Get it in the Specs

- 01-9115 general
- 04-2000 unit masonry
- 07- 2713 self-adhering sheet air barriers
- 07-2726 fluid-applied membrane air barriers
- 07-5400 adhered TPO roofing
- 08-4413 glazed aluminum curtainwall
- 08-5113 aluminum windows

Field Visits

- Describe air barrier requirements, mock-ups, inspections and tests to architects, owners, Construction managers, prime contractors, sub-contractors
- Inspections
- Mock-ups – inspection, testing
- Final Pressure Test


11/09/2008

Intermediate test

Planning and Conducting a Fan Pressure Test

- Planning
- Prepare the building
- Setup equipment and conduct test
- Analyze data
- Write the report

Planning

- New, unoccupied buildings/Occupied buildings
- Identify parties
- Select date
- Identify Test Enclosure Boundaries
- Identify HVAC equipment that must be turned off and penetrations that must be sealed

Identify Parties

- Owner
- Building Management
- Security – determine security procedures to protect property and privacy
- Health and Safety
- Fan testing team
- HVAC control person (contractor or in-house)

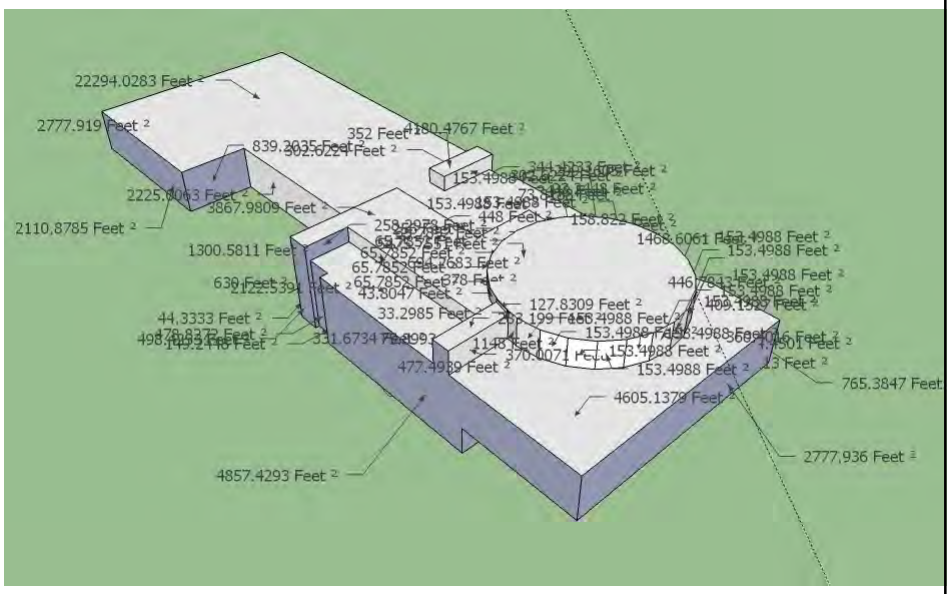
Select Date

- When the fewest people are in the building – weekends, holidays
- During the test you need:
  - Access to all rooms, mechanical rooms, locations where HVAC penetrations must be masked
  - HVAC controls contractor
  - Power for test fans

Test Enclosure Boundaries, Airflow Needed and Fan and Pressure Tap Locations

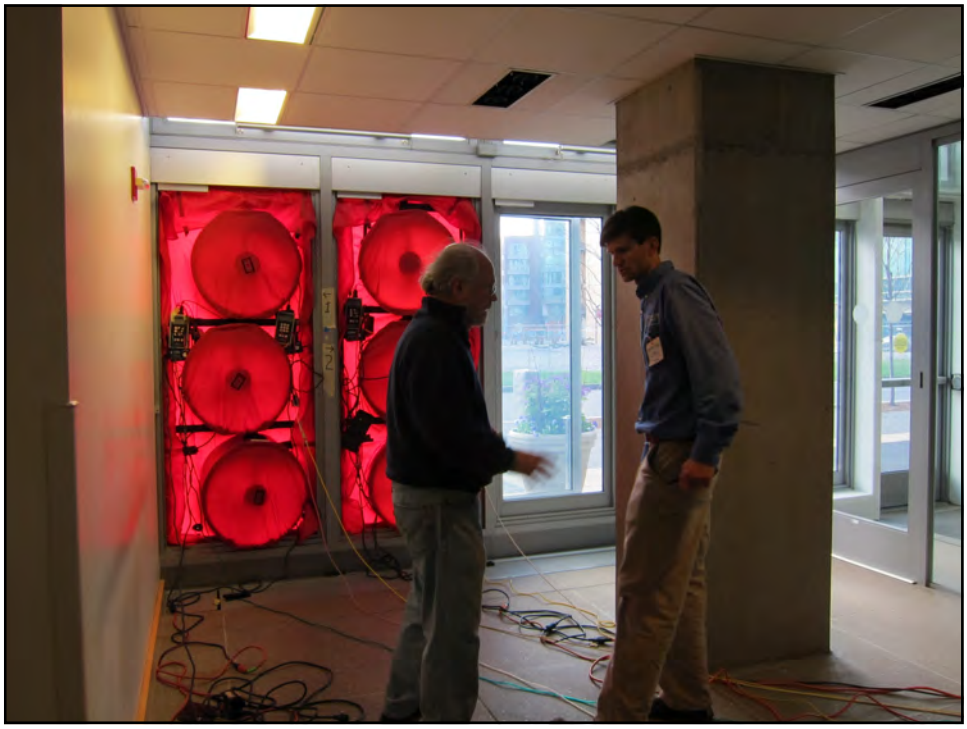
- Double check boundaries and enclosure areas specified in design drawings
- How much air do I need?
- Inspect the geometry for interior barriers to good pressure distribution
- Locate fans to provide uniform pressure distribution
- Locate interzonal pressure taps to document uniform pressure distribution

Sketchup models to identify test enclosure location and areas



How much air do I need?

- Maximum leakage rate specified
  - Bring enough to induce the specified pressure difference with the specified flowrate
  - E.g. Area enclosure (ft2) x 0.25 cfm/ft2 at 75 pascals (ACE spec)
  - 0.6 ACH x enclosure volume (ft3) / 60 m/hr (passiv haus)
- Ordinary construction
  - 0.2 – 1.2 cfm/ft2 at 75 pascals; ?

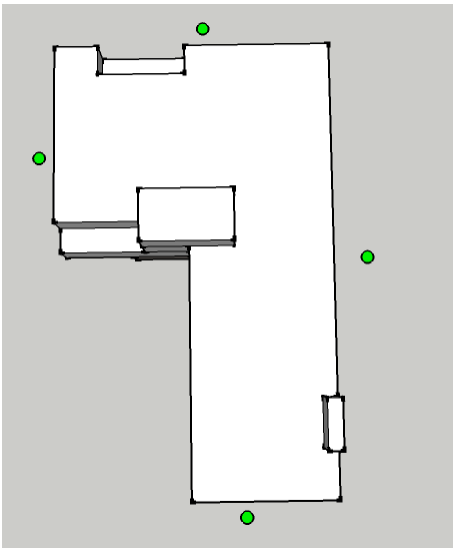



12
retrotec


What about using the Ventilation Equipment to do the test?


Place the pressure taps

Preferred Envelope Pressure Tap Locations



Prepare the Building

- If the whole building is one test zone
  - Close exterior doors and windows
  - Open interior doors
- If the test zone is a portion of the whole building
  - Close exterior doors and windows
  - Isolate test zone from surrounding building
    - Close doors
    - Tape off supply diffusers and return grilles that connect to ducts or equipment outside the test zone
  - Determine whether adjacent zones should be open to outdoors or closed
- Close or mask outdoor air intakes and exhaust outlets
  - Dampers
  - Gravity dampers
  - Plastic, foam board and tape

Block interior doors open
In occupied buildings this may present an unacceptable security issue

Identify and seal HVAC related enclosure penetrations

- Intention…
- Outdoor air intakes
- Exhaust systems
- Passive relief
- Steam vents
- Dampers: Motorized, gravity, none
- Fan runs continuously?
- Elevator vents and kitchen range hoods – no dampers

Preparation Schedule for Airtightness Testing

10-March, 2001 Big Buildings Testing, following draft ASHRAE 1478-RP

Opening	Location	Soonest can be sealed	Normal operation	Inline with continuous fan?	Damper type	Prep Method	Notes	out
Traps	throughout	Wed	NA	No	NA	fill with water		
EF-5	HVAC Classroom	Wed	Off	No	None	Seal from above suspended ceiling with 20" x 20" cardboard.	Fan is only used occasionally for ventilation when there is a large group in the room Sealed Wed	
SF-2	AH Room, 2nd fl	2 pm Friday	occupied hours, damper open and fan on,Unoccupied hours, damper closed and fan off.	No	motor	Turn off fan with BAS, Seal with plastic on roof	blows air into mechanical room (which is part of the return for this AHU) . Sealed Fri.	
EF-2	Kitchen Exhaust	2 pm Friday	Off	No	None	Seal with cardboard outside above back door	Used only when heating things in ovens	
EF-1	2nd floor toilet exhaust	2 pm Friday	On 24/7	Yes	None	Turn off via BAS, Seal At Roof	Sealed Fri - not controlled by BAS - turned off manually at roof.	
EF-4	1st floor toilet exhaust	Tuesday morning	On 24/7	Yes	None	Turn off via BAS, Seal At Roof	Also ventilates elevator room. Leave Elev room closed to garage during test.	
TELCOM Exhaust	Telcom room in basement	Tuesday morning	24/7	Yes	None	Seal grille in garage, manually turn off fan, prop open door to TELCOM for cooling		
AHU-1 intake	roof	Tuesday morning	During occupied hours OA dampers are partially open to provide ventilation. They are also opened fully for economizer mode. During unoccupied hours OA dampers are normally closed unless in economizer mode	No	motor	Turn AH fan off and close motorized OA dampers with BAS. Seal 2 hoods with cardboard and duct tape.		
AHU-1: Relief Air	roof	Tuesday morning	Dampers are gravity dampers that open when plenum pressure exceeds outside pressure. Exhaust fans (EF-7 and EF-8) are internal to AH and also run if pressure sensor in plenum senses need for more exhaust to control pressure.	No	Gravity exhaust dampers	Prop dampers in their closed position with foam and seal hoods with cardboard and tape.		
Elevator Vent	penthouse roof	Tuesday morning	Open 24/7	No	none	Seal from penthouse roof	unmask this last	
DHW	First floor	Tuesday morning		No	NA	Turn off, make sure it does not fire	No prep for natural draft vent through roof	

Test sequence
Everything sealed
pressurization

Everything sealed depressurization

cruise -75

unseal motorized dampers:

Sf-2 (OAF-1)
AHU-1 intake
dampers

unseal gravity exhaust dampers for non-continuous operating fans

AHU-1 relief
dampers both sides of AHU-1

unseal all undampered mechanical openings not connected to continuously operating fans

EF-2 Kitchen
Exhaust

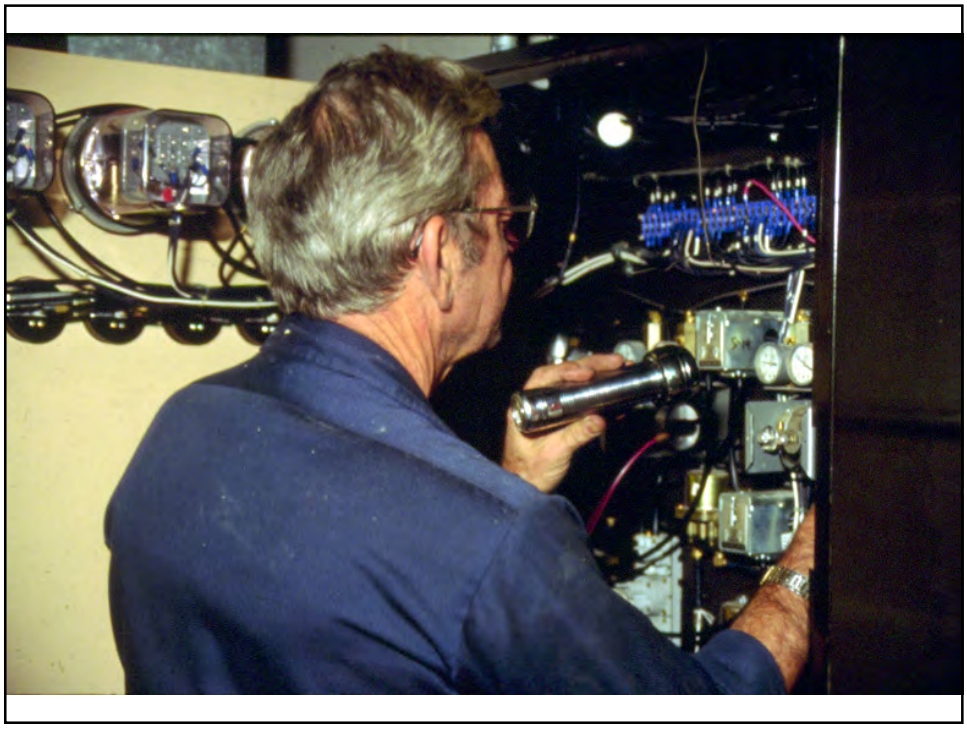
EF-5 HVAC Classroom
Elevator
Vent

(optional: unseal gravity intakes)

Turn off Blower Doors

Remove all seals
Restore all items listed above to normal operation, check of when done

					CFM75	
Item unsealed	pressure	Flow	induced	Q75	leakage	percent of sealed value
None (all sealed)	-74.3	10506	73.1	10669	10669	100%
SF-2	-74.1	10516	72.9	10697	28	0%
AHU-1-OA	-75	13158	73.8	13286	2589	24%
AHU-1-relief	-75	13311	73.8	13440	154	1%
EF-2-Kitchen	-75	13769	73.8	13903	462	4%
EF-5-HVAC	-75.1	14316	73.9	14443	541	5%
coiling door	-75	17186	73.8	17353	2910	27%
elevator vent	-75	18881	73.8	19065	1711	16%



No dampers, gravity dampers, motorized dampers, masking?

During pressurization tests gravity dampers blow open.


GRV-55


CAUTION ⚠ PRECAUCION
60° Min. Angle
60° Min. Angle
Rigging instructions:
Instrucciones de levante:
035-06719-000
Johnson Controls
YORK Solution XT
SKID 1 of 2
AHU-S10
Estimated Weight:
H 2,800
pounds


254-1

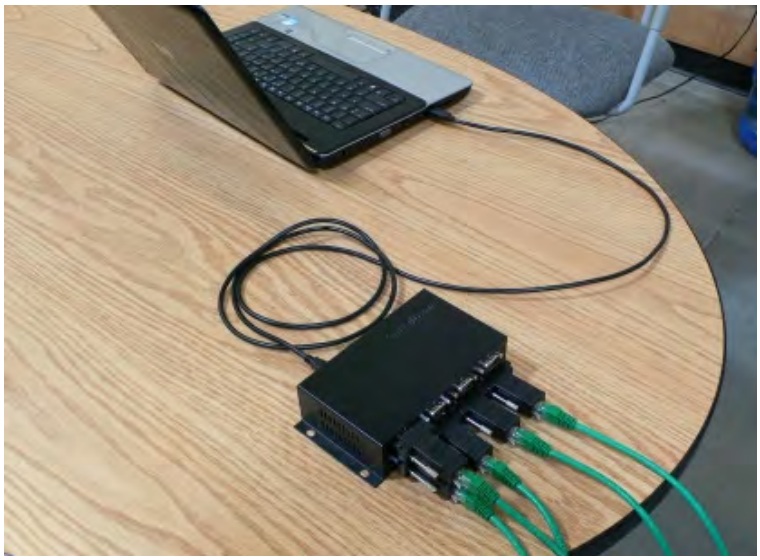

CAUTION
GREENHECK
CAUTION


Motor Speed
0 rpm
ready
run
fault
START
bypass
STOP
reset
HOA
enter

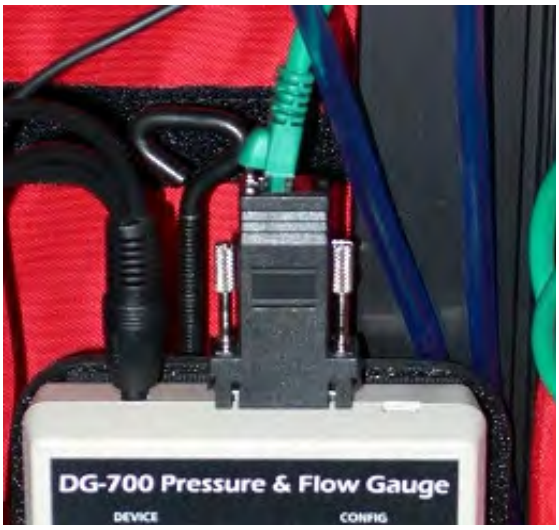
Hardware and Software Setup

- Data Acquisition and Control Hardware
- TECLOG2 Software
- Channel Types
- Auto fan control versus manual
- Collect Data and Conduct Analysis

Data Acquisition Hardware



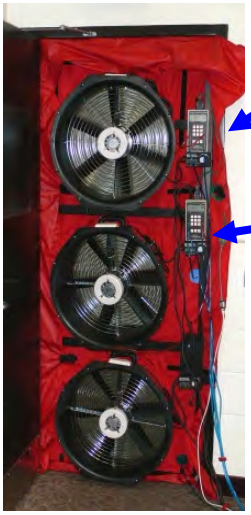
At the Other End…



Long Cable Runs…

- Use Network Pair Splitter AKA “RJ45 Y”

Two Gauges and Three Fans



Gauge 2
Ch A: Middle Fan
Ch B: Top Fan

Gauge 1
Ch A: Envelope Press.
Ch B: Bottom Fan

Fan Speed Control: Auto Versus Manual

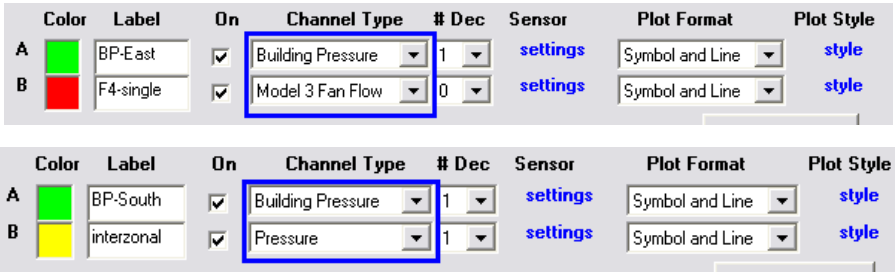
- Manual Control Advantages
  - Better flow precision
  - Lower current draw
  - Eliminates fan speed control cables
- Auto Control Advantages
  - Easier to hit precise targets
  - Can bring all fans up to speed together
  - Interruptions easier to deal with
  - Makes balancing pressures possible
- Hybrid Approach is also Possible

Fan Control Splitter

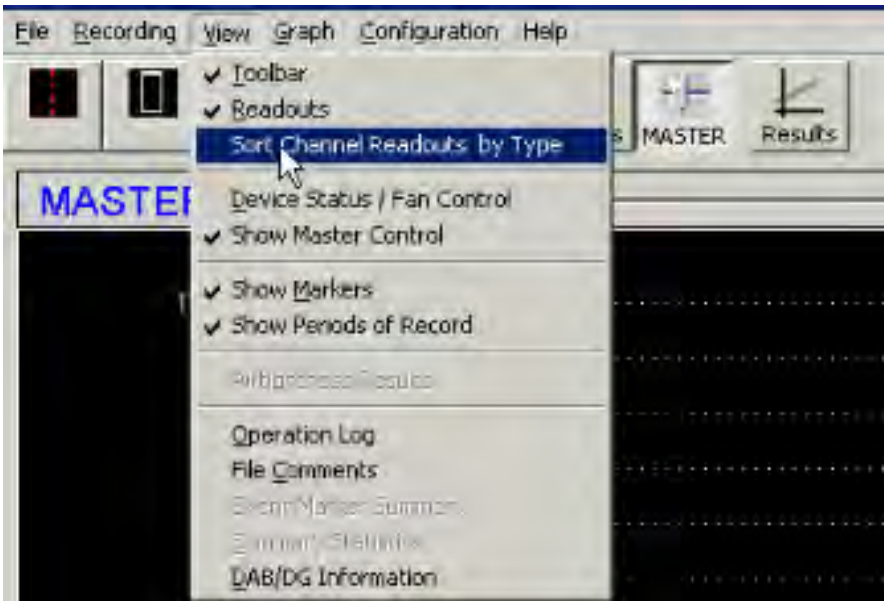
Software: TECLOG2

- Download www.energyconservatory.com
- Data Logger
  - Communicates with DG-700 gauges or APT via [virtual] COM ports.
- Flow Conversions and Total Fan Flow
- Average Envelope Pressure
- Periods of Record (POR)
- Calculations and Graph
- Export to Spreadsheet, TECTITE EXPRESS or Text File

Channel Types

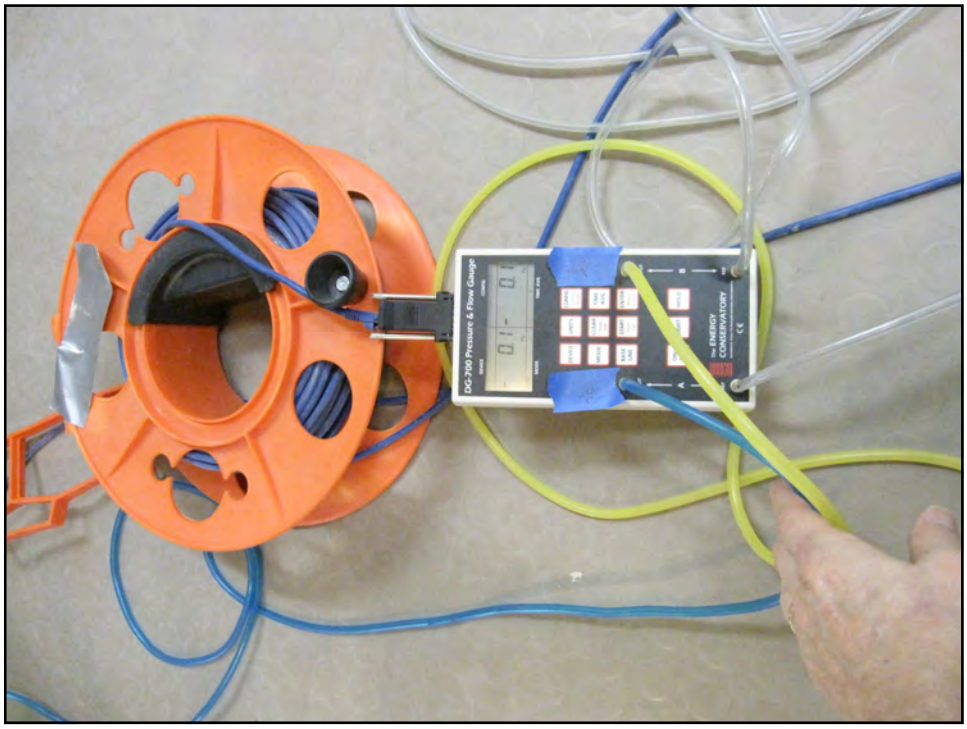


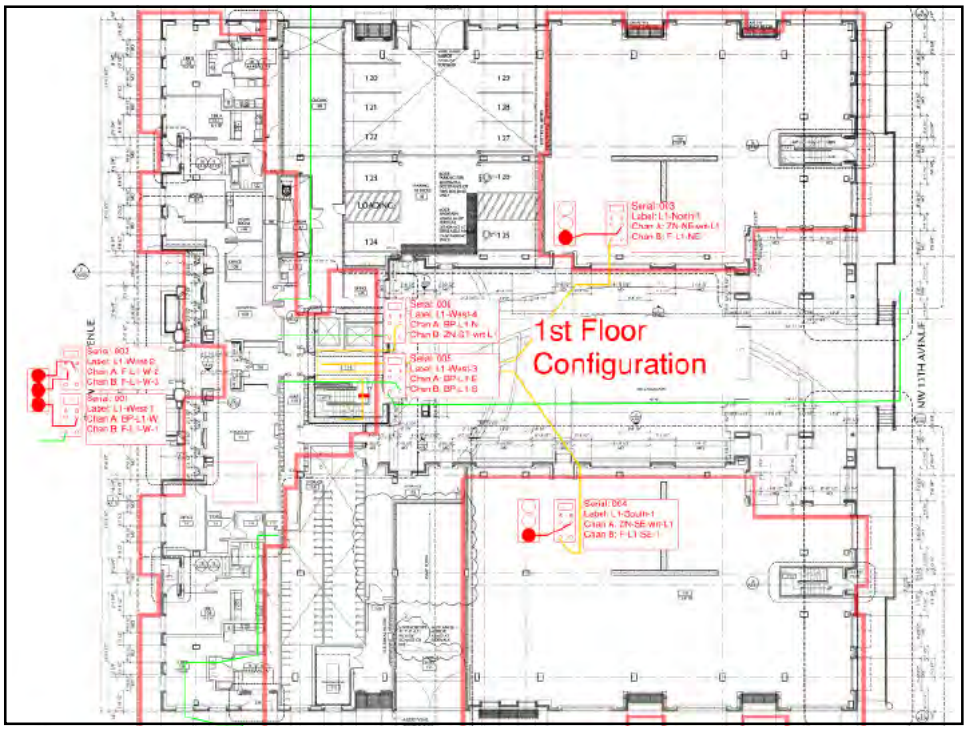
- Envelope Pressures (Green)
  - Averaged together and used in calculations
- Fan Flow Channels (Red)
- Interzonal Pressures (Yellow)
  - use generic “pressures” channel type

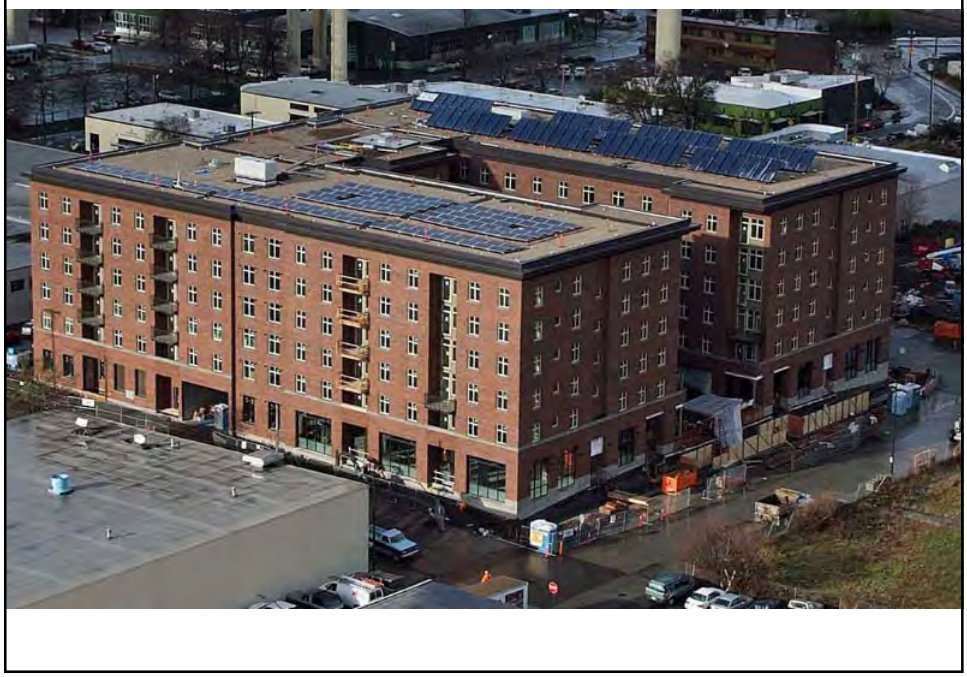


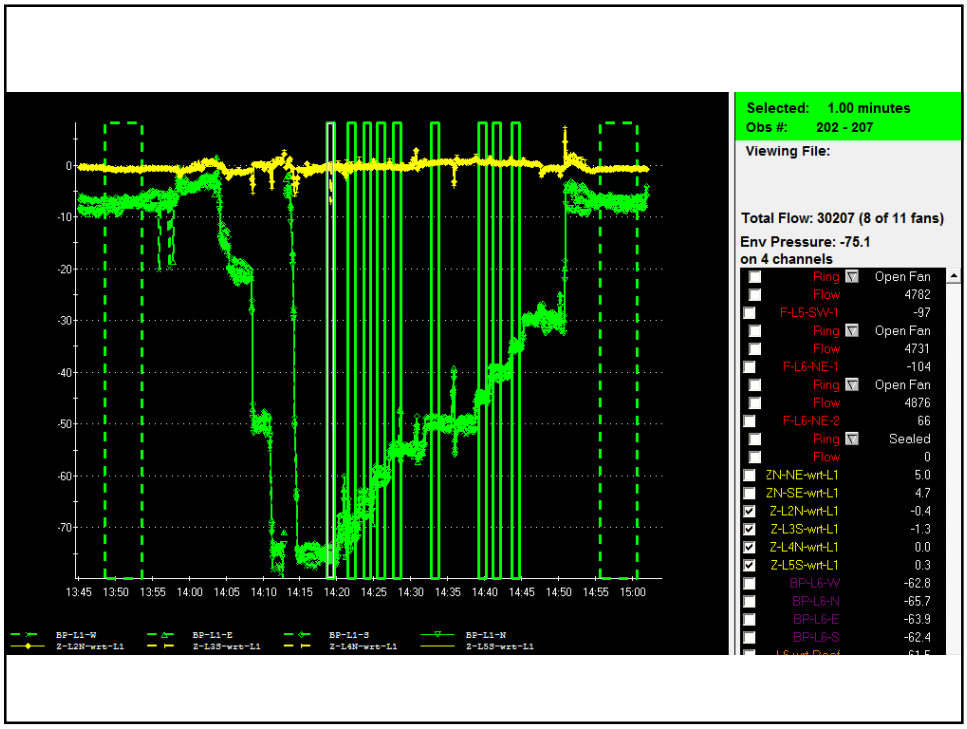
Interzonal Pressures

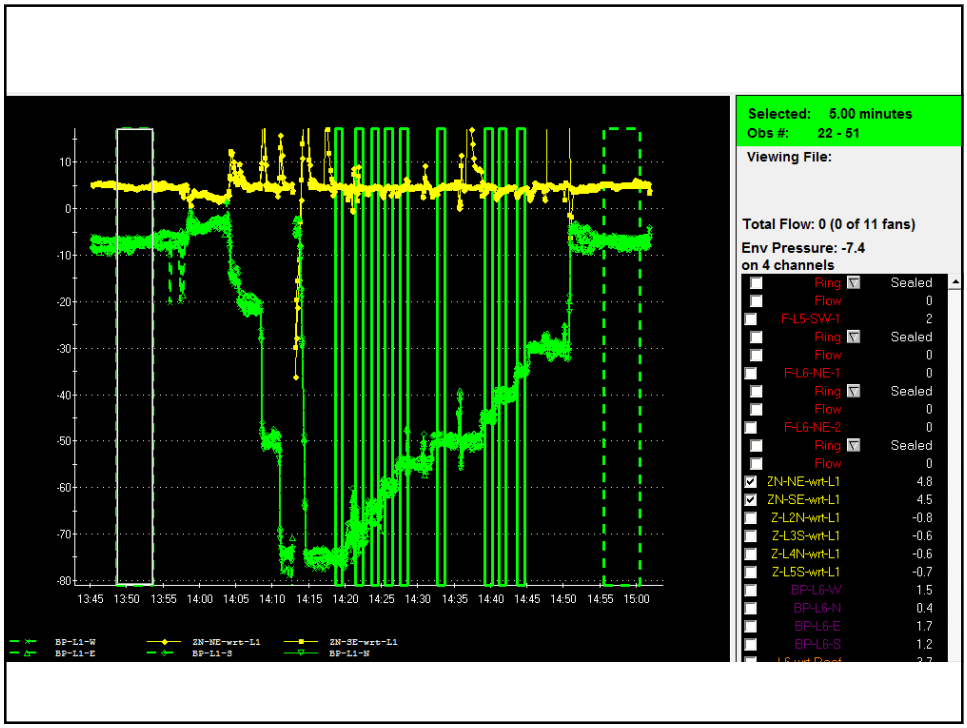
- Measure to check for pressure uniformity
  - Identify Suspected Pressure Drops
  - Measure or Monitor Interior pressure differences
  - USACE and ASTM E779 require no two spaces differ by more than 10% of test pressure (wording not clear)


DG-700 Pressure & Flow Gauge
ENERGY CONSERVATORY

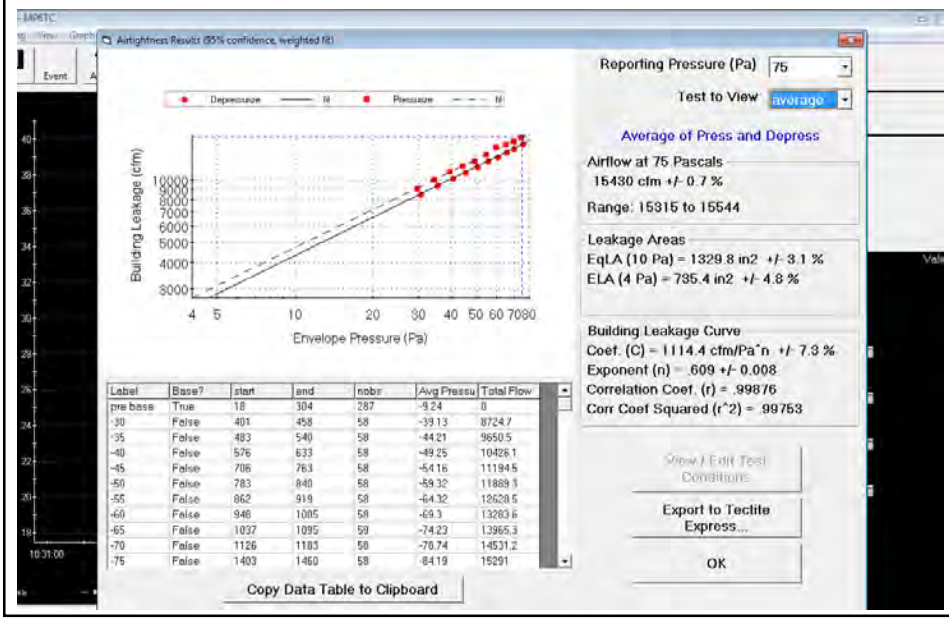

1st Floor
Configuration

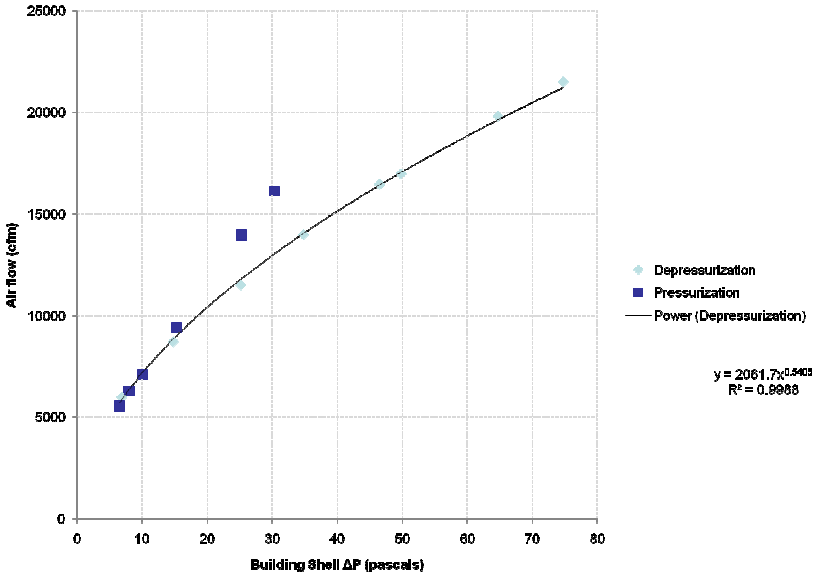



Selected: 1.00 minutes
Obs #: 202 - 207
Viewing File:
Total Flow: 30207 (8 of 11 fans)
Env Pressure: -75.1
on 4 channels
Ring Open Fan
Flow 4782
F-L5-SW-1 -97
Ring Open Fan
Flow 4731
F-L6-NE-1 -104
Ring Open Fan
Flow 4876
F-L6-NE-2 66
Ring Sealed
Flow 0
ZN-NE-wrt-L1 5.0
ZN-SE-wrt-L1 4.7
Z-L2N-wrt-L1 -0.4
Z-L3S-wrt-L1 -1.3
Z-L4N-wrt-L1 0.0
Z-L5S-wrt-L1 0.3
BP-L6-W -62.8
BP-L6-N -65.7
BP-L6-E -63.9
BP-L6-S -62.4
0
-10
-20
-30
-40
-50
-60
-70
13:45 13:50 13:55 14:00 14:05 14:10 14:15 14:20 14:25 14:30 14:35 14:40 14:45 14:50 14:55 15:00
BP-L1-W
Z-L2N-wrt-L1
BP-L1-E
Z-L3S-wrt-L1
BP-L1-S
Z-L4N-wrt-L1
BP-L1-N
Z-L5S-wrt-L1

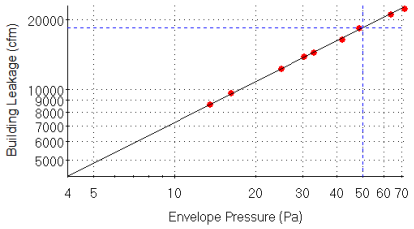


Show TECLOG Data



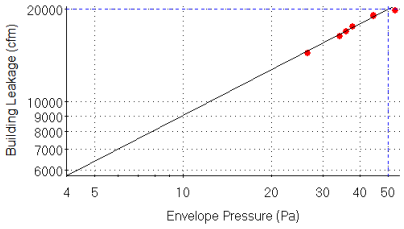


Depressurization



Airflow at 50 pascals: 18460 cfm ± 1%
Flow coefficient: 1899.4
n: 0.581±0.008
r^2: 0.9997

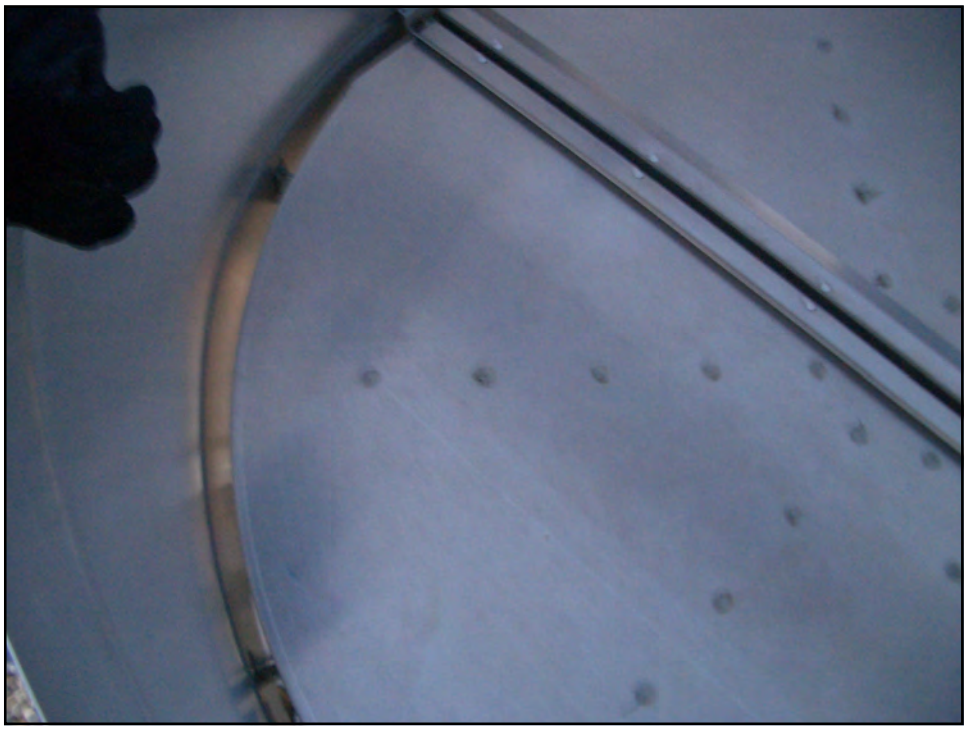
Pressurization

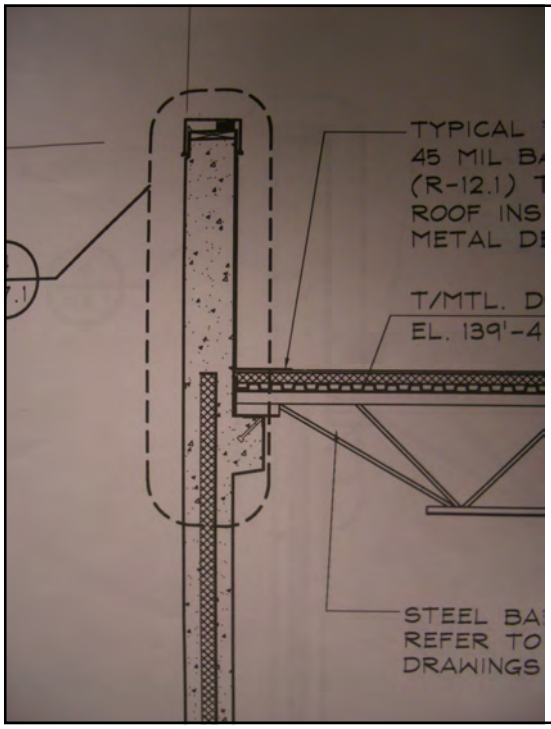


Airflow at 50 pascals: 19998 cfm ± 2.8%
Flow coefficient: 2893.4
n: 0.4941
r^2: 0.9791

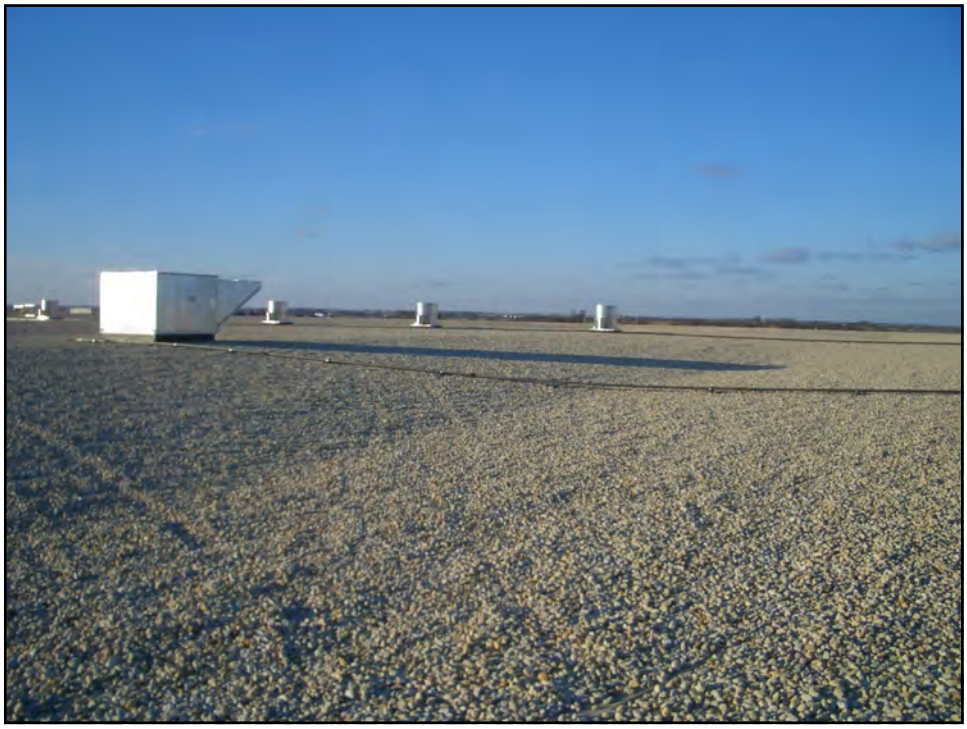
1:54 PM	57	36	45	29.56	NW	26.5	39.1
2:54 PM	57	35.1	44	29.58	NNW	23	39.1
3:54 PM	57	36	45	29.61	NW	24.2	33.4


4400 4400





0.05 cfm/ft2 enclosure at 75 pascals



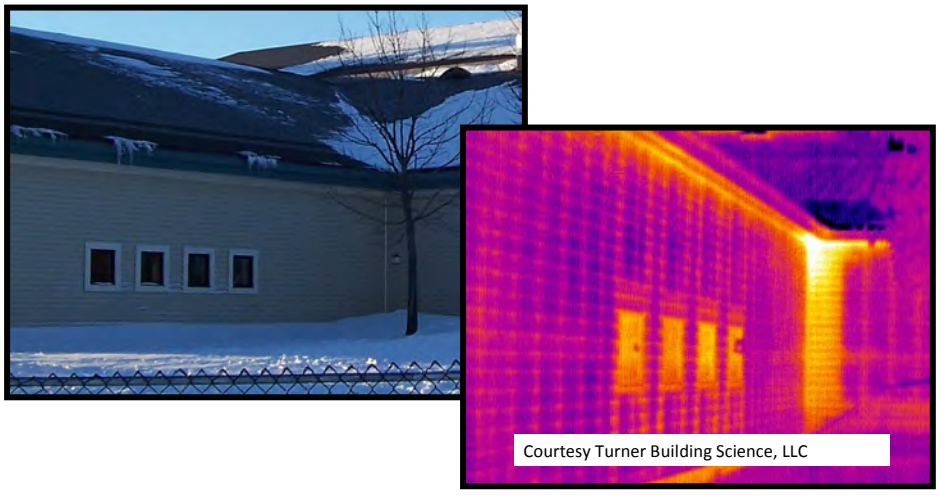
How accurate does the test have to be?

- It depends:
  - Just finding holes
  - Just getting a rough idea
  - Testing to a specific leakage rate

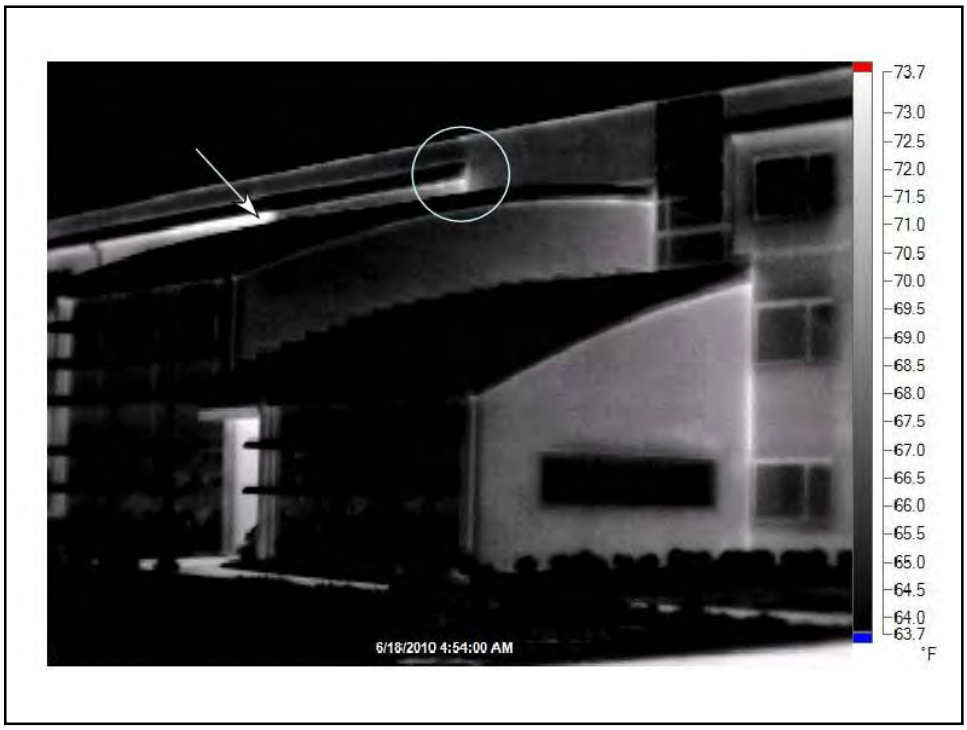
Sources of Uncertainty in Airtightness Testing

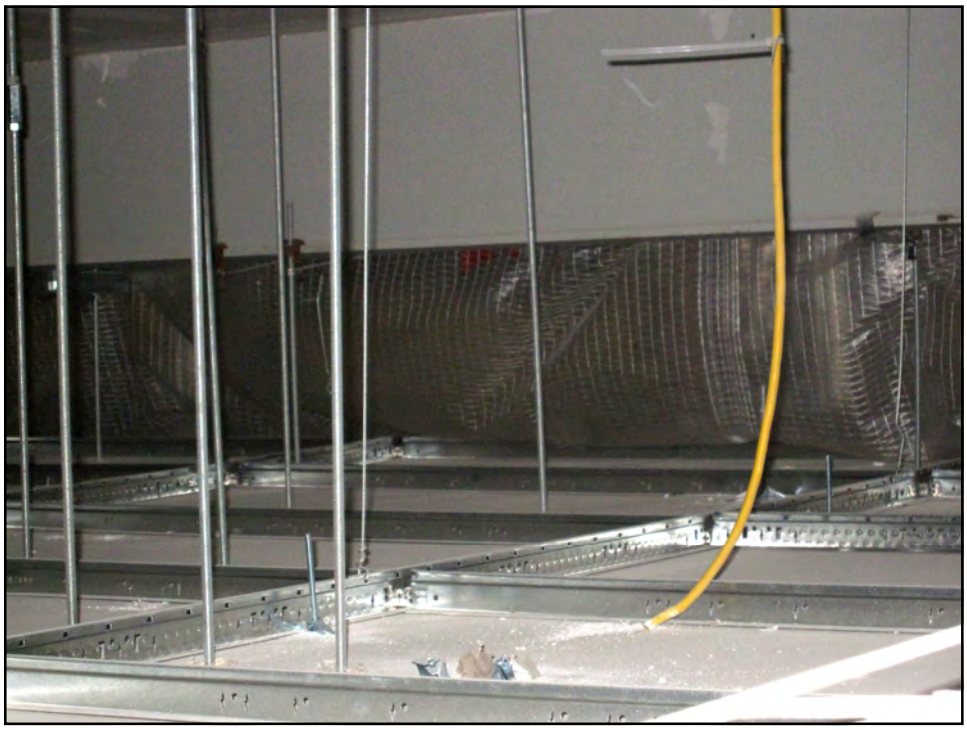
- Error in pressure difference across the shell
- Error in flow measurements
- Error in normalizing to volume or enclosure area
- Error in setting up building

Finding the holes



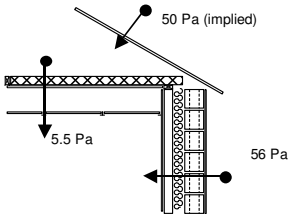
What are the coolest coolie-cool tools?

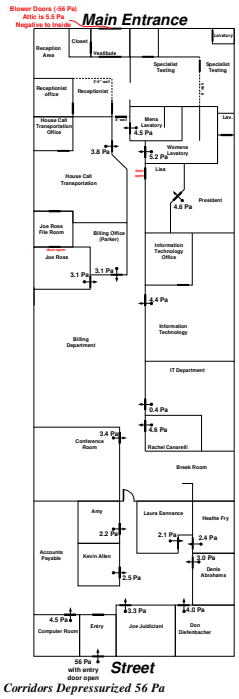

73.7
73.0
72.5
72.0
71.5
71.0
70.5
70.0
69.5
69.0
68.5
68.0
67.5
67.0
66.5
66.0
65.5
65.0
64.5
64.0
63.7
°F
6/18/2010 4:54:00 AM



Pressure Mapping

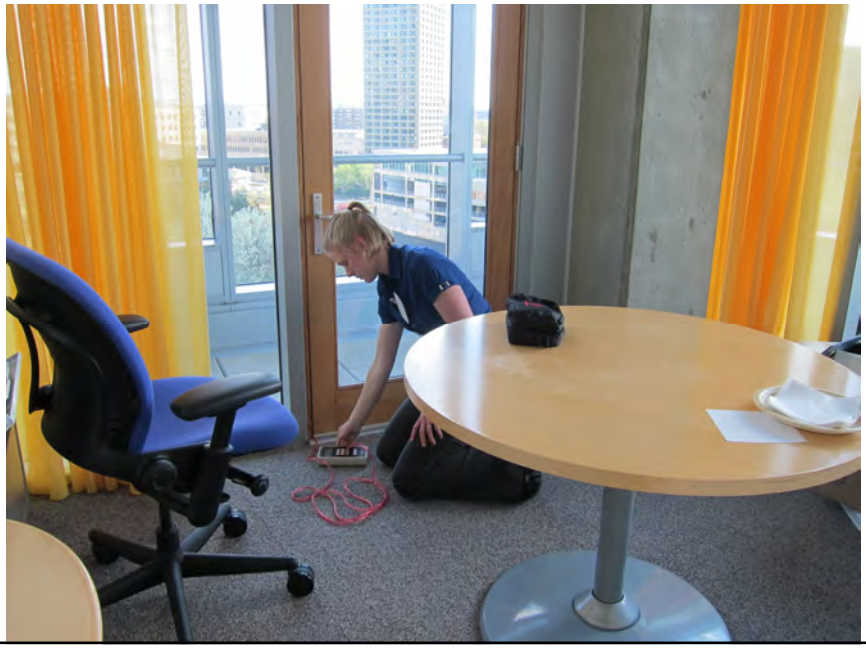
- Measure pressures with Blower Door ON to understand major leakage paths
- Provides qualitative information on leakage locations/sources





Corridors Depressurized 56 Pa

Series pressure drops

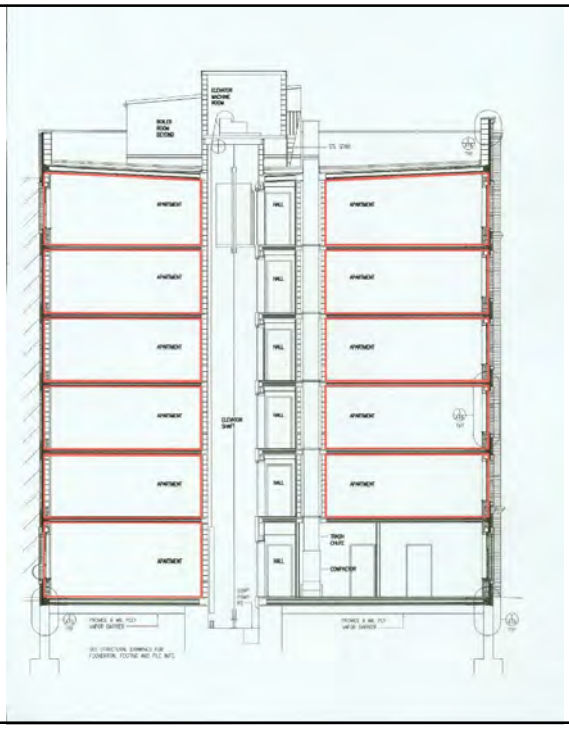


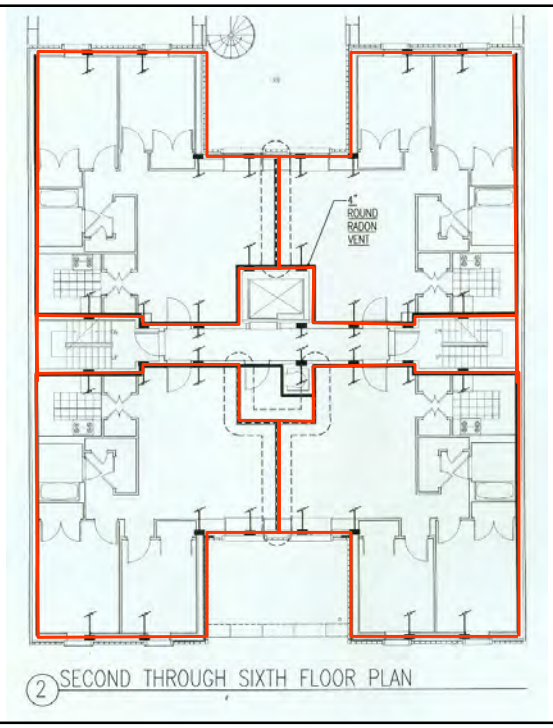
The coolest tools for finding leaks?

- Your eyes, ears and brain
- Blower doors
- Micromanometers and
- Smoke pencils and theatrical fog
- Tracer gas (CO2)
- Measuring flows

Compartmentalization Fan Test

- The test is applied to each unit:
- Doors and windows in each test unit closed but doors and windows in neighboring units open
- Intentional openings, supply diffusers and exhaust and return grilles temporarily sealed




4"
ROUND
RADON
VENT
2 SECOND THROUGH SIXTH FLOOR PLAN

Back to the blower door future

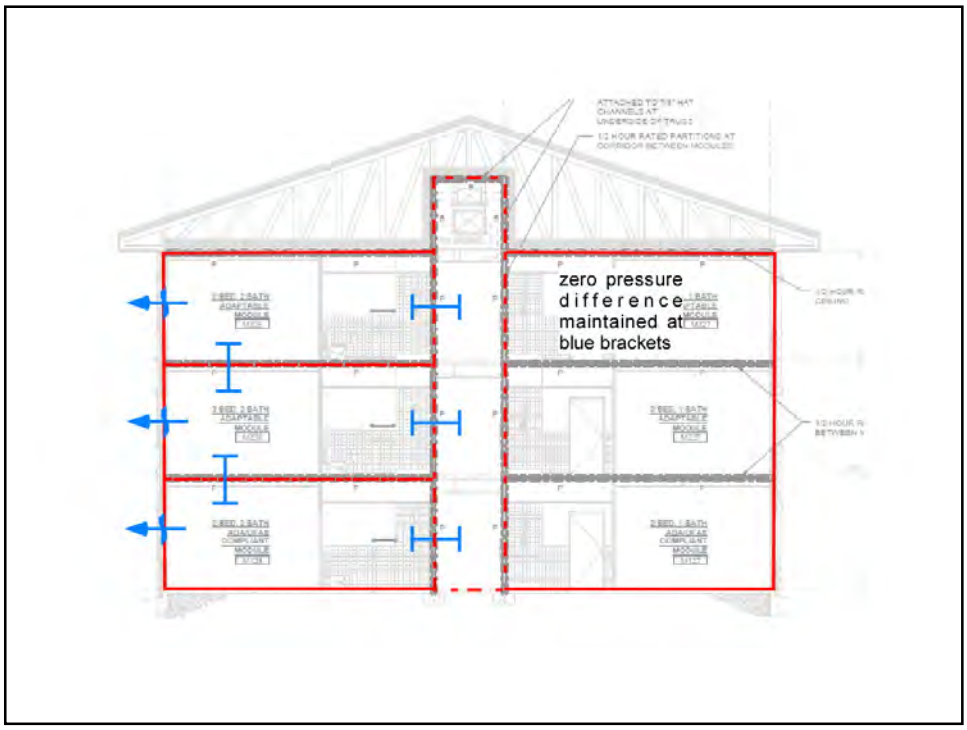
What's coming?

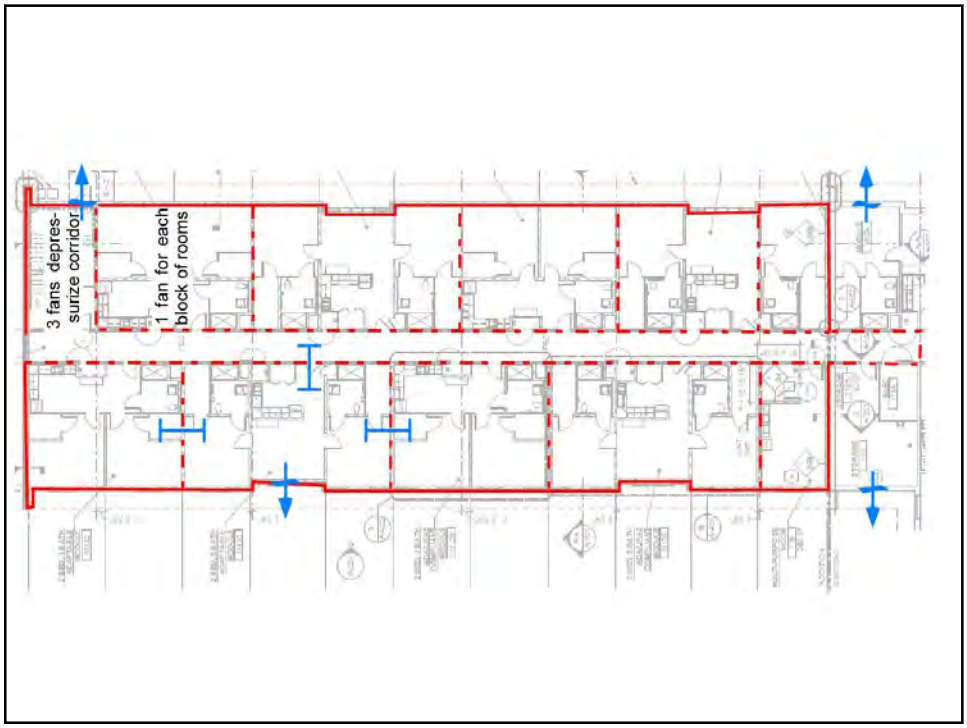
- Transfer knowledge from weatherization and homebuilder community to commercial and institutional design and construction community
- Barometers instead of micromanometers?
- Automated full tests (automatic baseline)
- Window sized duct blaster frames
- Corridor sized frames and shrouds
- Built-in HVAC system tests?
- TAB test problems?

End

Motivation

- ASHRAE RP-1478 data so far *appears* to have the characteristics of repeatable data
  - Narrow confidence intervals on CFM75
  - R-squared > .99
  - repeat tests look good
- Only a small number of repeats have been done
- Not much cold weather has been encountered
- Not much is known about how this protocol performs across a range of weather conditions on large/tall buildings.


zero pressure
difference
maintained at
blue brackets


3 fans depres-
surize corridor
1 fan for each
block of rooms