Designation: F1674 – 11

Standard Test Method for Joint Restraint Products for Use with PVC Pipe[1]

This standard is issued under the fixed designation F1674; 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 describes a procedure for qualifying the performance of joint restraint products for use on PVC pressure pipe systems by evaluating the effect of the joint restraint product on the performance characteristics of PVC pipe during cyclic pressure tests and static pressure tests. The PVC pipe property values referenced in this test method are for the 12454 compound as described in Specification D1784 and a 4,000 HDB shall be obtained by categorizing the LTHS in accordance with Table 1 in Test Method D2837. That includes, but is not limited to, pipe produced in accordance with the following standards: Specifications D1785 and D2241, AWWA C900 , and AWWA C905.

1.2 This test method determines the short-term performance of a joint restraint product on PVC pipe, which involves the testing of restrained joint test sections to the minimum burst pressure requirements of the pipe to determine quick burst performance.

1.3 This test method determines the long-term effect of a joint restraint product on PVC pipe, which involves the testing of restrained joint test sections to the sustained pressure requirements of the pipe for a period of 1000 h.

1.4 This test method addresses restraint products that are rated at the full pressure capacity of the PVC pipe on which they are used. There are joint restraint devices available that are not rated at the full pressure capacity of the pipe. While those products have proven acceptable and useful in the marketplace, this test method does not apply to those products.

1.5 This test method determines the performance of a joint restraint product on PVC pipe subjected to cyclic pressure surges. The performance is compared to the baseline performance of pipe without joint restraint products established by Herbert W. Vinson.[2]

1.6 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information purposes only.

1.7 *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:*[3]

D1784 Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

D1785 Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

D2241 Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)

D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

F412 Terminology Relating to Plastic Piping Systems

2.2 *AWWA Standards:*

AWWA C900 Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. through 12 In. (100 mm through 300 mm), for Water Distribution[4]

AWWA C905 Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings Pipe, Nominal Diameters 14 In. through 48 In. (350 mm through 1,200 mm), for Water Transmission and Distribution[4]

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F412 unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *base hoop stress*—the minimum hoop stress during cyclic testing; the base hoop stress shall be one half the peak hoop stress.

[1] This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.20 on Joining.

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[2] Vinson, Herbert W., Response of PVC Pipe to Large, Repetitive Pressure Surges, *International Conference on Underground Plastic Pipe*, American Society of Civil Engineers, New York, NY, 1981, p. 491.

[3] 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.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

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

3.2.2 *base pressure*—the internal pressure required to achieve the base hoop stress in the pipe wall.

3.2.3 *cycle*—an increase in the internal pressure in a cyclic pressure test specimen from the base pressure to the peak pressure, followed by a decrease in the internal pressure to the base pressure.

3.2.4 *failure of the pipe*—ballooning, bursting, cracking, splitting, or weeping (seepage of liquid) of the pipe during test.

3.2.5 *failure of the restraint product*—structural failure of the restraint product, leakage at the joint (where the restraint is also part of the sealing process, for example, a mechanical joint), premature failure of the pipe that can be directly attributed to the action of the restraint, or 0.25 in. (6.35 mm) of movement of the restraint mechanism on the pipe.

3.2.6 *minimum burst pressure requirement*—the minimum internal pressure that must be reached, within 60 to 70 s, in a restrained joint test specimen without failure.

3.2.7 *movement of the restraint mechanism*—slippage on the pipe of any part of the restraint mechanism which contacts the pipe with the purpose of resisting thrust forces.

3.2.8 *peak hoop stress*—the maximum hoop stress during cyclic testing.

3.2.9 *peak pressure*—the internal pressure required to achieve the peak hoop stress in the pipe wall.

3.2.10 *restraint device for PVC pipe*—a product which is mechanically attached to or is an integral part of PVC pipe and is intended to prevent separation of a joint involving PVC pipe, due to internal pressure or external force (that is, restraining of a mechanical joint, PVC pipe or fitting bell, or flange adapter).

3.2.11 *restrained joint test specimen*—a test section that is assembled with the joint restraint product being tested. The ends of the pipe are capped and all of the load from the end thrust is transferred to the pipe to induce longitudinal stress in the pipe wall, in addition to hoop stress. The restraint device being tested should provide all resistance to joint separation.

3.2.12 *sustained pressure requirement*—the internal pressure that must be maintained for 1000 h in a restrained joint test specimen for sustained pressure tests; it is dependent upon PVC compound and dimension ratio or pipe schedule.

3.2.13 *Vinson Equation*—An empirical equation developed by H. W. Vinson for the conservative estimation of cyclic pressure surge limits in the design of typical PVC pipe and is given by the following:

$$C = (5.05 \times 10^{21}) S^{-4.906} \text{ (see Footnote 2)}$$

where:

C = average number of cycles to failure and
S = peak hoop stress, psi, (MPa × 145.04 = psi).

4. Significance and Use

4.1 This test method is useful for establishing any effects that a joint restraint product has on the performance of PVC pressure pipe. This test method is designed so that success in all three parts of the test provides reasonable assurance that a joint restraint product may be used on PVC pipe at the full pressure rating and capacity of the pipe.

4.2 Restrained joint test specimens shall be subjected to internal pressures that are equal to the minimum burst pressure requirements for the pipe alone. The minimum burst pressure requirements for some common dimension ratios are shown in Table 1. The minimum burst pressures for other dimension ratios of pipe produced from 12454 PVC Compound (that is, pipe conforming to Specification D1785) may be determined based on a hoop stress of 6400 psi (44.13 MPa).

4.3 Testing of restrained joint test specimens for 1000 h at the sustained pressure requirements indicates any tendency of the restraint to fail in the long term. The minimum sustained pressure requirements for some common dimension ratios are shown in Table 2. The minimum sustained pressure for other dimension ratios of pipe produced from 12454 PVC Compound (for example, pipe conforming to Specification D1785) may be determined based on a hoop stress of 4200 psi (28.96 MPa).

4.4 A cyclic surge pressure test of restrained joint test specimens determines the effect of the joint restraint product on the cyclic fatigue life of PVC pipe. This test method provides a means for quickly identifying any reduction in performance that might result from the combination of the joint restraint product and the pipe. The peak hoop stress shall be determined for the pipe based on the Vinson equation for a period of 1 000 000 cycles. The base pressure shall be one half of the peak pressure. The peak pressure requirements for some common dimension ratios are shown in Table 3. The peak pressure for other dimension ratios for pipe produced from 12454 PVC Compound (for example, pipe conforming to Specification D1785) may be determined based on a hoop stress of 1587 psi (10.94 MPa).

5. Sampling, Test Specimens, and Test Units

5.1 *Pipe Specimen Length*—The specimen length shall be such that the distance between any combination of end closure or restraint product is as follows:

5.1.1 For nominal pipe sizes 6 in. (150 mm) or less, a minimum of five times the nominal outside diameter, but not less than 12 in. (305 mm),

5.1.2 For nominal pipe sizes 8 in. (200 mm) up to and including 20 in. (500 mm), a minimum of three times the nominal outside diameter, but not less than 30 in. (305 mm), and

TABLE 1 Minimum Burst Pressure Requirements for Some Common Dimension Ratios, 12454 PVC Compound

Dimension Ratio (DR)	Pressure, psi (kPa)[A]
13.5	1000 (6895)
14	985 (6791)
17	800 (5516)
18	755 (5205)
21	630 (4344)
25	535 (3689)
26	500 (3447)
32.5	400 (2758)
35	380 (2620)
41	315 (2172)
51	260 (1793)

[A] The pressures listed approximate a hoop stress of 6400 psi (44.13 MPa). Some minor adjustments have been made to keep the test pressures uniform in order to simplify testing.

TABLE 2 Sustained Pressure Requirements for Some Common Dimension Ratios, 12454 PVC Compound

Dimension Ratio (DR)	Pressure, psi (kPa)[A]
13.5	670 (4619)
14	650 (4482)
17	530 (3654)
18	500 (3447)
21	420 (2896)
25	350 (2413)
26	340 (2344)
32.5	270 (1862)
35	250 (1724)
41	210 (1448)
51	168 (1158)

[A] The pressures listed approximate a hoop stress of 4200 psi (28.96 MPa). Some minor adjustments have been made to keep the test pressures uniform in order to simplify testing.

TABLE 3 Cyclic Pressure Requirements for Some Common Dimension Ratios, 12454 PVC Compound

NOTE 1—Table 3 is based on Vinson equation for 1 000 000 cycles.

Dimension Ratio (DR)	Peak Pressure, psi (kPa)	Base Pressure, psi (kPa)[A]
13.5	254 (1751)	127 (876)
14	244 (1682)	122 (841)
17	198 (1365)	99 (683)
18	188 (1296)	94 (648)
21	159 (1096)	79 (545)
25	132 (910)	66 (455)
26	127 (876)	63 (434)
32.5	101 (696)	50 (345)
35	93 (641)	47 (324)
41	79 (545)	40 (276)
51	63 (434)	32 (221)

[A] The peak pressures listed approximate a peak hoop stress of 1587 psi (10.94 MPa).

5.1.3 For nominal pipe sizes 24 in. (600 mm) and larger, a maximum length of 60 in. (1524 mm).

5.2 *Joint Restraint Products*—All products that are to be tested shall be from normal production. Prototype products are allowed if they are representative of the final product.

5.3 *Test Specimens*—All parts of the test specimens are to be conditioned and assembled in the same temperature range as required for the pipe. Prepare a different restrained joint test specimen for each test performed.

6. Preparation of Apparatus

6.1 *Constant-Temperature System*—A water bath or other fluid bath shall be provided so that uniform temperature is maintained throughout the bath. This system may require agitation. If an air or other external gaseous environment is used, provision shall be made for adequate circulation. The test is to be conducted at 73°F (23°C) and the temperature tolerance requirements shall be ±3.6°F (2°C).

6.2 *Static Pressurizing System*—Any device that is capable of continuously applying constant internal pressure in the specimen or group of specimens may be used. The device shall be capable of holding the test pressure within ±2 % for the duration of the test. A timing device shall be connected to the pressurized fluid side of the system through a pressure switch or other indicator. This timing device shall be capable of indicating the time at pressure and be sufficient to accurately indicate a time span of 1000 h within ±1.0 %.

6.3 *Cyclic Pressurizing System*—Any device that is capable of bringing the test specimen or group of specimens from the required base pressure to the required peak pressure at a rate of 6 to 10 cycles/min. The device shall have the capability of reaching the peak pressure within ±2 % and releasing the pressure to the base pressure, or less. An effective means of counting the cycles shall be incorporated into the device. The device shall have a means of detecting failure and a means of recording the number of cycles at failure.

6.4 *Pressure Gage,* capable of indicating the maximum pressure of any test in which it is used to an accuracy better that ±1.0 %, and increments adequate to verify that the pressure tolerances of all tests in which it is used are met.

NOTE 1—To avoid wear which could affect accuracy on the gage that is used to monitor the cyclic pressure cycles, it may be desirable to have a method of removing or isolating the gage from the system and replacing it when periodic pressure checks are made.

7. Conditioning

7.1 Specimens to be tested shall be conditioned at the test temperature in a liquid bath for a minimum of 1 h or in gaseous medium for a minimum of 16 h before pressurizing.

8. Procedure

8.1 *Minimum Burst Pressure Test:*

8.1.1 Attach the restrained joint test specimen to the pressurizing system.

8.1.2 Increase the internal pressure uniformly and continuously so that the desired pressure is reached within 60 to 70 s. The test may be terminated after reaching the minimum pressure requirement. Failure of the test specimen to reach the minimum pressure requirement shall constitute failure of the restraint product to pass the test. If the pipe section fails before reaching the minimum pressure requirement, and it is obvious that the restraint product did not cause the failure, then a retest is in order. Any additional testing or data acquisition is optional. See 4.2 for the minimum pressure requirements.

8.2 *Sustained Pressure Test:*

8.2.1 Attach the restrained joint test specimen to the pressurizing system. Adjust the pressure regulator to the sustained pressure requirement for the pipe being used. See 4.3 for the sustained pressure requirements.

8.2.2 Increase the internal pressure uniformly and continuously to the desired pressure. Make sure that the timing device has started.

8.2.3 Hold the specimen at the desired pressure for a period of 1000 h. The test may be terminated after reaching the 1000-h requirement at the minimum sustained pressure. Any additional testing or data acquisition is optional. Failure of the test specimen to sustain pressure for 1000 h shall constitute failure of the restraint product to pass the test. If the pipe section fails before 1000 h, and it is obvious that the restraint product did not cause the failure, then a retest is in order.

8.3 *Cyclic Surge Pressure Test:*

8.3.1 Attach the restrained joint test specimen to the cyclic pressure test apparatus. Adjust the pressure limiting devices for the peak and base pressures for the pipe being tested. See 4.4 for peak pressure requirements for the pipe.

8.3.2 Start the pressure cycling apparatus.

8.3.3 The test may be terminated after reaching the 1 000 000 cycles requirement. Any additional testing or data acquisition is optional. Failure of the test specimen to reach 1 000 000 cycles at a peak pressure from Table 3 shall constitute failure of the restraint product to pass the test. If the pipe section fails before 1 000 000 cycles, and it is obvious that the restraint product did not cause the failure, then a retest is in order.

9. Assembly

9.1 Assembly of the joint restraint products shall be performed in accordance with the manufacturer's recommended assembly procedures.

10. Report

10.1 Report the following information (where applicable):

10.1.1 Complete identification of the joint restraint products being tested, including manufacturer's name, size range being tested, material composition, and product assembly numbers.

10.1.2 At each appropriate section, list the properties of the pipe, including the identification marks and PVC compound.

10.1.3 Prepare a table listing the results of the minimum burst pressure tests, including the size, dimension ratio or pipe schedule, pressure and hoop stress, mode and location of failure if any, and time to failure for each test specimen.

10.1.4 Prepare a table listing the results of the long-term tests, including the size, dimension ratio or pipe schedule, pressure and hoop stress, mode and location of failure, if any, and number of hours at pressure for each test specimen.

10.1.5 Prepare a table listing the results of the cyclic surge pressure tests, including the size, dimension ratio or pipe schedule, peak hoop stress and pressure, the base hoop stress and pressure, mode and location of failure, if any, and number of cycles to failure for each test specimen.

10.1.6 Test environment.

10.1.7 Dates of tests.

10.1.8 Name of laboratory and supervisor of the tests.

NOTE 2—It is not appropriate to consider all sizes of a joint restraint product series to have met the requirements of this test method based on tests of only one size. The same is true for testing on different pipe SDRs. It is recommended that tests of multiple sizes be performed to qualify a group within a joint restraint product series. Multiple tests should also be performed on different pipe SDRs to determine the performance of the restraint products in accordance with the requirements of this test method on different pipe thicknesses.

11. Precision and Bias

11.1 No statement is made about either the precision or the bias of this procedure for evaluating the performance of joint restraint products on PVC pipe, since the results merely state whether there is conformance to the criteria for success specified in the procedure.

12. Keywords

12.1 cyclic surge pressure test; joint restraint for PVC; mechanical joint restraint for PVC pipe; Vinson equation

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1674–09) that may impact the use of this standard.

(1) Inserted Hydrostatic Design Basis requirement into Scope, 1.1.

(2) Inserted Test Method D2837 into Referenced Documents, 2.1.