Zone Pressure Diagnostics: The Hole Story (Basic)

Pre-Conference Session

National Weatherization Conference
December 2009

Rick Karg
R.J. Karg Associates
www.karg.com

ZPD: The Hole Story (Basic)

Alden and the Minneapolis Blower Door, Model 3 from The Energy Conservatory

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Introduction

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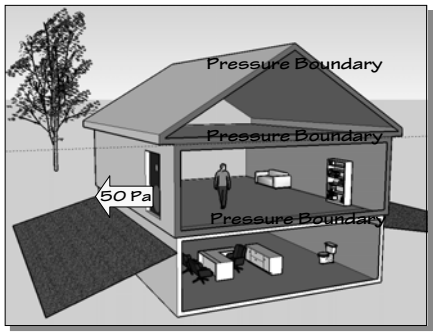

Series leakage or resistance

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Leakage Pathways

Zone	Interior Surfaces	Exterior Surfaces
Attic	Floor/ceiling, bypass paths	Roof, gables, soffits
Crawl space	Crawl ceiling	Crawl walls
Basement	Basement ceiling	Basement walls
Garage	House/garage wall garage ceiling	Exterior garage walls
Knee walls	Knee wall, floor	Roof, soffits, end walls

Series leakage or resistance

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Zone Pressure Diagnostics

- Objectives
  - Determine leakage area from building to zone.
  - Determine leakage area from zone to outdoors.
  - Determine total path CFM_{50} from building to outdoors through a zone.
  - To help appraise IAQ issues, such as CO from attached garages and bad air from crawl spaces.

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Zone Pressure Diagnostics - 1

- Allows analyst to determine if a space is connected by airflow (pressure) to the thermal envelope and/or the outdoors (secondary zones).
  - Pressure differences while blower door is running.
  - Be very cautious with this technique.
  - House/Zone + Zone/Outdoors = House/Outdoor ΔP.

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Zone Pressure Diagnostics - 2

- Allows analyst to determine the flow through two pressure boundaries in series (each individually and together) (primary zones).
  - Pressure differences while blower door is running.
  - Create a temporary opening in one pressure boundary.
  - Determine CFM_{50} flow House/Zone, Zone/Outdoors, and Total Path.
  - Determine square inches of leakage through pressure boundaries.
  - Important for Quality Assurance because method gives pre- and post-weatherization results.

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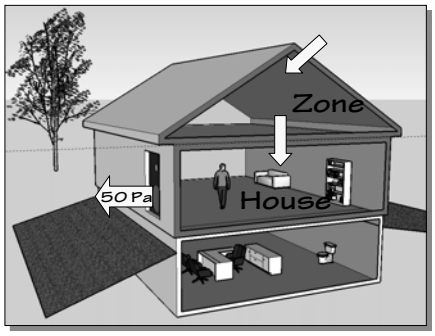

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Examples of Secondary Zones

(analyst is NOT able to open a hole)

- Joist cavities in Cape Cod style house.
- Crawl space with no access.
- Knee wall area with no access.
- Soffit above kitchen cabinets.
- Chimney cavities.
- Interior wall cavities.
- Attached porch roof/ceiling cavities.

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Is Porch Roof Connected?

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Examples of Primary Zones

(analyst IS able to open a hole)

- Attics
- Knee wall areas
- Garages
- Basements
- Crawl spaces

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A blower door is required for Zone Pressure Diagnostics, for both secondary and primary zone testing.

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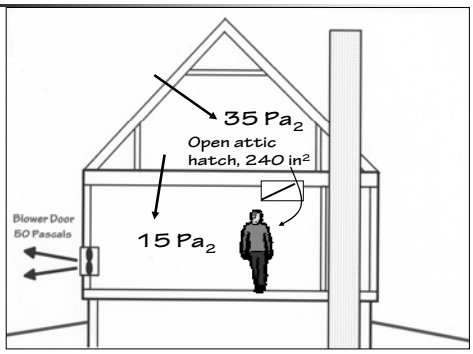

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Example House ZPD Details

- Sample Zone Pressure Diagnostics readings:
  - Attic as zone
    - Building/Zone = 2,295 CFM_{50}
    - Zone/Outdoors = 11,226 CFM_{50}
    - Total Path = 2,174 CFM_{50}
  - Crawl space as zone
    - Building/Zone = 7,504 CFM_{50}
    - Zone/Outdoors = 4,326 CFM_{50}
    - Total Path = 3,431 CFM_{50}

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Basic Principle of Series Leakage

- The ratio of pressure differences across interior and exterior boundaries is related to the ratio of their leakage areas.

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Pressures and Relative Leakage

Zone Pressures		Relative Size of Leaks	
House/Zone	Zone/Out	House/Zone	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

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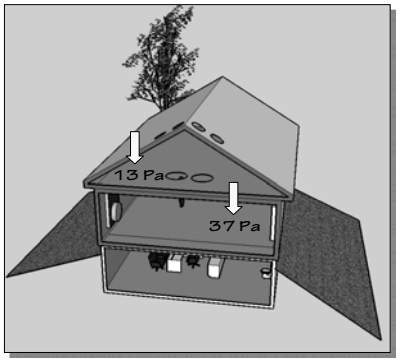

The ratio of leakage areas here. . .

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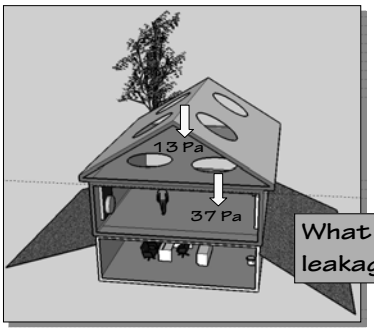

. . . is the same as here.

What about flow and leakage areas?

Click 1

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Zone Pressure Diagnostics

- Concepts – 1
  - Not every building needs Zone Pressure Diagnostics (ZPD) testing.
    - Very tight buildings usually don't need ZPD.
    - Sometimes very loose buildings don't need ZPD, at least not right away.
  - Every house does need safety checks.

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Zone Pressure Diagnostics

- Concepts – 2
  - When leakage air must follow path through two or more air barriers, for example, attic floor and building roof, it is helpful to know the leakiness of each of the air barriers.
    - The *relative* resistance to airflow is expressed as a *pressure difference*. For example, 35 Pascals or 15 Pascals of pressure difference.
    - The *absolute* leakage is expressed as a *flow*. For example, 1200 CFM_{50} or 950 CFM_{50}, always with the building to outdoor pressure difference of 50 Pascals.

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Zone Pressure Diagnostics

- Concepts – 3
  - Each pressure boundary imposes a resistance to airflow. The higher the pressure difference across the boundary, the greater its resistance to airflow.

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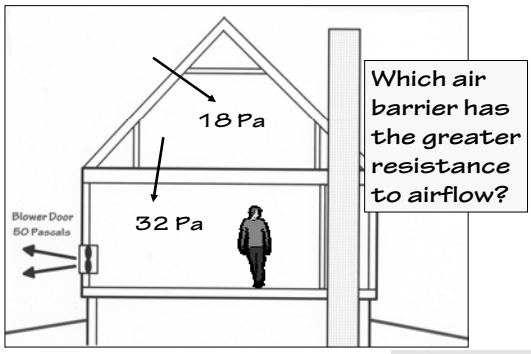

Which air barrier has the greater resistance to airflow?

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Secondary Zone Analysis

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Examples of Secondary Zones

(analyst is NOT able to open a hole)

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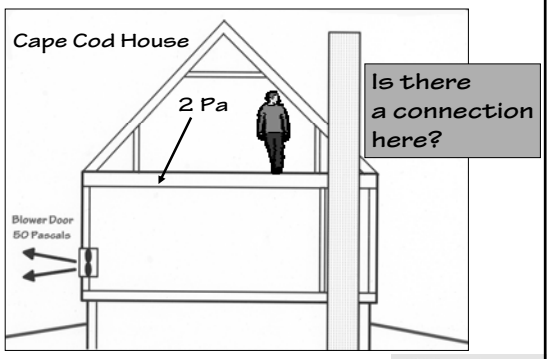

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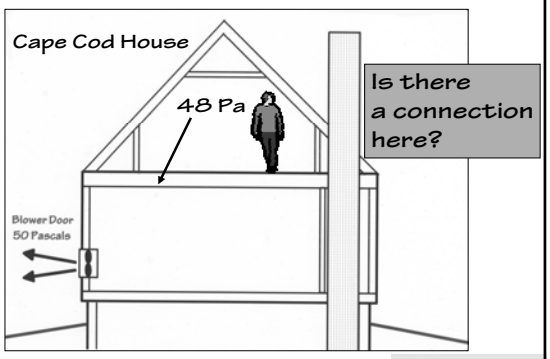

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Is Porch Roof Connected?

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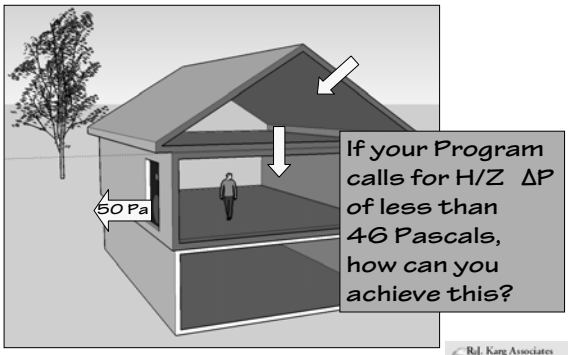

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Your Examples?

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Pressure Mapping: A Secondary Zone Analysis

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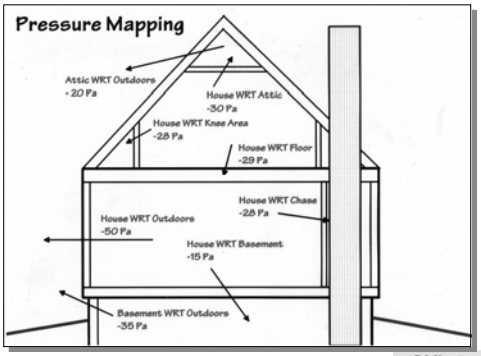

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Zone Pressure Diagnostics: The Hole Story (Intermediate)

Pre-Conference Session

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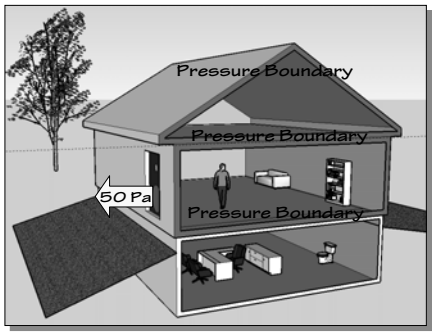
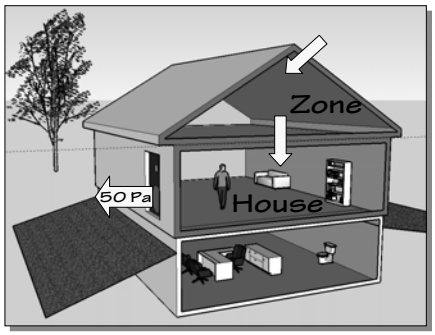
Quick Review of Basic ZPD Session



Series leakage or resistance

Zone Pressure Diagnostics

- Objectives
  - Determine leakage area from building to zone.
  - Determine leakage area from zone to outdoors.
  - Determine total path CFM_{50} from building to outdoors through a zone.
  - To help appraise IAQ issues, such as CO from attached garages and bad air from crawl spaces.



Examples of Secondary Zones
(analyst is NOT able to open a hole)

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Covered in Basic ZPD

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Examples of Primary Zones (analyst is able to open a hole)

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- Basements
- Crawl spaces

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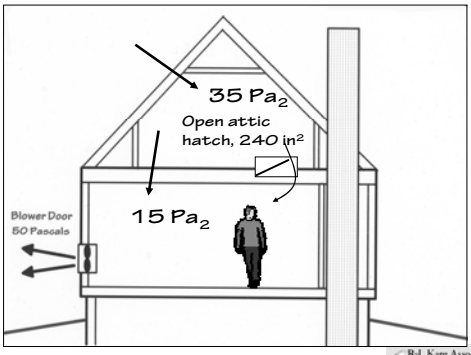

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Example House ZPD Details

- Sample Zone Pressure Diagnostics readings:
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    - Total Path = 2,174 CFM_{50}
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Primary Zone Analysis

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Examples of Primary Zones (analyst is able to open a hole)

- Attics
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- Basements
- Crawl spaces

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Add-a-Hole Method

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Add-a-Hole, Low-Tech Version

- With house at 50 Pa, measure House/Zone.
- Open a hole (attic hatch) just big enough to cut the House/Zone pressure in half.
- Keep house at 50 Pa.
- The hole you added is roughly equal to the existing leakage.

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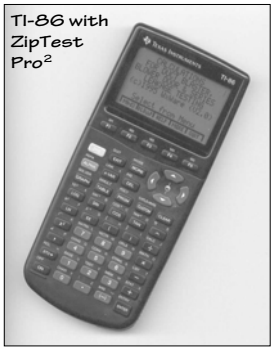
TI-86 with ZipTest Pro^2



Zone Pressure Diagnostics Screen

```
                    CFM50's
BLD/ZONE ----> 1419
ZONE/OUT ----> 2062
TOTAL PATH --> 1062
ENTERED DATA:
32  18 1 240   15  35
     HOLE METHOD
```

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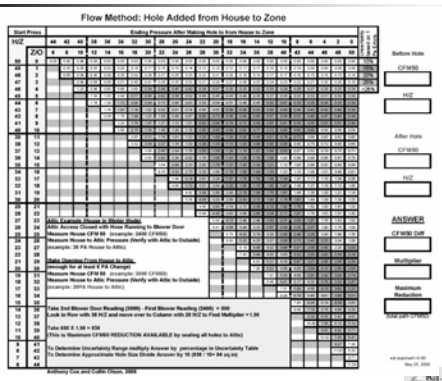

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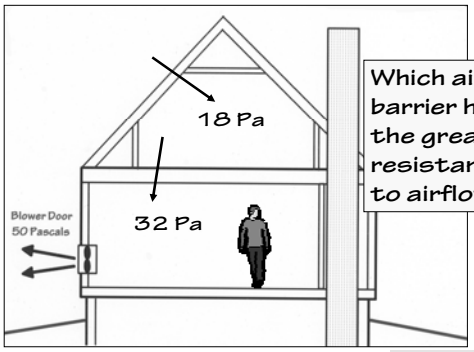

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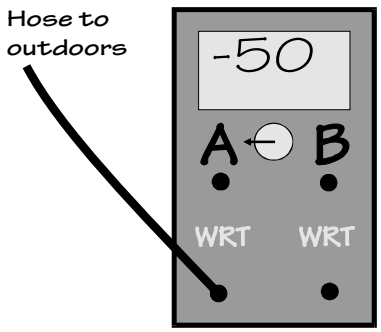
Pressure Gauge

Hose to outdoors



Based on The Energy Conservatory DG-2 and DG-3, digital pressure gauges

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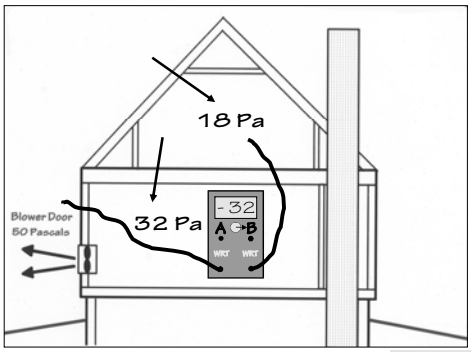

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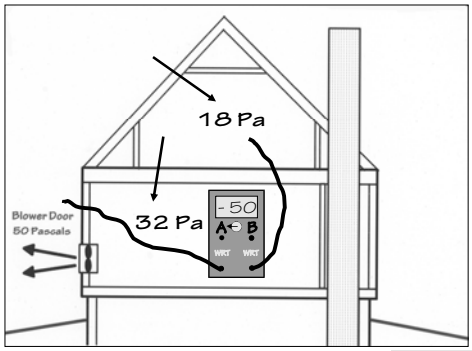

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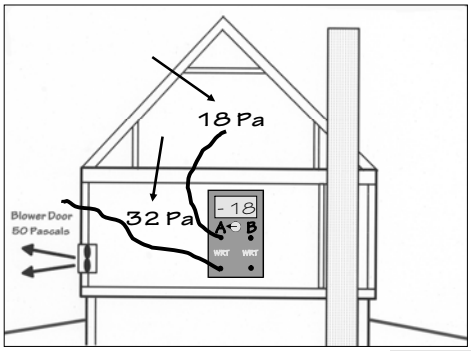

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Zone Pressure Diagnostics

- These pressure differences tell us which pressure boundary is most effective, but do *not* indicate the amount of leakage in either pressure boundary. Do not be mislead by these pressure difference numbers; their usefulness is very limited.

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Zone Pressure Diagnostics

- In order to determine the actual leakiness of an pressure boundary, we must determine the CFM_{50} flow through each air barrier.
  - This must be done by opening a hole from House/Zone or Zone/Outdoors using a standard procedure and
    - A special chart.
    - ZipTest Pro^{3}™ software.
    - Energy Conservatory Software.

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Zone Pressure Diagnostics

- Add-a-hole standard procedure:
  1. Depressurize house to – 50 Pascals;
  2. Measure H/Z and Z/O pressure differences;
  3. Create a temporary hole in the best of the two air barriers, large enough to drop the pressure difference across the air barrier by about 15 Pascals;
  4. Always keep house pressure at – 50 Pascals;
  5. Measure size of open hole in square inches;
  6. With hole open, measure H/Z and Z/O pressure differences;
  7. Determine H/Z, Z/O, and total path CFM_{50} (flow) values with ZipTest Pro™ software;
  8. Divide H/Z and Z/O CFM_{50} values by 10 to determine approximate leakage area in square inches.

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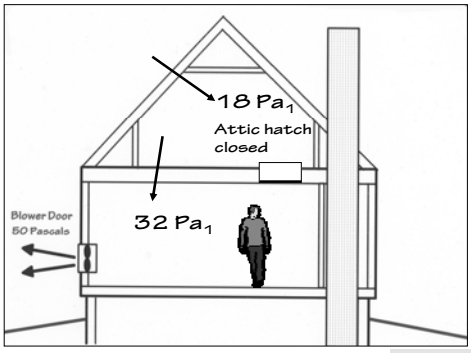

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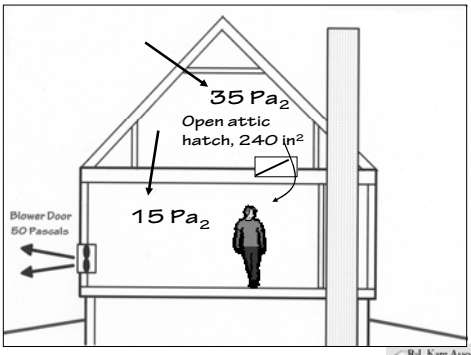

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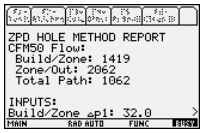
Zone Pressure
Diagnostics Screens



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What do the ZPD Numbers Mean?

- Building/Zone CFM_{50} of 1491
  - This pressure boundary – the ceiling – would leak at a rate of 1491 CFM_{50} if the other pressure boundary – the roof – were totally removed.
  - There are approximately 149 in^2 of leakage between the building or house and zone.

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ZPD: The Hole Story (Intermediate)

What do the ZPD Numbers Mean?

- Zone/Outdoor CFM_{50} of 2062
  - This pressure boundary – the roof – would leak at a rate of 2062 CFM_{50} if the other pressure boundary – the ceiling– were totally removed.
  - There are approximately 206 in^2 of leakage between the building or house and zone.

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What do the ZPD Numbers Mean?

- Total Path CFM_{50} of 1062
  - This represents the combined leakage of the two pressure boundaries – the ceiling and the roof – acting together or in series, both imposing a resistance to airflow.
  - The total path CFM_{50} is always less than either of the other two numbers (House/Zone or Zone/Outdoors).

(continued . . .)

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ZPD: The Hole Story (Intermediate)

What do the ZPD Numbers Mean?

- Total Path CFM_{50} of 1062 (. . . continued)
  - This is a representation of the portion of the whole building CFM_{50} leaking through the ceiling/roof.
    - For example, if the whole building CFM_{50} is 3200, 1062 of this can be attributed to ceiling/roof leakage. This means that 3200 – 1062 = 2138 CFM_{50} can be attributed to leakage in other parts of the envelope.

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Door Method

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ZPD Basic Door Methods - 1

- For this test, a door or other openable panel is closed for the first set of pressure readings and opened for the second set.
- The size of the opening does not have to be measured.

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ZPD Basic Door Methods - 2

- So, let's assume the garage is the zone.
- With the door to the garage closed, measure the whole-house CFM_{50}, say 2250.
- Now measure House/Zone ΔP, say 32 Pa.
- And measure Zone/Outdoor ΔP, say 18 Pa.

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ZPD Basic Door Methods - 3

- Now open the door to the garage and again measure the whole-house CFM_{50}, say 3000.
- The pressure now across the pressure boundary in which you opened the door (house to garage) should be less than 1 Pa.

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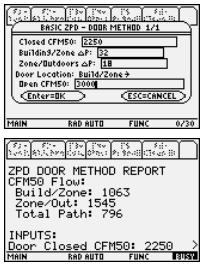
Zone Pressure Diagnostics Screens



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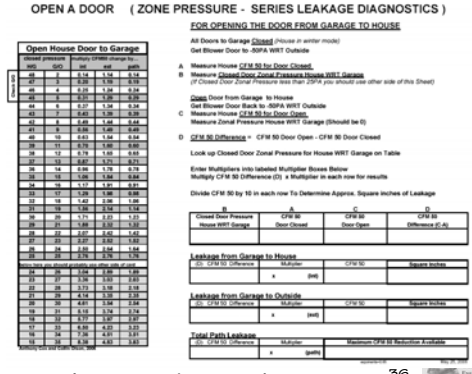

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Advanced ZPD Methods

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ZPD: The Hole Story (Intermediate)

Advanced ZPD

- Study Completed by Center for Energy and Environment, Michael Blasnik & Assoc. and the Energy Conservatory, 2001.
- To test how accurate the current tests are and when to use them.
- Actually ended up creating a Hybrid method by combining Add-a-Hole and Door Method.

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An Investigation Into Zone Pressure Diagnostic Protocols For Low Income Weatherization Crews

Phase I and Phase II Final Report Appendices

December 2001

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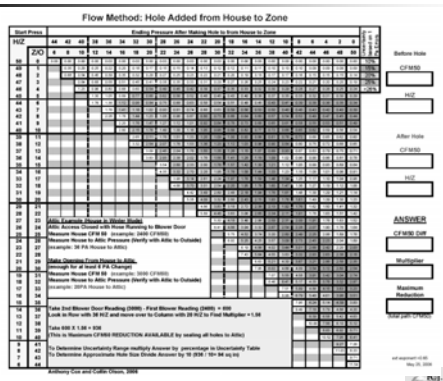

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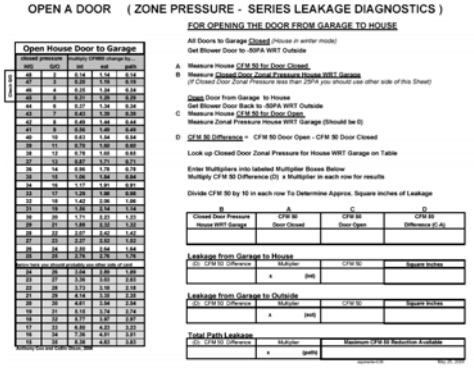

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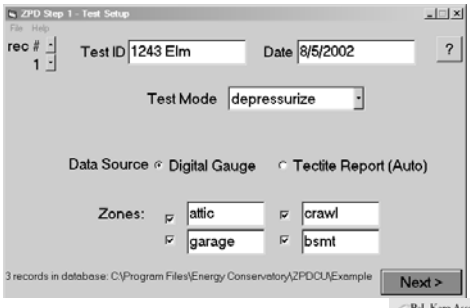
ZPD Utility by Energy Conservatory



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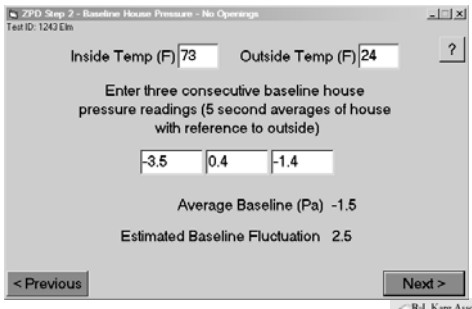
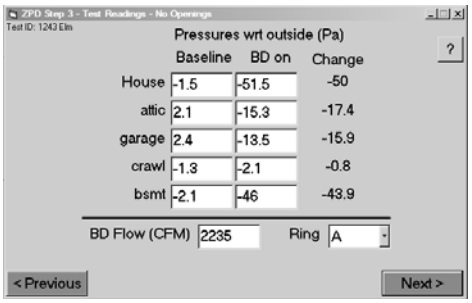
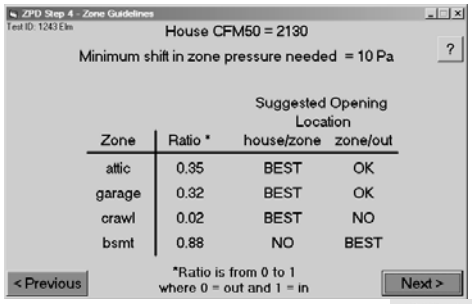
ZPD: The Hole Story (Intermediate)



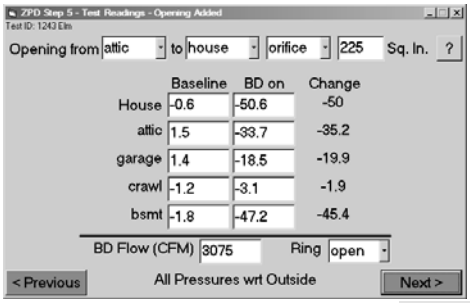
ZPD: The Hole Story (Intermediate)



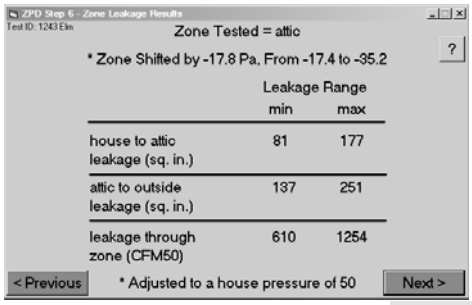
ZPD: The Hole Story (Intermediate)



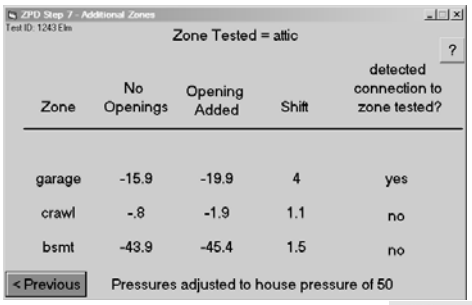
ZPD: The Hole Story (Intermediate)



ZPD: The Hole Story (Intermediate)



ZPD: The Hole Story (Intermediate)



ZPD: The Hole Story (Intermediate)

Some ZPD Standards

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ZPD: The Hole Story (Intermediate)

Attached Garage Hazard

CFM_{50} = 200 flow between house and garage is OK?

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ZPD: The Hole Story (Intermediate)

Leakage to Attic

Wisconsin Wx target: 10% or less of whole-house leakage to attic!

Example:
If whole-house leakage is CFM_{50} of 2200,
Attic total path leakage should be CFM_{50} of 220 or less.

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