

MIL-STD-883E

METHOD 1014.10

SEAL

1. **PURPOSE.** The purpose of this test is to determine the effectiveness (hermeticity) of the seal of microelectronic and semiconductor devices with designed internal cavities.

1.1 **Definitions.**

- a. **Standard leak rate.** Standard leak rate is defined as that quantity of dry air at 25°C in atmosphere cubic centimeters flowing through a leak or multiple leak paths per second when the high-pressure side is at 1 atmosphere (760 mm Hg absolute) and the low-pressure side is at a pressure of not greater than 1 mm Hg absolute. Standard leak rate shall be expressed in units of atmosphere cubic centimeters per second (atm cc/s).
- b. **Measured leak rate.** Measured leak rate (R_1) is defined as the leak rate of a given package as measured under specified conditions and employing a specified test medium. Measured leak rate shall be expressed in units of atmosphere cubic centimeters per second (atm cc/s). For the purpose of comparison with rates determined by other methods of testing, the measured leak rates must be converted to equivalent standard leak rates.
- c. **Equivalent standard leak rate.** The equivalent standard leak (L) of a given package, with a measured leak rate (R_1), is defined as the leak rate of the same package with the same leak geometry, that would exist under the standard conditions of 1.1a. The formula (does not apply to test condition B) in 3.1.1.2 represents the L/R ratio and gives the equivalent standard leak rate (L) of the package with a measured leak rate (R_1) where the package volume and leak test conditioning parameters influence the measured value of (R_1). The equivalent standard leak rate shall be expressed in units of atmosphere cubic centimeters per second (atm cc/s).

2. **APPARATUS.** The apparatus required for the seal test shall be as follows for the applicable test condition:

2.1 **Test conditions A₁, A₂, and A₄, ^{1/} tracer gas helium (He) fine leak.** Apparatus required shall consist of suitable pressure and vacuum chambers and a mass spectrometer-type leak detector preset and properly calibrated for a helium leak rate sensitivity sufficient to read measured helium leak rates of 10⁻⁹ atm cc/s and greater. The volume of the chamber used for leak rate measurement should be held to the minimum practical, since this chamber volume has an adverse effect on sensitivity limits. The leak detector indicator shall be calibrated using a diffusion-type calibrated standard leak at least once during every working shift. In addition for test condition A₄, the following apparatus is required:

- a. Fixture and fittings to mate the package to be tested to the leak detector.
- b. Surgical rubber gasket.
- c. Apeizon grease (type M or N), perfluorocarbon fluid ^{2/}, or equivalent, if required to obtain seal.

^{1/} A₃ was intentionally omitted.

^{2/} Perfluorocarbons contain no chlorine or hydrogen.

2.2 Test condition B, radioisotope fine leak. Apparatus for this test shall consist of:

- a. Radioactive tracer gas activation console.
- b. Counting equipment consisting of a scintillation crystal, photomultiplier tube, preamplifier, ratemeter, and krypton-85 reference standards. The counting station shall be of sufficient sensitivity to determine through the device wall the radiation level of any krypton-85 tracer gas present within the device. The counting station shall have a minimum sensitivity corresponding to a leak rate of 10^{-9} atm cc/s of krypton-85 and shall be calibrated at least once every working shift using krypton-85 reference standards and following the equipment manufacturer's instruction.
- c. A tracer gas consisting of a mixture of krypton-85 and dry nitrogen. The concentration of krypton-85 in dry nitrogen shall be no less than 100 microcuries per atmospheric cubic centimeter. This value shall be determined at least once each 30 days and recorded in accordance with the calibration requirements of this standard (see 4.5.1 of MIL-STD-883).

2.3 Test condition C, perfluorocarbon gross leak. Apparatus for this test shall consist of:

- a. A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 105 psia up to 23.5 hours.
- b. A suitable observation container with provisions to maintain the indicator fluid at a temperature of 125°C and a filtration system capable of removing particles greater than 1 micrometer in size from the fluid (condition C1 only).
- c. A magnifier with a magnification in the range between 1.5X to 30X for observation of bubbles emanating from devices when immersed in the indicator fluid (condition C1 only).
- d. Sources of type I detector fluids, and type II indicator fluids as specified in table I.
- e. A lighting source capable of producing at least 15 thousand foot candles in air at a distance equal to that which the most distant device in the bath will be from the source. The lighting source shall not require calibration but the light level at the point of observation (i.e., where the device under test is located during observation for bubbles), shall be verified (condition C1 only).
- f. Suitable calibrated instruments to indicate that test temperatures, pressures, and times are as specified.
- g. Suitable fixtures to hold the device(s) in the indicator fluid (condition C1 only).
- h. A perfluorocarbon vapor detection system capable of detecting vapor quantities equivalent to 0.167 or 1/6 microliter of type I fluid (condition C3 only).
- i. The vapor detector used for condition C3 shall be calibrated at least once each working shift using a type I fluid calibration source, and following the manufacturer's instructions.

2.4 Test condition D, penetrant dye gross leak. The following apparatus shall be used for this test:

- a. Ultraviolet light source with peak radiation at approximately the frequency causing maximum reflection of the dye (3650 Å for Zyglo; 4935 Å for Fluorescein; 5560 Å for Rhodamine B, etc.).
- b. Pressure chamber capable of maintaining 105 psia.
- c. Solution of fluorescent dye (such as Rhodamine B, Fluorescein, Dye-check, Zyglo, FL-50, or equivalent) mixed in accordance with the manufacturer's specification.
- d. A magnifier with a magnification in the range between 1.5X to 30X for dye observation.

2.5 Test condition E, weight gain gross leak. Apparatus for this test shall consist of:

- A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 90 psia up to 10 hours.
- An analytical balance capable of weighing the devices accurately to 0.1 milligram.
- A source of type III detector fluid as specified in table I.
- A filtration system capable of removing particles greater than 1 micrometer in size from the perfluorocarbon fluid.
- Suitable calibrated instruments to measure test pressures and times.

TABLE I. Physical property requirements of perfluorocarbon fluids. 1/

Property	Type I	Type II	Type III	ASTM test method
Boiling point (°C)	50-95	140-200	50-110	D-1120
Surface tension (Dynes/cm) at 25°C		< 20		D-971 D-1331
Density at 25°C (gm/ml)	> 1.6	> 1.6	> 1.6	D-941
Density at 125°C (gm/ml)		> 1.5		D-941
Dielectric strength (volts/mil)	> 300	> 300	> 300	877
Residue (:gm/gm)	< 50	< 50	< 50	D-2109
Appearance	Clear colorless			NA

1/ Perfluorocarbons contain no chlorine or hydrogen.

2.6 Test conditions C₄ and C₅ - optical gross/fine leak. Apparatus required shall consist of suitable vacuum or vacuum/pressure chamber with an integral interferometry leak detector. The optical leak detector shall be preset and properly calibrated for an equivalent standard leak rate sensitivity of 10⁻⁵ atm-cc/s and greater for gross leak detection (C₄), or 1 X 10⁻⁷ atm-cc/s and greater for fine leak detection (C₅). The leak detection system shall be tested with a known good specimen at the beginning and end of each work shift.

3. **PROCEDURE.** Fine and gross leak tests shall be conducted in accordance with the requirements and procedures of the specified test condition. Testing order shall be fine leak (condition A or B or C₂) followed by gross leak (condition C₁, C₃, C₄, D, or E) except when C₄ is used together with A, B, or C₂. When specified (see 4), measurements after test shall be conducted following the leak test procedures. Where bomb pressure specified exceeds the microcircuit package capability, alternate pressure, exposure time, and dwell time conditions may be used provided they satisfy the leak rate, pressure, time relationships which apply, and provided a minimum of 30 psia (2 atmospheres absolute) bomb pressure is applied in any case or for condition C₄, a minimum of 10 psi differential test pressure is applied in any case. When test condition A₄ is used, gross leak testing is not required. However A₄ shall not be used in lieu of the required seal testing of fidded packages. When batch testing (more than one device in the leak detector at one time) is used in performing test condition A or B and a reject condition occurs it shall be noted as a batch failure. Each device may then be tested individually one time for acceptance if all devices in the batch are retested within one hour after removal from the tracer gas pressurization chamber. For condition B only, devices may be batch retested for acceptance providing all retesting is completed within one hour after removal from the tracer gas pressurization chamber. For condition C₂ only, devices that are batch tested, and indicate a reject condition, may be retested individually one time using the procedure of 3.3.3.1 herein, except that repressurization is not required if the devices are immersed in detector fluid within 20 seconds after completion of the first test, and they remain in the bath until retest. For conditions C₄ and C₅ only, the package must meet lid stiffness requirements defined in 3.6.

3.1 **Test condition A₁, A₂, or A₄ tracer gas (He) fine leak.** Test condition A₁ is a "fixed" method with specified conditions in accordance with table II that will ensure the test sensitivity necessary to detect the required measured leak rate (R₁). Test condition A₂ is a "flexible" method that allows the variance of test conditions in accordance with the formula of 3.1.1.2 to detect the specified equivalent standard leak rate (L) at a predetermined leak rate (R₁). Test condition A₄ is a method that will detect the required measured leak rate (R₁) of an unsealed package.

3.1.1 **Test conditions A₁ and A₂, procedure applicable to "fixed" and "flexible" methods.** The completed device(s), shall be placed in a sealed chamber which is then pressurized with a tracer gas of 100 +0, -5 percent helium for the required time and pressure. The pressure shall then be relieved and each specimen transferred to another chamber or chambers which are connected to the evacuating system and a mass-spectrometer-type leak detector. When the chamber(s) is evacuated, any tracer gas which was previously forced into the specimen will thus be drawn out and indicated by the leak detector as a measured leak rate (R₁). (The number of devices removed from pressurization for leak testing shall be limited such that the test of the last device can be completed within 60 minutes for test condition A₁, or within the chosen value of dwell time t₂ for test condition A₂.)

3.1.1.1 **Test condition A₁, fixed method.** The device(s) shall be tested using the appropriate conditions specified in table II for the internal cavity volume of the package under test. The time t₁ is the time under pressure and time t₂ is the maximum time allowed after release of pressure before the device shall be read. The fixed method shall not be used if the maximum equivalent standard leak rate limit given in the acquisition document is less than the limits specified herein for the flexible method.

TABLE II. Fixed conditions for test condition A₁.

Volume of package (V) in cm ³	Bomb condition			R ₁ Reject limit (atm cc/s He)
	Psia ±2	Minimum exposure time hours (t ₁)	Maximum dwell hours (t ₂)	
<0.05	75	2	1	5 x 10 ⁻⁸
≥0.05 - <0.5	75	4	1	5 x 10 ⁻⁸
≥0.5 - <1.0	45	2	1	1 x 10 ⁻⁷
≥1.0 - <10.0	45	5	1	5 x 10 ⁻⁸
≥10.0 - <20.0	45	10	1	5 x 10 ⁻⁸

3.1.1.2 Test condition A₂, flexible method. Values for bomb pressure exposure time, and dwell time shall be chosen such that actual measured tracer gas leak rate (R₁) readings obtained for the devices under test (if defective) will be greater than the minimum detection sensitivity capability of the mass spectrometer. The devices shall be subjected to a minimum of 2 atmospheres absolute of helium atmosphere. If the chosen dwell time (t₂) is greater than 60 minutes, graphs shall be plotted to determine an R₁ value which will assure overlap with the selected gross leak test condition. The chosen values, in conjunction with the value of the internal volume of the device package to be tested and the maximum equivalent standard leak rate (L) limit (as shown below or as specified in the applicable acquisition document), shall be used to calculate the measured leak rate (R₁) limit using the following formula:

$$R_1 = \frac{LP_E}{P_0} \left(\frac{M_A}{M} \right)^{\frac{1}{2}} \left\{ 1 - e^{- \left[\frac{LT_1}{VP_0} \left(\frac{M_A}{M} \right)^{\frac{1}{2}} \right]} \right\} e^{- \left[\frac{LT_2}{VP_0} \left(\frac{M_A}{M} \right)^{\frac{1}{2}} \right]}$$

Where:

- R₁ = The measured leak rate of tracer gas (He) through the leak in atm cc/s He.
- L = The equivalent standard leak rate in atm cc/s air.
- P_E = The pressure of exposure in atmospheres absolute.
- P₀ = The atmospheric pressure in atmospheres absolute. (1)
- M_A = The molecular weight of air in grams. (28.7)
- M = The molecular weight of the tracer gas (Helium) in grams. (4)
- t₁ = The time of exposure to P_E in seconds.
- t₂ = The dwell time between release of pressure and leak detection, in seconds.
- V = The internal volume of the device package cavity in cubic centimeters.

3.1.1.2.1 Failure criteria. Unless otherwise specified, devices with an internal cavity volume of 0.01 cc or less shall be rejected if the equivalent standard leak rate (L) exceeds 5 x 10⁻⁸ atm cc/s air. Devices with an internal cavity volume greater than 0.01 cc and equal to or less than 0.4 cc shall be rejected if the equivalent standard leak rate (L) exceeds 1 x 10⁻⁷ atm cc/s air. Devices with an internal cavity volume greater than 0.4 cc shall be rejected if the equivalent standard leak rate (L) exceeds 1 x 10⁻⁸ atm cc/s air.

3.1.2 Test condition A₁, procedure applicable to the unsealed package method. The fixture and fittings of 2.1a. shall be mounted to the evacuation port of the leak detector. Proof of fixturing integrity shall be verified by sealing a flat surfaced metal plate utilizing the gasket of 2.1 (and grease or fluid of 2.1 if required to obtain seal) and measuring the response of the leak test system. Testing shall be performed by sealing the package(s) to the evacuation port and the package cavity evacuated to 0.1 torr or less. Care shall be taken to prevent contact of grease with package (seal ring not included) to avoid masking leaks. The external portion of the package shall be flooded with Helium gas either by the use of an envelope or a spray gun, at a pressure of 45 psia.

3.1.2.1 Failure criteria. Unless otherwise specified, devices shall be rejected if the measured leak rate (R_1) exceeds 1×10^{-8} atm cc/s He.

3.2 Test condition B, radioisotope fine leak test.

3.2.1 Activation parameters. The activation pressure and soak time shall be determined in accordance with the following equation:

$$Q_s = \frac{R}{skTP\bar{P}} \quad (1)$$

The parameters of equation (1) are defined as follows:

- Q_s = The maximum leak rate allowable, in atm cc/s Kr, for the devices to be tested.
- R = Counts per minute above the ambient background after activation if the device leak rate were exactly equal to Q_s . This is the reject count above the background of both the counting equipment and the component, if it has been through prior radioactive leak tests.
- s = The specific activity, in microcuries per atmosphere cubic centimeter, of the krypton-85 tracer gas in the activation system.
- k = The overall counting efficiency of the scintillation crystal in counts per minute per microcurie of krypton-85 in the internal void of the specific component being evaluated. This factor depends upon component configuration and dimensions of the scintillation crystal. The counting efficiency shall be determined in accordance with 3.2.2.
- T = Soak time, in hours, that the devices are to be activated.
- \bar{P} = $P_a^2 - P_i^2$, where P_a is the activation pressure in atmospheres absolute and P_i is the original internal pressure of the devices in atmospheres absolute. The activation pressure (P_a) may be established by specification or if a convenient soak time (T) has been established, the activation pressure (P_a) can be adjusted to satisfy equation (1).
- t = Conversion of hours to seconds and is equal to 3,600 seconds per hour.

NOTE: The complete version of equation (1) contains a factor $(P_o^2 - (\Delta P)^2)$ in the numerator which is a correction factor for elevation above sea level. P_o is sea level pressure in atmospheres absolute and ΔP is the difference in pressure, in atmospheres between the actual pressure at the test station and sea level pressure. For the purpose of this test method, this factor has been dropped.

3.2.2 Determination of counting efficiency (k). The counting efficiency (k) of equation (1) shall be determined as follows:

- a. Five representative units of the device type being tested shall be tubulated and the internal void of the device shall be backfilled through the tubulation with a known volume and known specific activity of krypton-85 tracer gas and the tubulation shall be sealed off.
- b. The counts per minute shall be directly read in the shielded scintillation crystal of the counting station in which the devices are read. From this value, the counting efficiency, in counts per minute per microcurie, shall be calculated.

3.2.3 Evaluation of surface sorption. All device encapsulations consisting of glass, metal, and ceramic or combinations thereof, including coatings and external sealants, shall be evaluated for surface sorption of krypton-85 before establishing the leak test parameters. Representative samples of the questionable material shall be subjected to the predetermined pressure and time conditions established for the device configuration as specified by 3.2.1. The samples shall then be counted every 10 minutes, with count rates noted, until the count rate becomes asymptotic with time. (This is the point in time at which surface sorption is no longer a problem.) This time lapse shall be noted and shall determine the "wait time" specified in 3.2.4.

3.2.4 Procedure. The devices shall be placed in radioactive tracer gas activation tank. The activation chamber may be partially filled with inert material to reduce pumpdown time. The tank shall be evacuated to 0.5 torr. The devices shall be subjected to a minimum of 2 atmospheres absolute pressure of krypton-85/dry nitrogen mixture for a minimum of 12 minutes. Actual pressure and soak time shall be determined in accordance with 3.2.1. The R value in counts per minute shall not be less than 600 above background. The krypton-85/dry nitrogen gas mixture shall be evacuated to storage until 0.5 to 2.0 torr pressure exists in the activation tank. The storage cycle shall be completed in 3 minutes maximum as measured from the end of the activation cycle or from the time the activation tank pressure reaches 60 psia if a higher bombing pressure is used. The activation tank shall then immediately be backfilled with air (air wash). The devices shall then be removed from the activation tank and leak tested within 1 hour after gas exposure with a scintillation-crystal-equipped counting station. Device encapsulations that come under the requirements of 3.2.3 shall be exposed to ambient air for a time not less than the "wait time" determined by 3.2.3. In no case will the time between removal from the activation chamber and test exceed 1 hour. This exposure shall be performed after gas exposure but before determining leak rate with the counting station. Device encapsulations that do not come under the requirements of 3.2.3 may be tested without a "wait time." (The number of devices removed from pressurization for leak testing shall be limited such that the test of the last device can be completed within 1 hour.) The actual leak rate of the component shall be calculated with the following equation:

$$Q = \frac{(\text{ACTUAL READOUT IN NET COUNTS PER MINUTE}) \times Q_s}{R}$$

Where Q = Actual leak rate in atm cc/s, and Q_s and R are defined in 3.2.1.

NOTE: CAUTION. Discharge of krypton 85 into the atmosphere must not exceed limits imposed by local and Federal regulations.

3.2.5 Failure criteria. Unless otherwise specified, devices that exhibit a leak rate equal or greater than the test limits of table III shall be considered as failures.

NOTE: CAUTION. Devices which do not exhibit a leak rate sufficient to fail seal test, may retain radioactive tracer gas in sufficient concentration to cause soft errors in complex, small geometry devices.

TABLE III. Test limits for radioisotope fine leak method.

Volume of package cc	Q_s
< 0.01	1×10^{-8}
> 0.01, ≤ 0.4	5×10^{-8}
> 0.4	5×10^{-7}

3.2.6 Personnel precautions. Federal, some state and local governmental regulations require a license for the possession and use of krypton-85 leak test equipment. In the use of radioactive gas, these regulations and their maximum permissible exposure and tolerance levels prescribed by law should be observed.

3.3 Test condition C₁ or C₃, perfluorocarbon gross leak. Test condition C₁ is a fixed method with specified conditions that will ensure the test sensitivity necessary. Test condition C₂ has been replaced by C₁. Test condition C3 is a fixed method that uses a vapor detection system instead of an indicator bath.

- * 3.3.1 Procedure applicable to fixed (C₁) method. The devices shall be placed in a vacuum/pressure chamber and the pressure reduced to 5 torr or less and maintained for 30 minutes minimum. The vacuum cycle may be omitted for packages with an internal volume $\geq 0.1 \text{ cm}^3$. A sufficient amount of type I detector fluid shall be admitted to cover the devices. When the vacuum cycle is performed, the fluid will be admitted after the minimum 30 minute period but before breaking the vacuum. The devices shall then be pressurized in accordance with table IV. When the pressurization period is complete the pressure shall be released and the devices removed from the chamber without being removed from a bath of detector fluid for greater than 20 seconds. A holding bath may be another vessel or storage tank. When the devices are removed from the bath they shall be dried for 2 ± 1 minutes in air prior to immersion in type II indicator fluid, which shall be maintained at $125^\circ\text{C} \pm 5^\circ\text{C}$. The devices shall be immersed with the uppermost portion at a minimum depth of 2 inches below the surface of the indicator fluid, one at a time or in such a configuration that a single bubble from a single device out of a group under observation may be clearly observed as to its occurrence and source. The device shall be observed against a dull, nonreflective black background through the magnifier, while illuminated by the lighting source, from the instant of immersion until, expiration of a 30-second minimum observation period, unless rejected earlier.

For packages greater than 5 grams, the effects of package thermal mass shall be determined by evaluating each package family with known leakers and measuring the time for bubbles to be observed. If the evaluation time exceeds the 30 seconds required for the observation time, then the observation time shall be extended to take into account the package thermal mass effect. Alternate methods may be used to meet this intent provided the method is documented and made available to the preparing or acquiring activity upon request.

3.3.1.1 Test condition C₁, fixed method. Allowable fixed method conditions shall be as shown in table IV, herein.

TABLE IV. Condition C pressurization conditions.

Pressure psia (min)	Minimum pressurization time (hour)	
	C ₁	C ₃
30	23.5	12
45	8	4
60	4	2
75	2	1
90	1	0.5
105	0.5	N/A

3.3.2 Failure criteria. A definite stream of bubbles or two or more large bubbles originating from the same point shall be cause for rejection.

- CAUTION: When the leak is large, the operator may notice a stream of liquid exiting the package without the release of bubbles. This condition shall result in the package being rejected.

3.3.3 Test condition C₃, perfluorocarbon vapor detection.

3.3.3.1 Procedure. The devices shall be placed in a vacuum/pressure chamber and the pressure reduced to 5 torr and maintained for 30 minutes minimum. A sufficient amount of type I detector fluid shall be admitted to the pressure chamber to cover the devices. The fluid shall be admitted after the 30 minute minimum vacuum period but before breaking the vacuum. The devices shall then be pressurized in accordance with table IV. The pressure shall be maintained for a period of 30 minutes minimum. Upon completion of the pressurization period, the pressure shall be released, the devices removed from the pressure chamber without being removed from a bath of detector fluid for more than 20 seconds and then retained in a bath of perfluorocarbon fluid. When the devices are removed from the fluid they shall be air dried for a minimum of 20 seconds and a maximum of 5 minutes prior to the test cycle. If the type I detector fluid has a boiling point of less than 80°C, the maximum drying time shall be 3 minutes.

The devices shall then be tested with a perfluorocarbon vapor detector that is calibrated in accordance with 2.3h and 2.3i. "Purge" time shall be in accordance with table V. Test time shall be a minimum of 3.5 seconds (unless the device is rejected earlier) with the perfluorocarbon vapor detector purge and test chambers at a temperature of 125 ±5°C, or 2.5 seconds minimum with the purge and test chambers at a temperature of 150 ±5°C.

NOTE: Air dry, purge and test limits for each device shall be complied with in all cases, including stick to stick handling.

NOTE: Test temperature shall be measured at the chamber surface that is in contact with the device(s) being tested. Device orientation within the test cell should maximize heat transfer from the heated chamber surface to the cavity of the device within the capability of the equipment.

3.3.3.2 Failure criteria. A device shall be rejected if the detector instrumentation indicates more than the equivalent of 0.167 or 1/6 microliter of type I detector fluid in accordance with table I.

TABLE V. Purge time for condition C₃.

Package with internal free volume (CM ³)	Purge time (seconds)
≤0.01	≤ 5
>0.01 ≤0.10	≤ 9
>0.10	≤ 13

NOTE: Maximum purge time can be determined by cycling a device with a 0.02 to 0.05 inch hole and measuring the maximum purge time that can be used without permitting the device to escape detection during the test cycle.

3.3.4 Precautions. The following precautions shall be observed in conducting the perfluorocarbon gross leak test:

- a. Perfluorocarbon fluids shall be filtered through a filter system capable of removing particles greater than 1 micrometer prior to use. Bulk filtering and storage is permissible. Liquid which has accumulated observable quantities of particulate matter during use shall be discarded or reclaimed by filtration for re-use. Precaution should be taken to prevent contamination.
- b. Observation container shall be filled to assure coverage of the device to a minimum of 2 inches.
- c. Devices to be tested should be free from foreign materials on the surface, including conformal coatings and any markings which may contribute to erroneous test results.
- d. A lighting source capable of producing at least 15 thousand foot candles in air at a distance equal to that which the most distant device in the bath will be from the source. The lighting source shall not require calibration but the light level at the point of observation (i.e., where the device under test is located during observation for bubbles) shall be verified.
- e. Precaution should be taken to prevent operator injury due to package rupture or violent evolution of bomb fluid when testing large packages.

- 3.4 Test condition D, penetrant dye gross leak. This test shall be permitted only for destructive verification of devices (see 3.7). The pressure chamber shall be filled with the dye solution to a depth sufficient to completely cover all the devices. The devices shall be placed in the solution and the chamber pressurized at 105 psia minimum for 3 hours minimum. For device packages which will not withstand 105 psia, 60 psia minimum for 10 hours may be used. The devices shall then be removed and carefully washed, using a suitable solvent for the dye used, followed by an air-jet dry. The devices shall then be immediately examined under the magnifier using an ultraviolet light source of appropriate frequency.

3.4.1 Failure criteria. Any evidence of dye penetration into the device cavity shall constitute a failure.

3.5 Test condition E, weight gain gross leak.

3.5.1 Procedure. The devices shall be placed in an oven at 125°C for 1 hour minimum, after which they shall be allowed to cool to room ambient temperature. Each device shall be weighed and the initial weight recorded or the devices may be categorized into cells as follows. Devices having a volume of <0.01 cc shall be categorized in cells of 0.5 milligram increments and devices with volume ≥ 0.01 cc shall be categorized in cells of 1.0 milligram increments. The devices shall be placed in a vacuum/pressure chamber and the pressure reduced to 5 torr and maintained for 1 hour except that for devices with an internal cavity volume ≥ 0.1 cc, this vacuum cycle may be omitted. A sufficient amount of type III detector fluid shall be admitted to the pressure chamber to cover the devices. When the vacuum cycle is performed, the fluid shall be admitted after the 1-hour period but before breaking the vacuum. The devices shall then be pressurized to 75 psia minimum except that 90 minimum psia shall be used when the vacuum cycle has been omitted. The pressure shall be maintained for 2 hours minimum. If the devices will not withstand the 75 psia test pressure, the pressure may be lowered to 45 psia minimum with the vacuum cycle and the pressure maintained for 10 hours minimum.

Upon completion of the pressurization period, the pressure shall be released and the devices removed from the pressure chamber and retained in a bath of the perfluorocarbon fluid. When the devices are removed from the fluid they shall be air dried for 2 ± 1 minutes prior to weighing. Transfer the devices singly to the balance and determine the weight or weight category of each device. All devices shall be tested within 4 minutes following removal from the fluid. The delta weight shall be calculated from the record of the initial weight and the post weight of the device. Devices which were categorized shall be separated into two groups, one group which shall be devices which shifted one cell or less and the other group which shall be devices which shifted more than one cell.

3.5.2 Failure criteria. A device shall be rejected if it gains 1.0 milligram or more and has an internal volume of $\leq 0.01 \text{ cm}^3$ and 2.0 milligrams or more if the volume is $> 0.01 \text{ cm}^3$. If the devices are categorized, any device which gains enough weight to cause it to shift by more than one cell shall be considered a reject. A device which loses weight of an amount which if gained would cause the device to be rejected may be retested after it is baked at 125°C for a period of 8 hours.

3.6 Test condition C_4 or C_5 - optical gross or gross/fine leak. Test conditions C_4 and C_5 are specific to packages with thin lids (thickness < 0.025 , typically metallic). Sensitivity is related to the extent of deflection of the lid due to a specific pressure change. For a specific lid material and size the following formula must be met:

For condition C_4 : $R^4 / E T^3 > 1.0 \times 10^{-4}$

For condition C_5 : $R^4 / E T^3 > 1.0 \times 10^{-3}$

Where:

- R = The minimum width of free lid (inside braze or cavity dimension in inches)
- E = The modulus of elasticity of the lid material
- T = The thickness of the lid (inches)

3.6.1 Test condition C_4 - optical gross leak. The completed device(s) shall be placed in the sealed test chamber. An optical interferometer is set to observe the package lid(s). The chamber is then evacuated while the deflection of the lid(s) is being observed with the optical interferometer. The deflection of the lid(s) with the pressure change, and the lack of continued deflection of the lid(s) with the reduced pressure held constant for time t_1 (or equivalent procedure), will be observed for each package in the field of view simultaneously.

3.6.1.1 Failure criteria. A device shall be rejected for any of the following criteria:

- a. If the optical interferometer did not detect deflection of the lid as the chamber pressure was initially changed.
- b. If the interferometer detects the lid deflecting as the chamber pressure is held constant (or equivalent procedure).

3.6.2 Test condition C_5 - optical gross/fine leak. The completed device(s) shall be placed in the sealed test chamber. An optical interferometer is set to observe the package lid(s). The chamber is then evacuated while the deflection of the lid(s) is being observed with the optical interferometer. The deflection on the lid(s) with the pressure change and the lack of continued deflection of the lid(s) with the reduced pressure held constant for time t_1 (or equivalent procedure), will be observed for each package in the field of view simultaneously.

The sealed test chamber is then pressurized with Helium gas to 30 psig. The lack of deflection of the lid(s) is then observed with an optical interferometer for time t_2 (or equivalent procedure).

3.6.2.1 Failure criteria. A device shall be rejected for any of the three following criteria:

- a. If the interferometer did not detect deflection of the lid as the chamber pressure was initially charged.
- b. If the interferometer detects the lid deflecting from the package leaking its entrapped internal pressure during time t_1 as the pressure is held constant (or equivalent procedure).
- c. If the interferometer detects the lid deflecting from the package leaking in the pressurized Helium gas during time t_2 as the pressure is held constant (or equivalent procedure).

3.7 Retest. Devices which fail gross leak (test conditions C or E) may be retested destructively. If the retest shows a device to pass, that was originally thought to be a failure, then the device need not be counted as a failure in the accept number of sample size number calculations. Devices which fail fine leak (test conditions A₁, A₂, A₄, or B) shall not be retested for acceptance unless specifically permitted by the applicable acquisition document. Where fine leak retest is permitted, the entire leak test procedure for the specified test condition shall be repeated. That is, retest consisting of a second observation on leak detection without a re-exposure to the tracer fluid or gas under the specified test condition shall not be permissible under any circumstances. Preliminary measurement to detect residual tracer gas is advisable before any retest.

4. SUMMARY. The following details shall be specified in the applicable acquisition document:

- a. Test condition letter when a specific test is to be applied (see 3).
- b. Accept or reject leak rate for test condition A or B or C_s when other than the accept or reject leak rate specified herein applies (see 3.1.1.1, 3.1.1.2, 3.1.2, 3.2.5, and 3.6.2.1).
- c. Where applicable, measurements after test (see 3).
- d. Retest acceptability for test conditions A and B (see 3.7).
- e. Order of performance of fine and gross if other than fine followed by gross except when using C₄ (see 3).
- f. Where applicable, the device package pressure rating shall be specified if that rating is less than 75 psia.
- g. Fine leak testing with condition C_s is only applicable for use where conditions A or B are not applicable. These conditions include package inspection on completed assemblies (PC boards), packages with external absorbing materials (connectors), or other special conditions.