Designation: F2023 – 21

Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Pipe, Tubing and Systems to Hot Chlorinated Water[1]

This standard is issued under the fixed designation F2023; 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 general requirements for evaluating the long-term, chlorinated water, oxidative resistance of cross-linked polyethylene (PEX) pipe or tubing produced in accordance with PEX specifications, such as Specification F876 or Specification F2788/F2788M by exposure to hot, chlorinated water. This test method outlines the requirements of a pressurized flow-through test system, typical test pressures, test-fluid characteristics, failure type, and data analysis.

NOTE 1—Other known disinfecting systems (chlorine dioxide, ozone, and chloramines) are also used for protection of potable water. Free-chlorine is the most common disinfectant in use today. A PPI research project examined the relative aggressiveness of free chlorine and chloramines on PEX pipes, both at the same 4.0 ppm concentration and the same test temperatures. The results of the testing showed pipe failure times approximately 40% longer when tested with chloramines compared to testing with free chlorine, at the tested conditions. Based on these results, the data suggests that chloramines are less aggressive than free chlorine to PEX pipes.

1.2 Guidelines and requirements for test temperatures, test hoop stresses, and other test criteria have been established by prior testing of PEX pipe or tubing produced by the three most common commercial methods of cross-linking: silane, peroxide, and electron-beam (see Note 2). Other related system components that typically appear in a PEX hot-and-cold water distribution system can be evaluated with the PEX pipe or tubing. When testing PEX pipe or tubing and fittings as a system, it is recommended that the anticipated end-use fitting type(s) and material(s) be included in the test circuit since it is known that some fitting types and materials can impact failure times. Specimens used shall be representative of the piping product(s) and material(s) under investigation.

NOTE 2—The procedures described in this test method (with some modifications of test temperatures or stresses, or both) have been used to evaluate pipes manufactured from polybutylene (PB), polyethylene (PE), polypropylene (PP), multilayer (polymer-metal composite), copper, and stainless steel.

1.3 This test method is applicable to PEX pipe or tubing and systems used for transport of potable water containing free-chlorine for disinfecting purposes. The oxidizing potential of the test-fluid specified in this test method exceeds that typically found in potable water systems across the United States.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 The following precautionary caveat pertains only to the test method portion, Section 12, of this specification. *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

F412 Terminology Relating to Plastic Piping Systems

F876 Specification for Crosslinked Polyethylene (PEX) Tubing

[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.

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

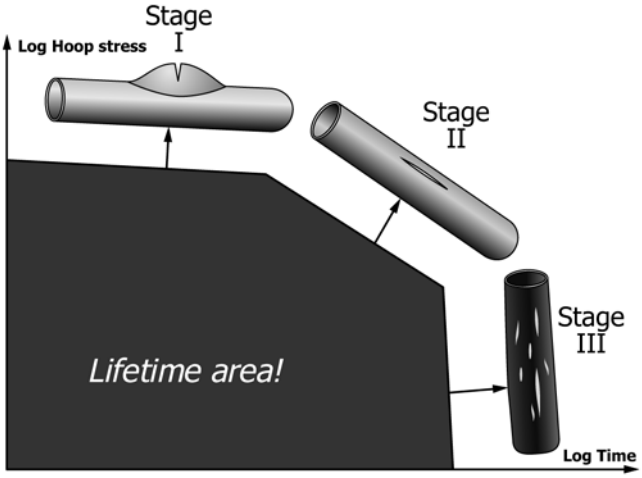

FIG. 1 Pictorial Illustration of Failure Types

F2788/F2788M Specification for Metric and Inch-sized Crosslinked Polyethylene (PEX) Pipe

2.2 *ISO Standards:*

ISO 9080 Thermoplastic Pipe for Transport of Fluids—Methods of Extrapolation of Hydrostatic Stress Rupture Data to Determine the Long Term Strength of Thermoplastic Pipe

ISO 13760 Plastic Pipe for the Conveyance of Fluids Under Pressure—Miners Rule—Calculation Method for Cumulative Damage[3]

2.3 *Plastics Pipe Institute (PPI) Document:*

TN-16 Rate Process Method for Projecting Performance of Polyethylene Piping Components[4]

2.4 *American Water Works Association (AWWA) Document:*

1996 WATER:\STATS Survey[5]

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.1.2 *brittle failure (Stage II), n*—failure in the pipe or tubing wall that is characterized by little or no material deformation in the failure area and is the result of a single crack emanating from the interior of the pipe or tubing to the outside surface typically resulting in a pinhole leak, see Fig. 1. Brittle failures produced with this test method shall not be used for data analysis.

3.1.3 *ductile failure (Stage I), n*—failure in the pipe or tubing wall that is characterized by obvious localized deformation of the material visible with the unaided eye, see Fig. 1. Ductile failures produced with this test method shall not be used for data analysis.

3.1.4 *environmental or oxidative failure (Stage III), n*—failure in the pipe or tubing wall characterized by a large number of cracks emanating from the interior surface of the pipe or tubing wall, see Fig. 1.

3.1.4.1 *Discussion*—Stage III failures may also be identified by a color shift in the failure area (typically brown or reddish-brown). Identification of environmental or oxidative failure, when not obvious by inspection with the unaided eye, can be performed with a 25× microscope or other similar device yielding the same level of magnification. Only Stage III environmental or oxidative failures shall be used for data analysis.

3.1.5 *hot-and-cold water distribution system, n*—a combination of components such as pipe or tubing, fittings, valves, and so forth, that when installed as a complete system, make up the interior water supply system of a commercial or residential structure.

3.1.6 *long-term oxidative resistance, n*—the extrapolated time-to-failure prediction as determined by analysis of time-to-failure test data by multiple linear regression utilizing the rate process method of PPI TN-16 or Model Q of ISO 9080. Where applicable, application of Miners Rule in accordance with ISO 13760 can be used to estimate time-to-failure at several differing conditions of temperature or stress, or both.

3.1.7 *multiple linear regression, n*—a three or four coefficient mathematical model used to analyze time-to-failure data from different temperatures and stresses to extrapolate projected time-to-failure at selected temperatures or stresses.

3.1.8 *Miners Rule, n*—a mathematical method for estimating the cumulative, irreversible damage that results from exposure to each of several differing conditions of stress or temperature, or both.

3.1.9 *oxidation reduction potential (ORP), n*—a measure of the total oxidizing power of a solution by means of a platinum-redox electrode. For a further explanation of ORP see Appendix X2.

3.1.10 *unaided eye, n*—observable without visual enhancement beyond correction for normal vision.

4. Summary of Test Method

4.1 The PEX pipe or tubing or pipe/tubing/fitting assemblies are exposed to pressurized test-fluid until failure. All time-to-fail data used for analysis shall be the result of oxidative degradation (Stage III). A minimum number of test temperature and hoop stress conditions are required to allow accurate data analysis and time-to-failure extrapolations.

5. Significance and Use

5.1 Environment or oxidative time-to-fail data derived from this test method, analyzed in accordance with Section 13, are suitable for extrapolation to typical end-use temperatures and hoop stresses. The extrapolated value(s) provides a relative indication of the resistance of the tested PEX pipe or tubing or system to the oxidative effects of hot, chlorinated water for conditions equivalent to those conditions under which the test data were obtained. The performance of a material or piping product under actual conditions of installation and use is

[4] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

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