Machining recommendations for AMPCO® and AMPCOLOY®-alloys

General guidelines

The recommendations for the machining of AMPCO® and AMPCOLOY® materials are based on extensive tests made at the AMPCO METAL factories, which also match the values of a great number of customers.
AMPCO® and AMPCOLOY® materials are basically easy to machine. For the machining of AMPCO® 21, AMPCO® 22, AMPCO® 25 and AMPCO® 26 special care is required, due to the fact that these alloys compared to tool steel of same hardness present a lower elongation and ductility. An inappropriate treatment of the parts can lead to fractures.

Since the cutting speeds so much depend on the type of cutting tools used, on the stiffness and stability of the machine-tools used and on the type of cooling and lubricating liquids used, the recommended machining speeds for AMPCO® and AMPCOLOY® alloys are indicated as a relative value compared to the machining speeds used for tool steel 1.7225 (DIN 42 Cr Mo 4), see correspondence table hereunder.

Germany	Great Britain	U.S.A.	Italy	Japan	France	Spain
W-Nr DIN	BS970	AISI/SAE	UNI	JIS	AFNOR	UNE
1.7225 42CrMo4	709M40 708M40	4140 4142	42CrMo4 G40CrMo4	SCM440(H) SNB7	42CD4 42CrMo40	F.8332 F.8232

Material	Brinell hardness HB 30/10	Cutting speed
1.7225 (DIN 42 Cr Mo 4)	Max. 250	100 %
AMPCO® 8	109 - 124	125 %
AMPCO® 18	159 - 183	130 %
AMPCO® M4	270 - 305	120 %
AMPCO® 21	285 - 311	115 %
AMPCO® 22	321 - 352	110 %
AMPCO® 25	356 - 394	100 %
AMPCO® 26	395 - 450	75 %
AMPCOLOY® 940,95,972	180 – 255	125 %
AMPCOLOY® 83	340-390	100 %
AMPCOLOY® 88	260-280	120 %

130 % for AMPCO® 18 means for instance, that you can machine this alloy with a 30 % higher cutting speed than for steel 1.7225 (same feed and depth). This analogy is valid for conventional machine-tools, as well as for CNC and high speed machining (HSC) centres.

Influencing values such as machine-tool rigidity, optimal heat extraction, specific cutting tool configuration and so on play independently from this a big role, which is even more marked with the harder AMPCO® grades.

Please take notice that the lifetime of the cutting tools for the harder grades will be considerably shorter.

In general all AMPCO® harder grades, from AMPCO® 21 upwards should be machined from the edge into the material or alternatively the edge can be generously chamfered at an angle of 45°. Non conformance to this rule will lead to breaking of the edge.

Machining tools

The clearance angle α for all AMPCO® and AMPCOLOY® alloys must be set at 6°. Cooling is more important than lubricating when machining AMPCO® material, specially for the harder grades M4, 21, 22, 25, 26. Water mixable lubricating coolant are recommended, where the emulsion generally contain 5 to 10% cooling lubricant. For parts where a high precision is requested, it is recommended to pre-machine first, then wait 48 hours before finish machining is performed. In special cases where the parts require very tight tolerances or for thin wall parts a stress-relieving heat treatment before or even better after the pre-machining can be done. Please ask your local AMPCO®-office for the necessary temperatures and holding time.

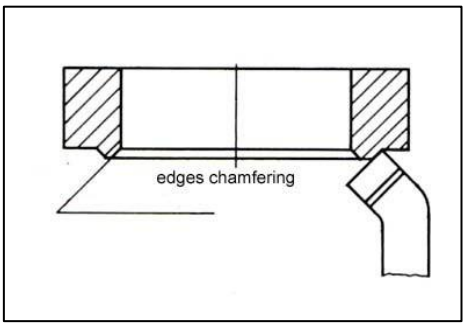
Sawing

The softer AMPCO® alloys up to AMPCO® 18 can be sawn with bimetal saw blades. The harder grades AMPCO® 21 up to AMPCO® 26 and M4 are best sawn with hardmetal saw blades. Depending on the section of the pieces to be cut, the number of sawing teeth will vary between 2 ½ and 3 teeth / inch.

Manufacturer recommendation: hard metal saw blades from WIKUS-Sägenfabrik, Wilhelm H. Kullmann GmbH & Co. KG www.wikus.de).

Turning

The cutting tool has to be set up in the centre of the part or up to 0,4 mm below this centre.



For roughing or finishing it is best to use hard metal cutting tool tips in the quality K10 / K20. For real fine machining (hole-shaft fits) a very good surface condition (N3) can be achieved with diamond tooling (PKD).

To avoid breaking of the edge when turning rings, you should always turn rings from outside of the material to inside of the material when machining the harder grades from AMPCO® 21 upwards. Alternatively a generous 45 degree chamfer can be machined before on the edge where the cutting tool will be finishing its turning operation coming out of the material.

Parameters for turning of AMPCO®

Alloys	AMPCO®		AMPCO® 8, 18.136, 18, 18.23, 45, M4	AMPCO® 21, 22	AMPCO® 25, 26
Roughing	Cutting-speed	vc (m/min)	see chart above	see chart above	see chart above
	Feed	f (mm/turn)	0,15 – 0,2	0,15 – 0,2	0,1 – 0,15
	Depth	a (mm)	up to approx. 4	up to approx. 3,5	up to approx.. 3,5
	Tool specification		K10 – K20	K10 – K20	K10 – K20
Finishing	Cutting speed	vc (m/min)	see chart above	see chart above	see chart above
	Feed	f (mm/turn)	0,05 – 0,1	0,05 – 0,1	0,05
	Depth	a (mm)	0,25 – 0,5	0,25 - 0,5	0,25- 0,5
	Tool specification		K10 – K20	K10 – K20	K10 – K20
Finishing with PKD	Cutting speed	vc (m/min)	200 – 600	180 – 400	150 – 300
	Feed	f (mm/turn)	0,05 – 0,08	0,05 – 0,08	0,05 – 0,08
	Depth	a (mm)	0,25 – 0,3	0,25 – 0,3	0,25 – 0,3

Manufacturer recommendation:
Company Seco,
CNMG 120408-MF1 in CP500
DCMT 11T304-F2 in CP200
VBMT 160404-F1 in CP500
Company Sumitomo,
DCGT 11 T3 04 N-SC in ACZ 310
CNMG 12 04 08 N-EX in EH 510Z
VBMT 16 04 08 N-SK in EH10Z

Parameters for turning of AMPCOLOY®

Alloys	AMPCOLOY®		AMPCOLOY® 95, 940, 972	AMPCOLOY® 83, 88
Roughing	Cutting speed	vc (m/min)	see chart above	see chart above
	Feed	f **(mm/turn)**	0,15 – 0,2	0,15 – 0,2
	Depth	a (mm)	up to approx. 4	**up to approx. 3,5**
	Tool specification		P10 – P20	P10 – P20
Finishing	Cutting speed	vc (m/min)	see chart above	see chart above
	Feed	f **(mm/turn)**	0,05 – 0,1	0,05 – 0,1
	Depth	a (mm)	0,25 – 0,5	0,25 - 0,5
	Tool specification		P10 – P20	P10 – P20

Manufacturer recommendation:

Company Seco,
CNMG 120408-MF1 in CP500
DCMT 11T304-F2 in CP200
VBMT 160404-F1 in CP500

Company Sumitomo type DCMT 11 T3 04 N-SU in AC700G

Company WNT www.wnt.de
DCGT 11 T3 02 – Al in CWK15
CCGT 12 04 04 FN – Al in CWK15

Important recommendations:

- For alloys AMPCO® 21 and above turn from the edge towards inside of the part
- Cooling lubricant is recommended

Milling

For the milling of AMPCO®, hard metal tools type K10 – K20 are best suited. To machine curves and cavities the standard hard metal tools with radius type K10 – K20 are best choice.
When using shaft milling tool, corner milling tool and two lips milling tool with hard metal tips it is a must to machine from outside to the inside of the part or otherwise the edges of the part to be machined must be first chamfered under an angle of 45° to avoid breaking of the edge.

Milling parameters for AMPCO®

Alloys	AMPCO®		AMPCO® 8, 18.136, 18, 18.23, 45, M4	AMPCO® 21, 22	AMPCO® 25, 26
Roughing	Cutting speed	vc (m/min)	see chart above	see chart above	see chart above
	Feed	f (mm/turn)	0,1 – 0,25	0,1 – 0,25	0,1 – 0,2
	Depth	a (mm)	up to approx. 5	up to approx. 5	up to approx. 4
	Tool specification		K10 – K20	K10 – K20	K10 – K20
Finishing	Cutting speed	vc (m/min)	see chart above	see chart above	see chart above
	Feed	f (mm/turn)	0,05 – 0,1	0,05 – 0,1	0,05
	Depth	a (mm)	0,1 – 0,5	0,2 - 0,5	0,2- 0,8
	Tool specification		K10 – K20	K10 – K20	K10 – K20
Finishing with PKD	Cutting speed	vc (m/min)	600 – 800	500 – 550	465 – 500
	Feed	f (mm/U)	0,03 – 0,08	0,03 – 0,08	0,03 – 0,08
	Depth	a (mm)	0,05 – 0,3	0,05 – 0,3	0,05 – 0,3

Manufacturer recommendation:
face milling
Company Ingersoll
PNCU 0805 GNTRJ in IN1030
Company Jongen, www.jongen.de
FP 528 HT35
cylindrical milling
Company Gühring, www.guehring.de (all milling tools type N pos.)
Ratio miller RF 100 art. nr. 3732 and nr. 3627 for roughing / finishing
Ratio miller RF 100 Art. Nr. 3631 for fine finishing
Company Ingersoll
Multi cutter SDMT 080305 N in IN1030 and SDCT 080305 FN-P in IN1030

Milling parameters for AMPCOLOY®

Alloys	AMPCOLOY®		AMPCOLOY® 95, 940, 972	AMPCOLOY® 83, 88
Roughing	Cutting speed	vc (m/min)	see chart above	see chart above
	Feed	f (mm/turn)	0,1 – 0,25	0,1 – 0,25
	Depth	a (mm)	up to approx. 5	up to approx. 4
	Tool specification		P10 – K20	P10 – K20
Finishing	Cutting speed	vc (m/min)	see chart above	see chart above
	Feed	f (mm/turn)	0,05 – 0,1	0,05 – 0,1
	Depth	a (mm)	0,1 – 0,5	0,25 - 0,8
	Tool specification		P10 – K20	P10 – K20

Manufacturer recommendation:
face milling
Company Ingersoll
PNCU 0805 GNTRJ en IN1030
Company Widia
SEKR 1203 AFN – MS THR
Company Hoffmann www.hoffmann-group.com
MPHX 11 K10/20
cylindrical milling
Company Ingersoll
Multi cutter SDMT 080305 N in IN1030 and SDCT 080305 FN-P in IN1030
Company Gühring www.guehring.de
Nr.3310 and 3126 and 3286

Important recommendations:

- For alloys from AMPCO® 21 upwards mill from outside of the part towards the inside of the part
- Hard metal milling tools with positive cutting angles are recommended.
- Cooling lubricant is recommended

Drilling, sinking and reaming

For the AMPCO® – grades 18 up to 26, hard metal plates drillers or fully hard metal drillers must be used. Since AMPCO® – alloys do not produce flowing chips, it is important to pay attention to a good chip removal. For deep holes it is recommended to withdraw the drilling tool and to remove the chip. For through holes (AMPCO® 21 up to 26) it is necessary to place a steel plate under the part or to drill the hole from both sides in order to avoid a breakage of the part around the exit end of the hole. A very good cooling of the drilling tool is absolutely necessary for AMPCO® and Ampcoloys.

Material	Brinell – hardness HB 30/10	Cutting speed
1.7225 (DIN 42 Cr Mo 4)	Max. 250	100 %
AMPCO® 8	109 - 124	125 %
AMPCO® 18	159 - 183	130 %
AMPCO® M4	270 - 305	120 %
AMPCO® 21	285 - 311	115 %
AMPCO® 22	321 - 352	110 %
AMPCO® 25	356 - 394	100 %
AMPCO® 26	395 - 450	75 %
AMPCOLOY® 940, 95, 97	180 – 255	125 %
AMPCOLOY® 83	340-390	100 %
AMPCOLOY® 88	260-280	120 %

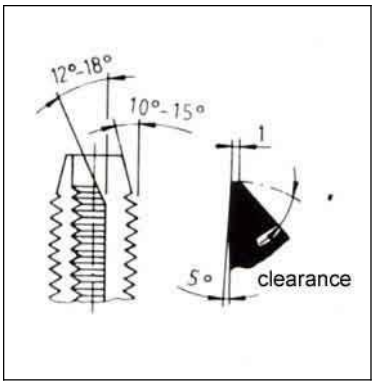
Manufacturer recommendation:
Fa. Gühring www.guehring.de
For AMPCO®-alloys: RT 100 U art. nr. 2471, 1243, 730, 732 and 305
For AMPCOLOY®: RT 100 F art. nr.1660, 1662 and 620

Important recommendations:

- For through holes in AMPCO® 21, 22, 25 and 26 drill from both sides
- Good chips removal has to be guaranteed
- Cooling with cooling lubricant
- If the depth of the chip is too small, the reaming tool will jam
- Hard metal plates reaming tools with unequal division
- When drilling with inner cooling tools observe the recommended cutting datas of the tool manufacturer

Machining of threads

For the middle hard and hard grades AMPCO® 18 up to 26 it is recommended to use thread cutting tools which are relief grinded. Hard metal thread cutting tools are an advantage compared to HSS thread cutting tools, they allow higher cutting speeds and last longer.



Manufacturer recommendation:
Fa. Gühring www.guehring.de
Art. nr. 969, 2506, 809 and 821

Important recommendations:

- For AMPCO® 25 and 26 the diameter for drilling of the hole before tapping must be 0,15 - 0,25mm bigger than the value of the diameter of the hole given by the norms.
- The hole must be chamfered on both sides before tapping when the threaded hole is a through hole.

Honing

When honing a part made out of AMPCO® alloy, a geometry precision of the machined part between 0.0005 and 0.015 mm with a surface roughness between 0,5 µm and 1,5 µm can be reached depending on the size and type of the part to be machined. For parts with a diameter between 25 and 130 mm, an undersize of 0.01 up to 0.038 mm must be foreseen for honing, for parts with a diameter greater than 130 mm up to 280 mm an undersize of 0.038 mm up to 0.063 mm must be foreseen.

Lapping

AMPCO® alloys can be lapped with especially high excellence. A precision of 0,1 µm up to 2 µm can be reached. The lapping powder used is corundum.

Grinding and polishing

One of the advantages of the AMPCO® alloys is that an excellent surface quality can be reached when fine machining. All AMPCO® grades can be grinded with feed rates as they are usual for steel. The grinding speed when deburring varies between 30 and 45 m/s, when flat or round grinding between 24 and 25 m/s. For flat or round grinding, silicon carbide grinding wheels will be used. Optimal results are achieved with rotating speeds of 5000 and 6000 RPM for the ginding wheels and when round grinding with a rotating speed of the part itself between 25 and 150 RPM. It is recommended to grind in wet condition.

The **polishing** of AMPCO® alloys is similar to steel. The parts to be polished will be first prepared by fine machining, for instance by flat grinding, or with grinding paper by hand, grain size 320 up to 500 or by fine grinding with a machine so that the grooves cannot be seen anymore with plain eyes. The parts to be polished will be then high gloss polished with a polishing wheel out of felt (driven by a drilling machine or special machine) and grinding / polishing paste.

EDM'ing

The group of AMPCO® alloys can be easily EDM machined with machine settings, rates of material removal and machining times extensively comparable with the applied values for the kind of steels generally used in tool making and mould making.

Wire EDM'ing of AMPCO® alloys and AMPCOLOY® is essentially straightforward except for the longer machining times required. Common brass wires are used, for instance with a diameter of 0.2 mm.

Therefore we are concentrating ourselves hereunder on the **sink erosion** of the high conductivity AMPCOLOY® 940 and AMPCOLOY® 944 (these recommendations are also valid for the other alloys of the AMPCOLOY® group of alloys).

AMPCOLOY® 940 and AMPCOLOY® 944 have a very good thermal and electrical conductivity. This property brings important practical advantages when these alloys are used in plastic injection moulds, allowing shorter cycle times due to faster cooling of the plastics. However, this property is less advantageous during EDM'ing. Therefore, due to the good conductivity of AMPCOLOY® 940 and AMPCOLOY® 944, the machining times will extend and a higher electrode wear will result.

The extent of the differences when EDM'ing AMPCOLOY® compared to steel materials depend mainly of:

a) The values of the settings, depending on the type of machine, especially on the type of generator
b) The type of used EDM'ing electrodes

a) Settings

According to the information available to us, the basic settings provided by the manufacturer of the machine can be followed, depending on the required surface quality, when roughing or finish machining.

Current intensity:
In correspondence to the above mentioned requirements, high current intensities will be necessary for roughing and low current intensities for fine surface machining. Large electrode surfaces require high current intensities, smaller electrode surfaces require less current intensity.
Due to the good electrical conductivity of AMPCOLOY® 940 and AMPCOLOY® 944, it is possible to use most of the time higher current intensities than with steel.

Polarity:
With modern EDM'ing machines, it is possible to use the normal polarity which is positive (+) for the electrode and negative (-)for the part to be machined. From case to case, it might be necessary with certain types of EDM'ing machines to reverse the polarity, i.e. negative (-) for the electrode and positive (+) for the part to be machined, also when using graphite electrodes.

On time settings of the different power levels (On time):
These on time settings depend on the type of electrode material; Copper-tungsten electrodes and premium graphite electrodes allow longer on time periods than copper electrodes. When using copper electrodes, the length of the on time periods must be shortened in order to avoid high electrode wear.

b) Electrode material

First choice for sink erosion of AMPCOLOY® 940 and AMPCOLOY® 944 is the use of copper-tungsten electrodes, whereby some limitations are encountered due to the availability of this material and its not straightforward machinability: the higher material and machining costs can very often be amortized when suitable geometries are present (for instance simple shapes such as round or square material) by higher EDM'ing rates of material removal.

Premium-graphite, respectively copper-graphite electrodes are generally less appreciated due to their so-called „dirty" machining characteristics. They are anyway usable as electrodes for EDM'ing of AMPCOLOY® 940 and AMPCOLOY® 944, the rate of wear is lower than for copper electrodes.

Electrolytic copper is for sure the mostly used electrode material for sink erosion, but it is also the nearest alloy compared to AMPCOLOY® 940 and AMPCOLOY® 944 as far as electrical conductivity is concerned and this results into the above mentioned difficulties, mainly higher electrode wear.
The wear of the copper electrode can be influenced by an optimal setting of the EDM'ing machine, for instance short on-time impulses, which will lengthen a little bit the machining time but reduce the wear rate. Also very important is an efficient flushing of the machined surface when EDM'ing to reduce electrode wear.

AMPCOLOY® 972 as EDM'ing electrodes have been quite appreciated by our customers, because it is easier to machine than electrolytic copper and coupled with the „copper-copper technology" or „copper-AMPCOLOY® technology" software setting programs of the EDM'ing machine manufacturers gave excellent results.

AMPCOLOY® 972 is available immediately from our stock in many dimensions.