PLAINTIFF'S EXHIBIT

CAP-1124

A/C Pipe
Producers Association
Public Affairs Committee
International Affairs Committee

Internal Correspondence

TO

FROM J. F. Welch, Vice President

DATE: April 2, 1982

SUBJECT U. S. Environmental Protection Agency (EPA) Presentation - "Monitoring for Corrosion of A/C Pipe"

ACTION REQUIRED: Review for information

Enclosed is a prepublication copy of a paper prepared by Gary Logsdon and James Millette of the EPA Municipal Environmental Research Laboratory (MERL). It was presented at the American Water Works Association Water Quality Technology Conference, December 6, 1981 and soon will be published by that organization.

The paper chronologically reviews the research undertaken by MERL's Drinking Water Research Division on the corrosion of A/C water pipe. It is rather broad in scope and specific technical details are wanting. However, it does provide a good overview of the research and its preliminary conclusions. In his transmittal letter to Staff, Logsdon said the A/C pipe industry might be pleased to know that he is going to spend some time discussing metal corrosion at the American Water Works Association Convention in Miami in June, 1982.

If you have any questions, please do not hesitate to call.

JFW/ajb

Enclosure

cc: A. Kahn, Esq.

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MONITORING FOR CORROSION OF A/C PIPE

by

Gary S. Logsdon

James R. Millette

Over the past several years, the Drinking Water Research Division has conducted research and has sponsored research by others to evaluate the condition of asbestos cement (A/C) water mains, to determine whether or under what conditions such mains might release asbestos fibers to drinking water, and to find ways of binding the fibers to the pipe wall and preventing further deterioration. In every study, one of the important questions addressed was how to evaluate whether a particular quality of water attacked and deteriorated the pipe. Methods used to measure changes in the pipe or in the water transported by the pipe have changed and evolved as reseach has progressed. A brief description of some of these research projects is given in order to describe the historical development of the analytical methods used in this research.

Research by Drinking Water Research Division

The first A/C pipe project undertaken by the DWRD was construction and operation of a pipe loop. This was previously described by Buelow et al. (1), and this section describes some of that work.

In late 1973 the USEPA DWRD investigated the performance of A/C pipe exposed to a variety of water quality conditions. A recirculating pilot scale experimental pipe loop using several full lengths of 10-cm (4-in.) and 15-cm (6-in.) diameter type 2 A/C pipe was built. This system included a holding tank that was open to the atmosphere and equipment for feeding chemicals to maintain the water quality desired for the experiments.

Two of the experiments performed were with waters having an aggressiveness index (AI) of 11.7 and one of 10.4. During both of these experiments the water

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was not saturated for calcium carbonate; it was maintained in an unstable condition through pH, alkalinity, and calcium adjustments. The aggressiveness index 11.7 conditions were achieved by maintaining a pH of 7.5, a calcium concentration of 150 mg/L as $CaCO_3$, and an alkalinity of 100 mg/L as $CaCO_3$. Continuous feed of sodium bicarbonate to maintain the desired alkalinity was opposed by continuous feed of HCl to maintain the pH at 7.5. The difficulties encountered in maintaining the pH and the alkalinity at the desired concentrations were caused by the operation of a system in which the water was in contact with carbon dioxide in the atmosphere in an open reservoir. Buelow et al. (1) concluded that a recirculating pipe loop in which water passed through a holding tank open to the atmosphere several times per hour was not representative of a water distribution system.

The unsatisfactory performance of the pilot scale A/C pipe loop experiments led to the development of a bench scale experimental apparatus described by Buelow et al. (1). This experimental arrangement was designed to allow ease in operation and extended use of recirculated water between changes. The 380-L (100-gal) volume of the recirculating water reacting on a small piece of A/C pipe satisfied this objective. The water was recirculated continuously through the PVC pipe that holds the A/C coupon. The water flowed at a rate of 0.2 L/s (3 gpm), providing a velocity of about 0.35 m/s (1 fps) past the coupon, a reasonable flow. A key feature of the test equipment was the cover and tygon tubing ring gasket that prevented atmospheric contact with the water at the small gap between the cover and the tank wall. Because the water in the tank and piping system was isolated from the atmosphere, water quality could be held at the desired value with substantially reduced effort.

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Results of the recirculating tank coupon tests were evaluated in a number of ways. Water quality was monitored, and changes in calcium and alkalinity were noted. When an additive, such as zinc chloride or zinc orthophosphate, was used, zinc in the water was measured. Pipe coupons were inspected visually and photographed with the scanning electron microscope. In addition, Buelow noted that some coupons had been softened in the six month long tests, so that they could be gouged with a fingernail. New A/C pipe coupons are hard and can not be gouged or scratched with a substance as soft as a fingernail. This finding was pursued in subsequent projects.

Greenwood, South Carolina

This research program was initiated to determine whether adding zinc orthophosphate to potable water would sufficiently coat an asbestos-cement pipe with zinc to prevent asbestos fibers from entering the water.

Storage tanks and chemical and feed pumps were set up at each of the Greenwood, SC, water treatment plants, and zinc orthophosphate was fed into the system at a target average rate of 0.3 mg/L. Two sections of new asbestos-cement pipe were installed to represent a low-flow and a high-flow water condition; they were removable for testing.

Water samples were periodically tested to determine the number of asbestos fibers in the water. Twice, after A/C pipe had been tapped in the sample location vicinity, high asbestos fiber counts were observed. Because pipe tapping operations can temporarily raise the fiber count in the distribution system, the use of tapping machines equipped to flush away drilling and tapping debris is recommended.

The scanning electron microscope (SEM) was used to examine the interior pipe wall of pipe samples removed from both sample locations. The interior surface of the 20-cm (8-inch) pipe was smooth, and some coating resulting from zinc treatment, actually 0.2 mg/L in the transported water, could be identified. The interior of the 15-cm (6-inch) pipe, which actually transported water with lower concentration of zinc (0.1 mg/L), had much larger uncoated areas on the pipe surface.

Regardless of which portion of the pipe was examined, the 20-cm (8-inch) pipe always showed better coverage than the 15-cm (6-inch) pipe. This indicated that the zinc or zinc compounds do adhere to the A/C pipe, and that to be effective, the zinc concentration should be 0.2 mg/L, or higher if possible.

Energy-dispersive, X-ray spectrometric elemental analyses were made on the surfaces of the two test pipes; these analyses were compared with that for a new, unused piece of pipe. On the unused pipe, the only large peak shown was calcium. High peaks were seen for iron and zinc on the 20-cm (8-inch) test pipe and the low peak seen for calcium could indicate that the pipe is well protected and the calcium is masked at this location. High silica and calcium peaks and a low zinc peak were observed for 15-cm (6-inch) pipe at the low-flow location. This again indicated that the low zinc concentration of 0.1 mg/L in the 15-cm (6-inch) A/C pipe is not adequate to provide a protective coating -- certainly not as effectively as the higher concentration (0.2 mg/L) at the other site.

In the energy-dispersive, X-ray spectrometric analyses, the peak size for zinc and iron varied with location in the pipe. A comparison of the zinc peaks from the 15-cm (6-inch) and the 20-cm (8-inch) pipes showed, however, that

the highest peaks of the 20-cm (8-inch) pipe were always higher than the highest peaks of the 15-cm (6-inch) pipe, and the lowest peaks of the 15-cm (6-inch) pipe were always lower than the lowest peaks of the 20-cm (8-inch) pipe. The results for the iron peaks suggest that iron in the water provides a partial protective coating to the A/C pipe in this system. This project was described by Grubb in an EPA project report. (2)

Weston, Wisconsin

Discovery of deteriorated A/C pipe in one part of the distribution system of the Town of Weston Water Utility resulted in application for and award of a cooperative agreement for in-place rehabilitation of A/C pipe. In 1980, a line was isolated from the distribution system for the research. Parts of the pipe line were treated by poly pig. Other sections were cleaned and scraped by the Centriline Division of Raymond International. This summer (1981) the entire main (3 blocks) was lined with cement mortar. In this project, bakelite mounted specimens of the A/C pipe were prepared and studied. The pipe segment was cut and mounted so that the exposed surface of the pipe in the mount had on one side, the inner pipe wall, and on the other side, the outer pipe wall. This mounting arrangement permits observation of a cross section of the pipe. When pipe specimens are mounted in this way, differences in the color and texture of a layer of pipe at the inner wall can be seen by optical microscope, or in extreme cases, by the unaided eye. When attack is not severe, subtle differences are not easily detected. Some of the Weston pipe specimens showed evidence of separation of the pipe layers nearest the inner wall. This may have been caused by the cutting and handling involved with obtaining the small segments used to prepare the bakelite mounts. Separation of layers was not observed with new pipe in a bakelite mount, however.

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Further investigation of the pipe cross-section was done by the X-ray analysis technique using the electron microscope. Elemental profiles of calcium and silicon concentrations have been produced. In new A/C pipe, the calcium and silicon concentrations are constant from the pipe inner wall through the pipe to the outer wall. In used pieces of pipe from Weston, the silicon concentration is constant, but the calcium concentration is lower near the inner wall than at other locations deeper within the pipe wall. The depth of pipe showing lower calcium concentrations ranged from 2.1 mm to 6.5 mm. Analysis of A/C pipe cross sections from four other cities showed calcium losses to depths ranging from 0.8 mm to 3.6 mm. This technique produces a quantitative measure of pipe deterioration.

Bellevue, Washington

In a project now underway at Bellevue, WA, corrosion control strategies are being tested in 100 gallon recirculating tanks, similar to the systems designed and used by Buelow. The tanks at Bellevue are made of polyethylene, rather than stainless steel, minimizing the amount of any kind of metal in the system. The Seattle Water Department, which sells water to Bellevue, is planning to implement a corrosion control program for both the Cedar River water and Tolt River water. Because little or no A/C pipe is used in the City of Seattle water distribution system, the objective of Seattle's program will be to protect the galvanized pipe and copper pipe in water consumers' plumbing. A corrosion control stratgegy to protect Bellevue's A/C pipe might involve attainment of a water quality different from that of Seattle or the use of other additives.

Eight of the 100 gallon tank recirculating systems developed by Buelow are being studied. The conditions for each tank are given in Table I.

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Table I.

Bellevue Pipe Protection Study

Tank	Source	Condition or Treatment
1	Tolt	no corrosion control
2	Cedar	no corrosion control
3	Cedar	Seattle strategy, add lime to pH 8.0
4	Cedar	Seattle strategy, plus lime and soda ash, pH 9.0
5	Cedar	Seattle strategy, plus zinc chloride 0.3 mg/L Zn
6	Cedar	Seattle strategy, plus zinc chloride 0.6 mg/L Zn
7	Cedar	Seattle strategy, plus sodium metaxilicate
8	Cedar	Seattle strategy, plus 0.1 - 0.3 mg/L Fe (ferric chloride)

The tank experiments were started in April and are still under way at the time of this meeting, (early December). Water quality in the closed recirculating systems has been stable, so large adjustments with various chemicals have not been needed on a week to week basis. After about one year, the coupons in the tanks will be evaluated, and a decision will be made with regard to which of the alternatives will be tried in a portion of Bellevue's distribution system.

One of the techniques for evaluating A/C pipe coupons that was first tried at Bellevue is hardness testing. Two techniques have been explored so far. The Rockwell "L" scale test and the Durometer hardness test have been used. Results were consistent between the two types of test. These procedures

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are being studied because the leaching of calcium from the A/C pipe wall can result in softening of the cement material that bonds the fibers in the pipe. This work is a part of the search for an inexpensive, easily used test to evaluate the condition of the inner pipe wall.

Our preliminary hardness testing data indicate reasonable results. Table II shows the test data from the testing laboratory. The differences between means were significant at the 0.05 level for both pipe A and pipe B as compared to the new pipe (pipe C). We will continue to utilize these procedures during the course of the study.

Table II.

Hardness Test Results for A/C Coupons (3/25/81)

	Sample Number	Shore "D" Hardness	Rockwell Hardness L Scale
Pipe exposed to Tolt water	A-1	67	7
	A-2	65	10
	A-3	66	5
	A-4	64	14
	Average	65.5	9.0
	Standard deviation	1.29	3.92
Used pipe, history unknown	B-1	68	64
	B-2	74	60
	B-3	67	65
	B-4	73	56
	Average	70.5	61.25
	Standard deviation	3.51	4.11
New pipe	C-1	79	99
	C-2	81	100
	C-3	82	98
	C-4	78	98
	Average	80.0	98.7
	Standard deviation	1.83	0.96

Summary

During studies of the effects of aggressive water on A/C pipe over the past several years, new methods used to evaluate those effects have been developed. Because of the high cost of transmission electron microscope analysis for asbestos fibers in water, the search for rapid, inexpensive ways to determine whether or not A/C pipes are in a like-new condition or have been deteriorated by aggressive water is continuing. As more data are collected, the relationships between pipe conditions, water quality, and results indicated by the various tests will need to be studied so that a consistent and logical evaluation technique can be developed.

Acknowledgement

Much of the scanning electron microscopy and x-ray analysis work was performed by Patrick J. Clark.

CAPCO JEN 0032001

References

1. Buelow, R.W., Millette, J.R., McFarren, E.F. and Symons, J.M. The Behavior of Asbestos-Cement Pipe Under Various Water Quality Conditions: A Progress Report. Jour. AWWA, 72:2:91 (Feb. 1980).

2. Grubb, C.E. Field Test of Corrosion Control to Protect Asbestos-Cement Pipe. Available from National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161. Order No. PB81-152878, Cost $5.00, subject to change.