Designation: D 2924 – ~~99~~01

An American National Standard

Standard Test Method for External Pressure Resistance of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe[1]

This standard is issued under the fixed designation D 2924; 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.

1. Scope*

1.1 This test method covers determination of the resistance of fiberglass pipe to external pressure. It classifies failures as buckling, compressive, and leaking. Both glass-fiber-reinforced thermosetting-resin pipe (RTRP) and glass-fiber-reinforced ~~plastic~~ polymer mortar pipe (RPMP) are fiberglass pipes.

NOTE 1—For the purposes of this standard, polymer does not include natural polymers.

1.2 The values stated in inch-pound units are to be regarded as standard. The SI units given in parentheses are for information only.

NOTE ~~1~~2—There is no similar or equivalent ISO standard.

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:*

C 33 Specification for Concrete Aggregates[2]

[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics, and is the direct responsibility of Subcommittee D20.23 on Reinforced Plastic Piping Systems and Chemical Equipment.

Current edition approved ~~March~~ June 10, ~~1999.~~ 2001. Published ~~June 1999.~~ August 2001.. Originally published as D 2924 – 70. Last previous edition D 2924 – 9~~3~~9.

***A Summary of Changes section appears at the end of this standard.**

D 618 Practice for Conditioning Plastics ~~and Electrical Insulating Materials~~ for Testing[3]
D 883 Terminology Relating to Plastics[3]
D 1600 Terminology for Abbreviated Terms Relating to Plastics[3]
F 412 Terminology Relating to Plastic Piping Systems[4]

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions are in accordance with Terminology D 883 or F 412 and abbreviations are in accordance with Terminology D 1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aggregate*, *n*—a siliceous sand conforming to the requirements of Specification C 33, except that the requirements for gradation shall not apply.

3.2.2 *buckling failure pressure*— the external gage pressure at which buckling occurs. Buckling is characterized by a sharp discontinuity in the pressure-volume change graph and subsequent fracture in the test specimen appearing as an axially oriented crack. Buckling is an elastic instability type of failure and is normally associated with thin-wall pipe.

3.2.3 *compressive failure pressure*—the maximum external gage pressure that the specimen will resist without transmission of the testing fluid through the wall. Compressive failure pressure will not be associated with a sharp discontinuity in the pressure-volume change graph nor lead to a fracture appearing as a sharp axially oriented crack. It will appear as a fracture which is the result of reaching the compressive strength limits of the material and is normally associated with thick-wall pipe. Failure is usually identified by a sudden drop in pressure.

3.2.4 *fiberglass pipe*, *n*—a tubular product containing glass fiber reinforcements embedded in or surrounded by cured thermosetting resin; the composite structure may contain aggregate, granular, or platelet fillers, thixotropic agents, pigments, or dyes; thermoplastic or thermosetting liners or coatings may be included.

3.2.5 *leaking pressure*—the external gage pressure at which the test fluid is transmitted through the pipe wall. It is characterized in this test by continuous volume change indications with no pressure increase.

3.2.6 *reinforced ~~plastic~~ polymer mortar pipe (RPMP)*, *n*—a fiberglass pipe with aggregate.

3.2.7 *reinforced thermosetting resin pipe (RTRP)*, *n*—a fiberglass pipe without aggregate.

4. Summary of Test Method

4.1 This test method consists of loading a specimen to failure in a short time interval by means of continuously increasing external fluid pressure at a controlled constant temperature. Fluid is also maintained inside the pipe, and changes in the inside volume are monitored with a bleed hole and fluid level tube. On Cartesian coordinates, pressure versus change in volume is plotted and the failure pressure selected as indicated by the graph. Scaling constants are presented for extending the results to other diameters.

5. Significance and Use

5.1 The values obtained by this test method are applicable only to conditions that specifically duplicate the procedures used.

5.2 After a scaling constant is determined for one diameter, this may be used for calculating the external failure pressures of other diameters as long as the resin and reinforcement (if used), the wall thickness-to-diameter ratio, and the reinforcement pattern (if reinforcement is used) are the same.

NOTE ~~2~~3—Based upon tests conducted on one size of pipe, a scaling constant is calculated according to 11.1 or 11.2. The appropriate constant is used to calculate failure pressure for other pipe diameters, but it can only be applied if the same resin and reinforcement are used, the wall thickness to diameter ratios are similar, and the reinforcement pattern is constant.

5.3 In the application of the following test requirements and recommendations, care must be exercised to ensure that the specimens tested are truly representative of the group being studied.

6. Apparatus (see Figs. 1 and 2)

6.1 *Test Chamber*—An external chamber capable of withstanding pressures to be encountered. It may be either the type that applies both hoop and axial loads as shown in Fig. 1 or the type that applies hoop load only as shown in Fig. 2. In either event, the report shall state which type loading was used for test.

6.2 *Volume or Weight Change Indicator*—The specimen shall be instrumented to measure changes in volume or weight. One of the following two devices shall be used.

6.2.1 *Transparent Tube*—connected to the test specimen so that the volume changes of the specimen result in changes in the level of fluid in the tube. A scale shall be affixed to the tube so variations in fluid level can be recorded. Absolute measurement of volume change is not required.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.
[3] *Annual Book of ASTM Standards*, Vol 08.01.
[4] *Annual Book of ASTM Standards*, Vol 08.04.

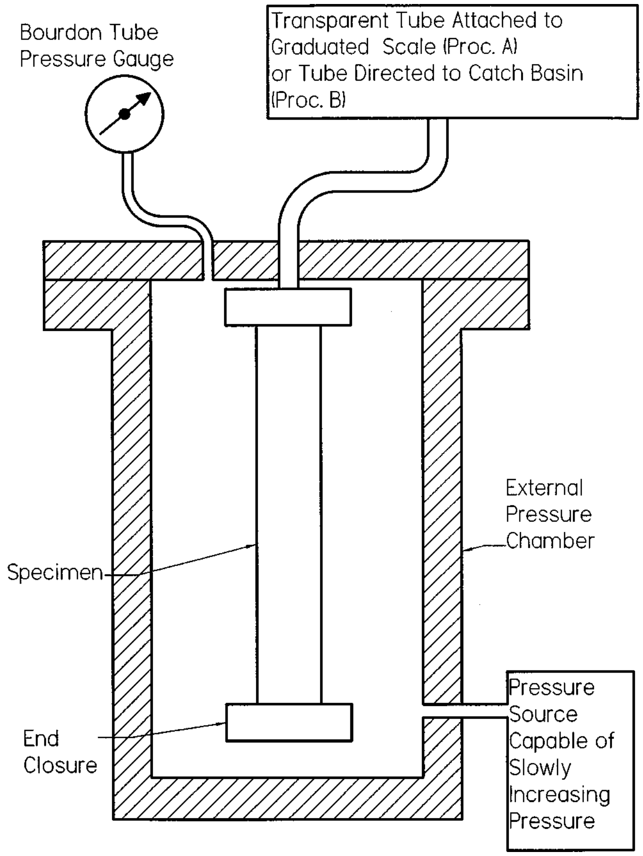

FIG. 1 Apparatus Showing Specimen Loading with Both Hoop and Axial Loads

6.2.2 *Scale*—A balance accurate to within ±0.1 g.

6.3 *Pressurizing System*—A device capable of exerting external fluid pressure to the specimen at a specified constant rate. A Bourdon-tube pressure gage or recording gage with an accuracy of± 1 % of full scale should be used, and the anticipated failure pressure should be in the middle two thirds of the gage range. Care should be exercised so the gage is placed where it will give a true reading of the external pressure on the test specimen.

6.4 *Test Fluid*—Water or hydraulic oil.

6.5 *Timer*—Any time-measuring device that can measure the duration of test with accuracy of 1 s.

6.6 *Temperature Regulator*—When temperatures other than ambient are being studied, a temperature-regulating system will be employed that will maintain the temperature of the testing fluid and specimen at a specified amount ±2°C.

7. Test Specimens

7.1 *Number of Specimens*—A minimum of five specimens shall be used for determining the external pressure resistance. Any specimens that are tested and fall outside the specified time limits shall be discounted and replaced with equivalent specimens, so that a minimum of five valid specimens are tested.

7.2 *Specimen Size*—The inside and outside diameters of the pipe specimens shall be as fabricated, with the permissible exception of that portion of the pipe within 2 in. (50 mm) of the end closures. The minimum specimen length exposed to external pressure shall be the greater of:

$$L = 10(D)$$

or Roark's formula for long tube length:[5]

$$L = 4.90r\sqrt{\frac{r}{t}}$$

[5] Roark, Raymond J., *Roark's Formulas for Stress and Strain*, McGraw-Hill Book Company, New York, NY, Sixth Edition, 1989, p. 690.

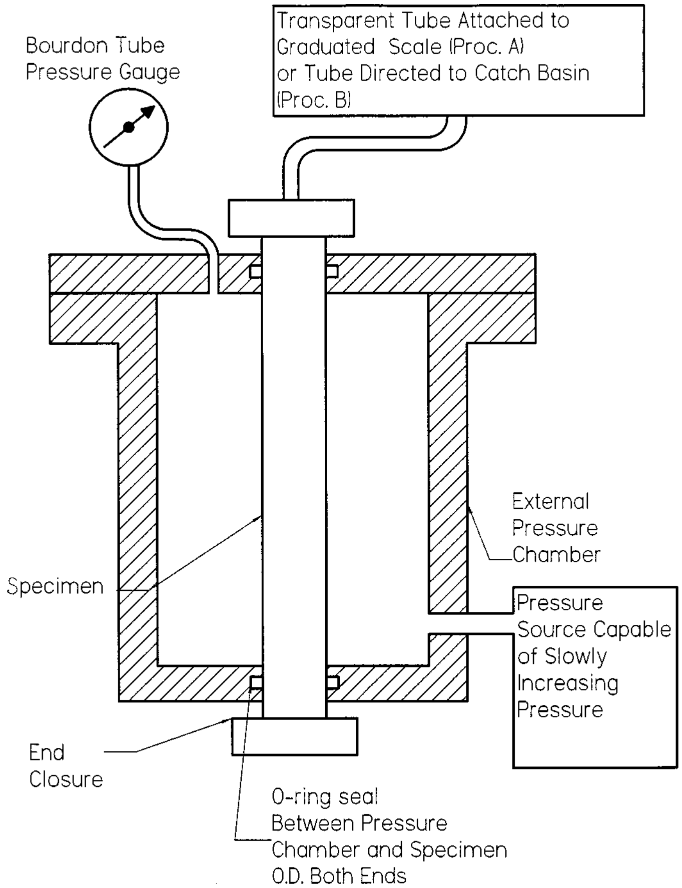

FIG. 2 Apparatus Showing Specimen Loading with Hoop Load Only

where:
L = length of test specimen exposed to external pressure, in. (or mm),
D = average outside diameter of pipe, in. (or mm),
r = mean wall radius (do not include unreinforced liner), in. (or mm), and
t = minimum wall thickness (do not include unreinforced liner), in. (or mm).

8. Conditioning

8.1 All samples shall be conditioned for a minimum of 2 h in the fluid in which they will be tested. The temperature of the fluid shall be uniform and stabilized to within ±2°C of the test temperature during conditioning.

9. Procedure A

9.1 Mount the specimen in the test chamber and fit the specimen with the volume change measuring tube with both external and internal volumes filled with the test fluid. Take care to expel all air from the inside of the specimen as any gaseous fluid escaping through the measuring tube during test will disqualify the test.

9.2 Condition the system at a temperature in accordance with Section 8.

9.3 Increase the pressure at a constant rate so failure occurs in not less than 1 min nor greater than 5 min. As the pressure is being increased, take readings of the pressure and associated volume change so a buckling pressure, if present, can be ascertained. Rapidly increasing volume change indications with a reduction in the pressurizing rates constitutes failure. Continue the test until the specimen fractures, if possible.

9.4 After the specimen has failed, remove it from the external pressure chamber and observe and record appearance.

9.5 Make a graph showing external pressure versus volume change. A sharp change in slope indicates either a buckling pressure or a pressure at which the pipe wall transmitted fluid. Either condition is classified as failure.

10. Procedure B

10.1 Mount the specimen in the test chamber and fill both internal and external volumes with the test fluid. Take care to expel all air from the inside of the specimen as any gaseous fluid escaping through the measuring tube during the test will disqualify the test. Fit the specimen with a tube to direct the fluid into a suitable basin for collecting and weighing. Condition the system at a temperature in accordance with Section 8.

10.2 Increase the pressure at an incremental rate. The increment shall be chosen to allow at least 10 readings before failure. After the fluid has stopped flowing from the tube, record the pressure and weight of the fluid displaced. Rapidly increasing weight of displaced fluid with a small increase in pressure indicates failure. Continue the test until the specimen fractures, if possible. Record the time to failure.

10.3 After the specimen has failed, remove it from the external pressure chamber and observe and record appearance.

10.4 Make a graph showing external pressure versus weight of fluid displaced. A sharp change in slope indicates either a buckling pressure or a pressure at which the pipe wall transmitted fluid. Either condition is classified as failure.

11. Calculation

11.1 For specimens that failed by buckling, calculate a buckling scaling constant as follows:

$$K = P/E\,(r/t)^3$$

where:
K = buckling scaling constant,
P = external collapse pressure, psi (or MPa),
E = circumferential modulus of elasticity,
r = mean wall radius (do not include unreinforced liner in reinforced wall), in. (or mm), and
t = minimum wall thickness (do not include unreinforced liner in reinforced wall), in. (or mm).

11.2 For specimens that failed by collapse, calculate a compressive failure scaling constant as follows:

$$C = P_c(D - t)/2t$$

where:
C = compressive failure scaling constant,
P_c = pressure at failure, psi (or MPa),
D = the average outside diameter of the specimen, in. (or mm), and
t = minimum pipe wall thickness (do not include liner in filament reinforced wall), in. (or mm).

11.3 Calculate the average failure pressure for all five specimens tested.

11.4 Calculate the average scaling constant for all five specimens tested.

12. Report

12.1 Report the following information:

12.1.1 Complete identification of the specimens, including material type, source, manufacturer's name, pipe trade name, and previous history,

12.1.2 *Pipe Dimensions*—Record dimensions of each specimen including nominal size, length exposed to external pressure, minimum wall thickness, and average outside diameter. The wall thickness and outside diameter shall be reinforced dimensions only. Unreinforced thickness shall also be recorded.

12.1.3 Test temperature and test fluid, (water or oil),

12.1.4 Type of loading used (hoop only or both hoop and axial), and procedure used (A or B),

12.1.5 Failure pressures for each specimen tested and the average,

12.1.6 Type of failure (buckling, compressive, or leaking),

12.1.7 Time to failure of each specimen tested,

12.1.8 Scaling constant (see 11.1 for buckling failures, 11.2 for compressive failures, no scaling permitted for leaking failures), and

12.1.9 Date of test.

13. Precision and Bias

13.1 The precision of this test method was determined from the results of one laboratory performing one set of tests by each loading method on each of six pipe sizes and conditions.

13.2 The following values of precision have been calculated from the above test program.

NOTE ~~3~~4—These values were developed using Procedure A. The samples were conditioned at 23 ± 2° (73.4 ± 3.6F) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D 618.

The critical differences indicate the maximum deviation of results beyond which measured values should be considered suspect at a probability level of 0.95. They are expressed as percentages of the mean value.

13.2.1 *Hoop Load Method*—For individual values within a set of five, the precision is ±8.4 %. Between averages of five determinations, the precision is ±4.9 %.

13.2.2 *Axial and Hoop Load Method*—For individual values within a set of five, the precision is ±13.1 %. Between averages of five determinations, the precision is ±7.6 %.

13.3 There are presently no definite means of establishing a true value, so no bias statement can be made.

14. Keywords

14.1 external pressure resistance; fiberglass pipe; pipe; reinforced ~~plastic~~ polymer mortar pipe (RPMP); reinforced thermosetting-resin pipe (RTRP)

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue, D 2924–99, that may impact the use of this standard.

(1) Changed acronym, RPMP, definition form reinforced *plastic* mortar pipe to reinforced *polymer* mortar pipe.