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Test Method A109
Hermeticity

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HERMETICITY

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TEST METHOD A109

HERMETICITY

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TEST METHOD A109

HERMETICITY

(From JEDEC Council Ballot JCB-86-25A, formulated under the cognizance of JC-14.1 Committee on Transportation/Automotive Electronics.)

1. PURPOSE

The purpose of this test is to determine the effectiveness of the seal of hermetically sealed solid-state devices.

The seal tests are considered nondestructive. They are intended to be used for 100% screen, lot acceptance, product monitoring or for qualification testing as applicable. The seal tests may also be employed as end points for other environmental durability tests.

1.1 Definition

Measured Leak Rate

The measured leak rate 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-cm3/s).

2. APPARATUS

2.1 Test Condition A - Helium Fine Leak Test

Apparatus required shall consist of suitable pressure and vacuum chambers and a mass spectrometer-type leak detector, preset and properly calibrated for a helium leak rate sensitivity to read measured helium leak rates of 10^{-9} atm-cm^3/s and greater. The volume of the chamber used for leak measurement should be held to the minimum practical, since this chamber volume has an adverse effect on sensitivity limits. The leak detector indicator shall be calibrated using a diffusion-type calibrated standard leak at least once during *every* working shift.

2.2 Test Condition B - Radioisotope Fine Leak Test

The apparatus for this shall consist of:

(1) Radioactive tracer gas activation console.

(2) 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 the radiation level of any krypton-85 tracer gas present within the device. The counting station shall have a minimum sensitivity corresponding to a leak rate of 10^{-9} atm-cm3/s of krypton-85 and shall be calibrated at least once every working shift using krypton-85 reference standards and following the equipment manufacturer's instruction.

(3) A tracer gas consisting of a mixture of krypton-85 and dry nitrogen. The concentration of krypton-85 in dry nitrogen shall be no less than 100 microcuries per atmospheric cubic centimeter. This value shall be determined at least once per month.

2.3 Test Condition C - Fluorocarbon Bubble Gross Leak

The apparatus for this test shall consist of:

(1) A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 75 psig for up to 10 hours.

(2) A suitable observation container with provisions to maintain the indicator fluid at a temperature of 125°C and a filtration system capable of removing particles greater than 1 micron in size from the fluid.

(3) A magnifier with a magnification in the range between 3X and 30X for observation of bubbles emanating from devices when immersed in the indicator fluid.

(4) Sources of FC-72, FC-84 or D-80 fluorocarbon detector fluids, and FC-40, FC-43 or DO-2 fluorocarbon indicator fluids.

(5) A lighting source capable of producing at least 15 thousand foot candles in air at a distance equal to that which the most distant device in the bath will be from the source. The lighting source shall not require calibration, but the light level at the point of observation (i.e., where the device under test is located during observation for bubbles) shall be verified.

(6) Suitable calibrated instruments to indicate that test temperatures, pressures and times are as specified.

(7) Suitable fixtures to hold the device(s) in the indicator fluid.

2.4 Test Condition D - Fluorocarbon Vapor Detection Gross Leak

The apparatus for this test shall consist of:

(1) A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 75 psig for up to 12.5 hours.

(2) Sources of FC-84 or D-80 fluorocarbon detector fluids.

(3) Suitable calibrated instruments to indicate that test temperatures, pressures and times are as specified.

(4) A fluorocarbon vapor detection system capable of detecting vapor quantities equivalent to 0.28 mg of FC-84.

(5) A calibration source for the vapor detector. The vapor detector shall be calibrated at least once each working shift per the manufacturer's instructions.

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, followed by gross leak. Where bomb pressure specified exceeds the device package capability, alternative pressure, exposure time and dwell time conditions may be used provided they satisfy the leak rate, pressure, time relationships which apply, and provided no less than 30 psia bomb pressure is applied in any case.

3.1 Test Condition A - Helium Fine Leak

3.1.1 Test Condition Al, A2

Test condition Al is a “fixed” method with specified conditions per Table I that will ensure the test sensitivity necessary to detect the required measured leak rate (R1). Test condition A2 is a “flexible” method that allows the variance of test conditions in accordance with the formula of 3.1.1.3 to detect the specified equivalent standard leak rate (L) at a predetermined leak rate (R1).

3.1.1.1 Test Conditions Al and A2 - Procedure Applicable to "Fixed" and "Flexible” Methods

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

3.1.1.2 Test Condition Al - Fixed Method

The device(s) shall be tested using the appropriate conditions specified in Table I for the internal cavity volume of the package under test. The time tl is the time under pressure and time t2 is the maximum time allowed after release of pressure before the device shall be read. The fixed method shall not be used if the maximum equivalent standard leak rate limit given in the procurement document is less than the limits specified herein for the flexible method.

TABLE I

Fixed Conditions for Test Condition A l

Volume of package (cm^3)		Bomb Condition: psia ±	Bomb Condition: Exposure time hours	Bomb Condition: Maximum dwell hours	R1 Reject limit (atm-cm^3/He)
<0.05		75	2	1	5×10^{-8}
≥0.05	< 0.5	75	4 +0.2, -0	1	5×10^{-8}
≥0.5	< 1.0	45	2 +0.2, -0	1	1×10^{-7}
≥1.0	< 10.0	45	5 +0.5, -0	1	5×10^{-8}
≥10.0	< 20.0	45	10 +1.0, -0	1	5×10^{-8}

3.1.1.3 Test Condition A2 - Flexible Method

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

$$R_1 = (LPe/Po)(MA/M)^{1/2}\left[1-e^{\left[-(LT1/VPo)(MA/M)^{1/2}\right]}\right]e^{\left[-(LT2/VPo)(MA/M)^{1/2}\right]}$$

Where:

R1 = The measured leak rate of tracer gas (He) through the leak in atm cm3/s (He) .

L = Equivalent standard leak rate in atm cm3/s(air) .

Pe = The pressure of exposure in atmospheres absolute.

Po = The atmospheric pressure in atmospheres absolute. (1)

M_A = The molecular weight in air in grams. (28.7)

M = The molecular weight of the tracer gas (He) in grams. (4)

tl = The time of exposure to Pe, in seconds.

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

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

3.1.1.3.1 Failure Criteria

Unless otherwise specified, devices with an internal cavity volume of 0.01 cm3 or less shall be rejected if the equivalent standard leak rate (L) exceeds 5×10^{-8} atm cm3/s(air) . Devices with an internal cavity volume greater than 0.01 cm3 and equal to or less than 0.5 cm3 shall be rejected if the equivalent standard leak rate (L) exceeds 1×10^{-7} atm cm3/s(air).

3.2 Test Condition B - Radioisotope Fine Leak Test

3.2.1 Activation Parameters

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

$$QS = \frac{R}{s\ K\ T\ \overline{P}\ t}$$

Where:

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

R = Counts per minute above the ambient background after activation if the device leak rate were exactly equal to QS. This is the reject count above the background of both the counting equipment and the component, if it has been through prior radioactive leak tests.

s = The specific activity, in microcuries per atmospheric cubic centimeter, of the krypton-85 tracer gas in the activation system.

k = The overall counting efficiency of the scintillation crystal in counts per minute per microcurie of krypton-85 in the internal void of the specific component being evaluated. This factor depends upon component configuration and dimensions of the scintillation crystal. The counting efficiency shall be determined in accordance with 3.2.2.

$\overline{P}$ = $P_{e}2 - P_{i}2$, where Pe is the activation pressure in atmospheres absolute, and Pi is the original internal pressure of the device in atmospheres absolute. The activation pressure (Pe) may be established by specification or if a convenient soak time (T) has been established, the activation pressure (Pe) can be adjusted to satisfy equation (1).

t = Conversion factor, 3,600 seconds per hour.

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

3.2.2 Determination of Counting Efficiency (k)

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

(1) Five representative units of the device type being tested shall be tubulated and the internal void of the device shall be backfilled through the tabulation with a known volume and known specific activity of krypton-85 tracer gas and the tabulation shall be sealed off.

(2) The counts per minute shall be directly read in the shielded scintillation crystal of the counting station in which the devices are read. From this value, the counting efficiency, in counts per minute per microcurie, shall be calculated.

3.2.3 Evaluation of Surface Sorption

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

3.2.4 Procedure

The devices shall be placed in a radioactive tracer gas activation tank. The activation chamber may be partially filled with inert material to reduce pumpdown time. The tank shall be evacuated to 0.5 torr. The devices shall be subjected to a minimum of 2 atmospheres absolute pressure of krypton-85/dry nitrogen mixture for a minimum of 12 minutes. Actual pressure and soak time shall be determined in accordance with 3.2.1. The R value in counts per minute shall not be less than 600 above background. The krypton-85/dry nitrogen gas mixture shall be evacuated to storage until 0.5 torr vacuum exists in the activation tank. This evacuation shall be completed within 3 minutes maximum. The activation tank shall then be backfilled with air (air wash) . The devices shall then be removed from the activation tank and leak tested within 1 hour after gas exposure with a scintillation-crystal-equipped counting station. Device encapsulations that do no come under the requirements of 3.2.3 may be tested without a "wait time". (The number of devices removed from pressurization for leak testing shall be limited such that the test of the last device can be completed within 1 hour) . The actual leak rate of the component shall be calculated with the following equation:

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

where Q = Actual leak rate in atm-cm3/s, and QS and R are defined in 3.2.1.

3.2.5 Failure Criteria

Unless otherwise specified, devices that exhibit a leak rate equal to or greater than 5×10^{-8} atm-cm^3/s (calculated Q) shall be considered failures.

3.2.6 Personnel Precautions

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

3.3 Test Condition C - Fluorocarbon Bubble Gross Leak

3.3.1 Procedure

(1) The devices shall be placed in a vacuum/pressure chamber and the pressure reduced to 5 torr and maintained for 1 hour, except that for devices with an internal volume > 0.1 cm3, this vacuum cycle may be omitted.

(2) A sufficient amount of FC-72 or equivalent detector fluid shall be admitted to cover the devices. When a vacuum cycle is performed, the fluid shall be admitted after the l-hour period, but before breaking the vacuum.

(3) The pressure shall then be increased to 60 +15/-0 psig for a duration of 2 hours minimum. For devices with an internal cavity volume of less than 0.05 cm3, an acceptable alternate condition is a pressure of 75 +5/-0 psig for 1 hour minimum. For devices with an internal cavity volume >0.1 cm3, if the package cannot be subjected to 60 +15/-0 psig, the pressure shall be decreased to 30 +15/-0 psig (or 45 +5/-0 psig if the vacuum cycle was omitted) and maintained for a duration of 10 hours minimum.

(4) At the end of this time, the pressure shall be released and the device removed from the pressure chamber and retained continuously immersed in a bath of the detector fluid. When the devices are removed from the bath they shall be dried for 2 ± 1 minutes in air prior to immersion in FC-40 or equivalent indicator fluid, which shall be maintained at 125°C ±5°C.

(5) The devices shall be immersed with the uppermost portion at a minimum depth of 2 inches below the surface of the indicator fluid, one at a time or in such a configuration that a single bubble from a single device out of a group under observation may be clearly observed as to its occurrence and source.

(6) 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, unless rejected earlier.

3.3.2 Failure Criteria

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

3.3.3 Precautions

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

(1) Fluorocarbons shall be filtered through a filter system capable of removing particles greater than 1 micron 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 reuse. Precaution should be taken to prevent contamination.

(2) The observation container shall be filled to assure coverage of the device to a minimum of 2 inches.

(3) Devices to be tested should be free from foreign materials on the surface, including conformal coatings and any markings that may contribute to erroneous test results.

(4) A lighting source capable of producing at least 15 thousand foot candles in air at a distance equal to that which the most distant device in the bath will be from the source. The lighting source shall not require calibration but the light level at the point of observation (i.e., where the device under test is located during observation for bubbles) shall be verified.

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