Historical and technical introduction of fusible alloys and fire safety fusible links

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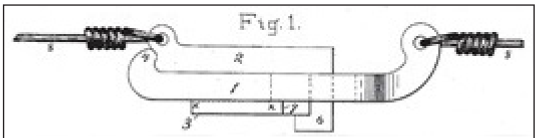
The first set of low temperature melting alloys was reported by Isaac Newton in 1701 for use as temperature standards.
In 1753, the French scientist Claude Geoffroy Le Jeune discovered Bismuth, previously confused with lead. However, he died before completing his research on the metal.
A set of low melting Bi/Pb/Sn alloys of varying composition were reported posthumously in 1772 by the German pharmacist, Valentin Rose the Elder (1736-1771), and are commonly referred to as "Rose's Metal,"
In 1775, the French chemist Jean Arcet provided to the Royal Academy of Sciences a report of his experiences on a fusible alloy of lead, bismuth and tin, which had the characteristic of melting at the water boiling temperature. A set of more than ten compositional variations for this system was reported and are known collectively as "D'Arcet's Alloys"
The first application of one of these alloy melting at 98 °, made of three parts of tin, eight parts of bismuth and five parts of lead was the manufacturing of stereotype printing plates.
But quickly, due to the development of steam boilers and steam engines, a new application was found as the ultimate safety device in steam boilers.
To overcome the frequent explosions occuring in early steam engines, the fusing plugs were invented, opening a safety valve when the steam temperature became too high.
Ternary alloys of bismuth, tin and lead, alloys took the name of their inventors:

- Rose's alloy (50% bismuth, 25-28% lead and 22-25% tin, with a melting point between 94° C and 98° C),
- Newton's alloy (50% bismuth, 31% lead and 19% tin, with a melting point at 95° C).
- Lichtenberg's alloy, melting at 92°C, contains 50% bismuth, 30% lead, and 20% tin.
- Homberg's alloy, melting at 121°C, contains 3 parts lead, 3 tin, and 3 bismuth.
- Malotte's metal, melting astatine 203°F (95°C), has 46% bismuth, 20 lead, and 34 tin.

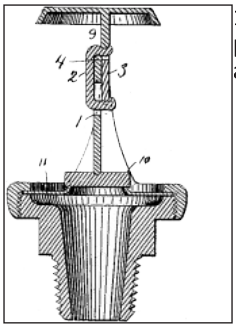
Fusible plugs quickly became mandatory: October 29, 1813, a governement decree obliged manufacturers of steam engines, in addition to safety valves, to apply a fusible cap on the boiler, melting at a temperature lower than the maximum allowed steam temperature.
Friedrich Stromeyer in 1817 was the first to produce cadmium. The addition of cadmium to bismuth, lead and tin alloys allowed, more than 30 years later to discover lower melting temperature alloys. The 28 October 1823 a imposed the use of two fusible plugs of different sizes on high pressure boilers (over 2 kg / cm ²), one at 10°C, the other at 20°C below the maximum limit of the boiler.

Fusible plugs on boilers of steam locomotives (1842). Cap "e" melts and releases steam

The discovery of Indium and the beginning of its production in 1867 made it possible to further reduce the melting points: Field alloy (32.5% Bismuth, 51% indium, tin 16.5%, fuses at 62 ° C)
In many fusible alloys, a small amount of Indium lowers the melting point of about 19°C for 1%
The need of fire detection systems between 1860 and 1890 (alarm or sprinklers) gave rise to the development of all current fire detection fusible links.
Wood's alloy, or Wood's fusible metal, was patented in 1860 and was the first metal used for automatic sprinkler plugs. It contains 50% bismuth, 27.6% lead, 13.3% tin and 10% cadmium, melting at 70°C ,and this point was adoptive as the operating temperature of sprinkler plugs in the United States and most of other countries; in England it is 155°F (68°C).
At the same time were invented Lipowitz's alloy (50% Bismuth, 27% lead, 13% tin, 10 % Cadmium, melting between 70-74 ° C, but very ductile),and Guthrie's alloy has 47.4% bismuth, 19.4% lead, 20 % tin, and 13.2% cadmium.
Problems of false tripping quickly appeared on links under permanent stress, because of the fusible alloys creep phenomena. Although the mechanical strength of the alloy is important, when subjected to a permanent constraint, near its melting point, it slides slowly and breaks. Manufacturers therefore invented mechanism to reduce the permanent stress on the fusible alloy solder, and soon appeared de-multiplied fuses and sprinkler heads.



1890 : de-multiplied fusible link assembled on a cable (Grinnel)



1890: Grinnell sprinkler head using parts welded together with a fusible alloy and a leveraging effort mechanism

From that time, many ternary and quaternary alloys were discovered to span values operating values between 17°C and 330°C
JPC fire detection fusible links are designed to use fusible alloys selected for their operating temperature, but also for their resistance to creeping.
The important cost of some alloys is due to the rarity of their components (Indium, Gold, Gallium)
Current trend to standards prohibiting heavy metals or toxic substances such as lead and cadmium are not currently applicable to mechanical fuses. However, there are a few alternatives to avoiding alloys using these metals, but they do not cover a large span of temperatures. If you are concerned with the use of heavy metals in fire safety fuses, please contact us.
As they do not rely on external energy to operate, these mechanical fusible links, when properly sized and installed, are reliable and safe.
The mechanical and thermal stresses to which they are subjected in normal use should be properly analyzed so as not to reach the creep zone. Thermal stress during transport and storage must also be taken into account in order not to overheat the alloy. Remember that a container stored in direct sunlight on a dock of a tropical country can reach 80°C ! Some countries have issued standards, but they are disparate and do generally not take into account the creeping drift. This is why we provide, besides the nominal melting temperature (Tm), the maximum permissible continuous temperature (Tc) and the maximum load below the Tf value which they may be subjected to.
This approach is similar to that of TCO (Electrical thermal fuses).
To reduce the risk of accidental opening due to creep or oxidation of metal parts, some countries recommend changing the fusible links during the annual maintenance. Please observe the local regulations.
Some fusible link models include bumping or ramps intended to provide a positive separation of the two parts to avoid resealing after breaking.
Fire detection fusible links are intended to react quickly in case of fast temperature rise, so it is important to place them in an appropriate location, and limit their mass, because their breaking time is proportional to their mass.