Deutsches Kupferinstitut
Copper Alliance

The effects of using bismuth as lead replacement

Due to the toxicological classification of lead, there have been regulations limiting the lead content in all materials, including copper alloys, for some time. On many occasions bismuth has been recommended as a suitable replacement for lead. Due to serious technological drawbacks and the complications it brings to the metal recycling process, bismuth remains problematic and hasn`t established itself as a potential replacement for lead in Europe.

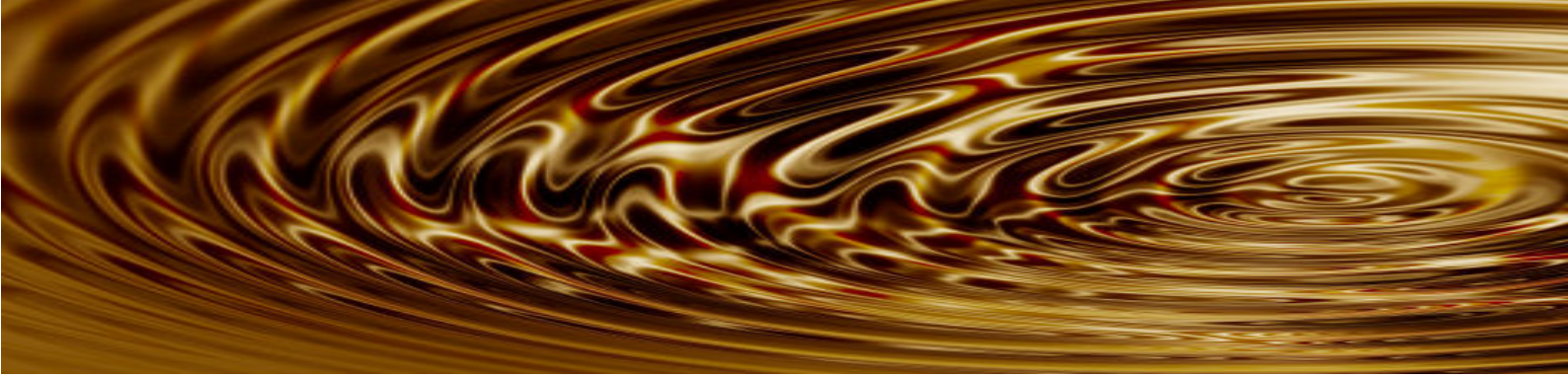
Bismuth, however, is increasingly being used as a substitute for lead in the US and Asian markets which will result in negative mid- and long-term effects on global recycling.

The Deutsche Kupferinstitut fundamentally advises against using bismuth as a lead substitute for the following reasons:

1) Processing and product quality

Among other things, lead is added in copper alloys to improve their machinability. This goal can also be achieved by using bismuth. However, due to its physical properties (it expands when solidifying), bismuth tends to create mechanical stress which, in turn, causes stress corrosion cracking in components.

Even a few ppm of bismuth in the material stream can cause considerable processing problems in otherwise bismuth-free copper materials, in particular during hot-working and forming processes. Due to this fact, the use of bismuth is detrimental to the copper industry.



2) Recycling and sustainability

Copper alloys are fully recyclable and lead content can be separated easily from copper in the smelter if needed. Unfortunately, this isn't possible with copper alloys containing bismuth. Due to bismuth's specific property, a separate circulation path would be required for scrap and chips containing bismuth.

Reclaimed material containing bismuth must be strictly separated from other materials – and also other metals – to avoid any bismuth contamination and negative effects in the processing stream as mentioned above. Such a strict separation is of course not feasible in practice.

The use of bismuth as an alloying element for free cutting copper materials and as a replacement for lead in solders and coatings would also have negative effects on the well-established, efficient, and sustainable circular management and life cycle of other metals such as cast iron and cast aluminium. Introducing bismuth in these metals would also affect the recycling paths by causing strong embrittling effects.

3) Environmental and health aspects

Not enough is known about the ecological and health effects of an increased use of bismuth. A considerable increase in the demand for bismuth could only be met by a significant increase in lead production: for 1 ton of bismuth, currently 30 to 200 tons of lead needs to be produced. Therefore, it is not possible to reduce large amounts of lead by replacing it with bismuth while at the same time reducing the amount of lead being produced.

4) Cost effectiveness

Bismuth occurs in the earth's crust 300 times less frequently than lead and is even rarer than silver, a precious metal. The growing demand for bismuth would likely bring an increase in production costs with it. Even today, bismuth is very expensive and has a volatile price in comparison to that of lead.