

Copper Pinhole Leaks

BUILDER TECHNOTE

Internal pitting corrosion of copper pipes is a rare but costly problem that leads to the formation of pinhole leaks. Although the factors that cause this problem are mostly unknown, it is well recognized that the chemistry of the water traveling through the pipes can influence the formation and propagation of pits.

Pinhole leaks are a major concern to homeowners as they may:

- be costly, given the effort required to find and repair each leak
- result in highly variable amounts of water damage per occurrence
- lead to loss of water resources from undetected leaks in service laterals
- lead to growth of mold and mildew
- result in higher premiums for or cancellation of homeowner insurance

There is also a legitimate concern for consumers that one leak might soon follow another. Insurance companies often raise premiums or simply do not renew policies, and homeowners distraught over leaks can reach the point they do not feel comfortable leaving the house without first turning off the water.

What is a Pinhole Leak?

A pinhole leak is a final breakthrough event of the progressive attack of pitting corrosion on copper water plumbing. A copper water plumbing system can be in a condition of having significant damage by pitting corrosion, but not have pinhole leaks. The challenge is how to discover pitting corrosion before pinhole leaks develop. Figures 1 and 2 show a pinhole leak in a copper pipe.

The State of Maryland Task Force to Study Pinhole Leaks in Copper Plumbing defines a copper pinhole leak as *“the perforation of copper tube, pipe or fittings used for domestic water distribution as the result of pitting corrosion initiated on the interior/waterside surface with the subsequent leakage of water.”*

How Many Homes are Affected?

There is no comprehensive source of information on the occurrence of pinhole leaks. Many utilities and water authorities have collected thousands of reports, submitted voluntarily by residents who have experienced pinhole leaks. Often, homeowners consider pinhole leaks as a plumbing problem, and do not report them to their water utility.

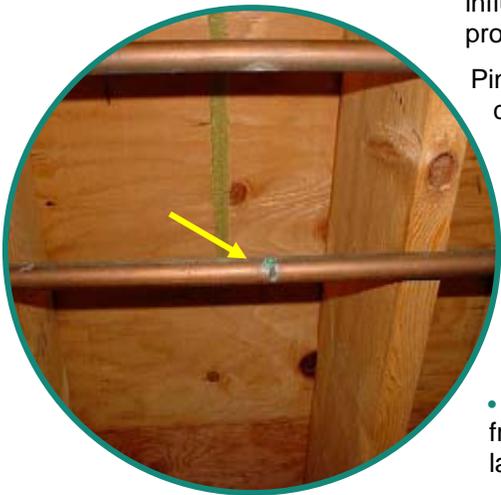


Figure 1
Pipe with Pinhole Leak
(Courtesy of WSSC)

Where Do Pinhole Leaks Happen Most Often?

Although pinhole leaks could happen in any copper pipe or tube within a house, the Washington Suburban Sanitary Commission (WSSC) reported that the majority of pinhole leaks that their customers had reported were in cold-water, horizontal copper piping. Most of the leaks were in older homes, and 80 percent of the reports involved homes built prior to 1970.

What is Copper Piping and Why is it Used?

Copper piping has been used for domestic water supply for over 50 years. Since 1963, over 5.3 million miles of copper plumbing tube has been installed in about 80 percent of all U.S. buildings. Copper is the most widely used material for plumbing systems because of its ease of use, resistance to corrosion, and resistance to permeation by liquids and gases, which may be sources of corrosion and contamination.

Copper tubing used for domestic water supply and distribution is manufactured to meet specification B88, *Standard Specification for Seamless Copper Water Tube*, established by the American Society for Testing and Materials (ASTM). According to the Copper Development Association Inc.'s *Copper Tube Handbook*:

“All tube supplied to these ASTM standards is a minimum of 99.9 percent pure copper and silver combined. The copper customarily used for tube supplied to these specifications is deoxidized with phosphorus and referred to as C12200 (Copper No. 122) or DHP Copper. Other coppers may also be used.”

In addition to copper, there is a maximum of 0.04 percent phosphorus in copper tubing. The techniques for manufacturing copper piping are the same now as they have been for decades.

Copper (Pitting) Corrosion

There are many forms of corrosion, but pitting corrosion is most likely to culminate in pinhole leaks in copper plumbing. Pitting corrosion is the non-uniform localized attack of the wall of copper tube, pipe, or fittings initiated on the interior/waterside surface in the domestic water distribution system, in which only small areas of the metal surface are attacked, while the remainder is largely unaffected. Pitting corrosion starts on metal surfaces for unknown reasons, and some combinations of water chemistry factors allow the process to continue while some do not. Pitting corrosion can be classified into three types:

Type I pitting is associated with hard or moderately hard waters with a pH between 7 and 7.8, and it is most likely to occur in cold water. The pitting is deep and narrow, and results in pipe failure.

Type II pitting occurs only in certain soft waters, with a pH below 7.2 and occurs rarely in temperatures below 140° F. The pitting that occurs is narrower than in Type I, but still results in pipe failure.

Type III pitting occurs in cold soft waters having a pH above 8.0. It is a more generalized form of pitting, which tends to be wide and shallow and results in blue water, byproduct releases, or pipe blockage.

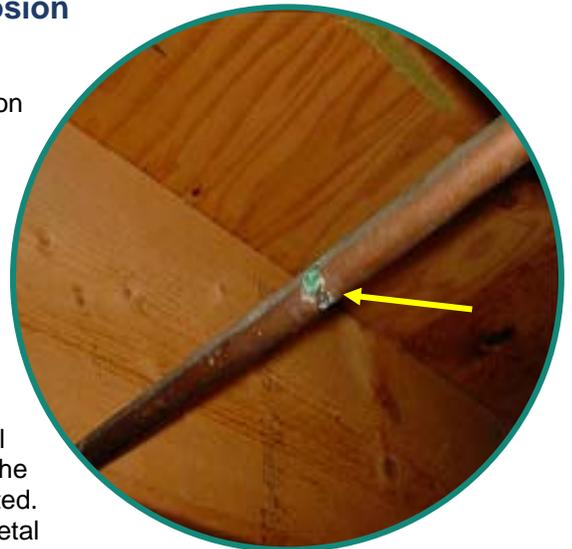


Figure 2
Pipe with Pinhole Leak
(Courtesy of WSSC)

What Causes Pinholes?

Several studies and research projects have been conducted to determine the possible cause of pinhole leaks in copper pipes, but no definitive causes have been established. Some blame it on the chemicals in the water, while

others blame it on workmanship and temperature gradients. The list below illustrates the different variables that are thought to cause pinhole leaks. These variables demonstrate the complexity of trying to pinpoint the suspected causes..

Possible Causes	Study or Research
Combination of high pH, low organic matter, aluminum solids, and free chlorine	Virginia Tech, study commissioned by WSSC, December 2004
Aggressive water, poor workmanship, and addition of water softeners	University of Florida School of Building Construction (1997)
Workmanship: Excessive use of fluxes; fluxes are corrosive by their nature	AWWA Research Foundation and DVGW-Technologiezentrum Wasser, 1996
Aluminum-bearing compounds (from concrete pipes, cement mortar lining of cast iron pipes, aluminum coagulant carryover from treatment plants)	Final report on Maryland Task Force on Pinhole Leaks in Copper Pipes
Combination of: use of soft waters with low pH; high suspended solids and assimilable organic carbon content; long-term or periodic water stagnation; low or nonexistent chlorine levels; maintenance of water temperatures that promote rapid growth and activity of naturally occurring bacteria; and/or the lack of an adequate monitoring program to periodically evaluate water quality and pipe wall condition	<u>Journal AWWA</u> , August 2001, Vol. 93, No. 8, pp. 82–91
Chloramines, which are chemicals caused by combining chlorine and ammonia (NH ₃)	Virginia Tech, study commissioned by WSSC, December 2004
Water velocity in undersized copper tubes. For tubing sizes normally installed in home plumbing, the design water velocity should be targeted toward 4 fps. The greatest effect of velocity occurs where the water is forced to change flow direction, such as at elbows and tees, but excessive water flow rates can be damaging to the entire plumbing system. When copper tubing is installed that is too small in diameter for the pressure and flow available, the resulting high flow rates can erode the protective coating creating areas of bare, unprotected copper. This effect can result in a high rate of corrosion wherever the protective coating is eroded.	A White Paper Review: History Of Use And Performance Of Copper Tube For Potable Water Service, Richard O. Lewis, P.E. Lewis Engineering and Consulting, Inc., www.wssc.dst.md.us/service/copperpipe.html

Sources of Suspect Pinhole Causes

The suspect causes for pinhole leaks come from different sources.

Element or Compound	Source
Aluminum & Silica	Cement main pipes; or Coagulant chemicals added during treatment
Solder flux	Poor workmanship
Water velocity	Improperly designed water distribution system

Factors that do not contribute to pinholes

Studies have shown that many factors that were thought to contribute to pinhole leaks in copper pipes have been proven otherwise or have little scientific basis. Some of these factors are:

Factor	Source
Manufacture of the copper plumbing materials	Final report on Maryland Task Force on Pinhole Leaks in Copper Pipes
Electrolysis	Symposium - Copper Plumbing Tube Pitting
Grounding of electrical systems/ phone systems to the piping system	
Harmonic divergence (the alignment of the planets)	
Solar flares/sun-spots	
Cellular phone/radio signals	
Cheap/inferior or imported copper	

Repair Options

Currently, homeowners have several options from which to choose. However, none of the options address the root cause of the problem; they simply try to correct the symptoms. Most of the options are also costly. These options include:

- Fixing the leak by application of external solder
- Replacing a small or larger section of tube
- Re-plumbing the entire house (However, even a complete re-plumb with new copper tubing does not guarantee that the problem will not recur after a period of time.)
- Re-plumbing and replacing copper with PVC or CPVC
- Coat the inside of existing pipes with epoxy - see the [Epoxy Pipe Lining Technology Inventory](#) item
- Purchasing potential cures (of questionable value), such as magnets

Pinhole Leak Prevention

It is difficult to totally eliminate or prevent copper pitting. However, there are a few things you can do to reduce them, such as:

Examine accessible/exposed copper piping for small, bluish-green stains on the pipes – away from joints. This can be an indication of a pinhole leak. Call a licensed plumber immediately at the first signs of leaks. (Bluish-green stains on copper pipes do not necessarily indicate there is a pinhole leak – they can appear on copper pipes in a damp environment, such as the basement.)

Before purchasing a home, self inspect plumbing (or have a licensed plumber do so), ask about the plumbing history, and

find out how long the house has been vacant, if applicable.

Purchase pipe clamps from any hardware store and install them over pinholes to stop leaks until repairs can be made.

Have your water tested for pH value. It may be necessary to do this a number of times at several day intervals, to catch variations. Your water pH should always be higher than 7. If it isn't, talk to your water department.

Reference Materials

- Task Force Study - Final report on MD Task Force on pinhole leaks in copper pipes "*Pinhole Leaks in Copper Plumbing*."
- www.mdarchives.state.md.us/msa/mdmanual/26excom/defunct/html/10copper.html
- Symposium - Copper Plumbing Tube Pitting
- www.copper.org/environment/NACE02122/nace02122c.html
- J.R. Meyers and A. Cohen, "Pitting Corrosion of Copper in Cold Potable Water Systems", *Materials Performance*, 34 (10), October 1995
- "Corrosion of Copper in Potable Water Systems." *Internal Corrosion of Water Distribution Systems, 2nd Edition*. AWWA Research Foundation and DVGW-Technologiezentrum Wasser, 1996.
- VA Tech research: Rushing and Edwards, 2004, and Marshall, 2004.

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