

## OVERVIEW

The Harris Products Group has been manufacturing high quality soldering, brazing and welding filler metals in the United States of America for over 50 years until becoming a global and reliable supplier for many of the leading manufacturers on the HVAC/R / Construction/ Electric/ Transportation and Green Energies industries. Our facilities are certified to ISO 9001 and ISO 14001.

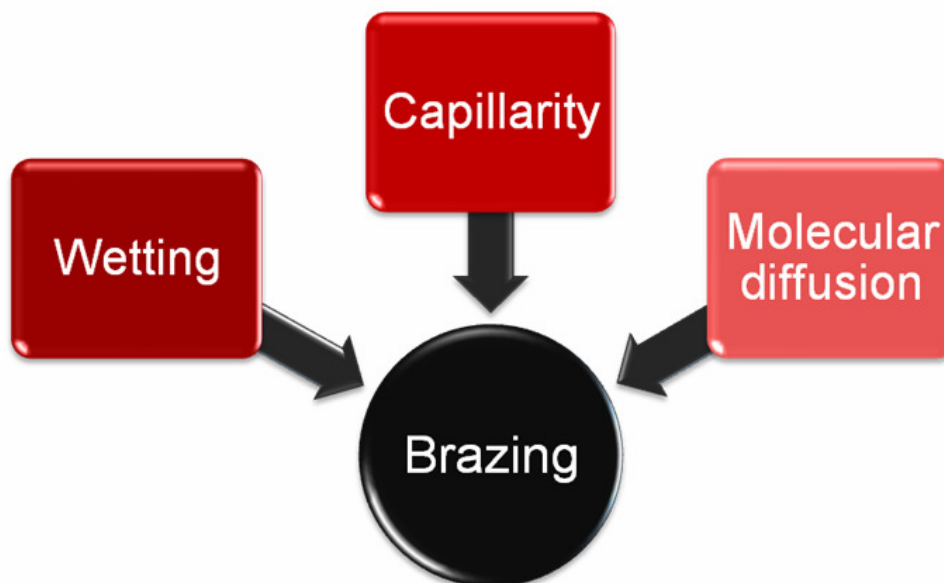
Throughout the last 50 years Harris has been developing exclusive manufacturing technology to ensure that every alloy manufactured is free of impurities and is reaching the Harris internal (Very closed) standards.

The Harris Products Group has the knowledge, experience and production capacity to give you a strong partner who will make your metal joining operations more profitable.

## BRAZING PROCESS

In the process of brazing, the temperature of the assembly to be brazed (brazement) is raised to a point where the filler metal comes molten and fills the joint gap between base materials. In most cases the interaction between the molten filler metal and the base materials results in the establishment of a metallurgical bond when the filler metal solidifies.

The brazing process occurs by the combined effects of wetting, capillarity and molecular diffusion.

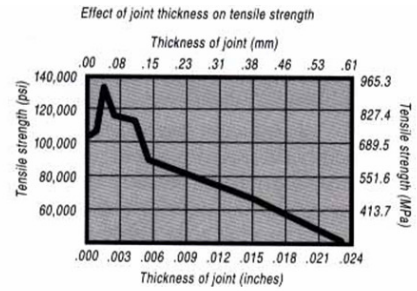
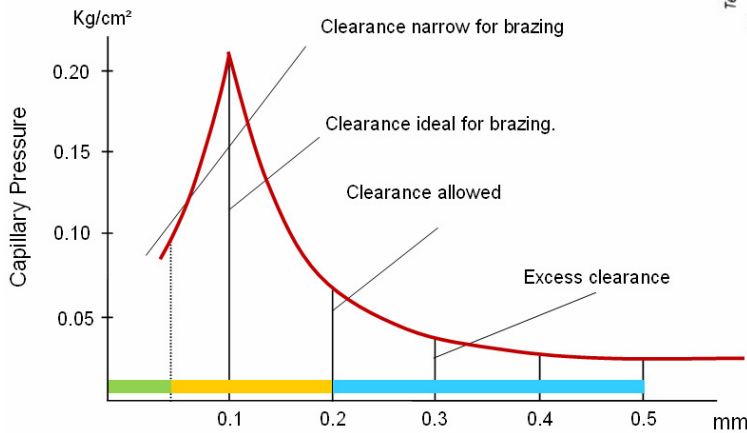


**Wetting:** Is the capability that a liquid has to wet a solid surface, flowing over it and leaving a film of this fluid.

**Capillarity:** Is a group of physical phenomena that promotes pressure on liquids making them to fill gaps between two surfaces placed together. In brazing capillarity is obtained through the gap between the parts to be joined by the filler metal.

**Molecular diffusion:** When the base metal is heated the grains increase the size and open small interstitial spaces between them, so the filler metal flows to this space. After that when the metal cools the filler metal is trapped between the grains of the base metal, obtaining a strong brazed joint.

# Capillarity:



- Controlled atmosphere**  
Furnace brazing, vacuum brazing
- Common atmosphere**  
Torch brazing, induction brazing etc.
- Brazing with brass alloy**

## PHOSPHOROUS COPPER ALLOYS

The Phosphorous copper alloys are designed to provide excellent mechanical, physical and chemical properties to ensure a long leak free service time under strong working conditions. Phosphorous containing alloys are self-fluxing on copper – copper applications and can be used on dissimilar copper alloys connections using the appropriate brazing flux. The Harris Products Group does not recommend using Phosphorous containing alloys for brazing other than copper alloys.

Despite of all Phosphorous Copper alloys can be used on copper alloys connections The Harris Products Group is manufacturing an extensive product range including some Harris Trademarks alloys covering the characteristics required on every single application from plumbing to aerospace industry.

## Copper Phosphorus Alloys:

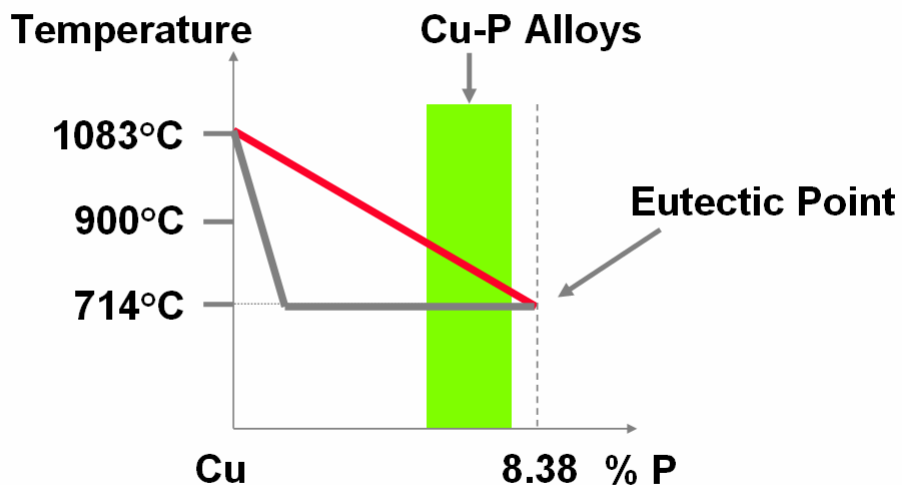
	Fluidity	Capillarity	Joint clearance	RM MPa	A aprox. %
0	<div style="width: 80%; height: 15px; background-color: red;"></div>	<div style="width: 20%; height: 15px; background-color: red;"></div>	<div style="width: 15%; height: 15px; background-color: red;"></div>	450	4
2	<div style="width: 70%; height: 15px; background-color: red;"></div>	<div style="width: 30%; height: 15px; background-color: red;"></div>	<div style="width: 25%; height: 15px; background-color: red;"></div>	550	6
5	<div style="width: 60%; height: 15px; background-color: red;"></div>	<div style="width: 40%; height: 15px; background-color: red;"></div>	<div style="width: 35%; height: 15px; background-color: red;"></div>	650	8
15	<div style="width: 40%; height: 15px; background-color: red;"></div>	<div style="width: 50%; height: 15px; background-color: red;"></div>	<div style="width: 45%; height: 15px; background-color: red;"></div>	700	10

RM = (Fracture) Mechanical strength (approximation)

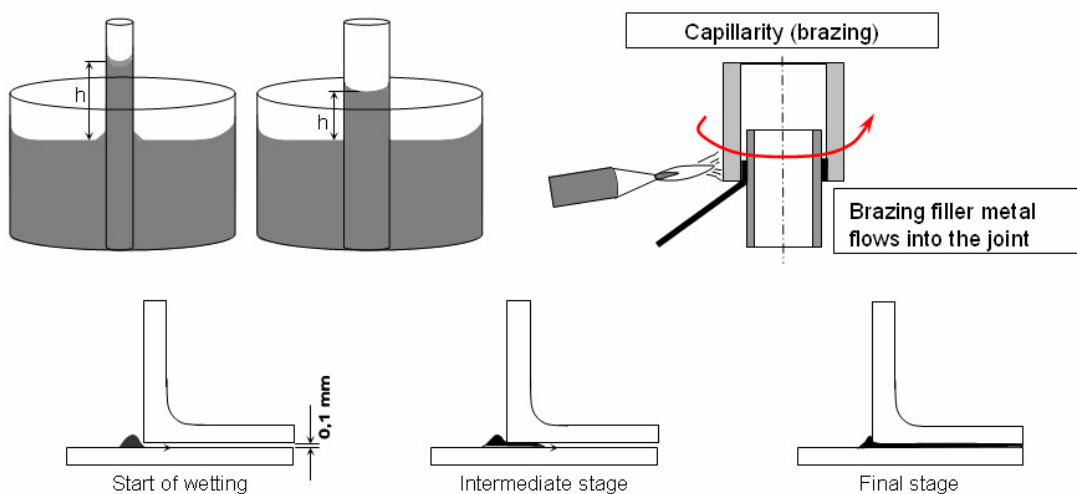
A = % elongation after fracture (approximation)

One of the critical factors to be considered on Phosphorous containing alloys that is managing the melting range and how alloys perform is the Phosphorous amount (%). The Harris Products Group is the brazing industries forerunner in developing the technology to control de phosphorous content. Our exclusive technology is so precise that operators no longer need to make temperature adjustments from batch to batch knowing that with Harris alloys the result is always the same. Our internal standard admits a temperature variation from batch no batch no longer that 3.3°C, much tighter that international standards requires.

## Brazing filler metals – melting range:



During the lasts years The Harris Products Group R&D team has been working on the development of new Trademark alloys designed to reduce the dependence of precious metals used on high responsibility connections keeping the Fluidity, Capillarity and Melting Range (flow characteristics) as well as keeping the mechanical strength and elongation required on the applications providing excellent molecular diffusion.























Over the decades many things have changed in our industry but our dedication to making the world's purest and most consistent brazing alloys has not changed.

## HIGH SILVER ALLOYS

The Harris Products Group is manufacturing their complete line of cadmium-free alloys with the same attention to quality found on Phosphorous Copper alloys. High silver alloys are developed to provide excellent mechanical / chemical and physical characteristics on most ferrous and non ferrous metals except aluminum, magnesium and metals with a melting point under 800 °C. Harris high silver alloys are used by many industries, including appliances, equipment manufacturing, air conditioning, refrigeration, plumbing, tooling, automotive, construction, aeronautics and others.

As the Phosphorous copper alloys The Harris Products Group is manufacturing a large product range covering the typical and special industrial / special requirements from plumbing to special vacuum furnaces applications.

### High Silver Alloys:

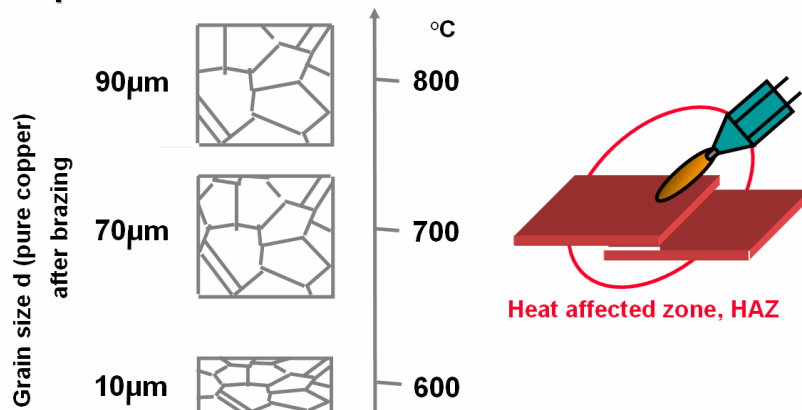
	Fluidity	Width of melting range	Mechanical strength	A %	Corrosion resistance
20					
30					
40					
50					

A = % elongation before fracture (approximation)

One of the critical factors to be controlled during the brazing process using high silver alloys is the brazing temperature. It has to be the minimum surface temperature in the joint at which the brazing or soldering alloy is able to wet, spread out and achieve bonding with the base metals.

It is always higher than the solidus temperature, but can be above, below or equal to the liquidus temperature.

**Temperature:** Lower brazing temperature = Less grain growth

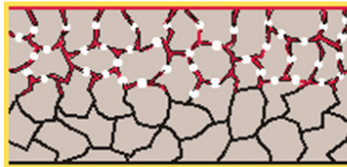


The Harris Products Group recommends controlling the Brazing temperature and if it possible not overpass the 750 °C to prevent the volatilization of the elements contained on the alloy, prevent the formation of an excessively coarse-grained structure or minimize the risk of overpass the active range of the used flux.

## Max Temperature:

Dangers of working temperatures > 750 °C:

1. The flux is slagging and lose its properties.
2. Creation of CrO<sub>2</sub> on the workpiece surface. The flux can not adhere.
3. Cracks caused by too deep infiltration of the brazing metal, especially by high-melting brass filler metals.



Caves: Accumulations of Cd-oxides, Zn-oxides, rests of flux, or air

Vaporizing temperatures: Zn (Zinc) = 907 °C ( $Zn + O_2 = ZnO_2$ )

Tests have shown that joints brazes with silver-brazed filler metals are used successfully for engine components which have service conditions up to 427 °C.

### SELECT THE APPROPRIATE FILLER METAL

#### **Metallurgical compatibility with the base metals being joined**

The brazing filler metals must interact with the base metals to produce a braze joint suitable for the particular application.

#### **Heating method and heating rate**

Filler metals with narrow melting ranges, generally less than 10°C between solidus and liquidus temperatures, can be used with any heating method.

Filler metals that tend to liquate should be used with heating methods that bring the joint to brazing temperature quickly.

#### **Service requirements**

Braze joints may be exposed to various conditions in service (Service temperature, Life expectancy of the assembly, Thermal cycling, Stress conditions, Corrosive conditions, Radiation stability).

#### **Brazing temperature**

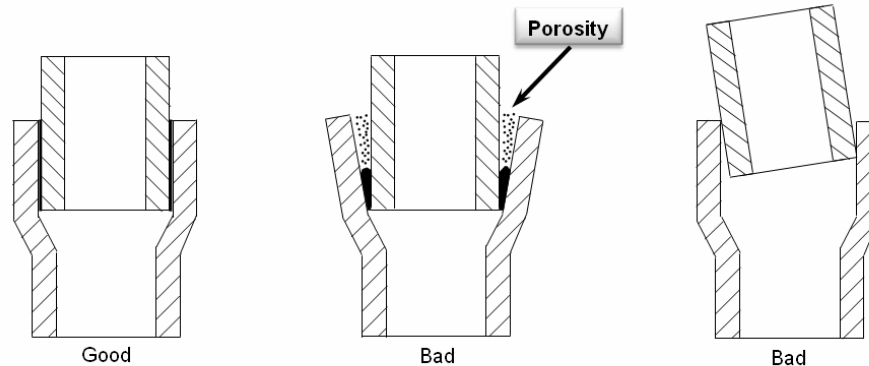
Generally, a filler metal with the lowest brazing temperature suitable for intended service requirements is preferred. (Minimize heating effects on base metals such as annealing, grain growth, and distortion).

#### **Joint design**

The design of the braze joint has an impact on the selection of the filler metal. Factors such as the choice of the base metals, the joint clearances, the mass of the parts and the length of the joint will all influence whether a fluid or sluggish filler metal is selected.

# Assembly:

Always make the assembly of joints with proper alignment to avoid compromising the capillarity effect.



## Safety Considerations

Hazardous or irritating ingredients may be present in the filler metals, fluxes and gases used in brazing. Generally, fumes and gases produced during the heating and melting of filler metals and fluxes are chief of concern, and adequate ventilation is a necessity.

Table 3.2  
Base Metal-Filler Metal Combinations

	Al & Al Alloys	Mg & Mg Alloys	Cu & Cu Alloys	Carbon & Low Alloy Steels	Cast Iron	Stainless Steel	Ni & Ni Alloys	Ti & Ti Alloys	Be, Zr, V, & Alloys Reactive Metals	W, Mo, Ta, Cb, & Alloys Refractory Metals	Tool Steels
Al & Al Alloys	BAI-Si										
Mg & Mg Alloys	X	BMg									
Cu & Cu Alloys	X	X	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>CuP</sub> , B <sub>Ni</sub> , RBCuZn								
Carbon & Low Alloy Steels	X	X	B <sub>Ag</sub> , B <sub>Au</sub> , RBCuZn, B <sub>Ni</sub>	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Cu</sub> , RBCuZn, B <sub>Ni</sub>							
Cast Iron	X	X	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Ni</sub> , RBCuZn	B <sub>Ag</sub> , B <sub>Ni</sub> , RBCuZn	B <sub>Ag</sub> , B <sub>Ni</sub> , RBCuZn						
Stainless Steel	BAI-Si	X	B <sub>Ag</sub> , B <sub>Ni</sub> , B <sub>Au</sub>	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Cu</sub> , B <sub>Ni</sub> , RBCuZn	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Cu</sub> , B <sub>Ni</sub> , RBCuZn	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Cu</sub> , B <sub>Ni</sub>					
Ni & Ni Alloys	BAI-Si	X	B <sub>Ag</sub> , B <sub>Au</sub> , RBCuZn	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Cu</sub> , B <sub>Ni</sub> , RBCuZn	B <sub>Ag</sub> , B <sub>Cu</sub> , B <sub>Ni</sub> , RBCuZn	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Cu</sub> , B <sub>Ni</sub>	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Cu</sub> , B <sub>Ni</sub>				

Table 3.2 — (Continued)

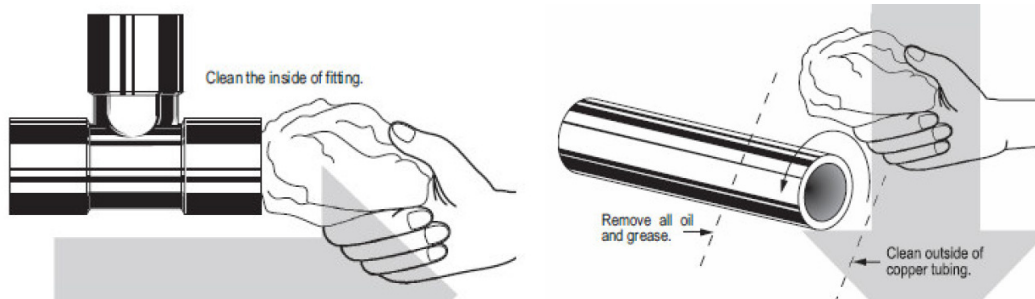
	Al & Al Alloys	Mg & Mg Alloys	Cu & Cu Alloys	Carbon & Low Alloy Steels	Cast Iron	Stainless Steel	Ni & Ni Alloys	Ti & Ti Alloys	Be, Zr, V, & Alloys Reactive Metals	W, Mo, Ta, Cb, & Alloys Refractory Metals	Tool Steels
Ti & Ti Alloys	BAI-Si	X	B <sub>Ag</sub> *	B <sub>Ag</sub> *	B <sub>Ag</sub> *	B <sub>Ag</sub> *	B <sub>Ag</sub> *	B <sub>Ag</sub> , BAI-Si*			
Be, Zr, V, & Alloys (Reactive Metals)	Y	X	B <sub>Ag</sub>	B <sub>Ag</sub>	B <sub>Ag</sub>	B <sub>Ag</sub> *	B <sub>Ag</sub> *	Y	Y		
W, Mo, Ta, Cb, & Alloys Refractory Metals	X	X	B <sub>Ag</sub>	B <sub>Ag</sub> , B <sub>Cu</sub> , B <sub>Ni</sub>	B <sub>Ag</sub> , B <sub>Cu</sub> , B <sub>Ni</sub>	B <sub>Ag</sub> , B <sub>Cu</sub> , B <sub>Ni</sub> , B <sub>Au</sub>	B <sub>Ag</sub> , B <sub>Cu</sub> , B <sub>Ni</sub> , B <sub>Au</sub>	Y	Y	Y	
Tool Steels	X	X	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Ni</sub> , RBCuZn	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Au</sub> , B <sub>Cu</sub> , RBCuZn	B <sub>Ag</sub> , B <sub>Au</sub> , RBCuZn, B <sub>Ni</sub>	B <sub>Cu</sub> , B <sub>Ni</sub> , B <sub>Ag</sub> , B <sub>Au</sub>	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Cu</sub> , B <sub>Ni</sub> , RBCuZn	X	X	X	B <sub>Ag</sub> , B <sub>Au</sub> , B <sub>Cu</sub> , B <sub>Ni</sub> , RBCuZn

NOTE: Refer to text for information on the specific compositions within each classification.  
 X - Not recommended; however, special techniques may be practicable for certain dissimilar metal combinations.  
 Y - Generalizations on these combinations cannot be made. Refer to appropriate individual chapters for usable filler metals.  
 \* - Special brazing filler metals are available and are used successfully for specific metal combinations. Refer to appropriate individual chapters.

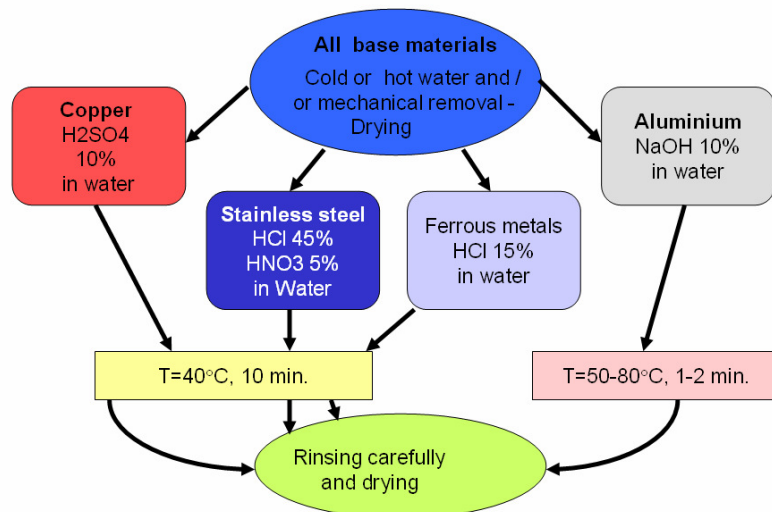
## FLUXES

The purpose of a brazing flux is to promote the formation of a brazed joint by protecting the base metals and filler metals from oxidation. The brazing flux may also serve to remove surface tension to promote freer flow of filler metal.

Flux are not designed or intended for the primary removal of oxides, coatings, oil, grease, dirt or other foreign materials from the parts to be brazed. All parts prior to brazing must be subjected to appropriate cleaning operations.



The Harris Products Group recommends removing the flux residues after brazing to avoid corrosion from remaining active chemicals. Removing flux from properly cleaned brazed parts can usually be accomplished by washing in hot water accompanied by light brushing. Flux residue removal may be accelerated by immersing the brazed joint in water before it has fully cooled from the brazing temperature. For residues which are difficult to remove special practices could be applied.



The Harris products Group is manufacturing an extensive range of brazing fluxes to be chosen according with the joint configuration.