



UDDEHOLM POCKET BOOK

The Uddeholm range of tooling materials

CONTENTS

UDDEHOLM STEEL GRADES	
– Composition	4 – 5
– International standards	6 – 7
– Heat treatment	8 – 9
– Hardness after hardening and tempering.....	10 – 11
STEEL FOR COLD WORK TOOLING	12 – 18
STEEL FOR INDUSTRIAL KNIVES	19 – 21
STEEL FOR DIE CASTING DIES	22 – 25
STEEL FOR EXTRUSION DIES	26 – 29
STEEL FOR FORGING DIES	30 – 33
MATERIALS FOR PLASTIC MOULDS.....	34 – 41
PRINCIPLES OF HARDENING	43
POWDER METALLURGY TOOL STEEL.....	44 – 45
UDDEHOLM COMPONENT BUSINESS	46 – 47
PRE-MACHINED TOOL STEEL.....	48 – 49
MACHINING SERVICE	50
HINTS ON	
– improved tool performance.....	51
– basic tool design	52
– tool heat treatment.....	53
– repair welding	53
– grinding tool steel.....	54
– EDM	55
– polishing mould steel	56 – 57
– photo-etching	58
HARDNESS CONVERSION TABLE.....	59
CONVERSION FACTORS AND FORMULAE.....	60 – 61
SI-UNITS OF MEASUREMENT	64 – 69
ISO-TOLERANCES.....	70
CONVERSION TABLE (temperature scale)	72 – 73
WEIGHT TABLES	74 – 78
DESIGNATIONS	79
PRINTED MATERIAL	80

UDDEHOLM POCKET BOOK presents, in a concise form, the Uddeholm range of high quality tool steel developed to meet specific needs and applications.

The information in this pocket book 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.

All information concerning the wide range of Uddeholm tool materials can't be given in this booklet.

More detailed information and advice is readily available from your nearest Uddeholm office or visit www.uddeholm.com

UDDEHOLM STEEL GRADES – COMPOSITION

Uddeholm Grade	Colour code	Typical analysis								
		C	Si	Mn	Cr	Mo	Ni	V	S	
ARNE	Yellow	0.95	0.3	1.1	0.6			0.1		W
BURE	Yellow/Violet	0.39	1.0	0.4	5.3	1.3		0.9		0.55
CALDIE	White/Grey	0.70	0.2	0.5	5.0	2.3		0.5		
CALMAX	White/Violet	0.60	0.35	0.8	4.5	0.5		0.2		
CARMO	Red/Violet	0.60	0.35	0.8	4.5	0.5		0.2		
										Al
CORRAX [®]	Black/Grey	0.03	0.3	0.3	12.0	1.4	9.2			1.6
DIEVAR [®]	Yellow/Grey	0.35	0.2	0.5	5.0	2.3		0.6		
ELMAX										
SUPERCLEAN ¹⁾	Blue/Black	1.70	0.8	0.3	18.0	1.0		3.0		
FORMAX	Black	0.18	0.3	1.3						
FORMVAR	Violet/ Yellowgreen	0.35	0.2	0.5	5.0	2.3		0.6		
HOLDAX	Yellow/Blue	0.40	0.4	1.5	1.9	0.2			0.07	
IDUN	Brown/ Dark green	0.21	0.9	0.45	13.5	0.2	0.6	0.25		
IMPAX										
SUPREME	Yellow/Green	0.37	0.3	1.4	2.0	0.2	1.0			
MIRRAX ESR	²⁾	0.25	0.3	0.5	13.3	0.3	1.3	0.3		+N
MIRRAX 40	Orange/Green	0.21	0.9	0.45	13.5	0.2	0.6	0.25		+N
NIMAX	Light blue/ Dark blue	0.1	0.3	2.5	3.0	0.3	1.0			
ORVAR										
SUPREME	Orange	0.39	1.0	0.4	5.2	1.4		0.9		
ORVAR 2M [®]	Orange/Violet	0.39	1.0	0.4	5.2	1.4		0.9		
QRO 90										
SUPREME	Orange/Brown	0.38	0.3	0.8	2.6	2.3		0.9		
RAMAX HH	⁴⁾	0.12	0.2	1.3	13.4	0.5	1.6	0.2	0.1	+N
RIGOR	Red/Green	1.00	0.3	0.6	5.3	1.1		0.2		
ROYALLOY	⁵⁾	0.05	0.4	1.2	12.6				+N +Cu	0.12
SKOLVAR	Red/Black	0.70	0.2	0.45	5.00	2.25		1.60		
SLEIPNER	Blue/Brown	0.90	0.9	0.5	7.8	2.5		0.5		
STAVAX ESR	Black/Orange	0.38	0.9	0.5	13.6			0.3		
VIKING	–	0.50	1.0	0.5	8.0	1.5		0.5		

Uddeholm Grade	Colour code	Typical analysis							
		C	Si	Mn	Cr	Mo	Ni	V	S
SVERKER 3	Red	2.05	0.3	0.8	12.7				W 1.1
SVERKER 21	Yellow/White	1.55	0.3	0.4	11.3	0.8		0.8	
TYRAX ESR	Black/Violet	0.4	0.2	0.5	12.0	2.3		0.5	+N
UHB 11	White	0.50	0.2	0.7					
UNIMAX	Brown/Grey	0.50	0.2	0.5	5.0	2.3		0.5	
VANADIS 4 EXTRA									
SUPERCLEAN ^{1)®}	⁶⁾	1.40	0.4	0.4	4.7	3.5		3.7	
VANADIS 8	Green/ Light violet	2.3	0.4	0.4	4.8	3.6		8.0	
SUPERCLEAN ¹⁾									
VANAX									N
SUPERCLEAN ¹⁾	Grey/Dark blue	0.36	0.3	0.3	18.2	1.1		3.5	1.55
VANCRON									N
SUPERCLEAN ¹⁾	Green/Dark blue	1.30	0.5	0.4	4.5	1.8		10.0	1.8
VIDAR									
SUPERIOR	⁷⁾	0.36	0.3	0.3	5.0	1.3		0.5	
VIDAR 1	Orange/ Light blue	0.38	1.0	0.4	5.0	1.3		0.4	
VIDAR 1 ESR	Orange/ Dark blue	0.38	1.0	0.4	5.0	1.3		0.4	
High speed steel		C			Cr	Mo	W	V	Co
VANADIS 23									
SUPERCLEAN ¹⁾	Violet	1.28			4.2	5.0	6.4	3.1	
VANADIS 30									
SUPERCLEAN ¹⁾	Green	1.28			4.2	5.0	6.4	3.1	8.5
VANADIS 60									
SUPERCLEAN ¹⁾	Gold	2.30			4.2	7.0	6.5	6.5	10.5

¹⁾ Powder Metallurgy tool steel

²⁾ Black/Orange with a white line across

³⁾ M = Microdized

⁴⁾ Black/Brown with a white line across

⁵⁾ Yellow/Blue with a black line across

⁶⁾ Green/White with a black line across

⁷⁾ Red/Orange with a white line across

⁸⁾ Is also available as powder for additive

manufacturing with similar properties as the bar material

INTERNATIONAL STANDARDS COMPARISON CHART

Uddeholm Grade	ASSAB	AISI (USA)	BS4659 (GB)	W.-Nr. (Germany)	SS (Sweden)	JIS (Japan)
ARNE	DF-2	O1	BO1	1.2510	(2140)	SKS 3
BURE	BURE	-	-	-	-	-
CALDIE	CALDIE	-	-	-	-	-
CALMAX	CALMAX	-	-	1.2358	-	-
CARMO	CARMO	-	-	1.2358	-	-
CORRAX	CORRAX	-	-	-	-	-
DIEVAR	DIEVAR	-	-	-	-	-
ELMAX	ELMAX	-	-	-	-	-
SUPER- CLEAN [®]	SUPERCLEAN ^{®1)}	-	-	-	-	-
FORMAX	-	-	-	-	2172	-
FORMVAR	FORMVAR	-	-	-	-	-
HOLDAX	-	-	-	1.2312	-	-
IDUN	IDUN	420, mod.	-	-	-	-
IMPAX	-	P20	-	-	-	-
SUPREME	718 SUPREME	modified	-	(1.2738)	-	-
MIRRAX ESR	MIRRAX ESR	420, mod.	-	-	-	SUS
MIRRAX 40	MIRRAX 40	420, mod.	-	-	-	-
NIMAX	NIMAX	-	-	-	-	-
ORVAR	-	H13	-	-	-	-
SUPREME	8407 SUPREME	improved	BH13	1.2344	2242	SKD 61
ORVAR 2M [®]	8407-2M	H13	BH13	1.2344	2242	SKD 61
QRO 90	QRO 90	-	-	-	-	-
SUPREME	SUPREME	-	-	-	-	-
RAMAX HH	RAMAX HH	(420F)	-	-	-	-
RIGOR	XW-10	A2	BA2	1.2363	2260	SKD 12
ROYALLOY	ROYALLOY	-	-	-	-	-
SKOLVAR	-	-	-	-	-	-
SLEIPNER	ASSAB 88	-	-	-	-	-
STAVAX ESR	STAVAX ESR	420, mod.	-	(1.2083)	2314	SUS 420
VIKING	VIKING	-	-	(1.2631)	-	-

Uddeholm Grade	ASSAB	AISI (USA)	BS4659 (GB)	W.-Nr. (Germany)	SS (Sweden)	JIS (Japan)
SVERKER 3	XW-5	(D6)	BD6	(1.2436)	2312	(SKD 2)
SVERKER 21	XW-42	D2	BD2	1.2379	2310	SKD 11
TYRAX ESR	TYRAX ESR	-	-	-	-	-
UHB 11	-	1148	-	1.1730	1650/1672	-
UNIMAX	UNIMAX	-	-	-	-	-
VANADIS 4	VANADIS 4					
EXTRAEXTRA SUPERCLEAN ¹⁾	SUPERCLEAN ¹⁾	-	-	-	-	-
VANADIS 8 SUPERCLEAN ¹⁾	VANADIS 8 SUPERCLEAN ¹⁾	-	-	-	-	-
VANAX SUPERCLEAN ¹⁾	VANAX SUPERCLEAN ¹⁾	-	-	-	-	-
VANCRON SUPERCLEAN ¹⁾	VANCRON SUPERCLEAN ¹⁾	-	-	-	-	-
VIDAR	VIDAR			1.2340		
SUPERIOR	SUPERIOR	(H11) ³⁾	(BH 11)	(1.2343) ³⁾	-	(SKD 6)
VIDAR 1	-	H11	BH11	1.2343	-	SKD 6
VIDAR 1 ESR	VIDAR 1 ESR	H11	BH11	1.2343	-	SKD 6
High speed steel						
VANADIS 23 SUPERCLEAN ¹⁾	ASSAB PM 23 SUPERCLEAN ¹⁾	M3:2	-	1.3395	2725	-
VANADIS 30 SUPERCLEAN ¹⁾	ASSAB PM 30 SUPERCLEAN ¹⁾	(M3:2+Co)	-	1.3294 ~CM3:2 +Co	2726	-
VANADIS 60 SUPERCLEAN ¹⁾	ASSAB PM 60 SUPERCLEAN ¹⁾	-	-	(1.3292)	2727	-

Some equivalents are approximate only ().

¹⁾ Powder Metallurgy tool steel

²⁾ M = Microdized

³⁾ W.-Nr. 1.2343 or AISI H11 premium modified

BASIC HEAT TREATMENT GUIDE*

Uddeholm Grade	HB ¹⁾	Soft-annealing temp. °C	Austenitizing (hardening) temperature °C	Quenching medium
ARNE	~190	780	790–850	Oil, step bath
BURE	~180	850	1020–1050	Gas, step, oil
CALDIE	~215	860	1000–1050	Gas, step
CALMAX	~200	860	950–970	Gas, step, oil
CARMO	~250 ²⁾	860	950–970	Gas, step, oil
CORRAX ⁴⁾	~330	–	–	–
DIEVAR ⁷⁾	~160	850	1000–1025	Gas, step, oil
ELMAX				
SUPERCLEAN ³⁾	~280	980	1050–1100	Gas, step, salt
FORMAX	~170	–	–	–
FORMVAR	<229	850	1000–1025	Gas, step, oil
HOLDAX	~310 ²⁾	700	as-del. cond.	–
IDUN	~420	–	–	–
IMPAX				
SUPREME	~310 ²⁾	700	as-del. cond.	–
MIRRAX ESR	~250	740	1000–1025	Gas, step
MIRRAX 40	~380 ²⁾	–	as-del. cond.	–
NIMAX	~380 ²⁾	–	as-del. cond.	–
ORVAR				
SUPREME	~180	850	1020–1050	Gas, step, oil
ORVAR 2 M ⁶⁾	~180	850	1020–1050	Gas, step, oil
QRO 90				
SUPREME	~180	820	1020–1050	Gas, step, oil
RAMAX HH	~340 ²⁾	740	as-del. cond.	–
RIGOR	~215	850	925–960	Gas, step
ROYALLOY	~310 ²⁾	–	as-del. cond.	–
SKOLVAR	<229	850	1050–1150	Gas, step, salt bath, oil
SLEIPNER	~235	850	950–1080	Gas, step
STAVAX ESR	~190	890	1010–1050	Step, salt bath, gas
SVERKER 3	~240	850	920–1000	Gas, step
SVERKER 21	~210	850	990–1080	Gas, step
TYRAX ESR	~190	860	1080	Gas, step
UHB 11	~200	700	as-del. cond.	–
UNIMAX	~185	850	1000–1025	Gas, step
VIKING	~225	880	980–1050	Gas, step, oil

Uddeholm Grade	HB ¹⁾	Soft-annealing temp. °C	Austenitizing (hardening) temperature °C	Quenching medium
VANADIS 4 EXTRA SUPERCLEAN ³⁾⁷⁾	~230	900	940–1180	Gas, step
VANADIS 8 SUPERCLEAN ³⁾	≤270	900	1020–1180	Gas, step
VANAX SUPERCLEAN ³⁾	260	980**	1080	Gas, step, oil + deep cooling
VANCRON SUPERCLEAN ³⁾	~300	900	950–1150	Gas, step
VIDAR SUPERIOR	~180	850	980–1000	Gas, step, oil
VIDAR 1	~180	850	990–1010	Gas, step, oil
VIDAR 1 ESR	~180	850	990–1010	Gas, step, oil
High speed steel				
VANADIS 23 SUPERCLEAN ³⁾	~260	875	1050–1180	Gas, step
VANADIS 30 SUPERCLEAN ³⁾	~300	875	1000–1180	Gas, step
VANADIS 60 SUPERCLEAN ³⁾	~320	875	1000–1180	Gas, step

* Choice of quenching media depends on the steel grade, the tool's complexity and size. Further heat treatment recommendations is given in the product information brochure available for each steel grade.

Stress relieving: after rough machining the tool should be heated through to 650°C.

Holding time: 2h. Cool slowly to 500°C, then freely in air. (Exception: Uddeholm Impax Supreme, Uddeholm Holdax, Uddeholm Mirrax 40 and Uddeholm Ramax HH use max 550°C as stress relieving temperature. For Uddeholm Nimax use 450°C.)

** In protected atmosphere

¹⁾ Normal delivery hardness

²⁾ Pre-hardened

³⁾ Powder Metallurgy tool steel

⁴⁾ Solution treated. Higher hardness is obtained by ageing. For additive manufacturing is solution treatment 850°C 30 minutes. Higher hardness is obtained by ageing

⁶⁾ M = Microdized

⁷⁾ Is also available in powder for additive manufacturing (AM)

For heat treatment recommendation of AM part, see technical brochure

APPROX. HARDNESS AFTER HARDENING AND TEMPERING

Uddeholm Grade	Austenitizing temperature °C	HRC at tempering temperature °C, 2 x 2 h					
		200	250	500	525	550	600
ARNE	830 ¹⁾	62	60	45	43	41	38
BURE	1020	52	52	53*	-	52	46
CALDIE	1020	3 x 525°C*** 60		3 x 540°C 59		3 x 560°C 56	
CALMAX	960	59	58	53	53	50	43
CARMO	960	59	58	53	53	50	43
CORRAX	850 ²⁾	-	-	-	-	-	-
DIEVAR	1020	53	52	52*	-	52	47
ELMAX	1080	59	58	60**	59**	58**	-
SUPERCLEAN ³⁾							
FORMAX	-	-	-	-	-	-	-
FORMVAR	1025	53	52	52*	-	52	47
HOLDAX	-	-	-	-	-	-	-
IDUN	-	-	-	-	-	-	-
IMPAX							
SUPREME	-	-	-	-	-	-	-
MIRRAX ESR	1020	-	50	52**	-	42**	36
MIRRAX 40	-	-	-	-	-	-	-
NIMAX ⁴⁾	-	-	-	-	-	-	-
ORVAR							
SUPREME ORVAR 2	1020	52	52	54*	-	52	46
MICRODIZED	1020	52	52	54*	-	52	46
QRO 90							
SUPREME	1020	49	49	51*	-	51*	50 ⁵⁾
RAMAX HH	-	-	-	-	-	-	-
RIGOR	950	61	59	56*	55*	53	46
ROYALLOY	-	-	-	-	-	-	-
SKOLVAR	1050	59	57	58	58	57	50
SLEIPNER	1030	3 x 525°C*** 62		3 x 540°C 60		3 x 560°C 58	
STAVAX ESR	1030	53	52	54**	-	43**	37
TYRAX ESR	1080	-	-	57**	58**	56**	45
SVERKER 3	960	60	59	56	53	-	-
VIKING	1010	59	57	59*	58	56	48

Uddeholm Grade	Austenitizing temperature °C	HRC at tempering temperature °C, 2 x 2 h					
		200	250	500	525	550	600
SVERKER 21	1020	63	59	60	57	54	48
UHB 11	–	–	–	–	–	–	–
UNIMAX	1020	–	–	–	57***	55	49
VIDAR							
SUPERIOR	1000	52	51	51*	–	50	45
VIDAR 1	1000	54	53	55*	–	52	46
VIDAR 1 ESR	1000	54	53	55*	–	52	46
VANADIS 4		3 x 525°C***		3 x 540°C		3 x 560°C	
EXTRA	1020 ⁷⁾	61		60		59	
SUPERCLEAN ³⁾	1180 ⁸⁾	64		64		63	
VANADIS 8	1020 ⁷⁾	61		60		59	
SUPERCLEAN ³⁾	1180 ⁸⁾	64		64		63	
VANAX							
SUPERCLEAN ⁶⁾	1080°C	60	60	–	–	–	47
VANCRON		3 x 540°C					
SUPERCLEAN ³⁾	950–1150	57–65					
High speed steel		3 x 560°C					
VANADIS 23							
SUPERCLEAN ³⁾	1050–1180	60–66					
VANADIS 30							
SUPERCLEAN ³⁾	1000–1180	60–67					
VANADIS 60							
SUPERCLEAN ³⁾	1000–1180	64–69					

* This tempering temp. should be avoided due to the risk of temper brittleness.

** For Uddeholm Stavax ESR, Uddeholm Mirrax ESR, Uddeholm Polimax and Uddeholm Elmax SuperClean corrosion resistance is reduced.

*** The lowest tempering temperature when high temperature tempering is 525°C.

¹⁾ Quench in oil

²⁾ Solution treatment. Ageing: ~51 HRC after 525°C/4h, ~44 HRC after 575°C/4h, ~41 HRC after 600°C/4h

³⁾ Powder Metallurgy tool steel

⁴⁾ The delivery hardness of Uddeholm Nimax can not be increased

Tempering shall be avoided as toughness will be reduced

⁵⁾ At 650°C 2 x 2h: 42 HRC

⁶⁾ Deep cooling directly after austenitizing is strongly recommended

STEEL FOR COLD WORK TOOLING

BLANKING, PIERCING, CROPPING, BENDING, FORMING

Uddeholm grade	Description/Applications
ARNE	A versatile tool steel for low production volume die sets for blanking, forming and deburring and for forming rolls. It is also suitable for gauges, bushes and engineering parts exposed to high stresses.
CALDIE	A modern matrix tool steel for cold work applications with high demands on chipping / cracking resistance and compressive strength. Uddeholm Caldie is a robust tool steel and is suitable for medium production volume tooling for blanking and forming difficult production materials such as advanced high strength steel.
CALMAX	A very versatile steel with adequate wear resistance and very high toughness. It is very suitable for low to medium production volume tooling for blanking thick production materials or in general when the tooling is exposed to high stresses.
RIGOR	A steel with a good combination of toughness, wear resistance and dimensional stability in hardening. It is a general cold work steel for medium production volume tooling.
Skolvar	A robust ESR grade with vanadium carbides. Suitable for medium production volume where the combination of wear resistance and ductility is desired.
SLEIPNER	A versatile steel with a very broad properties profile ranging from good wear resistance, compressive strength and good chipping / cracking resistance to good hardenability and machinability. This means that Uddeholm Sleipner is a modern general purpose steel for medium production volume tooling.
SVERKER 3	A steel similar to Uddeholm Sverker 21 but with more and larger carbides. It has an excellent abrasive wear resistance and this means that it is suitable for applications like brick pressing and transformer plate blanking.

Cont.



SVERKER 21	A 12% chromium steel suitable for medium production volume tooling where the production materials cause abrasive wear and the risk of chipping is not so high.
UNIMAX	A problem solver for applications where the demands on chipping / cracking resistance are very high. Uddeholm Unimax is a matrix steel with a unique combination of chipping / cracking resistance and wear resistance.
VANADIS 4 EXTRA SUPERCLEAN	A cold work tool steel produced by the powder metallurgy process. It is characterized by a superior combination of wear and chipping resistance and is particularly suitable for high volume production tooling for production materials such as annealed austenitic stainless steel, mild carbon steel, copper and aluminium.
AM VANADIS 4 EXTRA	A cold work tool steel that is characterized by a superior combination of wear and chipping resistance. Delivered as powder for additive manufacturing (AM) to be used in the same applications as Vanadis 4 Extra SuperClean bar material.
VANADIS 8 SUPERCLEAN	Uddeholm Vanadis 8 SuperClean is a PM (Powder Metallurgical) tool steel characterized by extremely high wear resistance (abrasive wear profile), high compressive strength, high surface hardness after hardening, very good through hardening properties, good toughness and very good stability in hardening. These characteristics combine to give a steel suitable for the manufacture of very long run tooling where abrasive wear is dominant, e.g. blanking and forming of abrasive material, blanking of electrical steel sheet, blanking of gaskets, paper and foil slitting, granulator knives, extruder screws, etc.
VANADIS 23 SUPERCLEAN	A high speed steel produced by the powder metallurgy process and is characterized by high wear resistance coupled with high chipping resistance and high compressive strength. It is suitable for high volume production tooling for hard to medium hard production materials. It also has a good hot hardness and good temper back resistance, making it a suitable grade for high speed blanking and for cutting tools.

VANCRON SUPERCLEAN	A nitrogen alloyed PM steel for applications where galling is the main failure mechanism. Its very low friction coefficient and surface topography after polishing mean that it is an alternative to tooling where coatings and cemented carbide used to be the only solution.
UHB 11	A bolster steel with medium high carbon content suitable for top and bottom plates and higher strength support parts.
FORMAX	A bolster steel with low carbon content suitable for large top and bottom plates and medium strength supports.
HOLDAX	A pre-hardened bolster steel for support plates and holders.

STEEL FOR SPECIAL APPLICATIONS

Uddeholm grade	Description/Applications
CARMO	A pre-hardened steel particularly suitable for car body dies. It can be flame / induction hardened or through hardened and has a much better weldability than other cold work tool steel. It is suitable for low production volume tooling in general and for prototype tooling.
VANCRON SUPERCLEAN	A nitrogen alloyed PM steel which often need not be coated to avoid galling, sticking and adhesive wear.
VANADIS 30 SUPERCLEAN	A high hardness high speed PM steel with improved compressive strength and hot hardness. Mainly used for cutting tools.
VANADIS 60 SUPERCLEAN	A very high hardness high speed PM steel with very high compressive strength, good hot hardness and very high wear resistance. Mainly used for cutting tools.

A comprehensive product brochure is available for each steel grade and contains information on application areas, heat treatment, machining, grinding etc.

PROPERTY COMPARISON GUIDE FOR COLD WORK STEEL

Uddeholm grade	Hardness	Machinability	Grindability	Dimension stability
ARNE				
CALMAX				
CALDIE				
RIGOR				
SLEIPNER				
SVERKER 21				
SVERKER 3				
UNIMAX				
VANADIS 4 EXTRA				
VANADIS 8				
VANADIS 23				
VANCRON				

SELECTION CHART

Part	Uddeholm grade	Hardness HRC
Punches, dies	ARNE, CALDIE, CALMAX, RIGOR, SVERKER 3, SVERKER 21, SLEIPNER, UNIMAX, VANADIS 4 EXTRA, VANADIS 8, VANCRON	54–64
Top- and bottom plates	FORMAX, UHB 11, HOLDAX	As supplied
Punch backing plate	ARNE	58–60

The tool steel choice and hardness level will depend on the production material type, its thickness and hardness and the intended production volume.

OTHER “COLD WORK” APPLICATIONS

Application	Uddeholm grade
Cold rolls	CALDIE, SLEIPNER, SVERKER 21, VANADIS 4 EXTRA, VANADIS 8, VANADIS 23, VANCRON
Forming rolls	SVERKER 21, CALDIE, CALMAX, SLEIPNER, VANADIS 4 EXTRA, VANADIS 8, VANCRON
Fine Blanking	CALDIE, VANADIS 4 EXTRA, VANADIS 8 VANCRON, VANADIS 30, VANADIS 60
Powder metal compaction	CALDIE, UNIMAX, VANADIS 4 EXTRA, VANCRON, VANADIS 8



STEEL SELECTION

When selecting a tool steel for any cold work operation it is important to identify which failure mechanism(s) is/are limiting the tool life:

- wear (abrasive/adhesive)
- chipping/cracking
- plastic deformation

The proper tool steel for the situation can be selected by means of the following comparison chart, which gives the relative resistance to the above failure mechanisms for the Uddeholm cold work tool steel.

PROPERTY COMPARISON GUIDE FOR COLD WORK STEEL

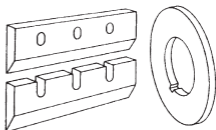
Uddeholm grade	Hardness/ Resistance against plastic deformation	Wear resistance		Fatigue cracking resistance	
		Abrasive	Adhesive	Ductility/ chipping	Toughness/ Gross cracking
ARNE	██████	████	████	████	████████
CALMAX	██████	████	██████	████████	██████████
CALDIE	██████	██████	████████	████████	██████████
RIGOR	██████	██████	████	████	████████
SLEIPNER	████████	██████	██████	████	████████
SVERKER 21	██████	██████	███	███	████████
SVERKER 3	████████	████████	███	███	████
UNIMAX	██████	████	██████	████████	██████████
VANADIS 4 EXTRA	████████	██████	██████	████████	██████
VANADIS 8	████████	████████	██████	████	██████
VANADIS 23	████████	██████	██████	████	██████
VANCRON	████████	██████	████████	████	██████

A rule of thumb is to select a steel with higher performance to avoid premature failures with such consequences as late deliveries and extra costs.

STEEL FOR INDUSTRIAL KNIVES

Close attention is paid to straightness, squareness, tolerance and decarburization levels on Uddeholm tool steel intended for the large-scale production of knives and cutters.

A nitrogen alloyed PM steel with the best combination of abrasive and adhesive wear resistance. For long runs in work materials that give high adhesion and wear.



Uddeholm grade	Description/Applications
ARNE	Low alloyed universal tool steel for short runs. Excellent machinability.
CALDIE	A robust tool steel with a good combination of high compressive strength and wear resistance and high chipping resistance.
CALMAX	Tool steel with a properties profile devoted to safe production, i.e. high chipping and cracking resistance and a fairly good wear resistance.
RIGOR	A tool steel with a good combination of toughness and general wear resistance.
SLEIPNER	A tool steel with properties well suited for knife applications. Good wear resistance, good resistance to chipping and high compressive strength give a knife with a good edge retention.
SVERKER 3 SVERKER 21	Steel with high C-Cr-content and an excellent wear resistance. Suitable for wood milling cutters.
UNIMAX	A really robust tool steel and the best choice for difficult blanking applications with demands on high hardness (max. 58 HRC) and very high chipping resistance.
VANADIS 4 EXTRA SUPERCLEAN	Cold work tool steel produced by the powder metallurgy process. Superior combination of adhesive wear resistance and toughness.

Cont.

VANADIS 8 SUPERCLEAN	Cold work tool steel produced by the powder metallurgy process. Very high abrasive wear resistance and fairly good toughness. Tool steel very suitable for severe abrasive conditions and long runs.
VANADIS 23 SUPERCLEAN	High speed steel produced by the powder metallurgy process. Good combination of wear resistance, chipping resistance, hot hardness and compressive strength. Suitable for production materials which cause mixed or abrasive wear.
VANCRON	A nitrogen alloyed PM steel with the best combination of abrasive and adhesive wear resistance. For long runs in work materials that give high adhesion and wear.
VIKING	Cr-Mo-alloyed steel developed by Uddeholm especially for chipper-knives and other knives exposed for high stresses. Combine toughness with wear resistance very well.

PROPERTY COMPARISON CHART FOR UDDEHOLM TOOL STEEL FOR INDUSTRIAL KNIVES

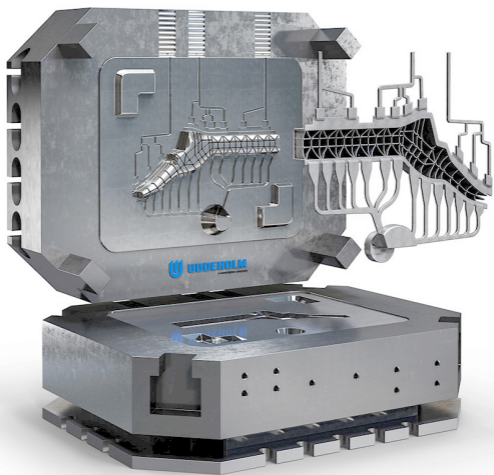
Uddeholm grade	Chipping resistance	Wear resistance	Machinability	Dimensional stability at hardening
ARNE	■	■	■	■
CALDIE	■	■	■	■
CALMAX	■	■	■	■
RIGOR	■	■	■	■
SLEIPNER	■	■	■	■
SVERKER 3	■	■	■	■
SVERKER 21	■	■	■	■
UNIMAX	■	■	■	■
VIKING	■	■	■	■
VANADIS 4 EXTRA	■	■	■	■
VANADIS 8	■	■	■	■
VANADIS 23	■	■	■	■

SELECTION CHART

Chipper knives	VIKING, SLEIPNER	56–58
Flaker knives	VIKING, SLEIPNER	56–58
Reducer knives	VIKING, SLEIPNER	56–58
Planer knives	SVERKER 21, SLEIPNER	58–60
Shear knives, HOT	CALDIE, DIEVAR, ORVAR 2 MICRODIZED, SKOLVAR, UNIMAX	52–54
COLD		
thin stock	SVERKER 21, SLEIPNER	58–60
thick stock	CALDIE, RIGOR, VANADIS 4 EXTRA CALMAX, SKOLVAR, SLEIPNER, UNIMAX	56–58 54–58
Circular slitting knives	SVERKER 21, RIGOR, SLEIPNER, VANADIS 4 EXTRA, VANADIS 8, UNIMAX, CALDIE, VIKING	58–62 56–64 54–58
Plastic granulator knives	RIGOR, SVERKER 21, SLEIPNER, VANADIS 4 EXTRA, ELMAX CALDIE, VANADIS 8 UNIMAX	58–60 58–64 54–58
Tobacco knives	ARNE, CALDIE	58–60
Fragmentation knives	CALDIE, CALMAX, RIGOR, SVERKER 21, SLEIPNER, VANADIS 4 EXTRA, VANADIS 8, UNIMAX	55–64
Paper knives	SVERKER 21, VANADIS 4 EXTRA, VANADIS 8, VANCRON	58–64
Food processing knives		
stainless	CORRAX, STAVAX ESR, RAMAX, ELMAX, VANAX, TYRAX	37–61
non stainless	VANADIS 4 EXTRA, VANADIS 8	56–64
Custom knives	ELMAX, VANADIS 4 EXTRA, VANAX	56–62
Rotary die cutting knives	SVERKER 21, SLEIPNER, VANADIS 4 EXTRA, VANADIS 8	58–64

STEEL FOR DIE CASTING DIES

Uddeholm grade	Description/Applications
DIEVAR	A premium Cr-Mo-V alloyed hot work die steel with good high temperature strength and excellent hardenability, toughness and ductility. Suitable for medium to large dies in aluminium die casting. It meets the requirements of NADCA #207-2018.
AM DIEVAR	A premium Cr-Mo-V alloyed hot work die steel with good high temperature strength and excellent hardenability, toughness and ductility. Delivered as powder for additive manufacturing (AM) to be used in die casting applications.
UNIMAX	A premium Cr-Mo-V alloyed steel with a good toughness and ductility up to a hardness of 58 HRC.
ORVAR SUPREME	Premium Cr-Mo-V-alloyed hot work die steel (H13) with good resistance to thermal fatigue. The steel is produced by a special melting and refining technique and meet the requirements of NADCA #207-2018.
VIDAR SUPERIOR	A premium Cr-Mo-V alloyed hot work die steel (H11 modified) with good resistance to cracking and meets the requirements of NADCA #207-2018.
QRO 90 SUPREME	A premium hot work die steel with high hot yield strength and good temper resistance. Especially suited for die casting of copper, brass and for small inserts and cores in aluminium die casting.
QRO 90 HT	A pre-hardened Uddeholm QRO 90 Supreme material supplied at 37-41 HRC and suitable for core pins.
IMPAX SUPREME	A pre-hardened Ni-Cr-Mo-steel supplied at ~310 HB suitable for die casting of zinc, lead and tin. Also used as a holder material and prototype dies.
HOLDAX	A pre-hardened steel with very good machinability supplied at ~310 HB for clamping and holding plates.



QUALITATIVE COMPARISON OF RESISTANCE TO DIFFERENT DIE FAILURES

Uddeholm grade	Heat checking	Gross cracking	Erosion	Indentation
DIEVAR				
UNIMAX				
ORVAR SUPREME				
VIDAR SUPERIOR				
QRO 90 SUPREME				

The longer the bar, the better.

Further information is given in the brochure "Uddeholm tool steel for die casting" and in the product information brochure available for each steel grade.

SELECTION CHART – DIE CASTING

Die part	Tin/Lead/Zinc	Aluminium/ Magnesium	Copper, Brass
Clamping plates Holder plates	HOLDAX/ IMPAX SUP. pre-hardened ~310 HB	HOLDAX/ IMPAX SUP. pre-hardened ~310 HB	HOLDAX/ IMPAX SUP. pre-hardened ~310 HB
Die Inserts	IMPAX SUP. ~310 HB ORVAR SUP. 46–52 HRC UNIMAX 52–56 HRC	ORVAR SUP. 42–48 HRC VIDAR SUPERIOR 42–48 HRC DIEVAR 44–50 HRC UNIMAX*	QRO 90 SUP. 40–46 HRC ORVAR SUP. 40–46 HRC
Fixed inserts Cores	ORVAR SUP. 46–52 HRC	DIEVAR 46–50 HRC ORVAR SUP. VIDAR SUPERIOR 44–48 HRC QRO 90 SUP. 42–48 HRC	QRO 90 SUP. 40–46 HRC

SUP. = Supreme

* For small die inserts where a good erosion resistance is needed.

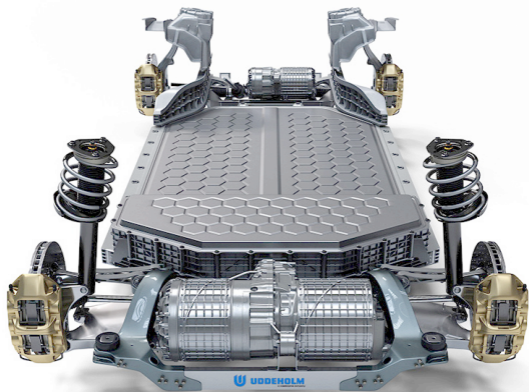
Die part	Tin/Lead/Zinc	Aluminium/ Magnesium	Copper, Brass
Core pins	ORVAR SUP. 46–52 HRC	QRO 90 SUP.* 44–48 HRC QRO 90 HT*	QRO 90 SUP. 42–46 HRC QRO 90 HT
Sprue parts	ORVAR SUP. 48–52 HRC	ORVAR SUP. 46–48 HRC QRO 90 SUP. 44–46 HRC	QRO 90 SUP. 42–46 HRC
Nozzle	ORVAR SUP. 35–44 HRC STAVAX ESR 40–44 HRC	ORVAR SUP. 42–48 HRC QRO 90 SUP. 42–46 HRC	QRO 90 SUP. 40–44 HRC ORVAR SUP. 42–48 HRC
Ejector pins	QRO 90 SUP. / ORVAR SUP. 46–50 HRC (nitrided)	QRO 90 SUP. / ORVAR SUP. 46–50 HRC (nitrided)	QRO 90 SUP. / ORVAR SUP. 46–50 HRC (nitrided)
Plunger Shot sleeve	FORMVAR 42–46 HRC ORVAR SUP. 42–46 HRC (nitrided)	FORMVAR 42–46 HRC ORVAR SUP. QRO 90 SUP. 42–48 HRC (nitrided)	FORMVAR 42–46 HRC QRO 90 SUP. / ORVAR SUP. / 42–46 HRC (nitrided)

SUP. = Supreme





























* Surface treatment is recommended.

STEEL FOR EXTRUSION DIES

ORVAR 2 MICRODIZED	A Cr-Mo-V-alloyed hot work steel (H13) with good high temperature strength and good resistance to abrasion. The steel is widely used for extrusion tooling.
VIDAR 1	A Cr-Mo-V-alloyed hot work steel (H11) with a good combination of high temperature strength, good toughness and good resistance to abrasion.
QRO 90 SUPREME	A premium hot work steel with very good strength and hot hardness at elevated temperatures. The steel can be recommended for all types of extrusion tooling subjected to maximum working temperatures.
FORMVAR	A high performance hot work tool steel with very good resistance to hot wear and plastic deformation.
DIEVAR	A premium Cr-Mo-V alloyed hot work steel with good high temperature strength and excellent toughness and ductility. Recommended in dies and extrusion components where the demands on toughness and ductility are the highest.
UNIMAX	A premium Cr-Mo-V alloyed steel with a good toughness and ductility up to a hardness of 58 HRC.
IMPAX SUPREME	Pre-hardened Ni-Cr-Mo-alloyed steel supplied at approx. 310 HB and suitable for mantles.
SKOLVAR	A high strength hot work tool steel with very high hot wear resistance.



QUALITATIVE COMPARISON OF RESISTANCE TO DIFFERENT TOOL FAILURES

Uddeholm grade	Hot wear	Plastic deformation	Premature cracking	Heat checking
ORVAR 2 M				
VIDAR 1				
QRO 90 SUPREME				
FORMVAR				
DIEVAR				
UNIMAX				
SKOLVAR				

The longer the bar, the better. M = Microdized.

Further information is given in the brochure "Uddeholm tool steel for extrusion".

SELECTION CHART – EXTRUSION

Tool part	Aluminium, Magnesium	Copper alloys	Steel
Support tools (at lower temp.)	IMPAX SUP. ~310 HB	IMPAX SUP. ~310 HB	IMPAX SUP. ~310 HB
Wedge block	IMPAX SUP. ~310 HB ORVAR 2 M 300–400 HB	IMPAX SUP. ~310 HB ORVAR 2 M 300–400 HB	IMPAX SUP. ~310 HB ORVAR 2 M 300–400 HB
Die ring	FORMVAR ORVAR 2 M 40–44 HRC	QRO 90 SUP. 40–44 HRC	QRO 90 SUP. 40–44 HRC

SUP. = Supreme, M = Microdized

Cont.

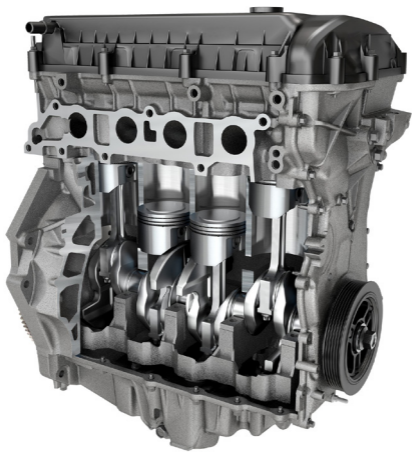
Tool part	Aluminium, Magnesium	Copper alloys	Steel
Die	FORMVAR VIDAR 1/ORVAR 2M/ QRO 90 SUP. 45–50 HRC DIEVAR 46–52 HRC UNIMAX 52–58 HRC	QRO 90 SUP. 45–49 HRC	QRO 90 SUP. 44–46 HRC
Mantle Intermediate liner	IMPAX SUP. ~310 HB ORVAR 2 M 37–43 HRC VIDAR 1 37–43	IMPAX SUP. ~310 HB ORVAR 2 M 37–43 HRC	IMPAX SUP. ~310 HB ORVAR 2 M 37–43 HRC
Liner	ORVAR 2 M 44–48 HRC QRO 90 SUP. 44–48 HRC VIDAR 1 44–48 HRC DIEVAR 44–50 HRC	QRO 90 SUP. 44–48 HRC	ORVAR 2 M 44–48 HRC
Dummy block	QRO 90 SUP. 44–48 HRC DIEVAR 46–52 HRC ORVAR 2 M 46–50	QRO 90 SUP. 44–48 HRC	QRO 90 SUP. 44–48 HRC
Stem	ORVAR 2 M 46–50 HRC	ORVAR 2M 46–50 HRC	ORVAR 2M 46–50 HRC
Mandrel	ORVAR 2 M 46–50 HRC QRO 90 SUP. 46–49 HRC	QRO 90 SUP. 45–49 HRC DIEVAR 46–52 HRC	QRO 90 SUP. 45–49 HRC

SUP. = Supreme, M = Microdized

STEEL FOR FORGING DIES

DIEVAR	A premium Cr-Mo-V alloyed hot work steel with good high temperature strength and excellent hardenability, toughness and ductility. Recommended in dies where the demands on toughness and ductility are the highest. It meets the requirements of NADCA #207-2018.
UNIMAX	A premium Cr-Mo-V alloyed steel with good toughness and ductility up to a hardness of 58 HRC.
ORVAR 2 MICRODIZED	Cr-Mo-V-alloyed hot work die steel (H13) with good high temperature strength and hot wear resistance.
ORVAR SUPREME	Premium Cr-Mo-V-alloyed hot work die steel (H13) with good resistance to thermal fatigue. The steel is produced by a special melting and refining technique. It meets the requirements of NADCA #207-2018.
VIDAR SUPERIOR	A Cr-Mo-V-alloyed hot work die steel (H11) modified with good resistance to cracking. It meets the requirements of NADCA #207-2018.
QRO 90 SUPREME	A premium hot work die steel with very good strength and hot hardness at elevated temperatures. Recommended for inserts and stamping of copper alloys.
FORMVAR	Uddeholm Formvar is a solid upgrade choice from H11/H13 forging dies. With good tempering back resistance and hot yield strength.
VANADIS 8* / VANADIS 4 EXTRA* / VANADIS 30*	PM-produced steels. Recommended for forging applications where very good wear resistance is needed.
SKOLVAR	A premium hot work grade with high hot wear resistance and hot strength.

* Uddeholm PM SuperClean tool steels



QUALITATIVE COMPARISON OF RESISTANCE TO DIFFERENT TOOL FAILURES

Uddeholm grade	Hot wear	Plastic deformation	Premature cracking	Heat checking
ORVAR SUPREME	██████	██████	██████	██████
ORVAR 2 M	██████	██████	██████	██████
VIDAR SUPERIOR	██████	██████	██████	██████
QRO 90 SUPREME	██████	██████	██████	██████
FORMVAR	██████	██████	██████	██████
DIEVAR	██████	██████	██████	██████
UNIMAX	██████	██████	██████	██████
SKOLVAR	██████	██████	██	██████

The longer the bar, the better. M = Microdized.

Further information is given in the brochure "Uddeholm tool steel for forging applications".

SELECTION CHART – FORGING

Forging application		Steel grade	Hardness range	Cavity depth
Hammer forging	Solid die blocks	FORMVAR – pre-hardened IMPAX SUPREME	400–440 HB 360–400 HB 320–360 HB ≤320 HB	Max. 20 mm (0.8 inch) Max. 50 mm (2 inch) Max. 150 mm (6 inch) Very deep
	Inserts	VIDAR SUPERIOR DIEVAR FORMVAR ORVAR SUPREME	38–50 HRC	
Press forging	Dies	DIEVAR VIDAR SUPERIOR ORVAR SUPREME QRO 90 SUPREME UNIMAX FORMVAR	38–57 HRC	
Warm forging	Tools	UNIMAX DIEVAR FORMVAR CALDIE SKOLVAR *	50–58 HRC	
Progressive forging	Tools	QRO 90 SUPREME UNIMAX DIEVAR FORMVAR SKOLVAR *	48–54 HRC	
Upset forging	Tools	UNIMAX DIEVAR FORMVAR SKOLVAR	46–56 HRC	

* Uddeholm PM grades can be used in some tool parts. Higher hardnesses can be used.

MATERIALS FOR PLASTIC MOULDS

Uddeholm grade	Description/Applications
IMPAX SUPREME	A pre-hardened Ni-Cr-Mo-steel, supplied at ~310 HB, with polishing and photo-etching properties. Suitable for a wide range of injection moulds, blow moulds and extrusion dies.
NIMAX	A low carbon steel, delivery hardness ~380 HB. Excellent toughness, machinability and weldability. Good polishing and etching properties.
STAVAX ESR	A through hardening corrosion resistant mould steel with a very good polishability. Recommended for medium and small moulds.
MIRRAX ESR	A through hardening corrosion resistant mould steel with a very good polishability. Recommended for medium and large moulds.
MIRRAX 40	A pre-hardened corrosion resistant mould steel supplied at ~380 HB, with good machinability, very good toughness and excellent polishability.
TYRAX ESR	A through hardened corrosion and wear resistant steel with excellent polishability. Suitable for reinforced plastics with corrosive additives, such as flame retardants.
UNIMAX	A through hardened steel with an optimised combination of toughness and wear resistance. Recommended for long production series and for reinforced plastics.
CALDIE	A through hardened steel with similar properties as for Unimax but with a higher wear resistance and lower toughness. Recommended for long production series and reinforced plastics.
CORRAX	A precipitation hardening steel with extremely good corrosion resistance.
AM CORRAX	A precipitation hardening steel with extremely good corrosion resistance. Delivered as powder for additive manufacturing (AM) to be used in the same applications as conventional Corrax.



ORVAR SUPREME	A versatile through hardening 5% Cr mould and die steel with good wear resistance and polishability.
VIDAR 1 ESR	A through hardened steel, suitable for large moulds with high demands on toughness in combination with very good polishability and texturing properties.
ELMAX SUPERCLEAN VANADIS 4 SUPERCLEAN VANADIS 8 SUPERCLEAN VANAX SUPERCLEAN	Powder metallurgically produced mould steel characterized by very good dimension stability, good polishability and wear resistance. Uddeholm Vanax and Uddeholm Elmax are corrosion resistant, Uddeholm Vanadis 4 Extra has the highest toughness and Uddeholm Vanadis 8 the best wear resistance. Recommended for long production runs of smaller and complicated shapes and/or abrasive plastics.
VANCRON SUPERCLEAN	Powder metallurgically produced tool steel Uddeholm Vancron is a good alternative to surface coating in order to reduce galling, sticking and adhesive wear and reduce friction. It also has a high polishability.
HOLDAX	A pre-hardened holder steel, supplied at ~310 HB, with a very good machinability.
ROYALLOY ¹⁾	A pre-hardened corrosion resistant holder steel, with good machinability, high tensile strength and excellent weldability.
RAMAX HH	Pre-hardened corrosion resistant holder steel, supplied at ~340 HB and can be used for dies and calibers for plastic extrusion as well as for holders/bolsters.
ALUMEC 89 ²⁾	High strength Al-alloy supplied at ~160 HB. Recommended for blow moulds, prototype moulds and for short runs with low demands on strength and wear resistance.

¹⁾ Uddeholm RoyAlloy is produced and patented by Edro Specialty Steels, USA

²⁾ Arconic is owner of the trade mark Alumec 89

For more detailed recommendations, see the application brochure “Steel for Moulds” or the product information brochure available for each steel grade.

PROPERTY COMPARISON GUIDE FOR MOULD STEEL

Uddeholm grade	Machinability*	Wear resistance	Polishability	Corrosion resistance
CALDIE	████	██████████	██████████	██
CORRAX	████	████	██████	██████████
ELMAX	████	██████████	██████████	██████
HOLDAX	██████████	██	██	██
IMPAX SUPREME	██████	██	██████	██
MIRRAX ESR	██████	██████	██████████	██████████
MIRRAX 40	██████████	████	██████████	██████
NIMAX ESR	██████	████	██████████	██
NIMAX	██████	████	██████████	██
ORVAR SUPREME	██████████	██████	██████████	██
POLMAX	██████████	██████	██████████	██████
RAMAX HH	██████	████	██	██████
RIGOR	██████	██████████	██████	██
ROYALLOY	██████████	██	██	██████
STAVAX ESR	██████████	██████	██████████	██████
TYRAX ESR	██████	██████████	██████████	██████
UNIMAX	██████████	██████████	██████████	██
VIDAR 1 ESR	██████████	██████	██████████	██
VANADIS 8	██	██████████	██████	██
VANADIS 4 EXTRA	██████	██████████	██████████	██
VANAX	██████	██████████	██████████	██████████
VANCRON	██████	██████████	██████████	██

* The Uddeholm mould steel Impax Supreme, Nimax ESR, Nimax, Mirrax 40, RoyAlloy, Holdax and Ramax HH are tested in pre-hardened condition. Uddeholm Corrax is tested in solution treated condition.

MOULD STEEL SELECTION

GENERAL RECOMMENDATIONS

Process	Material	Recommended	
		Steel grade	Hardness HRC (HB)
Injection moulding	Thermoplastics – pre-hardened mould steel	ALUMEC 89	(~160)
		IMPAX SUPREME	33(~310)
		RAMAX HH	37(~340)
		NIMAX ESR	40(~380)
		NIMAX	40(~380)
		MIRRAX 40	40(~380)
	– through hardened mould steel	CORRAX	36–50
		MIRRAX ESR	45–50
		ORVAR SUPREME	45–52
		VIDAR 1 ESR	45–52
		STAVAX ESR	45–52
		POLMAX	45–52
		UNIMAX	50–58
		TYRAX ESR	55–58
		CALDIE	59–61
Thermoset plastics	ELMAX	56–60	
	VANADIS 4 EXTRA	58–64	
	UNIMAX	52–58	
	TYRAX ESR	55–58	
	CALDIE	59–61	
Com- pression/ Transfer moulding	Thermoset plastics	ELMAX	56–60
		VANADIS 4 EXTRA	58–64
		MIRRAX ESR	45–50
		STAVAX ESR	45–52
		ORVAR SUPREME	45–52
		UNIMAX	52–58
		TYRAX ESR	55–58
CALDIE	59–61		

Cont.

Process	Material	Recommended	
		Steel grade	Hardness HRC (HB)
Blow moulding	General	ALUMEC 89 IMPAX SUPREME NIMAX	(~160) 33(~310) 40(~380)
	PVC	CORRAX RAMAX HH MIRRAX 40 MIRRAX ESR STAVAX ESR	36-50 37(~340) 40(~380) 45-50 45-52
Extrusion	General	IMPAX SUPREME NIMAX	33(~310) 40(~380)
	PVC	CORRAX RAMAX HH MIRRAX 40 MIRRAX ESR STAVAX ESR	36-50 37(~340) 40(~380) 45-50 45-52
Holder material	1. High strength, pre-hardened, free-machining	HOLDAX	33(~310)
	2. As, 1, plus corrosion resistance for low maintenance production runs. Also for "hygienic" operating conditions. No plating required.	ROYALLOY RAMAX HH	(~310) 37(~340)

SPECIAL RECOMMENDATIONS

Special req. or demand	Example	Recommended	
		Steel grade	Hardness HRC (HB)
Large mould size	For automotive components, panels, bumpers, fascias, etc.	ALUMEC 89 IMPAX SUPREME CORRAX ORVAR SUPREME VIDAR 1 ESR MIRRAX ESR MIRRAX 40 NIMAX ESR NIMAX	(~160) 33(~310) 36-46 36-50 36-50 36-50 40(~380) 40(~380) 40(~380)
	As above but with lower demands on the surface finish	HOLDAX RAMAX HH	33(~310) 37(~340)
High surface finish	For moulding optical/medical parts, clear covers/panels	NIMAX ESR MIRRAX 40 MIRRAX ESR STAVAX ESR POLMAX ORVAR SUPREME VIDAR 1 ESR UNIMAX TYRAX ESR ELMAX VANADIS 4 EXTRA	40(~380) 40(~380) 45-50 45-52 45-52 45-52 45-52 54-58 55-58 56-60 58-62
Complex shapes	1. For large automobile/household components	IMPAX SUPREME CORRAX MIRRAX ESR MIRRAX 40 NIMAX ESR NIMAX VIDAR 1 ESR	33(~310) 34-46 36-50 40(~380) 40(~380) 40(~380) 45-50
	2. For small parts with low wear demands	IMPAX SUPREME CORRAX MIRRAX 40 NIMAX ESR NIMAX	33(~310) 34-46 40(~380) 40(~380) 40(~380)
	3. For small parts with high wear demands, e.g. electrical/-electronic mouldings	MIRRAX ESR ORVAR SUPREME STAVAX ESR UNIMAX TYRAX ESR ELMAX VANADIS 4 EXTRA VANADIS 8	48-50 50-52 50-52 54-58 55-58 56-60 58-64 60-64

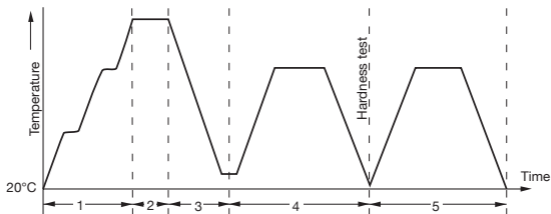
Cont.

Special req. or demand	Example	Recommended	
		Steel grade	Hardness HRC (HB)
Abrasive moulding materials	Reinforced/filled moulding materials	MIRRAX ESR	48–50
		ORVAR SUPREME	50–52
		STAVAX ESR	50–52
		UNIMAX	54–58
		TYRAX ESR	55–58
		ELMAX	56–60
		VANADIS 4 EXTRA	58–64
VANADIS 8	60–64		
Long production runs	For thermoplastic parts, including disposable cutlery, containers and packaging	MIRRAX ESR	45–50
		STAVAX ESR	45–52
		ORVAR SUPREME	45–52
		VIDAR 1 ESR	45–52
		UNIMAX	54–58
		TYRAX ESR	55–58
		ELMAX	56–60
VANADIS 4 EXTRA	58–64		
Corrosive	<ol style="list-style-type: none"> For corrosive moulding materials For humid moulding/mould storage conditions General resistance to surface staining/rusting Resistance to corrosion of cooling channels 	ROYALLOY	(~310)
		CORRAX	34–50
		RAMAX HH	37(~340)
		MIRRAX 40	40(~380)
		MIRRAX ESR	45–50
		STAVAX ESR	45–52
		TYRAX ESR	55–58
ELMAX	56–60		
Photo-etching	1. Pre-hardened steel	IMPAX SUPREME	33(~310)
		MIRRAX 40	40(~380)
		NIMAX ESR	40(~380)
		NIMAX	40(~380)
	2. Through-hardened steel	MIRRAX ESR	45–50
		ORVAR SUPREME	45–52
		VIDAR 1 ESR	45–52
		STAVAX ESR	45–52
		UNIMAX	54–58
		TYRAX ESR	55–58
ELMAX	56–60		
VANADIS 4 EXTRA	58–64		



PRINCIPLES OF HARDENING

HARDENING NORMALLY MEANS HEATING AND QUENCHING, FOLLOWED BY TEMPERING. THE FOLLOWING HEAT TREATMENT SEQUENCE AND GUIDE-LINES SHOULD BE OBSERVED.



1. Preheating. Heat slowly, Rapid heating increases the risk of distortion.

2. Austenitizing (hardening) temperature. Protect against decarburization by heating in a salt bath, protective atmosphere or vacuum. Decarburization of the surface increases the risk of cracking and low hardness.

3. Quenching. Use the quenching medium specified for the grade concerned, i.e. water, oil, air, etc., to achieve the optimum as-quenched hardness. Oil hardening steel can be quenched in a step bath with good results. Steel which can be hardened in oil or air should preferably be cooled in air for minimum distortion. Note: large blocks, however, should be quenched quickly enough to obtain a correct microstructure in the centre of the block. Discontinue cooling at approx. 50–70°C and temper immediately.

4, 5. Tempering. Heat slowly to reduce the risk of distortion and cracking! Holding time at temperature min. 2 hours. After the first temper, allow the material to cool to room temperature! Temper twice in the case of tool steel and three times in the case of Uddeholm Vanacron SuperClean and high speed steel. If extremely high austenitizing temperatures, >1100°C (2010°F), are used all Uddeholm Vanadis SuperClean grades should be tempered three times at 540°C (1000°F) in order to reduce the amount of retained austenite and to optimize the microstructure.

PM STEEL FOR IMPROVED PRODUCTION ECONOMY

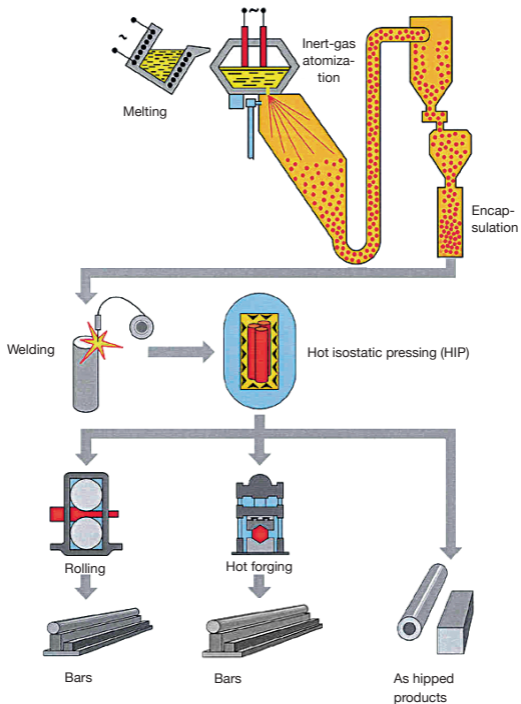
The powder metallurgy (PM) process is a rapid solidification process for the manufacturing of high-speed steel and tool steel. This method eliminates the problems which arise when steel solidifies in ingot moulds, such as local variations in chemical composition and microstructure in the form of segregations.

The PM steel is melted in the usual manner, but when it is tapped, the steel is fragmented by high speed gas jets into a shower of steel droplets which quickly solidify into powder. Each particle can be regarded as a tiny ingot, free of segregations thanks to the rapid cooling. The tiny particles are then compacted to form billets which can be fabricated by means of ordinary methods such as forging and rolling to the desired dimensions.

The PM tool steel Uddeholm Vanadis 4 Extra SuperClean, Uddeholm Vanadis 8 SuperClean, Uddeholm Vanadis 23 SuperClean, Uddeholm Vanax SuperClean and Uddeholm Elmax SuperClean are produced by a special PM process which gives an extremely clean tool steel, with improved properties over standard PM steel, like better polishability, toughness and bend strength. Uddeholm Vancron SuperClean and Uddeholm Vanax SuperClean is a nitrided PM steel offering advantages like low friction, antigalling and good resistance against adhesive wear and is an alternative to a surface coated PM steel in this respect. Uddeholm Vanax SuperClean have a corrosion resistance in parity with stainless steel and can be heat treated to 60 HRC. These properties makes the steel grade unique.

- Dimensional changes are reduced during hardening due to the absence of segregations.
- Tools made of PM steel feature a high and uniform level of performance.
- PM steel permit sharper cutting edges on press tools.
- PM steel are more ductile due to their lack of segregations.
- The absence of segregations permits higher contents of alloying elements as well as more effective use of them compared to conventionally produced steel resulting in dramatically increase in performance.
- Desirable characteristics such as abrasion resistance can be enhanced without sacrificing other vital properties.

THE PM ROUTE FOR PRODUCING TOOL STEEL



UDDEHOLM COMPONENT BUSINESS

Uddeholm Component Business markets the Uddeholm product range in other applications and components than in the traditional tool steel business, where the product characteristics of Uddeholm's premium tool steel lead to lower maintenance costs and contribute to enhanced performance and optimum overall economy.

Uddeholm Component Business applications and components can be found within any industry where there are high demands on properties such as wear resistance, strength, corrosion and heat resistance.

WEAR RESISTANCE

Wear costs industrial companies a lot of money every year largely due to abrasion. Within this area the key is to optimize strength and abrasion resistance.

Uddeholm's product range includes steel grades with a high level of combined durability and toughness. Certain grades for cold work tools are especially well



suited to withstand wear due to their structure containing hard phase particles.

STRENGTH

When it comes to comparing the strength of different steel grades it is soon evident that Uddeholm's tool steel show far better strength values compared to engineering steel grades. The advantage here is that the adaptive hardness of the material through quenching and tempering can be exploited according to specific demands. High fatigue strength can be achieved when combining the high strength and cleanliness of the steel. Uddeholm's ESR grades are a good example of this. This means a longer life for the finished component and these properties also enable weight reductions, which lead to lower costs and higher performance.

CORROSION RESISTANCE

Uddeholm's range of corrosion resistant steel often used for plastic moulds provides a unique combination of strength, corrosion resistance and durability, which enable brand new technical design solutions. This means that components do not need to be surface treated and the material can be used in environments where corrosion would normally be an issue.

HEAT RESISTANCE

Uddeholm's steel grades are also used in hot forging tools and consequently developed to withstand high temperatures. This property means major improvements in strength for parts that are exposed to heat during a long period of time, i.e. they are not losing strength and hardness as often is the case for engineering steel due to tempering back.



PRE-MACHINED TOOL STEEL

Starting from a rough or un-machined bar considerable amount of steel needs to be removed in order to reach final tolerances and to make sure that there is no decarburization left on the surface. For smaller dimensions, this can lead to 40 - 60% material loss. If the starting material instead is in fine machined execution, the material loss is reduced to an absolute minimum.

Uddeholm has therefore invested in considerable resources for further processing of the tool steel. In order to give the customer a steel which is less expensive overall, we grind and fine mill the tool steel in long runs to a standardised tool size and to a surface finish on which the toolmaker can layout directly.

The pre-machined bar can be delivered wrapped in protective paper in easy-to-handle 1-metre lengths.

FROM "BLACK" TO PRE-MACHINED – THE ADVANTAGES ARE MANY

Advantages for the toolmaker:

- Time saving
- Less consumption of material
- Surface defects, flaws and cracks and decarburization eliminated
- Own personnel can be used for more qualified jobs
- Simpler handling
- Cleaner handling (the chips stay at Uddeholm)
- Lower set-up costs
- Less tool wear
- Lower stock-keeping costs

All in all, this means better overall economy for the customer, i.e. greater and faster production at a lower cost.

TOLERANCES

Width $+0.4/+0.8$ mm ¹⁾

Maximum deviation in width on a 1000 mm long bar 0.1 mm.

Thickness $+0.4/+0.65$ mm ²⁾

Maximum deviation in thickness on a 1000 mm long bar 0.1 mm.

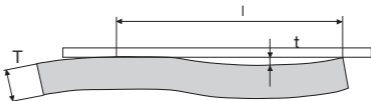
Flatness and straightness

Maximum deviation (t) divided by the length (l) according to the figure below, may not exceed $t/l = 0.0004 = 0.4$ mm/m.

Exception Elmax and Vanadis 23 (0,8 mm/m)

¹⁾ For Uddeholm UHB 11 and Formax $-0/+0,4$ mm

²⁾ For Uddeholm UHB 11 and Formax $-0/+0,2$ mm



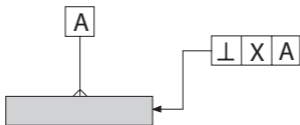
SURFACE FINISH

On the flat surfaces: Ra max 2.5 μ m.

On the edge surfaces: Ra max 6.3 μ m.

CORNER SQUARENESS

Material with a thickness up to 80 mm maximum deviation "X" = 0.1 mm. Thickness above 80 mm maximum deviation "X" = 0.15 mm.



MACHINING SERVICES

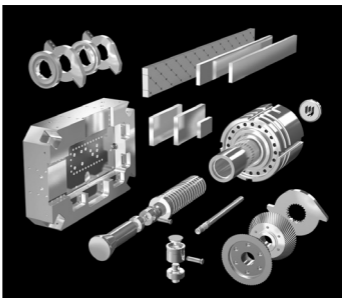
In addition to supplying a high proportion of our steel in the machined condition, in many cases we can offer following custom machining services.

FLAT AND SQUARE BARS

- Surface milling: non standard sizes of large moulds and holder blocks
- Cavity milling: machining of cavities and holes according to customer drawings
- Drilling: holes for pillars/bushes and cooling channels
- Grinding, fine milling: fine machined bars in non standard sizes

ROUND BARS

- Turning, Peeling: non standard sizes
- Centerless grinding: non standard sizes
- Hollow bar: non standard sizes



MACHINING ON ORDER OF SEMIFINISHED OR FINISHED PARTS IN ANNEALED OR HARDENED CONDITION

- Components for extrusion like containers, stems and dummy blocks
- Machine components shafts, wheels, knives etc.

HINTS ON IMPROVED TOOL PERFORMANCE

HOT WORK TOOLS

- Pre-heat tools to minimize thermal shock
- Minimize thermal fluctuations in the tool by using appropriate cooling methods
- Lubricate working surfaces to reduce contact with hot metal and aid release of parts
- Ensure tools are fully supported for maximum stability and to avoid deflection

COLD WORK TOOLS

- Pay careful attention to tool-setting and press alignment
- Ensure tools are fully supported for maximum stability and to avoid deflection
- Use lubricants as appropriate
- Re-grind tools regularly before major re-grinding is necessary. Use coolant to avoid overheating or grinding cracks
- Tooling subjected to repeated heavy loading will benefit from a low-temperature stress-tempering operation after a long production run at 25–30°C below tempering temperature
- Do not use tools for blanking strip thicknesses which are greatly different from those for which they were designed

PLASTIC MOULDS

- Stress temper after the rough machining but before fine machining for best results regarding dimensional changes, etching and welding
- Reduce the risk for corrosion on the mould surfaces and the risk for reduced cooling efficiency because of rust in cooling channels by using a corrosion resistant tool steel
- Wear due to reinforcement in the plastic can be reduced by changing to a more wear resistant tool steel or in some cases by surface treatment
- Reduce the risk for galling by using different material and/or different hardness on the two sliding metal surfaces
- Too low clamping force increases the risk for flashes and for deformation of the edges of the parting line

HINTS ON BASIC TOOL DESIGN

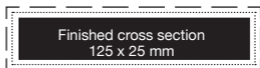
- Design around standard sizes wherever possible. Uddeholm normally supplies oversized bar with a machining allowance to finish at a convenient nominal size, e.g. 125 x 25 mm
- Use adequate overall dimensions!

Unmachined cross section:

133 x 28 mm

Pre-machined cross section:

125 x 25 mm with machining allowance



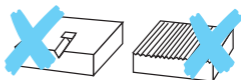
- Avoid sharp corners!



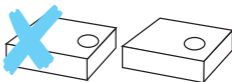
- Avoid uneven sections!



- Avoid potential stress raising marks, e.g. cold stamps, rough machining!



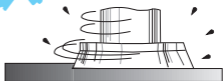
- Leave sufficient stock thickness between holes and plate edges!



- Solid blocks resist deflection!



- Remove surface decarburization!



HINTS ON TOOL HEAT TREATMENT

- Check thermocouples regularly
- Stress relieve tools after rough-machining
- Fully pre-heat
- Quench in the correct medium
- Temper immediately after quenching
- Double temper (or tripple)
- Don't hurry the heat treatment operation
- Don't forget to protect tools against decarburization or carburization
- Don't over-heat, over-soak
- Don't re-harden tools without annealing first

For further information see the Uddeholm brochure "Heat treatment of tool steel".

HINTS ON REPAIR WELDING

Even with the very best equipment and properly designed consumables, tool steel cannot be welded successfully unless considerable care is exercised in both joint preparation and in the actual welding operation. Recommended procedures are given in some detail on the product information brochures for the Uddeholm Weld range.

The following supplementary points can be made:

1. All dirt and grease must be thoroughly removed
2. On finished tools, protect surrounding area from spatter
3. Careful joint preparation is vital and welding should be performed immediately
4. Tools must be slowly pre-heated before welding
5. The principle is to put down a number of small cross section runs with low heat input, to clad the joint in weld metal, before increasing size of run and heat input for the remaining joint filling
6. Cool the tool slowly down to 50–70°C (120–160°F)
7. If welding has been performed on soft-annealed material, a soft annealing should be performed after finishing
8. If welding has been performed on material in hardened condition, a tempering should be performed after welding

For welding Uddeholm tool steel the following consumables are recommended:

Coated electrode:

Impax Weld, QRO 90 Weld, Caldie Weld and Calmax/Carmo Weld

TIG filler rod:

Impax TIG-Weld, Nimax TIG-Weld, Stavax TIG-Weld, Mirrax TIG-Weld, Unimax TIG-Weld, QRO 90 TIG-Weld, Dievar TIG-Weld, Calmax/Carmo TIG-Weld, Corrax TIG-Weld, Caldie TIG-Weld and RoyAlloy TIG-Weld.

Laser filler rod:

Nimax Laser Weld, Stavax Laser Weld and Dievar Laser Weld.

For further information see the Uddeholm brochure “Welding of tool steel”.

HINTS ON GRINDING TOOL STEEL

As in all machining operations operator technique and experience, tool and machine type and condition all play a part in a successful grinding operation.

- Ensure that the part is firmly secured to avoid vibration
- Use properly dressed, soft, open-grained grinding wheels wherever possible
- Restrict the peripheral speed and use plenty of coolant
- Refer to the grinding wheel manufacturer for specific advice on wheel selection and use
- Remove any “feather-edge” after grinding
- Don’t use excessive pressure when grinding, to avoid burning and grinding cracks
- Don’t grind tools in the untempered condition

For further information see the Uddeholm brochure “Grinding of tool steel”.

HINTS ON EDM

ELECTRO DISCHARGE MACHINING (EDM'ING)

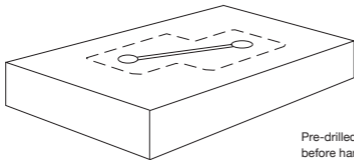
When spark eroding cavities, one or two important points should be noted in order to obtain satisfactory results. During the operation the surface layer of the steel is re-hardened and consequently in a brittle state. This may result in fatigue cracking and shortened tool life. To avoid this problem the following precautions should be taken:

- Finish the EDM operation by “fine” sparking (i.e. low amperage, high frequency)
- The affected surface layer should be removed by polishing or stoning
- If the spark-eroded surface texture is to be used in the finished mould it should be re-tempered at a temperature 15–20°C below that used previously
- If the spark-eroded surface is to be textured by photo-etching it is important that all of the surface layer affected is carefully removed by stoning etc.

For further information see the Uddeholm brochure “EDM of tool steel”.

WIRE EROSION

Complicated shapes can be easily cut from hardened steel blocks by this process. However, hardened steel always contains stresses, and when large volumes of steel are removed in a single operation, distortion may be caused or even cracking especially if the tool is low temperature tempered. These difficulties can be reduced by drilling holes joined by a saw-cut in the proposed aperture, before heat treatment; this allows the work piece to adjust to the final shape and stress pattern, during heat treatment.



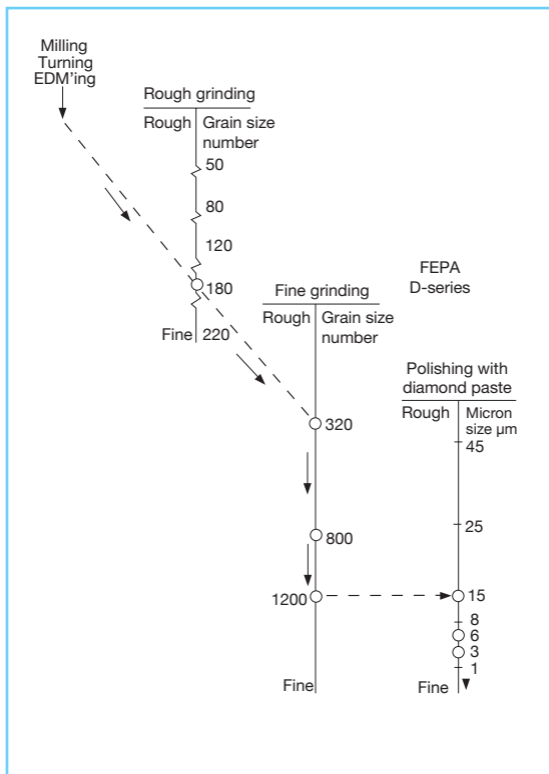
Pre-drilled holes connected by a saw-cut, before hardening and tempering will help to prevent distortion or cracking when wire-eroding thick sections.

HINTS ON POLISHING MOULD STEEL

In spite of an increasing number of mechanical polishing aids, the skilled technique and judgement of an experienced polisher is still an essential ingredient in obtaining the required surface finish as quickly as possible.

- Choose a good quality mould steel. All Uddeholm mould steel are vacuum de-gassed and/or electro-slag-refined (ESR) during manufacture to give a clean and homogeneous structure suitable for producing high surface finishes
- Carefully heat treat parts to be hardened, to give a uniform hardness and steel structure, this will help to give consistent polishing results.
- Follow a recommended polishing sequence
- Ensure absolute cleanliness at every stage of the polishing process.
- Do not transfer abrasive particles from one polishing step to the next
- Avoid excessive pressure when using mechanical polishing equipment

For further information see the Uddeholm brochures “Polishing of mould steel” and “Defect chart and hints for high gloss polishing of steel surfaces”.



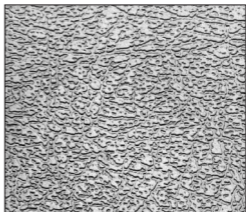
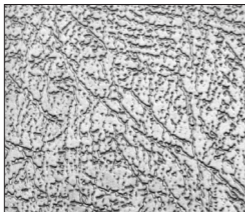
A typical polishing sequence.

HINTS ON PHOTO-ETCHING

Uddeholm Impax Supreme pre-hardened mould steel and Uddeholm Orvar Supreme yield particularly good and consistent results after photo-etching due to the very low sulphur content.

- If a number of parts are included in a tool and these are to be etched with the same pattern, the starting material and the rolling direction should be the same for these parts
- Complete the machining operation by stress-relieving, followed by finish-machining
- When etching heavy sections of Uddeholm Impax Supreme an extra tempering at 550°C before the etching is recommended
- Spark-eroded surfaces should always be ground or polished, otherwise re-hardened surface layers from the spark-erosion will cause a poor etching result
- Flame-hardening should be done after photo-etching
- In some cases, a welded tool can be photo-etched, provided that the same material is used in the weld as in the tool itself. In such cases the welded area should be indicated to the photo-etching company
- If a tool is to be nitrided this must be done after photo-etching
- The surface area of a mould cavity is greatly increased by texturing, which may cause ejection problems. Early consultation with the photo-etching specialist is recommended to determine the optimum draft angle for the shape and pattern concerned

For further information see the brochure “Photo-etching of tool steel”.



Examples of photo-etched pattern.

HARDNESS CONVERSION TABLE

These conversions are based on EN-ISO 18265:2013.

Approx. comparison between hardness and ultimate tensile strength.

Rockwell HRC	Brinell* HBW	Vickers HV10	Approx. UTS	
			N/mm ²	kp/mm ²
26	259	273	873	89
27	265	279	897	92
28	272	286	919	94
29	279	294	944	96
30	287	302	970	99
31	295	310	995	101
32	303	318	1024	104
33	311	327	1052	107
34	320	336	1082	110
35	328	345	1111	113
36	337	355	1139	116
37	346	364	1168	119
38	354	373	1198	122
39	363	382	1227	125
40	373	392	1262	129
41	382	402	1296	132
42	392	412	1327	135
43	402	423	1362	139
44	413	434	1401	143
45	424	446	1425	145
46	436	459	1478	151
47	448	471	1524	155
48	460	484	1572	160
49	474	499	1625	166
50	488	513	1675	171
51	502	528	1733	177
52	518	545	1793	183
53	532	560	1845	188
54	549	578	1912	195
55	566	596	1979	202
56	585	615	2050	209
57	603	634	2121	216
58		654		
59		675		
60		698		
61		720		
62		746		
63		773		
64		800		

* 10 mm all, 3000 kg load

CONVERSION FACTORS AND FORMULAE

LENGTH

To convert	to	multiply by
in	mm	25.40
in	cm	2.540
in	m	0.0254
mm	in	0.0394
cm	in	0.3937
ft	m	0.3048
m	ft	3.281
yd	m	0.9144
m	yd	1.094
miles	km	1.609
km	miles	0.6214

MASS (WEIGHT)

To convert	to	multiply by
lb	kg	0.4536
lb	ton1)	0.0004536
kg	lb	2.205
kg	tons2)	0.00098
tons2))	kg	1016
tons2)	ton1)	1.016
ton1)	tons2)	0.9844
kg/m	lb/ft	0.672
kg/m	kg/ft	0.3281
kg/ft	kg/m	0.3048
kg/ft	lb/m	7.23
lb/ft	kg/m	1.48

¹⁾ 1 ton (metric) = 1000 kg = 2205 lbs

²⁾ 1 ton (UK) = 1016 kg = 2240 lbs

1 short ton (USA) = 907 kg = 2000 lbs

1 long ton (USA) = 1 ton (UK) = 1016 kg = 2240 lbs

AREA

To convert	to	multiply by
mm ²	in ²	0.00155
in ²	mm ²	645.16
cm ²	in ²	0.1550
in ²	cm ²	6.452
ft ²	m ²	0.0929
m ²	ft ²	10.76
m ²	yd ²	1.196
yd ²	m ²	0.8361

VOLUME

To convert	to	multiply by
in ³	mm ³	16.3862
cm ³	in ³	0.06103
in ³	ft ³	0.000578
ft ³	in ³	1728
ft ³	m ³	0.02832
m ³	ft ³	35.3147
gal (UK)	l	4.546
l	gal (UK)	0.219969

Area of circle: $\pi \cdot r^2 \approx 0.7854 \cdot D^2$

TEMPERATURE CONVERSION

°C to °F: multiply by 1.8, then add 32

°F to °C: subtract 32, then multiply
by 0.56

Exact formulae:

$$^{\circ}\text{F} = \frac{^{\circ}\text{C} \times 9}{5} + 32$$

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times \frac{5}{9}$$

PRESSURE, TENSILE STRENGTH

To convert	to	multiply by
tons/in ²	N/mm ²	15.5
tons/in ²	kp/mm ²	1.57
tons/in ²	lb/in ²	2240
N/mm ²	kp/mm ²	0.102
N/mm ²	lb/in ²	145
N/mm ²	tons/in ²	0.065
kp/mm ²	lb/in ²	1422.34
kp/mm ²	tons/in ²	0.635
kp/mm ²	N/mm ²	9.81
lb/in ²	tons/in ²	0.00045
lb/in ²	N/mm ²	0.0069
lb/in ²	kp/mm ²	0.000703
lb/in ²	MPa	0.00689
MPa	lb/in ²	145
bar	ln/in ²	14.51

STEEL WEIGHTS

METRIC SIZES

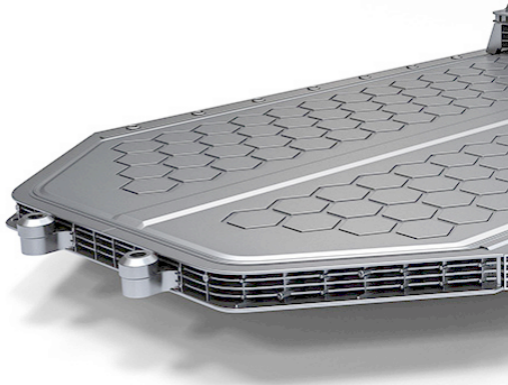
Flats and squares: W(mm) x T(mm) x L(m) x 0.00785 = weight in kg.

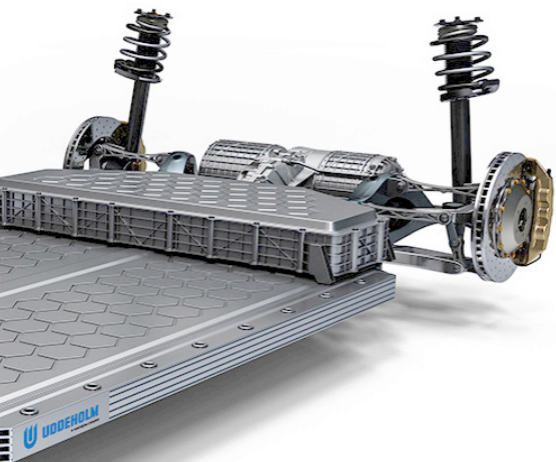
Rounds: D²(mm) x L(m) x 0.0062 = weight in kg.

INCH SIZES

Flats and squares: W(in) x T(in) x L(in) x 0.2833 = weight in lbs.

Rounds: D²(in) x L(in) x 0.2225 = weight in lbs.





NOTES

SI-UNITS OF MEASUREMENT FACTORS AND PREFIXES

Quantity	Name	Symbol	Derivation	Multiple	Factor	Prefix	Symbol
The seven basic units							
Length	metre	m		1 000 000 000 000	10^{12}	tera	T
Mass	kilogram	kg		1 000 000 000	10^9	giga	G
Time	second	s		1 000 000	10^6	mega	M
El.current	ampere	A		1 000	10^3	kilo	k
Temperature	kelvin	K		100	10^2	hekto	h
Lum.intensity	candela	cd		10	10^1	deka	da
Mol. w. in gr.	molemol						
Two supplementary units							
Plane angle	radian	rad		0,1	10-1	deci	d
Solid angle	steradian	sr		0,01	10-2	centi	c
Derived units with own names							
Force	newton		$1 \text{ N} = 1 \text{ kg} \cdot \text{m/s}^2$	0,001	10-3	milli	m
Pressure	pascal		$1 \text{ Pa} = 1 \text{ N/m}^2$	0,000 001	10-6	mikro	μ
Energy, work	joule	J	$= 1 \text{ Nm}$	0,000 000 001	10-9	nano	n
Power	watt	W	$= 1 \text{ J/s}$	0,000 000 000 001	10-12	piko	p
Additional units permitted until further notice							
Volume	litre	l	$= 10^{-3} \text{ m}^3$	0,000 000 000 000 001	10-15	femto	f
Mass	ton	t	$= 10^3 \text{ kg}$		10-18	atto	a
Energy	watt-hour		$1 \text{ Wh} = 3600 \text{ Ws (J)}$				
Pressure	bar	bar	$= 100 \text{ kPa}$				

Conversion factors

SI-units and
permitted units

Other units

LENGTH

	m	mm	in (inch)	ft (foot)	yd (yard)
1 m =	1	10^3	39.3701	3.2808	1.0936
1 mm =	10^{-3}	1	$39.37 \cdot 10^{-3}$	$3.281 \cdot 10^{-3}$	$1.094 \cdot 10^{-3}$
1 in (inch) =	$25.4 \cdot 10^{-3}$	25.4	1	$83.33 \cdot 10^{-3}$	$27.78 \cdot 10^{-3}$
1 ft (foot) =	0.3048	304.8	12	1	0.3333
1 yd (yard) =	0.9144	914.4	36	3	1
1 mile, eng. =	$1.6093 \cdot 10^3$	$1.6093 \cdot 10^6$	$63.36 \cdot 10^3$	$5.28 \cdot 10^3$	$1.76 \cdot 10^3$
1 naut. mil =	$1.852 \cdot 10^3$	$1.852 \cdot 10^6$	$72.91 \cdot 10^3$	$6.076 \cdot 10^3$	$2.025 \cdot 10^3$

1 km = 0.6214 mile, eng. = 0.5396 naut. mile

1 Å (Ångström) = 10^{-10} m = 10^{-4} μm

AREA

	m ²	mm ²	in ²	ft ²	yd ²
1 m ² =	1	106	1.55 . 103	10.76	1.196
1 mm ² =	10^{-4}	1	$1.55 \cdot 10^{-3}$	$10.76 \cdot 10^{-6}$	$1.196 \cdot 10^{-6}$
1 in ² =	$0.645 \cdot 10^{-3}$	645.16	1	$6.944 \cdot 10^{-3}$	$0.772 \cdot 10^{-3}$
1 ft ² =	$92.9 \cdot 10^{-3}$	92.9 . 103	144	1	0.1111
1 yd ² =	0.8361	836.1 . 103	$1.296 \cdot 103$	9	1
1 acre =	4.047 . 103	4.047 . 109	6.273 . 106	43.56 . 103	4.84 . 103
1 mile ² eng. =	2.58999 . 106	2.58999 . 1012	4.014 . 109	27.88 . 106	3.0976 . 106

1 km² = 247.1 acre = 0.3861 mile² eng.

VOLUME

	m ³	dm ³	in ³	ft ³	Yd ³
1 m ³ =	1	103	61.0237 . 103	35.3147	1.308
1 l = 1 dm ³ =	10 ⁻³	1	61.02	35.31 . 10 ⁻³	1.3 . 10 ⁻³
1 in ³ =	16.387 . 10 ⁻⁶	16.387 . 10 ⁻³	1	0.579 . 10 ⁻³	21.43 . 10 ⁻⁶
1 ft ³ =	28.317 . 10 ⁻³	28.317	1.728 . 103	1	37.04 . 10 ⁻³
1 yd ³ =	0.76455	764.55	46.656 . 103	27	1
1 gallon UK =	4.546 . 10 ⁻³	4.5461	277.4	0.1605	5.946 . 10 ⁻³
1 gallon US =	3.785 . 10 ⁻³	3.7854	231	0.1337	4.951 . 10 ⁻³

1 l = 1 dm³ = 0.219969 gallon UK = 0.264172 gallon US

1 cm³ = 0.061 in³

VELOCITY

	m/s	km/h	ft/s	mile/h	kn (knpo)
1 m/s =	1	3.6	3.2808	2.2369	1.9438
1 km/h =	0.2778	1	0.9113	0.6214	0.54
1 ft/s =	0.3048	1.0973	1	0.6818	0.5925
1 mile/h =	0.447	1.6093	1.4666	1	0.869
1 kn (knop) =	0.5144	1.852	1.6878	1.1508	1

1 knop = 1 nautical mile/h; 1 mach = ca 1.2 . 103 km/h;

1 mph = 1 mile/h

MASS (WEIGHT)

	kg	g	lb (pound)	slug	oz (ounce)
1 kg =	1	103	2.2046	68.52 · 10 ⁻³	35.274
1 g =	10 ⁻³	1	2.2 · 10 ⁻³	68.52 · 10 ⁻⁶	35.274 · 10 ⁻³
1 lb (pound) =	0.4536	453.59	1	31.08 · 10 ⁻³	16
1 slug =	14.594	14.5939 · 103	32.17	1	514.8
1 oz (ounce) =	28.35 · 10 ⁻³	28.35	62.5 · 10 ⁻³	1.943 · 10 ⁻³	1
1 long cwt GB =	50.8023	50.8023 · 103	112	3.481	1.792 · 103
1 long ton. GB =	1.016 · 103	1.016 · 106	2.24 · 103	69.62	35.84 · 103
1 short cwt. USA =	45.3592	45.3592 · 103	100	3.108	1.6 · 103
1 short ton USA =	907.185	907.185 · 103	2 · 103	62.16	32 · 103

1 long ton UK = 20 long cwt. UK 1 short ton US = 20 short cwt. US

1 kg = 0.9842 · 10⁻³ long ton UK = 1.1023 · 10⁻³ short ton US

1 kg = 19.684 · 10⁻³ long cwt. UK = 22.046 · 10⁻³ short cwt US

DENSITY

	kg/m3	g/cm3	lb/in.3	lb/ft3
1 kg/m3 =	1	10 ⁻³	36.13 · 10 ⁻⁶	62.43 · 10 ⁻³
1 g/cm3 =	103	1	36.13 · 10 ⁻³	62.428
1 lb/in3 =	27.6799 · 103	27.68	1	1.728 · 103
1 lb/ft3 =	16.0185	16.02 · 10 ⁻³	0.579 · 10 ⁻³	1

m³/kg called specific volume

FORCE

	N	dyne	kp	lbf
1 N =	1	0.1 . 106	0.10197	0.2248
1 dyn =	10 . 10 ⁻⁶	1	1.02 . 10 ⁻⁶	2.248 . 10 ⁻⁶
1 kp =	9.80665	980.665 . 103	1	2.2046
1 lbf =	4.448	444.8 . 103	0.4536	1

The unit kilopond (kp) has also been called kilogram-force (kgf)

MOMENT OF FORCE

	Nm	kpm	lbf . in	lbf . ft
1 Nm =	1	0.102	8.851	0.7376
1 kpm =	9.8067	1	86.7962	7.233
1 lbf . in =	0.113	11.521 . 10 ⁻³	1	83.33 . 10 ⁻³
1 lbf . ft =	1.356	0.1383	12	1

POWER

	W	kpm/s	kcal/h	hk	ft. lbf/s
1 W =	1	0.102	0.8598	1.36 . 10 ⁻³	0.7376
1 kpm/s =	9.80665	1	8.432	13.33 . 10 ⁻³	7.233
1 kcal/h =	1.163	0.1186	1	1.581 . 10 ⁻³	0.8578
1 hk =	735.5	75	632.5	1	542.5
1 ft . lbf/s =	1.356	0.1383	1.166	1.843 . 10 ⁻³	1
1 hp UK, US =	745.7	76.04	641.2	1.1014	550
1 Btu/h =	0.2931	29.89 . 10 ⁻³	0.252	398.5 . 10 ⁻⁶	0.2162

1 kcal/s = 4.1868 . 103W 1W = 238.8 . 10⁻⁶ kcal/s = 1.341 . 10⁻³hp

PRESSURE (STRESS)

	Pa= N/m ²	N/mm ² = MPa	bar	kp/mm ²	lbf/in ² (psi)
1 Pa= 1 N/m ² =	1	10 ⁻⁶	10 · 10 ⁻⁶	0.102 · 10 ⁻⁶	0.145 · 10 ⁻³
1 N/mm ² =1 MPa	106	1	10	0.102	145
1 bar =	100 · 103	0.1	1	10.2 · 10 ⁻³	14.5
1 kp/mm ² =	9.807 · 106	9.807	98.07	1	1.4211 · 103
1 kp/mm ² = at =	98.07 · 103	98.07 · 10 ⁻³	0.9807	10 · 10 ⁻³	14.21
1 lb/in ² = psi =	6.895 · 103	6.895 · 10 ⁻³	68.95 · 10 ⁻³	703	1
1 torr =	133.3	133.3 · 10 ⁻⁶	1.333 · 10 ⁻³	13.6 · 10 ⁻³	19.34 · 10 ⁻³
1 atm =	101.3 · 103	0.1013	1.013	10.33 · 10 ⁻³	14.7

1 mm Hg = 13.6 mm water gauge

1 mm water gauge = 9.81 Pa

1 dyne/cm² = 10Pa

1 Pa = 7.501 · 10⁻³ torr = 9.868 · 10⁻⁶ atm

1 torr = 1 mm Hg at 0°C and 9.81 m/s²

1 atm = 760 mm Hg (torr) = 1.013 · 10⁵ millibar

POWER

	J	kWh	kpm	kcal	ft. lbf
1 J =	1	0.278 · 10 ⁻⁶	0.102	0.239 · 10 ⁻³	0.7376
1 kWh =	3.6 · 106	1	367.1 · 103	859.8	2.655 · 106
1 kpm =	9.80665	2.724 · 10 ⁻⁶	1	2.342 · 10 ⁻³	7.233
1 kcal =	4.1868 · 103	1.163 · 10 ⁻³	426.9	1	3.088 · 103
1 ft. lbf =	1.356	376 · 10 ⁻⁹	0.1383	323.8 · 10 ⁻³	1
1 erg =	0.1 · 10 ⁻⁶	27.78 · 10 ⁻¹⁵	10.2 · 10 ⁻⁹	23.88 · 10 ⁻¹²	73.76 · 10 ⁻⁹
1 Btu =	1.055 · 103	0.293 · 10 ⁻³	107.6	0.2522	778.2

1 eV = 0.1602 · 10⁻¹⁸ J

1 J = 6.242 · 10¹⁸ eV = 107 erg = 0.3777 · 10⁻⁶ hkh

1 hkh = 2.648 · 106 J

ISO-TOLERANCES

THE TOLERANCE RANGE IT IN MM, IS GIVEN ACCORDING TO THE INTERNATIONAL ISO-SYSTEM

Diameter mm		IT 8	IT 9	IT 10	IT 11	IT 12	IT 13	IT 14	
over	up to								
	3	0.014	0.025	0.040	0.060	0.100	0.140	0.250	
3	6	0.018	0.030	0.048	0.075	0.120	0.180	0.300	
6	10	0.022	0.036	0.058	0.090	0.150	0.220	0.360	
10	18	0.027	0.043	0.070	0.110	0.180	0.270	0.430	
18	30	0.033	0.052	0.084	0.130	0.210	0.330	0.520	
30	50	0.039	0.062	0.100	0.160	0.250	0.390	0.620	
50	80	0.046	0.074	0.120	0.190	0.300	0.460	0.740	
80	120	0.054	0.087	0.140	0.220	0.350	0.540	0.870	
120	180	0.063	0.100	0.160	0.250	0.400	0.630	1.000	
180	250	0.072	0.115	0.185	0.290	0.460	0.720	1.150	
250	315	0.081	0.130	0.210	0.320	0.520	0.810	1.300	
315	400	0.089	0.140	0.230	0.360	0.570	0.890	1.400	
400	500	0.097	0.155	0.250	0.400	0.630	0.970	1.550	
500	630	0.110	0.175	0.280	0.440	0.700	1.100	1.750	
630	800	0.125	0.200	0.320	0.500	0.800	1.250	2.000	

Tolerance location. External dimensions, shafts:

h = minus only

js = half minus, half plus

k = plus only

H = plus only

JS = half plus, half minus

K = minus only

Inside dimensions, holes:



CONVERSION TABLE

TEMPERATURE SCALES

Refer to the center column and find the number of degrees to be converted. If °F is to be converted to °C, the required figure is to be found in the left-hand column under C; for converting °C to °F refer to the right-hand column.

C	°	F	C	°	F	C	°	F
-17.8	0	32	132	270	518	299	570	1058
-15.0	5	41	138	280	526	302	575	1067
-12.2	10	50	143	290	554	304	580	1076
-9.4	15	59	149	300	572	307	585	1085
-6.7	20	68	154	310	590	310	590	1094
-3.9	25	77	160	320	608	313	595	1103
-1.1	30	86	166	330	626	316	600	1112
1.7	35	95	171	340	644	318	605	1121
4.4	40	104	177	350	662	321	610	1130
7.2	45	113	182	360	680	324	615	1139
10.0	50	122	188	370	698	327	620	1148
12.8	55	131	193	380	716	329	625	1157
15.6	60	140	199	390	734	332	630	1166
18.3	65	149	204	400	752	335	635	1175
21.1	70	158	210	410	770	338	640	1184
23.9	75	167	216	420	788	341	645	1193
26.7	80	176	221	430	806	343	650	1202
29.4	85	185	227	440	824	346	655	1211
32.2	90	194	232	450	842	349	660	1220
35.0	95	203	238	460	860	352	665	1229
37.8	100	212	243	470	878	354	670	1238
43	110	230	249	480	896	357	675	1247
49	120	248	254	490	914	360	680	1256
54	130	266	260	500	932	363	685	1265
60	140	284	263	505	941	366	690	1274
66	150	302	266	510	950	368	695	1283
71	160	320	268	515	959	371	700	1292
77	170	338	271	520	968	377	710	1310
82	180	356	274	525	977	382	720	1328
88	190	374	277	530	986	388	730	1346
93	200	392	279	535	995	393	740	1364
99	210	410	282	540	1004	399	750	1382
104	220	428	285	545	1013	404	760	1400
110	230	446	288	550	1022	410	770	1418
116	240	464	291	555	1031	416	780	1436
121	250	484	293	560	1040	421	790	1454
127	260	500	296	565	1049	427	800	1472

C	°	F	C	°	F	C	°	F
432	810	1490	671	1240	2264	910	1670	3038
438	820	1508	677	1250	2282	916	1680	3056
443	830	1526	682	1260	2300	921	1690	3074
449	840	1544	688	1270	2318	927	1700	3092
454	850	1562	693	1280	2336	932	1710	3110
460	860	1580	699	1290	2354	938	1720	3128
466	870	1598	704	1300	2372	943	1730	3146
471	880	1616	710	1310	2390	949	1740	3164
477	890	1634	716	1320	2408	954	1750	3182
482	900	1652	721	1330	2426	960	1760	3200
488	910	1670	727	1340	2444	966	1770	3218
493	920	1688	732	1350	2462	971	1780	3236
499	930	1706	738	1360	2480	977	1790	3254
504	940	1724	743	1370	2498	982	1800	3272
510	950	1742	749	1380	2516	988	1810	3290
516	960	1760	754	1390	2534	993	1820	3308
521	970	1778	760	1400	2552	999	1830	3326
527	980	1796	766	1410	2570	1004	1840	3344
532	990	1814	771	1420	2588	1010	1850	3362
538	1000	1832	777	1430	2606	1016	1860	3380
543	1010	1850	782	1440	2624	1021	1870	3398
549	1020	1868	788	1450	2642	1027	1880	3416
554	1030	1886	793	1460	2660	1032	1890	3434
560	1040	1904	799	1470	2678	1038	1900	3452
566	1050	1922	804	1480	2696	1043	1910	3470
571	1060	1940	810	1490	2714	1049	1920	3488
577	1070	1958	816	1500	2732	1054	1930	3506
582	1080	1976	821	1510	2750	1060	1940	3524
588	1090	1994	827	1520	2768	1066	1950	3542
593	1100	2012	832	1530	2786	1071	1960	3560
599	1110	2030	838	1540	2804	1077	1970	3578
604	1120	2048	843	1550	2822	1082	1980	3596
610	1130	2066	849	1560	2840	1093	2000	3632
616	1140	2084	854	1570	2858	1121	2050	3722
621	1150	2102	860	1580	2876	1149	2100	3812
627	1160	2120	866	1590	2894	1177	2150	3902
632	1170	2138	871	1600	2912	1204	2200	3992
638	1180	2156	877	1610	2930	1232	2250	4082
643	1190	2174	882	1620	2948	1260	2300	4172
649	1200	2192	888	1630	2966	1288	2350	4262
654	1210	2210	893	1640	2984	1316	2400	4352
660	1220	2228	899	1650	3002	1343	2450	4442
666	1230	2246	904	1660	3020	1371	2500	4532

WEIGHT TABLES

The tables apply for unalloyed steel, density 7.85. Alloyed steel is sometimes somewhat heavier; high speed steel, for example, is approx. 10% heavier.

FLAT BARS KG/M

Width mm	Thickness mm										
	2	3	4	6	8	10	12	16	20	25	30
10	0.16	0.23	0.31	0.47	0.63	0.79	-	-	-	-	-
25	0.39	0.59	0.79	1.18	1.57	1.96	2.36	3.14	3.93	4.91	-
30	0.47	0.71	0.94	1.41	1.88	2.36	2.83	3.77	4.71	5.89	7.07
40	0.63	0.94	1.26	1.88	2.51	3.14	3.77	5.02	6.28	7.85	9.42
50	0.79	1.18	1.57	2.36	3.14	3.93	4.71	6.28	7.85	9.81	11.8
60	0.94	1.41	1.88	2.83	3.77	4.71	5.65	7.54	9.42	11.8	14.1
70	1.10	1.65	2.20	3.30	4.40	5.50	6.59	8.79	11.0	13.7	16.5
80	1.26	1.88	2.51	3.77	5.02	6.28	7.54	10.1	12.6	15.7	18.8
90	1.41	2.12	2.83	4.24	5.65	7.07	8.48	11.3	14.1	17.7	21.2
100	1.57	2.36	3.14	4.71	6.28	7.85	9.42	12.6	15.7	19.6	23.6
110	1.73	2.59	3.45	5.18	6.91	8.64	10.4	13.8	17.3	21.6	25.9
120	1.88	2.83	3.77	5.65	7.54	9.42	11.3	15.1	18.8	23.6	28.3
130	2.04	3.06	4.08	6.12	8.16	10.2	12.3	16.3	20.4	25.5	30.6
140	2.20	3.30	4.40	6.59	8.79	11.0	13.2	17.6	22.0	27.5	33.0
150	2.36	3.53	4.71	7.07	9.42	11.8	14.1	18.8	23.6	29.4	35.3
160	2.51	3.77	5.02	7.54	10.1	12.6	15.1	20.1	25.1	31.4	37.7
170	2.67	4.00	5.34	8.01	10.7	13.4	16.0	21.4	26.7	33.4	40.0
180	2.83	4.24	5.65	8.48	11.3	14.1	17.0	22.6	28.3	35.3	42.4
190	2.98	4.48	5.97	8.95	11.9	14.9	17.9	23.9	29.8	37.3	44.8
200	3.14	4.71	6.28	9.42	12.6	15.7	18.8	25.1	31.4	39.3	47.1
250	3.93	5.89	7.85	11.8	15.7	19.6	23.6	31.4	39.3	49.1	58.9
300	4.71	7.07	9.42	14.1	18.8	23.6	28.3	37.7	47.1	58.9	70.7
350	5.50	8.24	11.0	16.5	22.0	27.5	33.0	44.0	55.0	68.7	82.4
400	6.28	9.42	12.6	18.8	25.1	31.4	37.7	50.2	62.8	78.5	94.2
450	7.07	10.6	14.1	21.2	28.3	35.3	42.4	56.5	70.7	88.3	106
500	7.85	11.8	15.7	23.6	31.4	39.3	47.1	62.8	78.5	98.1	118
550	8.64	13.0	17.3	25.9	34.5	43.2	51.8	69.1	86.4	108	130
600	9.42	14.1	18.8	28.3	37.7	47.1	56.5	75.4	94.2	118	141
700	11.0	16.5	22.0	33.0	44.0	55.0	65.9	87.9	110	137	165
800	12.6	18.8	25.1	37.7	50.2	62.8	75.4	101	126	157	188
900	14.1	21.2	28.3	42.4	56.5	70.7	84.8	113	141	177	212
1000	15.7	23.6	31.4	47.1	62.8	78.5	94.2	126	157	196	236
1200	18.8	28.3	37.7	56.5	75.4	94.2	113	151	188	236	283

FLAT BARS KG/M

Width mm	Thickness mm											
	32	40	50	60	70	80	90	100	120	125	140	
10	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-
30	7.54	-	-	-	-	-	-	-	-	-	-	-
40	10.0	12.6	-	-	-	-	-	-	-	-	-	-
50	12.6	15.7	19.6	-	-	-	-	-	-	-	-	-
60	15.1	18.8	23.6	28.3	-	-	-	-	-	-	-	-
70	17.6	22.0	27.5	33.0	38.5	-	-	-	-	-	-	-
80	20.1	25.1	31.4	37.7	44.0	50.2	-	-	-	-	-	-
90	22.6	28.3	35.3	42.4	49.5	56.5	63.6	-	-	-	-	-
100	25.1	31.4	39.3	47.1	55.0	62.8	70.7	78.5	-	-	-	-
110	27.6	34.5	43.2	51.8	60.5	69.1	77.7	86.4	-	-	-	-
120	30.1	37.7	47.1	56.5	65.9	75.4	84.8	94.2	113	-	-	-
130	32.7	40.8	51.0	61.2	71.4	81.6	91.9	102	125	128	-	-
140	35.2	44.0	55.0	65.9	76.9	87.9	98.9	110	132	137	154	-
150	37.7	47.1	58.9	70.7	82.4	94.2	106	118	141	147	165	-
160	40.2	50.2	62.8	75.4	89.7	101	113	126	151	157	176	-
170	42.7	53.4	66.7	80.1	93.4	107	120	134	160	167	187	-
180	45.2	56.5	70.7	84.8	98.9	113	127	141	170	177	198	-
190	47.7	59.7	74.6	89.5	104	119	134	149	179	186	209	-
200	50.2	62.8	78.5	94.2	110	126	141	157	188	196	220	-
250	62.8	78.5	98.1	118	137	157	177	196	236	245	275	-
300	75.3	94.2	118	141	165	188	212	236	283	294	330	-
350	87.9	110	137	165	192	220	247	275	330	343	385	-
400	100	126	157	188	220	251	283	314	377	393	440	-
450	113	141	177	212	247	283	318	353	424	442	495	-
500	126	157	196	236	275	314	353	393	471	491	550	-
550	138	173	216	259	302	345	389	432	518	540	605	-
600	151	188	236	283	330	377	424	471	565	589	659	-
700	176	220	275	330	385	440	495	550	659	687	769	-
800	201	251	314	377	440	502	565	628	754	785	879	-
900	226	283	353	424	495	565	636	707	848	883	989	-
1000	251	314	393	471	550	628	707	785	942	981	1099	-
1200	301	377	471	565	659	754	848	942	1130	1178	1319	-

Cont.

FLAT BARS KG/M

	Thickness mm										
	150	180	200	250	300	350	400	450	500	550	600
160	188	-	-	-	-	-	-	-	-	-	-
170	200	-	-	-	-	-	-	-	-	-	-
180	212	254	-	-	-	-	-	-	-	-	-
190	224	269	-	-	-	-	-	-	-	-	-
200	236	283	314	-	-	-	-	-	-	-	-
250	294	353	393	491	-	-	-	-	-	-	-
300	353	424	471	589	707	-	-	-	-	-	-
350	412	495	550	687	824	962	-	-	-	-	-
400	471	565	628	786	942	1099	1256	-	-	-	-
450	530	636	707	883	1060	1236	1413	1590	-	-	-
500	589	707	785	981	1178	1374	1570	1766	1963	-	-
550	648	775	864	1079	1295	1511	1727	1943	2159	2375	-
600	707	848	942	1178	1413	1649	1884	2120	2355	2591	2826
700	824	989	1099	1374	1649	1923	2198	2473	2748	3022	3297
800	942	1130	1256	1570	1884	2198	2512	2826	3140	3454	3768
900	1060	1272	1413	1766	2120	2473	2826	3179	3533	3886	4239
1000	1176	1413	1570	1963	2355	2748	3140	3533	3925	4318	4710
1200	1413	1696	1884	2355	2826	3297	3768	4239	4710	5181	5652

ROUND AND SQUARE BARS, KG/M

SIZE MM	●	■	SIZE MM	●	■	SIZE MM	●	■
1	0.006	0.008	43	11.4	14.5	85	44.5	56.7
2	0.025	0.031	44	11.9	15.2	86	45.6	58.1
3	0.055	0.071	45	12.5	15.9	87	46.6	59.4
4	0.10	0.13	46	13.1	16.6	88	47.7	60.8
5	0.15	0.20	47	13.6	17.3	89	48.8	62.2
6	0.22	0.28	48	14.2	18.1	90	49.9	63.6
7	0.30	0.38	49	14.8	18.9	91	51.1	65.0
8	0.39	0.50	50	15.4	19.6	92	52.2	66.4
9	0.50	0.64	51	16.0	20.4	93	53.3	67.9
10	0.62	0.79	52	16.7	21.2	94	54.5	69.4
11	0.75	0.95	53	17.3	22.1	95	55.6	70.9
12	0.89	1.13	54	18.0	22.9	96	56.8	72.4
13	1.04	1.33	55	18.7	23.8	97	58.0	73.9
14	1.21	1.54	56	19.3	24.6	98	59.2	75.4
15	1.39	1.77	57	20.0	25.5	99	60.4	76.9
16	1.58	2.01	58	20.7	26.4	100	61.7	78.5
17	1.78	2.27	59	21.5	27.3	105	68.0	86.6
18	2.00	2.54	60	22.2	28.3	110	74.6	95.0
19	2.23	2.83	61	22.9	29.2	115	81.5	104
20	2.47	3.14	62	23.7	30.2	120	88.8	113
21	2.72	3.46	63	24.5	31.2	125	96.3	123
22	2.98	3.80	64	25.3	32.2	130	104	133
23	3.26	4.15	65	26.1	33.2	135	112	143
24	3.55	4.52	66	26.9	34.2	140	121	154
25	3.85	4.91	67	27.7	35.2	145	130	165
26	4.17	5.31	68	28.5	36.3	150	139	177
27	4.49	5.72	69	29.4	37.4	155	148	189
28	4.83	6.15	70	30.2	38.5	160	158	201
29	5.19	6.60	71	31.1	39.6	165	168	214
30	5.55	7.07	72	32.0	40.7	170	178	227
31	5.92	7.54	73	32.8	41.8	175	189	240
32	6.31	8.04	74	33.8	43.0	180	200	254
33	6.71	8.55	75	34.7	44.2	185	211	269
34	7.13	9.07	76	35.6	45.3	190	223	283
35	7.55	9.62	77	36.6	46.5	195	234	299
36	7.99	10.2	78	37.5	47.8	200	247	314
37	8.44	10.8	79	38.5	49.0	205	259	330
38	8.90	11.3	80	39.5	50.2	210	272	346
39	9.38	11.9	81	40.5	51.5	215	285	363
40	9.86	12.6	82	41.5	52.8	220	298	380
41	10.6	13.2	83	42.5	54.1	225	312	397
42	10.9	13.9	84	43.5	55.4	230	326	415

Cont.

ROUND AND SQUARE BARS, KG/M

SIZE MM	●	■	SIZE MM	●	■
235	340	434	445	1221	1555
240	355	452	450	1248	1590
245	370	471	455	1276	1625
250	385	491	460	1305	1661
255	401	510	465	1333	1697
260	417	531	470	1362	1734
265	433	551	475	1391	1771
270	449	572	480	1420	1809
275	466	594	485	1450	1847
280	483	615	490	1480	1885
285	501	638	495	1511	1923
290	518	660	500	1541	1963
295	537	683	550	1865	2375
300	555	707	600	2219	2826
305	573	730	650	2605	3317
310	592	754	700	3021	3847
315	612	779	750	3468	4416
320	631	804	800	3946	5024
325	651	829	850	4454	5672
330	671	855	900	4994	6359
335	692	881	1000	6165	7850
340	713	907			
345	734	934			
350	755	962			
355	777	989			
360	799	1017			
365	821	1046			
370	844	1075			
375	867	1104			
380	890	1134			
385	914	1164			
390	938	1194			
395	962	1225			
400	986	1256			
405	1011	1288			
410	1036	1320			
415	1062	1352			
420	1088	1385			
425	1114	1418			
430	1140	1451			
435	1167	1485			
440	1194	1520			

DESIGNATIONS

HB	Hardness Brinell
HRB	Hardness Rockwell B
HRC	Hardness Rockwell C
HV	Hardness Vickers

KCU	Impact toughness in kpm/cm^2 at use of U-notched specimen
KU	Impact toughness in Joule at use of Charpy U-notched specimen
KV	Impact toughness in Joule (earlier in kpm) at use of V-notched specimen

N	Newton, unit for force
---	------------------------

A_5	Elongation in percentage of length after fracture. Measuring length when round specimens are used: $L=5d$. Diameter: d , is the original diameter.
-------	---

R_m	Tensile strength	R_{mb}	Bending strength
$R_{p0.2}$	0.2% proof strength	R_m	Compressive strength

Z	Reduction of area (%)
---	-----------------------

SOME TECHNICAL INFORMATION FROM UDDEHOLMS AB

TOOL STEEL APPLICATION

- Uddeholm Tool Steels for Cold Work tooling
- Uddeholm Tool Steels for Die Casting
- Uddeholm Tool Steels for Extrusion
- Uddeholm Tool Steels for Forging applications
- Uddeholm Tool Steels for Plastic Moulding
- Uddeholm Tool Steels for Component Business
- Stamping with Uddeholm Vancron SuperClean

TREATMENT OF TOOL STEEL

- EDM of tool steel
- Grinding tool steel
- Heat treatment of tool steel
- Photo-etching of tool steel
- Polishing mould steel
- Defect chart and hints for high gloss polishing of steel surfaces
- Welding of tool steel
- Cutting data recommendations for PM tool steel

TOOL STEEL FACTS

- Product information brochures for each Uddeholm steel grade

TECHNICAL SERVICE REPORTS

- Cutting data recommendations for each steel grade

OTHERS

- Uddeholm Welding consumables
- Pre-machined cold work tool steel
- Tooling solutions for advanced high strength steels etc.


© UDDEHOLMS AB

No part of this publication may be reproduced or transmitted for commercial purposes without permission of the copyright holder.

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".

Edition 15.12.2023



Uddeholm is present on every continent. This ensures you high-quality Swedish tool steel and local support wherever you are. We secure our position as the world's leading supplier of tooling material. Our goal is clear – to be your number one partner and tool steel provider.

For more information, please visit
www.uddeholm.com