Diffusion of Gases

Diffusion is the phenomenon of the dispersion of one gas into another. Diffusion happens also with liquids, but in leak detection only the diffusion of gases is important. Under equal conditions, light gases diffuse faster than heavier gases. That is, the diffusion of gases is inversely proportional to their relative molecular mass. The diffusion law, also known as Graham's Law, is:

$$\frac{D_1}{D_2} = \frac{M_2}{M_1}$$

Where D is the diffusion coefficient and M is the molecular mass.
In the Annex at right, the diffusion coefficient for the most commonly-used gases is shown.

Diffusion Coefficient

Gas	Diffusion coefficient (mm^2/s)
Nitrogen	17.5
Oxygen	17.5
Argon	14.7
Hydrogen	67.1
Helium	69.7
Water vapor	21.9
Carbon dioxide	13.4

The diffusion of one gas into another at atmospheric pressure is relatively slow, so in order to increase the speed of diffusion, a lowering of the pressure inside the test unit, through the process of vacuum, is necessary. If this air is not removed, such as in the case of a coil with long tubes with closed ends, the tracer gas cannot bypass the air remaining in the end of the tube. This air cushion can remain there for some time, before it is finally mixed with the other gases by diffusion. Therefore, a leak at this end of the tube may not be detected by the sensor, which is only sensitive to the tracer gas.

To avoid this problem, test objects should be evacuated prior to filling with tracer gas. Diffusion speed increases with decreasing pressure since at low pressure the mean free path increases and, therefore, the collisions among gas particles decrease. In order to thoroughly and evenly distribute the tracer gas, a rough evacuation down to a pressure of 75 to 375 microns (.075 to .375 torr) is sufficient.