



Standard Test Method for External Pressure Resistance of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe¹

This standard is issued under the fixed designation D2924; 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 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 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:*²

[C33 Specification for Concrete Aggregates](#)

[D618 Practice for Conditioning Plastics for Testing](#)

[D883 Terminology Relating to Plastics](#)

[D1600 Terminology for Abbreviated Terms Relating to Plastics](#)

[F412 Terminology Relating to Plastic Piping Systems](#)

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions are in accordance with Terminology [D883](#) or [F412](#) and abbreviations are in accordance with Terminology [D1600](#), unless otherwise indicated.

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

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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.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aggregate, n*—a siliceous sand conforming to the requirements of Specification [C33](#), 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 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 incrementally 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

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

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 3—Based upon tests conducted on one size of pipe, a scaling constant is calculated according to 10.1 or 10.2. 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

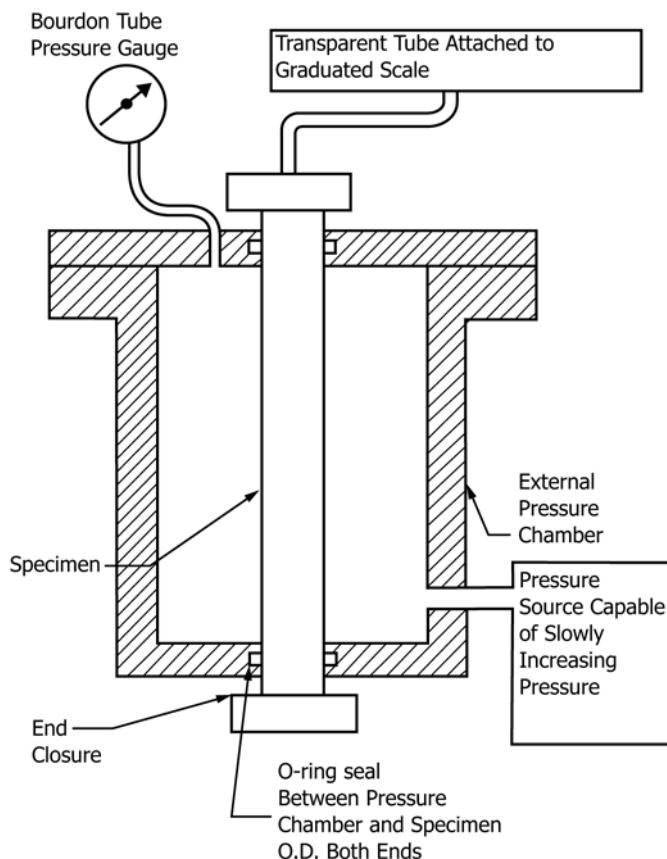


FIG. 2 Apparatus Showing Specimen Loading with Hoop Load Only

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 Weight Change Indicator—The specimen shall be instrumented to measure changes in weight by use of a balance accurate to within ± 0.1 g.

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.

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 $\pm 1\%$ 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

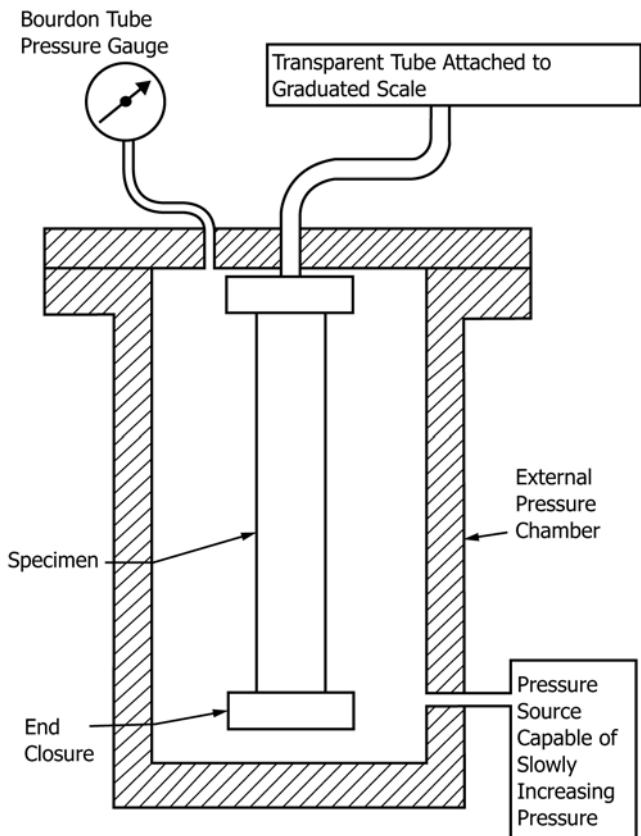


FIG. 1 Apparatus Showing Specimen Loading with Both Hoop and Axial Loads

will be employed that will maintain the temperature of the testing fluid and specimen at a specified amount $\pm 2^\circ\text{C}$.

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:³

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

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 $\pm 2^\circ\text{C}$ of the test temperature during conditioning.

9. Procedure

9.1 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.

9.2 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. Record the time to failure.

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

9.4 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.

10. Calculation

10.1 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).

10.2 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).

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

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

11. Report

11.1 Report the following information:

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

11.1.2 *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.

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

11.1.4 Type of loading used (hoop only or both hoop and axial),

11.1.5 Failure pressures for each specimen tested and the average,

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

11.1.7 Time to failure of each specimen tested,

11.1.8 Scaling constant (see 10.1 for buckling failures, 10.2 for compressive failures, no scaling permitted for leaking failures), and

11.1.9 Date of test.

³ Roark, Raymond J., *Roark's Formulas for Stress and Strain*, McGraw-Hill Book Company, New York, NY, Sixth Edition, 1989, p. 690.

12. Precision and Bias

12.1 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.

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

NOTE 4—These values were developed using Procedure A. The samples were conditioned at $23 \pm 2^\circ$ ($73.4 \pm 3.6\text{F}$) and $50 \pm 5\%$ relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D618.

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.

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

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

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

13. Keywords

13.1 external pressure resistance; fiberglass pipe; pipe; reinforced 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 (D2924 – 01(2006)) that may impact the use of this standard. (October 1, 2012)

(1) Revised Section 9, omitting the volume change procedure with continually increasing load and retaining the weight change procedure using an incrementally increased loading.

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