POCKET BOOK

The Uddeholm range of tooling materials

UDDEHOLM

CONTENTS

Uddeholm Tooling 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 but more detailed information and advice is readily available from your nearest Uddeholm office.

The wide range of printed material and technical information available is summarized on the last page.

UDDEHOLM STEEL GRADES — Composition

Uddeholm Grade	Colour code	Typical analysis								
		C	Si	Mn	Cr	Mo	Ni	V	S	
ALVAR 14	White/Black	0.55	0.3	0.7	1.1	0.5	1.7	0.1		
ALVAR	Red/Black	0.45	0.7	0.8	1.8	0.3	0.5	0.2		**W**
ARNE	Yellow	0.95	0.3	1.1	0.6			0.1		0.6
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		
CHIPPER[2]	–	0.50	1.0	0.5	8.0	1.5		0.5		**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[1]	Blue/Black	1.70	0.8	0.3	18.0	1.0		3.0		
FERMO[2]	–	0.48	0.4	0.9	1.5					
FORMAX	Black	0.18	0.3	1.3						
HOLDAX	Yellow/blue	0.40	0.4	1.5	1.9	0.2			0.07	
HOTVAR	Red/Brown	0.55	1.0	0.8	2.6	2.3		0.9		
IMPAX HI HARD	Brown	0.37	0.3	1.4	2.0	0.2	1.0		max. 0.01	
IMPAX SUPREME	Yellow/Green	0.37	0.3	1.4	2.0	0.2	1.0		max. 0.01	
MIRRAX ESR	[3]	0.25	0.35	0.55	13.3	0.35	1.35	0.35		**+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 SUPERIOR	Blue/Grey	0.39	1.0	0.4	5.2	1.4		0.9		
ORVAR 2 M[4]	Orange/Violet	0.39	1.0	0.4	5.3	1.3		0.9		
POLMAX	Green/Black	0.38	0.9	0.5	13.6			0.3		
QRO 90 SUPREME	Orange/Brown	0.38	0.3	0.8	2.6	2.3		0.9		
RAMAX HH	[5]	0.12	0.2	1.3	13.4	0.5	1.6	0.2	0.1	**+N**
RAMAX LH	Yellow/Brown	0.12	1.0	1.45	14.0	0.2	0.36	0.1	0.13	**+N**
RIGOR	Red/Green	1.00	0.3	0.6	5.3	1.1		0.2		
SLEIPNER	Blue/Brown	0.90	0.9	0.5	7.8	2.5		0.5		
SR 1855	Red/Blue	0.95	1.5	0.8	1.0					
STAVAX ESR	Black/Orange	0.38	0.9	0.5	13.6			0.3		

[1] Powder Metallurgy tool steel. [2] Minimum order quantity. [3] Black/Orange with a white line across. [4] M = Microdized [5] Black/Brown with a white line across.

Uddeholm Grade	Colour code	Typical analysis							
		C	Si	Mn	Cr	Mo	Ni	V	S
									W
SVERKER 3	Red	2.05	0.3	0.8	12.7				1.1
SVERKER 21	Yellow/White	1.55	0.3	0.4	11.8	0.8		0.8	
THG 2000	Yellow/Violet	0.39	0.5	0.4	5.3	1.3		0.9	
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[1]	[2]	1.40	0.4	0.4	4.7	3.5		3.7	
VANADIS 6[1]	Green/ Dark green	2.10	1.0	0.4	6.8	1.5		5.4	
VANADIS 10[1]	Green/Violet	2.90	0.5	0.5	8.0	1.5		9.8	
							W		N
VANCRON 40[1]	Gold/Dark blue	1.10	0.5	0.4	4.5	3.2	3.7	8.5	1.8
VIDAR SUPERIOR	[3]	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	
High speed steel		C			Cr	Mo	W	V	Co
VANADIS 23[1]	Violet	1.28			4.2	5.0	6.4	3.1	
VANADIS 30[1]	Green	1.28			4.2	5.0	6.4	3.1	8.5
VANADIS 60[1]	Gold	2.30			4.2	7.0	6.5	6.5	10.5

[1] Powder Metallurgy tool steel.

[2] Green/white with a black line across.

[3] Orange/red with a white line across.

International Standards Comparison Chart

Uddeholm Grade	ASSAB	AISI (USA)	BS4659 (GB)	W.-Nr. (Germany)	SS (Sweden)	JIS (Japan)
ALVAR 14	ALVAR 14	–	–	1.2714	–	–
ALVAR	–	–	–	1.2329	–	–
ARNE	DF-2	O1	BO1	1.2510	2140	SKS 3
CALDIE	CALDIE	–	–	–	–	–
CALMAX	635[1)]	–	–	1.2358	–	–
CARMO	CARMO	–	–	1.2358	–	–
CHIPPER	VIKING	–	–	(1.2631)	–	–
CORRAX	CORRAX	–	–	–	–	–
DIEVAR	DIEVAR	–	–	–	–	–
ELMAX[2)]	ELMAX[2)]	–	–	–	–	–
FERMO	–	–	–	–	–	–
FORMAX	–	–	–	–	2172	–
HOLDAX	–	–	–	1.2312	–	–
HOTVAR	HOTVAR	–	–	–	–	–
IMPAX HI HARD	718 HH	–	–	–	–	–
IMPAX SUPREME	718 SUPREME	P20 modified	–	1.2738	–	–
MIRRAX ESR	MIRRAX ESR	420, mod.	–	–	–	SUS 420 mod.
NIMAX	NIMAX	–	–	–	–	–
ORVAR SUPREME	8407 SUPREME	H13 improved	BH13	1.2344	2242	SKD 61
ORVAR SUPERIOR	–	H13 improved	BH13	1.2344	2242	SKD 61
ORVAR 2 M[3)]	8407-2M	H13	BH13	1.2344	2242	SKD 61
POLMAX	_	420, mod.	–	(1.2083)	2314	SUS 420
QRO 90 SUPREME	S-168	–	–	–	–	–
RAMAX HH	_	(420F)	–	–	–	–
RAMAX LH	–	(420F)	–	–	–	
RIGOR	XW-10	A2	BA2	1.2363	2260	SKD 12
SLEIPNER	ASSAB 88	–	–	–	–	–
SR 1855		–	–	(1.2108)	2092	–
STAVAX ESR	S-136 ESR[1)]	420, mod.	–	(1.2083)	2314	SUS 420

Some equivalents are approximate only ( ).

[1)] Designation used in South China and Taiwan. [2)] Powder Metallurgy tool steel.

[3)] M = Microdized

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
THG 2000	THG 2000	–	–	–	–	_
UHB 11	_	1148	–	1.1730	1650/ 1672	–
UNIMAX	UNIMAX	–	–	–	–	–
VANADIS 4 EXTRA[1)]	VANADIS 4 EXTRA[1)]	–	–	–	–	_
VANADIS 6[1)]	VANADIS 6[1)]	–	–	–	–	_
VANADIS 10[1)]	VANADIS 10[1)]	–	–	–	–	_
VANCRON 40[1)]	VANCRON 40[1)]	–	–	–	–	–
VIDAR SUPERIOR	VIDAR SUPERIOR	(H11)[2)]	(BH 11)	1.2340 (1.2343)[2)]	–	(SKD 6)
VIDAR 1	–	H11	BH11	1.2343	–	SKD 6
High speed steel						
VANADIS 23[1)]	–	M3:2	–	1.3344	2725	–
VANADIS 30[1)]	–	M3:2+Co	–	(1.3207)	2726	–
VANADIS 60[1)]	–	–	–	(1.3241)	2727	–

Some equivalents are approximate only ( ).

[1)] Powder Metallurgy tool steel.

[2)] Premium modified.

Basic Heat Treatment Guide*

Uddeholm Grade	HB[1)]	Soft-annealing temp. °C	Austenitizing (hardening) temperature °C	Quenching medium
ALVAR 14	≤250	700	830– 900	Oil, step, gas
ALVAR	≤250	780	880– 920	Oil, step, gas
ARNE	190	780	790– 850	Oil, step bath
CALDIE	215	860	1000–1025	Gas, step
CALMAX	200	860	950– 970	Oil, step, gas
CARMO	~250**	860	950– 970	Oil, step, gas
CHIPPER	225	880	980–1050	Oil, step
CORRAX	~330	–	solution treat. 850	Gas
DIEVAR	~160	850	1000–1030	Oil, step, gas
ELMAX[2)]	280	980	1050–1100	Oil, step, gas
FERMO	270**	770	flame hard. 850	Gas(water)
FORMAX	170	–	–	–
HOLDAX	~310**	700	as-del. cond.	–
HOTVAR	~210	820	1050–1070	Oil, step, gas
IMPAX HI HARD	~380**	700	–	–
IMPAX SUPREME	~310**	700	–	–
MIRRAX ESR	250	740	1000–1025	Gas, step
NIMAX	~380**	_	as-del. cond.	–
ORVAR SUPREME	180	850	1020–1050	Oil, step, gas
ORVAR SUPERIOR	180	850	1020–1050	Oil, step, gas
ORVAR 2 M[3)]	180	850	1020–1050	Oil, step, gas
POLMAX	215	890	1000–1050	Oil, step, gas
QRO 90 SUPREME	180	820	1020–1050	Oil, step, gas
RAMAXHH	~340**	740	as-del. cond.	–
RAMAX LH	~290**	740	as-del- cond.	–
RIGOR	215	850	925– 960	Oil, step, gas

* Detailed heat treatment rec. are published 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 Ramax LH, Uddeholm Ramax HH and Uddeholm Fermo use 550°C as stress relieving temp. For Uddeholm Nimax use 450°C.)

**Pre hardened

[1)] Normal delivery hardness. [2)] Powder Metallurgy tool steel. [3)] M = Microdized

Uddeholm Grade	HB[1]	Soft-annealing temp. °C	Austenitizing (hardening) temperature °C	Quenching medium
SLEIPNER	~235	850	950–1080	Gas, step
SR 1855	210	810	850– 880	Oil, step bath
STAVAX ESR	215	890	1010–1050	Oil, step, gas
SVERKER 3	240	850	920–1000	Step, gas
SVERKER 21	210	850	990–1050	Step, gas
THG 2000	185	850	900–1030	Oil, step bath, gas
UHB 11	~200	700	as-del. cond.	–
UNIMAX	185	850	1000–1025	Gas, step
VANADIS 4 EXTRA[2]	230	900	980–1100	Gas, step
VANADIS 6[2]	255	900	1000–1100	Gas, step
VANADIS 10[2]	275	900	980–1100	Gas, step
VANCRON 40[2]	300	900	950–1100	Gas, step
VIDAR SUPERIOR	180	850	980–1000	Oil, step, gas
VIDAR 1	180	850	990–1010	Oil, step, gas
High speed steel				
VANADIS 23[2]	260	875	1050–1180	Gas, step
VANADIS 30[2]	300	875	1000–1180	Gas, step
VANADIS 60[2]	300	875	1000–1180	Gas, step

[1] Normal delivery hardness.

[2] Powder Metallurgy tool steel.

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
ALVAR 14	850[1)]	54	53	45	–	42	38
ALVAR	900	54	53	45	–	43	41
ARNE	830[1)]	62	60	45	43	41	38
CALDIE	1020	–	–	–	61***	59	50
CALMAX	960	59	58	53	53	50	43
CARMO	960	59	58	53	53	50	43
CHIPPER	1010	59	57	59*	58	56	48
CORRAX	850[2)]	–	–	–	–	–	–
DIEVAR	1025	53	52	52*	–	52	47
ELMAX[3)]	1080	59	58	60**	59**	58**	–
FERMO	–	–	–	–	–	–	–
FORMAX	–	–	–	–	–	–	–
HOLDAX	–	–	–	–	–	–	–
HOTVAR	1050	–	56	–	–	57	53
IMPAX HI HARD	–	–	–	–	–	–	–
IMPAX SUPREME	–	–	–	–	–	–	–
MIRRAX ESR	1020	–	50	52**	–	42**	36
NIMAX[4)]	–	–	–	–	–	–	–
ORVAR SUPREME	1020	52	52	54*	–	52	46
ORVAR SUPERIOR	1020	52	52	54*	–	52	46
ORVAR 2 MICRODIZED	1020	52	52	54*	–	52	46
POLMAX	1030	53	52	54**	–	43**	37

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

** For Uddeholm Stavax ESR, Uddeholm Mirrax SER, Uddeholm Polmax and Uddeholm Elmax corrosion resistance is reduced.

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

[1)] Quench in oil

[2)] Solution treatment. Ageing: ~50 HRC after 525°C/2 h, ~46 HRC after 575°C/2h, ~40 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.

Uddeholm Grade	Austenitizing temperature °C	HRC at tempering temperature °C, 2 x 2 h					
		200	250	500	525	550	600
QRO 90 SUPREME	1020	49	49	51*	–	51*	50[1]
RAMAX HH	–	–	–	–	–	–	–
RAMAX LH	–	–	–	–	–	–	–
RIGOR	950	61	58	56*	55*	53	48
SLEIPNER	1030	60	59	62	62****	60****	48
SR 1855	850	63	62	50	48	46	42
STAVAX ESR	1030	53	52	54**	–	43**	37
SVERKER 3	960	60	59	56	53	–	–
SVERKER 21	1020	63	59	60	57	54	48
THG 2000	1020	52	52	53*	–	52	46
UHB 11	–	–	–	–	–	–	–
UNIMAX	1020	–	–	–	–	55	49
VANADIS 4 EXTRA[2]	1020	–	–	–	61	60***	52
VANADIS 6[2]	1050	63	62	63	61	59**	52
VANADIS 10[2]	1060	63	62	65	62	60**	52
				3 x 560°C			
VANCRON 40[2]	950–1100			57–65			
VIDAR SUPERIOR	1000	52	51	51*	–	50	45
VIDAR 1	1000	54	53	55*	–	52	46
High speed steel				**3 x 560°C**			
VANADIS 23[2]	1050–1180			60–66			
VANADIS 30[2]	1000–1180			60–67			
VANADIS 60[2]	1000–1180			64–69			

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

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

*** The lowest tempering temperature when high temperature tempering is 525°C (for hardening temperatures >1050°C: 540°C).

**** The lowest tempering temperature when high temperature tempering is 525°C (for hardening temperatures >1050°C: 540°C).

[1] At 650°C 2 x 2h: 42 HRC

[2] Powder Metallurgy tool steel.

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.
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.
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	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.
VANADIS 6	Uddeholm Vanadis 6 is a cold work steel produced by the powder metallurgy process and is characterized by high wear resistance and good chipping resistance and compressive strength. It has a simpler (cold work) heat treatment than a PM high speed steel and a better wear resistance than Uddeholm Vanadis 23. It is suitable for high volume production tooling for hard to medium hard production materials.
VANADIS 10	A cold work tool steel produced by the powder metallurgy process. It is characterized by a very high abrasive wear resistance coupled with reasonable toughness. It is very suitable for high volume production tooling for paper and foil slitting, granulation of plastics, gaskett stamping and electrical sheet stamping.
VANADIS 23	Uddeholm Vanadis 23 is 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.
VANCRON 40	Uddeholm Vancron 40 is 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 often not necessary to surface coat the tool to avoid galling.

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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 prehardened bolster steel for support plates and holders.

Steel for Special Applications

Uddeholm grade	Description/Applications
CARMO	A prehardened 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.
SR 1855	A low alloyed tool steel very suitable for profile rolls.
VANCRON 40	A nitrogen alloyed PM steel which often need not be coated to avoid galling, sticking and adhesive wear.

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	Machin-ability	Grind-ability	Dimension stability	Ductility
ARNE					
CALDIE					
CALMAX					
RIGOR					
SLEIPNER					
SVERKER 3					
SVERKER 21					
UNIMAX					
VANADIS 4 EXTRA					
VANADIS 6					
VANADIS 10					
VANADIS 23					
VANCRON 40					

Selection Chart

Part	Uddeholm grade	Hardness HRC
Punches, dies	ARNE, CALDIE, CALMAX, RIGOR, SVERKER 3, SVERKER 21, SLEIPNER, UNIMAX, VANADIS 4 EXTRA, VANADIS 6, VANADIS 10, VANADIS 23, VANCRON 40	54–64
Top- and bottom plates	FORMAX, UHB 11, HOLDAX	As supplied
Punch backing plate	ARNE	58–60
Punch retaining plate	ARNE precision ground flat stock	–
Stripper plate/ strip guide	ARNE, UHB 11 precision ground flat stock	–

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	ROP 20, SLEIPNER, SVERKER 21, VANADIS 6 VANADIS 10, VANADIS 23, VANCRON 40
Forming rolls	SVERKER 21, CALDIE, CALMAX, SLEIPNER, VANADIS 4 EXTRA, VANADIS 6, VANADIS 10, VANADIS 23, VANCRON 40
Pressing of ceramics	SVERKER 3, SVERKER 21
Powder metal compaction	CALDIE, UNIMAX, VANADIS 4 EXTRA, VANCRON 40

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.

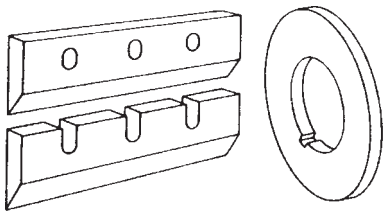
Property Comparison Guide for Cold Work Steel

Uddeholm Grade	Hardness/ Resistance against plastic deformation	Wear resistance		Fatigue cracking resistance	
		Abrasive	Adhesive	Ductility/ chipping	Toughness/ Gross cracking
ARNE					
CALDIE					
CALMAX					
RIGOR					
SLEIPNER					
SVERKER 3					
SVERKER 21					
UNIMAX					
VANADIS 4 EXTRA					
VANADIS 6					
VANADIS 10					
VANADIS 23					
VANCRON 40					

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.



Uddeholm grade	Description/Applications
CHIPPER	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.
SVERKER 3 SVERKER 21	Steel with high C-Cr-content and an excellent wear resistance. Suitable for wood milling cutters.
VANADIS 4 EXTRA	Cold work tool steel produced by the powder metallurgy process. Superior adhesive wear resistance and toughness.
VANADIS 6 VANADIS 10	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	High speed steel produced by the powder metallurgy process. Good combination of wear resistance, chipping resistance and compressive strength. Suitable for production materials which cause mixed or abrasive wear.
RIGOR	A tool steel with a good combination of toughness and general wear resistance.
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.

Cont.

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.
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.
ARNE	Low alloyed universal tool steel for short runs. Excellent machinability.

Property Comparison Chart for Uddeholm Tool Steel for Industrial Knives

Uddeholm grade	Chipping resistance	Wear resistance	Machin-ability	Dimensional stability at hardening
ARNE				
CALDIE				
CALMAX				
CHIPPER				
RIGOR				
SLEIPNER				
SVERKER 3				
SVERKER 21				
UNIMAX				
VANADIS 4 EXTRA				
VANADIS 6				
VANADIS 10				
VANADIS 23				

Selection Chart

Part			Uddeholm grade	HRC
Chipper knives			CHIPPER	56–58
Flaker knives			CHIPPER	56–58
Reducer knives			CHIPPER	56–58
Planer knives			SVERKER 21, SLEIPNER	58–60
Shear knives, hot			CALDIE, ORVAR 2 MICRODIZED, UNIMAX	52–54
	cold	thin stock	SVERKER 21	58–60
		thick stock	CALDIE, RIGOR, VANADIS 4 EXTRA CALMAX, SLEIPNER, UNIMAX	56–58 54–58
Circular slitting knives			SVERKER 21, RIGOR, SLEIPNER, VANADIS 4 EXTRA, VANADIS 6, VANADIS 10, VANADIS 23 UNIMAX	58–62 56–64 54–58
Plastic granulator knives			RIGOR, SVERKER 21, SLEIPNER, VANADIS 4 EXTRA CALDIE, VANADIS 6, VANADIS 10, VANADIS 23 UNIMAX	58–60 58–64 54–58
Tobacco knives			ARNE	58–60
Fragmentation knives			CALMAX, RIGOR, SVERKER 21, SLEIPNER, VANADIS 4 EXTRA, VANADIS 6, VANADIS 10, VANADIS 23, UNIMAX	55–64

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 #207-2006
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 #207–2006.
ORVAR SUPREME ORVAR SUPERIOR	Premium Cr-Mo-V-alloyed hot work die steel (H13) with good resistance to thermal fatigue. The steel are produced by a special melting and refining technique and meet the requirements of NADCA #207–2006.
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 prehardened Uddeholm QRO 90 Supreme material supplied at 37–41 HRC and suitable for core pins.
IMPAX SUPREME	A prehardened 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 prehardened steel with very good machinability supplied at ~310 HB for clamping and holding plates.
UNIMAX	A premium Cr-Mo-V alloyed steel with a good toughness and ductility up to a hardness of 58 HRC.

Qualitative Comparison of resistance to different die failures

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

The longer the bar, the better.

Further information is given in the Uddeholm brochure “Die Steel and improved Productivity in Die Casting”.

Selection Chart

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

SUP. = Supreme

Cont.

Selection Chart

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. / SUPERIOR 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. / SUPERIOR 42–48 HRC QRO 90 SUP. 42–46 HRC	QRO 90 SUP. 40–44 HRC ORVAR SUP. / SUPERIOR 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**	ORVAR SUP. 42–46 HRC (nitrided)	ORVAR SUP. / SUPERIOR QRO 90 SUP. 42–48 HRC (nitrided)	QRO 90 SUP. / ORVAR SUP. / SUPERIOR 42–46 HRC (nitrided)

SUP. = Supreme * Surface treatment is recommended.

STEEL FOR EXTRUSION DIES

Uddeholm grade	Description/Applications
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.
HOTVAR	A premium hot work steel with very good high temperature properties. Can be hardened and tempered to 58 HRC giving an outstanding hot wear resistance.
UNIMAX	A premium Cr-Mo-V alloyed steel with a good toughness and ductility up to a hardness of 58 HRC.
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.
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.
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.
ALVAR 14 / ALVAR	A Cr-Ni-Mo-alloyed hot work steel used for support parts for extrusion tooling, e.g. backers and bolsters.
IMPAX SUPREME	Prehardened Ni-Cr-Mo-alloyed steel supplied at 290–330 HB and suitable for mantles.

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 SUP.				
HOTVAR				
DIEVAR				
UNIMAX				

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

Selection Chart

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 ALVAR 14 / ALVAR 300–400 HB	IMPAX SUP. ~310 HB ALVAR 14 / ALVAR 300–400 HB	IMPAX SUP. ~310 HB ALVAR 14 / ALVAR 300–400 HB
Bolster	ALVAR 14 / ALVAR 45 HRC	ALVAR 14 / ALVAR 45 HRC	ALVAR 14 / ALVAR 45 HRC
Die ring	ORVAR 2 M 40–44 HRC	QRO 90 SUP. 40–44 HRC	QRO 90 SUP. 40–44 HRC
Die	VIDAR 1/ORVAR 2M/ QRO 90 SUP. 45–50 HRC DIEVAR 46–52 HRC HOTVAR 54–58 HRC UNIMAX 52–58 HRC	QRO 90 SUP. 45–49 HRC	QRO 90 SUP. 44–46 HRC

SUP. = Supreme, M = Microdized

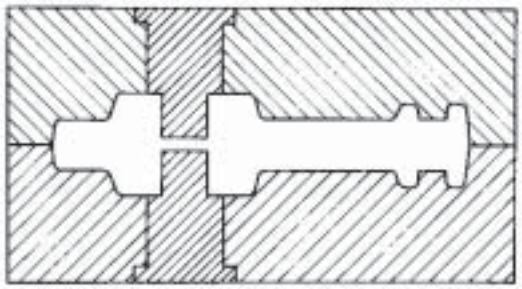
Cont.

Selection Chart

Tool part	Aluminium, Magnesium	Copper alloys	Steel
Mantle Intermediate liner	IMPAX SUP. ~310 HB ORVAR 2 M 37–43 HRC	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 DIEVAR 44–50 HRC	QRO 90 SUP. 44–48 HRC DIEVAR 44–50 HRC	ORVAR 2 M 44–48 HRC
Dummy block	QRO 90 SUP. 44–48 HRC DIEVAR 46–52 HRC	QRO 90 SUP. 44–48 HRC	QRO 90 SUP. 44–48 HRC
Fastener for fixed dummy block	IMPAX SUP. ~310 HB		
Stem	ORVAR 2M 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



Uddeholm grade	Description/Applications
DIEVAR	A premium Cr-Mo-V alloyed hot work steel with good high temperature strength and excellent toughness and ductility. Recommended in dies where the demands on toughness and ductility are the highest.
HOTVAR	A premium hot work steel with very good high temperature properties. Can be hardened and tempered to 58 HRC giving an outstanding hot wear resistance. Recommended as small inserts in "special forging" applications.
ORVAR SUPREME (H13) VIDAR SUPERIOR (modified H11)	Premium Cr-Mo-V-alloyed hot work die steel with good high temperature strength, very good toughness and resistance to hot wear.
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.
UNIMAX	A premium Cr-Mo-V alloyed steel with good toughness and ductility up to a hardness of 58 HRC.

Qualitative comparison of resistance to different tool failures

Uddeholm grade	Hot wear	Plastic deformation	Premature cracking	Heat checking
VIDAR SUPERIOR				
ORVAR SUPREME				
QRO 90 SUPREME				
HOTVAR				
DIEVAR				
UNIMAX				

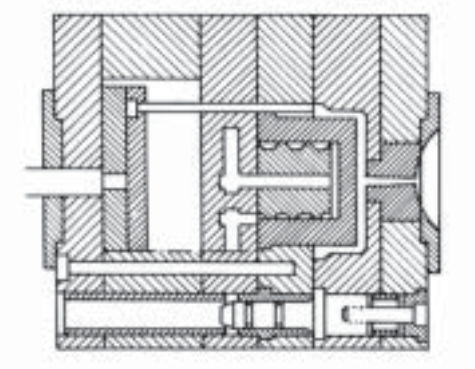
The longer the bar, the better.

Selection Chart—Press Forging

Tool part	Aluminium, Magnesium	Copper alloys	Steel
Die	QRO 90 SUPREME 44–50 HRC DIEVAR 46–52 HRC ORVAR SUPREME 44–52 HRC	QRO 90 SUPREME 42–48 HRC	VIDAR SUPERIOR/ ORVAR SUPREME/ DIEVAR 40–50 HRC QRO 90 SUPREME 42–48 HRC UNIMAX 50–56 HRC
Insert, cores	QRO 90 SUPREME 44–50 HRC	QRO 90 SUPREME 44–50 HRC HOTVAR 52–54 HRC	QRO 90 SUPREME 44–50 HRC HOTVAR 52–56 HRC UNIMAX 50–56 HRC

Selection Chart—Trimming Dies

Tool part	Aluminium, Magnesium	Copper alloys	Steel
Punch/Die (hot)	RIGOR 58–60 HRC	RIGOR 58–60 HRC	SVERKER 21 58–60 HRC
Punch/Die (cold)	RIGOR 56–58 HRC	RIGOR 58–60 HRC	RIGOR 56–58 HRC



Uddeholm recommends the following steel:

Uddeholm grade	Description/Applications
IMPAX SUPREME	A prehardened Ni-Cr-Mo-steel, supplied at 290–330 HB, with excellent polishing and photo-etching properties. Suitable for a wide range of injection moulds, blow moulds and extrusion dies.
NIMAX	Low carbon steel with delivery hardness of 360–400 HB. Excellent machinability and weldability. Very good toughness, polishability and texturing 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.
UNIMAX	A steel with very good hardenability suitable for surface treatment. Excellent combination of wear resistance and toughness. Recommended for long run moulds and for moulding of reinforced plastics.

Cont.

Uddeholm grade	Description/Applications
POLMAX	A through hardening corrosion resistant mould steel with an excellent polishability.
CORRAX	A precipitation hardening steel with extremely good corrosion resistance.
ORVAR SUPREME	A versatile through hardening 5% Cr mould and die steel with good wear resistance and polishability.
RIGOR	A through hardening steel recommended for very long production runs of smaller complicated moulding.
ELMAX VANADIS 4 EXTRA VANADIS 6 VANADIS 10	Powder metallurgically produced mould steel character-ized by very good dimension stability, good polishability and wear resistance. Uddeholm Elmax is corrosion resistant, Uddeholm Vanadis 4 Extra has the highest toughness and Uddeholm Vanadis 10 the best wear resistance. Recommended for long produc-tion runs of smaller and complicated shapes and/or abrasive plastics.
VANCRON 40	Uddeholm Vancron 40 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	Prehardened holder steel, supplied at 290–330 HB, with a very good machinability.
RAMAX HH RAMAX LH	Prehardened corrosion resistant sulphurized steel. Uddeholm Ramax HH is supplied at 320–352 HB and can be used for dies and calibers for plastic extrusion as well as for holders/bolsters. Uddeholm Ramax LH is supplied at 270–310 HB and has an extremely good machinability. Main application is mould bases.
ALUMEC	High strength Al-alloy supplied at ~160 HB. Recommend-ed for blow moulds, prototype moulds and for short runs with low demands on strength and wear resistance.

Cont.

MOLDMAX HH	High strength Beryllium-Copper alloy, supplied at 40 HRC.
MOLDMAX XL	High strength Nickel-Tin-Copper alloy supplied at ~30 HRC. The different Moldmax alloys are suitable mould materials for a variety of moulding situations where a combination of high thermal conductivity, corrosion resistance and good polishability are needed.

For more detailed recommendations, see the application brochure "Steel for Moulds".

Property Comparison Guide for Mould Steel

Uddeholm grade	Machin-ability*	Wear resistance	Polishability	Corrosion resistance
IMPAX SUPREME				
IMPAX HI HARD				
NIMAX				
STAVAX ESR				
MIRRAX ESR				
UNIMAX				
POLMAX				
CORRAX				
ORVAR SUPREME				
RIGOR				
ELMAX				
VANADIS 4 EXTRA				
VANADIS 6				
VANADIS 10				
VANCRON 40				
HOLDAX				
RAMAX HH				
RAMAX LH				

* Uddeholm Impax Supreme, Uddeholm Nimax, Uddeholm Holdax, Uddeholm Ramax HH and Uddeholm Ramax LH are tested in prehardened 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 – prehardened mould steel	ALUMEC	(~160)
		IMPAX SUPREME	33(~310)
		NIMAX	~380
	– through hardened mould steel	CORRAX	36–50
		ORVAR SUPREME	45–52
		STAVAX ESR	45–52
		MIRRAX ESR	45–50
		UNIMAX	50–58
		POLMAX	45–52
		ELMAX	58–60
		VANADIS 4 EXTRA	58–62
		VANADIS 6	60–64
	Thermoset plastics	RIGOR, ELMAX	58–60
		UNIMAX	52–58
		VANADIS 4 EXTRA	58–62
		VANADIS 6	60–64
Compression/Transfer moulding	Thermoset plastics	STAVAX ESR	45–52
		MIRRAX ESR	45–50
		UNIMAX	52–58
		ELMAX	58–60
		ORVAR SUPREME	45–52
		VANADIS 4 EXTRA	58–62
		VANADIS 6	60–64
Blow moulding	General	IMPAX SUPREME	33(~310)
		ALUMEC	(~160)
		NIMAX	~380
	PVC	STAVAX ESR	45–52
		MIRRAX ESR	45–50
		RAMAX HH	37(~340)
		CORRAX	36–50

Cont.

General Recommendations

Process	Material	Recommended Steel grade	Hardness HRC (HB)
Extrusion	General	IMPAX SUPREME	33(~310)
		NIMAX	~380
	PVC	STAVAX ESR	45–52
		MIRRAX ESR	45–50
		RAMAX HH	37(~340)
		CORRAX	36–50

Special Recommendations

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

Cont.

Special Recommendations

Special req. or demand	Example	Recommended Steel grade	Hardness HRC (HB)
Complex shapes	3. For small parts with high wear demands, e.g. electrical/electronic mouldings	RIGOR	60–62
		ORVAR SUPREME	50–52
		STAVAX ESR	50–52
		MIRRAX ESR	45–50
		UNIMAX	56–58
		ELMAX	58–60
		VANADIS 4 EXTRA	58–62
		VANADIS 6	60–64
Abrasive moulding materials	Reinforced/filled moulding materials	RIGOR	58–62
		ORVAR SUPREME	50–52
		STAVAX ESR	50–52
		MIRRAX ESR	45–50
		UNIMAX	56–58
		VANADIS 4 EXTRA	58–62
		ELMAX	58–60
		VANADIS 6	60–64
Long production runs	For thermoplastic parts, including disposable cutlery, containers and packaging	STAVAX ESR	45–52
		MIRRAX ESR	45–50
		UNIMAX	52–58
		ORVAR SUPREME	45–52
		ELMAX	58–60
		VANADIS 4 EXTRA	58–62
		VANADIS 6	60–64
Corrosive	1. For corrosive moulding materials 2. For humid moulding/mould storage conditions 3. General resistance to surface staining/rusting 4. Resistance to corrosion of cooling channels	ELMAX	58–60
		STAVAX ESR	45–52
		MIRRAX ESR (moulds)	45–50
		RAMAX HH	37(~340)
		RAMAX LH (holders)	~290
		CORRAX	34–50

Cont.

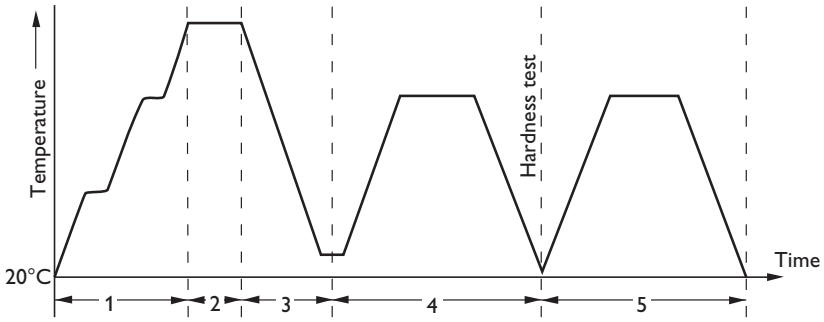
Special req. or demand	Example	Recommended Steel grade	Hardness HRC (HB)
Photo-etching	1. Pre-hardened steel	IMPAX SUPREME	33(~310)
		NIMAX	~380
	2. Through-hardened steel	ORVAR SUPREME	45–52
		STAVAX ESR	45–52
		MIRRAX ESR	45–50
		UNIMAX	50–58
		ELMAX	58–60
		VANADIS 4 EXTRA	58–62
		VANADIS 6	60–64
High thermal conductivity	For injection and blow moulds, cores and inserts; parts for hot runner systems	MOLDMAX* HH	~40
		MOLDMAX* XL	~30

* Moldmax is a trade mark registered by Brush Wellman Inc. Cleveland, Ohio.

NOTES

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 Vancron 40 and high speed steel. If extremely high austenitizing temperatures, >1100°C (2010°F), are used all Uddeholm Vanadis grades should be tempered three times in order to reduce the amount of retained austenite and to optimize the microstructure.

PM Steel for improved production economy

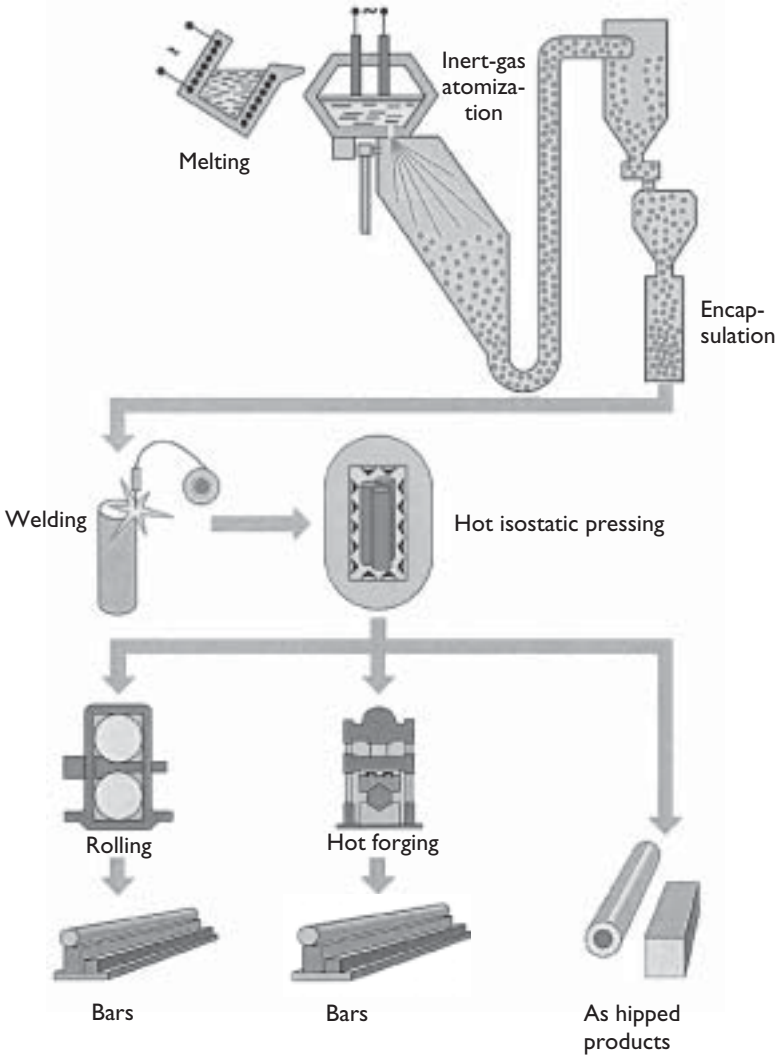
The powder metallurgy (PM) process is a rapid solidification process for the manufacturing of high-speed steel and tool steel. This method eliminates the problems which arise when steel solidifies in ingot moulds, such as local variations in chemical composition and microstructure in the form of segregations.

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, Uddeholm Vanadis 6, Uddeholm Vanadis 10, Uddeholm Vanadis 23 and Uddeholm Elmax are produced by a special PM process which gives a superclean tool steel, with improved properties over standard PM steel, like better polishability, toughness and bend strength. Uddeholm Vancron 40 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.

- 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 lack of segregations permits a more effective use of alloying elements and higher levels of alloying elements can be used than previously was possible with conventional steel
- Desirable characteristics such as abrasion resistance can be enhanced without sacrificing other vital properties

The PM route for producing tool steel



UDDEHOLM HIGH PERFORMANCE STEEL—HPS

Uddeholm High Performance Steel (HPS) markets the Uddeholm product range in other applications than industrial tooling, where the product characteristics of industrial tool steel lead to lower maintenance costs and contribute to enhanced performance and optimum overall economy. Development shall take place in close cooperation with manufacturers of machines and components.

HPS applications can be found anywhere within any industry:

- Recycling
- Pulp & Paper
- Steel Mill & Mining
- Manufacturing Industry
- Racing
- Engineering solutions

Recycling

Encompasses production processes, machine builders and component manufacturers operating businesses that reclaim or recycle material either themselves or through their customers. When recycling material there is almost always a stage wherein large pieces are reduced to smaller pieces by cutting or crushing. Profitability very much depends on how much material can be processed. Uddeholm's customers may be the machinery manufacturers themselves, or the end users, who recycle most types of material.

Pulp & Paper

Covers industries in the business of processing raw material from forestry. Examples are companies in the woodworking industry, board, paper and fibre pulp manufactures, and paper mills. Due to the often aggressive environment our stainless concept steel can be problem solvers.

Steel Mill & Mining

Includes the steelmaking and mining industries, along with companies providing service and maintenance related to these industries. There are many different applications where there is a need for more durable components with prolonged service life, where customers can benefit from better overall economy.

Manufacturing Industry

Covers manufacturing, where material from Uddeholm is used in large volumes and the customers manufacture large numbers of components. Customers are often machinery manufacturers or their subcontractors. Product examples are tool holders for cutting tools and components in automated production lines.

Racing

Includes material and components used for competitive purposes. Our target groups are teams who actively participate in competition, and component manufacturers whose customers use parts for racing. Examples of products that fit nicely into Uddeholm High Performance Steel are drive shafts, crankshafts, connecting rods, camshafts, valve guides, valve seats and fittings.

Engineering solutions

High Performance Steel largely targets end users, who often do not have their own engineering drawings or product manufacturing facilities. As a result we have to be able to produce and deliver finished, heat-treated and surface finished detail parts. Manufacturing takes place in our own production facilities, by external subcontracting manufacturers, or a combination. Parts can be delivered in their finished state of sample testing.

In full scale production we shall be able to offer assistance with providing optimal production paths, both internally and externally, based on previous test production. Products will then be phased in to some of the other industrial sectors.

HIGH PERFORMANCE STEEL FOR SHAFTS

Shafts are some of the most important components, they transfer torque and carry loads. Uddeholm High Performance Steel has a broad programme even for the very toughest conditions.

Some of the steel are delivered in prehardened condition. Products made from prehardened steel can be used directly after machining with no subsequent heat treatment, thus saving time.

The steel have many areas of application. The application can be optimised by choosing a steel type and supplementary heat treatment.

Example of steel used for shafts:

Uddeholm Dievar is an excellent steel when strength is vitally important. After machining, the steel is hardened and tempered to the right hardness and thereby strength for the specific requirement.

Uddeholm Orvar Supreme with good heat treatment properties mean stability with only minor changes in dimensions. The steel is successfully used as a drive shaft for track racing and rallycross.

Uddeholm THG 2000 HT is an extremely strong, tough steel. A pre-hardened steel for production of finished components, with no need for subsequent heat treatment.

Uddeholm Nimax is a prehardened universal steel with high toughness, excellent cutting properties and weldability.

Uddeholm Impax Supreme is a prehardened steel, available in large dimensions, which can be used without subsequent heat treatment. Nitriding further enhances wear resistance while increasing corrosion resistance. Uddeholm Impax Supreme is a very clean steel which, like our other steel, is ultrasonically tested.

Higher strength of material

Uddeholm Dievar
- Ø 25.4–712 mm
- Delivery condition: rough machined
- Delivery hardness: 160 HB
- Potential hardness: 48–52 HRC
- Soft annealed

Uddeholm Orvar Supreme
- Ø 10–550 mm
- Delivery condition: rough machined
- Delivery hardness: 180 HB
- Potential hardness: 48–52 HRC
- Soft annealed

Uddeholm THG 2000 HT
- Ø 16.2–110 mm
- Delivery condition: rough machined
- Delivery hardness: 39–43 HRC
- Prehardened

Uddeholm Nimax
- Ø 35–670 mm
- Delivery condition: rough machined
- Delivery hardness: 360–400 HB
- Prehardened

Uddeholm Impax Supreme
- Ø 12.7–800 mm
- Delivery condition: rough machined
- Delivery hardness: 300–330 HB
- Prehardened

PRE-MACHINED TOOL STEEL

In tool manufacture, material cost represents only a small fraction (approx. 10%) of the total cost of the tool. Machining represents a considerably larger portion. It has been calculated that rough machining prior to heat treatment accounts for about 20% of the total cost. Some of the rough machining is less qualified and should not have to be done by skilled toolmakers.

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 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 is 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.

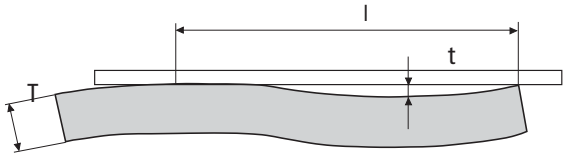
Tolerances

Width +0.4/+0.8 mm
Maximum deviation in width on a 1000 mm long bar 0.1 mm.

Thickness +0.4/+0.65 mm
Maximum deviation in thickness on a 1000 mm long bar 0.1 mm..

Flatness and straightness
Maximum deviation (t) devided by the length (l) according to the figure below, may not exceed the below stated values. As example for size 200 x 25 mm, measuring over 1000 mm, the maximum deviation may be t/1000 = 0.0005, t = 0.5 mm.

Thickness T, mm	Width mm	
	<160	≥160
	t/l max	
4–8	0.0013	0.0015
(8)–20	0.0008	0.0010
(20)–200	0.0003	0.0005

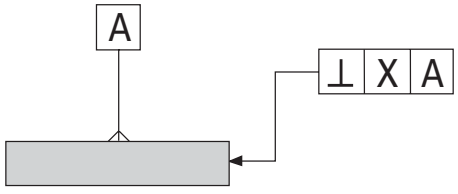


Surface finish

On the flat surfaces: Ra max 2.5 μm.
On the edge surfaces: Ra max 6.3 μm.

Corner squareness

Material with a thickness up to 80 mm maximum deviation “X” = 0.10 mm. Thickness above 80 mm maximum deviation “X” = 0.15 mm.



MACHINING SERVICES

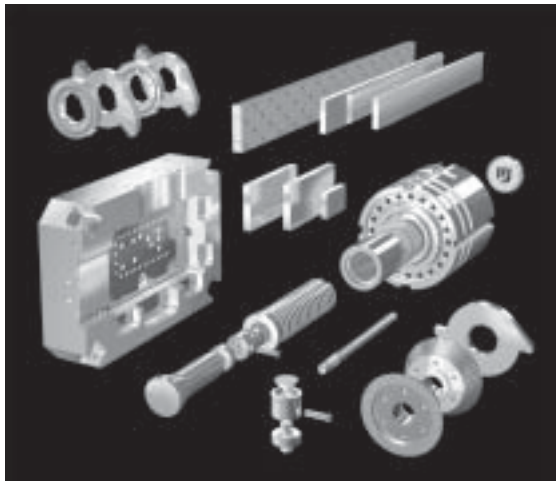
In addition to supplying a high proportion of our steel in the machined condition, in many cases we can offer following custom machining services.

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
- Re-temper after re-grinding operations
- 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

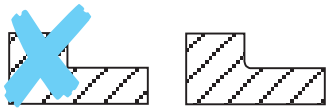
- Stress temper after the rough machining but before fine machining for best results regarding dimensional changes, etching and welding
- Reduce the risk for corrosion on the mould surfaces and the risk for reduced cooling efficiency because of rust in cooling channels by using a corrosion resistant 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

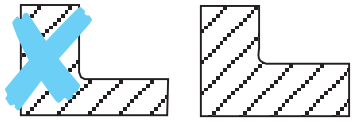
- Design around standard sizes wherever possible. Uddeholm Tooling normally supplies oversized bar with a machining allowance to finish at a convenient nominal size, e.g. 125 x 25 mm
- Use adequate overall dimensions!

Unmachined cross section:
133 x 28 mm
Pre-machined cross section:
125 x 25 mm with machining allowance

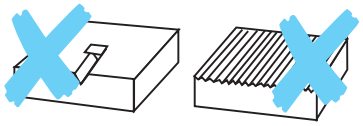
- Avoid sharp corners!



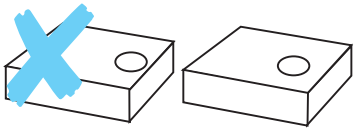
- Avoid uneven sections!



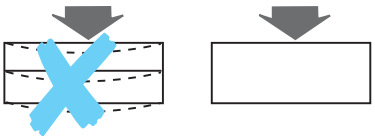
- Avoid potential stress raising marks, e.g. cold stamps, rough machining!



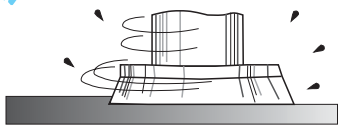
- Leave sufficient stock thickness between holes and plate edges!



- 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 (triple temper Uddeholm Vanadis)
- 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 tteels".

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 weld rod materials 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, Unimax TIG-Weld, QRO 90 TIG-Weld, Dievar TIG-Weld, Calmax/Carmo TIG-Weld, Corrax TIG-Weld, Caldie TIG-Weld and Moldmax WeldPak

For further information see the Uddeholm brochure "Welding 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
- Re-temper tools after re-grinding operations
- 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 tool steel".

HINTS ON EDM

Electro Discharge Machining (EDM'ing)

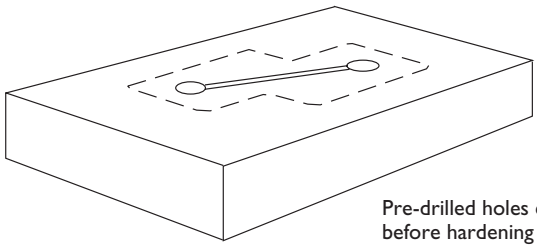
When spark eroding cavities, one or two important points should be noted in order to obtain satisfactory results. During the operation the surface layer of the steel is re-hardened and consequently in a brittle state. This may result in fatigue cracking and shortened tool life. To avoid this problem 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 tools 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 slot in the proposed aperture, before heat treatment; this allows the work piece to adjust to the final shape and stress pattern, during heat treatment.



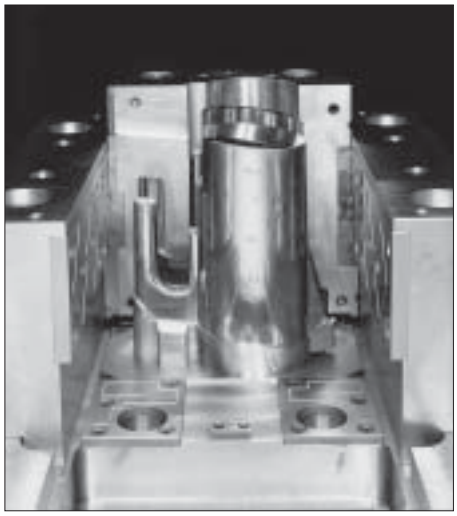
Pre-drilled holes connected by a saw-cut, before hardening and tempering, will help to prevent distortion or cracking when wire-eroding thick sections

HINTS ON POLISHING MOULD STEEL

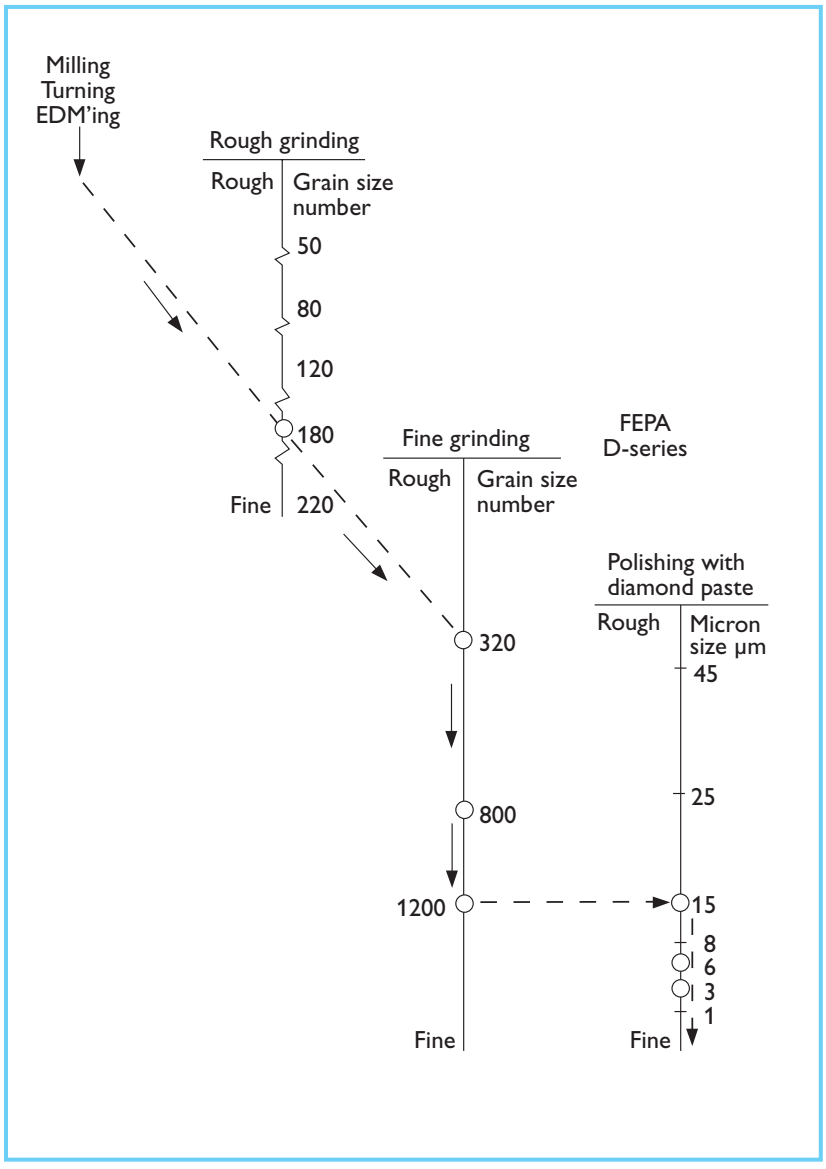
In spite of an increasing number of mechanical polishing aids, the skilled technique and judgement of an experienced polisher is still an essential ingredient in obtaining the required surface finish as quickly as possible.

- 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

Follow the recommended polishing sequences given in the Uddeholm brochure "Polishing mould steel". A typical sequence is shown on the opposite page.



A highly polished mould in Uddeholm Stavax ESR which produces the body for an electric kettle.



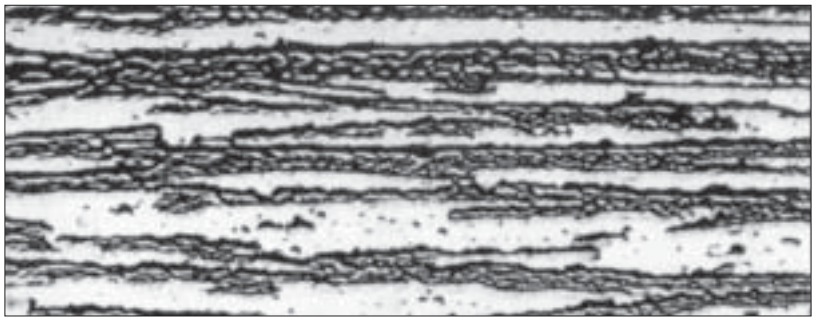
A typical polishing sequence.

HINTS ON PHOTO-ETCHING

Uddeholm Impax Supreme prehardened 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 angel for the shape and pattern concerned

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



Typical photo-etched pattern.

HARDNESS CONVERSION TABLE

Approx. comparison between hardness and ultimate tensile strength.

Rockwell		Brinell*	Vickers 30 kg	Approx. UTS		Shore sclero-scope
HRC	HRB			N/mm²	kp/mm²	
	78	133	140	446	46	21
	85	152	160	510	52	24
	91	171	180	570	58	26
	95	190	200	637	65	29
	98	209	220	696	71	32
		228	240	756	77	34
		247	260	824	84	37
		265	280	883	90	40
30		284	300	951	97	42
33		303	320	1020	104	45
35		322	340	1080	110	47
37		341	360	1150	117	50
39		360	380	1210	123	52
41		379	400	1280	130	55
42		397	420	1340	137	57
44		415	440	1410	144	59
46		433	460	1470	150	62
47		452	480	1530	156	64
48		471	500	1610	164	66
50		488	520	1690	172	67
51		507	540	1770	180	69
52		525	560	1850	188	71
53		545	580	1940	198	72
54		564	600			74
55		584	620			75
56		601	640			77
57		620	660			79
59		638	680			80
59			700			81
60			720			83
61			740			84
62			760			86
63			780			87
64			800			88
64			820			90
65			840			91
66			860			92
66			880			93

* 10 mm ball, 3 000 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	ton[1)]	0.0004536
kg	lb	2.205
kg	tons[2)]	0.00098
tons[2)]	kg	1016
tons[2)]	ton[1)]	1.016
ton[1)]	tons[2)]	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

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

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

Temperature conversion

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

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

Exact formulae:

$$°F = \frac{°C \cdot 9}{5} + 32$$

$$°C = (°F - 32) \cdot \frac{5}{9}$$

Pressure, tensile strength

To convert	to	multiply by
tons/in²	N/mm²	15.5
tons/in²	kp/mm²	1.57
tons/in²	lb/in²	2240
N/mm²	kp/mm²	0.102
N/mm²	lb/in²	145
N/mm²	tons/in²	0.065
kp/mm²	lb/in²	1422.34
kp/mm²	tons/in²	0.635
kp/mm²	N/mm²	9.81
lb/in²	tons/in²	0.00045
lb/in²	N/mm²	0.0069
lb/in²	kp/mm²	0.000703
lb/in²	MPa	0.00689
MPa	lb/in²	145
bar	ln/in²	14.51

Steel weights

Metric sizes

Flats and squares: W(mm) x T(mm) x L(m) x 0.00785 = weight in kg.
Rounds: D^2(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: D^2(in) x L(in) x 0.2225 = weight in lbs.

SI–UNITS OF MEASUREMENT

Factors and prefixes

Quantity	Name	Symbol	Derivation
The seven basic units			
Length	metre	m	
Mass	kilogram	kg	
Time	second	s	
El.current	ampere	A	
Temperature	kelvin	K	
Lum.intensity	candela	cd	
Mol. w. in gr.	mole	mol	
Two supplementary units			
Plane angle	radian	rad	
Solid angle	steradian	sr	
Derived units with own names			
Force	newton	1 N	= 1 kg · m/s^2
Pressure	pascal	1 Pa	= 1 N/m^2
Energy, work	joule	1 J	= 1 Nm
Power	watt	1 W	= 1 J/s
Additional units permitted until further notice			
Volume	litre	1 l	= 10^{-3} m^3
Mass	ton	1 t	= 10^3 kg
Energy	watt-hour	1 Wh	= 3600 Ws (J)
Pressure	bar	1 bar	= 100 kPa

Multiple	Factor	Prefix	Symbol
1 000 000 000 000	10^{12}	tera	T
1 000 000 000	10^9	giga	G
1 000 000	10^6	mega	M
1 000	10^3	kilo	k
100	10^2	hekto	h
10	10^1	deka	da
0,1	10^{-1}	deci	d
0,01	10^{-2}	centi	c
0,001	10^{-3}	milli	m
0,000 001	10^{-6}	mikro	µ
0,000 000 001	10^{-9}	nano	n
0,000 000 000 001	10^{-12}	piko	p
0,000 000 000 000 001	10^{-15}	femto	f
0,000 000 000 000 000 001	10^{-18}	atto	a

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	ft^2	Yd
1 m^2 =	1	10^6	$1.55 \cdot 10^3$	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 =	$92.9 \cdot 10^{-3}$	$92.9 \cdot 10^3$	144	1	0.1111
1 yd^2 =	0.8361	$836.1 \cdot 10^3$	$1.296 \cdot 10^3$	9	1
1 acre =	$4.047 \cdot 10^3$	$4.047 \cdot 10^9$	$6.273 \cdot 10^6$	$43.56 \cdot 10^3$	$4.84 \cdot 10^3$
1 $mile^2$ eng. =	$2.58999 \cdot 10^6$	$2.58999 \cdot 10^{12}$	$4.014 \cdot 10^9$	$27.88 \cdot 10^6$	$3.0976 \cdot 10^6$

1 km^2 = 247.1 acre = 0.3861 $mile^2$ eng.

Volume

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

1 l = 1 dm^3 = 0.219969 gallon UK = 0.264172 gallon US

1 cm^3 = 0.061 in^3

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 $1.2 \cdot 10^3$ km/h; 1 mph = 1 mile/h

Mass (weight)

	kg	g	lb (pound)	slug	oz (ounce)
1 kg =	1	10^{3}	2.2046	$68.52 \cdot 10^{-3}$	35.274
1 g =	10^{-3}	1	$2.2 \cdot 10^{-3}$	$68.52 \cdot 10^{-6}$	$35.274 \cdot 10^{-3}$
1 libra (pound) =	0.4536	453.59	1	$31.08 \cdot 10^{-3}$	16
1 slug =	14.594	$14.5939 \cdot 10^{3}$	32.17	1	514.8
1 onza (ounce) =	$28.35 \cdot 10^{-3}$	28.35	$62.5 \cdot 10^{-3}$	$1.943 \cdot 10^{-3}$	1
1 cwt larga GB =	50.8023	$50.8023 \cdot 10^{3}$	112	3.481	$1.792 \cdot 10^{3}$
1 ton. larga GB =	$1.016 \cdot 10^{3}$	$1.016 \cdot 10^{6}$	$2.24 \cdot 10^{3}$	69.62	$35.84 \cdot 10^{3}$
1 cwt.corta USA =	45.3592	$45.3592 \cdot 10^{3}$	100	3.108	$1.6 \cdot 10^{3}$
1 ton corta USA =	907.185	$907.185 \cdot 10^{3}$	$2 \cdot 10^{3}$	62.16	$32 \cdot 10^{3}$

1 ton. larga GB = 20 cwt. largas GB. 1 ton. corta USA = 20 cwt. cortas USA

1 kg = $0.9842 \cdot 10^{-3}$ ton. larga GB = $1.1023 \cdot 10^{-3}$ ton. corta USA
1 kg = $19.684 \cdot 10^{-3}$ cwt. larga GB = $22.046 \cdot 10^{-3}$ cwt corta USA

Density

	kg/m³	g/cm³	lb/in.³	lb/ft
1 kg/m³ =	1	10^{-3}	$36.13 \cdot 10^{-6}$	$62.43 \cdot 10^{-3}$
1 g/cm³ =	10^{3}	1	$36.13 \cdot 10^{-3}$	62.428
1 lb/in³ =	$27.6799 \cdot 10^{3}$	27.68	1	$1.728 \cdot 10^{3}$
1 lb/ft³ =	16.0185	$16.02 \cdot 10^{-3}$	$0.579 \cdot 10^{-3}$	1

m³/kg called specific volume

Force

	N	dyne	kp	lbf
1 N =	1	$0.1 \cdot 10^{6}$	0.10197	0.2248
1 dyn =	$10 \cdot 10^{-6}$	1	$1.02 \cdot 10^{-6}$	$2.248 \cdot 10^{-6}$
1 kp =	9.80665	$980.665 \cdot 10^{3}$	1	2.2046
1 lbf =	4.448	$444.8 \cdot 10^{3}$	0.4536	1

Una kilopondio (kp) también se denomina kilogramo-fuerza (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	$11.521 \cdot 10^{-3}$	1	$83.33 \cdot 10^{-3}$
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	$1.36 \cdot 10^{-3}$	0.7376
1 kpm/s =	9.80665	1	8.432	$13.33 \cdot 10^{-3}$	7.233
1 kcal/h =	1.163	0.1186	1	$1.581 \cdot 10^{-3}$	0.8578
1 hk =	735.5	75	632.5	1	542.5
1 ft · lbf/s =	1.356	0.1383	1.166	$1.843 \cdot 10^{-3}$	1
1 hp UK. US =	745.7	76.04	641.2	1.1014	550
1 Btu/h =	0.2931	$29.89 \cdot 10^{-3}$	0.252	$398.5 \cdot 10^{-6}$	0.2162

1 kcal/s = $4.1868 \cdot 10^{3}$W 1W = $238.8 \cdot 10^{-6}$ kcal/s = $1.341 \cdot 10^{-3}$hp

Pressure (stress)

	Pa= N/m²	N/mm²= MPa	bar	kp/mm²	lbf/in²(psi)
1 Pa= 1 N/m² =	1	10^{-6}	$10 \cdot 10^{-6}$	$0.102 \cdot 10^{-6}$	$0.145 \cdot 10^{-3}$
1 N/mm²=1 MPa	10^{6}	1	10	0.102	145
1 bar =	$100 \cdot 10^{3}$	0.1	1	$10.2 \cdot 10^{-3}$	14.5
1 kp/mm² =	$9.807 \cdot 10^{6}$	9.807	98.07	1	$1.4211 \cdot 10^{3}$
1 kp/mm²= at =	$98.07 \cdot 10^{3}$	$98.07 \cdot 10^{-3}$	0.9807	$10 \cdot 10^{-3}$	14.21
1 lb/in² = psi =	$6.895 \cdot 10^{3}$	$6.895 \cdot 10^{-3}$	$68.95 \cdot 10^{-3}$	703	1
1 torr =	133.3	$133.3 \cdot 10^{-6}$	$1.333 \cdot 10^{-3}$	$13.6 \cdot 10^{-3}$	$19.34 \cdot 10^{-3}$
1 atm =	$101.3 \cdot 10^{3}$	0.1013	1.013	$10.33 \cdot 10^{-3}$	14.7

1 mm Hg = 13.6 mm water gauge
1 mm water gauge = 9.81 Pa
1 dyne/cm² = 10Pa

1 Pa = $7.501 \cdot 10^{-3}$ torr = $9.868 \cdot 10^{-6}$ atm
1 torr = 1 mm Hg at 0°C and 9.81 m/s²
1 atm = 760 mm Hg (torr) = $1.013 \cdot 10^{3}$ milibar

Power

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

1 eV = $0.1602 \cdot 10^{-18}$ J 1 J = $6.242 \cdot 10^{18}$ eV = 10^{7} erg = $0.3777 \cdot 10^{-6}$ hkh 1 hkh = $2.648 \cdot 10^{6}$ J

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 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.

WEIGHT TABLES

Flat bars kg/m

Width mm	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	46.7	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_{mc}	Compressive strength

Z	Reduction of area (%)

SOME TECHNICAL INFORMATION FROM UDDEHOLM TOOLING

Tool Steel Application
Steel for coldwork tooling
Die steel and improved productivity in die casting
Die steel and components for extrusion
Steel for moulds

Treatment of Tool Steel
EDM of tool steel
Grinding tool steel
Heat treatment of tool steel
Photo-etching of tool steel
Polishing mould steel
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 steel
etc.

NOTES

NOTES

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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UDDEHOLM is present on every continent. This ensures you high-quality Swedish tool steel and local support wherever you are. ASSAB is our wholly-owned subsidiary and exclusive sales channel, representing Uddeholm in various parts of the world. Together we secure our position as the world's leading supplier of tooling materials.

For more information, please visit www.uddeholm.com or www.assab.com

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