Designation: E493/E493M – 11 (Reapproved 2017)

Standard Practice for Leaks Using the Mass Spectrometer Leak Detector in the Inside-Out Testing Mode[1]

This standard is issued under the fixed designation E493/E493M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This practice[2] covers procedures for testing devices that are sealed prior to testing, such as semiconductors, hermetically enclosed relays, pyrotechnic devices, etc., for leakage through the walls of the enclosure. They may be used with various degrees of sensitivity (depending on the internal volume, the strength of the enclosure, the time available for preparation of test, and on the sorption characteristics of the enclosure material for helium). In general practice the sensitivity limits are from 10^{-10} to 10^{-6} Pa m^3/s (10^{-9} standard cm^3/s to 10^{-5} standard cm^3/s at 0°C) for helium, although these limits may be exceeded by several decades in either direction in some circumstances.

1.2 Two test methods are described:

1.2.1 *Test Method A*—Test part preparation by bombing.

1.2.2 *Test Method B*—Test part preparation by prefilling.

1.3 *Units*—The values stated in either SI or std-cc/sec units are to be regarded separately as standard. The values stated in each system may not be exact equivalents: therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *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.*

1.5 *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:*[3]

E1316 Terminology for Nondestructive Examinations

2.2 *Other Documents:*

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing[4]

ANSI/ASNT CP-189 ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel[4]

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification[5]

NAS-410 Certification and Qualification of Nondestructive Test Personnel[6]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, see Terminology E1316, Section E.

4. Summary of Practice

4.1 The test methods covered in this practice require that the test part contain helium at some calculable pressure at the time of test. If the device cannot be sealed with a known pressure of helium inside, it is necessary to "bomb" the part in a helium pressure chamber in order to introduce helium into the test part if a leak exists.

4.2 After the test part has been subjected to helium pressurizing means, it is placed in an enclosure which is then evacuated and coupled to a mass spectrometer leak detector. In

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[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] The inside-out testing mode is characterized by an external vacuum and internal pressure. This standard covers "evacuated," "sealed with tracer," and "air-sealed" testing procedures shown in Terminology E1316.

[3] 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.

[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 Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

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

the event of a leak, an output signal will be obtained from the leak detector. If the actual leak rate of the test part must be known, this must then be calculated from the output reading and the test parameters.

5. Personnel Qualification

5.1 If specified in the contractual agreement, personnel performing examinations to this practice shall be qualified in accordance with a nationally-recognized NDT personnel qualification practice or standard, such as ANSI/ASNT CP-189, SNT-TC-1A, MIL-STD-410, 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. Significance and Use

6.1 Methods A or B are useful in testing hermetically-sealed devices with internal volumes. Maximum acceptable leak rates have been established for microelectronic devices to assure performance characteristics will not be affected by in-leakage of air, water vapor or other contaminants over the projected life expected. Care must be taken to control the bombing pressure, bombing time and dwell time after bombing or the results can vary substantially.

7. Interferences

7.1 Surface fissures, paint, dirt, polymer seals, etc., can all sorb helium during the bombing procedure and will contribute to the output signal on the leak detector. Unless this process is uniform and consistent, such that nonleaking test parts always give the same helium signal, the test sensitivity is limited by the background signal from sorbed helium. Either one or both procedures of nitrogen "washing" or baking parts for 30 min between bombing and testing will sometimes help to reduce this background signal.

7.2 In the case of large leaks or very small internal volumes in the test parts, the helium presumably sealed or bombed into the test part may have escaped prior to testing on the mass spectrometer leak detector. The test must be made for large leaks within a few seconds after removing the parts from the bomb or an alternate test method for large leaks must be employed—bubble testing,[7] liquid bombing and weight change. If the method for finding large leaks uses a liquid it must be performed after the helium leak test to avoid sealing the fine leaks.

8. Apparatus

8.1 *Mass Spectrometer Leak Detector (MSLD).*

8.2 *Roughing Pump,* to remove air from the test enclosure in which the test part is placed together with pressure-measuring means and suitable valving to connect the test enclosure to the leak detector after evacuating the test enclosure.

8.3 *Pressure Vessel,* capable of safely withstanding the desired helium "bombing" pressure. The pressure containers must meet applicable safety codes for pressure vessels.

[7] For further information on leak-testing terminology, see Terminology E1316.

9. Materials

9.1 *Helium* supply from a regulated source.

9.2 *Liquid Nitrogen* supply (if required by mass spectrometer leak detector).

9.3 *Dry Air or Nitrogen* (if required) for washing surface helium from test objects.

10. Calibration

10.1 Calibrate the mass spectrometer leak detector (MSLD) with a calibrated leak to read directly in Pa m^3/s or standard cm^3/s of helium in accordance with the manufacturers' instructions.

11. Procedure

11.1 *Test Method A (Bombing):*

11.1.1 Place a quantity of sealed parts to be tested in a pressure vessel.

11.1.2 Then either flush the pressure vessel with helium or evacuate the vessel (the latter is preferred).

11.1.3 Seal and pressurize the vessel with helium to the specified pressure.

11.1.4 Hold at the specified pressure for the time, *T*, required to give the desired test sensitivity (see 11.1.10) and pressure.

11.1.5 Release the helium at a considerable distance from the leak detector. (It may be piped out of the building or released into a holding tank to avoid raising the ambient helium pressure in the test area.)

11.1.6 Remove the test parts from the pressure vessel and flush with helium-free dry air or nitrogen to remove sorbed helium from the surface. The flush time can be determined experimentally.

11.1.7 Place the objects to be tested singly or in multiples in the MSLD test enclosure and test.

11.1.8 Record the indicated leak rate of each part and the length of time in seconds that the part has been out of the pressure vessel. (If multiple parts have been tested simultaneously and the MSLD indicates a leak, test the parts individually and note the leak rate of each part and the time in seconds that it has been out of the pressure vessel.)

11.1.9 To find the actual leak rate of a given part, the following simplified equation can be used, assuming molecular flow:

indicated leak rate = bombing pressure × % entering in bombing × % of this remaining × actual leak rate, more formally defined as:

$$S_t = \frac{P_e}{P_o}\left(1 - e^{-3600aT}\right)\left(e^{-at}\right)L$$

where:

S_t = indicated leak rate (Pa m^3/s or standard cm^3/s),
P_e = bombing pressure of helium in kPa (psia),
P_o = atmospheric pressure in kPa (psia),
T = bombing time (h),
t = waiting time (s) between bombing and testing,
L = actual leak rate (Pa m^3/s or standard cm^3/s) (Note 1),
a = L/V where V = internal volume (cm^3), and

e = 2.71 (natural logarithm).

11.1.9.1 The actual leak rate thus calculated will in no case be smaller than the actual leak, hence a safety factor is built in.[8]

11.1.10 If P_e is known, T can be kept constant in a repetitive process, and a desired maximum leak level L is known, a safe reject point for the MSLD leak rate indication (S_t) may be calculated by using the equation in 11.1.9. The maximum value of t should be used.

NOTE 1—The value that would be measured if the cavity contained 100 % trace gas at atmospheric pressure.

11.2 *Test Method B*—Filling with helium prior to sealing:

11.2.1 Fill the test part with helium at a known pressure prior to sealing.

11.2.2 Seal the test parts to be tested.

11.2.3 Same as 11.1.7.

11.2.4 Same as 11.1.8.

11.2.5 To find the actual leak rate of a given part, omit the first bracket of the equation shown in 11.1.9 as follows:

$$S_t = \frac{P_e}{P_o}\left(e^{-at}\right)L$$

11.2.6 If a and P_e /P_o are constants in a repetitive process and a desired maximum leak level L is known, a safe reject point for the MSLD leak rate indication (S_t) may be calculated by using the equation in 11.2.5. The maximum value of t should be used.

12. Keywords

12.1 bell jar leak test; bomb mass spectrometer leak test; helium leak test; helium leak testing; leak testing; mass spectrometer leak testing; sealed object mass spectrometer leak test

[8] A table of computer solutions to the equation given in 11.1.9 for various values of V, L, T and t commonly encountered in practice is available on request from Varian Vacuum Division/NRC Operation, 160 Charlemont St., Newton, MA 02161.