Measuring Air Leakage in High Rise Buildings

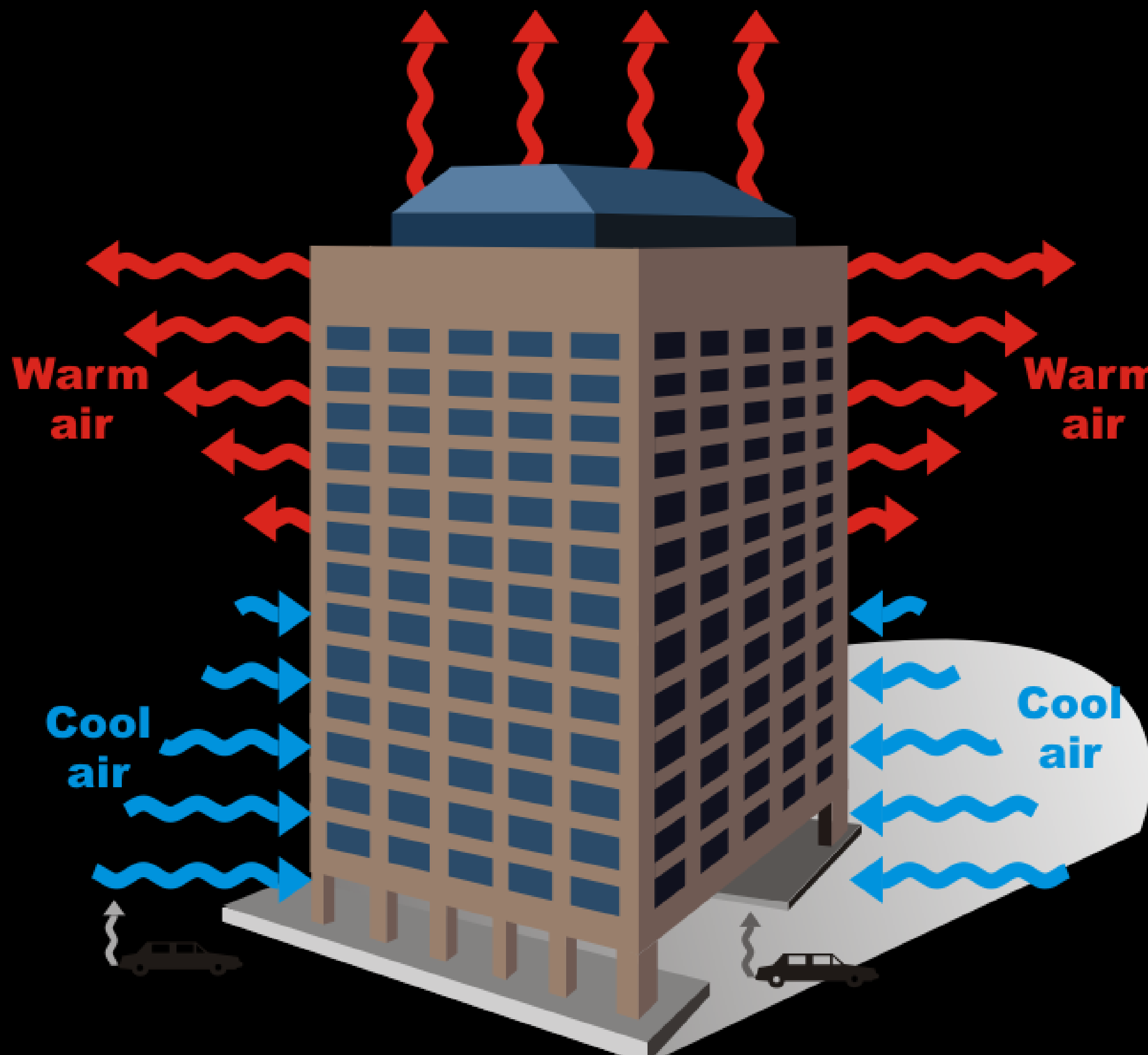
Denali Jones
Retrotec Energy Ltd

Contents

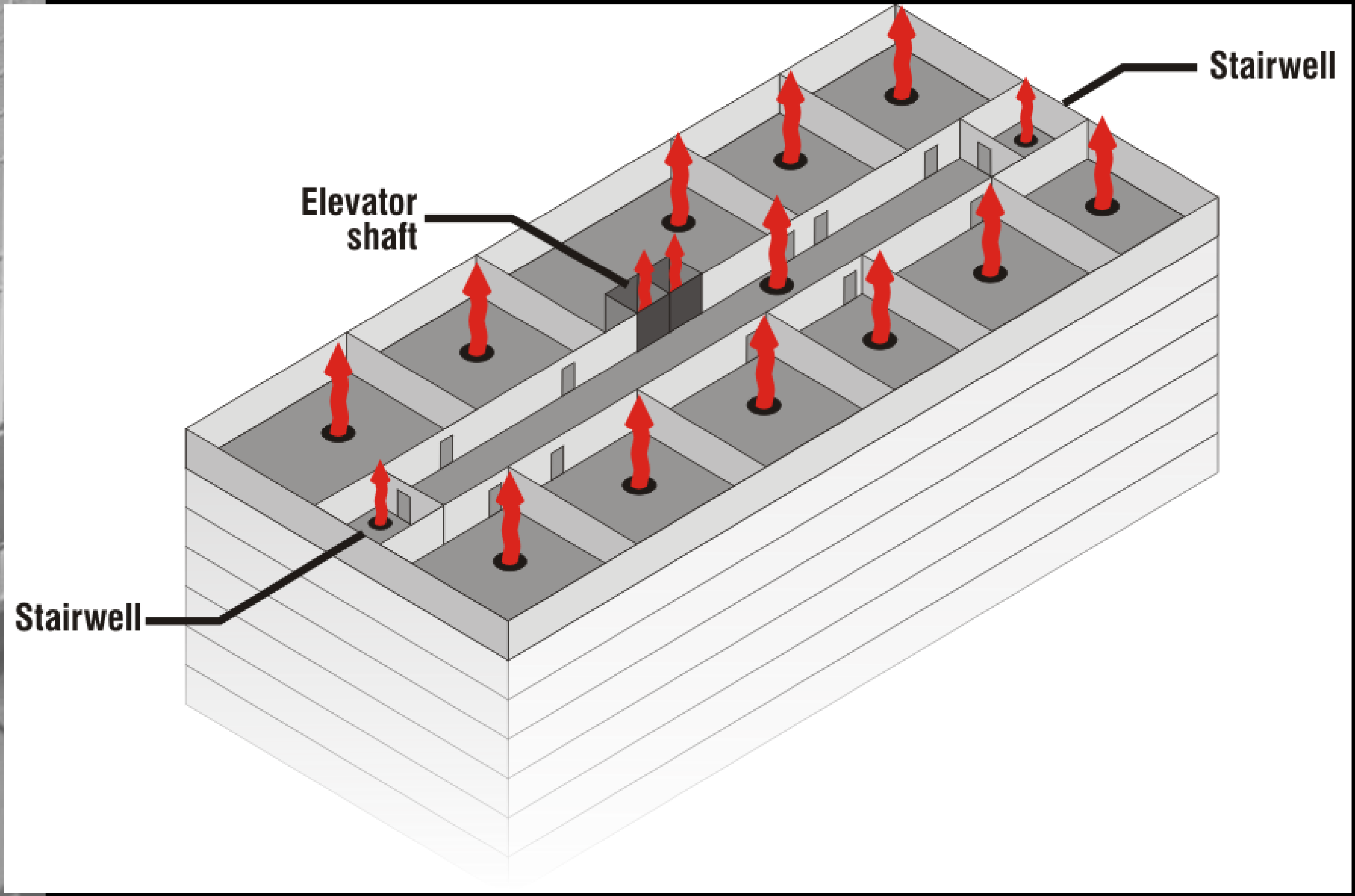
- Cause
- Problems
- Sites
- Benefits
- Ventilation
- Air barriers
- Locate and seal leaks
- Measure leaks
- Case Studies

Cause of air leakage

Stack Pressure + Holes = Leaks



Primary Boundaries for cold climates



14 windows open at -25 C

inset shows open window

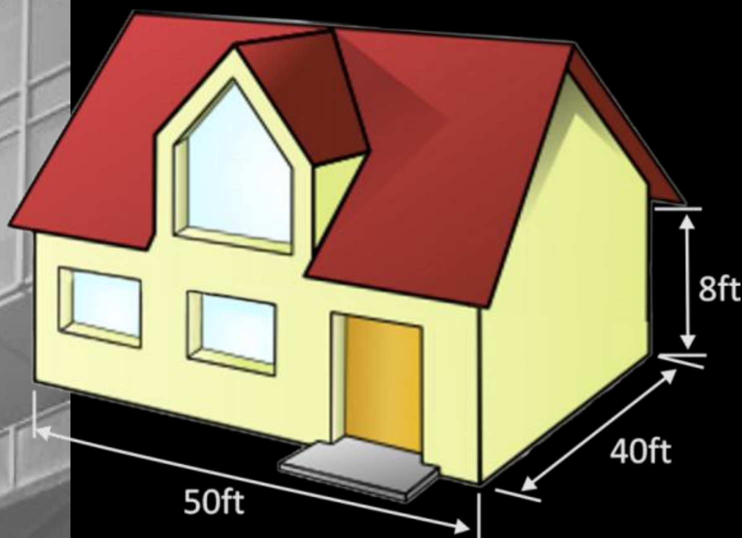
Why air tightness is important?

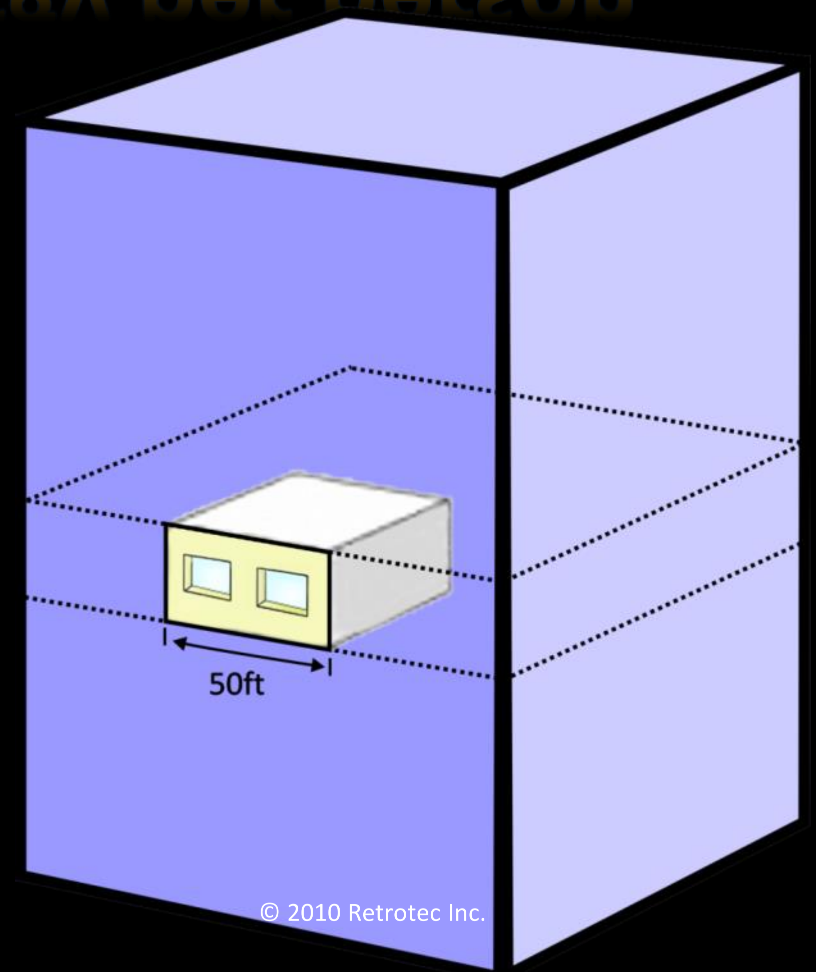
Airtightness defines a building

Impact on energy cost

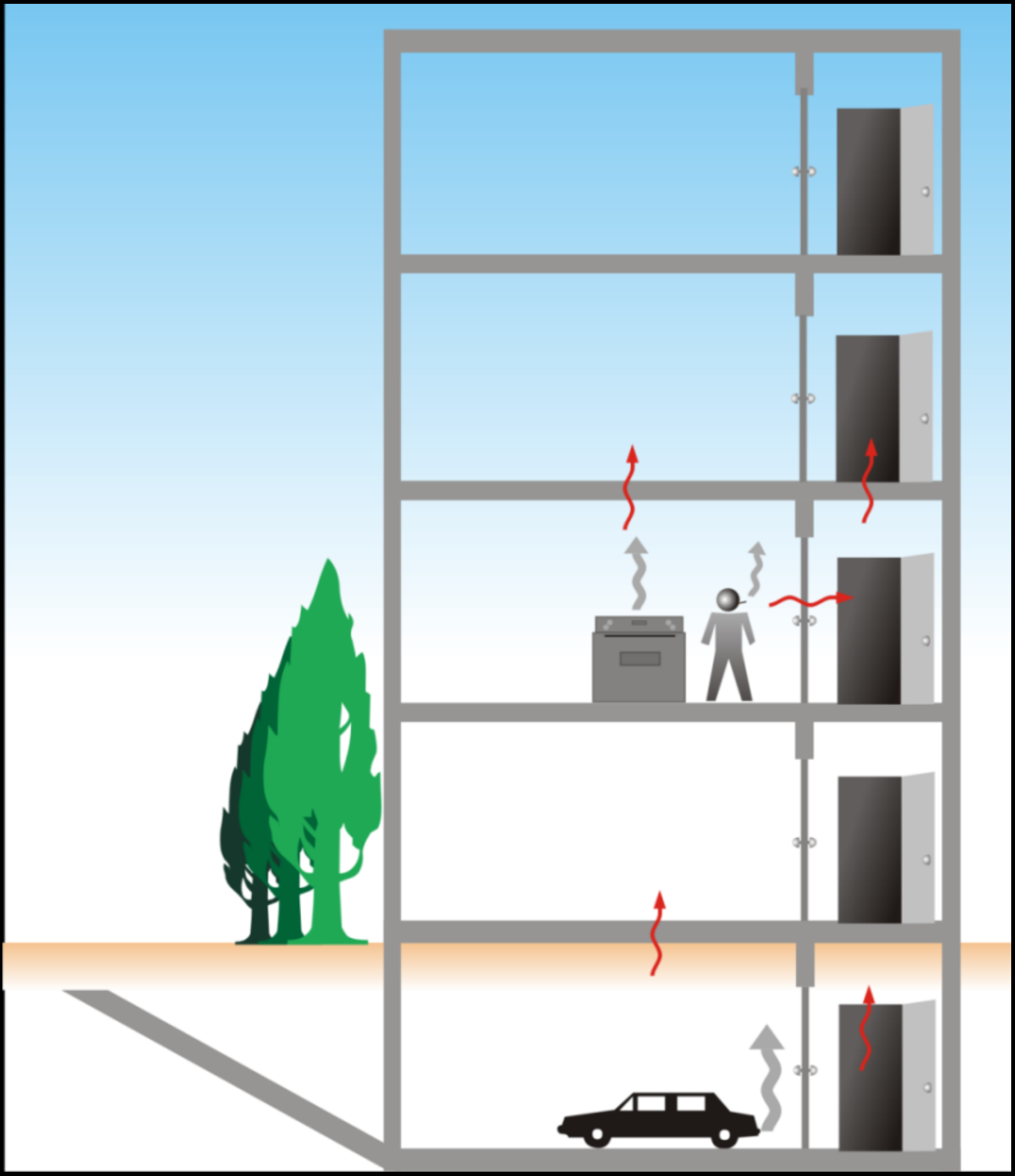
CFM 75/ft^2		
0.1	0%	Negligible
0.25	5%	Small
0.4	10%	Moderate
1.0	25%	Large
2.0	40%	Uncontrolled, severe

7x more exposure in a house = more energy per person

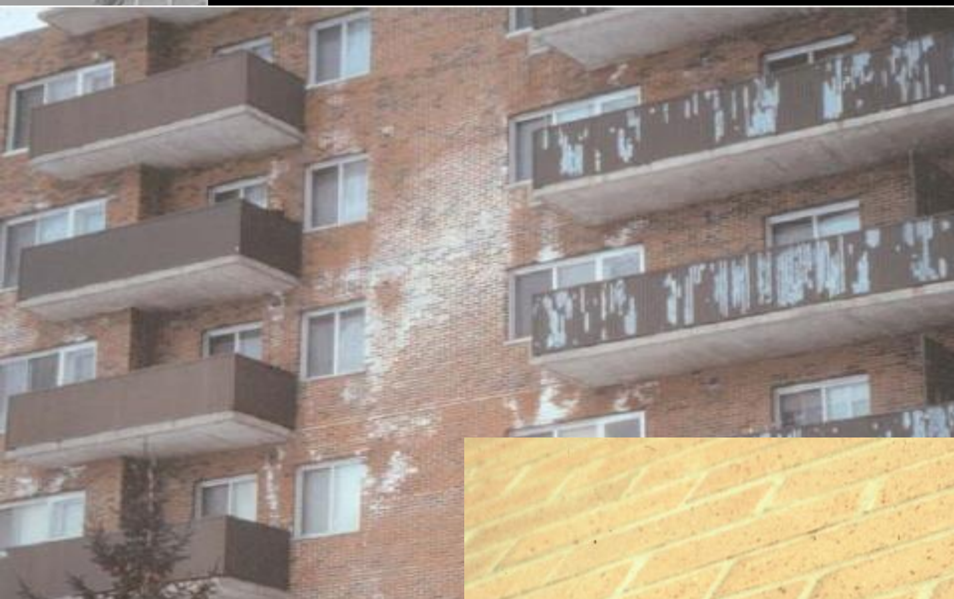


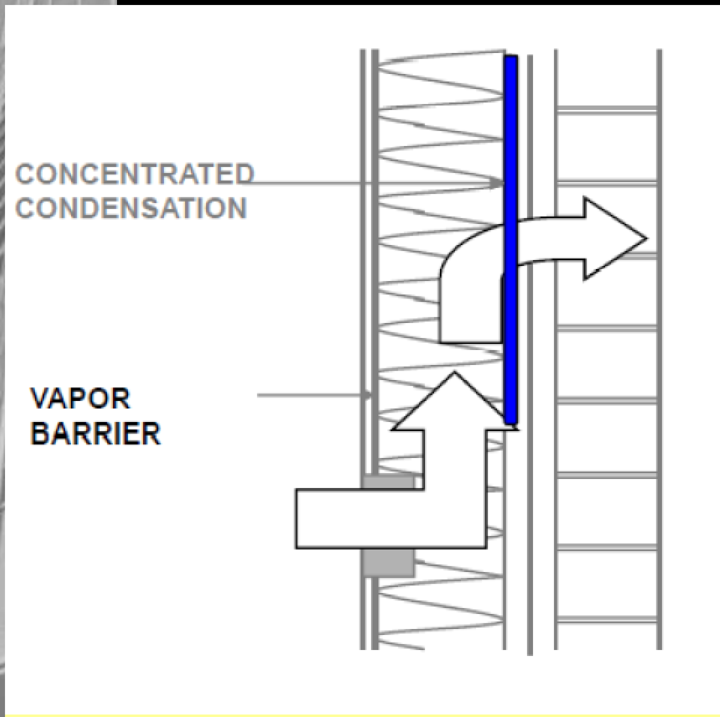


Real problems



Typical Leaky High-Rise Buildings:

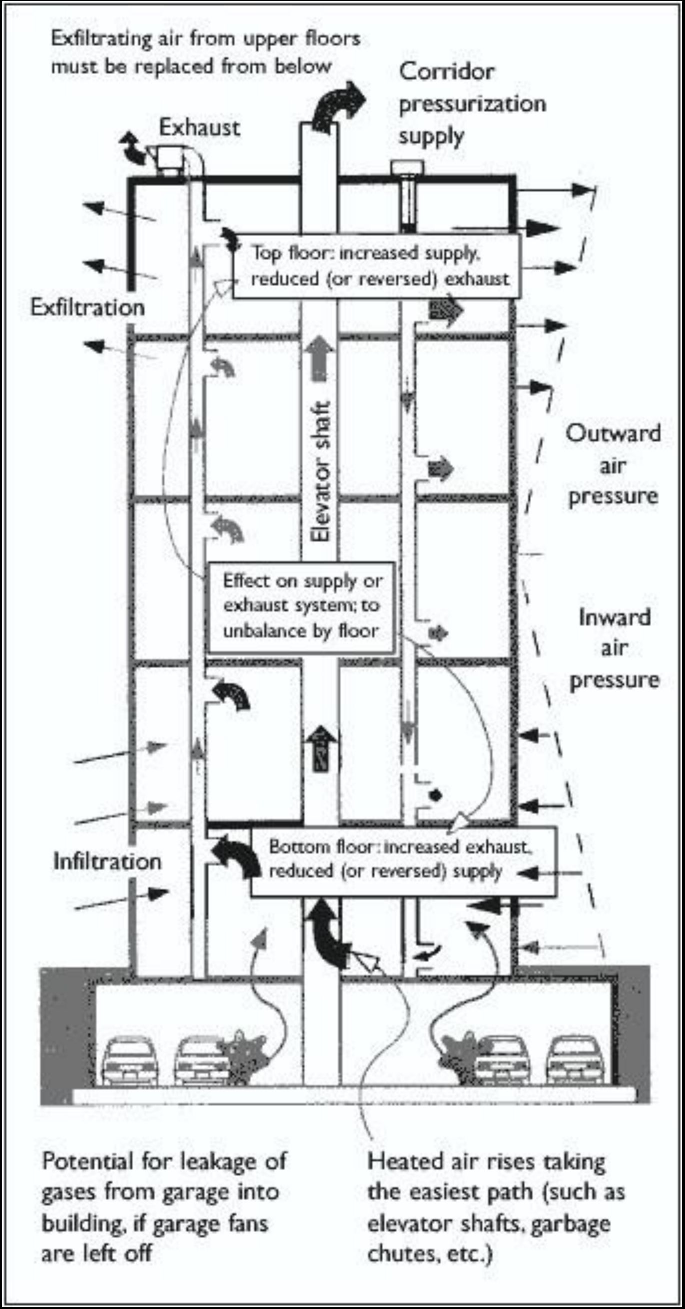



CONCENTRATED
CONDENSATION
VAPOR
BARRIER

Cool wall temperatures causes mold

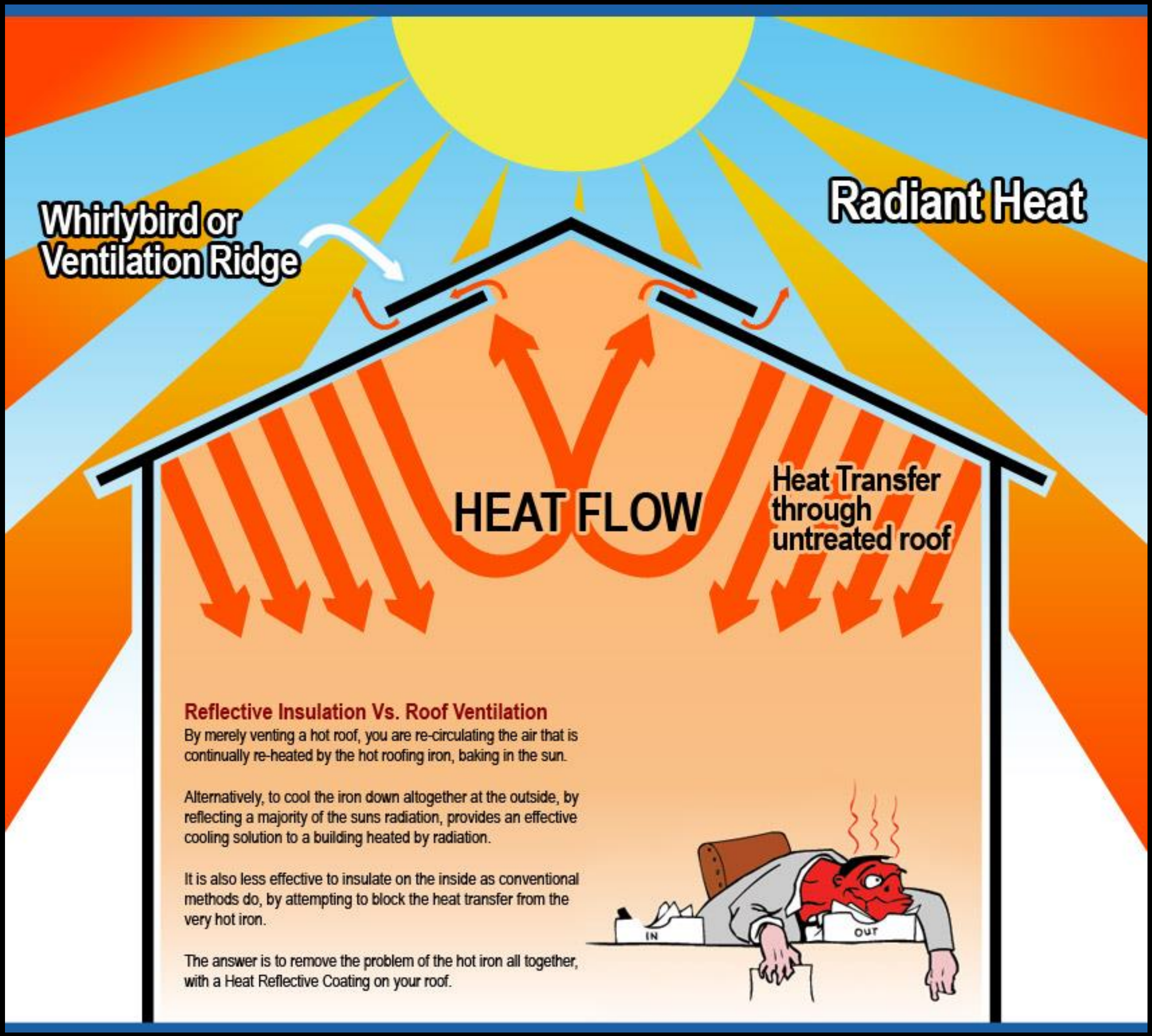
Smoke safety is affected by floor to floor leakage

Hallway mechanicals cannot keep up with flow requirements



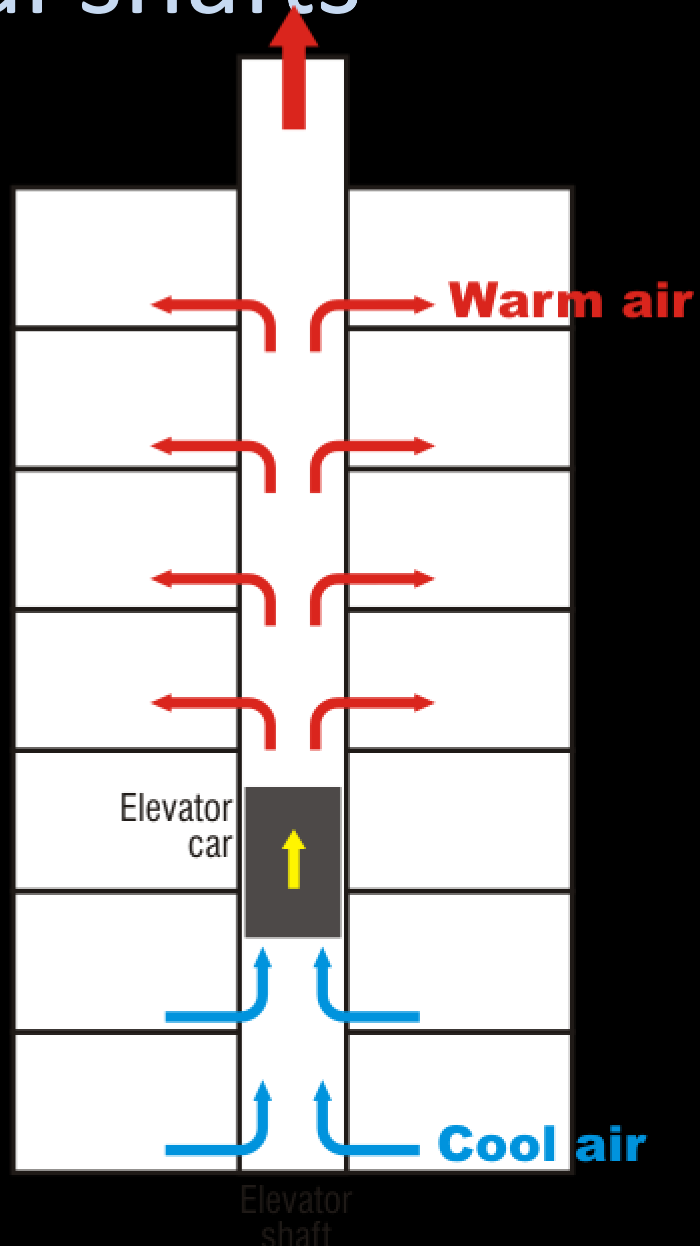
Reduce noise from outdoors

Reduced entry of hot humid air

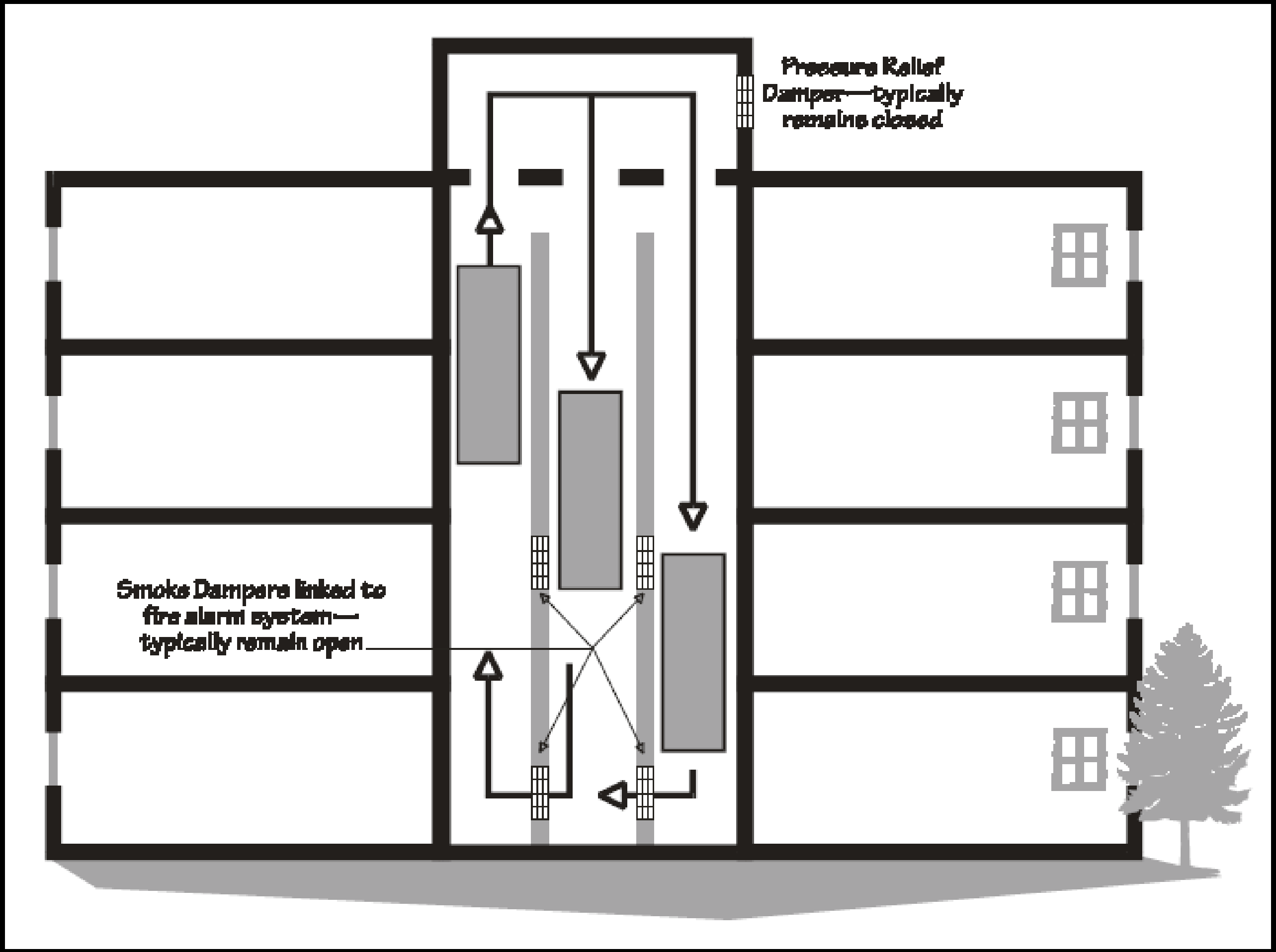


Disconnect Floors

Seal shafts



Improved Air tightness in Elevator Shafts



To determine pass/fail for new construction

"shall pass …0.25 CFM/sq ft …at 75 Pa …"

=1.0 liters/s @ 50 Pa /m^2

US Army Corps of Engineers®
Engineer Research and Development Center

Standards for air leakage – pass/fail

US Army Corps of Engineers

ICC INTERNATIONAL CODE COUNCIL

IgCC

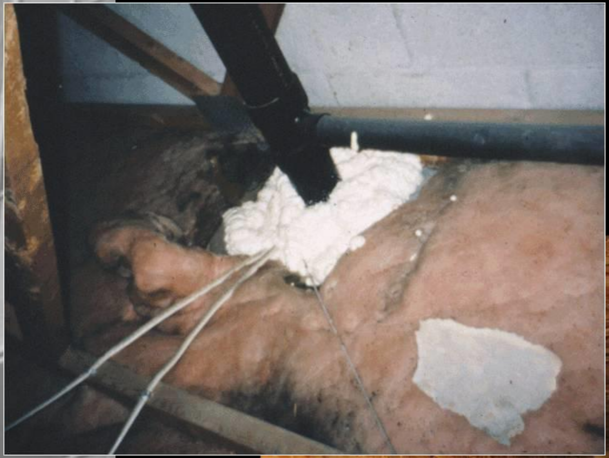
Required House tightness?

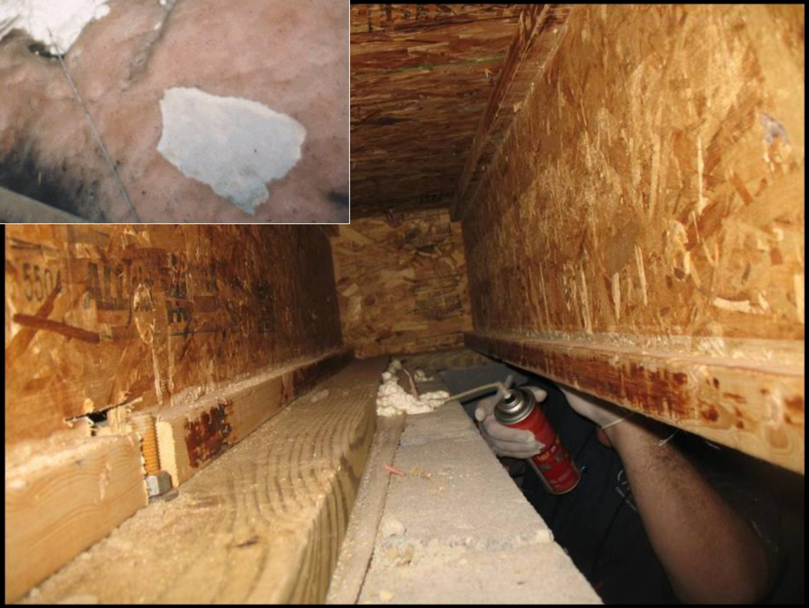
Standard	Requirement	CFM75/ ft^2
LEED	1.25 in^2 EfLA @ 4 Pa / 100 ft^2	**0.30**
2009 IECC	7.0 ACH50	**0.55**
2012 IECC	3.0 ACH50	**0.25**
Cdn R-2000	1.5 ACH50	**0.13**
Passiv Haus	0.6 ACH50	**0.05**

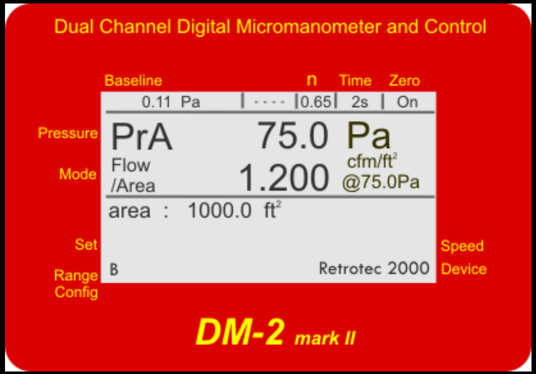
Large Bldg tightness?

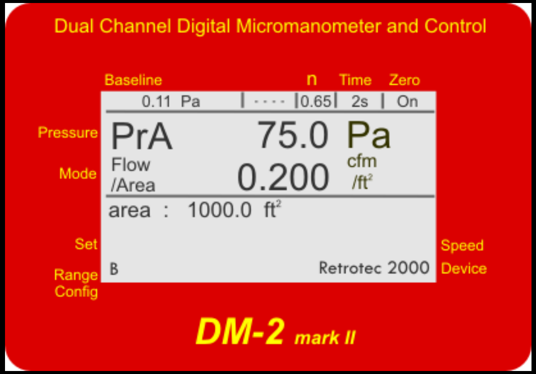
4 story building, 120 x 110 x 40 ft, n= 0.65			CFM75 / ft^2
USA	ASHRAE 90.1 Leaky		**0.60**
France		1.2 m^3/m^3/h @4Pa /m^2	**0.44**
USA	IECC, Washington State		**0.40**
Russia		**1.5 l/s @50Pa /m^2**	**0.385**
UK	TS-1Commercial, Best	5 m^3/h @50Pa /m^2	**0.36**
USA	ASHRAE 90.1 Average		**0.30**
USA	USACE, IGCC		**0.25**
UK	TS-1Commercial Tight	2 m^3/m^3/h @50Pa /m^2	**0.14**
USA	ASHRAE 90.1 Tight		**0.10**

Air leakage is measured to determine weatherization effectiveness



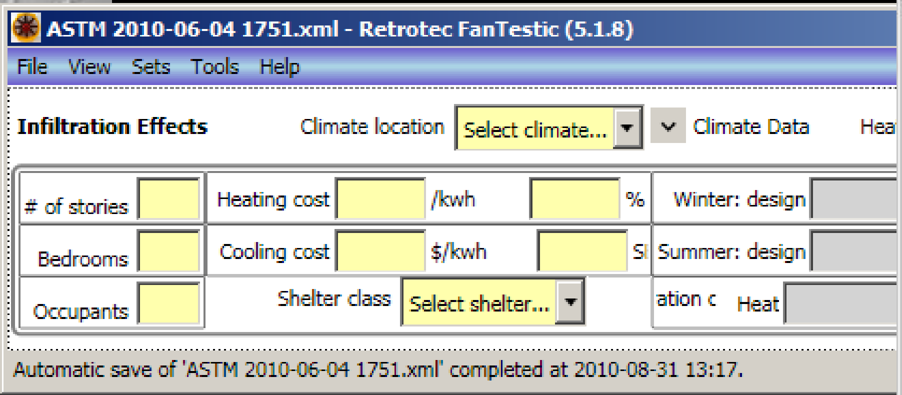


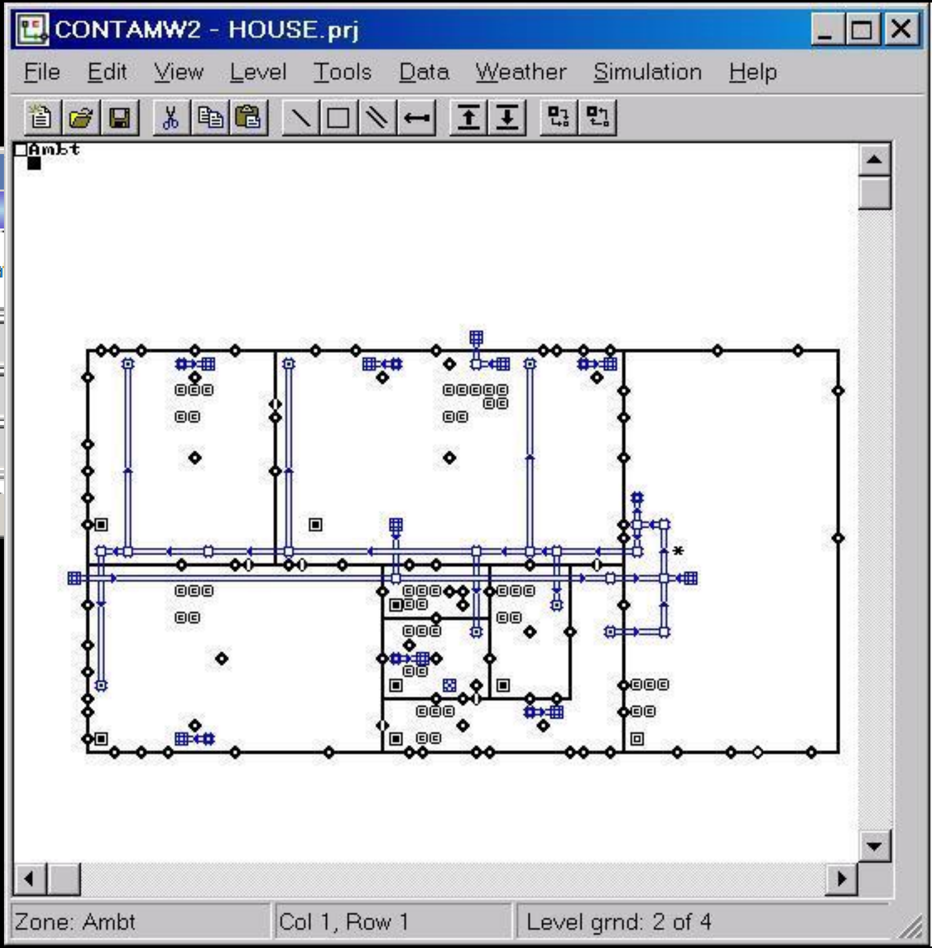




Why air leakage is measured 2

Air leakage is measured to run predictive models



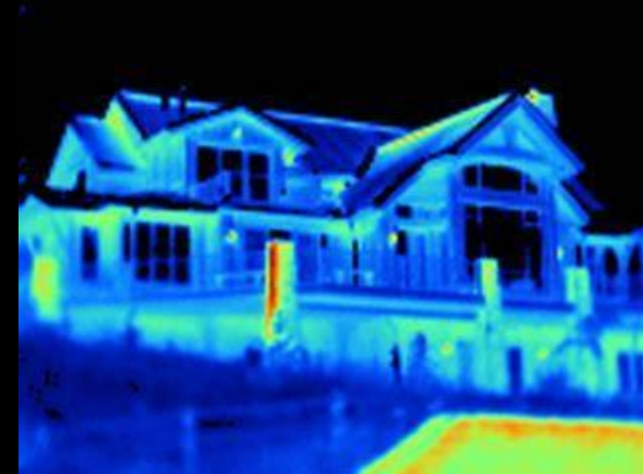


Recommendations

- Assemblies-0.01 cfm /ft2 @75
- Walls 0.1 cfm /ft2 @75
- Slabs 0.01 cfm /ft2 @75
- Paint all block walls
- Seal all shafts at each floor
- Enclose elevator lobbies from slab to slab
- Electronic exhaust fan & fire dampers

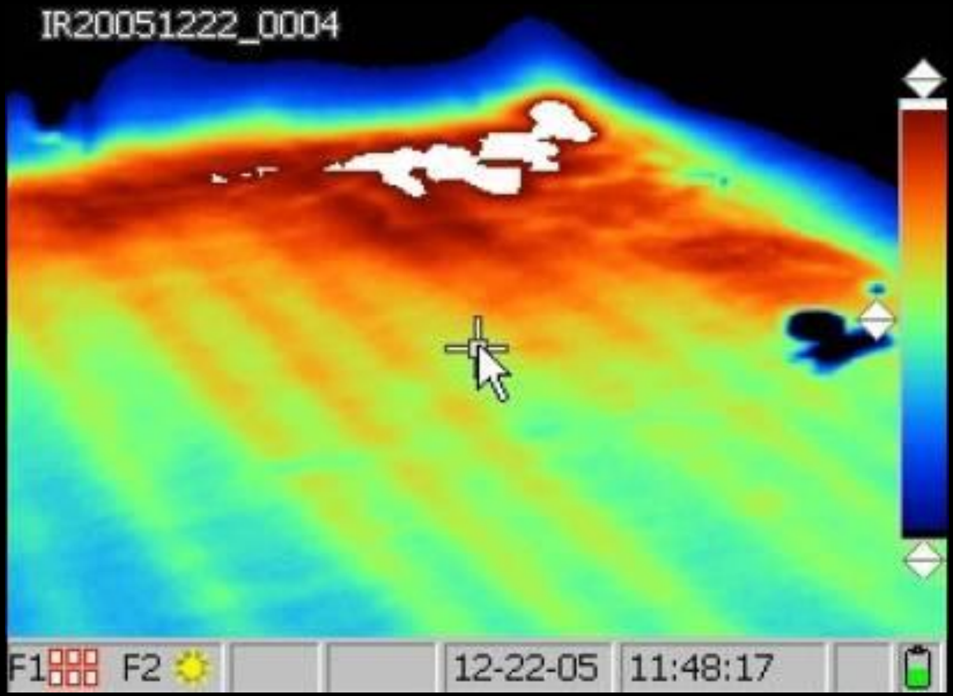
Locate and seal leaks

Locate leaks with door fan using smoke, infrared, hand

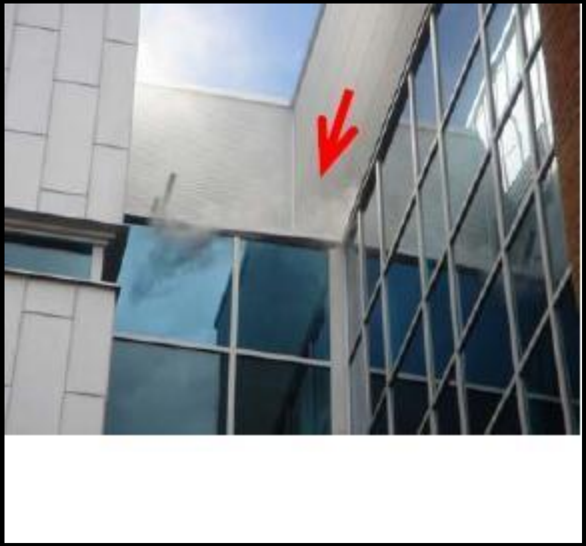


Door fan finds leaks

Door fans and infrared camera

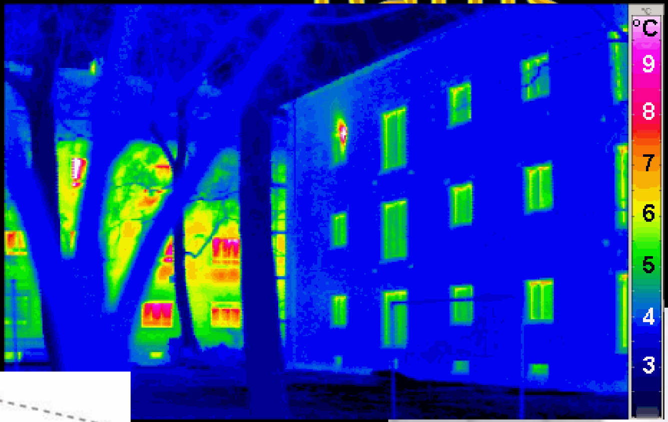


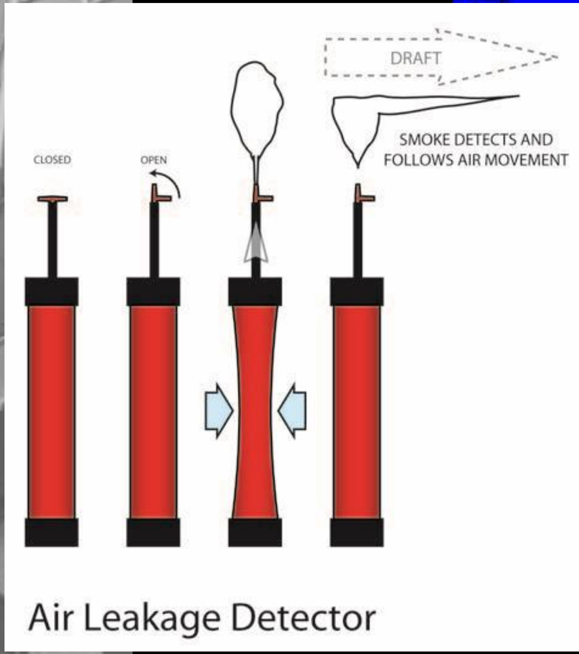
Exterior wall leaks

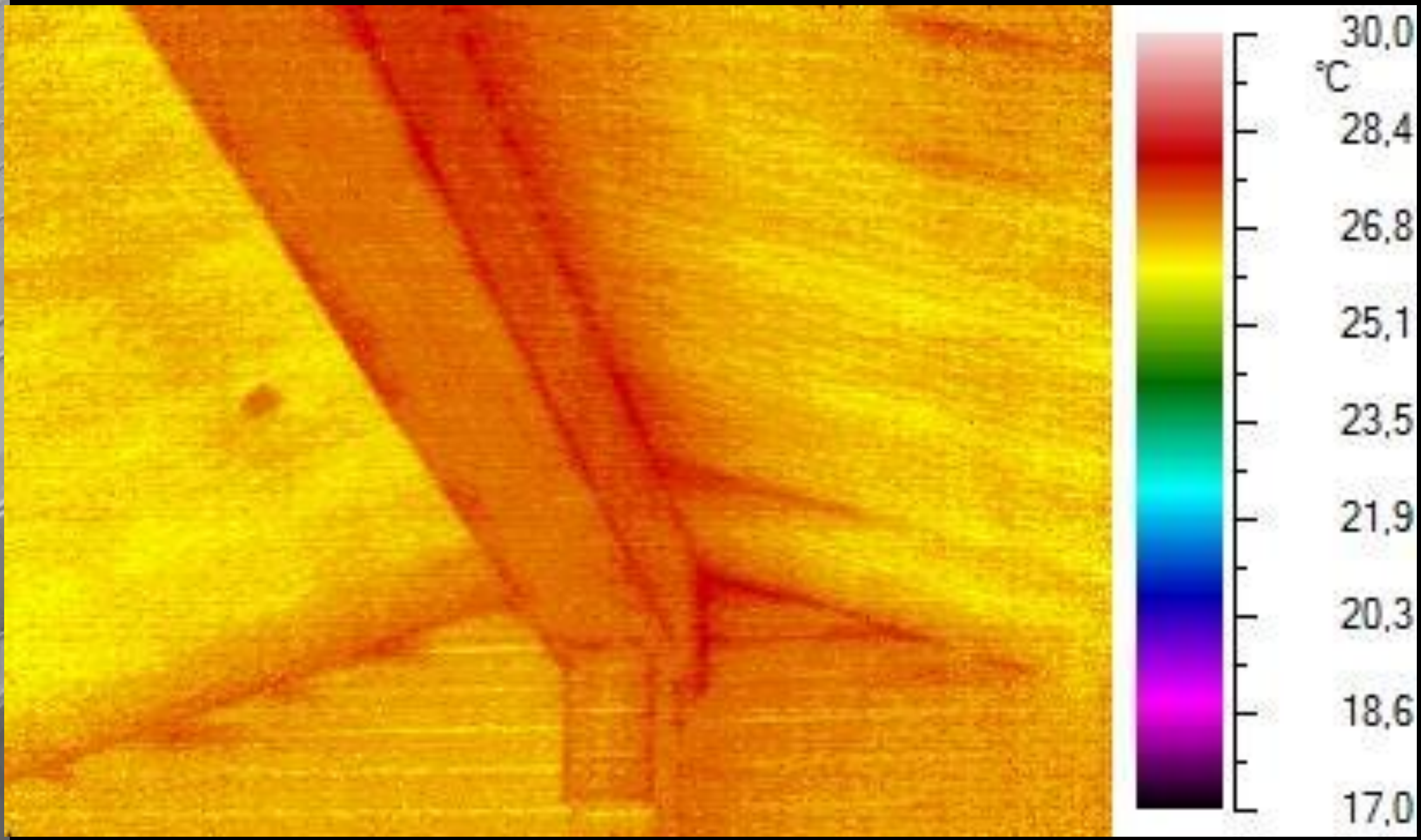


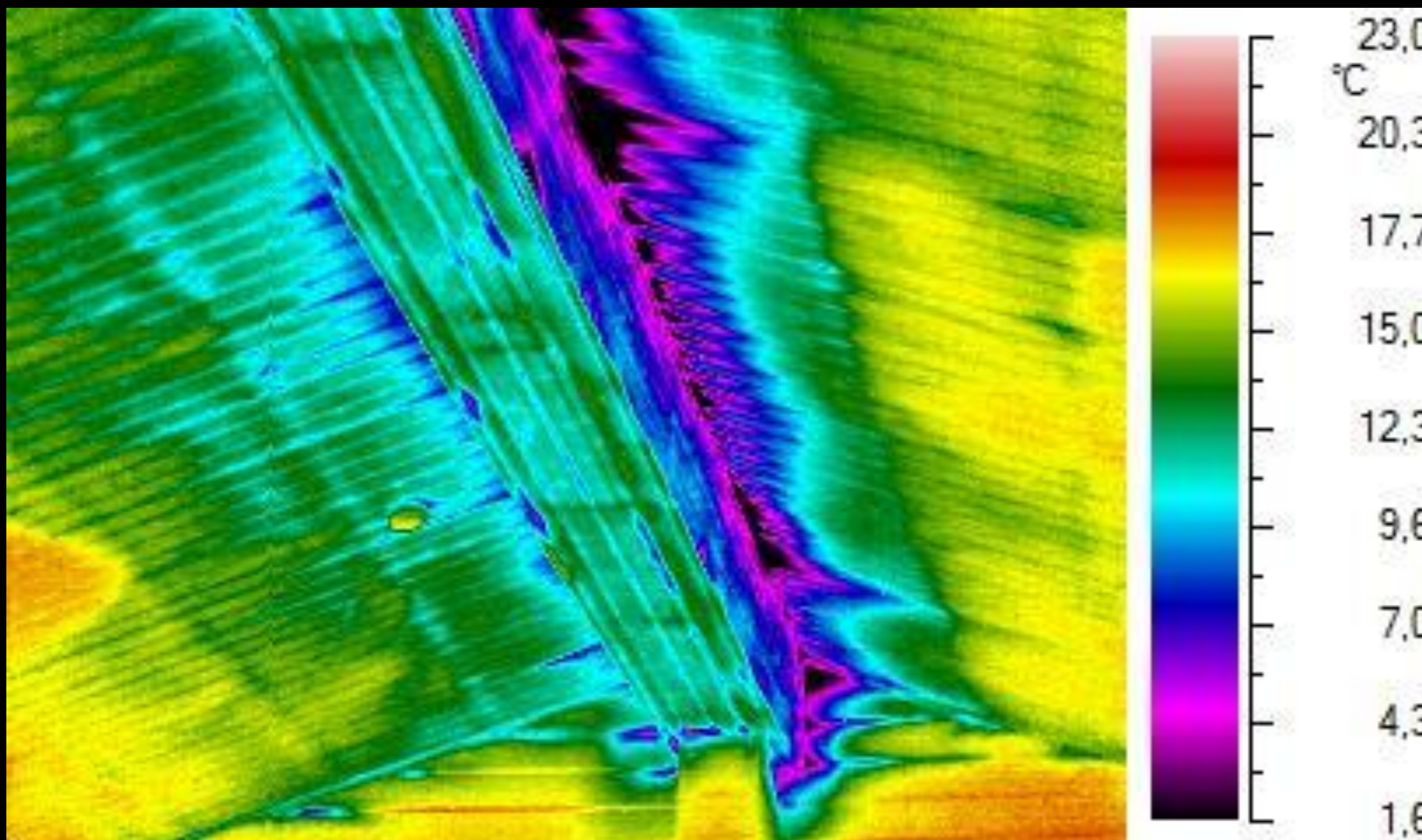
Smoke Testing Used to Confirm Air Barrier Discontinuity

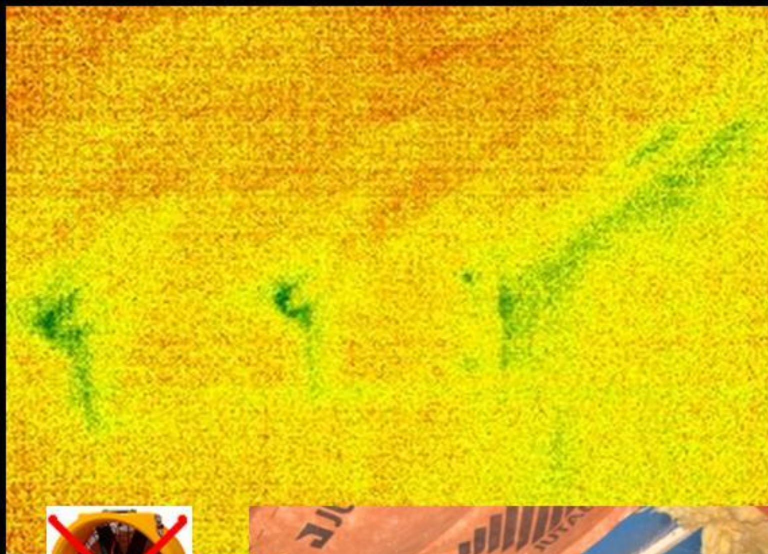
Smoke and IR identify air leakage paths

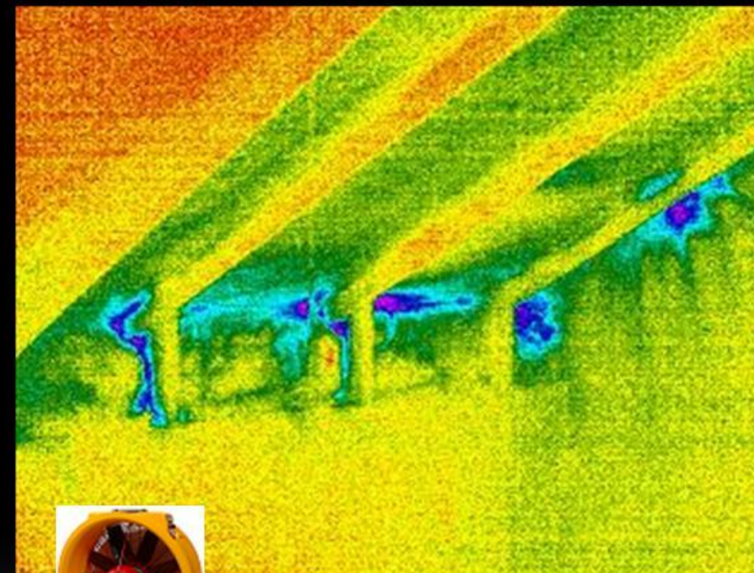




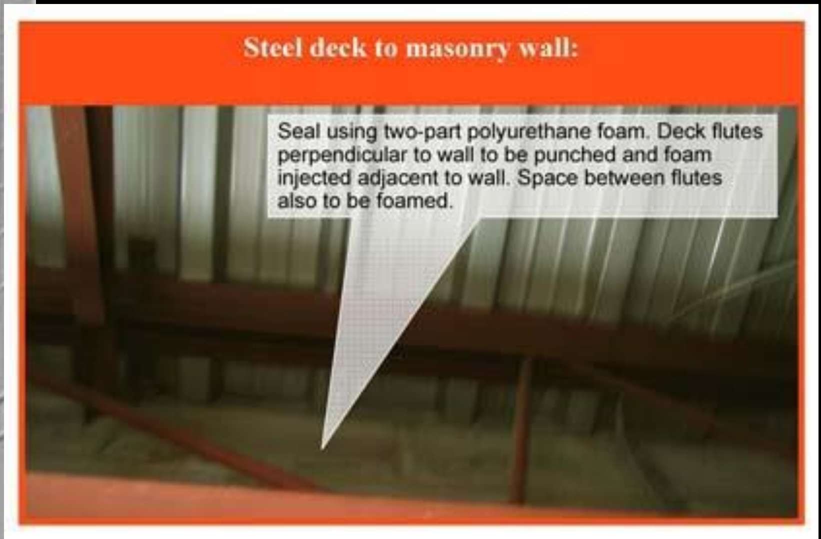

30,0
℃
28,4
26,8
25,1
23,5
21,9
20,3
18,6
17,0

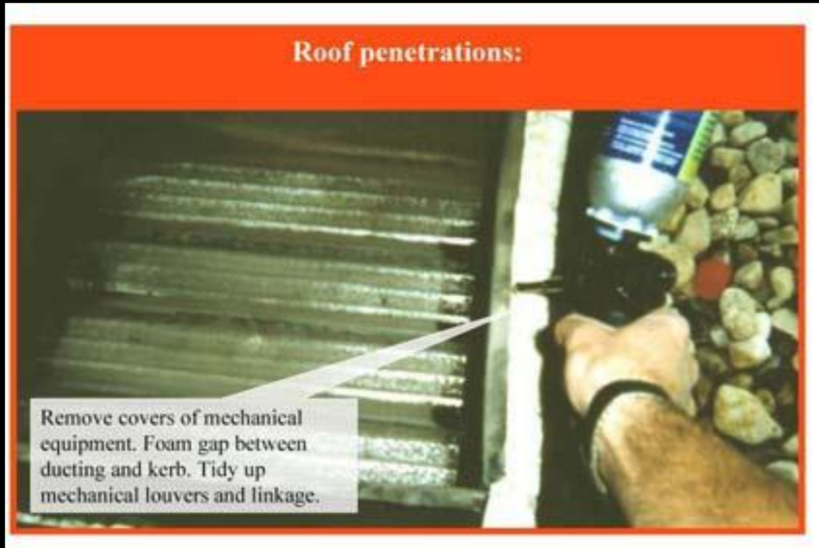

23,0
°C
20,3
17,7
15,0
12,3
9,6
7,0
4,3
1,6

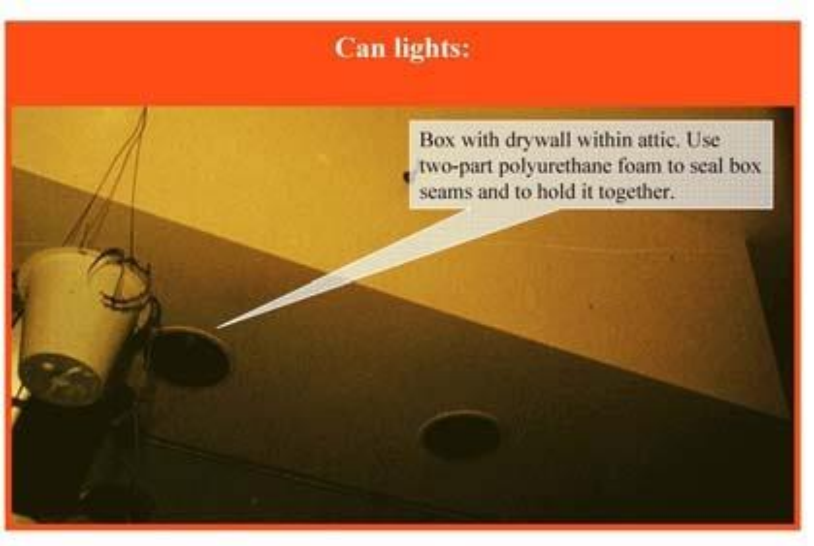




Sealing air leaks







Measure leaks

Door-Fan components
panel + calibrated fan +gauges

Bigger

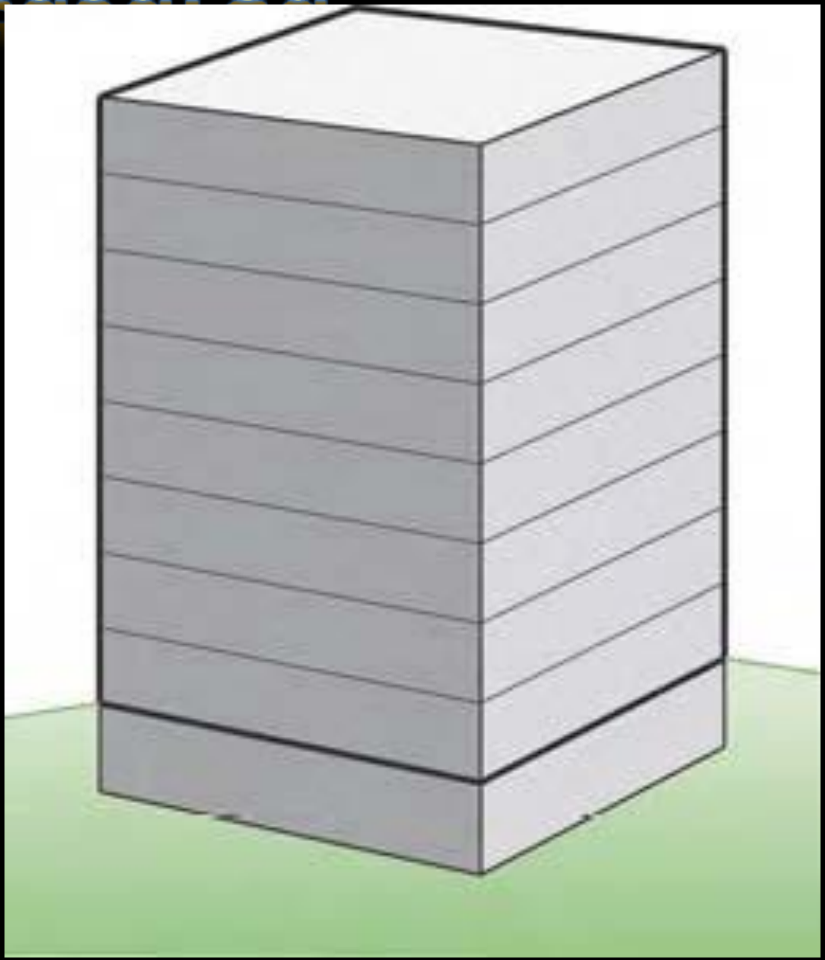
Seal these

Open interior doors

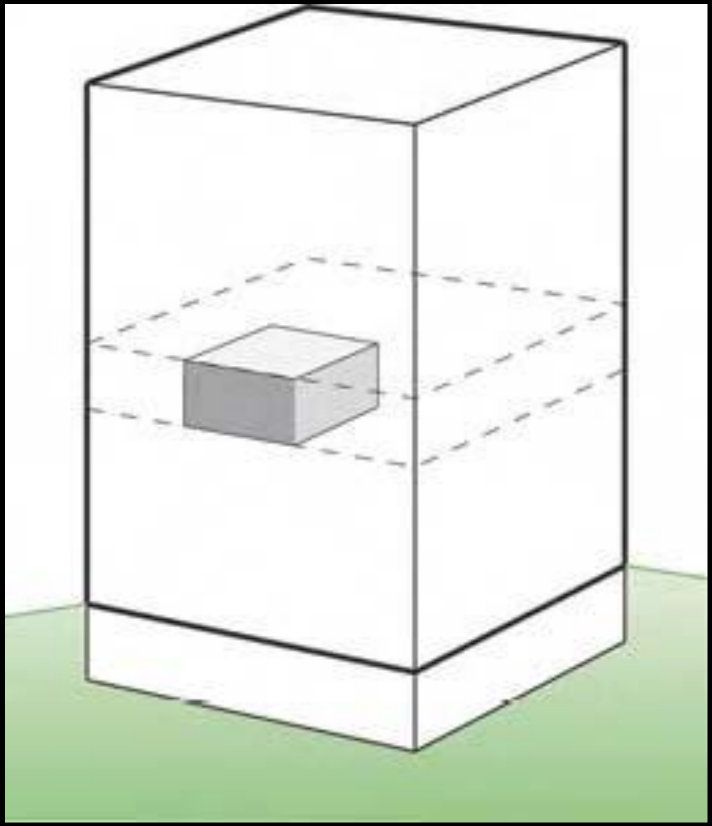
Setting up the test fans

What components of buildings can be measured?

Whole building envelopes can be measured



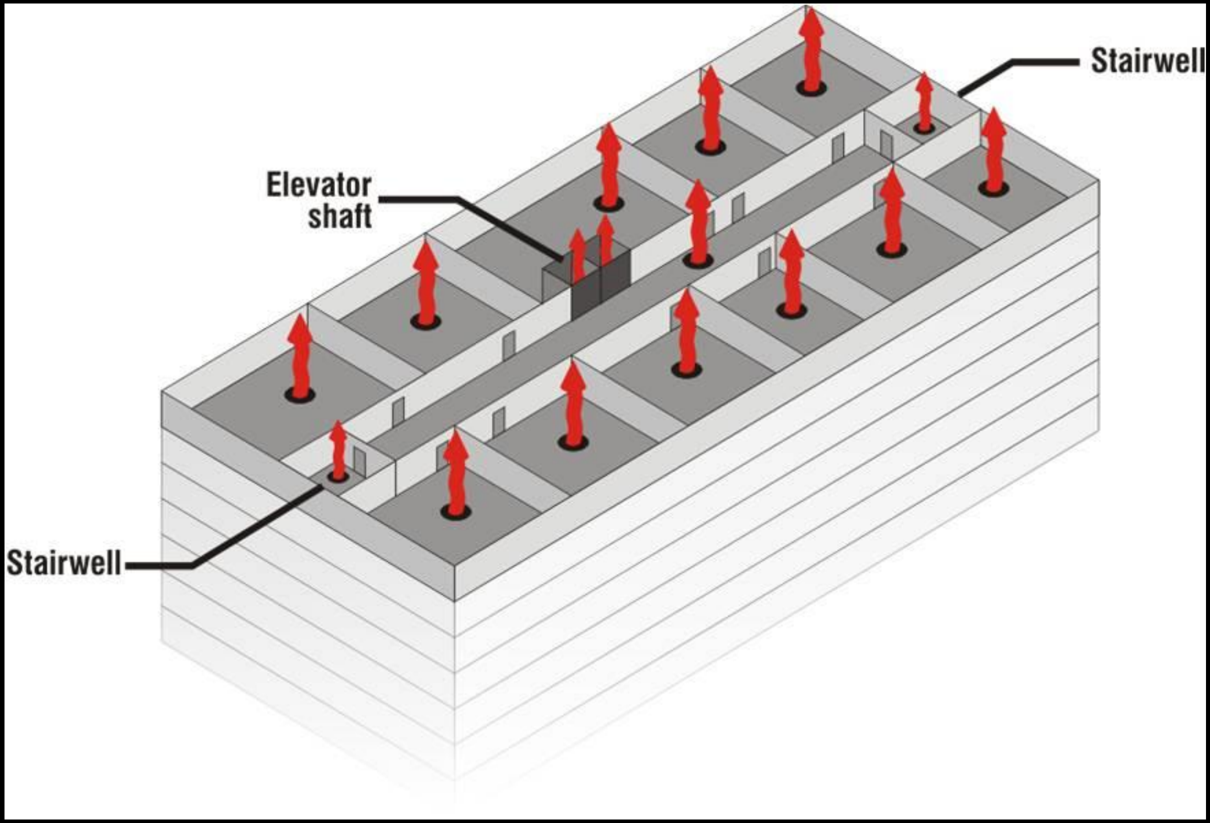
Individual apartments can be measured



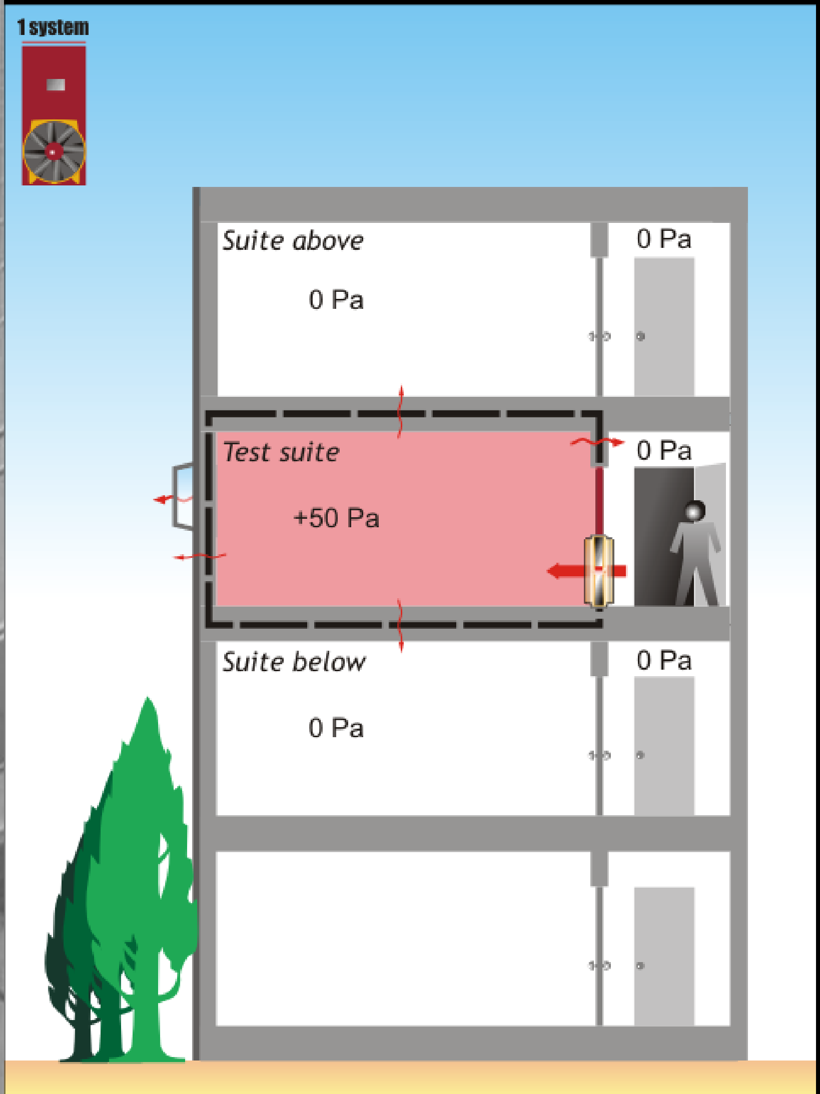
Hallways can be measured

Stairwells can be measured

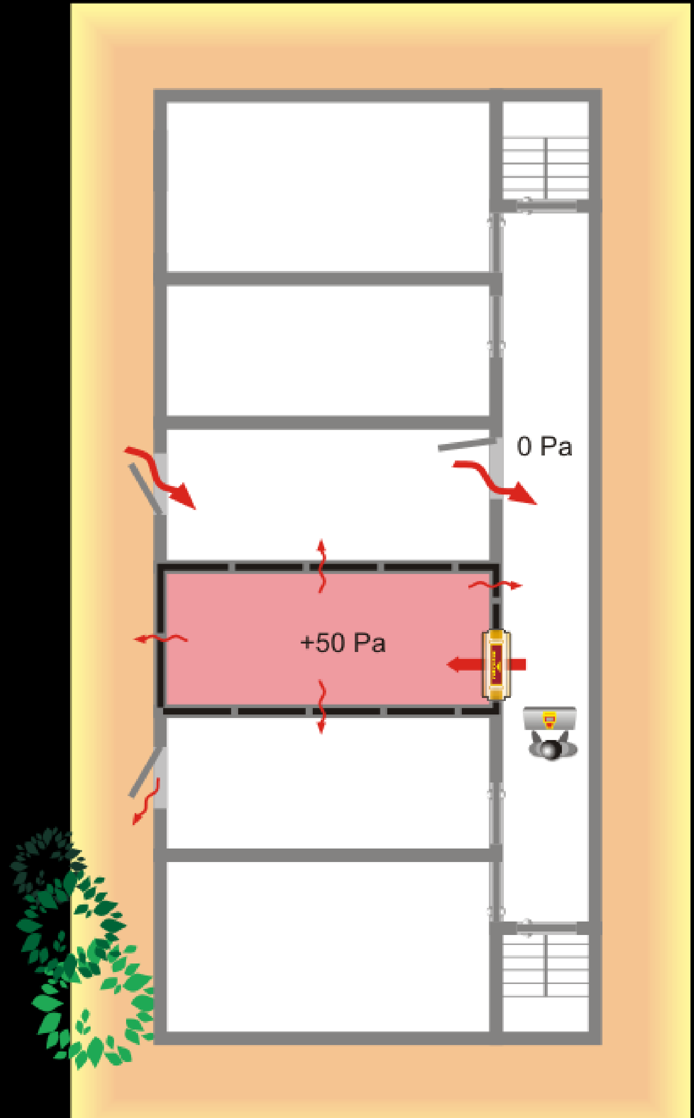
Floor to floor leakage can be measured



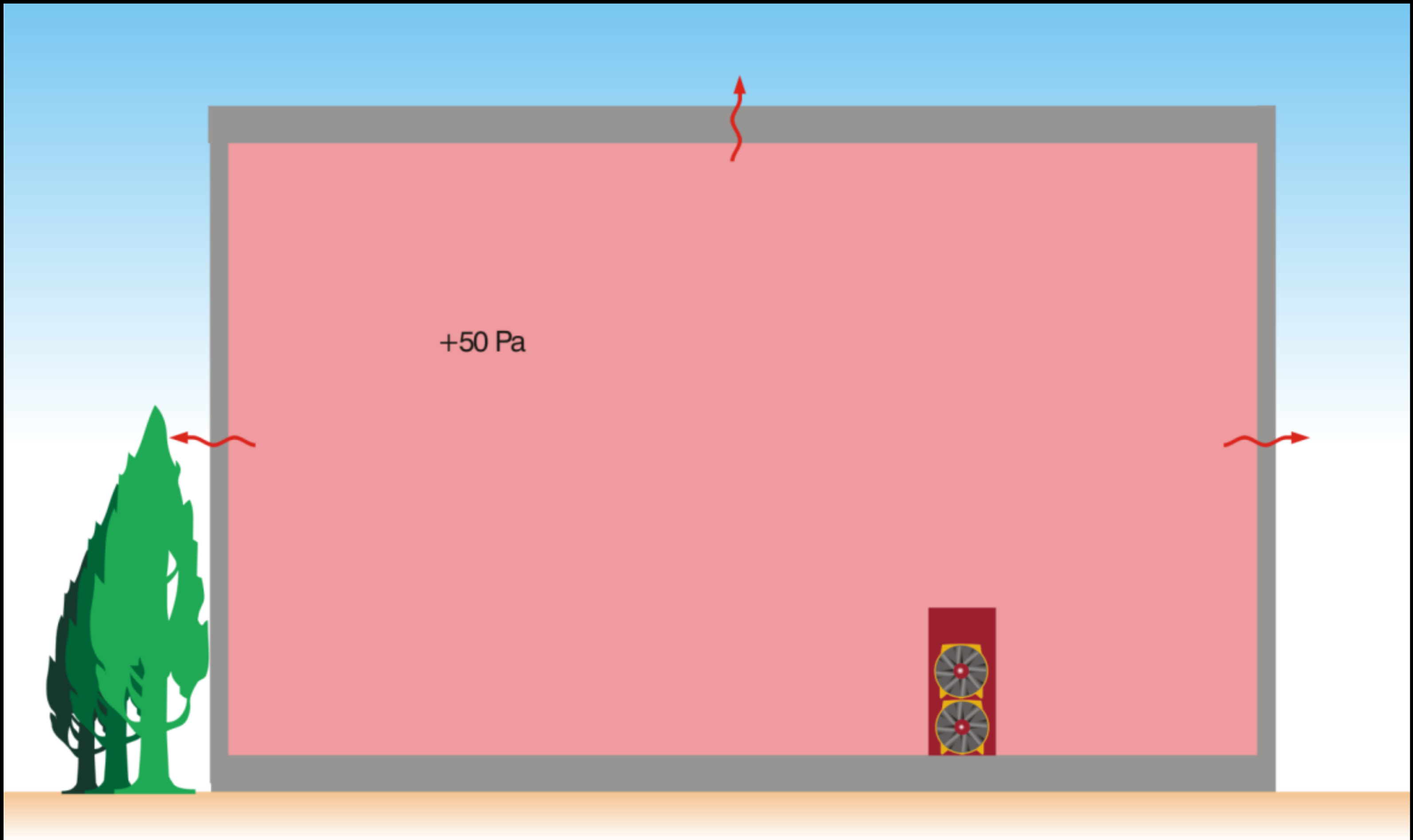
Total Unit Leakage - All 6 Sides, 1 Door Fan



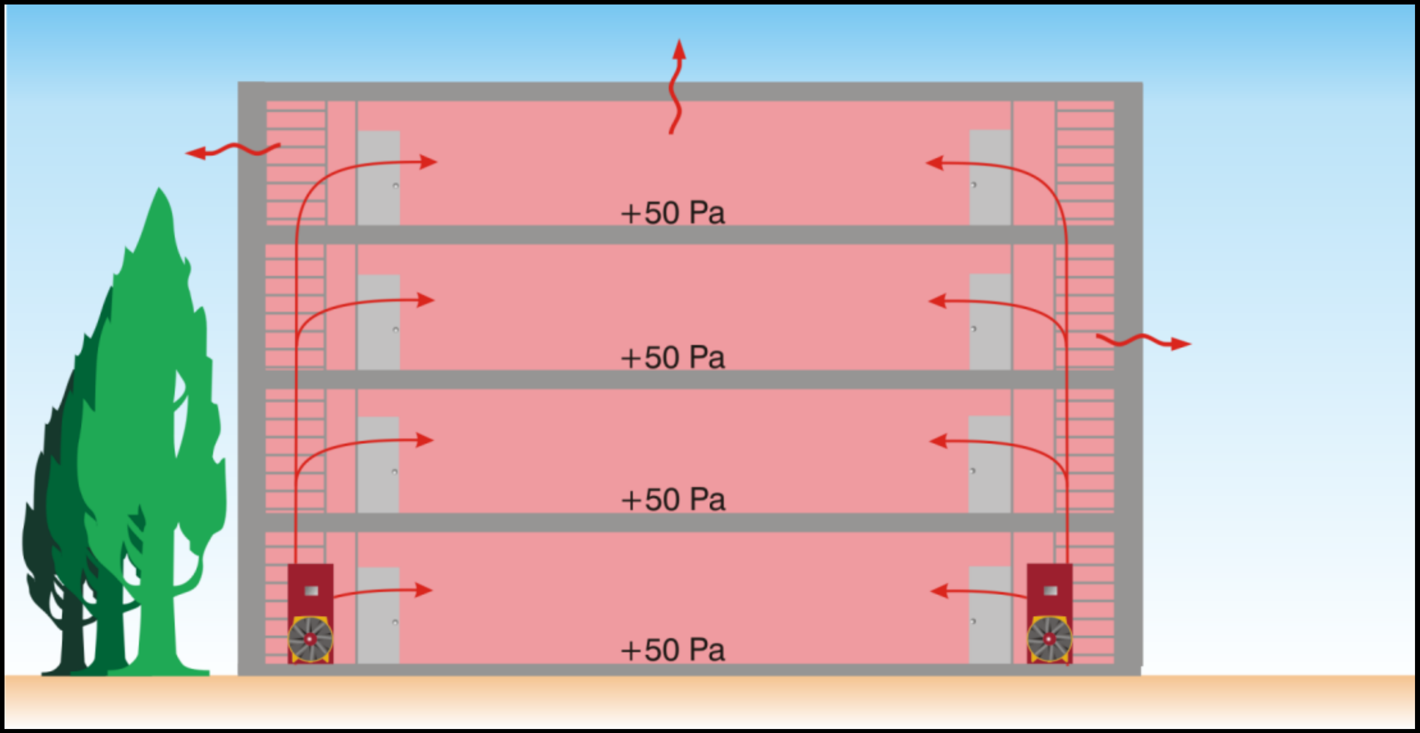
Side View



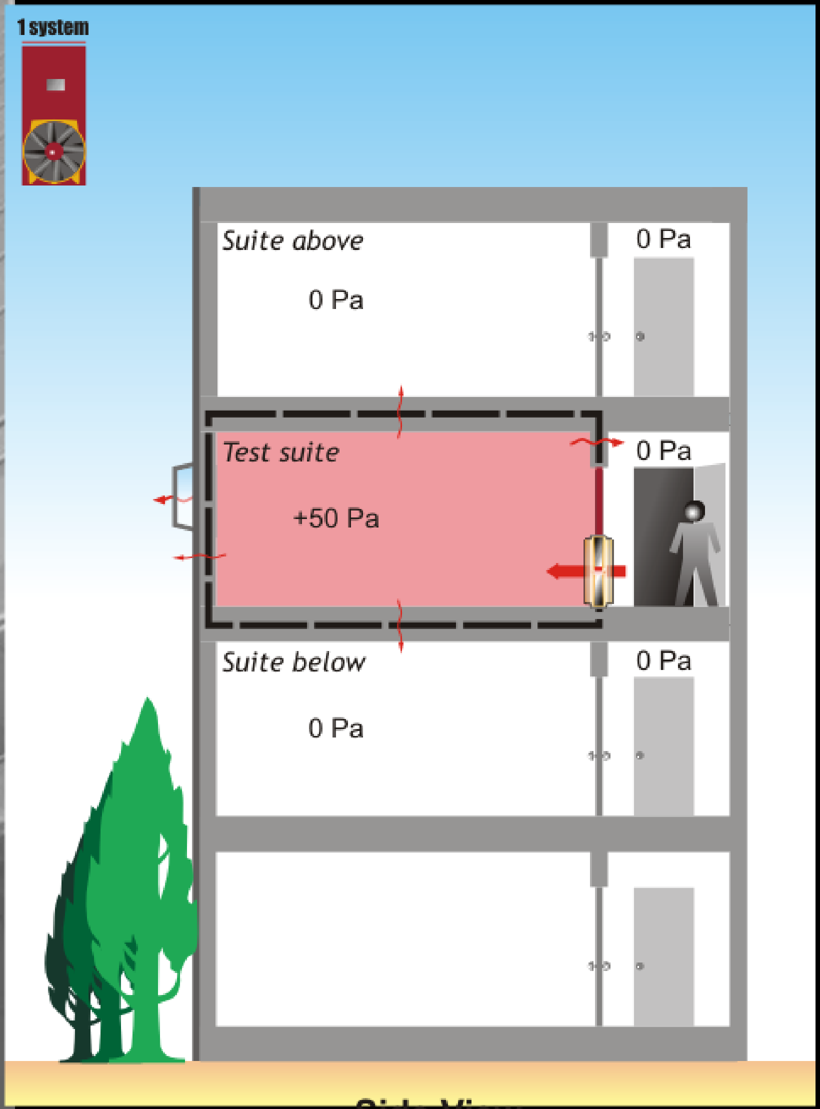
Top Down View


+50 Pa

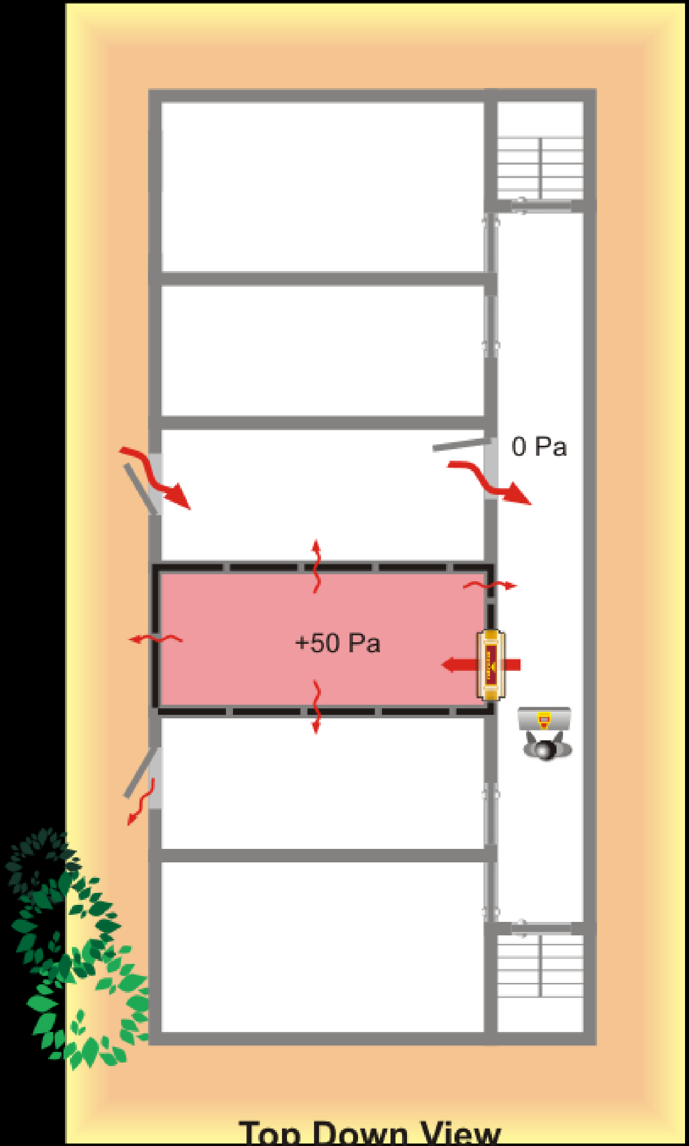
Measure Entire Envelope



Total Unit Leakage - All 6 Sides, 1 Door Fan

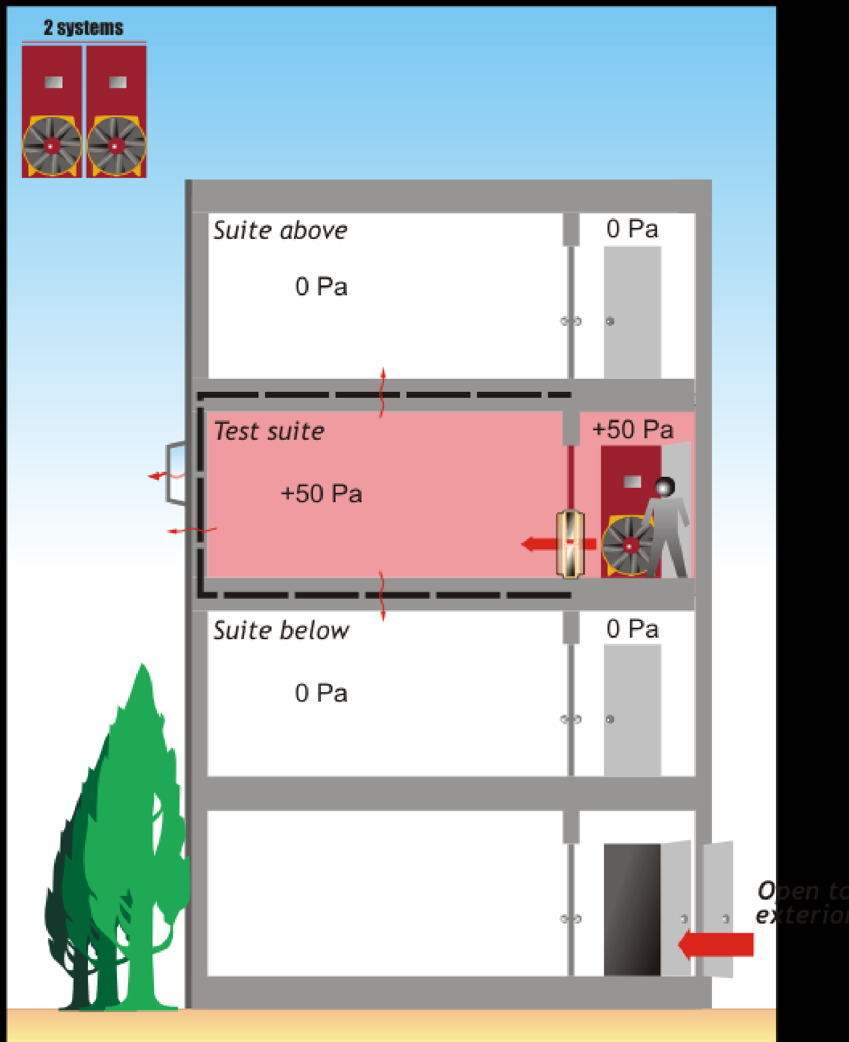


Side View

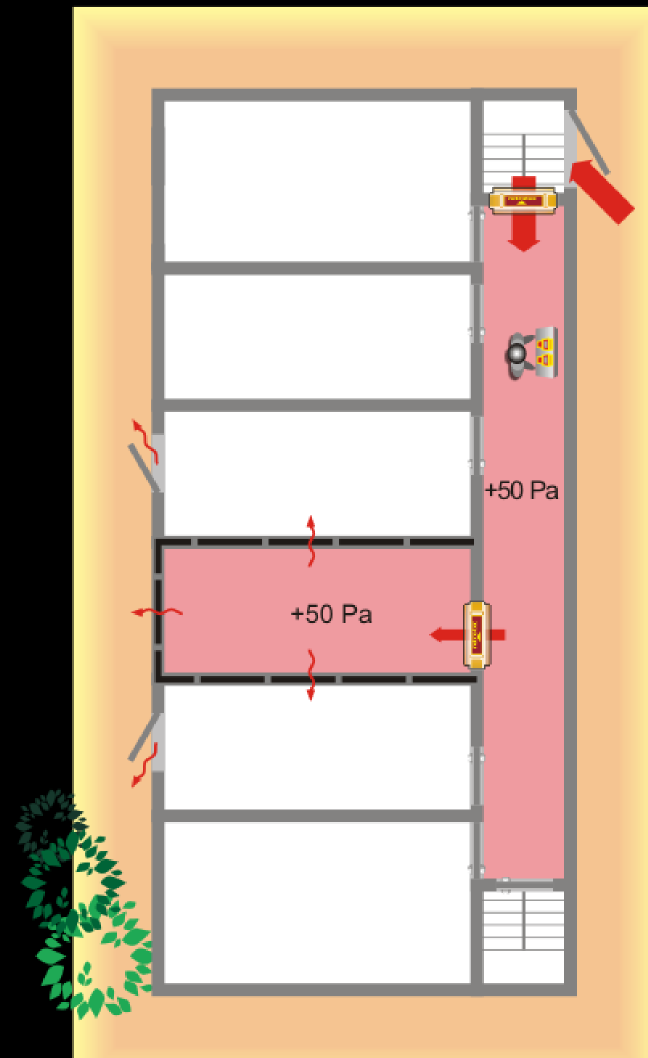


Top Down View

Leakage from Apartment to Hallway

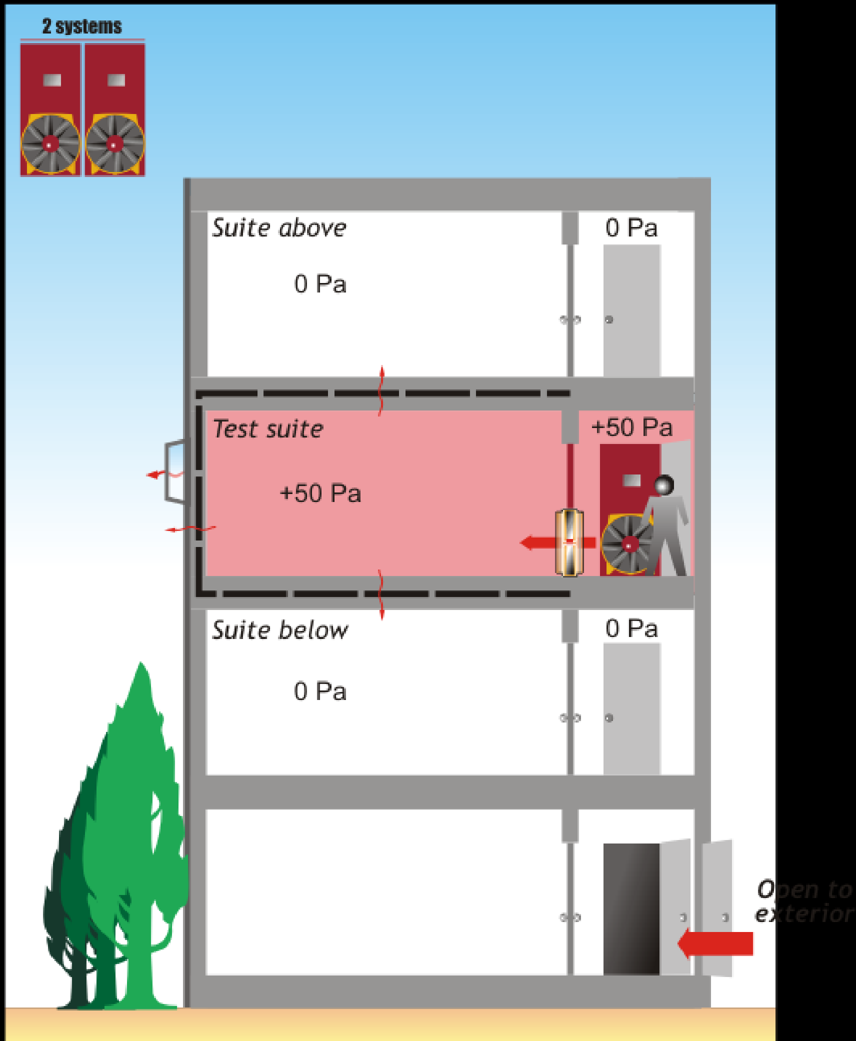


Side View

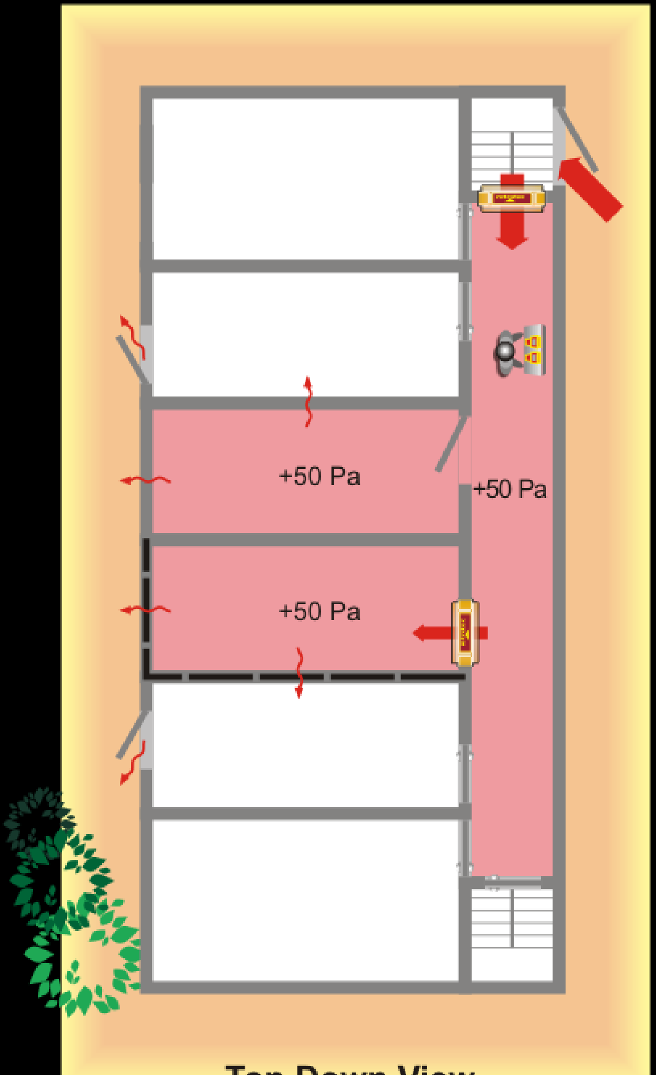


Top Down View

Leakage across 1st Party Wall

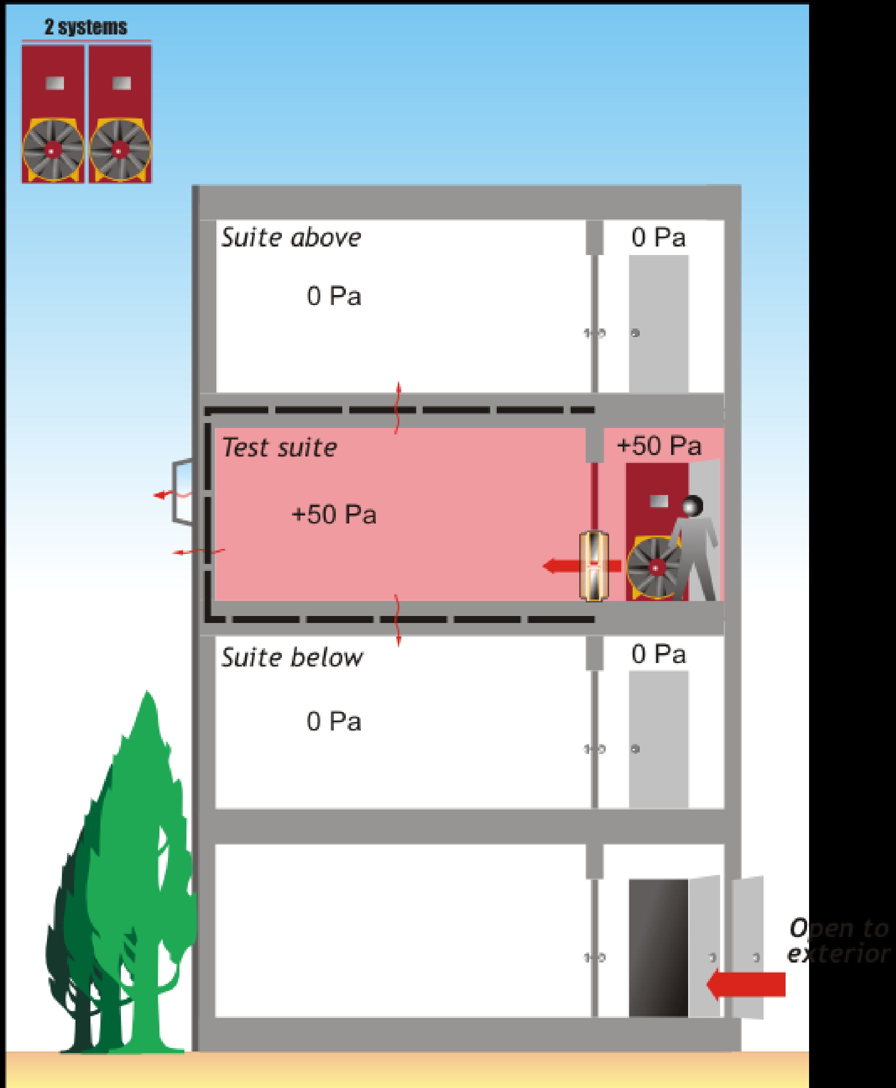


Side View

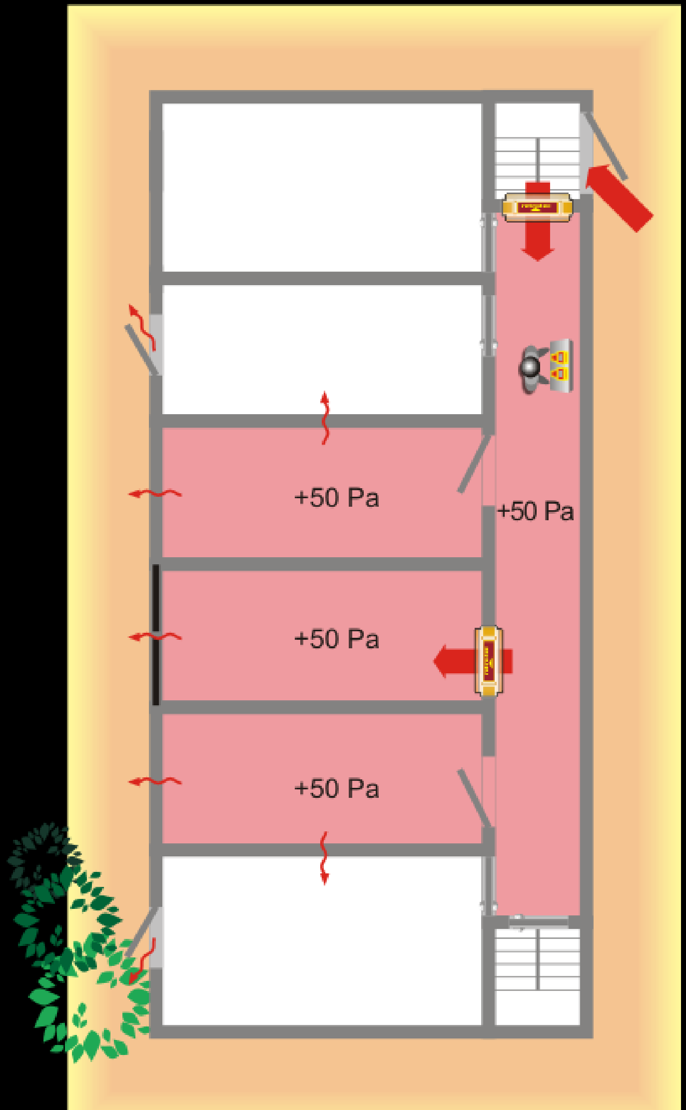


Top Down View

Leakage across 2nd Party Wall

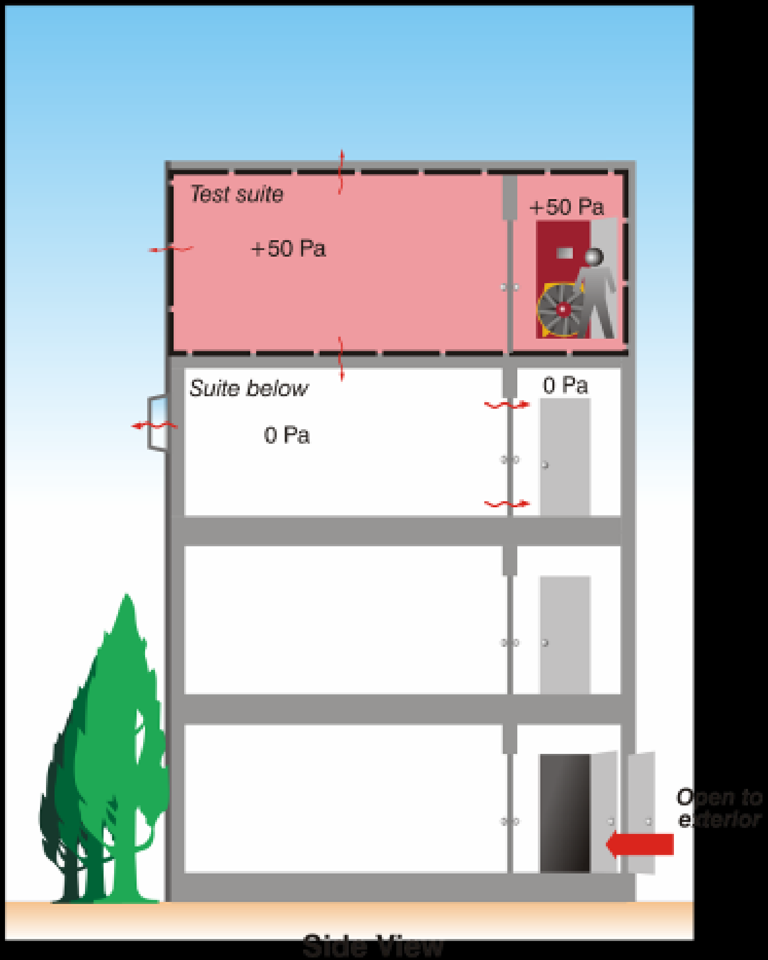


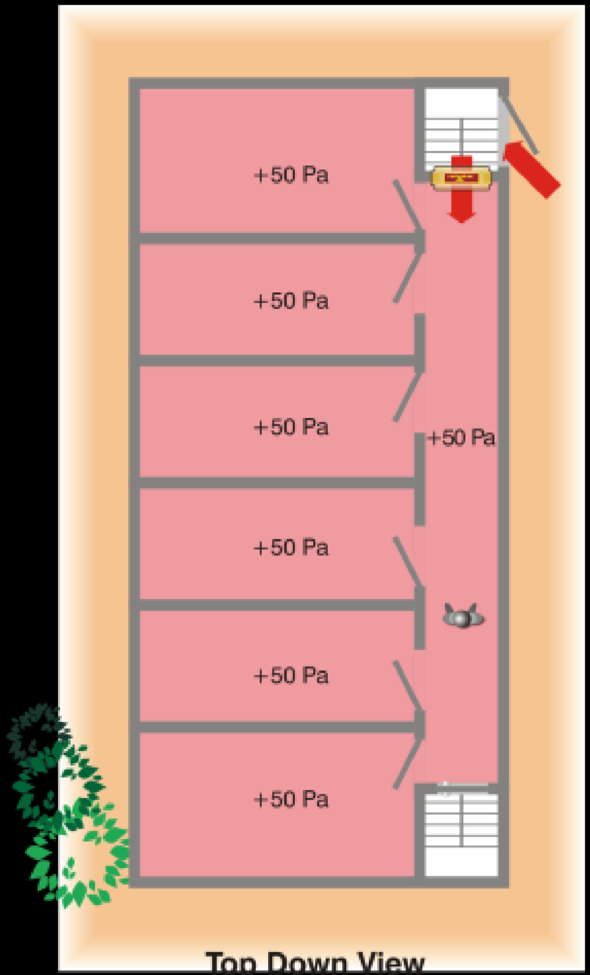
Side View



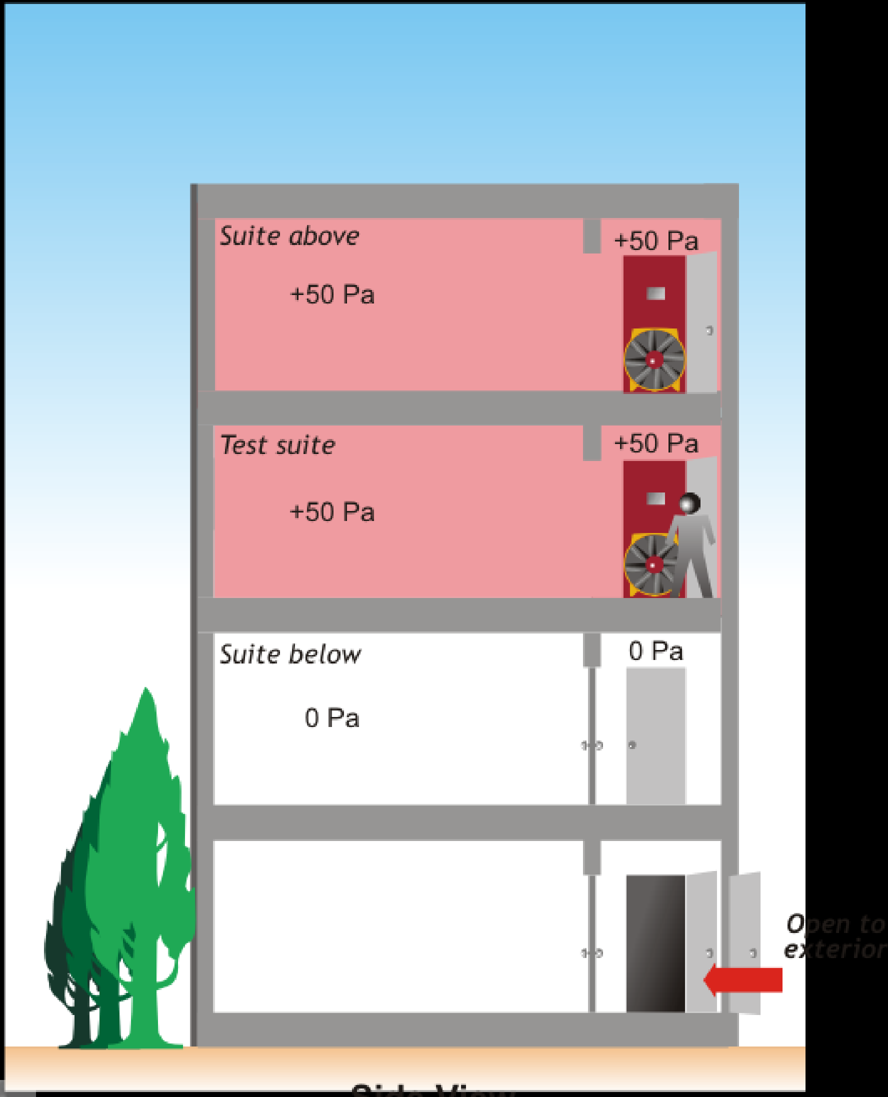
Top Down View

Slab leakage – total floor leakage

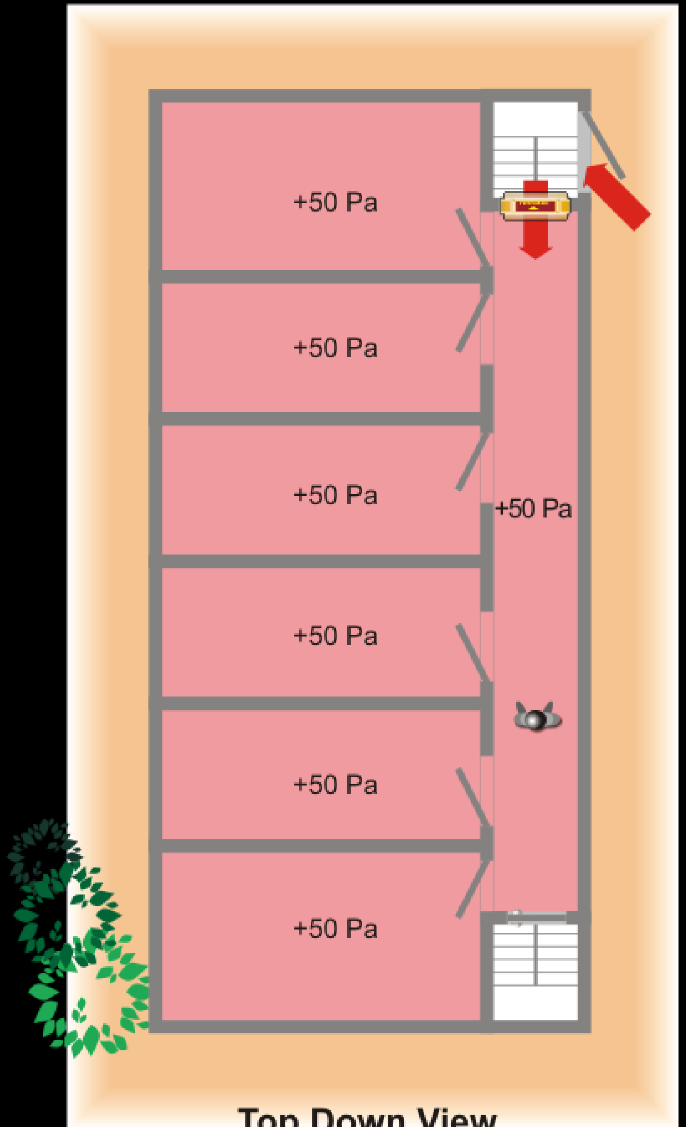




Pressurizing the Floor Above

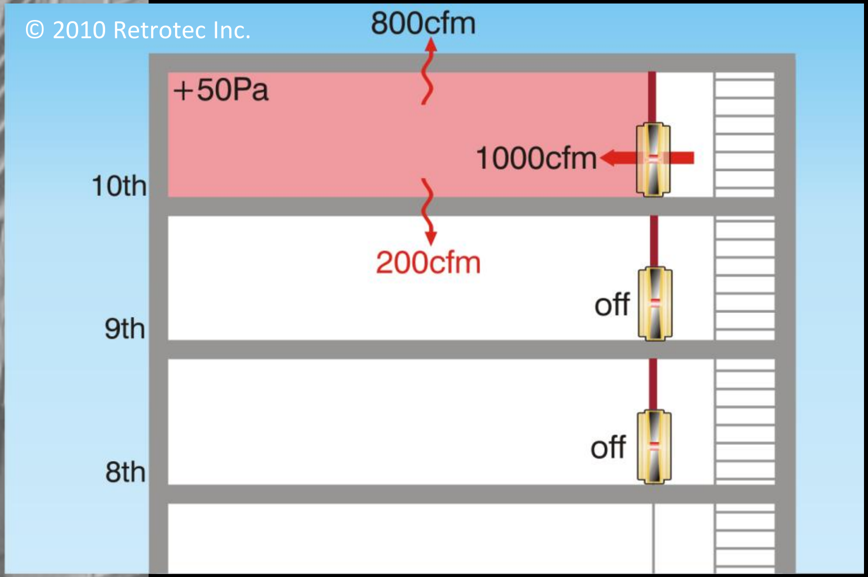


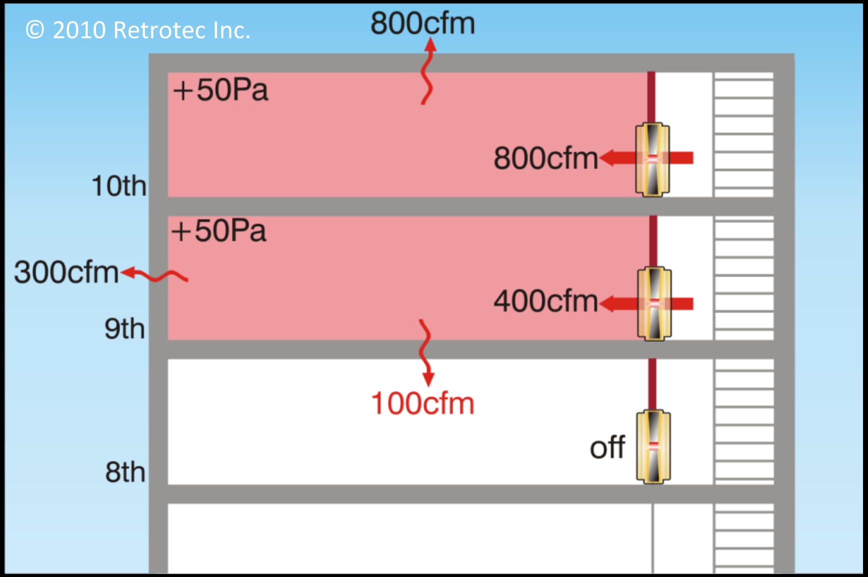
Side View



Top Down View

Floor to floor leakage can be measured





Elevator shafts can be measured

Case Studies

Air leakage Test Protocol for U.S. Army Corps Buildings

Requirements

- – Proper design
- – Plan review
- – Ongoing inspection
- – Mock up building materials
- – Pass air leakage protocol
    - easy
    - not just the ASTM E779 standard

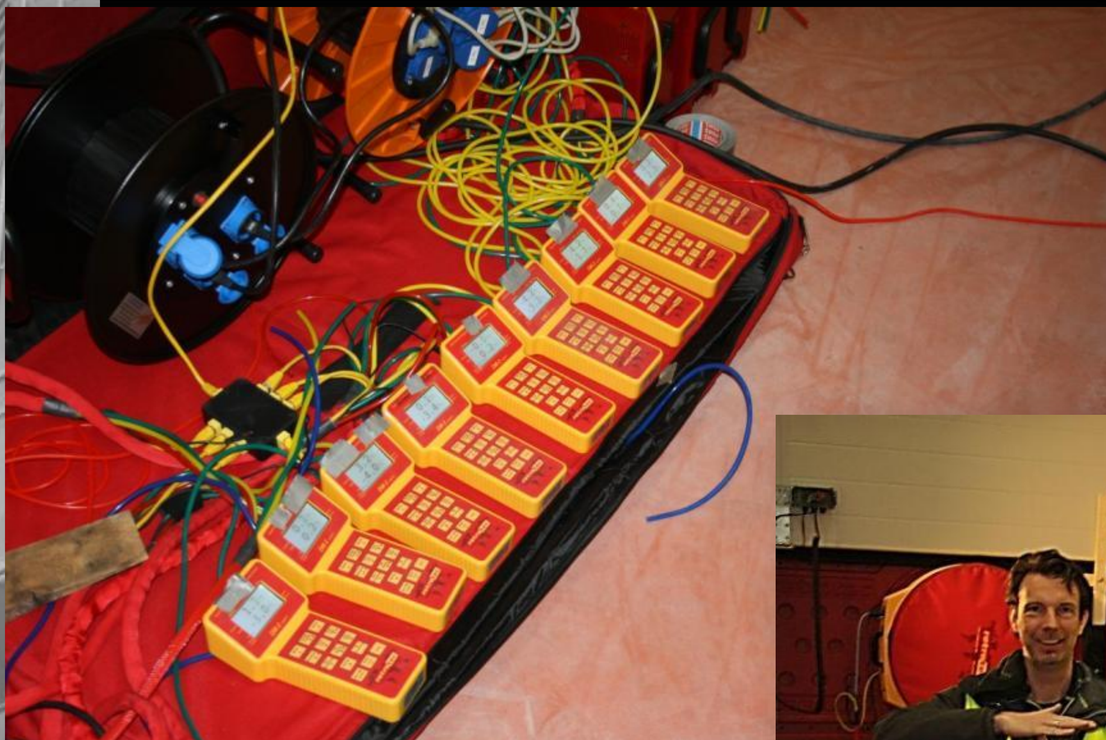
GUINNESS WORLD RECORDS

CERTIFICATE

Guiness World Record
15,000,000 cubic feet


www.blower-door-xxl.com
door-xxl.com
20
19
Ian Jack

Hallenumfang = 1,2 km



9 x 2

Refe

Real life test: EMAD

Antwerp, Belgium

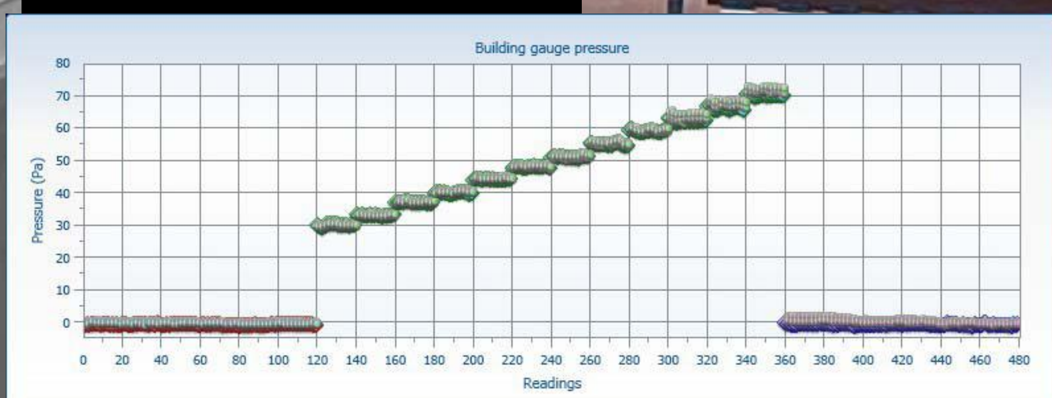
- Envelope Area = 11,250 m^2

- 0.601 CFM/ft^2 @ 75Pa
- 8.22 $m^3/h/m^2$

Real life test: BTC

South Carolina, USA

- Envelope A = 136,820ft^2
- 0.08 CFM/ft^2 @ 75Pa

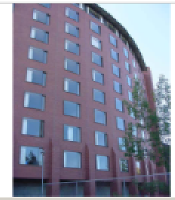


Real life test: Retrotec

Vancouver, Canada

- Envelope Area = 25,000 ft

- 0.4 CFM/ft^2 @ 75Pa
- 7.3 $m^3/h/m^2$



EN13829 2010-01-21 0909.xml - Retrotec FanTestic (0.9.62)

File View Sets Tools

Building Air Leakage Test

In compliance with European Norm EN13829

Retrotec FanTestic, version 0.9.62 License# Free Beta Version

Select Building Image

Test technician: Tim Lochner

#1 Door Fan Model: Retrotec DU200 | S/N: 0 | Gauge Model: DM-2 | S/N: 201653

Building Address:
1639 West 2nd Ave - Unit 330
Vancouver, BC
Canada V6J1H3

Elevation	0 m	Volume, V	500 m³
Height of Building above ground	20 m	Total envelope area, AT	480 m²
Building exposure to wind	A: Highly protected buildi	Floor area, AF	120 m²
		Accuracy of building measurements	5 %

Start date: 2010-1-21 | Start time: 09:37 | **Depressurization set**

Barometric press: 101 kPa from Stand. temp. and pressure | Wind speed (Beaufort): 0: Calm | Operator loc: Inside

Take 12 bias pressures for 10 sec each. | Take 12 building pressures from 15 to 70 | Temperatu indoors 20 °C outdoors 20 °C

Start Autotest | Show Graphs

Bias pressure, initial [Pa]	.02	-.109	-.033	.025	-.164	-.112	-.103	-.143	-.11	.018	-.131	-.066
Bias Average ΔP -0.076 / ΔP01- -0.108 / ΔP01+ 0.021												
Building gauge pressure [Pa]	-15.2	-20.9	-25.7	-30.4	-35.8	-40.1	-45.3	-49.9	-55.1	-59.7	-64.8	-69.4
Door Fan 1, Range Low	113.1	153.6	187.5	217.2	253.8	284.5	319.1	351.9	391.8	425	461.6	496.2
Door Fan 1, Range	113.1	153.6	187.5	217.2	253.8	284.5	319.1	351.9	391.8	425	461.6	496.2
Bias pressure, final [Pa]	-.694	-.099	-.118	-.032	-.374	-.413		-.03	-.159	-.13	-.136	.012
Bias ΔP02 -0.181 / ΔP02- -0.219 / ΔP02+ 0.006 / Temperatu indoors 20 °C outdoors 20 °C												
Total flow, Vr [m3/h]	30.3	36.3	40.7	44.2	48.3	51.4	54.8	57.8	61.2	63.8	66.6	69.1
Corrected flow rate, Venv [m3/h]	30	36	41	44	48	52	55	58	61	64	67	69
Error [%]	-0.42%	0.34%	0.57%	-0.14%	-0.15%	-0.06%	-0.21%	-0.19%	0.19%	0.14%	-0.05%	-0.02%

		Confidence Limit	
Correlation, r [%]	100.0		
Intercept, Cenv [m³/h.Paⁿ]	7.1	7.0	7.2
Intercept, CL [m³/h.Paⁿ]	7.1	7.0	7.2
Slope, n	0.537	0.533	0.541

Calculate | Clear data | Delete set | New set

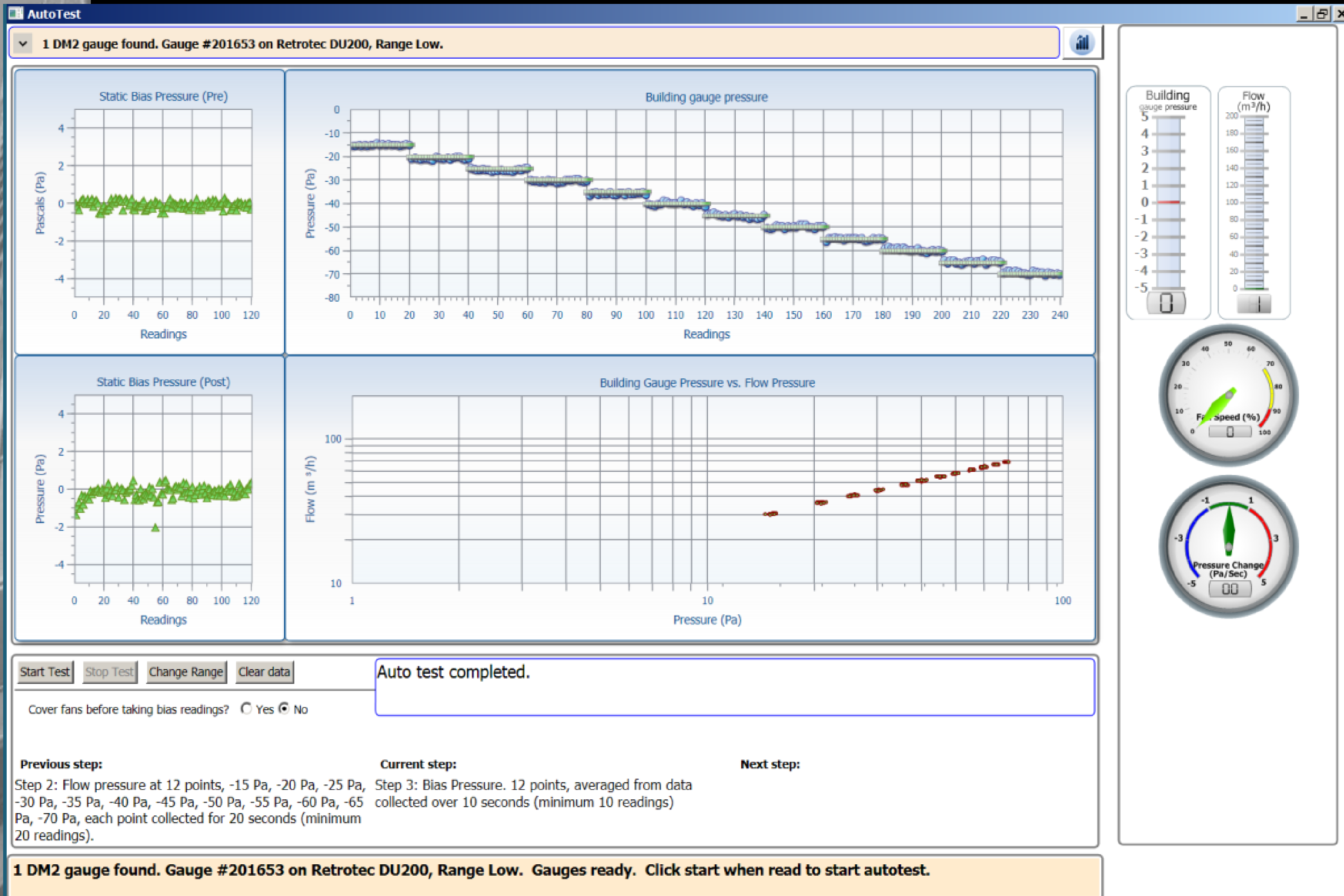
	Results	Uncertainty
Air flow at 50Pa, V_{50} [m³/h]	58	+/-10%
Air changes at 50 Pa, n_{50} [/h]	.12	+/-11%
Air flow at 4 Pa, V_4 [m³/h]	15	+/-10%
Permeability at 4 Pa, Q_4 [m³/h.m²]	.03	+/-11%
Effective leakage area at 4 Pa, AL [cm²]	16	+/-10%

Finish time: 09:59

(add notes here)

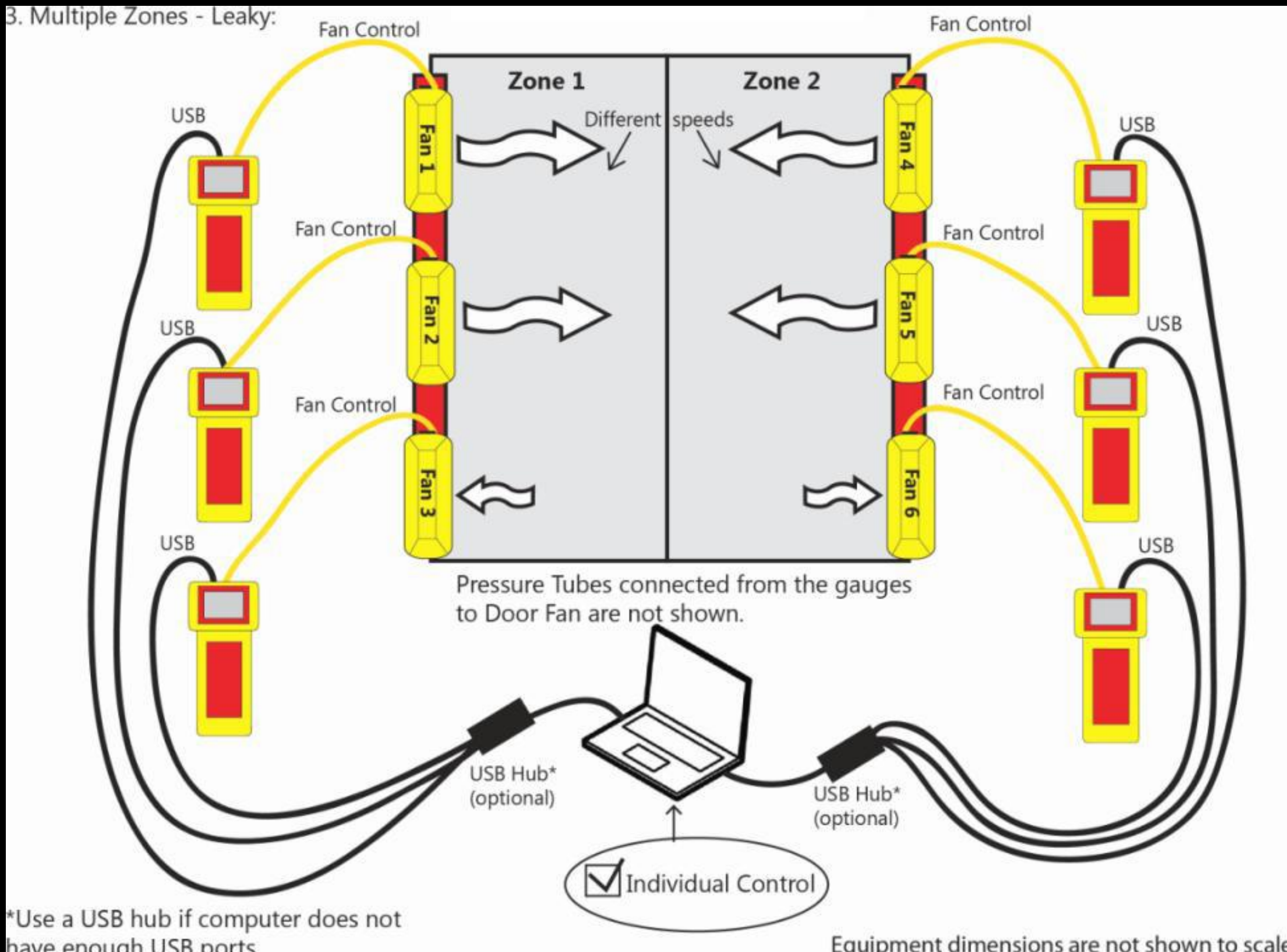
Warnings and Errors

Automatic save of 'EN13829 2010-01-21 0909.xml' completed at 2010-01-21 09:59.

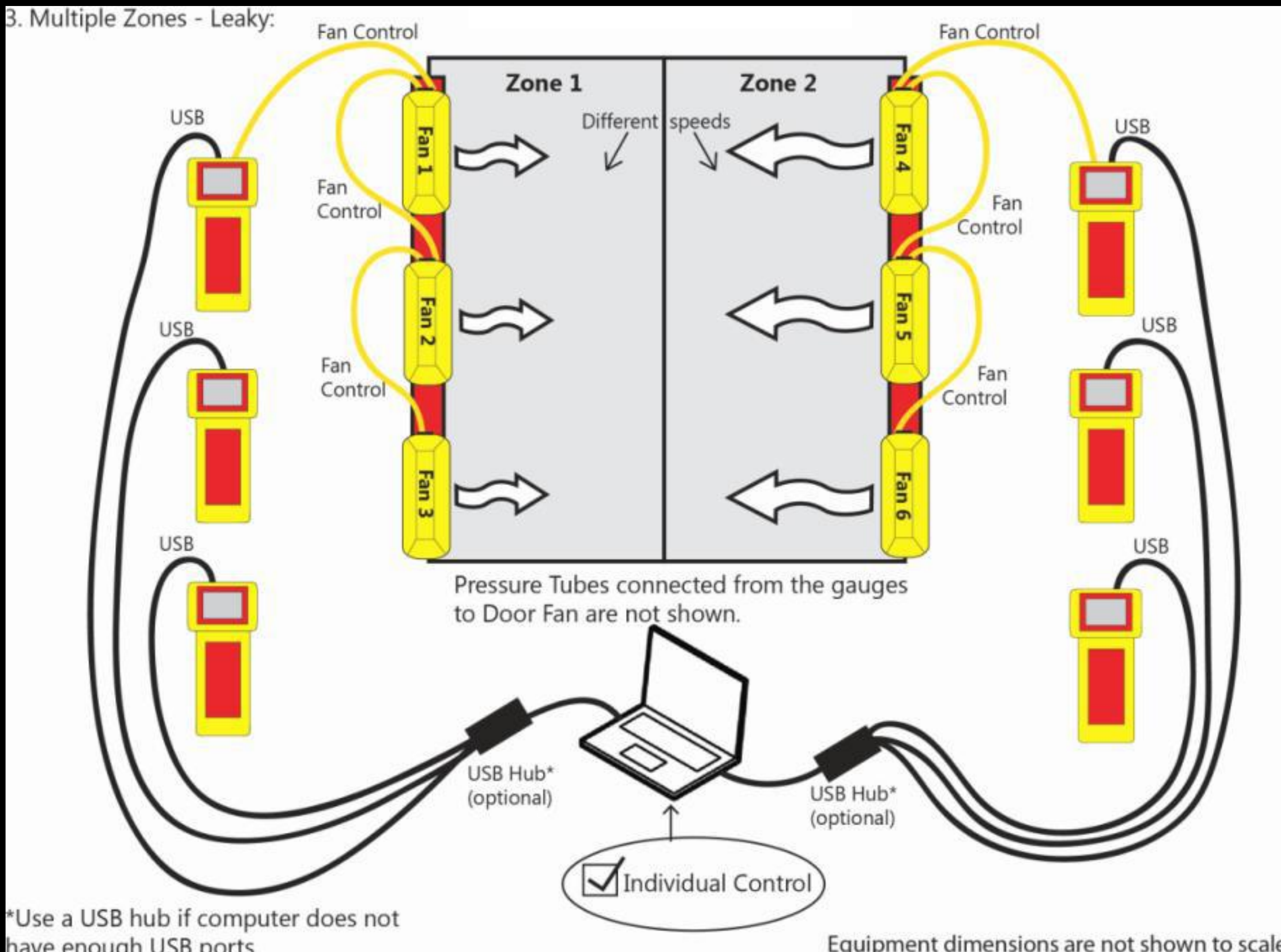

AutoTest
1 DM2 gauge found. Gauge #201653 on Retrotec DU200, Range Low.
Static Bias Pressure (Pre)
Pascals (Pa)
Readings
Building gauge pressure
Pressure (Pa)
Readings
Static Bias Pressure (Post)
Pressure (Pa)
Readings
Building Gauge Pressure vs. Flow Pressure
Flow (m³/h)
Pressure (Pa)
Building
gauge pressure
Flow
(m³/h)
Fan Speed (%)
Pressure Change
(Pa/Sec)
Start Test
Stop Test
Change Range
Clear data
Auto test completed.
Cover fans before taking bias readings? Yes No
Previous step:
Step 2: Flow pressure at 12 points, -15 Pa, -20 Pa, -25 Pa, -30 Pa, -35 Pa, -40 Pa, -45 Pa, -50 Pa, -55 Pa, -60 Pa, -65 Pa, -70 Pa, each point collected for 20 seconds (minimum 20 readings).
Current step:
Step 3: Bias Pressure. 12 points, averaged from data collected over 10 seconds (minimum 10 readings)
Next step:
1 DM2 gauge found. Gauge #201653 on Retrotec DU200, Range Low. Gauges ready. Click start when read to start autotest.


OFFICES FOR RENT
930 41 25

Imbalanced flow can be caused by individual set points.

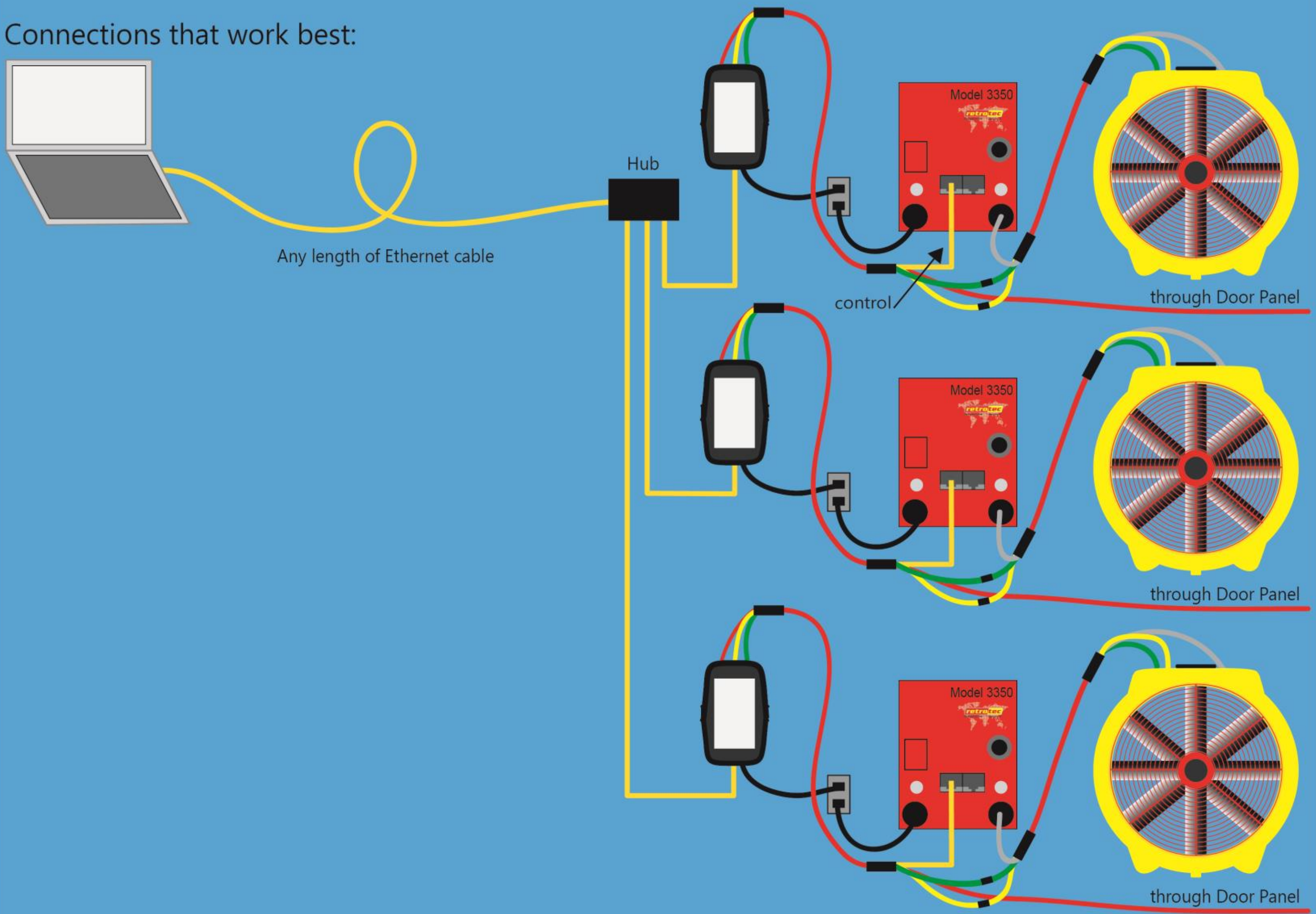


Individual set point *between zones*
Common set point within a zone.

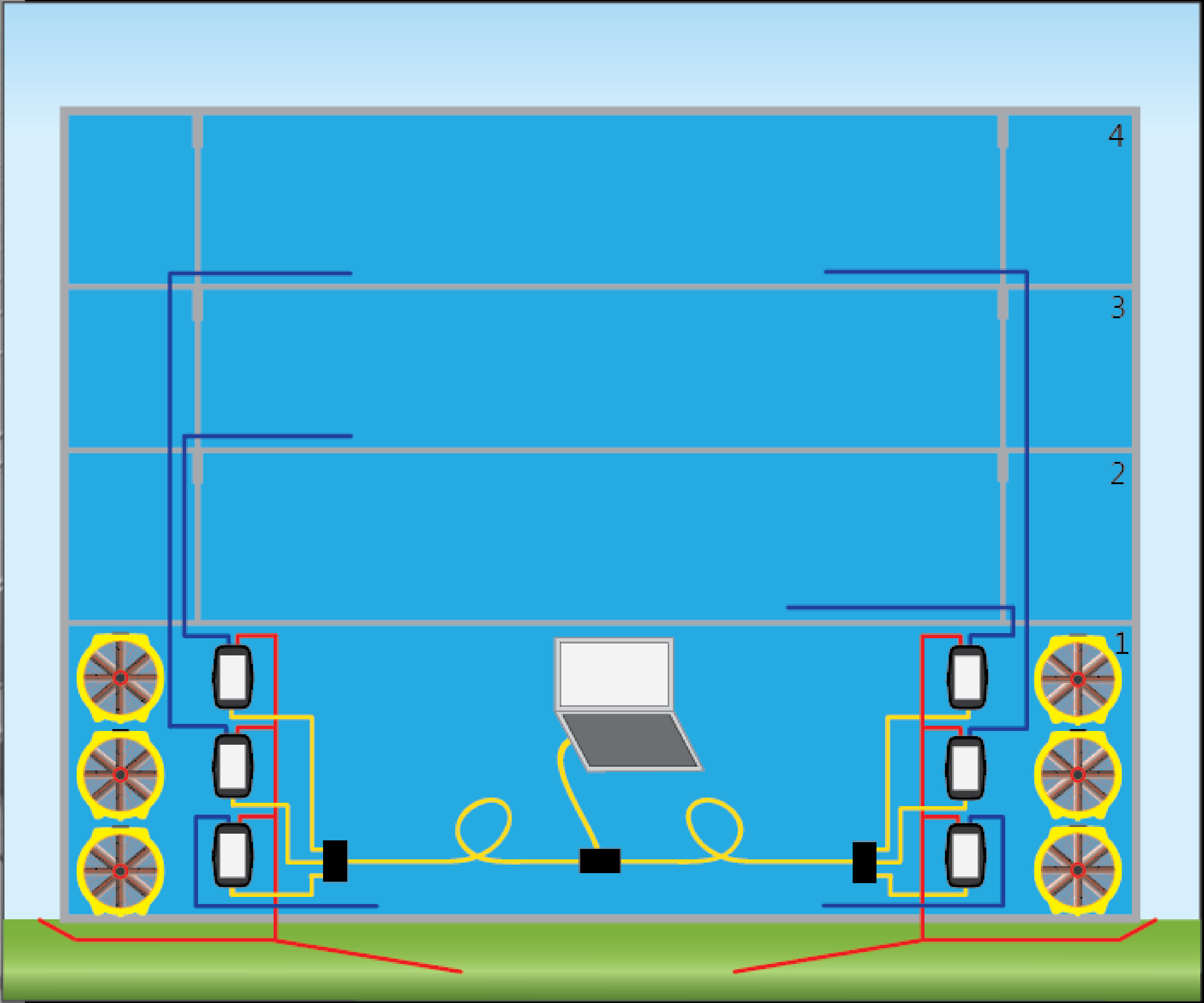


2012 Model Drives Setup
(Individual set point)

Connections that work best:



Colin Genge


4
3
2
1

Automatic vs. manual data collection

Start date 2010-06-02 | Start time 19:37 | Get Time | **Pressurization set**

Average wind speed 8 mph | Direction WN | Operator location Inside | Temperature, initial indoors 75 °F outdoors 87 °F

Start Auto-Test | Show Graphs

Bias pressure, initial [Pa]	.727	1.093	1.227	.649	.81	1.129	1.223	.881	.843	1.284	.971	1.011
									Greatest Initial Bias Pressure 1.284 Pa		Time per Bias Pressure 10 sec.	
#1 Building (gauge) pressure [Pa]	25.1	28.9	33.9	38.0	43.0	47.0	52.0	55.6	60.9	65.0	69.9	75.1
#2 Building pressure variation [%]	2.1%	2.4%	2.3%	2%	1.9%	2.1%	2.3%	2.1%	-.3%	%	.1%	.1%
#3 Building pressure variation [%]	3%	3.1%	3.3%	3%	2.8%	3%	2.9%	2.8%	1.4%	1.5%	1.2%	1.3%
#4 Building pressure variation [%]	2.6%	2.5%	2.7%	2.1%	1.7%	2.1%	2.2%	1.8%	1.8%	2%	1.8%	1.7%
#5 Building pressure variation [%]	-1.4%	-1.1%	-.7%	-.8%	-.9%	-.8%	-.7%	-1%	-3%	-2.7%	-3.1%	-3%
#6 Building pressure variation [%]	-.5%	-.5%	-.2%	-.1%	-.1%	-.1%	-.1%	-.1%	-2.8%	-2.3%	-2.6%	-2.8%
Door Fan 1 A [Pa]	88.9	109.2	131.2	152.7	167.6	189.8	212.8	237.0				
Door Fan 2 A [Pa]	75.9	93.6	116.9	136.8	160.7	181.5	206.5	227.1				
Door Fan 3 A [Pa]	91.1	108.3	134.4	155.3	176.8	194.8	217.0	227.7				
Door Fan 4 A [Pa]	98.4	114.5	138.3	158.1	180.3	200.0	224.0	242.2				
Door Fan 5 A [Pa]	71.6	89.3	111.7	129.7	152.2	171.2	196.0	215.4	115.6	126.4	140.4	155.5
Door Fan 6 A [Pa]	87.5	107.7	138.5	163.0	193.9	222.2	262.4	309.0				
Door Fan 1 Open(22) [Pa]									68.8	74.3	80.5	88.2
Door Fan 2 Open(22) [Pa]									62.9	68.2	77.2	84.1
Door Fan 4 Open(22) [Pa]									63.3	68.0	75.1	82.4
Door Fan 5 Open(22) [Pa]												
Door Fan 6 Open(22) [Pa]									105.6	118.5	133.4	148.7
Door Fan 3 Open(22) [Pa]									70.7	77.5	85.5	93.5
											Time per Building Pressure 20 sec.	
Bias pressure, final [Pa]	.206	.224	.345	-.018	-.038	-.17	-.149	.234	.132	.236	.129	.381

Temperature, final indoors 75 °F outdoors 87 °F

Questions?
Comments?
Angry rants?