METHOD 1014.14

SEAL

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

1.1 Definitions.

a. Standard leak rate. That quantity of dry air at 25°C in atmosphere cubic centimeters flowing through a leak or multiple leak paths per second when the high-pressure side is at 1 atmosphere (760 mm Hg absolute) and the low-pressure side is at near total vacuum (see 1.1e below). Standard leak rate shall be expressed in units of atmosphere cubic centimeters per second of air (atm cm^3/s air).

b. Measured leak rate. The implied leak rate that is measured on the detector for a given package using the specified conditions and employing a specified test medium (tracer gas) specific to that detector. Measured leak rate is expressed in units of atmosphere cubic centimeters per second (atm cm^3/s) for the medium used.

c. Leak-rate conversion factors for various test media.
atm cm^3/s (Kr85) X 1.71 = atm cm^3/s (air)
atm cm^3/s (Kr85) X 4.61 = atm cm^3/s (He)
atm cm^3/s (He) X 0.37 = atm cm^3/s (air)
atm cm^3/s (OL_{he}) X 0.37 = atm cm^3/s (air)

d. Equivalent standard leak rate. The leak rate that a given package would have under the standard conditions of 1.1a. The equivalent standard leak rate is determined by converting the implied leakage measured (L_a, R, Q or OL_{He}) to those conditions of 1.1c using appropriate calculations. For the purpose of comparison with rates determined by various media, the equivalent standard leak rate (for the medium used in the test) must be converted to the equivalent standard leak rate for the comparative medium (generally converted to air equivalents). The equivalent standard air leak rate shall be expressed in units of atmosphere cubic centimeters per second of air (atm cm^3/s air).

(1) L_a is the equivalent standard leak rate a package has expressed in term for air, or after converting to air from another medium.
(2) L is the maximum allowed equivalent standard leak rate L_a permitted for a package based on Table VII limits. For pass/fail criteria, L is compared to L_a.
(3) R is the implied leak rate of the medium (such as helium) as measured on a mass spectrometer.
(4) R_1 is the maximum allowed leak rate for the medium used. It is based on L using calculations to adjust for the specific test conditions used in the measurement (see paragraph 2.1.2.3). For pass/fail criteria, R is compared to R_1.
(5) Q is the implied leak rate of the medium (such as Krypton 85 (Kr85)) as measured on a radioisotope detector (see paragraph 2.2.6.c).
(6) Q_s is the maximum allowed leak rate for the medium used. It is based on L using calculations to adjust for the specific test conditions used in the measurement (see paragraph 2.2.5.1). For pass/fail criteria, Q is compared to Q_s
(7) OL_{He} is the implied leak rate (expressed in helium equivalents) as measured on an optical leak detector.

e. Near total vacuum. The reduction of atmospheric pressure to 2 mm Hg or less, absolute.

f. Pounds per square inch absolute (psia) gas. The sum of gauge pressure in the tank and barometric pressure. A tank showing zero gauge pressure is balancing the atmospheric conditions, hence has one atmosphere pressure (1 atm) inside. Absolute pressure takes this into consideration and is a measure of true content including this initial content. Thus, psia is the sum of the gauge pressure plus the barometric pressure.

1.2 Test Conditions. The following procedures are covered by this method:

1.2.1 Trace Gas (He). 1/
A_1 Fixed Fine Leak
A_2 Flexible Fine Leak
A_4 Fine Leak, applicable to the unsealed package.

1.2.2 Radioisotope (Kr85).
B_1 Fine Leak
B_2 Gross Leak
B_3 Wet Gross Leak

1.2.3 Perfluorocarbon Gross Leak.
C_1 Fixed Method that uses a liquid bath.
C_2 has been replaced by C_1.
C_3 Fixed Method that uses a vapor detection system instead of an indicator bath.

1.2.4 Optical.
C_4 Gross Leak
C_5 Fine Leak

1.2.5 Penetrant Dye Gross Leak.

1.2.6 Weight Gain Gross Leak.

1.2.7 Radioisotope (Kr85).
G_1 Thermal Leak Test for the evaluation of package hermetic integrity at elevated temperature.

1.2.8 Cumulative Helium Leak Detection (CHLD).
CH_1 Fixed Leak Detection for both Fine and Gross leak using the CHLD System.
CH_2 Flexible Leak Detection for both Fine and Gross leak using the CHLD System.
Z He Gross Leak Detection combined with one of several other tracer gases for Fine Leak Detection using the CHLD System.

1/ A_3 was intentionally omitted.

1.3 Test Structure. Fine and gross leak tests shall be conducted in accordance with the requirements and procedures of the specified test condition. Testing order shall be fine leak (condition A or B_1 or C_5) followed by gross leak (condition B_2, C_1, C_3, C_4, D, or E) except when C_4 or B_2 is used together with A, B_1, or C_5. Condition B_2 is a dry gas gross leak test and may be used prior to fine leak tests. When using the radioisotope tests, it is recommended practice to use B_2 first to remove gross leakers prior to the fine leak test B_1, which minimizes the Kr85 entrapped in rejected devices. When specified (see 4), measurements after test shall be conducted following the leak test procedures. Devices to be tested for thermal leakage shall first be subjected to a radioisotope gross leak test (B_2), a radioisotope fine leak test (B_1), or a gross/fine combination leak test, (B_2/B_1). Where bomb pressure specified exceeds the microcircuit package capability, alternate pressure, exposure time, and dwell time conditions may be used provided they satisfy the leak rate, pressure, time relationships which apply, and provided a minimum of 30 psia (2 atmospheres absolute) bomb pressure is applied in any case or for condition C_4, a minimum of 10 psi differential test pressure is applied in any case. When test condition B_2 is used to test large surface devices, a bomb pressure of 20 psia minimum may be used with the appropriate increase in bomb time (see paragraph 2.2.5.1). When test condition A_4 is used, gross leak testing is not required. However A_4 shall not be used in lieu of the required seal testing of lidded packages. When batch testing (more than one device in the leak detector at one time) is used in performing test condition A or B and a reject condition occurs it shall be noted as a batch failure. Each device may then be tested individually one time for acceptance if all devices in the batch are retested within one hour after removal from the tracer gas pressurization chamber. For condition B_1, B_2 only, devices may be batch tested and/or individually remeasured for acceptance providing all measuring is completed within one-half hour for B_1 and within 10 minutes for B_2 or combination B_2/B_1, after removal from the tracer gas pressurization chamber. For condition C_3 only, devices that are batch tested, and indicate a reject condition, may be retested individually one time using the procedure of 2.3.4.1 herein, except that re-pressurization is not required if the devices are immersed in detector fluid within 20 seconds after completion of the first test, and they remain in the bath until retest. For conditions C_4 and C_5 only, the package must meet construction requirements defined in 2.4.1. This includes devices that are conformal coated such as circuit board assemblies.

1.3.1 Retest. Devices which fail gross leak may be retested destructively. If the retest shows a device to pass, that was originally thought to be a failure, then the device need not be counted as a failure in the accept number of sample size number calculations. Devices which fail fine leak shall not be retested for acceptance unless specifically permitted by the applicable acquisition document. The applicable acquisition document must also state that a failed device that passes retest needs not be counted as a failure in the sample size accept number calculations, otherwise if will count. Where fine leak retest is permitted, the entire leak test procedure for the specified test condition shall be repeated. That is, retest consisting of a second observation on leak detection without a re-exposure to the tracer fluid or gas under the specified test condition shall not be permissible under any circumstances. Preliminary measurement to detect residual tracer gas is advisable before any retest.

1.3.2 Failure criteria. The failure criteria for Fine Leak is provided in Table VII of paragraph 3. Failure criteria for other conditions; i.e., Gross Leak and Thermal Leak, is provided following the procedure for each individual test.

1.4 Apparatus. The apparatus required for the seal test shall be as indicated in the procedure for the applicable test condition being performed.

2.2 Test Condition B, Radioisotope.

2.2.1 Radioisotope leak test apparatus. Apparatus for this test shall consist of:

a. Radioactive tracer gas pressurization console containing a Kr85/air mixture.

b. Counting equipment consisting of a scintillation crystal, photomultiplier tube, preamplifier, ratemeter, and Kr85 reference standards. The counting station shall be of sufficient sensitivity to determine through the device wall the radiation level of any Kr85 tracer gas present within the device.

(1) A "Flat Top Scintillation Crystal" counting station shall have a minimum sensitivity of 4,500 c/m/µCi Kr85 and a minimum detectable count rate of 500 counts per minute above ambient background.

(2) A "Well Crystal" counting station shall have a minimum sensitivity of 10,000 c/m/µCi Kr85 and a minimum detectable count rate of 500 counts per minute above ambient background.

(3) A "Tunnel Crystal" counting station shall have a minimum sensitivity of 4,500 c/m/µCi Kr85 and a minimum detectable count rate of 500 counts per minute above ambient background.

The counting station shall be calibrated at least once every working shift using Kr85 reference standards and following the equipment manufacturer's instruction. The actual calibration reading shall be recorded for each scintillation crystal detection system (Well, Tunnel, and Flat top) prior to performing testing.

c. A tracer gas that consists of a mixture of Kr85 and air. The concentration of the Kr85 in the Kr85/air mixture shall be no less than 100 micro-curies per atmospheric cubic centimeter. The determined values of each analytical sample shall be recorded in accordance with the calibration requirements of this standard (see 4.5.1 of MIL-STD-883). The specific activity may be measured automatically by the equipment during cycling of the equipment. If not, then an analytical sample of the Kr85 shall be taken at least once each 30 days to determine when the concentration drops by 5 percent in concentration and specific activity. If production use of the pressurization console averages 1000 of fewer bombings during the month analytical sampling may be annually. When the concentration drops by 5 percent, corrective action shall be taken to adjust the concentration.

d. ESD Protective Tubes shall be utilized to ensure the system is ESD safe when using the Well Counting Station.

e. All calibration records (e.g. daily, monthly, voltage crystal plateau graphs, and C of C for Kr85 reference standard, specific activity etc.) shall be maintained and made available to the qualifying activity.

f. The crystal voltage plateau graph shall be performed and documented semiannually. Examples of good plateau graphs and bad plateau graphs shall be included in the internal procedure.

2.2.2 Test condition B_2 – radioisotope gross leak package qualification. This test shall be used to qualify all packages with less than 0.1 cm^3 internal free volume that will undergo screening tests per the B_2 radioisotope gross leak, or the B_2/B_1 gross/fine leak combination test (see paragraph 2.2.6.b and c). The purpose is to assure that if such a packages has a leak, then that leak will be detectable under test conditions B_2 and B_2/B_1. Packages having 0.1 cm^3 internal free volume or larger do not require package qualification. Packages smaller than 0.1 cm^3 internal free volume shall be subjected to the following requirements:

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

b. The device shall be subjected to this test condition and removed from the pressurization tank. The device shall be measured in the counting station immediately after the tank is vented to atmosphere. A "net" reading indication of 500 counts per minute or greater is considered a reject. The device must remain a reject with a minimum of 500 counts per minute above ambient background for ten minutes after removal from the pressurization tank. If the device does not fail, test conditions B_2 and B_2/B_1 shall not be used.

2.2.3 Test condition B_2 and B_1 - radioisotope gross/fine combination leak. The apparatus for this test is that of paragraph 2.2. This test may be applied as a combination of conditions B_2/B_1 and is used in accordance with the requirements of those conditions for specified packages, as qualified under paragraph 2.2.2, with an atmosphere of Kr85/air mixture. Actual pressure and soak time for B_1 shall be determined in accordance with paragraph 2.2.5.1. When the soak time is completed, the Kr85/air mixture shall be evacuated until 2.0 torr pressure exists in the pressurization chamber. The evacuation shall be completed within 3 minutes from either the end of the pressurization cycle or the point at which the chamber pressure reaches 60 psia (if a higher pressure than 60 psia was used). The chamber shall then immediately be backfilled with air and the test devices removed from the chamber. The devices shall be measured using a scintillation crystal equipped counting station as specified in paragraphs 2.2.4.1, 2.2.4.2, or 2.2.5.2. Devices subjected to this gross/fine combination test must be measured within 10 minutes after removal from the pressurization system. The R value shall not be less than 500 counts per minute above background. If all of the tested devices cannot be measured within 10 minutes after removal from the pressurization cycle, the remaining devices at 10 minutes must be re-tested as above in this paragraph.

2.2.4 Determination of counting efficiency (k). The counting efficiency (k), or k-factor, is the efficiency of measurement of radioactive Kr85 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 (see 2.2.4.1, 2.2.4.2, 2.2.4.3, or 2.2.5.2). 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 2.2.4.1, 2.2.4.2, 2.2.4.3, or 2.2.5.2. Once established, the k-factor for each package configuration shall be recorded. This record shall list the methodology and procedure used to obtain the k-factor and shall be made available to the qualifying activity upon request.

2.2.4.1 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 counting efficiency (k). This representative sample shall have an accurately known micro-curie content of Kr85 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.

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 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.

2.2.4.2 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 counting efficiency (k). This representative sample shall have an accurately known micro-curie content of Kr85 placed within its internal void.

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 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.

2.2.4.3 Scintillation "Tunnel Crystal".

a. A Tunnel Crystal is either a solid block scintillation crystal similar to a flat-top crystal with an open tunnel through the body or can be a pair of solid scintillation crystals place one above the other in a parallel configuration. Devices pass through the tunnel or between the parallel crystals, usually on a conveyer belt, allowing dynamic measurements. This configuration is commonly used in high volume testing.

b. The k-factor must be determined for the Tunnel Crystal's dynamic condition which is usually less than in a static condition with the device standing at the center of the tunnel. See paragraph 2.2.5.2 to establish the k-factor for the sample using such a configuration. Alternately, this k-factor determination is commonly determined by the manufacturer upon request.

2.2.5 Test condition B_1, radioisotope fine or B_2/B_1 gross/fine leak combination test.

2.2.5.1 Testing parameters. The bombing pressure and soak time shall be determined in accordance with the following formula (see Eq (2)):

$$Q_S = \frac{R}{skTPt} \qquad \text{Eq (2)}$$

Where:

Q_S = The calculated maximum leak rate allowable, in atm cm^3/s Kr, for the devices to be tested.

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 background reading of the microcircuit, if it has been through prior radioactive leak tests.

s = The specific activity, in micro-curies per atmosphere cubic centimeter of the Kr85 tracer gas in the pressurization system.

k = The counting efficiency of the specific scintillation crystal used in the testing to measure Kr85 within the internal cavity of the specific component being evaluated. This k-factor must be determined in accordance with 2.2.4 for each device geometric configuration in combination with the specific scintillation crystal in which it will be measured.

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

P = P_e^2-P_i^2, where P_e is the bombing pressure in atmospheres absolute and P_i is the original internal pressure of the devices in atmospheres absolute. The activation pressure (P_e) may be established by specification or if a convenient soak time (T) has been established, the activation pressure (P_e) can be adjusted to satisfy equation (1).

t = Conversion of hours to seconds and is equal to 3,600 seconds per hour.

NOTE: The complete version of equation (1) contains a factor (P_O^2 - (ΔP)^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.

2.2.5.2 Dynamic Measurement of the k-factor 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 counting efficiency (k). This representative sample shall have an accurately known micro-curie content of Kr85 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.

2.2.5.3 Geometric configurations. 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, (2.2.4.1, 2.2.4.2, or 2.2.5.2).

Scintillation **"**well**"** crystals are capable of detecting (measuring) a maximum reading of 16,000 to 18,000 counts per minute from the emission of one micro-curie of Kr85 contained within the cavity of a device. This maximum reading of Kr85 emission is achieved with the DUT placed deep into the well-crystal and with no shielding from other devices or fixtures.

The counting efficiency (k-factor) for most device configurations and crystal combinations may be available from the equipment manufacturer by providing the equipment manufacturer with representative samples of the same geometric configuration as the device to be tested. Suitable facilities shall retain record of how the k-factor was established for each package configuration and made available to the qualifying activity.

2.2.5.4 Evaluation of surface sorption and wait time. All device encapsulations consisting of glass, metal, and ceramic or combinations thereof, that also include external coatings and external sealants or labels, shall be evaluated for surface sorption of Kr85 before establishing the leak test parameters. Devices susceptible to surface sorption must "wait" for the surface sorption to dissipate before being tested. This time lapse shall be noted and shall determine the "wait time" specified in 2.2.6.

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 2.2.5.1. The samples shall then be measured at the counting station every 10 minutes, with count rates noted. The total time taken for the count rate to become asymptotic is the "wait time".

Devices which are determined to have surface absorption should first be subjected to the radioisotope gross leak test procedure (B_2), and then to the fine leak test (B_1). The gross leak procedure will remove all leaking devices with leak rates greater than 5 X 10^{-6} atm-cm^3/sec.

2.2.5.4.1 Alternate β method. The surface sorption can also be determined by measuring the Beta (β) emission from any Kr85 absorbed into surface materials. The β particles will not penetrate the walls of the device; therefore, β emission detection means Kr85 is on the outer surfaces of a device. The β readings are monitored until they dissipate confirming the surface is free of Kr85 gas. This time to dissipate is the "wait time".

2.2.5.4.2 Removal of surface sorption. Devices with cavities > 0.1 cm^3, with leak rates in the fine leak range, will not lose their internal Kr85 gas in < 1 Hour. Therefore, such devices may be placed in a vacuum-oven at temperatures up to 100ºC and near total vacuum for 15-20 minutes following pressurization for B_1 without the concern of losing internal Kr85. This vacuum-oven procedure is capable of removing surface absorbed Kr85 from paints and labels. The removal of that surface Kr85 from the surface materials is accurately confirmed by verifying that there is no Beta radiation from the surface.

2.2.6 Test Procedure B_1, Fine Leak; B_2, Gross Leak; or B_2/B_1 Gross/Fine combination test. The devices shall be placed in a radioactive tracer gas pressurization chamber. The pressurization chamber may be partially filled with inert material (aluminum filler blocks), to reduce the cycle time and increase the efficiency of the system. It is the equipment manufacturer's recommendation that all 'small-cavity' devices be measured within 10 minutes after removal from the pressurization tank.

a. B_1 - Fine Leak: The tank shall be evacuated to 0.5 torr. The devices shall be subjected to a minimum of 2 atmospheres absolute pressure of Kr85/air mixture. Actual pressure and soak time for B_1 shall be determined in accordance with 2.2.5.1. When the 'soak time' is completed, the Kr85/air mixture shall be transferred to storage until 0.5 torr pressure exists in the pressurization chamber. The storage cycle shall be completed in 3 minutes maximum as measured from the end of the pressurization cycle or from the time the tank pressure reaches 60 psia if a higher bombing pressure was used. The tank shall then immediately be backfilled with air and the devices removed from the tank and measured within 1 hour after removal using a scintillation crystal equipped counting station as in 2.2.4.1, 2.2.4.2, or 2.2.5.2. Device encapsulations that come under the requirements of 2.2.5.4 shall be exposed to ambient air for a time not less than the 'wait time' determined by 2.2.5.4 (or following the bake cycle described in 2.2.5.4.2). Device encapsulations that do not come under the requirements of 2.2.5.4 may be tested without a 'wait time'. The R value of 2.2.5.1 shall not be less than 500 counts per minute above background.

   Note: If the devices are tested in the well crystal with the crystal wall shielded with a lead plug while measuring the device, and a background of approximately 500 counts per minute is achievable when the Ratemeter is in the "slow-time-constant" position, then reject values "R" of a minimum of 250 counts (net) above background may be measured for rejection of devices in high sensitivity testing.

b. B_2 - Gross Leak: Only product qualified under paragraph 2.2.2 shall be authorized to use this method. The devices shall be placed in a pressure chamber. The chamber shall be filled with inert material (aluminum filler blocks) so that the free volume is not greater than as qualified in 2.2.2. The tank shall be evacuated to 0.5 torr. The devices shall be subjected to a minimum of 2 atmospheres absolute pressure of Kr85/air mixture and the bomb time no less than 2 minutes. When the soak time is completed the Kr85/air mixture shall be transferred to storage until 2.0 torr pressure exists in the pressurization tank. The storage cycle shall be completed in 3 minutes maximum as measured from the end of the pressurization cycle. The tank shall then immediately be backfilled with air. The devices shall be removed from the tank and measured within 10 minutes after removal using a scintillation crystal equipped counting station as in 2.2.4.1, 2.2.4.2, 2.2.4.3 or 2.2.5.2. Any device indicating 500 counts per minute, 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 devices shall be returned to the pressurization chamber and re-pressurized to a minimum of 30 psia for a minimum of 0.01 hrs, and then measured at the counting station within 10 minutes. The counting station shall be checked at least once every shift using a Kr85 reference standard following manufacturer's procedure, and a record of proper function shall be maintained.

c. B_2/B_1 - Gross/fine combination: Only product qualified under paragraph 2.2.2 shall be authorized to use this method. The devices shall be placed in a pressure chamber. The chamber shall be filled with inert material (aluminum filler blocks) so that the free volume is not greater than as qualified in 2.2.2. The tank shall be evacuated to 0.5 torr. Actual pressure and soak time shall be in accordance with B_1 paragraph 2.2.5.1. The R value in counts per minute shall not be less than 500 above background. When the soak time is completed the Kr85/air mixture shall be transferred to storage until 2.0 torr pressure is in the pressurization chamber. The storage cycle shall be completed in 3 minutes maximum as measured from the end of the pressurization cycle, or from the time the tank pressure reaches 60 psia if a higher bombing pressure was used. The tank shall then immediately be backfilled with air. The devices shall be removed from the tank and measured within 10 minutes after removal using a scintillation crystal equipped counting station as in 2.2.4.1, 2.2.4.2, 2.2.4.3 or 2.2.5.2. Devices that require a "wait-time" per paragraph 2.2.5.4, which exceeds 10 minutes, cannot be subjected to this combination test. If all devices cannot be measured within the 10 minute window, then the remaining devices shall be returned to the pressurization chamber and re-pressurized to a minimum of 30 psia for a minimum of 0.01 hours, and then measured at the counting station within 10 minutes. The counting station shall be checked at least once every shift using a Kr85 reference standard following manufacture's procedure, and a record of proper function shall be maintained.

The actual Kr85 leak rate of the device tested using the radioisotope fine leak test shall be calculated with the following formula (see Eq 3)):

$$Q = \frac{(\text{ACTUAL READOUT IN NET COUNTS PER MINUTE}) \times Q_S}{R} \qquad \text{Eq (3)}$$

Where:
Q = Actual Kr85 leak rate in atm cm^3/s Kr85
Q_S and R are defined in 2.2.5.1.

2.2.7 Test condition B_3, Radioisotope Wet Gross Leak Test.

2.2.7.1 Intended Use. This is designed for small packages with less than 0.1 cm^3 internal free volume and packages that have not qualified to 2.2.2. This test may be used for larger than 0.1 cm^3 internal free volume packages. Packages up to 0.1 cm^3 internal free volume suspected of very large leaks are commonly subjected to this test.

2.2.7.2 Apparatus. Apparatus for this test shall be as in 2.2.1 and as follows:

a. 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.

b. Solutions:

(1) The red dye penetrant solution shall be kept clean and free of contaminants (including wash solvents). The solutions shall be tested to verify the efficiency of the solution for both Kr85 gettering and visual detectability. The most efficient red dye solution uses a mixture, by volume, of 95% light viscosity mineral oil and 5% oil-based red dye indicator. The solution must be evaluated for Kr85 absorption and retention.

(2) The solvent for washing the devices after immersion shall be acetone.

2.2.7.3 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 torr (~ 24 inches Hg) or less for 10 minutes and then pressurized with air for 10 minutes minimum at 310 kPa (45 psia) 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 and examined visually for red dye penetrant solution exiting from any leaking devices. Look for evidence of red dye leakage that is apparent without using the aid of visual magnification. Any devices with red dye penetrant solution leaking from them shall be rejected as gross leakers and removed.

Step 2. The remaining devices shall then be placed in the radioisotope pressurization chamber. The chamber shall be filled with inert material (aluminum filler blocks) so that the free volume is not greater than as qualified in 2.2.2. The chamber is evacuated to a pressure of 0.5 torr. The devices shall then be pressurized to a minimum of 45 psia of Kr85/air mixture for 0.2 hours minimum. The gas shall then be transferred to storage until a pressure of 2.0 torr maximum exists in the tank. This transfer shall be completed in 2 minutes maximum. The chamber 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 c/m or greater above the ambient background of the counting station shall be considered a gross leak. 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 Kr85 and may lose the Kr85 trapped within them. The devices shall be emptied onto a white surface 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 less than 0.1 cm^3 internal free volume 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 – 3, the procedure (starting with Step 2) shall be performed again until no more gross leakers are found.

2.7 Test condition G1, radioisotope thermal leak test.

2.7.1 Application. 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 been subjected to any prior liquid immersion testing (e.g. thermal shock, bubble test). The devices to be tested for thermal leakage shall first be subjected to a fine and dry gross leak test, 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.

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

a. Radioactive tracer gas pressurization console containing Kr85/air mixture. A Kr85 pressure/vacuum thermal test chamber capable of evacuation and pressurization at temperatures, and thermal cycling from ambient temperature to maximum temperature of the test desired while maintaining Kr85/air pressure.

b. Counting station as in paragraph 2.2.1b excluding Tunnel Scintillation Crystal.

c. A tracer gas as in paragraph 2.2.1c.

2.7.3 Testing parameters. Prior to the thermal-radioisotope test, the devices shall be pre-tested to the sensitivity requirement for that package in the standard. The bombing pressure and soak time for the pre-test shall be established for the package following 2.2.5.1.

2.7.3.1 Determination of counting efficiency (k). Shall be as in 2.2.4

2.7.3.2 Evaluation of surface sorption. Shall be as in 2.2.5.4

2.7.4 Procedures. The devices shall be placed in the radioactive tracer gas thermal-pressurization chamber. The tank shall be evacuated to 0.5 torr. The devices shall be subjected to a pressure of Kr85/air mixture at a pressure of 60 psia, (typical), or a minimum of 30 psia (dependent upon the structural compatibility of the package).

2.7.4.1 Thermal test. The devices are placed in the thermal/pressure chamber and pressurized with Kr85/air mixture to the pressure established in 2.2.5. The chamber is then heated to a temperature in the range of 100ºC to 125ºC and maintained at the elevated temperature for a minimum of 10 minutes. The heating rate should be 1ºC per minute minimum or as specified. The temperature is then returned to ambient, at which time the Kr85 is returned to storage and the devices are removed from the thermal/pressure chamber and measured at the scintillation crystal detection station for any Kr85 gas trapped within the devices. Device encapsulations that come under the requirements of 2.2.6 shall be exposed to ambient air for a time not less than the wait time determined by 2.2.5.4. In no case will the time between removal from the pressurization chamber and measurement exceed 60 minutes. 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.

2.7.5 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 Kr85, (greater than 500 c/m above ambient background), within the part after exposure to Kr85 pressure at temperature indicates a “thermal-reject”, (hermetic failure at elevated temperature).

Note: A thermal reject may be placed in a vacuum oven and the temperature increased for 10 minutes minimum, at 10ºC intervals, and the device removed to measure the Kr85 content after each 10ºC increase, until the temperature is reached at which the Kr85 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).

3. FAILURE CRITERIA. Unless otherwise specified, any device tested for Fine Leak that exhibits a leakage rate equal to or greater than the test limits of table VII shall be considered a failure.

TABLE VII. Test limits for all fine leak methods. 1/ 2/

Internal Free Volume of package (cm^3)	L Failure Criteria atm-cm^3/sec (air) Hybrid Classes B and H, and Monolithic Classes B, S, Q and V	L Failure Criteria atm-cm^3/sec (air) Hybrid Classes S and K only
≤ 0.05	$5 X10^{-8}$	$1 X 10^{-9}$
>0.05 - ≤ 0.4	$1 X 10^{-7}$	$5 X 10^{-9}$
> 0.4	$1 X 10^{-6}$	$1 X 10^{-8}$

1/ Leak rates for test conditions providing results in terms other than air must be converted to air equivalent leak rates using the conversion factors of 1.1.c. for comparison with this table's requirements.
2/ A purchase order may require space product failure criteria to be applied to non-space product for delivery.

3.1 Residual Krypton. Facilities with Laboratory Suitability from the qualifying activity for performing Kr85 testing shall have a documented procedure that is used to verify that the residual Krypton in tested devices are at an acceptable level (each lot/devices) as specified by applicable Nuclear Regulatory Agency requirements prior to shipping back to customers.

3.2. Failure of test equipment. Facilities with Laboratory Suitability from the qualifying activity shall inform the qualifying activity immediately if there are any problems with the equipment that may affect the proper testing and/or test results, as reflected in this test method.

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

a. Test condition letter when a specific test is to be applied (see 1.3).

b. Accept or reject leak rate for test condition A or B or C_5 when other than the accept or reject leak rate specified herein applies (see paragraph 3).

c. Where applicable, measurements after test (see 1 3).

d. Retest acceptability for test conditions A and B (see 1.3.1).

e. Order of performance of fine and gross if other than fine followed by gross except when using C_4/C_5 (see 1.3).

f. Where applicable, the device package pressure rating shall be specified if that rating is less than 75 psia.

g. Leak testing with conditions C_4 and C_5 also includes package testing on completed assemblies (PC boards), packages with external absorbing materials (connectors), or other special conditions.