Sample

WHITE PAPER

For Future Buyers

A White Paper Report:

About Pipe Problems

What Causes Them and What You Can Do About It

Compliments of

[redacted]

About Pipe Problems

The common thread to most pipe problems is that water comes in contact with metal. Both erosion and corrosion can wear away and weaken pipe walls. Failing pipe systems can result in a number of water problems that can range from annoying to costly to dangerous:

- Water Leaks
- Low water pressure / poor water flow
- Poor water quality
- Mold

Erosion

Friction alone is one of the major contributors to pipe failure. In situations where water is flowing more frequently or more rapidly - such as in a recirculation line - pipe walls will erode and need repair more quickly.

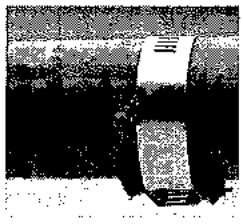
Corrosion

Since water reacts with metal, deterioration of some sort is inevitable. The chemistry of water flowing through pipes will have a direct impact on the speed and extent of pipe deterioration. The major factors that affect pipes and plumbing systems are:

- Oxygen suspended in water reacts with metals, which is the leading cause of pipe corrosion
- Low pH, or soft water, is acidic and can rapidly dissolve pipe walls, thinning the metal and eroding copper into the drinking water system.
- High pH, or hard water, is often full of dissolved minerals that can cause your pipes to become encrusted and plugged. In copper pipes, this can also contribute to pitting and pinhole leaks. Chlorine may contribute to pitting and associated pinhole leaks, and can dramatically increase the lead leaching from pipes and fittings.
- Temperature: the higher the temperature, the faster the rate of corrosion.

Pipe Leaks

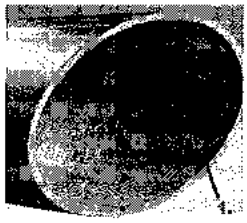
Leaking pipes can be an indication of a system-wide problem. Often, these water leaks are addressed by means of "spot repairs." However, spot repairs don't stop the corrosion, and become impractical and costly as the frequency and severity of pipe leaks progresses.



Spot repair of a pinhole leak in a copper pipe

Copper Pipes

Copper pipes are particularly susceptible to pinhole leaks. This phenomenon (sometimes referred to as "slab leaks" when pipes are installed under cement slabs) is well documented and increasingly common.



1. Scale/buildup on the walls of a copper pipe. 2. Pitting that will lead to pinhole leaks.

Pinhole leaks are particularly problematic because:

- They may cause water damage to plaster and sheetrock walls, electrical systems, flooring, ceilings or furniture.
- Undetected water leakage may result in mold growth.
- Repairing or replacing copper pipe, because of limited access, is generally costly.
- Water damage claims may result in homeowners' insurance premiums being raised, or non-renewal of policies.

Why do copper pipes develop pinhole leaks?

A pinhole leak is the final breakthrough on an area that has been affected by pitting. Pitting, a form of corrosion, can occur in both hard and soft water environments.

- Pinhole leaks have been widely studied, but their cause not scientifically confirmed. It is known that a combination of

water chemistry characteristics contribute to or speed up the pitting process.

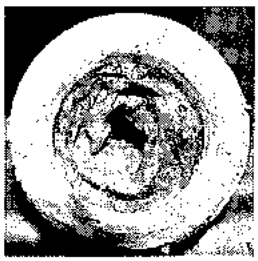
- Soft water, or water with a pH below 7, is acidic. This acidity will dissolve copper pipe walls and cause leaks to break through.
- In hard water, or water with a pH above 8, scale build up on the walls of the pipe will eventually lead to pitting, which will then lead to pinhole leaks.
- Poor quality materials or installation can also be a cause of copper pipe leaks. Builders may have used lower grade copper or smaller diameter pipes than appropriate. Plumbers sometimes take short cuts that compromise pipes. A common example is "cold bending" where plumbers bend copper pipes to make turns instead of installing elbow joints. Bending weakens the copper at the bend and water will erode the pipe material, eventually causing leaks.

Low Water Pressure

Low water pressure problems are commonly caused by a buildup of scale deposits inside of piping. Sometimes known as "tuberculation," this buildup reduces the interior pipe diameter and produces a very uneven interior surface. Reduced interior volume and increased friction combine to reduce water flow. Typically this buildup progresses over time, steadily lowering the water flow rate through the plumbing system.

Galvanized and Cast Iron Pipes

Galvanized or cast iron pipes are particularly susceptible to this problem. Hard water (pH over 8) is full of dissolved minerals. As the dissolved oxygen in water interacts with the metal, corrosion occurs and an rough surface forms. This rough surface gives these minerals a place to cling, and thus build up to the point of restricting water flow and pressure.



Serious tuberculation in water pipes in a residential home was the cause of discolored water and low water pressure.

Other Causes

Low water pressure problems can also be the result of improper design or installation. Plumbers may have installed piping that is either too small or they may have reduced the size of the piping too quickly. The result is restricted water flow and low water pressure at the tap.

In cases where water flow is restricted by deposit build up, epoxy pipe lining is often the most cost effective remedy. This is particularly true when the affected pipes are underground water mains or pipes in homes or buildings where tearing out and replacing old pipes will require extensive cutting into walls, floors, and other structures. In most cases, CuraFlo's Engineered Flow Lining System and Spincast epoxy pipe lining processes will completely remove corrosion build up from pipe interiors and the epoxy lining will restore the pipe interior and prevent future deterioration.

Discoloration, Odor, Stains, Taste, and Contamination

Badly corroded pipe interiors can cause clogged pipes and water quality problems, ranging from poor aesthetics to dangerous contamination:

Discolored water (red, brown, blue or yellow water)

Colored water is usually caused by high levels of dissolved or suspended corrosion by-products (i.e. the rust- or lime-like corrosion that gets flushed from the pipe wall into the water coming out of your tap)

Staining on sinks, tubs and fixtures

Staining is also the result of high levels of dissolved or suspended metals or minerals. As metal pipe walls corrode, the metal also erodes – right into your tap water. Metals absorbed into water can form deposits in appliances, in particular water heaters, causing their premature failure. Pipe restoration puts an end to staining and deposits.

Bad tasting water

Bacteria and other microscopic organisms can grow in the encrustation caused by corrosion,

leading to bad tasting water. In galvanized pipes, corrosion can lead to high levels of zinc or iron in the tap water, which impart a "metallic" taste to the water.

Odors

Similar to bad tasting water, odors are most often caused by bacteria and other organisms that cling to the corroded pipe walls. These will inevitably contaminate the water resulting in unpleasant smelling water.

Lead contamination

One of the most serious effects of pipe corrosion is lead contamination. While lead pipes are no longer used in plumbing materials, older buildings may still contain lead water delivery pipes. The primary way lead enters drinking water is the result of corrosion – or wearing away – of materials containing lead. These materials include:

- Lead-based solder used to join copper pipes
- Brass and chrome-plated brass faucets
- Pipes made of lead that connect your house to the water main or service line

CuraFlo's epoxy pipe lining solutions provide an effective barrier to protect against lead leaching into drinking water as well as provide an effective method of pipe restoration. See the Resource Center at CuraFlo.com for related documentation by the U.S. Army Corps of Engineers and the U.S. Navy.

History of Piping Materials

During the 19th and early 20th century lead was used very widely in the major cities of the U.S. for water pipes because of its durability and malleability. It was also the major source of lead-related health problems in the years before the health hazards of ingesting lead were fully understood; among these were stillbirth and high rates of infant mortality[1]. Lead pipes were superseded by galvanized steel and copper, and copper pipe became the predominant material selected for domestic water service and distribution in residential construction after World War II. Copper pipe still has over 80% market share for new indoor plumbing[2] with galvanized pipe and plastics being alternatives.

Lead

Some old homes and particularly the service lines from the water mains to the homes still have lead pipes. For example, Providence Water in Rhode Island announced in May 2007 that some 25,000 of its total of 74,000 water connections are made of lead and will be replaced over a 15 year period[3]. According to the Federal government[4], "Lead is unusual among drinking water contaminants in that it seldom occurs naturally in water supplies like rivers and lakes. Lead enters drinking water primarily as a result of the corrosion, or wearing away, of materials containing lead in the water distribution system and household plumbing. These materials include lead-based solder used to join copper pipe, brass and chrome plated brass faucets, and in some cases, pipes made of lead that connect your house to the water main (service lines)."

In 1986, Congress banned the use of lead solder containing greater than 0.2% lead, and restricted the lead content of faucets, pipes and other plumbing materials to 8.0%." This so-called "lead-free" brass can still legally contain up to 8% lead and plumbing systems installed prior to 1986 can contain high levels of lead from both plumbing components and lead solder.

The presence of lead in water from the tap is indicative of serious pipe corrosion that must be corrected for health reasons.

Galvanized pipes

Galvanizing of steel pipes involves the application of molten zinc to pre-formed steel pipes to provide a corrosion resistant coating. However many galvanized pipes in old buildings were manufactured using zinc that probably contained high levels of lead, which is a common impurity in the zinc. It was not until 1986 that the Wheatland Tube Company became the first galvanized pipe manufacturer to be certified to ANSI/NSF Stan-

dard 61 for its hot dip galvanized pipe. Galvanized pipes are still common in older homes and many commercial buildings. Galvanized pipes will corrode over time, as indicated by the following corrosion symptoms:

- high levels of zinc or iron in tap water
- a "metallic" taste of the water
- poor water flow due to blockage from mineral buildup
- discolored water (brown, red or yellow water)

Copper pipes

Copper is widely used for plumbing pipes because of its excellent corrosion resistance and safety. It is also very easy to work with: it is malleable and easily joined by fittings or soldering.

Copper plumbing pipe comes in three types:

- Type K: has the thickest walls
- Type L: walls are less thick than K, but thicker than M
- Type M: has the thinnest walls. Also, Type M is a hard tube, not easily bendable and is only supplied in straight lengths. It is most commonly used as the lowest cost tube in new buildings.

Despite its success as a plumbing material, copper pipe has sometimes failed well before its design lifetime, mainly because of pinhole leaks. This subject has been extensively studied for many years. Dr. Marc Edwards of the Virginia Polytechnic Institute and State University (Virginia Tech) believes and has testified during hearings of the U.S. House of Representatives and at City Council Hearings of the District of Columbia government that pinhole leaks in copper pipes are a major national problem.

1. W. Troesken, National Bureau of Economic Research, NBER Working Paper No. W9549, 2003
2. Copper Development Association
3. Providence Water, Press Release May 24 2007
4. Code of Federal Regulations (CFR Chapter 1, Part 141,143)

Water Composition

Water, by the time it has reached your drinking water system, has gone through many changes that keep it from being the "pure" H_2O you read about in chemistry books. It is a complex mixture of water plus materials such as oxygen, carbon dioxide, minerals, organic matter, impurities, and chemicals used to treat the water. And there are over 75,000 public water systems in the U.S., each with their own unique source of water.

Safe Drinking Water Act

Under the Safe Drinking Water Act in 1974, the EPA set mandatory standards for the quality and safety of water at the tap. These standards require that any water contaminants be within safe levels. These are:

pH	6.5 to 8.5 ppm*
Copper	1.3 ppm
Lead	0 ppm
Iron	0.3 ppm
Zinc	5.3 ppm

ppm = Parts per Million

**EPA recommends but does not mandate pH levels*

Another important regulation under the SDWA is the Disinfectants and Disinfection By-Products Rule. Many processes are used to treat water including coagulation using alum or ferric chloride, carbonate or bicarbonate treatment to increase pH, addition of orthophosphates or silicates to minimize pipe corrosion, aeration to lower CO_2 levels, and disinfection using chlorine or chloramines. This amendment reduces health risks by regulating the allowable concentration of disinfection by-products in the drinking water.

Aggressive Water

Compliance with these standards and regulations is a key aspect in assuring safe drinking water. However, even with these standard and treatment, there are many factors that can affect the piping system, including: pH of the water, oxygen content, chlorine and chlorinated by-products, and temperature:

- Dissolved oxygen reacts with metals, which is the leading cause of corrosion.
- Low pH, or soft water, can be acidic and can rapidly dissolve pipe walls, thinning the metal and eroding copper into the drinking water system.
- High pH, or hard water, can be full of dissolved minerals that can cause your pipes to become encrusted and plugged. In copper pipes, this can also contribute to pitting and pinhole leaks
- Chlorine may contribute to pitting and associated pinhole leaks, and can dramatically increase the lead leaching from pipes and fittings.
- Temperature- the higher the temperature, the faster the rate of corrosion

pH

In water, the essential "driving force" for corrosion is generally dissolved oxygen. However, this role can be taken over by acidity.

The pH level of drinking water reflects how acidic it is. pH is a logarithmic scale that measures the concentration of hydrogen ions in the water. pH is measured on a scale that runs from 0-14. Seven is neutral, indicating there is no acid or alkalinity present. A measurement below 7 indicates acid is present and a measurement above 7 indicates alkalinity. The EPA recommends but does not mandate that public water systems maintain pH levels of between 6.5 and 8.5.

Low pH water, commonly referred to as "soft" water, is particularly aggressive to metal plumbing systems. It can rapidly corrode galvanized and copper piping. In fact, NSF does not certify copper for use in water with a pH of less than 6.5. Copper can corrode rapidly and uniformly at low pH values, causing metal thinning. At higher pH values (above about pH 8), copper corrosion problems are almost always associated with non-uniform or "pitting" corrosion processes, causing pinhole leaks.

pH and Copper Pipe Pitting

Pitting corrosion has been 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.

Certified to Water Safety Standards

CuraFlo® is certified by various regulatory bodies to ensure that its processes and epoxies are the best and safest in the industry.

CuraFlo's CuraPoxy® is certified by IAPMO Research and Testing to meet ANSI/NSF Standard 61. This is the government standard for safe drinking water. This standard has been in place since 1988 and has been used to certify over 12,000 products. According to this certification, CuraFlo's CuraPoxy is...

- Safe to use for drinking water
- Approved for use in pipes where the water temperature can reach up to 180°F (commercial and industrial buildings)
- Cures in 5 hours, which means water service can often be returned the same day

CuraPoxy® is manufactured in compliance with all applicable UPC standards (IGC 189-2006).

ANSI - American National Standards Institute
NSF - NSF International
IAPMO - International Association of Plumbing and Mechanical Officials
UPC - Uniform Plumbing Code