# LEAD PIPING AND PLUMBOSOLVENCY

Occasionally, everyday water management issues are thrust under the public spotlight as a result of an incident. While for engineers engaged in the provision of water services the management and replacement of lead piping has been an ongoing issue, recent events have brought lead to the attention of the public and caused concern. Many consumers are asking what is lead and how does it find its way into our water supply? In this article, Rónan Daly and Martin Kimber of Atkins explore the main issues.

## Background

Lead is a chemical element, with a symbol Pb. It is a dense, relatively soft, malleable metal with a low tensile strength[1]. Lead is widespread, relatively easy to extract, has a low melting point and is easy to work. For these reasons it has been used for thousands of years for water pipes and for roofing. The Romans used lead pipes in water supply systems. It has also been used for weights, lead-acid batteries and shot as well as being part of solder, pewter and fusible alloys. Lead was also widely used in paints up until the late twentieth century.

Up until the introduction of lead-free petrol, a lead compound was added to petrol to prevent pre-ignition (knocking). Exposure to lead from paints and car exhausts, particularly in urban areas, was widespread up until relatively recently but now this is no longer a problem although caution is still needed with old paints which can contain lead. In the UK, it is estimated that the water supply to about 40 per cent of properties is via a lead pipe[2]. In most cases in Ireland, water distribution lead piping has been replaced with plastic and ductile iron piping, while service pipes tend to be of copper or plastic material.

## Health effects[3]

Research has found that lead affects multiple systems in the human body including the central and peripheral nervous systems, the gastrointestinal tract, the kidneys and the haematological system. The systems affected, and to what degree, depend in part on how much lead has been ingested and retained by the body. Lead is a cumulative toxin and, as such, repeated exposure does not produce immunity; instead repeated exposure even at low levels causes amounts to accumulate in the body and produce physiological damage.

## Plumbosolvency

Although lead is a heavy metal and relatively insoluble in water at neutral pH, where water is conveyed through lead pipes some lead will be dissolved in the water, with the process known as 'plumbosolvency'. This is the ability of water to dissolve lead. Where water comes into contact with lead in the presence of carbonates, the carbonate in the water reacts with lead forming one of several lead carbonates, mainly either lead carbonate ($PbCO_3$) or hydrated lead carbonate ($Pb_3(CO_3)2(OH)_2$). The form of the compound depends on the pH and alkalinity of the water.

Plumbosolvency is a concern both in older houses where house connections were made using small diameter lead pipes, and in newer houses, where although the house connection may use a plastic pipe, the water attacks the lead in solder used to join copper pipes within the building. This leads to increased levels of lead at the tap. Lead pipes were still in common use up to the 1970s, but since then lead pipe has not been used for potable systems. However, many older houses still contain lead piping, or are

connected to the public mains using lead 'house connections', i.e., the length of pipe that connects the main in the street to the stop-tap outside the house. Such properties can be at risk of elevated lead concentrations in the water at the tap.
A range of factors, including alkalinity, temperature and contact time, affects the dissolution of lead. In general, low alkalinity water with a low pH has a greater tendency to dissolve lead. Solubility increases with temperature, and higher concentrations are evident in summer than in winter months in affected supply areas. Where the water contains dissolved orthophosphate, the concentrations of lead are much lower as lead phosphate compounds are formed and these are less soluble than lead carbonates.
Lead in water supplies can be also be present as particulate lead. This is generally associated with lead flaking from old pipes and is best removed with a domestic filter at the property. In Ireland, Statutory Instrument No. 278 of 2007 relates to the European Communities (Drinking Water) Regulations of 2007. This SI dictates that the following parametric limits should apply to lead in drinking water[4]:
until 24 Dec 2013: parametric value of 25µg/l
from 25 Dec 2013: parametric value of 10µg/l
The SI also states that all appropriate measures shall be taken to reduce the concentration of lead in water intended for human consumption as much as possible, during the period needed to achieve compliance with the parametric value.

### Control of plumbosolvency[2]

Ideally, one would remove all existing lead piping from both the public and private services, and this approach is often followed where the opportunity arises through other schemes. However, the removal of some residual lead services can be technically difficult and prohibitively expensive.
An alternative approach to meeting the lead standard is to dose orthophosphate and also control the pH of water. Sufficient orthophosphate has to be dosed to maintain the necessary concentration of phosphate at the ends of the distribution system.
The dose required depends on the chemical composition, alkalinity and pH of the water, and the condition of the distribution system.
Typically between 0.6 and 1.8 mg P/l (phosphate per litre) is dosed to achieve the phosphate level required to minimise lead concentrations throughout the network. However, in conjunction with phosphate dosing, it is also necessary to ensure that the optimum pH value is attained, and also maintained, as the water passes through distribution.
This has implications for treatment, requiring that chemically stable water be produced at the treatment works. This can be difficult, particularly for low-alkalinity waters.
In the UK, corrective treatment has been promoted, as opposed to the widespread replacement of lead pipes, as an appropriate first stage of achieving the new European standards for lead in drinking water. In consequence, about 95 per cent of the UK's water supplies are now dosed with orthophosphate and it is reported that substantial compliance has been achieved with not only the interim standard of 25µg/l, but also with the future standard of 10µg/l. At least one water company has been dosing with phosphoric acid in the UK since the mid-1980s, without any reports of significant problems[5]. The widespread use of orthophosphate in the UK is also consistent with practice in the USA[2].
However, dosing on its own does not appear sufficient to meet the future standards consistently, and the argument remains that it is simply postponing the inevitable day when old lead pipes have to be replaced anyway. Given that "paper-thin" lead service pipes are known contributors to water losses from networks, we can expect that the accelerated replacement of lead would bring significant water conservation benefits as well as satisfying public health concerns. Indeed, this may be an opportunity for government to grant aid customers in the replacement of private service connections, thus improving water quality at the point of use and tackling customer-side water losses.

### Conclusion

Exposure to lead has been much reduced in recent years. Recent events, coupled with the forthcoming new limits on lead concentration in drinking water, have meant that a greatly increased focus has been placed on reducing plumbosolvency. Water service providers in Ireland have made progress to address the problem of lead piping, and are now refocusing where necessary to meet the 2013 standards Φ

**Rónan Daly, Chartered Engineer, is a Senior Engineer with Atkins Ireland and is based in its recently-opened Galway office. He is currently involved in providing plumbosolvency advice to a number of local authorities in Ireland.**

**Martin Kimber is a Principal Engineer with Atkins Water in the UK. He specialises in potable water quality and treatment and is co-author of the textbook *Basic Water Treatment.***

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