Designation: F 1248 – 96 (Reapproved 2002)ε1

An American National Standard

Standard Test Method for Determination of Environmental Stress Crack Resistance (ESCR) of Polyethylene Pipe[1]

This standard is issued under the fixed designation F 1248; 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.

ε[1] NOTE—Section 3.2.2 and Tables 1-3 were editorially revised in November 2002.

1. Scope

1.1 This test method covers the determination of a polyethylene pipe specimen's resistance to stress cracking when subjected to compression deformation in the presence of a surface active agent at elevated temperature.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses mathematical conversions to SI units, which are provided for information only and are not considered 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:*

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

D 1693 Test Method for Environmental Stress Cracking of Ethylene Plastics[3]

F 412 Terminology Relating to Plastic Piping Systems[4]

3. Terminology

3.1 *Definitions*—Definitions of terms are in accordance with Terminology 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 *environmental stress crack resistance (ESCR)*—a number in units of hours-to-failure indicating the resistance of PE pipe to cracking at stresses below the short-term mechanical stress values of the pipe while immersed in a surface-active liquid at elevated temperature.

3.2.2 *failure, n*—a crack in the surface of the pipe specimen, visible with the unaided eye.

3.2.2.1 *Discussion*—Extension of the controlled notch is not a failure. Appearance of more than one crack in a specimen shall be classified as a single failure.

4. Summary of Test Method

4.1 A ring specimen of the polyethylene pipe, having a controlled imperfection at one location, is exposed at an elevated temperature to the action of a surface active agent while compressed to deformation between parallel plates. The elapsed time in hours to observation of a stress crack failure in the specimen is recorded.

5. Significance and Use

5.1 This test method may be used to determine the environmental stress-crack resistance properties of a polyethylene pipe specimen while under high stress in the presence of the surface-active agent, and at an elevated temperature.

6. Apparatus

6.1 *Specimen Holder*—The test-specimen holder shall consist of two parallel plates having a width at least 1.2 times the nominal outside diameter of the pipe. Fig. 1 shows suggested dimensions for a holder for 1¼-in. pipe. Construction shall be of corrosion-resistant metal such as Type 304 or 316 stainless steel. The plates shall have a series of appropriately spaced holes through which bolts or threaded rod can be inserted to effect compression of the test specimen by the use of nuts. It is required that spacers having a thickness equal to the distance required for compression be used to minimize the time to effect compression of the test specimen to ensure consistent and uniform compression and to prevent overcompression. The plates shall remain parallel throughout the testing period.

6.2 *Notching Jig*—The blade used shall be a single-edge stainless blade[5] (Table 1). The blade shall be replaced after it has been used to produce 20 notches. Additionally, the blade

[1] This test method is under the jurisdiction of ASTM Committee F17 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 08.03.

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

[5] A blade made by the American Safety Razor Co., Industrial Products Division, Razor Blade Lane, Verona, VA 24482, or equivalent, has been found satisfactory for this purpose.

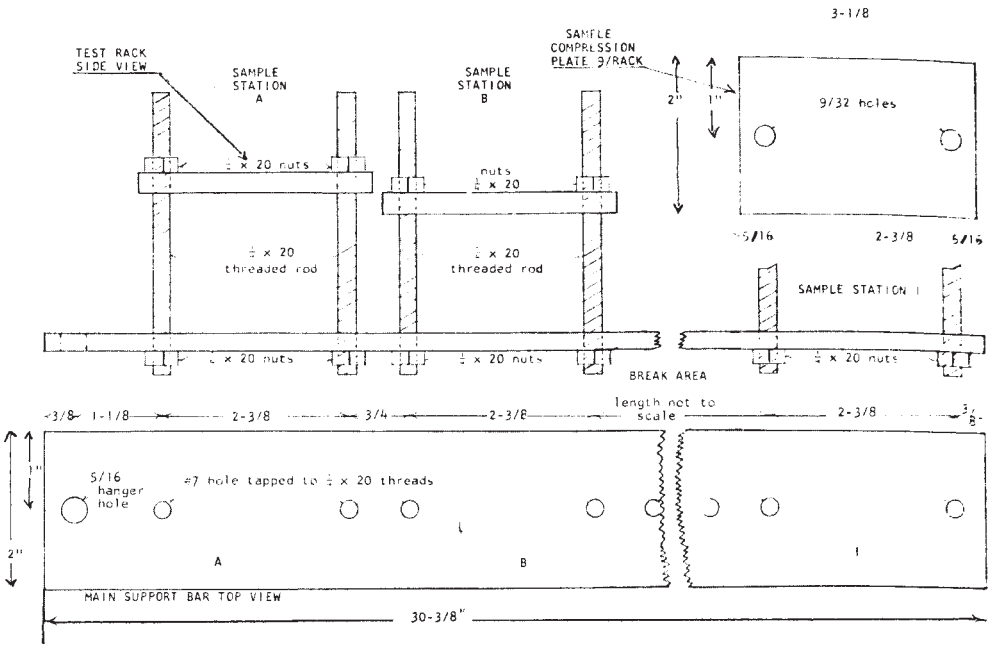


FIG. 1 Typical ESCR Fixture for 1¼-in. IPS Pipe

TABLE 1 Blade Dimensions and Notch Length

Pipe or Tubing Nominal Diameter	Blade[A] Length, in., Notch Length, in. + 1/16 in.
¼–2	¾
2½–6	1½
8	2
10	2½
12	3

[A] Blade Source: American Blade Co.

shall be inspected before each use employing a 4× magnifying glass, and shall be replaced whenever there is question of its having become dull or damaged. The required blade holder design and dimensions are shown in Fig. 2 and Fig. 3.

6.3 *Constant-Temperature Bath*—A covered container filled with the test reagent and maintained at 122 ± 3.6°F (50 ± 2°C). Add distilled water as necessary to maintain the specified concentration of the test reagent in the bath. The bath and other components shall be constructed of materials that are not attacked by the reagent. Preferred materials of construction are glass and 304 stainless steel. Specifically barred from the bath are components made of copper, aluminum, carbon steel, black iron and zinc.

7. Reagent

7.1 The test reagent shall be a solution of 25 ± 5 % nonylphenoxy poly(ethyleneoxy) ethanol and 75 ± 5 % distilled water by volume.[6]

NOTE 1—Store the reagent in closed containers because it is hygroscopic.

NOTE 2—The control specimen required in 9.4 will serve to indicate the effectiveness of the reagent.

8. Preparation of Test Specimen

8.1 Cut a uniform ring from the pipe to a width of 0.5 in. (13 mm) or 30 % of the nominal outside diameter of the pipe, whichever is greater, to a tolerance of +0.125 in. (3 mm) minus 0.0.

NOTE 3—Use a tubing cutter with a sharp wheel or some method that produces smooth cuts. The cutting process should not cause local heating.

8.2 Within 1 h prior to testing, cut a controlled sharp notch at the thinnest wall section of the specimen. The notch shall be

[6] This procedure is based on the use of "Igepal CO 630P,'' a GAF tradename for nonylphenoxy poly(ethyleneoxy) ethanol. The same chemical from other manufacturers is also acceptable.

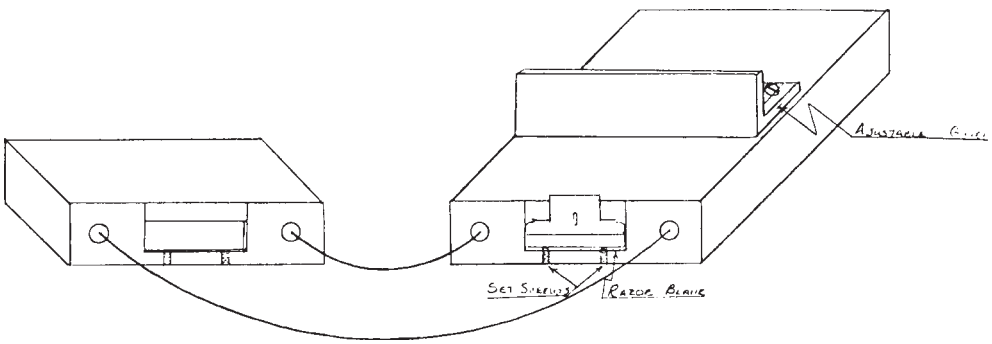


FIG. 2 Typical ESCR Blade Holder

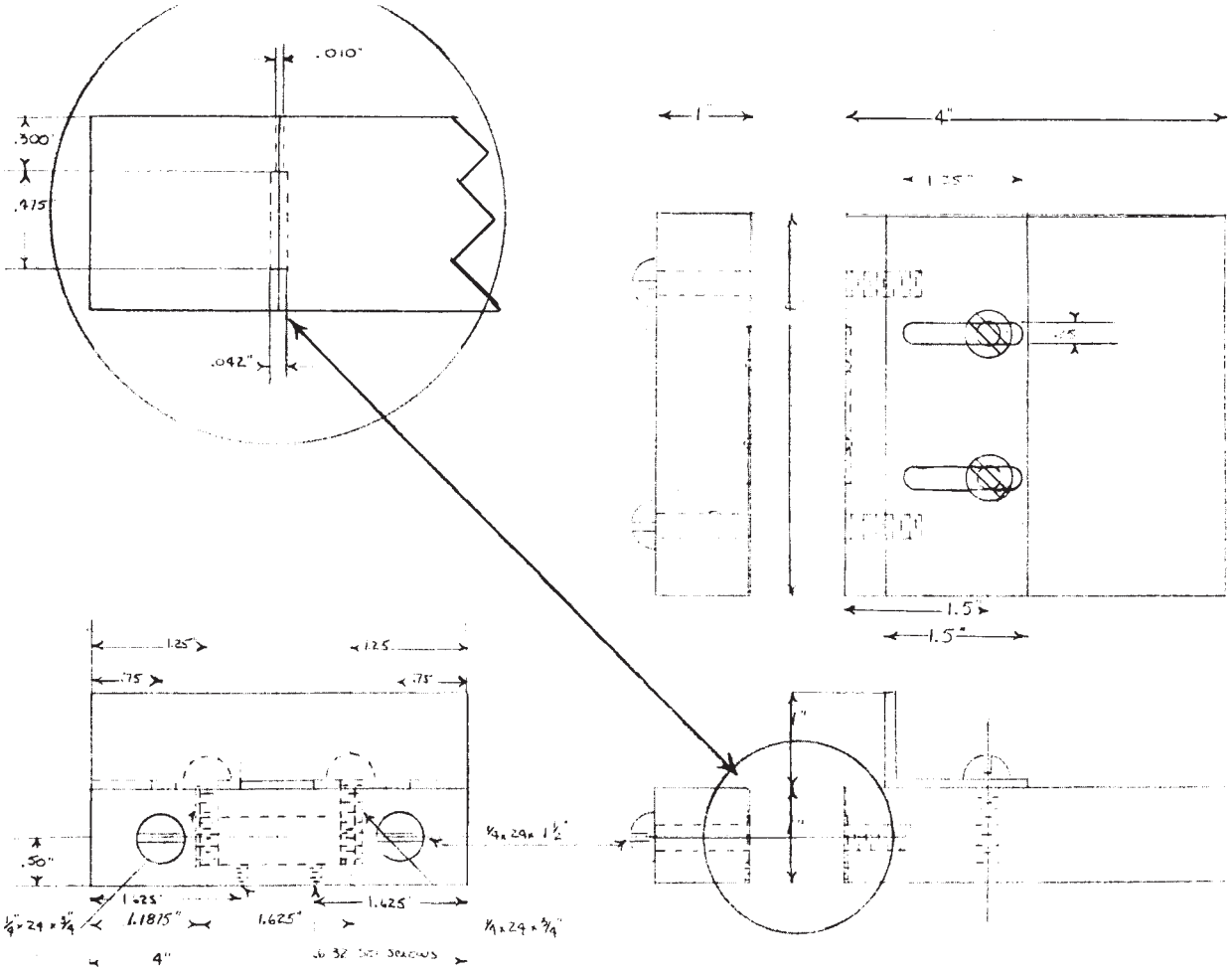
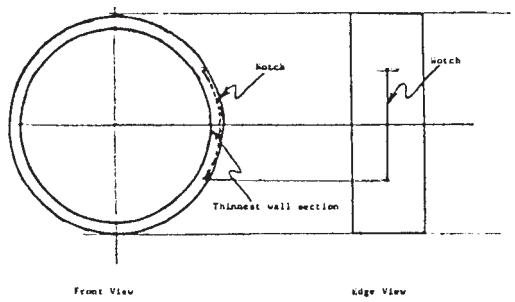


FIG. 3 Typical ESCR Blade Holder (Suggested Dimensions)

in the center of the ring with respect to its width and parallel to the edges of the ring. See Fig. 4. The depth of the notch is dependent on the nominal pipe size and DR and is shown in Table 2. The notch is produced by rolling the ring over the edge of the blade as shown in Fig. 5.

9. Procedure

9.1 Place the ring specimen between the parallel plates of the specimen holder with the notch centered on one side, and compress the specimen until the distance between plates is three times the specified minimum wall thickness as shown in Table 3. Fig. 6 shows ring specimens in the compressed state. (The spacers recommended in 6.1 are not shown.) The notch shall be in the center of the maximum bend area.



Notch depth is 20 % of specified minimum wall

FIG. 4 Location of Notch in Ring Specimen

9.2 Place the specimen holder, with the compressed ring specimen, into the test reagent 30 ± 5 min after initiation of compression. The instant of immersion is the zero point for determining the time to failure.

9.3 Inspect the test specimen at times appropriate to the pipe compound under test (see Note 4). When the failure of the specimen is first observed, record whether the failure is in the notch or outside of the notch. If it is outside of the notch, record the exact location of the failure, for example, between the notch and edge, or on the side opposite the notch. Examples of types of failure are shown in Fig. 7.

9.4 **Warning—**Based on round robin results, the value of this test as a quality index for a laboratory initially starting its use is greatly diminished when failure times exceed 200 h. A large reservoir of data demonstrating narrow variation is necessary when the test is used as a quality index where failure times are over 200 h.

NOTE 4—When the expected time to failure is not available from an outside source or previous tests, preliminary testing is necessary to determine an expected failure time span for a particular resin. The characteristic failure times for specific resins range from several hours to

TABLE 2 Notch Depth for Tubing and Pipe Size

Tubing Nominal Diameter	Notch Depth, in. ± 0.005 in. (mm± 0.13 mm)	
¼	0.012 (0.30)	or 20 % of specified minimum wall, whichever is greater
⅜	0.012 (0.30)	
½	0.012 (0.30)	
¾	0.012 (0.30)	
1	0.012 (0.30)	
1¼	0.012 (0.30)	
1¾	0.012 (0.30)	

Pipe Nominal Diameter	Pipe SDR →	Notch Depth, in. ± 0.005 in. (mm ± 0.13 mm)						
		32.5	26	21	17	13.5	11	9.3
½				0.012	0.012	0.012	0.015	0.018
				(0.30)	(0.30)	(0.30)	(0.38)	(0.45)
¾				0.018	0.018	0.018	0.019	0.023
				(0.45)	(0.45)	(0.45)	(0.48)	(0.58)
1				0.018	0.018	0.019	0.024	0.028
				(0.45)	(0.45)	(0.48)	(0.60)	(0.71)
1¼				0.018	0.020	0.025	0.033	0.036
				(0.45)	(0.51)	(0.63)	(0.83)	(0.91)
1½				0.018	0.022	0.028	0.035	0.041
				(0.45)	(0.56)	(0.71)	(0.89)	(1.0)
2				0.023	0.028	0.035	0.043	0.051
				(0.58)	(0.71)	(0.89)	(1.1)	(1.3)
2½				0.027	0.034	0.043	0.052	0.062
				(0.69)	(0.86)	(1.1)	(1.3)	(1.6)
3				0.033	0.041	0.052	0.064	0.075
				(0.83)	(1.0)	(1.3)	(1.6)	(1.9)
3½				0.038	0.047	0.059	0.073	0.086
				(0.96)	(1.2)	(1.5)	(1.9)	(2.2)
4				0.043	0.053	0.067	0.082	0.097
				(1.1)	(1.3)	(1.7)	(2.1)	(2.5)
5				0.053	0.066	0.083	0.101	
				(1.4)	(1.7)	(2.1)	(2.6)	
6		0.041	0.051	0.063	0.078	0.098	0.121	
		(1.04)	(1.30)	(1.6)	(2.0)	(2.5)	(3.1)	
8		0.053	0.066	0.082	0.102	0.128	0.157	
		(1.35)	(1.68)	(2.3)	(2.6)	(0.71)	(4.0)	
10		0.066	0.083	0.102	0.127	0.159	0.196	
		(1.68)	(2.11)	(2.6)	(3.2)	(4.0)	(5.0)	
12		0.078	0.098	0.122	0.150	0.189	0.232	
		(1.98)	(2.49)	(3.1)	(3.8)	(4.8)	(5.9)	

thousands of hours. Lot-to-lot variations greater than 30 to 1, that is, 30 to 900 h, are not uncommon. As the test time without failure increases, the interval between inspections may be increased from an initial every hour or two, to intervals that are about 10 % of the elapsed test time at the latest inspection. When failure occurs during a time gap greater than 10 % of the elapsed time at the last inspection, the test should be rerun with the start time positioned so that failure is likely during a convenient observation period.

9.5 Conduct a simultaneous or periodic control test using at least one specimen from pipe set aside specifically for control purposes. The frequency of the control test should be as experience warrants.

10. Report

10.1 Report the following information:

10.1.1 Complete identification of the pipe,

10.1.2 Ring width and wall thickness measurement at the notch location,

10.1.3 Lapsed time in hours from immersion time to inspection time when failure was first observed (location of failure, for example, failure in notch, between notch and ring edge, and side opposite notch), and

10.1.4 Range of results employing the precision statement.

10.2 The results of many tests may be statistically reported using the nomenclature F_x and test duration in hours. For an explanation of this reporting nomenclature, see Note 11 and Appendix X1 of Test Method D 1693.

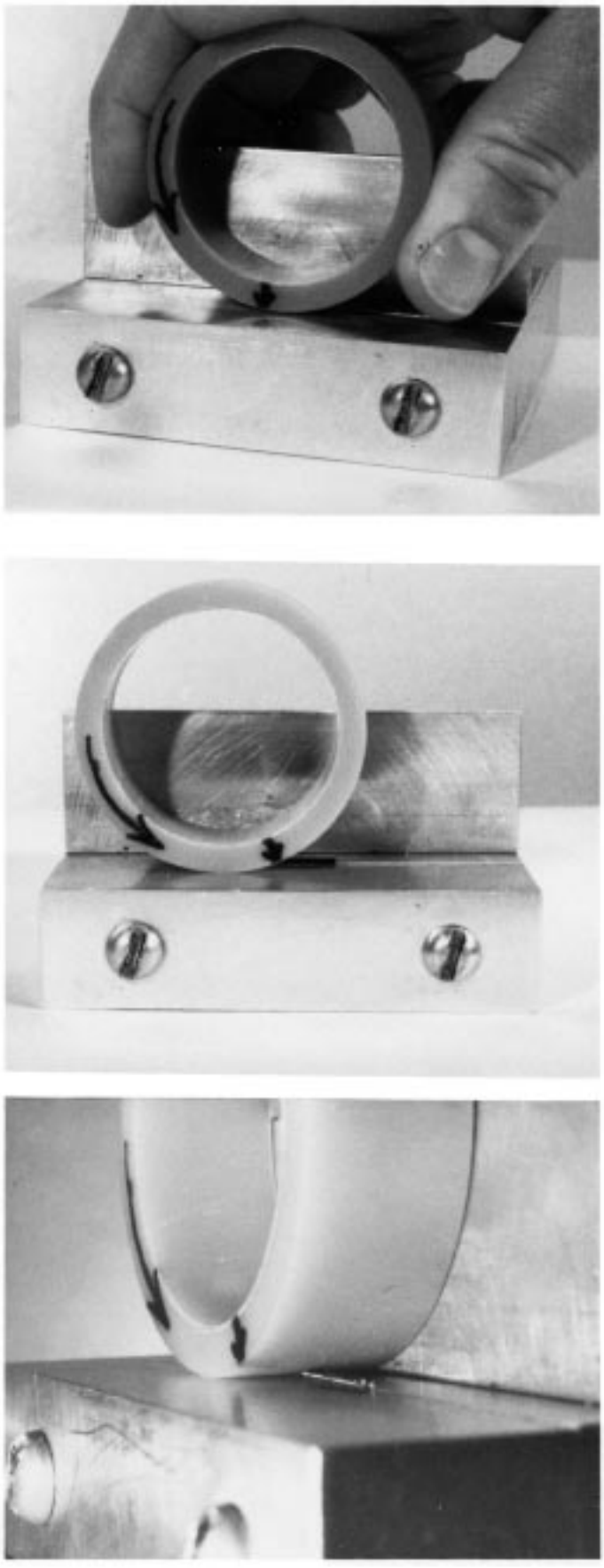


FIG. 5 Procedure for Cutting Notch in Ring Specimen

TABLE 3 Compression of Tubing and Pipe in ESCR Test

Tubing Nominal Diameter	Clearance Between Parallel Plates, in.± 0.005 in. (mm ± 0.13 mm)
¼	3 × specified minimum wall for all sizes.
⅜	
½	
¾	
1	
1¼	
1¾	

Pipe Nominal Diameter	Pipe SDR →	Clearance Between Parallel Plates, in. ± 0.005 in. (mm ± 0.13 mm)						
		32.5	26	21	17	13.5	11	9.3
½				0.186	0.186	0.186	1.228	0.270
(13)				(4.7)	(4.7)	(4.7)	(5.8)	(6.9)
¾				0.270	0.270	0.270	0.285	0.339
(19)				(6.9)	(6.9)	(6.9)	(7.2)	(8.6)
1				0.270	0.270	0.291	0.357	0.423
(25)				(6.9)	(6.9)	(7.4)	(9.1)	(10.7)
1¼				0.270	0.294	0.369	0.453	0.534
(32)				(6.9)	(7.5)	(9.4)	(11.5)	(13.6)
1½				0.270	0.336	0.423	0.519	0.613
(38)				(6.9)	(8.5)	(10.7)	(13.2)	(15.6)
2				0.339	0.420	0.528	0.648	0.765
(50)				(8.6)	(10.7)	(13.4)	(16.5)	(19.4)
2½				0.411	0.507	0.639	0.783	0.925
(63)				(10.4)	(12.9)	(16.2)	(19.9)	(23.5)
3				0.501	0.618	0.777	0.954	1.128
(76)				(12.7)	(15.7)	(19.7)	(24.2)	(28.7)
3½				0.570	0.708	0.888	1.089	1.298
(90)				(14.5)	(17.9)	(22.6)	(27.7)	(33.0)
4				0.642	0.780	0.999	1.227	1.449
(100)				(16.4)	(19.8)	(25.4)	(31.1)	(36.8)
5				0.795	0.984	1.239	1.518	
(125)				(20.2)	(25.0)	(31.5)	(38.6)	
6		0.612	0.765	0.948	1.170	1.473	1.809	
(150)		(15.5)	(19.4)	(24.1)	(29.7)	(37.4)	(45.9)	
8		0.795	0.996	1.230	1.524	1.917	2.355	
(200)		(20.2)	(25.2)	(31.2)	(38.7)	(48.9)	(59.8)	
10		0.993	1.239	1.533	1.899	2.391	2.934	
(250)		(25.2)	(31.5)	(38.9)	(48.2)	(60.7)	(74.5)	
12		1.176	1.470	1.824	2.250	2.835	3.480	
(300)		(29.8)	(37.3)	(46.3)	(57.2)	(72.0)	(88.4)	

11. Precision and Bias

11.1 *Precision*—Based on a seven laboratory round robin conducted on three sizes of medium density polyethylene pipe, the standard deviation of this test method based on the natural logarithmic of the failure times is as follows:

11.1.1 *Within-Laboratory*—±16 % (repeatability):

11.1.1.1 Sample calculation:

failure time = 100 h
ln (failure time) = 4.6052
±16 % of ln (failure time) = ±0.7368
ln (repeatability of failure time) = 3.8684 and 5.3420
repeatability of failure time = 48 and 209

Therefore, if this ESCR test is repeated for a similar specimen, the failure time will be between 48 and 209 h.

11.1.2 *Between-Laboratory*—±9 % (reproducibility).

11.2 *Bias*—No bias statement can be made since no reference method is available.

12. Keywords

12.1 environmental stress crack resistance; polyethylene

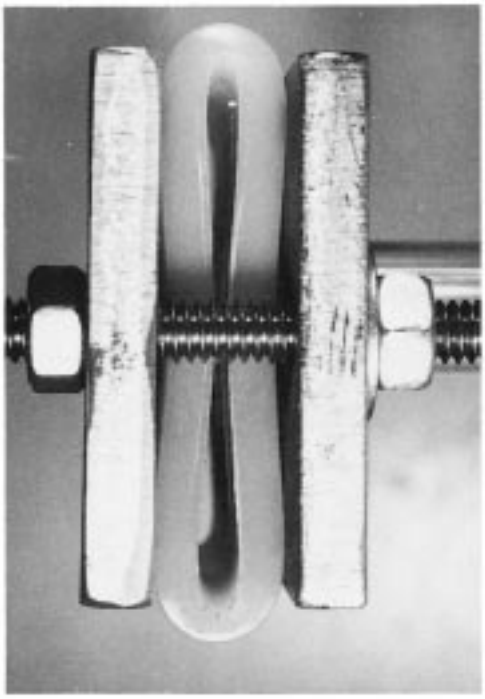


FIG. 6 Fully Compressed Rings in ESCR Test

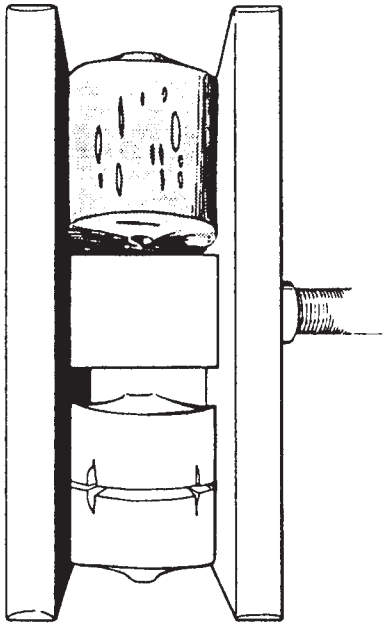


FIG. 7 Examples of Failure in ESCR Test