Leak Rate Units

sccm, ccm, accm

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Difference between sccm, ccm, and accm in leak measurement

The leak test industry in the U.S. has standardized on stating leak rates in units of "scc/m" or "scc/s" (atm cc/s) – standard cubic centimeters per minute or second. European industry uses "Pa-m^3/s" or "mbar-l/s." These are the SI gas leakage rate units defined in the Nondestructive Testing Handbook, Second Edition. These measurement units refer to the volume of gas leaking from the product in terms of standard conditions. Standard is referenced as 101.325 kPa (14.696 psia) and 293 K (20 C) in the "Handbook." From the "Handbook," "Expressing leakage rates in the SI units of Pa m^3/s (i.e. at standard conditions) provides a leakage rate valid at any pressure." [1] The reason that standard units are used in science is to eliminate ambiguity in reporting results and defining specifications.

Because the world uses these SI units like "scc/m" or "scc/s" as the standard units for measuring leak rates, it is occasionally shortened to "cc/m" assuming "scc/m." Recently some companies are now stating their leak rates in "cc/m" but meaning "acc/m," actual cubic centimeters per minute (which is volume of flow at the measurement pressure.) The use of "cc/m" is now confusing. It is like stating "psi" verses "psig" or "psia" or "psiv." "cc/m" does not define the conditions under which the volumetric flow is measured. At first glance "cc/m" is assumed to be the same measurement as "scc/m," but depending on the test pressure there is a significant difference between "cc/m" when it means "acc/m" verses "scc/m."

What is the relationship of "standard" cubic centimeter per minute (scc/m) to "actual" cubic centimeters per minute (acc/m)? "acc/m" defines the volume of air at the unique test pressure and temperature at the point of measurement. Standard cubic centimeters per minute defines the volume of air corrected to a standard pressure and temperature. Because air is a compressible fluid, there is a difference between "scc/m" and "acc/m" proportional to the relationship of absolute working (or test pressure) and standard pressure. Based on the Ideal Gas Law, the relationship is defined as:

$$(P_{atm}) \times (V_{atm}/\text{time}) = (P_{working}) \times (V_{working}/\text{time})$$

$$(P_{atm}) \times (LR_{scc/m}) = (P_{working}) \times (LR_{acc/m})$$

$$LR_{scc/m} = (P_{working}) / (P_{atm}) \times (LR_{acc/m})$$

Pressure is stated as absolute pressure (psia = psig + 14.7 psia)

1 Nondestructive Testing Handbook, Second Edition, Volume One Leak Testing, American Society of Nondestructive Testing, (American Society of Metals, 1982) xiv

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For example when testing at 150 psig, what is the difference between “scc/m” and “acc/m” (or “cc/m”)?

$LR_{scc/m} = \{(150 + 14.7 \text{ psia}) / (14.7 \text{ psia})\} \text{x } LR_{acc/m}$

$LR_{scc/m} = (164.7 \text{ psia}/14.7 \text{ psia}) \text{ x } LR_{acc/m}$

$LR_{scc/m} = 11.2 \text{ x } LR_{acc/m}$

So for a 150 psig test, the instrument displaying “scc/m” will show a leak rate that is 11.2 times greater than the leak rate displayed on an “acc/m” instrument. For the example above, 1.0 scc/m is the same leak rate as 0.089 acc/m at 150 psig. This discrepancy makes it look like an actual condition meter is performing a more sensitive test or finding a smaller leak, but it really is not.

For lower pressure tests, the difference is less dramatic. For example, a test at 20 psig would appear as follows.

$LR_{scc/m} = \{(20 \text{ psig} + 14.7 \text{ psia})/(14.7 \text{ psia})\} * LR_{acc/m}$

$LR_{scc/m} = 2.36 * LR_{acc/m}$

So a 1 scc/m leak rate would look like 0.42 acc/m at 20 psig on an actual “cc/m” instrument.

For an application where the leak rate is stated as “cc/m,” check to make sure under what conditions this volumetric flow is being stated, actual (at the test pressure) or standard (at standard atmospheric conditions which is 14.696 psia). There is some variation in standard conditions because temperature is part of the conditions. The “Handbook” states the reference temperature as 293 K (20 C). For some other scientific situations 0 C and 22 C are referenced as standard temperatures.

Standard conditions are the preferred units of measurement because they are universally applied by all flow measurement industries. It relates the measured gas flow to the volume of gas leaking from a part into atmospheric conditions. It is easy to relate when one part is leaking more than another. Therefore a 2 scc/m leak rate tested at 10 psig will show more bubbles leaking from a part than a 1 scc/m leak rate tested at 50 psig. Conversely, a 2 acc/m leak rate at 10 psig will show fewer bubbles leaking from a part than a 1 acc/m leak rate tested at 50 psig. When using “scc/m” no matter what the test pressure, the same number of bubbles will result from a 1 scc/m leak.

Pressure decay tests are usually calibrated using a leak standard with a certified flow at standard conditions. During the calibration procedure the instrument determines the pressure loss to standard leak rate relationship for the test part within the manufacturing plant conditions. Mass flow leak test instruments use a variety of flow meters and calibration methods. Thermal mass flow meters are traditionally calibrated to standard flow conditions. Laminar flow meters measure flow at working (test) conditions and then must correct for temperature and pressure to display standard conditions. Mass flow leak test systems using reference volumes must be calibrated to a leak standard to determine the volumetric relationship between the part and the reference volume. Systems that use a constant pressure sources do not require calibration to a leak standard.

CONVERSION OF SCCM AND ACCM UNITS

Test Pressure	Absolute Pressure psia	Multipliers to convert from accm at a test pressure to sccm	Multipliers to convert from sccm to accm at a Test pressure
		Abs. Test Press. / 14.7 psia	**14.7 psia / Abs. Test Press.**
1 Torr	0.0193	0.0013	761.6580
14 psiv	0.7	0.0476	21.0000
10 psiv	4.7	0.3197	3.1277
5 psiv	9.7	0.6599	1.5155
4 psiv	10.7	0.7279	1.3738
3 psiv	11.7	0.7959	1.2564
2 psiv	12.7	0.8639	1.1575
1 psiv	13.7	0.9320	1.0730
0 psig	14.7	1.0000	1.0000
1 psig	15.7	1.0680	0.9363
2 psig	16.7	1.1361	0.8802
5 psig	19.7	1.3401	0.7462
10 psig	24.7	1.6803	0.5951
20 psig	34.7	2.3605	0.4236
30 psig	44.7	3.0408	0.3289
40 psig	54.7	3.7211	0.2687
50 psig	64.7	4.4014	0.2272
60 psig	74.7	5.0816	0.1968
70 psig	84.7	5.7619	0.1736
80 psig	94.7	6.4422	0.1552
90 psig	104.7	7.1224	0.1404
100 psig	114.7	7.8027	0.1282
120 psig	134.7	9.1633	0.1091
150 psig	164.7	11.2041	0.0893
180 psig	194.7	13.2449	0.0755
200 psig	214.7	14.6054	0.0685

Multiple leak rate by the multiplier factor to determine leak rate under opposing conditions