

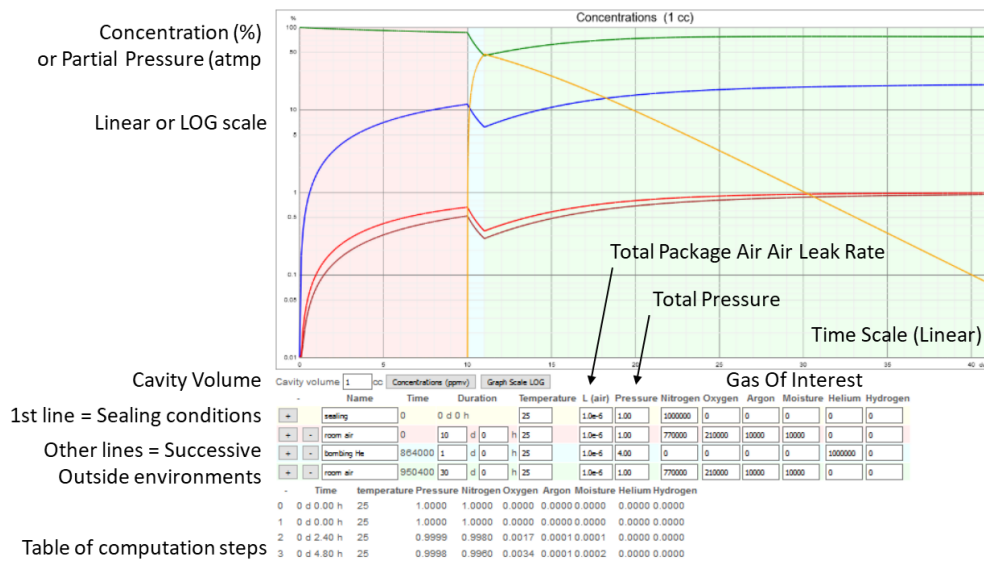
Gas Evolution Inside a Sealed Package, with a Leak --- A Web Page as Visualizing Tool ---

Very often, we try to explain the Gas Analysis results with gas exchanges, but the math computations are not intuitive. Our online tool (www.orsfr.com/leaks/gas-exchange.html) is meant to visualize the gas content of a sealed package, taking into account a leak with the exterior atmosphere.

The equations currently used in this tool are based on the Molecular Conductance of Gases for a Long Cylindrical Leak Path of Uniform Cross-Section. This is a first approach computation, with limitations, especially for large leak rates.

This tool was first presented at the Minnowbrook conference in October 2017.

Your feedbacks are very valuable, so don't hesitate to get back to us (info@orsfr.com) about comments, bugs, or suggestions.



Graph display options :

- The graph displays the various gases concentrations or partial pressures as a function of time. Each gas corresponds to a color. Total pressure is displayed in Black.
- Y scale can display either concentrations (Total always 100%, as in Gas Analyses) or partial pressures (in atmosphere).

Toggle display mode with button

- ATTENTION : make sure to be in "concentration" mode when you enter the individual gas values in the form. Partial pressure input might not work well right now...
- Y scale can be linear or LOG.

Toggle display mode with button

Information you can change :

- Package characteristics (cavity volume in cc, total air leak rate in atm-cc/s)
- 1st line : Sealing conditions (temperature in °C, total pressure, gas content as ppm).
REMINDER : There is an amount of Moisture at sealing time, which can be determined by gas analysis. Depending on package type, presence of polymerics, pre-seal bakes, and who knows what else, time zero internal moisture can be a lot higher than expected. Performing gas analysis on representative sample packages as soon as possible after seal gives a "time zero" moisture concentration to start modeling calculations.
- Other lines : Successive outside gaseous environments which the package will see. (temperature in °C, total pressure, gas content as ppm)
- Steps of outside environment can be added or removed
 - removes the current line ; + adds a step after the current line.
- ATTENTION : For a step to be taken into account, you need to specify the Duration, a total pressure (default is 1 atm) and gas concentrations which sum up to 1 000 000 ppm

Hints on form input :

- When entering a value, validate with the Enter key or change cell with the Tab key.
- Durations are presented in days + hours. For example, you can type 1.5 in the "day" column or 36 in the "hours" column, and you will get "1d 12h".
- Gas concentrations are displayed in ppm (10 000 ppm = 1%). You can input values in ppm directly (i.e. 15000) or type them as % with the "%" character at the end (i.e. 1.5%).
- Balance gas : The computation of the remaining concentration can be automated. Just enter an empty value in a gas cell and the complement to 100% will be computed. For example, for dry air, you can enter "20.95%" as Oxygen concentration, "9340" as Argon concentration, and "" as Nitrogen concentration. The display will change to 781160 ppm.
- Adding a gas to an existing gas mix (i.e. adding moisture to dry air) : You can prefix the gas concentration with a "+" sign, and the gas will be added to the current mixture. For example, if you entered dry air concentrations (781160 Nitrogen, 20950 Oxygen and 9340 Argon) and you type "+1%" for moisture, the end results will be 773348 Nitrogen, 207405 Oxygen, 9247 Argon (subtotal 99%), and 10000 Moisture (Known bugg : You might need to re-type the moisture value).
- To convert from Relative Humidity to ppmv of Moisture, you can use our conversion page www.orsfr.com/moisture_0.php
- Temperature indication is used to correct partial pressures based on perfect gas equation (Pressure · Volume / TemperatureKelvin = Constant). This effect is visible when looking at partial pressures. For example, using a sealing temperature of 100°C and then a temperature of 25°C will drop the total pressure from 1 atm to 0.8 atm.
- Partial pressure table is available at the bottom of the page. Each outside environment is split in a number of computation steps. This is the raw data used for the graph.
- Leak rate : When you change the value of the air leak rate, it gets copied to the steps below. You can also modify the leak rate of an intermediate step (i.e. to simulate the degradation of the package hermeticity).

Equations

Equation describing the Molecular Conductance of Gases for a Long Cylindrical Leak Path of Uniform Cross-Section (the Easy Case), as found in “Hermeticity Of Electronic Packages” by Hal Greenhouse :

$$P_2 = P_0 + (P_1 - P_0) \cdot e^{\frac{-T \cdot L \cdot \sqrt{\frac{M_{air}}{M_{gas}}}}{V}}$$

P : Partial pressure of the gas of interest

1 : start step 2 : end step O : outside (constant from 1 to 2) V : cavity volume

T : duration from 1 to 2 M : Molecular Weight L : Total Air Leak Rate

Interestingly, the Howell-Mann Equation used in Helium Fine Leak Tests and described in Mil-Std-883, Test Method 1014 and Mil-Std-750, Test Method 1071 is also based on Molecular Conductance of Gases.

$$R_1 = \frac{\sqrt{\frac{M_a}{M}} \cdot L \cdot P_e}{P_o} \cdot \left[1 - e^{-\frac{\sqrt{\frac{M_a}{M}} \cdot L}{P_o \cdot V} \cdot t_1} \right] \cdot e^{-\frac{\sqrt{\frac{M_a}{M}} \cdot L}{P_o \cdot V} \cdot t_2}$$

L : equivalent standard leak rate (atm·cc/s Air)

V : internal volume of the device package cavity (cc)

P_o : atmospheric pressure (atm absolute)

P_e : pressure of exposure (atm absolute)

t₁ : time of exposure to P_e (seconds)

t₂ : dwell time between release of pressure and leak detection (seconds)

R₁ : measured leak rate of tracer gas (atm·cc/s of Tracer Gas)

Computations with the above equation vs Howell-Mann is very good, and will be shown in a future revision of this document.

Presented by : Paul Roustan

Code by : Damien Revol