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An American National Standard

Standard Test Method for Determining Thermoplastic Pipe Wall Stiffness[1]

This standard is issued under the fixed designation F2433; 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 the determination of the load-deflection behavior of thermoplastic pipe wall sections under parallel plate loading conditions.

NOTE 1—These are not full pipe section tests, but pipe wall segment tests. The results of these tests will be different from pipe stiffness tests per Test Method D2412, although they may be proportional. This test provides quite different information, including , stress relaxation under constant strain, and comparisons of the function and stiffness of different pipe wall designs or materials.

1.2 This test method covers a loading test for determining the wall stiffness of a thermoplastic-pipe wall under a combined load of bending and compression. Changes in pipe wall profile geometry under load may also be determined.

1.3 This test method covers thermoplastic pipe.

1.4 The characteristics determined by this test method are wall stiffness and changes in profile wall dimensions at specific deformations.

1.5 The characteristics determined by this test method are wall stiffness, profile wall efficiency, and for some wall elements stability at specific Strain levels.

1.6 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.7 The text of this specification references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the specification.

1.8 *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]

D618 Practice for Conditioning Plastics for Testing

D695 Test Method for Compressive Properties of Rigid Plastics

D883 Terminology Relating to Plastics

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

D2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

F412 Terminology Relating to Plastic Piping Systems

2.2 *AASHTO Standards:*

M 252 Standard Specification for Corrugated Polyethylene Drainage Pipe[3]

M 294 Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm Diameter[3]

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600, unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *chord shortening, n*—the ratio of the reduction in pipe section chord shortening to the initial chord length expressed as a percentage.

3.2.2 Δ*y*, *n*—measured change in chord length (in the direction of load application) expressed in millimeters (inches).

3.2.2.1 *compressive deformation, n*—the measured change of the inside diameter in the direction of load application expressed in millimeters (or inches).

3.2.3 *load (F), n*—the force applied to the wall section to produce or maintain a given percent chord length shortening at

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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] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

any given unit of time; expressed as Newtons per meter (pounds-force per linear inch).

3.2.4 *mean radius (r), n*—the mid-wall radius determined by subtracting the average wall thickness from the average outside diameter and dividing the difference by two; expressed in millimeters (or inches).

3.2.5 *time-independent pipe stiffness K(0), n*—the value obtained by dividing the force per unit length on the curved beam specimen by the resulting deflection in the same units at the % deflection prescribed and extrapolating the linear portion of the curve of stiffness versus % deflection to the moment of application of load.

3.2.6 *time-dependent residual curved beam stiffness K(t) and residual pipe stiffness K(t), n*—the value obtained by dividing the force per unit length on the curved beam specimen by the constant target deflection in the same units, at any time t, $t > 0$.

3.2.7 *modulus of relaxation, n*—the residual pipe stiffness versus log(time).

3.2.8 *residual pipe stiffness K(50y), n*—the value obtained by extrapolating values of residual pipe stiffness versus time to 50 years.

3.2.9 *compliance C(t), n*—the inverse of stiffness *K(t)*.

3.2.10 *liner cracking or crazing, n*—the occurrence of a break or network of fine breaks in the liner visible to the unaided eye.

3.2.11 *wall cracking, n*—the occurrence of a break in the pipe wall visible to the unaided eye.

3.2.12 *wall delamination, n*—the occurrence of any separation in the components of the pipe wall visible to the unaided eye.

3.2.13 *rupture, n*—a crack or break extending entirely or partly through the pipe wall.

4. Summary of Test Method

4.1 The test is conducted by applying a controlled, nearly instantaneous, load to the longitudinally cut edges of curved beam sections cut from short lengths of pipe until a prescribed shortening of the chord connecting the longitudinal edges is achieved and held constant for prescribed intervals. Load and deformation data establish the time-independent measure of curved beam wall stiffness at the instant of load application, the measure of efficiency of the profile wall geometry, stability of the profile wall, a modulus of relaxation and long-term estimates of residual pipe wall stiffness.

4.2 A length of a 10 to 120° arc segment of a pipe wall, from one diameter length to one meter long is loaded across its chord length between two freely rotating end plates at a controlled rate of approach to one another. Load-deflection data of the wall section in combined bending and compression are obtained. Change in pipe wall thickness at the center of the section (springline) is determined. If cracking, crazing, delamination, rupture, or buckling occurs, the corresponding load, deflection, and/or time are recorded.

NOTE 2—If this test method is incorporated in a product standard it would be necessary to define the arc length to be tested. There are, however, many reasons various arc lengths might be tested, especially as a research or product development tool. Large arc lengths are primarily in bending, while short arc lengths are primarily in compression.

5. Significance and Use

5.1 The performance under bending and compression load of a thermoplastic plastic pipe wall design obtained by this method can be used for the following:

5.1.1 To determine the stiffness of the pipe wall section. This is a function of the pipe dimensions, the wall design, the arc length tested, and the physical properties of the material of which the pipe is made.

5.1.2 To compare the characteristics of various thermoplastic pipe wall designs.

5.1.3 To compare the characteristics of various plastics in pipe form.

5.1.4 To study the interrelations of dimensions, materials, and deformation properties of thermoplastic pipe designs.

5.1.5 To measure the deformation and load-resistance at any of several significant events which may occur during the test.

5.1.6 To provide a reasonable quality control/quality assurance test for very large diameter plastic pipes.

5.2 The time-dependent pipe wall stiffness of a thermoplastic pipe obtained by this test method may used for the following:

5.2.1 To predict the residual stiffness of the pipe wall in bending and compression at all times after initial loading.

5.2.2 For purposes of design, to determine a modulus of relaxation under sustained loads.

5.2.3 To quantify the influence of material formulations of thermoplastics on the modulus of relaxation.

5.2.4 To study the influence of geometric patterns of wall profiles on the modulus of relaxation.

5.3 The time-independent reduction of wall thickness at springline may be used for the following:

5.3.1 For pipe wall stiffness, to quantify the efficiency of all wall profiles of any material composition and a given geometry with that of a solid uniform thickness wall.

6. Apparatus

6.1 *Testing Machine*—A properly calibrated compression testing machine of the constant-rate-of-crosshead movement type meeting the requirements of Test Method D695 shall be used to make the tests. The rate of head approach shall be 63.5 ± 2.5 mm (2.5 ± 0.1 in.)/s. The machines must be capable of holding a required percent chord shorting for an extended period of time.

6.2 *Loading Grips*—The load shall be applied to the specimen through two parallel-axis grips. These assemblies shall be flat, smooth, and clean. Specimen contact surfaces of platen shall be coated with a PTFE spray lubricant. The thickness of the platens shall be sufficient so that no bending or deformation occurs during the test, but it shall not be less than 12 mm (0.5 in.). The nominal length of each grip shall equal or exceed the specimen length but shall not be less than 1040 mm (41 in.). Upper and lower grips shall be free to rotate about an axis in the plane of the applied and reacting line loads. Recommended arrangement of loading frame, upper and lower grips with test specimen are shown in Fig. 1.

6.3 *Deformation Indicator*—The change in total wall (major wall for profile wall pipe) thickness at springline, shall be measured with a suitable instrument meeting the requirements of 4.1.2 of Test Method D695, except that the instrument shall be accurate to the nearest 0.025 mm (0.001 in.). The instrument shall not affect in any way the load-deflection measurements.

6.4 *Load Sensor*—The change of load with time during the periods of displacement (loading) and during the period of constant displacement shall be digitally recorded with a precision of no less than 4 significant figures and at time intervals as noted in 9.3. The sensing element shall have a precision of ±2 % of maximum recorded value.

6.5 *Temperature Recorder*—Ambient temperature shall be continuously recorded using a sensor capable of recording to 1°C (1.8°F).

6.6 *Reaction Frame*—The reaction frame shall be sufficiently rigid such that the movement of the stationery platen shall not exceed 0.05 % of the displacement of the moving platen.

7. Test Specimens

7.1 Test specimens shall be cut from the pipe wall, with the cuts through the wall radial and parallel through the sample length. Test specimens may be the required arc length in degrees ±1° arc sections of the wall, as agreeable to the manufacturer and the purchaser, but not less than 10 degrees nor greater than 120 degrees. Test specimens should be a minimum of 600 mm (24 in.) long, and may be as much as 900 mm (36 in.), and for corrugated or profile pipe should be squarely cut in the corrugation or profile valley.

NOTE 3—Standard arc lengths for specimens should be 120°, 90°, and 30°, though other arc lengths may be used within the range of 120° to 10°, as determined by the needs of the owner, researcher, or testing laboratory.

8. Conditioning

8.1 Condition the pipe wall section for at least 24 h in air at a temperature of 23 ± 2°C (73.4 ± 3.6°F), and 50 ± 5 % relative humidity and conduct the test in a room maintained at the same temperature.

8.2 When a referee test is required, condition specimens for at least 40 h at 23 ± 2°C (73.4 ± 3.6°F), and 50 ± 5 % relative humidity per Practice D618 Procedure A and conduct the test under the same conditions.

9. Procedure

9.1 Before placing each test specimen in the test apparatus make the following measurements:

9.1.1 Measure, to the nearest 1 mm (0.04 in.), the longitudinal length with equally spaced parallel measurements at mid and quarter points of the arc of the curved beam. Determine the longitudinal length by averaging the three measurements.

9.1.2 For specimens prepared from AASHTO M 252M and AASHTO M 294M Type C pipes, at each of three points

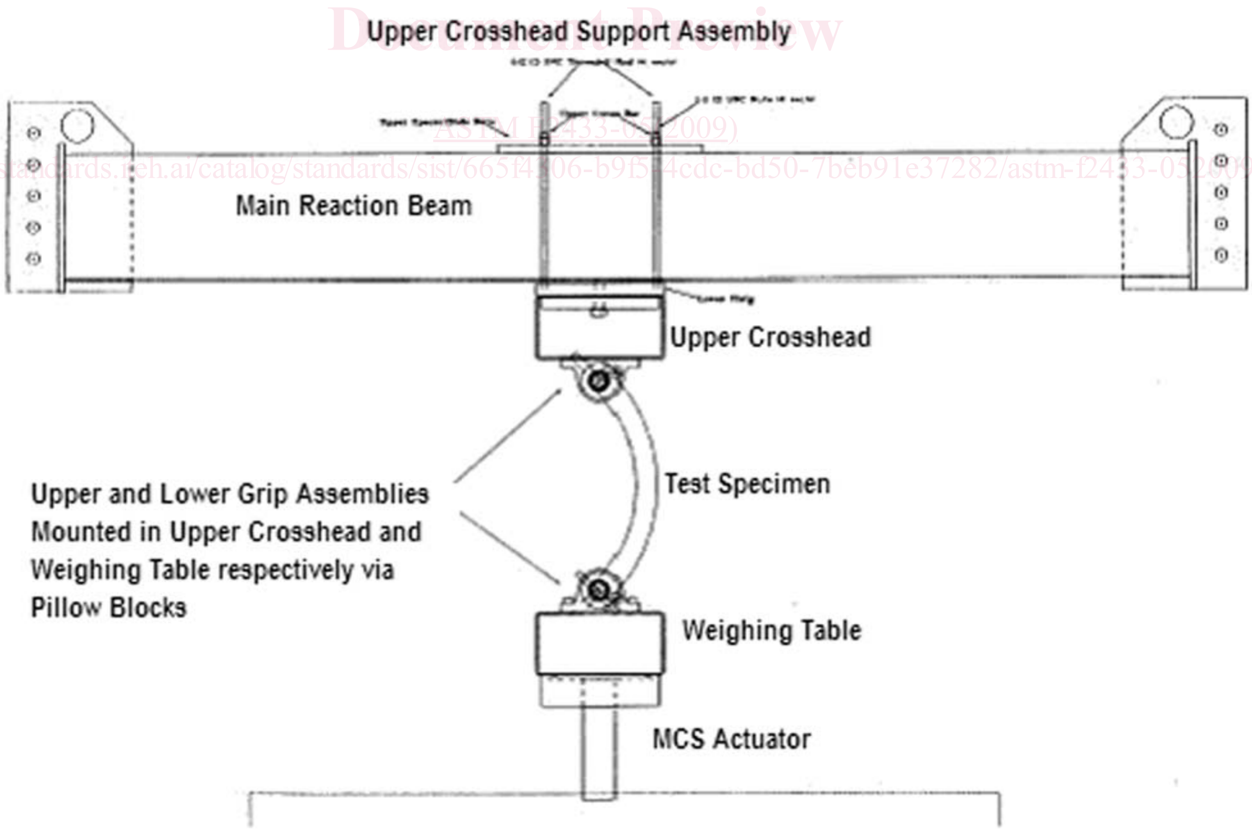

FIG. 1 Recommended Arrangement of Loading Frame, Upper & Lower Grips, and Test Specimen