VACUUM LEAK DETECTION

LACO TECHNOLOGIES

FILTRATION INDUSTRIAL

TECHNICAL REFERENCE GUIDE

Leak Rate Conversions

Convert From	Multiply By	Convert To
atm-cc/sec	1.013	mbar-liter/sec
atm-cc/sec	0.76	torr-liter/sec
torr-liter/sec	1.33	mbar-liter/sec
Pa-M^3/sec	9.87	atm-cc/sec
Air oz/yr	6.96×10^{-4}	atm-cc/sec

Comparison of Leak Detection Methods

Method	Minimum Detectable Leak (atm-cc/sec)	Leak Rate Measurement	Leak Location
Pressure Decay	Time Limited, Typically 0.01	Yes	No
Ultrasonic	0.01	No	Yes
Chemical Penetrants	0.001	No	Yes
Bubble Immersion	10^{-4}	No	Yes
Thermal Conductivity Sniffing	10^{-5}	Yes	Yes
Halogen Sniffing	10^{-9}	Yes	Yes
Helium Mass Spectrometer	10^{-11}	Yes	Yes

Equivalent Leak Rates

Freon R12 Leakage (oz/year)	Bubble Immersion (Time to form 1 bubble)	Helium Leak Rate (atm-cc/sec)	Air Leak Rate* (atm-cc/sec)
10.00	13.3 seconds	1.8×10^{-3}	6.7×10^{-4}
3.00	44.3 seconds	1.5×10^{-3}	2.0×10^{-4}
1.00	133 seconds	1.8×10^{-4}	6.7×10^{-5}
0.50	266 seconds	9.0×10^{-5}	3.3×10^{-5}
0.10	22.2 minutes	1.8×10^{-5}	6.7×10^{-6}
0.01	222 minutes	1.8×10^{-6}	6.7×10^{-7}

NOTE: Leak rates are approximate and based on similar test conditions.
* Leak rates calculated based on molecular flow.

Viscous vs. Molecular Flow Leaks

The flow regime encountered in leak testing is often difficult to determine. It can, however, be estimated by calculating the average mean free path of the gas molecule (l) divided by the estimated leak path diameter (d). Use the following guidelines to determine the flow regime:

VISCOUS FLOW leaks typically occur in systems leaking at atmosphere or larger pressures (l/d < 0.01). Viscous leaks are typically larger than 10^{-5} atm-cc/sec, but can occur at lower leak rates.
MOLECULAR FLOW leaks typically occur under vacuum conditions (l/d > 1.00). Molecular leaks are typically smaller than 10-5 atm-cc/sec.
TRANSITIONAL FLOW occurs between viscous and molecular flow regimes (0.01 < l/d > 1.00).

Leak Rate vs. Pressure

Viscous Flow: $Q_V = K/n\,(P_1^2 - P_2^2)$

Molecular Flow: $Q_M = K(T/M)^{1/2}\,(P_1 - P_2)$

Where: Q = Leak Rate
K = Constant relating leak path geometry
n = Gas Viscosity
M = Gas Molecular Weight
T = Absolute Temperature
$P_{1,2}$= Upstream and Downstream Absolute Pressure

Example: A helium leak in the viscous flow regime with 10 atm upstream (internal) and 1 atm downstream pressure has a leak rate of 0.001 atm-cc/sec. If the upstream pressure was doubled to 20 atm the new leak rate would be:

$$Q_{V,NEW} = Q_{V,OLD}\,((P_{1,NEW}^2 - P_{2,NEW}^2)/(P_{1,OLD}^2 - P_{2,OLD}^2))$$

$$Q_{V,NEW} = 0.001((20^2 - 1^2)/(10^2 - 1^2)) = 0.004 \text{ atm-cc/sec}$$

Using the table below the equivalent leak rate for air under the same conditions is:

$$Q_{V,AIR} = 0.004(1.08) = 0.0043$$

Helium Leak Rate vs. Other Gases

To Convert To	Multiply Helium Leak Rate By Viscous Flow	Molecular Flow
Argon	0.883	0.316
Neon	0.626	0.447
Hydrogen	2.23	1.41
Nitrogen	1.12	0.374
Air	1.08	0.374
Water Vapor	2.09	0.469