

INTRODUCTION OF ECOLOGICALLY SOUND MATERIALS FOR FUSIBLE ELEMENTS OF LOW VOLTAGE FUSES

Borut Kosec, Milan Bizjak, Ladislav Kosec
University of Ljubljana, Faculty of Natural Sciences and Engineering
Ljubljana
Slovenia

Viktor Martinčič
ETI Elektroelement d.d.
Izlake
Slovenia

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ABSTRACT

In EU countries the legislation forbids the production, processing and use of cadmium. By January 1st 2007 at the latest, all articles (colours, batteries) containing cadmium will either have to be withdrawn from sale or an appropriate substitute for this heavy metal will have to be found.

The present technology of production of fuses in slovenian firm ETI Elektroelement d.d and the action thereof are adapted to the existing ecologically harmful alloy of tin and cadmium SnCd20, which ought to be replaced by one or more ecologically safe alloys with technological and application properties as similar as possible to the existing ones.

In our contribution we want to present the technological and organisation problem, the procedure of its solution, and the final solution – patent. This work is an example of the successful direct cooperation on the relation industry – university.

1. FIRM ETI Elektroelement d.d.

Slovenian firm ETI Elektroelement d.d., Izlake is the biggest and the most important producer of appliances for the distribution of electric energy in this part of Europe [1]. The general data about the firm is collected in FIGURE 1.

Very important and very interesting is the fact, that at the moment a 54 % deal in the ownership structure have the employees in the firm (see FIGURE 2). At same type firms in Slovenia is the normal ownership deal of employees maximal to 15 %. So high ownership deal is the main reason that the employees have the great interest for successful work of their firm.

The production programme of ETI Elektroelement d.d. is divided into four main groups:

- electrotechnical products,
- technical ceramics,
- tools and equipment, and
- rubber and plastics.

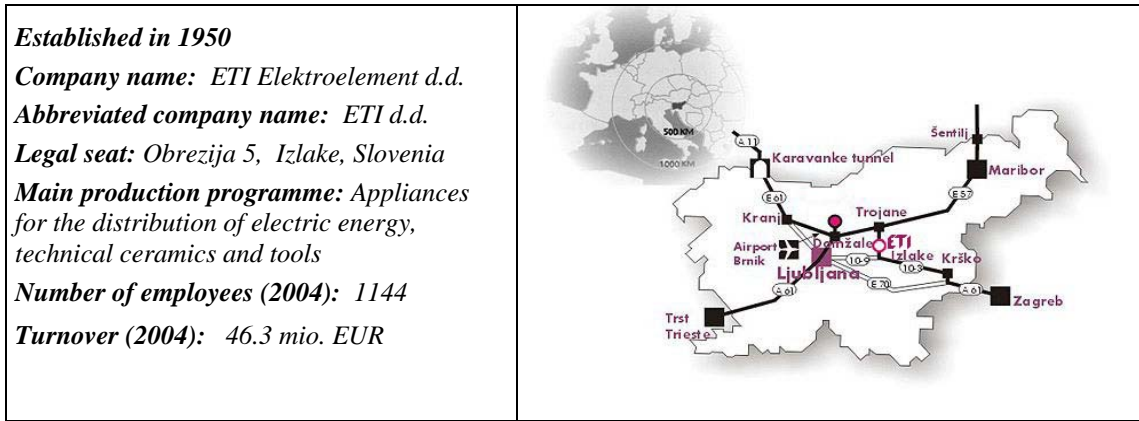


Figure 1. General Information About ETI Elektroelement D.D. [1].

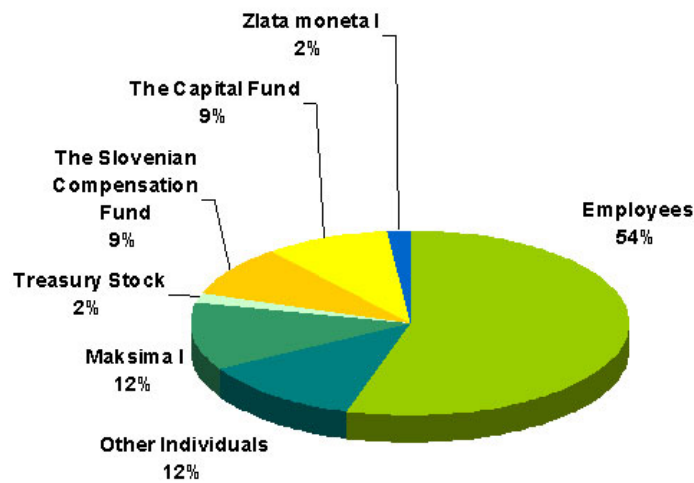


Figure 2. Ownership Structure of the ETI Elektroelement D.D. [1].

The most important production groups are electrotechnical products (modular protection devices, industrial devices, distribution systems, lampholders) and technical ceramics (ceramics for insulation in electrical engineering, thermoceramics, traditional silicate materials, special materials and products) (FIGURE 3).



Figure 3. Electrotechnical Products (Left) and Technical Ceramics (Right) from ETI Elektroelement D.D. Production Programme.

1.1. Quality Systems and Business Excellence

The system ETI Elektroelement d.d. has developed to secure quality is comprised of processes, procedures, organisation forms and instruments which combined together ensure the effective management of quality assurance systems. It has been designed to be applied to the technical and technological unity of all our products and business processes, guaranteeing the high quality of our products and services.



Figure 4. Certification of Quality System According to the ISO 9001 Standard (ETI Obtained the Quality Certificate According to ISO 9001 Already in 1993). in 2001 ETI Being Awarded the ISO 14001 Certification for the Environmental Management System. The Award of Republic of Slovenia for Business Excellence (PRSPO) is the Highest Recognition by the State for Achievements of Organizations in Implementing Systems for Modern, Effective and Complete Reaching of Products and Services Quality, and of the Business Operation Quality as a Result of the Knowledge and Development of Innovativeness. In the Year 2003 ETI D.D. was Ranking to the Top of Business Excellence in Slovenian Area.

2. ECOLOGICALLY SOUND MATERIALS FOR FUSIBLE ELEMENTS OF LOW VOLTAGE FUSES

2.1. Introduction

In EU countries the legislation forbids the production, processing and use of cadmium. By January 1st 2007 at the latest, all articles (colours, batteries) containing cadmium will either have to be withdrawn from sale or an appropriate substitute for this heavy metal will have to be found. That was the main reason that ETI Elektroelement d.d. still in year 2002 started intensive investigation cooperation with the University of Ljubljana, Faculty of Natural Sciences and Engineering.

The present technology of production of fuses in ETI Elektroelement d.d and the action thereof are adapted to the existing ecologically harmful alloy of tin and cadmium SnCd20, which ought to be replaced by one or more ecologically safe alloys with technological and application properties as similar as possible to the existing ones.

2.2. Technical Problem

Low melting alloys are functional components of low voltage high capacity blade-contact fuses. When an increased current runs through the fuse, the fusible element representing a vital part of the fuse heats up. If the temperature exceeds the melting point of the low melting alloy, the latter melts and begins to melt the fusible element, which is normally made of copper, silver or new silver, at an exactly defined position. The higher is the temperature the faster is melting, which is stopped by the breaking of the fusible element and an interruption of the circuit (FIGURES 5, 6).

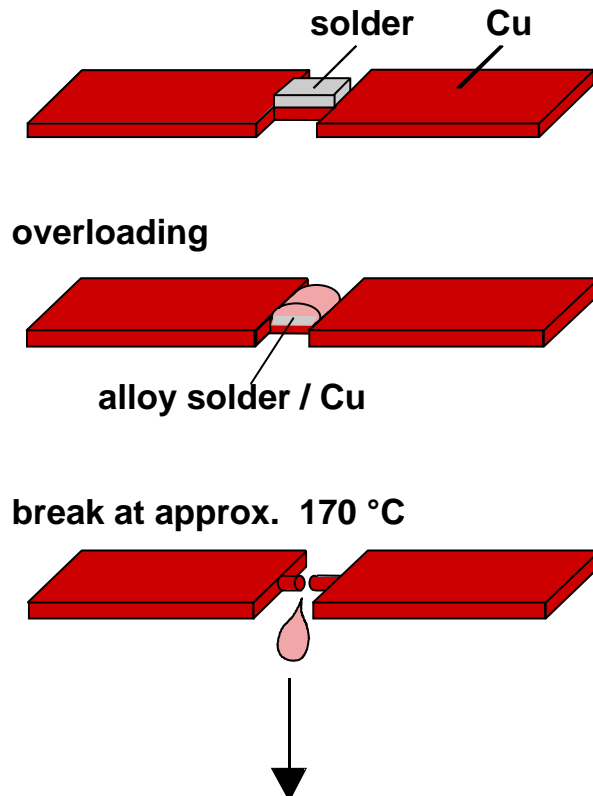


Figure 5. Breaking of the Fusible Element and an Interruption of the Circuit - Mechanism.

When selecting the low melting alloys there should be considered their physical-chemical, technological and ecological properties as well as economy. By taking all of them into account, the possibilities if choosing the alloy are relatively limited. It has turned out that the most suitable are tin-base alloys with chosen appropriate major alloying elements and a possible addition of minor alloying elements for the correction and optimization of the properties of the alloy.

As major alloying elements only bismuth (Bi) and indium (In) are technologically and economically acceptable. The properties of the alloys comprising these alloying elements are in principle and actually very different from the ones comprising cadmium (Cd). Therefore there must be provided additional alloying elements making the essential technological and application properties of the new alloys as similar as possible to SnCd20.

Thus, there existed a need for a new alloy, which would be ecologically acceptable in its composition and, with regard to its technical and technological as well as physical properties, could replace the existing ecologically harmful alloys for fusible elements of low voltage fuses.

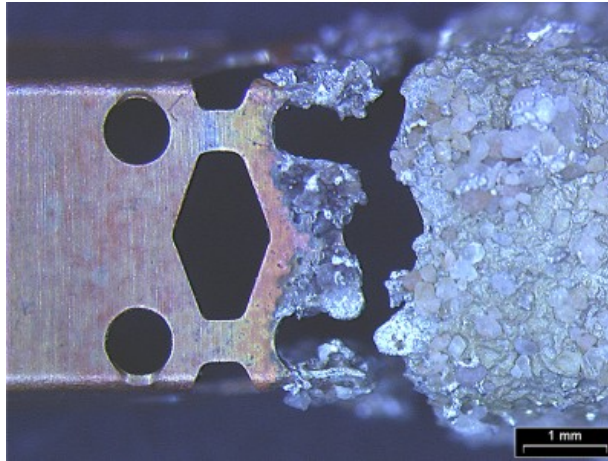


Figure 6. Fuse Element Broken to the Interruption of the Current by the Melting Phase. The Left-Part of the Fuse Element is Coated with Low Melting Alloy [2].

2.3. Prior Art

On each fusible element normally made of pure copper of very narrow tolerances (up to ± 0.003 mm) and with a conductivity of 58.8×10^6 S/m, there is applied, at an exactly defined position, a layer of a solder made of a tin-cadmium alloy and a few millimetres wide (FIGURE 7). This alloy is very important for a correct action of the fuse since by a correct proportion of the two elements it is achieved that at a defined overload current the fuse interrupts the circuit within the prescribed time and thus protects the installation and the user (transformer, engine,...) from being destroyed.

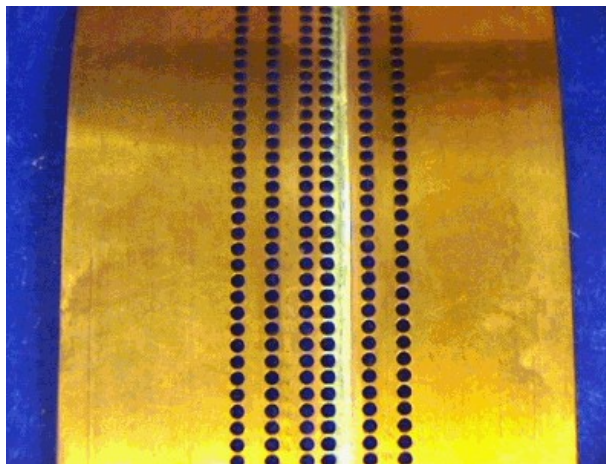


Figure 7. Band Made of Pure Copper and at an Exactly Defined Position A layer of a Solder Made of a Low Melt Alloy and a Few Millimeters Wide.

It is known that cadmium (Cd) is an element, which, already in small amounts, is very toxic to natural substances and living beings. In EU countries the legislation forbids the production, processing and use of cadmium. By January 1st 2007 at the latest, all articles (colours, batteries) containing cadmium will either have to be withdrawn from sale or an appropriate substitute for this heavy metal will have to be found.

There are also known alloys of lead and tin (Pb-Sn), which are also harmful to the environment due to the toxicity of lead.

Alloys that do not contain ecologically harmful elements like Cd and Pb, e.g. combinations Zn-Ag-Bi-Cu and Zn-In-Al, are used as well, yet due to their technical and physical properties such as melting point, wettability etc., they are limited only to certain uses.

In [3] there are described solders from tin - base alloys in combination with bismuth, copper and indium, which, however, are economically doubtful due to the high price of indium.

The present technology of production of fuses and the action thereof are adapted to the existing ecologically harmful alloy of tin and cadmium SnCd20, which ought to be replaced by one or more ecologically safe alloys with technological and application properties as similar as possible to the existing ones.

2.3. Technical Solution

We have found that the stated problems can be successfully solved by the low melting alloy of tin, bismuth and antimony ETI-Sn-Bi-Sb [4,5], which is ecologically safe and by its technical and physical properties (melting point, conductivity, wettability) corresponds to the requirements of the use for fusible elements of low voltage fuses.

The ecologically safe low melting alloy of tin, bismuth and antimony ETI-Sn-Bi-Sb by its technical and technological as well as physical properties entirely replaces the existing harmful alloys of tin and cadmium SnCd20 for fusible elements of low voltage fuses.

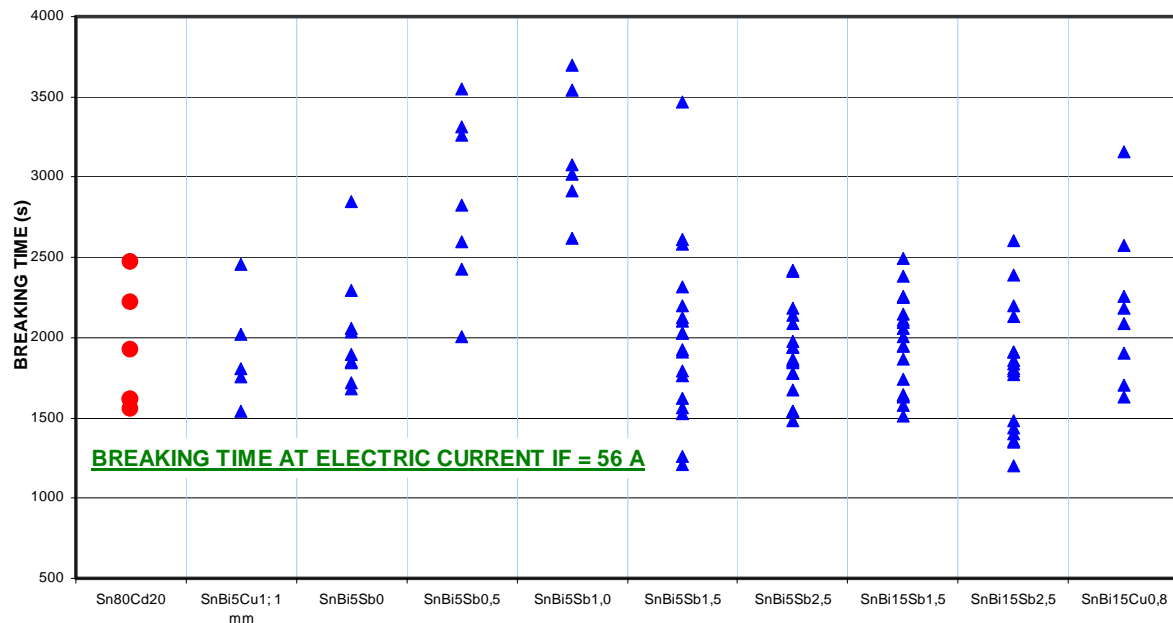


Figure 8. Breaking Time at Electric Current $I_5 = 56$ A.

The low melting alloy ETI-Sn-Bi-Sb containing from 4.0 % to 17.0 % by weight of bismuth and from 1.0 % to 3.0 % by weight of antimony, the rest being tin.

The above-disclosed low melting alloy is produced in the form of definite or infinite wire of a round or square longitudinal section of dimensions (diameter or side length) from 0.5 mm to 3.0 mm. And it is successful use for fusible elements of low voltage fuses. ETI

Elektroelement d.d. and authors of that paper took out a Slovenian national [4] and EU patent [5] for the ecologically safe low melting alloy named ETI-Sn-Bi-Sb

3. CONCLUSIONS

We have found that the stated problems can be successfully solved by the low melting alloy of tin, bismuth and antimony ETI-Sn-Bi-Sb, which is ecologically safe and by its technical and physical properties (melting point, conductivity, wettability) corresponds to the requirements of the use for fusible elements of low voltage fuses.

Alloy ETI-Sn-Bi-Sb by its technical and technological as well as physical properties entirely replaces the existing harmful alloys of tin and cadmium SnCd20 for fusible elements of low voltage fuses.

ETI Elektroelement d.d. and authors of that paper took out a Slovenian national and EU patent for the ecologically safe low melting alloy named ETI-Sn-Bi-Sb.

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- [1] ETI Elektroelement d.d.: <http://www.eti.si>.
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