Safe humidification?


South roof
20.5
PROTIMETER
SURVEYMASTER
47.9
North roof

Humidified Buildings Cold Climates


49.6
47
45
43
41
39
37
35
33
31
29
27
25
23
22.3
°F
4/19/2009 6:30:12 PM


DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
- 26.4
0.0
MODE
TIME AVG
DEVICE
UNITS
CONFIG
MODE
CLEAR
TIME AVG
BASE LINE
START
ENTER
INPUT
HOLD
A
B
the ENERGY CONSERVATORY


TOPGUARD II
05.23.2006 09:07


4 FEET DEEP
3 FEET 6 INCHES DEEP
GUARD

Mold when it’s hot and humid, out

Condensation in the enclosure - Hot and humid outside

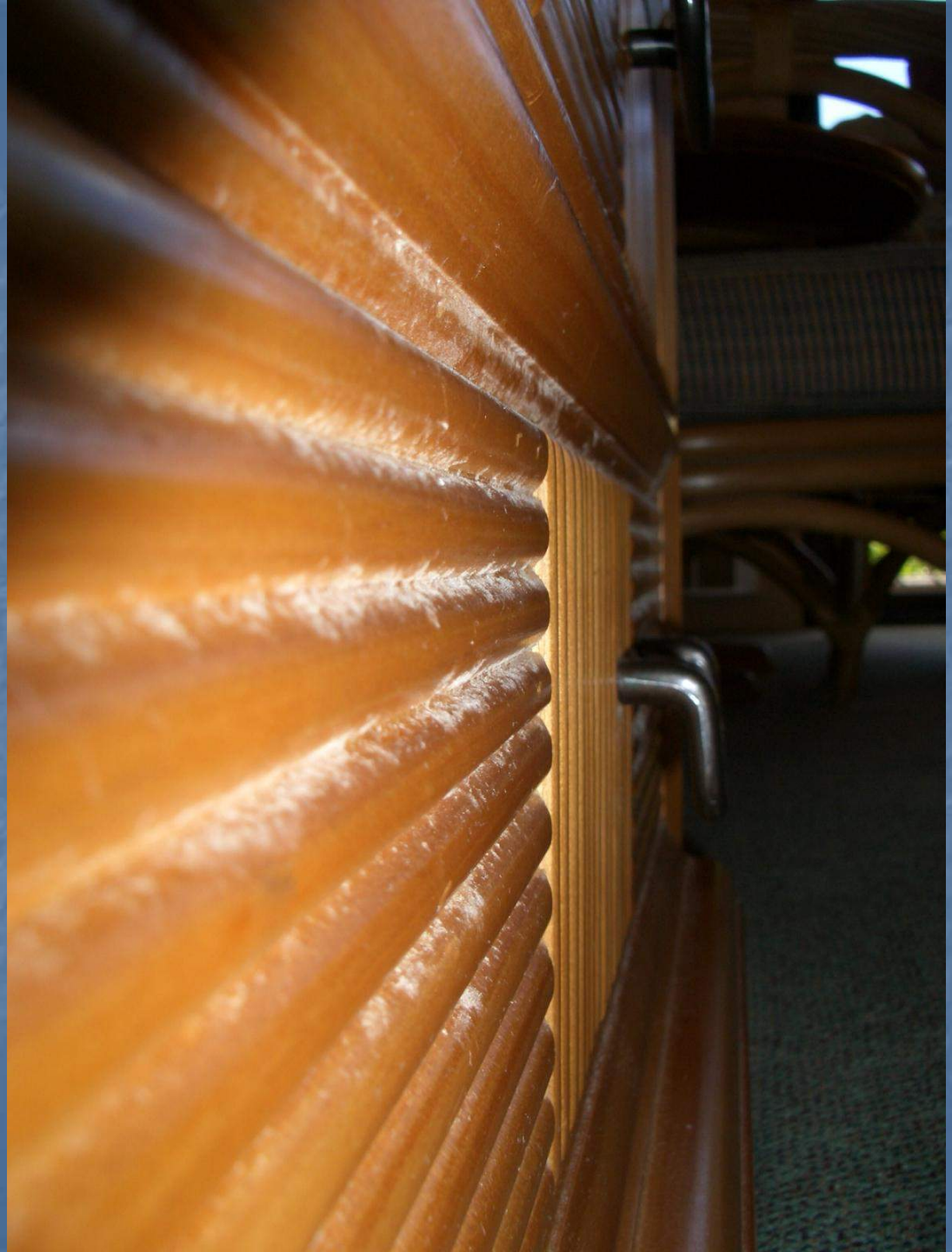
August 6

Mold in a wall cavity – outdoor air accidentally drawn into wall from attic by return plenum leaks.

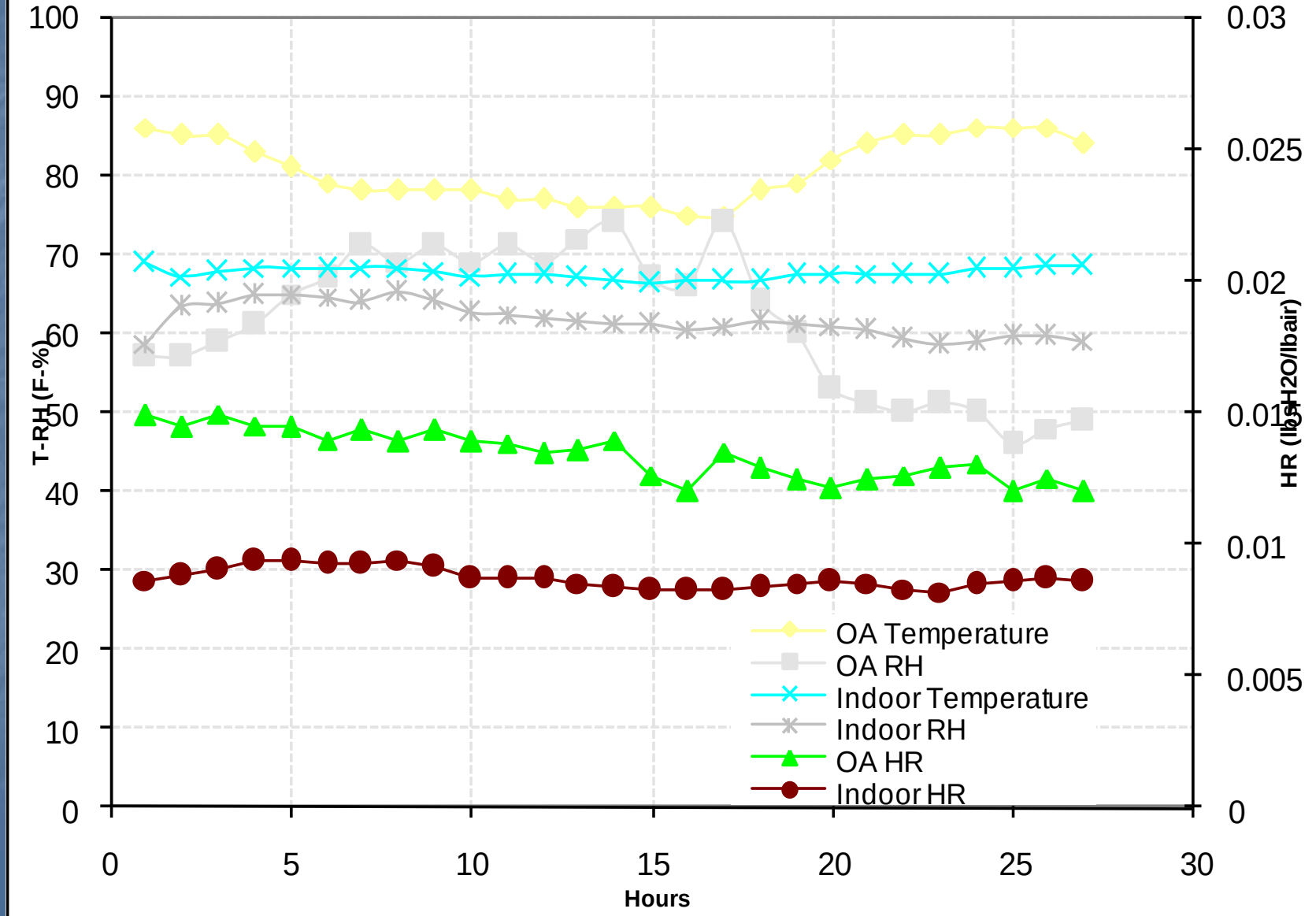
Calendar acts as accidental vapor retarder on cool side of wall during cooling conditions

Design to Dehumidify

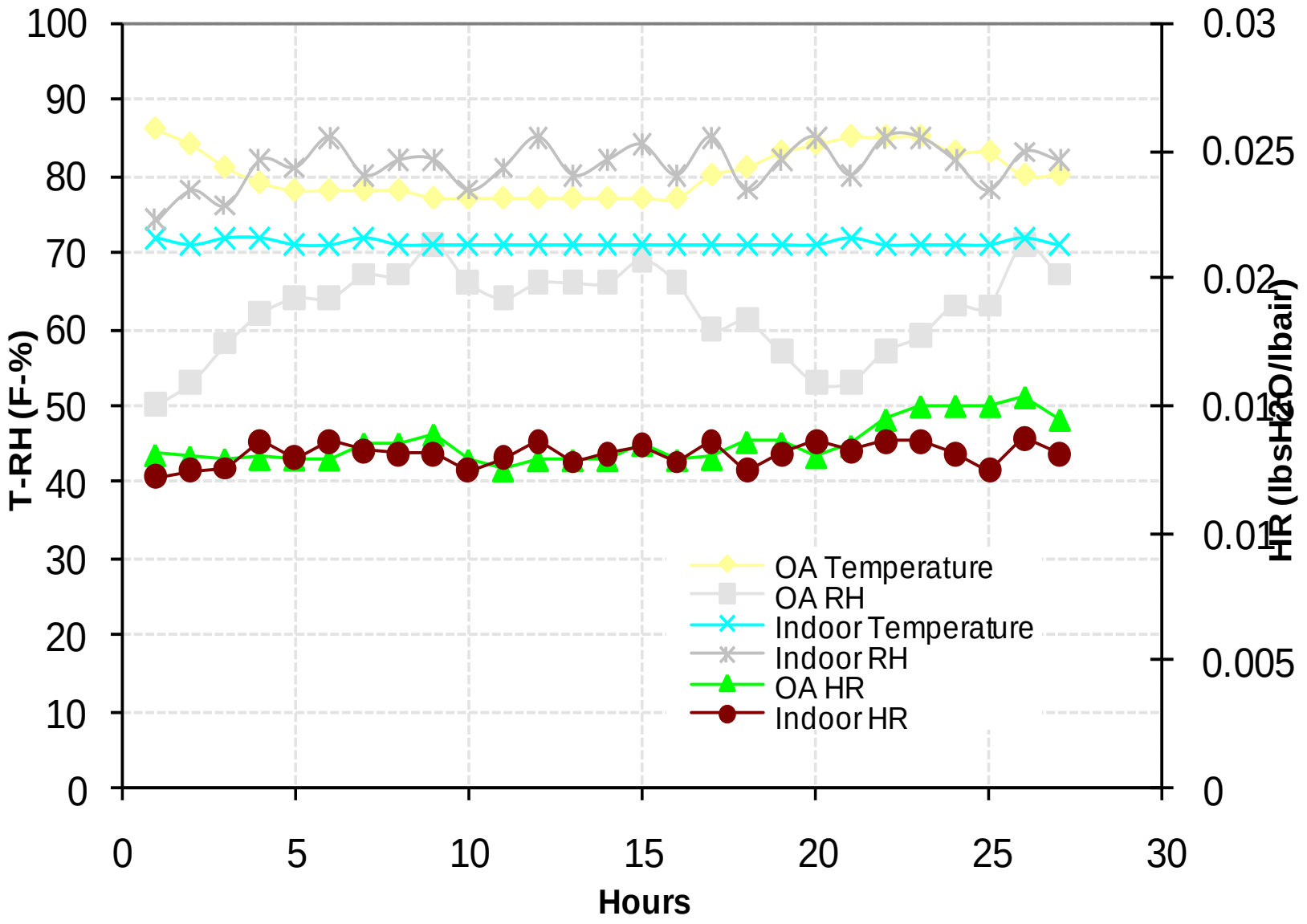
Design HVAC using ASHRAE Humidity Control Handbook



Correctly Sized AC Cools and Dehumidifies



2X oversized AC cools but does not dehumidify



HVAC Design

Equipment Design

- 55° F indoor dew point
- Use ASHRAE peak outdoor dew point for humidity control design (not peak temperature)
- Don't oversize cooling—it leads to major problems

Air-side Design

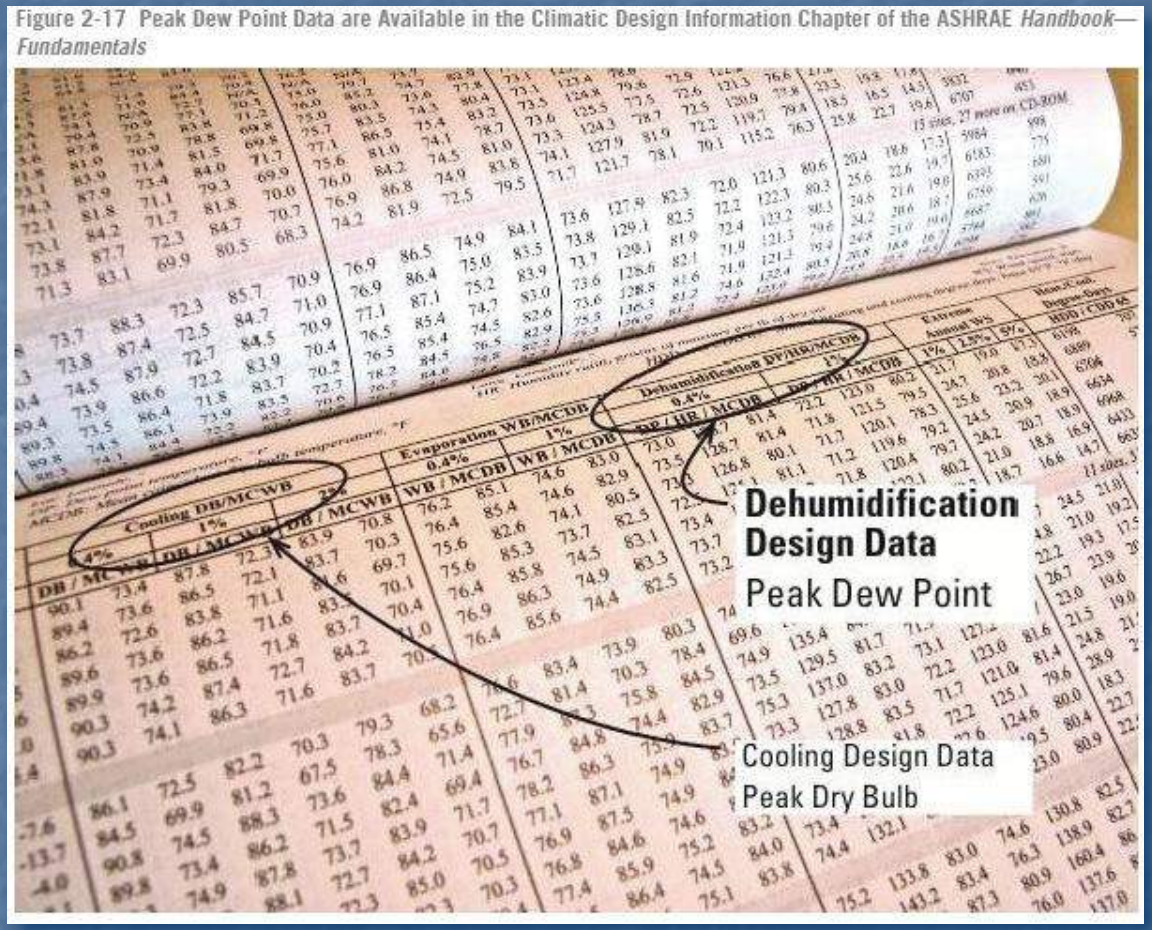
- Exhaust humid air and provide DRY makeup air
- Avoid plenums—Use sealed duct work instead
- Seal ALL duct connections, using mastic

HVAC

- Meet ASHRAE 62.1 air handler design criteria
- Air handlers and ductwork inside the enclosure

ASHRAE peak dew point design data

Figure 2-17 Peak Dew Point Data are Available in the Climatic Design Information Chapter of the ASHRAE *Handbook—Fundamentals*



Moisture Guidance from U.S. EPA

Moisture Control Principles For Construction

1. Things get wet during construction - That's life. But the building **must dry out**.
2. Understand the **purpose** of moisture-related design details.
3. **Installation** is often more important than design.
4. The **sequence of installation** matters—a lot

Construction

Planning

- Provide rain-protected storage for wall board
- Trade coordination meetings for air and water barrier installation sequence

Installation

- Pressure-test plumbing, air ducts and roof-wall air barrier joint BEFORE interior walls and ceilings are installed.
- Dry out concrete and masonry block before walls are installed.

Moisture Control Principles For Operation and Maintenance

1. Principles are less useful for maintenance personnel than component-specific **checklists**. Generate checklists and use them:

a. Site and foundation **drainage**

b. Walls and roof **leaks**

c. Plumbing **leaks** and HVAC **filters**

Troubleshooting checklist

Table 4-1 Troubleshooting Common Indoor Water Problems

SYMPTOMS	MOISTURE PROBLEM	POTENTIAL CAUSES		
		DESIGN	CONSTRUCTION	O&M
Mold growth	Leaks in the building enclosure due to problems with rain and groundwater controls	Missing or poorly designed details	Missing flashing or building wrap Incorrect sloping Damaged sub-grade drainage	Failure to identify and repair settled grading near foundation Damaged flashing on rooftop air handler curb Missing shingles
	Insufficient dehumidification by HVAC system[a]	Air conditioning equipment oversized Air conditioning equipment not designed for sufficient dehumidification at design and part load	Failure to properly wire humidity sensors	Chilled-water temperature set-point too warm Economizer set-point that allows introduction of humid outdoor air Continuously running air handler regardless of cooling demand
	Condensation on dirty surfaces inside HVAC systems	Poor condensate drain design Air handler inside surfaces insulated or hard to clean		Failure to clean HVAC system cooling coils Clogged drain pan
	Wet materials enclosed in building assemblies	Moisture-sensitive materials shown touching porous materials that are likely to get wet No values for moisture content or emission given in the specifications	Flooring placed on slab while it is too damp Vapor emission tests on slab may not have been conducted	Failure to seal penetrations during maintenance, repair or installation of new equipment
Peeling paint **Wood decay** **Corrosion**	Leaks in the building enclosure due to problems with rain and groundwater controls	Missing or poorly designed details	Missing flashing or building wrap Incorrect sloping Damaged sub-grade drainage	Failure to identify and repair settled grading near foundation Damaged flashing on rooftop air handler curb Missing shingles
Plumbing leaks and spills	Improper design Improper installation during construction Improper operations and maintenance practice	Locating water lines in a space that reaches freezing temperatures Poorly designed shower pan	Defective pipe joining Accidental penetration of pipe by one or more drywall screws	Failure to inspect plumbing and repair problems
Water travels to materials that cannot tolerate wetting	Capillary action (water wicks through porous building materials such as concrete or wood)	Moisture barrier omitted from building design Drainage layer beneath slab omitted from building design	Moisture barrier not installed during construction Drainage barrier not installed during construction	

Moisture Guidance from U.S. EPA

Operation and Maintenance

Drainage

- Keep water away from the foundation (rain leaders and finish grading)
- Make sure irrigation does not spray the building or puddle at the foundation

HVAC + Plumbing

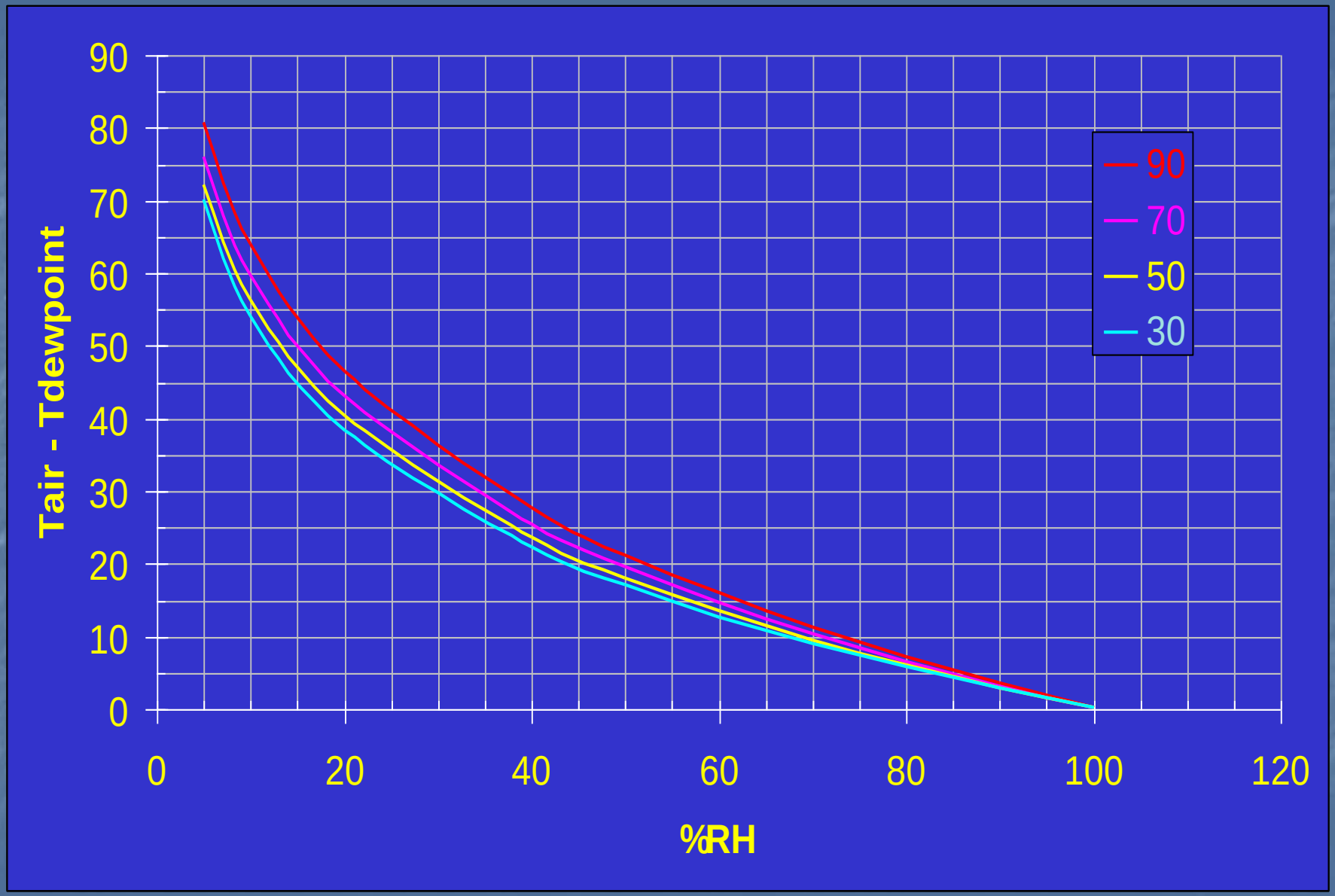
- Install clean outside air filters (monthly)
- Check damper positions and adjust outdoor air flow (annually)
- Drips and condensation matter—fix them and dry up any water

Moisture Guidance from U.S. EPA

Summarizing Guidance from EPA

1. Each stage of design, construction and operation has specific decisions that increase—or reduce risk of problems.
2. Design
    a. Foundation drainage including roof rain runoff management
    b. Walls with rain screen, water barrier and and pan flashing for windows
    c. Peak ASHRAE dew point for ventilation system design
3. Construction
    a. Rain-protected storage
    b. Subcontractor coordination for water/air barrier/flashing installation
    c. Pressure-test systems before installing interior walls and ceilings


BRINKMANN
ELECTRIC
BRINKMANN


90
80
70
60
50
40
30
20
10
0
Tair - Tdewpoint
0
20
40
60
80
100
120
%RH
90
70
50
30

Making Buildings Airtight

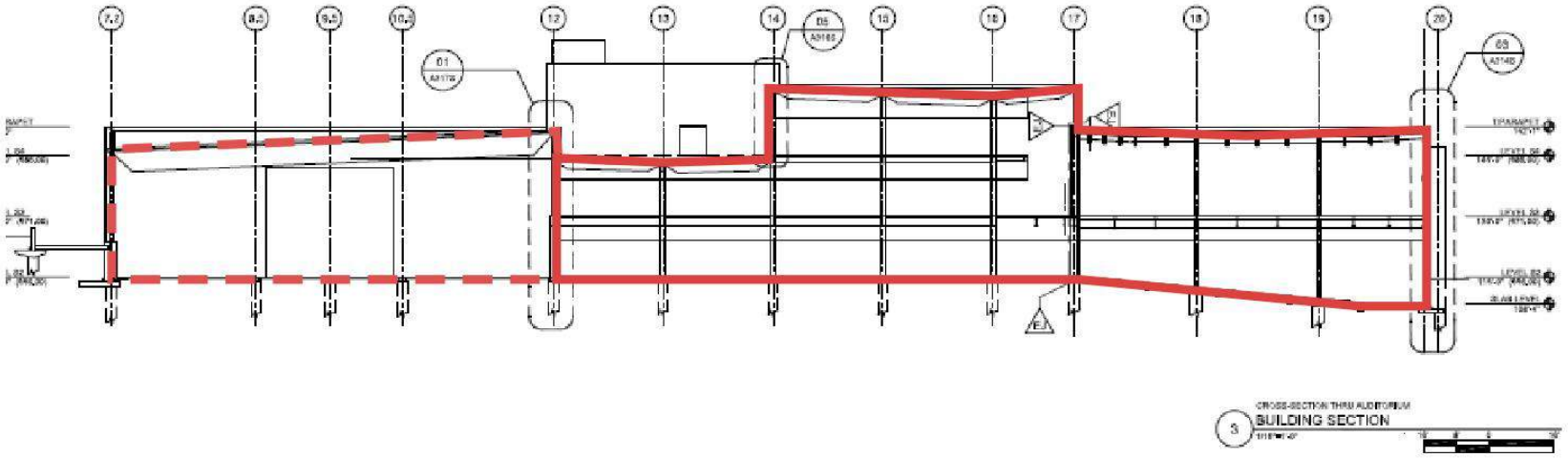
- Identify a target air tightness level
- Design to make them airtight
- Training, inspection, and quality assurance programs
- Conduct intermediate and final pressure testing
- Fix it and retest as needed

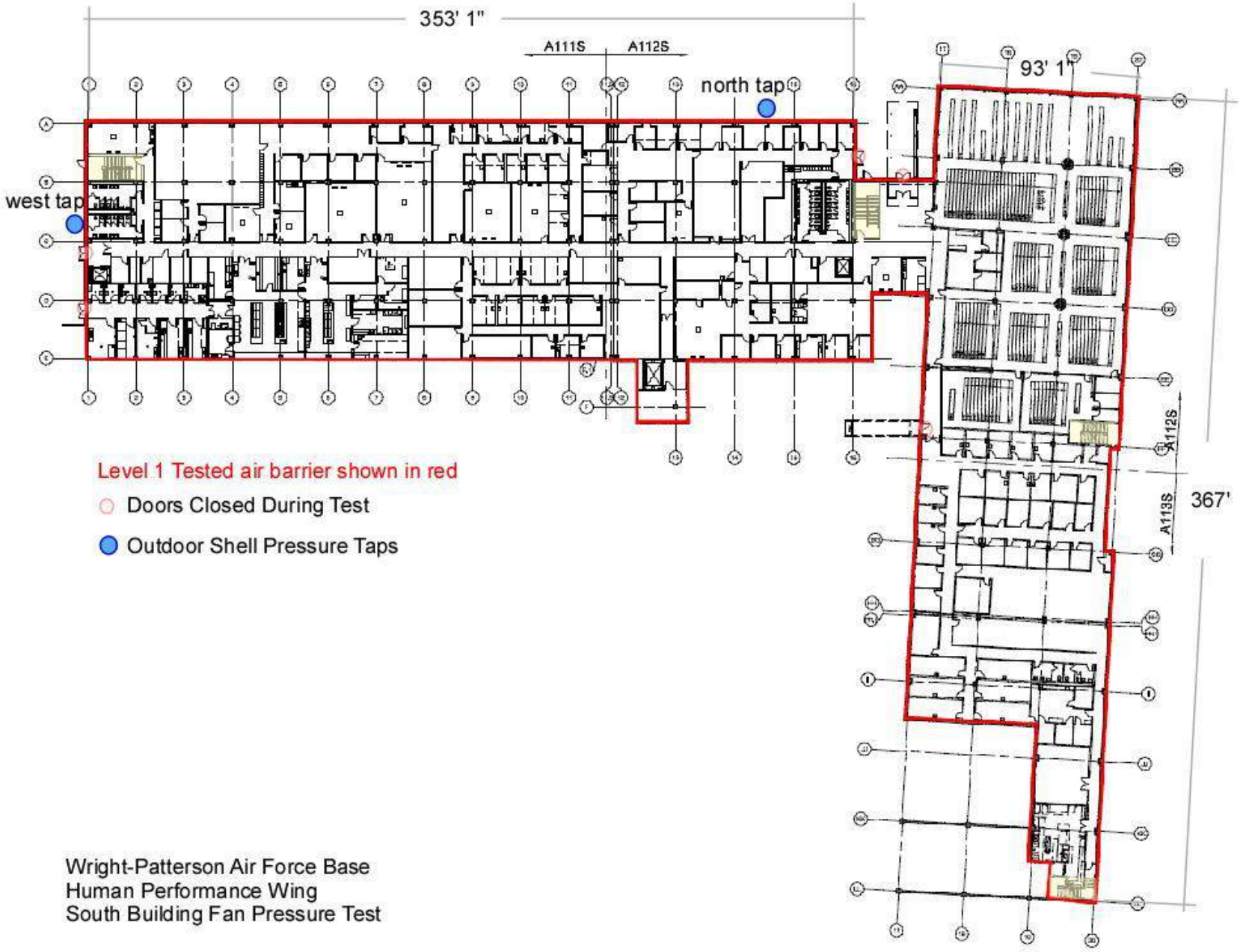
Design

- Identifying air barrier locations
- Making it easy/making it hard
- Air barrier materials and systems
- Provide details and specifications illustrating air barrier continuity at joints and penetrations
- Specify inspections, qualifications, QA and intermediate and final testing
- Air Barrier Association of America (ABAA)
  - Manufacturers
  - Contractors
  - QAP
- Assess section for condensation and drying potential, given climate and internal loads.

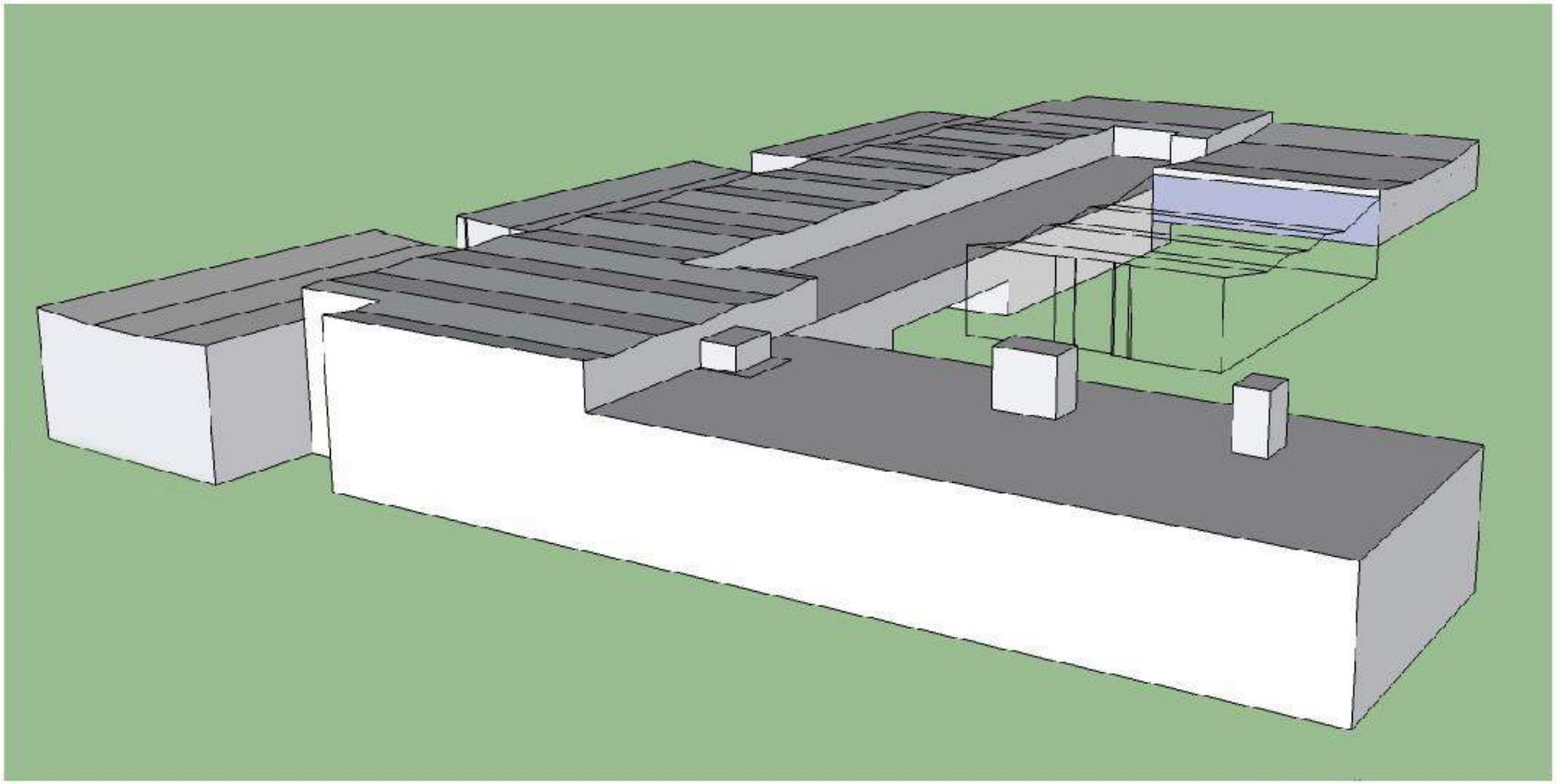
Air Barrier Association of America

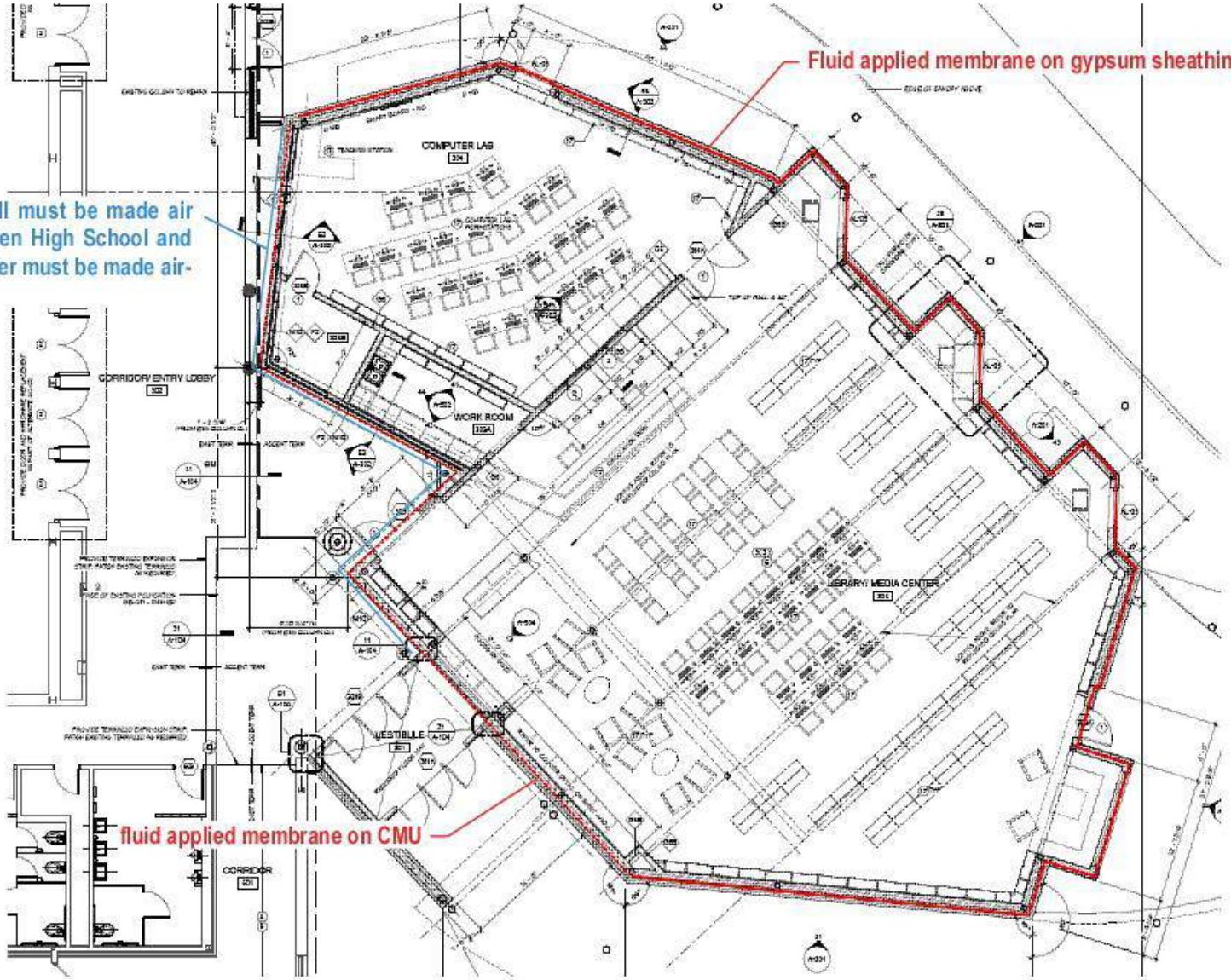
- Understand the concept of Air Barrier Systems
- Design Air Barrier Systems
- Specify Air Barrier Systems in your Building Enclosure
- Locate Manufacturers and Distributors of Air Barrier Materials
- Locate Contractors who Install Air Barrier Assemblies and Systems
- Incorporate ABAA's Quality Assurance Program into your Project
- http://www.airbarrier.org/index_e.php


BUILDING SECTION

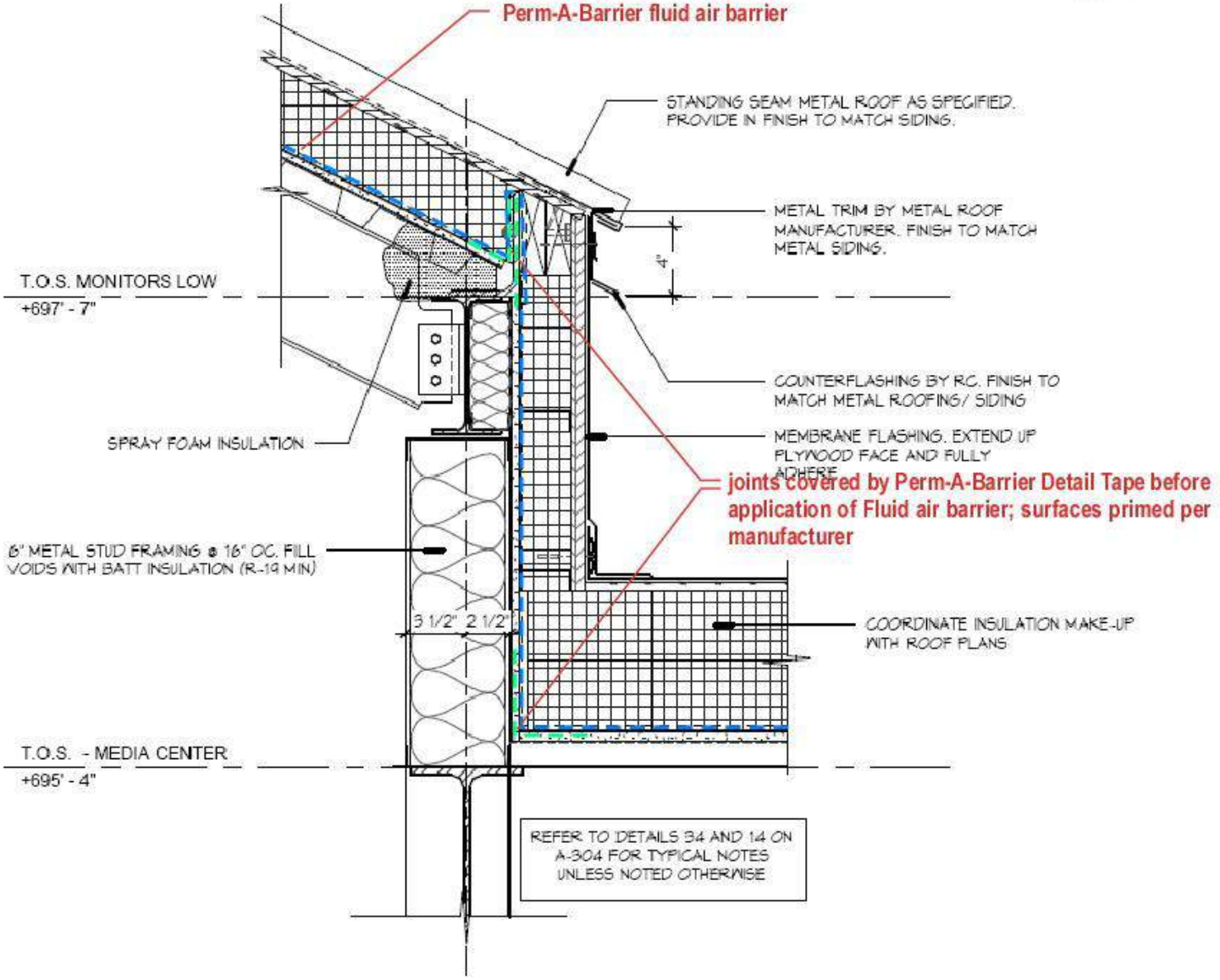


Wright-Patterson Air Force Base
Human Performance Wing
South Building Fan Pressure Test



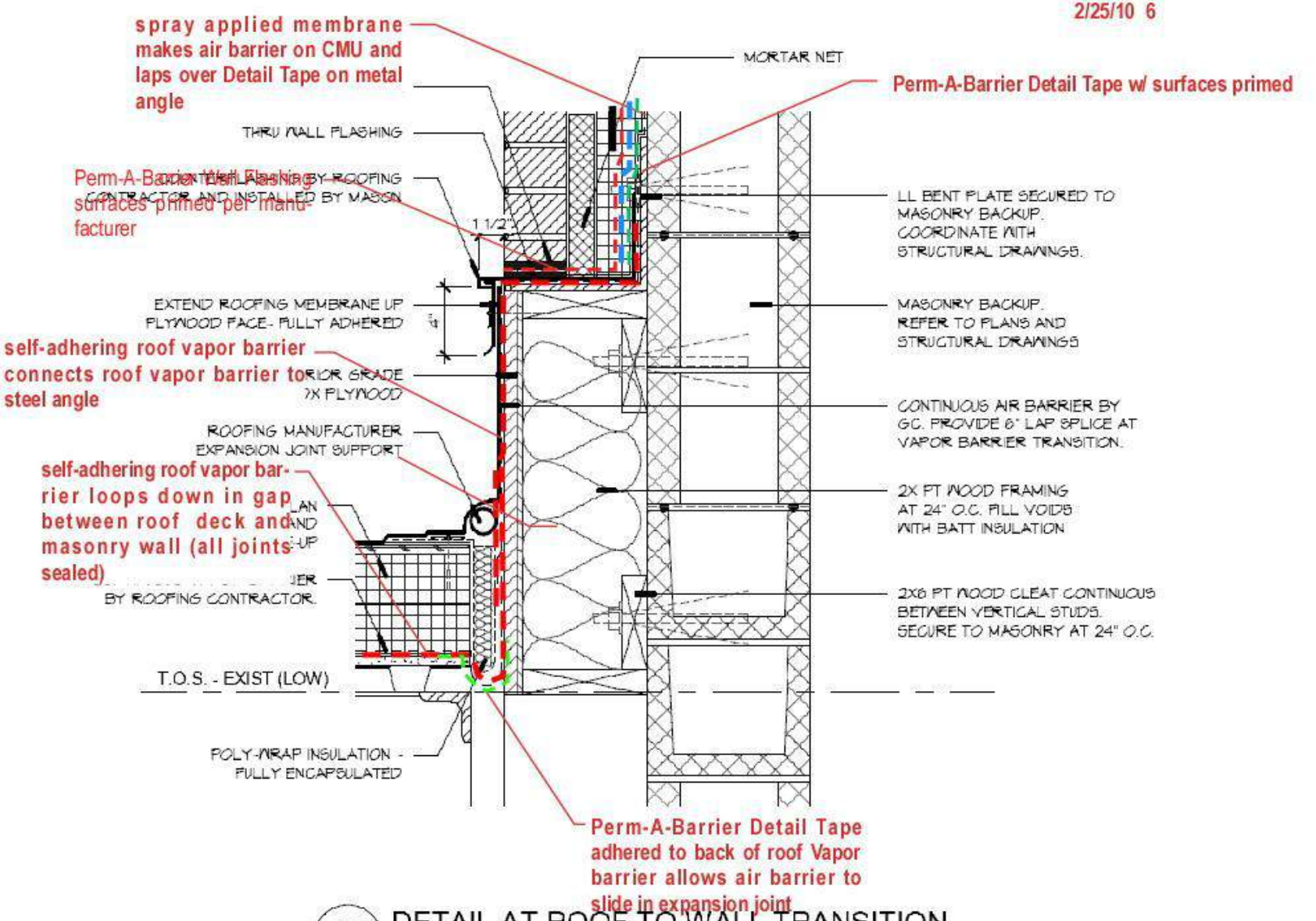


Location of air barrier around Media Center



35 DETAIL AT MEDIA CENTER MONITORS - LOW END

1 1/2" = 1'-0"



15 DETAIL AT ROOF TO WALL TRANSITION

1 1/2" = 1'-0"

A302

Get it in the specs

- Division 01; general requirements for hygrothermal control; coordination; testing
- Division 03; 04, 06, 09 concrete, CMU, sheathing surface prep
- Division 07; dampproofing, waterproofing, air barriers, vapor retarders, roofing, flashing, thermal insulation, sealants
- Division 08; doors, hatches, skylights, windows

Field Visits

- Kick-off: air barrier and moisture control requirements, mock-ups, inspections and tests described to all parties
- Inspections: General, subs, third party
- Mock-ups – inspection, testing
- Final Airtightness Test

Inspections and QA

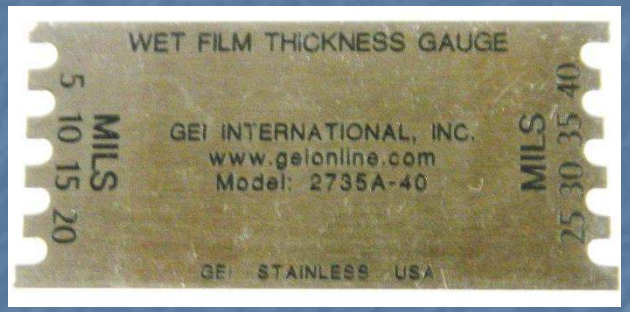
- Commissioning agent - periodic
  - Completed work and work in progress
  - Observe or conduct QA tests on installed material
  - Examine work logs
- Prime Contractor QA personnel – daily inspections
- Sub-contractors
  - Daily inspections, QA tests and documentation

Testing: what needs to be specified?

- Qualifications of testing agency
- What must be provided by the contractor
- The purpose of the test
- Test Method
- The target specification
- The boundaries, location, sampling procedure
- Conditions that must be met before a test can be conducted
- How the test result is interpreted:
  - Confidence intervals
  - Passing/failure
  - Report-retest?

Required enclosure function testing E2813-12 (black enhanced only, red enhanced and fundamental, blue fundamental only)	Laboratory test	Mock-up	In-situ field test
Acoustic performance		ASTM E966, E1014, E1503	
Air infiltration	ASTM E283	ASTM E783	ASTM E779, E1827, E783, E1186
Thermal performance and condensation resistance			ASTM C1153
Water penetration	ASTM E331	ASTM E1105; AAMA 501.2	ASTM D5957, E1105; AAMA 501.1, 501.2
Durability and appearance		ASTM D4541, E2359, C794, C1193 appendix X1-A; E488	ASTM D4541, E2359, C794, C1193 appendix X1-A; E488
Structural performance	ASTM E330		
Rain screen pressure equalization	AAMA 508-07		
Solar optical performance			
Moisture content			
Security			


Barrier


WET FILM THICKNESS GAUGE
MILS
5 10 15 20
GEI INTERNATIONAL, INC.
www.geionline.com
Model: 2735A-40
MILS
25 30 35 40
GEI STAINLESS USA

QA testing

Air Barrier Association of America

ABAA QAP Program

- Based on ISO9000
- Standards and specifications
- Product evaluation and acceptance
- Contractors accredited
- Certification of installers
- Daily inspections, tests and logs
- Third party Field audits


Inspections are crucial


SUNBELT
RENTALS


ActiGARD
11/09/2008


HOT WATER SUPPLY
TYPE 75


PROTECTION
HIGH TEMPER


CCW-705
Air & Vapor Barrier


OPINEL
CARBONE

Intermediate test

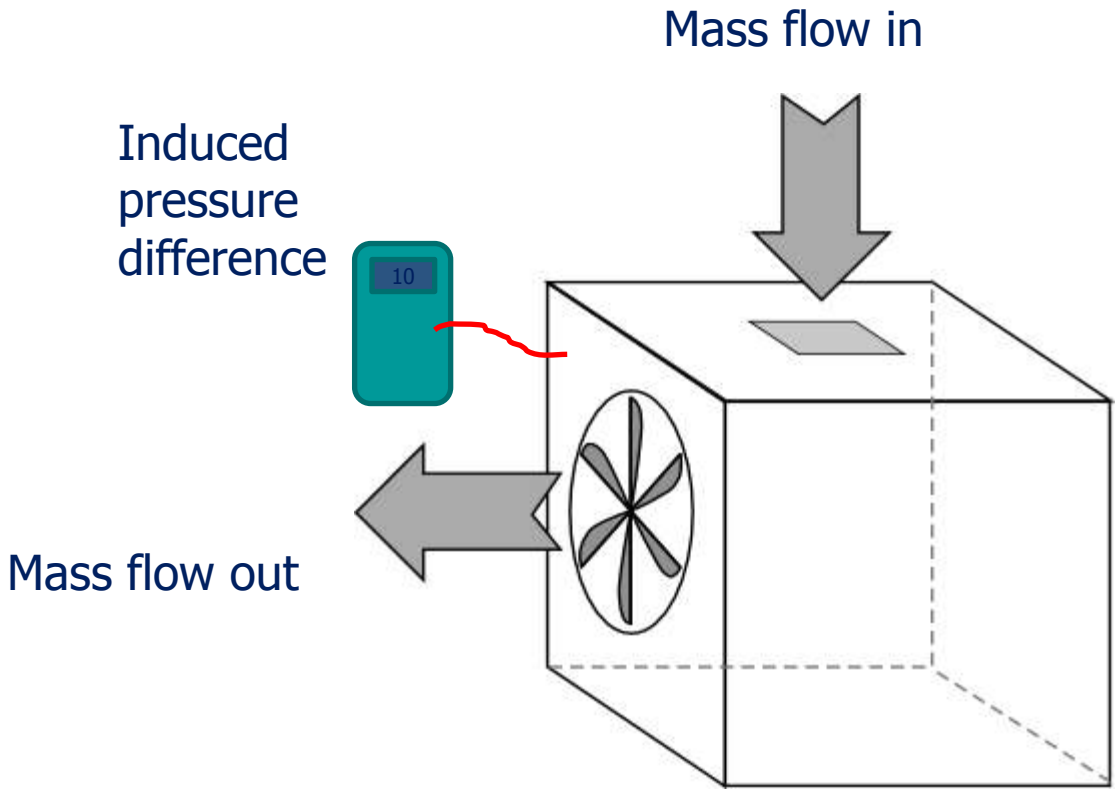

National Gypsum.
NATIONAL
RENTA-FENCE


Made in Mexico
nosco 1500
FOG MACHINE

Planning and Conducting a Whole Building Airtightness Test

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

Fan Pressurization Airtightness Test

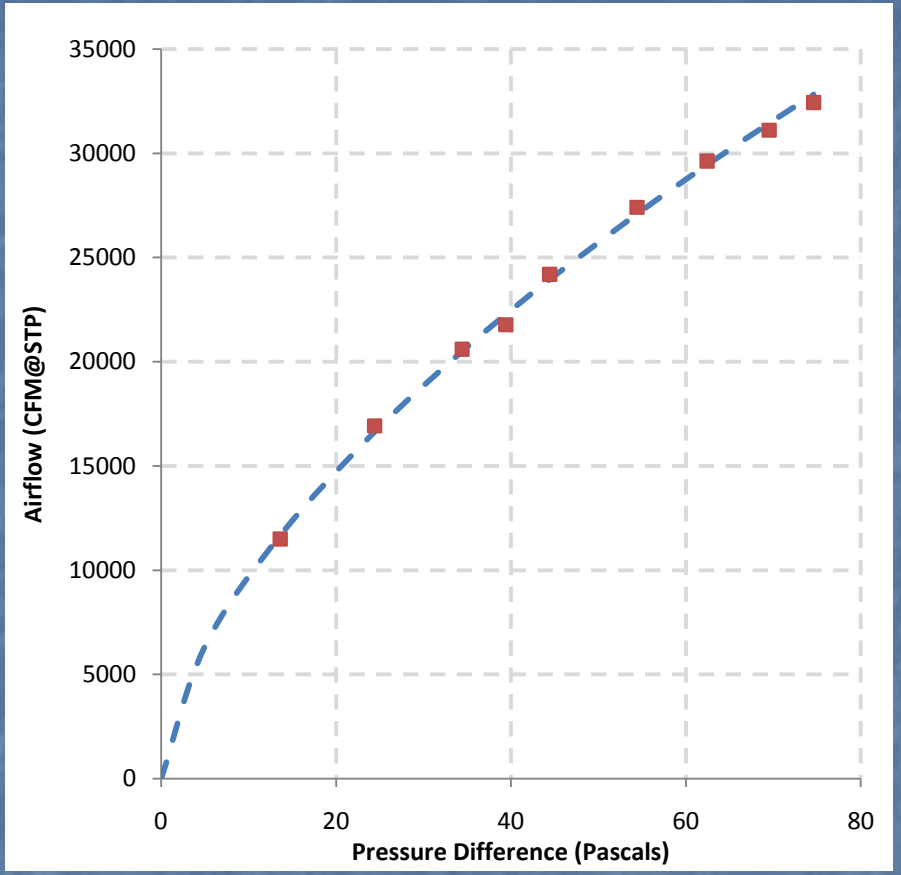


Multipoint regression test E779, USACE

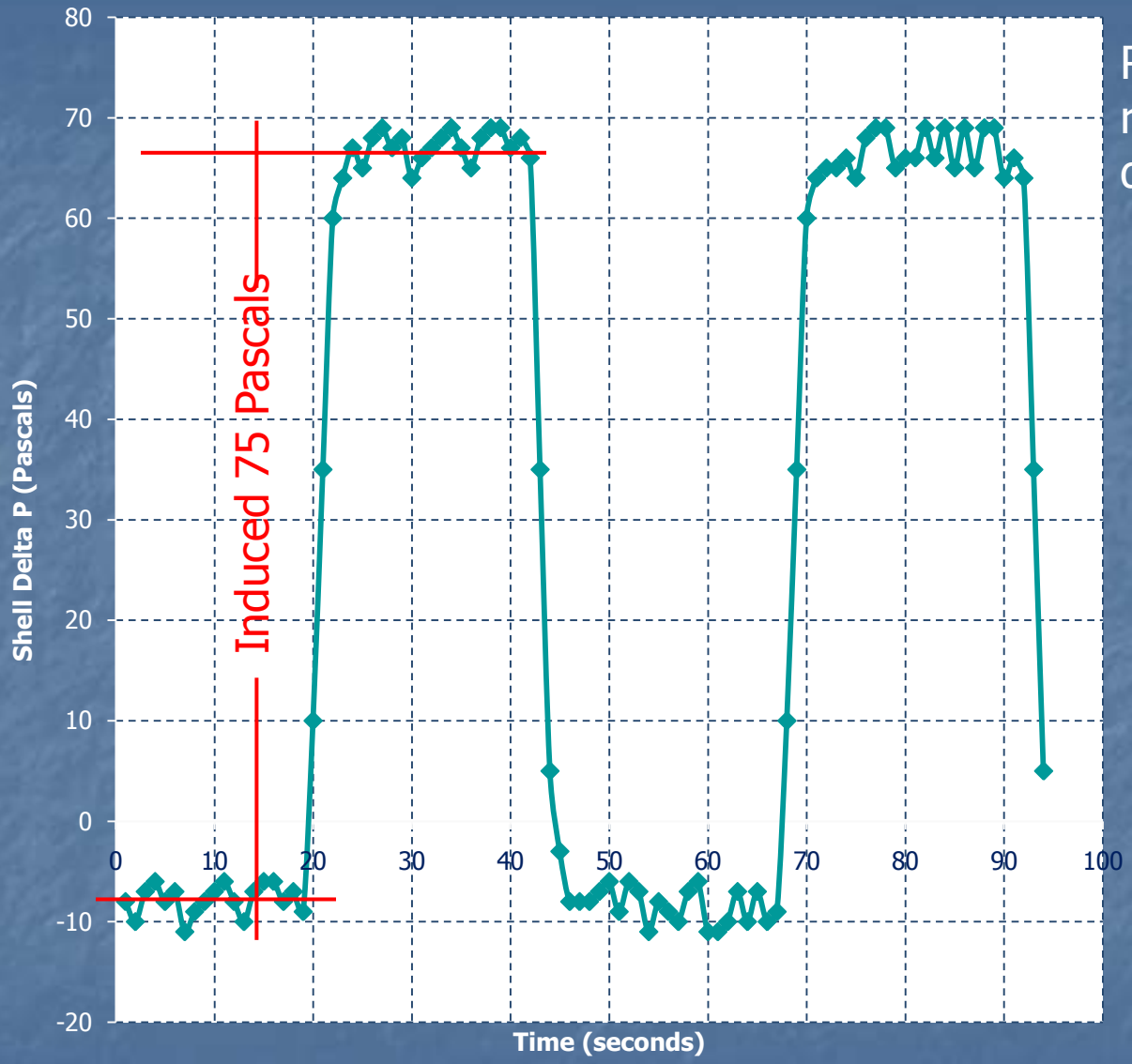
Regression analysis on
Transformed Nonlinear Function: (E779)
$Q_{cfm} = C*(\Delta P_{pascals})^n$

Where C = flow coefficient
n = flow exponent ($0.5 \leq n \leq 1.0$)

If it takes three fans to get to 25 Pascals it will take less than three to get to 50.



This is a simplification. Air density and viscosity also affect flow and the leakage curve really isn't a power law.



Repeated Tests at the reference induced pressure difference. E1827

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)

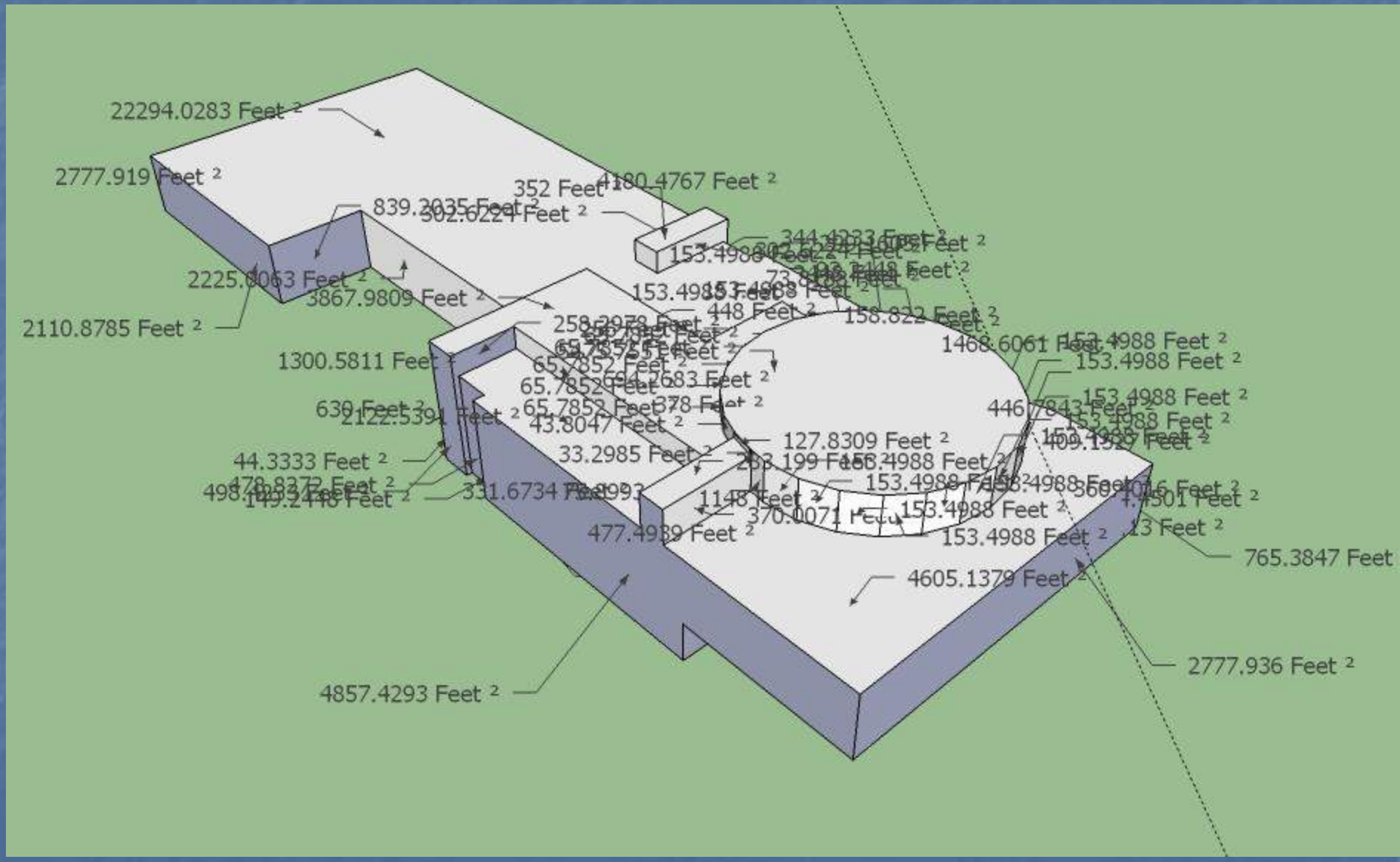
Select Date

- 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

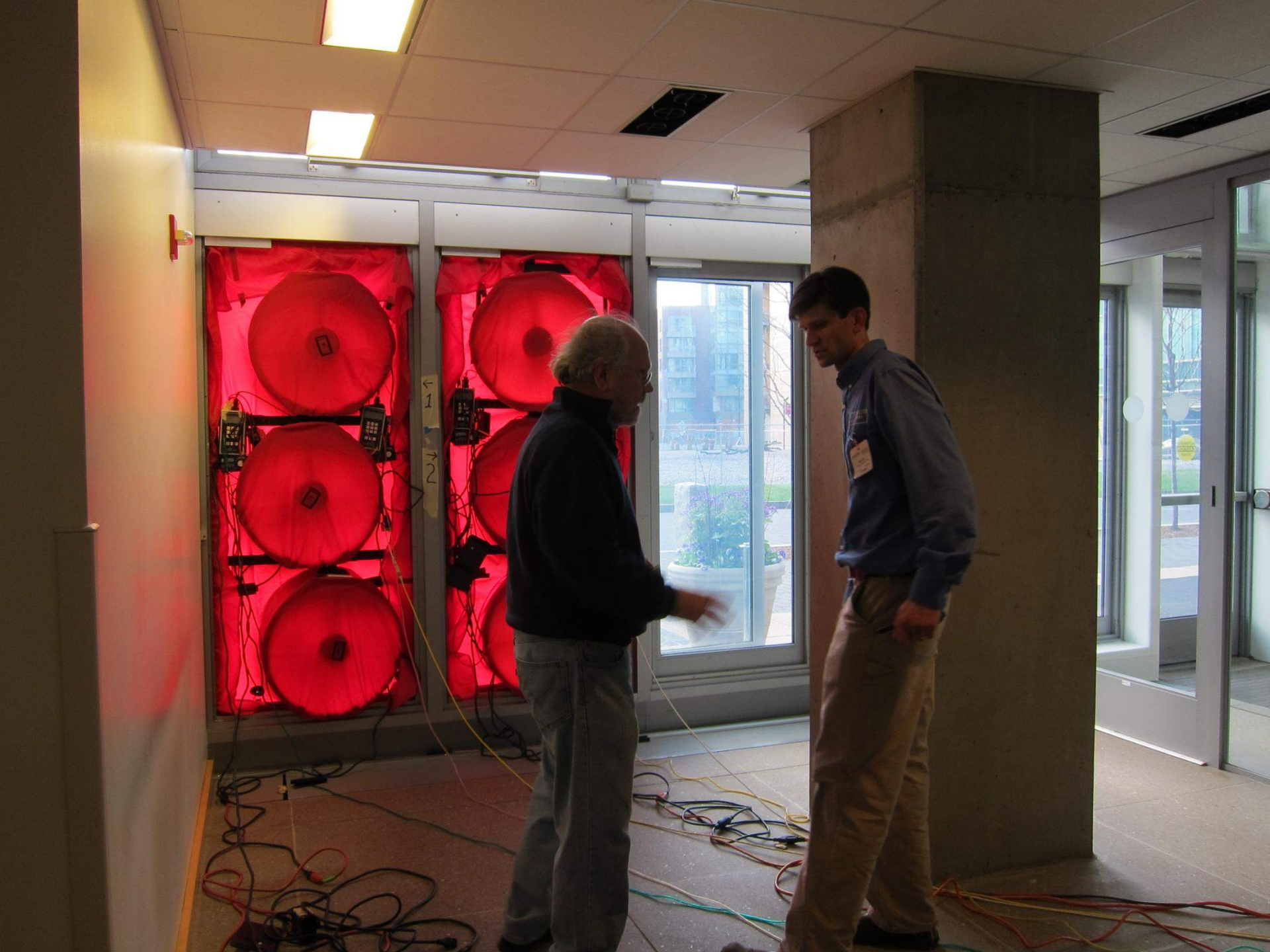
Sketchup models to identify test enclosure location and areas



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; ?

Calibrated fan doors



Wright-Patterson Air Force Base
Human Performance Wing
South Building Fan Pressure Test

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

Fans off


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

Dampers closed

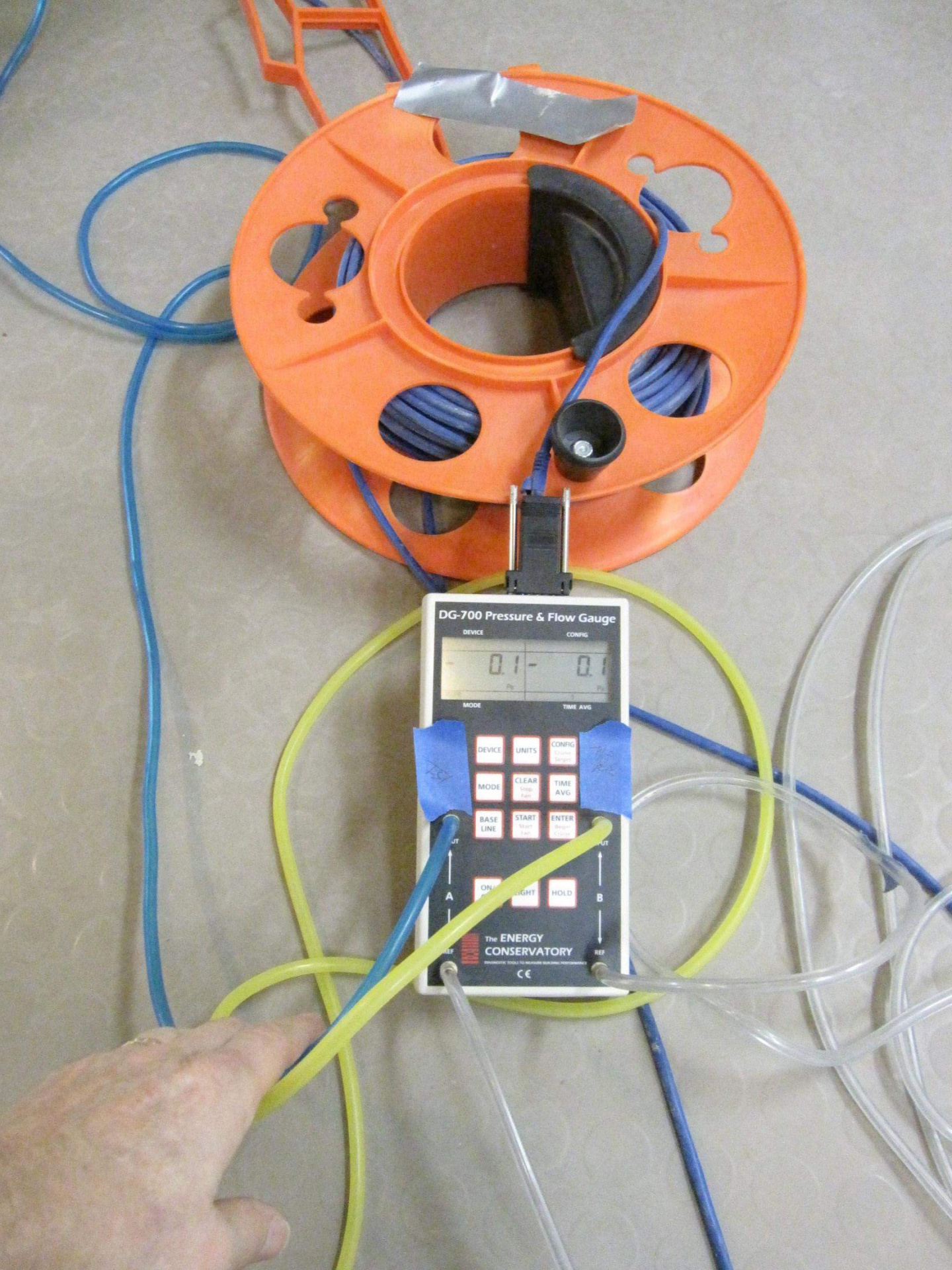
No dampers, gravity dampers, motorized dampers, masking?

During pressurization tests gravity dampers blow open.


ACPI
SYSTEMS

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
DEVICE
CONFIG
MODE
TIME AVG
DEVICE
UNITS
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MODE
CLEAR
TIME AVG
BASE LINE
START
ENTER
HOLD
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B
REF
REF
The ENERGY CONSERVATORY


4400 4400