The documentation and process conversion measures necessary to comply with this Notice shall be completed by 18 Aug 95.

NOTICE OF CHANGE

INCH-POUND

MIL-STD-750D
NOTICE 1
18 May 1995

MILITARY STANDARD

TEST METHODS FOR SEMICONDUCTOR DEVICES

TO ALL HOLDERS OF MIL-STD-750D:

1. THE FOLLOWING PAGES OF MIL-STD-750D HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

METHOD	NEW PAGE	DATE	SUPERSEDED PAGE	DATE
---	15	18 May 1995	13	28 February 1995
---	16	18 May 1995	14	REPRINTED WITHOUT CHANGE

2. THE FOLLOWING TEST METHODS OF MIL-STD-750D HAVE BEEN REVISED AND SUPERSEDE THE TEST METHOD LISTED:

METHOD	DATE	SUPERSEDED METHOD	DATE
1071.6	18 May 1995	1071.5	28 February 1995

3. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

4. Holders of MIL-STD-750D will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the military standard is completely revised or canceled.

CONCLUDING MATERIAL

Custodians:
Army - ER
Navy - EC
Air Force - 17
NASA - NA

Review activities:
Army - AR, . MI
Navy - AS, CG, MC, SH
Air Force - 19, 85, 99

Preparing activity:
DLA - ES

(Project 5961-1778)

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METHOD 1071.6

HERMETIC SEAL

1. Purpose. The purpose of this test is to determine the hermeticity of semiconductor devices with designed internal cavities.

2. Definitions.

a. Standard leak rate. Standard leak rate is defined as that quantity of dry air at +25°C in atmospheric cubic centimeters flowing through a leak or multiple leak paths per second when the high-pressure side is at 15 psi (101 kPa) and the low-pressure side is at a pressure of not greater than .0193 psi (133 pA). Standard leak rate shall be expressed in units of atmospheric cubic centimeters per second (atm cm^3/s air).

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 atmospheric cubic centimeters per second (atm cm^3/s of the gas medium used for the test). For purposes of comparison with rates determined by other methods of testing, the measured leak rates must be converted to the equivalent standard leak rates, (converted to air equivalents).

c. Equivalent standard leak rate. The equivalent standard leak rate (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 leak rate. The equivalent standard leak rate shall be expressed in units of atmospheric cubic centimeters per second (atm cm^3/s) (air).

NOTE: The leak rate measurements are not necessarily performed with a one atmosphere differential, as implied by the standard leak rate. The equivalent conversion represents gas medium only.

3. Test conditions.

a. Gross leaks. Test conditions A, B, C, D, E, J, K, or L should be specified for gross leaks.

(1) Test condition A: Radioisotope wet gross leak test (see 4.).

(2) Test condition B: Radioisotope dry gross leak test (see 5.).

(3) Test condition C: Fluorocarbon gross leak (see 6.).

(4) Test condition D: Bubble test (see 3b(1)).

(5) Test condition E: Penetrant dye gross leak (see 8.).

(6) Test condition J: Weight gain gross leak (see 11.).

(7) Test condition K: Fluorocarbon vapor detection gross leak (see 12.).

(8) Test condition L_1: Optical gross leak (see 13).

b. Gross leaks. Test condition D may be specified when a sensitivity of 1×10^{-3} atm cm^3/s or greater will satisfy reliability requirements.

This condition shall not be used for devices that have internal free volumes of less than 1 cm^3.

c. Fine leak. Test condition G, H, or L should be specified for the fine leak test.

(1) Test condition G: Radioisotope fine leak test (see 9.).

(2) Test conditions H_1 and H_2: Tracer gas leak test (Helium) (see 10.).

(3) Test conditions L_2: Optical fine leak test (see 13.).

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d. Obsolete.

e. Fine and gross leak test procedure. Unless otherwise specified by applicable detail specification, tests shall be conducted in accordance with table 1071-I. When specified (see 14.) measurements after test shall be conducted following the leak test procedures. Where bomb pressure specified exceeds the device package capability, alternate pressure, exposure time, and dwell time conditions may be used provided they satisfy the leak rate, pressure, and time relationships which apply and provided no less than 30 psi (207 kPa) bomb pressure is applied in any case, or for condition L_1, a minimum 10 psi differential test pressure is applied.

Fine and gross leak tests shall be conducted in accordance with the requirements and procedures of the specified test condition. Testing order shall utilize only the all-dry gas tests first, followed by any liquid immersion gross leak test (i.e.; the option to use the radioisotope gross and fine leak test conditions B and G_1, may be used together, or in succession, as long as the minimum test requirements are met). Optical gross leak test (L_1) is an all-dry gas test and can be used before any fine leak test. If any other gross leak test is used, (condition A, C, D, E, F, J, or K), the sequence of testing must use the dry gas fine leak test first, followed by the gross leak test except in accordance with 15a. When batch testing (more than one device in the leak detector at one time) is used in performing test condition G, H_1, H_2, 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 G, 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 K only, devices that are batch tested, and indicate a reject condition, may be retested individually one time using the procedure of 12.2 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.

TABLE 1071-I. Required test sequence.

Volume (cm^3)	Fine leak condition	Gross leak condition
≤0.4	G, H_1, H_2, L_2	A, C, D, E, J 1/, K 2/, L_1
>0.4	G, H_1, H_2, L_2	A, B, C, D, E, K, L_1
>0.4	J 3/	J 3/

1/ Condition J cannot be used for packages whose internal volume is <0.001 cm^3.
2/ Condition D cannot be used for packages whose internal volume is ≤ 1 cm^3.
3/ Condition J may be used as a single test for devices with an internal cavity volume of >0.4 cm^3 provided the specified requirements can be satisfied by a leak rate of 1×10^{-6} atm cm^3/s.

4. Test condition A, radioisotope wet gross leak test.

4.1 Apparatus. The apparatus required for the seal test shall be as follows:

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.

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c. A container of sufficient volume to allow the devices to be covered with oil and to be degreased with a suitable solvent.

d. Solutions:

(1) Hydrocarbon vacuum pump oil. The solution shall be kept clean and free of contaminants.

(2) Solvent capable of degreasing the devices.

e. 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, following manufacturer's procedure, and recorded in accordance with the calibration requirements of this standard.

4.2 Procedure. The devices shall be immersed in the oil and evacuated to a pressure of 10 torr or less, for 10 minutes, and then pressurized for one hour at 310 kPa (45 psi) minimum. The devices shall be removed from the oil and flushed with solvent to remove all of the surface oil. The devices shall then be placed in the radioisotope pressurization tank, and the tank evacuated to a pressure of 9.72×10^{-3} psi (67 Pa). The devices shall then be pressurized to a minimum of three atmospheres absolute pressure of krypton-85/nitrogen gas mixture for two to five minutes. The gas mixture shall then be evacuated to storage until a pressure of 0.0387 to 0.0483 psi (267 to 333 Pa) maximum exists in the tank. This evacuation shall be completed in two minutes maximum. The tank shall then be filled with air, and the devices immediately removed from the tank and leak tested within 15 minutes after gas exposure, with a scintillation crystal equipped counting station. Any device indicating 1,000 c/m or greater above the ambient background of the counting station shall be considered a gross leak.

4.2.1 Personnel precautions. Government regulations require a license for the possession and use of krypton-85 leak test equipment. These regulations should be followed carefully. The personnel should be properly instructed and monitored in accordance with the licensing requirements.

5. Test condition B, radioisotope dry gross leak. This test shall be only to test devices that internally contain some krypton-85 absorbing medium, such as electrical insulation, organic, or molecular sieve material. This test shall be permitted only if the following requirements are met:

a. A 5 to 10 mil diameter hole shall be made in a representative unit of the devices to be tested.

b. The device shall be subjected to this test condition with a count rate from 200 to 250 counts per minute above ambient background. The count rate shall be made two hours after removal from the activation tank. If the device fails, this test condition may be used, but only for those devices represented by the test unit. If the device does not fail, this test condition shall not be used.

5.1 Apparatus. Apparatus for this test shall consist of the following:

a. Radioactive tracer gas activation console containing krypton-85/dry nitrogen gas mixture.

b. Counting station with a minimum sensitivity of 12,000 counts per minute per microcurie of krypton-85 tracer gas and a minimum detectable count rate of 100 counts per minute above background level.

c. Tracer gas mixture of krypton-85/dry nitrogen with a minimum allowable specific activity of 100 microcuries per atmospheric cubic centimeter. The specific activity of the krypton-85/dry nitrogen mixture shall be determined on a once-a-month basis as a minimum.

5.2 Procedure. The devices shall be placed in a radioactive tracer gas activation tank and the tank shall be evacuated to a pressure not to exceed 9.72×10^{-3} psi (67 Pa). The devices shall then be subjected to a minimum of 25 psi (173 kPag) of krypton-85/dry nitrogen gas mixture for 2 to 5 minutes. The gas mixture shall then be evacuated to storage until a pressure of 0.0972 psi (670 Pa) maximum exists in the activation tank. This evacuation shall be complete in three minutes maximum. The activation tank shall then be backfilled with air (air wash). The devices shall then be removed from the activation tank and leak tested within 30 minutes after gas exposure with a scintillation-crystal-equipped counting station. Any device indicating 200 counts per minute or greater above the ambient background of the counting station shall be considered a gross leak failure.

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5.2.1 Personnel precautions. See 4.2.1.

6. Test condition C, liquid (fluorocarbon) gross leak.

6.1 Apparatus. Apparatus for this test shall consist of the following:

a. A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 90 psi (618 kPa) for a maximum of 24 hours.

b. A suitable observation container with provisions to maintain the indicator fluid at a temperature of +125°C ±5°C (+100°C for Germanium transistors with temperature rating of +100°C maximum) and a filtration system capable of removing particles greater than one micrometer in size from the fluid.

c. A magnifier capable of magnifying an object 1.5 to 30 times its normal size (4 to 120 diopters) for observation of bubbles emanating from devices when immersed in the indicator fluid.

d. Sources of type I detector fluids and type II indicator fluids as specified in table 1071-II.

TABLE 1071-II. 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 (µgm/gm)	< 50	< 50	< 50	D-2109
Appearance	Clear colorless			NA

1/ Perfluorocarbons contain no chlorine or hydrogen.

TABLE 1071-III. Condition C and K pressurization conditions.

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

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e. A lighting source capable of producing a collimated beam of at least 161,000 luxes (15,000 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 shall be placed for best detection of bubbles, without excessive incident or reflective glare being directed toward observer.

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.

6.2 Procedure. The devices shall be placed in a vacuum/pressure chamber and the pressure reduced to 0.0972 psi (670 Pa) or less and maintained for 30 minutes minimum, except for devices with an internal volume ≥ 0.1 cm^3 this vacuum cycle may be omitted. A sufficient amount of type 1 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 1071-III. 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°C ±5°C. The devices shall be immersed with the uppermost portion at a minimum depth of 2 inches (50.80 mm) 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. Unless rejected earlier, 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.

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

6.2.2 Precautions. The following precautions shall be observed in conducting the fluorocarbon gross leak test:

a. Perfluorocarbons fluids shall be filtered through a filter system capable of removing particles greater than one 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 (50.80 mm).

c. Devices to be tested shall be free of foreign materials on the surface, including conformal coatings and any markings which may contribute to erroneous test results.

d. Precaution should be taken to prevent operator injury due to package rupture or violent evolution of bomb fluid when testing large packages.

7. Test condition D, bubble test (type II indicator fluid as specified in table 1071-II.) (NOTE: These fluids replace ethylene glycol as a medium for the gross leak bubble test.)

7.1 Apparatus. Apparatus for this test shall consist of the following:

a. A device internal free volume of greater than 1 cm^3.

b. Container of sufficient volume to allow the devices to be covered with solution to a minimum depth of 2 inches (50.80 mm). The container shall have flat sides to minimize reflections and distortions (example of an acceptable container is a battery jar).

c. Liquid of sufficient volume maintained at no less than +125°C ±5°C for the duration of the test.

d. A light source capable of producing a collimated beam of at least 161,000 luxes (15,000 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.

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7.2 Procedure. The devices shall be placed in the container of liquid at +125°C, immersed to a minimum depth of 2 inches (50.80 mm) for a minimum of one minute, and observed during the entire immersion period for bubbles or bubbling. Side lighting (see 7.1d) shall be used to facilitate viewing the bubbles, and the devices shall be observed against a black nonreflective background.

7.2.1 Failure criteria. Any device that shows one or more nonreflective attached growing bubbles, one continuous stream, or a succession of two or more from the same point shall be considered a failure.

8. Test condition E, penetrant dye gross leak.

8.1 Apparatus. Apparatus for this test shall consist of the following:

a. Ultraviolet light source with peak radiation at approximately the frequency causing maximum reflection of the dye (3650Å for Zyglo; 4935Å for Fluroscein; 5560 Å for Rhodamine B).

b. Pressure chamber capable of maintaining 104 psi (719 kPa).

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 capable of magnifying an object 1.5 to 30 times its nominal size (4 to 120 diopters).

8.2 Procedure. This test shall be permitted only on transparent glass encased devices or for destructive verification of opaque devices. 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 104 psi (719 kPa) minimum for three hour minimum. For device packages which will not withstand 105 psi (724 kPa), 60 psi (414 kPa) 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. Transparent devices may be examined under magnification capable of magnifying an object up to 1.5 times its normal size (4 diopters) using ultraviolet light source of appropriate frequency for evidence of the dye penetration. For the destructive examination of opaque devices, the devices shall be delidded and examined internally under the magnifier using an ultraviolet light source of appropriate frequency.

8.2.1 Failure criteria. Any evidence of dye in the cavity of the device shall constitute a failure.

9. Test condition G_1. Radioisotope fine leak.

9.1 Apparatus. Apparatus for this test shall be as in 5.1.

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

$$Q_S = \frac{R}{S\,K\,T\,\overline{P}\,t} \qquad (1)$$

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 atmospheric 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 9.3.

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T = Soak time, in hours, that the devices are to be activated.

$\overline{P}$ = $P_e2 - P_i2$, where P_e 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_e) may be established by specification or if a convenient soak time (T) has been established, the activation pressure (P_e) 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 $(P_0^2 - (\Delta P)^2)$ in the numerator which is a correction factor for elevation above sea level. P_0 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.

9.3 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.

9.4 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 9.2. 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 9.5.

9.5 Procedure. The devices shall be placed in the 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 9.7×10^{-3} psi (67 Pa). The devices shall be subjected to a minimum of 29 psi (203 kPa) absolute pressure of krypton-85/dry nitrogen mixture of 12 minutes. Actual pressure and soak time shall be determined in accordance with 9.2. 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 9.7×10^{-3} psi (67 Pa) to 0.039 psi (270 Pa) pressure exists in the activation tank. The storage cycle shall be completed in three minutes maximum as measured from the end of the activation cycle or from the time the activation tank pressure reaches 60 psi (414 kPa) 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 one hour after gas exposure with a scintillation-crystal-equipped counting station. Device encapsulations that come under the requirements of 9.4 shall be exposed to ambient air for a time not less than the "wait time" determined by 9.4. In no case will the time between removal from the activation chamber and test exceed one hour. This air 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 9.4 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 one hour.) The actual leak rate of the component shall be calculated with the following equation:

$$Q = \frac{(\text{Actual readout in net counts per minute}) \times Q_S}{R} \qquad (2)$$

Where Q = Actual leak rate in atm cc/s, and Q_S and R are defined in 9.2.

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

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9.5.1 Failure criteria. Unless otherwise specified, devices that exhibit a leak rate equal to or greater than the test limits of table 1071-IV 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 1071-IV. 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}

9.5.2 Personnel precautions. See 4.2.1.

10. Test condition H_1 or H_2 tracer gas (H_e) fine leak. Test condition H_1 is a "fixed" method with specified conditions in accordance with table 1071-V that will ensure the test sensitivity necessary to detect the required measured leak rate (R_1). Test condition H_2 is a "flexible" method that allows the variance of test conditions in accordance with the formula of 10.2.1.2 to detect the specified equivalent standard leak rate (L) at a predetermined leak rate (R_1).

10.1 Apparatus. Apparatus required for test conditions H_1 and H_2 shall consist of suitable pressure and vacuum chambers and a mass spectrometer-type leak detector properly calibrated for a helium leak rate sensitivity sufficient to read measured helium leak rates of 1×10^{-9} atm cm^3/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 every working shift.

10.2 Procedure applicable to "fixed" and "flexible" methods. The completed devices(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 (an optional air nitrogen wash may be applied) 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 (R_1). (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 H_1 or within the chosen value of dwell time t_2 for test condition H_2.)

10.2.1 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 helium before establishing the leak test parameters. Representative specimens of the questionable devices should be opened and all parts of each device as a unit shall be subjected to the predetermined pressure and time conditions established for the device configuration as specified in table 1071-V and 10.2.1.2. The measured leak rate for each device shall be monitored and the lapsed time shall be determined for the indicated leak rate to fall to ≤0.5 R_1 as specified in table 1071-V for test condition H_1 or as predetermined for test condition H_2. The average of the lapsed time following the release of pressure will determine the minimum usable dwell time. Note that the sensitivity of measurement increases as this background indicated-leak-rate decreases relative to the R_1 reject level. Alternately, whole (unopened) specimens of the questionable devices shall be subjected to the same process; then, the shorted value of lapsed time so obtained will determine the minimum dwell time. The fixed method will not be used if the consequent dwell time exceeds the value specified in table 1071-V. It is noted that sorption may vary with pressure and time of exposure so that some trial may be required before satisfactory exposure values are obtained.

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10.2.1.1 Test condition H_1, fixed method. The device(s) shall be tested using the appropriate conditions specified in table 1071-V for the internal cavity volumes of the package under test. The t_1 is the time under pressure and time t_2 is the maximum time allowed after the release of pressure before the device shall be read. The fixed method shall not be used if the maximum standard leak rate limit given in the detail specification is less than the limits specified herein for the flexible method.

TABLE 1071-V. Fixed conditions for test condition H_1.

Volume of package (cm^3)	Bomb condition			R_1 reject limit (atm cm^3/s)
	kPa ±15 (psi) ±2	Exposure time in hours (t_1) (+1.0 - 0.0)	Maximum dwell time (hour)	
< 0.05	517 (75)	2	1	5×10^{-8}
> 0.05 < 0.5	517 (75)	4	1	5×10^{-8}
> 0.5 < 1.0	310 (45)	2	1	1×10^{-7}
> 1.0 < 10.0	310 (45)	5	1	5×10^{-6}
> 10.0 < 20.0	310 (45)	10	1	5×10^{-6}

10.2.1.2 Test condition H_2, flexible method. Values for bomb pressure, exposure time, and dwell time shall be chosen such that actual measured tracer gas leak rate (R_1) readings obtained for the DUTs (if defective) will be greater than the minimum detectable leak rate capability of a mass spectrometer. The devices shall be subjected to a minimum of 29 psi (203 kPa) of helium atmosphere. The chosen values of pressurization and time of pressurization, 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 specified in 10.2.2, shall be used to calculate the measured leak rate (R_1) limit using the following formula:

$$R_1 \frac{2.69\ L\ P_e}{P_o} \left[1 - \exp - \left(\frac{2.69\ L}{P_o\ V} \cdot t_1\right)\right] \exp - \left(\frac{2.69\ L}{P_o\ V} \cdot t_2\right) \qquad (3)$$

Where: R_1 = The measured leak rate of tracer gas (H_e) through the leak in atm cm^3/s.

L = The equivalent standard leak rate in atm cm^3/s.

P_e = The pressure of exposure in atmospheres absolute.

P_o = 1 standard atmosphere.

t_1 = The time of exposure to P_e in seconds.

t_2 = The dwell time between release of pressure and leak detection in seconds.

V = The internal volume of the device package cavity in cubic centimeters.

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The minimum detectable leak rate shall be determined as in 10.2.1 and shall be taken as the indicated value corresponding to a lapsed time $t_0 < t_2$. The lapsed time t_0 shall be taken as the minimum usable dwell time, and leak testing shall be accomplished in the interval between t_0 and t_2. Alternately, pressurization parameters may be chosen from the fine leak approximate solution of equation (3) for $L < 1 \times 10^{-5}$ as

$$L = \frac{P_o}{2.69}\left(\frac{R_1 V}{P_e t_1}\right)^{1/2} \qquad (4)$$

with a graphical representation given on figure 1071-1. If chosen dwell time t_2 is greater than 60 minutes, equation (2) shall be used to determine an R_1 value which will assure a maximum detectable standard leak rate large enough to overlap with the selected gross leak test condition. Alternately, the largest detectable leak rate L as a function of dwell time may be obtained from the approximate solution

$$L\ max = \frac{P_o V}{2.69\ t_2}\ \ln\left(\frac{2.69\ L\ P_e}{P_o R_1}\right) \qquad (5)$$

with graphical representation given on figure 1071-2. In each case (equations (4) and (5)) R_1 shall be taken large compared to the minimum detectable value. 1/

10.2.2 Failure criteria. Unless otherwise specified, devices with an internal cavity volume of 0.01 cm^3 or less shall not be accepted if the equivalent standard leak rate (L) exceeds 5×10^{-8} atm cm^3/s. Devices with an internal cavity volume greater than 0.01 cm^3 and equal to or less than 0.5 cm^3 shall not be accepted if the equivalent standard leak rate (L) exceeds 1×10^{-7} atm cm^3/s. Devices with an internal cavity volume greater than 0.5 cm^3 shall not be accepted if the equivalent standard leak rate (L) exceeds 1×10^{-6} atm cm^3/s.

11. Test condition J, weight gain gross leak.

11.1 Apparatus. Apparatus for this test shall consist of the following:

a. A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 90 psi (618 kPa) for up to 10 hours.

b. An analytical balance capable of weighing the devices accurately to 0.1 milligram.

c. A source of type III detector fluid as specified in table 1071-II.

d. A filtration system capable of removing particles greater than one micrometer in size from the fluid.

e. Suitable calibrated instruments to measure test pressures and time.

f. A suitable solvent.

1/ From "Standard Recommended Practices for Determining Hermeticity of Electron Devices with a Helium Mass Spectrometer Leak Detector," ASTM Designation F134, Annual book of ASTM Standards, Pt. 43 November 1980.

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11.2 Procedure. The devices shall be cleaned by placing them in a container of a suitable solvent at +25°C and allowed then to soak for two minutes minimum. The devices shall then be removed and placed in an oven at +125°C ±5°C for one 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 cm^3 shall be categorized in cells of 0.5 milligram increments and devices with volumes >0.01 cm^3 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 0.0967 psi (667 Pa) and maintained for one hour except that for devices with an internal cavity volume ≥0.1 cm^3, this vacuum cycle may be omitted. A sufficient amount of type III detector fluorocarbon 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 one hour period but before breaking the vacuum. The devices shall then be pressurized to 75 psi (517 kPa) except that 618 kPa (90 psia) shall be used when the vacuum has been omitted. The pressure shall be maintained for two hours minimum. If the devices will not withstand the 75 psi (517 kPa) test pressure, the pressure may be lowered to 45 psi (310 kPa) with the vacuum cycle and 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 fluorocarbon fluid. When the devices are removed from the fluid they shall be air dried for 2 ±1 minutes prior to weighing. The devices shall be transferred singly to the balance and the weight or weight category of each device determined. All devices shall be tested within four 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 of which shall be the devices which shifted one cell or less, and the other devices which shifted more than one cell.

11.3 Failure criteria. A device shall be rejected if it gains 1.0 milligram or more and has an internal volume of ≤0.01 cm^3 and 2.0 milligrams or more if the volume is >0.01 cm^3. If the devices are categorized, any device which gains enough weight to cause the device 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 ±5°C for a period of 8 hours minimum.

12. Test condition K, fluorocarbon vapor detection.

12.1 Apparatus. Apparatus for this test shall consist of:

a. A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 90 psi (620 kPa) for up to 12 hours.

b. A fluorocarbon vapor detection system capable of detecting vapor quantities equivalent to 0.28 milligram of type I fluid.

c. A source of type I detector fluid specified in table 1071-II.

d. Suitable calibrated instruments to indicate that test, purge times, and temperatures are as specified. The detection system shall be calibrated at least once each shift when production occurs by introducing 1 microliter of type I detector fluid into the test chamber. The resulting reading shall be adjusted in accordance with the manufacturer's instructions.

e. The vapor detector used for condition K shall be calibrated at least once each working shift using a type I fluid calibration source, and following the manufacturer's instructions.

12.2 Procedure. 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. 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 vacuum period but before breaking the vacuum. The devices shall then be pressurized and maintained in accordance with table 1071-III. Upon completion of the pressurization period, the pressure shall be released, the devices removed from the pressure chamber without being removed from the detector fluid for more than 20 seconds and then retained in a bath of fluorocarbon 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 fluorocarbon vapor detection system that is calibrated in accordance with 12.1. "Purge" time shall be in accordance with table 1071-VI. Test time shall be a minimum of 3.5 seconds unless the device is rejected earlier. The system's purge and test chambers shall be at a temperature of +125° ±5°C. Test time shall be 2.5 seconds minimum with the purge and test chambers at a temperature of +150°C ±5°C.

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NOTE: Test temperature shall be measured at the chamber surface that is in contact with the DUT.

12.3 Failure criteria. A device shall be rejected if the detector instrumentation indicates more than the equivalent of 0.28 milligrams of type I detector fluid in accordance with table 1071-II.

TABLE 1071-VI. Purge time.

Package with internal free volume (cm^3)	Purge time at +125° ±5°C (Seconds)
≤0.01	≤5
≥0.01 ≤0.10	≤9
≥0.1	≤13

NOTE: Purge time shall be defined as the total time the device is heated prior to entering the test mode. Maximum purge time can be determined by cycling a device with a .02 to .05-inch (0.51 to 1.27 mm) hole and measuring the maximum purge time that can be used without permitting the device to escape detection.

13. Test condition L_1 or L_2 - optical gross or gross/fine leak.

13.1 Apparatus:

a. An optical inspection station capable of evacuation and/or pressurization, and subsequent detection of package lid deformation.

b. Suitable calibration instrumention to indicate test results, times and pressures are as specified.

13.2 Lid stiffness. Test condition L_1 and L_2 are valid only for packages with thin lids (thickness < 0.025 typically for metallic lids). The test sensitivity is related to the extent of deformation of the lid due to the specific pressure change and the test time used. For a specific lid material ad size the following formula must be met:

for condition L_1: $R^4 / E\,T^3 > 1.0 \times 10^{-4}$ (1)

for condition L_2: $R^4 / E\,T^3 > 1.0 \times 10^{-3}$ (2)

Where: R = The minimum width of free lid (inside braze or cavity dimension in inches).

E = The modulus of elasticity of the lid material.

Aluminum: $E = 10 \times 10^6$ lb/in^2
Kovar: $E = 20 \times 10^6$ lb/in^2
Ceramic: $E = 60 \times 10^6$ lb/in^2

T = The thickness of the lid (inches).

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13.3 Leak sensitivity. The optical leak test shall be performed with a test pressure (P_o) and time (t), which will provide the leak rate sensitivity required. The leak rate sensitivity is provided by the following equation:

$$L = (-V_o / k_2 t) \ln(1 - dY_t / P_o L_o).$$

Where: L = The leak rate sensitivity of the test (atm-cc/sec).

V_o = The volume of the package cavity (in^3).

k_2 = The leak test gas constant (air = 1.0, He = 2.67).

t = The test duration time (seconds).

dY_t = The measured deformation of the package lid (inches).

P_o = The chamber pressure during the test (psig).

L_o = The lid stiffness constant calculated from the package dimensions (inch/psi).

13.4 Test condition L_1 - optical gross leak. The completed device(s) shall be placed in the sealed test chamber. The optical interferometer shall be set to observe the package lid. The chamber shall then be evacuated while the deformation of the lid is being observed with the optical interferometer. The deformation of the lid with pressure change, and the lack of continued deformation of the lid with reduced pressure held for time t_1 (or equivalent procedure), will be observed for each package in the field of view simultaneously.

13.4.1 Failure criteria. A device shall be rejected if the optical interferometer did not detect deformation of the lied as the chamber pressure was initially changed, or if the interferometer detects the lid deforming as the chamber pressure is held constant (or equivalent procedure).

13.5 Test condition L_2 - optical gross/fine leak. The completed device(s) shall be placed in the sealed test chamber. The optical interferometer shall be set to observe the package lid. The chamber shall then be evacuated while the deformation of the lid is being observed with the optical interferometer. The deformation of the lid with pressure change, and the lack of continued deformation of the lid with reduced pressure held 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 no more than 2 atmospheres. The lack of deformation of the lid is then observed with an optical interferometer to time t_2 (or equivalent procedure).

13.5.1 Failure criteria. A device shall be rejected for any of the three following criteria. If the interferometer did not detect deformation of the lid as the chamber pressure was initially changed. Or, if the interferometer detects the lid deforming form the package leaking its entrapped internal pressure during time t_1 as the pressure is held constant (or equivalent procedure). Or, if the interferometer detects the lid deforming from the package leaking in the pressurized Helium gas during time t_2 as the pressure is held constant (or equivalent procedure).

14. Summary. The following conditions shall be specified in the applicable detail specification:

a. Test condition letter when a specific test is to be applied (see 3.).

b. Accept or reject leak rate for test conditions G, H_1, or H_2 when other than the accept or reject leak rate specified herein applies (see 10.2.1.1, 10.2.2, and 9.5.1).

c. Where applicable, measurements after test (see 3.).

d. Retest acceptability for test conditions G and H (see 9.). For K, see 3e.

e. Order of performance of fine and gross if other than fine followed by gross (see 3.).

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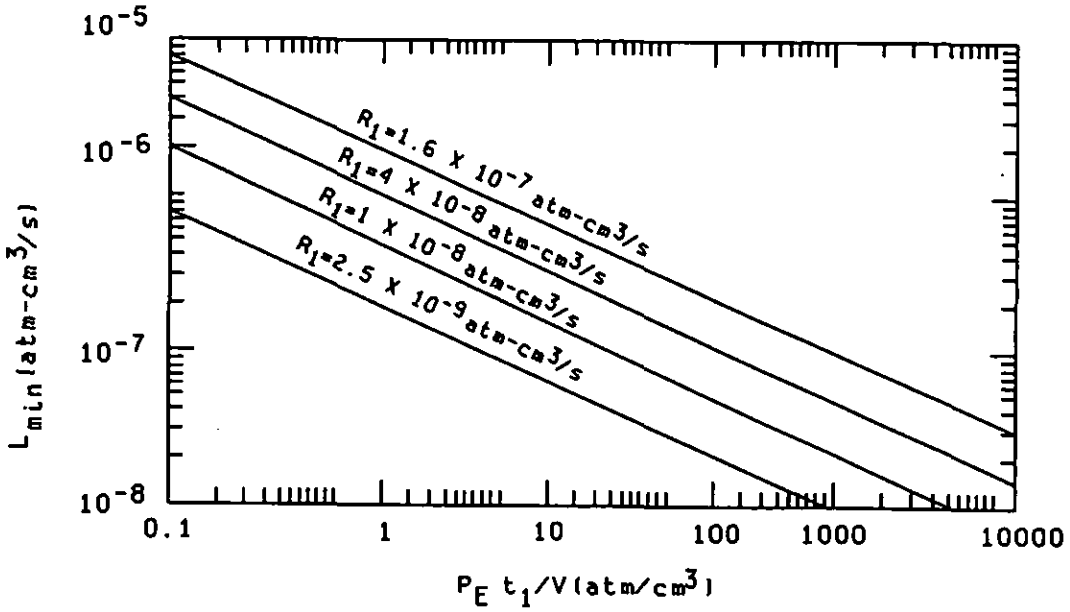
15. Notes.

a. The fine leak test shall be performed first if condition A, B, or E is used for gross leak. Gross leak may be performed prior to fine leak if condition C, D, J, K, or L is used for gross leak and provided that the vapor pressure of the fluorocarbon material used in condition C, J, and K (which may be inside the device) is greater than 59 psi (406 kPa), T_A = +125°C. The devices shall be subjected to a bake at this temperature for a minimum of one hour prior to performing the fine leak test. This sequence should be true regardless of whether the leak tests are part of a screening sequence or are included as group B or group C requirements.

b. For test conditions A through E, K, and L_1, the maximum allowable leak rate should not be specified because these tests are "go"/"no-go" type tests that do not provide an indication of actual leak rate. (Although test conditions A, B, K, and L_1 have a definite quantitative measurement to be met, they are still considered "go"/"no-go" tests.)

c. When retesting devices to test conditions G and H, the history of device exposure to helium and krypton-85, including dates, backfilling performed, tracer gas concentrations, pressure, and time exposed, should be known in order to ensure reliable results.



Reject value of equivalent standard leak rate as a function of pressurization conditions and indicated leak rate as computed from the approximate solution, for small leaks where dwell time t_2 is not a significant factor. The reject level R_2 shall be taken larger relative to the minimum detectable R value.

FIGURE 1071-1. Smallest detectable leak.

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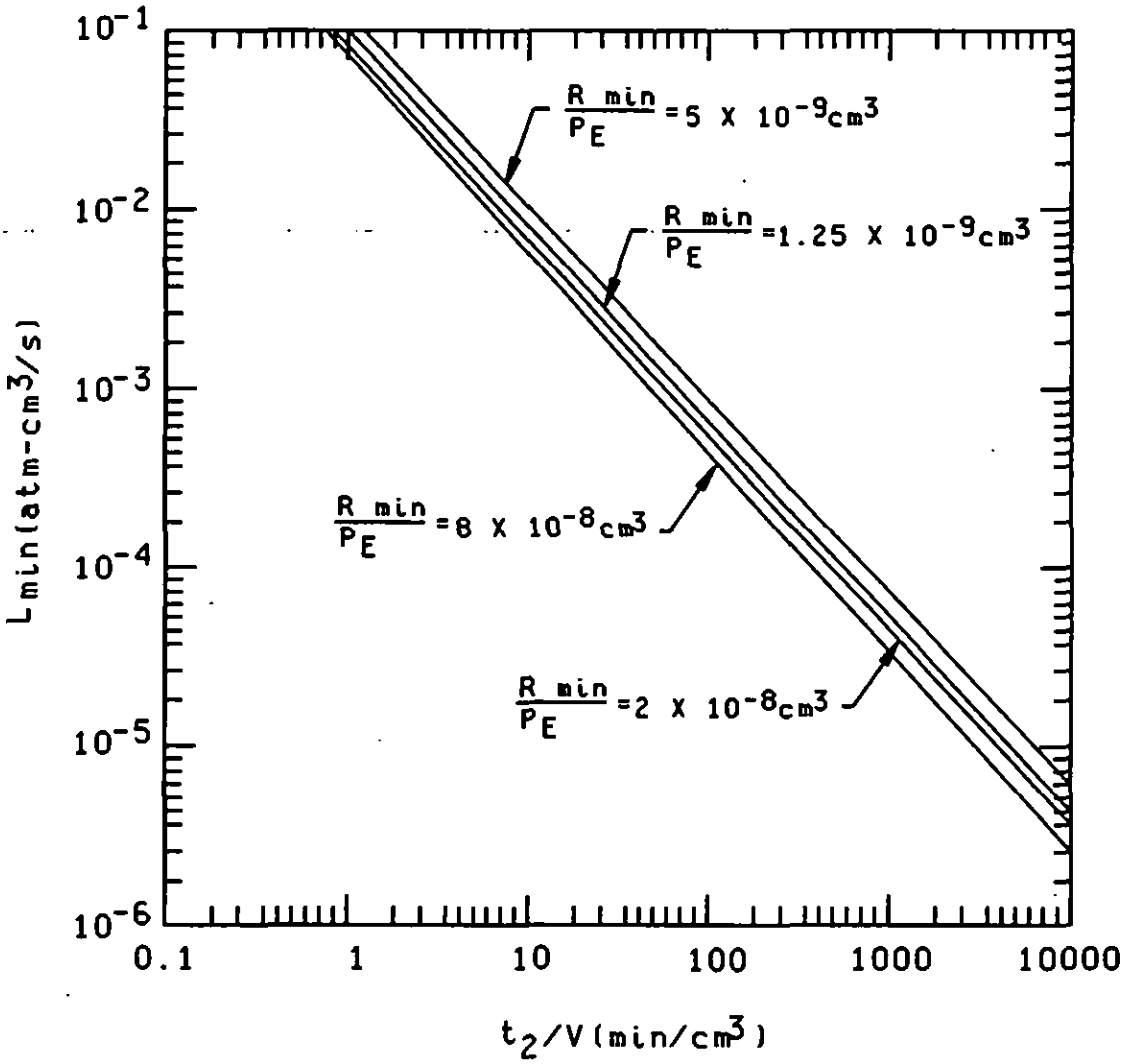

Upper test limit of equivalent standard leak rate as a function of dwell time, pressurization, and indicated leak rate as computed from the approximate solution, (e.g., for larger leaks where internal pressurization is complete).

FIGURE 1071-2. Largest detectable leak.

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