



Standard Specification for Non-Asbestos Fiber-Cement Underdrain Pipe¹

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1. Scope

1.1 This specification covers non-asbestos fiber-cement perforated and plain pipe intended for use in the conveyance of drainage water for the subsurface drainage of highways, airports, farms, foundations, and other similar drainage work.

1.2 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

C150 Specification for Portland Cement

C497 Test Methods for Concrete Pipe, Manhole Sections, or Tile

C500 Test Methods for Asbestos-Cement Pipe

C595 Specification for Blended Hydraulic Cements

C1154 Terminology for Non-Asbestos Fiber-Reinforced Cement Products

2.2 Federal Standard:

No. 123 Marking for Domestic Shipment (Civilian Agencies)³

2.3 Military Standard:

MIL-STD-129 Marking for Shipment and Storage³

¹ This specification is under the jurisdiction of ASTM Committee C17 on Fiber-Reinforced Cement Products and is the direct responsibility of Subcommittee C17.02 on Non-Asbestos Fiber Cement Products.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

2.4 Other Standards:

Uniform Freight Classification Rules⁴

National Motor Freight Classification Rules⁵

2.5 ISO Standards⁶

ISO 390 1993 Products in Fibre Reinforced Cement—Sampling and Inspection

ISO 2859 1999 Sampling Procedures for Inspection by Attributes Part 1: Sampling Schemes Indexed by Acceptance Quality Limit (AQL) for Lot-by-Lot Inspection

ISO 3951 1989 Sampling Procedures and Charts for Inspection by Variables for Percent Nonconforming

3. Terminology

3.1 Definitions:

3.1.1 Refer to Terminology C1154.

3.1.2 *coupling, n*—component made from a larger diameter pipe of the same type or class, or of Type II and a higher class, or produced otherwise to yield at least equal performance, for joining fiber-cement pipe that when properly installed, forms a silt-tight joint, allows alignment corrections and slight changes in direction and provides an assembled joint equivalent in serviceability and strength to the pipe sections.

4. Sizes and Types

4.1 Fiber-cement underdrain pipe furnished under this specification shall be known as “fiber-cement underdrain pipe.” It shall be furnished in nominal inside diameters of 4, 6, 8, 10, and 12 in. [100, 150, 200, 250, and 300 mm]. The types of pipe shall be known as Type I and Type II corresponding to the chemical requirements given in S3.

NOTE 1—To assist the purchaser in choosing the type of pipe most suitable for his use, guidelines for the definition of aggressiveness of water and of soil environments for selection of the proper type of cement pipe are covered in the appropriate sections of Test Methods C500.

NOTE 2—There are no chemical requirements for Type I pipe. Type II pipe is generally accepted as being unaffected by sulfates in groundwater which cause matrix expansion and consequential pipe deterioration.

⁴ Available from the Uniform Classification Commission, Room 1106, 222 S. Riverside Plaza, Chicago, IL 60606.

⁵ Available from National Motor Freight Inc., 1616 P St., NW, Washington, DC 20036.

⁶ Available from International Organization for Standardization (ISO), 1 Rue de Varambe, Case Postale 56, CH-1211, Geneva 20, Switzerland.

5. Materials and Manufacture

5.1 Fiber-cement underdrain pipe shall be composed of an intimate mixture of an inorganic hydraulic binder (see Specification **C150**) or a calcium silicate binder (see Specification **C595**) formed by the chemical reaction of a siliceous material and a calcareous material reinforced by organic fibers, inorganic non-asbestos fibers, or both. Process aids, fillers and pigments which are compatible with fiber-reinforced cement are not prohibited from being added. The material shall be of laminar construction, formed under pressure to a homogeneous structure, and cured to meet the physical and chemical requirements of this specification.

6. Crushing Strength

6.1 Crushing tests shall be conducted before shipment. The crushing strength test results when assessed in accordance with Section **11** (Sampling) shall comply with the specified minimum crushing strength in **Table 1**. Test Specimens 12 in. [300 mm] long cut from an unmachined portion of pipe shall be tested in accordance with the appropriate section of test methods **C497**, except that when the perforated underdrain pipe is tested, the sample shall contain four circumferential rows of holes with the first row 1.5 in. [40 mm] from the end. The specimen shall be tested with the line of symmetry of the rows facing downward, with the rows of holes being in the lower two quadrants.

7. Couplings

7.1 Each standard, short, or random length of pipe shall be provided with a coupling for the purpose of maintaining alignment and to ensure close joints.

8. Fittings

8.1 Fiber-cement underdrain pipe fittings shall be suitable in size, type, crushing strength, and design for the pipe with which they will be furnished.

9. Sizes and Dimensions

9.1 The nominal length for fiber-cement underdrain pipe shall be designated by the manufacturer. Unless otherwise agreed by the Owner, furnish a maximum of 15 % of the total footage of any one size and type for any order, at the manufacturer's option, in pipe lengths shorter than the nominal. These shall be termed random lengths.

9.2 A tolerance of 1 in. [25 mm] shall apply to nominal standard lengths, and 6 in. [150 mm] shall apply to random lengths. For billing purposes, random lengths shall be classified to 6 in. [150 mm] increments, allowing a tolerance of +5 and -1 in. [+125 and - 25 mm].

9.3 The average inside diameter of the pipe shall not be less than nominal by 0.25 in. [6 mm] or 1½ %, whichever is greater.

10. Perforations

10.1 Perforations, when required, shall be circular holes, 0.25 ± 0.05 in. [6 ± 1.5 mm] in diameter, arranged in rows parallel to the axis of the pipe. Perforations shall be approximately 3 in. [75 mm] center-to-center, along the rows. Rows shall be arranged in two equal groups on either side of the vertical center line of the pipe, and the total number of rows shall be as shown in **Table 2**. The lowermost rows of perforations in each group shall be separated by an arc of 90° [1.6 rad] and the upper most rows of perforations in each group shall be separated by an arc of 160° [2.8 rad]. The spacing of rows between these limits shall be uniform. Holes may appear at the ends of short and random lengths.

11. Sampling

11.1 All material tested under this specification shall be in a saturated condition after immersion under water at 73 ± 7°F [23 ± 4°C] for a minimum of 24 h.

11.1.1 Employ sampling procedures providing an average outgoing quality limit (AOQL) of 6.5 %, except where specific sampling is required by particular test procedures. Appendix X2 describes a sampling plan which provides an AOQL of 6.5 %.

11.1.2 The minimum sample size for sampling and acceptance by attributes or variables shall be in **Table 3**.

11.1.3 Pipes of different sizes or classes but of sequential manufacture in a continuous manufacturing process may be sampled as being in the same inspection lot.

11.2 For crushing tests sample the required number of full lengths of pipe according to the inspection lot size. Cut one test specimen 12 in. [300 mm] long from the unmachined end of each of the selected pipe lengths. (**Warning**—In addition to other precautions, when cutting fiber-cement products minimize the dust that results. Prolonged breathing or frequent breathing of significant airborne concentrations of silica is hazardous. When such dust is generated, effective measures shall be taken to prevent inhalation.)

NOTE 3—When sampling from continuous production, these tests may be conducted on dry, equilibrium, or saturated specimens, provided a relationship can be established between this testing and the specified values.

NOTE 4—A manufacturer's process with an AOQL of 6.5 % indicates that better than 93.5 % of the inspected production exceeds the specifications for marginally accepted product. This type of specification provides the protection and confidence of a clearly defined lower boundary. This would not be true if acceptance were based solely on the average value of the measured property. Examples of sampling schemes

TABLE 1 Crushing Strength

Nominal Size		Crushing Load, min	
in.	[mm]	lbf/ft	kN/m
4	100	1000	15
6	150	1100	16
8	200	1300	19
10	250	1400	20
12	300	1500	22

TABLE 2 Perforations

Nominal Size		Rows of Perforations
in.	[mm]	
4	100	4
6	150	4
8	200	4
10	250	6
12	300	6

TABLE 3 Minimum Quality Sample Size

Inspection by Variables		Inspection by Attributes	
Inspection Lot Size	Number Samples	Inspection Lot Size	Number Samples
<280	3	<150	5
281–500	4	151–500	8
502–1200	5	501–3200	13

which may be used can be found in documents such as ISO 390. Other sampling schemes may be used which maintain equally rigorous quality levels. Inspection by attributes consists of determining, for every item of a sample, the presence or absence of a certain qualitative characteristic (attribute) with respect to the applicable specification. It is, in essence, a pass-fail inspection which determines the number of items in a sample that do or do not conform to the specification. An attribute could be a dimensional measurement, or a flexural strength value, or others that are described in these test methods. Inspection by variable consists of measuring a quantitative characteristic for each item in a sample. Conformance with the applicable specification is determined from the mean values of the measured properties and the statistical variations of these values above and below the mean. Appendix X2 details sampling plans to suit all common sampling situations, and specifies the number of specimens to be taken from each batch and the acceptance/rejection criteria. The specified inspection levels have been selected to suit fiber-cement products, to balance the cost of assessment against confidence in results commensurate with this industry.

12. Inspection

12.1 All material furnished under this specification shall conform to the requirements stated herein and shall be subjected to the factory inspection and tests prescribed in this specification. When requested by the purchaser on his order, the manufacturer shall notify the purchaser of the time that the inspection and testing will take place to allow the purchaser to arrange for witnessing such tests and inspections at his own expense. In lieu of such inspection, when requested, the manufacturer shall be prepared to certify that his product conforms to the requirements of this specification.

12.2 Each pipe and coupling shall be inspected by the manufacturer before shipment for compliance with the standards for dimensions, tolerances, and workmanship and finish (see Section 9).

12.3 The manufacturer shall maintain a Quality Manual which includes organizational responsibilities in the manufacturing process, the specification of all raw materials, the specification of key process variables, the specification of test methods to be used for testing material in process, and a Process Quality Assurance Inspection and Test Plan which establishes those parts of the process which are subject to regular quality assurance inspection and test.

12.4 When requested by the purchaser for the purposes of quality assurance, and to ensure product conformity, a copy of the Process Quality Assurance Inspection and Test plan shall be supplied by the manufacturer.

13. Rejection and Rehearing

13.1 Failure of an inspection lot to comply with the minimum crushing loads of Table 1 using a sampling plan with an AOQL of 6.5 % shall be cause for rejection of that lot.

13.2 Material that fails to conform to the requirements of this specification constitutes grounds for rejection. Rejection shall be reported to the producer or supplier promptly in writing. In case of disagreement with the results of the test, either the producer or supplier is able to make claim for a rehearing.

14. Marking and Shipping

14.1 *Standard and Random Lengths*—Each standard or random length of pipe shall be marked clearly on the outside surface with the trade name, nominal inside diameter, type, and date of manufacture in alkali resistant ink or indelible paint.

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

15. Keywords

15.1 drainage; fiber-cement; perforated; pipe; subsurface; underdrain

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements S1 and S2 shall apply when material is supplied under this specification for U.S. Government procurement.

S1. Packaging

S1.1 Unless otherwise specified in the contract, the material shall be packaged in accordance with the producer's standard practice which will be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification Rules or National Motor Freight Classification Rules. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

S2. Responsibility for Inspection

S2.1 Unless otherwise specified in the contract or purchase order, the producer is responsible for the testing of all material to ensure compliance with the requirements specified herein. Except as otherwise specified in the contract or order, the producer will use suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser. The purchaser shall have the right to perform any of the inspections and tests set forth in this

specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

S3. Type II Pipes

S3.1 Supplementary requirements for Type II pipes shall consist of a once only supplementary test series for uncombined calcium hydroxide, with the manufacturer's statement of results provided upon purchaser's request. Fundamental changes in formulation or methods of curing, or curing cycles shall require the subsequent retesting of the supplementary test

for uncombined calcium hydroxide. This supplementary type test shall be conducted at least once per year.

S3.1.1 The uncombined calcium hydroxide for Type II pipes shall be less than 1% when tested in accordance with Test Methods C500.

S3.1.2 The uncombined calcium hydroxide test shall be carried out on a minimum of 5 specimens sampled at random and compliance with the specification of S3.1.1 for Type II pipe shall be achieved within an AOQL of 6.5 %.

APPENDIX

X1. SAMPLING AND INSPECTION PLANS WITH 6.5 % AOQL

X1.1 Inspection by Variables

X1.1.1 Inspection by Variable's Sample Size

X1.1.1.1 The sample size for batch inspection may be drawn in accordance with ISO 3951:1989 single sampling plan for normal inspection sampled at an inspection level S3. Under a sampling scheme by variables at an inspection level S3 the following Code Letters and sample sizes apply:

Lot Size	Sample Code	Number Samples
<280	B	3
281–500	C	4
501–1200	D	5

X1.1.1.2 Specimens in excess of those tabled may be used to determine compliance of the lot with the specification.

X1.1.1.3 Where the inspection sampling is from continuous production it is permissible to assess different sizes and classes of pipe of sequential manufacture as being part of the same lot provided a criteria independent of size and class is used to determine compliance with the specification. For example, a strength index may be used that is the actual pipe strength observed, divided by the minimum strength permitted by the specification.

X1.1.1.4 Where the inspection sampling is from continuous production it is recommended that the time period between sequential samples does not exceed 6 hours.

X1.1.2 Inspection by Variables Acceptance

X1.1.2.1 The measured values resulting from destructive tests or other observations X_1, X_2, \dots, X_n are recorded and the mean value (\bar{X}) and standard deviation (s) of the observations are calculated according to :

$$\bar{X} = \frac{\sum X_i}{n}$$

$$s = \sqrt{\frac{\sum (X_i - \bar{X})^2}{(n - 1)}}$$

X1.1.2.2 The minimum allowable mean value (X_s) is calculated according to:

$$X_s = L + ks$$

where:

L = specification limit

k = tabled value according to the sample size (n)

n	3	4	5	6	7	10	15
k	1.225	1.161	1.138	1.129	1.126	1.132	1.152
AOQL	6.5 %	6.5 %	6.5 %	6.5 %	6.5 %	6.5 %	6.5 %
AQL 90 %	1.1 %	2.1 %	2.8 %	3.4 %	3.9 %	4.8 %	5.7 %

X1.1.2.3 The inspection lot is accepted if the sample mean value (\bar{X}) is equal to or greater than the minimum allowable mean value (\bar{X}_s).

X1.2 Inspection by Attributes

X1.2.1 Inspection by Attributes Sample Size

X1.2.1.1 The sample size for batch inspection may be drawn in accordance with ISO 2859-1:1999 single sampling plan for normal inspection sampled at an inspection level S3. Under a sampling scheme by attributes at an inspection level S3 the following Code Letters and sample sizes apply:

Lot Size	Sample Code	Number of Samples
< 150	C	5
151 to 500	D	8
501 to 3200	E	13

X1.2.1.2 Specimens in excess of those tabled may be used to determine compliance of the lot with the specification.

X1.2.1.3 Where the inspection sampling is from continuous production it is permissible to assess different sizes and classes of pipe of sequential manufacture as being part of the same lot.

X1.2.1.4 Where the inspection sampling is from continuous production it is recommended that the time period between sequential samples does not exceed 6 h.

X1.2.2 Inspection by Attributes Acceptance

X1.2.2.1 The lot is accepted if the number of non-complying specimens is assessed for a given attribute is equal to or less than the acceptance number (A_c). The lot is rejected if the number of non-complying specimens for a given attribute is equal to or greater than the rejection number (R_e).

X1.2.2.2 The values for A_c and R_e are obtained from the following table:

Number Samples	5	8	13	20
A_c	0	0	1	2
R_e	1	1	2	3
AOQL	6.7 %	4.3 %	6.3 %	6.8 %
AQL 90 %	2.1 %	1.3 %	4.2 %	5.6 %

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