Understanding Leak Rates.

Leak detection has been a generally used process since the days when the beaver sat on the downstream side of his dam and looked for outlets, and the cave man plunged a broken coconut into the stream and lifted it above his head to observe cracks and holes. Both of these methods were quality control tests. These, as well as other similar checks, are still in modified use today. Consider the specifications that are presently being applied in leak detection. In too many cases, they are traditional, inherited, or most commonly, imposed without a complete understanding of what is involved in the leak testing problem.

Questions should be raised as to the technical level of the test, the life guarantee desired, the technical source or reference for the degree of test and perhaps above all, whether the chosen test method is best, and finally what is the justification for it over others.

The simple bubble test for example is purely go/no go. It is a test which is commonly interpreted quantitatively. Immersion in a fluid is no better than the eye of the observer who too often is looking for a bubble from a 10^{-1} to 10^{-5} cm^3 volume cavity. This technique essentially looks for one hole which actually might empty the part in 1 to 10 sec. if it lacked the bubble creating fluidic medium. Or consider the common case of porosity where a surface is lined with so many holes that the operator could wait weeks to see any one single bubble form. Remember, if the operator isn't looking right at a bubbling hole he may think he has a good part.

Another commonly used method senses the leakage of helium gas which has been introduced into a part. The leak rates measured are good for two-sided systems where the analyzer is on one side and pure helium on the other. Measured leak rates are always assumed to be for dry gas. This may not be the case as a result of a wetted hole due to water, solvent films, etc. The leak detection method is good, but in the fine leak range the leak rate measurement is often controlled by the solubility of helium in the liquid interface, possibly one-half magnitude below the true leak rate.

Hermetic devices can either be manufactured with helium initially sealed in the part, or the part can be pressure bombed in pure helium to introduce 10% helium for leak detection purposes. The greatest errors come from lack of proper utilization of the equation called out in the specification. It is usually applied very loosely, with each item of the equation not being fully satisfied. The Q.C. activity, however, expects quantitative accuracies to be obtained. The equipment operator must maintain the same standards by using the detector instrument to the letter of the procedure. It is certainly possible to get accurate leak rate numbers with proper care. The limits of range in which this accuracy exists is related to the device. A leak rate of 1×10^{-5} std. cm^3/sec. means that 0.00001 cm^3 of air will leak out of the part every second. If the leak is a single straight cylindrical hole, this is somewhat true. If it is a porosity of 100 each 1×10^{-7} std. cm^3/sec. holes, they are not 1 micron in diameter, but most likely very irregular and so small that they are likely to be liquid filled. (Perhaps from the final bubble test at the manufacturers plant.) Laboratory tests have demonstrated porosity leaks "sweating" fluorocarbon bubble fluids 6-12 months after the bubble test was performed. Another precautionary note is that the leak rates are sometimes reduced 1-3 orders of magnitude by immersion in liquid which "selectively" have ultra low helium solubility’s. Many fluids reduce the diffusion (transfer rate) of gases from seconds to 15-20 minutes. Under these circumstances it would be unusual to spend 15 minutes waiting for stability.

The radioisotope leak test method most used requires an inert gaseous isotope, Krypton-85, to be bombed or introduced into the hermetic part. This method is not applicable to two-sided systems except in special circumstances. When the isotope has entered the part, a leaker is sorted out by detecting the radiation emitted through the wall of a leaky part.

Different from helium, the concentration of radioactive gas in the part need not be known. A TO-5 canned device leaking at 1×10^{-7} std.cc/sec. has been bombed to introduce 10% helium or sealed with a known concentration inside. The part starts with 2.25×10^{19} molecules of air inside. To obtain 10% helium in the part requires the entry of 2.25×10^{18} molecules of helium. If the concentration of helium inside the part is only 5%, one order of magnitude error would result. Surface impregnation is detectable on parts by breaking one open and taking the resultant reading from both halves. The isotope has absorption problems also, but they are detected easily with Krypton-85. The gas inside is measured at a minimum detect ability of about 10^{11} molecules of Krypton-85 inside, through the wall.

A serious pitfall in both bombing methods exists with the equations used today since no distinction between molecular flow and viscous flow is applied. A 1×10^{-6} std. cm^3/sec. leak rate for Krypton-85 equals 1.7×10^{-6} std. cm^3/sec. of air equals 4.6×10^{-11} std. cm^3/sec. of helium; most fine leaks of these values are in the molecular flow region. Both methods are now being used for gross leak testing, but are only reliable on a go/no go basis with full understanding of the technique used.

The majority of applications of gaseous leak testing may seem related to the caveman's coconut test on a plus or minus order of magnitude basis; but commonly ±1/2 order for helium and ± 0.1 order for Krypton-85 are achievable.

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