Dick McKellson from J.D. Heaver 9/23/15

American Standard Specifications, A21.4-1953 (A.W.W.A. C104-53) FOR CEMENT MORTAR LINING FOR CAST IRON PIPE AND FITTINGS

(A revision of ASA—A21.4-1939)

PLAINTIFF'S EXHIBIT

CAP-842

SPONSORS

American Gas Association
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Section 4-1—Portland Cement. Portland cement shall meet all the requirements of Standard Specifications for Type II Portland Cement of the American Society for Testing Materials, ASTM designation C150, of latest revision.

ection 4-2—Sand. Sand shall consist of hard, strong, durable, uncoated, siliceous particles. Under the colorimetric test for organic impurities it shall not produce a color darker than the standard, unless it is shown by adequate tests that the impurities causing the color are not harmful to the strength or other specified properties of the finished lining. It shall lose not more than 3 per cent in the decantation test, and not more than 4 per cent in boiling hydrochloric acid. The sand shall be well graded from fine to coarse so as to produce a lining as nearly as practicable of maximum density and minimum water absorption consistent with the proportion of cement and the lining methods used, with workability of the mortar and with the other specified properties of the lining; provided that, when tested with standard sieves, it shall meet the following requirements:

	Per Cent
Total passing sieve having a clear opening of the size nearest to one-half the specified minimum thickness of lining	100
Passing No. 50 sieve, not more than	50
Passing No. 100 sieve, not more than	5

Section 4-3—Accepted Specifications. The specified tests of sand shall be made in accordance with the standard methods of the American Society for Testing Materials, of latest revision, as follows:

Colorimetric Test: Standard Method of Test for Organic Impurities in Sands for Concrete, ASTM designation C40.

Decantation Test: Standard Method of Test for Amount of Material Finer Than No. 200 Sieve in Aggregates, ASTM designation C117.

Solubility in Hydrochloric Acid: Standard Method of Testing Bituminous Mastics, Grouts, and Like Mixtures, ASTM designation D147.

Sampling: Methods of Sampling Stone, Slag, Gravel, Sand, and Stone Block for Use as Highway Materials, ASTM designation D75, Sections 14 and 15.

Section 4-4—Water. Water for tempering the mortar and for curing the lining shall be potable water, as defined in U. S. Public Health Service "Drinking Water Standards" of latest revision.

Section 4-5—Mortar. The mortar shall be an intimate and thorough mixture of portland cement, sand, and water of the qualities specified, and shall contain no other ingredient; except that, subject to the approval of the purchaser, other hydraulic cements producing linings having lower water-solubility, less shrinkage, or other advantages may be substituted for portland cement in whole or in part, or other ingredients may be incorporated in the mortar. Portland cement mortar for linings not exceeding ¼ in. in minimum thickness shall contain not less than one part of cement to two parts of dry sand by volume. (1) *

Section 4-6—Preparation of Pipe and Fittings for Lining. All pipe and fittings shall be thoroughly cleaned and surfaces to be lined shall be free from harmful amounts of blacking, grease, dirt, loose sand, rust, slag, soda, or other flux, and from tar or other coating, and shall be entirely free from sharp projections of iron which might reduce the thickness of the lining. Required hydrostatic tests shall be made before lining.

* Numbers in parenthesis such as that above refer to notes following this standard.

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7—**Method of Applying Cement Mortar Lin-** waterway surfaces of pipe and fittings shall be covered with as nearly as practicable a uniform of the specified mortar entirely free from holidays bubbles of air and thoroughly compacted through- ght pipe shall be lined by the centrifugal process, g high speed spinning and vibration, or by some ocess producing linings which are equal to such al linings in accuracy of surface contour, smooth- urface texture, density, low water absorption, and from shrinkage cracks and loose spots. The con- of the mortar and the time and speed of spinning so adjusted as to minimize the segregation of the m the cement, and to deliver the finished lining free itance. Fittings shall be lined by such process as will e linings equal, as nearly as practicable, in the above rated respects to the linings of straight pipe. Defective which have set shall not be patched but the linings all areas damaged in handling may be completely cut the metal, with square edges, the adjoining lining ughly wet, and the bare spot recoated by hand trowel- equivalent means and the patch cured as specified in 4-12.

ion 4-8—**Bell to Be Cleaned.** All mortar shall be re- ed from the joint surface of the bell.

tion 4-9—**Work to Be Protected.** The work of lining pipe and fittings shall be done in a building where the ducts shall be protected from the direct rays of the sun l from extreme weather conditions, such as frost, rain, . The product shall not be put in the yard until the ment has set sufficiently to avoid injury or damage thereto.

ction 4-10—**Thickness of Lining.** The thickness of lin- gs for pipe and fittings shall be nowhere less than the llowing for the respective diameters: 3 to 12 in., 1/8 in.; 4 to 24 in., 3/16 in.; 30 to 48 in., 1/4 in. Linings may taper t the ends. The length of taper shall be as short as practi- cable and shall not exceed 2 in. A plus tolerance of 1/8 in., but no more, shall be permitted on all sizes of pipe, and 1/4 in., but no more, on all sizes and patterns of fittings. Linings of greater thickness will be furnished when specified.

Section 4-11—Determination of Thickness. The thickness of lining may be determined by means of spear measurement, using a hardened steel point not larger than 1/16 in. in diameter, or by other approved gage. If tested by spear measurement, the inspector shall pierce the lining immediately after it is placed in the pipe, and before the mortar has set, at four equidistant points on two cross-sections of the pipe at both bell and spigot ends, making two sets of four thickness measurements each at each end. The first set shall not be more than 4 in. from the respective ends of the pipe and the second set shall be made as far into the interior of the pipe as can readily be reached without injuring the lining.

Section 4-12—Curing. Unless otherwise specified curing shall be effected by the application of a bituminous seal coating which shall cover and seal the cement mortar. This shall be applied while the lining is still moist. If the lining is not to be seal coated, it shall be kept constantly damp for at least 24 hours after the lining is placed and as much longer as may be necessary to control separation and cracking. (2) No pipe or fittings shall be shipped until the lining is thoroughly set and hard.

Section 4-13—The Finished Lining. The linings of both pipe and fittings, after curing and drying shall meet the following requirements:

(a) *Surface and Contour.* The lining shall have a hard, smooth surface and shall be free from noticeable ridges, corrugations, elevations, and depressions. The linings of pipe shall be cylindrical; the linings of fittings shall be as nearly as practicable of uniform thickness throughout and shall afford smooth waterways.

(b) *Water Absorption.* When tested for water absorption in accordance with Standard Specifications for Cement Concrete Sewer Pipe, ASTM designation C14, of latest revision, the lining shall show an absorption not exceeding 12 per cent of its dry weight. Samples for this test may be from linings placed for this purpose in the bell, provided that such linings are of the same thickness and mix, placed and compacted at the same time and by the same methods, and subjected to the same curing as the linings of the waterways. Samples at time of tests shall not be more than 30 days older than the most recently placed of the linings in the shipment or order which they represent. (3)

(c) *Cracks and Loose Spots.* Pipe showing any loose spot measuring 12 in. or more in greatest dimension, or any crack over 9 in. in length, or any crack of any length standing open perceptibly, shall be rejected. Surface crazing shall not be cause for rejection. (4)

Section 4-14—Outside Coating. Any coating which is to be applied to the outside of cement-mortar-lined pipe or fittings shall be specified in the agreement made at the time of purchase.

No pipe or fittings for water works service shall be furnished without protective coating unless specifically ordered by the purchaser.

Section 4-15—Bituminous Seal Coat. (a) *Characteristics.* The bituminous seal coat, after drying for 48 hours, shall have no deleterious effect upon the quality, color, taste or odor of potable water which has been standing for 48 hours in the pipe. (5) The seal coat shall adhere tenaciously to the mortar lining at all points. The seal coated pipe, when

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tested in accordance with Sec. 4-15 (b) shall not impart to the water more than 25 ppm of hardness, nor more than 25 ppm of total alkalinity, nor any caustic alkalinity.

(b) *Method of Testing.* Except as another form of specimen and test is agreed upon by the purchaser and manufacturer, the sample shall be a 6-in. length of 6- or 8-in. pipe, lathe-cut at both ends. The specimen shall be cut from a pipe whose lining is of the same age and which has been lined, cured, and seal-coated in all respects like the product which it represents, the seal-coat being applied 48 hours prior to the test. With this form of specimen, the test shall be made by bedding the specimen on end in a shallow pan of melted paraffin, allowing the paraffin to cool, filling the pipe nearly to the top with distilled or demineralized water at laboratory temperature, and covering with a glass plate on a seal of petroleum jelly. The water shall have an electrical resistivity (or resistance) exceeding 50,000 ohm-cm, or it shall contain not more than 10 ppm of the bicarbonates, chlorides, and sulfates of potassium, sodium, calcium, and magnesium, and it shall contain not more than 3.0 ppm of free carbon dioxide at the time of filling the test specimen. The water shall be changed and tested after 24 hours' contact on each of three successive days, and on each test shall be free from objectionable color, taste, and odor, and from hardness and alkalinity in excess of the limits specified in Sec. 4-15(a). Determination of hardness and alkalinity shall be made by methods prescribed in *Standard Methods for the Examination of Water and Sewage* of the American Public Health Association and the American Water Works Association, most recent edition. The purchaser shall indicate in his request for bids the number of tests and test specimens required. At the purchaser's option, this test may be made by him with the water with which the pipe is to be used.

Section 4-16—Frequency of Tests. A record of all specified tests shall be made and retained for at least one year. This record will be available to the purchaser at the foundry. If written transcripts of the test results or any additional tests are desired, this fact shall be noted on the order.

The several tests shall be made with at least the following frequencies:

Cement. (See Sec. 4-1) The manufacturer's analyses and physical tests of the cement of each shipment.

Sand. (See Sec. 4-2) One sieve analysis on each carload or, for sand otherwise delivered, one sieve analysis for each 50 tons.

The colorimetric, decantation and hydrochloric acid tests of sand from an established source of supply, once each 6 months; for sand from a new source not less often than once a month for period of 6 months.

Determination of Thickness. (See Sec. 4-11) One test for each 100 pipe, well distributed among the different sizes produced.

Water Absorption. (See Sec. 4-13 (b)) One test a month, well distributed among the different thicknesses of lining produced.

Bituminous Seal Coat. (See Sec. 4-15) Leaching test once a month on pipe selected at random from regular production.

NOTES

(These notes are not parts of the standard, but are given for information only.)

(1) The provision for the use of cements other than standard portland and for other modifications of the mortar, subject to the approval of the purchaser, permits taking advantage of any useful results of the development of hydraulic cements of special properties.

(2) The purchaser who is buying cement-mortar-lined pipe for use with a water that is corrosive to calcium carbonate, such as a soft water of low alkalinity and low pH, is advised, before omitting the seal coat, to satisfy himself by appropriate test that the lining to be furnished will not impart objectionable hardness or alkalinity to the water, *considering the amount of circulation in the proposed pipeline and the amount of blowing off of dead ends that he is prepared to do.* The procedure of Sec. 4-15 (b), omitting the seal coat and substituting for distilled water the water with which the pipe is to be used, is suggested as a convenient form of test.

Another advantage of the seal coat is in prolonging the life of the lining.

(3) The water absorption of cement-mortar linings which have been exposed to the atmosphere diminishes with increasing age of the lining, hence the 30-day limit so that the sample tested shall be reasonably representative of the shipment.

(4) Whitewash may be used to protect the pipe from the heat of the sun, which tends to expand the pipe away from the lining. If cement-mortar-lined pipe are to be stored for a long time along the trench or in the purchaser's yard, it is recommended that the whitewash be maintained on all sides exposed to the sun. The need for whitewashing varies with the size of the pipe, the climate and probably other conditions. Pipe 16 in. in diameter and larger are more likely to need whitewashing than smaller pipe.

(5) The following test for tendency of a seal coating material to impart color, taste, and odor to the water has been used: A 2- × 3- × 6-in. block of the mortar to be used in lining the pipe is dried, painted, and exposed to the air for 48 hours; it is then placed in a covered vessel with a volume of the water of the purchaser's supply equal, in cubic inches, to twice the area of the block, in square inches (the volume-area relation of an 8-in. pipe). After 48 hours at laboratory temperature it is tested for color, taste, and odor.

By changing the water and testing for hardness and total and caustic alkalinity for, say, 3 successive days, and thereafter at longer intervals, an indication of the protective value of the seal coat may be had.

WEIGHTS & THICKNESS OF CEMENT LININGS

Size	Standard Cement Lining			Enamelined		
	Minimum Thickness	Approx. Wt./Ft.	Approx. Wt./18 Ft., Length	Minimum Thickness	Approx. Wt./Ft.	Approx. Wt./18 Ft. Length
3"	1/8"	1.3	24	3/16"	0.7	13
4"	1/8"	1.5	27	3/16"	0.8	15
6"	1/4"	2.5	45	3/16"	1.3	24
8"	1/4"	3.3	60	3/16"	1.7	31
10"	1/4"	4.0	72	3/16"	2.0	36
12"	1/4"	4.8	87	3/16"	2.4	44
14"	3/16"	9.0	162	3/32"	4.5	81
16"	3/16"	10.3	186	3/32"	5.2	94
18"	3/16"	11.5	207	3/32"	5.8	105
20"	3/16"	12.8	231	3/32"	6.4	116
24"	3/16"	15.3	276	3/32"	7.7	139

The above weights of cement lining are not included in estimated weights of Bell-and-Spigot or Mechanical Joint Pipe as given in Section II of this catalog.