# Investigation of particulate matter from wave soldering processes at a printed circuit board manufacturing company

Z. Szoboszlai[1], Zs. Kertész[1], Z. Szikszai[1], A. Angyal[1], E. Furu[1,3], Zs. Török[1,3], L. Daróczi[2] and Á.Z. Kiss[1]

[1]Institute for Nuclear Research, Hungarian Academy of Sciences (ATOMKI), Debrecen, H-4001, P.O Box 51., Hungary
[2] Department of Solid State Physics, University of Debrecen, Debrecen, H-4010, P.O. Box 2., Hungary
[3]University of Debrecen, Debrecen, H-4032, Egyetem tér 1, Hungary
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Presenting author email: szoboszlai.zoltan@atomki.mta.hu

It is well known that the electronics products industry has exposed workers to high doses of metals. Several studies have reported that the inhalation of metal dust and fumes is associated with adverse health effects such as metal fume fever and other respiratory diseases.

In this study, our aim was to investigate indoor aerosol particles in a working environment where the soldering and testing of different kinds of printed circuit boards (PCB) and other electronic components takes place (Szoboszlai, 2012). Wave soldering is one of the main processes used for attaching metal components to the board during the manufacturing of PCBs. (The name is derived from the use of waves of molten solder. The constituents of the solder alloy are dependent on the type of wave solder e.g. leaded (Sn–Pb) or lead free wave solder (Sn–Ag–Cu–Sb)).

Aerosol samples were collected in a large working hall where approximately 100 people worked. Two 48-h long sampling campaigns were carried out. One was in October 2008 and the other was in May 2009. A two-stage sampler with Nuclepore polycarbonate filters of 8 μm and 0.4 μm pore diameter was used to collect the $PM_{2.5}$ and $PM_{2.5-10}$ size fractions separately. In addition, a ten-stage PIXE International cascade impactor was used to provide size resolved samples in the following ten fractions >16, 16-8, 8-4, 4-2, 2-1, 1-0.5, 0.5-0.25, 0.25-0.12, 0.12-0.06 and <0.06 μm aerodynamic diameter. Aerosol samples were collected in the following sites: next to 2 wave solders (in one of them unleaded and in the other leaded melt was used), below a supply air ventilator and close to a location named “store of hazardous materials”.

The elemental compositions (for $Z \geq 13$) of the bulk samples were measured by PIXE analytical method in the IBA Laboratory of ATOMKI. Additional information concerning the characteristics of the aerosol particles was drawn from individual particle analysis by scanning nuclear microscopy and SEM.

In this study, we have showed that the manufacturing of the PCBs is associated with aerosol emissions. Based on the elemental ratios and correlations, size distribution data and single particle analysis, the creation processes and the indoor sources were identified, e.g. soldering, fluxing, etching and cleaning. The concentration of PM and the elemental components increased at the wave solders. The main constituents of the leaded and the unleaded melt were recognized in the indoor aerosols. Flux-related (Zn, Cl), and etching-related (Fe, Cl) elemental compositions were also identified.

The PM concentrations measured indoors were higher in 2008 than in 2009. The differences between the two sampling periods could be attributed to the change in technology and working schedule. From 2008 to 2009 most of the leaded wave solders were put out of operation, which could be detected through the decrease in lead concentration.

It was confirmed that relative to the outdoor atmosphere inside the working hall the air was clean due to supply air ventilators and the low indoor emission rate. Although the concentrations of Pb were less than the limit value of the WHO, there was a maximum in the fine mode in the mass size distributions of Pb and other metals Ag, Cu, Zn (Fig. 1.). Based on the stochastic lung model calculations, the majority of the observed elements are deposited in the extrathoracic regions. These calculations showed higher deposition probability for Pb in the acinar region than for particles of natural origin.

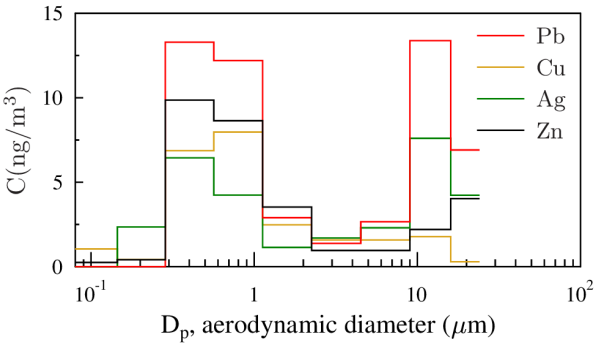


Figure 1. Mass size distribution of Pb, Cu, Ag and Zn elements (sampled in the workplace in 2008).

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