~~Designation:C506–10a~~ Designation: C506M – XXb

# Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe [Metric][1]

This standard is issued under the fixed designation C506M; 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.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope

1.1 This specification covers reinforced arch-shaped concrete pipe to be used for the conveyance of sewage, industrial wastes, storm water, and for the construction of culverts.

~~1.2This specification is the inch-pound companion to C506M; therefore, no SI equivalents are presented in the specification.~~

1.2 This specification is the metric counterpart of Specification C506.

NOTE 1—This specification is a manufacturing and purchase specification only, and does not include requirements for bedding, backfill, or the relationship between field load condition and the strength classification of pipe. However, experience has shown that the successful performance of this product depends upon the proper selection of the class of pipe, type of bedding and backfill, and care that the installation conforms to the construction specifications. The owner of the reinforced concrete pipe specified herein is cautioned that he must correlate the field requirements with the class of pipe specified and provide inspection at the construction site.

## 2. Referenced Documents

2.1 ~~*ASTM Standards:*~~

~~A36/A36M Specification for Carbon Structural Steel~~ ASTM Standards:[2]

A82/A82M Specification for Steel Wire, Plain, for Concrete Reinforcement

A185/A185M Specification for Steel Welded Wire Reinforcement, Plain, for Concrete

A496/A496M Specification for Steel Wire, Deformed, for Concrete Reinforcement

A497/A497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement ~~A706/A706M Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement~~



C33 Specification for Concrete Aggregates

C150 Specification for Portland Cement

C260 Specification for Air-Entraining Admixtures for Concrete

C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete

C494/C494M Specification for Chemical Admixtures for Concrete

C497M Test Methods for Concrete Pipe, Manhole Sections, or Tile [Metric]

C595 Specification for Blended Hydraulic Cements

C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

C822 Terminology Relating to Concrete Pipe and Related Products

C989 Specification for Slag Cement for Use in Concrete and Mortars

C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete

C1116 Specification for Fiber-Reinforced Concrete and Shotcrete

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[1] This specification is under the jurisdiction of ASTM Committee C13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.02 on Reinforced Sewer and Culvert Pipe.

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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. Terminology

3.1 *Definitions*—For definitions of terms relating to concrete pipe, see Terminology C822.

## 4. Classification

4.1 Pipe manufactured according to this specification shall be of three classes identified as Class A-II, A-III, and A-IV. The strength requirements are prescribed in Table 1.

## 5. Basis of Acceptance

5.1 Unless otherwise designated by the owner at the time of, or before placing an order, there are two separate and alternative bases of acceptance. Independent of the method of acceptance, the pipe shall be designed to meet both the 0.01-in. crack and ultimate strength requirements specified in Table 1..

5.1.1 *Acceptance on Basis of Plant Load Bearing Tests, Material Tests, and Inspection of Manufactured Pipe for Visual Defects and Imperfections*—Acceptability of the pipe in all diameters and classes produced in accordance with 7.1 or 7.2 ~~,~~ shall be determined by the results of the three-edge-bearing tests as defined in 11.3.1; by such material tests as are required in accordance with 6.1, 6.2, ~~6.3, 6.5,~~ and ~~6.66~~.4, by an absorption test of the concrete from the wall of the pipe ~~as required in 11.9;~~for each mix design that is used on an order; and by visual inspection of the finished pipe to determine its conformance with the accepted design and its freedom from defects.

5.1.2 *Acceptance on the Basis of Material ~~Tests~~Test and Inspection of Manufactured Pipe for Defects and Imperfections*—Acceptability of the pipe in all diameters and classes produced in accordance with 7.1 or 7.2 shall be determined by the results of such material tests as are required in accordance with 6.1, 6.2~~, 6.3, 6.5, and 6.6~~, and 6.4; by crushing tests on concrete cores or cured concrete cylinders; by an absorption test of the concrete from the wall of the pipe for each mix design that is used on an order; and by inspection of the finished pipe, including amount and placement of reinforcement, to determine its conformance with the accepted design and its freedom from defects.

5.1.3 When agreed upon by the owner and the manufacturer, any portion or any combination of the tests itemized in 5.1.1 or 5.1.2 may form the basis of acceptance.

5.2 *Age for Acceptance*—Pipe shall be considered ready for acceptance when they conform to the requirements as indicated by the specified tests.



## 6. Materials

~~6.1The aggregate shall be so sized, graded, proportioned, and mixed with such proportions of portland cement, blended hydraulic cement, or portland cement and supplementary cementing materials, or admixtures, or a combination thereof, if used, and water to produce a homogeneous concrete mixture of such quality that the pipe will conform to the test and design requirements of this specification. In no case, however, shall the proportion of portland cement, blended hydraulic cement, or a combination of portland cement and supplementary cementing materials be less than 470 lb/yd $^3$.~~

6.1 *Reinforced Concrete*—The reinforced concrete shall consist of cementitious materials, mineral aggregates, and water, in which steel has been embedded in such a manner that the steel and concrete act together.

6.2 *Cementitious Materials*:

6.2.1 *Cement*—Cement shall conform to the requirements of Specification C150, or shall be portland blast-furnace slag cement, or slag modified portland cement, or portland-pozzolan cement conforming to the requirements of Specification C595~~, except that the pozzolan constituent in the Type IP portland-pozzolan cement shall be fly ash.~~ , except that the pozzolan constituent in the Type IP portland pozzolan cement shall be fly ash and shall not exceed 25 % by weight.

6.2.2 *Ground Granulated Blast-Furnace Slag (GGBFS)*—GGBFS shall conform to the requirements of Grade 100 or 120 of Specification C989.

6.2.3 *Fly Ash*—Fly ash shall conform to the requirements of Class F or Class C of Specification C618.

6.2.4 *Allowable Combinations of Cementitious Materials*—The combination of cementitious materials used in the concrete shall be one of the following:

6.2.4.1 Portland cement only,

6.2.4.2 Portland blast furnace slag cement only,

6.2.4.3 Slag modified portland cement only,

6.2.4.4 Portland pozzolan cement only,

6.2.4.5 A combination of portland cement and ground granulated blast-furnace slag,

6.2.4.6 A combination of portland cement and fly ash, or

6.2.4.7 A combination of portland cement, ground granulated blast-furnace slag (not to exceed 25 % of the total cementitious weight) and fly ash (not to exceed 25 % of the total cementitious weight.

6.3 *Aggregates*—Aggregates shall conform to Specification C33 except that the requirement for gradation shall not apply.

6.4 *Admixtures and Blends*—The following admixtures and blends are allowable:

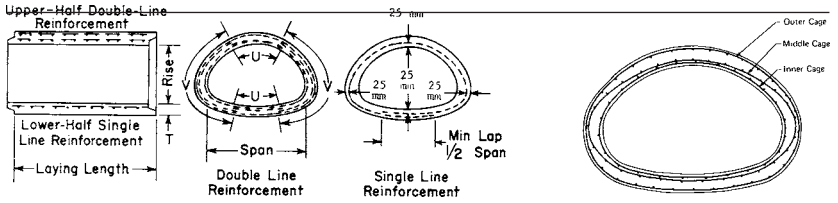
6.4.1 Air-entraining admixture conforming to Specification C260;

6.4.2 Chemical admixture conforming to Specification C494/C494M;

6.4.3 Chemical admixture for use in producing flowing concrete conforming to Specification C1017/C1017M; and

**TABLE 1 Strength Requirements for Reinforced Concrete Pipe[A]**

| Approximate Equivalent Round Size, ~~in.~~ mm | *T*, ~~in.~~mm | Minimum Rise, ~~in.~~mm | Minimum Span, ~~in.~~mm | $f'_c$, ~~ksi~~ MPA[B] | | | Double Line Reinforcement[C] | | | | | | | | | | | | | Single Line Reinforcement | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Continuous Basic Reinforcement = $A_s$[D] | | | | | | Additional Reinforcement = $A_s$[D] | | | | | | | | | |
| | | | | Class | | | Inner Cage | | | Outer Cage | | | "*U*" (Inner Cage) | | | | "*V*" (Outer Cage) | | | | | |
| | | | | A-II | A-III | A-IV | A-II | A-III | A-IV | A-II | A-III | A-IV | Dimension, ~~in.~~ mm | A-II | A-III | A-IV | Dimension, ~~in.~~ mm | A-II | A-III | A-IV | A-II | A-III | A-IV |
| ~~15~~ | ~~2¼~~ | ~~11~~ | ~~18~~ | 4 | 4 | 4 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ~~0.08~~ | ~~0.12~~ | ~~0.17~~ |
| 375 | 57 | 280 | 460 | 27.6 | 27.6 | 27.6 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1.7 | 2.5 | 3.6 |
| ~~18~~ | ~~2½~~ | ~~13~~ | ~~22~~ | 4 | 4 | 4 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ~~0.11~~ | ~~0.14~~ | ~~0.26~~ |
| 450 | 63 | 345 | 560 | 27.6 | 27.6 | 27.6 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2.3 | 3.0 | 5.5 |
| ~~21~~ | ~~2⅜~~ | ~~15~~ | ~~26~~ | 4 | 4 | 4 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ~~0.12~~ | ~~0.17~~ | ~~0.29~~ |
| 525 | 69 | 395 | 660 | 27.6 | 27.6 | 27.6 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2.8 | 3.6 | 6.1 |
| ~~24~~ | ~~3~~ | ~~18~~ | ~~28½~~ | 4 | 4 | 4 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ~~0.16~~ | ~~0.21~~ | ~~0.32~~ |
| 600 | 75 | 460 | 725 | 27.6 | 27.6 | 27.6 | ... | ... | ... | ... | ... | ... | 660 | ... | ... | ... | 735 | ... | ... | ... | 3.4 | 4.6 | 6.8 |
| ~~30~~ | ~~3½~~ | ~~22½~~ | ~~36¼~~ | 4 | 4 | 4 | ~~0.09~~ | ~~0.12~~ | ~~0.18~~ | ~~0.07~~ | ~~0.09~~ | ~~0.14~~ | ~~2 6~~ | ~~0.09~~ | ~~0.12~~ | ~~0.18~~ | ~~29~~ | ~~0.07~~ | ~~0.09~~ | ~~0.12~~ | ~~0.18~~ | ~~0.24~~ | ~~0.36~~ |
| 750 | 88 | 570 | 920 | 27.6 | 27.6 | 27.6 | 1.9 | 2.5 | 3.8 | 1.5 | 1.9 | 3.0 | 760 | 1.9 | 2.5 | 3.8 | 865 | 1.5 | 1.9 | 2.8 | 3.8 | 5.1 | 7.6 |
| ~~36~~ | ~~4~~ | ~~26~~ | ~~43⅜~~ | 4 | 4 | 4 | ~~0.11~~ | ~~0.15~~ | ~~0.21~~ | ~~0.09~~ | ~~0.12~~ | ~~0.17~~ | ~~30~~ | ~~0.11~~ | ~~0.15~~ | ~~0.21~~ | ~~34~~ | ~~0.09~~ | ~~0.12~~ | ~~0.16~~ | ~~0.21~~ | ~~0.30~~ | ~~0.44~~ |
| 900 | 100 | 675 | 1110 | 27.6 | 27.6 | 27.6 | 2.3 | 3.2 | 4.6 | 1.9 | 2.5 | 3.6 | 865 | 2.3 | 3.2 | 4.6 | 990 | 1.9 | 2.5 | 3.4 | 4.6 | 6.3 | 9.3 |
| ~~42~~ | ~~4½~~ | ~~31 5/16~~ | ~~51~~ | 4 | 4 | 4 | ~~0.12~~ | ~~0.18~~ | ~~0.27~~ | ~~0.10~~ | ~~0.14~~ | ~~0.21~~ | ~~34~~ | ~~0.12~~ | ~~0.18~~ | ~~0.27~~ | ~~39~~ | ~~0.10~~ | ~~0.14~~ | ~~0.21~~ | ~~0.26~~ | ~~0.36~~ | ~~0.54~~ |
| 1050 | 113 | 795 | 1300 | 27.6 | 27.6 | 27.6 | 2.8 | 3.8 | 5.7 | 2.1 | 3.0 | 4.4 | 1065 | 2.8 | 3.8 | 5.7 | 1090 | 2.1 | 3.0 | 4.6 | 5.5 | 7.6 | 11.4 |
| ~~48~~ | ~~5~~ | ~~36~~ | ~~58~~ | 4 | 4 | ... | ~~0.15~~ | ~~0.21~~ | ... | ~~0.12~~ | ~~0.17~~ | ... | ~~42~~ | ~~0.15~~ | ~~0.21~~ | ... | ~~43~~ | ~~0.12~~ | ~~0.17~~ | ... | ~~0.30~~ | ~~0.44~~ | ... |
| 1200 | 125 | 915 | 1485 | 27.6 | 27.6 | ... | 3.2 | 4.6 | ... | 2.5 | 3.6 | ... | 1220 | 3.2 | 4.6 | ... | 1245 | 2.5 | 3.6 | ... | 6.3 | 9.3 | ... |
| ~~54~~ | ~~5½~~ | ~~40~~ | ~~65~~ | 4 | 4 | ... | ~~0.18~~ | ~~0.24~~ | ... | ~~0.14~~ | ~~0.19~~ | ... | ~~48~~ | ~~0.18~~ | ~~0.24~~ | ... | ~~49~~ | ~~0.14~~ | ~~0.19~~ | ... | ~~0.36~~ | ~~0.48~~ | ... |
| 1350 | 138 | 1015 | 1650 | 27.6 | 27.6 | ... | 3.8 | 5.1 | ... | 3.0 | 4.0 | ... | 1320 | 3.8 | 5.1 | ... | 1395 | 3.0 | 4.0 | ... | 7.6 | 10.2 | ... |
| ~~60~~ | ~~6~~ | ~~45~~ | ~~73~~ | 4 | 4 | ... | ~~0.21~~ | ~~0.27~~ | ... | ~~0.17~~ | ~~0.21~~ | ... | ~~52~~ | ~~0.21~~ | ~~0.27~~ | ... | ~~55~~ | ~~0.17~~ | ~~0.21~~ | ... | ~~0.42~~ | ~~0.56~~ | ... |
| 1500 | 150 | 1145 | 1855 | 27.6 | 27.6 | ... | 4.4 | 5.9 | ... | 3.6 | 4.6 | ... | 1525 | 4.4 | 5.9 | ... | 1700 | 3.6 | 4.6 | ... | 8.9 | 11.8 | ... |
| ~~72~~ | ~~7~~ | ~~54~~ | ~~88~~ | 4 | 5 | ... | ~~0.26~~ | ~~0.36~~ | ... | ~~0.20~~ | ~~0.27~~ | ... | ~~60~~ | ~~0.26~~ | ~~0.36~~ | ... | ~~67~~ | ~~0.20~~ | ~~0.27~~ | ... | ~~0.52~~ | ~~0.72~~ | ... |
| 1800 | 175 | 1370 | 2235 | 27.6 | 34.5 | ... | 5.5 | 7.6 | ... | 4.2 | 5.9 | ... | 1725 | 5.5 | 7.6 | ... | 1955 | 4.2 | 5.9 | ... | 11.0 | 15.2 | ... |
| ~~84~~ | ~~8~~ | ~~62~~ | ~~102~~ | 4 | 5 | ... | ~~0.32~~ | ~~0.44~~ | ... | ~~0.24~~ | ~~0.34~~ | ... | ~~68~~ | ~~0.32~~ | ~~0.44~~ | ... | ~~77~~ | ~~0.24~~ | ~~0.34~~ | ... | ~~0.64~~ | ~~0.88~~ | ... |
| 2100 | 200 | 1575 | 2590 | 27.6 | 34.5 | ... | 6.8 | 9.3 | ... | 5.1 | 7.2 | ... | ... | 6.8 | 9.3 | ... | ... | 5.1 | 7.2 | ... | 13.5 | 18.6 | ... |
| ~~90~~ | ~~8½~~ | ~~72~~ | ~~115~~ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2250 | 213 | 1830 | 2920 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ~~96~~ | ~~9~~ | ~~77½~~ | ~~122~~ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2400 | 225 | 1960 | 3100 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ~~108~~ | ~~10~~ | ~~87⅛~~ | ~~138~~ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2700 | 250 | 2215 | 3505 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ~~120~~ | ~~11~~ | ~~96~~ | ~~154~~ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 3000 | 275 | 2460 | 3910 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ~~132~~ | ~~10~~ | ~~106½~~ | ~~168~~ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 3300 | 250 | 2705 | 4285 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |




~~D-Loads for 3-Edge-Bearing Method~~

D-Loads for 3–Edge-Bearing Method

| Class | 0.01-in. Crack | Ultimate |
|---|---|---|
| ~~I~~ | ~~1 000~~ | ~~1 500~~ |
| A-II | 50.0 | 75.0 |
| ~~II~~ A-III | 65.0 | 100.0 |
| ~~IV~~ A-IV | 100.0 | 150.0 |

Note—Test load in newtons per linear metre equals D-load × inside span in millimetres.

~~Note—Test load in pounds per linear foot equals D-load × inside span in feet.~~

[A]For modified or special designs, see 7.3.

[B] $f'_c$, ~~ksi~~ = minimum compressive strength of concrete in ~~thous~~ megands ~~of~~pounds ~~per square inch~~s.

[C]As an alternative to designs requiring double line reinforcement, the reinforcement may be positioned and proportioned so that the total reinforcement of the inner cage plus the middle cage shall not be less than that specified for the inner cage continuous basic reinforcement, and the additional reinforcement "*U*" and the total reinforcement of the outer cage plus the middle cage shall not be less than that specified for the outer cage continuous basic reinforcement and the additional reinforcement "*V*."

[D] $A_s$ = circumferential steel area in square ~~inch~~llimetres per longitudinal ~~foo~~ centimetre of pipe barrel in each continuous basic cage and additional cages in area denoted "*U*" and "*V*." Dimensions "*U*" and "*V*" are measured on the center line of the culvert wall.

6.4.4 Chemical admixture or blend approved by the owner.

6.5 *Steel Reinforcement*—Reinforcement shall consist of wire conforming to Specification A82/A82M~~or Specification~~ , or Specification A496/A496M~~:~~, or of wire ~~reinforcement~~fabric conforming to Specification A185/A185M~~or Specification~~ , or

Specification A497/A497M~~; or of bars conforming to Specification A36/A36M, Specification~~ , or of bars of Grade 300 steel conforming to Specification A615/A615M~~Grade 40 or 60, or Specification A706/A706M Grade 60.~~

~~6.6.~~

6.6 *Synthetic Fibers*—Collated fibrillated virgin polypropylene fibers may be used, at the manufacturer's option, in concrete pipe as a nonstructural manufacturing material. Only Type III synthetic fibers designed and manufactured specifically for use in concrete and conforming to the requirements of Specification C1116 shall be accepted.

## 7. Design

7.1 *Size and Dimensions*—The standard sizes of arch pipe are listed in Table 1. The internal dimensions for each standard size shall be as defined in Fig. 1, subject to the permissible variations of Section 12.

7.2 *Design Tables*—The wall thickness, compressive strength of concrete, and the area of circumferential reinforcement shall be as prescribed in Table 1, subject to the provisions of 7.3~~and Sections 11 and~~ , 11.4, and Section 12.

7.2.1 Footnotes to the tables herein are intended to be amplifications of the tabulated requirements and are to be considered applicable and binding as if they were contained in the body of the specification.

7.3 *Modified and Special Designs*:

7.3.1 If permitted by the owner, the manufacturer may request approval by the owner of modified designs that differ from the designs in this Section 7 or special designs for sizes and loads beyond those shown in Table 1, or special designs for pipe sizes that do not have steel reinforcement areas shown in Table 1.

7.3.2 Such modified or special designs shall be based on rational or empirical evaluations of the ultimate strength and cracking behavior of pipe and shall fully describe to the owner any deviations from the requirements of this Section 7. The descriptions of modified or special designs shall include the wall thickness, the concrete strength, and the area, type, placement, number of layers, and strength of the steel reinforcement.

7.3.3 The manufacturer shall submit to the owner proof of the adequacy of the proposed modified or special design. Such proof may comprise the submission of certified three-edge-bearing tests already made, which are acceptable to the owner or, if such three-edge-bearing tests are not available or acceptable, the manufacturer may be required to perform proof tests on sizes and classes selected by the owner to demonstrate the adequacy of the proposed design.

7.3.4 Such pipe must meet all of the test and performance requirements specified by the owner in accordance with Section 5.

7.4 *Area*—In this specification, when the word area is not described by adjectives, such as cross-sectional or single wire, it shall be understood to be the cross-sectional area of reinforcement per unit lengths of pipe.

## 8. Reinforcement

8.1 *Circumferential Reinforcement*—A line of circumferential reinforcement for any given total area may be composed of two layers for pipe with wall thicknesses of less than ~~7 in.~~180 mm or three layers for pipe with wall thicknesses of ~~7 in.~~180 mm or greater. The layers shall not be separated by more than the thickness of one longitudinal plus ~~in.~~6 mm. The multiple layers shall be fastened together to form a single cage. All other specification requirements such as laps, welds, and tolerances of placement in the wall of the pipe, etc., shall apply to this method of fabricating a line of reinforcement.

8.1.1 Where one line of reinforcement is used, it shall be placed so that the cover of the concrete over the circumferential reinforcement at the vertical and horizontal diameters of the pipe is ~~1 in.~~25 mm from the inside and outside surfaces of the pipe, except for wall thicknesses less than ~~2½ in.~~62 mm, the protective cover of the concrete over the circumferential reinforcement in the wall of the pipe shall be ~~in.~~18 mm.

8.1.2 Where two lines of reinforcement of arch shape corresponding to the contour of the pipe are used, each line shall be so placed that the covering of concrete over the reinforcement is ~~1 in.~~ 25 mm.

8.1.3 The location of the reinforcement shall be subject to the permissible variations in dimensions given in 12.5. Requirements for placement and protective covering of the concrete from the inner or outer surface of the pipe do not apply to that portion of a cage which is flared so as to extend into the bell or reduced in diameter so as to extend into the spigot.

8.1.4 The spacing center to center of circumferential reinforcement in a cage shall not exceed ~~4 in.~~100 mm for pipe up to and including pipe having a ~~4 in.~~100-mm wall thickness nor exceed the wall thickness for larger pipe, and shall in no case exceed ~~6 in.~~ 150 mm.

8.1.5 The continuity of the circumferential reinforcing steel shall not be destroyed during the manufacture of the pipe, except that when agreed upon by the owner, lift eyes or holes may be provided in each pipe for the purpose of handling.

8.1.6 If splices are not welded, the reinforcement shall be lapped not less than 20 diameters for deformed bars and deformed cold-worked wire, and 40 diameters for plain bars and cold-drawn wire. In addition, where lapped cages of welded-wire fabric are used without welding, the lap shall contain a longitudinal wire.

8.1.6.1 When splices are welded and are not lapped to the minimum requirements ~~above,~~ in 8.1.6, pull tests of representative specimens shall develop at least ~~90%~~50 % of the minimum specified ~~design yield~~ strength of the ~~circumferential wire,~~ steel and there shall be a minimum lap of ~~2 in. with sufficient weld length to develop the required strength.~~ 50 mm. For butt-welded splices in bars or wire, permitted only ~~in~~with helically wound cages, pull tests of representative specimens shall develop at least ~~110%~~75 % of the minimum specified ~~design yield~~ strength of the ~~circumferential wire.~~ steel.

8.2 *Longitudinal Reinforcement*—Each line of circumferential reinforcement shall be assembled into a cage that shall contain