

# ELMAX SUPERCLEAN<sup>3</sup>

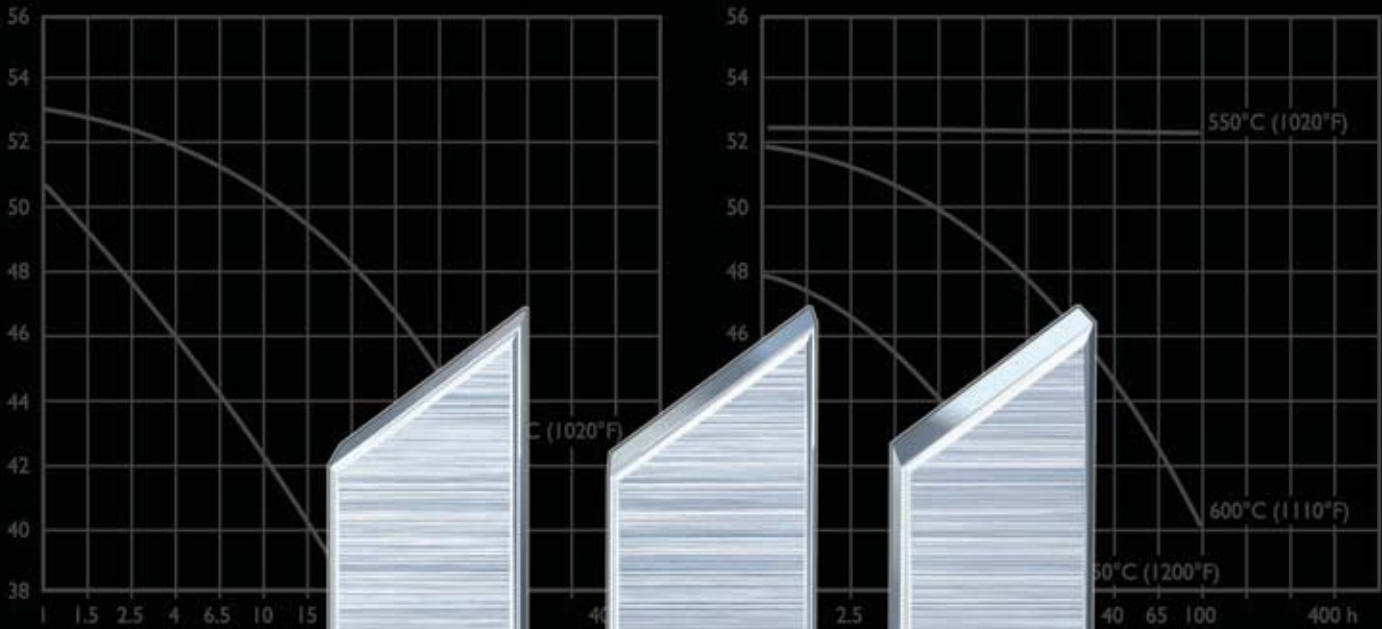
Powder Metallurgy Stainless mould steel

COLD WORK

PLASTIC MOULDING

HOT WORK

HIGH PERFORMANCE STEEL



Typical analysis %	C 2,05	Mn 0,8	Cr 4,5	W 0,2
Standard specification	AISI D6, ( )	D3) (W.Nr. 1.2796)		
Delivery condition	Soft annealed	to approx. 200 HB		
Colour code	Red	Colour code		

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density kg/m <sup>3</sup> lbs/m <sup>3</sup>	7 770 0,281	7 700 0,277	7 650 0,275
Modulus of elasticity N/mm <sup>2</sup> psi	194 000 28,1 × 10 <sup>6</sup>	188 000 27,3 × 10 <sup>6</sup>	173 000 25,1 × 10 <sup>6</sup>
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	to 100°C 11,7 × 10 <sup>-6</sup> to 212°F 6,5 × 10 <sup>-6</sup>	to 200°C 12 × 10 <sup>-6</sup> to 400°F 6,7 × 10 <sup>-6</sup>	to 400°C 13,0 × 10 <sup>-6</sup> to 750°F 7,3 × 10 <sup>-6</sup>
Thermal conductivity W/m °C Btu in (ft <sup>2</sup> h°F)	- -	27 187	32 221
Specific heat K/kg °C Btu/lbs °F	455 0,109	525 0,126	608 0,145

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

Elmax is a high chromium-vanadium-molybdenum-alloyed steel with the following characteristics:

- High wear resistance
- High compressive strength
- Corrosion resistant
- Very good dimensional stability.

High wear resistance is normally connected to low corrosion resistance and vice versa. In Elmax it has however been able to achieve this unique combination of properties by a powder-metallurgy-based production.

Elmax offers a possibility to make long-life, low-maintenance moulds for the best overall moulding economy.

Typical analysis %	C	Si	Mn	Cr	Mo	V
	1,7	0,8	0,3	18,0	1,0	3,0
Delivery condition	Soft annealed approx. 250 Brinell					
Colour code	Blue/black					

## Applications

New types of engineering plastics, with high filler contents, place greater demands on the tooling material, in terms of wear resistance and corrosion resistance. Elmax has been specially developed for high-tech applications. These include products within the electronic industry such as connectors, plugs, switches, resistors, integrated circuits, etc. Elmax can also be used in the food processing industry, where a combination of corrosion resistance and wear resistance is required for cutting applications.



## Properties

### PHYSICAL DATA

Hardened and tempered to 58 Rockwell C.

Temperature	(20°C) 68°F	(200°C) 392°F	(400°C) 752°F
Density kg/m <sup>3</sup> lbs/in.	7 600 0,275	7 560 0,273	7 500 0,271
Modulus of elasticity N/mm <sup>2</sup> psi	230 000 33,4 x 10 <sup>6</sup>	210 000 30,5 x 10 <sup>6</sup>	200 000 29,0 x 10 <sup>6</sup>
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	– –	10,6 x 10 <sup>-6</sup> 6,0 x 10 <sup>-6</sup>	11,4 x 10 <sup>-6</sup> 6,4 x 10 <sup>-6</sup>
Thermal conductivity* W/m °C Btu/in/ft <sup>2</sup> h °F	– –	15 104	21 146
Specific heat J/kg °C Btu/lb °F	460 0,110	– –	– –

\* Thermal conductivity is difficult to measure. The scatter may be as high as ±15%.

### COMPRESSIVE STRENGTH

The figures are to be considered approximate.

Hardness	60 RC	55 RC	50 RC
Compressive strength Rm N/mm <sup>2</sup> tsi psi	3 000 195 435 000	2 700 175 390 000	2 300 150 335 000
Yield point Rp0,2 N/mm <sup>2</sup> tsi psi	2 300 150 335 000	2 150 140 310 000	1 800 120 260 000

### CORROSION RESISTANCE

Moulds made from Elmax will have good resistance to corrosion when moulding corrosive plastics under normal production conditions.

# Heat treatment

## SOFT ANNEALING

Protect the steel and heat through to 980°C (1800°F), holding time 2h. Then cool in furnace 20°C (40°F)/h to 850°C (1560°F). Holding time 10h. Cool slowly to 750°C (1380°F). Then freely in air.

## STRESS-RELIEVING

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

## HARDENING

Preheating temperature: 600–850°C (1110–1560°F).  
Austenitizing temperature: 1050–1100°C (1920–2010°F), normally 1080°C (1980°F).

Temperature		Holding* time minutes	Hardness before tempering
°C	°F		
1050	1920	30	60 HRC
1080	1980	30	61 HRC
1100	2010	30	61 HRC

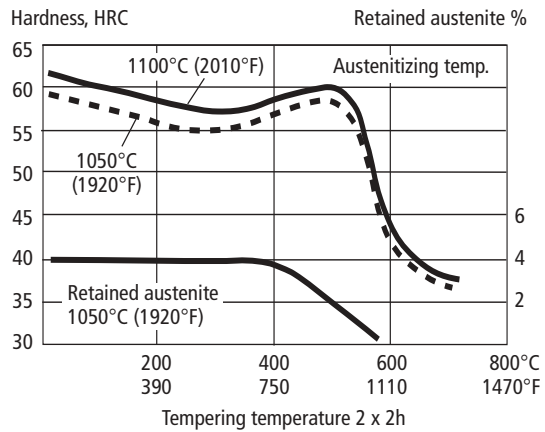
\* Holding time = time at austenitizing temperature after the tool is fully heated through.

Protect the part against decarburization and oxidation during hardening.

## TEMPERING

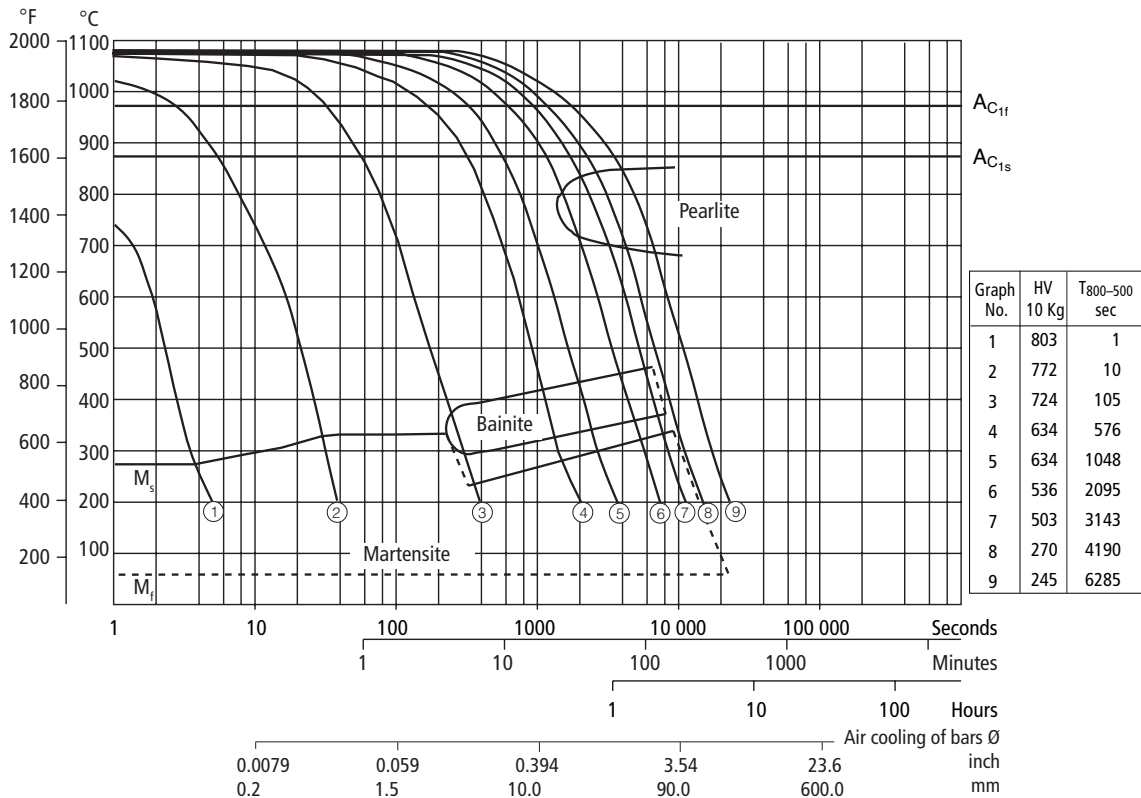
Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with intermediate cooling to room temperature. Lowest tempering temperature 180°C (360°F). Holding time at tempering temperature minimum 2 hours.

Tempering graph



## CCT-graph

Austenitizing temperature 1050°C (1920°F). Holding time 30 minutes.



## QUENCHING MEDIA

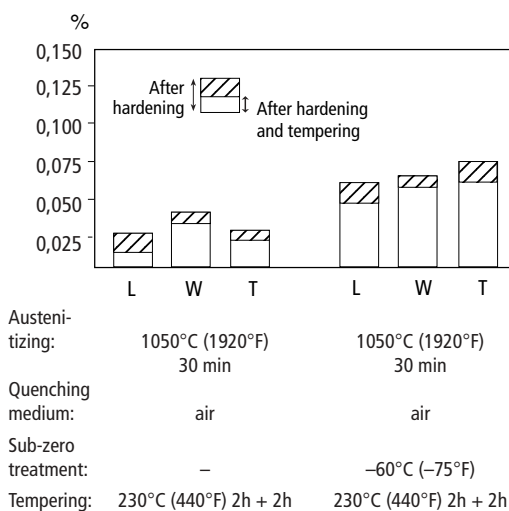
- Forced air/gas
- Fluidized bed or salt bath 200–550°C (390–1020°F), then cool in air.

*Note:* In order to obtain optimum properties, the cooling rate should be as fast as is concomitant with acceptable distortion. Temper immediately the tool reaches 50–70°C (120–160°F).

## DIMENSIONAL CHANGE OF ELMAX DURING HEAT TREATMENT

*Illustration of the effect from austenitizing temperature and subzero cooling.*

The test has been performed on sample size: 40 x 40 x 40 mm (1,6 x 1,6 x 1,6 in.).



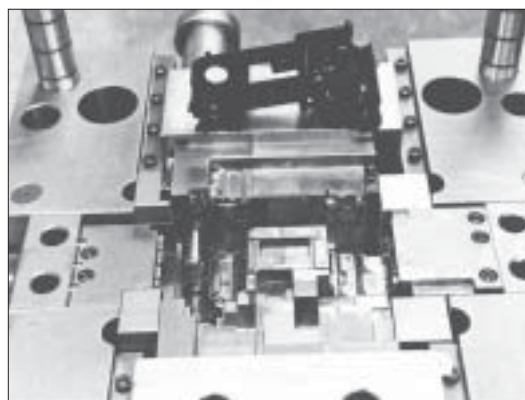
Austenitizing:	1050°C (1920°F) 30 min	1050°C (1920°F) 30 min
Quenching medium:	air	air
Sub-zero treatment:	–	–60°C (–75°F)
Tempering:	230°C (440°F) 2h + 2h	230°C (440°F) 2h + 2h

## SUB-ZERO TREATMENT

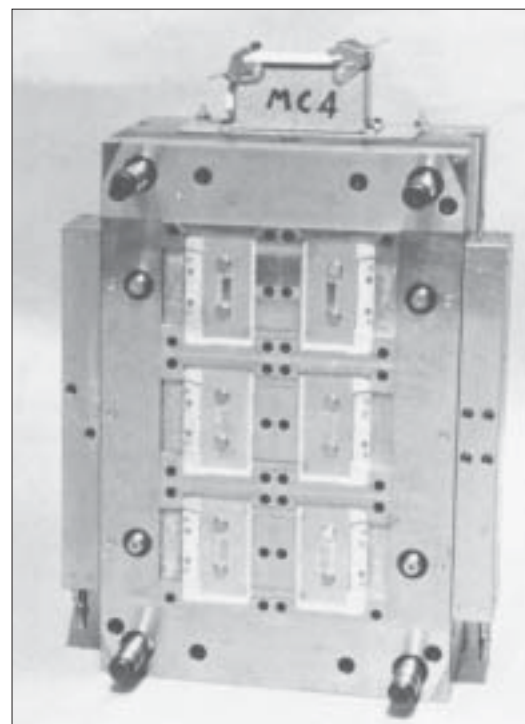
Parts requiring maximum dimensional stability should be sub-zero treated as volume changes otherwise may arise.

Immediately after quenching the piece should be sub-zero treated to between –40°C to –120°C (–40°F to –180°F) followed by tempering. Treatment for 1–3 hours will give a hardness increase of 1–3 HRC.

*Avoid intricate shapes as there is a risk of cracking.*



*A tool for injection moulding of a camera part. Insert mould material; Elmax, plastic moulded; Polycarbonate (30% GR).*



*Mould for tape-cassettes with inserts of Elmax.*

# Machining recommendations

The machining recommendations below are to be considered as guiding values which must be adapted to existing local conditions.

## 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.	70–120 230–395	120–140 395–460	10–14 33–46
Feed (f) mm/r i.p.r.	0,2–0,4 0,008–0,016	0,05–0,2 0,002–0,008	0,05–0,2 0,002–0,008
Depth of cut ( $a_p$ ) mm inch	2–4 0,08–0,16	0,5–2 0,02–0,08	0,5–3 0,02–0,12
Carbide designation ISO US	K20, P10–P20 C2, C7–C6 Coated* carbide	K15, P10 C2, C7 Coated* carbide	–

\* Use a wear resistant  $Al_2O_3$  coated carbide grade

## DRILLING

### High speed steel twist drills

Drill diameter		Cutting speed ( $v_c$ )		Feed (f)	
mm	inch	m/min.	f.p.m.	mm/r	i.p.r.
– 5	– 3/16	10–12*	33–39*	0,05–0,15	0,002–0,006
5–10	3/16–3/8	10–12*	33–39*	0,15–0,20	0,006–0,008
10–15	3/8–5/8	10–12*	33–39*	0,20–0,25	0,008–0,010
15–20	5/8–3/4	10–12*	33–39*	0,25–0,35	0,010–0,014

\* For coated HSS drills  $v_c = 18–20$  m/min. (60–65 f.p.m.).

### Carbide drills

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide <sup>1)</sup>
Cutting speed ( $v_c$ ) m/min. f.p.m.	90–120 295–395	60–80 195–265	30–35 98–115
Feed (f) mm/r i.p.r.	0,05–0,25 <sup>2)</sup> 0,002–0,01 <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> Drills with internal cooling channels and brazed carbide tip

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

## 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.	80–110 265–360	110–140 360–460
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 in	2–4 0,08–0,16	–2 0,08
Carbide designation ISO US	K20, P20 C2, C6 Coated* carbide	K15, P10 C2, C7 Coated* carbide

\* Use a wear resistant  $Al_2O_3$  coated carbide grade

### 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.	50–60 165–195	80–110 265–360	5–8 <sup>1)</sup> 16–26 <sup>1)</sup>
Feed ( $f_z$ ) mm/tooth in/tooth	0,01–0,2 <sup>2)</sup> 0,0003–0,008 <sup>2)</sup>	0,06–0,2 <sup>2)</sup> 0,002–0,008 <sup>2)</sup>	0,01–0,3 <sup>2)</sup> 0,0003–0,012 <sup>2)</sup>
Carbide designation ISO US	–	K15, P10–P20 C2, C7–C6 Coated <sup>3)</sup> carbide	–

<sup>1)</sup> For coated HSS end mill  $v_c = 14–16$  m/min. (46–52 f.p.m.).

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

<sup>3)</sup> Use a wear resistant  $Al_2O_3$  coated carbide grade.

## 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	B 151 R50 B3 <sup>1)</sup> A 46 GV
Face grinding segments	A36 GV	A 46 GV
Cylindrical grinding	A 60 KV	B 151 R50 B3 <sup>1)</sup> A 60 JV
Internal grinding	A 60 JV	B 151 R75 B3 <sup>1)</sup> A 60 IV
Profile grinding	A 100 IV	B 126 R100 B6 <sup>1)</sup> A 100 JV

<sup>1)</sup> If possible use CBN wheels for this application.

## Electrical-discharge machining

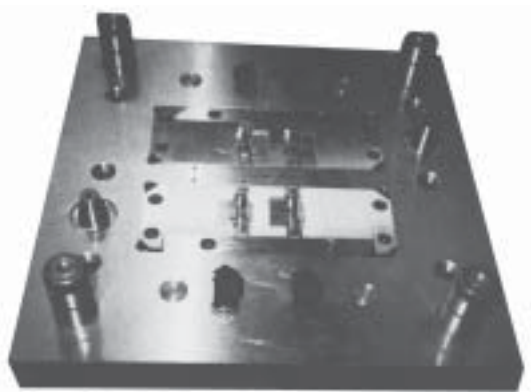
If EDM'ing, ("spark-erosion") is performed in the hardened and tempered condition the tool should then be given an additional temper at about 20°C (50°F) below the previous tempering temperature.

## Property comparison chart

Uddeholm steel grade	Wear resistance	Corrosion resistance	Dimensional stability
ELMAX	████████	██████	████████
RIGOR	██████	██	██████
STAVAX	██	██████	██████

## Further information

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



*A mould for production of connectors. Elmax is used as insert material.*