Designation: E2930 – 13

Standard Practice for Pressure Decay Leak Test Method[1]

This standard is issued under the fixed designation E2930; 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 describes a method for determining the leakage rate of a vessel subject to a positive pressure difference. The technique is based upon evaluation of the change of mass within the test object based on a pressure decay measurement. The pressure decay measurement uses the ideal gas equation of state and the measured pressures, temperatures, and time to determine the mass loss from the vessel. This method does not apply to deformable vessels.

1.2 *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]

E479 Guide for Preparation of a Leak Testing Specification (Withdrawn 2014)[3]

E543 Specification for Agencies Performing Nondestructive Testing

E1316 Terminology for Nondestructive Examinations

2.2 *ANSI/ASNT Standards:*[4]

ANSI/ASNT-CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel

SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification and Certification

2.3 *AIA Document:*[5]

NAS-410 Certification and Qualification of Nondestructive Testing Personnel

2.4 *ASME Standards:*[6]

ASME Boiler and Pressure Vessel Code Section V Article 10 (paragraph T-1044)

2.5 *ISO Standards:*[7]

ISO/IEC Guide 98–3 Uncertainty of Measurement — Part 3

3. Terminology

3.1 *Definitions:*

3.1.1 *pressure decay test resolution*—the resolution of the test that can be derived from the test equipment specifications and the volume of the test vessel. The test resolution is determined by evaluation of the individual resolutions of the pressure measurement, temperature measurement, and time measurement for a known vessel volume. The method for determining the test resolution is give in Annex A1.

3.1.2 *pressure decay test accuracy*—the test accuracy is the estimated accuracy of the test based on a combination of the measurement accuracies of contributing variables. The method for determining the test accuracy is given in Annex A2.

4. Summary of Test Method

4.1 This practice requires a known volume and the use of the pressure rate of decay technique for quantitative measurement of leakage rates. The practice is written to be usable over a wide range of pressures and system volumes. This method is only applicable to the test of non-deformable volumes or devices. Test devices which may have significant changes in volume due to pressurization should not be tested with this method. The method requires the measurement of the system pressure and temperature as a function of time and as such requires that these measurements be made with calibrated instrumentation. The range of the measurement technique can vary significantly but is generally applicable in the range greater than 1×10^{-8} mol/s (2.2×10^{-4} std cc/s)

5. Significance and Use

5.1 The equipment, test duration, and technique should be determined before commencement of the test based on the

[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.08 on Leak Testing Method.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

[5] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.

[6] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[7] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

required test sensitivity or accuracy (see Annex A1 and Annex A2). If the test is used to certify that the vessel has a minimum specified leakage rate, then the test equipment and test duration should be chosen to have a resolution ten times less than the specification and an accuracy which is four times less than the specification. The test should be designed so that the total pressure change is less than 10 % of the starting pressure. Leak test specifications should specify the vessel test pressure or differential pressure. If the test specification does not specify a test pressure, then a safe test pressure should be used that complies with the applicable safety standards[8].

6. Basis of Application

6.1 The following items are subject to contractual agreement between parties using or referencing this practice.

6.2 *Personnel Qualification:*

6.2.1 If specified in the contractual agreement, personnel performing examinations to this practice shall be qualified in accordance with a national or internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, NAS-410, or a similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

6.3 *Qualification of Nondestructive Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice E543. The applicable revision of Practice E543 shall be in the contractual agreement.

7. Interferences

7.1 Interferences in the reported leak values could result from desorption of gases from the vessel or adsorption of gases into the vessel. In addition, the effect of permeation of gases out of the test vessel may be significant for very low leak rate measurements. Eq A2.3 of Annex A2 can be modified to incorporate these additional effects if appropriate. This test assumes a nominal isothermal testing environment.

8. Apparatus

8.1 The required test equipment includes a pressure gauge/transducer of the appropriate range, automated or manual timing system for data collection, and a temperature measurement device along with proper fixtures as shown in Fig. 1.

9. Reagents and Materials

9.1 A non-condensable, inert gas is required for pressurization of the test vessel. If air is used, the dew point temperature must be lower than the tested temperature range.

10. Hazards

10.1 In no instance should the test pressure exceed the maximum allowed vessel design limits.

[8] See ASME Boiler and Pressure Vessel Code Section V Article 10 (paragraph T-1044)

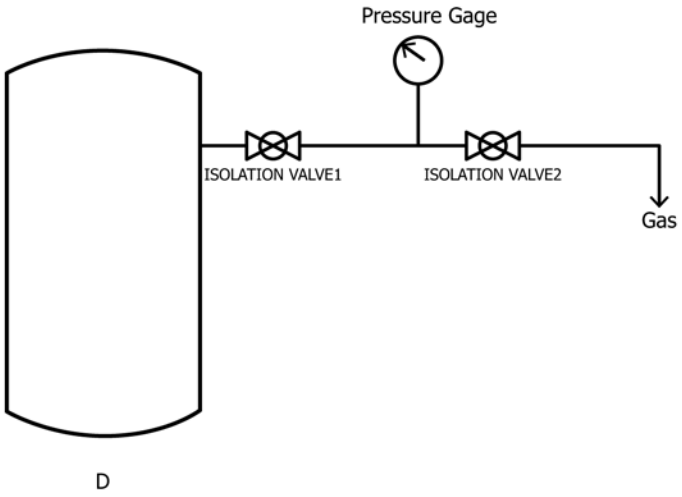

FIG. 1 Test Apparatus

11. Sampling, Test Specimens, and Test Units

11.1 The units for test should be in mol/s or pressure based units of Pa m^3/s or std cc/s with the units referenced to a standard temperature of 0°C or 273.15 K (unless otherwise specified in the test specification). The actual test temperatures can vary over the specified operable ranges of the instrumentation, as long as the temperature is stable enough to meet the test resolution requirements.

12. Preparation of Apparatus

12.1 *Vessel Preparation*—The test vessel should be clean and dry. Hydrostatic, bubble, and liquid penetrant testing should not be performed prior to a pressure decay test. All internal components subject to deformation or failure should be removed. Care should be taken where trapped or poorly accessible volumes may be encountered (double gasket seals) because they can increase the uncertainty of the test.

13. Calibration and Standardization

13.1 The test equipment (pressure measurement, temperature measurement, and time measurement) must be appropriately calibrated and traceable to national or international standards. The accuracy of the method depends on the determination of the test vessel volume as outlined in Annex A3.

13.2 Commercial pressure decay systems often use an internal leak standard to determine the volume of the test system. In this case the manufacturer should specify the accuracy of the determined volume as outlined in Annex A3.

14. Conditioning

14.1 The volume and test equipment should be allowed to thermally equilibrate before commencing the test. The test vessel should not be pressurized beyond the pressure specifications (or design limits).

15. Procedure

15.1 Assemble the test system and determine the system volume (see Annex A3). An isolation valve should be used between the test vessel and test system for isolation purposes.

15.2 Perform a leak test of the test system with the isolation valve closed and ensure that the leakage of the test system is less than 1 % of the target test value for the test vessel.

15.3 Determine the test parameters (initial pressure and test time) and calculate the test resolution and accuracies according to Annex A1 and Annex A2. Ensure that the calculated test resolution is at least ten times less than the target leakage rate. Ensure that the test accuracy is at least four times less than the target leakage rate.

15.4 Pressurize the vessel to the target pressure and close the isolation valve 2.

15.5 *Stabilization Time (Setting Time)*—After pressurization, the temperature and pressure should be monitored as a function of time over the test duration previously established in 5.1. The pressure should be recorded at a minimum of ten time intervals during the test sequence. The temperature should be recorded at the beginning and end of the test to ensure that the temperature is stable to within the previously assumed limits. Illustrative pressure decay leak test data is shown in Fig. 2. During the charge phase, gas is added to the test system. The pressure in the test system will naturally decay due to a number of factors (pressure equilibrating within the test system, gas temperature equilibrating, and so forth). The settling time will be dependent on the geometry of the test system, the test pressures, filling times, type of gas used, and other environmental factors.

The leak rate should be calculated from the individual measurements with the following equations:

$$N = (\Delta PV)/(RT(\Delta t)), \text{mol/s} \quad (1)$$

$$N = ((\Delta PV)/(\Delta t))(T_R/T), \text{Pa m}^3\text{/s, or Std cc/s} \quad (2)$$

where:

V = the vessel volume
R = the universal gas constant 8.3144 J/mol K (8.3144 Pa m^3/(mol K)
T = the vessel temperature, K
T_R = the reference temperature for the units (typically 273.15 K)
ΔP = the change in pressure between successive points
Δt = the change in time in seconds between successive points

Examples are provided in Eq 3 and 4

where:

ΔP = 10000 Pa (0.1 atm)
V = 0.0001 m^3
Δt = 100 sec.
T_R = 273.15
T = 298 K

$$N = \frac{(10000\ \text{Pa})\cdot 0.0001\text{m}^3\cdot 273.15\text{K}}{100\text{s}\cdot 293\text{K}} = 9.3\times 10^{-3}\text{Pa m}^3\text{/s} \quad (3)$$

$$N = \frac{(0.1\ \ \text{atm})\cdot 100\text{cm}^3\cdot 273.15\text{K}}{100\text{s}\cdot 293\text{K}} = 9.3\times 10^{-2}\text{Std cm}^3\text{/s} \quad (4)$$

15.6 Depending upon the test conditions, it may require seconds to hours for the indicated leak rate to stabilize. Stabilization criteria should be based on point to point variations in the measured leak rate with a target of less than three times the calculated test resolution. The test data used in the leak calculation in Section 16 will utilize data collected after stabilization.

15.7 The leak rate calculation can be calculated using one of two methods. Method A is preferred as it also allows for estimation of the precision of the test from the standard deviation of the measurements.

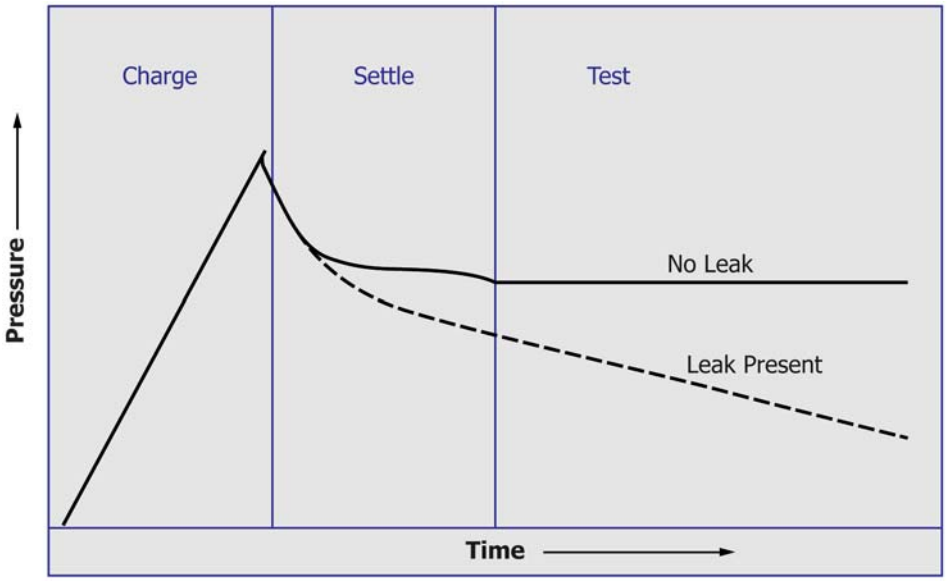

FIG. 2 Illustration of Pressure Decay Test Data