GRANE

Tool and mould steel

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

UDDEHOLM

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.

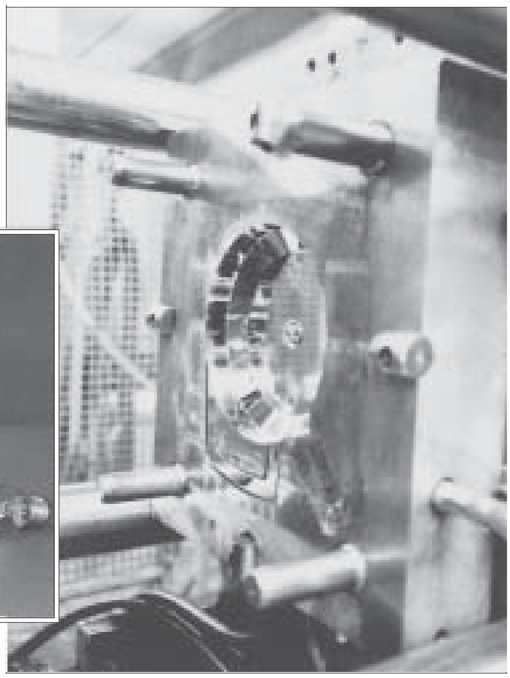
Application	HRC
Moulds for plastics:	
Injection moulds for: – thermoplastic materials – thermosetting materials	 50–56 50–56
Compression/transfer moulds	50–56
Shear blades (hot)	50–54
Shear blades (cold)	52–56
Drop forging dies	37–47
Cold stamping dies	40–50
Cold pressing tools; bending tools	52–56
Coining 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^3 lbs/in^3	7 880 0,284	7 850 0,283	7 800 0,282
Modulus of elasticity N/mm^2 tsi psi	 200 000 12 900 29,0 x 10^6	 190 000 12 260 27,6 x 10^6	 170 000 10 970 24,7 x 10^6
Coefficient of thermal expansion /°C from 20°C /°F from 68°F	–	10,8 x 10^{-6} 6,0 x 10^{-6}	11,9 x 10^{-6} 6,6 x 10^{-6}
Thermal conductivity W/m °C Btu in/(ft^{2}h °F)	 – –	 29 202	 33 229
Specific heat, J/kg °C Btu/lb. °F	460 0,110	–	–



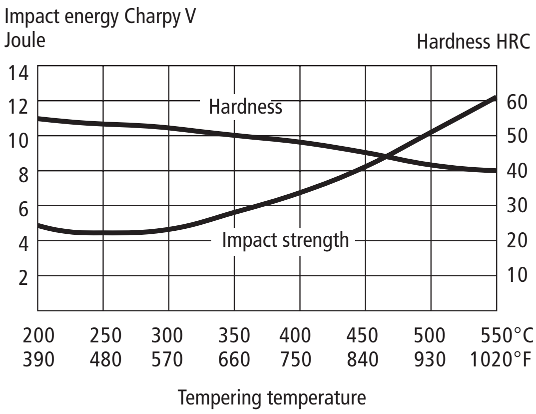
TENSILE STRENGTH AT ROOM TEMPERATURE

The tensile strength values are to be considered as approximate only. All specimens were taken from a bar Ø 25 mm (in the rolling direction). Hardened in oil from 850 ± 10°C (1560 ± 20°F) and tempered twice to the hardness indicated.

Hardness	56 HRC	43 HRC
Tensile strength Rm		
N/mm²	2 050	1 400
psi	297 000	203 000
Yield point Rp 0,2		
N/mm²	1 670	1 300
psi	242 000	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°C (1540°F), air quenched and tempered twice.



Mould for production of cullanders,

Heat Treatment

SOFT ANNEALING

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

STRESS-RELIEVING

After rough machining the tool should be heated through to 650°C (1200°F), holding time two hours. Cool slowly to 500°C (930°F), then freely in air.

HARDENING

Preheating temperature: 600–700°C (1110–1290°F).
Austenitizing temperature: 800–860°C (1470–1580°F), but usually 840°C (1550°F).

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

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

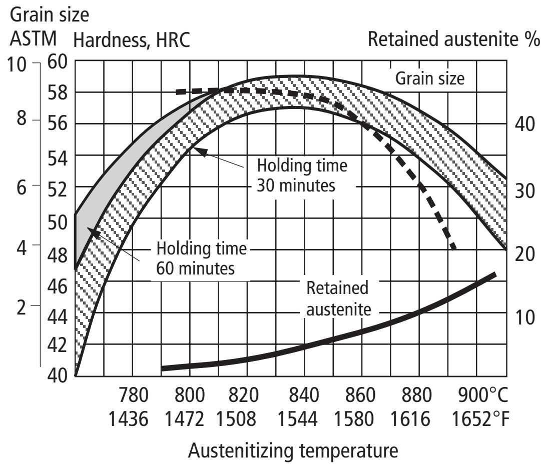
Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

- High speed gas or circulating atmosphere
- Fluidized bed or martempering bath at 200–550°C (390–1020°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 50–70°C (120–160°F).

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

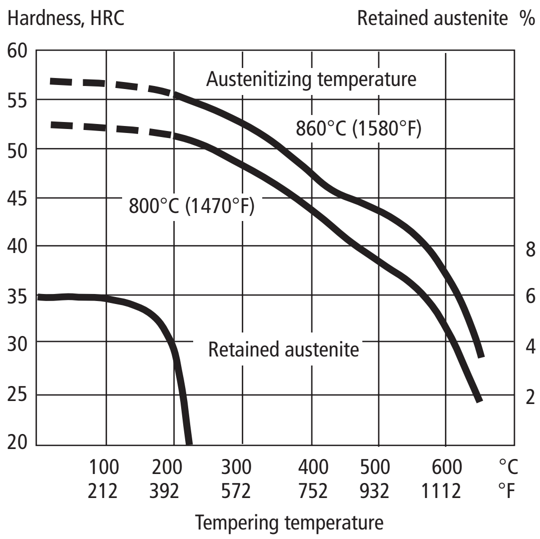


TEMPERING

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.

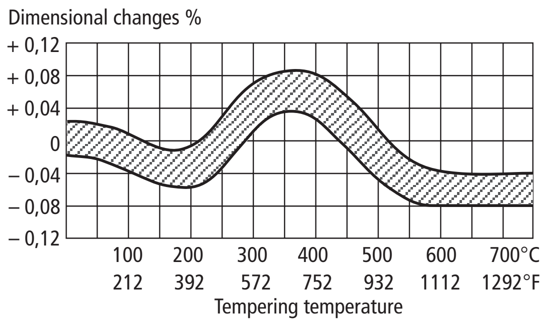
The size and geometric shape of the tool is also of essential importance.

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 %	Thick-ness %
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 leas 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 °C	Nitriding temperature °F	Nitriding time hours	Depth of case approx. in.	Depth of case approx. 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: Rough turning	Turning with carbide: Fine turning	Turning with high speed steel Fine turning
Cutting speed (v_c) m/min	150–200	200–250	20–25
f.p.m.	490–655	655–820	65–80
Feed (f) mm/r	0,2–0,4	0,05–0,2	0,05–0,3
i.p.r.	0,008–0,016	0,002–0,008	0,002–0,012
Depth of cut (a_p) mm	2–4	0,5–2	0,5–2
inch	0,08–0,16	0,02–0,08	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	Milling with carbide: Fine milling
Cutting speed (v_c) m/min	140–230	230–270
f.p.m.	460–755	755–886
Feed (f_z), mm/tooth	0,2–0,4	0,1–0,2
inch/tooth	0,008–0,016	0,004–0,008
Depth of cut (a_p), mm	2–5	–2
inch	0,08–0,20	–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	Type of milling: Carbide indexable insert	Type of milling: High speed steel
Cutting speed (v_c) m/min	110–140	130–180	30–35[1]
f.p.m.	360–460	430–600	100–115[1]
Feed (f_z) mm/tooth	0,01–0,2[2]	0,06–0,2[2]	0,01–0,35[2]
inch/tooth	0,0004–0,008[2]	0,002–0,008[2]	0,0004–0,014[2]
Carbide designation ISO	–	P20, P40	–

[1] For coated HSS end mill v_c = 50–55 m/min. (164–180 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	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	Type of drill: Solid carbide	Type of drill: Brazed carbide[1]
Cutting speed (v_c) m/min	200–220	120–150	70–90
f.p.m.	655–720	390–490	230–295
Feed (f) mm/r	0,05–0,15[2]	0,10–0,25[2]	0,15–0,25[2]
i.p.r.	0,002–0,006[2]	0,004–0,01[2]	0,006–0,01[2]

[1] Drill with internal cooling channels and brazed carbide tip.
[2] 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".

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

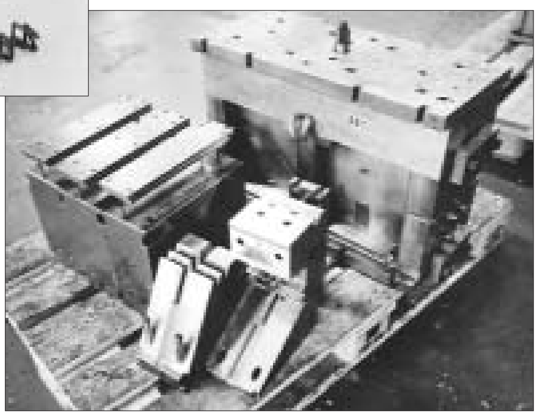
Grane has good polishability in the hardened and tempered condition.

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.



Mould for production of household articles.

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