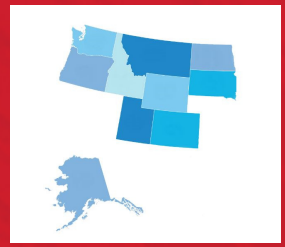
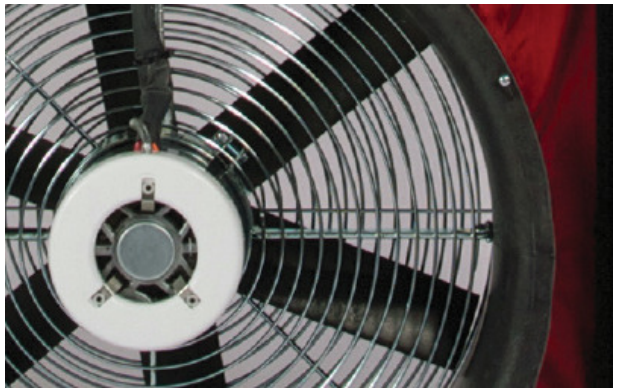
Regions 8 and 10 Conference | Fargo



Zone Pressure Diagnostics



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Paul Morin

Agenda

- Understanding pressures
- Intro to Zone Pressure Diagnostics
- Why aligning boundaries is important
- When to take direct zone measurements
- When to use advanced ZPD
- How to take the best measurements

Intro

- How many use Blower Doors regularly
- Using Infrared with Blower Door
- Doing Blower Door guided air sealing
- Zonal Pressures
  - Taking measurements
  - Using measurements to guide your work
- Pressure Pan Testing

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Intro

- What are you testing?
  - Attics, Garages, Crawlspace, Wall / Floor Cavities…
- How are you testing?
  - Direct Pressure
  - Charts
  - Calculators

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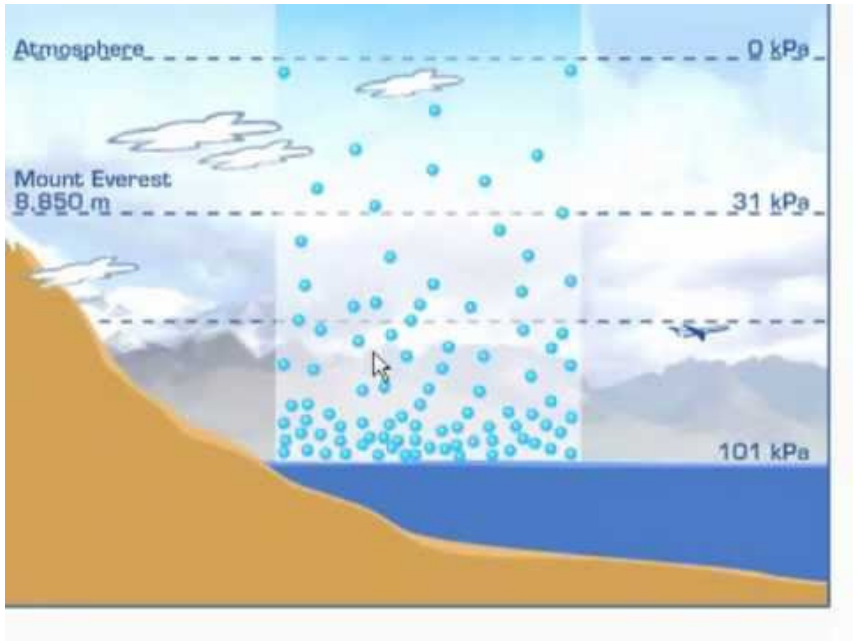
Understanding Stack Affect

- 1 atmosphere = 101,000 Pascals
- Or about 3 Pascals per foot of elevation
- Cold air is denser than warm air



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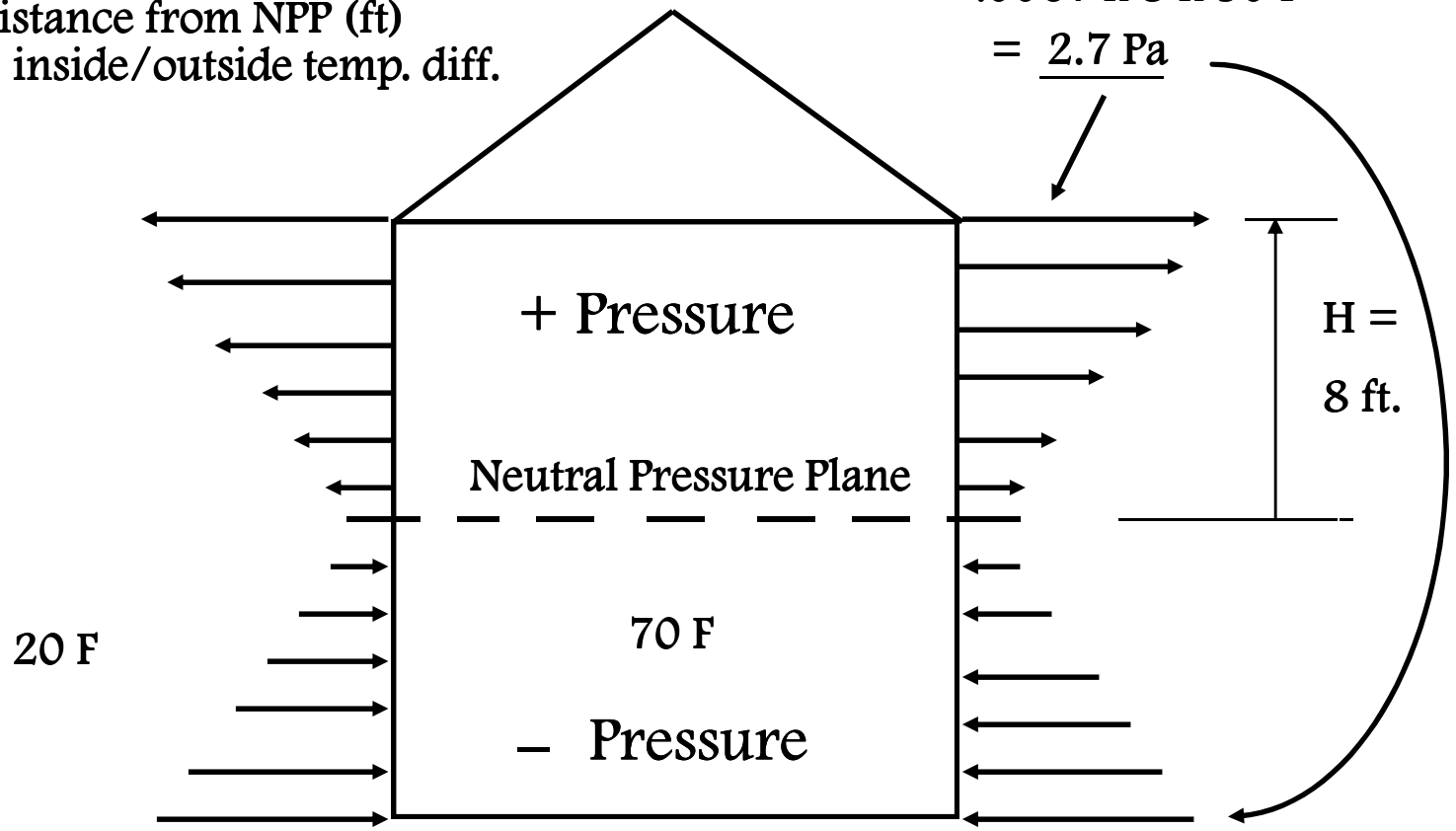
STACK EFFECT

Stack Pressure (Pa) =
(0.0067 x H x ΔT)

H = distance from NPP (ft)
△ T = inside/outside temp. diff.

At Top and Bottom:

Stack Pressure =
.0067 x 8 x 50 F
= 2.7 Pa



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STACK EFFECT

Stack Pressure (Pa) =
(0.0067 x H x ΔT)

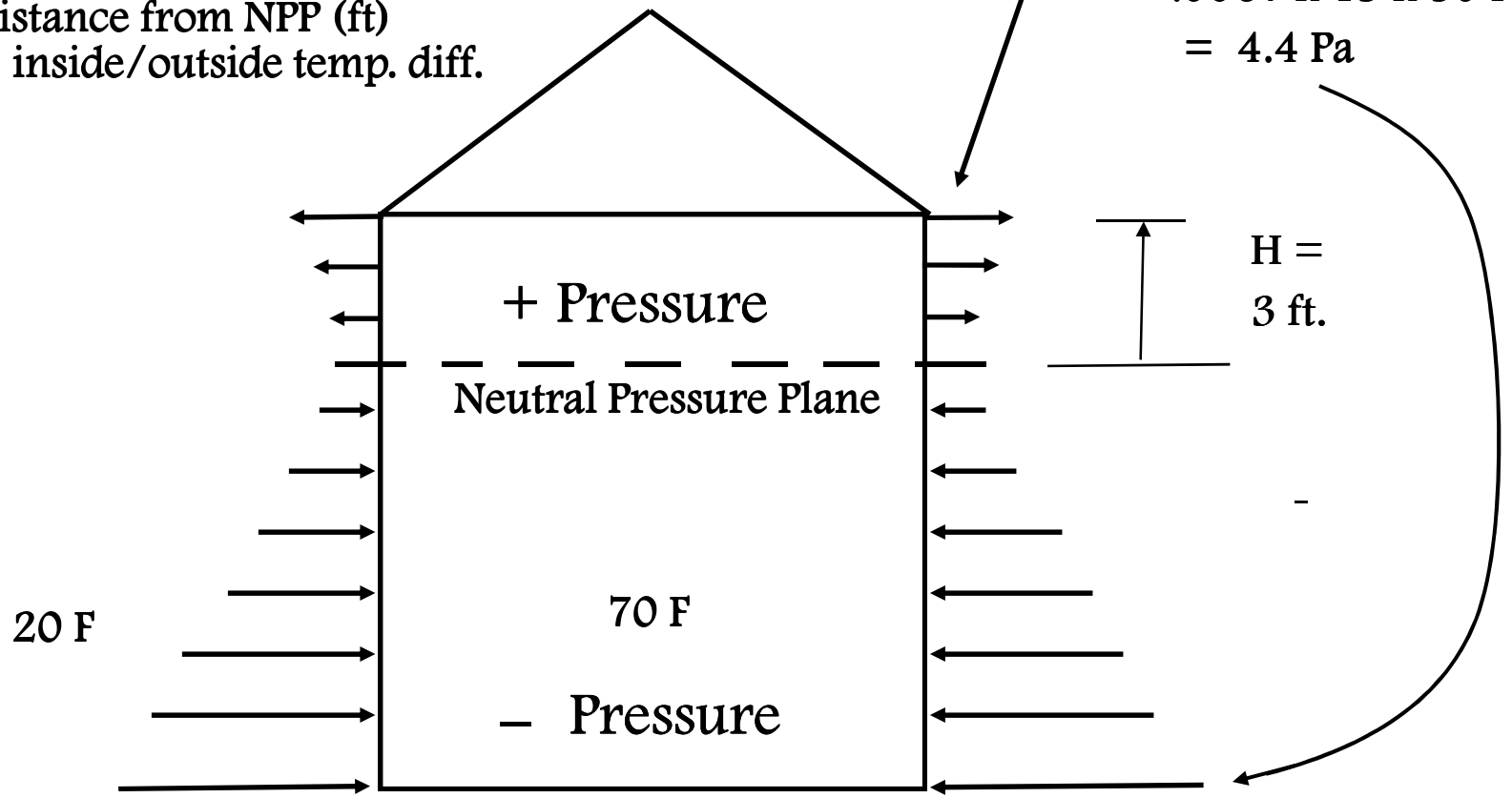
H = distance from NPP (ft)
△ T = inside/outside temp. diff.

At Top:

.0067 x 3 x 50 F
= 1.0 Pa

At Bottom:

.0067 x 13 x 50 F
= 4.4 Pa



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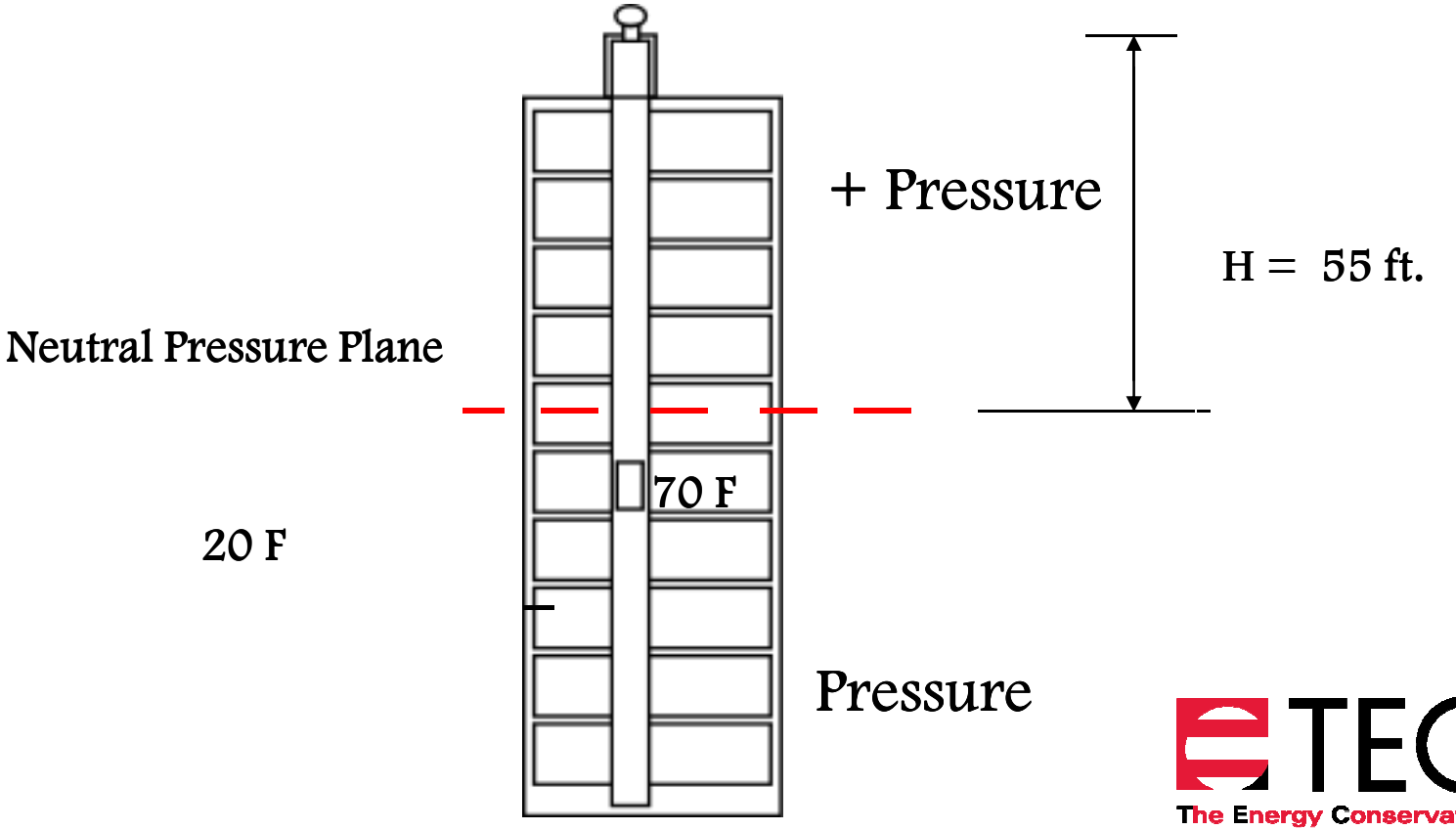
STACK EFFECT

Stack Pressure (Pa) =
(0.0067 x H x ΔT)

H = distance from NPP (ft)
△ T = inside/outside temp. diff.

At Top and Bottom:

Stack Pressure =
.0067 x 55 x 50 F
= 18 Pa



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Pascal's Principle

- When flow is added or removed from a single zone building, the pressure in the building changes by exactly the same amount everywhere.

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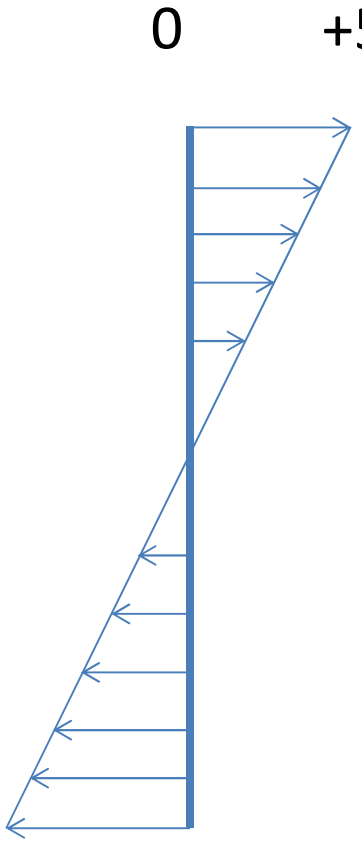
Baseline Pressures

SIDE ELEVATION



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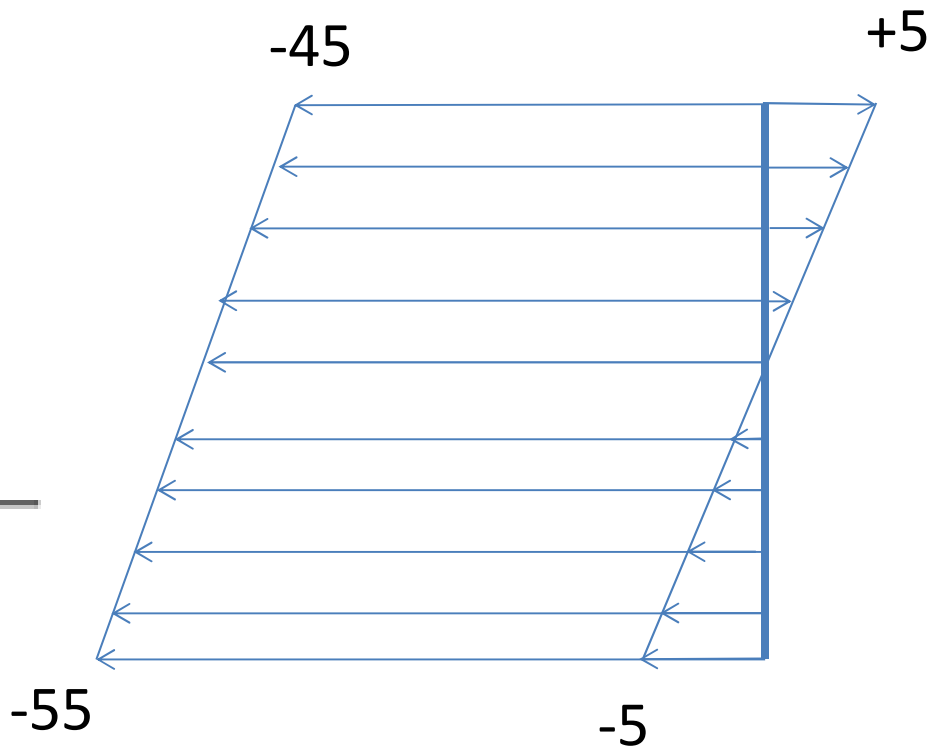
-50 Pa Induced Pressure

SIDE ELEVATION



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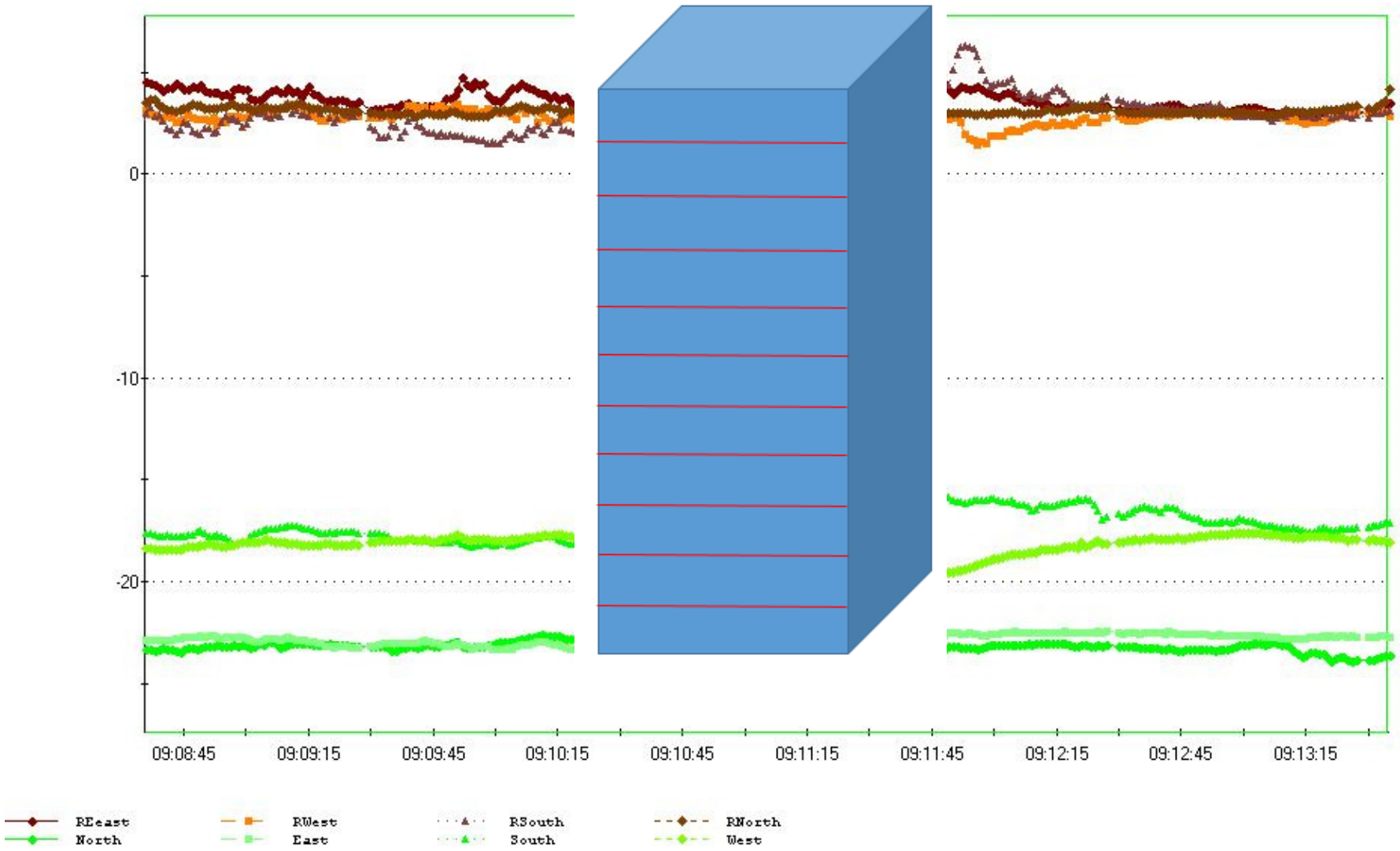
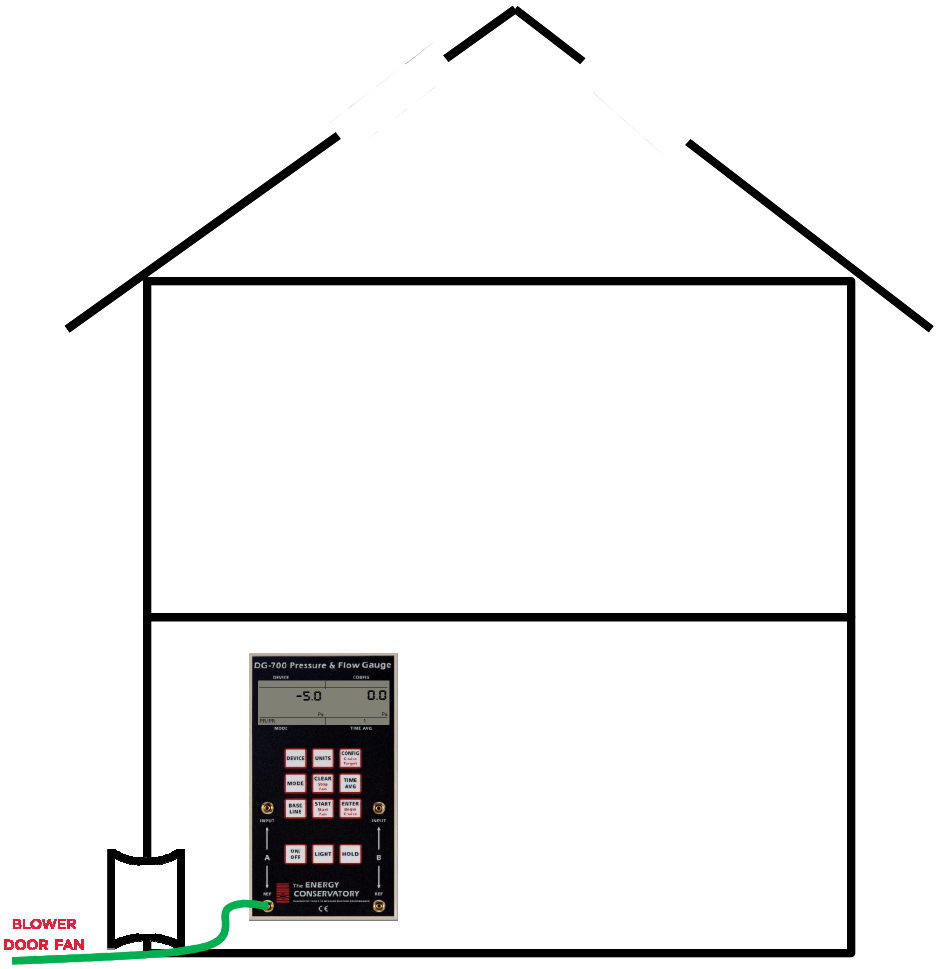
Understanding Pressures





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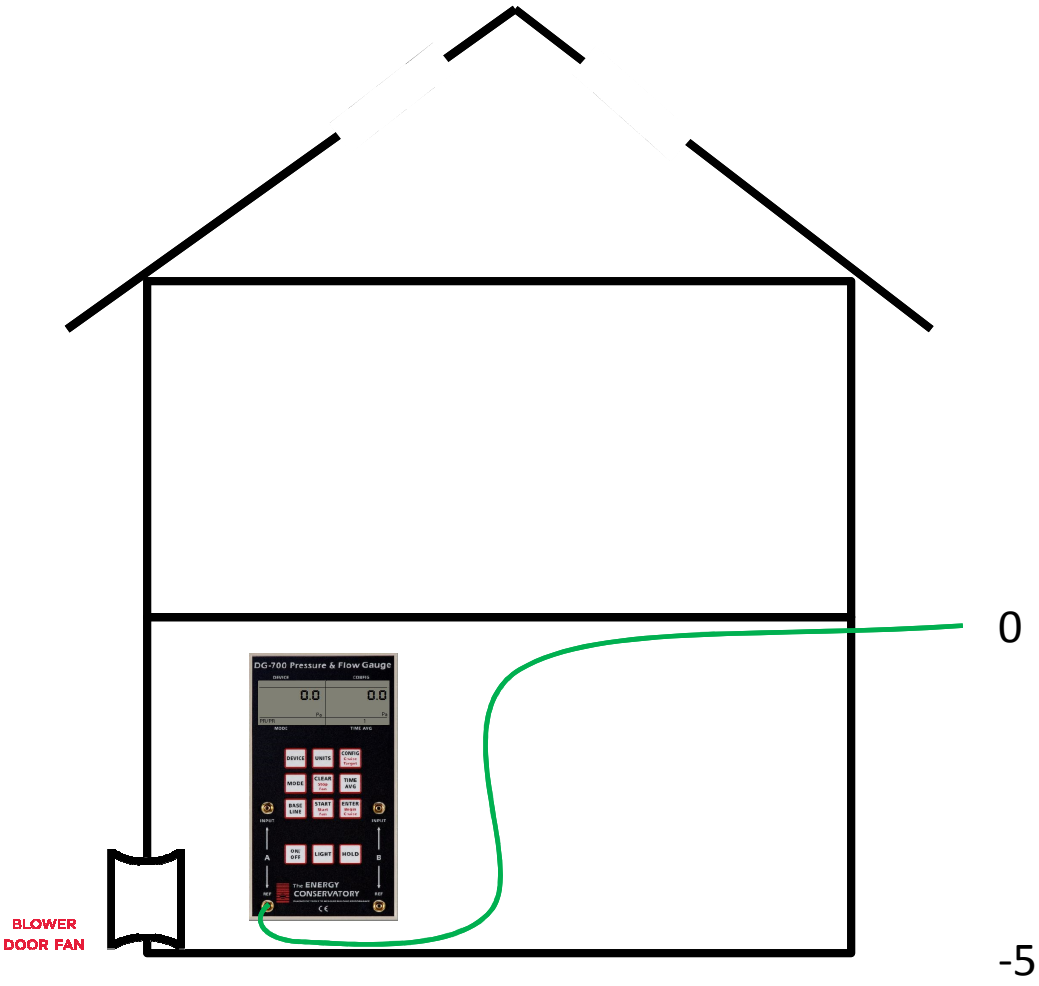

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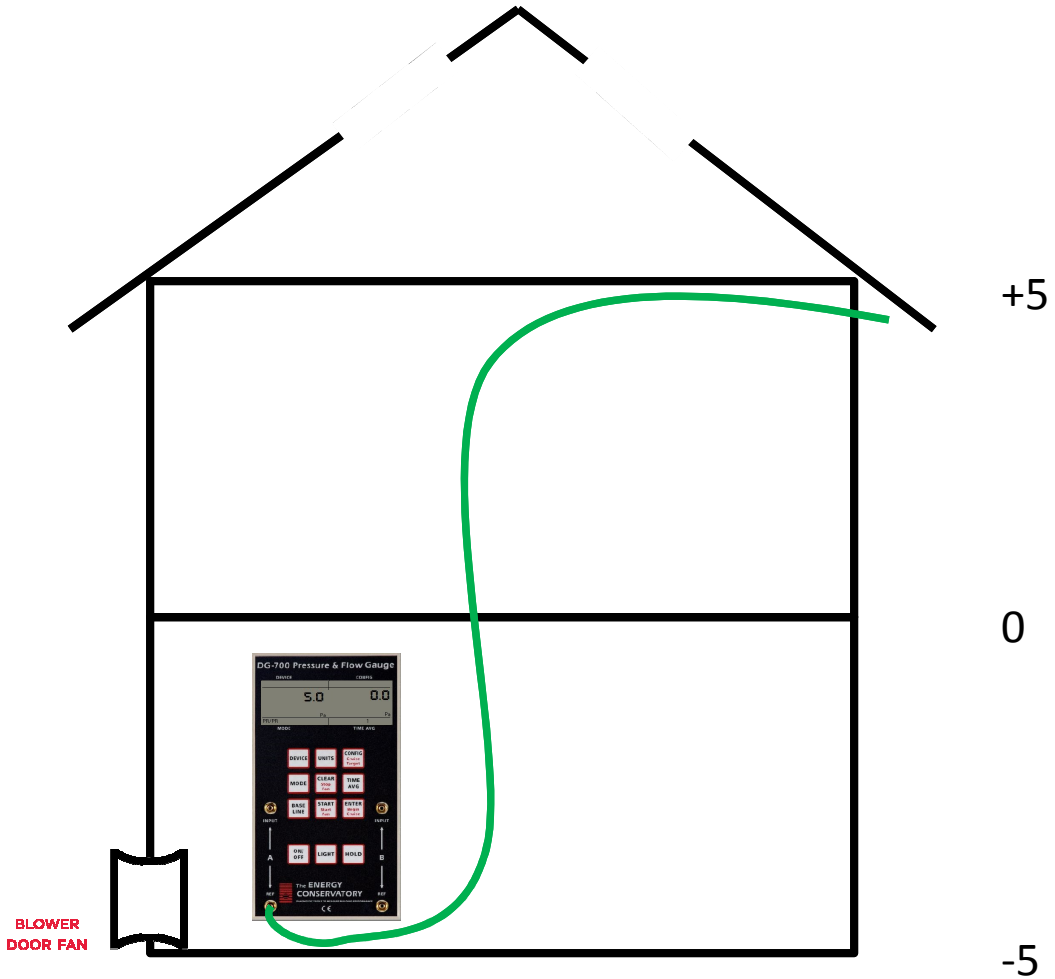

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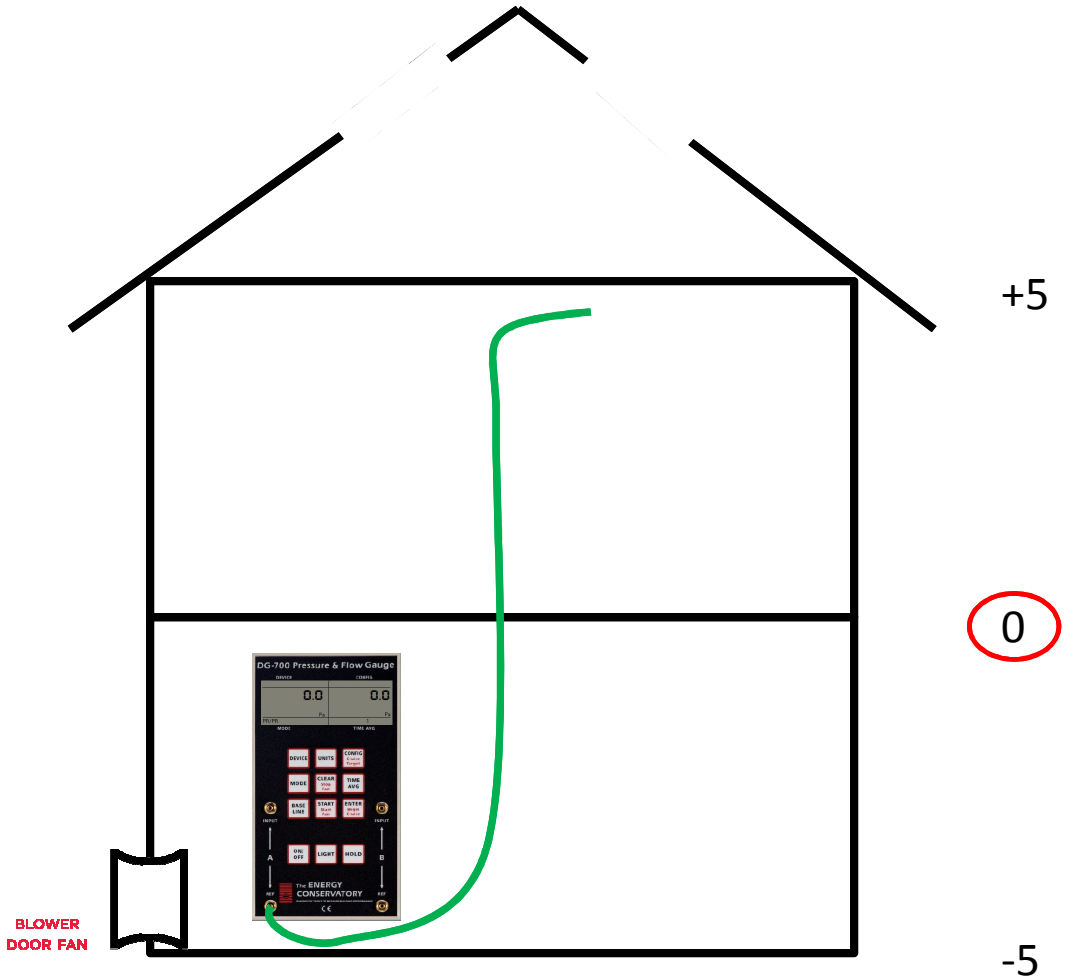

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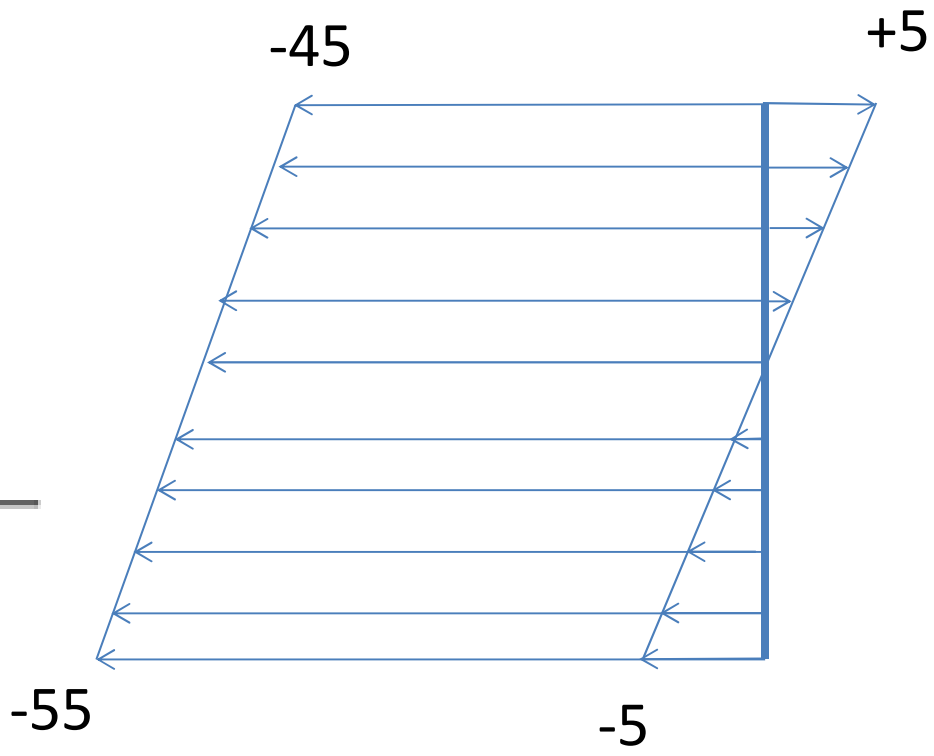
Pressure diagnostics - Important to measure baseline pressures

SIDE ELEVATION



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Wind Effect

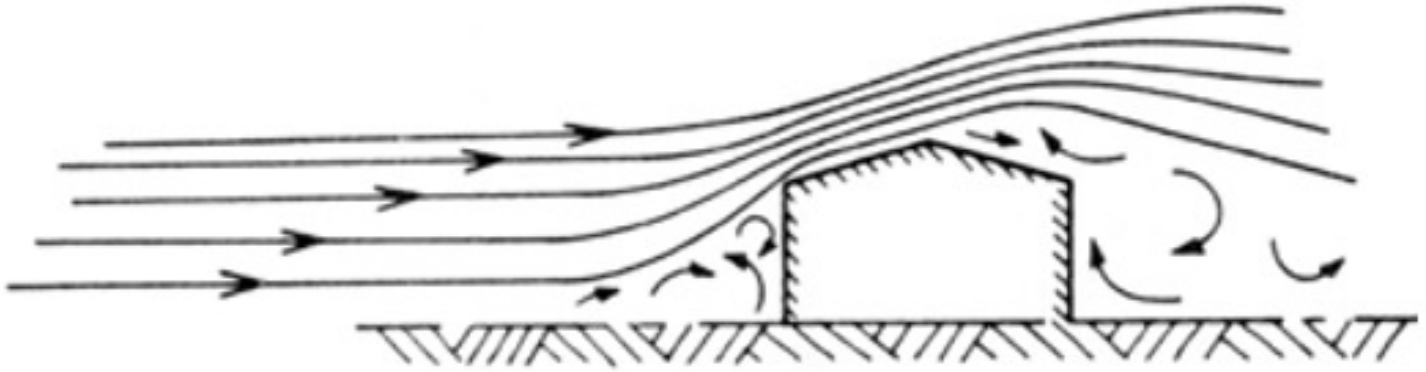

Figure 20 Flow lines around a simple building shape

CMHC Research - Canadian Building Digests

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Stack Effect + Wind Effect = Baseline

- Put outside reference tube on leeward side of the house
- Use time averaging
- On windy days use software
- Important to baseline:
  - Blower door test
  - Zonal pressure numbers

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ZPD Basics

- **What do we need to know:**
- Where is the air barrier (Pressure Boundary) so we can determine where to air seal
- Do the Pressure Boundary and insulation (Thermal Boundary) line up
- Are zones with poor air quality, such as garages or crawlspaces connected to the indoors
- Is warm moist air getting into cold attics
- How much can I reduce my blower door number by sealing the attic

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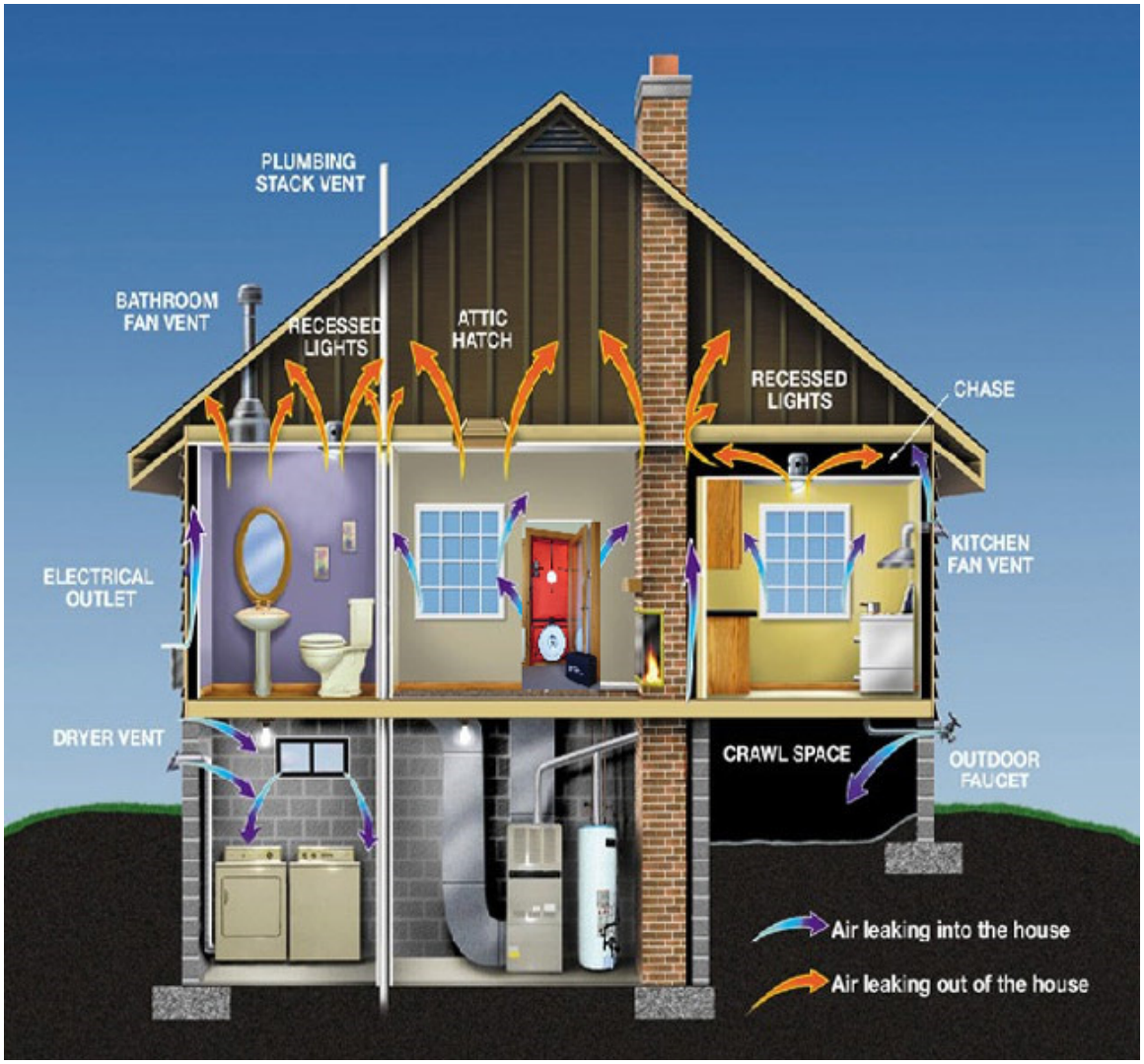
Intro to ZPD



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S-65
Genie
54


23
22
21
20
19
18
FIBER GLASS
LOOSEFILL
INSULATION

Pressure / Thermal Boundary

- Visible signs of boundary issues
  - Ice dams
  - Uneven snow melt
  - Attic moisture issues
- IR with Blower door
  - Attic temperature
- Two options when aligning boundaries
  - Seal attic bypasses
  - Add attic venting

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Adding Attic Venting

- Goal is to keep attic temp and RH same as outside
- Ice dam prevention can be different from energy saving goal
- Intake = exhaust
- Soffit vents + bypasses = roof vents
- No soffit vents = warm attic in winter
- Gable vents can be effective for a low attic

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Adding Attic Venting

- Adding venting alone:
  - Will make direct ZPD numbers look better
  - Increases CFM50
  - Can increase attic condensation and frost

- ZPD can help you determine how much effective attic venting you have

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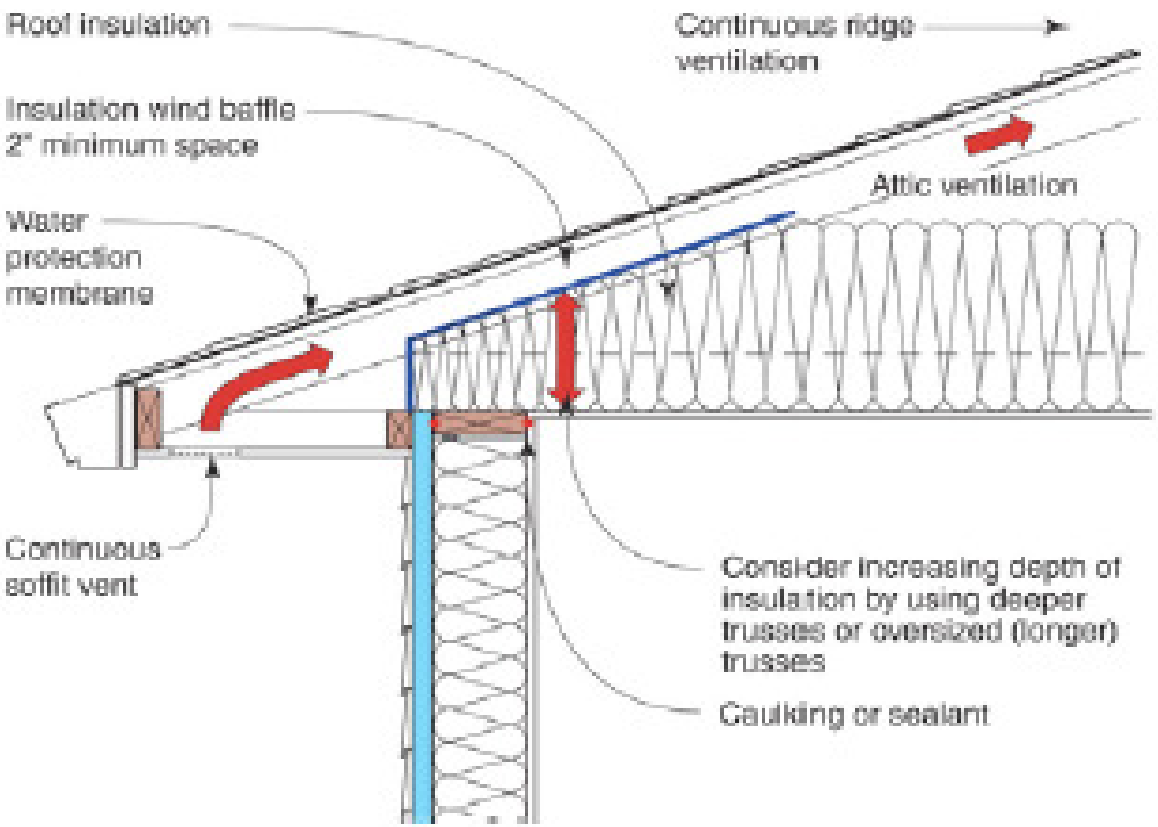
Attic Venting



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Intro to ZPD

Zone Pressures			Relative Size of Leaks	
Zone-House	Zone-Out		Zone-House	Zone-Out
12	38		2	1
25	25		1	1
37	13		½	1
41	9		1/3	1
45	5		¼	1
48	2		1/8	1
49	1		1/13	1

Sources: Michael Blasnik and Jim Fitzgerald

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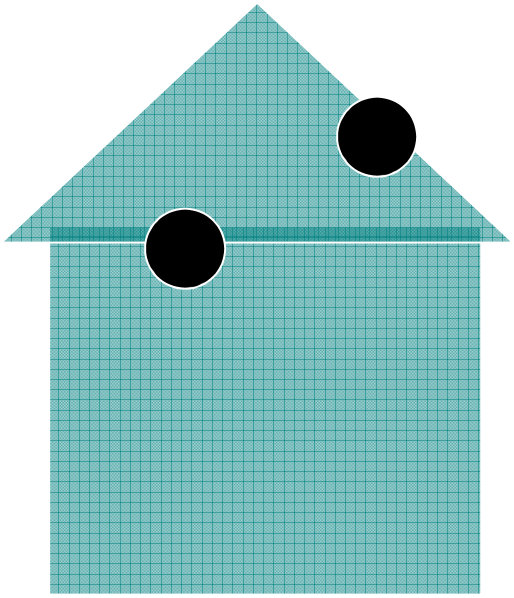
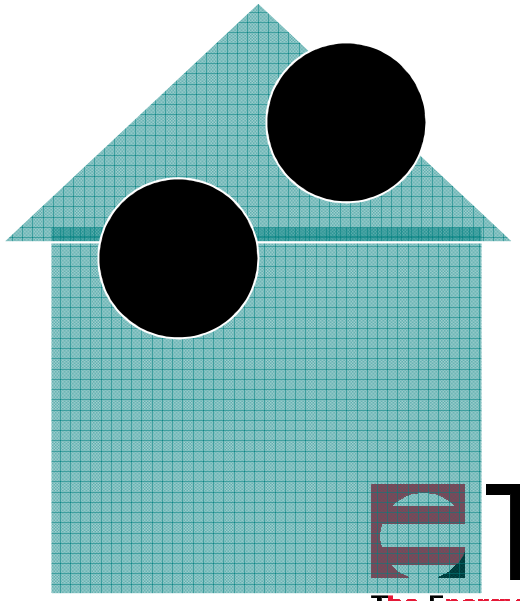
Intro to ZPD

Attic Zonal Reading of 25pa

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





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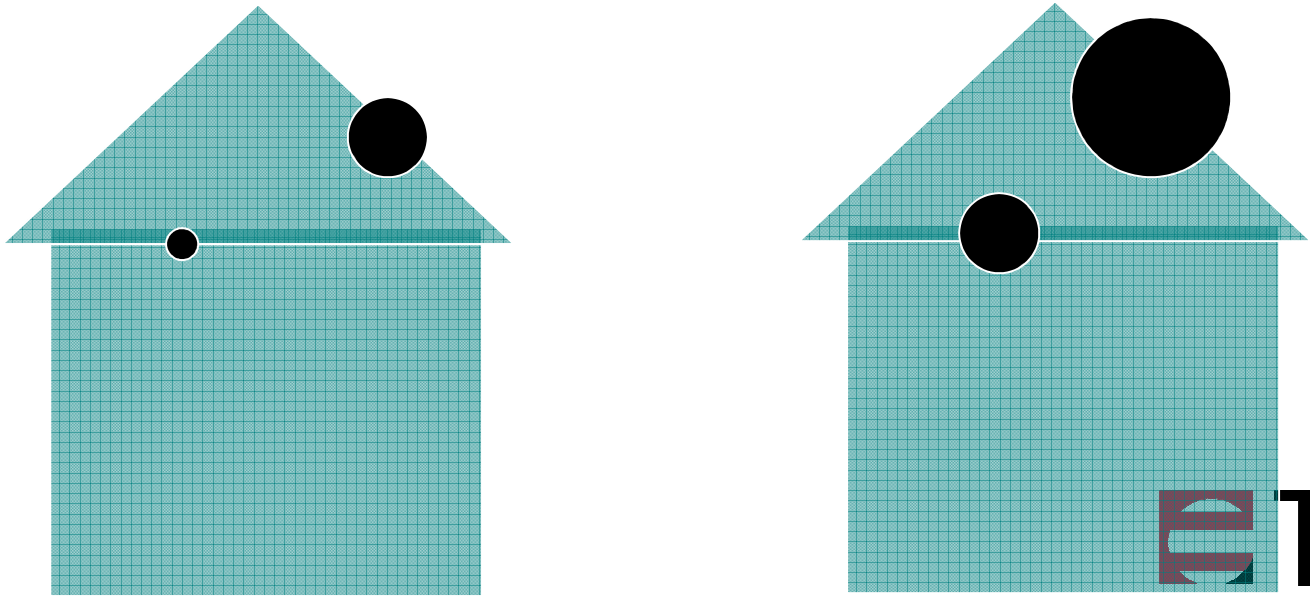
Intro to ZPD

Attic Zonal Reading of 48pa

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



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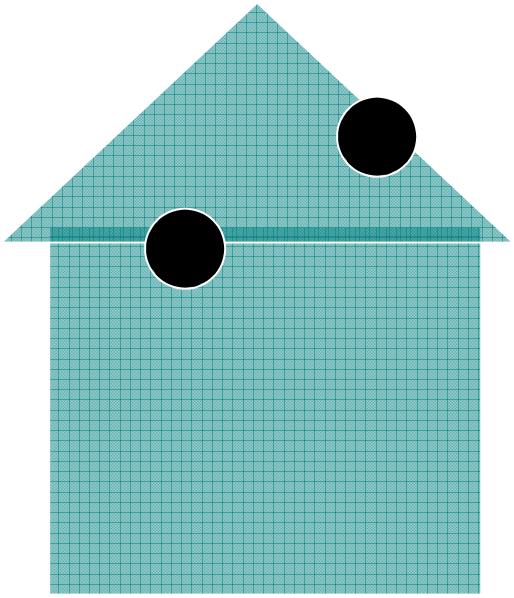
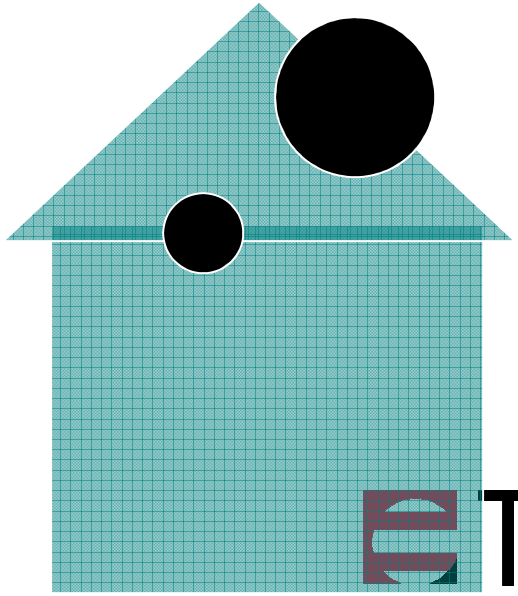
Intro to ZPD

Attic Reading of 25 Pa



Attic Reading of 48pa



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Direct ZPD Measurements

- Measure pressure change caused by blower door
- Examples:
  - Joist cavities in 1 ½ story house
  - Kitchen soffit
  - Attached porch roof

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Direct ZPD Measurements

- Misuses of Direct ZPD Measurements
  - Assume that a high house to attic number means air sealing is done
  - Set a house to attic target of 45 Pa or higher

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Direct ZPD Measurement Objectives

- Is a zone more connected to inside or outside
- Does Pressure Boundary and Thermal Boundary line up

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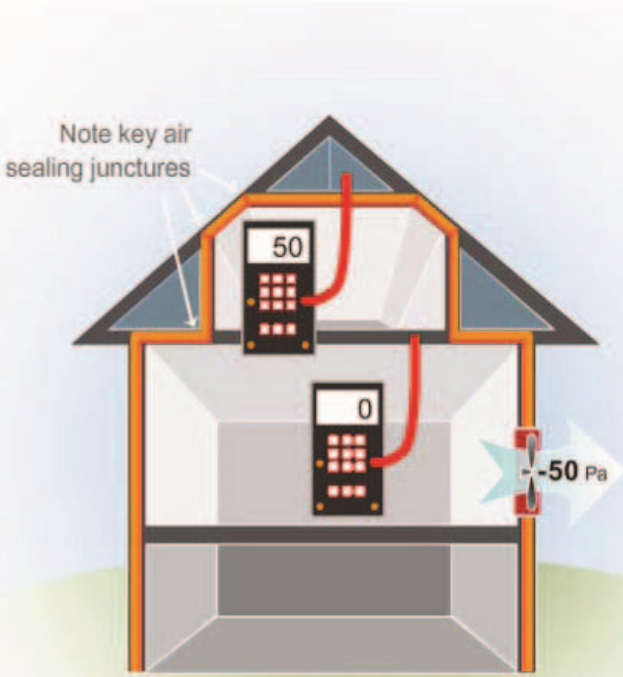
Direct ZPD Measurements



One-and-a-Half Story Cape Cod

Heated first and second floor rooms over a heated basement

☑ Air Sealed

☑ Insulated

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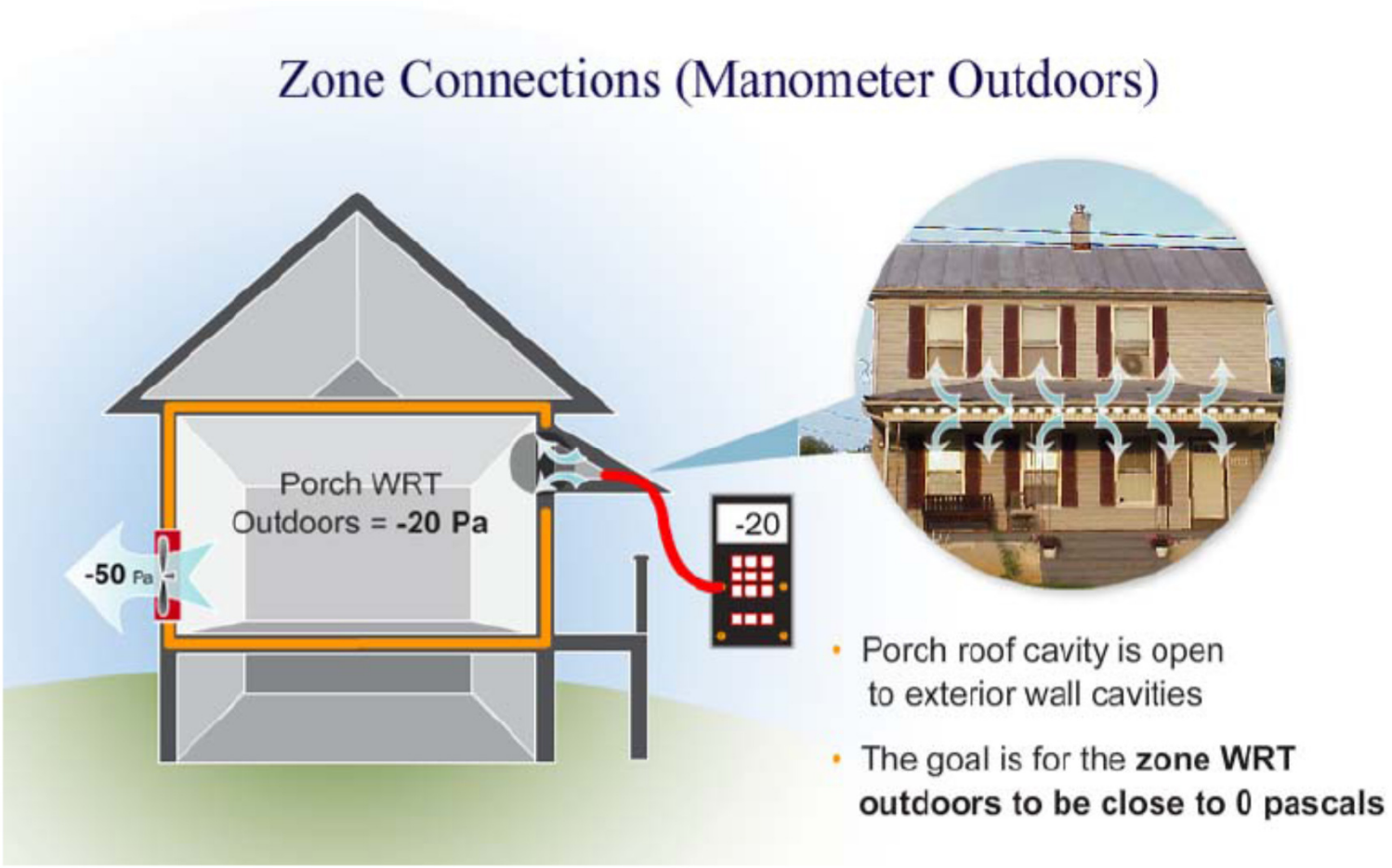
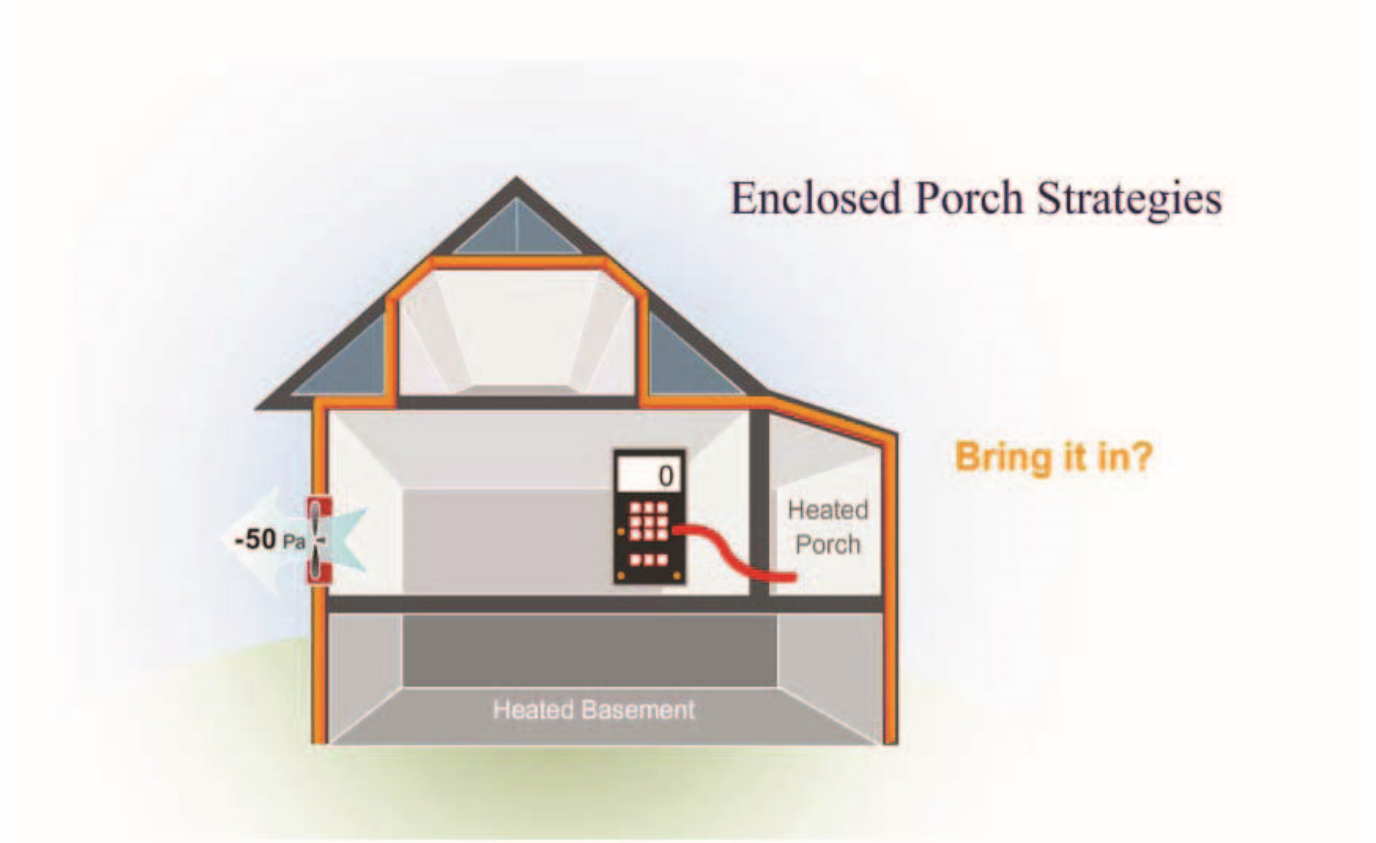
Direct ZPD Measurements



Direct ZPD Measurements



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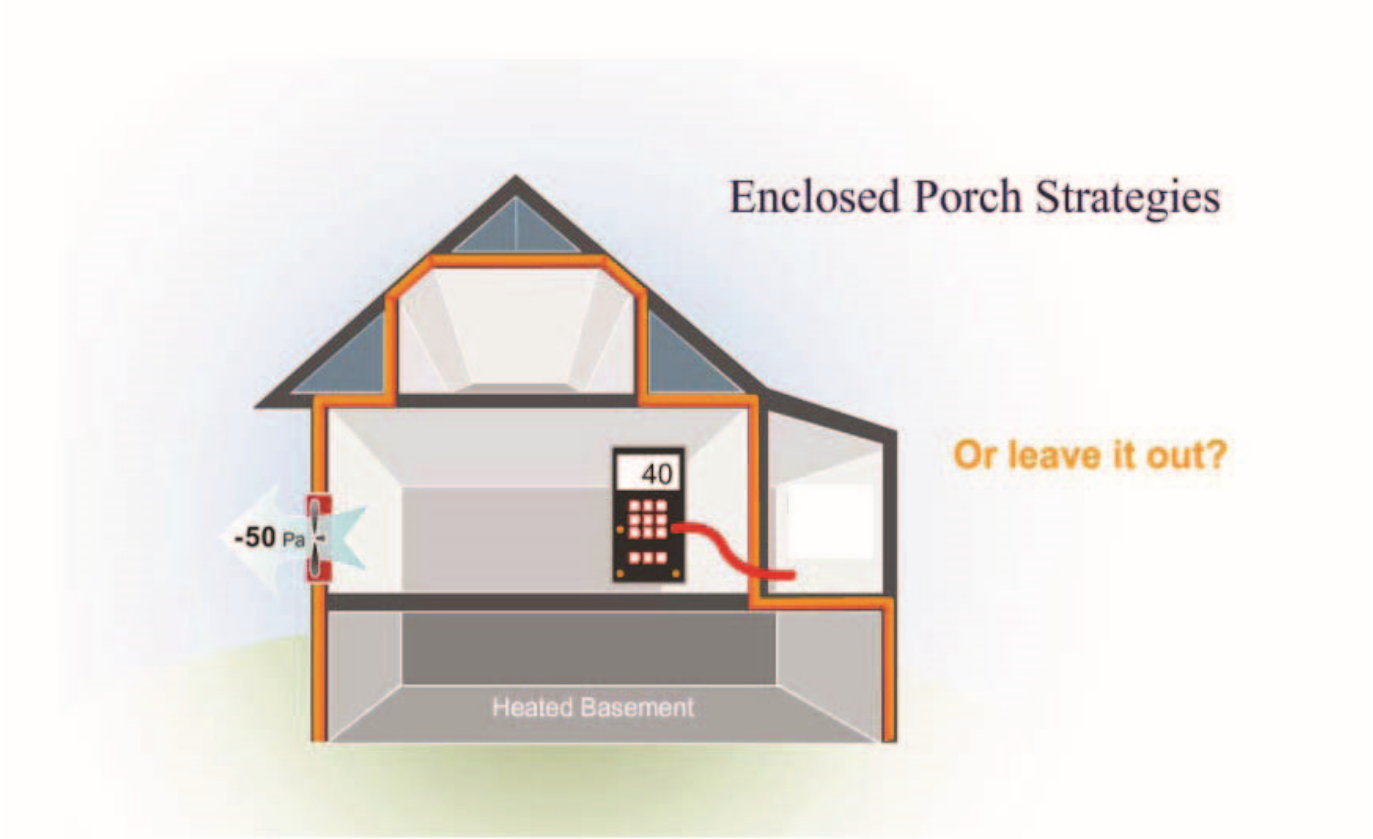
Direct ZPD Measurements



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ZPD Objectives

Advanced ZPD Measurement

- Determine leakage from building to outside
- Help access IAQ issues, such as CO from attached garage and bad air from crawl spaces
- Determine effectiveness of air sealing, pre and post
- Makes air sealing targets possible

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What is Advanced ZPD

- Using software or charts to calculate cfm leakage between the house and a zone
- Requires adding a hole or opening a door house to zone or zone to outside
- The expected value must be greater than the cost of performing the test.

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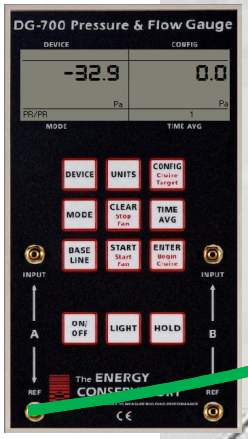
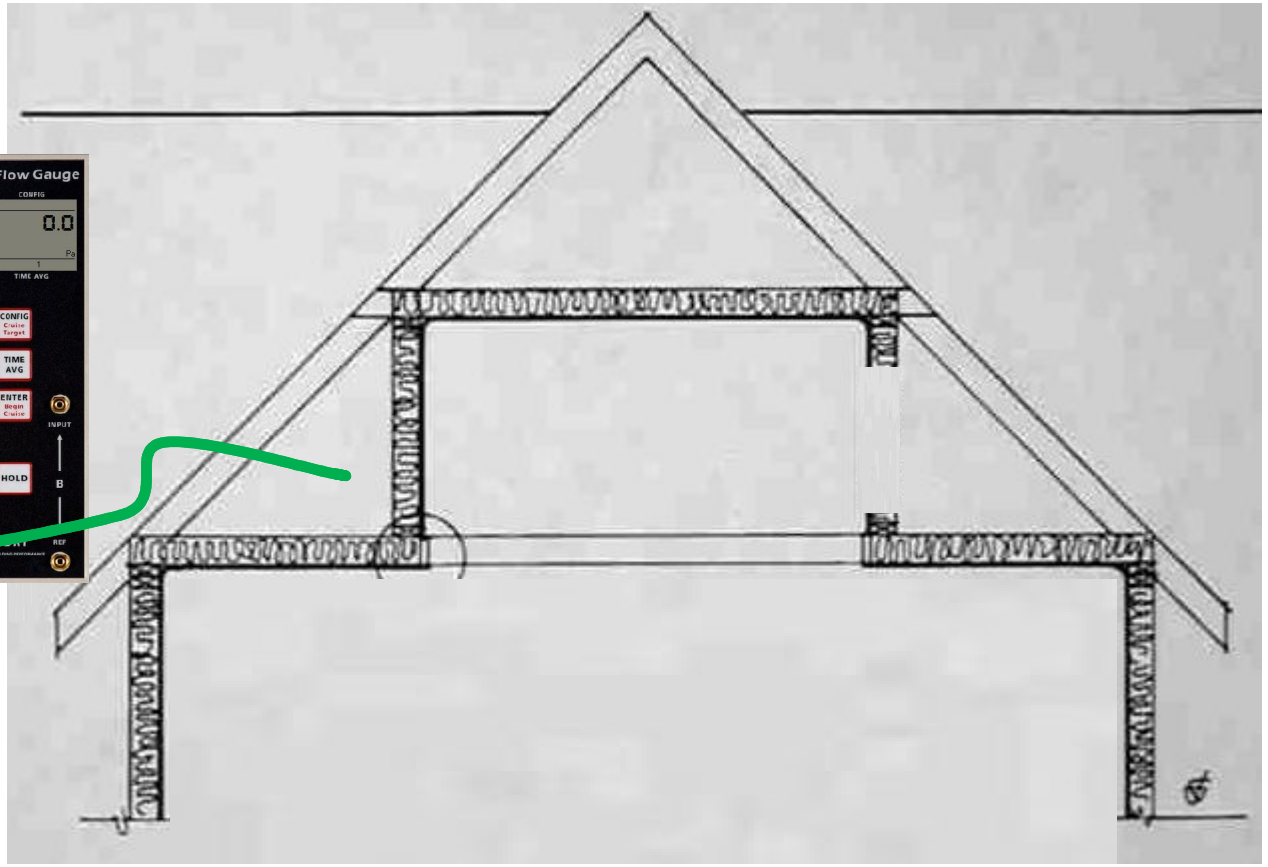
Interconnected Zones





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Calculating the Results

- ZPD Trainer with Cox / Olson charts
- TECTITE and ZPD calculation utility software
- RED ZPD Calc Tool

RED
RESIDENTIAL ENERGY DYNAMICS
INNOVATIVE SOFTWARE SOLUTIONS

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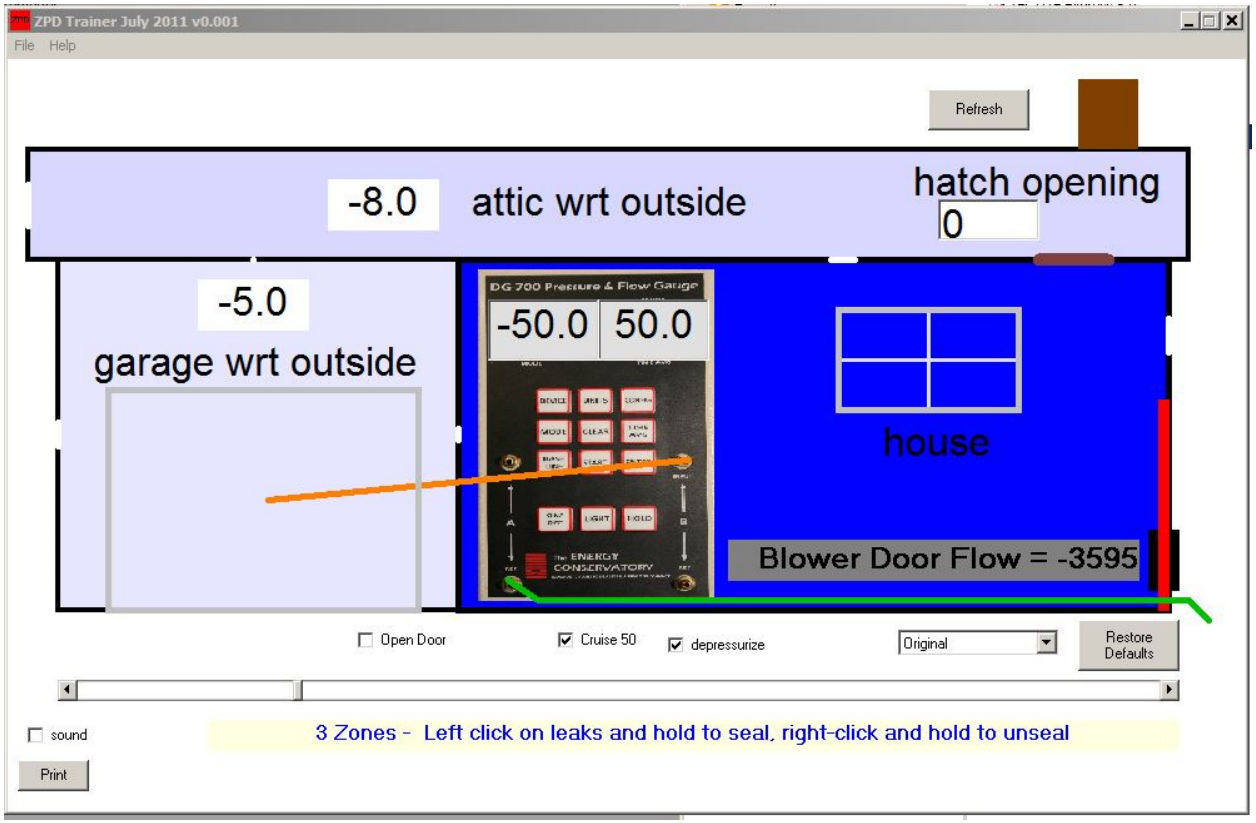
ZPD Trainer Demo



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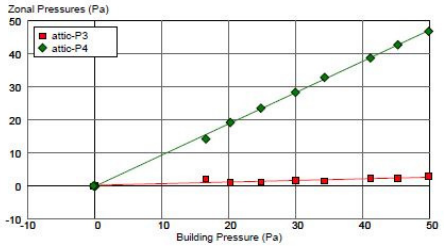
TECTITE to Gather the Data

Date of Test: 5/8/2017 Test File: 5-8-17 after hatch



Zone Name	Reference	Building to Zone @50Pa (Pa)	Zone to Outside @50Pa (Pa)	+/- Zone Pressure (Pa)	Pressure Ratio	+/- Pressure Ratio
attic-P3	out	47.52	2.48	0.47	0.050	0.009
attic-P4	in	47.40	2.60	0.51	0.052	0.010

Nominal Building Pressure (Pa)	attic-P3 Pressure (Pa)	attic-P4 Pressure (Pa)
0.11	0.21	-0.11
49.90	2.90	46.85
45.26	2.38	42.75
41.20	2.37	38.80
34.34	1.46	32.88
30.00	1.72	28.33
24.87	1.25	23.56
20.26	0.99	19.26
16.65	2.26	14.29
-0.21	-0.12	-0.06

Zone Data Report Page 2 of 2

Date of Test: 5/8/2017 Test File: 5-8-17 after hatch

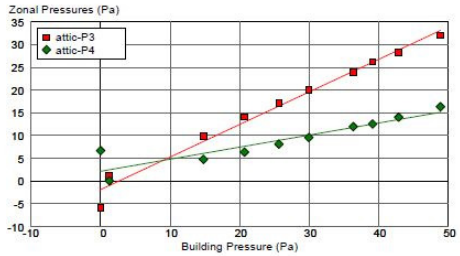
ZPD Input Table

Building Baseline Standard Deviation: 0.12 Pa

Zone Name	Zone to Outside Pressure @50 Pa
	-2.48
	-2.60

Blower Door Flow: 1218 CFM
Largest Ring Used: Ring A

Date of Test: 5/8/2017 Test File: Untitled



Zone Name	Reference	Building to Zone @50Pa (Pa)	Zone to Outside @50Pa (Pa)	+/- Zone Pressure (Pa)	Pressure Ratio	+/- Pressure Ratio
attic-P3	out	14.20	35.80	1.78	0.716	0.036
attic-P4	in	13.26	36.74	2.00	0.735	0.040

Nominal Building Pressure (Pa)	attic-P3 Pressure (Pa)	attic-P4 Pressure (Pa)
0.04	-5.89	6.74
48.92	32.08	16.36
42.90	28.33	14.06
39.15	26.22	12.56
36.37	23.96	11.98
29.99	20.01	9.61
25.68	17.23	8.15
20.72	14.16	6.40
14.83	9.86	4.79
1.27	1.18	0.07

Zone Data Report Page 2 of 2

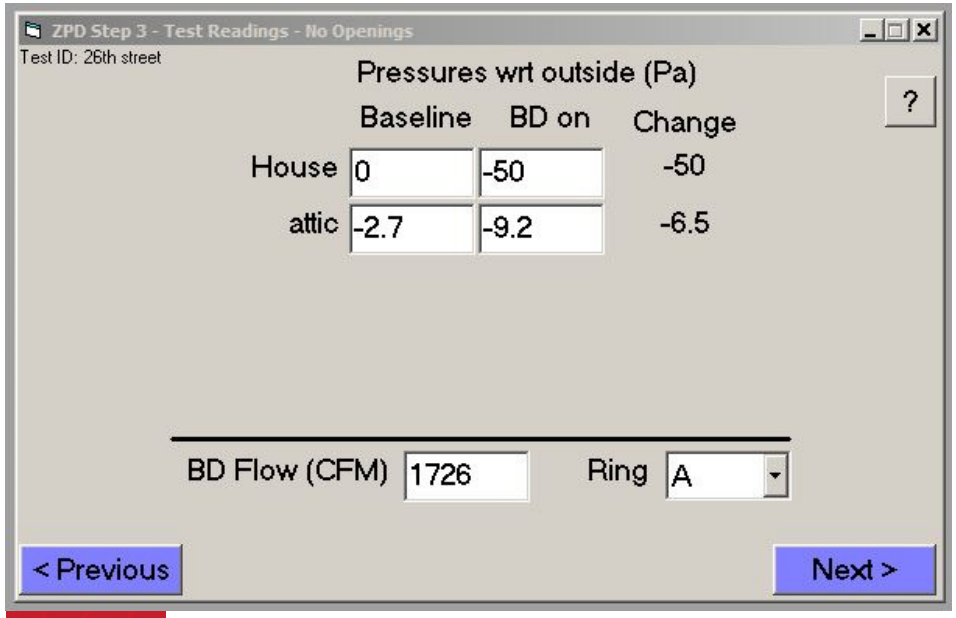
Date of Test: 5/8/2017 Test File: Untitled

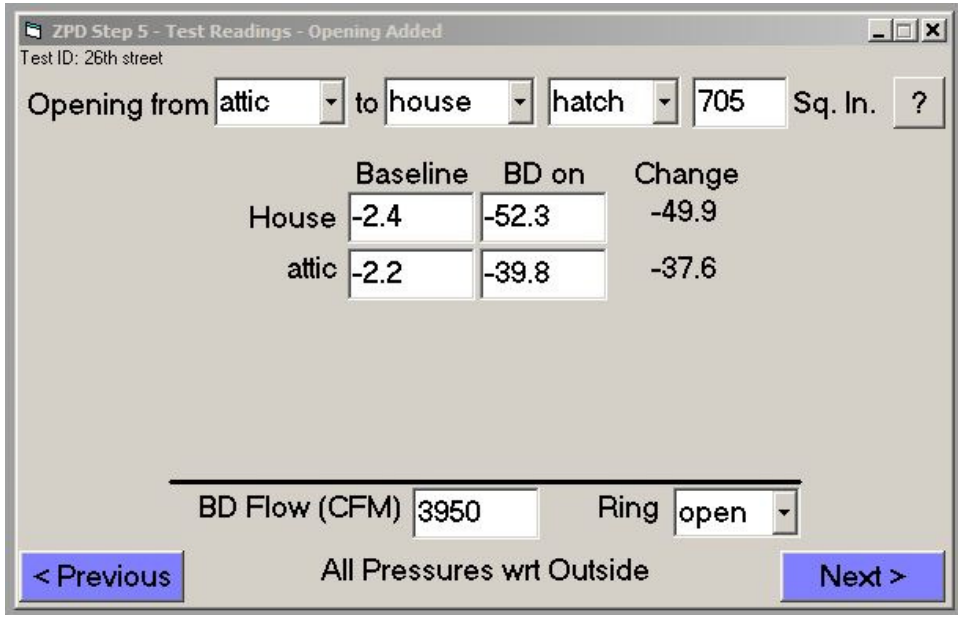
ZPD Input Table

Building Baseline Standard Deviation: 0.18 Pa

Zone Name	Zone to Outside Pressure @50 Pa
	-35.80
	-36.74

Blower Door Flow: 3748 CFM
Largest Ring Used: Open

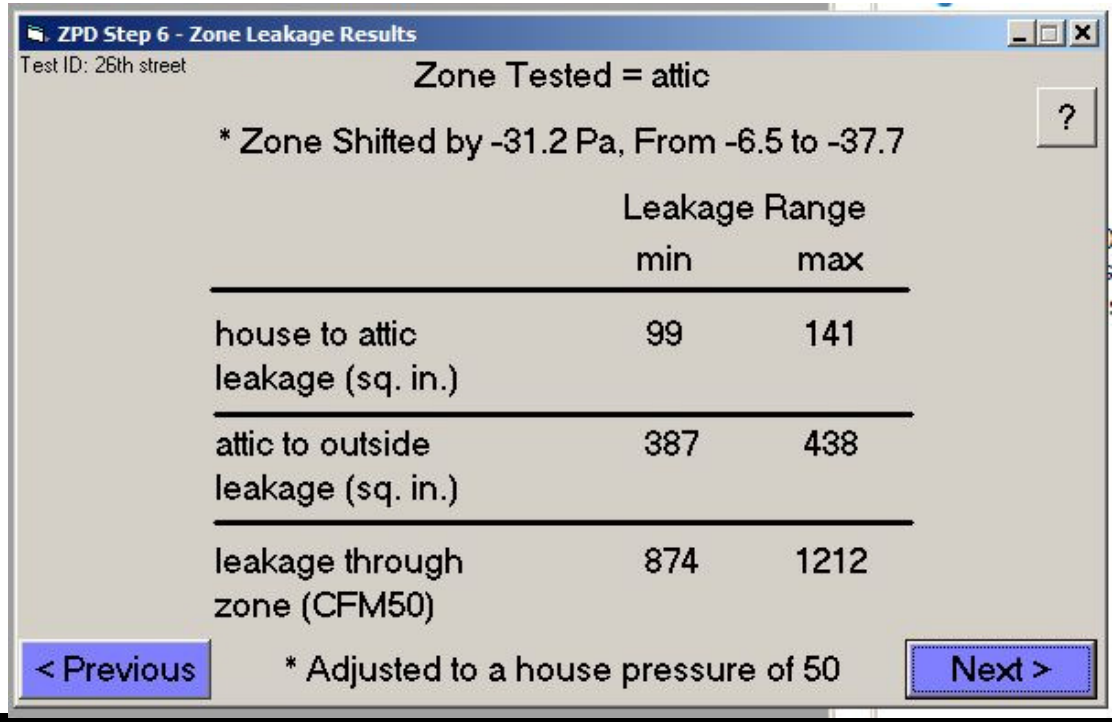


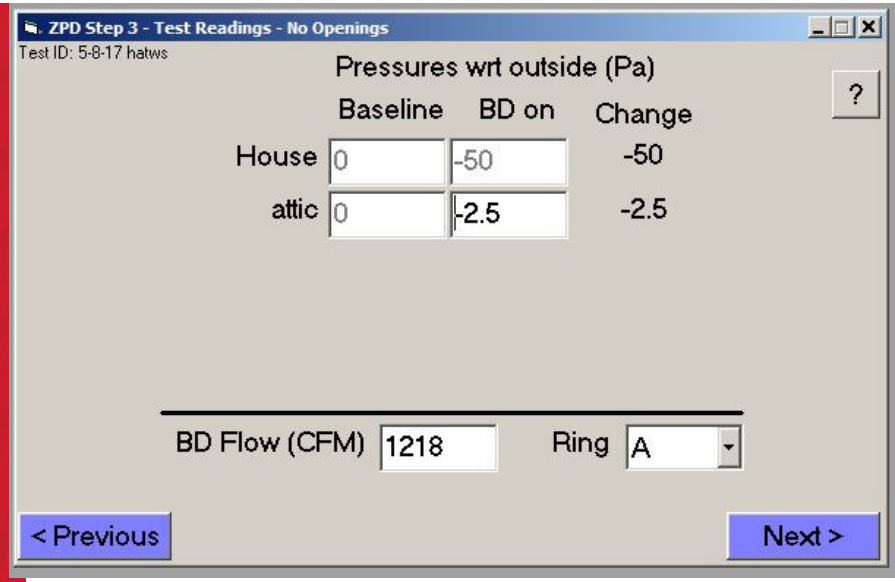


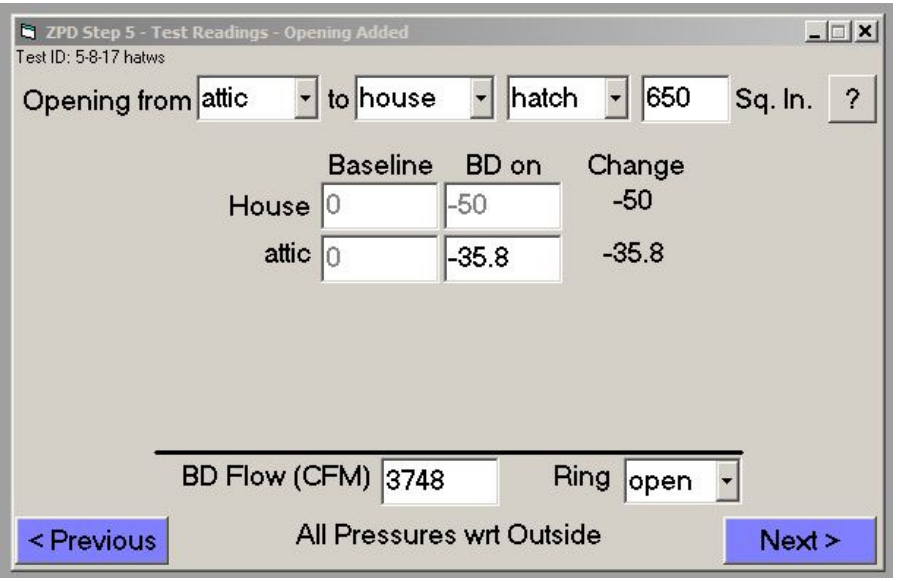
ZPDCU without TECTITE

1043 CFM50

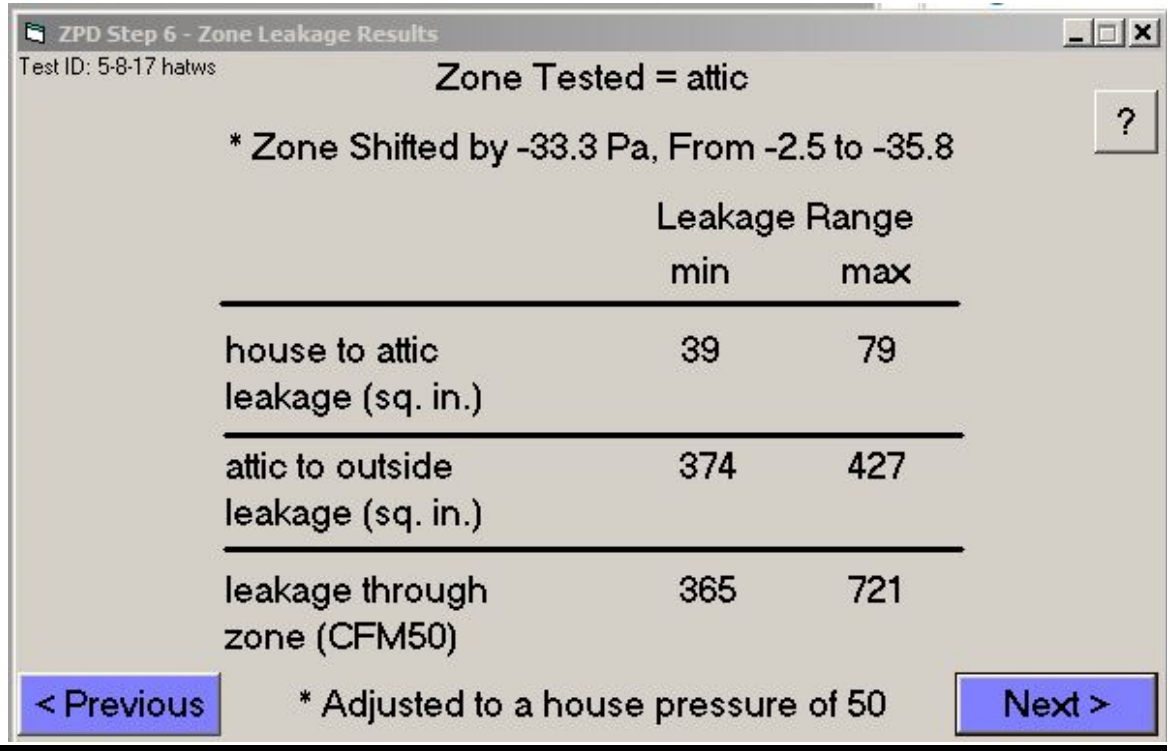
+/- 169







ZPDCU with TECTITE



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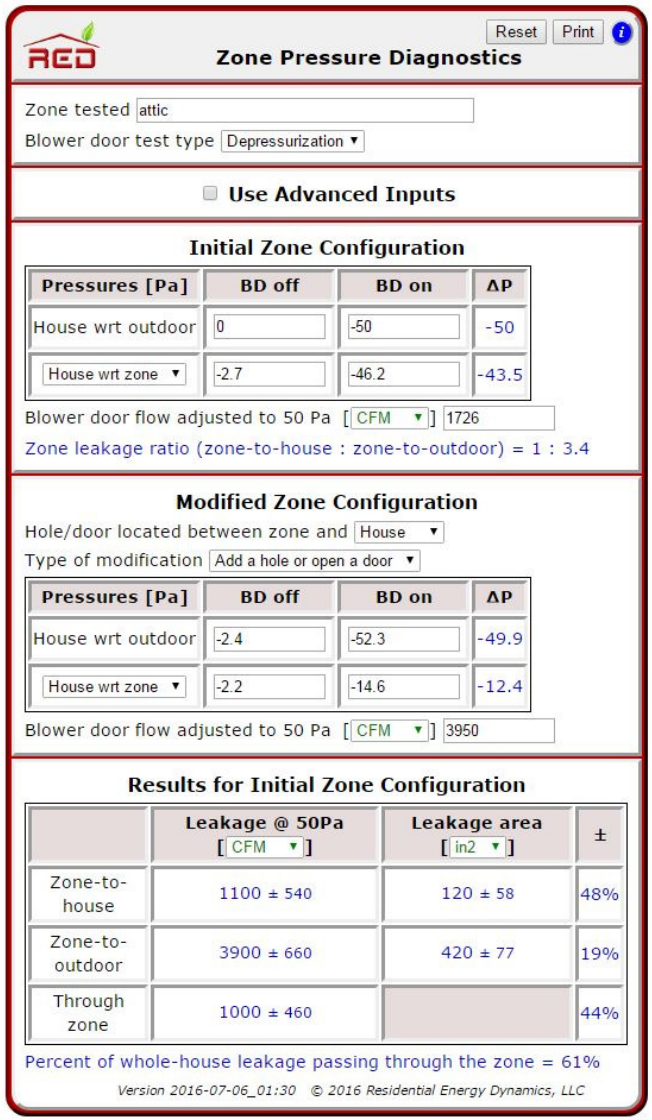
Web Based Software



RED — Reset | Print

Zone Pressure Diagnostics

Zone tested: attic
Blower door test type: Depressurization

☐ Use Advanced Inputs

Initial Zone Configuration

Pressures [Pa]	BD off	BD on	ΔP
House wrt outdoor	0	-50	-50
House wrt zone	-2.7	-46.2	-43.5

Blower door flow adjusted to 50 Pa [CFM] 1726

Zone leakage ratio (zone-to-house : zone-to-outdoor) = 1 : 3.4

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	-2.4	-52.3	-49.9
House wrt zone	-2.2	-14.6	-12.4

Blower door flow adjusted to 50 Pa [CFM] 3950

Results for Initial Zone Configuration

	Leakage @ 50Pa [CFM]	Leakage area [in2]	±
Zone-to-house	1100 ± 540	120 ± 58	48%
Zone-to-outdoor	3900 ± 660	420 ± 77	19%
Through zone	1000 ± 460		44%

Percent of whole-house leakage passing through the zone = 61%

Version 2016-07-06_01:30 © 2016 Residential Energy Dynamics, LLC

1000 CFM50
+/- 460

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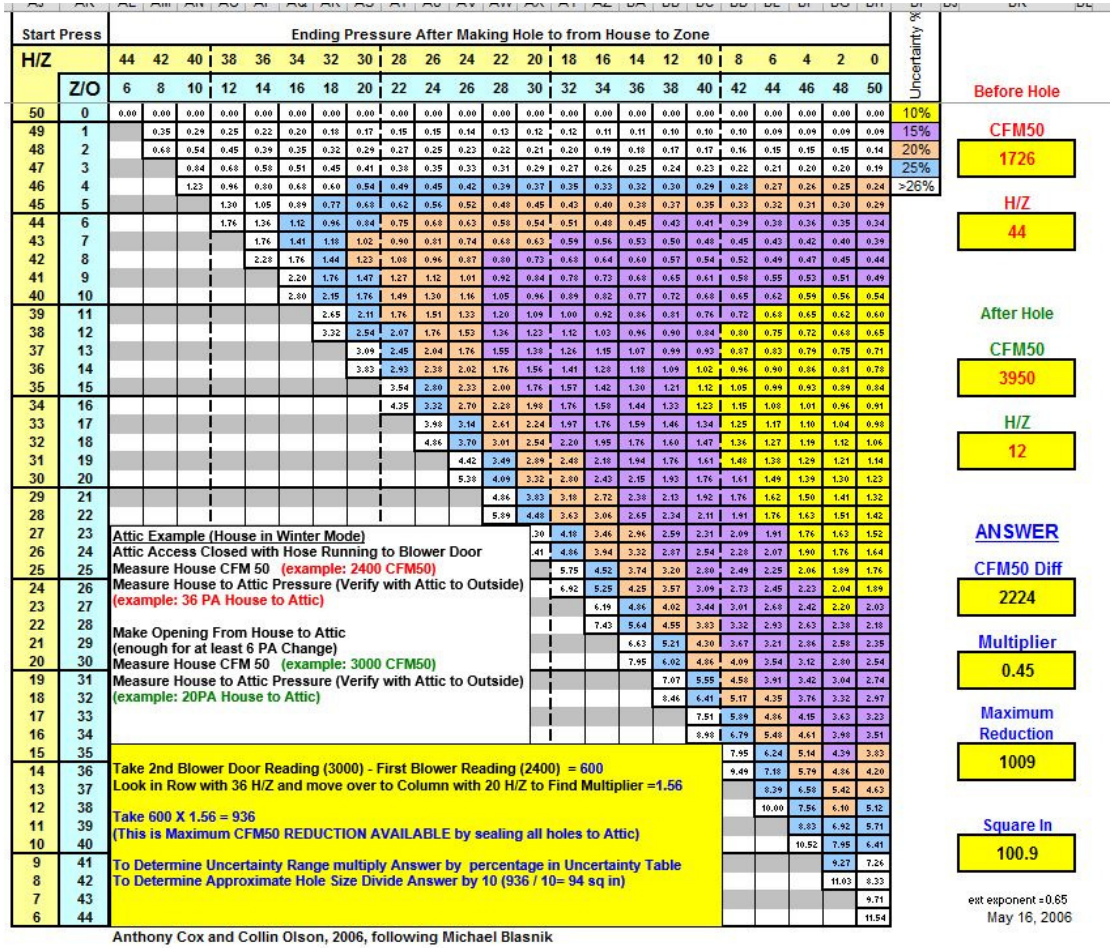
The Energy Conservatory

Cox and Olson Charts



Start Press		Ending Pressure After Making Hole to from House to Zone																							Uncertainty %
H/Z		44	42	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2	0	
	Z/O	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	
50	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10%
49	1		0.35	0.29	0.25	0.22	0.20	0.18	0.17	0.15	0.15	0.14	0.13	0.12	0.12	0.11	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.09	15%
48	2		0.68	0.54	0.45	0.39	0.35	0.32	0.29	0.27	0.25	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.17	0.16	0.15	0.15	0.15	0.14	20%
47	3			0.84	0.68	0.58	0.51	0.45	0.41	0.38	0.35	0.33	0.31	0.29	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.20	0.19	25%
46	4			1.23	0.96	0.80	0.68	0.60	0.54	0.49	0.45	0.42	0.39	0.37	0.35	0.33	0.32	0.30	0.29	0.28	0.27	0.26	0.25	0.24	>26%
45	5				1.30	1.05	0.89	0.77	0.68	0.62	0.56	0.52	0.48	0.45	0.43	0.40	0.38	0.37	0.35	0.33	0.32	0.31	0.30	0.29	
44	6				1.76	1.36	1.12	0.96	0.84	0.75	0.68	0.62	0.58	0.54	0.51	0.48	0.45	0.43	0.41	0.39	0.38	0.36	0.35	0.34	
43	7					1.76	1.41	1.18	1.02	0.90	0.81	0.74	0.68	0.63	0.59	0.56	0.53	0.50	0.48	0.45	0.43	0.42	0.40	0.39	
42	8					2.28	1.76	1.44	1.23	1.08	0.96	0.87	0.80	0.73	0.68	0.64	0.60	0.57	0.54	0.52	0.49	0.47	0.45	0.44	
41	9						2.20	1.76	1.47	1.27	1.12	1.01	0.92	0.84	0.78	0.73	0.68	0.65	0.61	0.58	0.55	0.53	0.51	0.49	
40	10						2.80	2.15	1.76	1.49	1.30	1.16	1.05	0.96	0.89	0.82	0.77	0.72	0.68	0.65	0.62	0.59	0.56	0.54	
39	11							2.65	2.11	1.76	1.51	1.33	1.20	1.09	1.00	0.92	0.86	0.81	0.76	0.72	0.68	0.65	0.62	0.60	
38	12							3.32	2.54	2.07	1.76	1.53	1.36	1.23	1.12	1.03	0.96	0.90	0.84	0.80	0.75	0.72	0.68	0.65	
37	13								3.09	2.45	2.04	1.76	1.55	1.38	1.26	1.15	1.07	0.99	0.93	0.87	0.83	0.79	0.75	0.71	
36	14								3.83	2.93	2.38	2.02	1.76	1.56	1.41	1.28	1.18	1.09	1.02	0.96	0.90	0.86	0.81	0.78	
35	15									3.54	2.80	2.33	2.00	1.76	1.57	1.42	1.30	1.21	1.12	1.05	0.99	0.93	0.89	0.84	
34	16									4.35	3.32	2.70	2.28	1.98	1.76	1.58	1.44	1.33	1.23	1.15	1.08	1.01	0.96	0.91	
33	17										3.98	3.14	2.61	2.24	1.97	1.76	1.59	1.46	1.34	1.25	1.17	1.10	1.04	0.98	
32	18										4.86	3.70	3.01	2.54	2.20	1.95	1.76	1.60	1.47	1.36	1.27	1.19	1.12	1.06	
31	19											4.42	3.49	2.89	2.48	2.18	1.94	1.76	1.61	1.48	1.38	1.29	1.21	1.14	
30	20											5.38	4.09	3.32	2.80	2.43	2.15	1.93	1.76	1.61	1.49	1.39	1.30	1.23	
29	21												4.86	3.83	3.18	2.72	2.38	2.13	1.92	1.76	1.62	1.50	1.41	1.32	
28	22												5.89	4.48	3.63	3.06	2.65	2.34	2.11	1.91	1.76	1.63	1.51	1.42	
27	23													5.30	4.18	3.46	2.96	2.59	2.31	2.09	1.91	1.76	1.63	1.52	
26	24													6.41	4.86	3.94	3.32	2.87	2.54	2.28	2.07	1.90	1.76	1.64	
25	25														5.75	4.52	3.74	3.20	2.80	2.49	2.25	2.06	1.89	1.76	
24	26														6.92	5.25	4.25	3.57	3.09	2.73	2.45	2.23	2.04	1.89	
23	27															6.19	4.86	4.02	3.44	3.01	2.68	2.42	2.20	2.03	
22	28															7.43	5.64	4.55	3.83	3.32	2.93	2.63	2.38	2.18	
21	29																6.63	5.21	4.30	3.67	3.21	2.86	2.58	2.35	
20	30																7.95	6.02	4.86	4.09	3.54	3.12	2.80	2.54	
19	31																	7.07	5.55	4.58	3.91	3.42	3.04	2.74	
18	32																	8.46	6.41	5.17	4.35	3.76	3.32	2.97	
17	33																		7.51	5.89	4.86	4.15	3.63	3.23	
16	34																		8.98	6.79	5.48	4.61	3.98	3.51	
15	35																			7.95	6.24	5.14	4.39	3.83	
14	36																			9.49	7.18	5.79	4.86	4.20	
13	37																				8.39	6.58	5.42	4.63	
12	38																				10.00	7.56	6.10	5.12	
11	39																					8.83	6.92	5.71	
10	40																					10.52	7.95	6.41	
9	41																						9.27	7.26	
8	42																						11.03	8.33	
7	43																							9.71	
6	44																							11.54	

Attic Example (House in Winter Mode)
Attic Access Closed with Hose Running to Blower Door
Measure House CFM 50 (example: 2400 CFM50)
Measure House to Attic Pressure (Verify with Attic to Outside)
(example: 36 PA House to Attic)

Make Opening From House to Attic
(enough for at least 6 PA Change)
Measure House CFM 50 (example: 3000 CFM50)
Measure House to Attic Pressure (Verify with Attic to Outside)
(example: 20PA House to Attic)

Take 2nd Blower Door Reading (3000) - First Blower Reading (2400) = 600
Look in Row with 36 H/Z and move over to Column with 20 H/Z to Find Multiplier =1.56

Take 600 X 1.56 = 936
(This is Maximum CFM50 REDUCTION AVAILABLE by sealing all holes to Attic)

To Determine Uncertainty Range multiply Answer by percentage in Uncertainty Table
To Determine Approximate Hole Size Divide Answer by 10 (936 / 10= 94 sq in)

Anthony Cox and Collin Olson, 2006, following Michael Blasnik

Before Hole
CFM50: 1726
H/Z: 44

After Hole
CFM50: 3950
H/Z: 12

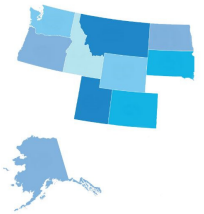
ANSWER
CFM50 Diff: 2224
Multiplier: 0.45
Maximum Reduction: 1009
Square In: 100.9

ext exponent = 0.65
May 16, 2006

1009 CFM50
=/- 152

	Low Range	High Range
10.00%	908	1110
15.00%	857	1160
20.00%	807	1210
25.00%	757	1261

The Energy Conservatory



Questions?

Thank you

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