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Project Summary

Control of Asbestos Fiber Loss from Asbestos-Cement Watermain

After the Weston, Wisconsin, Water Utility discovered the deterioration of a portion of its asbestos-cement watermain, research to identify and effective means of eliminating or reducing the release of asbestos fibers into its potable water was begun. Three techniques were investigated: (a) using zinc chloride to form a protective metallic precipitate layer on the pipe surface, (b) in situ cement-mortar lining of the pipe, and (c) flushing of watermains. Implementation of the above three asbestos control processes would have widely differing capital and operational costs.

The introduction of zinc into system water did not result in the expected formation of a protective layer onto pipe coupons, possibly because of interference from polyphosphates added to the system water to sequester iron and manganese. Cement-mortar lining of pipe appears to be a useful technique for rehabilitating still structurally sound pipe. Temporary elevation of values for pH as well as calcium and alkalinity concentrations can, however, be expected. Flushing does not appear to be an effective technique for reducing the concentrations of the fibers because concentration of asbestos fibers may become elevated during such high draw conditions. Of the three techniques studied at Weston, in situ cement mortar lining was the most promising approach for long term control of release of asbestos fibers from deteriorating asbestos cement watermains.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

In 1980, when a Water Utility crew was installing a tee in a 6-in. asbestos-cement watermain, they noted that the interior of a removed asbestos-cement pipe was very deteriorated and that the inner wall of the pipe was no longer as smooth as that of a new pipe. Because of concern for the condition of the pipe, ways to rehabilitate or protect asbestos-cement pipe and to remove accumulated debris from the mains were studied.

This research project evaluated three procedures for eliminating or minimizing the number of asbestos fibers being released from the watermains into the water system. The first method was to introduce a protective zinc coating on the pipe wall by adding zinc chloride solution into the water supply. This procedure to prevent the release of asbestos fibers would have a low initial capital outlay but would require perpetual annual operating costs associated with the necessary chemicals.

A second potential solution involved cement-mortar lining of the deteriorated pipe. Although this method would require a large capital cost, no additional operating and maintenance costs would be required.

Finally, watermain flushing was considered as a no-cost method of potential fiber reduction, because flushing is a regular operation and maintenance activity.

Zinc Precipitation Treatment

This test was designed to evaluate the effectiveness of a precipitated zinc pipe coating in preventing the release of asbestos fibers from both new and deteriorated asbestos-cement pipe. This test subjected sample pipe coupons to the utility's water supply treated with 1 mg/L $ZnCl_2$ without any adjustment of the pH of the water and to 2 mg/L ZnCl with pH adjustment to 8.5. Pipe sample coupons subject to existing utility water conditions were also included in this test as a control.

A PVC pipe header was constructed within a lift station located adjacent to Fox Street. Three individual lines were constructed; each contained a ball valve and pressure gage for flow control and a 3/4-in. water meter with totalizer and rate of flow indicator. During the test, flows averaged from 3.73 to 3.84 gpm. A PVC coupon holder, constructed of 2-1/2-in. diameter by 6-in. long pipe, was located downstream from each water meter. Each coupon holder was capable of containing two 3-in. by 1-3/4-in. pipe coupons held end to end. The water came directly from the distribution system, which in turn was supplied solely from the Mesker well.

Pipe coupons were prepared from both new and deteriorated asbestos-cement pipe. The pipe coupons were weighed, without any special drying considerations, and then placed in the coupon holders. After the coupon test header received a continuous flow of water for 6 mo, the coupons were removed and weighed. Again no particular attention was given to the moisture content of these coupons. When it was realized that the moisture content of the coupons may significantly affect the conclusions, the coupons were shipped to the EPA research laboratory in Cincinnati for drying and weighing. The relative hardness of each of the pipe samples was also determined by EPA (Table 1).

Table 1. Coupon Test of Zinc Treatment

Measurements	Pipe D New	Pipe D Old	Pipe E New	Pipe E Old	Pipe F New	Pipe F Old
Avg flow, gpm	3.84		3.73		3.74	
Avg zinc added, mg/L	None		1.4		2.8	
Initial wt, gr	96.99	94.30	88.82	97.83	93.63	77.46
Wet wt after test, gr	66.84	98.24	82.45	90.31	90.55	89.51
Dry wt (5 days drying) gr	57.23	79.78	71.12	72.92	78.13	72.48
Dry wt (97 days drying) gr	56.71	78.88	70.38	72.21	77.24	71.73
Relative hardness, Rockwell "L" scale	79	7	78	-6	81	5

Results of hardness testing do not show any benefits from the use of a zinc additive at Weston. This is in contrast to other experiments where adding zinc helped protect asbestos-cement pipe. The lack of positive results for both sample thickness measurement and hardness testing would indicate that zinc did not precipitate onto the pipe sample coupons to form a protective metallic layer. This may have been caused by the zinc's being sequestered by polyphosphates that were added to the water to sequester divalent iron and manganese. Further research may be needed to investigate the relationship between zinc and polyphosphates.

Coupon weight gain was inappropriate for estimating zinc precipitation on asbestos-cement pipe. Although this parameter may be acceptable for metallic or plastic pipe materials, an alternative method of evaluating asbestos-cement pipe coupons is necessary because this pipe material is porous and subject to chemical and physical reactions with water. For future asbestos-cement pipe research, establishing coupon "dry" weight may be necessary. Because obtaining reproducible dry weights with this porous material is difficult, and arbitrary "dry weight" standard should be established. Coupon weights were within 1% of the 97-day dry weight after the initial 5- to 7-day drying period, so a 5- to 7-day drying period should be used as such a standard.

Pipe Scraping, Polly Pigging, and Cement Mortar Lining

The length of the 6-in. asbestos-cement watermain on which the deterioration was initially discovered was subdivided into three tests sections labeled A (308 ft), B (439 ft), and C (427 ft) (Figure 1). Two-inch schedule 40 PVC pipe was constructed parallel to lines A and C to allow recirculation of water through these two sections. Sampling points were established at the one-third and two-thirds points along the length of each watermain test section.

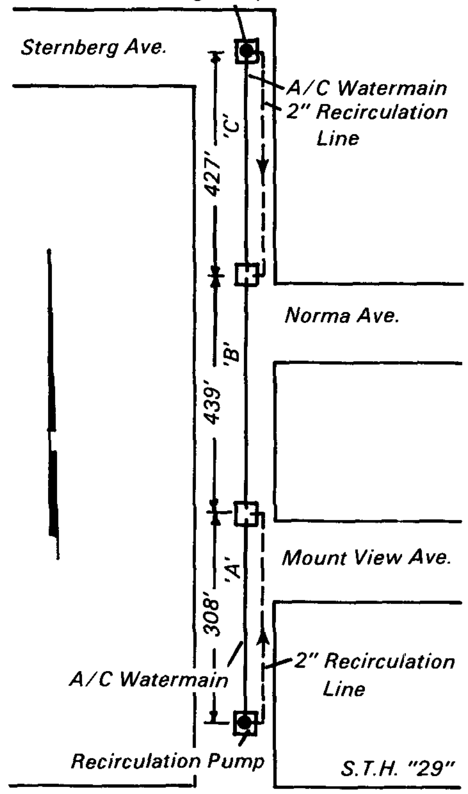

Figure 1. Schematic diagram of Fox Street watermain test sections A, B, and C.

After these sections were isolated from the distribution system and water customers were provided water from other mains, the maintenance and rehabilitation work began. Pipe scraping and cement-mortar lining work was done under direction of personnel from Centriline Division, Raymond International, Inc. Polly pigging work was directed by personnel from Becher-Hoppe Service Corporation. Pipe samples (controls) were taken before any work was done and more samples were taken after various stages of the work. At various times, the test sections were (1) flushed with 700 gal of well water delivered by tank truck to avoid contamination by asbestos fibers from the distribution system, (2) drained, and (3) filled with well water, which was recirculated in the lines for various times. The recirculated water was sampled and analyzed for asbestos fibers.

Test Section A was cleaned with a single pass of a rubber disc scraper and a pipe sample was taken. The line was then cleaned with a cable-pulled metal scraper, and another pipe sample was taken. The line was flushed, drained, and filled with test water. The recirculation volume before sampling was about 60,000 gal.

Test Section B, which did not have a recirculation line and pump, was scraped with a metal scraper and plugged. No further work was done. Line C was flushed, drained, and filled with water for recirculations three times after a series of passes with different types of Polly Pigs.* Water samples were taken after each series of passes; the recirculation volume before the last sampling was 173,700 gal. Line C was then drained and plugged temporarily. Later it was lined with cement mortar.

The effects of pipe maintenance and rehabilitation were evaluated in three ways: asbestos cement pipe thickness was measured and the recirculation water was analyzed for water chemistry changes and for asbestos fiber content.

Thickness of the pipe wall exceeded the minimum wall thickness of 19.81 mm for the Class 200 pipe used by the Town of Weston. Neither the scraping nor the pigging substantially reduced the thickness of the pipe wall. Table 2 shows that considerable variation in pipe wall thickness was observed. A scanning electron microscope showed that calcium leaching had occurred at the inner pipe wall. Aggressive water had caused calcium concentration in the cement matrix of the asbestos-cement pipe to decrease in depths of 2.1 to 6.5 mm into the pipe, as measured from the inner pipe wall-water interface (Table 2). Hardness of the pipe specimens, both before and after scraping or pigging, was less than hardness of new pipe.

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Water quality parameters including pH, alkalinity, and calcium concentrations were considerably elevated upon completion of recirculation test runs conducted after the cement-mortar lining. These elevated values are believed to have resulted from the curing of the cement-mortar material because these parameters had shown a definite decreasing trend with successive recirculation tests runs. This sort of result would not be expected for more than a few days or weeks in water distribution systems when flow is through and out of cement-mortar lined mains. No flushing action occurred during periods of recirculation tests, and this exaggerated the observed increases.

When the mains were flushed, drained, and filled with well water, which was then recirculated, water samples were withdrawn for analysis. The asbestos fiber counts (Table 3) after use of the steel scraper and Polly Pigs are high when compared with fiber counts in the well water and the water recirculated after the cement-mortar lining was applied. The amphibole asbestos fibers found in the background water sample came from the tank truck used to haul the well water.

The lack of any high values (greater than 10 million fibers per liter (MFL)) of chrysotile asbestos fibers found after the cement-mortar lining indicates that this process is effective in preventing the release of these fibers from the deteriorating pipe. This is consistent with the 96% to 99% reduction of tetrachloroethylene that resulted from placing a cement-mortar lining over vinyl-lined asbestos cement pipes in a Massachusetts test.

System Flushing

A flushing test was done in December 1981 on a 1400-ft section of 8-in. asbestos-cement main (installed in 1970) on Kirk Street. This portion of the watermain was isolated from the remainder of the system by closing valves as illustrated in Figure 2. During the test, water samples were taken through the exterior hose bib at two houses on the street.

This flushing test was conducted in two distinct segments. Flow Test One consisted of flushing the water in a northerly direction along the Kirk Street watermain and exiting the system at test flow Hydrant One. Water for Test One was supplied from the nearby well and the 250,000 gal elevated tower. In Flow Test Two, a high velocity flow occurred in the reverse (southerly) direction with water supplied from the distribution system to the west. During each test, a rate of flow and velocity were calculated from measurements of the static and flowing water

Table 2. *Analysis of Pipe Samples Taken During Cement-Mortar Lining Evaluation*

Process Step	*Pipe Sample*	*Sample Thickness (mm)*	*Calcium* Loss (mm)*	*Mean Ca/Si*	*Relative† Hardness*
Background	*New Pipe*	*21.97*	*0.0*	*0.83*	*72*
Test line A					
Control		*21.20*	*2.1*	*0.57*	*-2*
Rubber disk scraper	*1/3 pt. sample*	*21.39*	*2.2*	*0.80*	*-3*
	2/3 pt. sample	*20.77*	*2.5*	*0.60*	*16*
Metal scraper	*1/3 pt. sample*	*21.30*	*2.2*	*0.35*	*-11*
	2/3 pt. sample	*20.74*	*2.2*	*0.60*	*-32*
Test line B					
Control		*21.02*	*6.5*	*0.73*	*-6*
Metal scraper	*1/3 pt. sample*	*21.34*	*2.2*	*0.64*	*-5*
	2/3 pt. sample	*21.79*	*2.2*	*0.40*	*-8*
Test line C					
Control		*21.34*	*4.1*	*0.50*	*-24*
Polyurethane pig	*1/3 pt. sample*	*22.73*	*4.1*	*0.49*	*-20*
	2/3 pt. sample	*21.65*	*4.4*	*0.47*	*-13*
Red criss-cross pig	*1/3 pt. sample*	*25.57*	*6.5*	*0.68*	*-15*
Silicon carbide pig	*2/3 pt. sample*	*22.28*	*4.4*	*0.84*	*-12*
Wire scraper pig	*1/3 pt. sample*	*22.90*	*3.5*	*0.68*	*-13*
	2/3 pt. sample	*20.45*	*3.0*	*0.53*	*-12*

**Distance measured from the interior pipe surface.*
†Modified Rockwell "L" hardness scale.

Table 3. *Water Sample Asbestos Fiber Concentrations Taken During Cement-Mortar Lining Evaluation*

Line	Process Step	Asbestos Fibers Amphibole (MFL)*	Asbestos Fibers Chrysotile (MFL)
A	Background	0.32	1.6
A	After steel scraper	ND	8.4
C	After first red criss cross pig	ND	87.5
C	After silicon carbide coated pig	0.16†	10.9
C	After wire pig and second red	0.37†	8.4
	criss cross pig	ND	49.2
C	Background‡	ND	ND
		ND	1.71
C	After cement-mortar lining	ND	0.39†
		ND	2.1
C	After cement-mortar lining	ND	ND
		ND	1.6
C	After cement-mortar lining, line drained, flushed, and filled a second time	ND	1.3
C	Background§	ND	0.13†
		ND	0.42†
C	After cement-mortar lining,	ND	0.44†
	line drained, flushed, and filled a third time	ND	ND

*MFL - Million fibers per liter.
†Not statistically significant, less than 5 fibers counted.
‡Municipal well water samples from the tank truck.
§Mesker Street well hydrant sample.
Note: Two values are reported where replicate samples were analyzed.

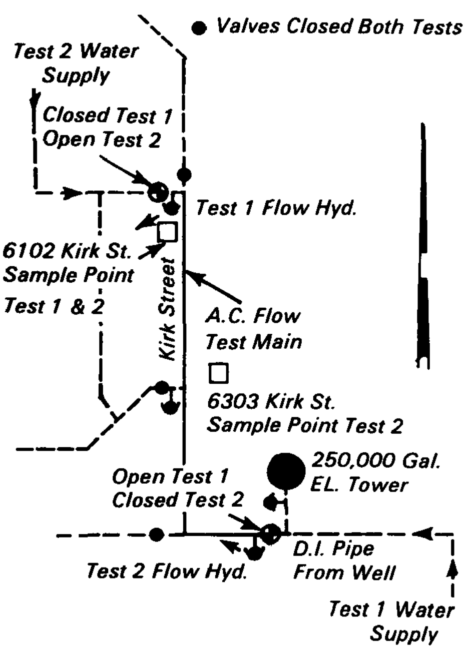

Figure 2. *Schematic diagram of flushing test on Kirk Street.*

pressures recorded at the discharge hydrant. The flow during Test One was approximately 1,100 gpm with an approximate velocity of 7 ft/s. During Test Two, the flow was calculated to be 820 gpm with an average velocity of 5 ft/s. The procedures followed during the flushing test and the chrysotile asbestos fiber concentrations are given in Table 4.

The flushing test revealed that chrysotile fiber counts were somewhat elevated when compared with counts for undisturbed water, even after 90 min of flushing. Other studies have indicated that main flushing results in higher asbestos fiber counts, possibly by stirring up asbestos-laden sediment in the mains. Further testing is needed before recommendations concerning flushing of asbestos-cement watermains can be made.

Conclusions

- Using zinc as a corrosion inhibitor in the presence of polyphosphates may not result in protection of asbestos-cement pipe.
- Disturbing the inner wall of asbestos-cement pipe by scraping or by using Polly Pigs resulted in high asbestos fiber counts in water that passed through the treated pipes.
- Lining asbestos-cement pipes with cement mortar is feasible. Cement mortar lining can be applied to asbestos-cement pipes.
- Eliminating or substantially reducing the asbestos-fiber contamination of potable water from asbestos-cement pipes is possible with the cement linning procedure.

The full report was submitted in fulfillment of Cooperative Agreement CR-808476010 by Weston Water Utility, Schofield, WI 54476 under the sponsorship of the U.S. Environmental Protection Agency.

Table. 4. *Flushing Tests and Chrysotile Asbestos Fiber Concentrations*

Sample Station	Test Condition	Chrysotile Concentration, MFL*
Test No. 1		
Background		0.18 MFL, NSS⁺
6102 Kirk Street	Flushing, 25 min	3.22 MFL
6102 Kirk Street	Waiting period, additional 85 min	9.95 MFL
6102 Kirk Street	Waiting period, additional 90 min	76.1 MFL
Test No. 2 (Valves at Test Hydrant 2 opened and closed (Figure 2)		
6102 Kirk Street Sample	Waiting period, 15 min	No fibers detected
6303 Kirk Street	Waiting period, additional 25 min	7.32 MFL
6102 Kirk Street	Hydrants closed and all valves opened; waiting period, 6 days	0.15 MFL, NS

*Million fibers per liter.
⁺Not statistically significant

This Project Summary was prepared by staff of the Town of Weston, Schofield, WI 54476.

***Gary S. Logsdon** is the EPA Project Officer (see below).*

The complete report, entitled "Control of Asbestos Fiber Loss from Asbestos-Cement Watermain," (Order No. PB 84-148 733; Cost: $10.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

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