



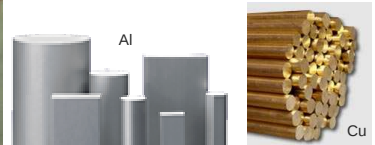
Design and manufacturing of plastic injection mould

07 – Mould materials

1

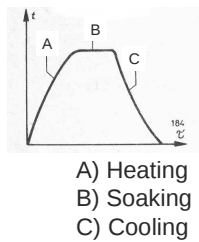
Mould materials

- Steel
- Aluminium
- Copper / Brass



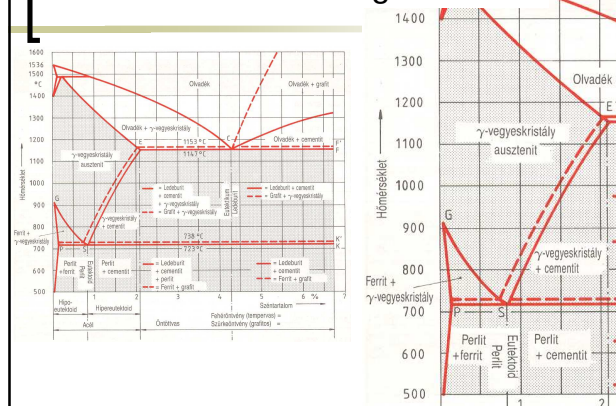
Heat treatments of steel

- Stress relieving
- Annealing
- Normalizing
- Hardening
- Tempering
- Hardening and tempering
- Carburizing and hardening



3

Iron – Iron carbide diagram



Stress relieving

Aim: decrease the stress after rough cutting

Higher temperature means higher decreasing

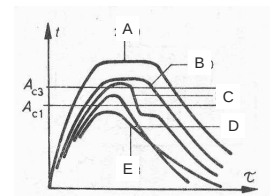
The temperature is under A_1
The heating and cooling are very slow

5

Annealing

Aim: ensure the easy-to-cut state by homogenous and small grain size

- A) Diffusion annealing
- B) Full annealing
- C) Isothermal annealing
- D) Stress relieving
- E) Recrystallisation annealing

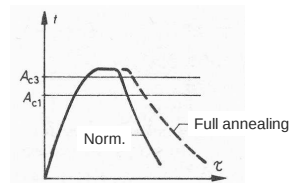


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Normalizing

Aim: homogenous fine grain structure for better mechanical properties

Heating up to A3, cooling in state air
Tool steels can be self hardened



7

Hardening

Aim: increase the hardness of the steel by austenite – martensite transformation

Precondition: C% > 0.2

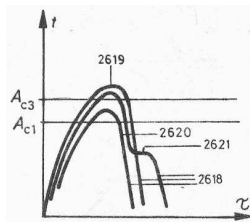
Heating up to A3, put the part to the warm furnace, sometimes the heating is periodical.
Soaking takes 4-6 minutes in case of unalloyed, and 6-10 minutes in case of alloyed steels

8

Hardening

The higher temperature and longer soaking cause grain coarsening.

Cooling material: water, oil, liquid metal, air, steel plates



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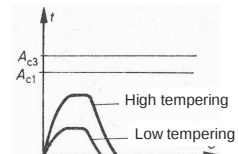
Tempering

Aim: decrease the rigidity and stress of the hardened steel

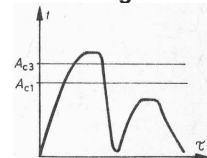
Heating: slowly to A1

Soaking: 1 hour

Cooling: slowly



Hardening + Tempering



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Heat treatment of mould steels

Normalizing is not possible, cause of self hardening skill (we can not cool enough slow speed)

Annealing with furnace

Heating in many steps

Multiple tempering (2-3x)

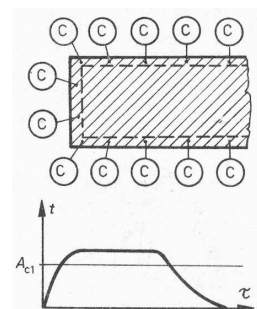
11

Carburizing

Aim: Hard surface layer

Precondition: C% < 0.2

Increase the C% in the surface, hardening, tempering



12

MSz 4354-82

Unalloyed tool steels

Grade	C%	HRC _{hardened}	Application
S45	0.45	52	Hand tools
S60	0.6	57	Hand tools, tool holders
S71, S72	0.7	62	Shears, Finishing blanking tool, Blanking press tool, File
S81, S82	0.8	62	Tap, Thread cutting die, Blanking press tool, Drawing press tool
S91, S92	0.9	62	Bending press tool, Medical tools, Measurement instruments
S101, S102	1.0	63	Milling cutters, Reamer, Press tools (piercing, drawing, ironing)
S111, S112	1.1	63	Die, Guiding pin
S121, S122	1.2	63	Hand tools
S131, S132	1.3	64	Engraving tools

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MSz 4352-84

Alloyed tool steel for cold work

Grade	C%	Alloy	HRC _{hardened}	Application
K4	1.0	Cr1.5	62	Drill, File, Press tool
K6	1.4	Cr0.5	64	Blade, File
K8	1.65	Cr12, Mo0.7, V1	61	
K9	2.2	Cr12, Mo0.7, V0.2, W0.7	62	
M1	0.85	Mn2	61	Die press tool,
W5	0.5	Cr1, W2	54	Die press tool
W6	0.6	Cr1, W2	57	Wear resistant steel
W9	1.0	Cr1, W1.4	62	Milling cutter, Drills, Saw

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MSz 4352-84

Alloyed tool steel for hot work

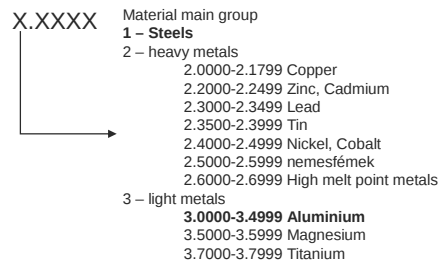
Grade	C%	Alloy	HV _{temp}	Application
NK	0.55	Cr0.8, Ni1.6, Mo0.2	420	Large die punch
NK2	0.55	Cr1.2, Ni1.8, Mo0.5	460	
K13	0.4	Cr4, Mo1.3, V1	550	Injection moulds
K14	0.28	Cr3, Mo3, V0.5	530	Medium size die, injection mould
W3	0.3	Cr2.5, V0.3, W4	500	Small size die, injection mould

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Steel grade

■ MSz, DIN, Werkstoff-Number (W-Num)

Material number (Werkstoff number):



16

1.1730

DIN: C45W MSz: C45W
Alloys (%): C – 0.45 Si – 0.3 Mn – 0.7

Properties: Hard surface, tough core

Application: mould base (house)
General state: 650 N/mm² (ultimate strength)
Price (Kind&Co. 2007.01.): 0.22 €/kg

Heat treatment:
Anneal: 680 – 710 C° Hardness: 190 HB
Hardening: 800 – 830 C° in water Hardness: 57 HRC
Tempering: 100 C° – 57 HRC
200 C° – 54 HRC
300 C° – 49 HRC
350 C° – 42 HRC

17

1.2083

DIN: X42Cr13 MSz: -
Alloys (%): C – 0.42 Cr – 13.0

Properties: Stainless steel, good to polishing, 780 N/mm²

Application: Mould base (PVC), Inserts
State: hardening + tempering
Price (Kind&Co. 2007.01.): 0.38 €/kg

Heat treatment:
Annealing: 760 – 800 C° in furnace, Hardness: 230 HB
Hardening: 1000 – 1050 C° in oil Hardness: 56 HRC
Tempering: 100 C° – 56 HRC
200 C° – 55 HRC
300 C° – 52 HRC
400 C° – 51 HRC
500 C° – 52 HRC
600 C° – 40 HRC

18

1.2085

DIN: X33CrS16 MSz: -
Alloys (%): C – 0.3 Cr – 16.5 Mn – 1.2 S – 0.06

Properties: Stainless steel, good to cutting, 1080 N/mm²

Application: Mould base (PVC), Inserts
State: hardening and tempering
Price (Kind&Co. 2007.01.): 0.69 €/kg

Heat treatment:
Annealing: 850 – 880 C° in furnace, Hardness: 230 HB
Hardening: 1000 – 1050 C° in oil Hardness: 48 HRC
Tempering: 100 C° – 48 HRC
200 C° – 48 HRC
300 C° – 47 HRC
400 C° – 46 HRC
500 C° – 47 HRC
600 C° – 30 HRC

19

1.2312

DIN: 40CrMnMoS 86 MSz: -
Alloys (%): C – 0.40 Si – 0.4 Mn – 1.5 Cr – 1.9 Mo – 0.2 S – 0.05
Properties: Good to cutting and polishing, **Bad to photo etching**, 1080 N/mm²

Application: Inserts
State: Hardening and tempering 280-325 HB
Price (Kind&Co. 2007.01.): 0.33 €/kg

Heat treatment:
Annealing: 710 – 740 C° in furnace, Hardness: 235 HB
Hardening: 840 – 870 C° in oil Hardness: 51 HRC (1730 N/mm²)
Tempering: 100 C° – 51 HRC – 1730 N/mm²
200 C° – 50 HRC – 1670 N/mm²
300 C° – 48 HRC – 1570 N/mm²
400 C° – 46 HRC – 1480 N/mm²
500 C° – 42 HRC – 1330 N/mm²
600 C° – 36 HRC – 1140 N/mm²
700 C° – 28 HRC – 920 N/mm²

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1.2311

DIN: 40CrMnMo7 MSz: -
Alloys (%): C – 0.40 Si – 0.4 Mn – 1.5 Cr – 1.9 Mo – 0.2
Properties: Good to cutting, polishing and photo etching, 1080 N/mm²
Application: Inserts
State: hardening and tempering 280-325 HB
Price (Kind&Co. 2007.01.): 0.33 €/kg

Heat treatment:
Annealing: 710 – 740 C° in furnace, Hardness: 235 HB
Hardening: 840 – 870 C° in oil Hardness: 51 HRC (1730 N/mm²)
Tempering: 100 C° – 51 HRC – 1730 N/mm²
200 C° – 50 HRC – 1670 N/mm²
300 C° – 48 HRC – 1570 N/mm²
400 C° – 46 HRC – 1480 N/mm²
500 C° – 42 HRC – 1330 N/mm²
600 C° – 36 HRC – 1140 N/mm²
700 C° – 28 HRC – 920 N/mm²

21

1.2316

DIN: X36CrMo 17 MSz: -
Alloys (%): C – 0.3 Cr – 16.0 Mo – 1.2

Properties: Stainless (better than 1.2083), good to polishing
Application: Stainless inserts
State: hardening and tempering (300 HB)
Price (Kind&Co. 2007.01.): 1.52 €/kg

Heat treatment:
Annealing: 760 – 800 C° in furnace, Hardness: 230 HB
Hardening: 1020 – 1050 C° in oil Hardness: 49 HRC
Tempering: 100 C° – 49 HRC
200 C° – 47 HRC
300 C° – 46 HRC
400 C° – 46 HRC
500 C° – 47 HRC
600 C° – 32 HRC

22

1.2343

DIN: X38CrMoV51 MSz: K12
Alloys (%): C – 0.38 Cr – 5.3 V – 0.4 Si – 1.0 Mo – 1.3

Properties: High temperature steel, tough, good thermal conductivity, good to photo etching, 780 N/mm²

Application: Inserts for high temperature plastic processing
State: Hardening and tempering (230 HB)
Price (Kind&Co. 2007.01.): 1.35 €/kg

Heat treatment:
Annealing: 750 – 800 C° in furnace, Hardness: 230 HB
Hardening: 1000 – 1030 C° in oil Hardness: 54 HRC (19 10 N/mm²)
Tempering: 100 C° – 52 HRC
200 C° – 52 HRC
300 C° – 52 HRC
400 C° – 52 HRC
500 C° – 54 HRC
600 C° – 48 HRC
650 C° – 38 HRC

23

1.2738

DIN: 40CrMnNiMo8 MSz: -
Alloys (%): C – 0.4 Mn – 1.5 Cr – 1.9 Ni – 1.0 Mo – 0.2
Properties: good to cutting, polishing and photo etching

Application: Insert for deep cavity and high pressure (vs. 1.2311)
State: hardening and tempering (280 HB)
Price (Kind&Co. 2007.01.): 0.71 €/kg

Heat treatment:
Annealing: 710 – 740 C° in furnace, Hardness: 235 HB
Hardening: 850 – 880 C° in oil Hardness: 52 HRC (1790 N/mm²)
Tempering: 100 C° – 52 HRC – 1730 N/mm²
200 C° – 51 HRC – 1630 N/mm²
300 C° – 49 HRC – 1480 N/mm²
400 C° – 46 HRC – 1330 N/mm²
500 C° – 42 HRC – 1110 N/mm²
600 C° – 35 HRC – 860 N/mm²
700 C° – 25 HRC

24

1.2767

DIN: X45NiCrMo4 MSz: -
Alloys (%): C – 0.45 Ni – 4.0 Cr – 1.4 Mo – 0.3
Properties: Good to hardening, tough, Good to polishing, photo etching end EDM, 830 N/mm²

Application: Inserts

State: Hardening and tempering(260 HB)

Price (Kind&Co. 2007.01.): 1.83 €/kg

Heat treatment:

Annealing: 610 – 650 C° in furnace, Hardness: 260 HB

Hardening: 840 – 870 C° in air, in oil Hardness: 56 HRc

Tempering: 100 C° – 56 HRc

200 C° – 54 HRc

300 C° – 50 HRc

400 C° – 46 HRc

500 C° – 42 HRc

600 C° – 38 HRc

25

1.2080

DIN: X210Cr12 MSz: K1
Alloys (%): C – 2.1 Cr – 12.0

Properties: Stainless, wear resistant, Good to polishing, 840 N/mm²

Application: Inserts

State: Hardening and tempering

Price (Kind&Co. 2007.01.): 0.32 €/kg

Heat treatment:

Annealing: 600 – 650 C° in furnace, Hardness: 250 HB

Hardening: 800 – 840 C° in oil Hardness: 64 HRc

Tempering: 100 C° – 63 HRc

200 C° – 62 HRc

300 C° – 59 HRc

400 C° – 57 HRc

500 C° – 54 HRc

600 C° – 46 HRc

26

1.2379

DIN: X155CrVMo 121 MSz: K8
Alloys (%): C – 1.55 Cr – 12.0 Mo – 0.7 V – 1.0
Properties: Wear resistant, tough, Good to nitriding, 830 N/mm²

Application: Inserts for GF plastics

State: Hardening and tempering (250 HB)

Price (Kind&Co. 2007.01.): 1.36 €/kg

Heat treatment:

Annealing: 830 – 860 C° in furnace, Hardness: 250 HB

Hardening: 1000 – 1050 C° in air, in oil Hardness: 63 HRc

Tempering: 100 C° – 63 HRc

200 C° – 61 HRc

300 C° – 58 HRc

400 C° – 58 HRc

500 C° – 58 HRc

525 C° – 60 HRc

550 C° – 56 HRc

600 C° – 50 HRc

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1.2363

DIN: X100CrMoV51 MSz: -
Alloys (%): C – 1.0 Cr – 5.3 Mo – 1.1 V – 0.2
Properties: Wear resistant, Good to hardening and polishing, Small size changing during hardening

Application: Inserts (vs. 1.2379)

State: Hardening and tempering

Price (Kind&Co. 2007.01.): 1.09 €/kg

Heat treatment:

Annealing: 800 – 840 C° in furnace, Hardness: 230 HB

Hardening: 930 – 970 C° in air, in oil Hardness: 63 HRc

Tempering: 100 C° – 63 HRc

200 C° – 62 HRc

300 C° – 60 HRc

400 C° – 57 HRc

500 C° – 59 HRc

600 C° – 52 HRc

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1.2436

DIN: 210CrW12 MSz: -
Alloys (%): C – 2.1 Cr – 12.0 W – 0.7
Properties: The highest hardness and wear resistant

Application: Inserts, Thin blade

State: Hardening and tempering

Price (Kind&Co. 2007.01.): 0.62 €/kg

Heat treatment:

Annealing: 800 – 840 C° in furnace, Hardness: 250 HB

Hardening: 950 – 980 C° in air, in oil Hardness: 64 HRc

Tempering: 100 C° – 63 HRc

200 C° – 62 HRc

300 C° – 60 HRc

400 C° – 58 HRc

500 C° – 56 HRc

600 C° – 48 HRc

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Steel suppliers

 UDDEHOLM



ThyssenKrupp

 BÖHLER

 KIND&CO
EDELSTAHLWERK

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Böhler – Mould steels

- M200 (1.2312)
- M201 (1.2311)
- M238 (1.2738)
- M261 EXTRA
- M300 (1.2316)
- M310 (1.2083)
- M314 (1.2085)
- M340 ISOPLAST
- M390 MICROCLEAN
- M461 EXTRA
- K100 (1.2080)
- K305 (1.2343)
- K600 (1.2767)
- K945 (1.1730)
- W300 (1.2343)



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Böhler – Mould steels

Mould steels

BÖHLER jel	Polishing	Stainless	Wear res.	Cutting ab.	Size ch.
M200	2)	2)	2)	2)	2)
M201	2)	2)	2)	2)	2)
M238	2)	2)	2)	2)	2)
M261 EXTRA	4)	4)	4)	4) 5)	4)
M300 ISOPLAST	2)	2)	2)	2)	2)
M310 ISOPLAST	3)	3)	3)	1)	3)
M314 EXTRA	2)	2)	2)	2)	2)
M340 ISOPLAST	3)	3)	3)	1)	
M390 MICROCLEAN	3)	3)	3)	1)	

1) lágyított
2) nemesített
3) edzett és megeresztett
4) öregített
5) oldó izított

M200 (1.2312)
M201 (1.2311)
M238 (1.2738)
M261 EXTRA
M300 (1.2316)
M310 (1.2083)
M314 (1.2085)
M340 ISOPLAST
M390 MICROCLEAN



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Uddeholm – Mould steels

- Corrax
- Elmax
- Grane (1.2721)
- Holdax (1.2314)
- Impax HI (1.2738)
- Ramax S (1.2085)
- Stavax (1.2083)
- UBH 11 (1.1730)
- Vidar (1.2343)
- QRO 90
- Dievar
- Alvar 14 (1.2714)
- Hotvar
- Orvar2 (1.2344)
- Arne (1.2510)
- Calmax (1.2358)
- Carmo (1.2358)
- Rigor (1.2363)
- Sleipner
- Sverker 3 (1.2436)



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Uddeholm – Mould steels



Uddeholm Minőség	Keménység HRC	Kopás- állóság	Korrózió- állóság
CORRAX	34		
CORRAX	50		
STAVAX ESU	52		
ELMAX	58		
RAMAX S	37		
IMPAX SUPREME	32		

Uddeholm minőség	Keménység	Forgácsol- hatóság	Készülék- telőség	Méret- stabilitás	Abrázív kopás	Adhézív kopás	Kipattogzás/ lörés	Képlé- keny de- formáció
ARNE								
CALMAX								
RIGOR								
SVERKER 21								
SVERKER 3								
VANADIS 4								
VANADIS 10								
VANADIS 23								

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Kind&Co - Mould steels

The main tool steels					
Material	DIN	Corrosion resistance	Polishable	Machinability	Hardness
TQ 1					max. 52-54 HRc
USN ESU 1.2343					max. 52-54 HRc
H11 ESR					max. 52-54 HRc
USN H11	1.2343				max. 52-54 HRc
N400 MST 1.2767					max. 52-54 HRc
CMR	1.2316		ESR		approx. 300 HB ²⁾
RF	1.2083		ESR		50-52 HRc
CRS	1.2085				approx. 300 HB
Plast 1 ¹⁾					approx. 320 HB ²⁾

¹⁾ Very good weldability. ²⁾ Usually pre-hardened



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Coating – PVD, CVD

- Better mould filling
- Better ejection
- Shorter cycling time
- Wear resistant surface
- Longer mould life
- Less maintenance

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Coating

Product name	Coating material	Microhardness HV	Friction coefficient against steel (dry)	Internal stress (GPa)	Max. service temperature (°C)	Coating color	Coating structure
BALINIT® A	TiN	2300	0,4	-2,5	600	gold-yellow	Monolayer
BALINIT® B	TiCN	3000	0,4	-4,0	400	blue-grey	multilayer, gradient
BALINIT® C1000	WC/C	1000	0,10 - 0,20	-1,0	250	black-grey	lamellar
BALINIT® C1500	WC/C	1500	0,10 - 0,20	-1,0	300	black-grey	lamellar
BALINIT® CAST	CrC	2200	0,35 - 0,4	-2,0	700	silver-grey	Monolayer
BALINIT® D	CrN	1750	0,5	-1,5 / -2,0	700	silver-grey	Monolayer
BALINIT® FUTURA NANO	TiAlN	3300	0,30 - 0,35	-1,3 / -1,5	900	violet-grey	Nano structured
BALINIT® LUMENA	TiAlN	3400	0,30 - 0,35	-1,3 / -1,5	900	violet-grey	Nano structured
BALINIT® TRITON	DLC (a-C:H)	2500	0,1 - 0,2		350	black-grey	Monolayer

www.coating-guide.balzers.com

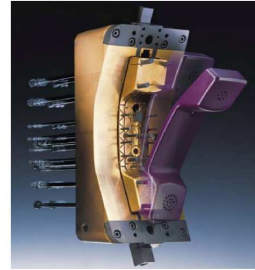
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Coating

cerlikon
balzers coating

BALINIT® reduces manufacturing costs

Costs (€) for the annual production of 1 million parts



	uncoated	BALINIT®-coated
Tools	31,800	15,700
Maintenance	17,200	
Coating		800
Total	49,000	16,500

Savings per year and model	32,500
Savings per year (200 different models)	6.5 Mio

Source: Siemens AG

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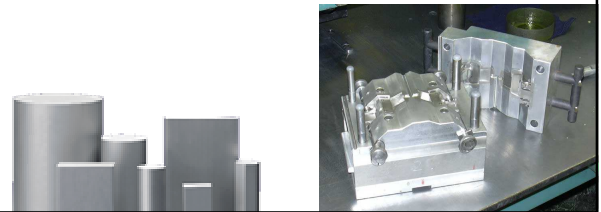
Aluminium alloys

- Faster cutting
- Less weight
- Material cost +15-25 %
- Less wear resistant
- Better thermal conductivity

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Al alloys

- AlMg3 – 3.3535 - EN AW 5754 – 177 N/mm²
- AlMg4,5Mn – EN AW 5083 – 265 N/mm²
- AlMgSi – EN AW 6060 – 216 N/mm² (hard.+temp.)
- AlSi1MgMn – EN AW 6082 – 275 N/mm² (hard.+temp.)
- AlZn5Mg2Cu – EN AW 7022 – 314 N/mm² (Cortal)



Copper alloys / Brass

- Good thermal conductivity
- Inserts for better cooling

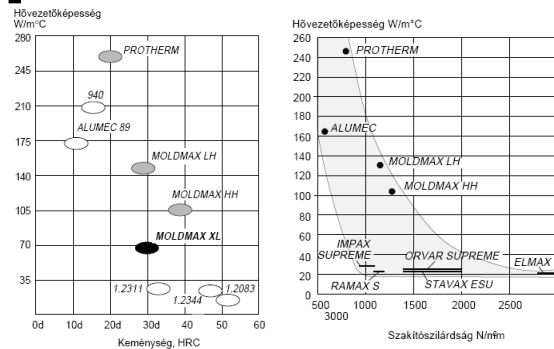
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Uddeholm - brass

- Moldmax HH (Cu-97,85%, Be-1,9%, Co+Ni-0,25%) 1170 N/mm², 40 HRC
- Moldmax XL (Cu-85%, Ni-9%, Sn-6%) 760 N/mm², 30 HRC

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Uddeholm - Brass



Ampco – www.ampcometal.com

AMPCOLOY® HIGH CONDUCTIVITY ALLOYS

ALLOY	Thermal Conductivity W/m°C	Thermal Diffusivity mm²/s	Brinell Hardness HB 30	Tensile Strength N/mm²	Yield Strength N/mm²	Elongation %	Coefficient of Expansion 10⁻⁶ /°C	Coefficient of Friction (dry conditions)
AA940	217	63	210	689	510	12	17.5	0.35
AA944	156	46	294	938	730	5	15.7	0.35
AA83	108	30	360	1310	827	5	16.5	0.20
AA95	218	60	240	723	537	17	17	0.14
AA88	230	60	270	890	680	14	17	0.17



Ampco - Renault

Temperature difference MP / FP (scaled result)

