Designation: E 493 – 97

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

This standard is issued under the fixed designation E 493; 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 These test methods[2] cover 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 4.4×10^{-15} to 4.4×10^{-11} moles/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 *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:*

E 1316 Terminology for Nondestructive Examinations[3]

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]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this standard, see Terminology E 1316, Section E.

4. Summary of Test Methods

4.1 These test methods 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 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 It is recommended that personnel performing leak testing attend a dedicated training course on the subject and pass a written examination. The training course should be appropriate for NDT level II qualification according to Recommended Practice No. SNT-TC-1A of the American Society for Nondestructive Testing or ANSI/ASNT Standard CP-189.

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

---

[1] These test methods are under the jurisdiction of ASTM Committee E-7 on Nondestructive Testing and are the direct responsibility of Subcommittee E07.08 on Leak Testing.

Current edition approved May 10, 1997. Published February 1998. Originally published as E 493 – 73. Last previous edition E 493 – 94.

[2] The inside-out testing mode is characterized by an external vacuum and internal pressure. This document covers "evacuated," "sealed with tracer," and "air-sealed" testing procedures shown in Terminology E 1316.

[3] *Annual Book of ASTM Standards*, Vol 03.03.

[4] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

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,[5] 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.

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:

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

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.[6]

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:

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

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

[5] For further information on leak-testing terminology, see Terminology E 1316.

[6] 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.

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. Precision and Bias

12.1 *Precision*—Replicate tests by the same operator with the same equipment should be considered suspect if more than .1 % of the devices previously accepted are found to be rejects. The test results for this method need not be considered suspect if less than 1 % of the devices are found to be rejects on subsequent tests by another facility.

12.2 *Bias*—The bias of the test is on the order of ±25 %.The commercially available calibrated leaks have stated uncertainties of ±10 % of their rated values. This test is not intended to be a measurement of actual leak rate but a determination of a leak rate in excess of a specified allowable leak rate.

13. Keywords

13.1 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