Copper Pitting Corrosion and Pinhole Leaks: A Case Study

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Presented at 2005 AWWA Annual Conference
San Francisco, CA, June

Introduction
Pitting Corrosion and Pinhole Leaks

- Leads to leaks, water damage, mold
- Costly plumbing repairs
- Process is complicated
  - Material, water quality, microbial
- Does not generally result in high copper levels

Localized Corrosion (Pitting)

- Type I – Cold Water Pitting
  - Attacks horizontal runs of cold water pipes in systems using well waters with a high sulfate to chloride ratio
- Type II – Hot Water Pitting
  - Occurs in hot water with a pH below 7.2
- Type III – Soft Water Pitting
  - Occurs in soft water below pH 8.0

Objective

- Analyze copper pipes that have been removed from a DS of a community with a pitting corrosion history
Approach

- Solids and surface analysis
  - Pitted pipes vs. non-pitted pipes
  - SEM-EDS, XRD, stereomicroscopy, TOFL-SIMS, others...
  - Water quality analysis
  - Systems that experience pitting versus those that do not
  - Electrochemical corrosion analysis approaches
  - Nature of pitting problem

Case Study

General Observations

- Cold water
- Horizontal runs of pipe
- ½ and 1/2" pipe
- Homes are about 7 years old
- Leaks occur near elbows and joints as well as in long runs
- No preference for the top or bottom of a pipe

Case Study

Water leaks

½" pipe

Elbows and joints

¾" pipe

Pipe Cross-Section

Anatomy of a Pit

Anatomy of a Copper Corrosion Pit
The Corrosion Cap

Cap Features

- Brochantite - $\text{Cu}_4\text{(OH)}_6(\text{SO}_4)$
- Ponsjakite - $\text{Cu}_4\text{(OH)}_6(\text{SO}_4)\cdot\text{H}_2\text{O}$

Hole

3 mm

Perforated Membrane

Literature suggests that the membrane consists of cuprite.

Breaking Through the Membrane

Pits are loosely packed with cuprite crystals beneath the permeable membrane.

A Dissected Pit Reveals the Extent of the Damage

“Homogeneous” Deposits

Si, Ca, Fe, Cu, O
Pit Propagation

Particle deposition, particle growth, and corrosion cell formation

All pictures taken at same magnification

“Protective” Film

Hot Water Plumbing

Cold Water Plumbing

Role of Plumbing Practice

Water in the Pit

pH of Pit Water

pH < 5.5 (tap water pH 9)
Future Work

- Survey individuals
- Contact plumbers and plumbing suppliers
- Examine more pipe
  - Carefully remove pipes
  - Microbiological analysis
- Water heater solids
- Sample distribution system water
- Cement Leaching Study

Acknowledgements

Michael R. Schock - U.S.EPA

Thank You