2.4 Test condition for optical leak test, (C_4 , C_4 and C_5).

2.4.1 Application. Optical Leak Test (OLT) applies to individual devices and to devices mounted on printed circuit boards or higher level assemblies. The operation for the OLT system is based on the ability to deflect the lid or package. The candidate package shall have a lid stiffness to deflect at least 0.005 microns/psi minimum. 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 as a result of pressure being applied. Generally, Helium is used as the pressure medium. Apparatus required shall consist of suitable pressure or vacuum/pressure chamber with an integral interferometry leak detector. The optical leak detector shall be preset and properly calibrated for an equivalent standard leak rate sensitivity sufficient to detect leakage to the required levels stated in Table VII of paragraph 3. 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 (He) then divided by the test duration and multiplied by the internal free volume, OL (atm-cm^3/sec)is determined. The leak rate would be denoted as OL_{air} for air or CDA (clean dry air), OL_{N2} for Nitrogen, or OL_{He} for Helium. The conversion factors for these gases are listed in 1.1.c. If the test gas is air then no conversion is necessary and the OLT output can be directly compared to the test limits listed in Table VII.

Note: Prior to performing optical gross/fine leak testing, the test designer will need to know the structural limits of the package. Extreme pressure/vacuum may cause damage to some devices. The test designer will need to design the test conditions around such limitations.

2.4.2 Apparatus. The apparatus required for test conditions C_4, C_4 and C_5 optical leak test 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 90 psia.

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 internal free volume and test duration is used to obtain leak rates OL.

f. An absolute pressure sensor installed that automatically accounts for changes in barometric pressure.

g. A temperature sensor (thermocouple) that is used for temperature variations for the Temperature Compensation Factor (TCF).

h. A heater that is used during the initial device profile set up only, for determining the Temperature Compensation Factor (TCF).

2.4.3 Apparatus initial setup. The optical gross/fine leak test equipment requires unique test parameters for each device type. . Package set up and calibration shall be performed using two or more devices with leak rates less than the test limits in Table VII. These set up devices will be used prior to production testing to determine if the optical leak tester can be used to test this specific package type and also to determine the specific parameters, P_a, T, and nominal lid stiffness for production testing. P_a and T are fixed values such that the test sensitivity is less than the test limits. P_a shall be the same pressure used during test and T is the minimum time required to achieve passing leak rates. The measured lid stiffness for each device (unique serial number) will be used to calculate the leak rate. This initial step can be skipped if the test set up information for this specific package type and geometry has already been previously determined, documented, and maintained in the system.

Note: Do not test the packages within 30 minutes of seam sealing or baking. The packages should be at the same ambient temperature as the leak tester.

* 2.4.4 Process monitoring. A group of "system check devices" shall be used for system operation verification at the beginning and end of each work shift. There shall be at least one device that is a gross leaker exhibiting no lid deflection, one fine leaker having a leak rate greater than the applicable test limit in Table VII, and at least one known good device having a leak rate less than the applicable test limits in Table VII. A leak rate log of the system check devices must be maintained for auditing and to demonstrate that the leak rates continue to meet the criteria specified above. The leak rate log and system check devices shall be made available to the qualifying activity. Checked devices shall be stored in a dry box or dry nitrogen purge cabinet and handled with gloves to prevent leak path obstruction.

2.4.5 Leak rate. The optical leak test shall be performed with a test pressure (P_a) and time (T), which will provide the leak rate sensitivity required. The leak rate is provided by the following equation (see Eq (4)):

$$OL = (V / TP_a) \times -\ln (\Delta P_f / \Delta P_i) \qquad \text{Eq (4)}$$

Where:
- OL = The implied leak rate of the test (atm-cm^3/sec He).
- V = The internal free volume of the package cavity (cm^3).
- T = The test duration time (seconds).
- ΔP_i = The chamber test pressure (psig). Since the internal package pressure is assumed to be 0 psig at the start of the test, the pressure difference is the test pressure.
- ΔP_f = The chamber test pressure – leakage (psig). Leakage is the change in pressure inside the package during the test. Leakage = lid movement (um) / lid stiffness (um/psi).
- P_a = The chamber test pressure, psig converted to atmosphere as a function of altitude, e.g. 1 atm = 14.7 psia at sea level.

* 2.4.5.1 Controlling sensitivity by controlling test time, pressure, and temperature. As stated above, for a specific package lid thickness, and volume V, the leak rate sensitivity OL is increased by increasing the test time T and chamber pressure P_a. A temperature increase of 2 °C or more during a test can cause the internal pressure of the device to increase and raise the lid up as if the device were leaking. Therefore, a means to compensate leak rate measurements for changes in room temperature and fluctuations in barometric pressure over long test times (> 45 minutes) shall be implemented. The Temperature Compensation Factor (TCF) will prevent a hermetic device from being falsely rejected. The TCF is determined by running devices with leak rates less than the test limits in Table VII with the same test parameters used in production. To set up the TCF for a new part type, a heater is used to raise the chamber temperature by 2 °C to 3 °C over the test time. The ΔPD (change in internal pressure of the device, also called leakage) will be measured which is the result of the device temperature changing and thermal mismatch between the lid and base. The heater is not used in production, only for the one-time test profile set-up run. The units for TCF are psi / °C and allows the OLT system to adjust ΔPD (leakage) for temperature prior to calculating the leak rate.

2.4.6 Procedure for optical leak test, C_4, C_4 and C_5. 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 or evacuated (vacuum) to a test pressure no higher than the maximum design pressure/vacuum as determined by the package manufacturer or the design limit of the chamber. For the duration of the test, the chamber pressure/vacuum 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), is measured for each package in the field of view simultaneously.

* 2.4.6.1 Failure criteria.

a. The failure criteria for Gross Leak, C4, is defined when one of the following two operational test characteristics is observed.
   1. One instance is when the optical interferometer does not detect deflection of the lid as the chamber pressure was changed.
   2. The second is when the lid initially deflects under pressure but quickly returns towards its unpressurized state due to the equalization of the internal device pressure caused by a gross leak.

b. The failure criteria for combined Gross and Fine Leak, C4 & C5 , is if the optical interferometer did not detect deflection of the lid as the chamber pressure was changed or that provided in Table VII of paragraph 3.

2.4.7 Test condition C_4, C_4 and C_5 retest. The package may be retested due to equipment malfunction or operator error causing the package to not be properly tested, or the test not being completed. If approved by the qualifying activity, retest may be performed due to other conditions and shall be documented accordingly. The proper wait time before performing a retest shall ensure the internal package pressure has equalized with the outside pressure. This proper wait time shall be determined through repeated testing of a fine leaking package and the data shall be available to the acquiring or qualifying activity upon request. The retesting shall be documented and records shall be retained for traceability.

* 2.4.7.1 Method for retest without error code (manual fringing test). If the system reports a device as “retest,” the device is most likely a gross leaker. A “retest” response implies collective data is insufficient to distinguish a gross leaker from a non leaking device. Therefore, the manual fringing method must be performed in accordance with the equipment manufacturer’s defined procedures. This additional testing shall be documented and records shall be retained for traceability.

* 2.4.7.2 Method for retest with error code. If the system reports a device as “retest” with an error code, a retest may be performed in accordance with the equipment manufacturer’s defined procedure. This procedure must address the proper wait time necessary to ensure the internal package pressure has equalized with the outside pressure before the test is repeated. This proper wait time shall be determined through repeated testing of a fine leaking package, and the data shall be available to the acquiring or qualifying activity upon request. This additional testing shall be documented and records shall be retained for traceability.

2.5 Test condition D, penetrant dye gross leak.

Note: This is a destructive test for verification per the requirements of 1.3.1 Retest.

2.5.1 Apparatus. The following apparatus shall be used for this test:

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

b. Pressure chamber capable of maintaining 105 psia.

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 with a magnification in the range between 1.5X to 30X for dye observation.

2.5.2 Test condition D, penetrant dye gross leak. 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 105 psia minimum for 3 hours minimum. For device packages which will not withstand 105 psia, 60 psia 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. Remove the lid from the device. The devices shall then be immediately examined under the magnifier using an ultraviolet light source of appropriate frequency.

2.5.2.1 Failure criteria. Any evidence of dye penetration into the device cavity shall constitute a failure.

2.6 Test condition E, weight gain gross leak.

2.6.1 Apparatus. Apparatus for this test shall consist of:

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

d. A filtration system capable of removing particles greater than 1 micrometer in size from the perfluorocarbon fluid.

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

2.6.2 Procedure. The devices shall be placed in an oven at 125°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