



Standard Specification for Non-Asbestos Fiber-Cement Storm Drain Pipe¹

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1. Scope

1.1 This specification covers non-asbestos fiber-cement pipe intended for use in storm-water drainage of highways, airports, farms, foundations, and other similar drainage systems.

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.

NOTE 1—Experience has shown that the successful performance of this product depends upon the proper selection of the pipe strength, the type of bedding and backfill, care that the installation conforms to the construction specifications, and provision for adequate inspection at the construction site. This specification does not include requirements for bedding, backfill, the relationship between field load conditions and the strength designation of the pipe, or durability. These requirements should be included in the project 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

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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.

2.2 Federal Standard:

Fed. Std. No. 123 Marking for Shipment and (Civil Agencies)³

2.3 Military Standards:

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes⁴

MIL-STD-129 Marking for Shipment and Storage⁴

MIL-STD-414 Sampling Procedures and Tables for Inspection by Variables for Percent Defective⁴

2.4 Other Standards:

Uniform Freight Classification Rules⁴

National Motor Freight Classification Rules⁵

2.5 ISO Standards:

ISO 390: 1993 Products in Fibre Reinforced Cement—Sampling and Inspection⁶

ISO 2859 –1: 1999 Sampling Procedures for Inspection by Attributes Part 1: Sampling Schemes Indexed by Acceptance Quality Limit (AQL) for Lot-by-Lot Inspection⁶

ISO 3951: 1989 Sampling Procedures and Charts for Inspection by Variables for Percent Nonconforming⁶

3. Terminology

3.1 Definitions:

3.1.1 Refer to Terminology C1154.

3.1.2 *coupling, n—in fiber-cement conduit, sewer, underdrain and storm drain pipe*—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. Alternatively, for storm drain couplings, sleeves made from other materials that, when properly installed develop sufficient tightness to prevent the surrounding soil from entering the drain, may be used as couplings.

³ Available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5904 Attn: NPODS.

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 Varembe, Case postale 56, CH-1211, Geneva 20, Switzerland.

4. Classification

4.1 The types of pipe shall be shown as Type I and Type II corresponding to the chemical requirements given in S3.

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.

4.2 Fiber-cement storm drain pipe furnished under this specification shall be designated as Class I, II, III, IV, and V. The corresponding strength requirements are prescribed in **Table 1**. The D load is the saturated crushing test load expressed in pounds-force per linear foot per foot of diameter. [The D1 load is the saturated crushing test load expressed in Newtons per linear metre per millimetre of diameter.] The pipe shall be furnished in 4, 6, 8, 10, 12, 15, 18, 21, 24, 27, 30, 33, 36, 42 and 48-in. [100, 150, 200, 250, 300, 375, 450, 525, 600, 675, 750, 825, 900, 1050 and 1200-mm] sizes.

4.3 When requested by the owner, the manufacturer shall provide the owner the relationship between the short-term crush load required to achieve long-term design loads with supporting estimates of service life using recognized calculation methods.

5. Composition and Manufacture

5.1 *Composition*—Fiber-cement drain pipes 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.

5.1.1 The manufacturer shall state the type of fiber used in the pipe, and, where requested, provide the owner with documented evidence that the fibers employed are compatible with other materials of that manufacturer.

5.2 *Manufacture*—The pipe wall shall be of laminar construction formed under pressure to be a homogeneous structure, and cured either under natural or accelerated conditions, to meet the physical requirements of this specification.

6. Dimensions, Mass, and Tolerances

6.1 The nominal length for fiber-cement storm drain 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 lengths.

6.2 The underrun in length of a section of pipe shall not be more than $\frac{1}{8}$ in./ft [10 mm/m] with a maximum of $\frac{1}{2}$ in. [12.7 mm] in length in any pipe.

6.3 The average inside diameter shall not be less than the nominal size by more than 0.25 in. [6 mm] or $1\frac{1}{2}$ % of the nominal size, whichever is greater in value.

6.4 The manufacturer shall state the minimum wall dimensions of the product it produces that complies with the minimum crush loads presented in **Table 1**.

7. Sampling

7.1 All material tested under this specification shall be tested in the saturated condition after immersion in water at an ambient temperature above 41°F [5°C] for a period of 21 to 28 days immediately prior to testing.

7.1.1 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 %.

7.1.2 The minimum sample size for sampling and acceptance by attributes or variables shall be in **Table 2**.

7.1.3 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.

7.2 For crushing tests sample the required number of full lengths of pipe according to the inspection lot size. Cut one test specimen no shorter than 6 inches [150 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 which may be used can be found in documents such as MIL-STD- 105, MIL-STD-414, or 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

TABLE 1 Minimum Crushing Load

Pipe Class	D Load lbf/ft/ft	D1 Load N/m/mm
I	1200	60
II	1500	75
III	2000	100
IV	3000	150
V	3750	175

TABLE 2 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

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.

8. Couplings

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

8.2 Joints shall be of a design, and the ends of the pipe sections so formed, that when the sections are laid together they will make a continuous line of pipe with a smooth interior free of appreciable irregularities in the flow line and all will be compatible with the tolerances given in Section 6.

9. Fittings

9.1 Fiber-cement storm drain pipe fittings shall be suitable in size, crush strength, and design for the pipe with which they will be furnished.

10. Test Methods

10.1 *Crushing Strength*—Conduct crushing tests before shipment. No shorter than 6 in. [150 mm] lengths of pipe cut from unmachined portions of the pipe shall be tested in accordance with the appropriate section of Test Methods C497.

11. Inspection

11.1 All material furnished under this specification shall conform to the requirements stated herein and shall be subjected to factory inspection and tests prescribed in this specification. When specified in the purchase order (see Appendix X1), 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. Instead of such inspection, when

requested, the manufacturer shall certify that his product conforms to the requirements of this specification.

11.2 Each pipe shall be inspected by the manufacturer before shipment for compliance with the standards for dimensions, tolerances, workmanship, and finish (see also Section 7).

11.3 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.

11.4 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.

12. Rejection

12.1 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. Product Marking and Shipping

13.1 Each standard and random length of pipe shall be marked by the manufacturer with the trade name, nominal size and class, and the date of manufacture, in alkali resistant ink or indelible paint. Type II pipes shall be so marked.

13.2 Couplings and fittings shall be marked with the size and class.

13.3 Pipe, couplings, and fittings shall be prepared for commercial shipment so as to ensure acceptance by common or other carriers.

14. Keywords

14.1 drain; drain pipe; fiber-cement; fiber-cement pipe; non-asbestos; storm drain pipe

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 an annual test of 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.

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 %.

APPENDIXES

(Nonmandatory Information)

X1. ADDITIONAL ORDERING INFORMATION

X1.1 It is suggested that the purchaser may request inclusion of the following information in his order or agreement for purchase of the pipe:

X1.1.1 Any tests, in addition to those prescribed by this specification, as the special circumstances may require.

X1.1.2 The place or places where any additional tests are to be made.

X1.1.3 Description of the additional testing facilities.

X1.1.4 Who shall bear the expense of such additional tests.

X1.1.5 Whether such additional tests may be made by any sound sampling process or other method approved by the parties.

X2. SAMPLING AND INSPECTION PLANS WITH 6.5 % AOQL

X2.1 Inspection by Variables

X2.1.1 Inspection by Variables Sample Size

X2.1.1.1 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

X2.1.1.2 Where the inspection sampling is from continuous production it is recommended that the time period between sequential samples does not exceed 6 hours.

X2.1.1.3 Specimens in excess of those tabled may be used to determine compliance of the lot with the specification.

X2.1.1.4 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 which is the actual pipe strength observed divided by the minimum strength permitted by the specification].

X2.1.2 Inspection by Variables Acceptance

X2.1.2.1 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:

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

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

X2.1.2.2 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 %	6.5 %
AQL 1.1 %	1.1 %	2.1 %	2.8 %	3.4 %	3.9 %	4.8 %	5.7 %

X2.1.2.3 The inspection lot is accepted if the sample mean value (\bar{X}) is equal to or greater than the minimum allowable mean value (X_s).

X2.2 Inspection by Attributes

X2.2.1 Inspection by Attributes Sample Size

X2.2.1.1 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 Samples
< 150	C	5
151 – 500	D	8
501 – 3200	E	13

X2.2.1.2 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.

X2.2.1.3 Specimens in excess of those tabled may be used to determine compliance of the lot with the specification.

X2.2.1.4 Where the inspection sampling is from continuous production, it is recommended that the time period between sequential samples does not exceed 6 hours.

X2.2.2 *Inspection by Attributes Acceptance*

X2.2.2.1 The lot is accepted if the number of non-complying specimens assessed for a given attribute is equal to

or less than the acceptance number (Ac). The lot is rejected if the number of non-complying specimens for a given attribute is equal to or greater than the rejection number (Re).

X2.2.2.2 The values for Ac and Re are obtained from the following table:

Number Samples	5	8	13	20
Ac	0	0	1	2
Re	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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