VIKING

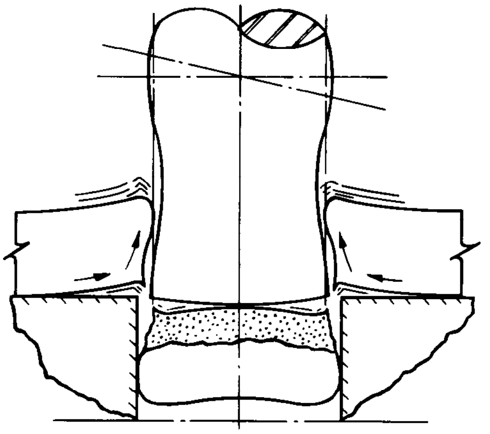
Tool steel for heavy duty blanking and forming

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

UDDEHOLM

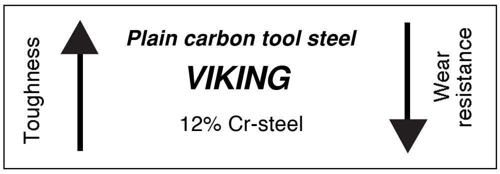
Tool operating conditions

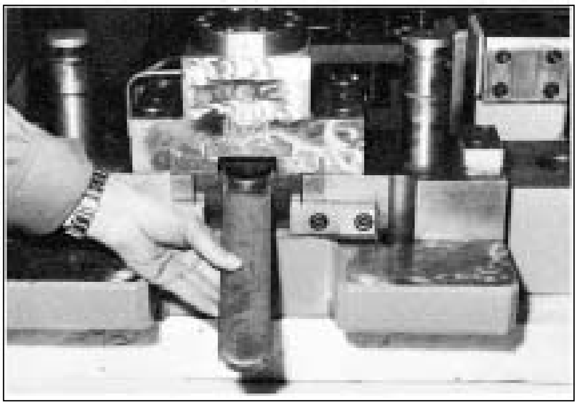
The tool behaviour is influenced by a number of factors such as lubrication and cooling, rigidity of the tool set, characteristics of the working material (abrasive and adhesive wear), thickness of the working material, tool and part design, length of production runs and so on.



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

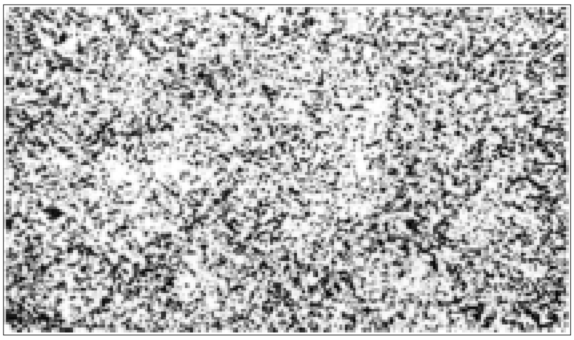
VIKING is a oil-air-vacuum-hardening steel which is characterized by:

- 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/m³ lbs/in³	 7 750 0,279	 7 700 0,27 7	 7 650 0,275
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	 – –	 11,6 x 10^{-6} 6,5 x 10^{-6}	 11,3 x 10^{-6} 6,3 x 10^{-6}
Modulus of elasticity N/mm² psi tsi	 190 000 27,5 x 10^6 12 300	 185 000 26,9 x 10^6 12 000	 170 000 24,6 x 10^6 11 000
Thermal conductivity W/m°C Btu in(ft²h°F)	 26,1 181	 27,1 188	 28,6 199
Specific heat J/kg °C Btu/lb °F	 460 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 Rm N/mm² tsi psi 1000 X	 1 960 125 300	 1 860 120 270	 1 620 105 230
Yield point Rp0.2 N/mm² tsi psi 1000 X	 1 715 110 250	 1 620 105 230	 1 470 95 210
Reduction of area, Z %	15	28	35
Elongation, A5 %	6	7	8

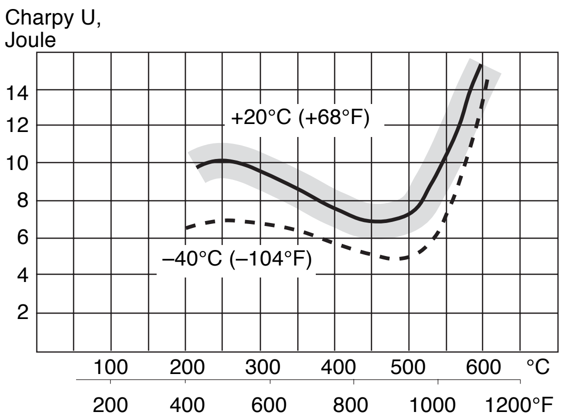
COMPRESSIVE STRENGTH

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 Rm N/mm² tsi psi 1000 X	 2 745 175 395	 2 450 155 355	 2 060 130 300
Compressive strength Rp0.2 N/mm² tsi psi 1000 X	 2 110 135 305	 2 060 130 300	 1715 110 250

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

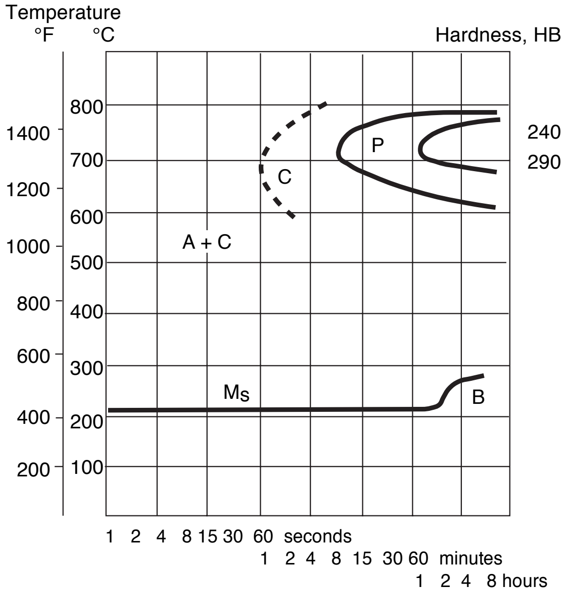
QUENCHING MEDIA

- 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).

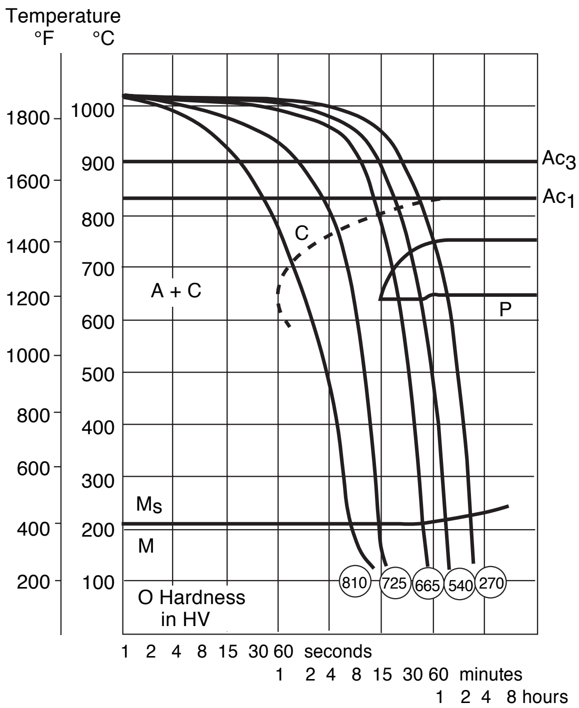
TTT-graph

Austenitizing temperature 1010°C (1850°F).



CCT-graph

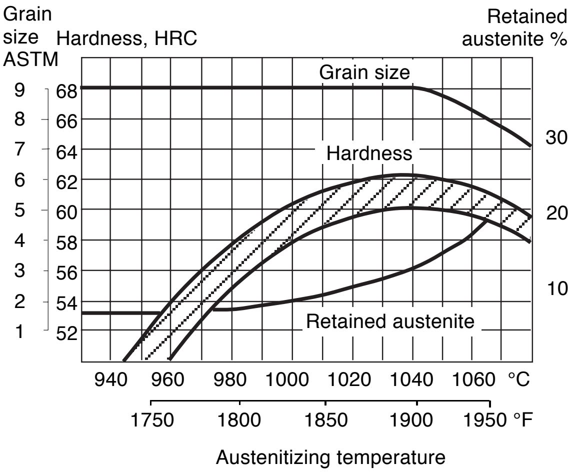
Austenitizing temperature 1010°C (1850°F).



Transformation temperature

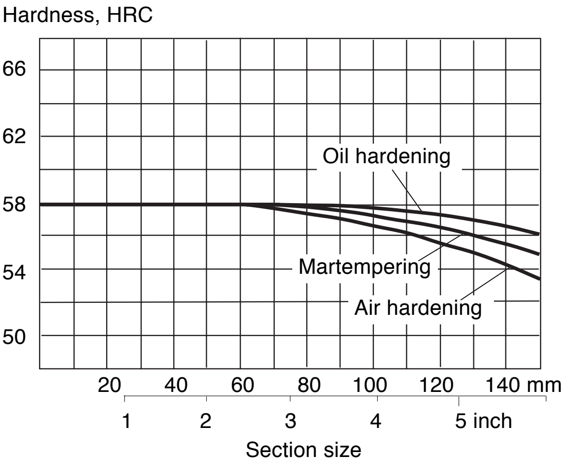
When heating 100°C (180°F) per hour, austenite (A1) starts forming at approx. 800°C (1470°F) and ends at approx. 850°C (1560°F).
When cooling 100°C (180°F) per hours, austenite (A1) starts transforming at approx. 820°C (1510°F) and ends at approx. 750°C (1380°F).

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).

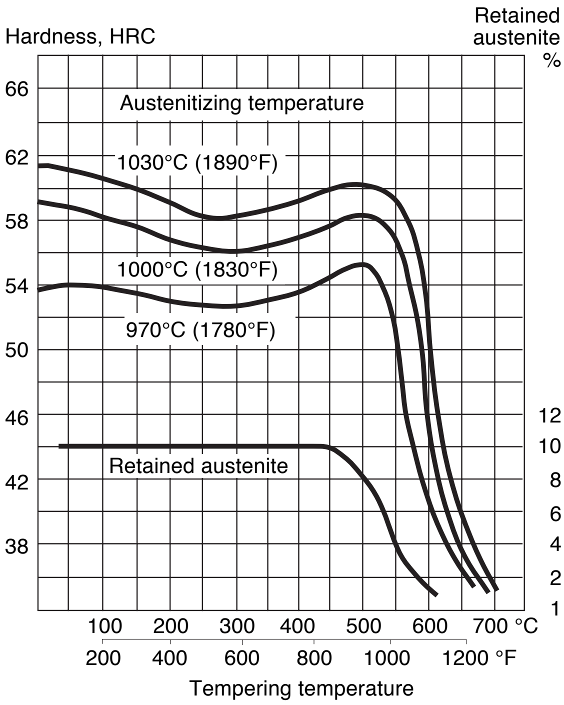


VIKING hardens through in all common sizes.

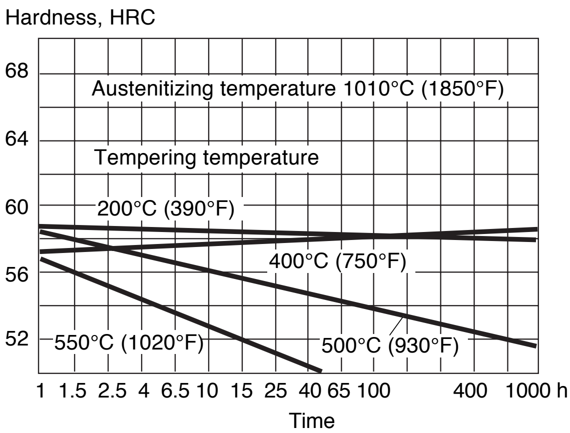
TEMPERING

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

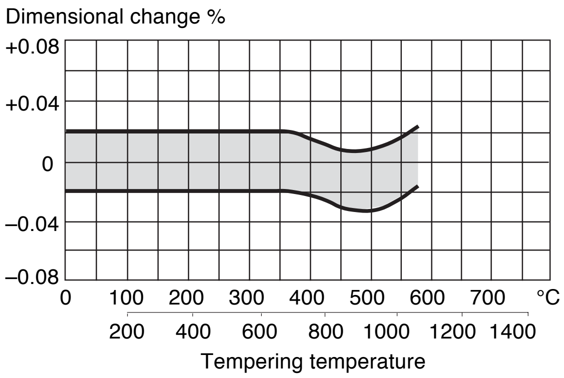
Both flame and induction hardening methods can be applied to *VIKING*.
In order to get a very uniform hardness after flame or induction hardening the steel can first be prehardened to approx. 35 ±2 HRC. After flame or induction hardening the steel should be tempered at at least 180°C (360°F).

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



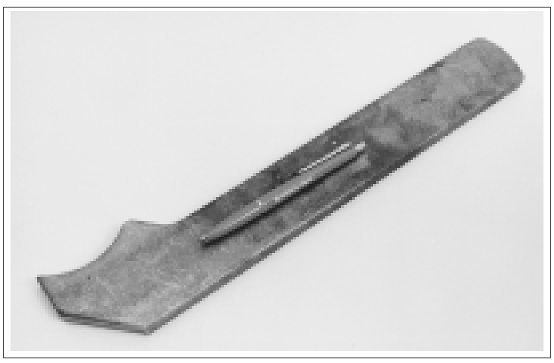
Note: The dimensional changes in hardening and tempering should be added together

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	Wheel recommendation 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.

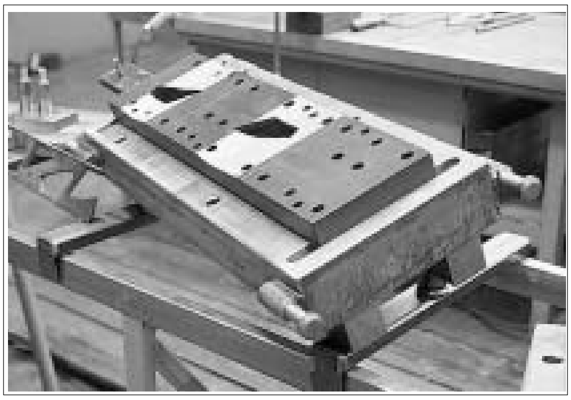
Welding

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.

UDDEHOLM EUROPE

AUSTRIA
UDDEHOLM
Hansaallee 321
D-40549 Düsseldorf
Telephone: +49 211 535 10
Telefax: +49 211 535 12 80

BELGIUM
UDDEHOLM N.V.
Waterstraat 4
B-9160 Lokeren
Telephone: +32 9 349 11 00
Telefax: +32 9 349 11 11

CROATIA
BOHLER UDDEHOLM Zagreb
d.o.o za trgovinu
Zitnjak b.b
10000 Zagreb
Telephone: +385 1 2459 301
Telefax: +385 1 2406 790

CZECHIA
BOHLER UDDEHOLM CZ s.r.o.
Division Uddeholm
U silnice 949
161 00 Praha 6 Ruzyne
Czech Republic
Telephone: +420 233 029 850,8
Telefax: +420 233 029 859

DENMARK
UDDEHOLM A/S
Kokmose 8, Bramdrupdam
DK-6000 Kolding
Telephone: +45 75 51 70 66
Telefax: +45 75 51 70 44

ESTONIA
UDDEHOLM TOOLING AB
Silikatsiidi 7
EE-0012 Tallinn
Telephone: +372 655 9180
Telefax: +372 655 9181

FINLAND
OY UDDEHOLM AB
Ritakuja 1, PL 57,
FIN-01741 VANTAA
Telephone: +358 9 290 490
Telefax: +358 9 2904 9249

FRANCE
UDDEHOLM S.A.
12 Rue Mercier, Z.I. de Mitry-Compans
F-77297 Mitry Mory Cedex
Telephone: +33 (0)1 60 93 80 10
Telefax: +33 (0)1 60 93 80 01

Branch office
UDDEHOLM S.A.
77bis, rue de Vesoul
La Nef aux Métiers
F-25000 Besançon
Telephone: +33 381 53 12 19
Telefax: +33 381 53 13 20

GERMANY
UDDEHOLM
Hansaallee 321
D-40549 Düsseldorf
Telephone: +49 211 535 10
Telefax: +49 211 535 12 80

Branch offices
UDDEHOLM
Falkenstraße 21
D-65812 Bad Soden/TS.
Telephone: +49 6196 659 60
Telefax: +49 6196 659 625

UDDEHOLM
Albstraße 10
D-73765 Neuhausen
Telephone: +49 715 898 65-0
Telefax: +49 715 898 65-25

GREAT BRITAIN, IRELAND
UDDEHOLM UK LIMITED
European Business Park
Taylors Lane, Oldbury
West Midlands B69 2BN
Telephone: +44 121 552 55 11
Telefax: +44 121 544 29 11
Dublin Telephone: +353 1 45 14 01

GREECE
UDDEHOLM STEEL TRADING
COMPANY
20, Athinon Street
G-Piraeus 18540
Telephone: +30 2 10 41 72 109/41 29 820
Telefax: +30 2 10 41 72 767

SKLERO S.A.
Steel Trading Comp. and
Hardening Shop
Frixou 11/Nikif. Ouranou
G-54627 Thessaloniki
Telephone: +30 31 51 46 77
Telefax +30 31 54 12 50

HUNGARY
UDDEHOLM TOOLING/BOK
Dunaharaszti, Jedlik Ányos út 25
H-2331 Dunaharaszti 1.Pf. 110
Telephone/Telefax: +36 24 492 690

ITALY
UDDEHOLM Italia S.p.A.
Via Palizzi, 90
I-20157 Milano
Telephone: +39 02 35 79 41
Telefax: +39 02 390 024 82

LATVIA
UDDEHOLM TOOLING AB
Deglava street 50
LV-1035 Riga
Telephone: +371 7 701 983, -981, -982
Telefax: +371 7 701 984

LITHUANIA
UDDEHOLM TOOLING AB
BE PLIENAS IR METALAI
T. Masiulio 18b
LT-3014 Kaunas
Telephone: +370 37 370613, -669
Telefax: +370 37 370300

THE NETHERLANDS
UDDEHOLM B.V.
Isolatorweg 30
NL-1014 AS Amsterdam
Telephone: +31 20 581 71 11
Telefax: +31 20 684 86 13

NORWAY
UDDEHOLM A/S
Jernkroken 18
Postboks 85, Kalbakken
N-0902 Oslo
Telephone: +47 22 91 80 00
Telefax: +47 22 91 80 01

POLAND
INTER STAL CENTRUM
Sp. z. o.o./Co. Ltd.
ul. Kolejowa 291, Dzieków Polski
PL-05-092 Lomianki
Telephone: +48 22 429 2260
Telefax: +48 22 429 2266

PORTUGAL
F RAMADA Aços e Industrias S.A.
P.O. Box 10
P-3881 Ovar Codex
Telephone: +351 56 58 61 11
Telefax: +351 56 58 60 24

ROMANIA
BÖHLER Romania SRL
Uddeholm Branch
Str. Atomistilor Nr 14A
077125 Magurele Jud Ilfov
Telephone: +40 214 575007
Telefax: +40 214 574212

RUSSIA
UDDEHOLM TOOLING CIS
25 A Bolshoy pr PS
197198 St. Petersburg
Telephone: +7 812 233 9683
Telefax: +7 812 232 4679

SLOVAKIA
UDDEHOLM Slovakia
Nástrojové ocele, s.r.o
KRÁCINY 2
036 01 Martin
Telephone: +421 842 4 300 823
Telefax: +421 842 4 224 028

SLOVENIA
UDDEHOLM Italia S.p.A.
Via Palizzi, 90
I-20157 Milano
Telephone: +39 02 35 79 41
Telefax: +39 02 390 024 82

SPAIN
UDDEHOLM
Guifré 690-692
E-08918 Badalona, Barcelona
Telephone: +34 93 460 1227
Telefax: +34 93 460 0558

Branch office
UDDEHOLM
Barrio San Martin de Arteaga, 132
Pol.Ind. Torrelarragoiti
E-48170 Zamudio
(Bizkaia)
Telephone: +34 94 452 13 03
Telefax: +34 94 452 13 58

SWEDEN
UDDEHOLM TOOLING
SVENSKA AB
Aminogatan 25
SE-431 53 Mölndal
Telephone: +46 31 67 98 50
Telefax: +46 31 27 02 94

SWITZERLAND
HERTSCH & CIE AG
General Wille Strasse 19
CH-8027 Zürich
Telephone: +41 1 208 16 66
Telefax: +41 1 201 46 15

UDDEHOLM NORTH AMERICA

USA
UDDEHOLM
4902 Tollview Drive
Rolling Meadows IL 60008
Telephone: +1 847 577 22 20
Telefax: +1 847 577 80 28

UDDEHOLM
548 Clayton Ct.,
Wood Dale IL 60191
Telephone: +1 630 350 10 00
Telefax: +1 630 350 08 80

UDDEHOLM
9331 Santa Fe Springs Road
Santa Fe Springs, CA 90670
Telephone: +1 562 946 65 03
Telefax: +1 562 946 77 21

UDDEHOLM
220 Cherry Street
Shrewbury, MA 01545
Telephone: +1 508 845 1066
Telefax: +1 508 845 3471

CANADA
UDDEHOLM LIMITED
2595 Meadowvale Blvd.
Mississauga, Ontario L5N 7Y3
Telephone: +1 905 812 9440
Telefax: +1 905 812 8659

MEXICO
ACEROS BOHLER UDDEHOLM,
S.A. de C.V.
Calle 8 No 2, Letra "C"
Fraccionamiento Industrial Alce Blanco
C.P. 52787 Naucalpan de Juarez
Estado de Mexico
Telephone: +52 55 9172 0242
Telefax: +52 55 5576 6837

UDDEHOLM
Lerdo de Tejada No.542
Colonia Las Villas
66420 San Nicolas de Los Garza, N.L.
Telephone: +52 8-352 5239
Telefax: +52 8-352 5356

UDDEHOLM SOUTH AMERICA

ARGENTINA
UDDEHOLM S.A
Mozart 40
1619-Centro Industrial Garin
Garin-Prov. Buenos Aires
Telephone: +54 332 744 4440
Telefax: +54 332 745 3222

BRAZIL
UDDEHOLM ACOS ESPECIAIS Ltda.
Estrada Yae Massumoto, 353
CEP 09842-160
Sao Bernardo do Campo - SP Brazil
Telephone: +55 11 4393 4560, -4554
Telefax: +55 11 4393 4561

UDDEHOLM SOUTH AFRICA
UDDEHOLM Africa (Pty) Ltd.
P.O. Box 539
ZA-1600 Isando/Johannesburg
Telephone: +27 11-974 2781
Telefax: +27 11-392 2486

UDDEHOLM AUSTRALIA
BOHLER-UDDEHOLM Australia
129-135 McCredie Road
Guildford NSW 2161
Private Bag 14
Telephone: +61 2 9681 3100
Telefax: +61 2 9632 6161

Branch offices
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Brisbane, Perth, Newcastle,
Launceston, Albury, Townsville

ASSAB

ASSAB INTERNATIONAL
Skytteholmsvägen 2
P O Box 42
SE-171 11 Solna
Sweden
Telephone: +46 8 564 616 70
Telefax: +46 8 25 02 37

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Telefax: +65 534 06 55

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Edition: 1, 01.1999