

The documentation and process conversion measures necessary to comply with this revision shall be completed by 30 September 2006.

**INCH - POUND**

**MIL-STD-883G**  
**28 February 2006**  
**SUPERSEDING**  
**MIL-STD-883F**  
**18 June 2004**

**DEPARTMENT OF DEFENSE**  
**TEST METHOD STANDARD**  
**MICROCIRCUITS**



AMSC N/A

FSC 5962

**IsoVac Summary of MIL-STD-883G, Test Method 1014.12 "Radioisotope Sections only"  
MIL-STD-883G**

**METHOD 1014.12**

**SEAL**

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

1.1 Definitions.

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

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

2.2 Test condition B<sub>1</sub>, radioisotope fine leak. Apparatus for this test shall consist of:

- a. Radioactive tracer gas pressurization console.
- b. Counting equipment consisting of a scintillation crystal, photomultiplier tube, preamplifier, ratemeter, and krypton-85 reference standards. The counting station shall be of sufficient sensitivity to determine through the device wall the radiation level of any krypton-85 tracer gas present within the device. The counting station shall have a minimum sensitivity of 10,000 counts per minute per micro-curie of krypton-85 and shall be calibrated at least once every working shift using krypton-85 reference standards and following the equipment manufacturer's instruction.
- c. A tracer gas that consists of a mixture of krypton-85 and dry nitrogen. The concentration of the krypton-85 in dry nitrogen shall be no less than 100 micro-curies per atmospheric cubic centimeter. This value shall be determined at least once each 30 days and recorded in accordance with the calibration requirements of this standard (see 4.5.1 of MIL-STD-883).

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\* 2.7 Test condition B<sub>2</sub> – radioisotope gross leak. This test shall be used to leak test devices with an internal free-volume greater than 0.02 cc; (or smaller, only if they can demonstrate that the following requirements are met:)

- 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 immediately after the tank is vented to atmosphere, and measured in the counting station. A "net" reading indication 1000 cpm or greater is considered a reject. The device must remain a reject for a minimum of ten minutes after removal from the pressurization tank. If the device does not fail, this test condition shall not be used.

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2.8 Test condition B<sub>1</sub> and B<sub>2</sub> – radioisotope gross/fine combination leak. The apparatus for this test is the apparatus as in paragraph 2.2. This test may be applied as combination of conditions B<sub>1</sub>/B<sub>2</sub> and is used in accordance with the requirements of those conditions.

3. PROCEDURE. Fine and gross leak tests shall be conducted in accordance with the requirements and procedures of the specified test condition. Testing order shall be fine leak (condition A or B<sub>1</sub> or C<sub>5</sub>) followed by gross leak (condition B<sub>2</sub>, C<sub>1</sub>, C<sub>3</sub>, C<sub>4</sub>, D, or E) except when C<sub>4</sub> or B<sub>2</sub> is used together with A, B<sub>1</sub>, or C<sub>5</sub>. When specified (see 4), measurements after test shall be conducted following the leak test procedures. Where bomb pressure specified exceeds the microcircuit package capability, alternate pressure, exposure time, and dwell time conditions may be used provided they satisfy the leak rate, pressure, time relationships which apply, and provided a minimum of 30 psia (2 atmospheres absolute) bomb pressure is applied in any case or for condition C<sub>4</sub>, a minimum of 10 psi differential test pressure is applied in any case. When test condition A<sub>4</sub> is used, gross leak testing is not required. However A<sub>4</sub> 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<sub>1</sub>, B<sub>2</sub> only, devices may be batch tested and/or individually remeasured for acceptance providing all measuring is completed within one-half hour for B<sub>1</sub> and within 10 minutes for B<sub>2</sub> or combination B<sub>1</sub>/B<sub>2</sub>, after removal from the tracer gas pressurization chamber. For condition C<sub>3</sub> only, devices that are batch tested, and indicate a reject condition, may be retested individually one time using the procedure of 3.3.3.1 herein, except that 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<sub>4</sub> and C<sub>5</sub> only, the package must meet lid stiffness requirements defined in 3.6.1. This includes devices that are conformal coated such as circuit board assemblies.

3.2 Test condition B<sub>1</sub>, radioisotope fine or B<sub>1</sub>/B<sub>2</sub> Combination gross/fine leak test.

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

$$Q_s = \frac{R}{skTPt} \quad (1)$$

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

Q<sub>s</sub> = The maximum leak rate allowable, in atm cc/s Kr, for the devices to be tested.

R = Counts per minute above the ambient background after pressurization if the device leak rate were exactly equal to Q<sub>s</sub>. 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 krypton-85 tracer gas in the pressurization system.

k = The counting efficiency of the specific scintillation crystal used in the testing to measure krypton-85 within the internal cavity of the specific component being evaluated. This k-factor must be determined in accordance with 3.2.2 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.

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

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

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NOTE: The complete version of equation (1) contains a factor  $(P_0^2 - (\Delta P)^2)$  in the numerator which is a correction factor for elevation above sea level.  $P_0$  is sea level pressure in atmospheres absolute and  $\Delta P$  is the difference in pressure, in atmospheres between the actual pressure at the test station and sea level pressure. For the purpose of this test method, this factor has been dropped.

\* 3.2.2 Determination of counting efficiency (k). The counting efficiency (k), or k-factor, is the efficiency of measurement of radioactive krypton-85 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 3.2.2.1, 3.2.2.2, 3.2.2.3). 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 3.2.2.1, 3.2.2.2, and 3.2.2.3.

### \* 3.2.2.1 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 krypton-85 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 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, ~~is not~~ 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.

### \* 3.2.2.2 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 krypton-85 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 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.

### \* 3.2.2.3 Dynamic 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 counting efficiency (k). This representative sample shall have an accurately known micro-curie content of krypton-85 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.

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- \* 3.2.2.4 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, (3.2.2.1, 3.2.2.2, or 3.2.2.3.).
  - \* 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 counts per minute from the emission from one micro-curie of krypton-85 contained within the cavity of a device. Those values are limited by the total radiation emitted from krypton-85; 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 c/m/ $\mu$ Ci.
  - \* The counting efficiency (k-factor) for most device configurations and crystal combinations can sometimes be obtained from the equipment manufacturer by providing the equipment manufacturer with representative samples of the same geometric configuration as the device to be tested.
- 3.2.3 Evaluation of surface sorption. 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 krypton-85 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 3.2.1. 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 3.2.4.
- \* 3.2.4 Test Procedure B<sub>1</sub>, Fine Leak; B<sub>2</sub>, Gross Leak; or B<sub>1</sub>/B<sub>2</sub> 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<sub>1</sub> – 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 krypton-85/air mixture. Actual pressure and soak time for B<sub>1</sub> shall be determined in accordance with 3.2.1. When the 'soak time' is completed, the krypton-85/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 30 minutes after removal using a scintillation crystal equipped counting station as in 3.2.2.1, 3.2.2.2, or 3.2.2.3. Device encapsulations that come under the requirements of 3.2.3 shall be exposed to ambient air for a time not less than the 'wait time' determined by 3.2.3. Device encapsulations that do not come under the requirements of 3.2.3 may be tested without a 'wait time'. The R value shall not be less than 500 counts per minute above background. (It is recommended practice that the number of devices pressurized for leak testing is limited such that the test of the last device can be completed within 30 minutes).
    - \* b. B<sub>2</sub> – Gross Leak: The tank shall be evacuated to 0.5 torr. The devices shall be subjected to a minimum of 2 atmospheres absolute pressure of krypton-85/air mixture and the bomb time no less than 2 minutes. When the soak time is completed the krypton-85/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 3.2.2.1, 3.2.2.2, or 3.2.2.3. (It is recommended practice that the number of devices pressurized for the gross leak test is limited such that the test of the last device can be completed within 10 minutes).
    - \* c. B<sub>1</sub>/B<sub>2</sub> Gross/fine combination: The tank shall be evacuated to 0.5 torr. The devices shall then be subjected to a minimum of 2 atmospheres absolute pressure of krypton-85/air mixture. The actual bomb time and pressure shall be in accordance with 3.2.1 for B<sub>1</sub>. When the soak time is completed the krypton-85/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, or from the time the tank pressure reaches 60 psia if a higher bombing

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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 3.2.2.1, 3.2.2.2, or 3.2.2.3. (It is recommended practice that the number of devices pressurized for the gross leak test is limited such that the test of the last device can be completed within 10 minutes). Devices requiring a 'wait time' per 3.2.3 must be subjected to B<sub>1</sub> and/or B<sub>2</sub> separately. Device encapsulations that do not come under the requirements of 3.2.3 may be tested without a 'wait time'.

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

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

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

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

TABLE III. Test limits for radioisotope fine leak method.

Volume of package cc	Q <sub>s</sub>
< 0.01	1 x 10 <sup>-8</sup>
> 0.01, ≤ 0.4	5 x 10 <sup>-8</sup>
> 0.4	5 x 10 <sup>-7</sup>