

ENGINEERING PRACTICE STUDY

PROJECT NUMBER: 5961-2013-001

TITLE: PROCEDURE FOR VERIFYING THE EFFICIENCY OF TEST SOLUTIONS FOR GETTERING KR85 GAS
IN ACCORDANCE WITH MIL-STD-750-1, TEST METHOD 1071, CONDITION A.

11 JANUARY 2013

FINAL REPORT

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ATTCH 1

I. OBJECTIVES: The objective of this study was to establish a procedure to be used for verifying the efficiency of test solutions for gettering Kr85 gas in accordance with MIL-STD-750-1, Test Method 1071, Condition A.

II. BACKGROUND: MIL-STD-750, Test Method 1071, paragraph 4.1.d (1) requires the equipment manufacturer to provide a test procedure for verifying the efficiency of solutions for Kr85 gettering. To be effective and gain suitability, Test Method 1071, Condition A requires a test solution which effectively getters Kr85 gas.

IsoVac Engineering, Inc., manufacturer of the Radiflo® Leak Detector, proposed a test procedure which has been evaluated by two 5961 suppliers. It was found that the proposed test procedure did contain a significant typographical error: the 2 minute pressurization time should have been 12 minutes. The results achieved by the two 5961 suppliers have confirmed the effectiveness of the corrected test procedure.

III. RESULTS: The final results of this effort along with recommendations and conclusions are documented in attachment 1.

IV. CONCLUSIONS: The noted changes (attachment 1) shall be incorporated in the next revision of MIL-STD-750-1.

V. RECOMMENDATIONS:

- a) All essential comments must be accepted or resolved through the DLA Land and Maritime spokesmen to the committees generating the drafts of those industry standards.
- b) All suggested comments should be addressed by the industry committees or authors responsible for the draft documents.

ATTACHMENT 1

METHOD 1071.10

HERMETIC SEAL

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

2. Terms and definitions.

2.1 Standard leak rate. The standard leak rate L is defined as that quantity of dry air at +25°C in atmospheric cubic centimeters (atm-cc) flowing through a leak, or multiple leak, paths per second when the high-pressure side is at 15 psia (103 kPa) and the low-pressure side is at a pressure of not greater than .0193 psia (133 Pa). The standard leak rate shall be expressed in units of atmospheric cubic centimeters per second of air (atm-cc/sec (air)).

2.2 Equivalent standard leak rate. The equivalent standard leak rate L of a given package, is the measured leak rate of the device under test, equated to the same package with the same leak geometry that would exist under the standard leak rate conditions. The equivalent standard leak rate shall be expressed in units of atmospheric cubic centimeters per second of air (atm-cc/sec (air)).

2.3 Leakage measurement. The measurement of gaseous leakage for a device package under test are defined as follows:

- a. For helium (He) measurements. The R_1 measurement of helium using a helium mass spectrometer (HMS) under specified conditions. The R_1 reading is not the leak rate of the device, but the result of the size of the leak, and the amount of helium that is within the package at the moment of measurement. The R_1 reading is the maximum value or pass/fail point of measurement. Any measured value greater than the calculated R_1 value indicates a leak failure.
- b. For radioisotope leakage measurements. Q_s is the measurement of the krypton-85 (^{85}Kr) that has entered the package under specified conditions. The measured leak rate shall be expressed in units of atmospheric cubic centimeters per second of the gas medium used for the test (e.g., atm-cc/sec (Kr)).

For purposes of comparison with rates determined by other methods of testing, all measured leak rates shall be converted to the equivalent standard leak rates, (converted to air equivalents).

2.4 Hermetic seal. A hermetic seal is one in which the gas or gases contained in the internal free volume of the sealed system shall not escape or be exchanged with any gas, vapor or liquid contained in the environment external to the sealed system, within the leak rate ranges detectable by this test method. For the purpose of this test method, a hermetically sealed device shall meet the requirements herein.

2.5 Air leak rate ranges.

Gross leak rate range:	Leak rates greater than 5×10^{-6} atm-cc/sec (air).
Fine leak rate range:	Leak rates less than 5×10^{-6} atm-cc/sec (air).
Fine-leak-rate ratios for krypton:	atm-cc/sec (Kr) $\times 1.712$ = atm-cc/sec (air).
Fine-leak-rate ratios for krypton:	atm-cc/sec (Kr) $\times 4.61$ = atm-cc/sec (He).
Fine-leak-rate ratios for helium:	atm-cc/sec (He) $\times .37$ = atm-cc/sec (air)
Fine-leak-rate ratios for helium:	atm-cc/sec (He) $\times .21$ = atm-cc/sec (Kr).

2.6 Fine leak failure criteria. The failure criteria in 10.2.2 in atm-cc/sec (air) shall apply for all dry gas leak test procedures in this test method.

2.7 Testing limitations. The history of device leak rate testing shall be maintained on travelers accompanying devices. Devices that have previously been subjected to bubble tests will not yield reliable test results when subjected to dry gas HMS leak testing. The radioisotope fine leak test condition G₁ can be used with the test sensitivity extended 1 order of magnitude. The leak rate detected of any device previously exposed to any liquid media (e.g. fluorocarbons) will be assumed to be one or two orders of magnitude larger than measured. It is important to note that fluorocarbon residues introduces "surface-sorption" problems that affect the standard testing procedures.

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.

2.8 Internal free cavity volume. The internal volume of a device less the area/volume of the die and any conformal coating.

3. Test conditions.

3.1 Gross leak test conditions. The following test conditions should be specified for gross leak testing:

- a. Test condition A (see 4): Radioisotope wet gross leak test.
- b. Test condition B (see 5): Radioisotope dry gross leak test.
- c. Test condition C (see 6 and 17.e): Liquid perfluorocarbon gross leak.
- d. Test condition D (see 7, 3.b, and 17.e): Bubble test.
- e. Test condition E (see 8): Penetrant dye gross leak.
- f. Test condition J (see 11): Weight gain gross leak.
- g. Test condition K (see 12): Fluorocarbon vapor detection gross leak.
- h. Test condition L₁ (see 13): Optical gross leak.
- i. Test condition G₂ (see 9.6): Radioisotope gross/fine combination.
- j. Test conditions CH₁ and CH₂ (see 10 and 15): Cumulative helium gross/fine combination.
- k. Test conditions H₁ and H₂ (see 10): Helium fine leak test.
- l. Test condition G₁ (see 3.3 and 14): Radioisotope thermal leak test.

3.2 Fine leak test conditions. The following test conditions should be specified for fine leak testing:

- a. Test condition G₁ (see 9), radioisotope fine leak test or G₁/G₂ (see 9.6) fine/gross combination leak test.
- b. Test conditions H₁ and H₂ (see 10): Tracer gas (helium) leak test.
- c. Test conditions CH₁ and CH₂ (see 10): Cumulative helium gross/fine combination.

3.3 Radioisotope thermal leak test (see 14). Test condition G_i should be used for radioisotope thermal leak testing.

3.4 Fine and gross leak test procedures. Unless otherwise specified by applicable performance specification sheet, tests shall be conducted in accordance with table 1071-I. When specified (see 15 herein) 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 shall be used provided they satisfy the leak rate, pressure, and time relationships which apply and provided no less than 30 psia (207 kPa) bomb pressure is applied in any case, or for condition L₁, a minimum 10 psia (69 kPa) 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, fine, or gross/fine combination leak test conditions B, G₁, and G₂ (respectively), may be used together, or in succession, as long as the minimum test requirements are met). The radioisotope dry gas gross leak test B or G₂ may be used for gross leak testing prior to any dry gas fine test. The optical gross leak test, L₁, is an all-dry gas test and can be used before any fine leak test. If any other gross leak test is used, (test conditions A, C, D, E, F, J, or K), the sequence of testing shall use the dry gas fine leak test first, followed by the gross leak test, except in accordance with 14, note 1. When batch testing (more than one device in the leak detector at one time) is used in performing test condition H₁, H₂, and CH a reject condition occurs, it shall be noted as a batch failure. Each device with a cavity greater than 0.5 cm³ may then be tested individually one time for acceptance if all devices in the batch are retested within the dwell time used to determine the pass/fail point. Devices with cavity less than 0.5 cm³ shall be measured within ten minutes or re-pressurized and then re-read. For condition G₁ only, devices may be batch tested for acceptance provided, if a reject occurs, all remeasuring of parts individually is completed within 30 minutes after removal from the tracer gas pressurization chamber. For condition G₂ only, devices may be batch tested for acceptance provided, if a reject occurs, all remeasuring of parts individually is completed within 10 minutes 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. For condition CH only, devices that are batch tested, and indicate a fine leak reject condition, may be retested individually if they are retested within the dwell time used to determine the pass/fail point using the Howl-Mann equation. For CH₁ and CH₂ only, devices which are batch tested, and indicate a gross leak reject condition, may be retested individually if they are retested within the dwell time used to determine the pass/fail point using the Howl-Mann equation or the devices can be re-bombed with helium for at least 60 seconds and then retested.

TABLE 1071-I. Required test sequence.

Volume (cm ³)	Fine leak condition	Gross leak condition
≤ 0.4	G ₁ , G ₂ , H ₁ , H ₂ , CH ₁ , CH ₂ , L ₂	CH ₁ , CH ₂ , A, B, C, E, G ₁ , G ₂ , J, K, L ₁ <u>1/</u> <u>2/</u>
> 0.4	G ₁ , G ₂ , H ₁ , H ₂ , CH ₁ , CH ₂ , L ₂	CH ₁ , CH ₂ , A, B, C, D, E, K, L ₁ <u>3/</u>
> 0.4	CH ₁ , CH ₂ , J <u>4/</u>	CH ₁ , CH ₂ , J <u>4/</u>

1/ Condition B and G₂ may be used for small cavity devices that contain approved getting material.

2/ Condition J cannot be used for packages whose internal volume is < 0.001 cm³.

3/ Condition D cannot be used for packages whose internal volume is ≤ 0.05 cm³.

4/ Condition J may be used as a single test for devices with an internal cavity volume of > 0.4 cm³ provided the specified requirements can be satisfied by a leak rate of 1 x 10⁻⁶ atm-cc/sec (air).

4. Test condition A – radioisotope wet gross leak test. Designed for packages with internal free cavity volume less than 0.05 cm³. This test condition may be used for larger packages to detect larger leak paths. This test condition is not intended to replace visual inspection for sealing defects.

4.1 Apparatus. The apparatus required for test condition A shall be as follows:

- a. Radioactive tracer gas pressurization console.
- b. Counting station equipment consisting of a scintillation crystal, photomultiplier tube, preamplifier, ratemeter, and ⁸⁵Kr reference standards. The counting station shall be of sufficient sensitivity to determine through the device wall, the radiation level of any ⁸⁵Kr tracer gas present within the device. The counting station detector shall have a minimum detectability of 500 cpm of ⁸⁵Kr above ambient background, and shall be calibrated at least once every working shift using ⁸⁵Kr reference standards and following the equipment manufacturer's instruction, and a record for proper function maintained.
- c. A container of sufficient volume to allow the devices to be covered with red-dye-penetrant solution, evacuated, and subjected to air pressure in the same container.
- d. Solutions:
 - (1) The red dye penetrant solution shall be kept clean and free of contaminants (including wash solvents). The solutions shall be tested and approved by the equipment manufacturer to ensure maximum gettering capability. The equipment manufacturer shall provide a test procedure to be used to verify the efficiency of the solution for both ⁸⁵Kr gettering and visual detectability (see 4.3).
 - (2) The solvent for washing the devices after immersion shall be acetone.
- e. A tracer gas consisting of a mixture of ⁸⁵Kr and air. The concentration of ⁸⁵Kr in air shall be no less than 100 microcuries per atmospheric cubic centimeter (μCi per atm-cc). This value shall be determined at least once each 30 days, following manufacturer's procedure, and recorded in accordance with the calibration requirements of the general test method standard MIL-STD-750. The specific activity may be measured automatically by the equipment during cycling of the equipment. However, it is recommended that an analytical sample of the gas be measured at least annually for low use systems and semiannually for high use systems.

4.2 Procedure. The following four steps shall be followed.

- Step 1: The devices shall be immersed in the red dye penetrant solution and evacuated to a pressure of 100 mm of Hg or less for 10 minutes and then pressurized with air for 10 minutes minimum at 45 psia (310 kPa) minimum. The devices shall be removed from the red dye penetrant solution and placed in a fine-screen basket and flushed with acetone by applying a fine-spray of acetone to remove the surface film of the solution. It is recommended that the devices in the fine-screen basket be held over funnel, with the funnel inserted into a large Erlenmeyer flask, (thus minimizing the acetone vapors released into the room). Do not allow any acetone to contaminate the red dye penetrant solution. Immediately following the wash, the devices shall be emptied onto a white surface (such as paper towels), and examined carefully for evidence of red dye penetrant solution exiting from any leaking devices. Any devices with red dye penetrant solution leaking from them shall be rejected as gross leakers.
- Step 2: The devices shall then be placed in the radioisotope pressurization tank, (with all excess free volume displaced with aluminum filler blocks), and the tank evacuated to a pressure of 0.5 mm of Hg. The devices shall then be pressurized to a minimum of three atmospheres absolute pressure of ⁸⁵Kr/air mixture for 12 minutes minimum. The gas mixture shall then be transferred to storage until a pressure of 2.0 mm of Hg maximum exists in the tank. This transfer shall be completed in 2 minutes maximum. The tank shall then be filled with air, and the devices immediately removed from the tank and leak tested within 5 minutes after gas exposure, with a scintillation crystal equipped counting station. It is recommended that batch sizes be kept small enough to allow all devices to be measured within 5 minutes. Any device indicating 500 counts per minute (cpm) or greater above the ambient background of the counting station shall be considered a gross leaker. If all of the devices cannot be measured within 5 minutes, they shall be retested starting at the beginning of step 2.

Step 3: Failing devices may cross contaminate compliant devices with red dye penetrant solution. Devices which contain red dye penetrant solution may effervesce after being pressurized with ^{85}Kr and may lose the ^{85}Kr trapped within them. The devices shall be emptied onto a white surface (such as paper towels), and examined carefully for any red dye penetrant solution exiting from any leaking devices. Any devices with red dye penetrant solution leaking from them shall be rejected as gross leakers. Gross leak failures with a internal free cavity volume less than 0.05 cm^3 shall be visually inspected at 30X to confirm that the red dye penetrant solution is actually leaking from the device.

Step 4: If any devices are rejected by steps 1 through 3, the procedure (starting with step 2) shall be repeated until no more gross leakers are found.

4.3 Procedure for verifying ^{85}Kr gettering efficiency.

Step 1: Gather five samples of each package. Each sample shall be tested separately. A separate test sequence shall be performed for each package type.

Step 2: Drill a .020" hole in the lid of the package samples.

Step 3: Immerse the samples in test solution and evacuate to near complete vacuum for 10 minutes (min).

Step 4: Pressurize the samples at 75 psia (while immersed in the test solution) for 10 minutes.

Step 5: Remove the samples and place in a screen basket and wash with a fine acetone spray per the Requirements of MIL-STD-750-1, Test Method 1071, paragraph 4.2, step 1.

Step 6: Place each sample in the ^{85}Kr counting station, and perform a gross leak test using the following conditions:

Bomb Pressure = 75 psia
Bomb Time = 12 minutes
Vent = 2 mmHg

Step 7: Remove the samples and perform a ^{85}Kr reading in a well crystal counting station using a slow time constant.

Step 8: Re-read the samples at 2 minutes, 4 minutes, 6 minutes, 8 minutes and 10 minutes (total of 6 measurements per sample).

Step 9: Each sample shall read 500 C/M above background for at least 10 minutes.

5. Test condition B – radioisotope dry gross leak. This test shall be used to test devices that internally contain some ^{85}Kr absorbing or adsorbing medium, such as electrical insulation, organic, or molecular sieve, or approved gettering material. If the device does not contain any adsorbing medium this can only be used on parts with 0.1 cc internal free volume or larger, or that can demonstrate that the following requirements are met:

- a. A .005 inch (0.13 mm) 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 and removed from the pressurization tank immediately after the tank is vented to atmosphere, and measured in the counting station. A net reading indicating 500 cpm or greater is considered a reject. The device shall remain a reject for a minimum of 10 minutes after removal from the pressurization tank. If the device does not fail, this test may not be used.

5.1 Apparatus. The apparatus required for test condition B shall be as follows:

- a. Radioactive tracer gas pressurization console containing ^{85}Kr /air mixture.
- b. A "well type" counting station with a minimum sensitivity of 10,000, cpm per μCi of ^{85}Kr tracer gas and a minimum detectable count rate of 500 cpm above background level. The counting station calibration shall be checked at least once every working shift using a ^{85}Kr reference standard following the equipment manufacturer's procedure, and a record of proper function shall be maintained.

- c. A tracer gas consisting of a mixture of ^{85}Kr and air. The concentration of ^{85}Kr in air shall be no less than 100 μCi per atm-cc. This value shall be determined at least once each 30 days, following manufacturer's procedure, and recorded in accordance with the calibration requirements of the general test method standard MIL-STD-750. The specific activity may be measured automatically by the equipment during cycling of the equipment. However, it is recommended that an analytical sample of the gas be measured annually for low use systems and semiannually for high use production systems.

5.2 Procedure. The devices shall be placed in a radioactive tracer gas pressurization tank, (with aluminum filler blocks placed in the tank to displace all unneeded free volume), and the tank shall be evacuated to a pressure not to exceed 66.7 Pa (0.5 torr). The devices shall then be subjected to a minimum of 30 psia (207 kPa) of ^{85}Kr /air gas mixture for 2 minutes. For devices that have pressure limits less than 30 psia (207 kPa), the pressure limit shall be specified and not exceeded. The gas mixture shall then be transferred to storage until a pressure of 266.7 Pa (2.0 torr) maximum exists in the pressurization tank. This gas transfer shall be complete in 3 minutes maximum. The tank shall then be backfilled with air. The devices shall then be removed from the tank and measured within 10 minutes after gas exposure, with a scintillation-crystal-equipped counting station. Any device indicating 500 cpm, or greater, above the ambient background of the counting station shall be considered a gross leak failure. If the devices are not all measured at the end of 10 minutes from removal from the pressurization chamber, the remaining device shall be returned to the pressurization chamber and re-pressurized to a minimum of 30 psia (207 kPa) for a minimum of 0.01 hours, and then measured at the counting station within 10 minutes.

6 Test condition C – liquid fluorocarbon gross leak. Device packages with less than 0.05 cm^3 internal free volume shall be tested with extremely careful observation. The number of test samples, configuration, and all critical test criteria shall be included in the manufacturer's test procedure.

6.1 Apparatus. The apparatus required for test condition C shall be as follows:

- a. A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 90 psi (620 kPa) for a maximum of 24 hours.
- b. A suitable observation container with provisions to maintain the indicator fluid at a temperature of $+125^\circ\text{C} \pm 5^\circ\text{C}$ ($+100^\circ\text{C}$ for Germanium transistors with temperature rating of $+100^\circ\text{C}$ 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 1.5X to 30X 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.
- 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.

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	D1120
Surface tension (dyness/cm) at +25°C		< 20		D971, D1331
Density at +25°C (gm/ml)	> 1.6	> 1.6	> 1.6	Not applicable
Density at +125°C (gm/ml)		> 1.5		Not applicable
Dielectric strength (volts/mil)	> 300	> 300	> 300	D877
Residue (Tgm/gm)	< 50	< 50	< 50	D2109
Appearance	Clear colorless			N/A

1/ Perfluorocarbons contain no chlorine or hydrogen.

6.2 Procedure. The devices shall be placed in a vacuum/pressure chamber and the pressure reduced to 0.0972 psia (670 Pa) or less and maintained for 30 minutes minimum, except for devices with an internal volume $\geq 0.1 \text{ cm}^3$ this vacuum cycle may be omitted. 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 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 minutes ± 1 minute 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 (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. Devices with an internal cavity less than 0.05 cm^3 shall be tested in groups of no more than five devices at one time. Unless rejected earlier, the device shall be observed against a dull, non-reflective 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.

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

6.2.1 Failure criteria. A definite stream of bubbles, or two or more bubbles originating from the same point, after the devices have reached a minimum 2 inch (50.80 mm) depth in the fluid, 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.
- e. Packages with less than 0.05 cm^3 internal free volume shall be tested, with extremely careful observation.
- f. Contamination of the fluid shall be tested weekly using a chemist "boiling chip". The chip shall be immersed into the fluid and any stream of bubbles indicates fluid contamination. Contamination is caused by solids, solvents and organics from the surface of devices, and from the accumulation of lower boiling point fluorocarbon fluids introduced from other test procedures.

NOTE: The fluid shall be changed when the boiling point falls outside the range as specified in table 1071-III.

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.) Packages with less than 0.01 cm^3 internal free volume shall be tested with extremely careful observation.

7.1 Apparatus. The apparatus required for test condition D shall be as follows:

- a. Only devices with an internal free volume greater than 0.05 cm^3 can be tested by this method.
- 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 $+125^\circ\text{C} \pm 5^\circ\text{C}$ 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.

7.2 Procedure. The devices shall be placed in the container of liquid at $+125^\circ\text{C}$, immersed to a minimum depth of 2 inches (50.80 mm) for a minimum of 1 minute, and observed during the entire immersion period for bubbles or bubbling. Side lighting (see 7.1.d) 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. The apparatus required for test condition E shall be as follows:

- a. Ultraviolet light source with peak radiation at approximately the frequency causing maximum reflection of the dye (3650Å for Zyglo; 4935Å for Flurosecein; 5560 Å for Rhodamine B).
- b. Pressure chamber capable of maintaining 104 psia (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 psia (719 kPa) minimum for 3 hour minimum. For device packages which will not withstand 105 psia (724 kPa), 60 psia (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.

8.2.1.1 Opaque devices. After de-lidding or separation of the device (as applicable), any evidence of dye penetration shall be cause for rejection. Area of examination shall be as shown on figures 1071-1 and 1071-2.

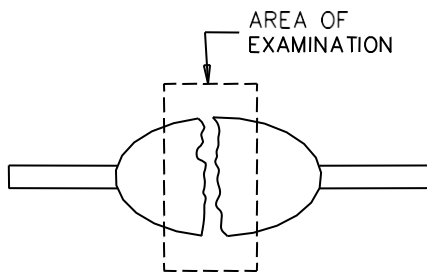


FIGURE 1071-1. Opaque construction.

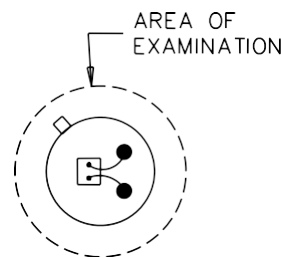


FIGURE 1071-2. Metal can construction.

8.2.1.2 Transparent glass, with large cavity (i.e. S bend, C bend, or straight-through constructions). Any evidence of dye penetration in the device cavity shall be cause for rejection. Area of examination shall be as shown on figure 1071-3.

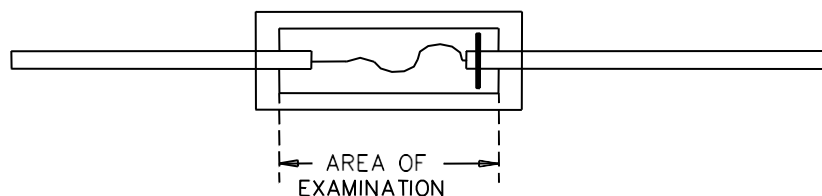


FIGURE 1071-3. Transparent glass or straight through construction.

8.2.1.3 Transparent glass, double plug construction (-1 and tungsten). Any evidence of dye penetration in the die area shall be cause for rejection. In addition, evidence of dye penetration into a crack, fracture, void, which is closer to the die than 50 percent of the designed seal length shall be rejected. Area of examination shall be as shown on figure 1071-4.

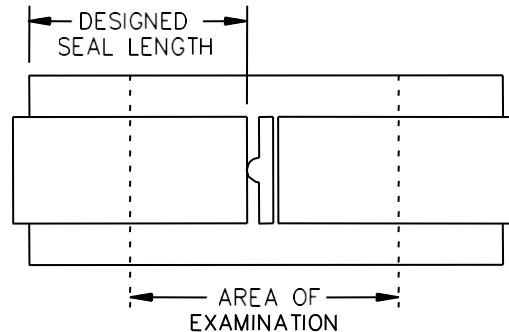


FIGURE 1071-4. Transparent glass double plug construction.

9. Test condition G₁ – radioisotope fine leak.

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

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

Equation (1):
$$Q_s = \frac{R}{SKT Pt}$$

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

- Q_S = The maximum leak rate allowable, in atm cc/sec (Kr), for the devices to be tested. (This value is the equivalent ⁸⁵Kr measured leak rate equal to the allowable "L" value (atm cc/sec (air)) in 10.2.2).
- R = Counts per minute above the ambient background after pressurization 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 μCi per atm-cc, of the ⁸⁵Kr tracer gas in the pressurization system.
- K = The overall counting efficiency of the scintillation crystal in counts per minute per microcurie of ⁸⁵Kr 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 9.3.2.
- T = Soak time, in hours, that the devices are to be pressurized.

- P = $P_e^2 - P_i^2$, where P_e is the pressure in atmospheres absolute, and P_i is the original internal pressure of the devices in atmospheres absolute. The bombing pressure (P_e) may be established by specification or, if a convenient soak time (T) has been established, the 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 $(P_O^2 - (\Delta P)^2)$ 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.

9.3 Determination of specific activity (S) and counting efficiency (K-factor).

9.3.1 Determination of specific activity of ^{85}Kr mixture.

- The specific activity S is the concentration of the ^{85}Kr /air mixture in the radioisotope pressurization system. This concentration is measured in μCi per atm-cc/sec of ^{85}Kr /air mixture.
- The specific activity must be maintained at 100 μCi per atm-cc/sec (minimum).
- The specific activity must be determined at least monthly, either by gas sample or automatically by the equipment.
- The specific activity must be measured at least semi-annually for high usage machines and annually for low usage machines, by sampling the gas following the manufacturer's procedure.

9.3.2 Determination of counting efficiency (K-factor). The counting efficiency K-factor of equation (1) shall be determined as follows:

- A representative unit of the device type being tested shall have a known microcurie content of ^{85}Kr placed in the internal void of the device.
- The counts per minute from the representative unit shall be measured in the shielded scintillation crystal of the counting station in exactly the same position as the actual samples will be measured. From this value, the counting efficiency, in counts per minute per microcurie (cpm per μCi), shall be calculated.
- The K-factor, is the efficiency of measurement of radioactive ^{85}Kr tracer gas within a device using a scintillation crystal as a detector. The K-factor must be determined for the combination of both the scintillation crystal detection system that is to be used for the measurement and for the specific geometry of the device to be tested. This is done using a device 'sample' of the same geometric configuration as the device to be tested. The geometric center of the cavity, or its internal void, is the point called the "center of mass" of the radioactive gas being measured. The location of the center of mass is the point referred to for the k-factor of the device as it is positioned in each of the scintillation crystal detection systems described in 9.3.2.1, 9.3.2.2, and 9.3.2.3.
- The equipment manufacturer may be able to provide K-factor data for most devices.
- A list of K-factors for all devices shall be maintained for each crystal used.

9.3.2.1 K-factor for a scintillation "well-crystal".

- a. A representative sample, consisting of a device with the same geometric configuration as the test sample device(s), shall be used to determine the K-factor. This representative sample shall have an accurately known micro-curie content of ^{85}Kr placed within its internal void.
- b. The counts per minute from the representative sample shall be measured in the well of the shielded scintillation crystal of the counting station. The sample device should be in the exact position as test devices will be tested. If not, then the sample device shall be located at a height not to be exceeded by any device tested (see note below). From this measured value, the counting efficiency, in counts per micro-curie shall be calculated for that device/crystal system.
- c. A scintillation "well crystal" shall have an efficiency of at least 10,000 cpm per μCi .

NOTE: The counting efficiency of the scintillation well crystal is reduced systematically at higher locations within the crystal's well. The K-factor for the sample at the bottom of the well crystal will be the greatest. If a device is placed on top of other devices such as in testing multiple devices simultaneously, then the top device will have the least measured K-factor effect. Thus, the measured K-factor, determination using the sample device located other than at the bottom of the crystal's well, determines the maximum height to be allowed for the actual test. This height shall be established and shall not be exceeded by any actual test device, including any one of the multiple devices being simultaneously tested.

9.3.2.2 K-factor for a scintillation "flat-top crystal".

- a. A representative sample consisting of a device with the same geometric configuration as the test sample device(s) shall be used to determine the K-factor. This representative sample shall have an accurately known micro-curie content of ^{85}Kr placed in the internal void of the device.
- b. The counts per minute from the representative sample shall be measured on the shielded scintillation crystal of the counting station. The sample must be in the exact position as the actual test devices will be tested. The K-factor for the sample shall be measured with the sample placed flat in a position centered to the main body of the crystal. Some flat-top crystals are solid cylinders of approximately 3 inches (76.2 mm) diameter, and the device sample is placed on the cylinder in the same manner, as mentioned. From this measured value, the counting efficiency, in counts per minute per micro-curie shall be calculated for that device/crystal system.
- c. A "flat top" crystal should have a minimum sensitivity of 4,500 cpm per μCi .

9.3.2.3 Dynamic K-factor measurement with a scintillation-crystal.

- a. A representative sample consisting of a device with the same geometric configuration as the test sample device(s) shall be used to determine the K-factor. This representative sample shall have an accurately known microcurie content of ^{85}Kr placed within its internal void.
- b. A crystal, (or crystals), can be used for dynamic testing of devices passing over or through the crystal(s). This configuration is commonly used in high volume testing. The K-factor must be determined in the 'dynamic condition', which will establish a K-factor value, (usually less than in a static condition with the device standing at the center of the tunnel.) The representative sample is measured dynamically, as it passes through the crystal. This establishes the maximum reading achievable for the sample. From this measured value, the counting efficiency, in counts per minute per micro-curie shall be calculated. This K-factor determination is most commonly determined by the equipment manufacturer.

9.3.3 General. The K-factor for each geometric configuration is determined and used for testing. As a convenience, the same K-factor may apply to similar geometric configurations. This allows the same K-factor to be used for multiple devices, as long as the same test procedure and equipment is used, and the devices are measured using the same measurement system, (9.3.2, 9.3.2.1, 9.3.2.2, and 9.3.2.3).

It should be noted that state-of-the-art scintillation crystals are only capable of detecting (measuring) a maximum reading of 16,000 to 18,000 cpm from the emission from one microcurie of ^{85}Kr contained within the cavity of a device. Those values are limited by the total radiation emitted from ^{85}Kr ; the mass of the sodium iodide crystal body; the physical proximity of the device to that crystal; and the materials of construction of the device. Most microcircuits and semiconductor devices have a K-factor of 14,000 to 16,000 cpm per μCi .

The efficiency of the counting station should be checked once every shift using a traceable ^{85}Kr reference sample. This is a functional test that assures the counting station is measuring within the tolerance of the scintillation crystal. Most "well-type" scintillation crystal will have an efficiency of 13,000 to 14,000 cpm per μCi . The reference standard should be corrected for half-life monthly and the measurements should be within ± 10 percent of the established crystal efficiency.

9.4 Evaluation of surface sorption. All device encapsulations consisting of glass, metal, substrate and chip coatings, and ceramic or combinations thereof, that also include external coatings and external sealants or labels, shall be evaluated for surface sorption of ^{85}Kr before establishing the leak test parameters. Representative samples with the questionable surface 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 measured at the counting station 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 pressurization tank. The tank may be partially filled with inert material (aluminum filler blocks), to reduce machine cycle time and increase the efficiency of the system. The tank shall be evacuated to 66.7 Pa (0.5 torr). The devices shall be subjected to a minimum of 30 psia (207 kPa) of ^{85}Kr /air mixture for a minimum 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 500 above background.

The ^{85}Kr /air gas mixture shall be transferred to storage until 66.7 Pa (0.5 torr) pressure exists in the pressurization tank. The storage cycle shall be completed in 3 minutes maximum as measured from the end of the bombing cycle or from the time the tank pressure reaches 60 psia (414 kPa) if a higher bombing pressure is used. The tank shall then immediately be backfilled with air. The devices shall then be removed from the tank and measured 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. The time between removal from the pressurization chamber and test should be completed within one hour, for devices less than 0.5 cm^3 , or within three hours, for devices greater than 0.5 cm^3 . Device encapsulations that do not come under the requirements of 9.4 may be tested without a "wait time".

If the devices are tested in the well-crystal with the crystal-well shielded with a lead-plug while measuring the device, and a background of approximately 500 cpm is achievable when the Ratemeter is in the "slow-time-constant" position; then reject values R of a minimum of 250 cpm (net) above background while using a lead plug, may be measured for rejection of devices in high sensitivity testing. The counting station calibration must be checked at least once every shift using a ^{85}Kr reference standard following equipment manufacturer's procedure, and a record of proper function shall be maintained.

The actual leak rate of the component shall be calculated with the following equation:

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

Where Q = actual leak rate in atm-cc/sec, and Q_s and R are defined in 9.2.

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. These limits are the ⁸⁵Kr equivalents for the air leak rates that are needed to provide a minimum exchange with atmosphere in 1 year.

TABLE 1071–IV. Test limits for radioisotope fine leak method.

Volume of package cm ³	Failure criteria for L atm-cc/sec (air)	⁸⁵ Kr reject level Q _s atm-cc/sec (Kr)
≤ 0.002	5 x 10 ⁻¹⁰	2.9 x 10 ⁻¹⁰
>0.002 ≤ 0.02	1 x 10 ⁻⁹	5.8 x 10 ⁻¹⁰
>0.02 ≤ 0.5	5 x 10 ⁻⁹	2.9 x 10 ⁻⁹
> 0.5	1 x 10 ⁻⁸	5.8 x 10 ⁻⁹

9.5.2 **Quantitative (read and record) leak rate procedure.** Devices subjected to the radioisotope fine leak procedure can be measured quantitatively for accurate leak rates following the procedure in 9.5. This procedure is usually applied to devices with internal cavities greater than 0.1 cm³, with leak rates less than 10⁻⁶ atm-cc/sec (air). Special techniques must be followed for devices with external organic materials. The shielding plug shall be placed over the scintillation crystal and the background reading determined for the crystal. The devices are then measured at the scintillation crystal counting station using the "slow-time-constant" on the Ratemeter. The devices are then measured one device at a time, reading the counts per minute very carefully with the shielding plug placed over the opening of the crystal to minimize the environmental background radiation. The 'net' counts per minute reading is determined for the DUT by subtracting the background reading from the reading of the DUT. The counting station calibration must be checked at least once every shift using a ⁸⁵Kr reference standard following equipment manufacturer's procedure" and a record of proper function maintained.

The reading in cpm must be verified as stable. The device must be measured for surface beta reading to assure that there is no external ⁸⁵Kr gas absorbed onto the part. If surface beta readings are found, the device must be placed in vacuum for 5 minute intervals (for devices with greater than 0.5 cm³ internal volumes), or, (for devices with less than 0.5 cm³ internal volume), allowed to stand in ambient atmosphere until the Beta readings dissipate. The ⁸⁵Kr readings must remain stable for 24 hours for devices with greater than 0.5 cm³ internal volumes, and for at least 4 hours for devices with less than 0.5 cm³ internal volumes.

The quantitative leak rate of the device, Q, shall be calculated as follows, (using Equation (2):

$$Q = \frac{(\text{Net reading of DUT in counts per minute})}{\text{"R"}} \times Q_s = \text{leak rate atm-cc/sec (Kr)}$$

The quantitative leak rate Q shall be converted to the equivalent atm-cc/sec (air) leak rate by multiplying the Q leak rate by a factor of 1.712.

NOTE 1: The exact internal volume of the device and the date code, if the device is to be subjected to further studies such as IGA.

NOTE 2: The history of the prior tests to which the device may have been subjected, i.e. fluorocarbon bubble tests, etc. (as the fluorocarbon fluid will skew the measured leak rate).

NOTE 3: When a group of the same lot of devices has been subjected to this procedure, it is suggested that at least one of the devices be subjected to 24 hours in vacuum with periodic readings taken to verify the slope of the loss of ⁸⁵Kr gas from the device. Those readings should show a linear ⁸⁵Kr loss for a molecular flow fine leak, unless the device has been previously subjected to fluorocarbon fluids. A non-linear slope also indicates that the measured leak rate is probably greater than measured.

9.6 Test conditions G₁ and G₂ – radioisotope gross/fine combination.

9.6.1 Apparatus. The apparatus required for test conditions G₁ and G₂ shall be in accordance with 5.1.

9.6.2 Testing parameters. The bombing pressure and soak time shall be in accordance with 9.2.

9.6.3 Determination of counting efficiency (K-factor). The determination of counting efficiency K-factor shall be in accordance with 9.3.

9.6.4 Evaluation of surface sorption. The evaluation of surface sorption shall be in accordance with 9.4.

9.6.5 Procedure G₁/G₂ combination gross/fine test. The devices shall be placed in a radioactive gas pressurization chamber. The pressurization chamber shall be filled with inert material (aluminum filler blocks), to reduce cycle time and make the test more efficient. The chamber shall be evacuated to 66.7 Pa (0.5 torr). The devices shall be subjected to a minimum of 30 psia (207 kPa) of ⁸⁵Kr/air mixture for a minimum of 12 minutes. Actual pressure and soak time for G₁ shall be in accordance with 9.5. The R value in counts per minute shall not be less than 500 cpm above background. When the soak time is completed the ⁸⁵Kr/air mixture shall be transferred to storage until 266.6 Pa (2.0 torr) pressure exists in the pressurization chamber. The storage cycle shall be completed in 3 minutes as measured from the end of the pressurization cycle or from the time the tank pressure reaches 60 psia, (if a higher pressure was used). The tank shall then be backfilled with air. The devices shall immediately be removed from the tank and measured at the counting station within 10 minutes after removal from the tank. Devices that come under the conditions of 9.6.4 and require a "wait time", cannot be subjected to the gross/fine combination test. Those devices must be subjected to G₁ and G₂ separately. The counting station calibration must be checked at least once every shift using a ⁸⁵Kr reference standard following equipment manufacturer's procedure, and a record of proper function shall be maintained.

10. Test condition H₁ or H₂ tracer gas (He) fine leak and CH₁ or CH₂ combined fine/gross leak. Test condition H₁ is a fixed method with specified conditions in accordance with table 1071-V that will ensure the required test sensitivity L in atm-cc/sec (air) is achieved. This required test sensitivity L will result in a mass spectrometer measurement of R₁ in atm-cc/sec (He). Test condition H₂ is a flexible method that allows the variance of test conditions in accordance with the formula of 10.2.1.2 to detect the required equivalent standard leak rate L as the measured leak rate R₁. Test conditions H₁ and H₂ are for fine leak testing only.

NOTE: Table 1071-V is derived from Equation 3, paragraph 10.2.1.2, using failure criteria L of paragraph 10.2.2.

10.1 Apparatus. The apparatus required for test conditions H₁, H₂, CH₁, and CH₂ shall be as follows:

- a. 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 one third the measured R₁ value. 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.
- b. The leak detector indicator shall be calibrated using a diffusion-type calibrated standard leak at least once every working shift.
- c. The calibration standard shall have a calibration value at least equal to or less than the leak rate measurement value R₁ for the equivalent standard leak rate L value required.
- d. In addition, the test apparatus for CH₁ and CH₂ shall utilize a specialized pumping system which enables the volume of helium released to be measured as well as the rate of change or "slope" of the helium such that the leak rate is determined from the slope measurement for fine leaks and the volume for gross leaks.

10.2 Procedure applicable to "fixed" and "flexible" methods. The completed device(s) shall be placed in a sealed chamber which is first evacuated to a maximum pressure of 25 inches of Hg (635 mm of Hg) and then pressurized with a tracer gas of 100 ± 0 , -5 percent helium for the required time and pressure. (The evacuation pressure, if used, shall be documented). The pressure shall then be relieved (an optional air nitrogen wash may be applied except for CH_1 and CH_2 where a dry air wash or other technique to reduce the effects of surface adsorption as specified in 10.2.1 can be used) 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 CH_1 or within the chosen value of dwell time t_2 for test condition H_2 or CH_2). Devices with cavities less than 0.05 cm^3 shall be tested within 30 minutes after removal from pressurization for H_1 , H_2 and within the dwell time selected for CH_1 and CH_2 .

NOTE: The helium absorption will be much more severe with the extended bomb times required to achieve the tightened sensitivities called for in this test method. It must also be noted that the determination of surface sorption on individual devices shall preclude the 'batch-testing' of that specific type of device. The surface sorption must be established for every package type before testing. At the higher sensitivity testing this surface sorption can vary with each batch of package material.

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 the leak test fluid (such as helium) before establishing the leak test procedures and 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 less than or equal 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. The data for the surface sorption measurement and the "wait-time" shall be recorded for each device tested in this method. (See 17.)

10.2.1.1 Test condition H_1 and CH_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. Time 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 performance specification sheet is less than the limits specified herein for the flexible method.

NOTE: The leak test limits specified in the fixed table are showing the limits achievable for conventional HMS systems, but with extended bomb times. This table also provides the bomb times required to give a signal at, or above, the background of the conventional helium mass spectrometers.

TABLE 1071–V. Fixed conditions for test condition H₁ and CH₁. 1/ 2/

Volume of package		Bombing conditions			Failure criteria	Mass spec.
Min volume of package (cc)	Max volume of package (cc)	Bomb pressure +2 psia (138 kPa) psia (kPa)	Min bomb time "t ₁ " (hrs)	Max dwell time "t ₂ " (hrs)	Air leak spec "L" (atm-cc/sec)	Reading (He) reject limit "R ₁ " (atm-cc/sec)
> 0	≤ 0.002	75 (518)	20	0.5	5.0E-10	3.2E-10
> 0	≤ 0.002	90 (620)	394	0.5	5.0E-10	5.0E-09
> 0.002	≤ 0.02	75 (518)	20	0.5	1.0E-09	2.6E-10
≤ 0.002	≤ 0.02	90 (620)	379	0.5	1.0E-09	5.0E-09
> 0.02	≤ 0.03	75 (518)	20	0.5	5.0E-09	2.1E-09
≤ 0.02	≤ 0.03	90 (620)	39	0.5	5.0E-09	5.0E-09
> 0.03	≤ 0.05	75 (518)	20	1	5.0E-09	1.3E-09
≤ 0.03	≤ 0.05	90 (620)	66	1	5.0E-09	5.0E-09
> 0.05	≤ 0.075	75 (518)	20	1	5.0E-09	8.7E-10
≤ 0.05	≤ 0.075	90 (620)	98	1	5.0E-09	5.0E-09
> 0.075	≤ 0.1	75 (518)	5	1	5.0E-09	1.6E-10
≤ 0.075	≤ 0.1	90 (620)	131	1	5.0E-09	5.0E-09
> 0.1	≤ 0.5	75 (518)	5	1	5.0E-09	3.3E-11
≤ 0.1	≤ 0.5	90 (620)	655	1	5.0E-09	5.0E-09
> 0.5	≤ 0.75	75 (518)	5	1	1.0E-08	8.7E-11
≤ 0.5	≤ 0.75	90 (620)	242	1	1.0E-08	5.0E-09
> 0.75	≤ 1	75 (518)	5	1	1.0E-08	6.6E-11
≤ 0.75	≤ 1	90 (620)	323	1	1.0E-08	5.0E-09
> 1	≤ 1.5	75 (518)	5	1	1.0E-08	4.4E-11
≤ 1	≤ 1.5	90 (620)	484	1	1.0E-08	5.0E-09
> 1.5	≤ 5	75 (518)	5	1	1.0E-08	1.3E-11
≤ 1.5	≤ 5	90 (620)	1613	1	1.0E-08	5.0E-09
> 5	≤ 10	75 (518)	10	1	1.0E-08	1.3E-11
≤ 5	≤ 10	90 (620)	3225	1	1.0E-08	5.0E-09
> 10	≤ 20	75 (518)	10	1	1.0E-08	6.6E-12
≤ 10	≤ 20	90 (620)	6450	1	1.0E-08	5.0E-09

1/ Dwell times (t₂): One (1) hour maximum for all devices with cavities greater than 0.05 cm³, and 30 minutes for devices with cavities less than 0.05 cm³.

2/ These values were derived using equation 3 for air and equation 3a for helium.

10.2.1.2 Test conditions H₂ and CH₄ flexible method. Based on the specified L value required for the device, (see 10.2.2), the values for bomb pressure, exposure time, and dwell time shall be chosen such that actual measured tracer gas readings R₁ obtained for the DUTs (if defective) will be one order of magnitude greater than the minimum detectable leak rate measurability of a mass spectrometer (background reading) during the measurement process (this is required to assure detection of a leaking device with a reading easily distinguished above the HMS background value.). The devices shall be subjected to a minimum of 29 psia (200 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 required for the device as specified in 10.2.2, shall be used to calculate the measured leak rate (R₁) limit using the following formula:

Equation (3):

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

Equation (3a): Any other tracer gas besides helium (He):

$$R_l = \sqrt{\frac{M_a}{M}} \frac{L P_e}{P_o} \left[1 - \exp - \left(\sqrt{\frac{M_a}{M}} \frac{L}{P_o V} \cdot t_1 \right) \right] \exp - \left(\sqrt{\frac{M_a}{M}} \frac{L}{P_o V} \cdot t_2 \right) \quad (3a)$$

Where: R₁ = The measurement of tracer gas (He) as measured on the mass spectrometer in atm-cc/sec (He). This value is not the actual leak rate of the device (see 10.2.1.1 and 10.2.1.2). It is the HMS reading resulting from the amount of helium within the DUT.

L = The equivalent standard leak rate in atm-cc/sec (air). This is the specified leak rate limit for the device, in atm-cc/sec (air) (see 10.2.1.2).

P_e = The pressure of exposure in atmospheres absolute.

P_o = 1 standard atmosphere.

t₁ = The time of exposure to P_e in seconds.

t₂ = The dwell time between release of pressure and leak measurement in seconds.

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

M_A = The molecular weight of ambient gas. (e.g. air = 28.7)

M = The molecular weight of the tracer gas (e.g. helium = 4, neon = 20.2, argon = 40, nitrogen = 28).

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 $L < 1 \times 10^{-5}$ atm-cc/sec (air) as:

Equation (4):

$$L = \frac{P_o}{2.69} \left(\frac{R V}{P_e t_l} \right)^{1/2}$$

with a graphical representation given on figure 1071-5. If chosen dwell time t_2 is greater than 60 minutes, equation (3) 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 $L_{\max}$ as a function of dwell time may be obtained from the approximate solution:

Equation (5):

$$L_{\max} = \frac{P_o V}{2.69 t_2} \ln \left(\frac{2.69 L P_e}{P_o R_l} \right)$$

with graphical representation given on figure 1071-6. In each case (equations (4) and (5)) R_1 shall be taken large compared to the minimum detectable value.

10.2.1.3 Package volume and leak rate limits for CH₁ and CH₂. For test methods CH₁, the minimum size package is determined by the ability of the apparatus to effectively detect a gross leak one hour after the device has been removed from the trace gas pressurization chamber with a signal to noise (background) ratio of at least three to one. It may be necessary to use a shorter test interval if the apparatus has a high background level of helium or the surface absorption of the device is high. A reasonable lower limit would be 0.0005 cm³. The only limit on maximum size is the size of the test chamber to accommodate the DUT. A gross leak is defined as a device with a measured leak rate greater than 5×10^{-6} atm-cc/sec (air). Very small packages may be stored in an atmosphere containing at least 10 percent helium after bombing to insure adequate signal to noise ratio for the gross leak test over the one hour test interval. Please note that for test method CH₂, the dwell time chosen should be less than 60 minutes or a 10 percent helium storage container shall be used to store the device from the time it is removed from the pressurization chamber to when it is inserted into the test apparatus. The demonstrated minimum detectable leak rate for this test method is 3×10^{-14} atm-cc/sec (air), however, the design of the apparatus can increase or decrease this limit.

NOTE: From ASTM F134 "Standard Test Methods for Determining Hermeticity of Electron Devices with a Helium Mass Spectrometer Leak Detector".

10.2.2 Failure criteria. Unless otherwise specified, devices with an internal cavity volume of 0.002 cm³ or less shall not be accepted if the equivalent standard leak rate L exceeds 5×10^{-10} atm-cc/sec (air). Devices with an internal cavity volume greater than 0.002 cm³, and equal to or less than 0.02 cm³, shall not be accepted if the equivalent standard leak rate L exceeds 1×10^{-9} atm-cc/sec (air). Devices with an internal cavity volume greater than 0.02 cm³, and equal to or less than 0.5 cm³, shall not be accepted if the equivalent standard leak rate L exceeds 5×10^{-9} atm-cc/sec (air). Devices with an internal cavity volume greater than 0.5 cm³ shall not be accepted if the equivalent standard leak rate L exceeds 1×10^{-8} atm-cc/sec (air).

11. Test condition J – weight gain gross leak.

11.1 Apparatus. The apparatus required for test condition J shall be as follows:

- a. A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 90 psia (620 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.

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 2 minutes minimum. After the devices are removed from the solution, they shall be baked in an oven at +125°C ±5°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 less than or equal to 0.01 cm³ shall be categorized in cells of 0.5 milligram increments and devices with volumes greater than 0.01 cm³ 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 psia (667 Pa) and maintained for 1 hour except that for devices with an internal cavity volume greater than or equal to 0.1 cm³, 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 1 hour period but before breaking the vacuum. The devices shall then be pressurized to 75 psia (517 kPa) except that 90 psia (620 kPa) 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 psia (517 kPa) test pressure, the pressure may be lowered to 45 psia (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 minutes ±1 minute 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 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 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 greater than or equal to 0.01 cm³, and 2.0 milligrams or more if the volume is less than 0.01 cm³. 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. The apparatus required for test condition K shall be as follows:

- a. A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 90 psia (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 667 Pa (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. The 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°C ±5°C. Test time shall be 2.5 seconds minimum with the purge and test chambers at a temperature of +150°C ±5°C.

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°C ±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 inch to .05 inch (0.51 mm to 1.27 mm) hole and measuring the maximum purge time that can be used without permitting the device to escape detection.

13. Test conditions L₁ or L₂ – optical gross leak and combined fine/gross leak. (These procedures need correlation data to substantiate the test conditions.)

13.1 Apparatus. The apparatus required for test conditions L₁ or L₂ shall be as follows:

- a. A laser interferometer to measure submicron lid deflection of one or more devices in response to a pressure change.
- b. A chamber to provide a controlled pressure of up to 5 atmospheres (75 psig) in a helium environment) in a helium environment.
- c. A means of measuring and inducing a small controlled pressure change and electronically calibrating the induced pressure change to lid deflection for each device simultaneously in order to determine the lid stiffness in microns per psi or equivalent units for each device.
- d. A means of tracking the lid movement of each device simultaneously over time.
- e. Processing electronics capable of using the measured lid position at the beginning and end of the test and the calibrated stiffness (c) to determine the change in internal pressure of the device. This change in internal pressure along with cavity volume and test duration is used to obtain true helium leak rates, L(He).

Leak rate is determined by the change in internal pressure of the package of a known internal free volume over a known period of time.

When this is normalized to one atmosphere pressure then divided by the test duration and multiplied by the package volume, L(He) in atm-cc/sec is determined. The true leak rate, L(air), is determined by applying the molecular conversion 2.69 X L(He). This is a direct measurement of leak rate.

These test conditions are valid for lidded devices constructed of metallic, ceramic or other materials which result in measurable deflection of the lid over time.

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

$$L = (-V / K T) \times \ln(1 - D / P L_0)$$

Where:

- L = The leak rate of the test (atm-cc/sec).
- V = The volume of the package cavity (cm³).
- K = The leak test gas constant (air = 1.0, He = 2.69)
- T = The test duration time (seconds).
- D = The measured deflection of the package lid (microns).
- P = The chamber pressure during the test (psig).
- L₀ = The measured lid stiffness (microns/psi).

Note: L₀ is measured for each package during the test.

13.2.1 Controlling sensitivity by controlling test time and pressure. As stated above, for a specific package lid thickness, and volume V, the leak rate sensitivity L, is increased by increasing the test time t and chamber pressure P.

13.3 Test condition L₁ – optical gross leak. This test shall be performed in conjunction with optical fine leak L₂. The completed device(s) shall be placed in the sealed test chamber. The optical interferometer shall be set to observe the package lid(s). The chamber shall then be pressurized or 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/or the lack of continued deflection of the lid(s) with the pressure P held for time t (or equivalent procedure), will be observed for each package in the field of view simultaneously.

Failure criteria. A device shall be rejected as a gross leak for any of the following criteria:

- a. If the optical interferometer did not detect deflection of the lid as the chamber pressure was changed.
- b. If the interferometer detects the deflection of the lid resulting in a leak rate L greater than the predetermined limit for gross leak or equivalent procedure.

13.4 Test condition L₂ – optical fine leak. This test may be performed in conjunction with optical gross leak L₁. The completed device(s) shall be placed in the sealed test chamber. An optical interferometer is set to observe the package lid(s). The sealed test chamber is then pressurized with helium gas or evacuated to a test pressure no higher than the maximum design pressure as determined by the package manufacturer or the design limit of the chamber, which ever is less. For the duration of the test, the chamber pressure is modulated sufficiently to obtain lid stiffness calibration for each device. The deflection of the lid(s) is measured with the optical interferometer. The deflection of the lid(s), with the pressure change for time t (or equivalent procedure), is measured for each package in the field of view simultaneously.

13.4.1 Failure criteria. The failure criteria for optical fine leak method L₂ shall be in accordance with table 1071–VII.

TABLE 1071–VII. Failure criteria for optical fine leak method L₂.

Vol. of package cm ³	Failure criteria L atm-cc/sec (air)	Reject level "L ₂ " atm-cc/sec (He)
≤ 0.002	5 x 10 ⁻¹⁰	1.37 x 10 ⁻⁹
>0.002 ≤ 0.02	1 x 10 ⁻⁹	2.74 x 10 ⁻⁹
>0.02 ≤ 0.5	5 x 10 ⁻⁹	1.37 x 10 ⁻⁸
> 0.5	1 x 10 ⁻⁸	2.75 x 10 ⁻⁸

14. Test condition G₁ – radioisotope thermal leak test. This test is for the evaluation of package hermetic integrity at elevated temperature. It is intended to verify that the package structural design will maintain hermetic integrity at elevated temperatures. Devices to be evaluated in this thermal leak test shall be packages that should not have not been subjected to any prior liquid immersion testing. The devices to be tested for thermal leakage shall first be subjected to test condition A, B, or G₂ to at least the sensitivity requirement for that package in the standard, and the hermeticity to that sensitivity, establishing the package is hermetic at ambient temperature.

14.1 Apparatus. The apparatus required for test condition G₁ shall be as follows:

- a. Radioactive tracer gas pressurization console containing ⁸⁵Kr/air mixture. A ⁸⁵Kr pressure/vacuum thermal test chamber capable of evacuation and pressurization at temperatures to 125°C, and thermal cycling from ambient temperature to 125°C while maintaining ⁸⁵Kr/air pressure.
- b. Counting station with a minimum sensitivity of 5,000 cpm per µCi of ⁸⁵Kr tracer gas and a minimum detectable count rate of 500 cpm above background level. The counting station calibration shall be checked at least once every working shift using a ⁸⁵Kr reference standard following the equipment manufacturer's procedure, and a record of proper function shall be maintained.
- c. A tracer gas consisting of a mixture of ⁸⁵Kr and air. The concentration of ⁸⁵Kr in air shall be no less than 100 µCi per atm-cc/sec. This value shall be determined at least once each 30 days, following manufacturer's procedure, and recorded in accordance with the calibration requirements of the general test method standard MIL-STD-750.

14.2 Testing parameters. Prior to performing this test condition, the devices shall be pre-tested to the sensitivity of the standard following the radioisotope procedure A and B, or G₂, radioisotope gross/fine test. The bombing pressure and soak time for the pre-test shall be established for the package following 9.2.

14.3 Determination of counting efficiency (K). The determination of K-factor shall be in accordance with 9.2.

14.4 Evaluation of surface sorption. The evaluation of surface sorption shall be in accordance with 9.4.

14.5 Procedure. The devices shall be placed in the radioactive tracer gas thermal-pressurization chamber. The tank shall be evacuated to 66.7 Pa (0.5 torr) . The devices shall be subjected to a pressure of ⁸⁵Kr/air mixture at a pressure of 60 psia (414 kPa) (typical), or a minimum of 30 psia (207 kPa) (dependent upon the structural compatibility of the package).

14.5.1 Thermal test. The devices are placed in the thermal/pressure chamber and pressurized with ⁸⁵Kr/air mixture to the pressure established in 14.5. The chamber is then heated to 100°C ±10°C minimum to 125°C ±10°C maximum, and maintained at the elevated temperature for 10 minutes minimum. The temperature is then returned to ambient, at which time the ⁸⁵Kr is returned to storage and the devices are removed from the thermal/pressure chamber and measured at the scintillation crystal detection station for any ⁸⁵Kr gas trapped within the devices. 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 pressurization chamber and measurement exceed 60 minutes. Any device containing measurable ⁸⁵Kr gas is a thermal-reject. This test is frequently applied to devices that have indicated leakage at ambient temperature in order to establish if they open to a larger leak rate at temperature.

14.6 Failure criteria. This test is a "go-no go" test to detect packages that 'open-up', or become non-hermetic at elevated temperature. The detection of a measurable amount of ⁸⁵Kr, (greater than 500 cpm above ambient background), within the part after exposure to ⁸⁵Kr pressure at temperature indicates a "thermal-reject", (hermetic failure at elevated temperature). A thermal reject may be placed in a vacuum oven and the temperature increased for 10 minutes minimum, at 10°C intervals, and the device removed to measure the ⁸⁵Kr content after each 10°C increase, until the temperature is reached at which the ⁸⁵Kr reading begins to decrease, indicating the temperature at which the device opened during pressurization. This will indicate the approximate temperature at which the device is leaking, (or increasing its leak rate).

15. Test conditions CH₁ and CH₂ – combined fine/gross leak. Test conditions CH₁ and CH₂ expand the range of helium fine leak to include the gross leak range and require the same test conditions using a specialized measurement apparatus Cumulative Helium Leak Detector (CHLD).

15.1 Apparatus. The apparatus for this procedure shall be as in 10.1 except that the optimum calibration leak standard is 5×10^{-10} atm-cc/sec, and since the slope of the accumulated helium is a linear function, measurements beyond 10^{-12} are achievable if the analyzer has sufficient sensitivity. A 5×10^{-12} helium leak standard shall be used to validate the sensitivity and linearity of the lower leak rate range and a 1×10^{-8} helium leak standard used for the higher range. The volume of the test chamber used for leak rate measurement should be held to the minimum practical, since too large (>100) a ratio between the device internal volume and the chamber dead volume will reduce the sensitivity limits when detecting gross leaks. The leak detector indicator shall be calibrated using a diffusion-type calibrated standard leak at least once every working shift. In addition, the test apparatus for CH₁ and CH₂ shall utilize a specialized pumping system which enables the volume of helium released to be measured as well as the rate of change or "slope" of the helium such that the leak rate is determined from the slope measurement for fine leaks and the volume for gross leaks.

The maximum ratio of test chamber dead volume to device internal volume Vc/Vd shall be established for individual part testing and batch testing to insure a gross leak amplitude will be detected with a signal to background ratio of at least 3 to one. This ratio is a function of the helium content of the purge gas as well as the internal volume and number of devices to be batch tested.

15.2 Procedure. The procedure for CH₁ "fixed" and CH₂ "flexible" methods shall be as in paragraph 10.2.

15.2.1 Evaluation of surface sorption. The evaluation of surface sorption shall be in accordance with 10.2.1.

15.2.1.1 Test condition CH₁. Test condition CH₁ fixed method shall be shall be in accordance with 10.2.

15.2.1.2 Test condition CH₂. Test condition CH₂ flexible method shall be shall be in accordance with 10.2.

15.2.1.3 Package volume and leak rate limits for CH₁ and CH₂. For test method CH₁ and CH₂, the minimum size package is determined by the ability of the apparatus to effectively detect a gross leak within the dwell time after the device has been removed from the tracer gas pressurization chamber with a signal to noise (background) ratio of at least three to one. It may be necessary to use a shorter test interval if the test chamber has a high background level of helium or the surface absorption (see 10.2.1) of the device is high. The only limit on maximum size is the size of the test chamber to accommodate the device under test. A gross leak for this test method is defined as a hole in the package at least 0.010 inches (0.254 mm) in diameter or smaller. With the appropriate gross leak threshold, a device without a seal or completely missing a lid, will be detected as a gross leak. In the worst case, a device with a gross leak will only contain atmospheric air and the instrument should demonstrate adequate sensitivity, i.e., the ability to measure the 5.0 ppm helium in ambient air contained in a device as a gross leak. The demonstrated minimum detectable leak rate for this test method is less than 1×10^{-13} atm-cc/sec, however, the design of the apparatus test chamber can increase or decrease this limit.

16. Summary. The following details shall be specified in the applicable performance specification sheet or acquisition document:

- a. Test condition letter when a specific test is to be applied (see 3).
- b. Accept or reject leak rate for test conditions G, H1, or H2 when other than the accept or reject leak rate specified herein applies (see 9.5.1, 10.2.1.1, and 10.2.2).
- c. Where applicable, measurements after test (see 3).
- d. Retest acceptability for test conditions G and H (see 9). For K, see 3.e.
- e. Order of performance of fine and gross if other than fine followed by gross (see 3). The radioisotope gross and fine leak test may be run in any order, as both are a dry gas leak test.

17. Notes.

- a The fine leak test shall be performed first if test condition E is used for gross leak. 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 Any device that has been subjected to fluorocarbon leak testing will then interfere with subsequent dry gas leak testing. This is most noticeable with helium leak testing where it is known to reduce the measured leak rate by up to two orders of magnitude. The radioisotope method may be used to test such devices, but they shall be tested to a higher sensitivity to detect leakage, which can be one order of magnitude or more, greater than the measurement indicates. These tests shall be validated on a case by case basis using IGA test method 1018 of this test method standard on select devices provided that the lot of devices is large enough to support the validation tests. Also see test history 2.7 for nullifying the effects of fluorocarbons.
- c When retesting devices to test condition H₁, H₂ or CH, the history of device exposure to helium including dates, backfilling performed, tracer gas concentrations, pressure, and time exposed should be known in order to ensure reliable results. The sum of the bombing times and the total dwell time from the first bombing interval to the expected subsequent leak test can be used in the Howl-Mann equation to compute a new R₁ value if no helium was sealed in the device. Whenever parts are sealed in helium, or prior helium testing may have been performed on a device, the internal helium content can be calculated using the following equation:

$$Q_{\text{He-total}} = Q_{\text{He}} + p_i(e^{-(L(\text{He})t/V)})$$

Where:

$Q_{\text{He-total}}$ = the total helium contained in the package at the time of test.

p_i = the atmospheres of helium sealed within the device.

$L(\text{He})$ = the true helium leak rate.

t = the time between seal and test.

V = the internal volume of the device in cc.

Q_{He} = the amount of helium forced into the device during bombing.

Where:

$$Q_{\text{He}} = \{P_E - [p_i(e^{-(L(\text{He})t/V)})]\}(1 - e^{-(L(\text{He})T/V)})$$

P_E = bombing pressure in absolute atmospheres.

T = the bombing time in seconds.

Once $Q_{\text{He-total}}$ is known, the leak rate test limit (R_1) can be determined from equation (5) of 15.2.1.3.

Any device detected as a marginal reject using test condition H or CH and no leak testing history is available can be retested using condition G₁ or G₂. When retesting devices the history of the prior testing is not required. The devices are pre-read for residual ⁸⁵Kr gas just prior to retesting. Any prior ⁸⁵Kr reading is subtracted from the reading after retesting. The new net reading indicates the leak rate of the package.

If the history of the part indicates that it has been subjected to fluorocarbon fluid testing, or if there is no history evidencing that it has not been subjected to any fluorocarbon fluids, then it shall be assumed that the part could be fluorocarbon contaminated and the recommendations of 17.

NOTE: "c" shall be followed.

- d. The radioisotope method G_1 may be used to re-screen devices that have been subjected to fluorocarbon fluids, but they shall be tested to a higher sensitivity to detect leakage. The true leak rate however is sometimes seen to be two orders of magnitude greater than the indicated leak rate. When fine leak rates are detected, a re-test will demonstrate a non-linear increase in ^{85}Kr reading if the device has previously been subjected to fluorocarbon fluid. A vacuum-decay test can confirm that the leak rate is either a fine-leak and the true leak rate of the part, or that it is a 'diffusion' or 'solubility' leak rate through a liquid medium. Surface sorption is not a problem with ^{85}Kr as surface fluorocarbon liquid is easily detected by measuring the Beta radiation from ^{85}Kr gas absorbed in surface fluorocarbon fluid residues, since the Beta radiation is only detectable on surfaces and will not penetrate from within the device, ^{85}Kr gas quickly desorbs from surface fluorocarbon fluids, reducing surface sorption problems. The gamma radiation readings will confirm the amount of ^{85}Kr that has actually penetrated into the device if it is non-hermetic, and that confirms the leakage into the device.
- e. When retesting devices to test condition H_1 the history of device exposure to helium including dates, backfilling performed, tracer gas concentrations, pressure, and time exposed, should be known in order to ensure reliable results. Whenever parts were sealed in helium, or prior helium testing may have been performed on a device, the internal helium content is unknown and any subsequent helium test may be flawed. In that case any device detected as a marginal reject should be retested using a different dry gas medium as in A, B, or G_2 . When retesting devices to conditions A, B, G_2 , the history of the prior ^{85}Kr testing is not required. The devices are pre-read for residual ^{85}Kr gas just prior to retesting. Any prior ^{85}Kr reading is subtracted from the reading after retesting. The new "net" reading indicates the leak rate of the package.

NOTE: The following procedure is based on the assumption that a complete and accurate history of prior helium testing has been accurately recorded.

- f. When retesting devices to test condition H_1 , H_2 or CH, the history of device exposure to helium including dates, backfilling performed, tracer gas concentrations, pressure, and time exposed, should be known in order to ensure reliable results. The sum of the bombing times and the total dwell time from the first bombing interval to the expected subsequent leak test can be used in the Howl-Mann equation to compute a new R_1 value if no helium was sealed in the device.
- g. If the history of the part indicates that it has been subjected to fluorocarbon fluid testing, or if there is no history evidencing that it has not been subjected to any fluorocarbon fluids, then it shall be assumed that the part could be fluorocarbon contaminated and the recommendations of 17.

NOTE: The requirements of 17.c and 17.d shall be followed.

- h. Surface adsorption: This test method has reduced the maximum allowable leak rate historically allowed for hermetic devices by several orders of magnitude and as a result, the effects of surface adsorption of the tracer gas from surface contamination such as moisture, grease, or oils, or attached or printed labels, or surface porosity or materials which have a significant diffusion rate for the tracer gas shall be addressed and requires additional diligence to obtain useful data in a reasonable time period. When helium is used as the tracer gas, it is particularly important to keep the devices under test clean and free of surface contamination as well as the test chamber and any associated fixturing. Especially troublesome are the low vapor pressure organic binders that are found in cosmetic products. Never handle devices to be leak tested or inlet chambers or fixtures of the leak tester with bare hands. Always use finger cots or ESD gloves which are clean. If any solvent cleaning is performed prior to leak testing, make certain the solvent is fully dispersed prior to any leak testing procedure.

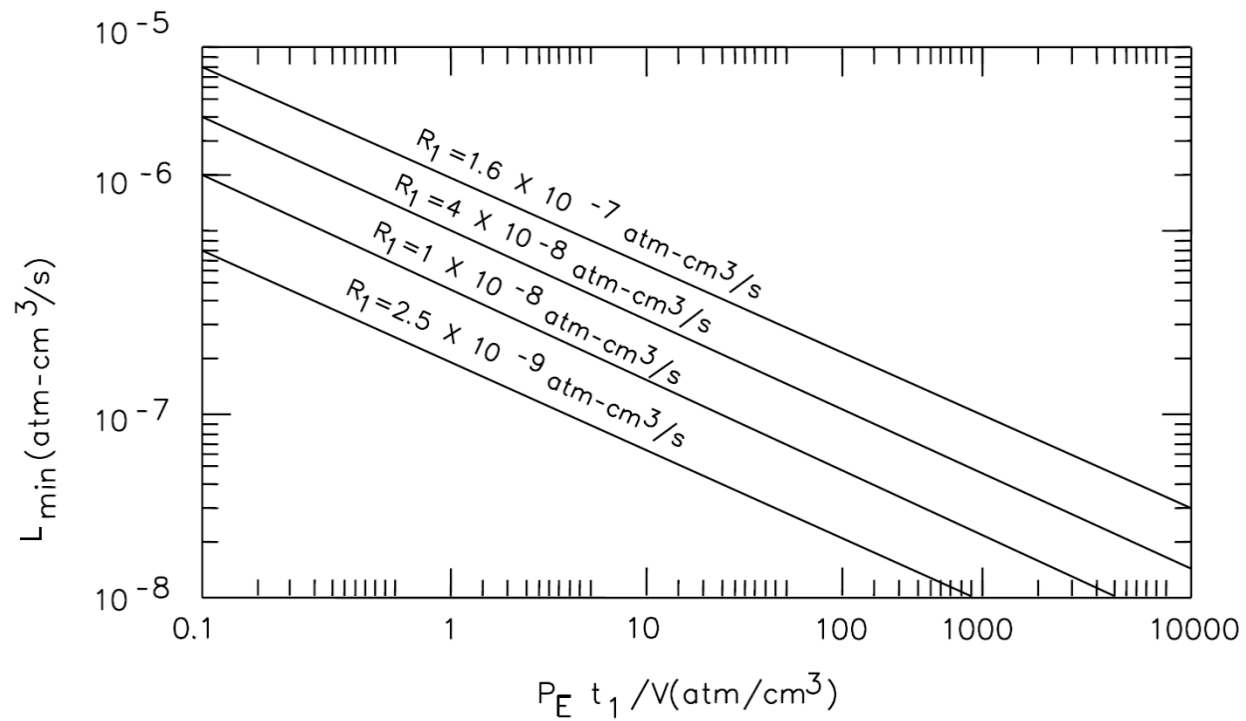
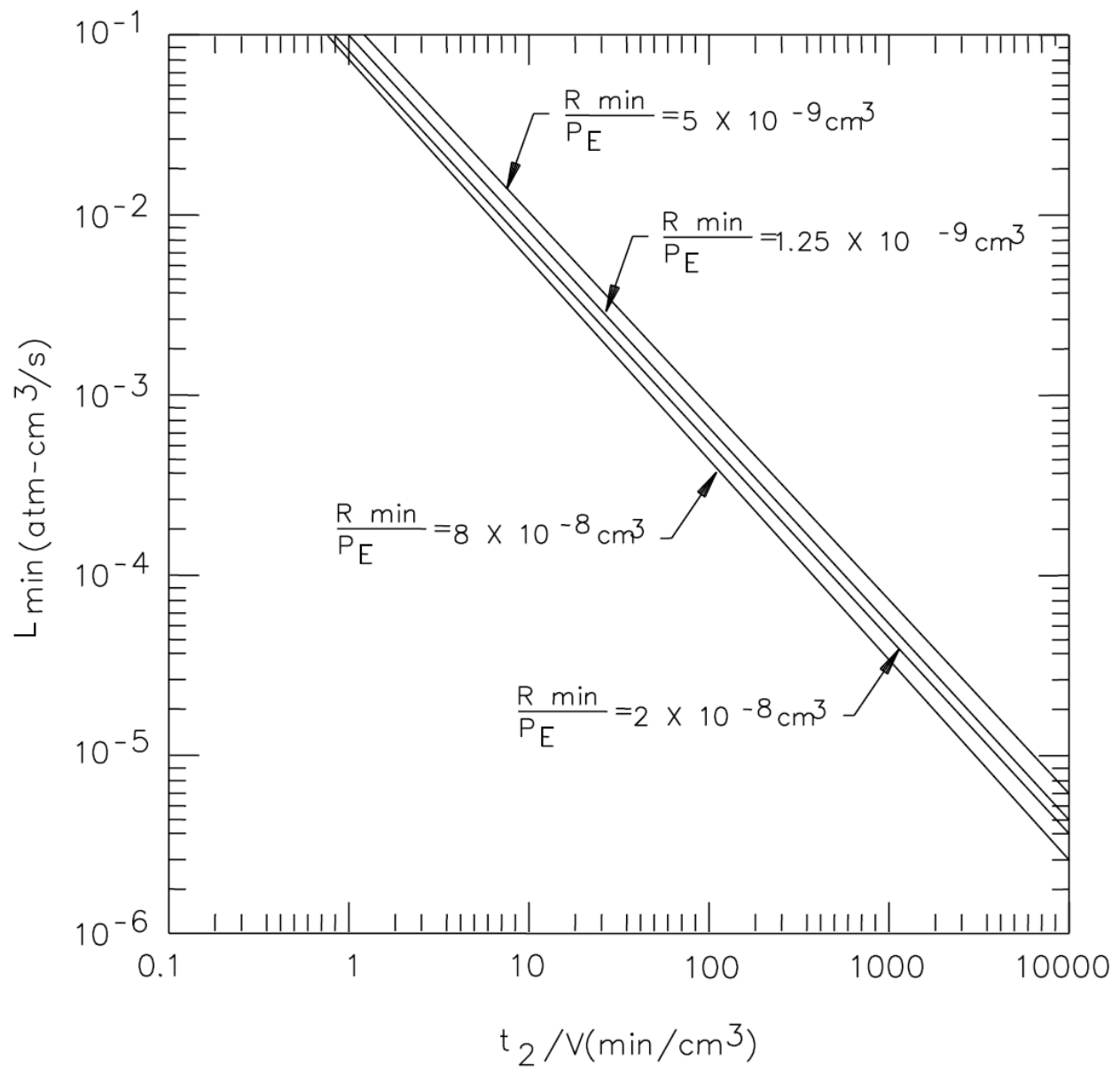


FIGURE 1071-5. Smallest detectable leak.



NOTE:

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 1071-6. Largest detectable leak.