American Water Works Association

AWWA C300-74

Revision of
AWWA C300-64

AWWA STANDARD

for

REINFORCED CONCRETE PRESSURE PIPE, STEEL CYLINDER TYPE, FOR WATER AND OTHER LIQUIDS

First edition approved by AWWA Board of Directors Dec. 11, 1947.
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AMERICAN WATER WORKS ASSOCIATION
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Foreword

This foreword is for information and is not a part of AWWA C300-74.

I—History of Standard

In April 1943, the AWWA Board of Directors authorized the preparation of "Tentative Emergency Specifications for Concrete Pressure Pipe." They covered a number of different types in a single document and served a useful purpose during the Second World War but are now obsolete and have been withdrawn.

The first standard prepared by AWWA Water Works Practice Committee 8320D—Reinforced Concrete Pipe, which was formed in 1946, covered the manufacture of reinforced concrete pipe, steel cylinder type, not prestressed. The standard is now designated AWWA C300. This type of pipe, first manufactured in 1919, consists of a welded steel cylinder with a steel joint ring welded at each end; a cage or cages of steel reinforcing bars or wire externally concentric with the cylinder; an encasing wall of dense concrete; and a preformed gasket of rubber to provide the joint seal between adjacent pipes. The pipe is manufactured in sizes ranging from 24 in. to more than 144 in. in diameter.

Reinforced concrete pipe, steel cylinder type, is designed for the specific combination of internal pressure and external load required for the project in accordance with the procedures outlined in the appendix of this standard. The pipe is normally limited in design to pressures of up to 260 psi.

This type of pipe is used for transmission mains, distribution feeder mains, pressure siphons, industrial pressure lines, sewer force mains, and sewer outfall lines.

The pipe is manufactured by first fabricating the steel cylinder and hydrostatically testing it with joint rings attached. Then, after the reinforcing cage(s) and steel cylinder have been assembled within a form, a concrete encasement is vertically cast, accompanied by mechanical vibration. Curing of the concrete is accomplished by means of water or steam. The pipe is generally made in 12- through 24-ft laying lengths. The circumferential steel of the cage provides 40 to 80 per cent of the reinforcement, depending on the conditions for which the pipe is designed.

The first edition of this standard was approved as "Tentative" on Dec. 11, 1947. It was revised and approved as "Standard" on Jan. 13, 1952. The second edition was approved as "Tentative" on Jul. 19, 1957, and made "Standard" on Jan. 27, 1964.

Installation of this pipe is covered by AWWA Manual M-9, "Installation of Concrete Pipe."

II—Information Regarding Use of This Standard

When purchasing pipe under the provisions of this standard, the purchaser shall furnish supplementary specifications that include specific details

on the following:

1. Standard used; that is, AWWA C300–74.
2. Manner of storage and delivery if required of the manufacturer.
3. The working pressure, the transient pressure, the depth of earth cover, the trench bedding condition, and the live load for which the pipe is to be designed (Sec. 1.4.1).
4. Whether pipe may be supplied from inventory (Sec. 1.5.1).
5. Whether a tabulated layout schedule (Sec. 1.5.2) will be required.
6. Identification marks required (Sec. 1.6).
7. Whether elliptical reinforcement is acceptable (Sec. 1.6 and Appendix A4).
8. Whether the purchaser desires to inspect the pipe and fittings at the manufacturer's plant (Sec. 1.7.1).
9. Whether steel test reports (Sec. 1.9.3) and test specimens (Sec. 1.9.4) will be required.
10. Whether submission of rubber gasket material test reports (Sec. 1.9.5 and 2.11.8) will be required.
11. Testing of welds (Sec. 1.9.6) if required.
12. Whether an affidavit of compliance (Sec. 1.10) will be required.
13. Type of cement required if there is a preference (Sec. 2.1.1).
14. Whether aggregate samples (Sec. 2.4) will be required.
15. Whether submission of manufacturer's design calculations (Sec. 3.2) will be required.
16. Type of protective coating on exposed portions of joint rings (Sec. 3.3.3) if there is a preference.
17. Whether submission for approval of details of materials and methods for welding (Sec. 3.5 and 3.6) will be required.
18. Whether a specific seal coat (Sec. 3.9) will be required.
19. Details of fittings (Sec. 4.1).
20. Testing of steel cylinders for fittings (Sec. 4.2 and 4.3).
21. Whether lining and coating of structural steel connections (Sec. 4.5) will be required.
22. Variance in curing if permitted (Sec. 3.8.1).

III—Major Revisions

The major revisions in this edition consist of the following:

1. The title has been changed to reflect the scope of the standard more accurately. The phrase "water pipe" has been changed to "pressure pipe," the term "not prestressed" was eliminated as redundant, and the following phrase was added: "for water and other liquids."
2. The entire standard was carefully reviewed, and changes were made in most of the sections to improve understanding and readability.
3. Use of the standard was improved by the addition of titles to all sections.
4. The format and terminology of the standard are patterned after AWWA C301–72 to establish a consistency in concrete pressure pipe standards.
5. The scope, which formely provided for pipe in sizes from 20 in. to 96 in., was changed to provide for sizes from 24 in. to 144 in. This change was made to conform to present industry practice.
6. Concrete admixtures for reducing water content and controlling setting time may be used by the manufacturer as provided in Sec. 2.6.
7. The laying length of pipe, previously required to be nominally 12, 14, or 16 ft, is now set at a minimum of 8 ft and a maximum of 20 ft for

24-in. to 36-in. pipe and 24 ft for 39-in. pipe and larger.

8. The minimum time required for steam curing has been reduced from 32 to 24 hr. The actual time used will depend on temperature, which may vary from 110F to 150F, and other conditions. This reduction does not relax the concrete strength requirements.

9. A design appendix has been added to the standard to provide a method of designing reinforced concrete cylinder pipe to resist internal pressures and external loads. This appendix provides a uniform approach to design so that the user of the standard will find it easier to undertake the design of the pipe and to review the manufacturer's computations. By incorporating all the design considerations in the appendix, it was possible to simplify Sec. 3, Design and Fabrication of Pipe.

American Water Works Association

AWWA C300–74

Revision of
AWWA C300–64

AWWA Standard for

Reinforced Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids

Section 1—General

Sec. 1.1—Scope

This standard covers the manufacture of reinforced concrete cylinder pipe that is not prestressed or pretensioned and is in sizes from 24 to 144 in., inclusive.* This type of pipe is designed for working pressures of 40 psi and higher that are combined with external loading conditions designated by the purchaser. This standard does not include requirements for handling, delivery, laying, field testing, or disinfection of the pipe.

Sec. 1.2—Definitions

In this standard, the following definitions shall apply:

1.2.1 *Purchaser.* The word "purchaser" shall mean a person, firm, corporation, or government subdivision entering into a contract or agreement to purchase pipe and fittings according to this standard.

1.2.2 *Contractor.* The word "contractor" shall mean the person, firm, or corporation executing the contract or agreement with the purchaser to furnish pipe and fittings according to this standard.

1.2.3 *Manufacturer.* The word "manufacturer" shall mean the person, firm, or corporation that actually manufactures the pipe, acting either directly as the contractor or as a subcontractor or supplier. If the manufacturer is acting as a subcontractor under the contractor or otherwise as a supplier to the contractor, the obligations of the manufacturer under this standard shall be considered as obligations of the contractor, and the contractor shall be responsible for the performance.

1.2.4 *ASTM.* The term "ASTM" does mean the American Society for Testing and Materials. When specific ASTM specifications are cited without dates, the designation shall be construed as referring either to the latest revision under the same specification number or to superseding specifications under a new number, except for provisions in the revised specifications that clearly are inapplicable.

* Pipe may be manufactured in larger diameters provided the purchaser is in full accord with the design.

1.2.5 *ANSI.* The term "ANSI" does mean the American National Standards Institute, Inc.

1.2.6 *Approved.* The term "approved" shall mean having received the approval of the purchaser.

1.2.7 *Working pressure.* The working pressure shall be the maximum sustained internal hydrostatic pressure to which the pipe is to be subjected.

1.2.8 *Transient pressures.* Transient pressures are internal pressure overloads of relatively short duration in excess of working pressure.

1.2.9 *Dead loads.* Dead loads are those loads due to the weights of the earth over the pipe, the water contained by the pipe, and the pipe itself.

1.2.10 *Live loads.* Live loads are those loads that result from the passage of vehicles over the installed pipe.

1.2.11 *Pipe diameter.* The term "pipe diameter" or "size" shall mean the design inside (waterway) diameter of the pipe.

Sec. 1.3—Essential Requirements

The pipe shall have the following principal features: a welded steel cylinder with steel joint rings welded to its ends; a reinforcing cage or cages of steel bars, wire, or welded wire fabric surrounding the steel cylinder; a wall of dense concrete covering the steel cylinder and reinforcing cage or cages inside and out; and a joint with a preformed gasket of rubber, so designed that the joint will be watertight under all conditions of service.

Sec. 1.4—Plans and Data to Be Furnished by Purchaser

1.4.1 *Design data.* The purchaser shall designate the working pressure, the transient pressure, the depth of earth cover, the trench bedding condition, and the live load for which the pipe shall be manufactured.

1.4.2 *Plans.* At least one month prior to manufacture, the purchaser shall furnish the contractor plans and profiles showing the following: alignment and grades; the location of all outlets, connections, and special appurtenances; the design pressures for each part of the line; and such special details or information as are necessary for the manufacture of the pipe and fittings in accordance with this standard and with the specific requirements of the work for which the pipe is made.

Sec. 1.5—Data to Be Submitted by Manufacturer

1.5.1 *Detailed drawings and schedules.* The manufacturer shall submit for approval of the purchaser drawings and schedules showing full details of the reinforcement, concrete, and joint dimensions for the pipe and fittings. All pipe and fittings shall be fabricated in accordance with these approved drawings and schedules. Pipe may be supplied from inventory unless the purchaser has indicated otherwise.

1.5.2 *Tabulated layout schedule.* When specifically required, the data submitted by the manufacturer shall include a tabulated layout schedule, with reference to the stationing and grade line shown on the drawings supplied by the purchaser. The schedule shall show pressure zones, and the point of change from one zone to the next shall be clearly indicated by station number. The diameter of the pipe, the working pressure and thickness of pipe wall, and the area of steel (per linear foot of pipe) in the reinforcing cage or cages and steel cylinder shall be listed for each portion of the pipeline.

Sec. 1.6—Marking

Each length of straight and special pipe and each fitting shall have plainly marked inside on the bell or spigot end the identification marks specified by the purchaser. These shall include the working pressure for which the pipe or fitting is designed. Special marks or identification sufficient to show the proper location of the pipe or fitting in the line by reference to layout drawings and schedules specified under Sec. 1.5 shall be placed on the pipe if specifically required. All beveled pipe shall be marked with the amount of the bevel, and the point of maximum pipe length shall be marked on the beveled end. If elliptical reinforcement is used, the minor axis of the reinforcement shall be identified.

Sec. 1.7—Inspection and Testing by Purchaser

1.7.1 *Inspection at manufacturer's plant.* If the purchaser desires to inspect pipe and fittings at the manufacturer's plant, the purchaser shall so specify in the contract or agreement, stating the conditions (such as the time and the extent of inspection) under which the inspection shall be made.

1.7.2 *Access to work.* The purchaser shall have free access to those parts of the manufacturer's plant that are necessary to assure compliance with this standard. The manufacturer shall make available for the purchaser's use such gages as are necessary for inspection. The manufacturer shall provide the purchaser with such assistance as is necessary for the handling of pipe and fittings.

1.7.3 *Responsibility.* Inspection by the purchaser or failure of the purchaser to provide inspection shall not relieve the manufacturer of his responsibility to furnish materials and to perform work in accordance with this standard.

1.7.4 *Tests.* Tests under Sec. 1.9 that the purchaser makes on material samples shall be made without delay. If any sample fails to meet the requirements, the manufacturer shall be notified immediately. Material affected by the test results shall be set aside pending final disposition. The manufacturer may then request a review of test procedures and additional tests on the material. Duplicate samples, the number of which is to be agreed upon, should be tested by the purchaser or his representative and by the manufacturer. The manufacturer's tests shall be performed by a commercial testing laboratory or in the manufacturer's laboratory, with proper certification. Tests by either party may be witnessed by the other. If the duplicate samples meet the test requirements, the material shall be accepted. If the material is rejected after retesting, the manufacturer shall pay all costs of retesting.

1.7.5 *Rejection.* Material, fabricated parts, and pipe that are discovered to be defective or that do not conform to the requirements of this standard will be subject to rejection at any time prior to final acceptance of the pipe. Rejected material and pipe shall be promptly removed from the site of the work.

Sec. 1.8—Material and Workmanship

All material furnished by the manufacturer shall be new and of the quality specified. All work shall be done in a thorough, workmanlike manner by mechanics skilled in their various trades. When a lower limit or minimum dimension is given herein for a steel com-

ponent, the minus tolerance (as stated in the applicable ASTM specification) for such limit or dimension shall be understood to define the true lower limit or dimension.

Sec. 1.9—Tests

1.9.1 *Cylinder assembly.* Each completed cylinder with joint rings welded to its ends shall be subjected to a hydrostatic test as specified under Sec. 3.5.3.

1.9.2 *Concrete.* Samples of the mixed concrete shall be taken for making compression test cylinders as specified under Sec. 3.7.4.

1.9.3 *Steel reports.* Mill test reports or plant test reports on each heat from which the steel is rolled shall be obtained by the manufacturer and made available to the purchaser on request.

1.9.4 *Steel specimens.* If required by the purchaser, the manufacturer shall provide test specimens cut from each shipment of steel for reinforcing and for cylinders.

1.9.5 *Gasket rubber.* Test reports showing the physical properties of rubber used in the gaskets, as specified in Sec. 2.11.8, shall be obtained by the manufacturer and shall be made available to the purchaser on request.

1.9.6 *Welds in reinforcement.* If required by the purchaser, samples of welds in reinforcing bars shall be tested for conformance with Sec. 3.6.

1.9.7 *Expense.* The expense of testing materials and submitting test reports to the purchaser in accordance with this standard and the purchaser's supplementary specifications, referred to in the foreword, of testing the completed steel cylinder in accordance with Sec. 1.9.1 and of testing concrete in accordance with Sec. 1.9.2 shall be borne by the manufacturer. All other tests shall be made by the purchaser at the purchaser's expense, except as otherwise specificially provided.

Sec. 1.10—Affidavit of Compliance

The purchaser may require an affidavit from the manufacturer that the pipe and fittings furnished under the purchaser's contract or agreement comply with all applicable provisions of this standard.

Section 2—Material Specifications

Sec. 2.1—Cement

2.1.1 *Type.* Cement for concrete work shall conform to the "Specifications for Portland Cement" (ASTM Designation C150). Either Type I or Type II may be used unless the purchaser specifies a particular type. Sampling and testing shall conform to the individual ATSM specification designated therein.

2.1.2 *Inspection.* Satisfactory facilities shall be provided for identifying, inspecting, and sampling cement at the mill, the warehouse, and the site of the work. The purchaser shall have the right to inspect the cement and obtain samples for testing at any of these points.

2.1.3 *Storage.* Cement shall be stored in a weathertight, dry, well-ventilated structure.

2.1.4 *Unusable.* Cement salvaged by cleaning cement sacks, mechanically or otherwise, shall not be used in the work. Cement containing lumps shall be rejected and shall be immediately removed from the site of the work.

2.1.5 *Temperature.* If the temperature of the cement exceeds 150F, it shall be stored until cooled to that temperature.

Sec. 2.2—Fine Aggregate

2.2.1 *General.* Fine aggregate for concrete and mortar shall consist of clean, hard, durable, uncoated particles of natural sand or of sand prepared from the product obtained by crushing stone or gravel. At the time of use the fine aggregate shall be entirely free of frozen material.

2.2.2 *Gradation.* Fine aggregate shall be well graded from coarse to fine and, when tested by means of laboratory sieves in accordance with the "Method of Test for Sieve or Screen Analysis of Fine and Coarse Aggregates" (ASTM Designation C136), shall conform to the gradation requirements in Table 1.

TABLE 1

Gradation Requirements for Fine Aggregate

Sieve Size	Total Passing, by Weight, %
⅜ In.	100
No. 4	95–100
No. 8	65– 98
No. 16	45– 80
No. 30	20– 70
No. 50	5– 50
No. 100	2– 10
No. 200	0– 5

The gradation requirements given in Table 1 represent the extreme limits for determining the suitability of fine aggregate under this standard. To maintain uniformity of gradation for aggregate from any given source, a fineness modulus determination shall be made upon representative samples from that source. Thereafter the fineness modulus of all shipments therefrom shall not vary by more than ±0.20 from the fineness modulus of the representative sample, unless suitable, approved mix adjustments are made.

2.2.3 *Impurities.* Fine aggregate shall be free from injurious amounts of organic impurities and shall conform to Sec. 4.2 of "Specifications for Concrete Aggregates" (ASTM Designation C33–71a).

Sec. 2.3—Coarse Aggregate

2.3.1 *General.* Coarse aggregate for concrete shall consist either of hard, durable particles of crushed stone or of crushed or uncrushed gravel that conforms to the requirements and tests given in Sec. 2.3.2 and 2.3.3.

2.3.2 *Gradation.* Coarse aggregate shall be well graded from coarse to fine. The maximum size and gradation shall be subject to the approval of the purchaser and shall be such that the concrete can be readily placed in the mold, by the particular method used in placing it, to provide a solid, compact, homogeneous wall with a smooth surface. Tests for gradation of coarse aggregate shall be in accordance with the "Method of Test for Sieve or Screen Analysis of Fine and Coarse Aggregates" (ASTM Designation C136). Thin and elongated pieces, the maximum dimension of which exceeds five times the minimum, shall not be

TABLE 2

Permissible Amounts of Deleterious Substances in Coarse Aggregate

Material	Maximum Weight Limit, %
Soft particles	5.00
Coal and lignite	0.50
Clay lumps	0.25
Material finer than 200 sieve	1.00
Combined total of above items	5.00

in excess of 10 per cent of the coarse aggregate by weight.

2.3.3 *Impurities.* Deleterious substances in coarse aggregate shall not exceed the amounts given in Table 2, as determined by sampling and testing procedures listed in the "Specifications for Concrete Aggregates" (ASTM Designation C33).

Sec. 2.4—Samples of Aggregates

At least four weeks prior to mixing concrete, the manufacturer, if required, shall provide, in suitable containers, samples of not less than 1 cu ft each of fine aggregate and coarse aggregate for preliminary approval. All samples shall be plainly labeled to indicate the source of the material, the date, and the name of the collector. Methods of sampling aggregates shall be in accordance with the "Methods of Sampling Aggregates" (ASTM Designation D75).

Sec. 2.5—Water

Water used for concrete and for curing pipe shall be fresh water and shall be clean and free from oil, acid, strong alkalies, or vegetable matter.

Sec. 2.6—Admixtures

At the option of the manufacturer, the concrete may contain a water-reducing, set-controlling admixture conforming to the "Specification for Chemical Admixtures for Concrete" (ASTM Designation C494). No admixture shall contain calcium chloride. The type and amount of admixture shall be subject to the approval of the purchaser.

Sec. 2.7—Steel for Cylinders and Fittings

2.7.1 *Steel sheets.* Steel sheets for pipe cylinders and fittings may be in cut lengths or coils and shall meet the requirements of the "Specifications for Hot-Rolled Carbon Steel Sheets and Strip, Structural Quality" (ASTM Designation A570), Grade B or C, or "Specifications for Hot-Rolled Carbon Steel Sheets and Strip, Commercial Quality" (ASTM Designation A569), except that for steel covered by ASTM A569, the maximum carbon content shall be 0.25 per cent and the minimum yield shall be 27,000 psi.

2.7.2 *Steel plates.* Steel plates for pipe cylinders and fittings shall conform to the "Specifications for Low and Intermediate Tensile Strength Carbon Steel Plates for Structural Quality" (ASTM Designation A283), Grade B or C.

Sec. 2.8—Steel for Bar, Wire, and Wire Fabric Reinforcement

2.8.1 *Bars.* Steel bar reinforcement for concrete pipe or fittings shall be plain or deformed and shall conform to "Specifications for Carbon Steel Bars Subject to Mechanical Property Requirements" (ASTM Designation A306), Grade 80, or to "Specifications for Deformed Billet-Steel Bars for Concrete Reinforcement" (ASTM Designation A615–68), Grade 40, except that for plain bars supplied under ASTM A615–68, (1) the requirements of Sections 6, 7, and 14.3 shall not apply, (2) intermediate bar diameters shall meet the requirements of the next smaller bar number designation, and (3) bar diameters less than No. 3 shall meet the requirements for No. 3 bar.

2.8.2 *Wire.* Steel wire for reinforcement of concrete pipe shall conform to the "Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement" (ASTM Designation A82) or to the "Specifications for Deformed Steel Wire for Concrete Reinforce-

ment" (ASTM Designation A496). Wire used for ties may be annealed.

2.8.3 *Wire fabric.* Wire fabric reinforcement for concrete pipe or for mortar coating for fittings shall conform either to the "Specifications for Welded Steel Wire Fabric for Concrete Reinforcement" (ASTM Designation A185) or to the "Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement" (ASTM Designation A497).

Sec. 2.9—Steel for Joint Rings

Steel for bell rings less than ¼ in. thick shall conform to "Specifications for Hot-Rolled Carbon Steel Sheets and Strip, Structural Quality" (ASTM Designation A570), Grade A, or to "Specifications for Hot-Rolled Carbon Steel Sheets and Strip, Commercial Quality" (ASTM Designation A569). Special shapes for spigot joint rings and steel for bell rings ¼ in. or more in thickness shall conform to "Specifications for Carbon Steel Bars Subject to Mechanical Property Requirements" (ASTM Designation A306), Grade 50, or to "Specifications for Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality" (ASTM Designation A283), Grade A, or to "Specifications for Merchant Quality Hot-Rolled Carbon Steel Bars" (ASTM Designation A575), Grade 1012, or to "Specifications for Special Quality Hot-Rolled Carbon Steel Bars" (ASTM Designation A576), Grade 1012, or to "Specifications for Steel Sheet and Strip, Carbon, Hot-Rolled Commercial Quality, Heavy-Thickness Coils (Formerly Plate)" (ASTM Designation A635).

Sec. 2.10—Steel Castings for Fittings

Steel castings for fittings shall conform to the "Specifications for Mild to Medium Strength Carbon Steel Castings for General Application" (ASTM Designation A27), Grade 70–36, normalized.

Sec. 2.11—Rubber for Gaskets

2.11.1 *General.* The gasket shall have smooth surfaces free from pitting, blisters, porosity, and other imperfections. The rubber compound shall contain not less than 50 per cent by volume of first-grade natural crude or first-grade synthetic rubber. The remainder of the compound shall consist of pulverized fillers free from rubber substitutes, reclaimed rubber, and deleterious substances. The compound shall meet the following physical requirements when tested in accordance with the indicated conditions and designated ASTM test methods.

2.11.2 *Tensile strength.* The tensile strength of the compound shall be at least 2,700 psi for natural rubber gaskets and 2,000 psi for synthetic rubber gaskets—"Method of Tension Testing of Vulcanized Rubber" (ASTM Designation D412).

2.11.3 *Elongation at rupture.* The elongation at rupture shall be at least 400 per cent for natural rubber gaskets and 350 per cent for synthetic rubber gaskets—"Method of Tension Testing of Vulcanized Rubber" (ASTM Designation D412).

2.11.4 *Specific gravity.* The specific gravity shall not vary by more than ±0.05 within the range of 0.95–1.45—"Methods for Chemical Analysis of Rubber Products" (ASTM Designation D297).

2.11.5 *Compression set.* The percentage of compression set shall not exceed 20. The compression set determination shall be made in accordance with "Methods of Test for Compres-

sion Set of Vulcanized Rubber" (ASTM Designation D395), Method B, with the exception that the disc shall be a $\frac{1}{2}$-in.-thick section of the rubber gasket stock.

2.11.6 *Tensile strength after aging.* After being subjected to an accelerated aging test for 96 hr in air at 70C in accordance with "Method of Test for Accelerated Aging of Vulcanized Rubber by the Oven Method" (ASTM Designation D573) or in a pressure chamber for 48 hr at 70C in an oxygen atmosphere at 300 psi in accordance with "Method of Test for Accelerated Aging of Vulcanized Rubber by the Oxygen-Pressure Method" (ASTM Designation D572), the tensile strength of the compound shall be not less than 80 per cent of the tensile strength before aging.

2.11.7 *Shore durometer.* The Shore A durometer hardness shall be in the range of 50 to 65 and shall be determined in accordance with "Method of Test for Indentation Hardness of Rubber and Plastics by Means of a Durometer" (ASTM Designation D2240–68), with the exception of Section 4 thereof. The determination shall be taken directly on the gasket.

2.11.8 *Test reports.* If required by the purchaser, the manufacturer shall submit test reports showing the physical properties of the rubber compound used in the manufacture of the gaskets.

Section 3—Design and Fabrication of Pipe

Sec. 3.1—General Requirements

3.1.1 *Laying lengths.* In general, pipe shall have a minimum nominal laying length of 8 ft, unless shorter lengths are required by weight or other considerations. The maximum lengths shall be as follows:

Internal Diameter *in.*	Maximum Laying Length *ft*
24 to 36 inclusive	20
39 and larger	24

3.1.2 *Diameter tolerances.* Pipe shall be round and true and shall have a smooth and dense interior surface. The mean internal diameter of any portion of each piece of pipe shall be not less than the design diameter or size specified by more than $\frac{1}{4}$ in. for 36-in. pipe, and smaller; by more than $\frac{3}{8}$ in. for 42-in. and 48-in. pipe; by more than $\frac{1}{2}$ in. for 54-in. to 78-in. pipe; or by more than $\frac{3}{4}$ in. for 84-in. pipe, and larger.

3.1.3 *Wall tolerances.* The minimum design thickness of pipe wall and the minimum thickness of concrete lining for each size of pipe shall be as shown in Table 3. At the spigot section, the concrete lining thickness may be less than shown in Table 3, provided that the interior surface of the lining at the spigot shall not depart from a true right cylinder projected from the interior surface of the lining in the body of the pipe. The thickness of walls shall be not less than the design thickness by more than $\frac{1}{8}$ in. for 36-in. pipe, and smaller; by more than $\frac{3}{16}$ in. for 42-in. and 48-in. pipe; by more than $\frac{1}{4}$ in. for 54-in. to 72-in. pipe; or by more than $\frac{3}{8}$ in. for pipe larger than 72 in.

Sec. 3.2—Design of Pipe

The reinforcement of the pipe shall consist of a welded steel cylinder surrounded by one or more cages of welded steel hoops, helically wound steel bar or wire, or welded wire fabric

TABLE 3

*Requirements for Pipe of Various Sizes**

Pipe ID in.	Minimum Thickness	
	Total Pipe Wall in.	Concrete Lining in.
24	3½	1
30	3½	1
36	4	1
42	4½	1
48	5	1¼
54	5½	1¼
60	6	1¼
66	6½	1½
72	7	1½
78	7½	1½
84	8	1½
90	8	1¾
96	8½	1¾

* For pipe larger than 96 in. in diameter, dimensions and details of design shall be subject to approval by the purchaser.

properly spaced and supported with longitudinal reinforcing. The minimum thickness of the cylinder shall be 16 gage. The cross-sectional area of the circumferential steel in the cylinder and in the reinforcing cage or cages shall be such that the conditions required by the design methods in the appendix are met. If required by the purchaser, the manufacturer shall submit design calculations for approval prior to the manufacture of any pipe.

Sec. 3.3—Joint Rings

3.3.1 *General.* The steel bell and spigot joint rings shall be so designed and fabricated that when the pipe is laid and the joint completed, the gasket will be enclosed on four sides. Each ring shall be formed by one or more pieces of steel butt-welded together. The contact surfaces in the joint shall be such as not to cause cutting of the rubber gasket during installation. Welds on gasket contact surfaces shall be ground smooth and flush with the adjacent surfaces. The rings shall be expanded by a press beyond their elastic limits so that they are accurately sized.

3.3.2 *Tolerances.* On the finished pipe, the circumference of the inside bell ring contact surface shall not exceed the circumference of the outside spigot ring contact surface by more than $\frac{3}{16}$ in. for gaskets $\frac{3}{4}$ in. in diameter or by more than $\frac{1}{4}$ in. for gaskets greater than $\frac{3}{4}$ in. in diameter. The out-of-roundness of either contact surface, measured as the difference between the maximum and minimum joint ring diameters, shall not exceed 0.5 per cent of the average of these diameters. The minimum thickness of the completed bell rings shall be $\frac{3}{16}$ in. for 36-in. pipe, and smaller, and $\frac{1}{4}$ in. for pipe larger than 36 in. The rings shall conform to the details submitted by the manufacturer and approved by the purchaser.

3.3.3 *Protective coating.* The portions of the joint rings that will be exposed on the completed pipe shall be protected from corrosion by an approved coating.

Sec. 3.4—Rubber Gaskets

Joints shall be sealed with a continuous solid-ring rubber gasket having a circular cross section with a diametral tolerance of $\pm\frac{1}{64}$ in. Gaskets shall be of sufficient volume to fill substantially the recess provided when the pipe joint is assembled, so that the gasket will be compressed to form a pressure-tight seal. The gasket shall be the sole element depended upon to make the joint watertight.

Sec. 3.5—Fabrication of Steel Cylinders

3.5.1 *General.* The cylinders shall be formed by shaping and welding to-

gether cut lengths or coils of specified material and thickness. The cylinders shall be accurately shaped to the size required, and the joint rings shall be welded to the ends before testing.

3.5.2. *Welding.* Butt-welding, lap-welding, or offset lap-welding, shall be used for the longitudinal and circumferential or helical seams. The sheets shall be closely fitted prior to welding and shall be firmly held during welding. If required, the manufacturer shall submit for approval the specific details of materials and methods he proposes to use before any welding is done.

3.5.3 *Hydrostatic test.* Each steel cylinder, with joint rings welded to its ends, shall be subjected to a hydrostatic test. When the cylinder is tested in a horizontal position, the stress shall be at least 20,000 psi, but not greater than 25,000 psi. When the cylinder is tested in a vertical position, the stress at the lower end shall be 25,000 psi. While under pressure test, all welds shall be thoroughly inspected and all parts showing leakage shall be marked. Cylinders that show any leakage under test shall be rewelded at the points of leakage and subjected to another hydrostatic test. The finished cylinder, with joint rings attached, shall not be used in the work unless it is completely watertight under the required test pressure.

3.5.4 *Cleaning steel surfaces.* Before the concrete is placed, steel surfaces shall be cleaned to remove loose or other foreign matter that would interfere with the bonding of the concrete.

Sec. 3.6—Fabrication of Reinforcement Cage

3.6.1 *Circumferential reinforcement.* The circumferential reinforcement shall either be steel bar or wire in helical or hoop form or be welded wire fabric shaped and lap- or butt-welded into cages. The quality of the welds and welding procedures shall be assured by the testing of a representative number of butt or lap welds to a test stress of 25,000 psi.

3.6.2 *Longitudinal reinforcement.* The circumferential reinforcement in cages shall be accurately spaced and rigidly assembled by the attaching of longitudinal bars securely, so that the cage is maintained in proper shape and position during the casting of the pipe.

3.6.3 *Placement.* The minimum distance between the circumferential reinforcing steel and the surface of the pipe shall be 1 in.

Sec. 3.7—Concrete for Pipe

3.7.1 *Proportioning.* The proportions of cement, fine aggregate, coarse aggregate, and water used in concrete for pipe shall be subject to the approval of the purchaser. The proportions shall be determined and controlled as the work proceeds in order to obtain homogeneous, dense, workable, durable concrete of specified strength in the wall of the pipe and a minimum of defects in the surface of the pipe. The proportions shall be those that will give the best overall results with the particular materials used for the work. A minimum of six bags of cement shall be used for each cubic yard of concrete. The water–cement ratio shall be such as to assure that the concrete will meet the strength requirements.

3.7.2 *Measurement of materials.* A barrel of cement shall be considered 4 cu ft or 376 lb, and a bag of cement shall be considered 1 cu ft or 94 lb. Cement in standard sacks need not be weighed, but bulk cement shall be weighed. Water for mixing shall be measured by volume or by weight.

Concrete aggregates for each batch shall be measured separately by weighing. The proportions of aggregates shall be computed on both the saturated and surface-dry basis, and the water-cement ratio shall exclude the water absorbed by the aggregates. The equivalent unit weights for both fine and coarse aggregates shall be determined in accordance with the "Method of Test for Unit Weight of Aggregate" (ASTM Designation C29). The equipment and devices for weighing and measuring shall at all times be accurate within 1 per cent.

3.7.3 *Mixing.* The mixing shall be thoroughly done by a mixer of accepted type. Mixing time shall be consistent with the type of mixer used. Transit mixing shall not be used except by written authorization and under specific requirement of the purchaser.

3.7.4 *Standard test cylinders.* A set of at least four standard test cylinders shall be taken from each day's pour of the mixed concrete. Standard test cylinders shall be made in conformance with the "Method for Making and Curing Concrete and Compressive and Flexural Test Specimens in the Field" (ASTM Designation C31). The curing of the test cylinders shall be in conformity with the curing of the pipe.

3.7.5 *Testing cylinders.* All test cylinders shall be tested by an approved testing laboratory at the expense of the manufacturer, unless the manufacturer has approved testing facilities at the site of the work. In such event, the tests shall be made by the manufacturer in the presence of the purchaser and at the manufacturer's expense or, if permitted by the purchaser, certified test reports may be submitted by the manufacturer.

3.7.6 *Strength of concrete.* The design strength of concrete shall be the strength used in designing the pipe by the method described in the Design Appendix. The design strength of concrete shall be not less than 4,500 psi for vertically cast concrete or 6,000 psi for centrifugally cast concrete. The compressive strength of concrete cylinders shall equal or exceed $\frac{3}{4}$ of the design strength in 7 days and the design strength in 28 days. To conform to the requirements of this section, the average of any ten consecutive strength tests of cylinders representing each type of concrete shall be equal to or greater than the design strength, and no cylinder shall have a strength less than 80 per cent of the design strength. Damaged cylinders shall be discarded. Pipe made from concrete that does not meet the strength tests in accordance with the foregoing shall be subject to rejection.

3.7.7 *Forms.* The forms shall be of steel made with butt joints throughout and with the interior surface smooth and true. The forms shall be so constructed that the inner and outer forms, joint rings, and reinforcement shall be held in position throughout placing of the concrete and so designed that the pipe can be stripped from the forms rapidly and without damage to the pipe surfaces. Forms shall be sufficiently tight to prevent leakage of mortar, and they shall be stiff enough and so braced as to withstand, without deformation, all operations incident to the pouring and setting of the concrete. Forms shall be cleaned and oiled before each use.

3.7.8 *Placing concrete.* The transporting and placing of concrete shall be carried out by methods that will not cause the separation of concrete materials or the displacement of the steel cylinder and reinforcement from their

proper positions in the form. Accepted methods of mechanical vibrating shall be used to compact the concrete in the forms and to secure satisfactory interior surfaces. Forms shall not be removed until the concrete has set sufficiently to avoid spalling or damage to the pipe during removal of the form.

Sec. 3.8—Curing of Pipe

3.8.1 *General.* The purpose of curing pipe as prescribed in the following sections is to obtain concrete of the strength specified for test cylinders under Sec. 3.7.6. The pipe shall be cured by steam or by water unless otherwise specifically permitted. Water curing and steam curing may be used interchangeably on a time–ratio basis of 4 hr of water to 1 hr of steam curing except that the water curing may be used only if the minimum ambient temperature exceeds 40F.

3.8.2 *Steam curing.* The pipe shall be placed in the steam-curing chamber or otherwise covered by a suitable enclosure that will allow proper circulation of steam. A delay period of from 1 to 4 hr shall be allowed before moist steam is admitted to contact the pipe. The temperature within the enclosure shall be gradually raised to at least 110F and to not more than 150F for a period of at least 24 hr. The delay period shall be included in the 24-hr period. Curing by steam shall be continuous except during a period sufficient to remove the forms or supporting rings. The forms shall not be removed until at least 6 hr after the begining of the curing. After this minimum 6-hr period, the pipes may be "tipped" from their bases, and curing shall be continued by either steam or water.

3.8.3 *Water curing.* The pipe shall be kept moist by intermittent water spraying for a period of at least 32 hr. The water-curing period shall be extended 1 hr for each hour in the first 24 during which the ambient air temperature is below 50F. Following this minimum period, they may be "tipped" from their bases but shall be kept continuously moist by intermittent spraying for an additional period of at least 3 days.

Sec. 3.9—Seal Coat

If the purchaser specifically orders a bituminous seal coat, the materials and application shall comply with the appropriate provisions of AWWA C104 (ANSI A21.4) insofar as they are applicable. The material shall be applied after the pipe is cured.

Section 4—Fittings and Special Pipe

Sec. 4.1—General

Fittings and special pipe shall include bends, tees, wyes, connections to main-line valves, closures, beveled pipe for curves, and pipe with outlets required for manholes, air valves, and blowoffs, as shown on the purchaser's drawings or as ordered by the purchaser. Fittings shall conform to the details furnished by the purchaser or, if required, to the details furnished by the manufacturer and approved by the purchaser. Fittings shall be either type

as described in Sec. 4.2 and 4.3 at the option of the manufacturer and shall be designed for the same pressures as the pipe.

Sec. 4.2—Fittings (Type A)

Type A fittings are composed of steel cylinders, concrete or mortar lining, and reinforced concrete or mortar exterior coating. The steel for the cylinder shall be cut, shaped, and welded to form the properly shaped bend, tee, reducer, or other fitting. The welds shall be inspected, and the completed cylinder shall be tested for tightness by the dye penetrant method or other approved method, if specifically required by the purchaser. A cage or cages of steel reinforcement with approved cross-sectional areas shall be formed around the cylinder and openings. Longitudinal reinforcement sufficient for the additional stresses in the fitting walls shall be provided. The interior and exterior concrete or mortar shall be placed in an accepted manner. Curing shall be as specified in Sec. 3.8.

Sec. 4.3—Fittings (Type B)

Type B fittings are composed of cut and welded steel plate of a thickness to provide the design strength, with mortar coating on interior and exterior surfaces.

4.3.1. *Steel fabrication.* The steel for the fabricated steel plate fittings shall be cut, shaped, and welded so that the finished fitting shall have the required shape and interior dimensions. The deflection angle between adjacent segments of a bend shall be no greater than 22½ deg. Adjacent segments shall be joined by lap or butt welding. Fabrication and welding shall conform to the requirements of Sec. 3.5 of this standard. The welds shall be inspected, and the completed cylinder shall be tested for tightness by the dye penetrant method or other approved method, if specifically required by the purchaser.

4.3.2 *Reinforcement.* Wire fabric reinforcing shall be applied to the interior and exterior surfaces of the fabricated fitting. The reinforcement shall be 2 × 4-in. W1 welded-wire fabric, held ⅜ in. from the surfaces of the steel plate. The members on the 2-in. spacing shall extend circumferentially around the fitting, with ends overlapped 4 in. and tied together. Longitudinal splices shall be staggered.

4.3.3 *Mortar.* Steel plate fittings shall be lined with mortar at least ¾ in. thick at adapter ends, or outlets, but under no conditions shall the lining be less than ⅜ in. thick. The exterior shall be coated with mortar at least 1 in. thick. The mortar shall contain no less than 1 part cement to 3 parts sand of a grading approved for the method of application used.

4.3.4 *Curing.* Mortar-lined and mortar-coated fittings in Sec. 4.3.3 shall be cured by water spraying, by steam, or by curing compounds. The curing compounds shall meet the requirements of "Liquid Membrane—Forming Compounds for Curing Concrete" (ASTM Designation C309), Type II, white pigmented.

Sec. 4.4—Curves, Bends, and Closures

Long radius curves and small angular changes in pipe alignment shall be formed by deflecting joints, by straight pipe with beveled ends, by bevel adapters, or by a combination of them. Pipe ends may be beveled up

to 5 deg. Short-radius curves and closures shall be formed by fittings.

Sec. 4.5—Openings and Connections

Manholes and flanges, spigot or bell connections for air valves, blow offs, or connections to other pipe shall be built into the walls of the concrete pipe at locations shown on the purchaser's drawings or ordered by the purchaser. Wall openings shall be suitably reinforced. If required, the interior and exterior surfaces of structural steel connections shall be lined and coated with mortar.

Appendix A

Design Requirements

This appendix is for information and is not a part of AIVIVA C300–74.

A1—General

Reinforced concrete cylinder pipe covered by this standard shall be designed by the method described herein to resist the internal pressures and external loads designated by the purchaser.

A2—Hydrostatic Design

To resist internal pressure alone, the cross-sectional area of the circumferential steel reinforcement shall be no less than the maximum determined from equations (1) and (2):

$$A_s = \frac{6P_w D_y}{12{,}500} \qquad (1)$$

$$A_s = \frac{6(P_w + P_t)D_y}{16{,}500} \qquad (2)$$

A_s = Cross-sectional area of circumferential steel reinforcement, including the steel cylinder, square inches per foot of pipe wall
P_w = Working pressure, psi
P_t = Transient pressure, psi
D_y = Inside diameter of steel cylinder, inches

A3—Combined Load Design

The pipe shall be designed to resist the flexural and axial stresses from each of the following load conditions:

1. A combination of working pressure, transient pressure, and dead loads (earth, pipe, and water)
2. A combination of working pressure, dead loads, and live loads
3. Dead loads and live loads with no internal pressure.

External dead loads and live loads shall be computed in accordance with recognized and accepted theories, such as presented in *Soil Engineering* by M. G. Spangler [International Textbook Co., Scranton, Pa. (2nd ed., 1960), pp. 396–418] and in *Concrete Pipe Design Manual* [American Concrete Pipe Assn., Arlington, Va., (1970)].

The coefficients for moment and thrust shall also be from recognized and accepted theories, such as presented in "Stress Coefficients for Large Horizontal Pipes" by J. M. Paris [*Engineering News-Record*, vol. 86, p. 768 (1921)] and in "Stress Analysis of Concrete Pipe" by H. C. Olander [Eng. Monograph No. 6, US Bureau

of Reclamation, Dept. of the Interior, Washington, D.C.]. The bedding angle used in design shall be compatible with the installation specified by the purchaser.

The reinforced concrete design shall be according to the applicable provisions of ACI Standard 318, with either the strength method or the alternate design method (working stress method) being used.

For the strength method, the load factor shall be 1.8; the capacity reduction factor, ϕ, shall be 1.0; and an equivalent rectangular concrete stress distribution shall be used. The design yield strength, f_y, shall not exceed 40,000 psi for the sides of the pipe, and the design yield strength shall not exceed the value determined by equations (3a) or (3b) for the crown and invert of the pipe.

f_{yi} = 27,000 psi, where $A_r < \frac{1}{3}(A_r + A_y)$ (3a)

f_{yi} = 33,000 psi, where $A_r \geq \frac{1}{3}(A_r + A_y)$ (3b)

f_{yi} = Design yield strength for the crown and invert of the pipe, psi

A_r = Cross-sectional area of rod reinforcement in the tensile zone of the crown and invert, square inches per foot of pipe wall

A_y = Cross-sectional area of steel cylinder, square inches per foot of pipe wall

For the alternate design method, the load and ϕ factors shall each be 1.0; the calculated compressive stress in the concrete shall not exceed 0.45 f_c' (the specified 28-day compressive strength); and the allowable tensile stress in the reinforcement shall not exceed 22,000 psi at the sides of the pipe and shall not exceed the value determined by equation (4) for the crown and invert of the pipe, with the applicable value of f_{yi} from (3a) or (3b) being used.

$$f_{si} = 0.55 f_{yi} \quad (4)$$

f_{si} = Allowable tensile stress for the inner layer of steel reinforcement at the crown and invert, psi

When the transient pressure is combined with other loads, the required capacity for the strength method shall be reduced by 25 per cent, or allowable stresses for the alternate method shall be increased by one third. The provisions of this paragraph apply only to load condition 1.

A4—Reinforcement Cage Configurations

Reinforcement shall consist of a steel cylinder and one or more cages. The cages may be circular or elliptical in shape and may be used singly or in combination. The cross-sectional area of the circumferential rod reinforcement per linear foot of pipe shall be no less than 40 per cent of the total area of reinforcement per linear foot of pipe. When the reinforcement consists of a combination containing an elliptical cage, the cross-sectional area of the circular reinforcement, including the steel cylinder, shall be no less than that determined by Eq (1), with an allowable steel stress of 25,000 psi.

The design depth of the pipe wall section shall be taken to the centroid of the tensile steel. The design clear concrete cover for an outer circular cage or for the horizontal axis of an elliptical cage shall be 1½ in. For the steel cylinder, the design clear cover shall be the nominal lining thickness designated by the manufacturer but no less than the minimum lining thickness shown in Table 3 of Sec. 3.1.3.