Designation: C 1448/C 1448M – 05

Standard Specification for Non-Asbestos Fiber-Cement Conduit[1]

This standard is issued under the fixed designation C 1448/C 1448M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

Note— The Editorial Review Board approved changes on April 5, 2005.

1. Scope

1.1 This specification covers non-asbestos fiber-cement conduit for use in electric-power systems and communication systems. The service is for both underground and exposed conditions.

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]

C 150 Specification for Portland Cement

C 497 Test Methods for Concrete Pipe, Manhole Sections, or Tile

C 500 Test Methods for Asbestos-Cement Pipe

C 595 Specification for Blended Hydraulic Cements

C 1154 Terminology for Non-Asbestos Fiber-Reinforced Cement Products

2.2 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[3]

2.3 *Federal Standard:*

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

2.4 *ISO Standards:*

ISO 390 Products in Fibre Reinforced Cement—Sampling and Inspection[4]

ISO 2859–1 Sampling Procedures for Inspection by Attributes Part 1: Sampling Schemes Indexed by Acceptance Quality Limit (AQL) for Lot-by-Lot Inspection[4]

ISO 3951 Sampling Procedures and Charts for Inspection by Variables for Percent Nonconforming[4]

2.5 *Other Standards:*

Uniform Freight Classification Rules[5]

National Motor Freight Classification Rules[6]

3. Terminology

3.1 *Definitions*—Refer to Terminology C 1154.

3.1.1 *conduit, n*—fiber-cement pipe used to protect wires for electric-power or communication systems, for both underground and exposed situations.

3.1.2 *coupling*—component made from a larger diameter pipe of the same type or Type II and of the same class or 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.

3.1.3 *fittings*—fittings such as adapters, reducers, increasers, bends, and bell ends, for use in laying fiber-cement conduit as described in Section 5 and made to such dimensions as will provide equivalent strength and silt-tight joints when assembled with the conduit.

4. Classification

4.1 The classes of conduit shall be as follows:

4.1.1 *Class B*—Intended for use encased in concrete after installation, and

4.1.2 *Class C*—Intended for use without concrete encasement, or for exposed services.

[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 Avenue, Philadelphia, PA 19111-5094.

[4] Available from International Organization for Standardization (ISO), 1 rue de Varembé, Case postale 56, CH-1211, Geneva 20, Switzerland.

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

[6] Available from National Motor Freight Inc., 1616 P St., NW, Washington, DC 20036.

4.2 The types of conduit shall be known as Type I and Type II corresponding to the chemical requirements given in Section S3 of this specification. For a more thorough understanding and as a guide to the chemical resistance of fiber-cement conduit, reference is made to Test Methods C 500.

NOTE 1—There are no chemical requirements for Type I Conduit.

NOTE 2—To assist the purchaser in choosing the type of conduit most suitable for his use, the following descriptions of usage may be considered:

4.2.1 *Type I*—For use where nonaggressive water and soil of moderate sulfate content are expected to come in contact with the conduit, and

4.2.2 *Type II*—For use where moderately aggressive water or water and soil of high sulfate content, or both, are expected to come in contact with the conduit.

4.3 The conduit shall be furnished in 1.5, 2, 3, 4, 5, and 6-in. [40, 50, 75, 100, and 150 mm] nominal sizes and shall have a circular cross section.

5. Materials and Manufacture

5.1 Fiber-cement conduit shall be composed of an intimate mixture of an inorganic hydraulic binder (see Specification C 150) or a calcium silicate binder (see Specification C 595) 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. All 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. Mechanical Properties

6.1 *Flexural Strength*:

6.1.1 Each 10 or 13 ft [3048 or 3962 mm] standard length and each 9.5 ft [2896 mm] or longer random length conduit shall have sufficient flexural strength to withstand, without failure, the total load prescribed in Table 1, when tested in accordance with 6.1.1.1.

6.1.1.1 The specimen shall be mounted longitudinally on "V" blocks, preferably of hard wood or of steel, 2 in. [50 mm] long, 120° [2 rad] angle of "V," faces 5 by 2 in. [130 by 50 mm], and the load applied through a rectangular block, 2 in. [50 mm] in width, at the center of the span. The spans between the faces of supporting blocks shall be as given in Table 1 for the particular class of conduit. The breaking loads, the average of at least two specimens from each length, shall not be less than those given in Table 1 for the particular class of conduit.

TABLE 1 Flexural Strength Requirements

Nominal Inner Diameter		Test Span (Free Span)		Class B Applied Test Load		Class C Applied Test Load	
in.	[mm]	in.	[mm]	lbf	[kN]	lbf	[kN]
1.5	40	30	760	600	2.70	850	3.80
2	50	30	760	600	2.70	850	3.80
3	75	30	762	600	2.70	850	3.80
4	100	30	762	980	4.40	1260	5.60
5	130	48	1219	1100	4.90	1500	6.70
6	150	54	1372	1300	5.80	2000	8.90

6.2 *Crushing Strength*—Crushing tests shall be conducted before shipment. 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 C 497.

7. Dimensions, Mass, and Tolerances

7.1 The average inside diameter measured at the end of the conduit shall be ±0.1 in. [±3 mm] of the nominal inside diameter.

7.2 The bore of the conduit shall pass freely through a mandrel 3 ft [1 m] long and 0.25 in. [6 mm] less in diameter than the nominal inside diameter of the conduit.

7.3 The inner dimensions of the bends shall be such that a ball 0.4 in. [10 mm] less in diameter than the nominal inside diameter of the conduit, shall pass freely through them.

7.4 Couplings and coupling areas of the conduit shall be machined or otherwise finished to such dimensions as will provide silt-tight joints when assembled with proper accessories and put into the service for which the conduit is intended.

7.5 The nominal length for fiber-cement conduit 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.

8. Workmanship, Finish and Appearance

8.1 Machined ends of the conduit that receive the coupling shall be free of dents and gouges that will affect the silt-tightness of the joint.

8.2 Each conduit shall be free of bulges, dents, and tears on the inside surface that result in a variation of more than 0.2 in. [5 mm] from the adjacent unaffected portions of the surface.

8.3 All inside edges of the conduit shall be rounded and smooth. The ends of each length of conduit shall be at right angles to the axis of the conduit.

9. Sampling

9.1 Test all material under this specification after immersion under water at 73 ± 7°F [23 ± 4°C] for a minimum of 24 h for the crushing tests and in a normal air-dried condition in equilibrium with atmospheric humidity for the flexural tests.

9.1.1 Employ sampling procedures providing an average outgoing quality limit (AOQL) of 6.5 %, except where specific sampling is required by particular test procedures. Appendix X1 describes a sampling plan which provides an AOQL of 6.5 %.

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

9.1.3 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.

9.2 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

TABLE 2 Crushing Strength Requirements

Nominal Diameter		Minimum Crushing Loads			
		Class B		Class C	
in.	[mm]	lbf	[kN]	lbf	[kN]
1.5	40	500	2.2	1200	5.3
2	50	500	2.2	1200	5.3
3	75	500	2.2	1200	5.3
4	100	500	2.2	1200	5.3
5	130	500	2.2	900	4.0
6	150	500	2.2	800	3.6

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

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 that may be used can be found in documents such as ISO 390. Other sampling schemes may be used that 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 that 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 X1 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.

10. Inspection

10.1 All material furnished under this specification shall conform to the physical and chemical requirements stated herein and may be subject to factory inspection by the purchaser. All conduit shall be inspected by the manufacturer for compliance to dimensional tolerances and workmanship. The manufacturer shall accept to certify that his product conforms to the requirements of this specification.

10.2 The manufacturer shall maintain a Quality Manual that 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 that establishes those parts of the process that are subject to regular quality assurance inspection and test.

10.3 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.

10.4 On orders requiring inspection by the purchaser, the manufacturer shall arrange the time of testing so that the purchaser or his authorized inspector may be present to witness such tests at the purchaser's expense.

11. Rejection and Rehearing

11.1 Failure of an inspection lot to comply with the minimum Flexural Strength Requirements of Table 1 or Crushing Strength Requirements of Table 2 using a sampling plan with an AOQL of 6.5 % shall be cause for rejection of that lot.

11.2 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.

12. Product Marking

12.1 Each standard and random length of conduit shall be marked by the manufacturer with the trade name, nominal size, type, class, and the date of manufacture, in alkali resistant ink or indelible paint. Each carton containing coupling sleeves shall be marked by the manufacturer with the nominal size, type, and class for the conduit with which it shall be used.

13. Packaging

13.1 Conduit and couplings shall be prepared for commercial shipment so as to ensure acceptance by common or other carriers.

13.2 Refer also to S1.1.

14. Keywords

14.1 conduit; fiber-cement

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 Conduit

S3.1 Supplementary requirements for Type II conduit 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 conduit shall be less than 1 % when tested in accordance with Test Methods C 500.

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

(Nonmandatory Information)

X1. SAMPLING AND INSPECTION PLANS WITH 6.5 % AOQL

X1.1 Inspection by Variables

X1.1.1 *Inspection by Variables Sample Size*:

X1.1.1.1 The sample size for batch inspection may be drawn in accordance with ISO 3951 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 h.

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, ... X_n are recorded and the mean value ($\bar{X}$) and standard deviation (s) of the observations are calculated according to:

$$\bar{X} = \frac{\sum X_i}{n} \tag{X1.1}$$

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

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

$$X_s = L + ks \tag{X1.2}$$

where:

L = specification limit, and

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 (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 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

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 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).

X1.2.2.2 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%