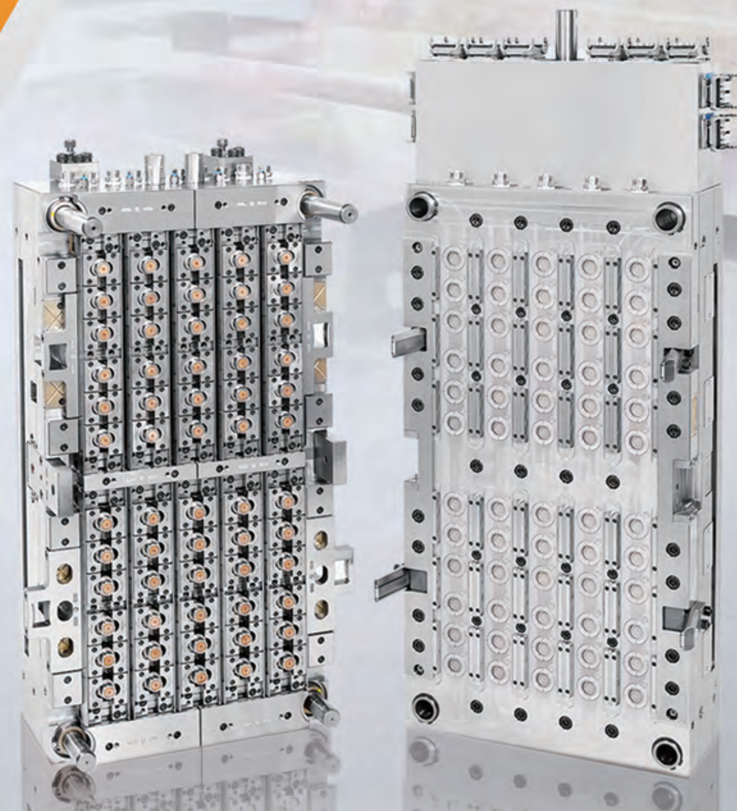
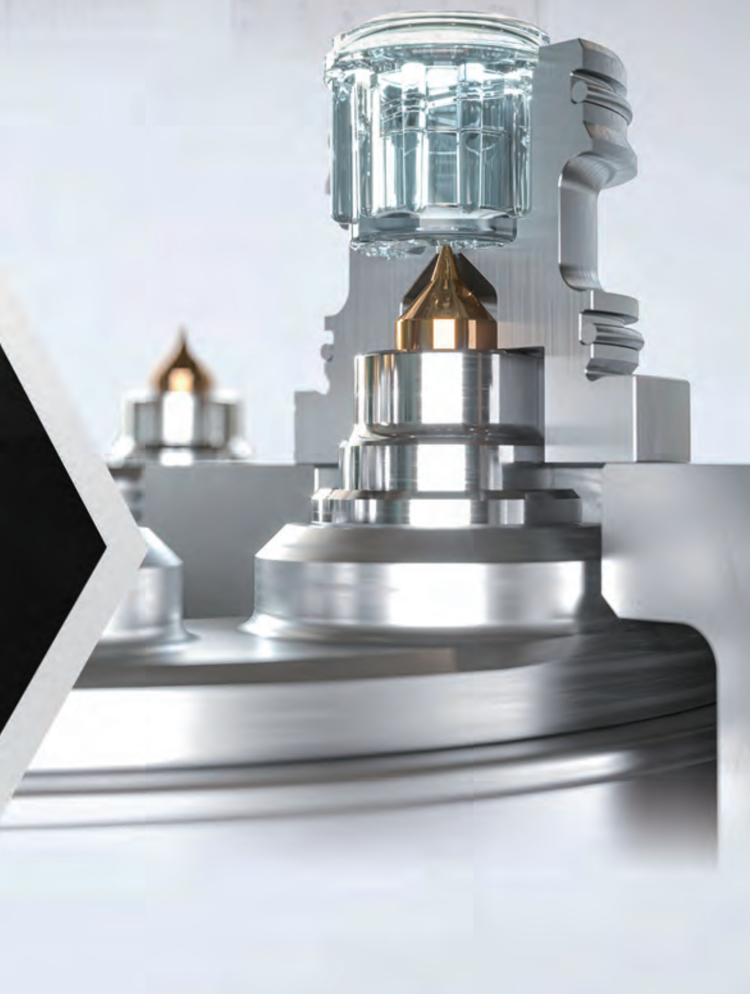
AMPCO®

EXCELLENCE IN ENGINEERED ALLOYS



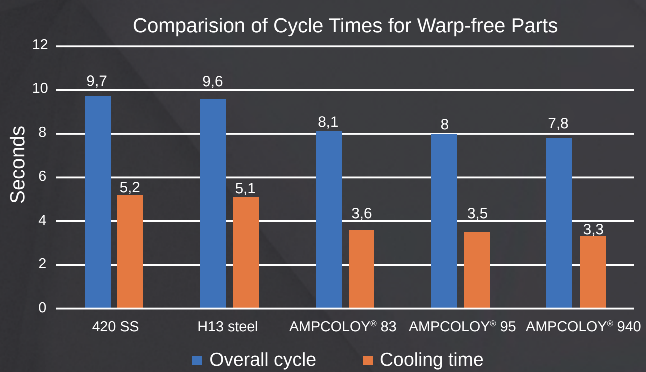


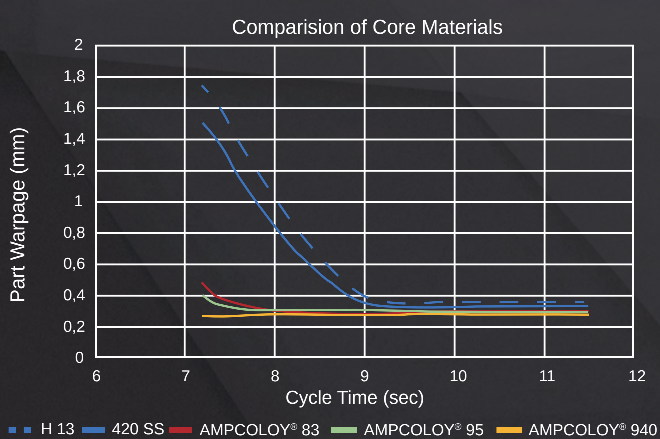
HIGH CONDUCTIVITY COPPER ALLOYS FOR

Plastic Injection
Plastic Extrusion
Blow Moulding
Thermo Forming

www.ampcometal.com

AMPCO METAL is the global reference in metal solutions, producing and distributing specialized copper-based alloys.





AMPCO METAL offers an extensive range of special alloys with high conductivity, specifically designed to enhance the efficiency of plastic molding tools. We offer a comprehensive selection of alloys to optimize thermal conductivity, hardness, corrosion resistance and wear resistance:

AMPCOLOY® 83 - Copper beryllium alloys.

AMPCOLOY® 940 and AMPCOLOY® 944 for higher conductivity alternatives to beryllium copper alloys.

1. Improved Productivity

Every core material was tested under identical processing conditions, with cooling time being the only variable. When AMPCO® alloys are used instead of conventional mold steels, the graph below illustrates the cycle advantages and reduction in cooling times that occur.

2. Better Product Quality

The second graph illustrates the disparity in millimeter warpage of parts among the three AMPCO® alloys and two steel materials at various cycle times. The AMPCO® alloys remove heat so efficiently that the part's warpage is minimal, even for shorter cycle times.

3. Longer Service Life

Rapid temperature equalization is made possible by AMPCOLOY® alloys' excellent thermal conductivity and diffusivity. As a result, thermal stresses are minimized and the likelihood of thermal cracking is decreased. This is a significant benefit of achieving a long service life. Outstanding corrosion resistance is another quality that prolongs service life, by protecting against chemical attack from PVC or other chemical emitting resins alike.

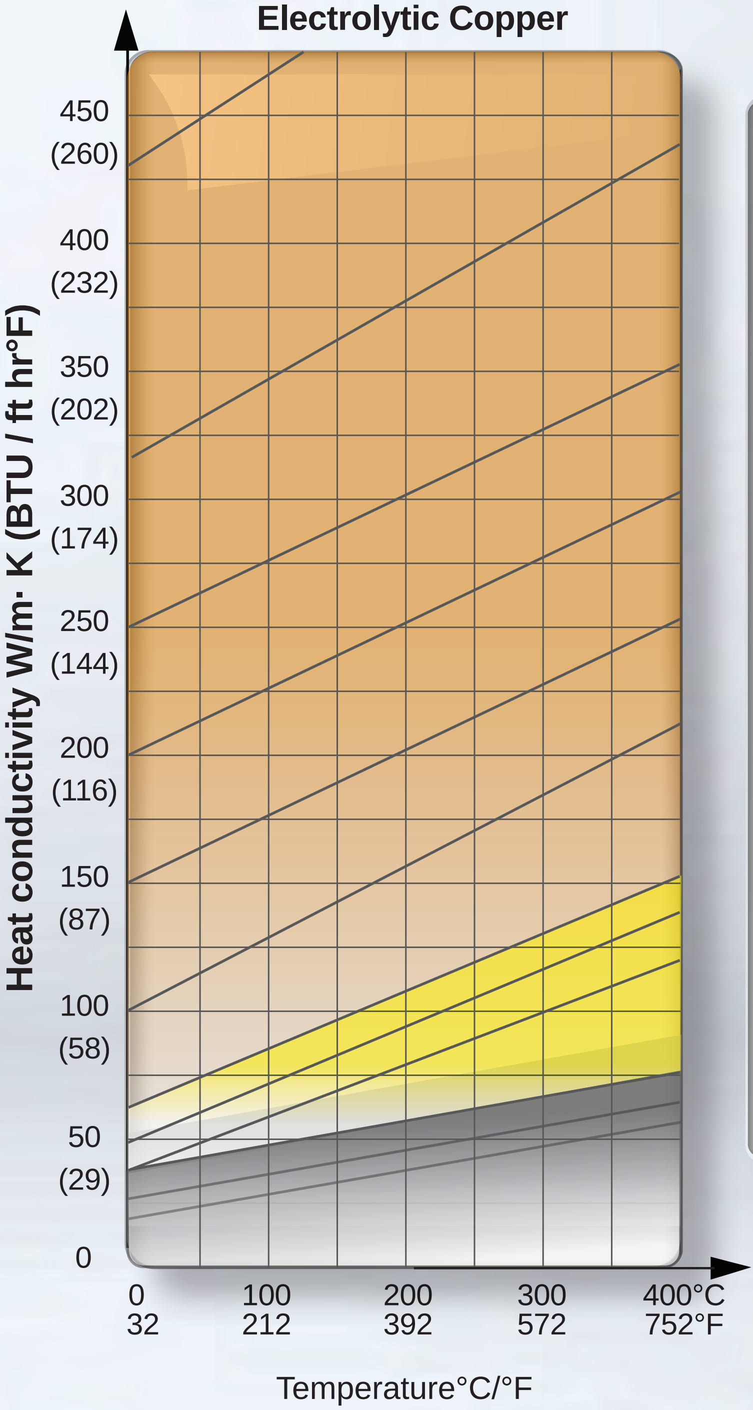
4. Lower Machining Costs

No additional heat treatment is necessary for AMPCOLOY® alloys. By using these alloys, distortion and finishing issues are prevented. Costs associated with machining are significantly reduced, thanks to the design flexibility of cooling channels.

AMPCOLOY® Alloys

Cycle Reductions and Quality Improvements in Plastic Injection

Heat conductivity and hardness



Hardness

	Brinell	Rockwell
AMPCOLOY® 972	152	82 B
AMPCOLOY® 95	240	21 C
AMPCOLOY® 940	210	95 B
AMPCOLOY® 944	294	31 C
AMPCOLOY® 83	380	40 C
AMPCO® 18	192	92 B
AMPCO® M4	285	30 C
AMPCO® 21	286	30 C
P-20	285	30 C
H-13	425	45 C
420	490	50 C

The thermal conductivity of AMPCOLOY® materials increases with the material working temperature!

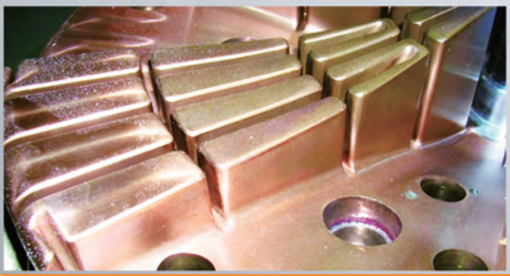
AMPCOLOY® 940

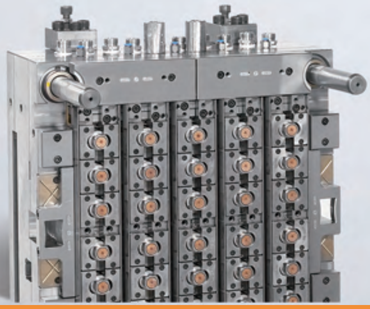
Beryllium Free

Chemical Composition	Mechanical Properties	Sand Casted	Extruded	Forged
	Tensile strength: MPa (ksi)	544 (79)	689 (100)	648 (94)
	Yield strength: MPa (ksi)	475 (69)	517 (75)	496 (72)
	Hardness: HBW	210	210	210
	Elongation: %	8	13	11
	Coefficient of expansion: 10^{-6}/K (in/°F)	17.5 (9.72x10^{-6})	17,5 (9,72x10^{-6})	17,5 (9,72x10^{-6})
Cu: Balance Ni: 2,5% Si: 0,7% Cr: 0,4%	Modulus of Elasticity E: MPa (ksi)	131000 (19000)	131000 (19000)	131000 (19000)
	Thermal conductivity: W/m· K (BTU/ft hr°F)	20°C (68°F) 208 | (0.497) 200°C (392°F) 243 | (0.581)	20°C (68°F) 208 | (0.497) 200°C (392°F) 243 | (0.581)	20°C (68°F) 208 | (0.497) 200°C (392°F) 243 | (0.581)
	Electrical conductivity: %IACS	48	48	48
	Specific heat cp: J/g·K (Btu/LB·°F)	0,38 (0,091)	0,38 (0,091)	0,38 (0,091)
	Maximum working temperature	450°C (842°F)	450°C (842°F)	450°C (842°F)

The above are nominal values. Please contact your local AMPCO METAL representative if specific minimum figures are needed.

AMPCOLOY® 940 has a superb combination of high thermal and electrical conductivity, with high hardness and strength, good corrosion and abrasion resistance: Beryllium free. Mold parts for plastic injection molding, injection-nozzles, cooling pins and hot runner systems.





AMPCOLOY® 940 standard sizes

Ø 9,5	Ø 12	Ø 13	Ø 16	Ø 20	Ø 25	Ø 30	Ø 33	Ø 36	Ø 40
Ø 45	Ø 51	Ø 57	Ø 61	Ø 64	Ø 66	Ø 71	Ø 76	Ø 81	Ø 86
Ø 92	Ø 102	Ø 111	Ø 122	Ø 132	Ø 142	Ø 160	Ø 180	Ø 255	Ø 305

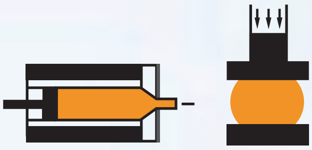
AMPCOLOY® 940 Plates ranging from 10 mm to 304,8 mm in thickness.

AMPCOLOY® 940 welding wire

To weld repair AMPCOLOY® 940: Make use of AMPCO-TRODE® 940 or AMPCO-TRODE® 940 laser. The material becomes softer in the relevant area after being repaired with AMPCO-TRODE® 940. For this reason, we advise using AMPCO-TRODE® 940 laser.

To weld AMPCOLOY® 940: Make use of COPR-TRODE®.

To weld AMPCOLOY® 940 and stainless steel: Make use of AMPCO-TRODE® 10.



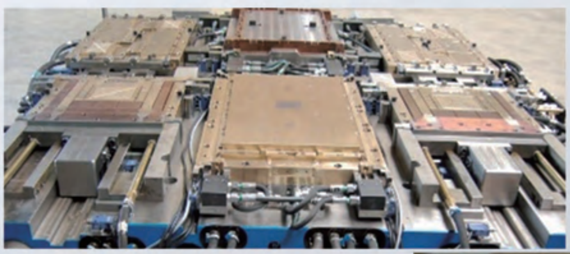
AMPCOLOY® 944

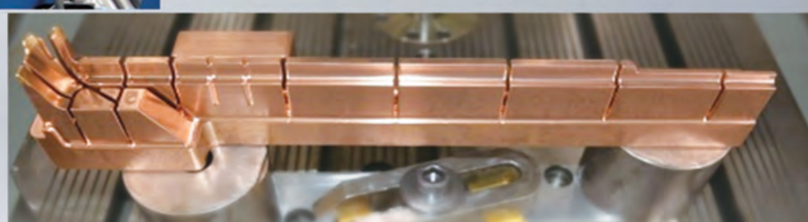
Beryllium Free

Chemical Composition	Mechanical Properties	Extruded	Forged
	Tensile strength: MPa (ksi)	938 (136)	793 (115)
	Yield strength: MPa (ksi)	730 (106)	655 (95)
	Hardness: HBW	294	270
	Elongation: %	5	4
Cu: Balance Ni: 7% Si: 2% Cr: 1% Other: max. 0,5%	Coefficient of expansion: 10^{-6}/K (in/°F)	17,5 (9,72x10^{-6})	17,5 (9,72x10^{-6})
	Modulus of Elasticity E: MPa (ksi)	151000 (21900)	135000 (19600)
	Thermal conductivity: W/m· K (BTU/ft hr°F)	20°C (68°F) 156 | (0.373) 200°C (392°F) 190 | (0.454)	20°C (68°F) 156 | (0.373) 200°C (392°F) 190 | (0.454)
	Electrical conductivity: %IACS	30	35
	Specific heat cp: J/g·K (Btu/LB·°F)	0,38 (0,091)	0,38 (0,091)
	Maximum working temperature	400°C (752°F)	400°C (752°F)

The above are nominal values. Please contact your local AMPCO METAL representative if specific minimum figures are needed.

AMPCOLOY® 944 has been developed by AMPCO METAL to obtain an alloy with ultimate thermal conductivity, good tensile strength, and exceptional hardness, as an alternative for Beryllium copper, which necessitates more stringent health and safety instructions on the implementation of noxious elements. Applications: Plastic injection mold tools and inserts, thermoforming, blow molding.





AMPCOLOY® 944 standard sizes

Ø 13	Ø 26,5	Ø 33	Ø 38,1	Ø 50.8	Ø 65	Ø 76.2

AMPCOLOY® 944 Plates ranging from 10 mm to 203,2 mm in thickness.

AMPCOLOY® 944 welding wire

For minor weld repair on AMPCOLOY® 944: Make use of AMPCO-TRODE® 940 or AMPCO-TRODE® 940 laser.

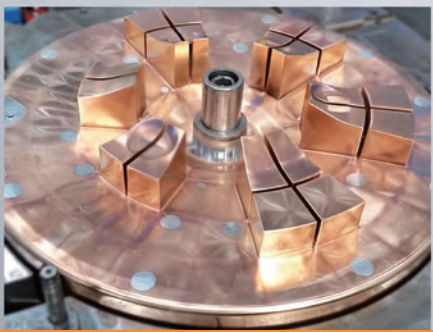
To weld AMPCO-TRODE® 944 to stainless steel (like Stavax): Make use of AMPCO-TRODE® 10 in TIG or MIG process.

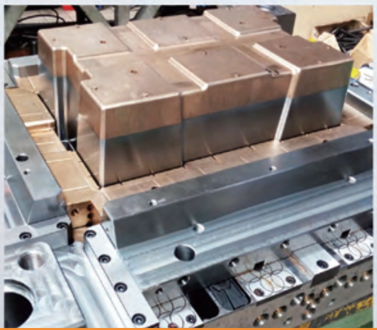
AMPCOLOY® 83

Chemical Composition	Mechanical Properties	Extruded	Forged
Cu: Balance Be: 1,9% Co+Ni: 0,5% Other: max. 0,5%	Tensile strength: MPa (ksi)	1250 (190)	1140 (165)
	Yield strength: MPa (ksi)	1000 (145)	1000 (145)
	Hardness: HBW	380	360
	Elongation: %	4	5
	Coefficient of expansion: 10^{-6}/K (in/°F)	17,5 (9,72x10^{-6})	17,5 (9,72x10^{-6})
	Modulus of Elasticity E: MPa (ksi)	131000 (19000)	128000 (18560)
	Thermal conductivity: W/m·K (BTU/ft hr°F)	20°C (68°F) 106 | (0.253) 200°C (392°F) 145 | (0.347)	20°C (68°F) 106 | (0.253) 200°C (392°F) 145 | (0.347)
	Electrical conductivity: %IACS	22	22
	Specific heat cp: J/g·K (Btu/LB·°F)	0,38 (0,091)	0,38 (0,091)
	Maximum working temperature	300°C (572°F)	300°C (572°F)

The above are nominal values. Please contact your local AMPCO METAL representative if specific minimum figures are needed.

AMPCOLOY® 83 is a 2% Beryllium copper alloy which exhibits exceptionally high levels of hardness and strength, in addition to having superior electrical and thermal conductivity. Applications: Injection mold tools and inserts. Cooling pins, hot runner system, injection nozzles, neck rings or bottom plates for blow molds of plastic bottles.





AMPCOLOY® 83 standard sizes:

Ø 9,5	Ø 12,7	Ø 15,9	Ø 19	Ø 22,2	Ø 25,4	Ø 31,8	Ø 38,1
Ø 44,4	Ø 50,8	Ø 57,1	Ø 63,5	Ø 69,8	Ø 76,2	Ø 88,9	Ø 101,6
Ø 127	Ø 152,4	Ø 203,2	Ø 254	Ø 345,4			

AMPCOLOY® 83 Plates ranging from 10 mm to 304,8 mm thickness.

AMPCOLOY® 83 welding wire:

To repair AMPCOLOY® 83: Make use of COPR-TRODE® and AMPCO-TRODE® BeCu (only on request)

To weld CuBe alloys together: Make use of COPR-TRODE®

To weld AMPCOLOY® 83 to steel: Make use of SIL-TRODE® or AMPCO-TRODE® 10

For minor defect repair of CuBe, you can also use AMPCO-TRODE® 940

Please adhere to safety instructions for welding Be-containing alloys

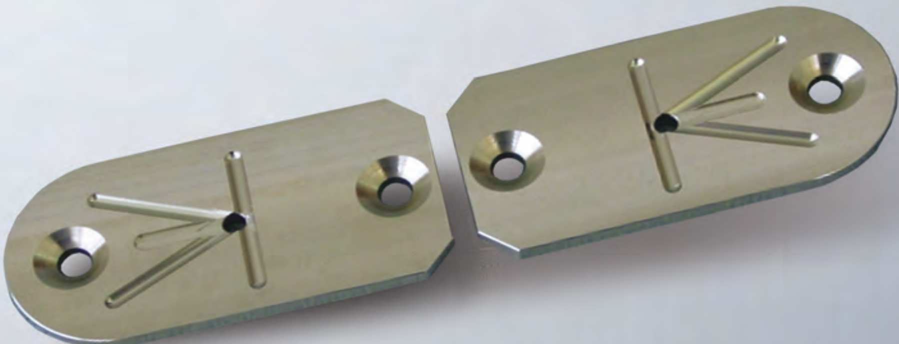
WEAR COMPONENTS

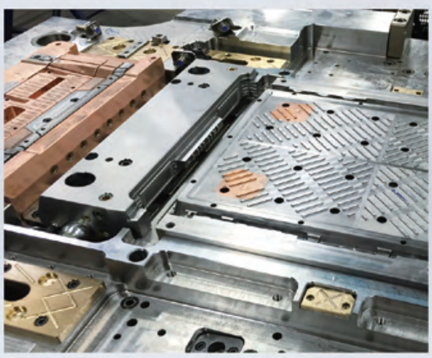
In Plastic Mold

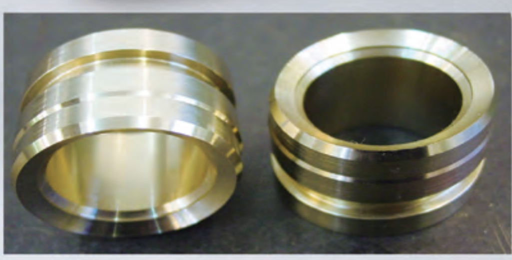
AMPCO METAL offers an expanded selection of components such as wear plates, ejector pins, and bushings to the plastic processing industry. Production of the best wear resistant and nickel-free materials, such as AMPCO® 18 and AMPCO® 21, ensures increased durability and lower maintenance costs over the lifespan of the components. This can save valuable time and money. Furthermore, utilizing AMPCO® alloys as the base material for ejector sleeves results in significant benefits, including the reduction of friction coefficients with tool steel. Our alloys strategically eliminate the need for heat treatments (both pre and post heat treatment machining). They can operate against steel without galling. Nitrides of any sort become unnecessary. The conductivity level far exceeds a tools steel like P20.

ALLOY	THERMAL CONDUCTIVITY W/mK (BTU/ft hr °F)	THERMAL DIFFUSIVITY MM2/S (ft2 hr)	HARDNESS BRINELL (ROCKWELL B/C)	TENSILE STRENGTH MPa (KSI)	YIELD STRENGTH MPa (KSI)	ELONGATION %	COEFFICIENT OF EXPANSION 10-6 1/K (10-6 1/°F)	COEFFICIENT OF FRICTION (DRY CONDITIONS)
AMPCO® 18	63(37)	19,8(0,77)	192 (92B)	724 (105)	358 (52)	14	16 (9)	0.18
AMPCO® 21	43(25)	15.2 (0.59)	286 (30C)	758 (110)	414 (60)	1	16 (9)	0.21
AMPCO® M4	42(24)	12.4 (0.48)	285 (30C)	960 (139)	725 (105)	8	16 (9)	0.23

The above are nominal values. Please contact your local AMPCO METAL representative if specific minimum figures are needed.





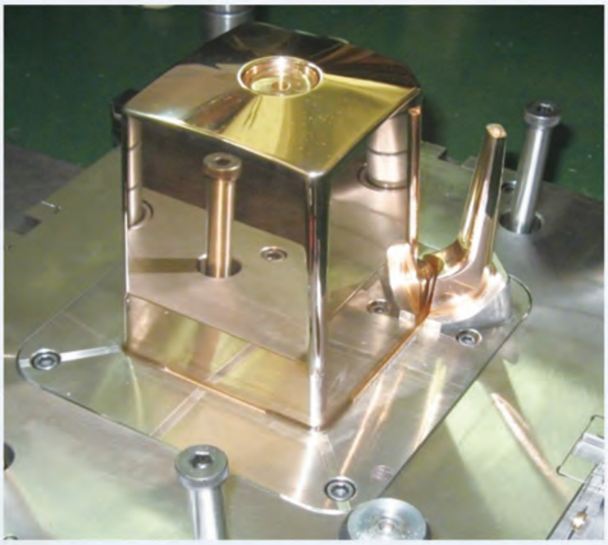


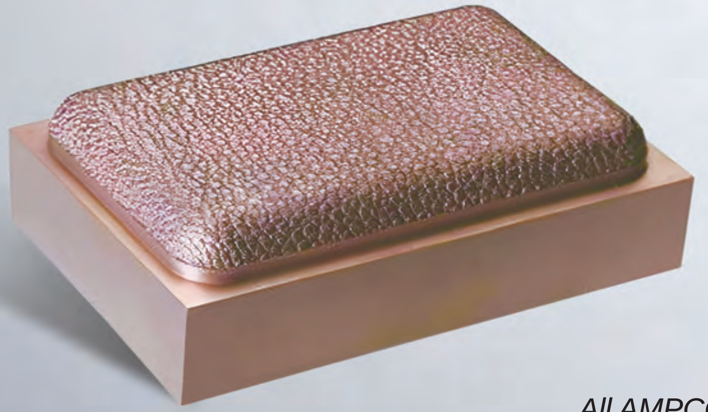
AMPCO® 18 and AMPCO® M4 can be combined with graphite inserts, to eliminate all liquid lubrication.

POLISHING

To achieve the best possible injected plastic part quality, the material must have a very good polishability.
AMPCOLOY® 83 and AMPCOLOY® 944 have outstanding mirror polishability. We conducted tests with POLISAR, a Swiss polishing company, on round material with a diameter of 63,5mm both in AMPCOLOY® 83 and AMPCOLOY® 944. AMPCOLOY® 83 hardness 383 HB: Achieved roughness overall: Ra= 0,011 µm AMPCOLOY® 944 hardness 298 HB: Achieved roughness in the center: Ra= 0,041 µm Achieved roughness in the outside: Ra= 0,016 µm
These extremely low roughness values are better than:

- N1 surface finish for AMPCOLOY® 83
- N1 to N2 surface finish for AMPCOLOY® 944.





TEXTURING

Injection mold cavity temperatures frequently need to be raised in order to exactly replicate surface microstructures or fine-textured mold surfaces. This naturally results in extended cooling times. Our AMPCOLOY® alloys may also be the key to making a difference.

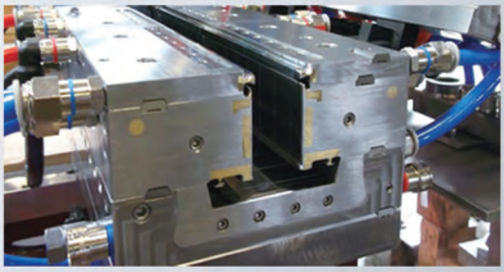
All AMPCOLOY® alloys accept any kind of etching or texturing.

EDM'ing

Bronze alloys such as AMPCO® 18, AMPCO® 21, and AMPCO® M4 can be electro-eroded with ease using settings with values that are highly similar to those required for the EDM'ing tool steel used in the mold industry. The group of high conductivity alloys like AMPCOLOY® 940, 944 and 83 are high conductivity alloys that can also be electro-eroded. High conductivity alloys are challenging to machine with sinker EDM, because the high conductivity characteristics defeats the EDM removal process. However, modern EDM tools with linear motion systems significantly increase the rates of alloy removal and electrode wear. On linear motor systems, the motor is the only moving part (Z axis). Due to the electrode's direct connection to the motor, the system operates at extremely high speeds without vibrations. The result is a better machining time and surface finish.

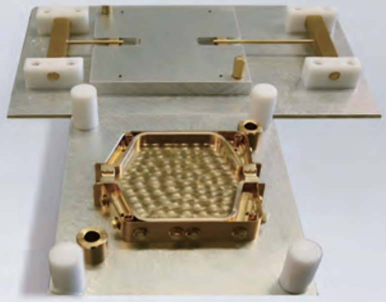
BLOW MOULDING

AMPCOLOY® alloys exhibit lower wear, improved conductivity and corrosion resistance in blow molding compared to aluminum. In pinch-offs and neck rings, these alloys are more conductive than steel, resulting in quicker cycle times, less maintenance and improved part quality.



EXTRUSION

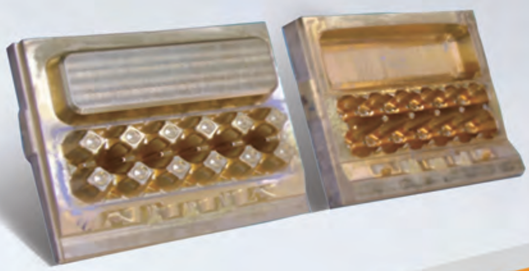
In plastic extrusion, the basic material is first plasticized in the first extruder before being forced into a die to obtain the desired form. This is then calibrated and cooled down by calibrators. For the first calibrator, AMPCOLOY® 940, 944 or 83 (with or without coating) is utilized when elements are challenging to cool (long and narrow profiles, for instance). They can produce up to 300'000 meters before having to change the tool. While AMPCO® 18 can also be used, it is not suitable for white profiles due to the iron content in the alloy. As the profile hardens, wear becomes more significant, which is why the subsequent dies are made of carbide.



THERMO FORMING

During repetitive HF welding and cooling in thermo forming process, the tools and surroundings can become quite hot, which may require an increase in cooling time. One solution is to use welding electrodes in AMPCO® bronze material.

Thermo forming blister packaging for products such as blood bags.



COATINGS and PLATINGS

The application of diverse coatings and platings has proven to be a cost-effective way to further enhance the already remarkable effectiveness of AMPCOLOY® alloys in mold applications. It is important to note that the heat removal characteristics of AMPCOLOY® alloys remain unaffected by the coatings and platings.

Wear resistance - It is normally correlated with friction coefficient and hardness. To increase wear resistance, the AMPCOLOY® alloys can be easily coated with electroless nickel, hard chrome or PVD (Physical vapor deposition) coatings.

Corrosion resistance - While AMPCOLOY® alloys resist a variety of corrosive environments, the coating will enhance the overall corrosion resistance of the mold. Corrosion is also a concern for the whole mold during storage (due to moisture) or even on the vents during compression of gasses. This phenomenon is referred to as the dieseling effect.

Demolding - Related also to the coefficient of friction. Significant when dealing with small or even negative draft angles. To facilitate the extraction of plastic parts during demolding, electroless nickel can be combined with Teflon (PTFE) or boron nitride.

Example of electroless nickel coating (25 microns) on AMPCOLOY® 940 alloy. Uniformity coating in the ribs!
Material to inject: PP with 25% fiber glass.

ELECTROPLATING - The process of passing an electric current between the anode (the metal to be deposited) and the cathode (the object to be coated). The thickness of the coating is determined by the intensity of the current, resulting in thicker deposits on the edges.

PVD - Physical vapor deposition is applied in a vacuum chamber by vaporizing the coating material. By introducing reactive gas, a uniform coating is achieved, even on parts in complex shapes.

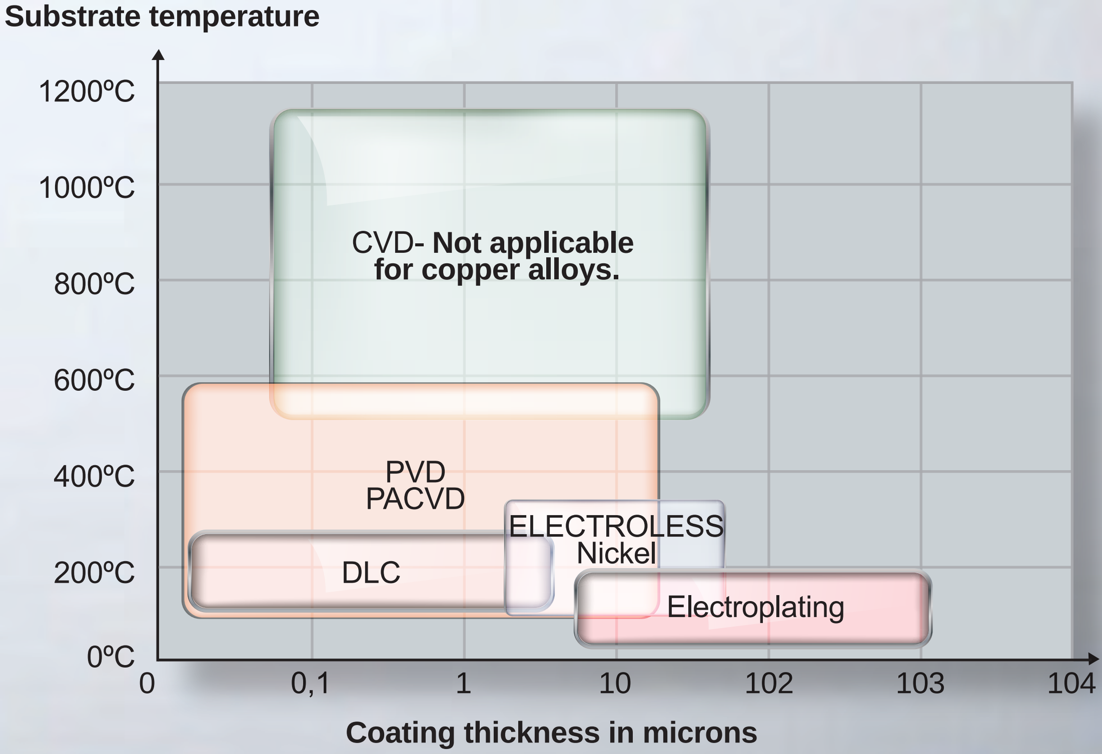
DLC - Diamond Like Carbon. Coating comprised of small particles of carbon. Coating is made generally with PVD process. (PACVD as well) Very high hardness > 90HRC.

PACVD, PECVD - Plasma activated process. The precipitation of layers from the gas phase is aided by plasma. Need a much lower temperature than the CVD process.

CVD - Chemical vapor deposition. The film material is formed by chemical reactions which take place in the gas phase as well as on the substrate surface. To make surface reactions possible, increased substrate temperatures are necessary, which can reach up to as high as 1000 °C. **Due to the extreme temperatures involved, this technique is not a viable choice for our alloys.**

ELECTROLESS NICKEL COATING - Film is applied without current. One major benefit of this type of coating is its capacity to conform to complex shapes, which sets it apart from electroplating. The level of hardness can be regulated by the substances added to the plating bath along with the possible heat treatment performed post-plating.

COATINGS and PLATINGS



Interests of the coatings

From molder's side:
An asset to increase tool life and meet specifications in terms of number of injections or cycle time

From end user side:
Increased productivity and quality
Less machine downtime
Shorter cycle time
Less waste and better quality of the injected products

From maintenance side:
Possibility to reduce or even eliminate the lubrication of certain elements
Reduced, spaced out and safe cleaning intervention

Δ One overlooked aspect of mold coating is the removal and reapplication. Even super hard coatings can wear, especially that these layers tend to be very thin. Consequently, it's important to remove the current coating without damaging the surface of the base material.

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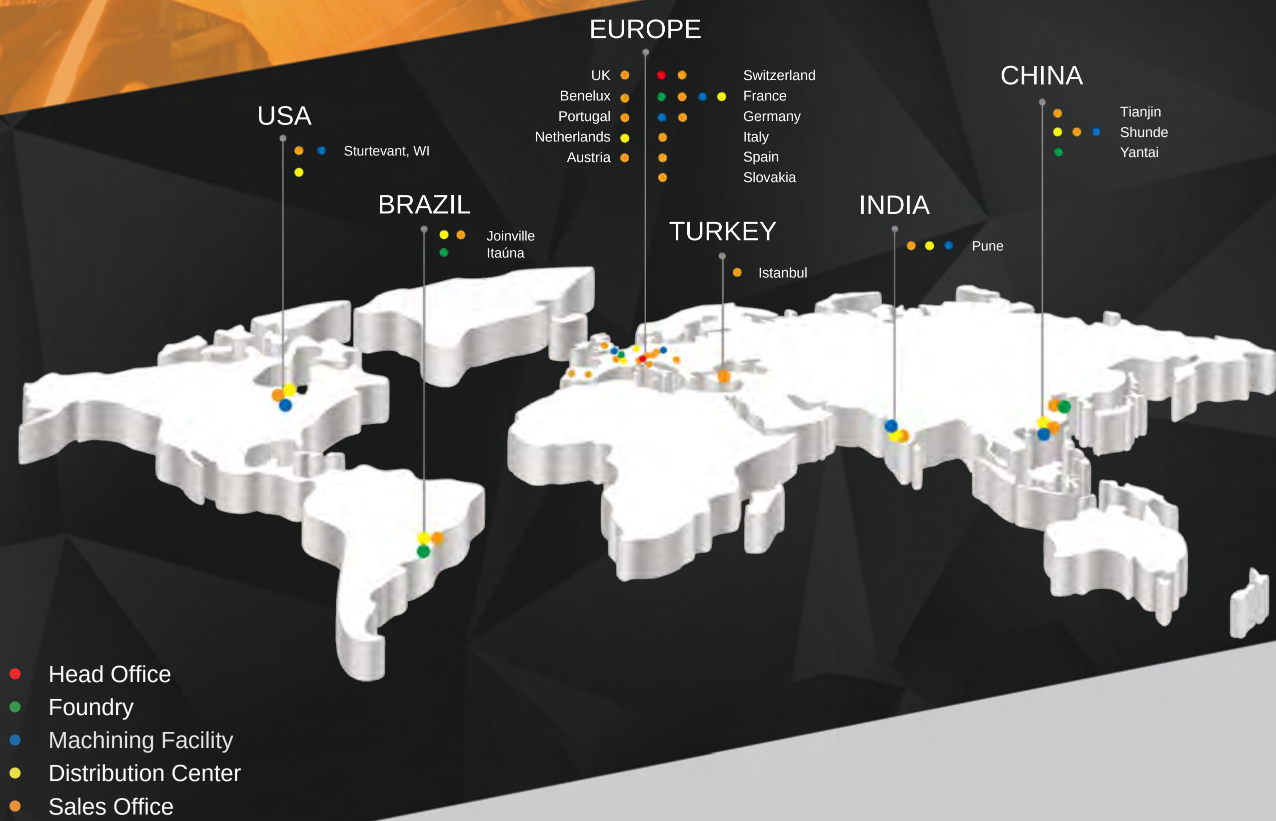

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