

BY RANDY WILLIAMS

An Introduction to Zonal Pressure Diagnostics

Zonal pressure diagnostics, or ZPD, is a testing method used to compare pressure differences between spaces, or “zones,” in a building. These zones may be areas like attics or crawlspaces that are already separated from the main living space, or areas that we can isolate from the rest of the house to gather information. Detecting pressure differences between zones helps us evaluate the effectiveness of the air barrier between the zone and the conditioned area of the home and decide whether to focus our air-sealing attention on that zone. Two ZPD tests are performed using a blower door: simple and advanced. A third ZPD test uses the fan from a forced-air heating system instead of a blower door to determine if the supply and return ducts are balanced in the room being tested. I will discuss all three types of testing in this article.

SIMPLE ZPD TESTING

As an example of how a simple ZPD test might work, let's say we are blower-door testing a home and find it has a high rate of air (measured in cubic feet per minute, or cfm) moving across the fan during the test. This suggests that the home may benefit from air-sealing. A hunch tells us that the ceiling of the home is the issue. The ceiling drywall in this home is the air barrier; above the ceiling is an unconditioned and vented attic that should be completely outside the conditioned space of the home. To determine if this is the case, we operate the blower door at a negative or positive 50 pascals of pressure with reference to the outside. All the spaces outside the conditioned space of the home should be at 50 pascals of pressure (either positive or negative, depending on if the test is pressurized or depressurized) with reference to the home. If 50 pascals is measured between the home and the attic space, we have a perfect ceiling air barrier—exactly what we are looking for.

However, if we test the pressure of the attic space with reference to inside the home and find it is at 25 pascals, we can surmise the attic space is connected to both the home and outside and that the size of the holes between



During a ZPD test of attic pressure with respect to the living space, a manometer that shows this zone at a pressure near 50 pascals (1) indicates that the ceiling air barrier is nearly perfect, because the attic is at the same pressure as the outside. However, if the zone pressure reads near zero (2), the attic zone is completely connected to both outside and inside.

Photos by Randy Williams

the outside and the vented attic is equal to the size of the holes between the home and the attic. We don't know how many holes, and we don't know their exact locations; we just know that the holes between the attic and the home and those between the attic and the outside are equal in area. If the attic space is at 0 pascals, there is no separation between the outside and the home; the attic is completely connected to both the outside and the inside.

Our example is an attic, but this sort of simple ZPD test is commonly used to test other house zones, including attached garages, the "attic" spaces behind knee walls, unconditioned crawlspaces, sunrooms, and other spaces connected to the home that should be outside the thermal and air boundaries.

While we don't know the exact number and size of the holes in the air barrier we found with our simple ZPD test, we can deduce something about the *relative* size of the holes, as described in the chart below.

RATIO OF PRESSURES TO LEAKAGE

Zone Pressures (in pascals)		Relative Size of Leaks	
Zone to House	Zone to Outside	Zone to House	Zone to Outside
12	38	2	1
25	25	1	1
37	13	1/2	1
41	9	1/3	1
45	5	1/4	1
48	2	1/8	1
49	1	1/13	1

Source: Michael Blasnik and Jim Fitzgerald

In the chart above, the test is reading the zone to the outside compared to the zone to the house. The pascal reading on the manometer indicates a ratio of leakage. If the zone-to-house reading is 12 pascals, we can deduce that the cumulative holes in the air barrier are twice the size of the holes between the attic and the outside. If the zone-to-house reading is 37, the cumulative holes in the air barrier are half the size of the holes between the attic and outside. As long as the blower door test uses 50 pascals as the test pressure, the zone-to-house plus the zone-to-outside pressure readings will always equal 50.

This simple ZPD test is telling us only hole-size ratios, not how big the holes are. However, it is possible to roughly estimate the size of the holes between the outside and the attic by measuring the actual ventilation openings, then multiplying by the ratio. But these measurements won't account for unseen holes in the gable ends or roof sheathing. We would need more advanced ZPD testing to evaluate those.

Another simple ZPD test compares rooms that should be completely inside the building or air barrier with regard to an adjacent inside space. As an example, we could compare the pressure in a bedroom with the pressure in the hallway outside of it. For this test to work, we need to be able to isolate the two spaces from each other; usually that only requires closing a door. Ordinarily when conducting a blower door test, we keep all the doors open, so all rooms and areas inside the air barrier are connected with the blower door. When performing this ZPD test, however, we close a door to one of the spaces and measure the pressure difference between inside and outside that closed space.

Because the spaces are completely inside the air barrier, the pressures between the spaces should be the same—that is, the manometer should read 0 pascals. If the manometer reads any other number, we suspect that we have some type of connection in the closed-off space with the outside. This connection could be through an outside wall, an attic, the ceiling of the space, or the floor. But we could also be pulling air from other spaces, such as an adjacent room that has its own air leaks to the outside, or through any ductwork in the room. Because there is a possibility of pulling air from adjacent rooms or ducts, room-by-room testing can be unreliable; a reading on the manometer only suggests there is a potential air leak, which is a starting point for finding that leak. But further testing will be needed to confirm the location and amount of leakage.

ADVANCED ZPD TESTING

Advanced ZPD testing yields much more information. This test, also known as "add a hole," can estimate the amount of air leakage (measured in cfm) between two spaces that are supposed to be completely separated from each other. To conduct this test, we first perform a standard blower door test and register the test pressure both in pascals and cfm rate. During this first blower door test, we also measure the pascal reading between the attic and the home with the attic hatch closed. After attaining those values, we perform a second blower door test with the attic hatch open (hence, "adding a hole"), recording the new number of cfm along with the pascals of pressure in both the attic and the home.

Here's an example: Let's say the blower-door pressure

RED Zone Pressure Diagnostics

Zone tested: Vented Attic
Blower door test type: Depressurization

Use Advanced Inputs

Initial Zone Configuration

Pressures [Pa]	BD off	BD on	ΔP
House wrt outdoor	0	-50.1	-50.1
Zone wrt outdoor	0	-19.2	-19.2

Blower door flow adjusted to 50 Pa [CFM] 2056
Zone leakage ratio (zone-to-house : zone-to-outdoor) = 1 : 1.4

Modified Zone Configuration

Hole/door located between zone and House
Type of modification: Add a hole or open a door

Pressures [Pa]	BD off	BD on	ΔP
House wrt outdoor	0	-49.2	-49.2
Zone wrt outdoor	0	-38.7	-38.7

Blower door flow adjusted to 50 Pa [CFM] 2770

Results for Initial Zone Configuration

	Leakage @ 50Pa [CFM]	Leakage area [in ²]	±
Zone-to-house	1640 ± 430	170 ± 46	26%
Zone-to-outdoor	2240 ± 370	240 ± 45	19%
Through zone	1200 ± 270		22%

Percent of whole-house leakage passing through the zone = 58%

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Test results on this ZPD app indicate that there are 170 +/- 46 square inches of leakage between the outside and the vented attic space. Between the attic and the home, there are 240 +/- 45 square inches. The results also show that about 1,200 cfm of air is leaking through the ceiling. With the home at a total leakage rate of 2,056 cfm, 58% of this total leakage is between the unconditioned, vented attic and the indoor living space of the home. Air-sealing the attic would be the clear recommendation.

of the home with reference to the outside is 50.1 pascals. The unconditioned and vented attic space with reference to inside the home reads 19.2 pascals on the manometer. The total leakage of air through the blower door is 2,056 CFM50. These readings are taken with the attic hatch sealed.

The next step is to retest the home with the attic hatch open. In our example home, the manometer now reads 49.2 pascals for the home with reference to the outside. The reading in the attic with the hatch open is 38.7 pascals and the total airflow through the fan is

2,770 cfm. For the best accuracy, be sure to baseline the manometer before each test.

To simplify the calculation required, I like to use Residential Energy Dynamics' Zonal Pressure Diagnostics tool (redcalc.com). An example of the results it displays is shown at left.

This advanced ZPD test method would be the same for testing any other zone or space that should be outside the air and thermal boundary, as long as there is an opportunity to open the spaces to each other. This advanced ZPD test is not possible if there is no access between the spaces.

HVAC ZPD TESTING

The third type of ZPD testing does not use a blower door to induce a pressure difference. Instead, it uses forced-air heating or cooling equipment. This test is used to find out if the room's pressure ends up positive or negative depending on whether the supply and return ductwork is properly balanced.

As an example, consider the house we started with: We first check with the blower if there is any pressure difference between a bedroom and a hallway outside it, without the forced-air system in operation. We throw a manometer tube on the floor across the door opening and close that door. If the HVAC supply and return are equal, the manometer will read 0 pascals, indicating a balanced system. If the manometer shows anything else, we will want to determine the cause. It may be windy or some other ventilation system may be in operation, such as a balanced ventilation system like an ERV/HRV. If we are at (or very close to) 0 pascals, we can now start the forced-air system. If a negative pressure is produced, we know we have more return than supply. If a positive pressure is present, that means more supply than return. If any reading is greater than +/-3 pascals, we may want to suggest balancing the system.

ZPD testing is one of many tools in an energy auditor's or building diagnostic practitioner's toolbox. When used correctly, the information provided can help to identify and quantify air-sealing goals. It may also suggest if forced-air heating and cooling systems are operating correctly. Testing equipment and third-party software and apps, such as the RED Zonal Pressure Diagnostics tool mentioned earlier can simplify the complex calculations needed to estimate test results. The Energy Conservatory (energyconservatory.com) and Retrotec (retrotec.com) both have excellent YouTube channels with useful video training on ZPD.

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