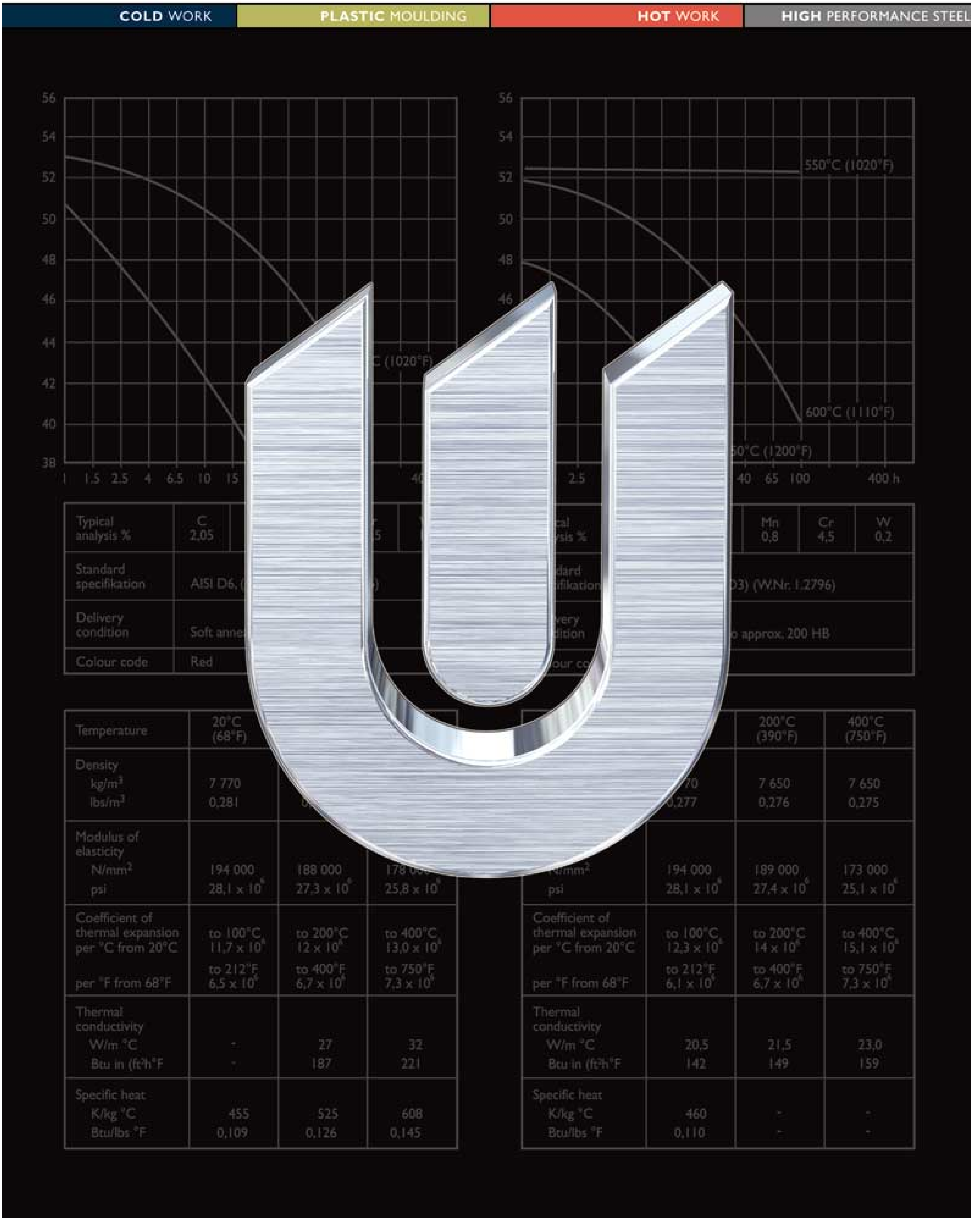
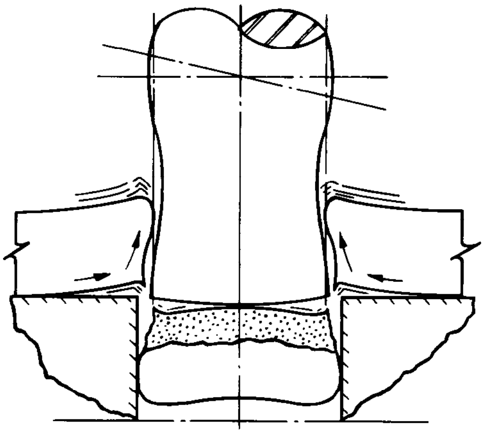
VIKING

Tool steel for heavy duty blanking and forming



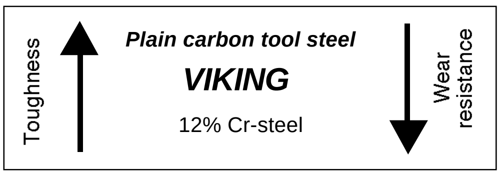
Tool operating conditions

The tool behaviour is influenced by a number of factors such as lubrication and cooling, rigidity of the tool set, characteristics of the working material (abrasive and adhesive wear), thickness of the working material, tool and part design, length of production runs and so on.



Exaggerated sketch of a typical punch and die in action.

In blanking operations, the tools must possess a certain amount of toughness. When cutting thick sheet and strip stock, the cutting edges are subjected to very high tensile stresses. Thus the tool must possess high toughness so that it does not chip. This demand on toughness increases with increasing thickness of the material being cut. A tough and shock resistant steel must therefore be used. At the same time the tool must have an adequate wear resistance to ensure an economical production run.



Cold cropping tool made from VIKING.

VIKING applications

The regular shock resistant steels available for heavy duty blanking and forming do not offer the optimum combination of properties required by the process:

S1 – poor hardenability and wear resistance

W.-Nr. 1.2767 – poor wear resistance

H 13 – insufficient wear resistance and compressive strength

S 7 – insufficient wear resistance for longer production runs

VIKING is a versatile, high alloyed tool steel characterized by the right combination of toughness and wear resistance required for heavy duty blanking and forming.

- Blanking and piercing of thick materials up to 25 mm.

Other applications:

- Fine blanking
- Shear blades
- Deep drawing
- Cold forging
- Swaging dies
- Rolls
- Cold extrusion dies with complicated geometry
- Tools for tube drawing

General

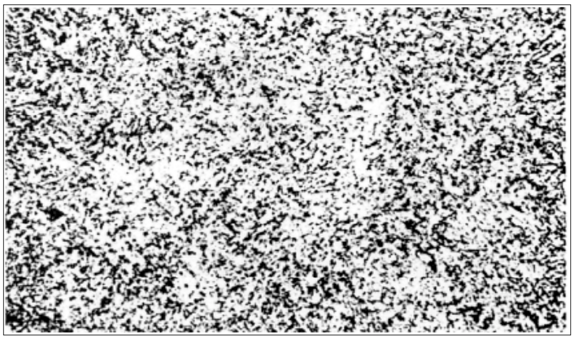
VIKING is a oil-air-vacuum-hardening steel which is characterized by:

- Good dimensional stability during heat treatment
- Good machinability and grindability
- Excellent combination of toughness and wear resistance
- Normal hardness in the range 52–58 HRC.

Typical analysis %	C 0,5	Si 1,0	Mn 0,5	Cr 8,0	Mo 1,5	V 0,5
Delivery condition	Soft annealed to max. 225 HB.					
Colour code	Red/white					

STRUCTURE

The structure of *VIKING*, hardened from 1010°C (1850°F) and tempered twice at 540°C (1000°F), consists of carbides, tempered martensite, and approx. 1% retained austenite.
The photomicrograph below shows the typical heat treated microstructure through the cross section of a bar.



Magnification 800X

Properties

PHYSICAL DATA

Hardened and tempered to 58 HRC. Data at room temperature and elevated temperatures.

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density kg/m^3	7 750	7 700	7 650
lbs/in^3	0,279	0,27 7	0,275
Coefficient of thermal expansion per °C from 20°C	–	11,6 x 10^{-6}	11,3 x 10^{-6}
per °F from 68°F	–	6,5 x 10^{-6}	6,3 x 10^{-6}
Modulus of elasticity N/mm^2	190 000	185 000	170 000
psi	27,5 x 10^6	26,9 x 10^6	24,6 x 10^6
tsi	12 300	12 000	11 000
Thermal conductivity W/m°C	26,1	27,1	28,6
Btu in(ft^{2}h°F)	181	188	199
Specific heat J/kg °C	460	–	–
Btu/lb °F	0,110	–	–

TENSILE STRENGTH

The tensile strength figures are to be considered as typical values only. All samples were taken in the rolling direction from a round bar 35 mm (13/8") diam. The samples have been hardened in oil from 1010 ±10°C (1850 ±20°F) and tempered twice to the hardness indicated.

	Hardness HRC		
	58	55	50
Tensile strength R_m N/mm^2	1 960	1 860	1 620
tsi	125	120	105
psi 1000 X	300	270	230
Yield point $R_{p0.2}$ N/mm^2	1 715	1 620	1 470
tsi	110	105	95
psi 1000 X	250	230	210
Reduction of area, Z %	15	28	35
Elongation, A5 %	6	7	8

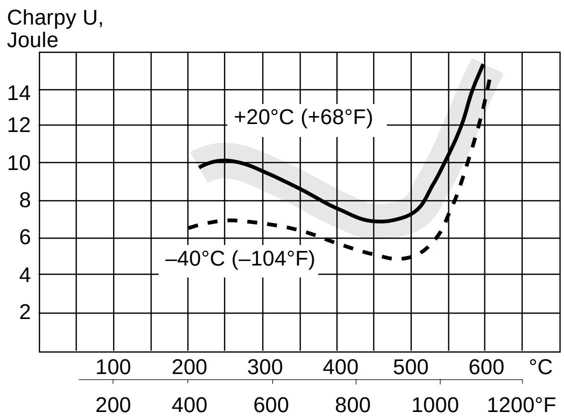
COMPRESSIVE STRENGTH

The sample have been taken out and heat treated in the same way as the samples when testing the tensile strength.

	Hardness HRC		
	58	55	50
Compressive strength R_m N/mm^2	2 745	2 450	2 060
tsi	175	155	130
psi 1000 X	395	355	300
Compressive strength $R_{p0.2}$ N/mm^2	2 110	2 060	1715
tsi	135	130	110
psi 1000 X	305	300	250

Impact strength

Approx. values. The samples have been taken out and heat-treated in the same way as the samples when testing the tensile strength.



Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 880°C (1620°F). Then cool in the furnace at approx. 10°C (20°F) per hour to 650°C (1200°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.

FORGING

Forging temperature 1090–900°C (2000–1650°F). The steel should be heated slowly and uniformly to approx. 700°C (1290°F) then faster to full forging temperature. After forging cool slowly in furnace, dry charcoal, sand or vermiculite.

HARDENING

Pre-heating temperature: 600–700°C (1110–1290°F).
Austenitizing temperature: 980–1050°C (1800–1920°F) normally 1010°C (1850°F).

Temperature °C	°F	Holding time* minutes	Hardness before tempering (approx.)
980	1800	40	57
1010	1850	30	60
1050	1920	20	60

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

Protection against decarburization

Protection against decarburization and oxidation, while heating for hardening, is obtained by:

- Heating in neutral saltbath
- Packing in spent cast-iron chips, spent coke or paper
- Protective atmosphere—endothermic gas
- Vacuum.

Hardening temperature °C	°F	Carbon activity ac	Dew point approx. °C	°F	Content of carbon-dioxid $\%CO_2$
980	1800	0.07	+10	050	0.45
1010	1850	0.06	+ 4	+40	0.40
1050	1920	0.06	+ 1	+35	0.30

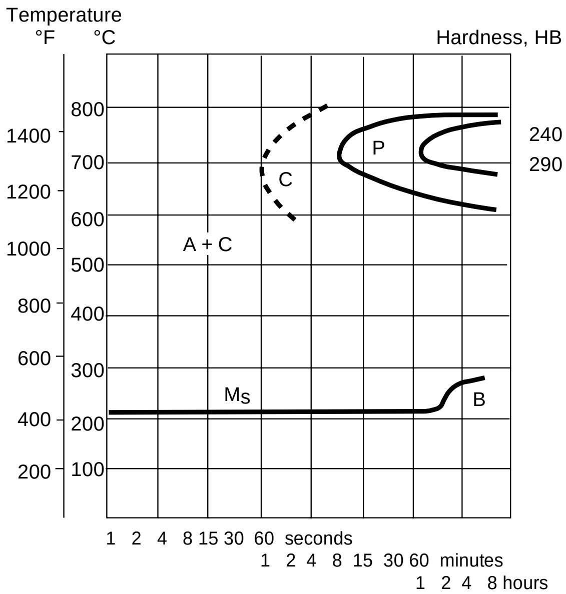
QUENCHING MEDIA

- Circulating air or atmosphere
- Air blast
- Martempering bath 200–550°C (390–1020°F) 1–120 minutes, then cool in air
- Oil.

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

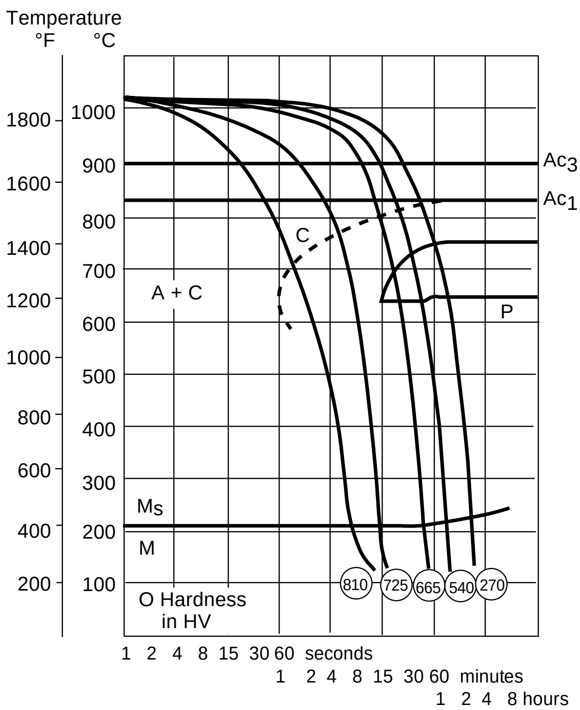
TTT-graph

Austenitizing temperature 1010°C (1850°F).



CCT-graph

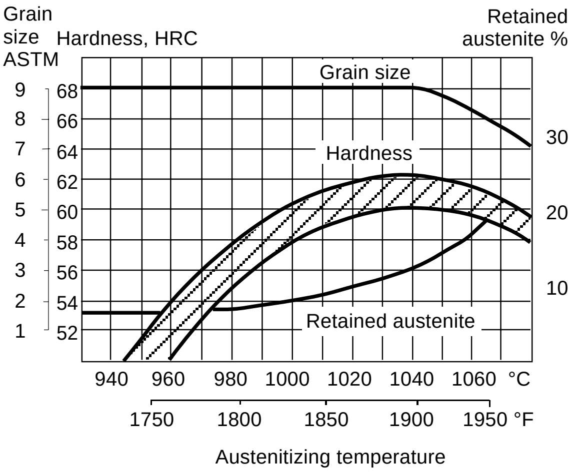
Austenitizing temperature 1010°C (1850°F).



Transformation temperature

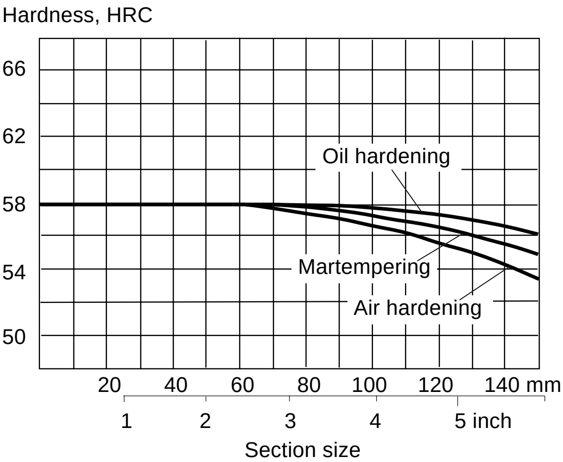
When heating 100°C (180°F) per hour, austenite (A1) starts forming at approx. 800°C (1470°F) and ends at approx. 850°C (1560°F).
When cooling 100°C (180°F) per hours, austenite (A1) starts transforming at approx. 820°C (1510°F) and ends at approx. 750°C (1380°F).

Hardness, grain size and retained austenite as functions of austenitizing temperature.



Hardenability

Hardness as a function of section thickness. Tempering temperature 180°C (360°F).

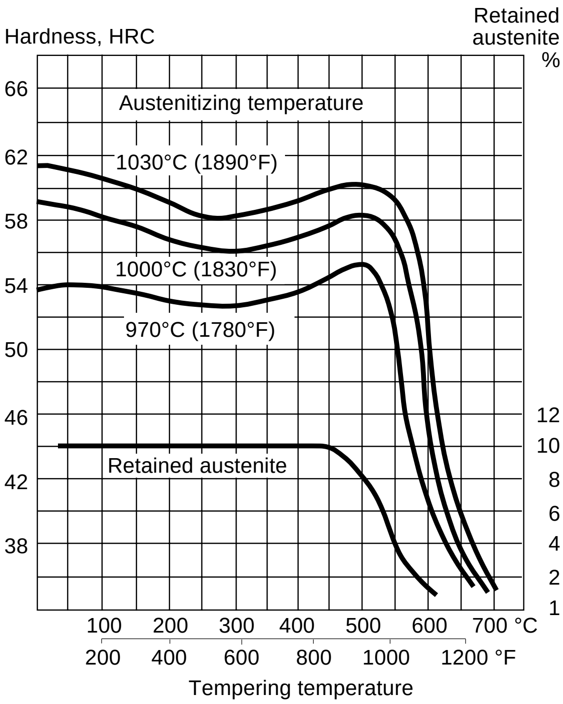


VIKING hardens through in all common sizes.

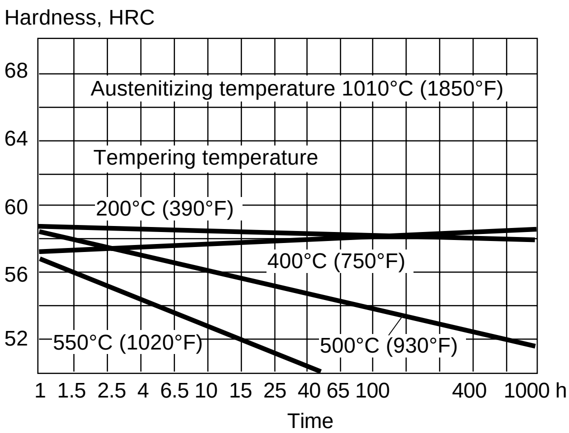
TEMPERING

Heating to tempering temperature should be carried out slowly and uniformly. Tempering should be carried out twice. Lowest temperature 180°C (360°F). Holding time at temperature min. 2 hours.

Tempering graph



Effect of time at tempering temperature



FLAME AND INDUCTION HARDENING

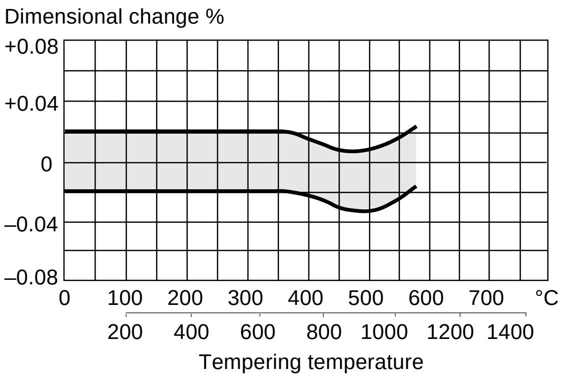
Both flame and induction hardening methods can be applied to *VIKING.*
In order to get a very uniform hardness after flame or induction hardening the steel can first be prehardened to approx. 35 ±2 HRC. After flame or induction hardening the steel should be tempered at at least 180°C (360°F).

DIMENSIONAL CHANGES AFTER COOLING IN AIR

Sample plate, 100 x 100 x 25 mm, (4" x 4" x 1").

Austenitizing temperature		Width %	Length %	Thickness %
970°C (1780°F)	Min. Max.	–0.01 +0.03	–0.02 +0.04	+0.04 +0.08
1000°C (1830°F)	Min. Max.	+0.02 +0.08	+0.02 +0.09	+0.04 +0.12
1030°C (1890°F	Min. Max.	+0.01 +0.12	+0.01 +0.10	+0.04 +0.12

DIMENSIONAL CHANGES AFTER TEMPERING



Note: The dimensional changes in hardening and tempering should be added together

NITRIDING

Nitriding gives a hard surface layer that is resistant to wear and erosion. The surface hardness after nitriding at a temperature of 525°C (980°F) in ammonia gas will be approx. 1000 HV.

Nitriding time, h	20	30	60
Depth of case approx., mm inch	0.15 0.006	0.25 0.010	0.30 0.012

Nitrocarburizing at 570°C (1060°F) for 2 hours will give a thin hard surface layer with a hardness of 900–1000 HV.

Cutting data recommendations

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

TURNING

	Turning with carbide		Turning with high speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min. f.p.m.	140–170 470–570	170–220 570–730	20 65
Feed (f) mm/r i.p.r.	0,3–0,6 0,012–0,024	–0,3 –0,012	–0,3 –0,012
Depth of cut (a_p) mm inch	2–6 0,08–0,24	–2 –0,08	–2 –0,08
Carbide designation, ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	–

MILLING

Face and square shoulder milling

	Milling with carbide		Milling with high speed steel
	Rough milling	Fine milling	Fine milling
Cutting speed (v_c) m/min. f.p.m.	100–140 360–460	140–180 460–590	20 65
Feed (f_z) mm/tooth inch/tooth	0,2–0,4 0,008–0,016	0,1–0,2 0,004–0,008	–0,1 –0,004
Depth of cut (a_p) mm inch	2–5 0,08–0,20	–2 –0,08	–2 –0,08
Carbide designation, ISO	P20–P40 Coated carbide	P10–P20 Coated carbide or cermet	–

A support arm produced in a blanking tool made from VIKING.

End milling

	Type of milling		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min. f.p.m.	50 160	120–150 390–490	25[1)] 80[1)]
Feed (f_z) mm/tooth inch/tooth	0,03–0,20[2)] 0,001–0,008[2)]	0,08–0,20[2)] 0,003–0,008[2)]	0,05–0,35[2)] 0,002–0,014[2)]
Carbide designation ISO	–	P20–P40 Coated carbide	–

[1)] *For coated HSS end mill v_c ~35 m/min (115 f.p.m.).*
[2)] *Depending on the type of milling (side or slot) and cutter diameter.*

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	15*	50*	0,08–0,20	0,003–0,008
5–10	3/16–3/8	15*	50*	0,20–0,30	0,008–0,012
10–15	3/8–5/8	15*	50*	0,30–0,35	0,012–0,024
15–20	5/8–3/4	15*	50*	0,35–0,40	0,014–0,016

* *For coated HSS drills v_c ~22 m/min (73 f.p.m.).*

Carbide drill

	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1)]
Cutting speed (v_c) m/min. f.p.m.	130–180 425–590	55 180	50 160
Feed (f) mm/r i.p.r.	0,05–0,25[2)] 0,002–0,01[2)]	0,10–0,25[2)] 0,004–0,01[2)]	0,15–0,25[2)] 0,006–0,01[2)]

[1)] *Drills with internal cooling channels and a 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 brochure "Grinding of Tool Steel"

Type of grinding	Wheel recommendation	
	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

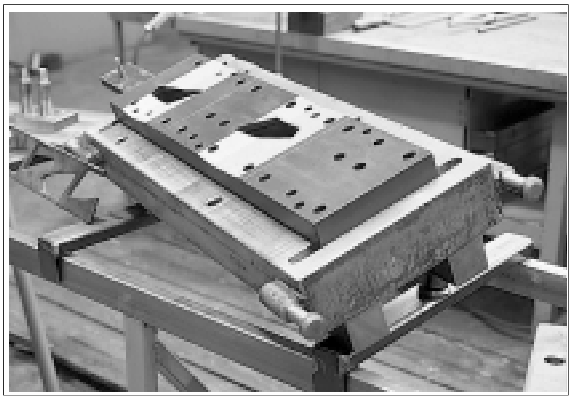
If spark-erosion is performed in the hardened and tempered condition the tool should then be given an additional temper at approx. 25°C (50°F) below the previous tempering temperature.

Welding

Welding of tool steel can be performed with good results if proper precautions are taken regarding elevated temperature, joint preparation, choice of consumables and welding procedure.
VIKING can be welded. It is essential, however, to pre-heat the part concerned prior to welding to avoid cracking. An outline on how to proceed is given below:

1. Welding of soft annealed *VIKING*
   - Pre-heat to 300–400°C (570–750°F)
   - Weld at 300–400°C (570–750°F)
   - Immediately soft anneal after slowly cooling to approx. 80°C (175°F)
   - Harden and temper.
2. Repair welding of *VIKING* in hardened and tempered condition
   - Pre-heat to the previously used tempering temperature, min. 250°C (480°F), max. 300°C (570°F)
   - Weld at this temperature. Do not weld below 200°C (390°F)
   - Cool in air to approx. 80°C (175°F)
   - Temper immediately at a temperature 25°C (45°F) below the previous tempering temperature.

Note: When welding soft annealed *VIKING* always use an electrode with the same analysis as the base material.



Blanking tool set for producing a plate part.

When welding *VIKING* in the hardened condition use OK Selectrode 84.52 or UTP 67S for MMA-welding. For TIG welding use UTP A67S or Castolin Casto TIG 5.

The weld material will have approximately the same hardness as the base material

Further information

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