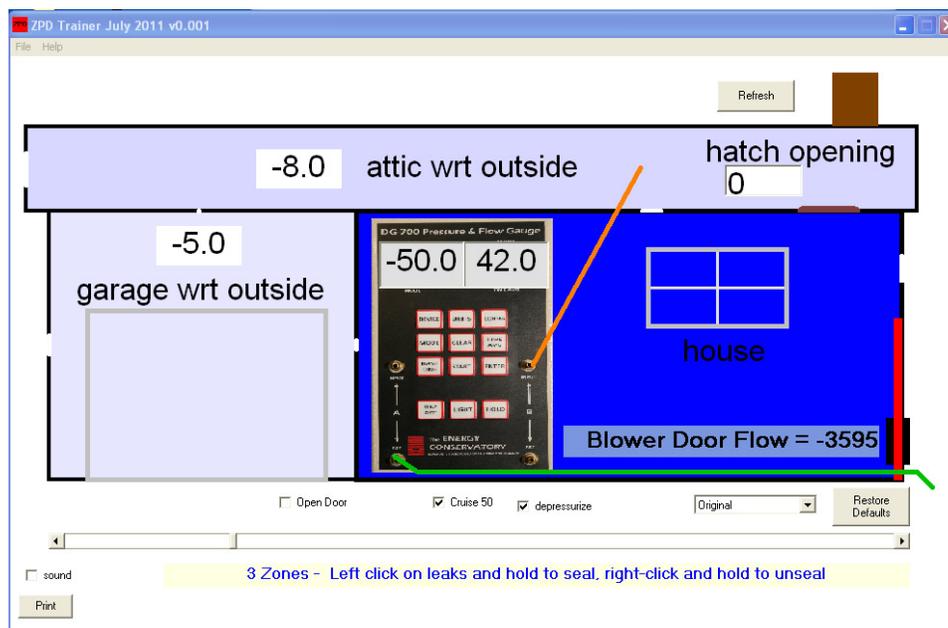


Zone Pressure Diagnostics (ZPD) Trainer

Software User's Guide



The **ENERGY**
CONSERVATORY

DIAGNOSTIC TOOLS TO MEASURE BUILDING PERFORMANCE

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Chapter 1 Introduction to the ZPD Trainer

Zone pressure diagnostics (ZPD) are widely used by weatherization professionals to prioritize airsealing efforts in houses by estimating the amount of air leakage from attached zones (e.g. attics, crawlspaces, and garages). Advanced ZPD techniques go beyond simply taking a zone pressure number and combine Blower Door airtightness test results with zone pressure measurements that are made both before and after an opening or hole has been added to one surface of the zone being tested to determine how much air leakage is occurring between the house and that zone.

The ZPD Trainer and the Cox Olson charts were developed for a conference training and are now being made available as a training aid to help simplify and clarify the complex topic of Zone Pressure Diagnostics. ZPD Trainer is designed to be used with the Cox Olson charts to determine an estimated air leakage between the zone being tested and the home. The charts will also provide the percentage uncertainty associated with the readings.

This manual includes an exercise that will help students become familiar with the use of the charts so they can use them in the field to determine how much air leakage is occurring between the house and a zone.

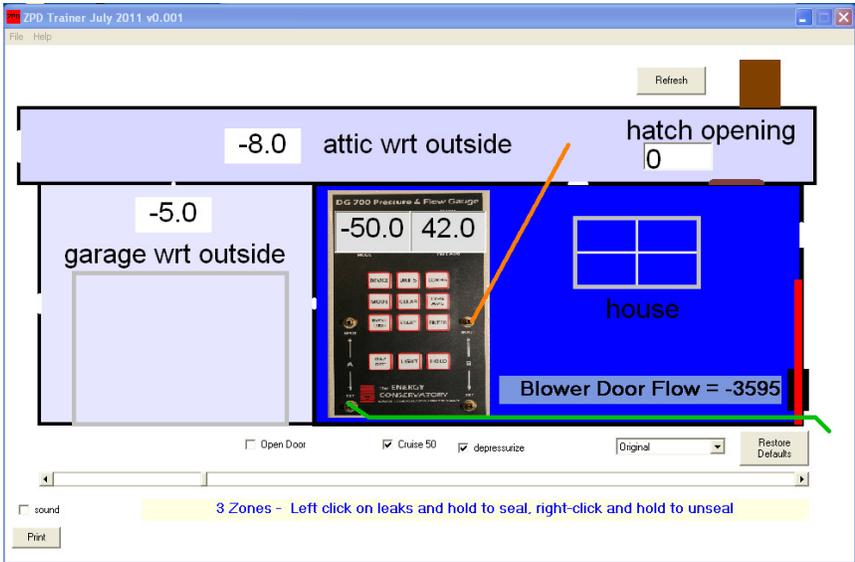
Installing the ZPD Trainer

The ZPD Trainer software is available to download from The Energy Conservatory's website in the Products...Software section. Simply click on the downloaded file and the program will self-extract and prompt you through the installation process.

Starting the ZPD Trainer

To start the program, click on **Start...Programs...Energy Conservatory...ZPD Trainer**.

The main ZPD Trainer screen will now appear, with the hole sizes between zones, pressure measurements between zones and the Blower Door Flow reading in the original default position.



Chapter 2 Overview of the ZPD Trainer

The ZPD trainer contains three zones: the house, the garage and the attic. Each zone has an adjustable leak to the other two zones and an adjustable leak to the outside. As the leaks are made larger or smaller, the pressure differences between the zones will change. As pressures in attic or garage get closer to the outside pressures, they will become closer to the outside color white. As pressures in attic or garage get closer to the inside pressures, they will become closer to the inside color blue. Adjusting the leaks allows the trainer to demonstrate the following:

Sealing or Adding Attic Leaks

Sealing attic leaks will make the attic with respect to (WRT) outside number lower, making the attic color closer to the outside color and it will make the Blower Door number go down. Adding leaks to the attic, such as adding recessed lights will have the opposite effect.

Adding or Removing Vents to the Attic

When adding roof venting, it is best if the amount of high venting (roof vents) is equal in net free area to low venting (soffit vents) to help keep the attic at similar temperature and humidity levels as the outside. Adding attic vents will make the attic with respect to (WRT) outside number lower, making the attic color closer to the outside color and it will make the Blower Door number go up. Removing attic venting will have the opposite effect.

Sealing or Adding Air Leaks Between the House and Outside

Dense packing insulation into empty exterior wall cavities is one of the most cost effective measures that can be performed on a house. Sealing leaks between the house and outside will make the Blower Door CFM50 numbers go down.

Sealing Air Leaks between the House and Garage

Sealing air leaks between the house and zones with potential air quality issues, such as a garage or crawlspace, is always a high priority. This will make the garage with respect to (WRT) outside number lower, making the garage color closer to the outside color and it will make the Blower Door number go down.

Sealing or Adding Air Leaks Between the Garage and Outside

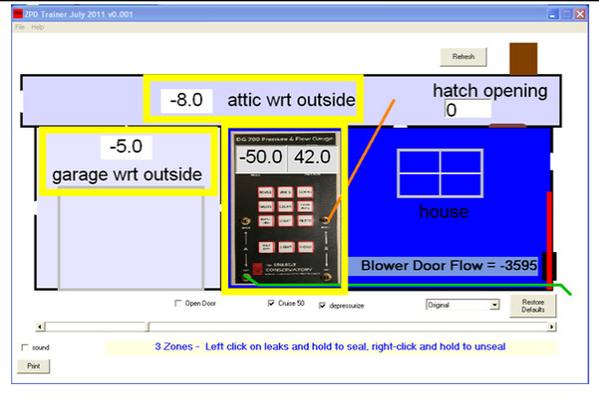
Adding vents between the garage and outside will help reduce concentrations of potential pollutants in the garage. This will make the garage with respect to (WRT) outside number lower, making the garage color closer to the outside color and it will make the Blower Door number go up. Sealing air leaks between the garage and outside is not recommended because of the potential air quality issues.

Chapter 3 ZPD Trainer Features

This chapter will review all of the functions and features of the ZPD trainer.

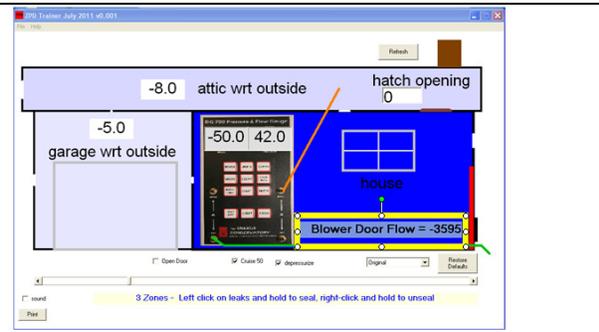
The Pressure Gauge

- Channel A – There is a green hose attached to the reference tap on channel A going to the outside. The hose locations for Channel A are fixed.
- Channel B – There is an orange hose attached to the input tap on channel B.
- Moving hose location - The location of the input hose for Channel B can be changed by left clicking on a zone.
- The current attic WRT outside and the garage WRT outside pressures are always displayed.



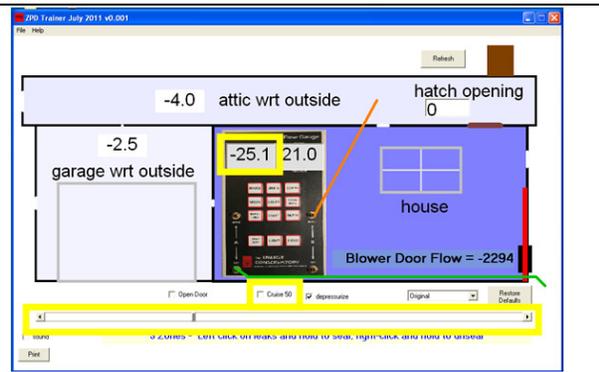
Blower Door Flow

- The Blower Door flow is displayed on the lower right side of the house zone.



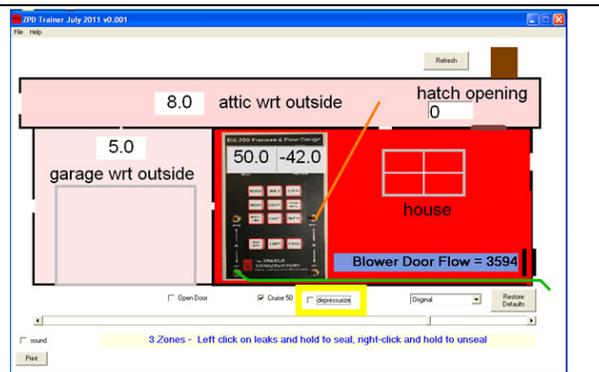
Cruise 50 / Fan Speed Controller

- The **Cruise 50** box can be unchecked by left clicking on the box if you would like manual control of the house pressure.
- The movable tab on the fan speed controller slide bar now becomes active to adjust the Blower Door flow and the house pressure.
- The shade of blue in all zones will become lighter as the pressure in the house is lowered.



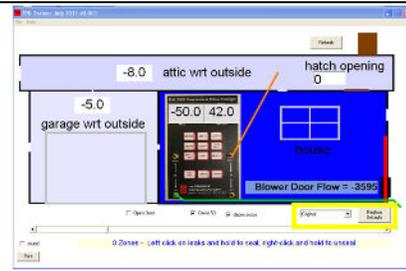
Depressurize or Pressurize

- Zone Pressure Diagnostics can be done with the house depressurized or pressurized.
- To pressurize the house unchecked the **depressurize** box below the DG-700 gauge.
- The color in the zones will change from blue to red during a pressurization test.

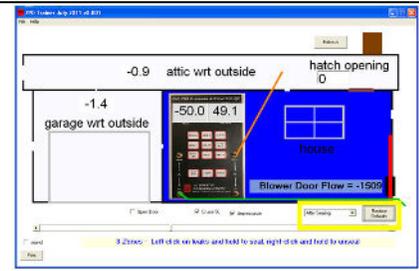


Defaults

- All settings can be changed back to their default positions by clicking the **Restore Default** button.
- There are two default options to choose from to the left of the **Restore Defaults** button: **Original** and **After Air Sealing**



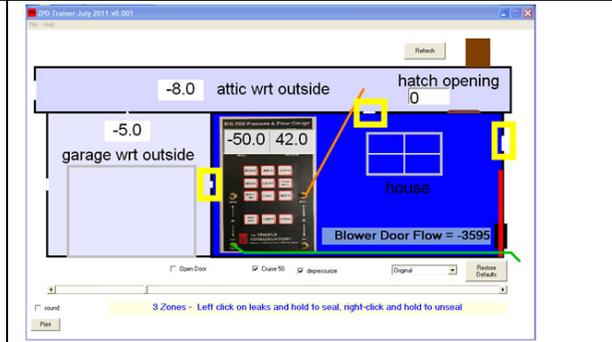
Original Default



After Air Sealing Default

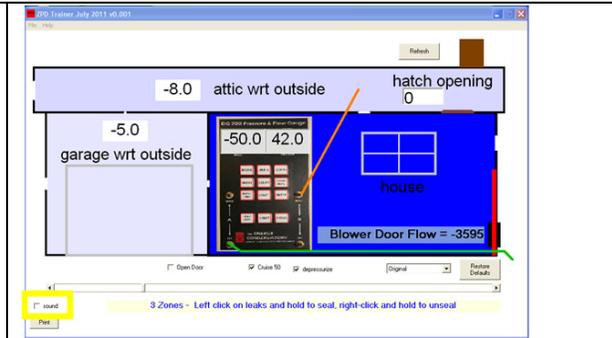
Changing a Leak Size

- Each zone has a hole to the other two zones and to the outside. All holes can be sealed with a mouse left click and hold or can be unsealed with a right click and hold. The first left-click on a leak simply selects that leak.
- Sealing a hole at any location will decrease the Blower Door flow and unsealing a hole at any location will increase the Blower Door flow.



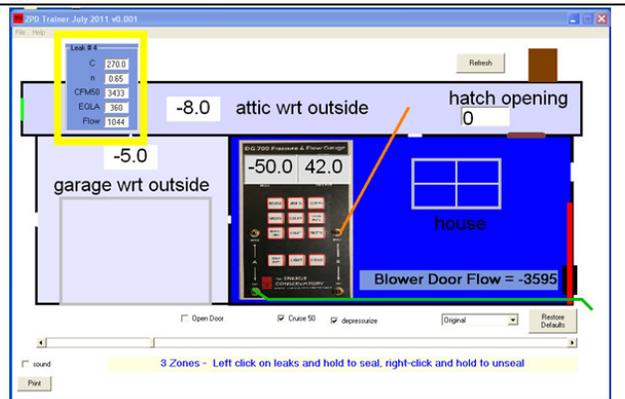
Sound Effects

Clicking the **Sound** box will activate sounds when you seal or unseal leaks.



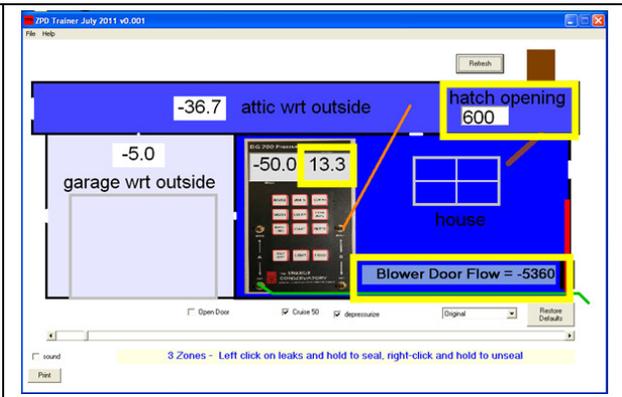
Equivalent Leakage Area

- When a hole is sealed or unsealed a box appears with data on the flow coefficient, exponent, CFM at 50 Pa of pressure, equivalent leakage area, and the flow through at the current pressure across that hole.
- The current example will tell you the equivalent leakage area (EQLA) in square inches of the roof venting. You can simulate adding or removing roof or soffit vents if you know the net free area of the vents.



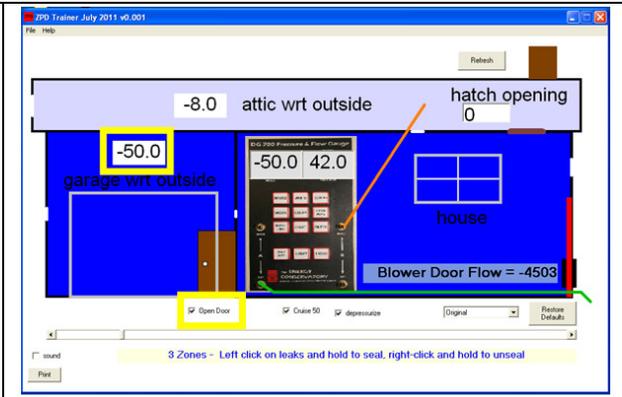
Adding a Hatch Opening

- Advanced pressure diagnostics can be performed to calculate how much leakage there is between the house and attic. This is done by adding a hole between the zones and entering data into software or using charts. See example later in this document.
- Enter the square inches of the hatch opening into the box and hit the tab button on your key board.
- You will notice the color of the attic will become closer to the color of the house and the attic WRT outside pressure will increase.



Opening the Garage Door

- Advanced pressure diagnostics can be performed with the garage zone by left clicking the *Open Door* box. This will open the door between the house and garage and bring the house and garage to the same pressure.
- You will notice the house and garage are now the same color because they are at the same pressure WRT outside.



Chapter 4 Using Charts to Calculate Air Flow Between Zones

It is important for students to understand the concept that zone pressure measurements indicate a ratio of the relative size of the leaks in a home and not how much air leakage is occurring. If you want to calculate the air flow between zones, an additional step of adding a hole or opening a door between the house and zone or the zone and outside must be done. Charts or software must then be used to perform the calculation.

The **Ratio of Pressures to Leakage** chart below shows how these ratios relate. The easiest example to make this point is to choose the zone pressure of 25 Pa. With the house at 50 Pa, the Zone to House pressure and the Zone to outside pressure are both 25 Pa. In this example there is a 1 to 1 ratio in the relative size of the leaks. In other words, the leaks between the house and the zone are equal in size to the leaks between the zone and outside.

The two **Pressures and Leakage** diagrams below demonstrate how the relative size of the leaks does not tell you how large the leaks are. The diagram on the left shows a Zone to House pressure of 25 Pa and the leaks can be small or large. The diagram on the right shows a Zone to House pressure of 48 Pa that can have the same size leak to the zone as the home with a Zone to House pressure of 25 Pa.

The **Ratio of Pressures to Leakage** chart and the two **Pressure and Leakage** diagrams are included in the Help menu so they can be used as PowerPoint slides or handouts.

Taking zone pressure measurements can be very helpful in determining if pressure boundaries and thermal boundaries are aligned. The chart at the right shows the correlation between pressure measurements and the relative size of leaks.

The images below demonstrate how zone pressure measurements can tell you the relative size of the leaks but will not tell you the actual leakage area. You will notice that the size of the attic bypasses can be the same with a zonal reading of 25 Pa or 48 Pa.

Calculating the leakage areas requires adding a hole in the zone and entering data into software or charts.

Ratios of Pressures to Leakage

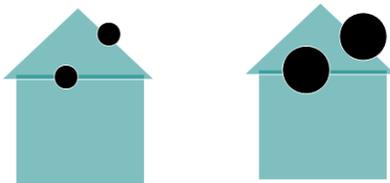
Zone Pressures		Relative Size of Leaks	
Zone-House	Zone-Out	Zone-House	Zone-Out
12	38	2	1
25	25	1	1
37	13	1/2	1
41	9	1/3	1
45	5	1/4	1
48	2	1/8	1
49	1	1/13	1

Sources: Michael Blasnik and Jim Fitzgerald

Pressures and Leakage

Attic Zonal Reading of 25pa

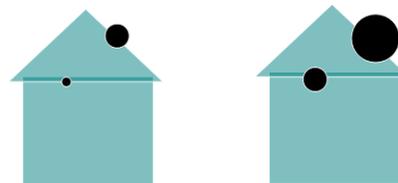
Means hole between Attic and House is Same size as Hole Between Attic and Outdoors



Pressures and Leakage

Attic Zonal Reading of 48pa

Means hole between Attic and House is 1/8th size of Hole Between Attic and Outdoors



The Cox-Olson Charts

The *Help* menu includes four charts that can be used to calculate air leakage between the house and a zone:

- Two of the charts use the **Flow Method** which requires adding a hole or opening a hatch.
 - The **Add a Hole #1** chart is for adding a hole or opening a hatch between the house and zone. When performing this test in the field, it may work best to pressurize the house for this test so you will not pull loose insulation into the home.
 - The **Add a Hole #2** chart is for adding a hole between the zone and the outside. When performing this test in the field, one way to simulate adding a hole is to seal off a roof vent or two during the first part of the test and unseal them for the second part.
- Two of the charts use the **Open a Door Method** which requires opening a door.
 - The **Open a Door #1** chart is for opening a door between the house and garage.
 - The **Open a Door #2** chart is for opening a door between the garage and outside. You should open the door that has the highest pressure across it when the house is at 50 Pa.

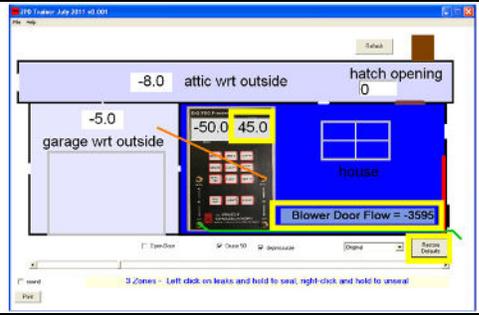
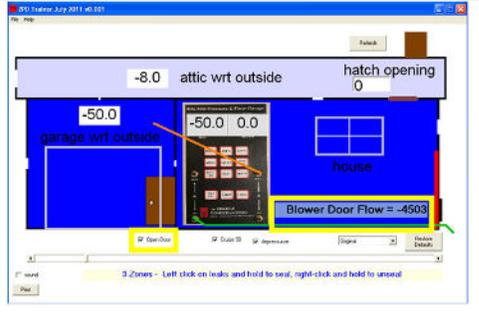
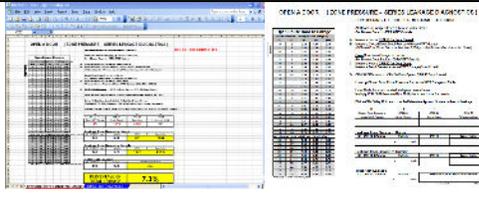
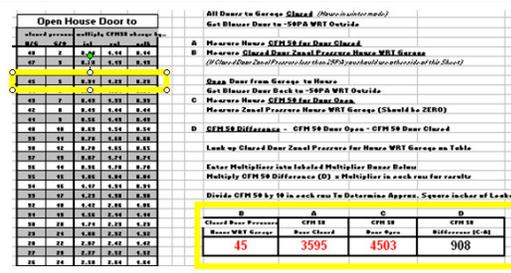
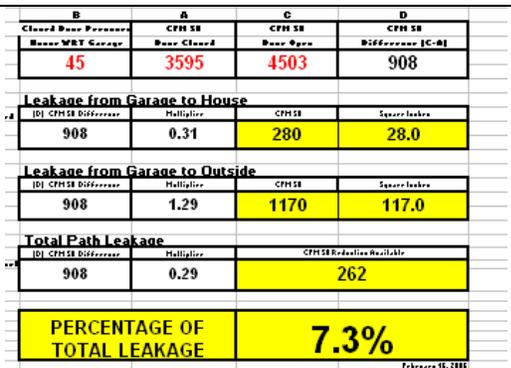
If you have Microsoft Excel installed on your computer, you can also access an Excel version of the **Add a Hole #1** and the **Open a Door #1** charts from the *Help* menu by clicking on the ZPD Training spreadsheet file. This spreadsheet will perform all of the calculations once the required data is entered.

Data Needed for the Charts

Two CFM50 readings and one pressure reading will be needed to make the necessary calculations:

- The Blower Door CFM flow at 50 Pa with garage doors closed
- The pressure between the house and garage with the Blower Door at 50 Pa
- The Blower Door CFM flow at 50 Pa with the garage door open

Using Data from ZPD Trainer and the *Open a Door #1* Chart for a Demonstration

<p>Click on the Default button to return all settings to the default positions.</p> <p>Click in the garage zone to move the orange hose to that zone.</p> <p>Write down the garage WRT house pressure (45).</p> <p>Write down the Blower Door flow with the garage door closed (3,595 CFM50).</p>	
<p>Click on the Door Open button to open the door between the house and garage. This is the door with the highest pressure across it.</p> <p>When the door is opened the pressure between the house and the garage is equalized.</p> <p>The cruise function is activated so the Blower Door fan will ramp up to bring the house to 50 Pa WRT outside.</p> <p>Record the new Blower Door flow with the garage door open (4,503 CFM50).</p>	
<p>We are now ready to enter the data into the charts. Two images are shown at the right. The first is the ZPD Training Excel spreadsheet and the second is the ZPD Open Door #2 chart.</p> <p>The excel spreadsheet will perform all of the calculations once the three required data numbers are entered.</p>	
<p>The three required data entry numbers are shown in red on the Excel spreadsheet:</p> <ul style="list-style-type: none"> • Garage WRT house pressure (45 Pa) • Flow w/ door closed (3,595 CFM50) • Flow w/ door open (4,503 CFM50) 	
<p>If you are using the Open a Door #1 chart instead of the Excel spreadsheet, you will use the chart to determine multipliers. In this case find the number 45 in the first column and follow it across to find the correct multipliers. This is explained in more detail below.</p>	

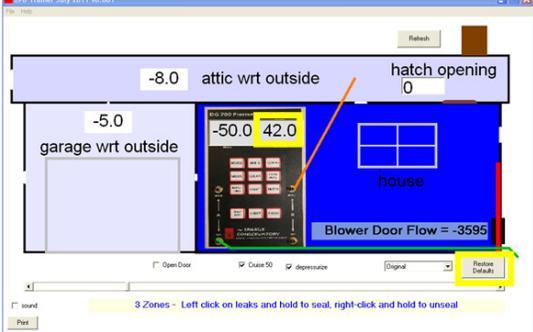
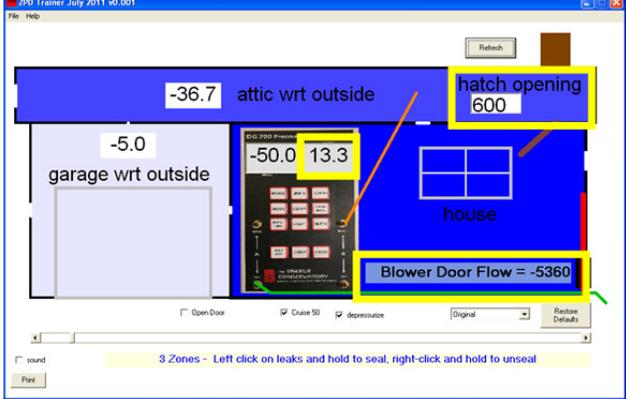
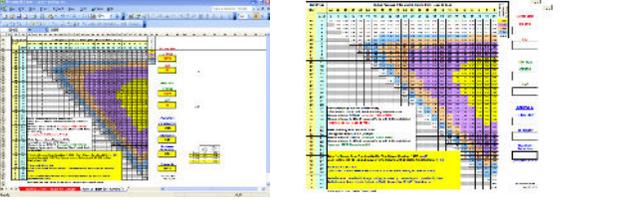
Using Data from ZPD Trainer and the *Add a Hole #1* Chart for a Demonstration

Air leakage between the house and a zone, such as an attic or a crawlspace, can be calculated if a hole can be added between the zone and the house or between the zone and the outside. Opening an attic hatch would be a typical way of adding a house to attic hole. Adding vents to an attic would be a typical way to add a hole between the attic and the outside. There are two different charts depending on if you are adding the hole between the zone and outside or between the zone and the house. If you have a choice, you will want to add a hole to the barrier with the largest pressure across it when the house is at 50 Pa. This is usually at the attic hatch (house to attic).

Data needed for the charts

Two CFM50 readings and two pressure readings will be needed to make the necessary calculations:

- The Blower Door CFM flow at 50 Pa before a hole is added
- The pressure between the house and zone with the house at 50 Pa before the hole is added
- The Blower Door CFM flow at 50 Pa after a hole is added
- The pressure between the house and zone with the house at 50 Pa after the hole is added

<p>Click on the Default button to return all settings to the default positions.</p> <p>Click in the attic zone to move the orange hose to that zone.</p> <p>Write down the attic WRT house pressure (42).</p> <p>Write down the Blower Door flow with the garage door closed (3,595 CFM50).</p>	
<p>For this example enter 600 in the Hatch Opening box. This number represents the square inches of hatch opening area.</p> <p>When the hatched is opened the pressure between the house and attic becomes smaller.</p> <p>The cruise function is activated so the Blower Door fan will ramp up to bring the house to 50 Pa WRT outside.</p> <p>Record the new Blower Door flow with the attic hatch open (5,360 CFM50 and record the new attic to house pressure (13.3).</p>	
<p>We are now ready to enter the data into the charts. Two images are shown at the right. The first is the <i>ZPD Training</i> Excel spreadsheet and the second is the <i>Flow Method #1</i> chart.</p> <p>The Excel spreadsheet will perform all of the calculations once the four required data numbers are entered.</p>	

The four required data entry numbers are shown in red on the right:

- Before Hole CFM50 (3,595)
- Before Hole H/Z pressure (42)
- After Hole CFM50 (5,360)
- After Hole H/Z pressure (13)

The Excel spreadsheet will calculate the CFM50 difference between the two readings, the maximum reduction possible, and the uncertainty based on the numbers entered. Multiplying the *CFM difference* by the *Multiplier* will give you the *Maximum Reduction*.

Before Hole

CFM50
3595

H/Z
42

After Hole

CFM50
5360

H/Z
13

ANSWER

CFM50 Diff
1765

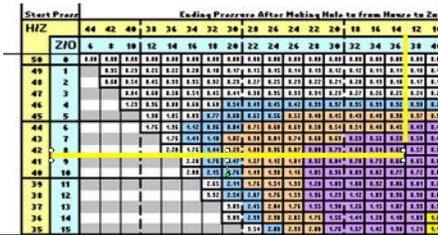
Multiplier
0.60

Maximum Reduction
1064

Square In
106.4

	Low Range	High Range
10.00%	958	1171
15.00%	905	1224
20.00%	852	1277
25.00%	798	1331

In this example, the multiplier is determined from the chart by moving down the *Start Pressure H/Z* column to 42 and move across *Ending Pressure H/Z* row to between 13 and 14. Interpolation can be done between rows or columns for odd numbers. The number at the intersection will be the multiplier.



The colors on the chart represent a percentage of uncertainty. The legend for the uncertainty is at the upper right side of the chart. The lowest levels of uncertainty are the multipliers in the yellow section. Your starting H/Z numbers will need to be between 23 and 40 in order to end up in the gold uncertainty color. Adding larger holes to the zone for the test can reduce the uncertainty.

Uncertainty

10% 8% 6% 4% 2% 0%

Before Hole

CFM50
3595

H/Z
42

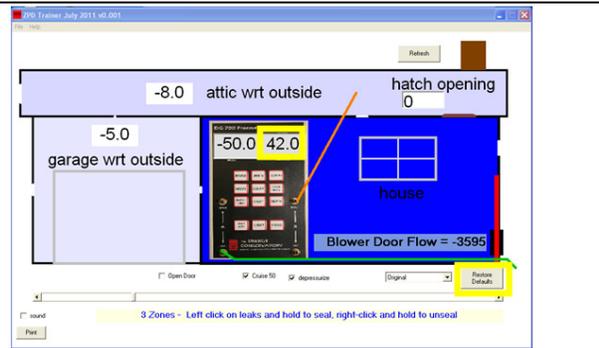
Chapter 5 Other Uses for ZPD Trainer

Quick Check to Determine the Amount of Attic Venting

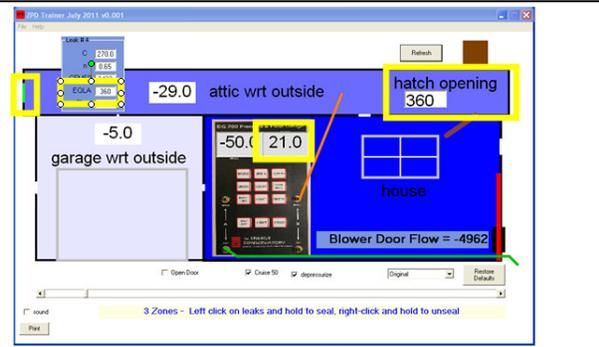
Often it is helpful to know how much effective attic venting a home has. Sometimes aluminum soffits are added over wood soffits that did not have venting or vents may get blocked over time by bird nests or lint. This method offers a way to calculate the equivalent leakage area (net free area) of venting between the attic and the outside without the use of software or charts.

If you add a hatch opening between the house and attic zone that is large enough to reduce the house to attic pressure by half, the area of the hatch opening will be approximately equal to the equivalent leakage area of the attic venting. Listed below is an example using the ZPD Trainer that will demonstrate this method:

Click on the **Default** button and click in the attic space to move the orange hose to the attic. You will notice that the house WRT attic pressure is 42 Pa. You will now, through the process of trial and error, add a hatch opening that will reduce this number by half to 21 Pa.



You will find that a hatch opening of 360 square inches will reduce the attic pressure of 42 Pa by half to 21 Pa. If you click on leak #4, the leak between the attic and outside you will notice the leak turns green and a box appears that gives you data about the leak. One of the pieces of data is the EQLA or equivalent leakage area of this leak. You will notice that this number (360) is equal to the square inches of hatch opening that you added.



An equivalent leakage area (EQLA) of 360 square inches is approximately six R60 roof vents. Ideally you would like half of the venting to be high venting or 3 roof vents and the other half to be low venting or soffit vents. If all of the roof venting is high venting, it may be getting a significant portion of its intake air from the house. If half of the venting is low venting, the attic is more likely to become similar in temperature and relative humidity to the outdoors.

Leakage Area Matching Method to Determine H / Z leakage

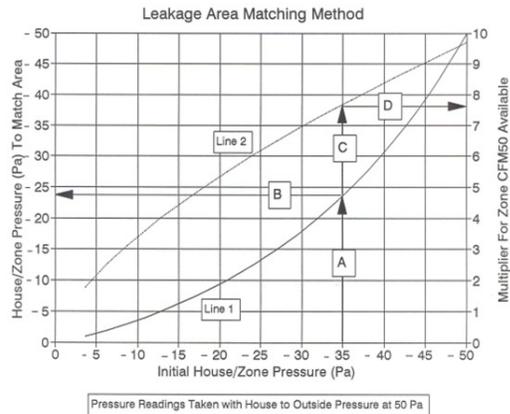
The Leakage Area Matching Method can be used to quickly estimate the leakage area between the building and a zone. In addition, you can estimate the total airtightness (CFM50) reduction available if all leaks between the building and zone were perfectly sealed. This method requires adding a hole between the house and the zone while the house is pressurized to 50 Pa to achieve a predetermined house to zone **match area** pressure.

The *Leakage Area Matching Method* chart is available in the *Help* menu.

Step 1 – With the house pressurized to cruise at 50 Pa measure the initial H/Z pressure. Find the initial pressure along the bottom axis of the chart and follow it up (arrow A) to line 1. Follow it across (arrow B) to find your predetermined house to zone (H/Z) **match area** pressure.

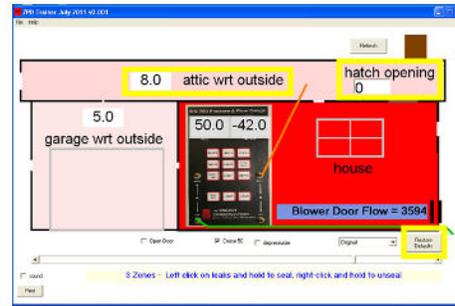
Step 2 – Add a hole H/Z with the house cruising at 50 Pa until the H/A pressure reaches the house to zone **match area** pressure. Estimate the size of the hole added in square inches. This hole is roughly equivalent to the existing leakage area between the house and the zone.

Step 3 – To estimate the available CFM50 reduction in that zone, continue to draw the initial H/Z pressure line until it intersects Line 2 (arrow C). From this point draw a line to the right, across the graph until it intersects the right vertical axis (arrow D). Take this multiplier times the size of the hole determined in **Step 2** to determine the available CFM50 reduction available in that zone.

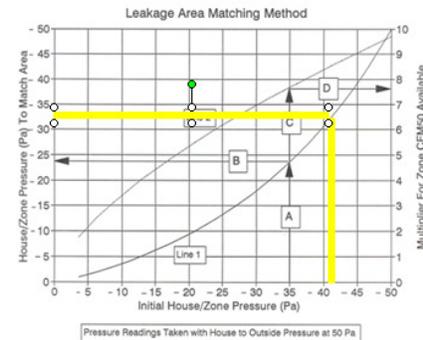


Demonstrate the Leakage Area Matching Method using the ZPD Trainer

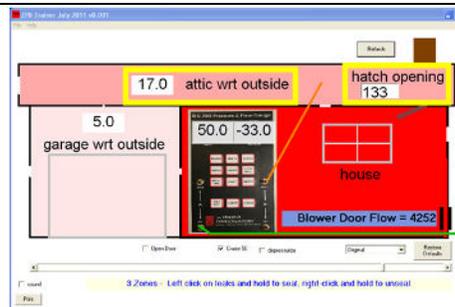
Step 1 – Select the “original” scenario. Click the **Default** button to revert all settings back to the default position. Click in the attic space to move the orange hose to the attic. Click on the **depressurize** box to change from the Blower Door test from depressurize to pressurize. Pressurizing the house will reduce pulling dust and insulation into the home when a hatch is opened the attic space.



You will notice the H/Z pressure before adding a hole is 42 Pa. Find 42 Pa along the bottom axis of the chart and follow it up (arrow A) to line 1. Then follow it across (arrow B) to the left axis. This gives you approximately 33 Pa as your **match area** target pressure.



Step 2 – Add a hole H/Z using trial and error with the house cruising at 50 pa until the H/A pressure reaches the **match area** pressure of 33 Pa. You will see that in this example the size of the hole added is 133 square inches. This hole is roughly equivalent to the existing leakage area between the house and the zone.



Step 3 – To estimate the available CFM50 reduction in that zone, continue to draw the initial H/Z pressure line until it intersects Line 2 (arrow C). From this point draw a line to the right, across the graph until it intersects the right vertical axis (arrow D). Take this multiplier, 8.8, times the size of the hole determined in **Step 2** to determine the available CFM50 reduction available in that zone. This multiplier $8.8 \times$ the 133 square inch hole size = a potential of about 1,170 CFM50 reduction possible if all attic bypasses are sealed perfectly.

