

Carbon Monoxide (CO) measured from a single cigar and a single cigarette in a large living room.
 The air exchange rate was 1.24 ach; the residence time was 50 minutes.
 (Background levels masked the decay of the cigarette's CO; particles were not masked, see insert)

A Practical Guide to Measuring Air Exchanges

Bear Facts -- #79

Prior Bear Facts show data gathered to observe ventilation and the mathematical logic outlining the derivation of air exchange measurements. Here are the exact steps used to identify this parameter from your measurements.



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the DataBear

Bear Facts are published to provide useful insights into the operation and applications for the DataBear™ Measurer and associated complete instruments.

Often technologists make observations that, to them, become self-evident. Their day-to-day usage assumes familiarity with the calculations or analytical programs or routines that make derivation matter-of-fact. Too often, those who might benefit from this end result, while quite competent, are not fluent in the transition to the end result. Thus, a technique passes unused. Here is a step-by-step way to measure air exchange in an indoor space to make the task easier to understand.

Knowledge of a space's ventilation-- the frequency of air replacement, the air exchange rate, air changes per hour ('ach')-- can be very helpful in understanding the potential of indoor pollution. It can also be helpful in determining the efficiency of air conditioning. As discussed in earlier Bear Facts (#74, December 1996, and #77, March 1997) the observance of the decay of carbon monoxide (CO) in any space contains the data. Here is how to get this number, the 'ach' (which may be thought of as changes of total 'air volumes' of the selected space per hour).

Given a source of CO, when it stops, the resulting measurements dissipate over time. How long this takes is determined by the ventilation of the space. As previously shown in the mathematical derivation, the natural log plot of this decay forms a straight line, the slope of which is the 'ach'! The inverse of the slope is the 'residence time' of a single volume of air within the selected space. Stated another way, the slope of the natural log, $m = \text{vertical value}/\text{horizontal value}$. Vertical value is measured in 'volumes' of the selected space. Horizontal value is residence time.

Thus, if such a plot is created (in Microsoft Excel®, for example, or even by hand), the residence time is shown as the time between logarithmic intervals.

Regression Statistics
Multiple R 0.97204651
R Square 0.94487442
Adjusted R Square 0.9446227
Standard Error 0.07893083
Observations 221

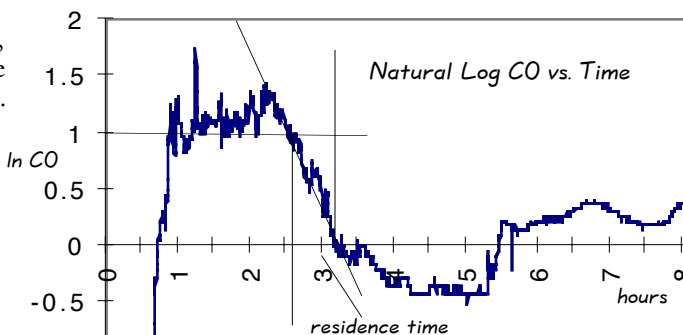
ANOVA

df
Regression 1
Residual 219
Total 220

Coefficients

Intercept 4.11226361

X Variable 1 -1.2237624 = the slope. Equivalent to $1/1.22 = 49$ minutes residence

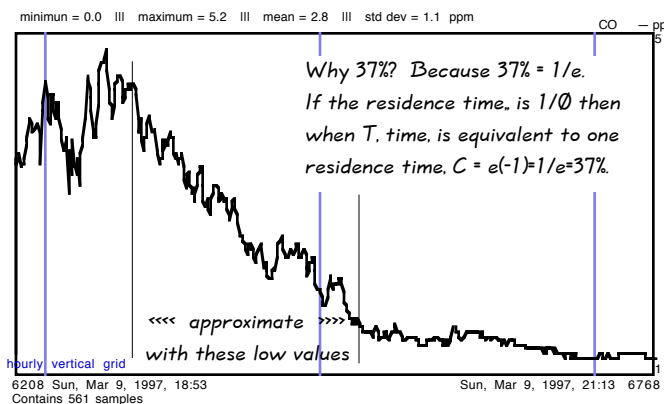


<<< To do this: 1) export the data retrieved into a text file; import this into Excel. You will have date, time and CO columns. 2) Ignore the date. Convert the time into incremental hourly values. Convert the CO into 'ln(CO, ppm, minus background CO, ppm). 3) Use the new time column as the 'x' factor and the natural log CO column as the 'y' factor in the regression dialog.

When one uses the 'regression' data analysis capability from Excel*, a full regression analysis is created on a separate 'sheet', with a summary as shown above. The 'R Square' result shows how well the straight line decay compares to a perfect line (1.00 is perfect, >0.9 is adequate.) The 'X Variable 1', a negative value, is the slope, the ach. $1/\text{ach}$ is the residence time.

Given only a plot of the data, in the Langan software for example (shown is the expanded 'Probe' View), the residence time during the exponential decay is that which is 37% of its initial value. In this example, from the time the source ceased, the value is 4.2 ppm, 37% is 1.55 ppm. The time it takes to decay from 5.2 to 1.6 ppm is the residence time. Divide this into one to get the air exchange rate in ach.

All three methods will agree, given the vagaries of nature!



* it may be necessary to add this capability; see the Window/Add Functions dialog.

Langan CO Instruments provide a very simple way to measure ambient air quality. Using the retrieval and display software, graphics can be copied for immediate use. These can be scaled, skewed and/or combined to tell about the results. The combined capabilities of easy gathering, retrieval and communication are efficient and valuable.