ELSIA

European Lead Sheet Industry Association

Lead Sheet Goes Full Circle

Science in support of fact

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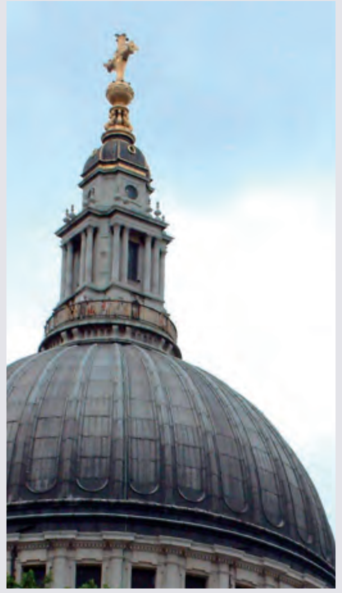
Negative perceptions are self-perpetuating if left unchallenged. And in a world ever more eager to observe environmental protocols, and growing consumer awareness of the need to protect our planet, legislators and those who advise them face a constant challenge to sort fact from fiction.

This document sets out to provide a scientifically sound appraisal of the use of lead sheet in construction applications.



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Introduction

For centuries lead sheet has been the material of choice to protect buildings from the weather. It can be found in use on roofs, around windows and in gutters, in soaring Gothic cathedrals and in humble homes, simply because no other product can match its performance. It is heavy, malleable, attractive, and when properly installed, will outlast the building to which it is fitted. There are many historic monuments throughout Europe, some of them more than 500 years old, which are still protected from the ravages of nature by original lead sheets.

This exceptional longevity is one reason why lead sheet is a truly environmentally friendly product. Another is because, unlike other materials which lay claim to the description "green," lead can be endlessly recycled, leading to a metal recovery rate in excess of 95% with no loss of properties or potential end uses.

Conversion of scrap to new lead sheet has only a nominal impact on global warming because of lead's low melting temperature. This efficient and effective metal recovery demonstrates a first class "closed loop" product management system which is so good that not to recycle would waste a valuable and versatile resource. Lead sheet provides a unique example of a sustainable product with centuries of proven safe, continuous use.

However, despite these facts, there are still misplaced perceptions about lead sheet which may cause concern to the public at large. In order to investigate their validity, the European Lead Sheet Industry Association (ELSIA) has made considerable investments in independent research. Details of the research findings appear later in this brochure but can be briefly summarised thus: lead sheet poses no risk to the environment, even when water run-off is taken into account, and does not present any risk to human beings. Furthermore, providing simple hygienic precautions are observed, such as rigorous hand-washing, people who handle significant quantities of lead do not expose themselves to health risks.

Key Facts

- Lead sheet used in the building industry poses no risk to the environment or people
- Lead sheet out performs all man-made materials in its field
- More than 95% of lead used in the manufacture of lead sheet comes from recycling
- The relatively low melting point of lead, 327°C, means the process has a low carbon footprint and a minimal environmental impact
- Lead sheet affords attractive, permanent protection against the weather
- The proven life of lead sheet is hundreds of years

Benefits and Risk

The European Lead Sheet Industry Association (ELSIA) is at the forefront of the industry's approach to health, safety, the environment and product management. Its website (www.elsia-web.org) sets out in detail the responsible approach the organisation takes to the use of lead sheet on both public and private buildings as well as to the health and safety of the skilled workers who handle and install the product on a daily basis.

The website also carries a wealth of information about lead and lead sheet, including its history and application in historic and modern buildings where, hundreds of years after its weather-proof properties were first put to use, it is still specified as the material of choice for roofing, chimney flashings, gutter and valley linings and apex caps. Full copies of the three major research programmes undertaken by the independent Netherlands Organisation for Applied Scientific Research (TNO) between 2002 and 2006 can also be downloaded from the site. These studies were:

- Life Cycle Assessment (LCA): Environmental performance of lead sheet and alternative weatherproofing products
- Experimental study of new lead alloys for atmospheric application III
- Environmental aspects of the use of lead sheet in the building industry

In addition, the Institute of Occupational Medicine conducted a study in 2006 to assess dermal exposure to inorganic lead caused by direct skin contact with lead sheet to help determine whether physical contact with lead sheet might represent a risk to health (Institute of Occupational Medicine Research Report TM/06/04).

Much of the raw material for manufacturing lead sheet comes from demolition, during which old lead sheet and pipe work is recovered because of its high resale value, making it probably the only building material which would be difficult to find in any waste landfill sites. This old lead is collected and taken to specialist recycling plants where, under stringent environmental controls, the process of producing new lead sheet begins.

The first step in the process is to melt the scrap lead at the relatively low, eco-friendly temperature of 327°C, which allows any non-lead items to be removed. This is followed by a metal refining stage to bring the material within the metallurgical specification EN 12588, the European quality standard for lead sheet. Any lead oxides generated during these processes are sent to specialised lead smelting plants for a further stage of recovery.

Once it has been refined, the metal is turned into lead slabs ready for forming in sophisticated rolling mills that squeeze the slabs, making them progressively thinner until they reach the required thickness of around 2mm, although this can vary depending on the specific application for the finished sheet. The entire recycling process, from scrap to new lead sheet is usually completed in a matter of days with the flexibility and softness of the material allowing producers to supply the finished product in a variety of widths and lengths to meet customers' requirements.

The speed and simplicity of this efficient process means it is energy saving and has a lower impact on global warming, giving lead sheet a considerable advantage over other metals. There is no limit to the number of times lead sheet can be recycled, making it the most cost effective weatherproofing material available.

Nonetheless, commonly held public perceptions persist about lead and one of ELSIA's principal tasks has been to try to bring about a shift in those beliefs using respected independent research establishments.

One of the major perceptions is that working with, or even simply touching lead, is harmful to health. The Institute of Occupational Medicine in Edinburgh was engaged to carry out an assessment of whether lead absorbed through the skin posed a health risk to people who might come into contact with it in a consumer or residential environment. Controlled laboratory tests were carried out as well as contact tests at two historic sites where lead sheet is part of the building fabric.

Both sets of tests concluded that occasional exposure by touching lead surfaces posed no risk to individuals and that those who worked with lead on a regular basis could negate any risk through simple best practice methods such as hand washing before eating or drinking. Wearing dust masks and gloves avoids contamination by dust particules when handling old lead sheet during demolition or recycling.

Another notion is that lead is damaging to the environment, particularly old lead sheet from which rainwater may carry particles to the ground. TNO in the Netherlands was engaged to investigate atmospheric corrosion of lead sheet and any environmental impact it may have. After a year long study, it was concluded that exposure to the atmosphere causes lead sheet to react rapidly to form a tightly adherent, stable patina of virtually insoluble lead compounds. The concentration of lead in rainwater run-off was found to be less than previously thought and has no public health or environmental impact.

TNO also tested the effectiveness of lead sheet against aluminium-reinforced SEBS, aluminium-reinforced PiB and glass-reinforced plastics which many modern builders perceive to be substitute products. The lead sheet was found to out-perform all its rivals.

Although the Institute of Occupational Medicine found no specific risk from working with lead, ELSIA as a responsible organisation has produced a few guidelines which, if followed, will ensure there is no adverse impact on the health of lead sheet workers. The guidelines are simple and no more stringent than those recommended for many other metals and chemicals in common use. They are:

- Wear gloves to keep hands clean or use a barrier cream if gloves are impractical
- Wash hands thoroughly before eating, drinking or smoking. This will avoid accidental ingestion of lead
- Wear a paper dust mask when removing or handling old lead sheet
- Manually handling lead sheet of more than 25kg of should be avoided. Use a hoist or even a crane. Specific guidance on manually handling lead sheet can be found in the revision of standard EN12588
- With a specific weight of 11.34g/cm^3 lead is one the heaviest metals in the world and great care is needed to ensure above-ground storage is strong enough to take the weight. It should also keep the metal dry to avoid unsightly staining through damp

The Lead Sheet Trade Associations in the UK, Netherlands, France and Germany all provide training courses on handling and working with lead sheet.

Foundation for the Facts

Because of the perceptions that surround the use of lead sheet, it is worthwhile repeating in some detail the findings of the various independent studies which have been undertaken in an attempt to dispel the myths that surround this most useful of metals.

The Institute of Occupational Medicine was founded as a charity in 1969 by the UK coal industry in conjunction with the University of Edinburgh and became fully independent in 1990. It has evolved into an independent, impartial, international centre of scientific excellence in the fields of occupational and environmental health, hygiene and safety. In 2006 the Institute undertook a study on the risks posed by handling lead. The following is a summary of its findings:

Assessment of the transfer of lead to the hands through direct skin contact with lead sheet: *(Institute of Occupational Medicine Report TM/06/04. Assessment of dermal exposure to inorganic lead caused by direct skin contact with lead sheet and moulded PVC profiles.)*

The Institute of Occupational Medicine conducted a study in 2006 into the assessment of dermal exposure to inorganic lead caused by direct skin contact with lead sheet in order to help determine whether physical contact with lead sheet might represent a significant route of exposure and hence be a risk to health.

It was noted that lead uptake can occur via inhalation and ingestion exposure, while dermal absorption is thought to be minimal. However, dermal exposure is still important as it can contribute to ingestion exposure due to transfer from the skin to the mouth via the fingers. The study was designed to provide information about the potential for dermal lead exposures caused by direct skin contact with lead sheet material as it might occur in a consumer or residential environment.

Controlled tests were carried out in the laboratory to evaluate the rate of transfer of lead to the skin by varying the number of skin contact events with lead sheets and lead ingots. Contact tests were also carried out at six different sites at two historic buildings where lead sheet had been used as part of the building fabric or to provide weather or physical protection in keeping with the historic nature of the site.

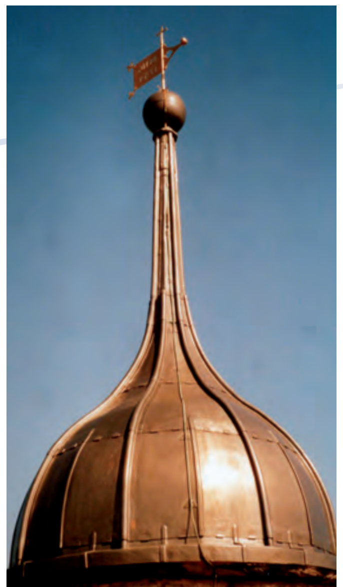
A total of 54 dermal samples were collected from six volunteers participating in the lead contact tests. Exposures were low, ranging from less than the limit of detection to 2.24 $\mu g/cm^2$. In general, tests on lead sheeting and ingots indicated that as the number of contacts with the lead surface increased, the amount of lead transferred to the hands increased. Thirty six samples were collected during the field survey and exposure ranged from 0.07 to 5.05 $\mu g/cm^2$. A similar pattern of increasing lead exposure with increasing contact was observed.

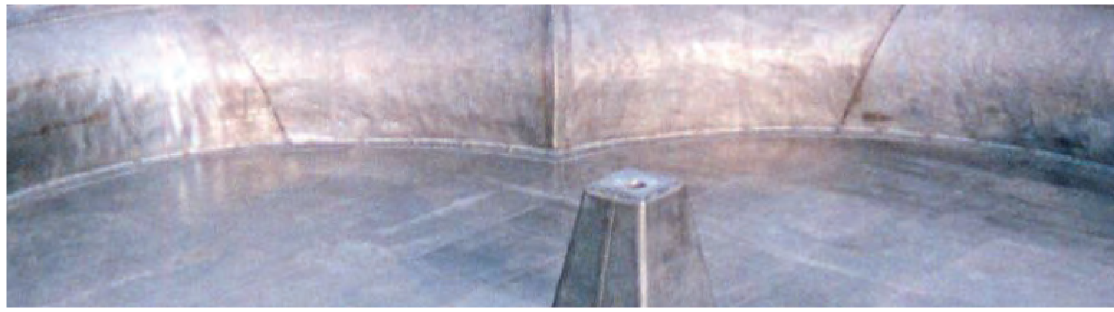
Overall, dermal exposures were low and the exposure of individuals touching lead surfaces on an occasional basis is likely to be minimal.

TNO, the Netherlands Organisation for Applied Scientific Research, is one of the world's leading bodies investigating how science can aid and improve modern life. It functions in five main areas:

- Quality of life
- Defence, security and safety
- Science and industry
- Built environment and geosciences
- Information and communication technology

The organisation has carried out a number of investigations into lead sheet, covering its environmental impact, its performance against alternative products and the effects of atmospheric corrosion. What follows are summaries of TNO's findings:





TNO STUDY ON "ENVIRONMENTAL ASPECTS OF THE USE OF LEAD SHEET IN THE BUILDING INDUSTRY."

(TNO Report R2005/306. The use of lead sheet in the building industry: an environmental profile.)

Concerns have been voiced about possible environmental problems in relation to the use of lead sheet in the building industry. The building industry is the main user of lead sheet which has a variety of applications, the largest of which is flashings to prevent water penetrating the structure of a building. The second most important use is roofing and cladding. TNO was therefore requested to assess whether the lead compounds that run-off from exposed lead sheet applied on buildings result in significant toxic effects in the natural environment. To be able to answer these questions five main items were researched:

1. The principal lead emission sources.
2. The contribution of lead sheet to total lead emissions.
3. Lead concentrations in the environment.
4. Environmental thresholds for lead.
5. The risk of environmental effects from lead in the environment.

The conclusions of the research were:

- Based on derived risk factors, there are no environmental risks related to anthropogenic emissions of lead.
- As the use of lead sheet contributes less than 10% to total anthropogenic lead emissions, lead sheet can be excluded as causing an environmental risk.
- The first two conclusions are still valid even when it is assumed that the roofs of all buildings are disconnected from the sewer system and the runoff enters the environment directly.

These results are confirmed and supported by other independent research notably:

Paper by D.N.Wilson in 2003 for a UNECE conference on corrosion of metals in building; two papers published by the American Society for Testing & Materials (ASTM,1944; Hiers et al, 1955); the Association of German Chemical Works (Dechema,1976); a Lead Industry Association (LIA) guide (Friend, 1929; Forgeson et al, 1958; ASTM, 1962); the German organisation Bleiberatung (Shulze-Rettmer, 1955) and various Dutch authors (Annema et al, 1993; Coppoolse et al, 1993; Bentum et al, 1996; Lanting et al, 1996).

TNO STUDY ON "ENVIRONMENTAL PERFORMANCE OF LEAD SHEET AND ALTERNATIVE WEATHER-PROOFING PRODUCTS."
(TNO Report 2006-A-R0232/B)

The main goal of this study was to compare the environmental impact of lead sheet as a building weatherproofing material with the impact of selected competing materials applied in the German and Dutch markets. A second goal was to determine which aspects of the life cycle were of greatest significance.

Weatherproofing a building can be divided into a number of different functions such as roof or wall cladding, protection of cavity walls and protection of the transition from roof to wall. The three functions investigated here were:

- Weatherproofing used in cavity walls (lead sheet, aluminium-reinforced SEBS, reinforced EPDM, PVC)
- Weatherproofing in wall-roof junctions (lead sheet, aluminium-reinforced SEBS, aluminium-reinforced PiB)
- Discharge of rainwater by valley gutters from sloping roofs (lead sheet, glass-reinforced plastics)

The comparisons of environmental performance for 1m^2 of installed weatherproofing material for a 75 year service period were expressed in terms of the shadow cost (€) of products for weatherproofing of cavity walls, wall-roof junctions and as valley gutters. This approach of summing the costs associated with the required abatement of the diverse environmental effects enables a simple comparison to be made between different products.

Lead sheet was found to provide excellent environmental performance compared with the other products due to its long life and its limited need for primary raw materials. The largest part of the environmental impact of lead sheet results from small losses of lead during installation and end of life collection, which cause the life cycle not to be fully closed. From a life cycle assessment perspective, such losses are expected to be replenished with primary lead. However, the modelling of the losses in this way is a very conservative approach because in reality the losses would be made up from secondary lead which is available in abundance as a result of extraordinarily high levels of lead recycling from other sources, such as old lead pipe.

Sensitivity analyses for the SEB: bitumen ratio for the aluminium-reinforced SEBS-bitumen, for the production process of glass fibre reinforced polyester and for the recovery percentage of aluminium from the aluminium reinforced products showed some impact on the environmental performance of the products but did not result in a change in the ranking of the products.

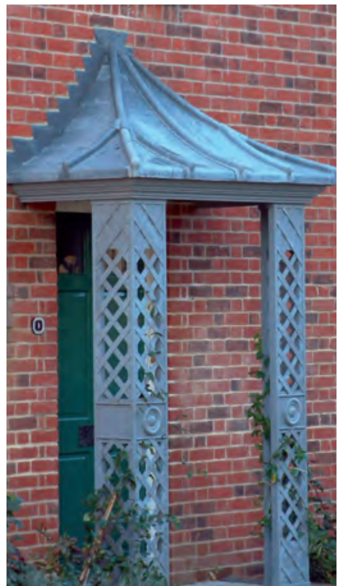
Based upon the life cycle assessment of lead sheet and other weatherproofing products, it was concluded that lead sheet has the best environmental performance as a weatherproofing product of all the products that were assessed.

TNO STUDY ON "EXPERIMENTAL STUDY OF NEW LEAD ALLOYS FOR ATMOSPHERIC APPLICATION III" 2002-2005. *(TNO Report CA05.8041)*

With the help of a literature study the corrosion behaviour of lead alloys under atmospheric conditions was reviewed. This literature review was carried out as a first step in the development of new alloys with better properties. To investigate the long-term run-off behaviour, four exposure programmes were executed in which lead sheets of these new alloys were exposed outdoors. Each month, rainwater from the exposed samples was collected and analysed for the contents of lead. In addition, the run-off from experimental roofs and two real houses was collected and analysed too.

Based upon the results of these four exposure programmes the following final conclusions were drawn:

- The run-off from both experimental and real roofs is 3 to 4 times lower than that of the reference (normally used lead sheet).
- The run-off of normally used lead is reduced by the addition of copper. With respect to the workability, economic aspects and compliance with the EN 12588 standard, the amount of added copper should be limited to 0.05%. Therefore, the alloy Pb0.05Cu in normally used lead is recommended.
- A higher tin content, up to 0.1%, is also permissible as this also improves corrosion resistance.



In 2001, Enviros Aspinwall, an Edinburgh-based consultancy specialising in assessment management and mitigation, risk assessment, process authorization and consent and pollution prevention and control carried out an investigation into what happened to lead during construction and demolition work. This is a summary of their findings:

INVESTIGATION INTO THE FATE OF LEAD SHEET DURING CONSTRUCTION AND DEMOLITION WORK.
(Enviros Aspinwall Report LE0280002a. Lead in construction and demolition waste: qualitative study.)

The scoping study on lead in construction and demolition waste was conducted in response to concerns raised by the lead industry about the publication of a European Commission (DG Environment) working document on the management of construction and demolition waste. This document included a proposal to substitute lead in new buildings in order to make waste less hazardous and to facilitate recycling because it was assumed that significant quantities of lead enter construction and demolition waste. The Enviros Aspinwall study was designed to:

- Understand whether lead arises in construction and demolition waste
- If it does arise, to identify in what quantities and
- To identify from which sources lead arises.

The work was carried out through literature review, consultations and two case studies, one on a construction site and one on a demolition site.

The literature review revealed that research into the composition of construction and demolition waste in relation to lead, heavy metals or metals in general was limited. Indications were found that the proportion of all metals in such waste streams is of the order of 4% but can range from 0.03% to 13%, with levels for specialist activities extending to 41%. Although a number of studies mentioned lead, none quantified its content in the waste stream. There was, therefore, no conclusive evidence as to whether lead was present in construction and demolition waste and no research to estimate quantities.

In the absence of empirical evidence, a qualitative approach was adopted to consider ways in which management and general construction/demolition practice could allow or prevent lead entering the construction and demolition waste stream. Practices at all stages of the building lifecycle were considered: construction, renovation/refurbishment, demolition, recycling and disposal.

The sources of lead in construction were found to range from materials already on site (e.g. naturally occurring) to off-cuts from weatherings and flashings installed on new buildings. Quantities were likely to vary with building type, style and geographical location. Off-cuts were the primary source on the construction case study site. Lead from this source could be managed in a number of ways, including salvage for reuse on another building (larger off-cuts), sent for recycling, disposed of in a skip (for off-site management) or disposed of informally on-site by burial. The weight and price for soft lead scrap, coupled with the ease with which the material could be recycled and the nature of construction sub-contracts, meant that the push to recycle was strong. However, there appeared to be a minimum size at which recycling was not cost effective. Smaller off-cuts tended to appear in the general fill used on site.

The sources of lead in demolition waste were similar, including flashings and weatherings, but also materials from historical uses (pipes, paint). Due to their more mixed nature and the low cost, rapid techniques needed to demolish a building, it was found that demolition wastes would be likely to include more lead than construction waste. The quantity of lead in construction and demolition waste would depend on factors such as location, style and age of the building and the waste management practices employed. A number of points were identified where lead would be removed from the building being demolished, including informal removal (theft) before demolition contractors arrived, removal at the soft-strip stage, removal during sorting/segregation of materials and removal during loading of waste vehicles. Economics and ease of recovery encouraged lead to be recycled, but small sections or concealed parts would be more likely to enter the waste stream.

Consideration was given to the level at which lead within the waste stream could be seen as significant. For recycled aggregate, significance relates to contamination and the impact that this could have on performance and the surrounding environment. The major performance inhibiting contaminants are usually listed as wood, soil and steel-reinforced concrete, not lead. Similarly, research indicated no serious concerns about the effect of reclaimed aggregates on water quality. Nevertheless, individual products must be tested for their qualities before being utilised and should be fit for the purpose to which they are put.

Significance at the landfill relates to the extent to which lead would enter leachate. Existing research indicated that the levels of leachate generally do not exceed recognised benchmarks.

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