U.S.A.C.E. BUILDING ENVELOPE AIR LEAKAGE TESTING – A SIMPLIFIED EXPLAINATION

Simply put we either exhaust air from the building (a depressurization test), and/or blow air into the building (a pressurization test) to change the indoor/outdoor pressure differences. As we are doing this we measure the volumes of air we are exhausting or supplying and the resultant indoor/outdoor pressure differences. From these data points we can calculate many things but the one we are most interested in is the volume of air leaking through the building envelope, commonly called the air barrier, at an indoor/outdoor pressure difference of 75 Pascals (0.3 in. w.g.).

The Army Corps of Engineers requires most buildings such as barracks, dining facilities, company operations facilities and the like to have a leakage rate of no more than 0.25 cfm/sq. ft. of air barrier area at a 75 Pascal pressure difference. Mixed use buildings such as tactical equipment maintenance facilities with office and work bays with large leaky overhead doors may have a different requirement, typically 0.75 cfm/sq. ft for the work bays and 0.25 cfm/sq. ft. for the office areas.

The first step in the process is to calculate the total area of the air barrier. This should be done by the Designer of Record and supplied to the testing team long before we arrive to do the test. Figure 1 illustrates a simple rectangular building. The air barrier area includes the floor slab, the roof, and all four walls. Most buildings are not this simple in design.

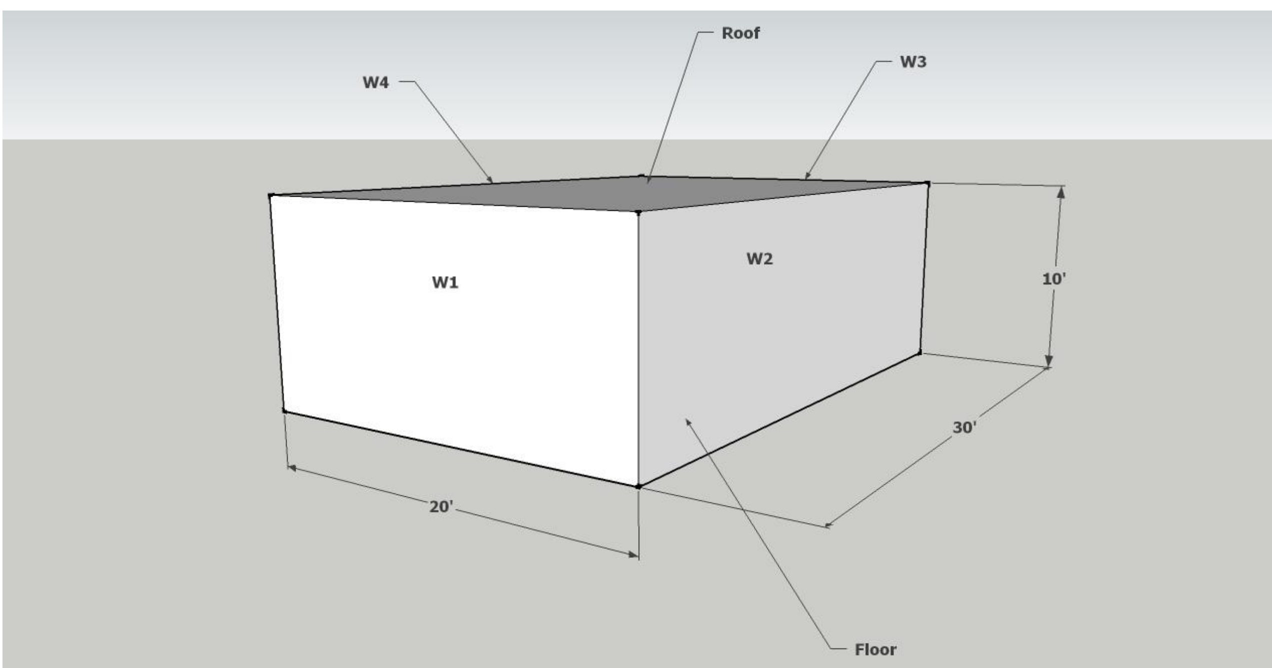


Figure 1.

The building is 20’x30’x10’. Areas are:

Element	Dimensions	Area (sq. ft.)
Floor	20’ x 30’	600
Roof	20’ x 30’	600
W1	20’ x 10’	200
W2	30’ x 10’	300
W3	20’ x 30’	300
W4	30’ x 10’	300
	Total Air Barrier Area	2,300

For our basic building the total air barrier is 2,300 sq. ft. If the maximum allowable leakage rate at an indoor/outdoor pressure difference is 0.25 cfm/sq. ft. at 75 Pascals pressure difference the maximum volume of air we can exhaust (or supply if pressurizing the building) is 575 cfm (2,300 x 0.25). If the allowable leakage rate is higher, say 0.75 cfm/sq. ft. at 75 Pa, the maximum volume of air we can exhaust is 1,725 cfm (2,300 x 0.75).

We use calibrated orifice blower doors to exhaust or supply air to the building for the test. The blower doors are placed in an exterior door and connected to instruments that measure and record the air flow volumes and the resultant pressure differences. Figure 2 illustrates a typical blower door set up to test a building. This particular set-up has a single fan. Depending on the size of the building tested, two or even three fans may be placed in the door. For large buildings multiple blower doors with multiple fans may be needed.

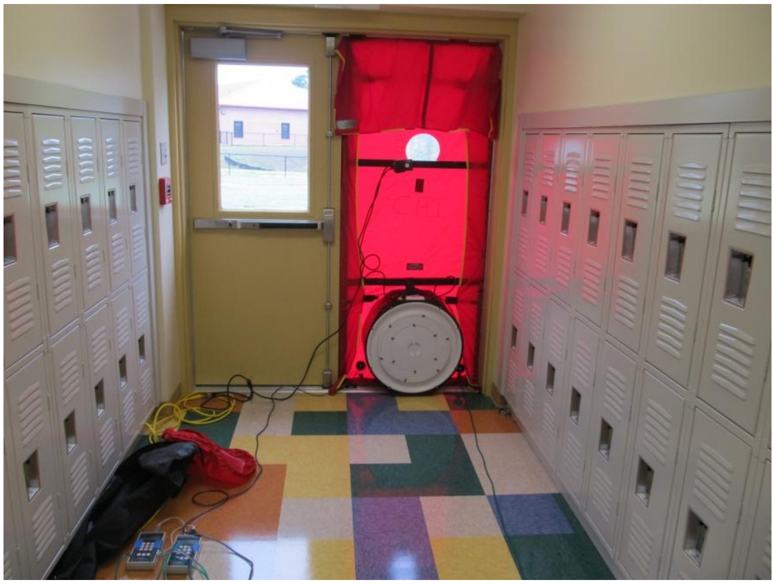


Figure 2.

Before we do the test the building must be prepared properly. Interior doors are opened to make sure we develop an even pressure difference throughout the building. We also may have to remove some ceiling tiles for the same reason. Windows and exterior doors are closed. HVAC systems exhaust fans and make-up air systems are turned off. Dampers leading to the outdoors are closed or, if necessary, temporarily sealed. Once these and other preparations are made we begin the test.

We first measure the indoor/outdoor pressure difference with the blower door fan(s) off and sealed as shown in Figure 2. This gives us what is called a baseline pressure. This is the pressure difference caused by factors such as wind blowing across the building and the indoor/outdoor temperature difference. We also take a baseline measurement after the test. It is important for us to know the baseline pressures because we need to account for them when we analyze the pressures and air flows we collect during our test.

Once we have turned the fans on we start measuring and recording the air flow volumes and pressure differences. Figure 3 illustrates data collected from a recent test. The lines are the pressure differences between the inside of the building and all four outdoor sides of the building. If at all possible we measure the pressure difference between inside and all four sides. The green rectangles contain the data we will use for the analysis. We select the data we will use based on what we feel is a valid measurement. For example, notice the drop in pressure at about 11:43 on Figure 3. The drop was caused by someone opening an exterior door during the test. That obviously would not be a valid data point so it isn't used for analysis.

As shown on Figure 3 we typically first start out creating a 75 Pascal pressure difference. We do this because that is the pressure required by ACE and we are anxious to know if the building will pass. If we find the building will pass the test we decrease the fan speed to change the pressure differences, usually in 5 Pascal increments. If the building will not pass the test we investigate the cause. It may be someone opened a window or door or we missed sealing an outdoor air intake. Once we are satisfied we have everything sealed that test protocols allow, we conduct a full test – even if we know the building will not pass. This is required by ACE test protocols.

If the building will pass we continue with the test, restore the building to the pre-test conditions such as unmasking any intakes we sealed, pack our equipment and go home. If it fails we begin a diagnostic investigation to find out why it failed. Often we can quickly locate the cause, have it corrected and retest. Unfortunately it doesn't always work out that way and it takes a considerable effort to find and correct leakage areas.

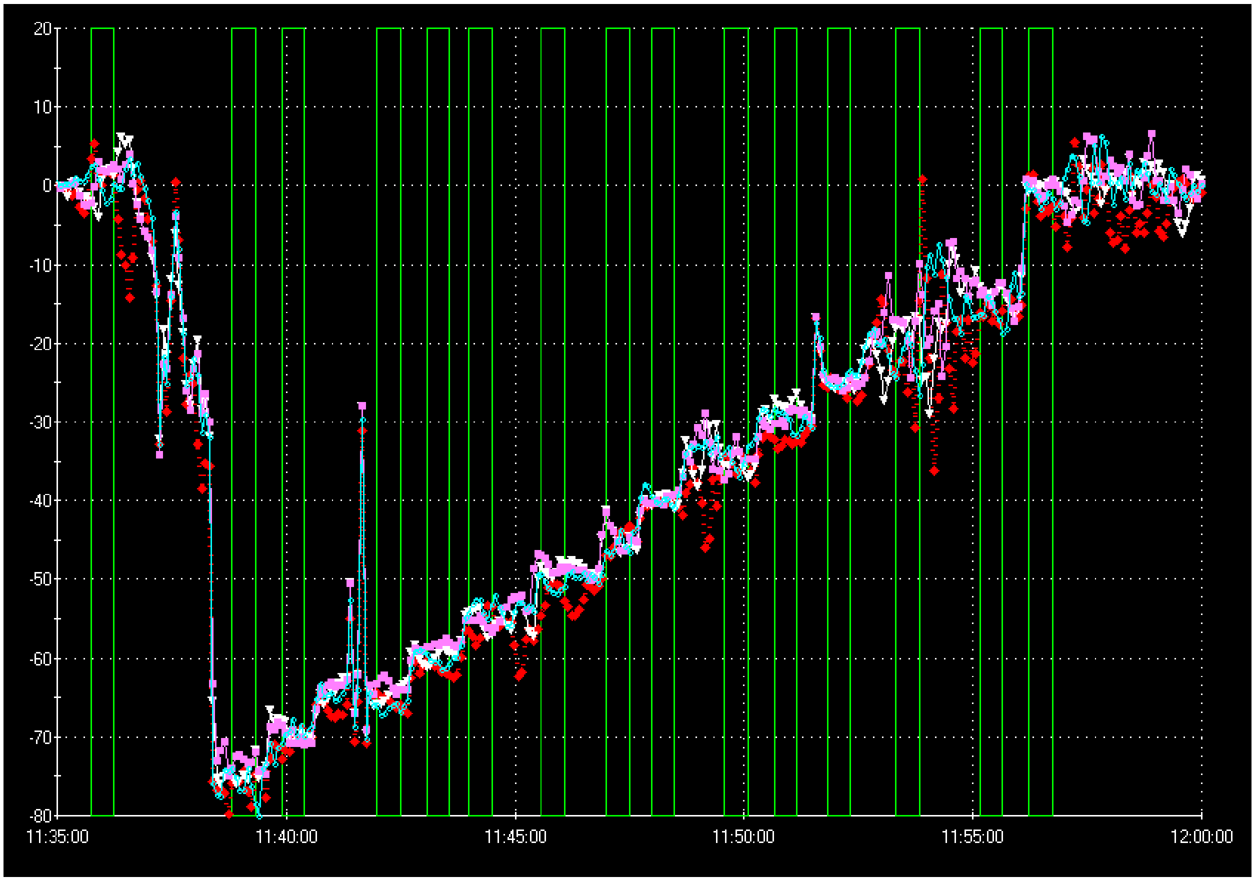
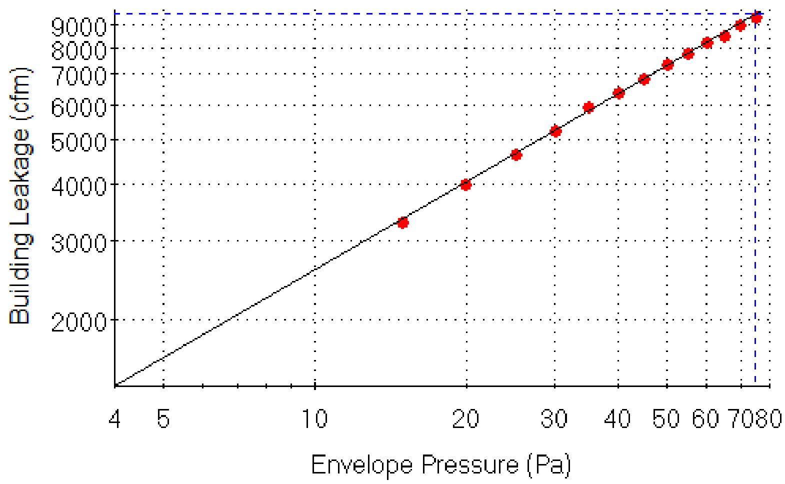


Figure 3.

When we have completed the test we analyze the collected data. As mentioned ACE requires buildings to meet a specific leakage rate at an indoor/outdoor pressure difference of 75 Pascals. ACE also requires the test data to meet certain quality requirements such as a 95% confidence interval of at least 25% and a correlation coefficient of at least 0.98. Figure 4 illustrates the test data and analysis results for the test shown on Figure 3.



Airflow at 75 Pascals

9484 cfm +/- 1.1 %

Range: 9384 to 9584

Leakage Areas

EqLA (10 Pa) = 760.0 in2 +/- 2.0 %

ELA (4 Pa) = 406.6 in2 +/- 3.2 %

Building Leakage Curve

Coef. (C) = 586.1 cfm/Pa^n +/- 5.0 %

Exponent (n) = .645 +/- 0.013

Correlation Coef. (r) = .99950

Corr Coef Squared (r^2) = .99901

Figure 4.

As can be seen, the volume of air needed to create the required 75 Pascal pressure difference was 9,484 cfm. The air barrier area for this building totaled 53,690 sq. ft. The maximum allowable volume of air needed to meet a 75 Pascal pressure difference is 13,425 cfm. The test revealed only 9,484 cfm was needed to reach 75 Pascals. Dividing the 9,484 cfm by the 53,690 sq. ft. of air barrier area provides a leakage rate of 0.18 cfm/sq. ft. which significantly betters the ACE requirement of 0.25 cfm/sq. ft.