REPORT ON ASBESTOS/CEMENT PIPE USE
IN
THE CITY WATER BOARD OF SAN ANTONIO, TEXAS

PREPARED FOR:

THE A/C PIPE PRODUCERS ASSOCIATION
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AT

THE CITY WATER BOARD OF SAN ANTONIO, TEXAS

Introduction

The City Water Board of San Antonio, Texas is the fifth of ten water systems studied under the Municipal Analysis Program of the A/C Pipe Producers Association. In this detailed site visit, as well as the other nine, the objective was to investigate the use of A/C pipe from every perspective. The broad functional categories covered by this fact-finding mission are as follows:

- Operational
  - Decisionmaking, Specification, and Procurement
  - Installation and Testing
  - Operation and Maintenance
  - Repair and Replacement
  - Detection and Prevention
- Financial
- Institutional

Each of these categories of information is discussed in detail in this report.

Background on the San Antonio Site Visit

The two day site visit to San Antonio was conducted on February 1-2, 1982. Officials interviewed during the course of the visit included the following:

Osmund Brynie, Director of Operations
Hugh Anderson, Director of Engineering
Roger Haller, Director of Purchasing
Edward Busheme, Supervisor, Construction Inspection
Al Perez, Maintenance Supervisor
Lowell Roberts, Engineer

The General Manager of the San Antonio system is Mr. Robert Van Dyke, who was inteviewed only briefly during the visit.

However, as he has done in the past, Mr. Van Dyke extended the full cooperation of his department staff for the site visit. San Antonio has been quite supportive of AACPP product studies and development programs for many years. In 1980, Mr. Van Dyke presented a paper entitled "Asbestos-Cement Pipe In San Antonio" at the Association's Eighth Annual Meeting in Hamilton, Bermuda.

San Antonio Water Board personnel are most interested in working with the Association and the A/C pipe industry in improving product design and performance. In 1980, the system cooperated with the Association on a survey of improved pipe tapping measures that reduce the incidence of loose fiber. During the course of this field study, and on previous occasions, they have repeatedly offered to work with the industry in finding a resolution to the beam break problems in smaller diameter A/C pipe being experienced in San Antonio.

Institutional and Background Information

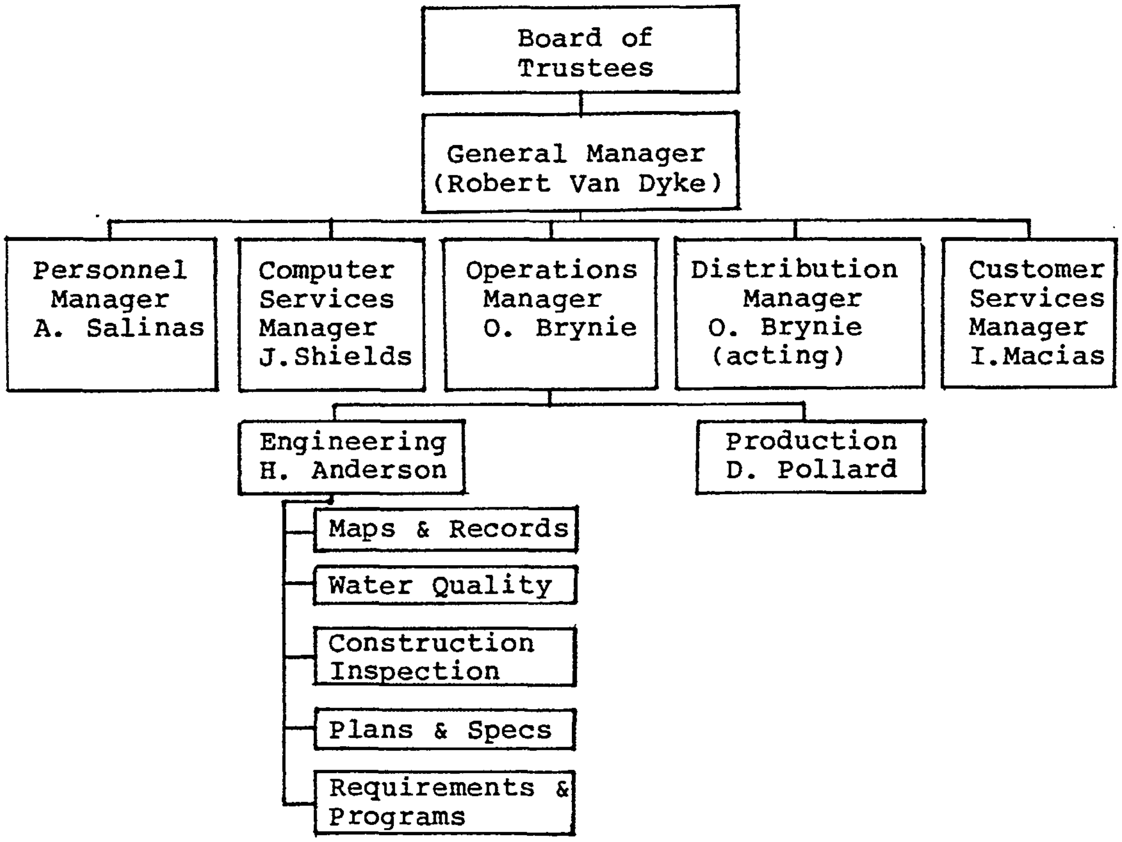
Operation of the municipal water supply by the City of San Antonio began in 1925 with the purchase of the previously private system for 7 million dollars. At that time, the system served some 38,000 persons with about 25 million gallons per day of water drawn from a system of wells. Since that time, the system has grown rapidly until the present and is now serving about 690,000 people (200,000 connections) with about 55 billion gallons of water annually. This amounts to a per capita usage of roughly 220 gallons per day, including commercial usage. The service area covers some 260 square miles and includes most of the city and some suburban areas as well. San Antonio's population is growing steadily, resulting in an annual increase of about 5000 connections to the system.

In total, about 100 water systems, most of which are quite small, serve the metropolitan area. The San Antonio Water Board (SAWB) is pursuing a long term policy of acquiring these systems when it is in the interests of better service and/or water supply aquifer protection.

The SAWB is a semi-autonomous department of the City of San Antonio, under the direct control of a Board of Trustees consisting of the City's mayor and four appointed members who must be residents of the City. The Board is responsible for overall management of the system, subject to City Council review. The SAWB's funding and revenues are separate from other City departments, and the Board has primary responsibilities for long range planning, system expansion and rehabilitation, determining revenue and bonding needs, and personnel management. The water system is required to be fully self sufficient in its expenditures and revenues with the exception that it must supply free water to the city for fire protection. SAWB members serve eight year terms that are staggered on 2 year intervals. A conscious effort has been made to divorce the activities of the SAWB from politics and encourage its operation as an independent utility.

Longevity of service and professionalism characterizes the staff of the organization. The General Manager, Robert Van Dyke, has been associated with the SAWB since 1960 and holds a Master of Science degree in Sanitary Engineering, plus professional registration. Osmund Brynie has been with the SAWB since 1970 and has an MS in Environmental Management. The organization has the largest percentage of State certified water works operators of any water utility in Texas. Personnel policies encourage, and provide partial support for, continued education by staff members.

The management structure of the organization, shown below, is arranged around 5 functional divisions which report to the General Manager, who in turn is accountable to the Board of Trustees.



The SAWB began in the 1970's to rely more on outside contractors for pipe installation to control labor costs. SAWB personnel is used for monitoring and quality control of the work. The system also uses outside contractors to supplement its own crews during periods of unusually high maintenance demand. As of March 1981, the City Water Board had 724 employees including 69 officials and managers, 29 professionals, and 225 craftsmen and operators.

The system obtains its water supply from 71 wells ranging in depth from 600 to 1800 feet and in capacity from 2.0 to 21.6 million gallons per day. To meet future demands, as well as avoid over pumping of the water supply aquifer, future plans call for using surface water supplies.

The Transmission and Distribution System

As of December 31, 1981, the SAWB's distribution system was made up of 2698 miles of main, ranging in diameter from 3.5 to 42 inches. Pipe materials used in the system include cast iron, steel, steel cylinder reinforced concrete, and asbestos cement. Since 1960, San Antonio has used A/C pipe almost exclusively, except in the very large sizes. There is little use of PVC pipe with the exception of some test sections installed in the last several years in a small scale test program. Polyethylene pipe has been used for small diameter service connections and is a major source of maintenance problems. The table below summarizes the pipe sizes, materials and footages contained in the SAWB system as of the close of 1981.

Diameter (inches)	Construction Material	Amount (feet)	Amount (miles)
42	reinforced concrete	3,034	0.574
36	reinforced concrete	44,496	8.428
36	cast iron and steel	550	0.105
30	reinforced concrete	117,899	22.327
30	cast iron and steel	2,864	0.544
24	reinforced concrete	290,230	54.967
24	cast iron and steel	66,034	12.508
24	asbestos cement	66,060	12.513
20	reinforced concrete	102,970	19.499
20	cast iron and steel	22,036	4.174
20	asbestos cement	100,892	19.112
18	cast iron and steel	7,960	1.508
16	reinforced concrete	1,274	0.241
16	cast iron and steel	222,936	42.220
16	asbestos cement	609,726	115.483
12	cast iron and steel	480,764	91.047
12	asbestos cement	1,356,629	256.942
10	cast iron and steel	125,376	23.743
10	asbestos cement	29,069	5.506
8	cast iron and steel	1,037,811	196.521
8	asbestos cement	2,404,712	455.454
6	cast iron and steel	2,569,423	486.615
6	asbestos cement	3,620,276	685.660
5	cast iron and steel	763	0.145
4	cast iron and steel	110,106	20.854
4	asbestos cement	3,692	0.701
3.5 or smaller	miscellaneous	848,313	160.656
TOTAL		14,245,898	2,698.056

Total A/C mileage amounts to 1551.4 miles, or 57.5% of the total.

The predominantly clay soil throughout much of the San Antonio region results in a highly corrosive environment for metallic pipe. By 1954, San Antonio was experiencing a severe problem of exterior corrosion of its iron and steel pipe. A detailed study of the problem, beginning in 1954, included soil analyses and resistivity measurements throughout the service area, as well as test installations of pipe. The study confirmed the relationship between soil resistivity and corrosion.

Resistivity measurements were made at depths ranging from one to four feet and at 2500 foot intervals. The readings were then plotted on a map and the resistivity contours sketched in. When investigators overlaid this map with the locations of corrosion caused main breaks, they found that the greatest number were within those areas in which the soil resistivity is less than 700 ohm/cm^3. The majority of the breaks occurred within the 300-600 ohm/cm^3 zones. These findings have been used by the system to predict the degree of corrosiveness in specific areas of the city and take preventive and remedial actions.

As a result of the study, San Antonio began to install A/C pipe almost exclusively. This practice has continued to the present, despite a significant beam break failure rate in the smaller sizes (4-8 inch diameter). The system is installing about 100 miles of pipe per year, most of which is A/C. Between 1975 and 1981, the percentage of A/C in the system increased from 48.2 to 57.5 percent of the total installed pipe and the trend is continuing. During the same period, the amount of steel and cast iron pipe used fell from 43.3 percent to 36 percent. As yet, there is no significant usage of PVC pipe in San Antonio. The severe problems experienced with polyethylene pipe have prejudiced the system's top executives against the use of any form of plastic pipe. Steel cylinder reinforced concrete continues to be the material of choice for transmission mains, in pipe 20 inch diameter and larger. The system does not use A/C for transmission pipe.

On the surface, the A/C pipe usage trend in San Antonio is healthy. However, there is increasing concern regarding the beam break problems of A/C pipe in the smaller diameters. Problems with 6 and 8 inch A/C have had a major impact on maintenance costs since these sizes represent about 67 percent of total installed footage. They do not feel that the industry has been responsive in dealing with this problem, despite repeated offers to cooperate with and actively support research efforts to resolve the problems. As a result, there is an active program to find alternative pipe materials, including the installation of test sections of PVC and corrosion protected (wrapped) ductile iron pipe. There is still ample opportunity for the industry to respond and thereby retain this valuable customer, but SAWB officials note that Mr Van Dyke is less than two years away from making a definitive move, which would probably be toward exclusive use of ductile iron.

OPERATIONS

Specification, Decisionmaking, and Procurement

Like most U.S. water utilities, San Antonio purchases pipe on an installed basis, relying on private contractors to actually buy the pipe from suppliers for new installations. They stock a limited amount for usage by SAWB maintenance crews. In all cases, the selection of pipe material is specified in all bid documents. This is backed up by a program of inspection of piping materials on the job site. Since the late 1950's, when the beam break problem first became apparent, the system has specified Class 200 A/C pipe for 6 and 8 inch sizes and Class 150 for larger sizes.

San Antonio's A/C pipe material specifications (Specification 05-01, attached), basically follow AWWA and ASTM specifications, with the exception that minimum actual inside diameters are specifed. The SAWB also specifies that the pipe must be supplied by CAPCO, Certain-Teed, Johns-Manville, Mexalit, Asbestos de Mexico, or approved equal. These specifications are backed up with a fairly rigorous site inspection procedure which relies on a team on 18 inspectors within the operations department using the formal checklist attached. On several occasions, shipments of A/C pipe have been rejected for reasons that include poor machining (ragged edges) and excess loose material inside the pipe.

The selection of pipe materials in San Antonio is largely determined by two predominant characteristics of the local soils: Corrosivity and expansion/contraction. The clay soils, coupled with extreme wet/dry climatic cycles, lead to severe problems of soil expansion and contraction. As noted previously, San Antonio uses A/C pipe as a solution to external corrosion problems. However, they have found it to be subject to shear and break type failures caused by expansion, contraction, or shifting soils. The SAWB first attempted to deal with this problem by specifying a higher class of pipe. Later specification changes have focused on improved inspection and quality control during installation, plus the use of a minimum 4 inch sand envelope around the pipe when it is laid. System engineers believe that the solution to the problem lies in shorter pipe lengths, noting the use of lengths as short as 6.5 feet in Israel to solve similar problems. The SAWB would like to the shorter lengths in the 6 and 8 inch sizes, but have been frustrated to date by the unavailability of shorter pipe from North American vendors (with the exception of J-M).

Other considerations favoring A/C include cost and ease of installation. As detailed later, A/C is less costly than ductile iron pipe, both in initial and installed cost.

In late 1980, there was a flurry of concern about the health aspects of A/C pipe use following disclosure of the results of several water samples with high asbestos levels. The SAWB moved quickly to defuse the situation by conducting an immediate investigation of the causes of high readings and by consulting with outside experts at the U.S. EPA and the Southwest Research Institute. Internal pipe corrosion was ruled out, due to the nonagressive nature of the local waters. It was concluded that the free asbestos was coming from two main sources: handling and machining during installation, and the use of dry or non purged tapping equipment. The former was dealt with by better installation and main flushing specifications while the latter was solved by going to water purged pipe tapping machines such as the Mueller B-100 or A-3 pipe tappers. In late 1980, the interest and activity about A/C and health subsided in the local media and has not recurred to date.

An in-house Standards Committee is primarily responsible for advising the General Manager on pipe purchasing. This six man group includes managers from maintenance, operations, and engineering, and is chaired by the Director of Purchasing. The group meets periodically to consider the latest findings on pipe material performance and costs, and review material and installation specifications. Specifications for pipe purchase and installation are developed by the engineering department under the direction of the Standards Committee.

Design Considerations

Service water pressures in the system range from 35 to 175 psi., with operating pressures seldomly exceeding 115 psi. Where main pressures exceed 100 psi., the customer is required to install a pressure reducing valve. Ductile iron pipe is being considered for those areas where pressure in in the 175 psi. range.

Beam strength is the major design concern of the SAWB. Past design efforts have focused on development and implementation of better bedding specifications for all pipe, plus the use of heavier, stronger A/C pipe (class 200 instead of class 150). Consideration is currently being given to specifying 10 foot pipe lengths or possibly even using 6.5 foot lengths. The latter might be supplied by cutting the standard 13 foot lengths in half, machining the ends, and supplying additional couplings. However, this could severely reduce the price advantage of A/C over other materials.

Installation and Testing

Pipe is installed in San Antonio by contractors, developers, and Water Board forces. Total installed footages of pipe for the period including 1975-1980 are tabulated below by type of material used.

Year	Cast Iron & Steel (1000 ft)	Concrete Steel Cylinder (1000 ft)	Asbestos Cement (1000 ft)
1975	4796	447	5974
1976	4796	456	6122
1977	4779	457	6368
1978	4751	478	6728
1979	4712	526	7153
1980	4664	545	7701

Over the same period of time, the system replaced or abandoned 134.5 miles of water mains.

Construction Materials

Asbestos cement is generally specified for sizes above 4 inch up to 20 inch diameter pipe. Lined, coated and polyethylene wrapped ductile iron pipe is being used for high pressure applications or where beam loading is known to be high. Except on an experimental basis, PVC is not used. Steel cylinder reinforced concrete or coated and wrapped steel is used for large diameter pipe.

Trenching

The SAWB's specifications state allowable minimum and maximum widths for specific pipe materials and diameters, as shown below:

Pipe	Minimum Trench Width (inches)	Maximum Trench Width (inches)
6" A/C, DI, & Steel	22	30
8" A/C, DI, & Steel	24	32
12" A/C, DI, & Steel	28	36
16" A/C, DI, & Steel	32	40
20" A/C, OI, & Steel	36	48
24" A/C, DI, & Steel	40	54
30" DI & Steel	46	60
36" DI & Steel	52	66
42" Steel	58	72
20" CSC	42	48
24" CSC	48	54
30" CSC	54	60
36" CSC	60	66
42" CSC	66	72

Normal depth of cover is 4 feet, with 3 feet used in very rocky terrain. A 4 inch sand envelope is required for 6, 8 and 12 inch diameter A/C pipe. The contractor is required to over-excavate to a depth of 2 inches for ductile iron and 4 inches for A/C, which is then backfilled to the grade line using a material acceptable to the inspector (sand for the sizes of A/C noted above). The specification allows use of standard bedding and cushion materials for A/C sizes larger than 12 inches. A 6 inch sand envelope, for the purpose of corrosion control, is specified for ductile iron pipe.

Backfilling and Compaction

Except as noted above for soil expansion or corrosion protection, backfill is with native materials. Stones larger than 2 inches in diameter cannot be used except in the backfill that is 2 feet above the top of the pipe, where stones up to 4 inches in diameter are allowed. For 6,8, and 12 inch A/C pipe, the specification requires 8 inches of sand above the top of the pipe. The contractor is required to hand compact the material around and up to 6 inches over the top of the pipe, working in 3 inch layers. Flooding, jetting, or other inspector approved compacting method is used on the balance of the trench.

Pipe Handling Procedures

No special handling is required for any of the pipe materials used by the SAWB. The specification simply calls for the use of due care in unloading the pipe, lowering it into the trench, and joining sections.

Disinfection and Pressure Testing

The contractor is required to disinfect the newly installed pipe with a 50 ppm concentrated chlorine solution which must remain in the line for a minimum of 24 hours. Flushing of the line is at the direction of the SAWB engineer on the job. The pipe is pressure tested to 150 psi except in those areas that are designated as "high pressure" where the test standard is 200 psi. Pressure test duration is 4 hours for jobs in excess of 1000 feet, 1 hour otherwise. The specifications provide tables for leakage allowances. The maximum leakage allowance for 6000 feet of 6 inch A/C pipe is 8.52 gallons per hour. The allowance for 1550 feet of the same pipe would be 2.2 gallons per hour. The tables used to calculate allowable leakage are attached.

Tapping

Prior to the 1980 A/C pipe and health publicity regarding A/C pipe and health, the SAWB used time honored procedures for pipe tapping. Pipe was either tapped dry, at the time of installation, or service tapped using a non purging tapper. In either case, much of the material from the tap could be expected to be deposited within the pipe. Following the adverse publicity, San Antonio equipped their existing wet tappers with purge taps, tightened up their dry tapping/flushing specifications, and took other steps to make maintenance crews and inspectors more aware of good tapping practice.

Recommended Work Practices

SAWB managers are familiar with Recommended Work Practices For A/C Pipe. Copies of the AACPP booklet have been circulated to maintenance staff and contractors. Section S-4.11 of the SAWB specification specifically defines acceptable cutting tools for A/C pipe and bans the use of shear type cutters.

Operation and Maintenance

Repair of water main breaks has been the principal activity of the Distribution Division for some time. Consequently, the SAWB has invested considerable effort into studying the causes and cures of main breaks. There are two main causes of line breaks in San Antonio: External corrosion of unprotected metallic pipe and shear/beam failure of A/C pipe due to soil expansion/contraction and shifting. The former is well understood and is the target of an ongoing program of pipe replacement whereby much of the existing cast/ductile iron pipe will be replaced by A/C or other corrosion resistant pipe. The latter, which is particularly severe during prolonged drought and alternating wet/dry weather, is not fully understood at this time. It has also been observed that the pipe is more likely to break when installed under roadways. Various remedial strategies have been tried, such as using a higher class of pipe and sand bedding, with inconclusive results.

San Antonio has an excellent program for monitoring and analyzing main breaks. Detailed data have been kept since the mid 1950s. Currently, the main break data program is being computerized. Summarized on the following page are the main break data from 1967 through November 1981.

An analysis of main break data presented by Mr. Van Dyke at the Association's Eight Annual Meeting indicated that A/C pipe, which made up about 54% of the system in 1980, accounted for 32% of the main breaks. An analysis of main break data from 1974-1979 indicated that most A/C pipe breaks occur in 6 and 8 inch sizes and that the rate of breakage for 6 inch pipe is more than double that for 8 inch pipe. The same analysis noted that the failure rate on the system's metallic pipe continues to increase significantly. Also, it was noted that most of the failures occur during the dry summer months of July, August and September, when soil contraction is the greatest.

Main Break Data

	Metallic Pipe Break Data			A/C Pipe Break Data		
YEAR	COR	SS	ACC	SS	ACC	TOTAL BREAKS
1967	672	377	30	212	17	1,308
1968	650	265	8	190	3	1,116
1969	683	217	9	247	7	1,163
1970	825	103	3	211	1	1,143
1971	870	26	2	206	0	1,104
1972	700	49	2	210	2	963
1973	548	173	39	201	38	999
1974	631	267	27	421	49	1,395
1975	562	365	37	425	50	1,439
1976	640	223	35	255	32	1,185
1977	965	322	30	617	47	1,981
1978	875	294	--	411	45	-----
1979	652	262	26	478	60	1,478
1980	669	238	26	527	16	1,476
1981*	483	176	20	317	21	1,019

*11 months data, December not included

KEY: COR-Corrosion SS-Soil Shift ACC-Accidental

The same study revealed most breaks occur near the center of the 13 foot pipe sections indicating beam failure as the primary cause of the failure. About 75% of the failures were found to have occurred in the highly corrosive and plastic soil of the Houston Black Terrace-Knippa-Lewisville type.

Most repairs are made using leak clamps or sleeves. Alternatively, a short section or full section is installed.

Repair costs for the SAWB were calculated in 1979 to cost $315 per break, up from $150 per break in 1974. Current costs are probably averaging nearly $400 per break. This does not include the cost of repairing paving, which would greatly increase the total cost. The total repair budget for mains and hydrants was $2.53 million in 1981, up from $1.36 million in 1977.

San Antonio has a program for routine flushing of dead end mains of which there are about 2600 in the system. The flushing operation is handled by the same crews that carry out chlorination of new or repaired mains.

The San Antonio water, drawn from groundwater aquifers of the Edwards Limestone Formation, is classified as mildly aggressive to nonaggressive, with an AI range of 11.5-12.2. The water requires little treatment other than light chlorination and is monitored for metals, insecticides and herbicides, organics, radioactivity, asbestos fiber, bacteria and viruses.

Detection and Prevention

Unaccounted for water in San Antonio has ranged between 10 and 21 percent in the 1975-1980 period. The SAWB has a leak detection crew, equipped with a Heath Son-I-Kit sound detector. At the time of the site survey, the leak detection program was inactive.

FINANCIAL

The SAWB's 1982 budget for the Distribution Department of $4,964,515 includes about $1.8 million for main construction and $3.5 million for main maintenance (see page 13). The per customer (connection) cost of this budget approximates $26.55 and represents about one quarter of total operating costs. The system is required to be self supporting and it generally produces a small surplus each year.

The system issued $15 million in bonds in 1981, principally for expansion and replacement. A bond issue of $24 million has been proposed to the City Council for 1982. Funds from this issue will be used largely to replace inadequately sized and/or aging mains and failing polypropylene service connections. The latter are a major problem for the system, and it is estimated that total costs could amount to $36 million to replace all of these connections.

The 1982-1985 Capital Improvement Plan proposes to spend $9 million annually during the 4 years period for replacement of mains and service connections. In addition, an expansion program would spend the following annual amounts for construction of trunk mains:

Year	Expenditure (millions)
1982	$6.560
1983	6.303
1984	4.912
1985	5.575

In total, this program would spend $23.35 million of which about one third would be spent to purchase pipe.

San Antonio depreciates water mains and valves over a 50 year time period. Water meters and service lines are depreciated over 25 years. Fifteen year depreciation is applied to ground water pumps.

CITY WATER BOARD SAN ANTONIO

SUMMARY

BRANCH: DISTRIBUTION	FUND: System
DEPARTMENT: Maintenance & Construction	CODE: 6-2-00

CLASSIFICATION	ADOPTED BUDGET 1981	ESTIMATED EXPENDITURES 1981	PROPOSED BUDGET 1982
PERSONAL SERVICES	$ 3,227,270	$ 3,000,285	$ 3,700,640
CONTRACTUAL SERVICES	971,090	853,950	1,160,490
MATERIALS & SUPPLIES	1,567,425	1,258,165	2,131,875
OTHER CHARGES	439,845	356,610	501,860
SUBTOTAL	6,205,630	5,469,010	7,494,865
INTERFUND TRANSFERS	(2,469,505)	(1,465,780)	(2,530,350)
EXPENSE REIMBURSEMENTS	-0-	-0-	-0-
TOTAL REQUIREMENTS	$ 3,736,125	$ 4,003,230	$ 4,964,515

FUNCTION: This Department is responsible for the repair of main leaks and breaks, valves, and hydrants, service line maintenance, street repair, and field meter maintenance. This Department is also responsible for main, valve, hydrant, and service line replacement and construction.

Distribution By Areas:			
Office of the Director	$ 55,215	$ 54,390	$ 60,185
Main Construction	704,505	605,345	715,985
Service Construction	1,545,900	1,188,430	1,795,155
Main Maintenance	1,940,995	1,828,200	3,479,295
General Maintenance	1,287,335	1,252,795	745,645
Field Meter Maintenance	671,680	539,850	698,600
Subtotal	6,205,630	5,469,010	7,494,865
Transfers To Other Funds	(2,469,505)	(1,465,780)	(2,530,350)
TOTAL	$ 3,736,125	$ 4,003,230	$ 4,964,515

Comparative bid data also were obtained. A September 1981 bid for 6000+ feet of 6 inch pipe resulted in the following bids:

Ductile Iron		Asbestos Cement	
Furnish	Install	Furnish	Install
$4.50	$6.00	$3.30	$5.00
5.91	7.50	5.36	6.00
5.89	7.78	4.51	7.72
3.60	9.90	3.60	9.40
4.80	9.30	3.53	9.30
5.00	11.00	5.38	10.50
6.00	20.00	5.00	20.00

Note that the low bidder actually bid less for ductile iron than for A/C in this case. Other bid data provided during the site visit showed low furnish and install bids of $9.93 for 5047 feet of 6 inch A/C pipe, $11.80 per foot for 2240 feet of 8 inch A/C installed, and $17.20 per foot for 1145 feet of 12 inch A/C.

At the Eighth Annual Meeting of the Association, Robert Van Dyke cited 1980 installed costs for 6 inch A/C pipe of $14 per lineal foot versus $21 for 6 inch ductile iron.

Summary and Conclusion

San Antonio is a significant and long term A/C pipe customer. Equally as important, the SAWB's senior managers such as Van Dyke, Brynie and Anderson are professionally active and articulate. A decision by this system to return to the use of metallic pipe will hand the ductile iron manufacturers a major propaganda victory in an important A/C market area. On the other hand, a substantive response by the industry at this time will probably result in retention of this valuable customer. San Antonio continues to experience major growth and can be expected to be a steady and major pipe purchaser for the foreseeable future.

An immediate cooperative program to determine the causes and potential solutions to the A/C pipe failures at San Antonio is recommended. The SAWB would probably be willing to assume the major portion of the costs associated with this research. SAWB executives feel they reached an agreement to co-sponsor research at the industry/water system meeting of December 16-17, 1981. They would like to retain Southwest Research Institute to study the problem. To not enter into such a cost sharing research arrangement at this point would likely jeopardize the relationship with the SAWB.

Mr. Van Dyke and the Standards Committee also are being increasingly influenced by the successful experience of nearby Bexar Water District with poly-wrapped ductile iron pipe. Bexar's pipe failure rate is far below that of SAWB even though most of the pipe is installed in highly corrosive soils. Mr. Van Dyke and the Bexar Director compare notes often and Van Dyke does not like what he hears. Thus, pressure on SAWB management to return to the use of ductile iron pipe is mounting from several directions, thus making early action by the Association imperative.

05-01

CITY WATER BOARD
SAN ANTONIO, TEXAS

SPECIFICATIONS FOR ASBESTOS-CEMENT WATER PIPE

REVISED OCTOBER 1980

1. SCOPE

This specification covers asbestos-cement pipe 6 inches through 16 inches in size.

2. GENERAL REQUIREMENTS

a. Except as otherwise modified or supplemented herein, the latest revision of AWWA Standard C400 for "Asbestos-Cement Distribution Pipe 4 in. through 16 in. for Water and Other Liquids," shall govern the design, components, materials, manufacture, and testing of all pipe furnished under this specification.

b. Pipe, couplings, and jointing materials furnished under this specification shall be as manufactured by one of the following or approved equal:

Cement Asbestos Products Company
Certain-Teed Products Corporation
Johns-Manville Sales Corporation
Mexalit Del Norte, S. A.
Asbestos De Mexico, S. A.

c. Unless otherwise specified pipe in sizes 8 inches and smaller shall be AWWA Class 200, and sizes larger than 8 inches shall be AWWA Class 150, designed for a working pressure of 200 psi and 150 psi respectively.

d. Section 3.2 of the AWWA Standard C400 is superseded by the following:

Nominal Diameter Inches	Minimum Actual Inside Diameter, Inches
6"	5.70"
8"	7.60"
10"	9.50"
12"	11.40"
16"	15.20"

e. Pipe lengths shall be 13 foot lengths in all sizes unless otherwise specified.

f. All pipe and couplings furnished shall be tested in accordance with the latest revision of Section 5, Inspection, Testing, and Rejection, AWWA Standard C400, at the manufacturer's expense. The City Water Board may at its discretion and expense request additional testing to be performed at the place of manufacture by an independent testing laboratory.

g. An affidavit of compliance in accordance with the latest revision of Section 1.3 of AWWA Standard C400 shall be furnished by the manufacturer.

h. All pipe furnished under this specification must be approved for use by the Underwriter's Laboratories, and each length of pipe shall be labeled.

i. Each full length of pipe furnished under this specification shall have a coupling installed and tested hydrostatically as a unit prior to delivery to the designated job site: All units tested shall be inspected and tested in accordance with the latest revision of Sections 5.1, 5.2, 5.3, 5.4 and 5.5 of AWWA Standard C400. "As an alternate to the preceeding, suppliers shall: have a coupling installed on each full length of the pipe prior to delivery to the designated job site; mark the pre-coupled joint to permit identification; assume full responsibility for any failure or leakage of the pre-coupled joint, and agree to pay for all labor and material, and damage of any nature that may result from such failure or leakage together with all expense incurred therewith."

j. Rubber rings shall be either vulcanized natural or vulcanized synthetic rubber free of porous areas, foreign materials and visible defects. They shall conform to ASTM Standard D-1869, or the latest revision thereof, and shall impart no objectionable color, odor, or taste to water.

k. Acceptance of pipe will be subject to compliance with all the provisions contained in the Specifications. Any deviation from the Specifications will be cause for rejection of part or of all of the material delivered.

CHECK LIST
ASBESTOS CEMENT PIPE AND COUPLINGS

		YES	NO
1.	General Requirements		
a.	An affidavit to be furnished with each shipment confirming all material complies with all applicable requirements of AWWA Standard C400.		
b.	All material upon visual inspection to be neatly packaged, clean, free of stains, blemishes or unusual markings.		
2.	Pipe		
a.	Standard (13 feet) and Random Lengths		
b.	Stamped with Underwriters Laboratories label		
c.	Has coupling attached		
d.	Is marked as follows:		
(1)	Trade Name		
(2)	Nominal inside diameter		
(3)	Class (6" & 8" - 200) (12" thru 24" - 150)		
(4)	Type (II)		
(5)	Hydrostatic test pressure		
(6)	Date and shift of manufacture		
e.	Short lengths to be marked in accordance with (2), (3), and (4) above and stamped "T" indicating hydrostatically tested.		
f.	Interior surface free from tears or blisters more than 3/16" deep.		
g.	Machined ends not chipped more than 1/2" from end, 1/8" deep, 1/2" around pipe.		
h.	Machined ends completely clean of cuttings		
3.	Couplings		
a.	Marked as follows:		
(1)	Type (II)		

(2) Class (6" & 8" - 200) (12" thru 24" - 150) __________

(3) Nominal diameter of pipe __________

(4) Stamped "T" (for tested on coupled end) __________

b. Rubber rings (one attaching coupling to pipe) __________

(one for storage in warehouse) __________

TABLE 8

HYDROSTATIC TEST LEAKAGE ALLOWANCES (MAXIMUM) @ 200 psi

Gallons Per Hour (GPH)

SIZE & TYPE PIPE	Pipe Length in Feet													
	100	200	300	400	500	600	700	800	900	1,000	2,000	3,000	4,000	5,000
6" A.C.	0.16	0.33	0.49	0.65	0.82	0.98	1.14	1.30	1.47	1.63	3.26	4.89	6.52	8.15
6" CI*	0.13	0.25	0.38	0.51	0.64	0.76	0.89	1.02	1.14	1.27	2.54	3.81	5.08	6.35
8" A.C.	0.22	0.44	0.65	0.87	1.09	1.31	1.53	1.74	1.96	2.18	4.36	6.54	8.72	10.90
8" CI*	0.17	0.34	0.51	0.68	0.85	1.02	1.19	1.36	1.53	1.70	3.40	5.10	6.80	8.50
12" A.C.	0.33	0.65	0.98	1.30	1.63	1.96	2.28	2.61	2.93	3.26	6.52	9.78	13.04	16.30
12" CI*	0.26	0.51	0.77	1.02	1.28	1.53	1.79	2.04	2.30	2.55	5.10	7.65	10.20	12.75
16" A.C.	0.44	0.87	1.31	1.75	2.19	2.62	3.06	3.50	3.93	4.37	8.74	13.11	17.48	21.85
16" CI*	0.34	0.68	1.02	1.36	1.70	2.04	2.38	2.72	3.06	3.40	6.80	10.20	13.60	17.00
20" A.C.	0.55	1.09	1.64	2.18	2.73	3.27	3.82	4.36	4.91	5.45	10.90	16.35	21.80	27.25
20" CI*	0.43	0.85	1.28	1.70	2.13	2.55	2.98	3.40	3.83	4.25	8.50	12.75	17.00	21.25
20" C.S.C.	0.08	0.16	0.24	0.32	0.40	0.47	0.55	0.63	0.71	0.79	1.58	2.37	3.16	3.95
24" A.C.	0.65	1.31	1.96	2.62	3.27	3.92	4.58	5.23	5.89	6.54	13.08	19.62	26.16	32.70
24" CI*	0.51	1.02	1.53	2.04	2.55	3.06	3.57	4.08	4.59	5.10	10.20	15.30	20.40	25.50
24" C.S.C.	0.10	0.19	0.29	0.38	0.48	0.57	0.67	0.76	0.86	0.95	1.90	2.85	3.80	4.75
30" A.C.	0.82	1.63	2.45	3.27	4.09	4.90	5.72	6.54	7.35	8.17	16.34	24.51	32.68	40.85
30" CI*	0.64	1.27	1.91	2.55	3.19	3.82	4.46	5.10	5.73	6.37	12.74	19.11	25.48	31.85
30" C.S.C.	0.12	0.24	0.35	0.47	0.59	0.71	0.83	0.94	1.06	1.18	2.36	3.54	4.72	5.90
36" A.C.	0.98	1.96	2.94	3.92	4.90	5.88	6.86	7.84	8.82	9.80	19.60	29.40	39.20	49.00
36" CI*	0.76	1.53	2.29	3.06	3.82	4.58	5.35	6.11	6.88	7.64	15.28	22.92	30.56	38.20
36" C.S.C.	0.14	0.28	0.43	0.57	0.71	0.85	0.99	1.14	1.28	1.42	2.84	4.26	5.68	7.10
42" CI*	0.89	1.78	2.68	3.57	4.46	5.35	6.24	7.14	8.03	8.92	17.84	26.76	35.68	44.60
42" C.S.C.	0.17	0.33	0.50	0.66	0.83	1.00	1.16	1.33	1.49	1.66	3.32	4.98	6.64	8.30
48" CI*	1.02	2.04	3.06	4.08	5.10	6.11	7.13	8.15	9.17	10.19	20.38	30.57	40.76	50.95
48" C.S.C.	0.19	0.38	0.57	0.76	0.95	1.13	1.32	1.51	1.70	1.89	3.78	5.67	7.56	9.45

*CI includes Ductile Iron in both mechanical and push-on joints.

NOTE: Leakage allowances may be determined for footages not specifically listed by interpolation and/or by the combination of various tabular data.

Example No. 1: The maximum leakage allowance for 6,000 LF of 6" AC pipe would be the sum of the values for 5,000 LF and 1,000 LF, or 8.15 GPH plus 1.63 GPH equals 9.78 GPH.

Example No. 2: The maximum leakage allowance for 1,550 LF of 6" AC pipe would be the sum of the values for 1,000 LF and the interpolated value for 550 LF, or 1.63 GPH plus 0.90 GPH equals 2.53 GPH.

TABLE 7

HYDROSTATIC TEST LEAKAGE ALLOWANCES (MAXIMUM) @ 150 psi

Gallons Per Hour (GPH)**

SIZE & TYPE PIPE	Pipe Length In Feet													
	100	200	300	400	500	600	700	800	900	1,000	2,000	3,000	4,000	5,000
6" A.C.	0.14	0.28	0.43	0.57	0.71	0.85	0.99	1.14	1.28	1.42	2.84	4.26	5.68	7.1[illegible]
6" CI*	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	2.20	3.30	4.40	5.50
8" A.C.	0.19	0.38	0.56	0.75	0.94	1.13	1.32	1.50	1.70	1.80	3.76	5.64	7.52	9.4[illegible]
8" CI*	0.15	0.29	0.44	0.59	0.74	0.88	1.03	1.18	1.32	1.47	2.94	4.41	5.88	7.35
12" A.C.	0.28	0.57	0.85	1.13	1.42	1.70	1.98	2.26	2.55	2.83	5.66	8.49	11.32	14.1[illegible]
12" CI*	0.22	0.44	0.66	0.88	1.10	1.32	1.54	1.76	1.98	2.20	4.40	6.60	8.80	11.00
16" A.C.	0.38	0.75	1.13	1.50	1.88	2.26	2.63	3.01	3.38	3.76	7.52	11.28	15.04	18.8[illegible]
16" CI*	0.29	0.59	0.88	1.18	1.47	1.76	2.06	2.35	2.65	2.94	5.88	8.82	11.76	14.70
20" A.C.	0.47	0.94	1.41	1.88	2.35	2.82	3.29	3.76	4.23	4.70	9.40	14.10	18.80	23.5[illegible]
20" CI*	0.39	0.74	1.10	1.47	1.84	2.21	2.55	2.94	3.31	3.68	7.36	11.04	14.72	18.4[illegible]
20" C.S.C.	0.08	0.16	0.24	0.32	0.40	0.47	0.55	0.63	0.71	0.79	1.58	2.37	3.16	3.95
24" A.C.	0.57	1.13	1.70	2.26	2.83	3.39	3.96	4.52	5.09	5.65	11.30	16.95	22.60	28.2[illegible]
24" CI*	0.44	0.88	1.32	1.76	2.21	2.65	3.09	3.53	3.97	4.41	8.82	13.23	17.64	22.05
24" C.S.C.	0.10	0.19	0.29	0.38	0.48	0.57	0.67	0.76	0.86	0.95	1.90	2.85	3.80	4.7[illegible]
30" A.C.	0.71	1.41	2.12	2.82	3.53	4.24	4.94	5.65	6.35	7.06	14.12	21.18	28.24	35.30
30" CI*	0.55	1.10	1.66	2.21	2.76	3.31	3.86	4.42	4.97	5.52	11.04	16.56	22.08	27.6[illegible]
30" C.S.C.	0.12	0.24	0.35	0.47	0.59	0.71	0.83	0.94	1.06	1.18	2.36	3.54	4.72	5.9[illegible]
36" A.C.	0.85	1.70	2.54	3.39	4.24	5.09	5.94	6.78	7.63	8.48	16.96	25.44	33.92	42.4[illegible]
36" CI*	0.66	1.32	1.99	2.65	3.31	3.97	4.63	5.30	5.96	6.62	13.24	19.86	26.48	33.1[illegible]
36" C.S.C.	0.14	0.28	0.43	0.57	0.71	0.85	0.99	1.14	1.28	1.42	2.84	4.26	5.68	7.1[illegible]
42" CI*	0.77	1.54	2.32	3.09	3.86	4.63	5.40	6.18	6.95	7.72	15.44	23.16	30.88	38.6[illegible]
42" C.S.C.	0.17	0.33	0.50	0.66	0.83	1.00	1.16	1.33	1.49	1.66	3.32	4.98	6.64	8.3[illegible]
48" CI*	0.88	1.77	2.65	3.53	4.42	5.30	6.18	7.06	7.95	8.83	17.66	26.49	35.32	44.1[illegible]
48" C.S.C.	0.19	0.38	0.57	0.76	0.95	1.13	1.32	1.51	1.70	1.89	3.78	5.67	7.56	9.4[illegible]

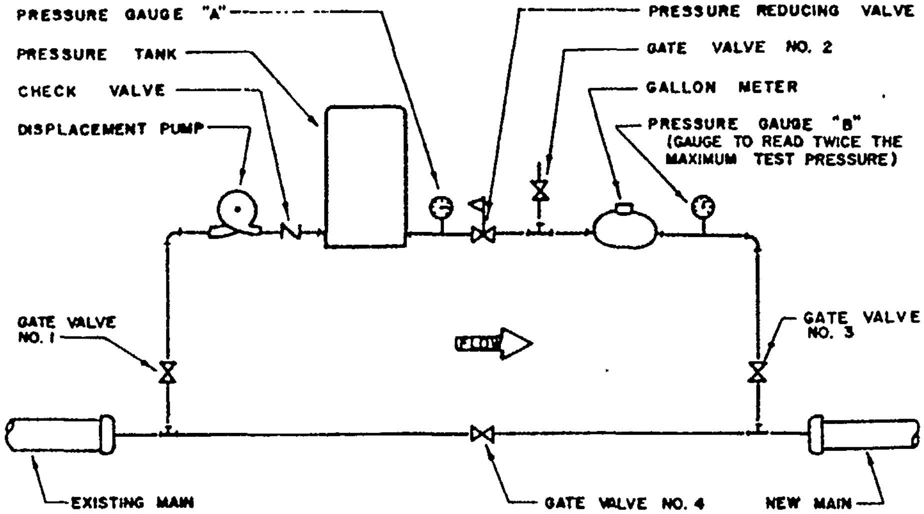
*CI includes Ductile Iron in both mechanical and push-on joints.

**GPH for C.S.C. are manufacturer's maximum.

NOTE: Leakage allowances may be determined for footages not specifically listed by interpolation and/or by the combination of various tabular data.

Example No. 1: The maximum leakage allowance for 6,000 LF of 6" AC pipe would be the sum of the values for 5,000 LF and 1,000 LF, or 7.10 GPH plus 1.42 GPH equals 8.52 GPH.

Example No. 2: The maximum leakage allowance for 1,550 LF of 6" AC pipe would be the sum of the values for 1,000 LF and the interpolated value for 550 LF, or 1.42 GPH plus 0.78 GPH equals 2.20 GPH.



<u>Step One</u>: Close Gate Valve No. 3 and Gate Valve No. 4 and open Gate Valve No. 1 and Gate Valve No. 2 and fill test piping to system pressure. All test equipment and joints on test equipment must be watertight. If leakage occurs, the test should not be continued until appropriate repairs are made.

<u>Step Two</u>: Close Gate Valve No. 1, Gate Valve No. 2 and Gate Valve No. 3. Open Gate Valve No. 4 and fill new main to system pressure. All air should be expelled from the new main at this time.

<u>Step Three</u>: Close Gate Valve No. 4 and open Gate Valve No. 1 and Gate Valve No. 2, leaving Gate Valve No. 3 closed. Start pump and with flow through Gate Valve No. 2, set the maximum test pressure on the down stream side of the pressure reducing valve. Pressure Gauge "B" should read maximum test pressure in pounds per square inch.

<u>Step Four</u>: Close Gate Valve No. 2 and open Gate Valve No. 3, leaving Gate Valve No. 1 open and Gate Valve No. 4 closed. Pump pressure tank to a pressure 20% greater than the maximum test pressure and maintain a positive head on the pressure reducing valve during the test period. Pressure Gauge "A" should always read higher than Pressure Gauge "B" during the test period. When Pressure Gauge "B" reaches maximum test pressure, record reading on gallon meter and start timing the hydrostatic pressure test. After the specified time has passed, record reading on gallon meter and compare water loss with Table 7 or Table 8 "<u>Hydrostatic Test Leakage Allowances</u>," as appropriate, in the City Water Board Standard Specifications For Water Works Construction.

<u>HYDROSTATIC FIELD TEST EQUIPMENT SCHEMATIC AND</u>

<u>FIELD TESTING SEQUENCE</u>

Exhibit S-8.3.2

acceptance by the Engineer. Where designated as "high pressure area," all new mains shall be hydrostatically field tested at a maximum test pressure of 200 psi before acceptance by the Engineer. It is the intent of these Specifications that all joints be watertight and that all joints which are found to leak either by observation of during any test shall be made watertight by the Contractor. In case repairs are required, the hydrostatic field test shall be repeated until the pipe installation conforms to the specified requirements and is acceptable to the Engineer. The Contractor shall notify the Engineer prior to beginning the test and the City Water Board Construction Inspector shall be present during the pressure test.

S-8.3.2 Test Procedures. After the new main has been laid and backfilled as specified, but prior to chlorination and replacement of pavement, it shall be filled with water for a minimum of 24 hours and then subjected to a hydrostatic pressure test.

The specified test pressure shall be supplied by means of a pump connected to the main in a satisfactory manner. The pump, pipe connection, and all necessary apparatus including gauges and meters shall be furnished by the Contractor. Unless otherwise specified, the Owner will furnish water for filling lines and making tests through existing mains.

Before applying the specified test pressure, all air shall be expelled from the main. To accomplish this, taps shall be made, if necessary, at the points of highest elevation and afterwards tightly plugged.

At intervals during the test, the entire route of the new main shall be inspected to locate any leaks or breaks. If any are found, they shall be stopped or repaired and the test shall be repeated until satisfactory results are obtained.

The hydrostatic test shall be made so that the maximum pressure at the lowest point does not exceed the specified test pressure.

The duration of each pressure test shall be a minimum of four (4) hours for new mains in excess of 1,000 lineal feet and a minimum of one (1) hour for new mains less than 1,000 lineal feet after the main has been brought up to test pressure. The test pressure shall be measured by means of a tested and properly calibrated pressure gauge acceptable to the Engineer. All pressure tests shall be continued until the Owner is satisfied that the new main meets the requirements of these Specifications.

Should any test of pipe in place disclose leakage greater than that listed in Table 7 or 8, Hydrostatic Test Leakage Allowances, as applicable, the Contractor shall at his own expense locate and repair the defective joints until the leakage is within the specified allowance.

Leakage is defined as the quantity of water supplied into the newly laid main, or any valved section of it, necessary to maintain the specified leakage test pressure after the main has been filled with water and the air expelled.

At Exhibit S-8.3.2 is a schematic showing the arrangement of the test apparatus as well as the detailed procedure for conducting the hydrostatic field test.

REPORT ON ASBESTOS/CEMENT PIPE USE
AT
THE SAN DIEGO WATER DEPARTMENT, CALIFORNIA

PREPARED FOR:

THE A/C PIPE PRODUCERS ASSOCIATION
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PREPARED BY:

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ARLINGTON, VA 22205

APRIL 20, 1982

REPORT ON ASBESTOS/CEMENT PIPE USE

AT

THE SAN DIEGO WATER DEPARTMENT, CALIFORNIA

Introduction

The San Diego City Water Department, of San Diego, California, is the fourth of ten water systems studied under the Municipal Analysis Program of the A/C Pipe Producers Association. In this detailed site visit, as well as the other nine, the objective was to investigate the use of A/C pipe from every perspective. The broad functional categories covered by this fact-finding mission are as follows:

- Operational
  - Decisionmaking, Specification, and Procurement
  - Installation and Testing
  - Operation and Maintenance
  - Repair and Replacement
  - Detection and Prevention
- Financial
- Institutional

Each of these categories of information is discussed in detail in this report.

Background on the San Diego Site Visit

The two day site visit to San Diego was conducted on January 13-14, 1982. Officials interviewed during the course of the visit included the following:

Chett Chew, Deputy Director for Water Services
Jag Bhola, Associate Civil Engineer
Jim Mueller, Civil Engineer
Glenn Awrey, Plan Check Engineer
Al Broyles, Maintenance Division Supervisor

The Water Utilities Director, Mr. R. W. King, was a guest speaker at the Association's Ninth Annual Meeting, held in 1981 in Palm Springs, California. Another Deputy Director, Mr. Roger Graff, is a member of the AWWA standards committee for A/C pipe, which was meeting at the time of the visit to San Diego. Personnel of the San Diego water utility were mildly interested but not enthusiastic about the study. Officials interviewed provided their time, sometimes reluctantly, and they were not able to provide the depth of data and analysis that many of the other systems have provided. There did not seem to be any particular interest in working with the Association, although satisfaction was expressed with the performance of A/C pipe. The oldest A/C pipe in the system is a section of 4 inch main installed in 1935.

Institutional and Background Information

Water supply and sewerage services are a joint service bureau of the City of San Diego. This is cited as an advantage since the integrated utility is better able to consider joint solutions to water supply and wastewater management problems. Because arid San Diego must import almost 100 percent of its water supply, the Water Utilities Department is actively researching water reuse schemes.

The City's raw water supply is drawn largely from surface waters of the Colorado River which is conveyed to Southern California by the California Aqueduct, and is treated in three plants which serve 100 pressure zones in the City. Management of the area's water supplies, and importation from the Colorado River Aqueduct, is managed by the San Diego County Water Authority (SDCWA), which serves 6 cities including San Diego, 2 irrigation districts, 15 local water districts, and the Pendleton Military Reservation. The City purchases water from the Authority, which in turn obtains water from the Metropolitan Water District of Southern California (MWDSC).

The water utility is semi-autonomous from the City's general fund as a matter of policy. Revenues are based on user charges and other fees and are set so that the system produces a small annual surplus. Operations of the sewerage utility are accounted for separately. A joint annual fiscal report is produced by the Department. All operating revenues of the water utility go to a Water Operating Fund which disburses operating funds. Any surplus in this fund is transferred monthly to the Water Revenue Bond Fund. The latter acts as a funding authority for debt service, capital additions and replacements, and charges from the MWDSC AND SDCWA. Overall policy control is vested in the City Council and Mayor of San Diego. The system is operated on a "pay as you go" basis and has not issued bonds for many years.

The Water Utility is divided into three divisions:

Water Quality: Responsible for obtaining and treating raw water supplies.

Water Systems: Responsible for treated water transmission and distribution to customers, including service lines and meters.

Water Services: Divided into two branches, engineering design and new services/billing.

The engineering design section develops bid specifications for new or replacement projects, and supervises installation of mains.

The water system serves approximately 800,000 persons with about 62.5 billion gallons of water annually. The California-American Water Company, a private utility located within the City serves about 6000 persons with 1.4 billion gallons annually. The average consumption rate in the San Diego area is 192 gallons per capita per day. The system has approximately 200,000 metered connections with a growth rate of 3500 connections per year.

The Transmission and Distribution System

San Diego's transmission and distributions system includes 2180 miles of mains, ranging in diameter from 1.5 inches to 72 inches. Pipe materials in use include lined and coated steel, cast iron, cement lined ductile iron, PVC, prestressed concrete steel cylinder, steel cylinder rod wrapped, reinforced concrete steel cylinder, and asbestos cement. As of 1979, the usage distribution between types was as shown below:

Pipe Material	Amount (feet)
cast iron	1,397,350
asbestos cement	7,374,273
pre-stressed concrete, steel cylinders	66,345
reinforced concrete steel cylinders	357,220
steel cylinder, rod wrapped, coated	407,689
steel, bitumen lined and coated	43,984
steel, cement lined and coated	70,039
ductile iron, cement lined	11,704
wrought iron	71,144
unreinforced concrete	9,621
PVC	5,700
copper	8,106
TOTAL	11,278,225

A/C pipe constitutes 65 percent of the total installed footage for all pipe materials and is distributed as shown in the table on the next page. Six inch, 8 inch and 12 inch sizes make up 27.3, 41.4, and 16.0 percent of the total A/C footage. Four, 10 and 16 inch sizes account for 14.2 percent of the total footage.

Pipe Diameter, (inches)	Amount (feet)
4	275,240
5	4,980
6	2,010,075
8	3,050,635
10	447,407
12	1,183,049
16	326,367
18	5,427
20	58,829
23	864
24	3,857
30	7,543
TOTAL	7,374,273

Most of the cast iron in the system is not corrosion protected and is subject to external corrosion from corrosive clay soils common to the region. The system has budgeted $277,000 annually for pipe replacement for the last two years, funded out of a $3 million Capital Improvements Program budget. An expenditure of $182,000 is anticipated for 1982. This replacement program is planned to continue at this level until the year 2000.

Service lines up to and including 1 inch diameter are either copper or polyethylene. PVC is used for larger service connections, 2-4 inches in diameter. The use of 4 inch A/C is avoided because of the pipe's relatively low beam strength, plus the perceived need to use tapping saddles for all taps.

San Diego reports good experience with A/C pipe in sizes up to 16 inches diameter. Some structural problems were reported with the larger 20 and 30 inch sizes. By experience, San Diego has determined that most A/C pipe breaks will occur within the first year after installation, and is mainly caused by poor installation. The system has experienced problems recently with staff turnover in the inspections department. They feel this has contributed significantly to recent pipe failure problems.

Virtually all pipe in the San Diego system is installed by contractors. The Water Systems Division also stocks pipe for its own use in making repairs. Contractors are required to guarantee their work for one year.

San Diego's philosophy on pipe purchasing can be described as price oriented. As long as A/C maintains its price advantage, it is likely that the system will continue to use it as the predominant pipe material, particularly for sizes up to 16 inch diameter. In 1981, 264,770 feet of A/C pipe, ranging in size from 4 to 24 inches was installed in the system, much of it for replacement of cast iron mains. A/C is the preferred pipe material in San Diego because of (1) cost, and (2) resistance to external corrosion.

OPERATIONS

Specification, Decisionmaking, and Procurement

The San Diego Water Utility purchases A/C pipe directly for its maintenance activities. All other pipe is provided by contractors and developers. In 1981, the City spent $33,000 on a package of standard pipe, MOA, MEO, couplings and gaskets for a one year supply. The detailed breakdown of this purchase is attached.

By contrast to utilities such as San Antonio and Pueblo, San Diego follows a very general approach to the specification of pipe. Within very broad limits, a contractor can bid a variety of pipe materials on a given job if the pipe is 16 inches or less in diameter (PVC is allowed in sizes up to 6 inch diameter). Sand bedding is specified for all pipe. Ductile iron may be specified where cover is less than 2 feet. Where pipe is covered more than 5 feet and A/C pipe is used, Class 200 pipe is required. For most applications between 2 and 5 foot cover, contractors can provide Class 150 A/C pipe. All A/C pipe must meet the AWWA C-400 specifications. PVC pipe is allowed in sizes up to 12 inches. Ductile iron pipe must be protected against external corrosion.

A typical contract specification used by San Diego is based on reference specifications which are on file in the Office of the City Clerk. These include the following:

1. Standard Specifications for Public Works Construction, 1979 Edition.

2. Standard Special Provisions-1979 Edition (Regional Standard Special Provisions)

3. City of San Diego Standard Special Provisions

4. California Department of Transportation, "Manual of Traffic Controls, Warning Signs, Lights and Devices for Use in Performance of Work Upon Highways", dated 1977

For specific jobs, the contract documents will refer to these standard specifications and only itemize those changes and special conditions which apply to the individual contract. The contract document may also refer to standard drawings as well.

Within these boundaries, purchasing decisions are made based on the price quoted by the lowest responsible bidder. A/C pipe is highly price competitive in the 4-16 inch diameter size range, as evidenced by its dominance in those sizes.

Design Considerations

For the most part, designs are based on standard practices and specifications. Special design conditions are developed by the engineering section of the Water Services Division, where the proposed designs for new developments are also reviewed and approved. For service pressures up to 170 psi., Class 150 A/C pipe is allowed. Class 200 A/C pipe is required for higher pressures. The standard design practice required a minimum of 3 feet of cover and sand equivalent backfilling. There are no provisions for earthquake design even though the region is seismic. Minimum allowable radius of curvature for 8 inch A/C pipe is 200 feet, per Johns-Manville recommended practices.

Other design requirements are based directly on the system's experience. Severe corrosion of the existing cast iron pipe resulted in requirements for metallic pipe to be protectec against external corrosion. Poor experience with A/C pipe in 20 and 30 inch sizes resulted in the predominant use of steel or reinforced concrete pipe in the larger diameters. PVC pipe is limited to 6 inch or less diameters because of the City's lack of experience with this relatively new pipe material. There may be some preference by managers for ductile iron pipe. Jag Bhola expressed a belief that most utilities would use ductile iron if it were competitive with A/C in price, though he also stated that San Diego's experience with A/C has been good.

Installation and Testing

Water distribution pipe in San Diego is mostly installed by the developers of new projects or by contractors hired for new or replacement main projects. Installation data for A/C pipe for the three year period 1979-81 was provided and is tabulated below:

Size	Year Installed	Quantity (feet)	Unit Cost	Value ($1000)
4	1979	1,158	$13.09	$ 15.2
4	1980	2,843	13.37	38.0
4	1981	3,441	24.89	85.6
6	1979	14,923	13.64	206.6
6	1980	22,667	15.69	355.7
6	1981	32,483	27.33	887.9
8	1979	85,304	16.17	1,379.5
8	1980	101,287	17.12	1,734.3
8	1981	159,113	22.16	3,525.7
10	1979	22,131	17.28	382.5
10	1980	29,497	18.73	552.4
10	1981	29,514	21.61	637.7

Size	Year Installed	Quantity (feet)	Unit Cost	Value ($1000)
12	1979	37,681	19.70	742.1
12	1980	48,911	20.97	1,025.9
12	1981	25,385	28.36	719.8
16	1979	9,701	21.96	213.0
16	1980	6,208	25.31	157.1
16	1981	11,376	31.06	353.3
20	1979	132	28.03	3.7
20	1981	3,301	47.65	157.3
24	1980	25	228.36	5.7

Total installed A/C footage in 1979 was 171,030; in 1980, 211,438; and in 1981, 264,613. Six and 8 inch A/C made up 58.6 percent of the total in 1979 and 1980, and 72.4 percent of the total in 1981.

Although some slowdown in the sharp upward trend of pipe usage is expected in 1982 due to a slowed local economy, the long term market for A/C in the San Diego area should remain strong for the foreseeable future. Overall experience with A/C is good; A/C is price competitive with other materials, and A/C pipe and health has not been a big issue locally.

Pipe Handling Procedures

Contractors are expected to followed the pipe manufacturers recommendations for handling and working pipe. Because of strict OSHA standards for cutting and machining of A/C pipe, both contractors and city crews use short sections of PVC or MOA A/C for special joints, and splices.

Trenching, Bedding, and Backfilling

Minimum cover for all installations is normally 3 feet. Trench width specifications follow the applicable AWWA and ASTM specs. Bedding and backfilling is with "a sand equivalent of not less than fifty (50) and an expansion when saturated with water of not more than 0.5 of one percent." Bar tamping around the pipe, followed by water flooding or jetting are acceptable for backfill compaction. Minimum compaction density required is 85 percent.

Tapping

A/C pipe under pressure is tapped with a Mueller purged tapping machine. Service taps up to and including 1 inch sizes are made by threading the pipe wall. For larger taps, tapping saddles or service clamps are used.

Disinfection and Pressure Testing

AWWA C-601 is the primary specification used for disinfection of mains. Flushing must be done from the end of the section of main installed, in accordance with Section 5 and notes 1 and 2 of the AWWA spec. Either liquid chlorine or hypochlorite can be used, as per Section 6.21 of AWWA C-601. Residual chlorine, tested by the City inspectors using Section 7.1 of C-601, must be 50-100 mg/l for at least 24 hours. Following notification of successful bacteriological testing by the City, the contractor is allowed to complete flushing per Section 8 of the C-601 specification.

All newly installed mains are pressure tested to 225 psi, a pressure which was set to allow for surge pressures as well as the normal 60-100 psi service range in San Diego.

Recommended Work Practices

San Diego Water Utility managers are aware of Recommended Work Practices for A/C pipe and use them where appropriate. Mr. King commented on the utility of this document in his presentation at the 1981 AACPP Annual Meeting. Contractors are responsible for their own workers in knowing and following these and OSHA rules.

Operation and Maintenance

Given that San Diego is located in an arid climate, and must import water over long distances, one might expect the utility to have a well developed program for leak detection and control However, this is apparently not the case. None of the persons interviewed could provide data for, or estimate, unaccounted for water consumption. There is no leak location program currently in operation. Data from the 1981 Fiscal report shows that 7,901.7 million cubic feet of water were sold by the system in 1981. The same report states that total water deliveries from the system were 68,395 million gallons that year. Based on these two figures, the difference between deliveries and billings is 9,290 million gallons which is about 13.6 percent of the total water delivered.

Main break frequency in the system is quite low, with cast iron failures due to external pipe corrosion being the major cause of failure. Main break data from 1960-1980 is tabulated beginning on the next page.

Cast iron failures, which accounted for 71.4 percent of the failures in 1978, 77.7 percent in 1979, and 70.6 percent in 1980 are declining as the cast iron mains are replaced, usually with A/C pipe. Most main breaks in A/C are caused by improper installation and show up in the first year. Construction activities adjacent to the pipe, or accidentally digging up or hitting the pipe, account for most of the other A/C breaks.

Year	Cast Iron	A/C	Miscellaneous	Total
1960	432	88	3	513
1961	285	68	7	360
1962	218	58	7	283
1963	295	41	114*	450
1964	322	49	141*	512
1965	312	83	36	431
1966	258	66	29	353
1967	286	55	38	379
1968	385	63	48	496
1969	282	46	55	383
1970	256	44	40	340
1971	265	41	23	329
1972	261	43	28	331
1973**	211	49	22	282
1974	186	45	26	257
1975	152	76	14	242
1976	219	52	17	288
1977	239	65	34	338
1978	227	69	22	318
1979	303	76	11	390
1980	199	65	18	282

*Prior to 1963, breaks on sub-standardard mains not included
**From 1973 on, breaks reported on a fiscal year (ends June 30) basis.

A/C pipe has performed extremely well throughout the system with the exception of some sections of 20 and 30 inch diameter A/C that was installed in an area having a high tidal water table. A number of breaks have occurred and system officials believe A/C pipe salesmen oversold the capability of the pipe in this application.

Most repairs for circumferential breaks in A/C pipe are made by using copper or stainless steel bands which are poly wrapped for corrosion protection. Larger breaks are repaired using short sections of PVC pipe, section of MOA A/C pipe, and poly wrapped Dresser couplings. A/C main breaks typically require 50 man hours ($450 labor cost) plus excavation and pavement repair. Total cost approaches $4000-5000 per break.

Repair & Replacement

In addition to the rapid growth of the system, largely financed by developers, San Diego is spending approximately $3 million per year for installation of larger mains and replacement of failing cast iron mains. This work is being financed wholly out of accrued revenues; no additional bonds are being issued. In addition, the Water Utility's own internal maintenance budget ranges between $200,000 and $300,000 annually.

FINANCIAL

The San Diego Water Utility is in excellent condition financially. Much of the system is fairly new, revenues are growing rapidly, and new development is required to assume much of the burden for system expansion. The system has not found it necessary to issue bonds for either repair or expansion for many years and does not plan to do so in the future. Total bonded indebtedness is less than $3.2 million and decreasing rapidly. Total assets of the system are $236 million. Net available working capital increased by over $5 million in 1981 alone.

On the negative side, the system appears to pay a high price for pipe installation. System officials cited figures of $28-30 per foot for 6 inch pipe, $30-32 for 8 inch pipe, and $42-45 for 12 inch pipe replacement projects. These figures are quite high relative to other surveyed utilities (except for EBMUD) and may reflect the rockiness of local soils plus high local labor rates. Glenn Awrey cited his belief that local contractors routinely overcharge the city for this type of work. Sand backfilling accounts for only about $1 per foot of the cost.

Service life for existing cast iron mains has been assumed at 50 years. A/C and ductile iron (corrosion protected) pipe is assumed to have an expected life of 75 years in the system.

No bid data was provided for PVC or ductile iron pipe. However, system officials emphasized the cost competitiveness of A/C pipe, particularly in the size range from 6 to 16 inch diameter. They noted that ductile iron is very competitive in the 20 inch size range and that steel pipe is generally the most economical for 24 inch diameter and over.

CONCLUSIONS

San Diego has had excellent experience with A/C pipe. Given this fact, it is hard to understand the lack of enthusiasm for A/C voiced by several of the officials interviewed. A/C pipe and health is not an issue of consequence with this utility. Main break frequency is very low and mostly attributable to contractor error. It would appear that A/C suffers from an image problem in San Diego. Problems with the 20 and 30 inch pipe installed in areas of high tidal water table contribute to this situation. Jim Mueller noted more than once that San Diego officals believe that they were "sold a bill of goods" by A/C distributors of this pipe. This has left them with a residue of ill feeling and reinforced their tendency to view A/C as "cheap" pipe.

San Diego presents a real opportunity to the A/C pipe industry as an example of the performance benefits of asbestos cement pipe. Some good PR work is needed to overcome the past mistakes and highlight the overall excellent A/C story in San Diego.