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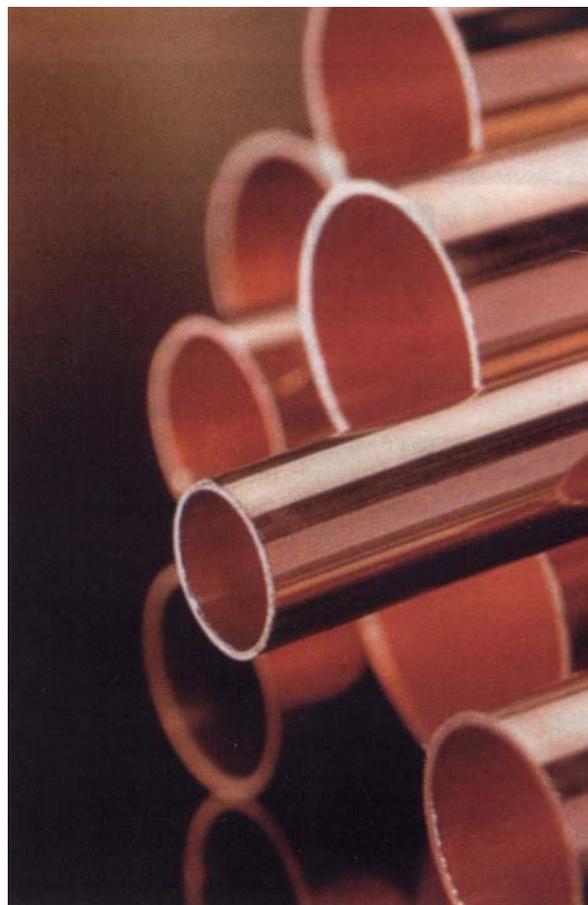


Homeowners in several U.S. states are experiencing pinhole leaks in their copper plumbing after years of trouble-free service. Researchers are working to solve the problem, but the cause is still a mystery (p. 16). Photo courtesy of the Copper Development Association, New York, New York.

# Insidious Leaks Plague Homeowners

*Researchers hope  
to shed light on  
puzzling pinhole leaks  
in copper tubing.*

MATTHEW V VEAZEY, STAFF WRITER



**I**magine that you have lived in the same house for 40 years. Although it may have developed peculiarities such as a creaking front door or a slightly shaky banister, you have come to rely on your home as an oasis of security and stability. One day, however, dripping noise and discover that a pinhole leak has formed in the copper tubing that until now has performed so well. Shortly after patching the leak, dismissing it as a random event, you find another pinhole. Then another. Your plumber offers little comfort because he is just as baffled as you are. Dismayed by the prospect of spending several thousand dollars repiping your home and repairing water damage, you wonder when you will be able to regain that now-foreign sense of security.

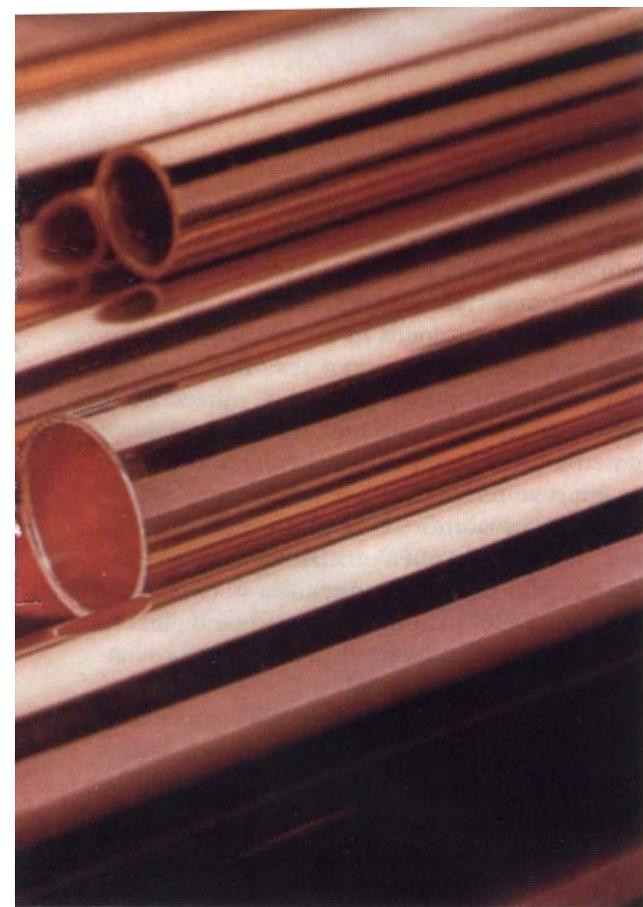
Although the preceding paragraph is a dramatization, such events have become all too real for homeowners in the Washington, D.C., area, Tennessee, Florida, Ohio, and other parts of the U.S. Although theories abound, the exact cause of this relatively recent phenomenon remains a mystery. This article discusses what researchers, waterworks officials, and others have learned about the leaks and what they are doing to address what some believe is an escalating problem.

## **An Uncontrollable Problem... At Least for Now**

"Ironically, although consumers suffer all consequences of home plumbing corrosion and pay all the costs either directly or indirectly, they have virtually no control over the problem," says Marc Edwards, a Professor of Civil and Environmental Engineering (CEE) at Virginia Polytechnic Institute and State University (Virginia Tech) (Blacksburg, Virginia) who has studied pitting corrosion extensively for more than 10 years.

The Washington Suburban Sanitary Commission (WSSC) (Laurel, Maryland) and other water utilities throughout the country have yet to determine the cause of the pinhole leaks. "We've been aggressively working as an advocate for our customers to determine why this is occurring and what steps we can take to try and minimize future occurrences," says WSSC Public Communications Manager Chuck Brown.

According to Brown, numerous reports of pinhole leaks from homeowners in Montgomery and Prince George's counties, Maryland, prompted WSSC to launch an investigation in the summer of 2000. County and WSSC officials, representatives from the Copper Development Association



An estimated 80% of U.S. homes are plumbed with copper tubing, which has a long-standing reputation for reliable service. Photo courtesy of the Copper Development Association, New York, New York.

- ❑ Nearly 80% of the reports received thus far have involved homes built before 1970.
- ❑ Copper plumbing has been used extensively in the WSSC service area for more than 50 years.
- ❑ Regardless of the age of the pipes, the majority of pinhole leaks reported to the utility first occurred in the mid-1990s.

Earlier studies by Edwards and his colleagues failed to identify a link between a plumbing system's susceptibility to developing pinhole leaks with factors such as geography, climate, and the age of copper tubing. "After years of trying to make such correlations, without any success, we began to focus our attention on the water supplied to homes as a likely causal factor," says Edwards. "Some trends began to emerge, and our most recent laboratory experiments have given us a high degree of confidence that we are on the right track. We are also convinced that certain changes in water treatment practice, recently required in response to U.S. Environmental Protection Agency [EPA] [Washington, D.C.] regulations, are dramatically increasing the risk of pitting corrosion in many localities."

EPA rules promulgated in the 1990s in response to the Safe Drinking Water Act (SDWA) amendments required treatment changes to reduce natural organic matter (NOM) levels and lead and copper levels. Utilities subsequently have employed higher free-chlorine levels to prevent outbreaks of waterborne disease and typically have raised the water pH for a variety of reasons. For reasons that are unclear at this time, there has been an increase in the content of aluminum in water supplied to consumers' homes.

The EPA's mandate to meet the above water chemistry goals, coupled with the surge in the number of reports of pinhole leaks from homeowners, has led Edwards and others to suspect a connection between the two factors. Although the water chemistry hypothesis is not the only possible explanation advanced thus far, Edwards maintains that recent progress on the part of his team should lend credence to what is now a controversial idea. "We actually invested some years of futile efforts in tracking down the chemistry and found some significant tendencies, but it was only recently that we discovered a combination of factors that gives every indication of causing pits as they occur in practice," he explains, adding that this particular discovery cannot explain all instances of pitting. "That result is awaiting scientific review and confirmation but is also consistent with considerable hard-earned practical experience."

(CDA) (New York, New York), master plumbers from the Washington Suburban Master Plumbers Association (Rockville, Maryland), and copper corrosion experts Edwards, Steve Reiber of HDR Engineering, Inc. (Bellevue, Washington), and Richard Lewis of Lewis Engineering & Consulting (Gainesville, Florida) all have collaborated in the ongoing study.

"The investigation was undertaken to determine the potential cause[s] of copper pipe pinhole leaks, better understand why this area has experienced an increased number of such leaks, and identify possible activities that may minimize future occurrences of copper pipe pinhole leaks," explains Brown. Although many questions remain, Brown says that WSSC has observed the following trends among an estimated 4,500 customers (out of a 410,000-customer account base) who have reported pinhole leaks to the utility via a questionnaire:

- ❑ The majority of pinhole leaks being reported are in cold-water, horizontal copper piping.
- ❑ Customers living in and around the older communities of Montgomery and Prince George's counties-Beltsville, Laurel, Bethesda, Chevy Chase, and Silver Spring-have reported the majority of pinhole leaks.



Copper tubing installed in a typical water distribution system. Under normal circumstances, installed copper tubing can last the life of a building. Photo courtesy of the Copper Development Association, New York, New York.

Disregarding the water chemistry theory, other researchers have blamed the pinhole leaks on factors such as tubing defects, stray currents, and even lightning. Recalling his own investigations, Edwards counters that the process of elimination makes the rival interpretations implausible. "For instance, while there might be variations in the manufactured tube surfaces that contribute somehow, we'd see this problem for all types of tubes and manufacturers," he says. "So if there is a 'defect,' it has to be one that occurs universally with a high frequency, and that doesn't make sense considering that pinhole leaks do not occur at all in most localities." He is equally skeptical about the stray current theory, asserting that numerous studies conducted worldwide have "invariably" determined that the phenomenon has no quantifiable impact on this particular internal copper corrosion problem. "I think that lightning appeals to many parties because it is an act of God, and therefore no one can be held legally responsible, but there have been direct lightning hits on copper that did not cause pitting and copper pipes in complete electrical isolation that did develop pinholes," he says. "We are not sure that water chemistry is the whole story, but I am confident now that it is a major part of it in many circumstances, and going forward the onus will be on proponents of other theories to prove that their own hypotheses have merit."

More than 5 decades ago, the corrosion scientist Hector Campbell first hypothesized that NOM in water somehow prevents pinhole leaks from occurring in copper pipe. Subsequent laboratory experiments proved that NOM acts as an anodic inhibitor to copper and that metals corrode very differently in waters with NOM than in those

without it. In spite of those developments, however, no one has ever reproduced the basic problem of copper pitting in the lab as it occurs in practice, notes Edwards. "Until we can reproduce the pitting phenomena in the lab, from a scientific perspective, we cannot scientifically determine how to stop it," he explains. "Anecdotally, however, many cases of pinhole leaks have been noted to occur after treatments were instituted to improve removal of NOM from the drinking water." The author on multiple occasions attempted to contact EPA officials for their perspective on the possible connection between the modified water treatment standards and pinhole leaks in copper tubing. At press time, those attempts were unsuccessful.

"Through this investigation, we've been able to discount many factors as the primary causes of pinhole leaks in our service area," says Brown. "Unfortunately, despite our best efforts, we probably never will know the exact cause of pinhole leaks affecting WSSC customers in Montgomery and Prince George's counties. However, we are optimistic our efforts will yield a proven method that may help reduce future leaks for many of our customers." Earlier this year, WSSC launched a pilot program that entails using the corrosion inhibitor orthophosphate in a Laurel apartment building that has experienced more than 20 pinhole leaks since January 2001. According to Brown, orthophosphate was effective in stopping pinhole leak activity. "With approximately 50% of utilities nationwide using phosphates, we are confident that adding orthophosphates to the treatment process is completely safe," he says. "Many water utilities have been safely using phosphates since the passage of the EPA's Lead and Copper Rule in 1992 to reduce lead and copper levels in tap water."

## A Comprehensive Study

In July 2002, the National Science Foundation (NSF) (Arlington, Virginia) awarded a \$110,000 planning grant to a research team led by Edwards to initiate a comprehensive research project designed to evaluate the costly impacts of corrosion on water quality, drinking water tastes and odors, and home plumbing. "To my knowledge, no one has funded research to directly protect the consumer's interest in these important issues," says Edwards, who has studied pitting corrosion since earning his doctorate in 1990.

Edwards maintains that investigations of pinhole leaks in copper tubing traditionally have been limited in scale and scope. "None [of the other studies] have simultaneously considered

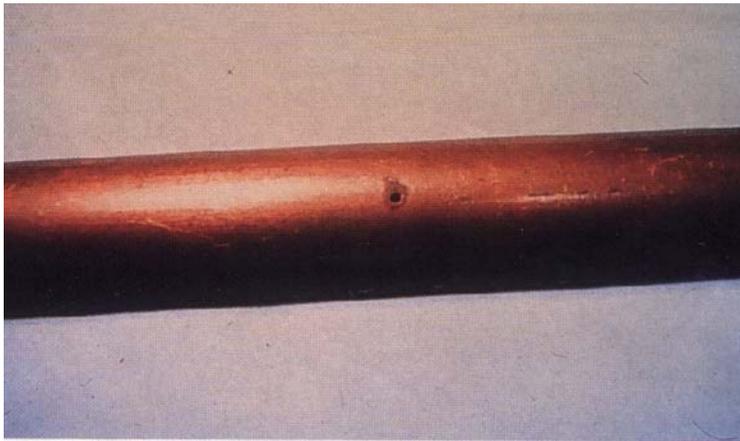
health, aesthetics, and plumbing performance," he says. "These were relatively low-budget projects designed to identify solutions to a specific problem by a trial-and-error testing approach." He is optimistic that his project, which he hopes will receive additional NSF funding following the planning stage, will make breakthroughs in terms of prediction and prevention rather than just remediation. "The goal is to develop a capability to rationally predict and prevent problems, as opposed to identifying solutions through a brute-force approach with an uncertain likelihood of ultimate success," he explains.

Edwards is joined in the study by several Virginia Tech colleagues, including Associate Professors of CEE Andrea Dietrich and G.V. Loganathan, Associate Professor of Food Science and Technology Susan Duncan, Health Educator Sharon Dwyer, and Professor of Agriculture and Applied Economics Daryl Bosch. Others on the cross-disciplinary team represent the following: the U.S. Army Center for Health Promotion and Preventive Medicine (Aberdeen Proving Ground, Maryland), the EPA, the U.S. Department of Health and Human Services' Office of Global Health Affairs (Rockville, Maryland), the American Water Works Association (AWWA) (Denver, Colorado), the AWWA Research Foundation (Denver, Colorado), the U.S. Department of the Interior's Virginia Water Resource Research Institute (Blacksburg, Virginia), Montana State University (Bozeman, Montana), and the Instituto de Nutricion y Tecnologia de los Alimentos (Santiago, Chile).

## A Tarnished Reputation

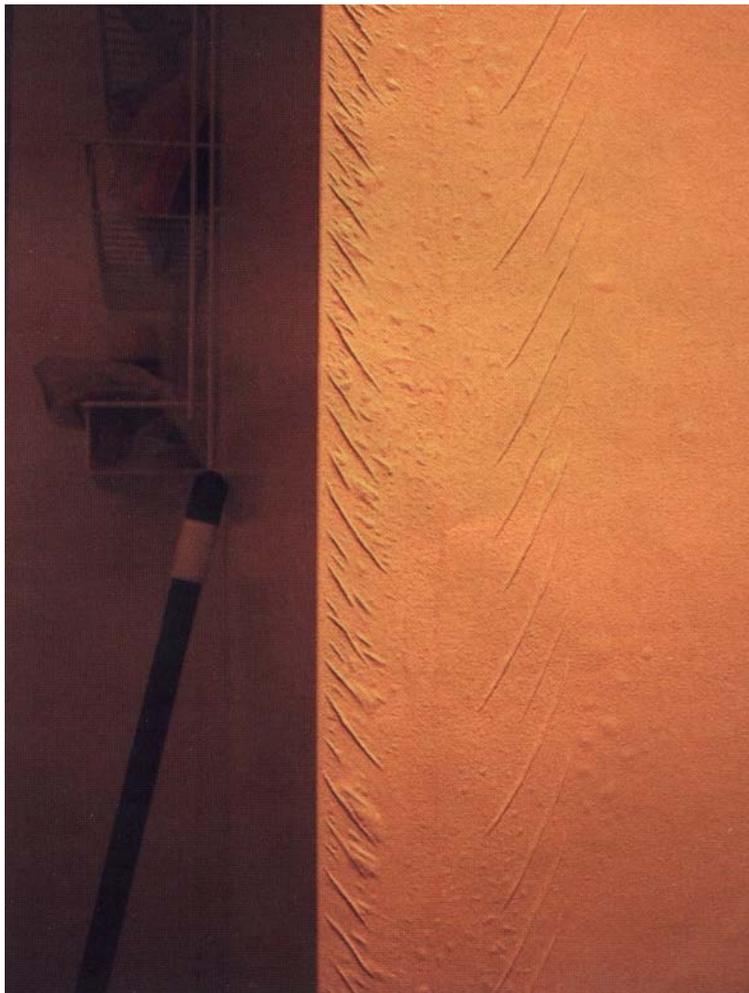
"Expectedly, and much to the dismay of many of the consumers that we have talked to in the affected areas, we have seen a decrease in copper tube installed in residential plumbing systems in [areas with unusually high numbers of documented cases]," says Andrew G. Kireta, Jr., CDA's National Program Manager for Tube, Pipe & Fittings. Kireta, who estimates that 80% of U.S. homes are plumbed with copper, says that an increasing number of builders and plumbing contractors in suburban Washington, D.C., and other areas experiencing pinhole leaks have little choice but to substitute other materials for copper. "[They] could do nothing to change the chemistry of the water or the interaction of this water with the piping system," he explains.

Kireta is quick to point out that copper has a well-deserved reputation as a superior plumbing material. "In normal circumstances,



A pinhole leak in copper tubing. Photo courtesy of the Copper Development Association, New York, New York.

is expected to last the lifetime of the building in which it is installed, and more than 75 years of use in the U.S. is a testament to the quality and reliability of the material in plumbing systems," he says. "Since the end of World War II, when copper went from being not only acceptable but preferred, billions of feet of copper tube have



Water emanating from a pinhole leak created a herringbone pattern in this drywall.

## One Homeowner's

For the approximately 4,000 residents who call it home, Tellico Village, Tennessee, is a pleasant place to retire. Situated southwest of Knoxville near the Great Smoky Mountains, the upscale master planned community offers its residents ample opportunities for golfing, boating, fishing, and numerous other ways to spend their golden years. Recently, however, retirement has become less enjoyable for a handful of the village's residents as pinhole leaks have become a problem in this East Tennessee community.

One Tellico Village homeowner, who wishes to remain anonymous, says that he has found three pinhole leaks in his 14-year-old home in the past year. "The majority of the damage to our home was confined to the drywall ceilings in two rooms and a hallway ceiling," he recalls. "We also had to replace the drywall on two walls in the bedroom. Chairs, bedding, carpeting, and furniture were salvaged through the quick action of my wife and myself. We suffered more damage from the repair process because we elected to replace all of our 3/4-in. [1.9-cm] horizontal cold water pipes with an upgrade pipe [Type L] in lieu of the original Type M."

The resident notes that he has spent several thousand dollars out of pocket to cover repairs. "I have a \$1,000 [homeowner's insurance] deductible and each leak is con-

sidered a separate incident," he says. "Therefore, considering all possible options, I ate the cost on our losses." He adds that he and his wife had to shoulder the entire cost of replacing their 3/4-in. pipe because their insurance company views such repairs as maintenance.

The leaks also forced the couple to refrain from using the first floor of their house for nearly 2 months in order to facilitate repair work. "Outside of the financial loss, losing the use of our downstairs was immeasurable," the homeowner says. "We had a family 50<sup>th</sup> wedding anniversary, and family members counting on staying with us had to stay in motels. Also, we enjoy entertaining family and friends. We were robbed of this enjoyment for the 45 days in mid-summer that our home was down for repairs."

Despite the inconveniences, the resident says that he and his wife consider themselves relatively lucky. "One neighbor lost numerous, irreplaceable family photos," he says. "Another had five leaks in a short period and his insurance paid for the first without question, repaired the second but raised his premium, and canceled his policy on the third. He elected not to report the fourth leak to his new insurance company in fear of being canceled, so he ate the \$1,200 repair cost. One resident had a single simple leak, but the damage ran over \$5,000."

been installed in buildings within the U.S., and it is still installed at the rate of better than 600 million lb [272.1 million kg] -better than 1 billion ft [304.8 million m]-per year. When one considers the number of corrosion occurrences and failures in the context of the amount of copper tubing installed, it is truly a very, very small percentage and attests to the fact that pitting failures are generally few and unusual."

Approximately 4,500 of WSSC's 410,000 customers have reported leaks. Each customer who filed a report had an average of three leaks, bringing the total number of leaks reported to WSSC to an estimated 15,000. Keep in mind that the 410,000-customer account base represents 1.6 million residents. An apartment complex, for example, may count as one customer but could have hundreds of residents and hence hundreds of leaks. Such under-reporting has led Edwards and others to suspect that the actual number of leaks in WSSC's service area may be greater than 100,000.

Kireta says that the copper industry takes the matter seriously and has actively worked to address the problem for the past 4 years. "We recognize and are concerned that although corrosion failures occur in a relatively small amount [of homes], these occurrences can represent serious consequences to consumers, and we are working to find a solution," he says. Specifically, the CDA has provided funding for Edwards' investigation and has collaborated in other endeavors with the WSSC and Washington-area plumbers.

## Only the Beginning?

AWWA estimates that it will cost U.S. water utilities \$325 billion during the next 2 decades to replace losses from corrosion and upgrade water distribution systems. Cautioning that it is difficult to calculate a similar cost corresponding to residential pinhole leaks, Edwards nevertheless uses the expression "tip of the iceberg" to describe the current situation. "My gut feeling is that the overall cost of home plumbing corrosion problems are of the same magnitude as corrosion for drinking water utilities-currently about \$16 billion per year," he says. "We are currently working on developing a better back-of-envelope cost estimate."

Kireta fears that a solution will be out of reach unless stakeholders work together in addressing the problem. "With ever-changing regulations on water quality and water treatment we feel that this solution will only come through cooperation between water utilities, regulators and those setting the regulations, and industry," he says. "The time to act is now. With water utilities making sweeping changes to meet the 1996 amendments of the SDWA, the chemistries of water supplied through our nation's piping systems can be changed almost daily-changes that can have a significant impact on the longevity and reliability of water supply and distribution systems. We must also keep in mind moving forward that changes in water quality regulations and water treatment should consider not only the health of our people, but also the health of our infrastructure." *NP*