Blower Door Training

Presenter: Mark Rogers

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- RESNET® Certified HERS Rater and Quality Assurance Designee
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  Building Analyst, Building Envelope, Multifamily Building Analyst, and Residential Air Leakage Control Installer
- Certified Infrared Thermographer
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Session Goals

- Learn to operate the Energy Conservatory Blower Door
  - Set up
  - Equipment operation
  - Testing and results interpretation
- Some discussion about Retrotec® blower doors
- Learn basic blower door calculations
- Pressurization vs. depressurization testing
- Multifamily testing
- Learn about blower door software
- Learn mechanical ventilation calculations

Why Use a Blower Door?

•A blower door can help you find and demonstrate air leaks to your customers, especially when used with an infrared camera.

•Fixing these leaks can save your customer money – typically between 10% and 35% on their heating and cooling bills!

•Fixing the leaks can also make their home more comfortable and reduce moisture problems such as mold and rot caused by air leaking into or out of the house.

•Reducing heating and cooling load prolongs the life of the mechanical equipment.

•Home Energy Rating System (HERS) requires it as part of the inputs for an energy rating score for houses.

•"Green" building certification programs like
Energy Star for New Homes require it

Why Use a Blower Door?

International Energy Conservation Code (IECC) 2009 requires a choice between blower door testing and completing an Air Barrier Checklist.

- Requires less than or equal to 7 ACH_{50} on the blower door test
- Air Barrier Checklist: Table 402.4.2

IECC 2012 makes blower door testing mandatory.

- Requires less than or equal to 5 ACH_{50} in climate zones 1 &2, and 3 ACH_{50} in all other climate zones.
- Builders must also comply with Table R402.4.1.1, "Air Barrier and Insulation Installation."

What is a Blower Door?

The Blower Door is a diagnostic tool designed to measure the air tightness of buildings and to help locate air leakage sites. Building air tightness measurements are used for a variety of purposes including:

- Documenting the air tightness of new and existing buildings.
- Estimating natural infiltration rates in houses.
- Finding air leakage for retrofit work.

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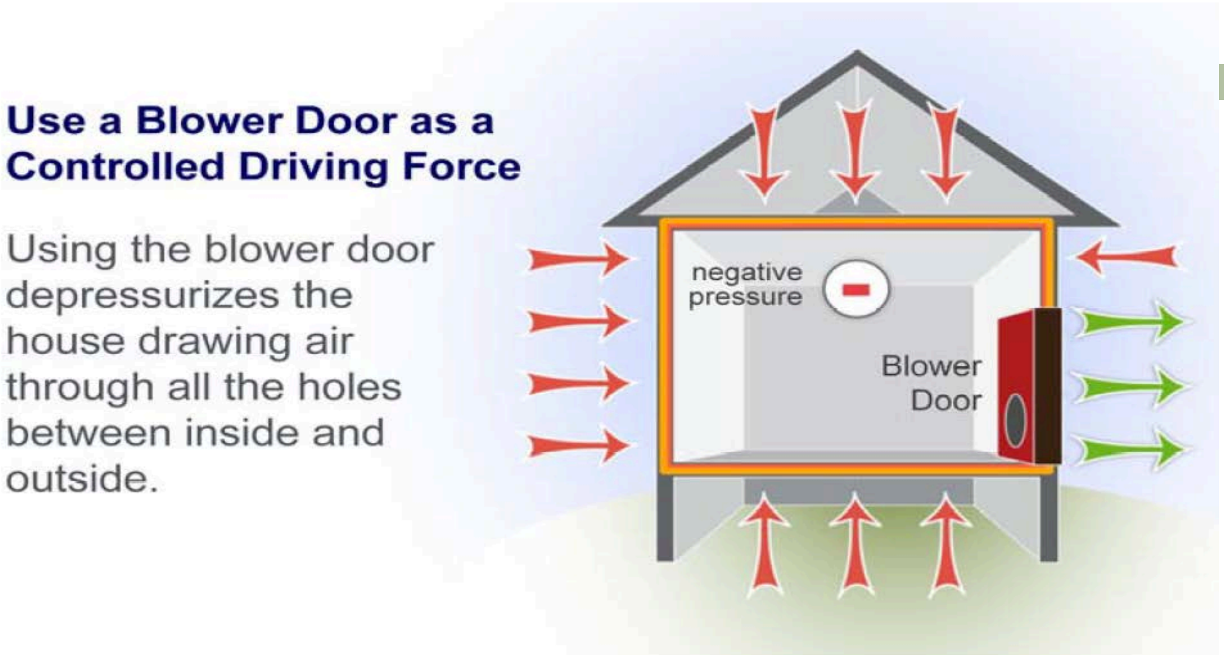
What is a Blower Door?

- The Blower Door is a calibrated fan that is placed in an exterior doorway. The fan is used to blow air into or out of the building to create a slight pressure difference between inside and outside.
- The pressure difference between inside and outside forces air through all holes and penetrations in the exterior envelope.
- By simultaneously measuring the air flow through the fan and its effect on the air pressure in the building, the Blower Door system measures the airtightness of the entire building envelope.
- The tighter the building (e.g. fewer holes), the less air you need from the Blower Door fan to create a change in building pressure.

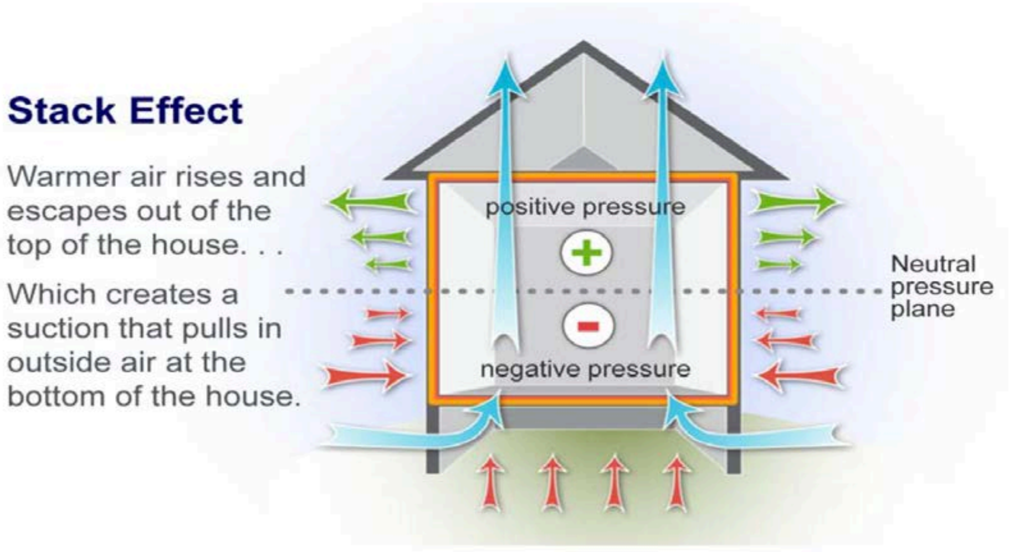
Retrotec vs. Energy Conservatory

Retrotec Q46	Energy Conservatory Minneapolis Blower Door BD4
Slightly more powerful fan	Lighter weight
Better for bigger or leakier homes	Works well for almost all homes
$3295	$2495


Use a Blower Door as a Controlled Driving Force
Using the blower door depressurizes the house drawing air through all the holes between inside and outside.
negative pressure
Blower Door

Stack Effect

Air enters at the lower levels and exits at the top.
This is known as *Stack Effect.*



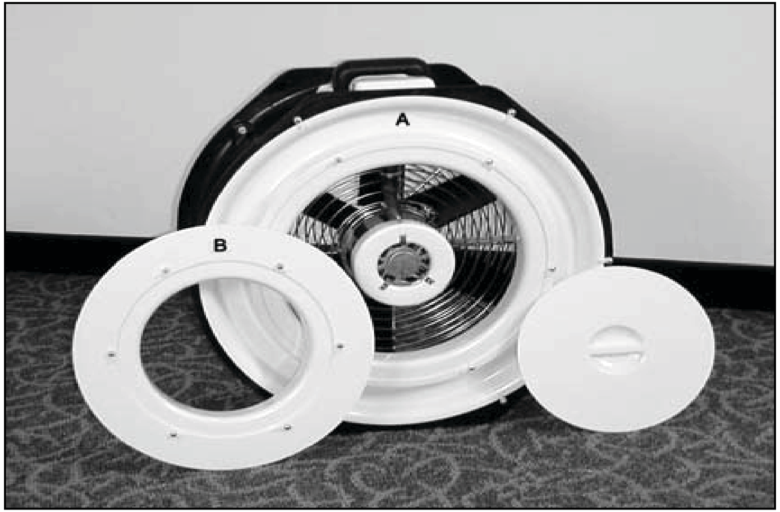
Blower Door Components

There are three main components of the Minneapolis Blower Door.

1. Door Frame & Cover

Blower Door Components

2. Fan, flow rings and speed controller



Blower Door Components

3. Digital gauge (DG-700)

Blower Door Terminology

- When air is forced into a home it raises the pressure in the home With Reference To (WRT) the outside and when air is removed from a home this lowers the pressure inside of the home With Reference To (WRT) the outside.
- We always measure inside pressure against the constant outside pressure
- $CFM_{50:}$ This is a direct measurement of airflow (in Cubic Feet per Minute) through the fan at 50 Pascals of pressure, read on channel B. It is used to calculate other test results.

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Blower Door Terminology

•Baseline: The difference in pressure between inside and outside the house, which is measured just prior to blower door testing. This measurement is done with the fan cover on. Read on Channel A.

•Baseline Feature: This feature of the DG-700 gauge allows the baseline pressure to be automatically subtracted from the Channel A measurement of indoor vs. outdoor pressure. If "ADJ" is displayed on the gauge it indicates the baseline feature is being used to adjust the pressure readout on Channel A. This feature is used to reduce or eliminate the effect of stack effect and wind.

- •To use this feature, Press Mode to set the gauge to the mode you wish to use, (usually PR/FL@50 mode), then press Baseline, then Start, wait 15 seconds or so or until the number stabilizes, and then press Enter.

House Setup

Before operating the Blower Door, the house needs to be prepared for testing.

- Close all exterior doors and windows.
- Open all interior doors.
- Ensure all fans which ventilate to outside and the clothes dryer are off.
- Close all fireplace flue dampers.
  - We don’t want to pull any ashes into the home.

House Setup

- Disable all combustion appliances so they cannot operate during the test (to avoid bringing exhaust and/or flames into the home).
  - This includes hot water heaters, furnaces, and fireplaces.
  - Turn the gas valves to "pilot" setting, and leave your vehicle keys at the appliance (so you remember to turn it back on when finished!)
- Leave all intentional openings to the house (such as combustion air vents) open, as they do contribute to air leakage.

Quiz – House Setup

Q: Why is it important to disable combustion appliances before beginning the blower door test?

A: The blower door will depressurize the house, and if a water heater, furnace, fireplace, or other combustion appliance were to turn on during the test, exhaust gases and/or flames could enter the home, causing safety risks to life and property.

Q:Why is it important to make sure the fireplace is clean and the flue is closed?

A: Ashes and soot could be pulled into the home, creating an expensive cleanup situation.

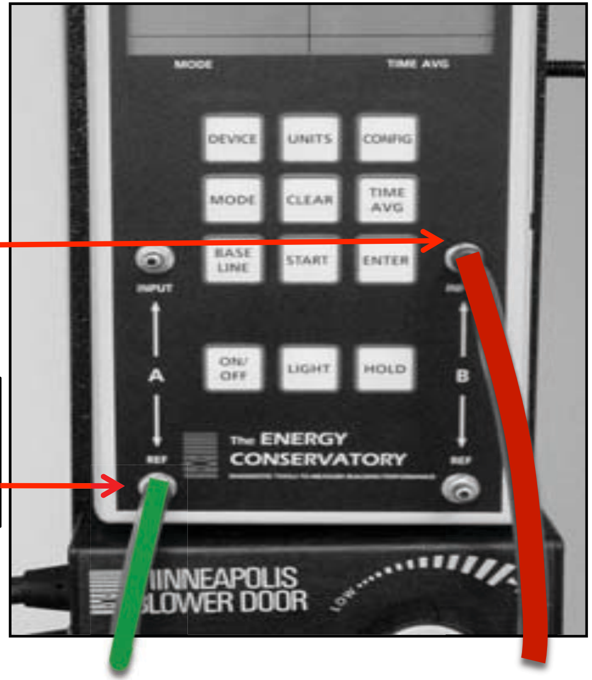
Blower Door Gauge Setup

The DG-700 gauge measures and displays the pressure at the Input tap WRT the Reference tap.

- Attach the green tube from outside to the *Reference* port on Channel A.
- Attach the red tube from the pressure tap on the fan to the *Input* port on Channel B.

Connect the Red tubing to the Channel B Input tap. *Channel B is used to measure Fan pressure and flow.*

Connect the Green tubing to the Channel A Reference tap. *Channel A is used to measure building pressure with reference to outside.*



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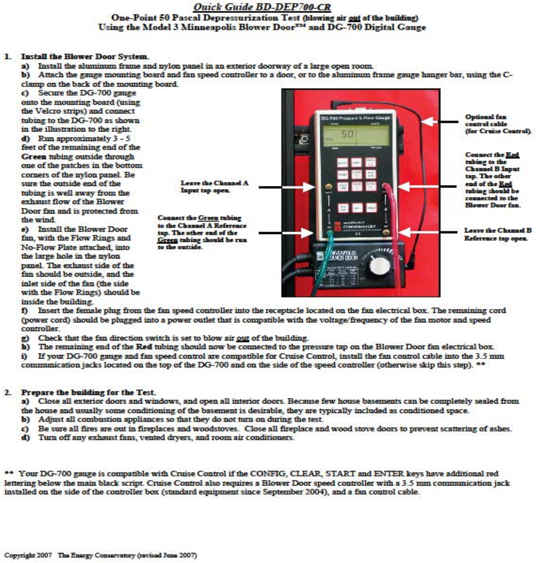
The DG 700 Digital Gauge

- The DG-700 Pressure and Flow Gauge is a multi-functional differential pressure gauge with 2 independent measurement channels.
- The DG-700 is programmed to operate with other Energy Conservatory test devices to provide air flow measurements during building performance test procedures. It is ideally suited for a wide range of building performance testing applications including:
  - Blower Door airtightness testing.
  - Duct system airtightness testing.
  - Air handler flow measurements.
  - Exhaust fan flow measurements.
  - Building depressurization and combustion safety testing.

Blower Door Setup & Operation

Print and refer to this guide (QuickBD_DepressurizationGuide-DG700) in the field. The blower door manual is also an excellent resource.



Quick Guide BD-DEP700-CR

One-Point 50 Pascal Depressurization Test (blowing air out of the building)
Using the Model 3 Minneapolis Blower Door™ and DG-700 Digital Gauge

1. **Install the Blower Door System.**
   a) Install the aluminum frame and nylon panel in an exterior doorway of a large open room.
   b) Attach the gauge mounting board and fan speed controller to a door, or to the aluminum frame gauge hanger bar, using the C-clamp on the back of the mounting board.
   c) Secure the DG-700 gauge onto the mounting board (using the Velcro strips) and connect tubing to the DG-700 as shown in the illustration to the right.
   d) Run approximately 3 - 5 feet of the remaining end of the **Green** tubing outside through one of the patches in the bottom corners of the nylon panel. Be sure the outside end of the tubing is well away from the exhaust flow of the Blower Door fan and is protected from the wind.
   e) Install the Blower Door fan, with the Flow Rings and No-Flow Plate attached, into the large hole in the nylon panel. The exhaust side of the fan should be outside, and the inlet side of the fan (the side with the Flow Rings) should be inside the building.
   f) Insert the female plug from the fan speed controller into the receptacle located on the fan electrical box. The remaining cord (power cord) should be plugged into a power outlet that is compatible with the voltage/frequency of the fan motor and speed controller.
   g) Check that the fan direction switch is set to blow air out of the building.
   h) The remaining end of the **Red** tubing should now be connected to the pressure tap on the Blower Door fan electrical box.
   i) If your DG-700 gauge and fan speed control are compatible for Cruise Control, install the fan control cable into the 3.5 mm communication jacks located on the top of the DG-700 and on the side of the speed controller (otherwise skip this step). **

Leave the Channel A Input tap open.

Connect the Green tubing to the Channel A Reference tap. The other end of the Green tubing should be run to the outside.

Optional fan control cable (for Cruise Control).

Connect the Red tubing to the Channel B Input tap. The other end of the Red tubing should be connected to the Blower Door fan.

Leave the Channel B Reference tap open.

2. **Prepare the building for the Test.**
   a) Close all exterior doors and windows, and open all interior doors. Because few house basements can be completely sealed from the house and usually some conditioning of the basement is desirable, they are typically included as conditioned space.
   b) Adjust all combustion appliances so that they do not turn on during the test.
   c) Be sure all fires are out in fireplaces and woodstoves. Close all fireplace and wood stove doors to prevent scattering of ashes.
   d) Turn off any exhaust fans, vented dryers, and room air conditioners.

** Your DG-700 gauge is compatible with Cruise Control if the CONFIG, CLEAR, START and ENTER keys have additional red lettering below the main black script. Cruise Control also requires a Blower Door speed controller with a 3.5 mm communication jack installed on the side of the controller box (standard equipment since September 2004), and a fan control cable.

Quiz – Blower Door Setup

Q: What does the baseline feature do?
A: It subtracts the influence of the stack effect from the house pressure WRT outside measurement.

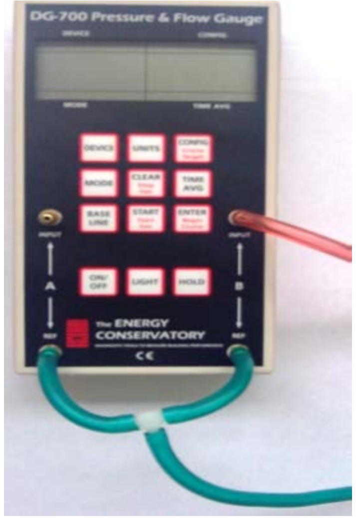
Q: Do you put the red fabric panel on the frame before or after sizing the frame to the doorway?
A: After

Q: How do you use the baseline feature?
A: Prior to the test with the fan cover on, put the gauge in the proper mode, then press Baseline, then Start, wait about 15 seconds or until the pressure stabilizes, and then press Enter.

Pressurization Testing

Why do pressurization instead of depressurization testing?

- Prevent pollutants like soot and ash from entering the home through the fireplace
- Asbestos in the attic or siding
- Mold
- Some testing standards require averaging pressurization and depressurization testing (mainly in commercial buildings).



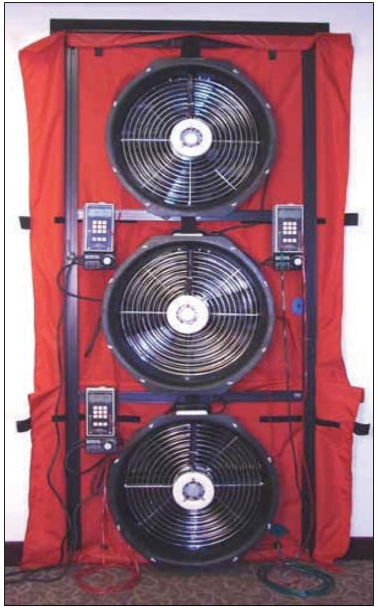
How do you do it?

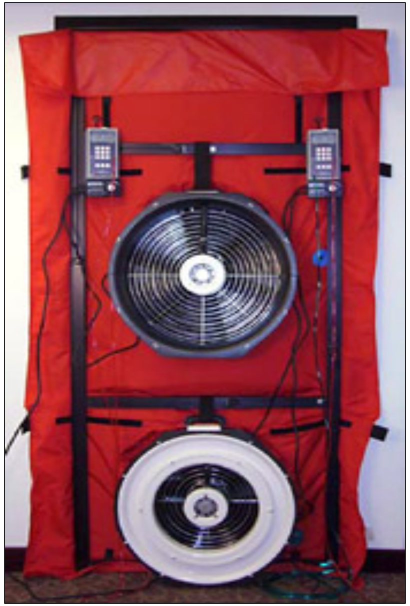
- Join reference taps of channels A & B together with tee and two short lengths of hose, and connect tee to outside reference hose. (Or you can run two reference hoses to outside).
- Run Channel B input hose to fan.
- Obtain baseline pressure as usual.
- Configure the fan ring you think will work best.
- Turn the fan around (do NOT use flow-reversing switch).
- Measure and record the flow as usual.

Multifamily Blower Door Testing

- CFM50 measurement from one unit does not tell the whole story.
    - Why?
- Ideally you need to determine how much leakage is coming from outside vs. adjacent unit using a blower door on the adjacent unit at the same time.

Testing Large Buildings





Very large (~10,000 sq. ft.) or very leaky homes may require more than one blower door fan. Check with the manufacturer for equipment & instructions.

What Do The Numbers Mean?

ACH_{50}

- Air Changes per Hour with the home at 50 Pascals WRT outside.
- Formula: (CFM_{50} x 60)/Bldg. volume
- Example: 2200CFM_{50} x 60 = 132000/10000 = 13.2 ACH50

What Do The Numbers Mean?

NACH (Natural Air Changes per Hour) or ACHn

- This is a calculation of how much the building leaks based on CFM_{50} , building volume, and weather data, on a seasonal average.
- NACH=ACH50 / n-factor

n-Factors for Zone 2 (Front Range)				
# stories	**1**	**1.5**	**2**	**3**
well shielded	22.2	20.0	17.8	15.5
normal	18.5	16.7	14.8	13.0
exposed	16.7	15.0	13.3	11.7

n-Factor: The number which adjusts for climate, stack effect, and wind shielding.

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Typical NACH Levels

Type of Home	NACH
Very leaky older home	0.80 & up
Average existing home	0.55
Old ASHRAE 62.89 standard	0.35
Typical ENERGY STAR new home	0.10 to 0.25
German Passive House Standard	< 0.05

Calculating House Volume

In order to calculate ACH_{50} and NACH, you will need to calculate the volume of the house.

Step 1: Measure and draw the exterior footprint of the house on graph paper

- A scale of one square for two linear feet works well for most houses.
- Measure to the exterior corners, which includes the volume of walls & cantilevers.

Step 2: Fill in details on your drawing

- Garage-to-house boundary
- Flat and vaulted ceiling heights
- Split-levels
- Basement &/or crawlspace: is either "unconditioned"? See below

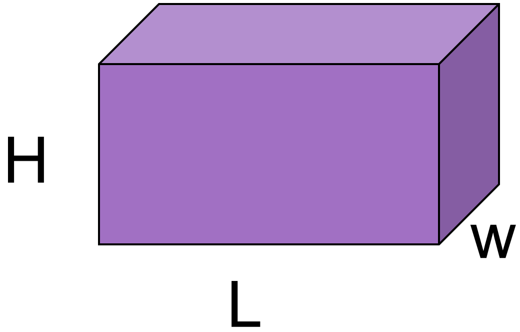
Unconditioned space: Areas such as crawlspaces or basements whose temperatures are likely to be close to the setpoint of the home's thermostat. Crawlspaces and basements are usually considered conditioned if they contain uninsulated ductwork and/or do not have insulation between them and the rest of the house.

Calculating House Volume

Step 3: Calculate square footage and volume of conditioned space

- Cubes: Length x width x height
- Vaulted ceiling space: ½ (base x height x length)

Volume

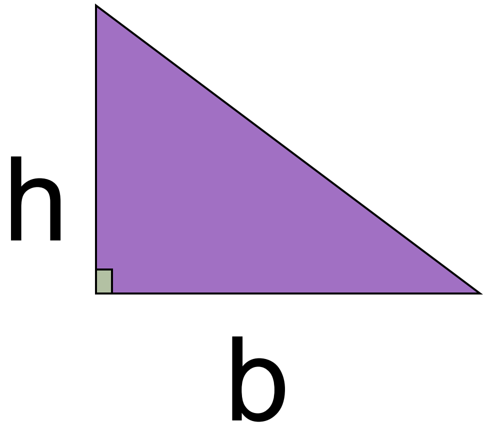


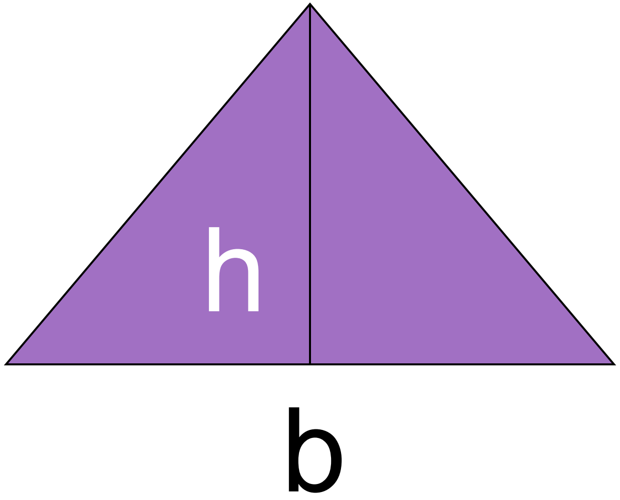
Length x Width x Height = Volume in Cubic Feet

Volume of a Vaulted Space: Area of a Triangle

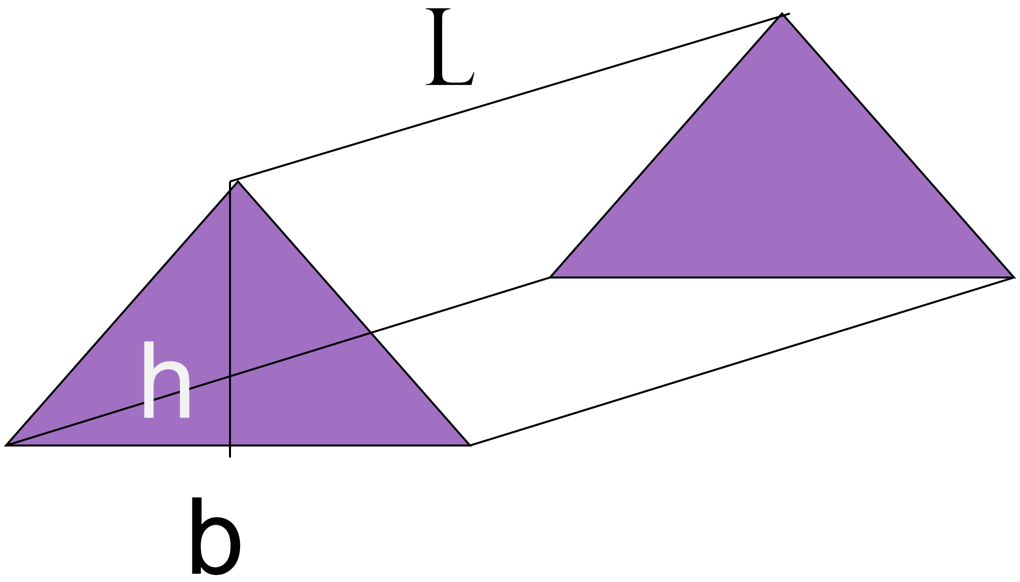
½ x Base x Height = Area

½ x b x h = A



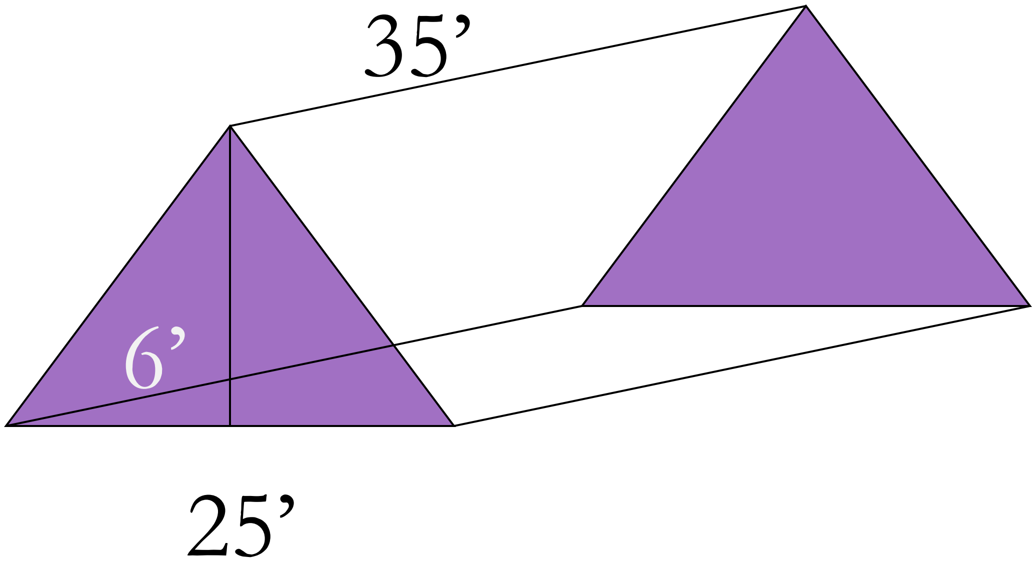


Volume of a Vaulted Space



½ x b x h x l = volume

Example – Volume of Vaulted Space



½ x 25’ x 6’ x 35’= 2625cuft.

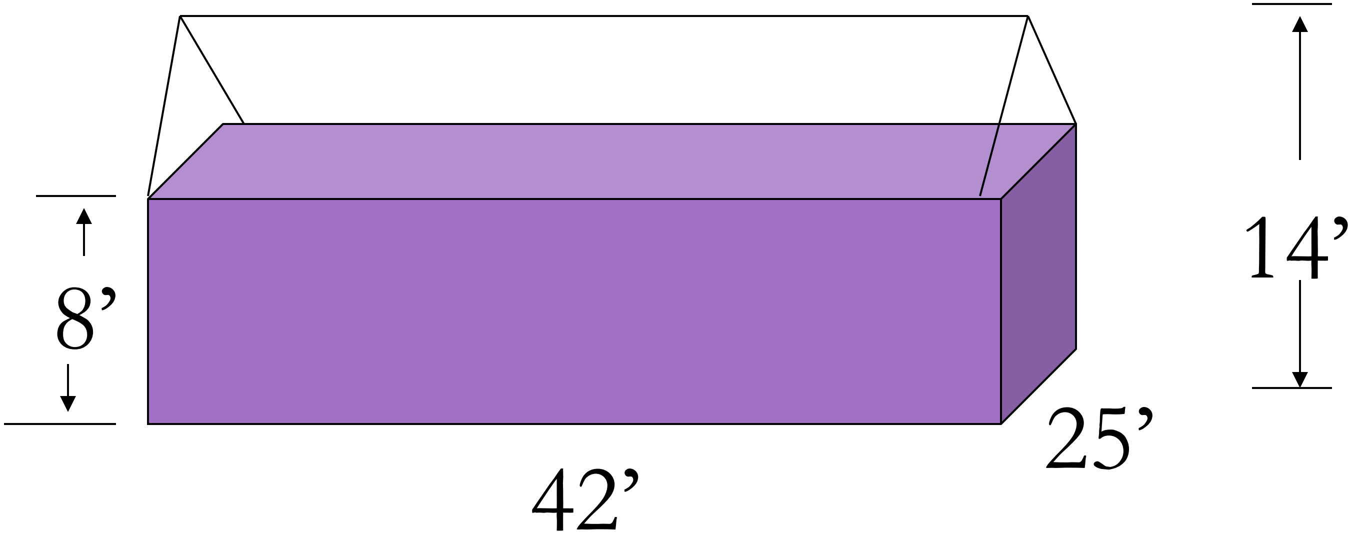
Volume of Turrets

Determining the volume of turrets requires that you determine the area of a circle and then multiply by the height.

Formula is 3.14 r^2 x height

Quiz

Determine the volume of this house, including the vaulted portion at the top.



Volume bottom = L x W x H
Volume top = ½ B x H x L

Total Volume

1. Volume bottom, 42' x 25' x 8' = 8400 c.f.
2. Volume top, ½ x 25' x 6' x 42' = 3150 c.f.
3. 8400cuft + 3130 c.f. = 11550 c.f.

NACH Example

Building Data:

Living Space: 1700 ft^2 with 10 ft ceilings

Conditioned Basement Area:

800 ft^2 with 8 ft ceilings

Number of stories above grade: 1.5 (normal exposure)

Blower door # = 3,600 CFM_{50}

n-Factors for Zone 2 (Front Range)				
# stories	1	1.5	2	3
well shielded	22.2	20.0	17.8	15.5
normal	18.5	16.7	14.8	13.0
exposed	16.7	15.0	13.3	11.7

Volume Calculation:

1700 x 10 = 17,000 c.f.

800 x 8 = 6,400 c.f.

17,000 + 6,400 = **23,400 c.f.**

ACH_{50} formula =

(CFM_{50} x 60) / volume

ACH_{50} = 3,600 x 60 /23,400 = **9.23**

NACH formula = ACH_{50} / N factor

NACH = 9.23 ACH_{50} / 16.7 = **0.55**

NACH Quiz

Building Data

Volume = 25,700 c.f.

Number of stories above grade = 2 normal exposure

Blower door # = 2,600 CFM_{50}

n-Factors for Zone 2 (Front Range)				
# stories	**1**	**1.5**	**2**	**3**
well shielded	22.2	20.0	17.8	15.5
normal	18.5	16.7	14.8	13.0
exposed	16.7	15.0	13.3	11.7

NACH Formula:

NACH = ACH_{50} / N factor

NACH Calculation

2,600 x 60 / 25,700= **6.07ACH_{50}**

6.07 ACH_{50} / 14.8= **0.41 NACH**

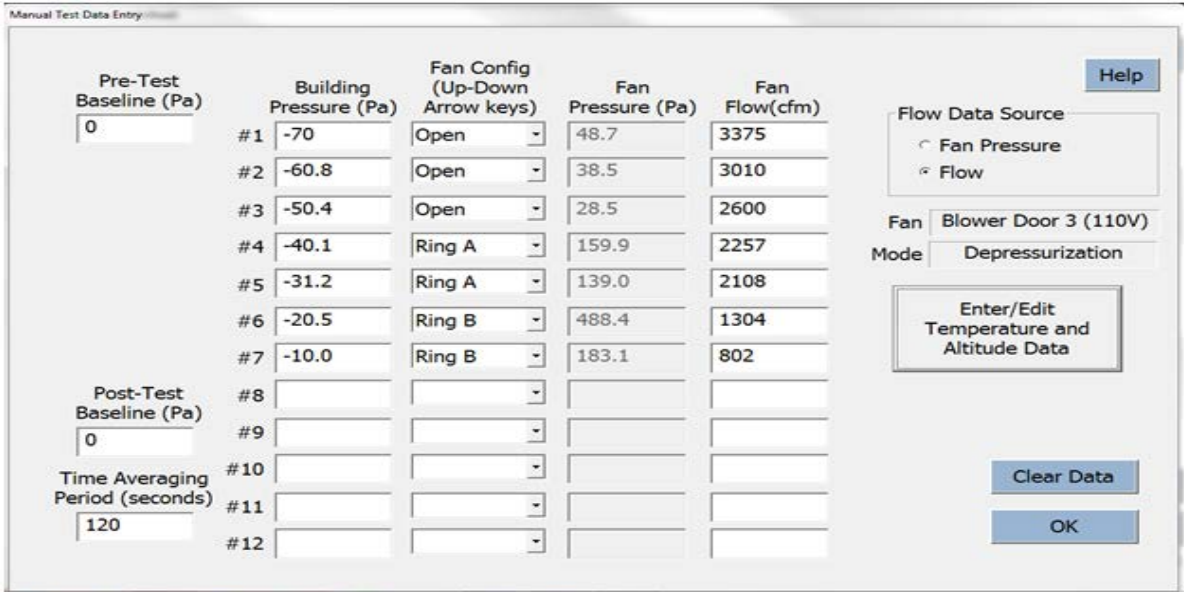
Software (TECTite)

The Energy Conservatory (TEC) has free software called TECTite which can be used to improve accuracy of testing and deliver professional-looking reports to customers.

Multi-point testing may be required by certain certification programs or to further improve accuracy. Software like TECTite will be needed if you are trying to comply with ASTM Standard E1827-11.

- This requires the blower door technician to use PR/FL mode on the gauge, not PR/FL@50 mode.
- At least two data points (preferably 8 or more) are recorded at different pressures WRT outside. Data points must be taken at approximately 50Pa and 12.5Pa.
- The effect of wind can be reduced by taking additional data points at higher pressures, such as 60 to 80Pa.

Software (TECTite) -Inputs



Manual Test Data Entry

Pre-Test Baseline (Pa): 0

	Building Pressure (Pa)	Fan Config (Up-Down Arrow keys)	Fan Pressure (Pa)	Fan Flow(cfm)
#1	-70	Open	48.7	3375
#2	-60.8	Open	38.5	3010
#3	-50.4	Open	28.5	2600
#4	-40.1	Ring A	159.9	2257
#5	-31.2	Ring A	139.0	2108
#6	-20.5	Ring B	488.4	1304
#7	-10.0	Ring B	183.1	802
#8				
#9				
#10				
#11				
#12				

Post-Test Baseline (Pa): 0

Time Averaging Period (seconds): 120

Help

Flow Data Source
- Fan Pressure
- Flow

Fan: Blower Door 3 (110V)

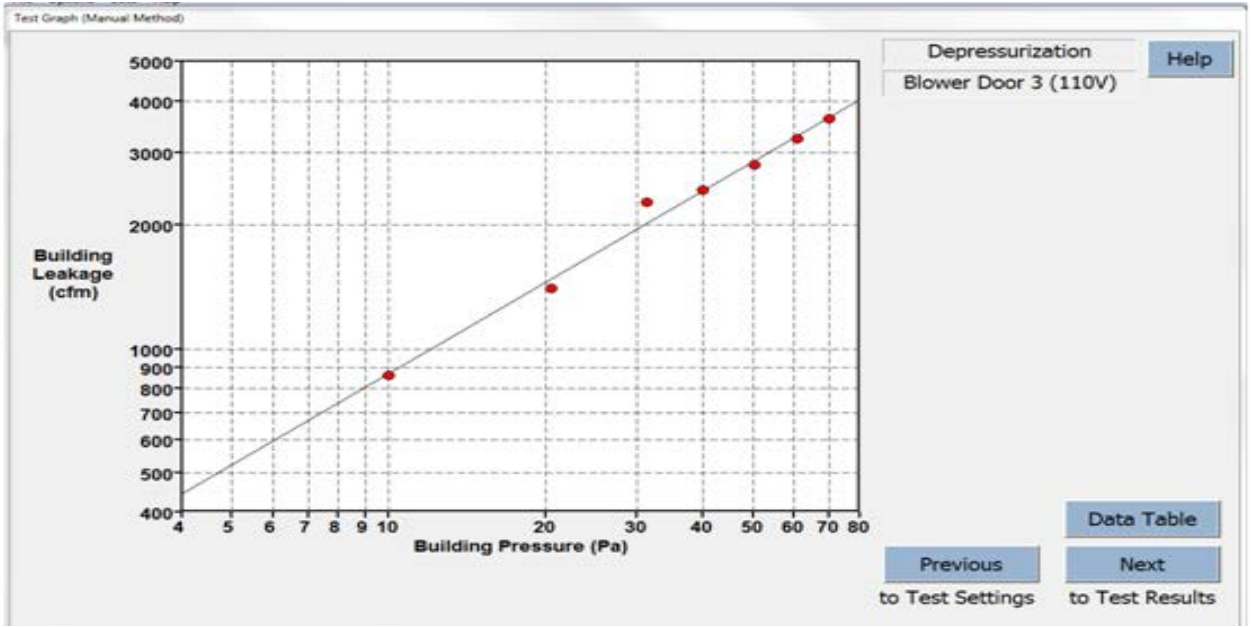
Mode: Depressurization

Enter/Edit Temperature and Altitude Data

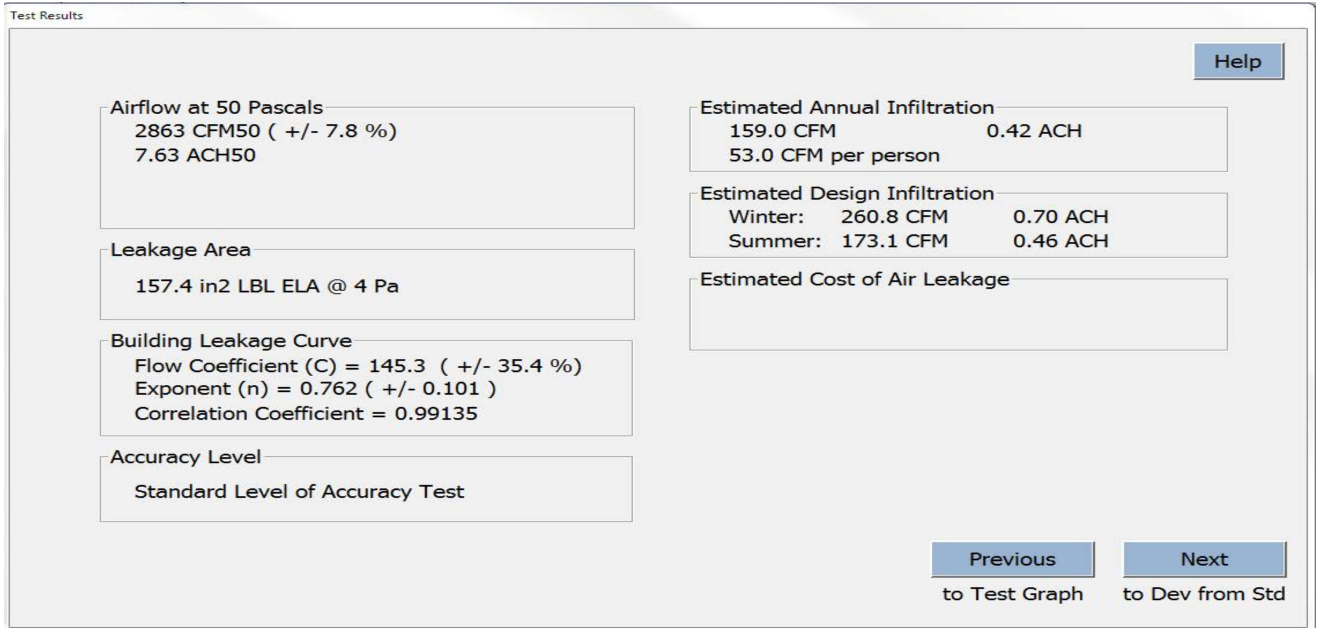
Clear Data

OK

Software (TECTite) -Graph



Software (TECTite) -Results



Mechanical Ventilation

When do you need it?
How much do you need?

ASHRAE 62.2 is the standard way to determine this in homes up to three stories.

- Formula for new homes:
  (Square footage /100) + ((number of bedrooms+1) x 7.5 cfm)
- For further reading: “User’s Guide to ASHRAE 62.2”

Three common strategies for ventilation:

- Exhaust (Bathroom fans, kitchens, etc.)
- Supply Ventilation (via HVAC ductwork)
- Balanced Ventilation (Combination of the first two, or use of HRV or ERV)

Mechanical Ventilation

If your jurisdiction requires new homes to comply with the 2012 IRC, any new home with a blower door test result of less than 5.0 ACH_{50} must include a whole-house ventilation system complying with requirements listed in 2012 IRC section M1507.3.

Since the new code requires homes in all zones except zones 1 and 2 to achieve 3 ACH_{50}, the code effectively mandates a whole-house mechanical ventilation system for homes in zones 3 through 8.

Further Reading & Resources:

Air Leakage Testing:
ASTM E1827-11: Air leakage testing with a blower door
ANSI Standard E779: Air leakage testing without a blower door

Mechanical Ventilation:
ASHRAE Standard 62.2: Ventilation in Low Rise Residential Buildings
ASHRAE: User's Guide to ASHRAE 62.2
ASHRAE Standard 136: Determining Air Change Rates in Detached Dwellings (as it relates to indoor air quality)

ANSI, ASTM, and ASHRAE Standards:
http://www.ansi.org/

Blower Door Manufacturers:
www.energyconservatory.com
www.retrotec.com