



Standard Test Method for Outdoor Weathering Exposure of Crosslinked Polyethylene (PEX) Tubing¹

This standard is issued under the fixed designation F2657; 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 the procedure for exposing crosslinked polyethylene (PEX) tubing produced in accordance with Specification [F876](#) to natural (sunlight) ultraviolet (UV) radiation and evaluating the effects of the exposure. This test method outlines the requirements for specimen size and preparation, exposure orientation, minimum UV exposure energy, post exposure testing and reporting.

NOTE 1—While other laboratory UV exposure systems are available, this test method relies on natural sunlight as the UV radiation source. Laboratory methods may be added in the future if testing confirms a correlation between natural sunlight and laboratory exposure.

1.2 PEX tubing is not designed for outdoor use. Data from short-term exposure testing per this test method can be used to judge the relative performance of PEX tubing stored outdoors for short periods of time prior to installation completely shielded from sunlight.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 The following precautionary caveat pertains only to the test method and post exposure testing portions, Sections 8 and 9 of this test method. *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

[D1435](#) Practice for Outdoor Weathering of Plastics

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 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.

- [D1598](#) Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
- [D1600](#) Terminology for Abbreviated Terms Relating to Plastics
- [F412](#) Terminology Relating to Plastic Piping Systems
- [F876](#) Specification for Crosslinked Polyethylene (PEX) Tubing
- [F2023](#) Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Tubing and Systems to Hot Chlorinated Water
- [G147](#) Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology [F412](#) and abbreviations are in accordance with Terminology [D1600](#), unless otherwise indicated.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *nominal exposure time period, n*—the number of months corresponding to the measured TUV as defined in [Table 1](#).

3.2.2 *polar orientation, n*—the longitudinal direction of the specimens with respect to the Equator.

3.2.3 *solar UV radiation, n*—the portion of the light spectrum falling within the range of 295nm to 385nm.

3.2.4 *total solar UV radiation (TUV), n*—the sum of measured UV Energy for the time period specimens are exposed, expressed in MJ/m². The historical average monthly TUV values for Central Arizona, 5° off horizontal exposure are listed in [Table 1](#).

3.2.5 *tubing bow, n*—the resultant curvature of a tubing sample taken from a coil.

3.2.6 *UV energy, n*—the amount of solar UV radiation per unit time based on a 5° off horizontal specimen placement for Central Arizona expressed as MJ/m².

3.2.6.1 *Discussion*—UV Energy for Central Arizona was selected as it represents the worst case North American location based on a 4-year average of 1998 through 2001. This information was provided by Atlas Material Testing Technology LLC.

TABLE 1 Total UV (TUV) Energy per Monthly Time Period^A

Nominal Exposure Time Period	TUV Solar Radiation MJ/m ²	Highest Consecutive UV Month Range
1 month	40	June
2 months	80	May-June
3 months	119	May-July
4 months	154	May-August
5 months	187	April-August
6 months	218	April-September
7 months	246	March-September
8 months	270	March-October
9 months	289	February-October
10 months	307	February-November
11 months	324	January-November
12 months	339	January-December

^ASolar UV radiation is based on Central Arizona 5° off horizontal for the 4 year period of 1998 through 2001 as reported by Atlas and Testing and Technology LLC.

4. Summary of Test Method

4.1 PEX tubing specimens are exposed to solar UV radiation for a period of time and then removed. The exposed specimens are then tested in accordance with one of the following methods:

4.2 *Potable Water Applications*—UV exposed specimens are tested at one temperature and pressure condition in accordance with Test Method **F2023** to determine the average time to failure. The average time to failure for the UV-exposed specimens is then compared to the average time to failure of non UV-exposed specimens of the same PEX material or to the predicted time to failure for the same material based on a complete Test Method **F2023** data set. The percentage decrease in the average time to failure for the UV exposed specimens and the TUV of the exposure are reported.

4.3 *Non-Potable Water Applications*—PEX tubing for non-potable water applications is post-exposure tested in accordance with 4.2 or, alternately, tested in accordance with the stabilizer functionality test in Specification **F876**. The pass or fail result of the stabilizer functionality test and the TUV of the exposure are reported.

5. Significance and Use

5.1 During shipment, storage and installation, PEX tubing may be exposed to UV radiation prior to being shielded from further exposure after installation. The effects of UV exposure on PEX tubing is determined by use of this test method. By first exposing specimens to solar UV radiation and subsequently testing specimens for oxidative resistance or stabilizer functionality, changes as a result of solar UV radiation exposure can be evaluated. This information can be used to determine the maximum allowable total UV exposure prior to permanent shielding provided by installation.

5.2 The results of short-term exposure tests can provide an indication of relative outdoor performance, but they should not be used to predict the absolute long-term performance of a material. The results of tests conducted for less than twelve months will depend on the particular season of the year in which they begin.

6. Apparatus

6.1 *Test Site*—Exposure site shall be in accordance with Practice **D1435** and shall be in a hot, dry climate (for example, Phoenix, AZ).

6.2 *Specimen Rack*—Specimen racks shall be in accordance with Practice **D1435** and shall allow for vertical mounting of samples free of torsional or tensile stress. The rack shall position the exposed surface of the specimens at a tilt angle in the range of 5° to 45° inclusive.

6.3 *Backing*—specimens shall be tested un-backed.

6.4 *UV Energy Measurement Equipment*—UV radiation shall be measured using an Ultraviolet Radiometer conforming to the requirements of Practice **D1435**. Radiometer shall be mounted in the same attitude as the exposed samples.

7. Sampling and Specimen Preparation

7.1 *Sampling*—specimens shall be representative of the product/material being evaluated. Select a sufficient amount of tubing to satisfy the testing requirements. Specimens can be straight or can have a bow when cut from a coil.

7.2 *Test Specimen Size*—PEX tubing specimens shall be of nominal size ½ in., SDR 9, and shall be a minimum of 380 mm (15 in.) in length for the UV exposure portion of this method.

7.3 *Number of Test Specimens:*

7.3.1 *Post Exposure Testing to Test Method F2023*—when a complete data set exists for the PEX material being evaluated to Test Method **F2023** and that data will be used for calculation in accordance with 10.4, a minimum of five specimens are required. When no data set exists for the PEX material being evaluated to Test Method **F2023**, or the existing data set will not be used for calculation in accordance with 10.4, a minimum of ten specimens are required, five for UV exposure and five for the non UV-exposed portion of this method.

7.3.2 *Post-Exposure Testing to Stabilizer Functionality* — a minimum of six specimens are required when stabilizer functionality is used for post UV exposure testing.

NOTE 2—The minimum specimen requirements are based on a single Nominal Exposure Time Period (NETP) for the material being evaluated. When the expected NETP for the material is unknown, additional specimens may be UV exposed for various levels of NETP and post-exposure test data can be evaluated against non-UV exposed data.

8. Procedure

8.1 *Required Specimens*—obtain sufficient specimens in accordance with Section 7.

8.2 *Preparation*—condition and prepare specimens in accordance with Practice **G147** prior to exposure testing. Samples to be used for non-UV exposed testing, when required, shall be shielded from any UV exposure source (for example, sunlight, fluorescent lighting, HID lamps, etc.) with opaque covering.

8.3 *Mounting Specimens for UV Exposure:*

8.3.1 *Polar Orientation*—position specimens in the North-South orientation with respect to the Equator. See Fig. 1.

8.3.2 *Mounting*—mount specimens on the specimen rack vertically free of torsional or tensile stress.

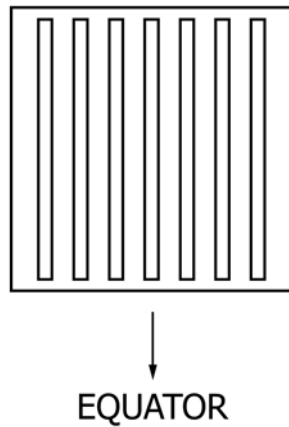


FIG. 1 North-South Polar Orientation

8.3.3 *Tubing Bow*—bowed specimens, such as those cut from a coil, shall be positioned with the crown of the bow $90^\circ \pm 5^\circ$ to the plane of the rack. The crown may be positioned in the up or the down position. All bowed specimens in a rack shall be bowed in the same direction either outward or inward relative to the plane of the rack. See Fig. 2. Tubing orientation shall not permit containment of water.

8.3.4 *Markings Positioning*—any print lines, markings or stripes shall be positioned so that no portion of them lie within the region of $\pm 45^\circ$ from the vertical axis centerline (top dead center). See Fig. 3.

8.4 *UV Exposure*—Expose specimens. Once the desired TUV in accordance with Table 1 is achieved remove specimens.

NOTE 3—Since each PEX compound will have different resistance to UV exposure, exposure at several TUV levels may be required to determine the maximum TUV that can be tolerated by the particular compound being evaluated.

8.5 *Handling Exposed Specimens*—exposed specimens shall be handled in accordance with G147. Exposed specimens shall be shielded from any UV exposure source (for example, sunlight, fluorescent lighting, HID lamps, etc.) with opaque covering.

9. Post UV-Exposure Testing

9.1 Test UV-Exposed Specimens generated in Section 8 to either 9.2 or 9.3. When required, test non UV-exposed specimens in accordance with 9.4.

9.2 *Oxidative Resistance Testing to Test Method F2023*—test the exposed specimens at one temperature and pressure condition in accordance with Test Method F2023. Test all specimens to failure. All failures shall be Stage III brittle oxidative failures. See Specification F876.

NOTE 4—The selection of the temperature and pressure for post-exposure oxidative resistance testing is not critical. However, testing at a higher temperature will reduce the test duration. When a data set in accordance with Test Method F2023 exists for the PEX tubing being evaluated, selecting a temperature and pressure condition of that data set is preferred so that the effects of UV exposure can be directly calculated.

9.3 *Stabilizer Functionality Testing to Specification F876*—test a minimum of six UV-exposed specimens in accordance with the stabilizer functionality section of Specification F876.

9.4 *Non UV-Exposed Specimen Testing*— When no data set in accordance with Test Method F2023 exists for the PEX tubing being evaluated, or when an existing data will not be used to evaluate the effects of UV exposure, test a minimum of five non UV-exposed specimens in accordance with Test Method F2023 at the same temperature and pressure condition as for the exposed specimens. Test all specimens to failure. All failures shall be Stage III brittle oxidative failures.

10. Calculation

10.1 When performing post UV-exposure testing per 9.2, calculate the average of the failure times in hours for the UV-exposed specimens ($X_{UV \text{ Exposed}}$).

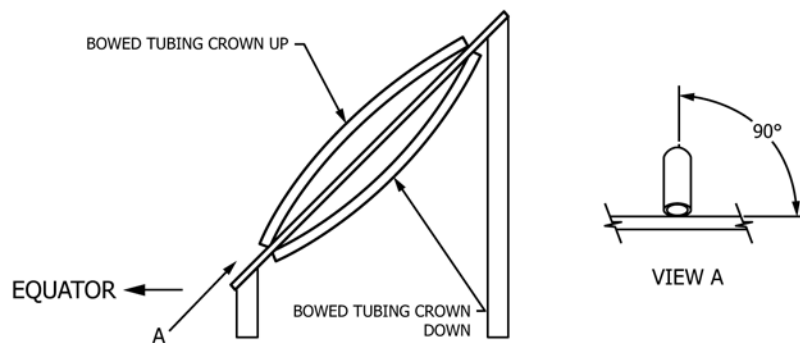


FIG. 2 Bowed Tubing Racking

TOP DEAD CENTER

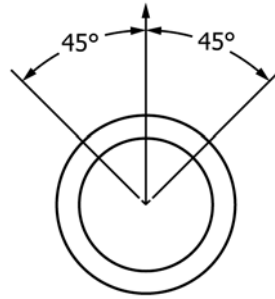


FIG. 3 Top Dead Center

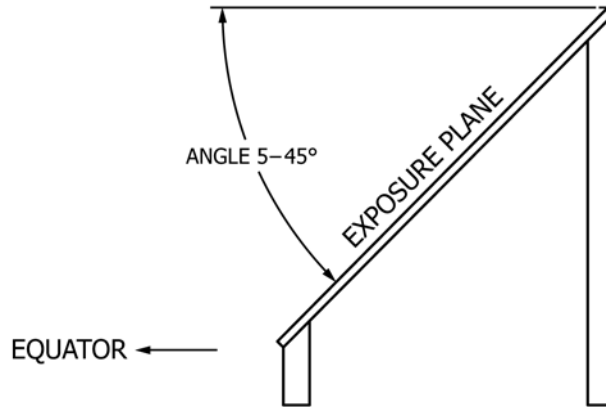


FIG. 4 Exposure Plane Angle

10.2 When performing non UV-expose testing per 9.4, calculate the average of the failure times in hours for the non-exposed samples ($X_{\text{non UV-exposed}}$).

10.3 When existing oxidative stability data in accordance with F2023 exists for the material being evaluated and that data is used to evaluate the effects of UV exposure for the same material, calculate the expected time to failure ($X_{\text{non UV-exposed}}$) for the same temperature and pressure condition used for the UV-exposed specimens based on the regression equation developed in Test Method F2023 for the PEX material.

10.4 Calculate the percentage decrease in average failure times of the UV-exposed specimens relative to the non UV-exposed specimens or calculated value from 10.3:

$$\% \text{ decrease in failure time} = \left(1 - \frac{(X_{\text{UV Exposed}})}{(X_{\text{non UV-exposed}})} \right) * 100\% \quad (1)$$

11. Report

11.1 *Material and Sample Identification*— Report the following information:

- 11.1.1 Tubing nominal size and DR or wall thickness specification,
- 11.1.2 Tubing manufacturer’s name,
- 11.1.3 Trade designation,
- 11.1.4 Tubing lot number (if applicable),
- 11.1.5 Resin manufacturer’s name,

11.1.6 Compound designation and lot designation (for in-plant compounded materials, resin manufacturer’s name may be omitted), and

11.1.7 Cross-linking process.

11.2 *Exposure Conditions*—report the exposure conditions in accordance with Standard Practice D1435 and this method including:

- 11.2.1 Total radiant UV exposure (TUV),
- 11.2.2 Total solar radiant exposure,
- 11.2.3 Nominal Exposure Time Period,
- 11.2.4 Dates of exposure,
- 11.2.5 Exposure location and laboratory name,
- 11.2.6 Mounting method ,
- 11.2.7 Racking Angle,
- 11.2.8 Polar orientation,
- 11.2.9 Marking position, and
- 11.2.10 Tubing bow position (crown up or crown down).

11.3 *Oxidative Resistance Test*—report as per the requirements of Section 14 of Test Method F2023. Report the $X_{\text{UV exposed}}$, $X_{\text{non-UV exposed}}$ and method of calculating, and the % decrease in failure time as calculated in 10.4.

11.4 *Stabilizer Functionality*—report as per the reporting requirements of Test Method D1598 and report the pass or fail as per the requirement of Specification F876 for stabilizer functionality.

12. Precision and Bias

12.1 *Precision*—It is not possible to specify the precision of the procedure in Test Method F2657 for measuring UV Resistance of PEX tubing because no material having an accepted reference value is available.

12.2 *Bias*—No information can be presented on the bias of the procedure in Test Method F2657 for measuring UV

Resistance of PEX tubing because no material having an accepted reference value is available

13. Keywords

13.1 crosslinked polyethylene; PEX; sunlight; tubing; UV exposure; weathering

APPENDIX

(Nonmandatory Information)

X1. TUV ENERGY BY MONTH FOR CENTRAL ARIZONA, 5° OFF HORIZONTAL FOR THE 4 YEAR PERIOD OF 1998 THROUGH 2001

X1.1 See [Table X1.1](#).

TABLE X1.1 TUV Energy by Month for Central Arizona, 5° off Horizontal for the 4 Year Period of 1998 through 2001

Nominal Exposure Time Period	Monthly TUV Solar Radiation MJ/m ²	Cumulative TUV Solar Radiation MJ/m ²
January	17	17
February	19	36
March	28	64
April	33	97
May	40	137
June	40	177
July	39	216
August	35	251
September	31	282
October	24	306
November	18	324
December	15	339

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