LACO TECHNOLOGIES

TECHNICAL REFERENCE GUIDE

LEAK TESTING

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 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-M3/sec	9.87	atm-cc/sec
Air oz/yr	6.96×10^{-4}	atm-cc/sec

COMPARISON OF LEAK DETECTION METHODS

METHOD	MIN. DETECTABLE LEAK*	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

*atm-cc/sec

EQUIVALENT LEAK RATES

FREON R12 LEAKAGE (OZ/YEAR)	IMMERSION (TIME TO FORM 1 BUBBLE)	HELIUM LEAK RATE (ATM-CC/SEC)	BUBBLE 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.

HELIUM LEAK RATE VS. OTHER GASES

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

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 atmupstream (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 above the equivalent leak rate for air under the same conditions is: $Q_{V,AIR} = 0.004(1.08) = 0.0043$

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VACUUM TECHNOLOGY

VACUUM /PRESSURE

TO CONVERT FROM	PASCAL	TORR	ATM	MBAR	MICRON	PSIA	IN. HG	
PASCAL	1	$7.5x10^{-3}$	$9.87x10^{-6}$	0.01	7.5	$1.45x10^{-4}$	$2.95x10^{-4}$	
TORR	133	1	$1.315x10^{-3}$	1.333	1000	0.01934	0.0394	
ATMOSPHERE	$1.013x10^{5}$	760	1	1013	$7.6x10^{5}$	14.7	29.92	Standard Atmospheric
MILLIBAR (MBAR)	100	0.75	$9.87x10^{-4}$	1	750.1	0.0145	0.0295	
MICRON	0.1333	0.001	$1.316x10^{-6}$	$1.333x10^{-3}$	1	$1.934x10^{-5}$	$3.94x10^{-5}$	
PSIA	$6.89x10^{3}$	51.71	0.068	68.9	$5.17x10^{4}$	1	2.036	
IN. HG ABS	$3.39x10^{3}$	25.4	0.03342	33.9	$2.54x10^{4}$	0.4912	1	

CFM - SCFM - ACFM

TERM	DEFINITION
CFM	Cubic feet per minute, displacement of pump chamber at 100% efficiency
SCFM	Standard cubic feet per minute, mass flow of air at standard conditions
ACFM	Actual cubic feet per minute, volumetric flow of gas that has been expanded

$ACFM = SCFM \times \frac{760}{P}$ P = pressure in Torr

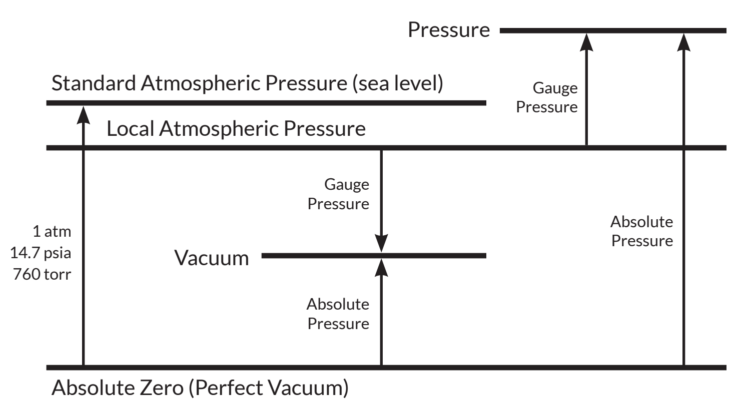
PUMPING SPEED/LEAK RATE

FROM	MULTIPLY BY PUMP SPEED	TO
ft^3/min	1.697	m^3/hr
m^3/hr	0.589	ft^3/min
liters/sec	3.6	m^3/hr
liters/sec	2.12	ft^3/min
FROM	**MULTIPLY BY LEAK RATE**	**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

ELEVATION VS. VACUUM

ELEVATION (FT.)	MAX. RELATIVE VACUUM (IN. HG)	PERCENT LOSS
0 (sea level)	29.92	0
1,000	28.85	3.6%
2,000	27.82	7.0%
3,000	26.82	10.4%
4,000	25.84	13.6%
5,000	24.89	16.8%
6,000	23.98	19.9%
7,000	23.06	22.9%
8,000	22.20	25.7%
9,000	21.38	28.5%
10,000	20.58	31.2%

ABSOLUTE VS. RELATIVE PRESSURE



3085 West Directors Row, Salt Lake City, UT 84104 | Phone: 801-486-1004 Fax: 801-486-1007 | info@lacotech.com www.lacotech.com