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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Determination of the Critical Pressure for Rapid Crack Propagation in Plastic Pipe[1]

This standard is issued under the fixed designation F 1589; 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 determines the minimum internal air pressure at which rapid crack propagation (RCP) can be sustained along a section of plastic pipe. This is termed the *critical pressure*.

1.2 This technique achieves steady state RCP in a small specimen by restraining the decompression which normally accompanies fracture, and therefore indicates a lower critical pressure than that measured on the same pipe using full-scale tests. This test method has been called "Small Scale Steady State" or S4.

1.3 This test method was developed for polyethylene pipe, and has been shown to correlate with the full-scale RCP test method. The user should determine if it is applicable to other plastic piping methods.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *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:*

D 1600 Terminology for Abbreviated Terms Relating to Plastics[2]

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings[3]

F 412 Terminology Relating to Plastic Piping Systems[3]

2.2 *ISO Standard:*

ISO 3126 Plastic pipes—Measurement of dimensions[4]

3. Terminology

3.1 Definitions—Definitions are in accordance with Terminology F 412, unless otherwise specified.

3.1.1 *axial pitch*—the center to center distance of the retaining rings that surround the outside diameter.

3.1.2 *baffle pitch*—center to center distance of baffles.

3.1.3 *chisel-ended striker*—the knife-edged projectile (striker) that is used to initiate crack.

3.1.4 *gage length*—nominally 7*D* less initiation section and sealing sections; at least 4.5*D*.

3.2 Symbols—The following symbols are used in this test method for outside diameter controlled pressure pipe:

3.2.1 *a*—axial crack length into the gage length of the pipe test piece.

3.2.2 *D*—minimum outside diameter of pipe, which is the average outside diameter less the minus tolerance.

3.2.3 *p*—internal pressure within the gage length of the pipe test piece.

3.2.4 *PcS4*—critical pressure for rapid crack propagation, measured using the S4 method.

3.2.5 d_{min}—minimum inside diameter of pipe, calculated as follows:

$$d_{min} = D\left[1 - \frac{2.24}{SDR}\right]$$

3.3 Other abbreviations are in accordance with Terminology D 1600.

4. Significance and Use

4.1 A specified length of pipe, subject to constant internal air pressure, is penetrated near one end by a chisel-ended striker to result in a fast-running axial crack, under conditions where the crack initiation process itself disturbs the pipe as little as possible.

4.2 A series of tests at various measured pressures is used to identify the critical pressure, at which there is a sharp transition from abrupt arrest of this initial crack to continued steady propagation. The crack is said to propagate if the crack length *a* is greater than 4*D*. The critical pressure, P_{cS4}, is the maximum arrest pressure below the lowest propagation pressure. Rapid decompression due to propagation of the crack is retarded by internal baffles and by an external cage which restricts flaring of the pipe at the edges of the fracture. The RCP critical pressure becomes more significant for plastic pipe as the pipe size increases or the internal pressure increases, or both.

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[1] This test method is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.40 on Test Methods.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.04.

[4] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

5. Apparatus

5.1 The apparatus should generally conform with Fig. 1.

5.2 The containment cage shall allow free expansion of the pipe during pressurization, but must restrict radial expansion during fracture to within a maximum diameter of 1.1*D* at all points around the circumference. All pipe dimensional measurements shall be made using Test Method D 2122 or ISO 3126.

5.3 The axial pitch of containment rings shall be less than 0.4*D*, and their axial separation shall be (0.25± 0.05)*D*, between the initiation impact point and the end of the gage length.

5.4 The internal gage length shall be greater than 4.5*D*. At least 70 % of the internal volume of the gage length shall be occupied by compressed air which can expand without restriction to drive the pipe wall radially outward.

5.5 Instrumentation shall be provided to measure the internal static pressure of the gage length to an accuracy of ±0.75 psi (±5 kPa) (±0.05 bar).

5.6 The decompression baffles shall be not less than $0.94d_{min}$ and not greater than $0.96d_{min}$ in diameter. The baffle pitch must not be greater than *D*/2.

5.7 Crack initiation shall be effected by axial splitting with a chisel-ended striker. The centerline of striker penetration shall be an axial distance of at least 2/3*D* from the gage section and at least *D* from the end of the specimen.

5.8 The axial length of the chisel blade edge shall not exceed *D*/2. An internal anvil shall ensure that the inner surface of the pipe cannot deform, under impact of the blade, within a diameter of $0.96d_{min}$ throughout the initiation section.

6. Sampling

6.1 The test pieces shall be straight sections of pipe, cut with square ends to a length of 7*D* (−0, +1*D*).

6.2 The pipe surfaces along the gage length shall not be prepared, notched, or treated in any way.

6.3 Internal or external notching of the pipe surface along the initiation zone may be carried out to facilitate crack propagation. Chamfering of the initiation end to facilitate fitting of the pipe over the core may be carried out.

7. Conditioning

7.1 Pressurize the specimen with test pressure *p* using compressed air.

7.2 Pipe specimens shall be conditioned at the test temperature for a minimum of 1 h in a liquid bath or a minimum of 16 h in a gaseous medium.

NOTE 1—The normal test temperature of 32°F (0°C) will usually be attained by immersion in a water and ice mixture for at least 6 h prior to testing.

7.3 All necessary precautions should be taken to ensure that no significant increase in temperature of the pipe occurs prior to testing. Crack initiation must follow within 3 min of removal of the specimen from the conditioning medium.

7.4 Conditioning shall be detailed in the test report.

8. Procedure

8.1 *Establishing Crack Initiation Conditions*:

8.1.1 This procedure may be conducted on short pipe sections having a minimum gage length of 1.5*D*.

8.1.2 Maintaining the gage length at atmospheric pressure, establish initiation zone conditions (impact velocity, notch geometry, etc.) to generate a crack length *a* of at least *D*/3. The impact velocity of the striker shall be at least 66 ft/s (20 m/s).

8.2 *Determining Critical Pressure*:

8.2.1 This procedure shall be conducted on pipe sections having a gage length of at least 4.5*D* (Fig. 1).

8.2.2 Maintaining the initiation conditions, conduct a series of tests at various incremental test pressures, *p*. Note for each specimen the crack length *a* at arrest.

8.2.3 The crack is said to propagate if the crack length is greater than $a = 4D$. The critical pressure, p_{cS4}, is the maximum test pressure below which propagation has not occurred. At least three tests shall be performed between pressures of p_{cS4} and $1.5p_{cS4}$ and at least three between $0.5p_{cS4}$ and p_{cS4}.

8.2.4 Plot *a/D* as a function of *p*. Fig. 2 shows typical data in a schematic form.

9. Report

9.1 Report the following information:

9.1.1 A complete identification of the plastic pipe under test: manufacturer, material, nominal dimensions, and lot identification,

9.1.2 The number of specimens tested, with dates of testing,

9.1.3 The testing temperature and conditioning method,

9.1.4 The plot of ratio of crack length to outside diameter of pipe, *a/D*, at arrest versus gage length pressure, *p*.

9.1.5 The determined value of critical pressure, p_{cS4}.

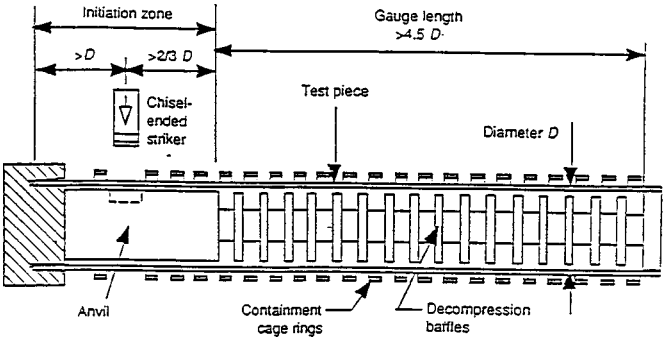

FIG. 1 Apparatus for S4 Test

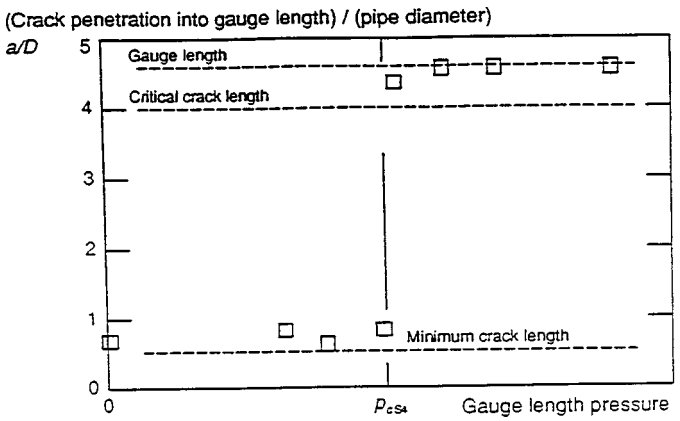

FIG. 2 Typical Data (Schematic)

10. Precision and Bias

10.1 The precision and bias of this test method for measuring the critical pressure for rapid crack propagation is being determined for polyethylene (PE) pipe.

11. Keywords

11.1 critical pressure; rapid crack propagation; small-scale steady state