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EPP Rapid Research
Rehabilitating Home Water Pipes with Epoxy Coatings
Homeowner's Association (Anonymous Request)

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Request

Epoxy lining for lead pipes prevents leaching of lead into drinking water; however, how safe are these epoxy linings? Is epoxy-lining the environmentally preferable solution to rehabilitating old pipes?

Key Findings

- Epoxy pipe-lining has been widely used in Europe and the United States for the rehabilitation of drinking water pipes for two or more decades without evidence of significant on-going health concerns.
- ANSI/NSF 61 certification is the principal US safety testing standard for plumbing materials and includes a process to quantify chemical contamination of drinking water from epoxy pipe-lining materials.
- Independent laboratory tests have shown unacceptable levels of hazardous organic chemicals leaching into water during tests of ANSI/NSF 61 – certified materials, but we don't know how these materials compare with epoxy-lining formulations currently available on the market.
- Some suppliers' current epoxy pipe-lining materials contain dangerous or controversial chemicals, including bisphenol-A. Independent experience and vendor-supplied materials suggest that improper pipe preparation, epoxy formulation problems, or improper application procedures may increase the risk of chemical contamination of drinking water after pipe-lining.
- Copper and plastic pipes, fittings and pipe-lining materials all present some risk of contamination of drinking water. The need for skilled operators and complex installation procedures increase the chemical contamination risk for epoxy pipe-lining versus conventional plumbing techniques. Do your homework to understand the options and tradeoffs for your situation.

Background

Low-level lead contamination is a serious household safety issue and children are especially at risk for neurological and learning deficits from lead exposure (1). While paint, dust and soil are the most common routes of lead exposure (2), lead-contaminated water accounts for 14-20% of the total lead exposure for children (1). In some cases, lead contamination arises from old plumbing techniques or standards, such as, leaching from lead service lines or lead solder, but modern brass or chrome-plated brass fittings can also leach significant quantities of lead. The steady, incremental damage of corrosion in metal pipes over time can exacerbate these problems and cause additional color, taste and particle issues. One option is replacement of old pipes and fixtures. As problem pipes are often buried or embedded in walls or floors, the project can be expensive and time-consuming.

Since the 1990's, new techniques have entered the US market to facilitate home water pipe rehabilitation. By coating the wall of water distribution pipes from the inside with an epoxy, a protective barrier is established to shield water from the sources of contamination at the pipe wall. The process is conceptually simple: water supply pipes are first emptied and dried, then sand-blasted from the inside to remove corrosion and scale; an epoxy formulation is applied and cured in place before a final sterilization and return to service.

The epoxy-lining process has several benefits: the lining immediately reduces or eliminates lead and corrosion-based water quality problems; the removal of corrosion during the preparation process can improve pipe flow in previously degraded systems. Since the work is done without excavation or extensive interior demolition, the process is comparatively fast and often less expensive than the more labor intensive pipe removal and replacement (3). There may be additional environmental benefits from a reduction in demolition waste or in new materials required for pipe replacement and structural repairs.

Are epoxy-linings safe for use in drinking water pipes?

While epoxy-lining is generally effective for reducing lead exposure, concerns have been raised about new chemical contamination leaching from the epoxy-lining material. Chemical contamination is difficult to detect in the absence of visual or odor clues.

What reassurance can I take from water quality regulation?

Drinking water standards are designed to offer some protection against contamination. Under the Safe Drinking Water Act, the United States Environmental Protection Agency (USEPA) establishes regulations for contaminant levels in drinking water distribution systems (4). These standards mainly address water quality *where it enters the distribution system* and do not address changes in quality from contamination downstream, such as in home plumbing.

In 1985, the USEPA initiated a third-party certification program to address, in part, the concern of downstream contamination. One outcome was ANSI/NSF[1] Standard 61, initially published in 1988. ANSI/NSF Standard 61 governs the safety of products, components and materials that come into contact with drinking water, and is widely recognized by government regulating authorities. Thirty-six states have adopted these standards as requirements for residential plumbing, but major plumbing codes, such as the Uniform Plumbing Code used by some local governments for residential enforcement, do not require that materials meet ANSI/NSF 61 (4).

For NSF certification testing, plumbing materials are placed in contact with various test water samples (typically a three-week exposure), including waters with typical post-disinfection chemical characteristics and a range of acidity levels to simulate different "in-use" conditions (5).The contact water is then tested for the presence of over 300 chemicals and compared with "safe" levels.[2] Unfortunately, the list of contaminants monitored in ANSI//NSF 61 are not widely available. You must purchase the standard document from NSF, or find a copy at a local regulatory authority or public library to learn whether specific chemicals are included in the certification review. The NSF process also includes a provision to test for leaching of additional chemical substances on a case-by-case basis. While the process seems reasonable, the consumer is left with a yes/no certification result, but almost no other information.

Is there evidence to suggest concern about epoxy safety?

Prior to its use in pipe-lining, epoxies have served as barrier coats in water storage vessels. This process is much simpler than lining a pipe, but the process and chemistry are still complex, and there are many opportunities for problems. Failures in substrate preparation, e.g., insufficient drying, errors in mixing of ingredients, etc., may lead to problems in the finished coating, some of which can affect barrier integrity (6). An incorrect formulation could lead to incomplete curing and the potential for chemicals to leach from the coating into drinking water.

Water contamination from some epoxy pipe-lining materials has been found in independent laboratory tests. Alben el al. found that methyl isobutyl ketone and xylene leached from epoxy-coated test panels and from epoxy-lined water storage tanks [cited in (5)]. Hazardous volatile organic chemicals, among them benzene and

[1] ANSI – American National Standards Institute, NSF – National Sanitary Foundation

[2] For example, with the USEPA listed organic contaminants, the ANSI/NSF 61 standard requires that contaminant levels be no more than one-tenth of the maximum level allowed in water by the USEPA or other regulating authorities.

xylene, were found to leach from epoxy into water at levels above the acceptable maximum specified by US and Canadian regulations, and some of the tested materials were ANSI/NSF 61 certified (7). The Satchwill report concludes, "It was found that these linings can cause significant contamination of the drinking water" (7).

The US military services have used epoxy pipe-lining since the 1990's to deal both with high corrosion environments aboard ships and for pipe-rehabilitation to avoid lead contamination in drinking water (8) (9). In 1992, the Naval Research Laboratory's (NRL) coating development program was delayed and forced to shift to new formulations. Changes in federal regulations that year tightened restrictions on one of the existing coating components, a toxic, carcinogenic epoxy hardener, 4,4'-methylene dianiline (10). While the main concern was safety of the epoxy workers, the components of some epoxy systems used for pipe rehabilitation clearly pose a potential risk for toxic chemical contamination.

In the United Kingdom (UK), epoxy-lining for pipe rehabilitation began in the 1970's and became common-place in the 1990's (11). Concerned that the aging of rehabilitated piping systems might pose health hazards, regulators commissioned a study. The 2007 report to the UK Drinking Water Inspectorate concluded that, "…any leaching from the pipe linings is at a low level" (11). Pipes lined with five UK-approved epoxy formulations were surveyed. The report notes that, "Evidence of leaching of 4-t-butylphenol (4-TBP) from Resin C was found…", however, the concentration was quite low (in the part per billion range). While 4-TBP is an irritant, it is not otherwise believed to present a significant health risk.[3] It is important to note that in the UK, in-place epoxy-lining can only be performed by approved contractors.

Some epoxy materials used for pipe-lining are formed from the controversial bisphenol-A (BPA). Repeated studies by the US Centers for Disease Control and Prevention have detected BPA in the urine of 93% of tested individuals (age 6 and above) (12). BPA is an endocrine disruptor, and there are significant concerns about the safety of chronic exposure to low-levels in food (13). While pipe-lining suppliers say their products are safe, vendor documents acknowledge that there is some risk for bisphenol-A exposure above ANSI/NSF 61 certification levels when lining installation procedures are not rigorously followed (14).

Most vendor websites provide little detail on the chemical formulations of their epoxies. Even worse, there may be serious inaccuracies, for example, the Cleanncoat site states, "…Cleanncoat™ does not use any chemicals in the pipe restoration process. We use three elements: air, sand, and epoxy" (15). There is no doubt that chemicals, and in some cases hazardous ones, are used to produce epoxy pipe-linings. Any claim to the contrary should be a red-flag for potential customers.

Am I better off with copper or plastic pipes?

The Lead and Copper Rule of 1991 established a set of monitoring and water treatment requirements to address the risk of corrosion-induced lead and copper contamination of drinking water. While not generally a problem, your local water authority can provide advice as to the risk of copper contamination in your area.

Lead contamination is still an issue for new replacement plumbing. Plumbing pipes or fixtures can contain up to 8% lead and be considered "lead-free." Leaching usually diminishes over time as the more easily accessible lead is washed away, unfortunately, into the drinking water. While these products are generally subject to the same ANSI/NSF 61 certification process, there are concerns about whether the certification testing is rigorous enough to identify the full risks (16). New lower-lead standards for go into effect in 2012.

[3] Recent analyses by the European Union suggest that it 4-TBP, while a severe irritant, has low toxicity, low bioaccumulation, is not mutagenic or carcinogenic, and has very weak estrogenic activity (19).

While there have been reports of taste and odor problems with some plastic piping materials, chlorinated polyvinyl chloride[4] (CPVC) has been shown to produce only low levels of organic contamination (17). The USEPA reports that there have been no examples of contamination above maximum permitted levels for post-1977 formulation PVC piping (5). Newer plumbing types, such as the high density polyethylene (HDPE) and cross-linked polyethylene (PEX), seem to have more odor and/or organic contamination potential, but specific health concerns were not identified in this study (17).

In addition to contamination from leaching processes, chemicals can enter drinking water by permeation of contaminants through the pipe wall from contaminated soil around the piping (5). In most cases, permeation problems have involved plastic (polymeric) plumbing materials and diesel or petroleum-product contaminated soils in industrial areas or, for example, near a gasoline station. Undamaged, quality copper plumbing materials will not suffer from permeation problems.

In most cases, copper is a good choice for pipe replacement. Epoxy-lining will be attractive in cases where there is a need to rehabilitate long underground lines or plumbing buried in walls or floors. For a hundred-year-old, multi-story apartment building or hospital, the costs might be dramatically lower for epoxy-lining.

Conclusions

Epoxy-lining for the rehabilitation of drinking water pipes has been widely applied in Europe and the United States for decades. No evidence has been found for any widespread health problems related to the use of epoxy-lining in water systems. In spite of that fact, there have been several independent studies showing that organic contaminants can and do leach from ANSI/NSF 61-approved epoxy coatings into water.

The chemical formulations of pipe-lining epoxies are not readily available, but some are known to contain hazardous or controversial chemicals, including bisphenol-A. Practical experience with epoxies suggests that the risk of water contamination increases if there are deficiencies in the pipe-lining process. This suggests that should you choose epoxy pipe-lining, it is critical to find an experienced vendor, and important to ask for assurances that no part of the process be short-changed in any way. There may be an additional margin of safety if the drying, curing and flushing processes are given extra time, to maximize final coating integrity.

There are pros and cons to any choice of piping materials, but it seems likely that the risk of chemical contamination from copper piping is smaller and better understood than for epoxy-lined pipe. A significant risk of contamination still exists from pipe fixtures. Be sure to quiz suppliers about lead content and lead contamination potential for new fixtures. Lastly, conventional plumbing installation is not highly technical or as dependent on skilled operators as the complex epoxy-lining process. Still, in some situations, plumbing rehabilitation may be less expensive with epoxy-lining techniques.

Other Notes

- Pipe-lining companies often suggest that coatings extend the lifespan of aging piping for many decades, however, warranties are commonly in the ten- to fifteen-year range (18).
- It is not clear how the epoxy-lining process impacts needs for later upgrades to piping systems, such as extensions to new fixtures or remodel-associated plumbing changes. For example, will an epoxy-lining be damaged by new solder joints as plumbing is extended?

[4] PVC and CPVC are addressed here only from a water quality standpoint. There is an international effort to reduce the use of PVC due to concerns for manufacturing worker chemical exposure and contaminant release from incineration of PVC waste.

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