

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".

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SS-EN ISO 9001
SS-EN ISO 14001

General

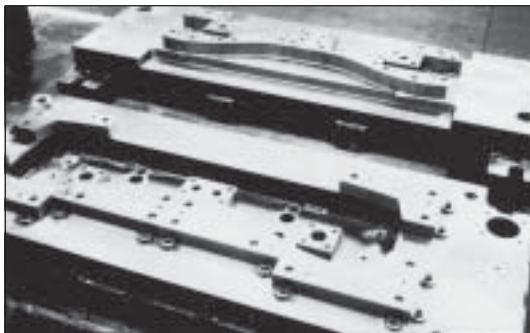
Uddeholm Calmax is a chromium molybdenum-vanadium alloyed steel characterized by:

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

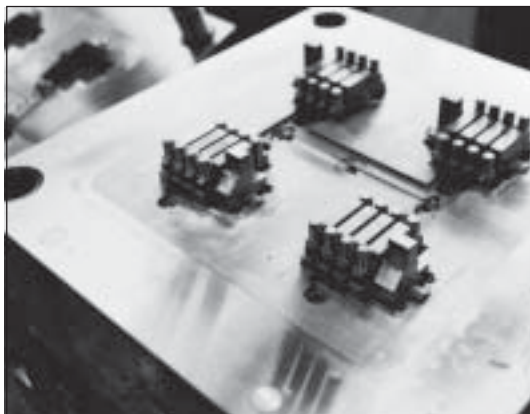
Typical analysis %	C	Si	Mn	Cr	Mo	V
	0,6	0,35	0,8	4,5	0,5	0,2
Delivery condition	Soft annealed to approx. 200 HB					
Colour code	White/violet					

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

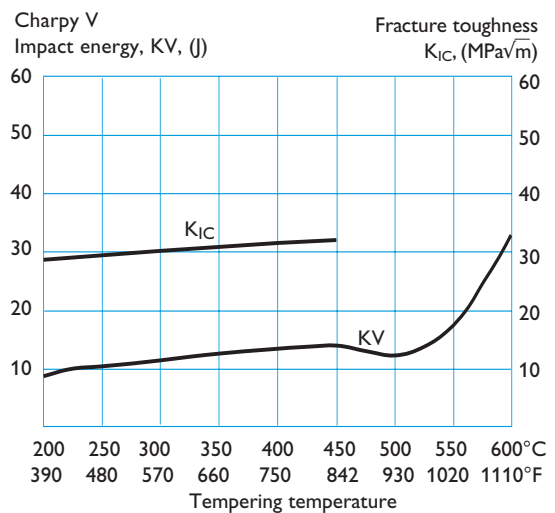
Compressive strength

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.

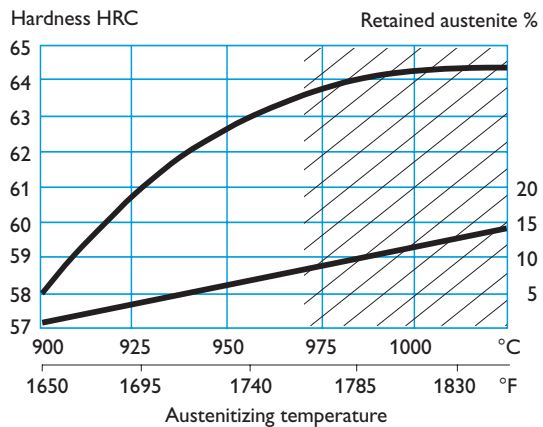
Quenching media

- 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).

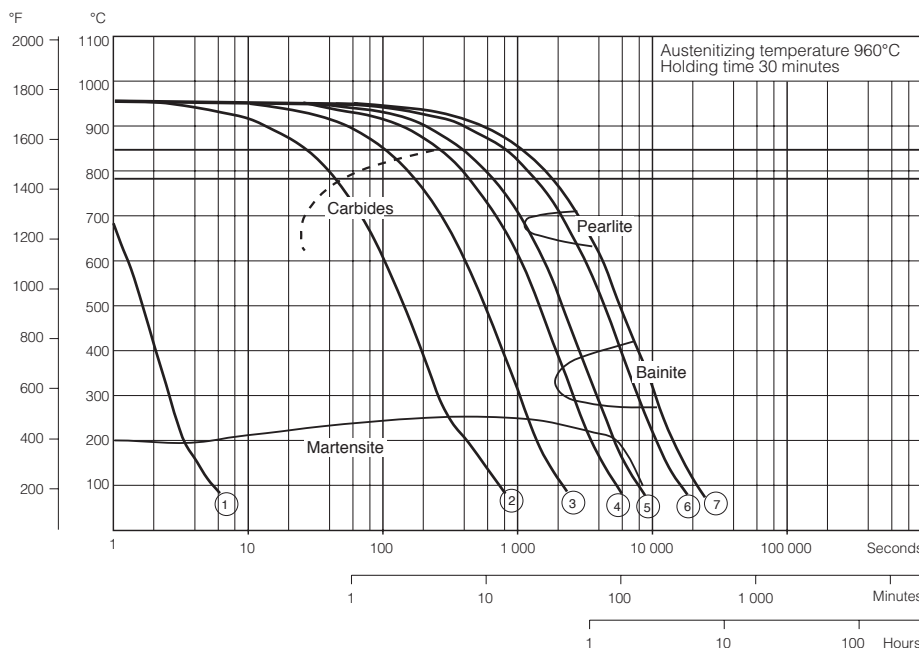
HARDNESS AND RETAINED AUSTENITE AS A FUNCTION OF AUSTENITIZING TEMPERATURE



▨ Risk for grain growth causing reduced toughness

CCT-GRAPH

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

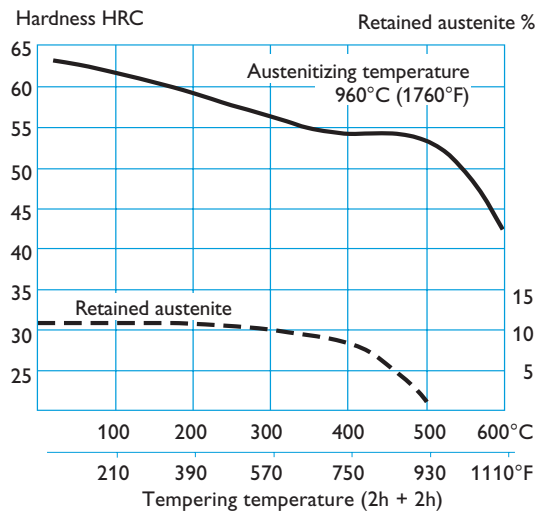


Cooling Curve No.	Hardness HV10	T ₈₀₀₋₅₀₀ sec.
1	820	1
2	762	107
3	743	423
4	734	1071
5	657	1596
6	455	3228
7	413	4292

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

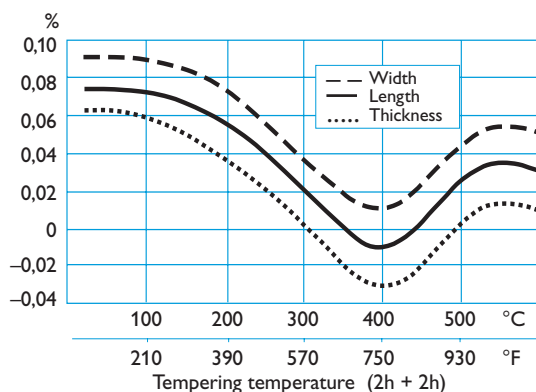


Dimensional changes

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.

Europe

Austria

Representative office

UDDEHOLM
Albstraße 10
DE-73765 Neuhausen
Telephone: +49 7158 9865-0
www.uddeholm.de

Belgium

UDDEHOLM
Europark Oost 7
B-9100 Sint-Niklaas
Telephone: +32 3 780 56 20
www.uddeholm.be

Croatia

BÖHLER UDDEHOLM Zagreb
d.o.o za trgovinu
Zitnjak b.b
10000 Zagreb
Telephone: +385 1 2459 301
Telefax: +385 1 2406 790
www.bohler-uddeholm.hr

Czech Republic

BÖHLER UDDEHOLM CZ s.r.o.
Division Uddeholm
U Silnice 949
161 00 Praha 6, Ruzyně
Telephone: +420 233 029 850,8
www.uddeholm.cz

Denmark

UDDEHOLM A/S
Kokmose 8, Bramdrupdam
DK-6000 Kolding
Telephone: +45 75 51 70 66
www.uddeholm.dk

Estonia

UDDEHOLM TOOLING AB
Silikatsiidi 7
EE-11216 Tallinn
Telephone: +372 655 9180
www.uddeholm.ee

Finland

OY UDDEHOLM AB
Ritakuja 1, PL 57
FI-01741 VANTAA
Telephone: +358 9 290 490
www.uddeholm.fi

France

Head office
UDDEHOLM
Z.I. de Mitry-Compans, 12 rue Mercier,
FR-77297 Mitry Mory Cedex
Telephone: +33 (0)1 60 93 80 10
www.uddeholm.fr

Branch offices

UDDEHOLM S.A.
77bis, rue de Vesoul
La Nef aux Métiers
FR-25000 Besançon
Telephone: +33 (0)381 53 12 19

LE POINT ACIERS
UDDEHOLM - Aciers à outils
Z.I. du Recou, Avenue de Champlevvert
FR-69520 GRIGNY
Telephone: +33 (0)4 72 49 95 61

LE POINT ACIERS
UDDEHOLM - Aciers à outils
Z.I. Nord 27, rue François Rochnax
FR-01100 OYONNAX
Telephone: +33 (0)4 74 73 48 66

Germany

Head office
UDDEHOLM
Hansaallee 321
DE-40549 Düsseldorf
Telephone: +49 211 5351-0
www.uddeholm.de

Branch offices

UDDEHOLM
Falkenstrabe 21
DE-65812 Bad Soden/TS
Telephone: +49 6196 6596-0

UDDEHOLM
Albstraße 10
DE-73765 Neuhausen
Telephone: +49 7158 9865-0

UDDEHOLM
Friederikenstraße 14b
DE-06493 Harzgerode
Telephone: +49 39484 727 267

Great Britain

UDDEHOLM DIVISION
BOHLER-UDDEHOLM (UK) LIMITED
European Business Park
Taylors Lane, Oldbury
GB-West Midlands B69 2BN
Telephone: +44 121 552 5511
Telefax: +44 121 544 2911
www.uddeholm.co.uk

Greece

STASSINOPOULOS-UDDEHOLM
STEEL TRADING S.A.
20, Athinon Street
GR-Piraeus 18540
Telephone: +30 210 4172 109
www.uddeholm.gr

SKLERO S.A.
Heat Treatment and Trading of Steel
Uddeholm Tool Steels
Industrial Area of Thessaloniki
P.O. Box 1123
GR-57022 Sindos, Thessaloniki
Telephone: +30 2310 79 76 46
www.sklero.gr

Hungary

UDDEHOLM TOOLING/BOK
Dunaharaszti, Jedlik Ányos út 25
HU-2331 Dunaharaszti 1. Pf. 110
Telephone/fax: +36 24 492 690
www.uddeholm.hu

Ireland

Head office:
UDDEHOLM DIVISION
BOHLER-UDDEHOLM (UK) LIMITED
European Business Park
Taylors Lane, Oldbury
UK-West Midlands B69 2BN
Telephone: +44 121 552 5511
Telefax: +44 121 544 2911
www.uddeholm.co.uk
Dublin:
Telephone: +353 1845 1401

Italy

UDDEHOLM
Divisione della Bohler Uddeholm
Italia S.p.A.
Via Palizzi, 90
IT-20157 Milano
Telephone: +39 02 39 49 211
www.uddeholm.it

Latvia

UDDEHOLM TOOLING LATVIA SIA
Piedrujas Street 7
LV-1035 Riga
Telephone: +371 7 702133
Telefax: +371 7 185079

Lithuania

UDDEHOLM TOOLING AB
BE PLIENAS IR METALAI
T. Masiulio 18B
LT-52459 Kaunas
Telephone: +370 37 370613, -669
www.besteel.lt

The Netherlands

UDDEHOLM
Isolatorweg 30
NL-1014 AS Amsterdam
Telephone: +31 20 581 71 11
www.uddeholm.nl

Norway

UDDEHOLM A/S
Jernkroken 18
Postboks 85, Kalbakken
NO-0902 Oslo
Telephone: +47 22 91 80 00
www.uddeholm.no

Poland

INTER STAL CENTRUM
Sp. z.o.o./Co. Ltd.
ul. Kolejowa 291, Dziekanów Polski,
PL-05-092 Lomianki
Telephone: +48 22 429 2260, -203, -204
www.uddeholm.pl

Portugal

F RAMADA Açoes e Industrias S.A.
P.O. Box 10
PT-3881 Ovar Codex
Telephone: +351 256 580580
www.ramada.pt

Romania

BÖHLER-UDDEHOLM Romania SRL
Atomistilor Str. No 96-102
077125 - com. Magurele, Jud. Ilfov.
Telephone: +40 214 575007
Telefax: +40 214 574212

Russia

UDDEHOLM TOOLING CIS
9A, Lipovaya Alleya, Office 509
RU-197183 Saint Petersburg
Telephone: +7 812 6006194
www.uddeholm.ru

Slovakia

Bohler-Uddeholm Slovakia s.r.o.
divizia UDDEHOLM
Čsl.Armády 5622/5
SK-036 01 Martin
Telephone: +421 (0)434 212 030
www.uddeholm.sk

Slovenia

Representative office
UDDEHOLM
Divisione della Bohler Uddeholm
Italia S.p.A.
Via Palizzi, 90
IT-20157 Milano
Telephone: +39 02 39 49 211
www.uddeholm.it

Spain

Head office
UDDEHOLM
Guiñfó 690-692
ES-08918 Badalona, Barcelona
Telephone: +34 93 460 1227
www.acerosuddeholm.com

Branch office

UDDEHOLM
Barrio San Martín de Arteaga,132
Pol.Ind. Torrelarragoiti
ES-48170 Zamudio (Bizkaia)
Telephone: +34 94 452 13 03

Sweden

Head office
UDDEHOLM TOOLING SVENSKA AB
Aminogatan 25
SE-431 53 Mölndal
Telephone: +46 31 67 98 50
www.uddeholm.se

Branch offices

UDDEHOLM TOOLING SVENSKA AB
Box 45
SE-334 21 Anderstorp
Telephone: +46 371 160 15

UDDEHOLM TOOLING SVENSKA AB
Box 148
SE-631 03 Eskilstuna
Telephone: +46 16 15 79 00

UDDEHOLM TOOLING SVENSKA AB
Aminogatan 25
SE-431 53 Mölndal
Telephone: +46 31 67 98 70

UDDEHOLM TOOLING SVENSKA AB
Nya Tanneforsvägen 96
SE-582 42 Linköping
Telephone: +46 13 15 19 90

UDDEHOLM TOOLING SVENSKA AB
Derbyvägen 22
SE-212 35 Malmö
Telephone: +46 40 22 32 05

UDDEHOLM TOOLING SVENSKA AB
Honnörsgratan 16A
SE-232 36 Växjö
Telephone: +46 470 457 90

Switzerland

HERTSCH & CIE AG
General Wille Strasse 19
CH-8027 Zürich
Telephone: +41 44 208 16 66
www.hertsch.ch

Turkey

Head office
ASSAB Korkmaz Celik A.S.
Organize Sanayi Bölgesi
2. Cadde No: 26 Y. Dudullu
Umraniye-Istanbul Turkey
Telephone: +90 216 420 1926-121/124
www.assabkorkmaz.com

Ukraine

DC CETAB UKRAINE
Box 2431
49040 Dniepropetrovsk
Telephone: +380 562 32 68 65
www.cetab.com

America

Argentina

ACEROS BOEHLER UDDEHOLM S.A
Mozart 40
1619-Centro Industrial Garin
Garin-Prov.
AR-Buenos Aires
Telephone: +54 332 7444 440
www.uddeholm.com.ar

Brazil

AÇOS BOHLER-UDDEHOLM DO
BRASIL LTDA- DIV. UDDEHOLM
Estrada Yae Massumoto, 353
CEP 09842-160
BR-Sao Bernardo do Campo - SP Brazil
Telephone: +55 11 4393 4560, 4554
www.uddeholm.com.br

Canada

Head Office & Warehouse

UDDEHOLM
2595 Meadowvale Blvd.
Mississauga, ON L5N 7Y3
Telephone: +1 905 812 9440
www.bucanada.com

Branch Warehouses

UDDEHOLM
3521 Rue Ashby
St. Laurent, QC H4R 2K3
Telephone: +1 514 333 8000

UDDEHOLM

730 Eaton Way - Unit #10
New Westminster, BC V3M 6J9
Telephone: +1 604 525 3354

Heat Treating

THERMO-TECH
2645 Meadowvale Blvd.
Mississauga, ON L5N 7Y4
Telephone: +1 905 812 9440

Colombia

AXXECOL S.A.
Carrera 35 No 13-20
Apartado Aereo 80718
CO-Bogota 6
Telephone: +57 1 2010700
www.axxecol.com

ASTECO S.A.

Carrera 54 No 35-12
Apartado Aereo 663
CO-Medellin
Telephone: +57 4 2320122
www.asteco.com

Dominican Republic

RAMCA, C. POR A.
Luis Puigbó Alegre, EPS P-2289
P O Box 02-5261
DO-Santo Domingo
Telephone: +1 809 682 4011
domrep@assab.com

Ecuador

IVAN BOHMAN C.A.
Cagilla Postal 17-01370
Quito
Telephone: +593 2 2248001

IVAN BOHMAN C.A.

Apartado 1317
Km 6 1/2 Via a Daule
Guayaquil
Telephone: +593 42 254111

El Salvador

ACAVIDA DE C.V.
25a. Avenida Sur 463
zona 1
Apartado Postal 439
SV-San Salvador
Telephone: +503 22 711700
www.acavisa.com

Guatemala

IMPORTADORA ESCANDINAVA
Apartado postal 2042
GT-Guatemala City
Telephone: +502 23 659270
guatemala@assab.com

Mexico

Head office

ACEROS BOHLER UDDEHOLM S.A.
de C.V.
Calle Ocho No 2, Letra "C"
Fraccionamiento Industrial Alce Blanco
C.P. 52787 Naucalpan de Juarez
MX-Estado de Mexico
Telephone: +52 55 9172 0242
www.bu-mexico.com

Branch office

BOHLER-UDDEHOLM MONTERREY,
NUEVO LEON
Lerdo de Tejada No.542
Colonia Las Villas
MX-66420 San Nicolas de Los Garza,
N.L.
Telephone: +52 81 83 525239

Peru

C.I.P.E.S.A.
Av. Oscar R. Benavides
(ante Colonial) No. 2066
PE-Lima 1
Telephone: +51 1 336 8673
peru@assab.com

U.S.A.

Head Office

UDDEHOLM
4902 Tollview Drive
Rolling Meadows IL 60008
Telephone: 1-847-577-2220
Sales phone: 1-800-638-2520
www.bucorp.com

Region East Warehouse

UDDEHOLM
220 Cherry Street
Shrewsbury MA 01545

Region Central Warehouse

UDDEHOLM
548 Clayton Ct.
Wood Dale IL 60191

Region West Warehouse

UDDEHOLM
9331 Santa Fe Springs Road
Santa Fe Springs, CA 90670

Venezuela

PRODUCTOS HUMAR C.A.
Multicentro Empresarial del Este,
Edf Libertador, Núcleo A.
Piso 9, Of. A-93, Chacao
VE-Caracas 1060
Telephone: +58 212 2655040
humar@assab.com

Other Countries in America

ASSAB INTERNATIONAL AB
Box 42
SE-171 11 Solna, Sweden
Telephone: +46 8 564 616 70
www.assab.se

Asia & Pacific

Australia

BOHLER UDDEHOLM Australia
129-135 McCredie Road
Guildford NSW 2161
Private Bag 14
AU-Sydney
Telephone: +61 2 9681 3100
www.buau.com.au

Bangladesh

ASSAB INTERNATIONAL AB
P.O. Box 17595
Jebel Ali
AE-Dubai
Telephone: +971 488 12165
www.assab.se

North China

Head office

ASSAB Tooling (Beijing) Co Ltd
No.10A Rong Jing Dong Jie
Beijing Economic Development Area
Beijing 100176, China
Telephone: +86 10 6786 5588
www.assabsteels.com

Branch offices

ASSAB Tooling (Beijing) Ltd
Dalian Branch
8 Huanghai Street, Haerbin Road
Economic & Technical Develop. District
Dalian 116600, China
Telephone: +86 411 8761 8080

ASSAB Qingdao Office

Room 2521, Kexin Mansion
No. 228 Liaoning Road, Shibei District
Qingdao 266012, China
Telephone: +86 532 8382 0930

ASSAB Tianjin Office

No.12 Puwangli Wanda Xincheng
Xinyibai Road, Beichen District
Tianjin 300402, China
Telephone: +86 22 2672 0006

Central China

Head office

ASSAB Tooling Technology
(Shanghai) Co Ltd
No. 4088 Humin Road
Xinzhuang Industrial Zone
Shanghai 201108, China
Telephone: +86 21 5442 2345
www.assabsteels.com

Branch offices

ASSAB Tooling Technology
(Ningbo) Co Ltd
No. 218 Longjiaoshan Road
Vehicle Part Industrial Park
Ningbo Economic & Technical Dev.
Zone
Ningbo 315806, China
Telephone: +86 574 8680 7188

ASSAB Tooling Technology

(Chongqing) Co Ltd
Plant C, Automotive Industrial IPark
Chongqing Economic & Technological
Development Zone
Chongqing 401120, China
Telephone: +86 23 6745 5698

South China

Head office

ASSAB Steels (HK) Ltd
Room 1701-1706
Tower 2 Grand Central Plaza
138 Shatin Rural Committee Road
Shatin NT - Hong Kong
Telephone: +852 2487 1991
www.assabsteels.com

Branch offices

ASSAB Tooling (Dongguan) Co Ltd
Northern District
Song Shan Lake Science & Technology
Industrial Park
Dongguan 523808, China
Telephone: +86 769 2289 7888
www.assabsteels.com

ASSAB Tooling (Xiamen) Co Ltd

First Floor Universal Workshop
No. 30 Huli Zone
Xiamen 361006, China
Telephone: +86 592 562 4678

Hong Kong

ASSAB Steels (HK) Ltd
Room 1701-1706
Grand Central Plaza, Tower 2
138 Shatin Rural Committee Road
Shatin NT, Hong Kong
Telephone: +852 2487 1991
www.assabsteels.com

India

ASSAB Sripad Steels LTD
T 303 D.A.V. Complex
Mayur Vihar Ph I Extension
IN-Delhi-110 091
Telephone: +91 11 2271 2736
www.assabsripadsteels.com

ASSAB Sripad Steels LTD

709, Swastik Chambers
Sion-Trombay Road
Chembur
IN-Mumbai-400 071
Telephone: +91 22 2522-7110, -8133

ASSAB Sripad Steels LTD

Padmalaya Towers
Janaki Avenue
M.R.C. Nagar
IN-Chennai-600 028
Telephone: +91 44 2495 2371

Indonesia

Head office

PT ASSAB Steels Indonesia
Jl. Rawagelam III No. 5
Kawasan Industri Pulogadung
Jakarta 13930, Indonesia
Telephone: +62 21 461 1314
www.assabsteels.com

Branch offices

SURABAYA BRANCH
Jl. Berbek Industri 1/23
Surabaya Industrial Estate, Rungkut
Surabaya 60293, East Java, Indonesia
Telephone: +62 31 843 2277

MEDAN BRANCH

Komplek Griya Riatur Indah
Blok A No.138
Jl. T. Amir Hamzah
Halvetia Timur, Medan 20124
Telephone: +62 61 847 7935/6

BANDUNG BRANCH

Komp. Ruko Bumi Kencana
Jl. Titian Kencana Blok E
No.5 Bandung 40233
Telephone: +62 22 604 1364

TANGERANG BRANCH

Pusat Niaga Cibodas
Blok C No. 7 Tangerang
Telephone: +62 21 921 9596, 551 2732

SEMARANG BRANCH

Jl. Imam Bonjol No.155
R.208 Semarang 50124
Telephone: +62 358 8167

Iran

ASSAB INTERNATIONAL AB
P.O. Box 19395
IR-1517 TEHRAN
Telephone: +98 21 888 35392
www.assabiran.com

Israel

PACKER YADPAZ QUALITY
STEELS Ltd
P.O. Box 686
Ha-Yarkon St. 7, Industrial Zone
IL-81106 YAVNE
Telephone: +972 8 932 8182
www.packer.co.il

Japan

UDDEHOLM KK
Atago East Building
3-16-11 Nishi Shinbashi
Minato-ku, Tokyo 105-0003, Japan
Telephone: + 81 3 5473 4641
www.assabsteels.com

Jordan

ENGINEERING WAY Est.
P.O. Box 874
Abu Alanda
JO-AMMAN 11592
Telephone: +962 6 4161962
engineeringway@assab.com

Malaysia

Head office
ASSAB Steels (Malaysia) Sdn Bhd
Lot 19, Jalan Perusahaan 2
Batu Caves Industrial Estate
68100 Batu Caves
Selangor Malaysia
Telephone: +60 3 6189 0022
www.assabsteels.com

Branch offices

BUTTERWORTH BRANCH
Plot 146a
Jalan Perindustri Bukit Minyak 7
Kawasan Perindustri Bukit Minyak
14000 Bukit Mertajam, SPT Penang
Telephone: +60 4 507 2020

JOHOR BRANCH

No. 8, Jalan Persiaran Teknologi
Taman Teknologi
81400 Senai
Johor DT, Malaysia
Telephone: +60 7 598 0011

New Zealand

VIKING STEELS
25 Beach Road, Otahuhu
P.O. Box 13-359, Onehunga
NZ-Auckland
Telephone: +64 9 270 1199
www.ssm.co.nz

Pakistan

ASSAB International AB
P.O. Box 17595
Jebel Ali
AE-Dubai
Telephone: +971 488 12165
www.assab.se

Philippines

ASSOCIATED SWEDISH STEELS
PHILS Inc.
No. 3 E. Rodriguez Jr., Avenue
Bagong Ilog, Pasig City
Philippines
Telephone: +632 671 1953/2048
www.assabsteels.com

Republic of Korea

Head office
ASSAB Steels (Korea) Co Ltd
116B-8L, 687-8, Kojan-dong
Namdong-ku
Incheon 405-310, Korea
Telephone: +82 32 821 4300
www.assabsteels.com

Branch offices

BUSAN BRANCH
14B-5L, 1483-9, Songjeong-dong
Kangseo-ku, Busan 618-270, Korea
Telephone: +82 51 831 3315

DAEGU BRANCH

Room 27, 7-Dong2 F
Industry Materials Bldg.1629
Sangyeog-Dong, Buk-Ku
Korea-Daegu 702-710
Telephone: +82 53 604 5133

Lebanon

WARDE STEEL & METALS SARL MET
Charles Helou Av, Warde Bldg
P.O. Box 165886
LB-Beirut
Telephone: +961 1 447228
lebanon@assab.com

Saudi Arabia

ASSAB INTERNATIONAL AB
P.O. Box 255092
SA-Riyadh 11353
Telephone: +966 1 4466542
saudiarabia@assab.com

Singapore

Head office Pacific
ASSAB Pacific Pte Ltd
171, Chin Swee Road
No. 07-02, SAN Centre
SG-Singapore 169877
Telephone: +65 6534 5600
www.assabsteels.com

Jurong

ASSAB Steels Singapore (Pte) Ltd
18, Penjuru Close
SG-608616 Singapore
Telephone: +65 6862 2200

Sri Lanka

GERMANIA COLOMBO (Ptd) Ltd
451/A Kandy Road
LK-Kelaniya
Telephone: +94 11 2913556
www.iwsholdings.com

Syria

WARDE STEEL & METALS SARL MET
Charles Helou Av, Warde Bldg
P.O. Box 165886
LB-Beirut
Telephone: +961 1 447228
lebanon@assab.com

Taiwan

Head office
ASSAB Steels (Taiwan) Co Ltd
No. 112 Wu Kung 1st Rd.
Wu Ku Industry Zone
TW-Taipei 248-87, Taiwan (R.O.C.)
Telephone: +886 2 2299 2849
www.assabsteels.com

Branch offices

NANTOU BRANCH
No. 10, Industry South 5th Road
Nan Kang Industry Zone
Nantou 540-66, Taiwan (R.O.C.)
Telephone: +886 49 225 1702

TAINAN BRANCH

No. 180, Yen He Street,
Yong Kang City
Tainan 710-82, Taiwan (R.O.C.)
Telephone: +886 6 242 6838

Thailand

ASSAB Steels (Thailand) Ltd
9/8 Soi Theedinthai,
Taeparak Road, Bangplee,
Samutprakarn 10540, Thailand
Telephone: +66 2 385 5937,
+66 2 757 5017
www.assabsteels.com

United Arab Emirates

ASSAB INTERNATIONAL AB
P.O. Box 17595
Jebel Ali
AE-Dubai
Telephone: +971 488 12165
www.assab.se

Vietnam

CAM Trading Steel Co Ltd
90/8 Block 5, Tan Thoi Nhat Ward
District 12, Ho Chi Minh City
Vietnam
Telephone: +84 8 5920 920
www.assabsteels.com

Other Asia

ASSAB INTERNATIONAL AB
Box 42
E-171 11 Solna, Sweden
Telephone: +46 8 564 616 70
www.assab.se

Africa

Egypt

UNITED FOR IMPORT AND
INDUSTRIAL SUPPLIES
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Flat No 14
Al Ahram Street-El Tabia
EG-Giza Cairo
Telephone: +20 2 7797751
www.assab.se

Kenya

SANDVIK Kenya Ltd
P.O. Box 18264
Post code 00500
KE-Nairobi
Telephone: +254 20 532 866
sandvik@africaonline.co.ke

South Africa

UDDEHOLM Africa (Pty.) Ltd.
P.O. Box 539
ZA-1600 Isando/Johannesburg
Telephone: +27 11 974 2781
www.bohler-uddeholm.co.za

Tunisia

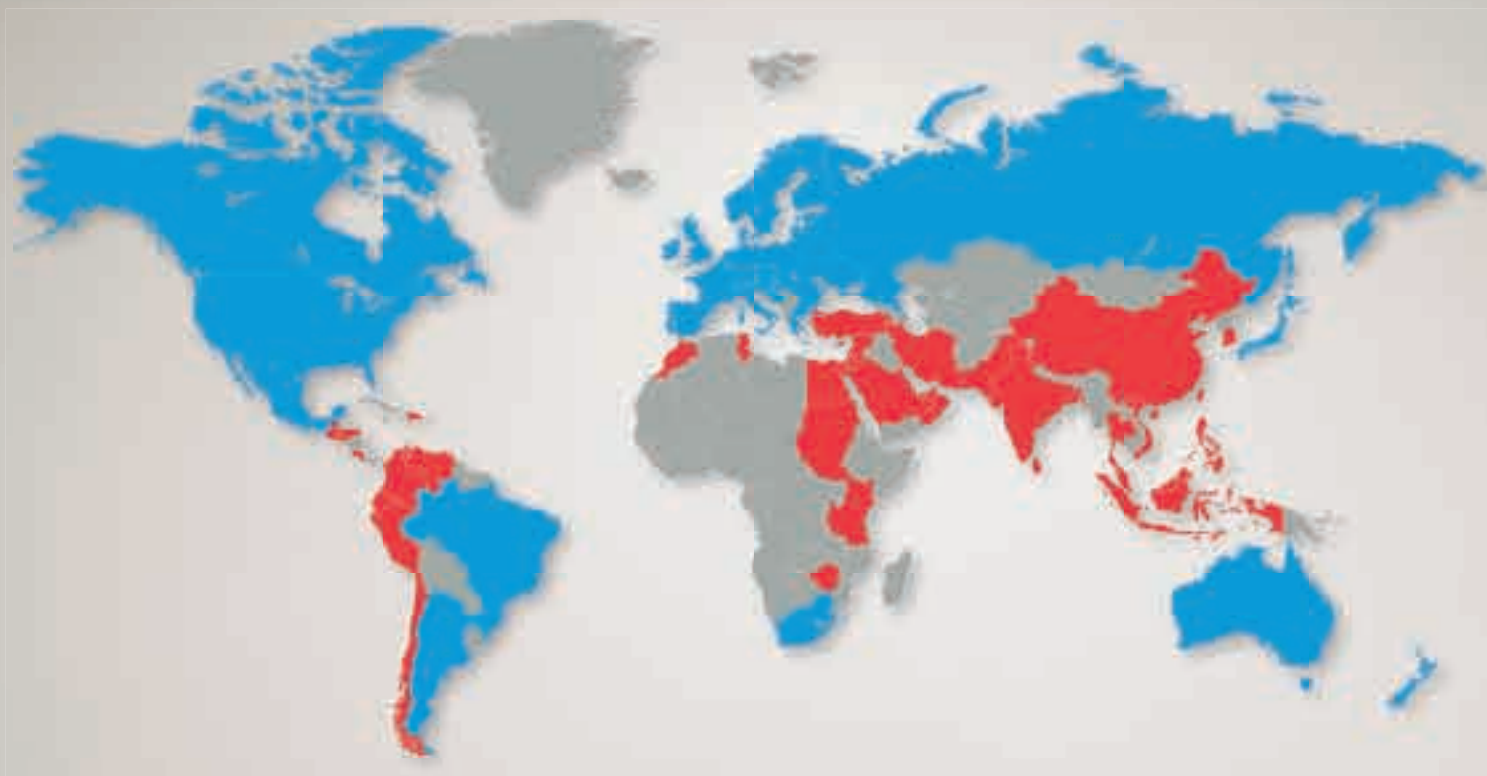
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2035 Chargula 1
TN-Tunis
Telephone: + 216 71 802479
www.mcm.com.tn

Zimbabwe

Representative office:
UDDEHOLM Africa (Pty.) Ltd.
P.O. Box 539
ZA-1600 Isando/Johannesburg
Telephone: +27 11 974 2781
www.assab.se

Other African Countries

ASSAB INTERNATIONAL AB
Box 42
SE-171 11 Solna, Sweden
Telephone: +46 8 564 616 70
www.assab.se



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