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Standard Practice for Field Leak Testing of Polyamide-12 (PA12) Pressure Piping Systems Using Gaseous Testing Media Under Pressure (Pneumatic Leak Testing)[1]

This standard is issued under the fixed designation F3535; 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 practice provides information on apparatus, safety, pre-test preparation, and procedures for conducting field tests of polyamide-12 (PA12) pressure piping systems after installation using gaseous testing media such as un-odorized inert non-toxic gas or air, and applying pressure to determine if leaks exist in the system (pneumatic leak testing). This practice applies only to testing to discover leakage. Testing for other purposes such as testing to establish operating pressure is beyond the scope of this practice.

1.2 Leak testing with pressurized gaseous testing media shall be used only if one or both of the following conditions exists:

1.2.1 The piping system is so designed that it cannot be filled with a liquid, or

1.2.2 The piping system service cannot tolerate traces of liquid testing media.

1.3 Where hydrostatic testing is specified in contract documents or by the authority having jurisdiction, testing using pressurized gaseous testing media (pneumatic) testing shall not be substituted without the express consent and authorization of the authority having jurisdiction.

1.4 Some manufacturers prohibit or restrict testing of their products with pressurized gaseous testing media. Contact component manufacturers for information. Where the manufacturer of a test section component prohibits or restricts testing with pressurized gaseous testing media testing in accordance with this practice shall not be used without the express consent and authorization of the authority having jurisdiction and the component manufacturer.

NOTE 1—Components that are not suitable for testing with gaseous testing media may not be suitable for service with pressurized gas.

1.5 This practice does not address leak testing using pressurized liquids (hydrostatic testing). For field leak testing using pressurized liquids, consult the manufacturer for guidance.

1.6 This practice does not apply to leak testing of non-pressure, negative pressure (vacuum), or non-PA12 (polyamide-12) piping systems.

1.7 This practice does not apply to fuel gas piping systems that extend from the point of delivery to the appliance connections. For other than undiluted liquefied petroleum gas (LP-Gas) systems, the point of delivery shall be considered to be the outlet of the service meter assembly or the outlet of the service regulator or service shutoff valve where no meter is provided. For undiluted LP-Gas, the point of delivery shall be considered to be the outlet of the final pressure regulator, exclusive of line gas regulators, in the system. This practice does not apply to LP-Gas systems covered under NFPA 58.

1.8 This practice is intended for use with PA12 pressure piping that conveys gaseous media under pressure (compressed gas) if the owner or operator or installer of the line does not have an established leak testing procedure that is acceptable to the authority having jurisdiction.

1.9 **Warning—**Failure during a pressurized gaseous testing media leak test can be extremely violent and dangerous because energy that is applied to compress the gaseous testing media and to pressurize the system will both be suddenly released.

NOTE 2—To illustrate the violent hazard of failure, assume a 5 HP compressor is used to raise the test section to test pressure and that it takes 1 h to achieve test pressure. If sudden rupture occurs, energy release may occur in 2 s. Therefore, the horsepower of the energy release would be 5 HP × 1 h × 3600 s/h / 2 s = 9000 HP. Further, if diameter is doubled, energy release is four times greater. For an example test section that is twice the diameter, energy release would be 36 000 HP.

1.10 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. Numbered

[1] This practice 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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notes and information in parentheses in the text of the practice are non-mandatory information. Table notes are mandatory information.

1.11 *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.*

1.12 *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

F412 Terminology Relating to Plastic Piping Systems

2.2 *PPI Standard:*[3]

PPI TR-4 PPI HSB Listing of Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Strength Design Basis (SDB), Pressure Design Basis (PDB), Minimum Required Strength (MRS) Ratings and Categorized Required Strength (CRS) For Thermoplastic Piping Materials or Pipe

2.3 *NFPA Standard:*[4]

NFPA 58 Liquefied Petroleum Gas Code

3. Terminology

3.1 Abbreviations and terms are in accordance with Terminology D1600 and Terminology F412 unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *authority having jurisdiction, n*—the organization, office or individual responsible for "approving" equipment and installation, or a procedure.

3.2.1.1 *Discussion*—The term "authority having jurisdiction" is used in this practice in a broad manner since jurisdictions and "approval" agencies vary, as do their responsibilities. Where public safety is concerned, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshall, chief of a fire prevention bureau, labor department, building official, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau or other insurance company representative may be the "authority having jurisdiction". In many circumstances, the property owner or his authorized engineer or agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

3.2.2 *approve, v*—(*approved, approving, approval*) acceptable to or authorized by the authority having jurisdiction.

3.2.3 *authorized persons, n*—persons that are fully informed of the testing procedure and hazards of field pressure testing, and that are qualified to operate the onsite testing equipment, and that are qualified to perform onsite leak detection.

3.2.3.1 *Discussion*—Authorized persons may be agents or representatives or inspectors for the authority having jurisdiction, or may be employees of the party conducting the test. Contract documents may identify responsibilities, but regardless of assigned responsibilities, only authorized persons shall be allowed in proximity of test sections when testing (in accordance with Section 9) is underway.

3.2.4 *gaseous testing media, n*—a non-toxic, non-flammable fluid that is chemically compatible with piping system components, and at testing temperature and pressure exists in a non-solid, non-liquid state.

3.2.5 *pressure piping system, n*—a piping system where all components in the system are pressure rated and intended for conveying a fluid under continuous internal pressure. (See also Terminology F412, pressure pipe, and non-pressure pipe.) To verify suitability for pressure service, consult the component manufacturer.

3.2.5.1 *Discussion*—PPI TR-4 provides information about stress ratings for some plastic piping compounds, materials, and products.

3.2.6 *restraint, n*—temporary or permanent structural measures or devices that restrict, guide, prevent, or safely limit disjoining and movement of the piping system and piping components while the system is under pressure during testing or service conditions. Restraint may include backfill, anchors, thrust blocks, external clamps and tie rods (joint restraints), pipe guides, etc.

3.2.6.1 *Discussion*—Restraint means that if violent separation or failure occurs during pressurization or testing, any movement of components or parts is sufficiently constrained or prevented such that damage or injury is prevented.

3.2.7 *system design pressure, n*—the limiting continuous internal pressure specified by the piping system designer. System design pressure may be less than the pressure ratings of components in the system. System design pressure may be limited by component pressure ratings, by code or application requirements, or by other restrictions.

3.2.8 *visible leakage, n*—the visible escape (bubbles, drip, spray, stream, flow, etc.) of test media from the test section through components, joints, connections, appurtenances and the like in the test section. Visibility of gaseous media leakage is enhanced by the application of leak detection fluid at joints, seals or seams where leakage is likely.

4. Summary of Practice

4.1 The section of the piping system to be tested shall be isolated from other parts of the system, and shall be restrained as described in 3.2.6. Components that are not to be subjected

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

[4] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

to test pressure or that could be damaged by test pressure shall be removed, or shall be isolated and vented to atmosphere. The test section is filled with the gaseous testing media, raised to the test pressure and allowed to stabilize. The system is inspected or monitored for leakage, and then test pressure is relieved. If repairs or corrections are necessary, they are performed only when the test section is depressurized. If necessary, retesting is performed after leak repairs or corrections and a relaxation period. At the conclusion of an acceptable test (approval), the test section may be placed in service. Purging or disposal of the gaseous testing media from the test section may be necessary.

4.2 Test pressure and test duration are dependent on piping system volume and piping system temperature. The volume of compressed gaseous testing media available or compressor capacity will determine the test section length that can be raised to test pressure within specified test duration and test pressure limits. Elevated temperatures anywhere in the test section, especially where test section areas are exposed to sunlight heating, require reduced test pressure.

4.3 Acceptance is determined by the approval of the authority having jurisdiction.

4.4 If applicable, the authority having jurisdiction specifies procedures or requirements for gaseous testing media disposal or containment during depressurizing or purging.

5. Significance and Use

5.1 If required by the authority having jurisdiction, pressurized gaseous testing media leak testing is conducted after installation to discover and correct or repair leaks or faults in a newly constructed or modified PA12 pressure piping system before placing the system in service. Leakage or faults most commonly occur at connections, joints, and mechanical seals where sealing under pressure is required.

5.2 Safety is of paramount importance when conducting pressurized gaseous testing media leak tests because testing results include no leaks, leaks, sudden violent rupture, or catastrophic failure.

5.3 Systems that contain lower pressure rated or non-pressure rated components that cannot be isolated or removed from exposure to test pressure, or where temporary caps or closures are not practical, are not suitable for testing in accordance with this practice.

5.4 *Leakage Allowance*—Leakage is not allowed for butt and electrofusion joints, and restrained gas-tight mechanical joints. See 7.6. Contact the joint, connection or component manufacturer for leakage correction information if leakage occurs at a joint, connection or component having a mechanical seal.

5.5 *Poisson-Effect Expansion and Contraction*—When test pressure is applied to plastic piping systems that have fully restrained joints such as heat fusion, electrofusion, bolted flanges, etc., either reduction of overall pipe length or an increase in longitudinal stress results from diametrical expansion of the pipe. Disjoining (pull-out) of partially restrained or non-restrained connections or joints, such as some in-line mechanical connectors having insufficient resistance to pull-out stress or length reduction, is possible when partially restrained or unrestrained joints are in-line with the fully restrained test section. To prevent Poisson-effect disjoining of partially restrained or non-restrained joints take measures such as installing external joint restraints (diametrical clamps and tie-rods) on in-line partially restrained or non-restrained joints, installing in-line thrust anchors at the ends of fully restrained piping sections to prevent end movement of the fully restrained section, or isolating a fully restrained test section from piping with unrestrained or partially restrained joints.

NOTE 3—A tensile stress applied to a material will cause elongation in the direction of the applied stress, and will cause a decrease in dimension at right angles to the direction of the applied stress. The ratio of decrease to elongation is the Poisson ratio. Under test pressure, piping materials will expand slightly in diameter and contract in length slightly according to the Poisson ratio of the material.

6. Apparatus and Equipment

6.1 Isolation and closure components such as caps, valves, blind flanges, and other devices that are used to isolate and close the test section from other parts of the system, and that are used to isolate components that are not to be subjected to test pressure from the test section are required.

6.1.1 Test section isolation and closure components shall be rated for pressures equal to or greater than the test pressure applied to the test section, and shall be restrained against longitudinal separation (pull out or push off) such that the PA12 pipe and the isolation or closure component shall not separate under the pressure forces and loads imposed during testing. Excessively worn, deteriorated or damaged equipment shall not be used. Equipment that is not capable of proper operation shall not be used.

6.1.2 Pipe squeeze-off shall not be used to isolate or sectionalize piping for test.

NOTE 4—Squeeze-off cannot always prevent gas flow.

6.2 *Gaseous Testing Media*—An adequate supply of non-toxic and non-flammable gaseous testing media is required. Gases such as natural gas, LP gas, propane, butane, hydrogen sulfide, and other flammable or toxic gases shall not be used as testing media.

6.3 *Leak Detection*—Leak detection fluids shall be non-toxic and chemically benign to PA12 piping material and other materials used in connections, joints and seals. Leak detection fluids shall not be injected into or added to the gaseous testing media.

NOTE 5—Leakage usually occurs at a connection, joint, or seal in the system. Depending upon the type of connection, joint, or seal, leakage may be seepage, spray, or a stream of gaseous testing media. Leak detection fluids applied to the connection, joint, or seal typically produce bubbles from leakage.

6.4 *Filling and Pressurizing Equipment*—Filling and pressurizing equipment such as a compressor or pressurized cylinders of gaseous testing media are required. Filling and pressurizing equipment shall supply sufficient compressed gaseous testing media so that test duration limits are not

exceeded. See 8.2.3. Filling equipment and pressurizing equipment shall be the same or separate equipment. All gaseous testing media shall pass into the test section through a single connection.

6.5 *Pressure Monitoring and Regulating*—Pressure monitoring and regulating equipment shall display, control, and maintain test pressure for the duration of the procedure, and shall incorporate means to prevent overpressure.

NOTE 6—Excessive test pressure can cause damage or test section failure. One means to prevent overpressure is to install a calibrated pressure relief valve in the test section that is set to relieve test section pressure at a pressure that is not more than 5 psi (34.5 kPa) or 3 percent above test pressure.

6.5.1 Use at least two calibrated pressure gauges or sensors that are properly scaled for the test and accurate to within two percent (2 %) of full scale. The gauge or sensor full scale value shall not be more than twice the test pressure, and scale graduations shall be no greater than two percent (2 %) of the full-scale value. A test tree combines valves, tees, a gauge cock for bleeding, a pressure snubber, and duplicate pressure gauges or sensors. See Fig. 1 for an example test tree. A continuous pressure-recording device is recommended.

6.5.2 Pressure monitoring equipment shall be calibrated against a recognized standard acceptable to the authority having jurisdiction. Records of calibration not more than twelve (12) months prior to use shall be made available to the authority having jurisdiction. Pressure monitoring and regulating equipment that has not been calibrated within twelve (12) months prior to use or is damaged or otherwise incapable of proper operation shall not be used.

6.5.3 Locate the test pressure gauge or sensor to display and monitor test pressure in the test section.

NOTE 7—Duplicate pressure sensing and monitoring at several points in the test section are helpful by providing redundancy in the event of pressure gauge or sensing device error or failure.

6.6 Temperature measuring equipment such as pyrometers or infrared temperature gauges accurate to within ±5 °F (±3 °C) to measure in situ temperature of exposed pipe in test sections is required for determination of maximum test pressure. Temperature monitoring equipment that has not been calibrated within twelve (12) months prior to use or is damaged or otherwise incapable of proper operation shall not be used.

6.7 Timing equipment such as clocks, wrist watches, stopwatches or other devices that display time in hours and minutes, the means to record beginning, intermediate, and ending times, and the means to determine the duration of applicable time periods are required. At least two timing devices shall be used. Timing equipment shall be accurate to within 5 min in 24 h.

6.8 Other equipment to connect a compressor or pressurized cylinders of gaseous testing media to the test section, to control the flow of gaseous testing media, to power compressors and other equipment, to connect pressure regulating and monitoring equipment to the test section, to monitor pressure, and to purge the gaseous testing media from the test section are required as applicable.

7. Safety Precautions

7.1 This safety information is in addition to safety information in other sections of this practice.

7.2 Always take precautions to eliminate hazards to persons near lines being tested. Only authorized persons that are conducting the test or inspecting the piping section being tested are allowed to be in the proximity of the section under test for the entire duration of the procedure and for any subsequent retesting, including filling, initial pressurization, time at test pressure, and de-pressurization.

7.3 For the entire duration of the procedure, the test section and the work area around the test section and equipment shall be supervised or secured with barricades and warnings so that unauthorized persons are kept a safe distance away.

7.4 Failure during the procedure may result in sudden, violent, uncontrolled, and dangerous movement of system piping, or components, or parts of components. (See 1.9.)

7.5 *Restraint against Movement and Exposure of Connections, Joints and Seals*—Take measures to ensure that

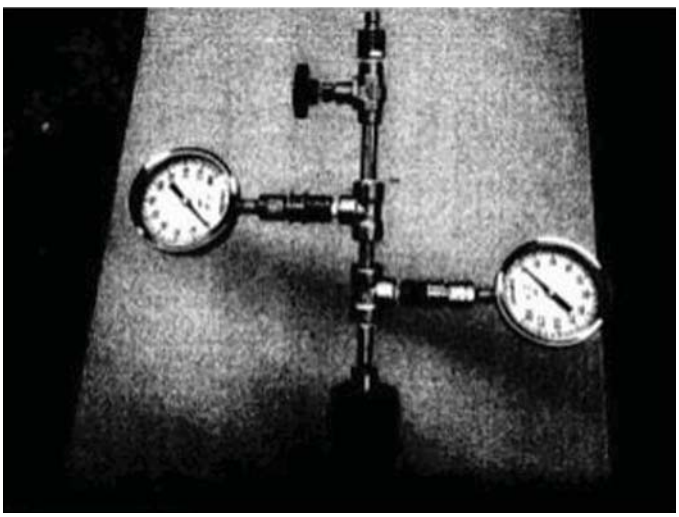

FIG. 1 Example Test Tree

all parts of the section under test are structurally restrained as described in 3.2.6 against movement if failure occurs. Observe manufacturer's precautions for securing and restraining mechanical end (test) caps. End closures or mechanical end caps that are defective or that cannot be fully restrained to the test section shall not be used.

7.5.1 When connections, joints and seals are to be exposed for leakage observation during the test, use restraint methods as described in 3.2.6 to control movement in the event of joint or connection separation, giving due consideration to restraining thrust forces. In particular, joints that derive primary restraint from the interaction of the pipe and soil shall have mechanical restraints installed across the joint and shall be backfilled prior to testing.

7.5.2 Pipe that is connected to connections, joints and seals that are exposed for leakage observation shall be restrained on both sides of the connection, joint, or seal. The unrestrained exposed pipe distance to the side of the exposed connection, joint or seal shall not exceed the greater of 5 pipe diameters or 3 ft (1 m).

7.6 When properly made, heat fusion joints in PA12 pipe are structurally comparable to the parent PA12 pipe material and do not leak. Leakage at a fusion joint indicates a structurally deficient joint having the imminent potential for complete separation. If leakage is observed at a fusion joint, move away immediately, and depressurize the test section.

7.7 The test section shall be isolated from piping systems sections that contain flammable or toxic gas.

8. Pre-Test Preparation and Set-Up

8.1 *General:*

8.1.1 Before testing, heat fusion joints shall be completely cooled. Mechanical joints shall be completely assembled with all necessary seals and all fasteners installed and securely tightened. Parts that seal service tees such as threaded caps shall be secured in accordance with manufacturer's instructions.

8.1.2 If required, flushing, pigging, or other means of cleaning the system to remove dirt and debris shall be performed before testing.

8.1.3 Before testing, concrete supports, blocking, and anchors in the test section shall be cured until they have developed sufficient strength to withstand test pressure thrust forces.

8.1.4 Before pressure is applied, connections to test equipment, connections within the test section and, if applicable, connections between the test section and services shall be in proper operating condition and secure.

8.1.5 Before pressure is applied, isolated components or devices shall be vented to atmosphere.

8.1.6 Before pressure is applied, disconnect or isolate and vent all low-pressure components.

8.1.7 All parts of the test section and components that will be subjected to test pressure shall be restrained against movement in the event of failure as described in 3.2.6. Expansion joints and expansion compensators shall be removed, restrained or isolated before starting the procedure. See 7.5.

8.2 *Test Section*—Testing may be conducted on the entire system, or on sections of the system. Test section size is determined by the capacity of the filling and pressurizing equipment. It is necessary to conduct the procedure within the allowable test duration. Equipment that has inadequate capacity will not be able to complete the test within the allowable test duration. If so, use higher capacity test equipment, or test a smaller (shorter) section of the system.

8.2.1 *Test Temperature*—Standard pressure ratings for PA12 piping materials are for 73 °F (23 °C) and lower. Reduced test pressure is required where any part of the test section is above 73 °F (23 °C), especially areas of the test sections that are exposed for leakage inspection. Contact fitting and other component manufacturers for guidance on the effects of elevated temperatures on those components.

NOTE 8—When testing using liquids, a cooler liquid filling the test section helps reduce overall test section temperature, especially sections that are exposed to sunlight heating in warmer climates. But testing with a gaseous testing media does not have a similar cooling effect. Heated compressed gas from a compressor, or sunlight heating of exposed test section piping, can raise exposed test section piping temperatures to 140 °F (60 °C) and higher. To reduce the temperature, increase in exposed parts of the test section, measures such as conducting tests during non-daylight or cooler early daytime hours, or shielding exposed parts of the test section against direct exposure to sunlight heating may be employed.

8.2.2 *Maximum Test Pressure*—To assure safety and prevent damage, maximum test pressure shall not exceed the lower of *(1)* the pressure rating of the lowest pressure rated component, fitting, or device that is in (or cannot be removed from) the test section, or *(2)* the leak test pressure calculated in accordance with 8.2.2.1. Test pressure tolerance is controlled by test pressure monitoring and regulating equipment that is in accordance with 6.5.

NOTE 9—Lower pressure rated components or devices may include components or devices such as pipe or fittings made from other plastics or metals, or appurtenances such as valves, hydrants, regulators, pressure relief devices, or the like, or some types of mechanical connections such as lower pressure rated compression couplings or flanges with lower pressure rated back-up rings. Consult the component or device manufacturer for pressure rating information.

8.2.2.1 Calculate the PA12 pipe leak test pressure, $P_{(T)}$, for the intended test duration, and pipe temperature as follows:

$$P_{(T)} = \frac{2 \times HDS}{(DR - 1)} \times F_T \times H_t = PR \times F_T \times H_t \quad (1)$$

where:

$P_{(T)}$ = Leak Test Pressure, psi (MPa), for Leak Test Time, T,
T = Leak test Time, hours, in accordance with Table 1,
HDS = PA12 material hydrostatic design stress for water at 73 °F (23 °C), psi (MPa) in accordance with Table 2,
F_T = PA12 material temperature reduction factor in accordance with 8.2.2.2,
H_t = Leak Test Duration Factor for leak test time T in accordance with Table 1,
PR = Pipe Pressure Rating or Pressure Class for water at 73 °F (23 °C), and
DR = Pipe dimension ratio = pipe average outside diameter, in (mm) / pipe minimum wall thickness, in (mm).