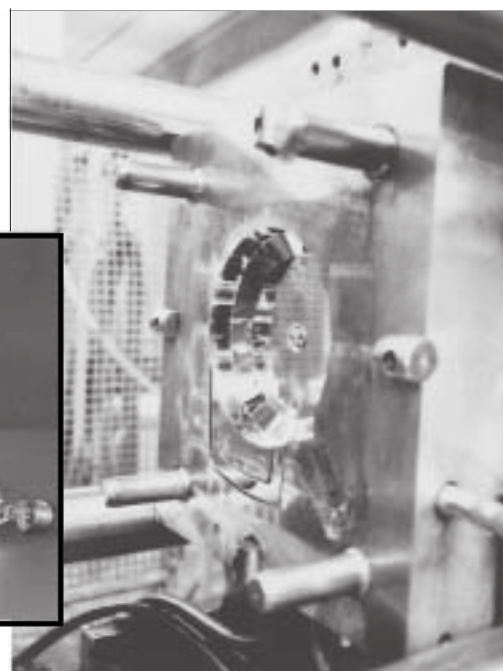
Application	HRC
<i>Moulds for plastics:</i>	
Injection moulds for:	
– thermoplastic materials	50–56
– thermosetting materials	50–56
Compression/transfer moulds	50–56
Shear blades (hot)	50–54
Shear blades (cold)	52–56
Drop forging dies	37–47
Cold stamping dies	40–50
Cold pressing tools; bending tools	52–56
Coining dies (cold)	52–56
High-strength constructional parts	40–56

## Properties

### PHYSICAL DATA

Hardened and tempered to 54 HRC. Data at room and elevated temperatures.

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density, kg/m <sup>3</sup> lbs/in <sup>3</sup>	7 880 0,284	7 850 0,283	7 800 0,282
Modulus of elasticity N/mm <sup>2</sup> tsi psi	200 000 12 900 29,0 x 10 <sup>6</sup>	190 000 12 260 27,6 x 10 <sup>6</sup>	170 000 10 970 24,7 x 10 <sup>6</sup>
Coefficient of thermal expansion /°C from 20°C /°F from 68°F	–	10,8 x 10 <sup>-6</sup> 6,0 x 10 <sup>-6</sup>	11,9 x 10 <sup>-6</sup> 6,6 x 10 <sup>-6</sup>
Thermal conductivity W/m °C Btu in/(ft <sup>2</sup> h °F)	– –	29 202	33 229
Specific heat, J/kg °C Btu/lb. °F	460 0,110	–	–



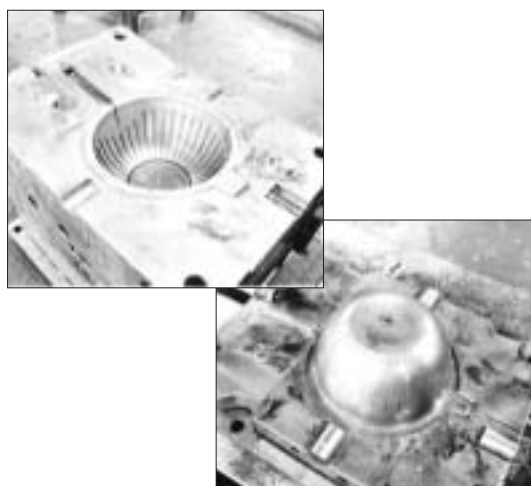
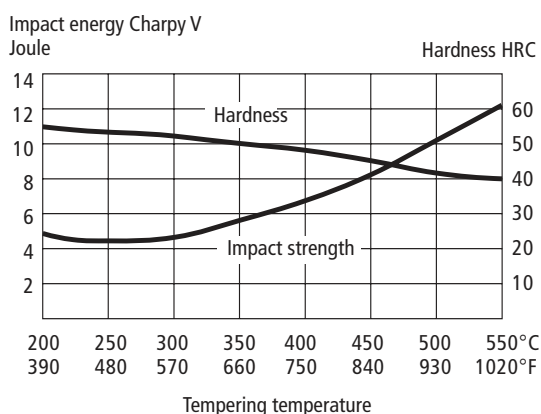
## TENSILE STRENGTH AT ROOM TEMPERATURE

The tensile strength values are to be considered as approximate only. All specimens were taken from a bar  $\varnothing$  25 mm (in the rolling direction). Hardened in oil from  $850 \pm 10^\circ\text{C}$  ( $1560 \pm 20^\circ\text{F}$ ) and tempered twice to the hardness indicated.

Hardness	56 HRC	43 HRC
Tensile strength Rm N/mm <sup>2</sup> psi	2 050 297 000	1 400 203 000
Yield point Rp 0,2 N/mm <sup>2</sup> psi	1 670 242 000	1 300 189 000

## IMPACT STRENGTH AT ROOM TEMPERATURE

The impact energy values are to be considered as approximate. The specimens were taken from a bar 250 x 80 mm (9,85 x 3,15"). They were austenitized 30 minutes at  $840^\circ\text{C}$  ( $1540^\circ\text{F}$ ), air quenched and tempered twice.



Mould for production of cullanders,

## Heat Treatment

### SOFT ANNEALING

Protect the steel and heat through to  $770^\circ\text{C}$  ( $1420^\circ\text{F}$ ). Then cool in the furnace at  $10^\circ\text{C}$  ( $20^\circ\text{F}$ ) per hour to  $600^\circ\text{C}$  ( $1110^\circ\text{F}$ ), then freely in air. Reheat to  $650^\circ\text{C}$  ( $1200^\circ\text{F}$ ) – holding time 10 h. Furnace cooling to  $500^\circ\text{C}$  ( $930^\circ\text{F}$ ), then freely in air.

### STRESS-RELIEVING

After rough machining the tool should be heated through to  $650^\circ\text{C}$  ( $1200^\circ\text{F}$ ), holding time two hours. Cool slowly to  $500^\circ\text{C}$  ( $930^\circ\text{F}$ ), then freely in air.

### HARDENING

*Preheating temperature:*  $600\text{--}700^\circ\text{C}$  ( $1110\text{--}1290^\circ\text{F}$ ).

*Austenitizing temperature:*  $800\text{--}860^\circ\text{C}$  ( $1470\text{--}1580^\circ\text{F}$ ), but usually  $840^\circ\text{C}$  ( $1550^\circ\text{F}$ ).

Temperature		Soaking time* minutes	Hardness before tempering (HRC)
°C	°F		
800	1470	30	$57 \pm 2$
825	1520	30	$58 \pm 2$
860	1580	30	$59 \pm 2$

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

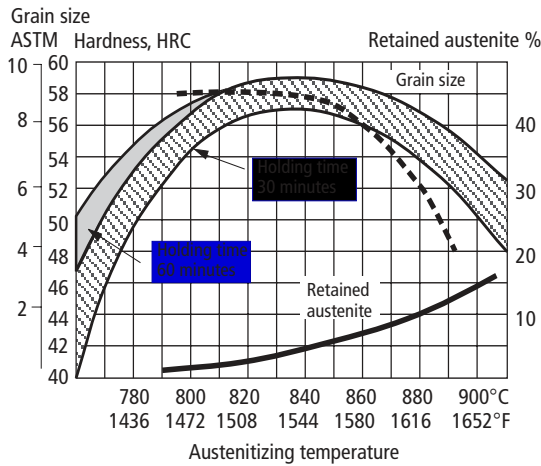
*Protect the part against decarburization and oxidation during hardening.*

### QUENCHING MEDIA

- High speed gas or circulating atmosphere
- Fluidized bed or martempering bath at  $200\text{--}550^\circ\text{C}$  ( $390\text{--}1020^\circ\text{F}$ ) for 15–30 minutes, then cool in air.
- Oil

In order to obtain optimum properties, the cooling rate should be as fast as is concomitant with acceptable distortion. Temper immediately when the tool reaches  $50\text{--}70^\circ\text{C}$  ( $120\text{--}160^\circ\text{F}$ ).

*Hardness, grain size and retained austenite as a function of the austenitizing temperature*

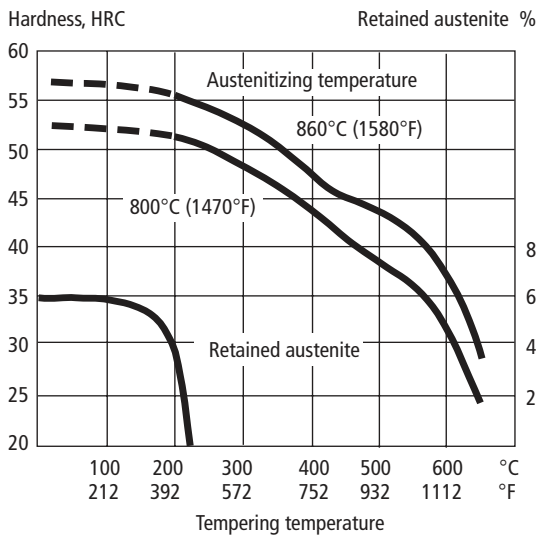


**TEMPERING**

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 temperature minimum 2 hours.

*To avoid "temper brittleness" do not temper in the range 300–350°C (570–660°F).*

*Tempering graph*



Above curves are valid for small samples. Achieved hardness depends on mould size.

**DIMENSIONAL CHANGES DURING HARDENING AND TEMPERING**

The dimensional changes during hardening and tempering vary depending on temperatures, type of equipment and cooling media used during heat treatment.

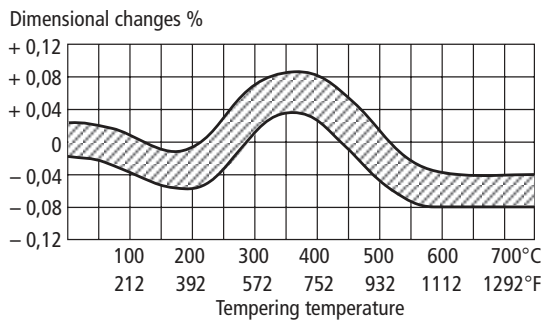
The size and geometric shape of the tool is also of essential importance.

Thus, the tool shall always be manufactured with enough working allowance to compensate for dimensional changes. Use 0,15% as a guideline for Grane.

An example of dimensional changes on a plate, hardened under ideal conditions, 100 x 100 x 25 mm (4" x 4" x 1") are shown below.

Hardening from 825°C (1520°F)		Width %	Length %	Thickness %
Oil hardened	Min. Max.	+ 0,06 + 0,12	+ 0,08 + 0,13	0 + 0,08
Martempered	Min. Max.	0 + 0,01	+ 0,07 + 0,08	+ 0,05 - 0,04
Air/Vacuum hardened	Min. Max.	+ 0,02 + 0,04	- 0,01 - 0,05	+ 0,15 + 0,15

**DIMENSIONAL CHANGES DURING TEMPERING**



*Note:* Dimensional changes during hardening and tempering should be added together.

**NITRIDING**

Prior to nitriding the tool should be hardened and tempered at a temperature at least 20°C higher than the nitriding temperature.

Nitriding gives a hard surface which is very resistant to wear and erosion. A nitrided surface also increases the corrosion resistance. The surface hardness after nitriding at a temperature of 525°C (980°F) in ammonia gas will be approx. 600 HV.

Nitriding temperature		Nitriding time hours	Depth of case approx.	
°C	°F		in.	mm
525	980	10	0,008	0,20
525	980	30	0,012	0,30
525	980	60	0,016	0,40

### NITRO-CARBURIZING

Nitro-carburizing of hardened and tempered Grane at 580°C (1080°F) will give a surface hardness of approx. 450 HV. After 2 hours' treatment, the hard layer will be approx. 0,15 mm (0,006 in.) thick.

## Cutting data 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 high speed steel Fine turning
	Rough turning	Fine turning	
Cutting speed ( $v_c$ ) m/min f.p.m.	150–200 490–655	200–250 655–820	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	0,5–2 0,02–0,08
Carbide designation ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	–

### 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.	140–230 460–755	230–270 755–886
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 0,08–0,20	–2 –0,08
Carbide designation ISO	P20–P40 Coated carbide	P10–P20 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.	110–140 360–460	130–180 430–600	30–35 <sup>1)</sup> 100–115 <sup>1)</sup>
Feed ( $f_z$ ) mm/tooth inch/tooth	0,01–0,2 <sup>2)</sup> 0,0004–0,008 <sup>2)</sup>	0,06–0,2 <sup>2)</sup> 0,002–0,008 <sup>2)</sup>	0,01–0,35 <sup>2)</sup> 0,0004–0,014 <sup>2)</sup>
Carbide designation ISO	–	P20, P40	–

<sup>1)</sup> For coated HSS end mill  $v_c = 50–55$  m/min. (164–180 f.p.m.)

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

### DRILLING

#### High speed steel twist drill

Drill diameter		Cutting speed ( $v_c$ )		Feed (f)	
mm	inch	m/min	f.p.m.	mm/r	i.p.r.
– 5	–3/16	15–17*	49–56*	0,05–0,15	0,002–0,006
5–10	3/16–3/8	15–17*	49–56*	0,15–0,20	0,006–0,008
10–15	3/8–5/8	15–17*	49–56*	0,20–0,25	0,008–0,010
15–20	5/8–3/4	15–17*	49–56*	0,25–0,35	0,010–0,014

\* For coated HSS drill  $v_c = 26–28$  m/min. (85– 92 f.p.m.)

#### Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide <sup>1)</sup>
Cutting speed ( $v_c$ ) m/min f.p.m.	200–220 655–720	120–150 390–490	70–90 230–295
Feed (f) mm/r i.p.r.	0,05–0,15 <sup>2)</sup> 0,002–0,006 <sup>2)</sup>	0,10–0,25 <sup>2)</sup> 0,004–0,01 <sup>2)</sup>	0,15–0,25 <sup>2)</sup> 0,006–0,01 <sup>2)</sup>

<sup>1)</sup> Drill with internal cooling channels and brazed carbide tip.

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

### GRINDING

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

#### Wheel recommendation.

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 JV
Profile grinding	A 100 KV	A 120 JV

## Electrical-discharge machining

If spark-erosion is performed in the hardened and tempered condition, the tool should then be given an additional temper at about 25°C (50°F) lower than previous tempering temperature.

## Welding

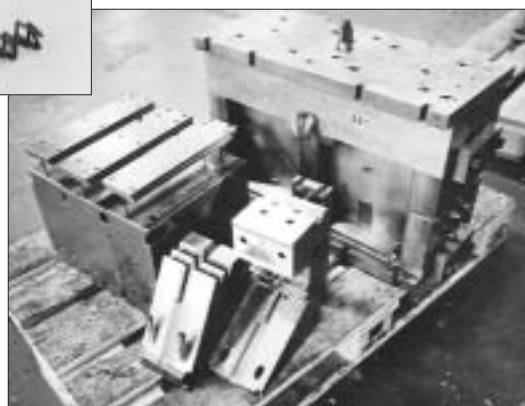
Good results when welding tool steel can be achieved if proper precautions are taken to elevated working temperature, joint preparation, choice of consumables and welding procedure.

Welding method	TIG	MMA (SMAW)
Working temperature	225–275°C (440–520°F)	225–275°C (440–520°F)
Consumables	UTPA 73G2 UTPA 67S	UTP 73G2 UTP 67S
Hardness after welding	55–58 HRC	55–58 HRC

Further information is given in the Uddeholm brochure "Welding of Tool Steels".



*Mould for production of household articles.*



## Hard-chromium-plating

After hard-chromium-plating, the tool should be tempered for approx. 4 hours at 180°C (360°F) in order to avoid hydrogen embrittlement.

## Photo-etching

Grane has a very homogeneous structure with a low content of non-metallic inclusions, having been subjected to the vacuum degassing process during manufacture. This ensures accurate and consistent pattern reproduction from the photo-etching process.

Further information is given in the Uddeholm brochure "Photo-etching of Tool Steel".

## Polishing

Grane has good polishability in the hardened and tempered condition.

Each steel grade has an optimum polishing time which largely depends on hardness and polishing technique. Overpolishing can lead to a poor surface finish (e.g. an "orange peel" effect).

Further information is given in the Uddeholm brochure "Polishing 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.

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