

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: 5, 12.2006



SS-EN ISO 9001
SS-EN ISO 14001

General

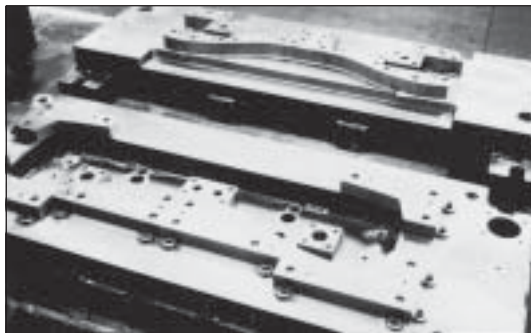
Uddeholm Calmax is a chromium molybdenum-vanadium alloyed steel characterized by:

- High toughness
- Good wear resistance
- Good through hardening properties
- Good dimensional stability in hardening
- Good polishability
- Good weldability
- Good flame- and induction hardenability.

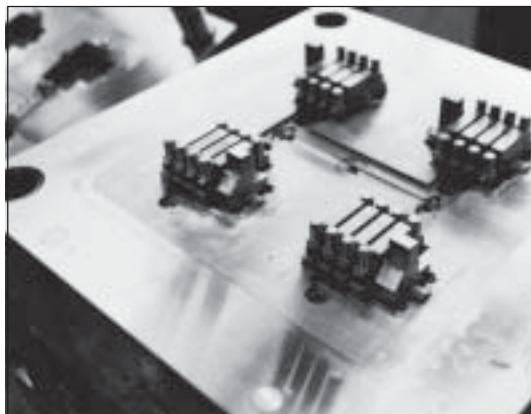
Typical analysis %	C	Si	Mn	Cr	Mo	V
	0,6	0,35	0,8	4,5	0,5	0,2
Delivery condition	Soft annealed to approx. 200 HB					
Colour code	White/violet					

Applications

Uddeholm Calmax is a steel suitable for both cold work and plastic applications. For further information see page 7 and 8.



Typical blanking die where Uddeholm Calmax could be used because of the high demands on toughness.



Mould for the production of electrical components. Uddeholm Calmax would be a good choice here because of the high demands on wear resistance.

Properties

Physical data

Temperature	20°C (68°F)	200°C (400°F)	400°C (750°F)
Density kg/m ³ lbs/in ³	7 770 0,281	7 720 0,279	7 650 0,276
Modulus of elasticity N/mm ² psi	194 000 28,1 × 10 ⁶	188 000 27,3 × 10 ⁶	178 000 25,8 × 10 ⁶
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	to 100°C 11,7 × 10 ⁻⁶ to 212°F 6,5 × 10 ⁻⁶	to 200°C 12,0 × 10 ⁻⁶ to 400°F 6,7 × 10 ⁻⁶	to 400°C 13,0 × 10 ⁻⁶ to 750°C 7,3 × 10 ⁻⁶
Thermal conductivity W/m °C Btu in (ft ² h°F)	– –	27 187	32 221
Specific heat J/kg°C Btu/lbs°F	455 0,109	525 0,126	608 0,145

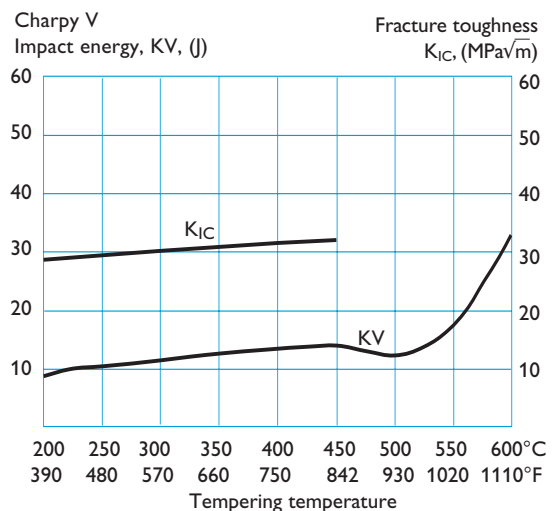
Compressive strength

Approximate values at room temperature.

Hardness HRC	R _{cm} N/mm ²	R _{c0,2} N/mm ²
56	2300	1900
58	2500	2000
60	2700	2100

Impact strength

Approximate values at room temperature for different tempering temperatures. Hardened at 960°C (1760°F). Quenched in air. Tempered twice.



Heat treatment

Soft annealing

Protect the steel and heat through to 860°C (1580°F), holding time 2h. Cool in furnace 20°C/h to 770°C (35°F/h to 1420°F), then 10°C/h to 650°C (18°F/h to 1200°F) and subsequently freely in air.

Stress relieving

After rough machining the tool should be heated through to 650°C (1200°F), holding time 2h. Cool slowly to 500°C (930°F), then freely in air.

Hardening

Preheating: 600–750°C (1110–1380°F).
Austenitizing temperature: 950–970°C (1740–1780°F), normally 960°C (1760°F).

Temperature		Holding* time minutes	Hardness before tempering (HRC)
°C	°F		
950	1740	30	62
960	1760	30	63
970	1780	30	64

* Holding time = time at austenitizing temperature after the tool is fully heated through

Protect the part against decarburization and oxidation during hardening.

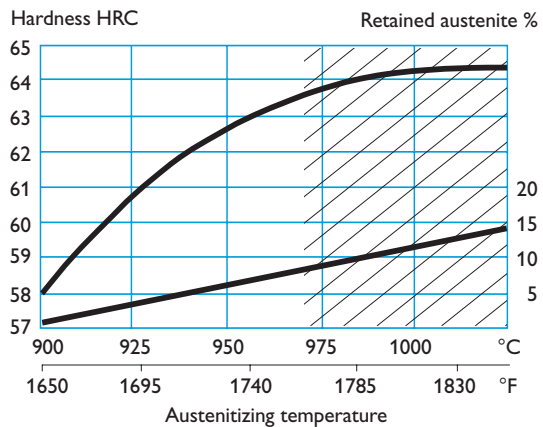
Quenching media

- Forced air/gas
- Vacuum furnace with sufficient overpressure
- Martempering bath or fluidized bed at 200–550°C (320–1020°F) followed by forced air cooling
- Oil.

Note 1: Quenching in oil gives an increased risk for dimensional changes and cracks.

Note 2: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

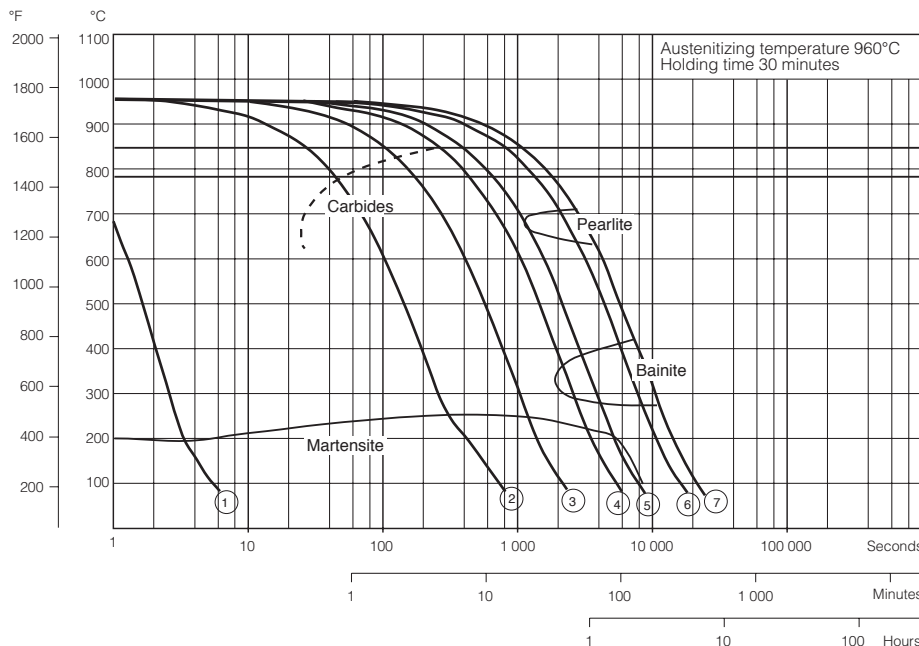
HARDNESS AND RETAINED AUSTENITE AS A FUNCTION OF AUSTENITIZING TEMPERATURE



▨ Risk for grain growth causing reduced toughness

CCT-GRAPH

Austenitizing temperature 960°C (1760°F). Holding time 30 minutes.

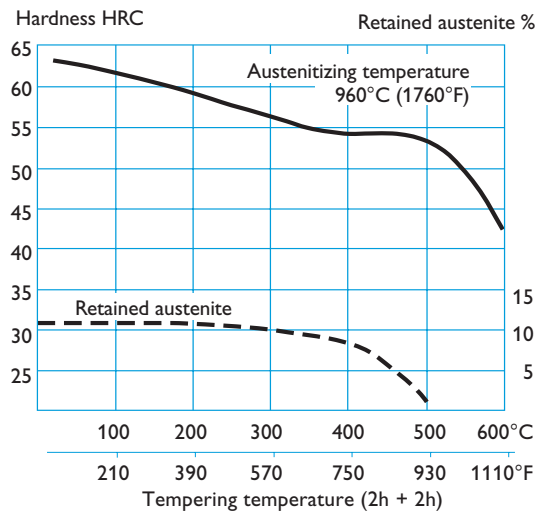


Cooling Curve No.	Hardness HV10	T ₈₀₀₋₅₀₀ sec.
1	820	1
2	762	107
3	743	423
4	734	1071
5	657	1596
6	455	3228
7	413	4292

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 2h.

TEMPERING GRAPH

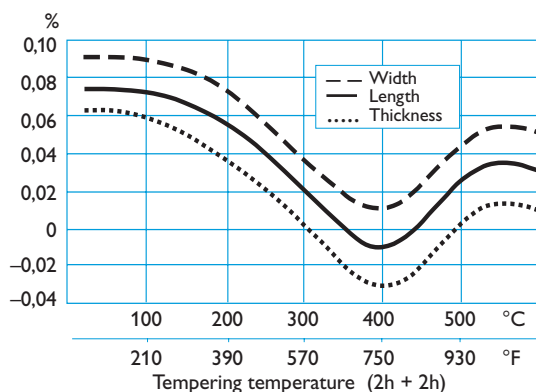


Dimensional changes

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

The size and geometric shape of the tool are also of essential importance. Thus the tool should always be manufactured with enough working allowance to compensate for distortion. Use 0,20% as a guideline for Uddeholm Calmax.

An example of dimensional changes for a plate 100 x 100 x 10 mm, hardened and tempered under ideal conditions, is shown in the figure below. Hardening: 960°C (1760°F)/ 30 min./air.



Surface treatment

Some tools are given a surface treatment in order to reduce friction and increase tool wear resistance. The most commonly used treatments are nitriding and surface coating with wear resistant layers of titanium carbide and titanium nitride (CVD, PVD).

Two commonly used nitriding processes are ion nitriding and gas nitriding. Ion nitriding is normally performed at a lower temperature than gas nitriding and is, therefore, the preferred method for Uddeholm Calmax when a substrate hardness of ~54 HRC is required.

Nitriding process	Temp. °C (°F)	Time (h)	Case depth μm	Substrate hardness HRC	Case hardness HV
Ion	465* (870*)	18	200	54	1075
Gas	510* (950*)	12	200	52	1075

* The nitriding temperature used should be 15–25°C (59–77°F) lower than the previously used tempering temperature

A thick case depth considerably reduces the toughness of the tool. The case depth, which can be controlled by the nitriding time, should be selected to suit the application in question.

Uddeholm Calmax can also be CVD coated but the deposition temperature should not exceed 960°C (1760°F). The tool should be re-hardened after being coated.

PVD coatings can be deposited at temperatures between 200°C (390°F) and 500°C (930°F). If 200°C (390°F) is used, the Uddeholm Calmax substrate hardness will be higher than that obtained at a deposition temperature of 500°C (930°F). However, the adhesion of the coating on the steel is better if a deposition temperature of 500°C (930°F) is used. The PVD deposition temperature should be approx. 20°C (68°F) lower than the previously used tempering temperature.

Machining recommendations

The cutting data below are to be considered as guiding values which must be adapted to existing local condition.

The cutting data recommendations, in following tables, are valid for Uddeholm Calmax in soft annealed condition to approx 200 HB.

Turning

Cutting data parameters	Rough turning carbide	Fine turning carbide	Fine turning High speed steel
Cutting speed (v _c) m/min f.p.m	150–200 492–656	200–250 656–820	20–25 66–82
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 0,002–0,01
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	– –

Drilling

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm inch	Cutting speed (v _c)		Feed (f)	
	mm	inch	mm/r	i.p.r.
–5 –3/16	13–15*	43–49*	0,05–0,10	0,002–0,004
5–10 3/16–3/8	13–15*	43–49*	0,10–0,20	0,004–0,008
10–15 3/8–5/8	13–15*	43–49*	0,20–0,25	0,008–0,010
15–20 5/8–3/4	13–15*	43–49*	0,25–0,30	0,010–0,012

* For coated HSS drill v_c = 23–25 m/min. (75–82 f.p.m.)

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Solid carbide	Indexable insert	Brazed carbide ¹⁾
Cutting speed (v _c) m/min f.p.m	120–150 394–492	210–230 689–755	70–100 230–328
Feed (f) mm/r i.p.r	0,10–0,35 ²⁾ 0,004–0,014 ²⁾	0,03–0,12 ²⁾ 0,001–0,005 ²⁾	0,15–0,40 ²⁾ 0,006–0,016 ²⁾

¹⁾ Drills with internal cooling channels and a brazed tip

²⁾ Depending on drill diameter

Milling

FACE AND SIDE MILLING

Cutting data parameters	Rough milling carbide	Fine milling carbide
Cutting speed (v _c) m/min f.p.m	160–240 525–787	240–280 722–919
Feed (f _z) mm/tooth in/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 US	P20–P40 C6–C5 Coated carbide	P10–P20 C6–C7 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	120–150 394–492	150–200 492–656	40–45 ¹⁾ 131–148 ¹⁾
Feed (f _z) mm/tooth in/tooth	0,006–0,20 ²⁾ 0,0002–0,008 ²⁾	0,06–0,20 ²⁾ 0,002–0,008 ²⁾	0,01–0,35 ²⁾ 0,0004–0,014 ²⁾
Carbide designation ISO US	– –	P15–P40 C6–C5	– –

¹⁾ For coated HSS end mill v_c = 55–60 m/min. (180–197 f.p.m.)

²⁾ Depending on radial depth of cut and cutter diameter.

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 HV
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 LV	A 120 JV

Welding

Good results when welding Uddeholm Calmax can be achieved if proper precautions are taken.

1. Always keep the arc length as short as possible. The electrode should be angled at 90° to the joint sides to minimize under cut. In addition, the electrode should be held at an angle of 75–80° to the direction of forward travel.
2. For large repairs, weld the initial layers with a soft weld metal. Make the two first layers with the same electrode diameter and current.
3. Large repair welds should be made at elevated temperature.
4. The joints should be prepared properly.

TIG WELDING RECOMMENDATIONS

Consumables	Hardness as welded	Hardness after rehardening	Preheat temper
UTPA 73G2	53–56 HRC	51 HRC	} 200–250°C (390–480°F)
UTPA 67S	55–58 HRC	52 HRC	
CALMAX/CARMO TIG WELD	58–61 HRC	58–61 HRC	

MMA (SMAW) WELDING RECOMMENDATIONS

Consumables	Hardness as welded	Hardness after rehardening	Preheat temper
UTP 67S	55–58 HRC	52 HRC	} 200–250°C (390–480°F)
CALMAX/ CARMO WELD	58–61 HRC	58–61 HRC	

Heat treatment after welding

HARDENED CONDITION

Temper at 10–20°C (50–70°F) below the original tempering temperature.

SOFT ANNEALED CONDITION

Heat through to 860°C (1580°F) in protected atmosphere. Cool in furnace at 10°C/h to 650°C (18°F/h to 1200°F), then freely in air.

Further information on welding of tool steel is given in the Uddeholm brochure “Welding of Tool Steel”.

EDM

If spark erosion is performed in the hardened and tempered condition, the tool should be given an additional temper at about 25°C (35°F) lower than previous tempering temperature.

Cold work applications

Typical application areas

- General blanking and forming
- Heavy duty blanking and forming
- Deep drawing
- Coining
- Cold extrusion dies with complicated geometry
- Rolls
- Shear blades
- Prototype tooling

Traditional presswork steels

The majority of presswork tools used today are manufactured using traditional tool steels such as O1, A2, D2, D3 or D6. These steels offer an apparent adequate wear resistance and their hardness range is suitable for most applications. However, the poor toughness, flame- and induction hardenability and weldability of these grades often results in low productivity and high maintenance costs due to unexpected tool failure. For this reason, the new general presswork tool steel Uddeholm Calmax has been developed. The aim of Uddeholm Calmax is to secure an optimal tooling economy, i.e. the lowest tooling costs per part produced.

Today's demands

The pressworking industry has gone through some considerable changes in the last decades. Stainless steel and surface coated strip have been commercialized and high speed presses have been developed. To these technological advances just in time (JIT) manufacture and the moves toward increased productivity and tool life guarantees must be added. The traditional presswork tool steels are still routinely specified and selected but often result in poor tool performance and productivity.

The well balanced properties profile of Uddeholm Calmax is much better matched to modern work materials and manufacturing methods. Uddeholm Calmax offers the high degree of safety which is essential for optimal tooling performance and maximum productivity.

Resistance to failure mechanisms

Uddeholm grade	Abrasive wear	Adhesive wear	Chipping	Gross Cracking	Deformation
ARNE	■	■	■	■	■
CALMAX	■	■	■	■	■
CALDIE	■	■	■	■	■
RIGOR	■	■	■	■	■
SLEIPNER	■	■	■	■	■
SVERKER 21	■	■	■	■	■
SVERKER 3	■	■	■	■	■

finish after polishing. Etching should be done in a media used for steel with high chromium content.

Further information is given in the Uddeholm brochure “Photo-etching of Tool Steel” and “Polishing Mould Steel”.

Welding

For best results after polishing and etching use consumables with the same composition as the mould steel, i.e. use Uddeholm Calmax/Carmo consumables.

Plastic moulding applications

Typical application areas

- Long run moulds
- Moulds for reinforced plastics
- Moulds for compression moulding

The excellent combination of toughness and wear resistance makes Uddeholm Calmax suitable for different moulding applications.

Moulds made in Uddeholm Calmax will have good resistance to abrasion and give a safe and long production life.

Photo-etching and polishing

Uddeholm Calmax has a very homogeneous structure. This coupled with its low content of non metallic inclusions (due to vacuum degassing during manufacturing) ensures accurate and consistent pattern reproduction after the photo-etching process and very good surface

Property comparison chart

Uddeholm grade	Wear resistance	Toughness	Polishability
CALMAX	■	■	■
GRANE	■	■	■
ORVAR SUPREME	■	■	■
RIGOR	■	■	■

Further information

Please contact your local office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels, including the publications “Steels for Moulds” and “Steels for Cold Work Tooling”.



Cold work and plastic products where Uddeholm Calmax would be a good choice for the die/mould.

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