



American Water Works Association

AWWA C400-77

(Revision of
AWWA C400-75)

AWWA STANDARD
for
**ASBESTOS-CEMENT DISTRIBUTION PIPE,
4 IN. THROUGH 16 IN., FOR WATER
AND OTHER LIQUIDS**

*First edition approved by AWWA Board of Directors May 15, 1953.
This edition approved Jan. 30, 1977.*

AMERICAN WATER WORKS ASSOCIATION
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Foreword

This foreword is for information only and is not a part of AWWA C400.

I—History of Standard

A new pipe material consisting of an intimate mixture of portland cement and asbestos fibers was introduced to the North American market in 1931 following several years of satisfactory usage in other countries, particularly Italy.

In the ensuing years this type of pipe gained popularity, and in 1949 AWWA established a committee on standard specifications for asbestos-cement pipe under the chairmanship of S.M. Clark of Greeley and Hanson, Chicago.

The committee developed a standard for asbestos-cement water pipe which was approved by the AWWA Board of Directors as a tentative standard, AWWA C400-53T, May 15, 1953. In 1958, the committee was reactivated as Committee 8340D on Asbestos-Cement Pipe under the chairmanship of Roy H. Ritter of Whitman, Requardt and Assocs., Baltimore to review several suggested changes and to recommend revisions to the standard. The committee produced a revised tentative standard adopted by AWWA as C400-64T Jan. 27, 1964, which was advanced to standard without revision Jul. 2, 1965.

In 1968 the committee was reactivated as the Standards Committee on Asbestos-Cement Pipe to review and revise all AWWA standards on asbestos-cement pipe. The committee produced a revised standard approved by the Board of Directors Jan. 31, 1972 designated as AWWA C400-72, "Asbestos-Cement Pressure Pipe for Water and Other Liquids."

In 1972 and 1973 the committee was reorganized and enlarged to include representation of national organizations having an interest in the scope of the committee and wishing to participate in the work. The reorganized committee reaffirmed C400-72 without revision so that it could be presented to the American National Standards Institute for designation as an American National Standard.

In 1975 the committee produced a revised standard approved by the AWWA Board of Directors Jan. 26, 1975 designated as AWWA C400-75, "Asbestos-Cement Pressure Pipe, 4 in. Through 24 in., for Water and Other Liquids." At that same time a new standard was produced by the committee and approved by the AWWA Board of Directors and designated as AWWA C402-75, "Asbestos-Cement Transmission Pipe, 18 in. Through 42 in., for Water and Other Liquids."

The possibility of confusion between the two standards—C400 and C402—was carefully reviewed by the committee. The result is this edition of C400-77 which reduces the sizes covered from 4 in. through 24 in. to 4 in. through 16 in. There is no overlap of sizes anymore.

II—Information Regarding Use of This Standard

II.A *General.* When ordering pipe covered by this standard, local installation and operating conditions should be considered to determine the class and type of pipe to specify. Also, certain other items must be specified to describe completely the pipe required.

According to the conditions of installation and operation in many water distribution systems, the pipe may be used at operating pressures equal to the class designations. The purchaser should determine for himself from AWWA C401, "Standard Practice for the Selection of Asbestos-Cement Distribution Pipe," the proper class of pipe to be used under the installation and operating conditions that will exist for the project on which the pipe is to be used.

The purchaser is referred to AWWA C603, "Installation of Asbestos-Cement Pressure Pipe," for guidance in laying of the pipe.

II.B *Flexural load test.* The flexural load tests for pipe sizes 4, 6, and 8 in. (Sec. 2.2.1 and 5.2.3) are intended only for use as a quality control test, not as a simulated service test. Asbestos-cement pipe will not be subjected to flexural stresses if properly installed with satisfactory bedding methods.

For diameters 10 in. and larger, the wall thickness increases to a point at which the flexural strength is not a controlling factor, and hence, routine testing is not required.

II.C *Type of pipe.* The following

criteria are presented for determining the type of pipe to be used under various soil and water conditions. Each condition should be considered separately even though each may exist in combination with others. These criteria are based on exposures within the temperature range of 40–80F (5–28C). For exposure of pipe to temperatures beyond these limits, consult the manufacturer.

The following criteria are referenced as:

1. Internal water (Table F.1).
2. External water (Table F.2).
3. Nonacid soluble sulfates—internal and external (Table F.3).
4. Acid soluble sulfates—internal and external.

II.C.1 *Internal water.* Aggressiveness of water transported through asbestos-cement pipe is related to the type designation of asbestos-cement pipe suitable for such use in Table F.1. Aggressiveness of water is defined as follows:

- a. Highly aggressive:

$$\text{pH} + \log (AH) < 10.0$$

- b. Moderately aggressive:

$$\text{pH} + \log (AH) = 10.0\text{--}11.9$$

- c. Nonaggressive:

$$\text{pH} + \log (AH) \geq 12.0$$

where

pH = Index of acidity (or alkalinity) of the water—standard pH units

A = Total alkalinity—ppm (mg/l) as CaCO_3

H = Calcium hardness—ppm (mg/l) as CaCO_3

TABLE F.1

Asbestos-Cement Pipe Type Recommended for Internal Water Aggressiveness

Internal Water Aggressiveness	Recommended Pipe Type*
Highly aggressive	†
Moderately aggressive	II
Nonaggressive	I and II

* Type I—no limit on uncombined calcium hydroxide; Type II—per cent or less uncombined calcium hydroxide.

† The serviceability of pipe for such applications should be established by the purchaser in conjunction with the manufacturer.

TABLE F.2

*Aggressiveness of Nonsulfate Acidic Soils
to Asbestos-Cement Pipe*

Water Conditions Within the Soil Environment	Minimum pH of Acidic Soils When Using Asbestos- Cement Pipe	
	Type I	Type II
Essentially quiescent	5.0	4.0
Mildly fluctuating	5.5	5.0
Rapidly moving or grossly cyclic	6.3	5.5

It should be recognized that water that has a $\text{pH} + \log (AH)$ less than or equal to 10 is an extremely aggressive water and would be very corrosive to almost all materials found in a typical water system, including the plumbing in consumers' homes. Such waters should be treated to increase pH or hardness to protect the entire network of materials making up the system. If such water treatment is not undertaken, the manufacturer of each item used in the water system should be consulted for recommendations regarding the use of his product in an extremely corrosive environment.

NOTE: The expression $\text{pH} + \log (AH)$ is a modification of the Langelier Index. It has been prepared so that the aggressiveness of the water can be determined easily. A reasonable comparison of the two would be as indicated below.

Highly aggressive water	
Moderately aggressive water	
Nonaggressive water	

TABLE F.3

*Asbestos-Cement Pipe Type Designation
Chemical Resistance to Nonacid
($\text{pH} = 7.0$) Soluble Sulfates
in Water and Soils*

Type Designation	Chemical Resistance to Nonacid Soluble Sulfates in Water and Soils
I*	Will be attacked to various degrees by all but the non-aggressive levels of sulfate concentrations in waters and soils.
II	Resistant to all levels of soluble sulfates.

*The guideline criteria for sulfate resistance of Type I pipe were taken from the *Concrete Manual*, 8th edition, Bureau of Reclamation, 1974. Sulfate resistance here applies to all soluble sulfates regardless of the cation.

II.C.2 *External water.* Aggressiveness of external water (water within the soil environment) is related to asbestos-cement pipe in Table F.2. The guidelines for the use of asbestos-cement pipe in nonsulfate acidic soils are based upon minimum pH factors alone. Asbestos-cement pipe may or may not perform satisfactorily in acidic soil environments that have pH values below those listed in Table F.2. To determine the suitability of asbestos-cement pipe in soils having lower pH values, each situation should be evaluated individually and take into consideration all aspects of soil environment that affect asbestos-cement pipe corrosiveness.

II.C.3 *Nonacid soluble sulfates—internal and external.* Aggressiveness of nonacid ($\text{pH} \geq 7.0$) soluble sulfates in water and soils is related to the type designation of asbestos-cement pipe suitable for such use in Table F.3.

$\text{pH} + \log (AH)$	Langelier Index
< 10.0	< -2.0
$10.0-11.9$	-2.0 to -0.1
≥ 12.0	≥ 0

Sulfate Aggressiveness Classification	Water	Soil
	Water Soluble Sulfates— <i>ppm SO₄</i>	Water Soluble Neutral Sulfates— <i>ppm SO₄</i>
Nonaggressive	150 and less	1000 and less
Mildly aggressive	150–1500	1000–2000
Moderately aggressive	1500–10 000	2000–20 000
Highly aggressive	10 000 and greater	20 000 and greater

Sulfate aggressiveness in water and soil can be classified as indicated above.

II.C.4 *Acid soluble sulfates—internal and external.* Aggressiveness of acid ($\text{pH} < 7.0$) soluble sulfate waters and soils to asbestos-cement pipe must be evaluated independently.

Acid sulfate soils and waters, whether the acid is inorganic or organic, must be evaluated independently of the criteria and guidelines set forth in Sec. II.C.2 and II.C.3 and must take into consideration soil permeability and other factors. Consult the manufacturer for guidance.

II.D *Supplementary specifications.* The following information summarizes the conditions and items that the purchaser should consider when preparing his supplementary specifications. The section in the standard where they can be found is also listed.

1. The standard used; that is, AWWA C400–77.
2. Affidavit of compliance, if required (Sec. 1.3).
3. Type of pipe to be furnished (Sec. 2.3 and Foreword II.C).
4. Class of pipe (Sec. 3.1).
5. Nominal inside diameter (Sec. 3.2).
6. Lineal feet to be furnished in

standard and random lengths (Sec. 3.3).

7. Number, size, type, class, lengths, and extent of machining of special short lengths (Sec. 3.3.3).

8. Whether inspection by the purchaser (Sec. 5.1) and special marking (Sec. 6.1.4) are required.

III—Major Revisions

Major changes to the 1975 standard that were made in this revision are

1. The title has been changed to indicate that the pipe is intended for use in distribution systems.
2. The size range has been changed to limit the maximum size covered by this standard to 16-in. diameter pipe.
3. A more detailed description of aggressive soil and water criteria has been added in Sec. II of the Foreword.
4. The lot definition of paragraph 1.2.3 has been revised to limit the quantity to a maximum of 300 sections instead of all sections manufactured in a shift.
5. Paragraph 5.2.5 *Machines for Testing* has been revised to allow couplings to be hydrostatically tested with a rubber bladder inside the coupling at 4× the pipe's class rating.



American Water Works Association

AWWA C400-77

(Revision of
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AWWA Standard for

**Asbestos-Cement Distribution Pipe,
4 in. Through 16 in., for Water
and Other Liquids**

Section 1—General

Sec. 1.1—Scope

This standard covers three pressure classes of Type I and Type II asbestos-cement pipe, 4-16 in. in diameter, for water and other liquids intended to be laid underground in public and private rights-of-way.

1.1.1 *Use.* Asbestos-cement distribution pipe is to be used in pipe systems having relatively unpredictable flows and many appurtenances that do not permit reasonable hydraulic analyses, including that for surge pressure.

1.1.2 *Pressure classes.* The pressure class designations of class 100, class 150, and class 200 are the same as those used in AWWA C401 (formerly AWWA H2) "Standard Practice for the Selection of Asbestos-Cement Distribution Pipes."

Sec. 1.2—Definitions

Under this standard, the following definitions shall apply:

1.2.1 *Inspection.* Inspection of the pipe and the tests by the inspector.

1.2.2 *Inspector.* The authorized representative of the purchaser, entrusted with the duty of inspecting

pipe produced and tests performed under this standard.

1.2.3 *Lot.* A lot as used herein is defined as all pipe of any one class, type, and size manufactured on any one machine in 24 hr but not to exceed 300 lengths.

1.2.4 *Manufacturer.* The person, firm, or corporation that manufactures the pipe.

1.2.5 *Operating pressure.* The maximum hydrostatic pressure to which the pipe will be subjected in normal operation after installation, exclusive of allowance for water hammer.

1.2.6 *Purchaser.* The person, firm, corporation, or government agency entering into a contract or agreement to purchase pipe according to the provisions of this standard.

Sec. 1.3—Affidavit of Compliance

Whether factory inspection has been required or not, the purchaser's supplemental specifications may require an affidavit of compliance from the manufacturer to the effect that the materials furnished under the purchaser's order comply with all applicable requirements of this standard.

Section 2—Materials

Sec. 2.1—Composition

Asbestos-cement pipe shall be composed of an intimate mixture of either: (1) portland cement or portland blast furnace slag cement and asbestos fiber with or without silica; or (2) portland pozzolana cement and asbestos fiber. Both (1) and (2) can be with or without the addition of curing agents. The pipe shall be formed under pressure and cured. The finished pipe shall be free from organic materials.

Sec. 2.2—Physical Requirements

2.2.1 Flexural strength. Each length of 4-, 6-, and 8-in. pipe tested in flexure by the procedure specified in this standard shall, except as otherwise provided, support the load indicated in Table 1.

2.2.2 Bursting strength. Each length of pipe and each coupling sleeve shall have sufficient strength to withstand the design internal pressure indicated for its class in Table 2 when subjected to the hydrostatic test procedure specified in this standard.

TABLE 1

Flexural Test Loads

Nominal Diameter in.	Class 100	Class 150	Class 200
	Total Applied Load—lb		
4	1,200	1,470	1,870
6	2,800	3,700	4,900
8	5,330	7,600	10,130

2.2.3 Crushing strength. Each length of pipe shall have sufficient strength to support the design external load indicated for its class in Table 2 when subjected to the crushing-test procedure specified in this standard.

Sec. 2.3—Chemical Requirements

Pipe shall be designated as either *Type I* or *Type II* according to its content of uncombined calcium hydroxide as determined by the test procedures in this standard for uncombined calcium hydroxide. The requirements for each type are

Type I—no limit on uncombined calcium hydroxide,

Type II—1 per cent or less uncombined calcium hydroxide.

TABLE 2

*Design Internal Pressure and Design External Load**

Pipe Size in.	Class 100		Class 150		Class 200	
	Internal Pressure psi	External Load lb/lin ft	Internal Pressure psi	External Load lb/lin ft	Internal Pressure psi	External Load lb/lin ft
4	417	4,100	616	5,400	809	8,700
6	441	4,000	632	5,400	815	9,000
8	472	4,000	653	5,500	824	9,300
10	490	4,400	650	7,000	826	11,000
12	490	5,200	658	7,600	830	11,800
14	500	5,200	650	8,600	826	13,500
16	500	5,800	654	9,200	825	15,400

* It is necessary to apply a load factor (see AWWA C401) to the three-edge bearing loads obtained in the crushing tests specified in Sec. 5.2.4 of this standard in order to correlate them to the field loads.

Section 3—Design

Sec. 3.1—Pipe Classes

Pipe supplied under this standard shall be made in one or more of the following classes: 100, 150, or 200.

Sec. 3.2—Pipe Diameters

Pipe shall be made with nominal inside diameters of 4, 6, 8, 10, 12, 14, and 16 in. The average inside diameter of a standard or random pipe length shall not be less than the nominal diameter by more than 5 per cent.

Sec. 3.3—Pipe Lengths

Pipe shall be produced in standard, random, and short lengths. At least 90 per cent of the total footage of pipe of any class, type, and size, excluding short lengths, shall be furnished in standard lengths. The remaining 10 per cent may be in random lengths.

3.3.1 Standard lengths. Standard lengths shall be 10 or 13 ft ± 1 in. for pipe 4 in. and 6 in. in diameter, and 13 ft ± 1 in. for pipe 8 in. in diameter or larger.

3.3.2 Random lengths. Random lengths shall be cut from standard lengths and shall not be less than 7 ft.

3.3.3 Short lengths. Short lengths for making connections to valves, fittings, or structures and for making closures shall be furnished as specified by the purchaser.

3.3.4 Coupling areas. Coupling areas for all lengths of pipe shall be properly machined at ends or over their entire length to serve their intended purpose, as specified by the purchaser.

Sec. 3.4—Couplings

A coupling shall consist of an asbestos-cement sleeve of the same type and class as the pipe and two rubber rings or a device that has equal or better jointing characteristics, strength, and serviceability as that of an asbestos-cement coupling. The manufacturer shall submit specifications and drawings of alternate couplings to the purchaser for approval prior to manufacturing.

3.4.1 Amount furnished. One coupling of the same size and class as the pipe shall be furnished with each standard and random length of pipe.

3.4.2 Rubber rings. Rubber rings shall conform to the requirements of the latest edition of ASTM D1869, "Rubber Rings for Asbestos-Cement Pipe."

Sec. 3.5—Joints

Joints shall be capable of withstanding, without leakage, a hydrostatic pressure test as defined in Sec. 5.2.2.1.

Sec. 3.6—Wall Thickness

The wall thickness of the machined portion of any length of pipe shall not be less than the manufacturer's standard by the tolerance listed in Table 3.

TABLE 3

Wall Thickness Tolerance

Pipe Size—in.	Wall Thickness Tolerance—in.
4-12	-0.06
14-16	-0.12

Section 4—Workmanship and Finish

Sec. 4.1—Imperfections

4.1.1 *Interior surfaces.* The inside surface of each length of pipe shall be free from bulges, dents, and tears that could result in a variation in diameter of more than 0.20 in. from the diameter of adjacent unaffected portions of the surface.

4.1.2 *Coupling areas.* The coupling areas of the barrel of each length of pipe shall be free from dents and gouges that could cause leakage from the joint.

4.1.3 *Exterior surfaces.* Flaking on the exterior surface and edge of ma-

chined ends shall not extend back by more than 0.500 in. from the end, have a depth of more than 0.125 in., or extend around the perimeter for more than 0.500 in. at any one location.

4.1.4 *Straightness.* Each length of pipe shall not vary in straightness by more than 0.05 in./ft of length when the variation is measured as follows:

Measure the maximum ordinate from the exterior surface of the pipe by placing a straightedge or line that exceeds the pipe length against the exterior surface and measure the maximum distance from the exterior pipe surface to the straightedge or line.

Section 5—Inspection, Testing, and Rejection

Sec. 5.1—Inspection

5.1.1 *General.* Inspection by the purchaser shall not relieve the manufacturer of the responsibility to furnish material conforming in all respects to the requirements of this standard.

5.1.2 *Notification.* If inspection is specified by the purchaser under paragraph 5.1.4, the manufacturer shall notify the purchaser in advance of the date, time, and place of testing of the pipe so that the purchaser may be represented at the test.

5.1.3 *Access.* The inspector shall have free access to those parts of the manufacturer's plant that are involved in work performed under this standard. The manufacturer shall afford him, without charge, all reasonable facilities for determining whether the pipe meets the requirements of this standard.

5.1.4 *Testing.* If inspection is specified by the purchaser, he may, at his option, witness any or all test phases. The pipe to be tested will have passed the routine inspection and testing of this specification. The number of tests to be conducted for flexural strength (4, 6, and 8 in.), hydrostatic proof ($3\frac{1}{2}\times$ class), and, when required, crushing strength, shall be limited to 1 per each 300 standard lengths of each size, type, and class of pipe on the order. If uncombined calcium hydroxide tests are required, the number of tests will be one for each size, type, and class of pipe on the order. The purchaser or his authorized inspector may select the pipe to be tested. Retesting and rejection stipulations as shown in Sec. 5.3 shall apply.

Sec. 5.2—Physical Test Requirements

5.2.1 *Test specimens.* All pipe and couplings tested under this standard shall be in a normal air-dried condition when tested.

5.2.2 *Hydrostatic tests.*

5.2.2.1 Each standard, random, or short length of pipe and each coupling sleeve shall be tested under an internal hydrostatic pressure as shown for the proof test in Table 4. All air shall be expelled and the water pressure shall be increased to the test pressure at a uniform rate of not less than 100 psi/s. The test pressure shall be maintained for at least 5 s. Any pipe length or coupling sleeve showing leakage, sweating, or other defects shall be rejected.

5.2.2.2 From each lot that has passed the hydrostatic proof test, one standard length shall be hydrostatically tested to the lot test in Table 4 for that class in the manner specified in paragraph 5.2.2.1. Each length of the pipe so tested shall be retested in the manner and at the pressure specified in paragraph 5.2.2.1.

5.2.3 *Flexure tests.* Each standard length of pipe and each random length

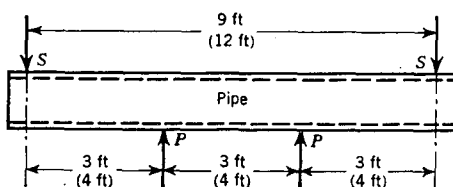


Fig. 1. Flexure Test Assembly

The numbers not in parentheses represent the distances between bearings S and load points P for lengths of pipe shorter than 12.5 ft. The numbers in parentheses indicate the spacing that may be used on lengths of pipe longer than 12.5 ft. One half of the total load is applied at each point P.

TABLE 4
Hydrostatic Tests

Class	Proof Test* psi	Lot Test† psi
100	350	400
150	525	600
200	700	800

* Every length per paragraph 5.2.2.1.

† One per lot per paragraph 5.2.2.2.

of more than 9.5 ft, having a nominal diameter of 4, 6, or 8 in., shall be tested in flexure for at least 5 s. The supports shall be 9 ft apart, except that, at the manufacturer's option, lengths greater than 12.5 ft may be tested on supports 12 ft apart at 75 per cent of the load specified in Table 1. The total load shall be divided equally and applied at the third points of the clear span as shown in Fig. 1. Each pipe so tested shall support, without evidence of cracks or other defects, the applicable total load shown in Table 1. The load shall be applied at a minimum rate of 250 lb/s, and the total load shall be maintained for at least 5 s.

5.2.4 *Crushing tests.* On lots containing more than 100 lengths of each size and class, one length from each 300 lengths or fraction thereof, shall be tested for crushing strength. If inspection by the purchaser has been specified, the length of pipe to be tested may be selected by the inspector. From each selected length, one unmachined section of pipe 1 ft long shall be cut. This section shall be tested by the crushing test method shown in Fig. 2. After 75 per cent of the specified load has been reached, the loading shall be applied at a uniform rate of approximately 2000 lb/min. The test section shall not fail

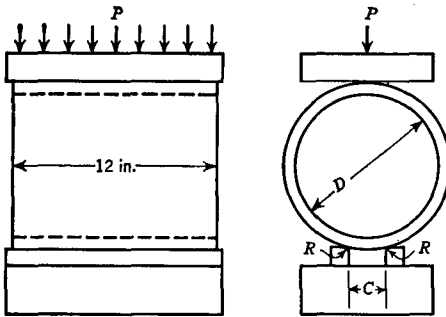


Fig. 2. Crushing Test Assembly

The diagram at the left shows a side view of the test assembly; that at the right, an end view. P represents load; R, approximately 0.5 in.—the radius of the bearings; D, the nominal diameter of the pipe; and C, the clear space between supports. C should be approximately 1 in./ft of internal pipe diameter but in no case less than 1 in.

until the total load applied meets or exceeds the applicable value shown in Table 2.

5.2.4.1 For this test, the two lower bearings shall consist of two straight strips with vertical sides, each strip having its interior top edge rounded to a radius of approximately 0.5 in. The strips shall be of hardwood or metal; if metal, a piece of leather belting $\frac{3}{16}$ in. in thickness shall be laid over each of them. The strips shall be fastened securely to a rigid block with the interior vertical faces parallel and at a distance apart of approximately 1 in./ft of internal pipe diameter but in no case less than 1 in. The upper bearing shall be a rigid wooden block straight and true from end to end. The upper and lower bearings shall extend the full length of the test section.

5.2.5 Machines for testing.

5.2.5.1 The machine used for the hydrostatic test shall have gaskets that seal the ends of the pipe, coupling, or

pipe and coupling with factory assembled joint, but exert no end pressure. Couplings may be hydrostatically tested with a rubber bladder inside the couplings, and if so tested, each coupling shall have sufficient strength to withstand a test pressure of 4 times the class of the coupling.

5.2.5.2 The machines used for the flexure and crushing test shall be substantial and rigid throughout so that the distribution of the load will not be appreciably affected by the deformation or yielding of any part of the machine.

Sec. 5.3—Retests (Physical) and Rejection

5.3.1 *Crushing strength.* The failure of any specimen tested for crushing strength to support 75 per cent of the crushing load required in Table 2 shall be cause for rejection of that portion of the lot of that size, type, and class manufactured during the same shift as the test specimen. If any specimen tested for crushing strength supports more than 75 per cent but less than 100 per cent of the crushing load, two additional pipe sections of the same size, type, and class manufactured during the same shift shall be subjected to the same crushing test. The additional lengths may be selected by the inspector if inspection by the purchaser has been specified. The failure of one of these additional specimens to meet the full crushing strength requirement shall be cause for rejection of that portion of the lot of that size, type, and class manufactured during the same shift as the test specimen.

5.3.2 *Hydrostatic tests.* If any pipe subjected to the hydrostatic tests specified in Sec. 5.2.2.2 fails to withstand the specified pressure, two additional lengths of the same size and class man-

ufactured during the same shift shall be subjected to the same hydrostatic test. The failure of one of these additional lengths to withstand the specified pressure shall be cause for rejection of that portion of the lot of that size, type, and class manufactured during the same shift as the test lengths.

Sec. 5.4—Test for Uncombined Calcium Hydroxide

The manufacturer shall perform this test as often as necessary to ensure compliance with the requirements for uncombined calcium hydroxide in Type II pipe.

5.4.1 Reagents.

Phenolphthalein indicator. Dissolve 1.0 g of phenolphthalein in 100.0 ml of absolute ethanol.*

Glycerol-ethanol solvent. Prepare a solution consisting of glycerol and anhydrous, or absolute ethanol,* 1:2 by volume. To each liter of this solution, add 2.0 ml phenolphthalein indicator. Adjust the solvent to slightly basic with either dilute NaOH in absolute ethanol* or standard ammonium acetate, depending on the original pH.

Strontium nitrate [$\text{Sr}(\text{NO}_3)_2$].

Standard ammonium acetate solution. Dissolve 16.0 g of dry crystalline ammonium acetate in 1 l of anhydrous or absolute ethanol.*

Standardize the ammonium acetate solution by titrating against pure CaO that has been freshly prepared by calcining pure calcium carbonate or calcium oxalate to constant weight in a platinum crucible at 1650–1830F (900–1000C).

When the calcined CaO has cooled in a desiccator, perform the following

* Specially denatured alcohol No. 30, 3a, or 2b of the US Bureau of Internal Revenue, or alcohol consisting of 95 per cent specially denatured alcohol No. 3a plus 5 per cent isopropanol may be substituted.

operations in rapid succession. Grind the CaO in an agate mortar. Then weigh out 0.05–0.06 g into a clean, dry 250-ml Erlenmeyer flask and add 60 ml of the glycerol-ethanol solvent and 2.0 g of anhydrous strontium nitrate to the flask. Place a TFE-encapsulated magnetic stirring bar into the flask and attach a reflux condenser. Adjust the heating rate and stirring speed to obtain a vigorous boiling and complete agitation. Titrate the hot solution with ammonium acetate solution every 5 min. The end point is reached when no further color appears in the solution after 10 min. of boiling. Titration is to be carried out only on a hot solution. A good titration procedure is evidenced by a change in the color of the solution to pink upon cooling.

5.4.2 Procedure.

Step 1. Brush representative pieces of the pipe free of dust and drill with a clean, sharp 0.25-in. carbide-tipped drill inward from the outer surface at a rate of penetration of approximately 1 in./min until the drill point emerges from the inside wall. Catch the drillings on a clean sheet of glazed paper, using a soft brush to collect all drillings. Screen through a 20-mesh screen immediately, and place in a weighing bottle.

Step 2. Place the bottle, with top removed, into a drying oven at 220F (105C) for 2 hr and then cool to room temperature in a desiccator.

Step 3. Weigh out $1 \text{ g} \pm 0.010 \text{ g}$ of the dried sample to the nearest 0.001 g and place in a clean, dry 250-ml Erlenmeyer flask to which a TFE-encapsulated stirring bar, 60 ml of the glycerol-ethanol solvent, and 2.0 g $\text{Sr}(\text{NO}_3)_2$ have been added. Attach the flask to a water-cooled condensor (with a standard 24/40 glass joint) and

place on a hot plate with a magnetic stirrer. Boil the solution gently for 30 min, stirring slowly. Then remove the flask and filter the mixture, under vacuum, through a Buchner funnel. Bring the filtrate to a boil and titrate to a colorless end point with the standardized ammonium acetate reagent. Determine the end point by comparison with a similar mixture containing no phenolphthalein indicator.

5.4.3 Calculations.

$$E = \frac{W\text{CaO} \times 1.32}{V_a}$$

where

E = the weight in grams of $\text{Ca}(\text{OH})_2$ per milliliter of standardized ammonium acetate solution.

$W\text{CaO}$ = the weight in grams of CaO in the standardized ammonium acetate solution.

V_a = the volume in milliliters of standardized ammonium acetate used in titration of the solution.

Percentage uncombined $\text{Ca}(\text{OH})_2$

$$= \frac{EV}{W} \times 100$$

where

V = the volume of standardized ammonium acetate solution required by the sample, in milliliters.

W = the weight of the sample in grams.

Sec. 5.5—Test Records

The results of all tests shall be recorded and retained for one year, and shall be available to the purchaser at the place of manufacture.

Section 6—Marking and Delivery

Sec. 6.1—Marking

6.1.1 *Standard and random lengths.* Each standard or random length of pipe shall be clearly marked on the outside surface with the trade name, nominal inside diameter, class, type, hydrostatic test pressure, and date and shift of manufacture.

6.1.2 *Short lengths.* Each short length of pipe shall be clearly marked on the outside surface with the nominal inside diameter, class, type, and the letter *T* to indicate that it has been hydrostatically tested.

6.1.3 *Couplings.* All component parts of each coupling shall be clearly

marked for use with the pipe for which they are intended. Each coupling sleeve shall also be marked with the letter *T* to indicate that it has been hydrostatically tested.

6.1.4 *Special markings.* If factory inspection is made by the purchaser or his authorized inspector, each pipe and each coupling sleeve shall receive an additional special marking of no more than three letters, as specified by the purchaser.

Sec. 6.2—Preparation for Shipment

All pipe and couplings, unless otherwise specified, shall be prepared for standard commercial shipment.

