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General

Uddeholm 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
- Ideal for surface coating (CVD, PVD)

| | | | | | | |
|--------------------|-------------------------------|-----------|-----------|-----------|-----------|----------|
| 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 Uddeholm 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

Applications

Uddeholm 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.

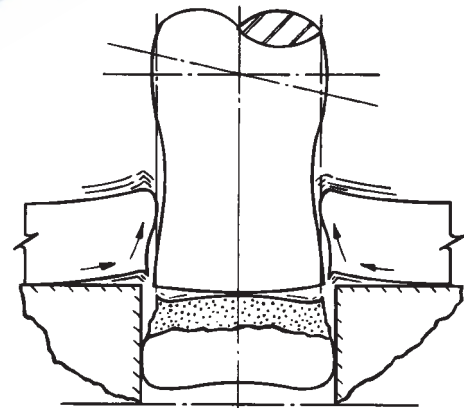
- Blanking and piercing of thick materials up to 25 mm.

Other applications:

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

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.

The chemical composition of Uddeholm Viking gives a hardness potential of 58 HRC with compressive strength and wear resistance accordingly. The small amount of primary carbides means a high chipping resistance and with 8 % chromium follows a very good hardenability and also a fairly good resistance to corrosion.

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 lbs/in ³ | 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/mm ² 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/(ft ² h°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 (1 3/8") 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 tsi psi 1000 X | 1 960 125 300 | 1 860 120 270 | 1 620 105 230 |
| Yield point Rp _{0.2} N/mm ² tsi psi 1000 X | 1 715 110 250 | 1 620 105 230 | 1 470 95 210 |
| Reduction of area, Z % | 15 | 28 | 35 |
| Elongation, A ₅ % | 6 | 7 | 8 |

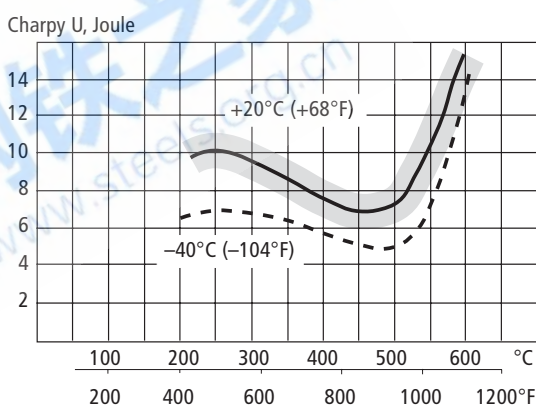
COMPRESSIVE STRENGTH

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 tsi psi 1000 X | 2 745 175 395 | 2 450 155 355 | 2 060 130 300 |
| Compressive strength Rp _{0.2} N/mm ² 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.



Cold cropping tool made from Uddeholm Viking.

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.

HARDENING

Pre-heating temperature: 600–700°C (1110–1290°F).

Austenitizing temperature: 980–1050°C (1800–1920°F) normally 1010°C (1850°F).

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

* 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.

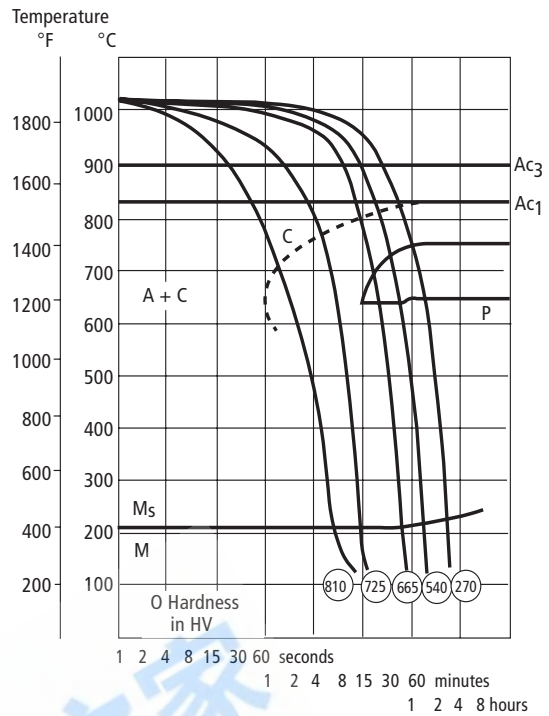
QUENCHING MEDIA

- 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).

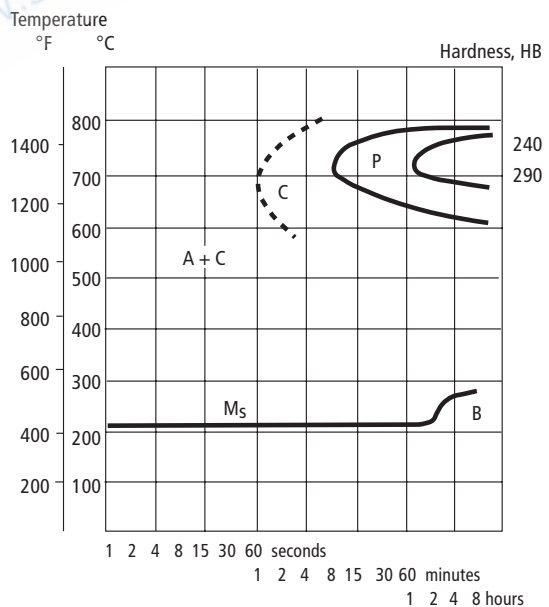
CCT-graph

Austenitizing temperature 1010°C (1850°F).



TTT-graph

Austenitizing temperature 1010°C (1850°F).

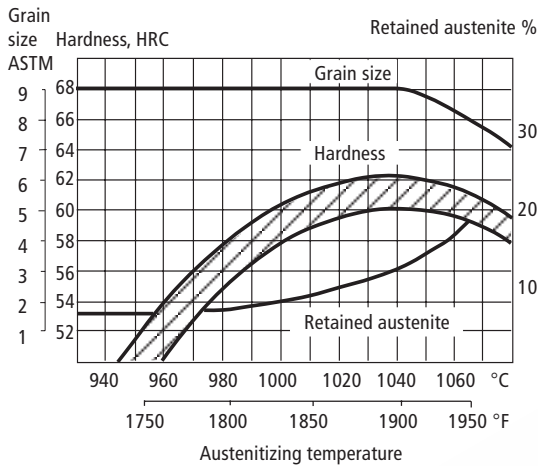


Transformation temperature

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).

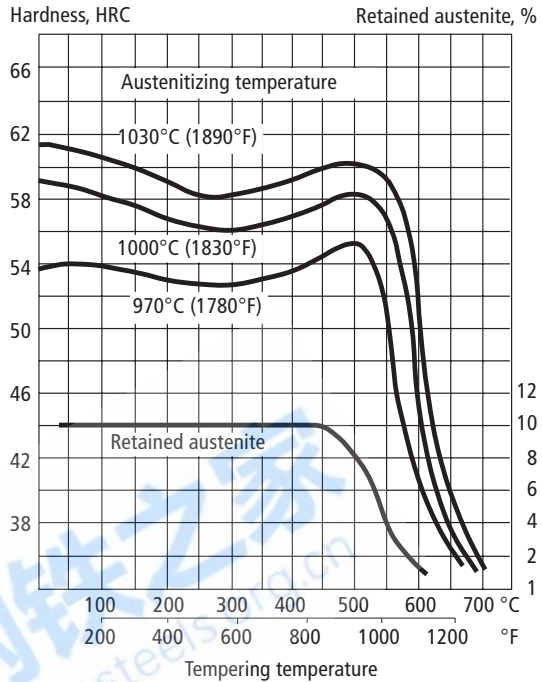
Hardness, grain size and retained austenite as functions of austenitizing temperature



TEMPERING

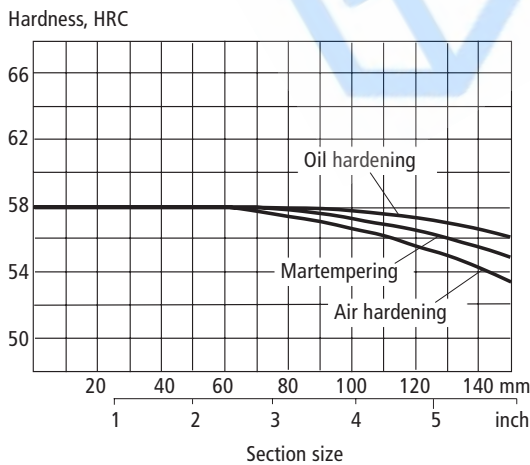
Heating to tempering temperature should be carried out slowly and uniformly. Tempering should be carried out twice. Lowest temperature 180°C (360°F). Holding time at temperature minimum 2 hours.

Tempering graph

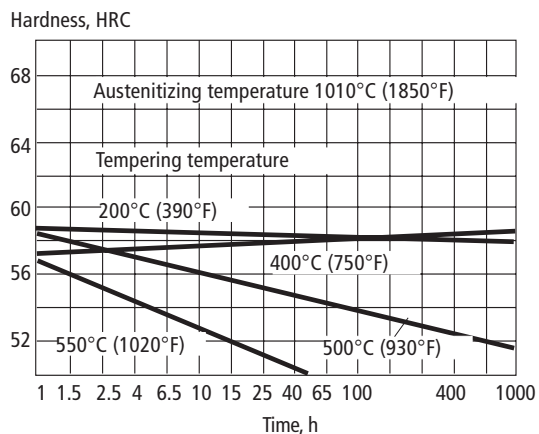


Hardenability

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



Effect of time at tempering temperature



Uddeholm Viking hardens through in all common sizes.

A support arm produced in a blanking tool made from Uddeholm Viking.



FLAME AND INDUCTION HARDENING

Both flame and induction hardening methods can be applied to Uddeholm 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).

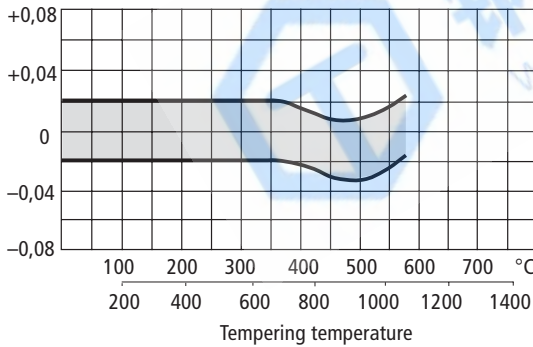
DIMENSIONAL CHANGES AFTER COOLING IN AIR

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

Dimensional change %



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

NITRIDING

Nitriding and nitrocarburizing result in hard surface layer which is very resistant to wear and galling. The surface hardness after nitriding is approximately 1000–1200 HV_{0,2 kg}. The thickness of the layer should be chosen to suit the application in question. For cold work applications a thickness of 10–50 μm is recommended and for hot work applications an increased case depth (up to 0,3 mm) might be appropriate.

PVD AND CVD

The good tempering resistance and dimensional stability at heat treatment means possibilities for CVD and PVD of Uddeholm Viking, if 58 HRC is enough for the application.

Physical Vapour Deposition, PVD, is a method for applying wear-resistant surface coating at temperatures between 200–500°C (390-930°F).

Chemical vapour deposition, CVD, is a method for applying wear resistant surface coating a a temperature of around 1000°C (1830°F)

General machining recommendations

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

TURNING

| Cutting data parameter | Turning with carbide | | Turning with high speed steel Fine turning |
|---|---------------------------|---------------------------------|---|
| | Rough turning | Fine turning | |
| Cutting speed (v_c) m/min. f.p.m. | 160–210 525–690 | 210–260 690–850 | 20–25 65–80 |
| Feed (f) mm/rev i.p.r. | 0,2–0,4 0,008–0,016 | 0,05–0,2 0,002–0,008 | 0,05–0,3 0,002–0,012 |
| 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 | P20–P30 Coated carbide | P10 Coated carbide or cermet | – |

DRILLING

High speed steel twist drill

| Drill diameter Ø | Cutting speed (v_c) | Feed (f) | |
|------------------|-------------------------|-----------|-------------|
| | | mm/rev | i.p.r. |
| 5–10 | 15–17* | 0,08–0,20 | 0,003–0,008 |
| 10–15 | 15–17* | 0,20–0,30 | 0,008–0,012 |
| 15–20 | 15–17* | 0,30–0,35 | 0,012–0,024 |
| | | 0,35–0,40 | 0,014–0,016 |

* For coated HSS drills $v_c = 26–28$ m/min (85–92 f.p.m.).

Carbide drill

| Cutting data parameter | Type of drill | | |
|---|---|---|---|
| | Indexable insert | Solid carbide | Brazed carbide ¹⁾ |
| Cutting speed (v_c) m/min. f.p.m. | 200–220 655–730 | 110–140 360–465 | 70–90 260–295 |
| Feed (f) mm/rev 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 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 IV |
| Profile grinding | A 100 KV | A 120 JV |

MILLING

Face and square shoulder milling

| Cutting data parameter | Milling with carbide | |
|---|---------------------------|-------------------------------------|
| | Rough milling | Fine milling |
| Cutting speed (v_c) m/min. f.p.m. | 140–230 460–755 | 230–270 755–885 |
| Feed (f_z) mm/tooth inch/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 | P20–P40 Coated carbide | P10–P20 Coated carbide or cermet |

End milling

| Cutting data parameter | Type of milling | | |
|---|--|--|---|
| | Solid carbide | Carbide indexable insert | High speed steel |
| Cutting speed (v_c) m/min. f.p.m. | 110–140 360–460 | 130–180 425–590 | 20–25 ¹⁾ 65–80 ¹⁾ |
| Feed (f_z) mm/tooth inch/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 | – | P20–P40 Coated carbide | – |

¹⁾ For coated HSS end mill $v_c = 40–45$ m/min (130–148 f.p.m.).

²⁾ Depending on the type of milling (side or slot) and cutter diameter.

Electrical-discharge machining

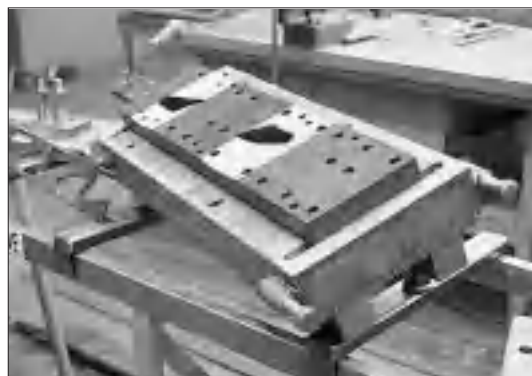
If spark-erosion is performed in the hardened and tempered condition the tool should then be given an additional temper at approx. 25°C (50°F) below the previous tempering temperature.

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.

Uddeholm 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 Uddeholm 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.



Blanking tool set for producing a plate part.

2. Repair welding of Uddeholm 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 Uddeholm Viking always use an electrode with the same analysis as the base material.

When welding Uddeholm Viking in the hardened condition use OK Selectrode 84.52 or UTP 67S for MMA-welding. For TIG welding use UTP A67S or Castolin CastoTig 45303W.

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

