Derivation of Pressure loss to Leak Rate Formula from the Ideal Gas Law

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Ideal Gas Law PV = nRT

P (pressure) V (volume) n (number of moles of gas) T (temperature) R(constant)

After **t** seconds, if the leak rate is **L.R (volume of gas that escapes per second)**, the moles of gas lost from the test volume will be:

$$N_{lost} = \frac{L.R.\ (t)\ P_{atm}}{RT}$$

And the moles remaining in the volume will be:

$$n' = n - N_l = \frac{PV}{RT} - \frac{L.R.\ (t)\ P_{atm}}{RT}$$

Assuming a constant temperature, the pressure after time (t) is:

$$P' = \frac{n'\,RT}{V} = \left\{ \frac{\frac{PV}{RT} - \frac{L.R.\ (t)\ P_{atm}}{RT}}{V} \right\} RT = P - \frac{L.R.\ (t)\ P_{atm}}{V}$$

$$dP_{Leak} = P - P' = \frac{L.R.\ (t)\ P_{atm}}{V}$$

Solving for **L.R.** yields:

$$\mathbf{L.R.} = \frac{\mathbf{V}\ \mathbf{dP_{Leak}}}{\mathbf{t}\ \mathbf{P_{atm}}}$$

The test volume, temperature, and P_{atm} are considered constants under test conditions. The leak rate is calculated for the volume of gas (measured under standard atmospheric conditions) per time that escapes from the part. Standard atmospheric conditions (i.e. 14.696 psi, 20 C) are defined within the Non-Destructive Testing Handbook, Second Edition, Volume One Leak Testing, by the American Society of Nondestructive Testing.

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Because most testing is performed without adequate fill and stabilization time to allow for all the dynamic, exponential effects of temperature, volume change, and virtual leaks produced by the testing process to completely stop, there will be a small and fairly consistent pressure loss associated with a non-leaking master part. To correct the calculation for the consistent temperature, volume, and /or virtual leak changes that occur during the test cycle, there is a "tare" factor that offsets the pressure loss measurement. This "tare" factor is called the "No Leak Loss" value or the pressure loss that occurs during the test time "t" for a Master-No-Leak-Part. This "tare" factor is determined during the calibration process that also establishes the part and test system volume (V) for the test. The equation that considers the "tare" factor is:

$$L.R_{sccs.} = \frac{V \times (dP_{meas} - dP_{no\text{-}leak})}{t \times P_{atm}}$$

The units of measurement are:

$\mathbf{LR_{sccs}}$	Leak rate (in scc/s)
V	Volume (in cubic centimeters)
t	Test time (in seconds)
$\mathbf{dP_{meas}}$	Pressure loss measured during test cycle (in psi or other pressure units)
$\mathbf{dP_{No\text{-}Leak}}$	Pressure loss for a non-leaking part measured during test cycle (in psi or other pressure units)
$\mathbf{P_{atm}}$	Standard atmospheric pressure (in psi or other pressure units)

All three pressure units must be the same.

Pressure decay usually states leak rates as scc/m (standard cubic centimeter per minute).

For **LR** leak rate (in scc/m), the formula above is converted to:

$$L.R_{sccm} = \frac{V \times (dP_{meas} - dP_{no\text{-}leak}) \times 60\ sec/min}{t \times P_{atm}}$$