Explanation of Blower Door Terms and Results

Information taken from "TECTITE BUILDING AIRTIGHTNESS TEST" by The Energy Conservatory

AIRFLOW AT 50 PASCALS

CFM50: This is the airflow (in Cubic Feet per Minute) needed to create a change in building pressure of 50 Pascals. CFM50 is the most commonly used measure of building airtightness.

ACH at 50 Pa: The Air Changes per Hour (ACH at 50 Pa) is another commonly used measure of building airtightness. ACH at 50 Pa is the number of complete air changes that will occur in one hour with a 50 Pascal pressure being applied uniformly across the building envelope. ACH at 50 Pa is a useful method of adjusting (or normalizing) the leakage rate by the size (volume) of the building. If you did not enter the building volume on the Building Information screen, ACH50 will not be calculated.

ACH at 50 Pa = (CFM50 x 60) / building volume in cubic feet

CFM50/square foot of floor area: This is the CFM50 reading for the building divided by the floor area of the building. CFM50/square foot adjusts (or normalizes) the leakage rate by the size (floor area) of the building. If you did not enter the floor area on the Building Information screen, this variable will not be calculated.

CFM50/square foot = CFM50 / floor area in square feet

CFM50/square foot of surface area (MLR): Also known as the Minneapolis Leakage Ratio (MLR), this is the measured CFM50 divided by the above grade surface area of the building. MLR is a useful method of adjusting (or normalizing) the leakage rate by the amount of envelope surface through which air leakage can occur. The MLR has been particularly useful for weatherization crews working on wood frame buildings. Experience to date has shown that for buildings with a MLR above 1.0, very large cost-effective reductions in infiltration can often be achieved using blower door guided infiltration and insulation techniques. In buildings with a calculated MLR in the 0.5 to 1.0 range, it is often more difficult to achieve economical improvements in airtightness. If you did not enter an Above Grade Surface Area value into the Building Information screen, MLR will not be calculated.

MLR = CFM50 / above grade surface area in square feet

LEAKAGE AREAS

Once the leakage rate for the building has been measured, it is useful to estimate the cumulative size (in square inches) of all leaks or holes in the building's air barrier. The estimated leakage areas not only provide us with a way to visualize the physical size of the measured holes in the building, but they are also used in infiltration models to estimate the building's natural air change rate (i.e. the air change rate under natural weather conditions).

The results screen includes two leakage area calculations, based on differing assumptions about the physical shape of the hole, which are compatible with the two most commonly used infiltration models.

Equivalent Leakage Area (EqLA):EqLA is defined by Canadian researchers at the Canadian National Research Council as the area of a sharp edged orifice (a sharp round hole cut in a thin plate) that would leak the same amount of air as the building does at a pressure of 10 Pascals. The EqLA is used in the AIM infiltration model (which is used in the HOT2000 simulation program).

Effective Leakage Area (ELA): ELA was developed by Lawrence Berkeley Laboratory (LBL) and is used in their infiltration model. The Effective Leakage Area is defined as the area of a special nozzle-shaped hole (similar to the inlet of your Blower Door fan) that would leak the same amount of air as the building does at a pressure of 4 Pascals.

Notes on Leakage Areas: When using leakage area calculations to demonstrate physical changes in building airtightness, we recommend using the EqLA measurement. Typically, EqLA more closely approximates physical changes in building airtightness.

For example, if you performed a Blower Door test, and then opened a window to create a 50 square inch hole and repeated the test, the estimated EqLA for the building will have increased by approximately 50 square inches from the initial test results.

BUILDING LEAKAGE CURVE

Coefficient (C) and Exponent (n):Once an automated airtightness test sequence (or manual entry of data into the table) has been completed, a best-fit line (called the Building Leakage Curve) is drawn through the collected Blower Door data. The Building Leakage Curve can be used to estimate the leakage rate of the building at any pressure. If you conduct a single point test (i.e. input a single target pressure into the custom pressure list), the program assumes an exponent (n) of 0.65 in its calculation procedures.

The Building Leakage Curve is defined by the variables Coefficient (C) and Exponent (n) in the following equation:

$$Q = C \times P^n$$

where: Q is airflow into the building (in CFM).

C is the Coefficient.
P is the pressure difference between inside and outside of the building.
n is the Exponent.

Example: Use the Building Leakage Curve to estimate the exhaust fan airflow in a building needed to create a 5 Pa negative pressure. From our Blower Door test we determined the following Building Leakage Curve variables.

C = 110.2 n = 0.702 From the equation above:

Airflow (at 5 Pa) = 110.2 x 5^.702 = 341 CFM. In other words, we estimate from the Building Leakage Curve that it would take exhaust fans with a combined capacity of 340 CFM to cause a 5 Pa pressure change in this building.

Correlation Coefficient: The correlation coefficient is a measure of how well the collected Blower Door data fit onto the best-fit Building Leakage Curve. The closer all data points are to being exactly on the Building Leakage Curve, the larger the calculated correlation coefficient (note: the largest possible value for the correlation coefficient is 1.0). Under most operating conditions, the correlation coefficient will be at least 0.99 or higher.

Testing in very windy weather can sometimes cause the correlation coefficient to be less than 0.99. In this case, you may want to repeat the test, or increase the number of Samples Per Station. Achieving a correlation coefficient of 0.99 or higher is particularly important in the estimation of Leakage Areas, or when using the Building Leakage Curve to estimate leakage rates at low building pressures.

ESTIMATED ANNUAL INFILTRATION

Estimating the natural infiltration rate of a building is an important step in evaluating indoor air quality and the possible need for mechanical ventilation. Blower Doors do not directly measure the natural infiltration rates of buildings. Rather, they measure the building leakage rate at pressures significantly greater than those normally generated by natural forces (i.e. wind and stack effect). Blower Door measurements are taken at higher pressures because these measurements are highly repeatable and are less subject to large variations due to changes in wind speed and direction.

In essence, a Blower Door test measures the cumulative hole size, or leakage area, in the building's air barrier (see Leakage Areas above). From this measurement of leakage area, estimates of natural infiltration rates can be made using mathematical infiltration models. TECTITE uses the calculation procedure contained in ASHRAE Standard 136-1993 to estimate the average annual natural infiltration rate of the building.

CFM, ACH and CFM/person: The estimated annual natural infiltration rate (based on ASHRAE Standard 136-1993) is expressed in Cubic Feet per Minute (CFM), Air Changes Per Hour (ACH), and CFM per person. When determining occupancy for the CFM/person calculation, the program uses the number of bedrooms plus one, or the number occupants, whichever is greater.

Notes on Estimated Infiltration Rates: Daily and seasonal naturally occurring air change rates will vary dramatically from the estimated average annual rate calculated here due to daily changes in weather conditions(i.e. wind and outside temperature).

The physical location of holes in the building air barrier compared to the assumptions used in the infiltration model will cause actual annual infiltration rates to vary from the estimated values. Research done in the Pacific Northwest on a large sample of houses suggests that estimated infiltration rates for an individual house (based on a Blower Door test) may vary by as much as a factor of two when compared to measured infiltration rates using PFT tracer gas. (PFT tracer gas tests are one of the most accurate methods of measuring actual natural infiltration rates). The annual average infiltration estimates from ASHRAE Standard 136-1993 should be used only for evaluating detached single-family dwellings, and are not appropriate for use in estimating peak pollutant levels or energy loss due to infiltration. If any of the building leakage is located in the forced air distribution system, actual air leakage rates may be much greater than the estimates provided here. Duct leaks result in much greater air leakage because they are subjected to much higher pressures than typical building leaks.

ESTIMATED DESIGN INFILTRATION

In addition to estimating an annual infiltration rate above, the program estimates the design winter and summer infiltration rates for the building. The design infiltration rates are the infiltration rates used to calculate winter and summer peak loads for purposes of sizing heating and cooling equipment. The calculated design infiltration rates can be used in ACCA Manual J load calculations in lieu of the estimation procedures listed in Manual J. The estimation procedure uses the design wind speed and temperature difference values input into the Climate Information Screen, and are based on the calculation procedures listed in the ASHRAE Fundamentals Handbook, Chapter on Infiltration and Ventilation.

Winter and Summer: CFM, ACH: The estimated design infiltration rates are expressed in Cubic Feet per Minute (CFM), and Air Changes per Hour (ACH).

MECHANICAL VENTILATION GUIDELINE

It is possible (even easy) to increase the airtightness of a building to the point where natural air change rates (from air leakage) may not provide adequate ventilation to maintain acceptable indoor air quality. To help evaluate the need for mechanical ventilation in buildings, national ventilation guidelines have been established by ASHRAE. The recommended whole building mechanical ventilation rate presented in this version of TECTITE is based on ASHRAE Standard 62-2003, and is only appropriate for low-rise residential structures.

Recommended Whole Building Mechanical Ventilation Rate: This value is the recommended whole building ventilation rate to be supplied on a continuous basis using a mechanical ventilation system. The recommended mechanical ventilation rate is based on 7.5 CFM per person (or number of bedrooms plus one, whichever is greater), plus 1 CFM per 100 square feet of floor area. This guideline assumes that in addition to the mechanical ventilation, natural infiltration is providing 2 CFM per 100 square feet of floor area.

For buildings where the estimated annual natural infiltration rate (based on the Blower Door test) is greater than 2 CFM per 100 square feet of floor area, the recommended mechanical ventilation rate is reduced to provide ventilation credit for excess infiltration. In these cases, the recommended mechanical ventilation rate is reduced by the following amount:

0.5 x (est. annual natural infiltration rate (CFM) minus 0.02 CFM x sq. ft. of floor area)

Notes on the Ventilation Guideline: ASHRAE Standard 62.2-2003 also contains requirements for local kitchen and bathroom mechanical exhaust systems. These local exhaust systems may be incorporated into a whole building ventilation strategy. Consult Standard 62.2-2003 for more information on ventilation strategies and specific requirements and exceptions contained in the Standard.

Compliance with the ventilation guideline does not guarantee that a moisture or indoor air quality (IAQ) problem will not develop. Many factors contribute to indoor air quality including ventilation rates, sources and locations of pollutants, and occupant behavior. Additional testing (including combustion safety testing) is needed to fully evaluate air quality in buildings. In many cases, a combination of pollutant source control and mechanical ventilation will be required in order to ensure adequate indoor air quality.

Previous versions of TECTITE used ASHRAE Standard 62-1989 to determine an annual ventilation guideline. The Standard 62-1989 guideline (which was superceded by Standard 62.2-2003) was based on 15 CFM per person or 0.35 Air Changes per Hour (whichever was greater).

ESTIMATED COST OF AIR LEAKAGE

The program estimates the annual cost associated with air leakage, both for heating and cooling. Because these cost estimates are based on estimated infiltration rates and many other assumptions, actual cooling costs may differ significantly from the estimates. The equations used to calculate the annual cost for air leakage are:

$$\text{Annual Heating Cost} = \frac{26 \times HDD \times \text{Fuel Price} \times CFM50}{N \times \text{Seasonal Efficiency}} \times 0.6$$

- HDD is the annual base 65 F heating degree-days for the building location.
- The Fuel Price is the cost of fuel in dollars per Btu.
- N is the Energy Climate Factor from the Climate Information Screen (adjusted for wind shielding and building height). See Appendix E of the Model 3 Blower Door Operation Manual for more information on this calculation procedure.
- Seasonal Efficiency is the AFUE rating of the heating system.

$$\text{Annual Cooling Cost} = \frac{.026 \times CDD \times \text{Fuel Price} \times CFM50}{N \times SEER}$$

- CDD is the base 70 F cooling degree days for the building location.
- The Fuel Price is the cost of electricity in dollars per kwh.
- N is the Energy Climate Factor from the Climate Screen (adjusted for wind shielding and building height). See Appendix E of the Model 3 Blower Door Operation Manual for more information on this calculation procedure.
- SEER is the SEER rating for the air conditioner.

Note: The Cooling Cost procedure does not include latent loads. In humid climates, latent loads due to air leakage can be greater than the sensible loads, which are estimated by this procedure.