



EXCELLENCE IN ENGINEERED ALLOYS



# TUBE BENDING TUBE FORMING DEEP DRAWING

FLEXIBLE BALL MANDRELS  
WIPER DIES & INSERTS  
END FORMING TOOLS  
LINKS  
FORMING & WELDING ROLLS  
DIE & BLANKHOLDER

[www.ampcometal.com](http://www.ampcometal.com)



## Who We Are....

Through excellent quality control, a spirit of innovation and customer service, AMPCO METAL remains the established world leader in the production and distribution of speciality copper-based alloys. AMPCO METAL - the first name in premium copper alloys established in 1914 - is an integrated manufacturer and distributor of specialty bronzes, copper-based alloys and related products serving a variety of sectors including: metal processing, aerospace, automotive, oil and offshore drilling, glass and plastic moldmaking and a wide range of industrial engineering applications. Fully aware of its impact on the environment and wanting to support sustainable development, AMPCO METAL recycles at all phases of the alloys casting process and utilizes advanced technology throughout its plants to rigidly maintain clean air and clean water programs.

### microcast<sup>®</sup> PROCESS key to Superiority

- Superior wear characteristics
- Greater resistance to corrosion
- Higher mechanical properties
- A consistent, reliable product



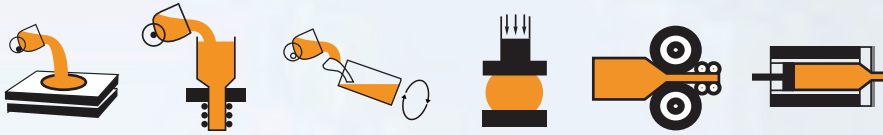
Competitor



AMPCO<sup>®</sup> 18



Through a combination of consistent metallurgical control and melting know-how, our proprietary AMPCO<sup>®</sup> specification is produced with unique microstructure, largely attributable to the phases in the alloys. The phase alpha, beta and the intermetallic compound. The distinctiveness of that intermetallic compound in AMPCO<sup>®</sup> alloys is readily recognized and has come to be known as AMPCO-PHASE<sup>®</sup>. Totally distinct from the large and segregated compound in generic bronzes which tends to contribute to weak alloy properties.



# AMPCO® 18

Chemical Composition	Mechanical Properties	Continuous Casted	Extruded
Cu: Balance Al: 10.5 Fe: 3.5	Tensile Strength: MPa (ksi)	620 (90)	655 (95)
	Yield Strength: MPa (ksi)	252 (37)	338 (37)
	Hardness: HBW	179	187
	Elongation: %	14	14
	Charpy: J (lbs*f)	14 (10.3)	14 (10.3)
	Electrical Conductivity: % IACS	14	12
	Permeability:	1.16	1.16
	Average Speed: m/s (fps)	1.5 (4.9)	1.5 (4.9)
	Average Load: MPa (ksi)	100 (14.5)	100 (14.5)

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

AMPCO® 18 - This primary alloy is used for heavy duty applications involving wear, abrasion and fatigue, where the absence of nickel in this composition significantly reduces the risk of mechanical abrasion with mating steel surfaces. This is the material of choice for wear plates, bearings, tie bar nuts, gears, worm-wheels, tube bending tools, wiper dies and similar applications. AMPCO® 18 is readily machinable and should be used in critical situations where it is essential to avoid unnecessary down-time or damage steel parts. When compared with generic alloys, the superior mechanical properties of AMPCO® 18 provide better impact resistance and resistance to distortion, which are particularly important attributes for aerospace and steel production applications.

Heat treated variations of AMPCO® 18 are possible:

AMPCO® 18.136 - Tailor made for steel mill applications.


AMPCO® 18.22 - A second variation of AMPCO® 18 with a special chemistry, giving a substantially higher tensile strength, yield strength and hardness. Recommended for bushing, bearings, liners and slides.

AMPCO® 18.23 - Provides successful performance under heavy loads and elongation remains the same. Ideal for heavy duty worm gears, for wiper dies and similar applications.

AMPCO® 18 standard sizes							
6.4 x 25.4	6.4 x 38.1	6.4 x 50.8	6.4 x 63.5	9.5 x 25.4	9.5 x 38.1	12.7 x 25.4	12.7 x 38.1
12.7 x 50.8	12.7 x 76.2	12.7 x 152.4	15.9 x 25.4	15.9 x 38.1	15.9 x 50.8	15.9 x 101.6	19 x 25.4
15.9 x 101.6	19 x 25.4	19 x 38.1	19 x 50.8	25.4 x 25.4	25.4 x 38.1	25.4 x 50.8	25.4 x 76.2
25.4 x 101.6	31.8 x 38.1	31.8 x 63.5	31.8 x 101.6	31.8 x 152.4	31.8 x 203.2	31.8 x 31.8	31.8 x 50.8
38.1 x 76.2	38.1 x 101.6	50.8 x 50.8	50.8 x 76.2	50.8 x 101.6	50.8 x 127	50.8 x 203.2	63.5 x 76.2
63.5 x 127	76.2 x 76.2	76.2 x 127	82.5 x 101.6	101.6 x 101.6	101.6 x 304.8	101.6 x 381	

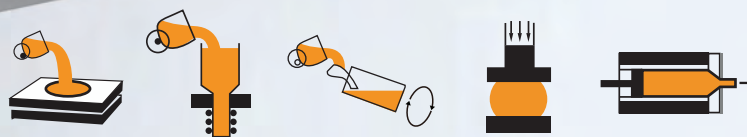
AMPCO® 18 standard sizes							
Ø 12.7	Ø 15.9	Ø 20.6	Ø 25.4	Ø 28.6	Ø 31.8	Ø 34.9	Ø 38.1
Ø 44.4	Ø 50.8	Ø 57.1	Ø 60.3	Ø 63.5	Ø 69.8	Ø 76.2	Ø 82.5
Ø 88.9	Ø 92	Ø 101.6	Ø 114.3	Ø 120.6	Ø 127	Ø 139.7	Ø 146
Ø 165.1	Ø 203.2	Ø 228.6					

AMPCO® 18 standard sizes							
Ø 50.8 / 19	Ø 50.8 / 25.4	Ø 57.1 / 25.4	Ø 57.1 / 38.1	Ø 63.5 / 25.4	Ø 63.5 / 38.1	Ø 63.5 / 44.4	Ø 69.8 / 31.8
Ø 69.8 / 44.4	Ø 69.8 / 50.8	Ø 76.2 / 25.4	Ø 76.2 / 38.1	Ø 76.2 / 44.4	Ø 76.2 / 50.8	Ø 82.5 / 38.1	Ø 82.5 / 57.1
Ø 82.5 / 63.5	Ø 88.9 / 44.4	Ø 88.9 / 50.8	Ø 88.9 / 57.1	Ø 88.9 / 63.5	Ø 95.2 / 50.8	Ø 95.2 / 69.8	Ø 101.6 / 38.1
Ø 101.6 / 57.1	Ø 101.6 / 69.8	Ø 114.3 / 63.5	Ø 114.3 / 76.2	Ø 127 / 63.5	Ø 127 / 88.9	Ø 139.7 / 76.2	Ø 152.4 / 76.2

 AMPCO® 18 Plates ranging from 8 mm to 260 mm in thickness.

AMPCO® 18 welding wire:

Welding	AMPCO-TRODE® 150	AWS Class ER CuAl-A3
Overlaying	AMPCO-TRODE® 10 / AMPCO-CORE® 200	AWS Class ER CuAl-A2
Repairing	AMPCO-TRODE® 150	AWS Class ER CuAl-A3
GTAW	AMPCO-TRODE® 150	
GMAW	AMPCO-CORE® 200, AMPCO-TRODE® 150	
Covered electrodes	AMPCO-TRODE® 160	AWS Class E CuAl-B

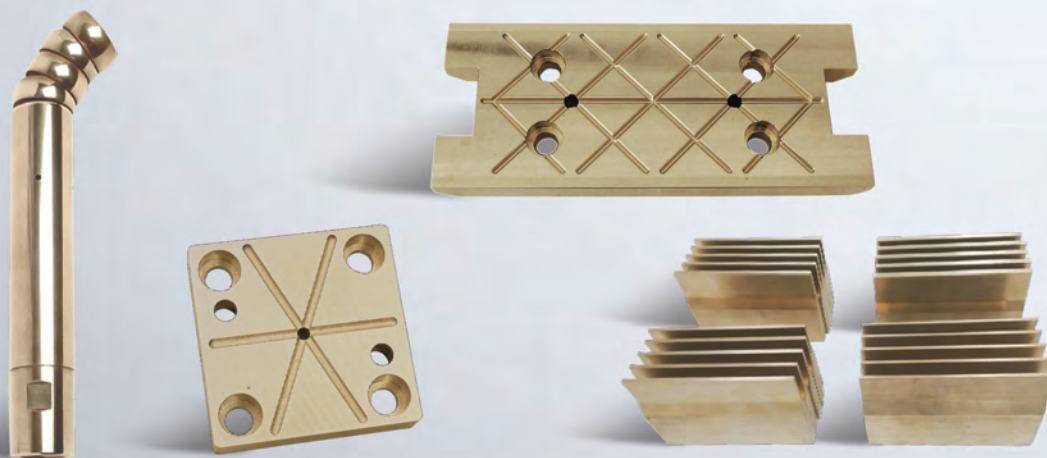


# AMPCO® 21

Chemical Composition	Mechanical Properties	Continuous Casted	Extruded
Cu: Balance Al: 13.1 Fe: 4.4	Tensile Strength: MPa (ksi)	703 (102)	724 (105)
	Yield Strength: MPa (ksi)	407 (59)	407 (59)
	Hardness: HBW	285	286
	Elongation: %	1	1
	Charpy: J (lbs*f)	3 (2)	2.7 (2)
	Electrical Conductivity: % IACS	10	10
	Permeability:	1.12	1.12
	Average Speed: m/s (fps)	0.7 (2.3)	0.7 (2.3)
	Average Load: MPa (ksi)	115 (16.7)	115 (16.7)

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

AMPCO® 21 is used for guide port bushings and wear strips replacing hardened steel and for cams, when no impact is involved. However, the most common uses are as die rings, inserts, forming rolls etc. in forming, bending or drawing operations, especially when stainless steel is the material being processed. This material is also widely used as work support blades for the centerless grinding of steel rods.



AMPCO® 21 standard sizes

Ø 15.9	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 76.2	Ø 88.9	Ø 101.6	Ø 127	Ø 139.7	Ø 152.4	Ø 203.2
Ø 228.6							

AMPCO® 21 standard sizes

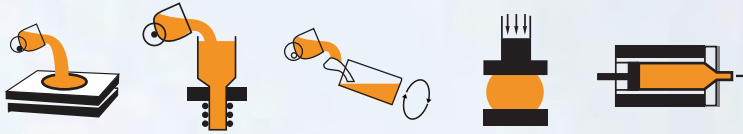
6.4 x 38.1	6.4 x 50.8	9.5 x 38.1	9.5 x 50.8	12.7 x 25.4	12.7 x 38.1	12.7 x 50.8	12.7 x 76.2
12.7 x 152.4	15.9 x 25.4	15.9 x 38.1	15.9 x 50.8	15.9 x 101.6	19 x 25.4	19 x 38.1	19 x 50.8
25.4 x 25.4	25.4 x 38.1	25.4 x 50.8	25.4 x 76.2	25.4 x 101.6	31.8 x 38.1	31.8 x 63.5	31.8 x 101.6
31.8 x 152.4	31.8 x 203.2	38.1 x 38.1	38.1 x 50.8	38.1 x 76.2	50.8 x 50.8	50.8 x 76.2	50.8 x 101.6
50.8 x 203.2	63.5 x 76.2	63.5 x 127	76.2 x 76.2	101.6 x 101.6	101.6 x 304.8	101.6 x 381	

AMPCO® 21 Plates ranging from 6 mm to 260 mm in thickness.

AMPCO® 21 welding wire

Welding		
Overlying	AMPCO-TRODE® 250	AWS Class RCuAl-C
Repairing	AMPCO-TRODE® 250	AWS Class RCuAl-C
GTAW	AMPCO-TRODE® 250	AWS Class RCuAl-C
GMAW	AMPCO-CORE® 250	

Covered electrodes



# AMPCO® 22

Chemical Composition	Mechanical Properties	Continuous Casted	Forged
Cu: Balance Al: 14.1 Fe: 4.7	Tensile Strength: MPa (ksi)	586 (85)	620
	Yield Strength: MPa (ksi)	489 (71)	531
	Hardness: HBW	331	338
	Elongation: %	0.5	0.5
	Charpy: J (lbs*f)	2.7 (2)	2.7 (2)
	Electrical Conductivity: % IACS	10	10
	Permeability:	1.12	1.12
	Average Speed: m/s (fps)	0.6 (2)	0.6 (2)
	Average Load: MPa (ksi)	120 (17.4)	120 (17.4)

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

AMPCO® 22 is a duplex structure alloy of approximately 50% of each phase - gamma 2 and beta. It is remarkable because of its hardness, its excellent compression/wear resistance and its sliding properties. As the elongation of the material is very low, thin sections should be avoided and the material should be well backed up.



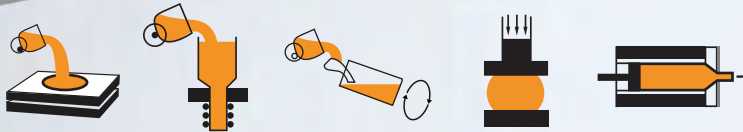
## AMPCO® 22 standard sizes

Ø 9.5	Ø 12.7	Ø 15.9	Ø 22.2	Ø 31.8	Ø 38.1	Ø 44.4	Ø 50.8
Ø 57.1	Ø 63.5	Ø 76.2	Ø 82.5	Ø 88.9	Ø 101.6	Ø 114.3	Ø 152.4
Ø 203.2							

## AMPCO® 22 Plates ranging from 80 mm to 260 mm in thickness.

## AMPCO® 22 welding wire

Welding		
Overlaying	AMPCO-TRODE® 250	AWS Class RCuAl-D
Repairing	AMPCO-TRODE® 250	AWS Class RCuAl-D
GTAW	AMPCO-TRODE® 250	AWS Class RCuAl-D
GMAW	AMPCO-CORE® 250	
Covered electrodes		

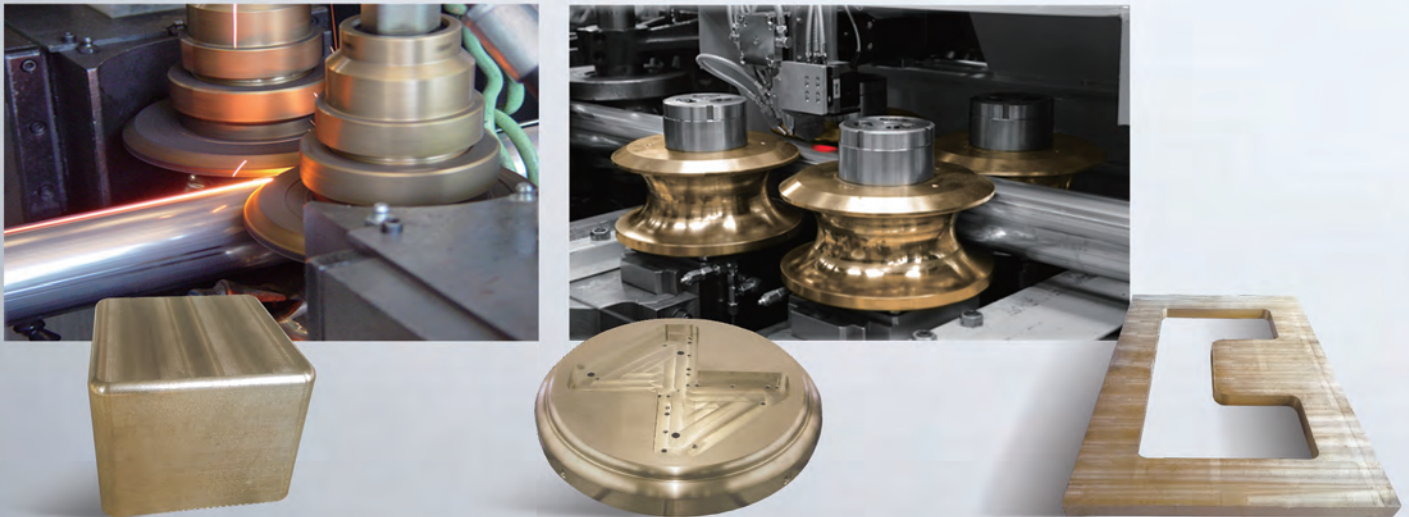


# AMPCO® 25

Chemical Composition	Mechanical Properties	Continuous Casted	Forged
Cu: Balance Al: Not published Fe: Not published	Compressive Strength: MPa (ksi)	1551	1579
	Compressive Strength 0.1%: MPa (ksi)	689	706
	Hardness: HBW	364	375
	Elongation: %	0	0
	Electrical Conductivity: % IACS	8	8
	Permeability:	1.008	1.008
	Average Speed: m/s (fps)	0.5 (1.6)	0.5 (1.6)
	Average Load: MPa (ksi)	125 (18.1)	126 (18.1)

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

AMPCO® 25 is a patented alloy which displays outstanding mechanical properties. The extreme hardness, linked with an excellent compressive strength and very good friction properties, make it ideal as a forming and drawing die material. As the elongation of the material is nil, thin sections should be avoided and the material must be well backed up.



### AMPCO® 25 standard sizes

6.4 x 50.8	25.4 x 50.8	25.4 x 76.2	31.8 x 203.2	38.1 x 101.6	50.8 x 101.6	50.8 x 127	50.8 x 203.2
82.5 x 101.6	101.6 x 381						



### AMPCO® 25 standard sizes

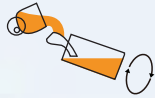
Ø 25.4	Ø 31.8	Ø 38.1	Ø 50.8	Ø 63.5	Ø 76.2	Ø 88.9	Ø 101.6
Ø 114.3	Ø 127	Ø 139.7	Ø 152.4	Ø 165.1	Ø 177.8	Ø 190.5	Ø 203.2



AMPCO® 25 Plates ranging from 9 mm to 150 mm in thickness.

### AMPCO® 25 welding wire

Welding		
Overlaying	AMPCO-TRODE® 300 / AMPCO-CORE® 300	AWS Class RCuAl-E / -
Repairing	AMPCO-TRODE® 300 / AMPCO-CORE® 300	AWS Class RCuAl-E / -
GTAW	AMPCO-TRODE® 300	AWS Class RCuAl-E
GMAW	AMPCO-CORE® 300	
Covered electrodes		

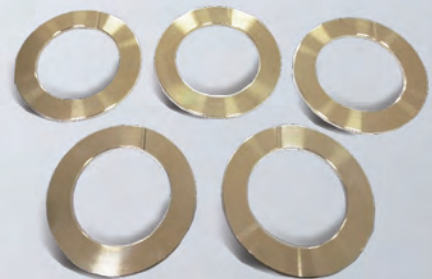
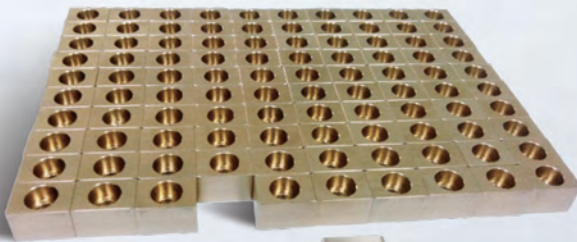


# AMPCO® M4

Chemical Composition	Mechanical Properties	Centrifugal Casted	Forged
Al: 10.5 Fe: 4.8	Tensile Strength: MPa (ksi)	930 (135)	965
	Yield Strength: MPa (ksi)	724 (105)	724
	Hardness: HBW	293	286
	Elongation: %	6	8
	Charpy: J (lbs*f)	6.8 (5)	7 (5)
	Electrical Conductivity: % IACS	8.2	8.2
	Permeability:	1.15	1.15
	Average Speed: m/s (fps)	1 (3.3)	1 (3.3)
	Average Load: MPa (ksi)	330 (47.9)	330 (47.9)

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

AMPCO® M4 was initially developed as an aircraft specification alloy for gears in retractable landing assemblies, engine spacer bearings and other similar applications. It is rapidly growing in use, where higher mechanical properties at elevated temperatures together with corrosion-resistant properties are required. Used for example in tricorne rotary drill bit.



### AMPCO® M4 standard sizes

Ø 19	Ø 25.4	Ø 31.8	Ø 38.1	Ø 44.4	Ø 50.8	Ø 60	Ø 63.5
Ø 69.8	Ø 76.2	Ø 82.5	Ø 95.2	Ø 101.6	Ø 127	Ø 152.4	



### AMPCO® M4 Plates ranging from 10 mm to 150 mm in thickness.

### AMPCO® M4 welding wire

Welding	AMPCO-TRODE® 46	AWS Class ER CuNiAl
Overlaying	AMPCO-TRODE® 46	AWS Class ER CuNiAl
Repairing	AMPCO-TRODE® 46	AWS Class ER CuNiAl
GTAW	AMPCO-TRODE® 46	AWS Class ER CuNiAl
GMAW	AMPCO-TRODE® 46	AWS Class ER CuNiAl
Covered electrodes	AMPCO-TRODE® 46	AWS Class E CuNiAl

# TUBE BENDING





# MANDRELS, WIPER DIES & END FORMING TOOLS

For tube bending of stainless steel and titanium material pipes, AMPCO® 18, AMPCO® 18.23, AMPCO® 21, AMPCO® 22 and AMPCO® M4 are used with great benefits for product quality and long-life of the production tooling. Advantages of AMPCO® 21 and AMPCO® 22 mandrels and balls: Extended life, no hardening or expensive coatings on the mandrel required, no galling. Advantages of AMPCO® 18, AMPCO® 18.23 and AMPCO® M4 wiper dies: Extended life (20 times longer with AMPCO® M4), easier set-up, no galling, no scratching, no corrosion starting point.



This type of end forming tooling supports material forming from both sides to deliver tighter roundness tolerances for joining or welding.

**Advantages:** Provides high quality surface finish, form non-symmetrical and symmetrical shapes, easy to regrind.

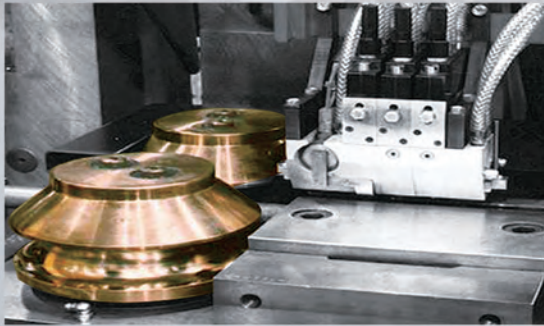
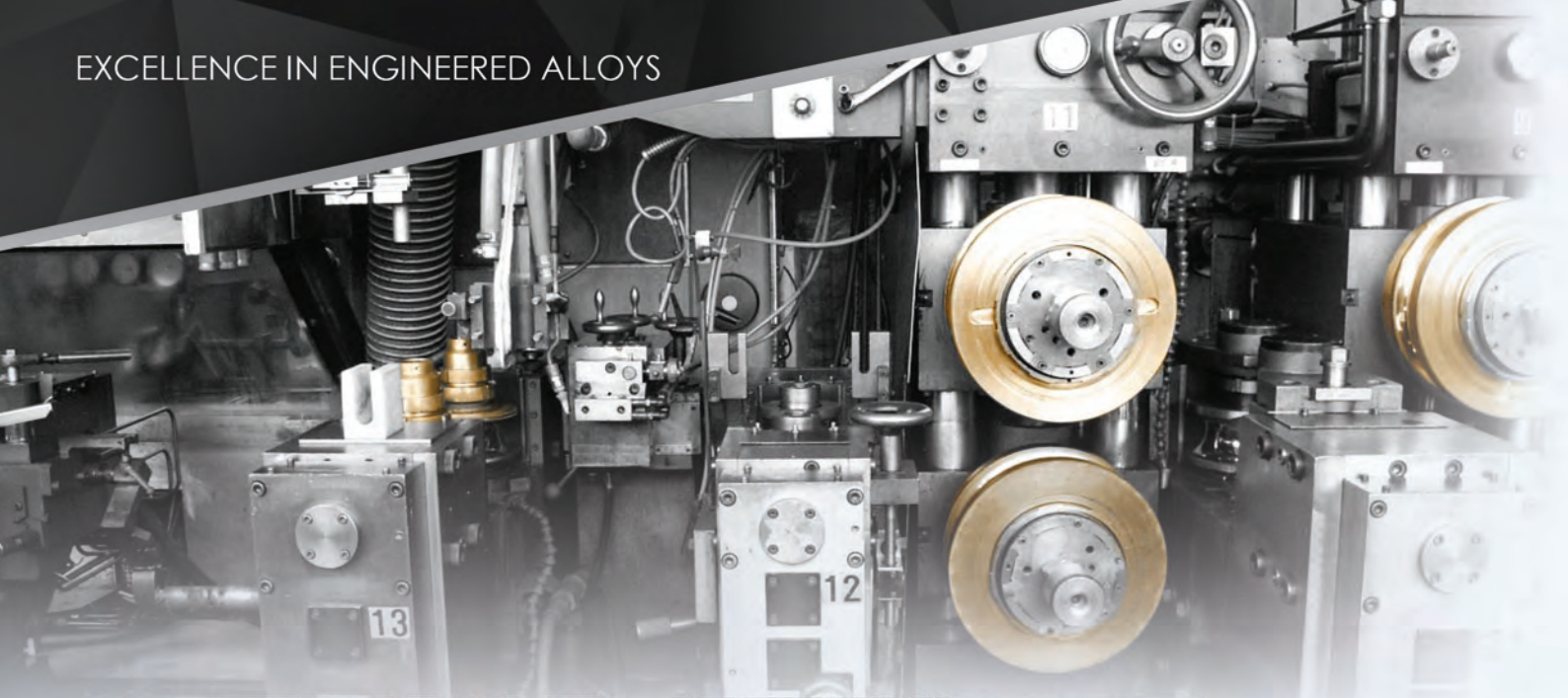
## Design System Flexible Mandrel

### TECHNICAL SPECIFICATIONS

D of Bend = Center Line Radius / Tube Outside Diameter

Wall Factor	D of Bend											
	1 D	1.25 D	1.5 D	1.75 D	2 D	2.25 D	2.5 D	2.75 D	3 D	3.5 D	4D	
10												
15	1W	1W	1W	1W	1	1	1	1				
20	2W	2W	1W	1W	1W	1	1	1	1	1	1	1
25	3W	3W	2W	2W	2W	2W	1W	1W	1W	1W	1W	1W
30	3W	3W	3W	3W	2W	2W	2W	2W	2W	2W	2W	2W
35	4W	4W	3W	3W	3W	3W	3W	3W	3W	3W	3W	3W
40	4W	4W	3W	3W	3W	3W	3W	3W	3W	3W	3W	3W
45	4W	4W	3W	3W	3W	3W	3W	3W	3W	3W	3W	3W
50	4W	4W	3W	3W	3W	3W	3W	3W	3W	3W	3W	3W
55	4W	4W	4W	3W	3W	3W	3W	3W	3W	3W	3W	3W
60	4W	4W	3W	3W	3W	3W	3W	3W	3W	3W	3W	3W
65	5W	5W	5W	5W	5W	3W	3W	3W	3W	3W	3W	3W
70	5W	5W	5W	5W	5W	5W	5W	3W	3W	3W	3W	3W
80	5W	5W	5W	5W	5W	5W	5W	3W	3W	3W	3W	3W
90	5W	5W	5W	5W	5W	5W	5W	5W	5W	5W	5W	5W
100	5W	5W	5W	5W	5W	5W	5W	5W	5W	5W	5W	5W
125	6W	6W	6W	6W	6W	6W	5W	5W	5W	5W	5W	5W
150	6W	6W	6W	6W	6W	6W	5W	5W	5W	5W	5W	5W
175	8W	8W	8W	8W	7W	7W	7W	7W	6W	6W	6W	6W
200	10W	10W	10W	10W	10W	10W	9W	9W	9W	9W	9W	9W
225		10W	10W	10W	10W	10W	10W	10W	10W	10W	10W	10W

Plug Mandrel    Regular Pitch    Close Pitch    Ultra Close Pitch    W = Wiper Dies Needed



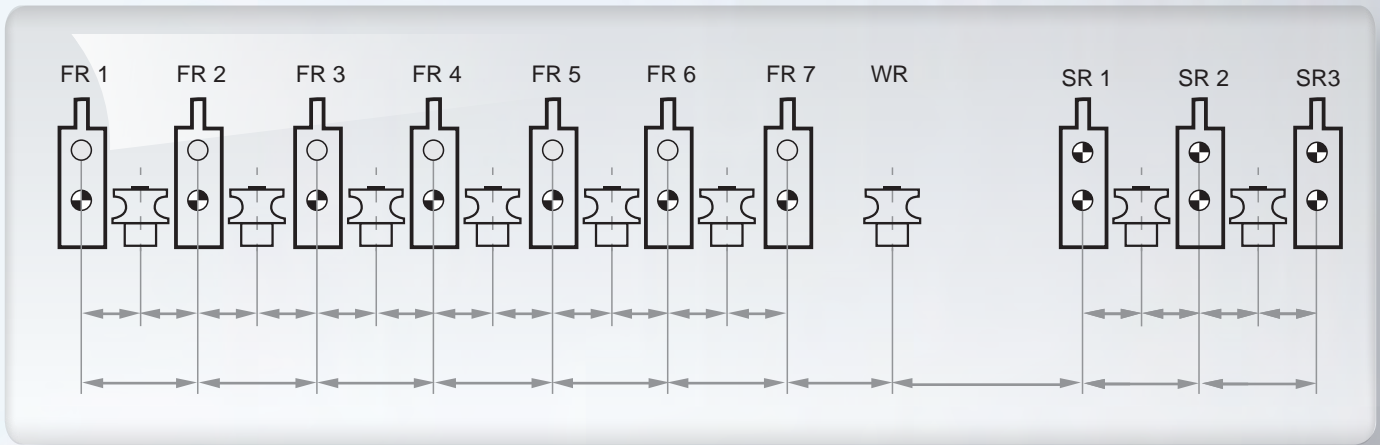
## TUBE FORMING


When producing stainless steel tubes from strips, so called cold welds might occur on the forming rolls. These cold welds on the forming rolls are damaging the surface of the steel tubes. Additionally working on a semi-circular forming roll in order to obtain a tube out of a flat steel strip, the differences in tangential speeds along the surface of the tube induce sliding between forming roll, calibration roll and the stainless steel sheet. Because of the cold welding effect and the difference in speed on the forming rolls, these rolls must be chosen out of a material with very good sliding characteristics in order to obtain an absolutely perfect surface on the stainless steel tubes. AMPCO METAL guarantees a wide range of material satisfying the highest requirements. For example, the patented alloy AMPCO® 25 offers multiple advantages especially for welding rolls, forming (break down) and calibration (sizing) rolls. The greater the number of forming stations, the more gradual is the absorption of plastic deformation and the less the stress generated in the material. This can be important for meeting dimensional tolerance requirements during assembly.

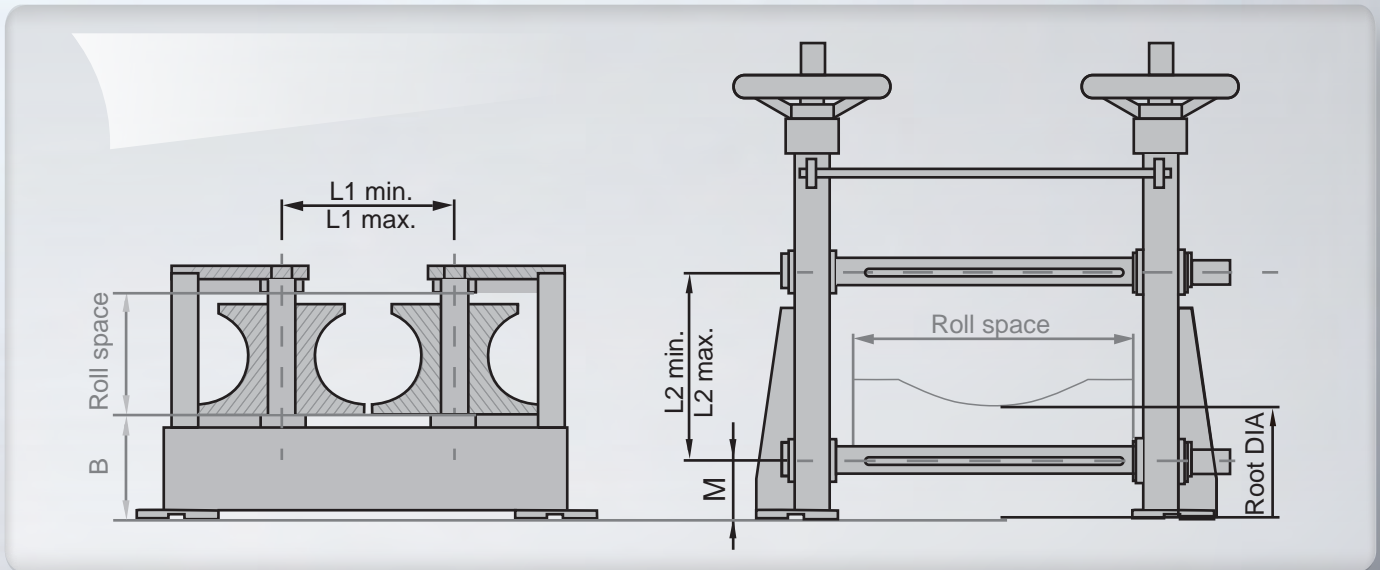
### BENEFITS:

- Very good sliding characteristics
- No cold welds on the forming rolls
- Absolutely perfect surface on carbon, stainless steel and titanium tubes
- Extended life time of forming rolls
- No hardening or expensive coatings required on the rolls
- Easy to regrind
- Less power consumption in HF welding process

In case of new development we can offer the complete set of rolls (design and machining). We just need a few information according the tube mill. See hereunder.



-  **Driven shaft**
- FR: Forming rolls**
- FP: Fin-passes**
- WR: Welding rolls**
- SR: Sizing rolls**



Vertical stand

Horizontal stand

### Strip details:

#### Material

Standard name

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Thickness of strip

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Yield strength (Rp0,2)

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Tensile strength (Rm)

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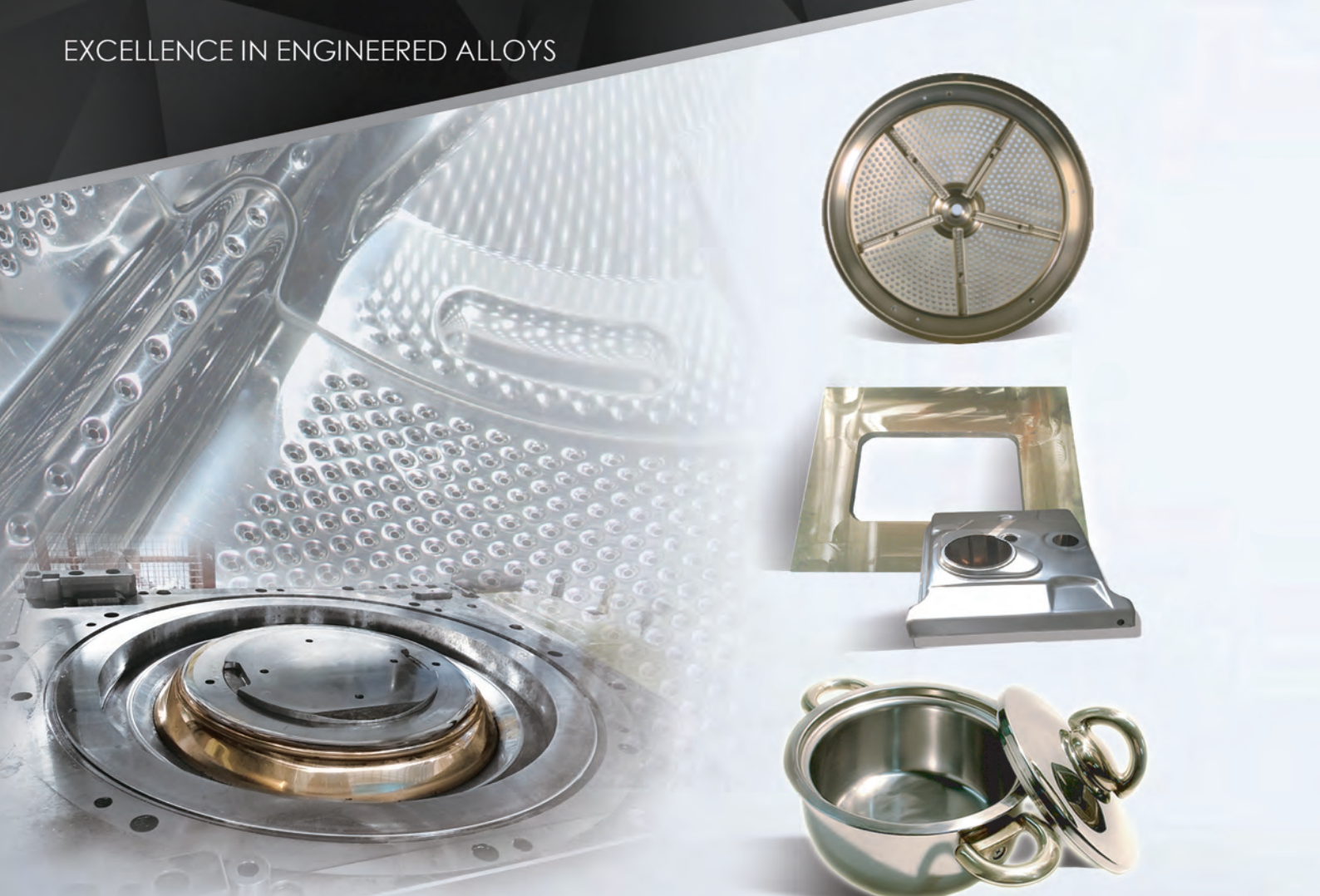
Elongation %

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Coated strip (Yes/No)

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Complementary information: (dimensions of the shaft, key way, bearings)



## DEEP DRAWING

In deep drawing, conventional materials tend to suffer from various disadvantages. Cast iron for example may have good sliding properties, but the rate of wear of the tool is far too high. Tools from hardened steel have satisfactory working lives, but have pick-up tendencies. If coated, the result will be better, but after a certain number of shots the sliding properties will tend to decrease, consequently increasing the coefficient of friction. (See graph on the next page). AMPCO® 21, AMPCO® 22 and especially AMPCO® 25 combine very high strength and hardness with remarkably low resistance to friction. These qualities are derived from hardness associated with very special metallurgical structure. Due to the exceptional resistance of AMPCO® materials to corrosive and atmospheric influences, no special arrangements are necessary to prevent oxidation. Because of the higher linear coefficient of expansion of AMPCO® material, the drawing gap between die and punch must be approximative +12% of hot-rolled blank thickness and +10% of cold-rolled blank thickness.

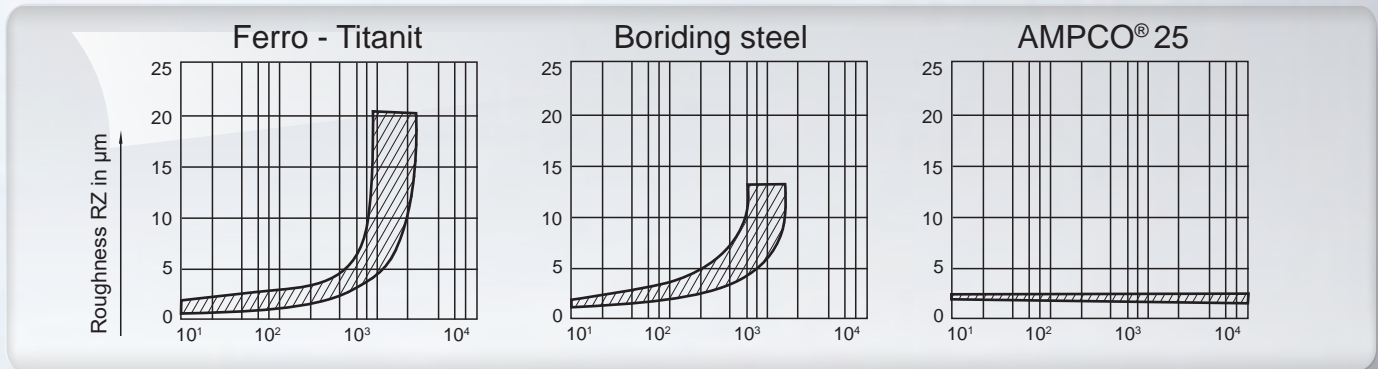
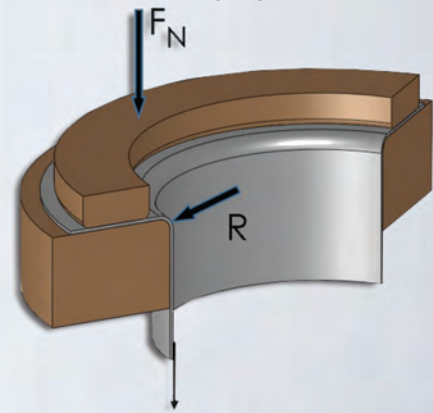
The face which are subjected to stresses (drawing edges) must definitively be polished (AMPCO® alloys polishes well). Care must be taken to ensure that faces are perfectly flat and not wavy! Unevenness can be created by hand polishing, affecting surface finishing and reducing tool life.

### BENEFITS:

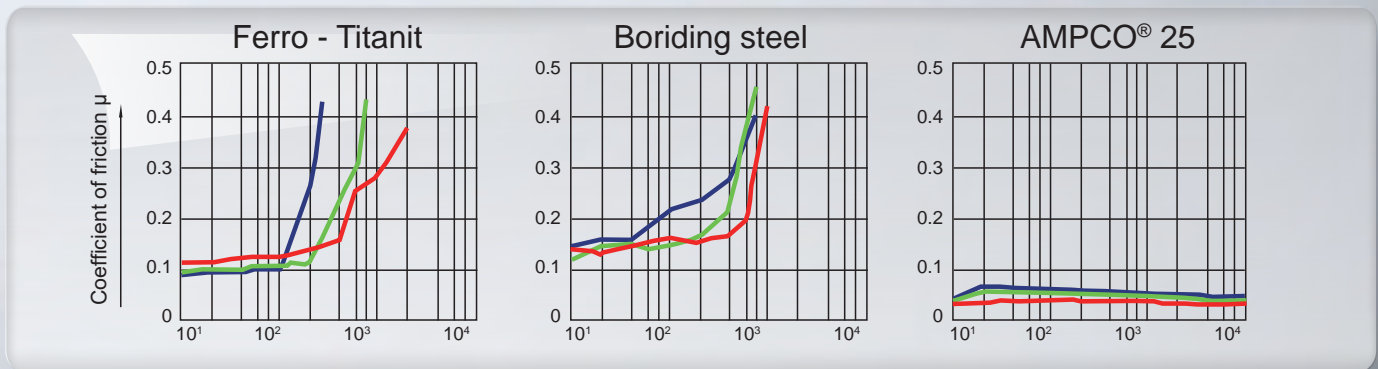
- **Over tool steel:**  
Lower friction, no galling, tool manufacturing without heat treatment, easier modification.
- **Over commercial bronze:**  
Higher hardness and quality due to homogeneous microstructure. Better sliding properties and lower wear.
- **Over coated materials:**  
Bigger wear area definition possible. Changes of geometry possible at any time, solid proof that the “best coating in the world is the one you do not need”.

Friction is not a static parameter, but can vary during the tool life. Important cause of friction variations is originated by material transfert. This is caused by particules being scraped from workpieces, which then adhere to the tools. Here under you can see an analysis from the "Institut für Umformtechnik" in Darmstadt, showing the evolution of the coefficient of friction and evolution of wear properties in term of numbers of draw.

Material to draw: X5CrNi 18 9  
 Delivery Roughness:  $R_z = 2.0 \pm 0.3 \mu\text{m}$ .  
 Blank thickness: 0.8 mm  
 Die Radius:  $R = 4 \text{ mm}$   
 Strength on blankholder:  $F_N = 3000 \text{ N}$   
 Maximum process speed:  $v = 0.25 \text{ m/s}$



Number of shots



Number of shots

### General rules for AMPCO® tools:

- Die radius: 5 to 7 x blank thickness (Ideally > 3 mm.)
- Punch radius: 8 x blank thickness
- Die height: 5 to 7 x die radius. (Minimum 30 mm)
- Flatness and parallelism tolerance of the die: 0.02 mm.

# SPECIFY AMPCO®



## Wear-Resistant Bronzes Corrosion-Resistant Bronzes



Deep Drawing  
AMPCO® 21/22/25/26



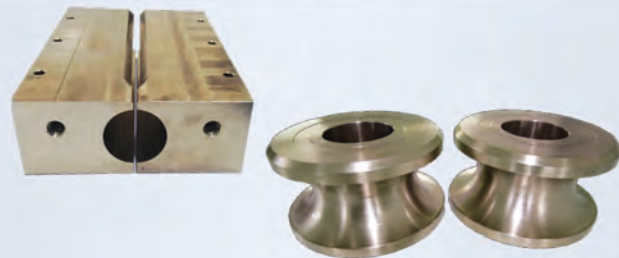
General Engineering  
AMPCO® 18/21/M4



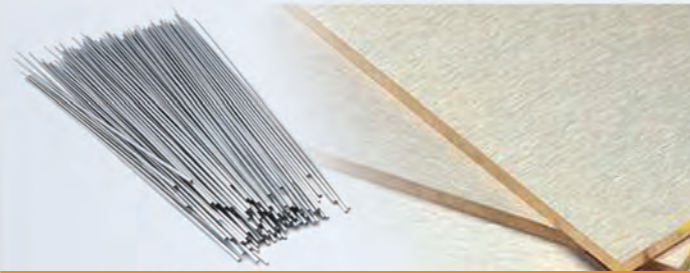
Rollercoasters  
AMPCO® 18/M4



Tube Bending  
AMPCO® 18/21/22/25/M4



Tube Forming  
AMPCO® 18/21/22/25



Cu/W  
Wires up to 0.25mm



Work Rest Blades  
AMPCO® 21



Steel Mill  
AMPCO® 18/21/45/M4



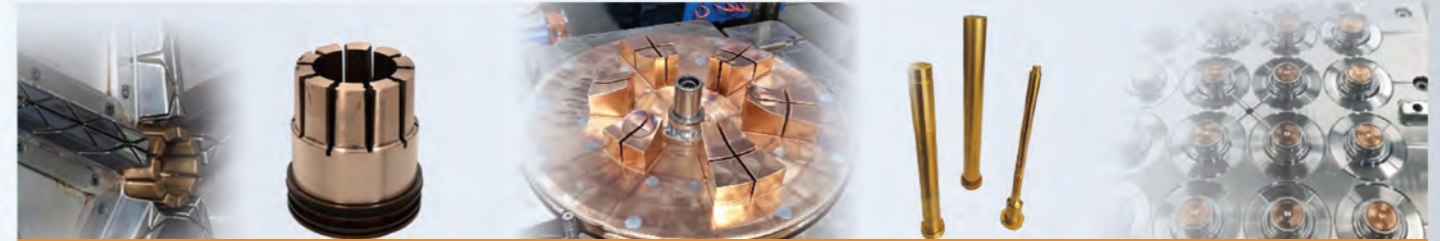
Corrosion Application Chemical Industry  
AMPCO® 8



AMPCO® SAFETY TOOLS



## High-Conductivity Alloys



Plastics Industries

AMPCOLOY® 940/944/83/95



Blow Moulding  
AMPCOLOY® 940 AMPCO® 18



Aerospace & Offshore  
AMS 4640/4590/4880/4881



Die Casting  
AMPCOLOY® 940/89/95



Soap Mould  
AMPCOLOY® 940



AMPCOLOY® NOZCAP



Welding Materials  
AMPCO - TRODE®

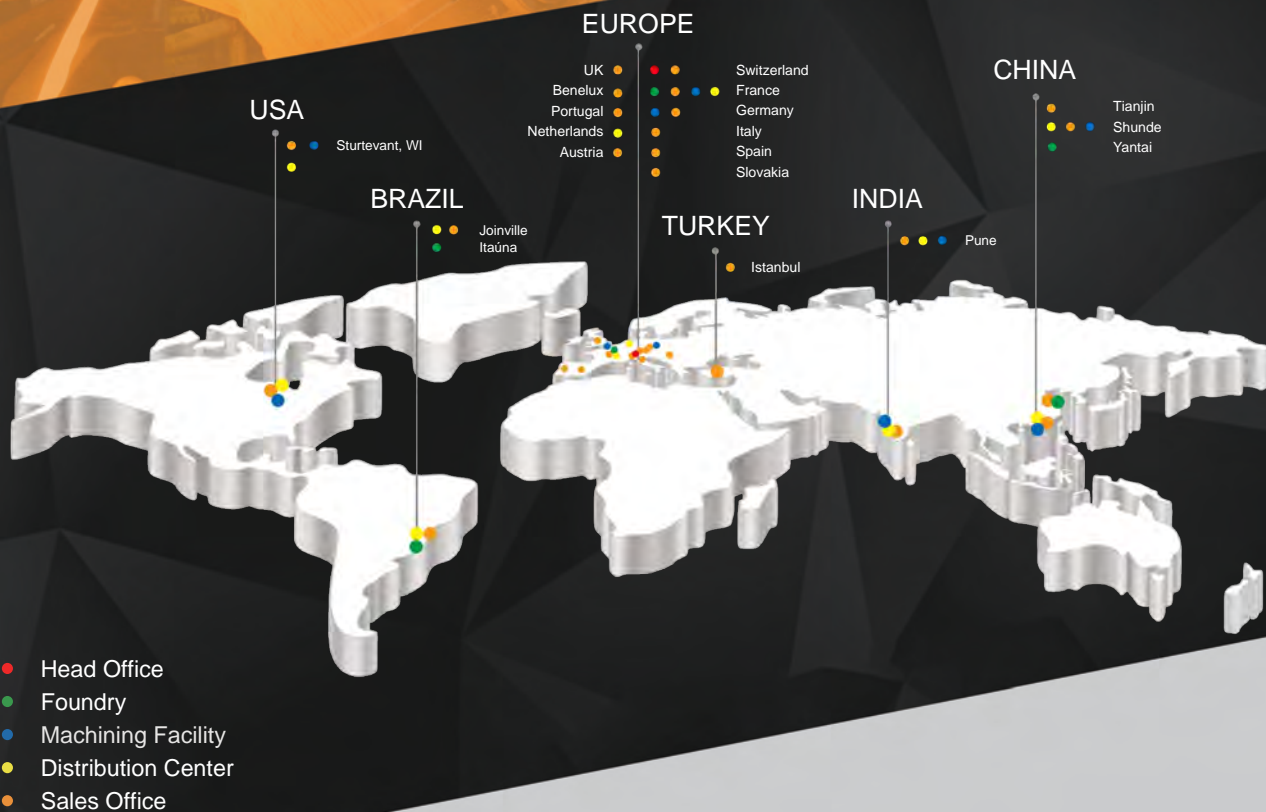


Resistance Welding & Plunger Tips  
AMPCOLOY® 972/940/83/95





EXCELLENCE IN ENGINEERED ALLOYS



**EUROPE (Headquarters)**

**AMPCO METAL S.A.**

Route de Chésalles 48  
P.O.Box 45, 1723 Marly  
SWITZERLAND  
TOLL FREE PHONE: 800 8080 5050  
Tel.: +41 26 439 93 00  
Fax: +41 26 439 93 01  
Info@ampcometal.com

**BRASIL**

**AMPCO METAL Brasil Ltda.**

Rua Dona Francisca 8400 - galpão 2  
Zona Industrial Norte  
Joinville, SC - 89219 - 600  
Tel.: +55 47 3305 0020  
Fax: +55 47 3305 0021  
Infobrasil@ampcometal.com

**CHINA**

**AMPCO METAL (Foshan) Co., Ltd**

Warehouse 9-1 No 9 Xinyue road  
Jinqiao Industrial city, Wusha  
Daliang town, Shunde, Foshan  
Guangdong Province, P.R.China.  
P.C.528333  
TOLL FREE PHONE: 4008 899 028  
Tel.: +86 (0) 757 2232 6571  
Fax: +86 (0) 757 2232 6570  
Infochina@ampcometal.com

**INDIA**

**AMPCO METAL INDIA PVT. LTD.**

A-8/4, Village - Nighoje,  
Chakan MIDC, Phase IV, Tal : Khed  
Pune – 410501, Maharashtra - INDIA  
Tel.: +91 2135 610 810  
Fax: +91 2135 610 811  
Infoindia@ampcometal.com

**U.S.A**

**AMPCO METAL Inc.**

1221 Grandview Pkwy  
Sturtevant, WI 53177  
Tel.: +1 800 844 6008  
Fax: +1 847 437 6008  
Infousa@ampcometal.com

