Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

JOINT POSITION PAPER
Lead (Pb) in Drinking Water
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This position paper has been developed by the Health Service Executive (HSE) and the Environmental Protection Agency (EPA). It provides a summary of the issues in relation to lead in drinking water including health, legislation and interventions.

1. KEY POINTS

Exposure to lead (Pb) has reduced in Ireland since the 1970s, due to the banning of lead in paint and petrol. However, drinking water can still be a source of lead where lead pipework or lead-containing fixtures and solder are present. For most people, the main source of lead is our food, with drinking water accounting for only a small portion of our overall exposure. However, in formula-fed infants, drinking water can form a significant proportion of the total daily intake of lead where lead pipework or lead-containing fixtures and solder are present.

The purpose of this paper is to set out the Health Service Executive and the Environmental Protection Agency joint position in relation to lead in drinking water. The key points in this paper are:

- People should try to drink water with as little lead as possible, especially those who are most vulnerable, such as babies and young children. Consistent consumption of low levels of lead in drinking water can have adverse health effects.
- The main source of lead in drinking water is old lead pipes and plumbing, especially service connection pipes and internal plumbing.
- The removal of lead in drinking water presents more challenges than the removal of lead in fuel or paint, due to issues such as old infrastructure, incomplete pipe-laying records and costs to property owners.
- The responsibility for actions to reduce the level of lead in drinking water is collective and requires actions on behalf of the Water Services Authorities, property owners (public or private) and water suppliers or personnel installing or carrying out works on drinking water supply pipes.
- Consumers in properties built before around the 1970s should check whether lead has been used in the pipework of service connections or internal plumbing. This can be done with the assistance of a suitably qualified plumber and/or by testing the water for lead. See 'Drinking Water Consumer Advice Note – Lead' at www.drinkingwater.ie.
- The legal parametric value for lead in drinking water will be set at 10µg/l from 25th December 2013.
- Where a lead exceedance above the parametric value of 10µg/l has been identified, flushing the cold water tap before consumption may reduce the level of lead. However, the effectiveness of flushing should be verified by testing the water.
- If the drinking water lead level remains above 10µg/l, an alternative source of potable drinking water should be used, especially by formula-fed infants, young children and pregnant women. See 'Frequently Asked Questions – Lead in Drinking Water' at www.lenus.ie/hse/.
- Replace identified lead distribution mains and any newly identified lead distribution mains as soon as they are identified.
- All lead pipes and plumbing in public and private ownership should be replaced over time.
- Water suppliers and personnel installing or carrying out works on drinking water supply pipes should ensure that all materials that come in contact with drinking water are on the list of approved products and processes.

2. BACKGROUND

Lead (Pb) is a naturally occurring metal which is found in rocks and soil, water and air. Worldwide, most high levels of lead found in the environment come from human activities, including burning fossil fuels, mining, and manufacturing.[1]

Lead has many different uses. It is used in pipes, solder and plumbing fittings, in batteries, ammunition, as roofing sheets or as a shield from X-rays. It was used extensively as an anti-knock and lubricating agent in fuel, such as petrol, and in paints, as a pigment in dyes and ceramic glazes, and in food cans. The use of lead in fuel, paint, food cans and pipes has been phased out over the last 40 years. This has resulted in a pronounced reduction in human lead exposure.[2]

However, recent evidence has shown that continuing to minimise exposure to lead should remain a key public health concern, particularly because of its effects on infants and young children.

3. EXPOSURE SOURCES

Human exposure to lead is mainly through food and water, with some exposure via air, soil and dust.[2] Following the successful removal of the principal sources of environmental lead, such as in fuel and paints, the focus has turned, in recent years, to drinking water as a possible source of preventable human lead exposure.

As lead rarely dissolves into water from natural sources, such as from rocks and soil, it is unlikely to be present in raw water or in water leaving a treatment plant. Its presence in drinking water is primarily from the leaching of lead from plumbing systems.[3,4] Such plumbing systems may contain lead in mains or service connection pipes to buildings, in solder or fittings, or the water storage tank may be lined with lead.

The amount of lead dissolved from a plumbing system into water depends on several factors, including the pH and alkalinity, temperature, water hardness, the presence of chloride and dissolved oxygen, the type of disinfectant used, the amount of lead fittings and solder or length of lead pipes and the length of time that water is lying in the plumbing system. Lead is more likely to leach into water where soft, acidic water is present.[1] There is no simple relationship between temperature and corrosion processes, but the corrosion reaction rate is expected to increase with a rise in temperature.[5] The level of leaching can be reduced by corrosion control measures, such as the adjustment of pH.[5,6]

Food can contain small amounts of lead.[3] Food is the major source of exposure to lead for the majority of the population in Europe.[2] Lead content can be increased when the water used for cooking, or the cooking utensils, contain lead or when the food, especially if acidic, has been stored in lead-ceramic pottery ware or lead-soldered cans.

Soils and household dust can also be a significant source of lead exposure for small children but the levels are highly variable. International studies have shown that peeling leaded paint, or dust originating from leaded paint, especially during removal, may contribute significantly to children's exposure to lead.[7] Lead has been found in soil, especially near roadways, older houses and mining or industrial sites.

Occupational exposure, such as from lead smelting, soldering and battery manufacturing, and exposure from hobbies, such as stained glass making, can also be a source of lead.[1] A small number of cosmetic products which do not conform to European legislation have been found to contain significant amounts of lead. Examples have included lipstick, eye-liner and children's facepaints.[8]

4. LEAD INTAKE AND BIOAVAILABILITY

Continuous exposure to significant levels of lead will result in an accumulation of lead in the body over a lifetime, mainly deposited in the skeletal system.[1]

Worldwide, more than 80% of the daily intake of lead, in older children and adults, is derived from the ingestion of food, dirt and dust.[3] Drinking water forms a relatively small proportion of their total daily intake of lead.

However, in formula-fed infants, drinking water can form a significant proportion of the total daily intake of lead where lead pipework or lead-containing fixtures and solder are present.[3]

Young children absorb 40-50% of the lead contained in food and water[9], while adults absorb approximately 3-10%.[10,11]

Once absorbed into the blood stream not all lead is retained in the body. Some will be excreted unchanged in the urine and faeces.[1] Retained lead initially appears in the blood stream and is dispersed into soft tissues (liver, lungs, spleen, etc) over 4-6 weeks. Over time, lead is also deposited in the skeletal system (bones and teeth). The half-life of lead in the skeletal system is 10-30 years.[12] Due to the short half-life of lead in blood (approximately 30-35 days), blood lead levels may reflect only the intake of lead over the previous 4-6 weeks.[12]

Placental transfer of lead occurs in humans as early as 12-14 weeks gestation.[13] The concentration of lead in umbilical cord blood is almost the same as the concentration of lead in maternal blood, with a strong linear relationship.[14] Stored lead in the mother's skeletal system can serve as a source of lead transfer to the foetus when maternal bone is resorbed for the production of the foetal skeleton.[15]

Overall, unborn babies, infants and young children are more likely to have a higher absorption of lead, and severity of adverse health effects due to lead, because:

- Children eat and drink more per unit body weight than adults, so that their relative lead intake is increased;[16]
- Children have behavioural characteristics (outdoor activity, less concern for hygienic conditions, hand-to-mouth activities), which increase the risk of lead exposure from dirt and dust;[16]
- Lead absorption in the gastrointestinal tract is substantially higher in children;[16]
- There is a greater prevalence of nutritional deficiencies (e.g. iron and vitamin D) among children, which enhance the absorption of lead from the gastrointestinal tract;[16]
- The incomplete development of the blood-brain barrier in foetuses and in infants increases the risk of lead's entry into the developing nervous system.[1]

5. HEALTH EFFECTS OF LEAD EXPOSURE

The severity of adverse health effects of lead exposure, from whatever source, is influenced by the total amount of lead consumed, the duration of lead exposure and the age at which exposure occurs.[17]

5.1 Adverse Health Effects of Lead

The acute and chronic effects of lead exposure are numerous. At very high levels of exposure, lead can cause damage to most organs in the body, particularly the kidneys and central nervous and blood systems. Death can occur at extremely high levels.[18] Legislation to control the use of lead in industry, in fuel and paint has ensured that high levels of lead exposure are now rare in developed countries.[18]

However, studies over the last 30 years have shown that adverse health effects can also result from chronic exposure to lower levels of lead. In particular, the epidemiological evidence indicates that chronic exposure to low levels of environmental lead can adversely affect cognitive development in children.[19] Chronic exposure to lead can also cause:

- renal toxicity;
- disturbances in cardiac conduction and rhythm and increase in blood pressure;
- hepatic damage;
- anaemia and other haematological effects;
- reproductive and developmental toxicity;
- gastrointestinal disturbances.

Inorganic lead compounds are classified by the International Agency for Research on Cancer (IARC) as *probably* carcinogenic to humans i.e. Group 2A*.[20]

The Joint FAO/WHO Expert Committee on Food Additives (JECFA) concluded that, for children, the weight of evidence is greatest, and evidence across studies is most consistent, for an association of blood levels with impaired neurodevelopment, specifically a reduction of IQ.[19] This effect has generally been associated with lower blood lead concentrations than those associated with the effects observed in other organ systems. Although the estimated IQ decrease is small when viewed as the impact on an individual child, especially compared to other environmental influences on IQ, the decrement is considered to be important when interpreted as a reduction in population IQ.

For adults, the adverse effect for which the weight of evidence is greatest and most consistent is a lead-associated increase in blood pressure.[19] As with the lead-associated reduction in IQ, the increase is small when viewed as the effect on an individual's blood pressure, particularly in comparison to other environmental influences on blood pressure. However, the increase is important when viewed as a shift in the distribution of blood pressure within a population.

Research on dose-responses could not identify a threshold level below which lead intake would be considered safe so, in 2011, the JECFA concluded that it was not possible to establish a provisional tolerable weekly intake (PTWI) that would be considered health protective.[19]

* Group 2A - There is *limited evidence* from studies of carcinogenicity in humans and *sufficient evidence* of carcinogenicity in experimental animals.

5.2 Irish Data

Cases of lead toxicity rarely present in Ireland. Hospital In-Patient Enquiry (HIPE) data for years 2009-2012 inclusive shows that two patients treated in acute public hospitals in Ireland were coded as having been treated for the 'toxic effect of lead and its compounds' in those years.[21] HIPE does not differentiate between cases caused by lead in drinking water and lead from other sources.

A recent study was carried out in Britain and Ireland over a 2 year period to identify newly recognised cases of lead toxicity in children under 16 years of age, referred to paediatricians with blood lead concentrations ≥10 µg/dL.[22] Preliminary results identified one such case in Ireland.[23]

A study carried out in 1999 in Ireland, in an area of historic lead mining, measured blood lead levels of children and adults.[24] The study showed that the average blood lead level within the study population was 2.7 µg/dL. Follow-up studies in 2000 and 2001 showed that the mean blood levels in primary school children in that area decreased over the study period.[25] Results of drinking water from within the study area were, on the whole, compliant with the Drinking Water Regulations in force at that time (50 µg/l). Currently in the US a reference value of 5µg/dL is recommended for identification of children with elevated blood lead levels.[26]

6. PARAMETRIC VALUE FOR LEAD IN DRINKING WATER

The level of lead in drinking water is one of the chemical parameters measured by Water Services Authorities (WSAs)[†] and by group and private water suppliers as part of the monitoring and enforcement framework for drinking water set down under EU drinking water legislation.

The European Communities (Quality of water intended for human consumption) Regulations, 1988 (S.I. No. 81 of 1988) first set out a parameter for lead of 50 µg/l in running water.[27]

The current parametric value for lead, as set out in European Communities (Drinking Water) (No. 2) Regulations 2007 (S.I. No. 278 of 2007), is 25 µg/l but from 25th December 2013 the level will be set at 10 µg/l - see *Table 1*.[28]

Table 1: Parametric values for lead in drinking water

Parameter	Parametric value[‡]
Lead (Pb)	25 µg/l (until 24th December 2013) 10 µg/l (from 25th December 2013)

The 2007 Regulations refer to a minimum frequency of sampling of water supplies, which depends on the volume of water distributed or produced each day, or the number of inhabitants, within a supply zone.

The World Health Organization (WHO) had previously recommended a guideline value for lead in drinking water of 10 µg/l.[29] The WHO also recommended a provisional tolerable weekly intake (PTWI) of 25 µg/kg body weight for infants and children. In 2011, the WHO reviewed this guidance and, having noted that the JECFA now considered that there is no tolerable threshold dose, changed their guidance to recommend a *provisional* guideline value for lead in drinking water of 10 µg/l. This was based on the recognition that lead exposure arises from a number of sources, of which drinking water is just one, and that, in practical terms, achieving lead levels in drinking water of less that 10 µg/l may be technically very difficult.[3] They no longer supported the PTWI as a part of a risk assessment as there does not appear to be a threshold for the key effects of lead.

[†] Currently the designated Water Services Authorities (WSAs) are the 34 city and county councils/local authorities. They are responsible for the provision and monitoring of drinking water from over 900 public water supplies serving 80% of the population. WSAs have a supervisory role in relation to group water schemes and private supplies. From January 1st 2014, Irish Water will become the Water Service Authority.

[‡] The value applies to a sample of water intended for human consumption obtained by an adequate sampling method at the tap and taken so as to be representative of a weekly average value ingested by consumers and that takes account of the occurrence of peak levels that may cause adverse effects on human health.

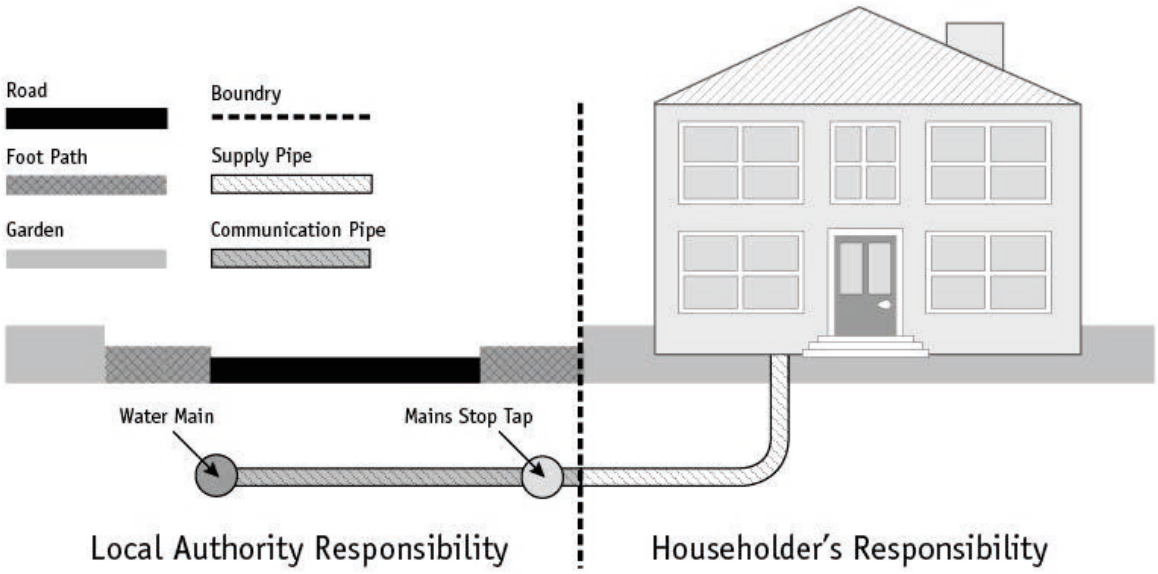
7. SCOPE OF THE PROBLEM

7.1 Lead Pipes and Fittings

Most lead in drinking water comes from old lead pipes, fittings, lead-based solder or lead-lined tanks within a building or from the service pipe connecting the property to the mains supply at the mains stop tap (also sometimes called the 'external stopcock'). In Ireland, homes built before around the 1970s may contain lead in their plumbing systems if the lead fittings or pipes have not been replaced.

In general, responsibility for the maintenance of mains and communication pipes lies with the water supplier (see *Figure 1*) while responsibility for the maintenance of the supply (or service connection) pipe and internal plumbing pipes, tanks and fittings lies with the house or premises owner. The supply pipe can also be called the 'service connection pipe'. The water mains pipe is sometimes called the 'distribution mains' pipe.

Figure 1: Types of water distribution pipes[30]



Lead distribution mains were used for some distribution networks prior to 1970. The Environmental Protection Agency (EPA) has surveyed WSAs to identify any remaining lead distribution mains and the results indicate that, while the majority have been replaced over time by the WSAs, there are still approximately 5,000 metres of lead mains in use.[31] Directions have been issued for the replacement of such mains. There is a possibility that other lead distribution mains may exist that have not yet been identified because of a lack of knowledge of the existence of such pipes, e.g. due to inadequate records from many decades ago.

While there are few lead distribution mains remaining in use in Ireland, there are still a significant number of lead communication pipes in the ownership of WSAs. The exact numbers are not known due to inadequate records from many decades ago and subsequent replacement of some communication pipes as part of mains rehabilitation works.

Lead may also be present in the service pipe and internal plumbing of properties built before around the 1970s where such pipework has not been replaced by the property owner.

Although the use of lead in drinking water plumbing systems is not recommended, there is some evidence that, if lead-containing solder or fittings have been used, leaching of lead into drinking water can occur in more recently constructed buildings.[32]

The most effective way of ensuring compliance with the lead parametric value is the full replacement of the lead communication pipe, service pipe and internal plumbing. Partial replacement (e.g. where the WSA replaces the communication pipe from the mains to the property boundary or external stopcock, but the lead pipes from the boundary to the building and lead plumbing internal to the building are not replaced) may not be effective in returning the supply to compliance.[33] However, in some circumstances (e.g. where the communication pipe is a significant proportion of the overall pipe length) partial replacement may go some way to reducing the level of lead in drinking water.

7.2 Exceedances of Lead Parametric Values in Drinking Water

In the EPA report on drinking water for the year 2012, a total of 14 supplies reported lead exceedances above the current parametric value of 25 µg/l during 2012 (one more than 2011) - see *Table 2*.[31] However, 41 supplies reported levels of lead in excess of the new parametric value of 10 µg/l, to be used from 25th December 2013 (down from 42 in 2011). The majority of these are public water supplies.

Table 2: Compliance with the lead parametric value in 2012 [31]

	Current Standard (25 µg/l)		New Standard (10 µg/l)	
	% of samples complying	No. of non-compliant WSZs[§]	% of samples complying	No. of WSZs with > 10 µg/l
Public water supplies	99.3	13	97.4	38
Public group water schemes	100	0	100	0
Private group water schemes	100	0	100	0
Small private supplies	99.9	1	99.6	3
Overall	**99.5**	**14**	**98.2**	**41**

In the past, many samples tested for lead tended to have been fully flushed before sampling. However, this does not meet the requirements of the current Regulations and it is recommended that the random daytime sampling[††] method be used.[31]

§ Water supply zones.

†† Random daytime sampling is defined as taking water directly from the tap normally used for consumption without any prior water abstraction, flushing or cleaning of the tap prior to sampling. The sample should be chosen randomly during the day but during normal office hours

8. PUBLIC HEALTH ADVICE

It is recommended that everybody should minimise their intake of lead (Pb) from all sources. This recommendation is based on evidence of the potential impact of lead on longer term health. Following the successful removal of the principal sources of environmental lead, such as in fuel and paints, the focus has turned, in recent years, to drinking water as a possible source of preventable human lead exposure.

Everyone should try to drink water with as little lead as possible and no level is considered completely safe. The higher the level of lead in drinking water and the longer that this water is consumed, the greater the risk. Unborn babies, infants and young children are at particular risk.

Where a lead exceedance above the parametric value of 10 µg/l has been identified, flushing the cold water tap before consumption may reduce the level of lead (see Section 9.2). However, the effectiveness of flushing should be verified by testing the water.

If the drinking water lead level remains above 10 µg/l, an alternative source of potable drinking water should be used, especially by formula-fed infants, young children and pregnant women. See Frequently Asked Questions – Lead in Drinking Water.[34] The priority should be, however, to keep well hydrated. This particularly applies to infants and young children.

All lead pipes and plumbing in public and private ownership should be replaced over time.

9. INTERVENTIONS

The removal of lead in drinking water presents more challenges than the removal of lead in fuel or paint, due to issues such as old infrastructure, incomplete pipe-laying records and costs to property owners. It should be possible, however, to implement interventions, on a phased basis, which will reduce the amount of lead in drinking water over time. The responsibility for actions to reduce the level of lead in drinking water is collective and requires actions on behalf of the Water Services Authorities (WSAs), property owners (public or private) and water suppliers or personnel installing or carrying out works on drinking water supply pipes. In order to support the reduction of lead in drinking water, this position paper proposes the following interventions.

9.1 Water Services Authorities (WSAs)

To reduce exposure of consumers to lead in drinking water, it is recommended that WSAs should carry out the following actions:[30, 35]

- Optimise the quality of the treated water to reduce the plumbosolvency of water in the distribution network (e.g. control of pH and alkalinity, use of corrosion inhibitors).
- Complete the lead surveys as outlined in EPA Advice Note No.1 to identify areas in the distribution network at risk of elevated levels of lead in drinking water.
- Information on the location of lead services should be gathered, mapped and assessed as part of the metering programme led by Irish Water.
- Replace identified lead distribution mains and any newly identified lead distribution mains as soon as they are identified.

- Continue to replace over time lead communication pipes under the control of the WSAs. Priority should be given to lead communication pipes where:
  - The property owner agrees or requests to replace their lead service connection and internal plumbing.
  - Removal is likely to bring excessive levels of lead below the parametric value.
- Remove lead service connections and lead plumbing in Local Authority-owned housing and other buildings, starting with buildings where the lead limit of 10 µg/l is being exceeded or is likely to be exceeded.
- Ensure the replacement of lead service connections and internal plumbing in public buildings where people may consume water, and in particular in properties with vulnerable populations (e.g. crèches, schools, hospitals etc).
- Advise consumers where lead is present or likely to be in the communication pipes, service connections or internal plumbing of the actions they can take to reduce exposure including advising them to replace their pipework.

9.2 Property Owners

To reduce exposure of consumers to lead in drinking water, property owners should:

- Determine whether there is any lead pipework or plumbing in their ownership. A suitably qualified plumber could assist where this is unclear. See also 'Drinking Water Consumer Advice Note – Lead'.[36]
- Arrange for the water to be tested in properties built before around the 1970s where the service connection and internal plumbing has not been replaced. The sample to be analysed should be taken from the first draw of water before water is used in the property in the morning. A second, fully-flushed sample (i.e. where the contents of the pipe between the main and the tap is run to waste) should also be taken which can be used to determine whether flushing the tap will lead to reduced lead levels below the parametric value. The WSA could be contacted for advice about the testing of the water for lead.
- Where a lead exceedance has been identified, flushing the cold water tap may reduce the level of lead. This should be done first thing in the morning and if the water has been stagnant for a period of time. Whether or not this is successful depends on the length of the lead pipes or source/s of lead in the plumbing system. The water could be tested first thing in the morning and after running the tap (1, 2 or 3 sink-fulls) to check whether this reduces the lead concentration. This will establish how much water needs to be removed before being used for drinking or cooking.
- If the drinking water lead level remains above 10 µg/l, an alternative source of potable drinking water should be used, especially by formula-fed infants, young children and pregnant women. See 'Frequently Asked Questions – Lead in Drinking Water'.[34]
- Use only a tap from the rising main (usually the cold water tap in the kitchen) for drinking, cooking and making baby formula.
- If a lead exceedance in drinking water has been identified in a premises, inform all users of such drinking water, including lodgers, long-term visitors, people renting or buying the premises, of steps that can be taken to limit lead exposure.
- Ensure that personnel installing or carrying out works on drinking water supply pipes or fittings, whether during new works or renovations, use materials which are on the list of approved products and processes published by the Drinking Water Inspectorate of England and Wales (www.dwi.gov.uk) or other equivalent EU Member State approval scheme.

In addition, **owners of public buildings**** should:

- Replace or re-line lead pipework, fittings or solder in the service connection and internal plumbing of any premises where it has been found.

In addition, **owners of private properties** should:

- Contact the WSA if it is decided to replace the lead service connection and internal plumbing to ensure that the communication pipe is replaced at the same time.
- Consider replacing or re-lining lead pipework, fittings or solder in the service connection and internal plumbing of any premises where it has been found.
- Prior to the purchase of any property verify that there are no lead service connections or lead internal plumbing present.

9.3 Water suppliers and personnel installing or carrying out works on drinking water supply pipes should:

- Ensure that lead solder is not used on any pipes that come in contact with drinking water.
- Ensure that all materials that come into contact with drinking water (e.g. pipework, fittings, etc) are on the list of approved products and processes published by the Drinking Water Inspectorate of England and Wales (www.dwi.gov.uk) or other equivalent EU Member State approval scheme.

** Including premises where water is supplied for human consumption as part of a commercial or public activity (including but not limited to schools, hospitals and restaurants).

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