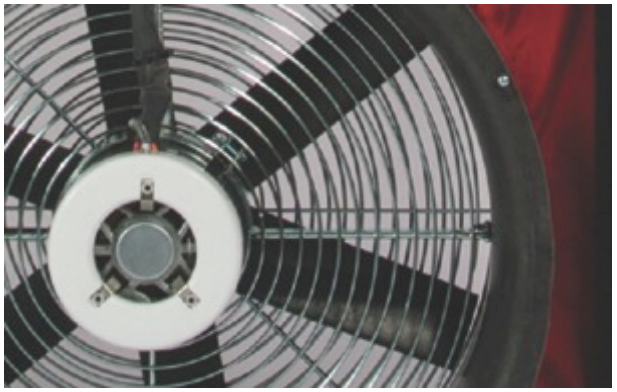
So, tell me about your problem house



TEC®
The Energy Conservatory

Paul Morin

In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors** continuing education requirements."

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Agenda

- The Basics:
  - Moisture
  - Air
- Diagnostic tools
- Asking the right questions
- Case studies

The Basics - Moisture

- A blessing and a curse
- A moisture problem always suggests 4 questions
  - Where did the moisture come from – **the source.**
  - How did the moisture get to where it caused the problem – **the path.**
  - Was the moisture a vapor, bulk water or a condensate or combination of the three – **the moisture form.**
  - Was it gravity, air pressure, capillarity, or diffusion that carried the moisture from one place to another– **the driving / pulling force.**

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The Basics - Moisture

» Most moisture problems fall into two types:

- Location of problem, source of moisture, and path of moisture are all close together

- Both moisture source and path are not at all obvious

The Basics - Moisture

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The Basics - Moisture

- Location of problem, source, and path are all close together
  - Wet carpet in corner of basement
    - **Source** - It just rained and downspout is disconnected
    - **Path** - Grade slopes toward that corner and concrete block foundation is porous
    - **Form** – Bulk water
    - **Driving force** – gravity
  - Foundation wall exposed poly is wet during summer (1 corner)
    - **Source** – Automatic sprinkler wets the foundation
    - **Path** – Moisture comes through concrete block and insulation to the poly
    - **Form** – Bulk water turns to vapor and then condenses on cold poly
    - **Driving force** – gravity, capillary action. vapor pressure increases when the sun hits the wet block

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The Basics - Moisture

- Both moisture source and path are not at all obvious
- Details later in case studies

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The Basics - Air

- Stack effect
- Wind effect
- Mechanical effect
- Ability of air to carry heat and moisture

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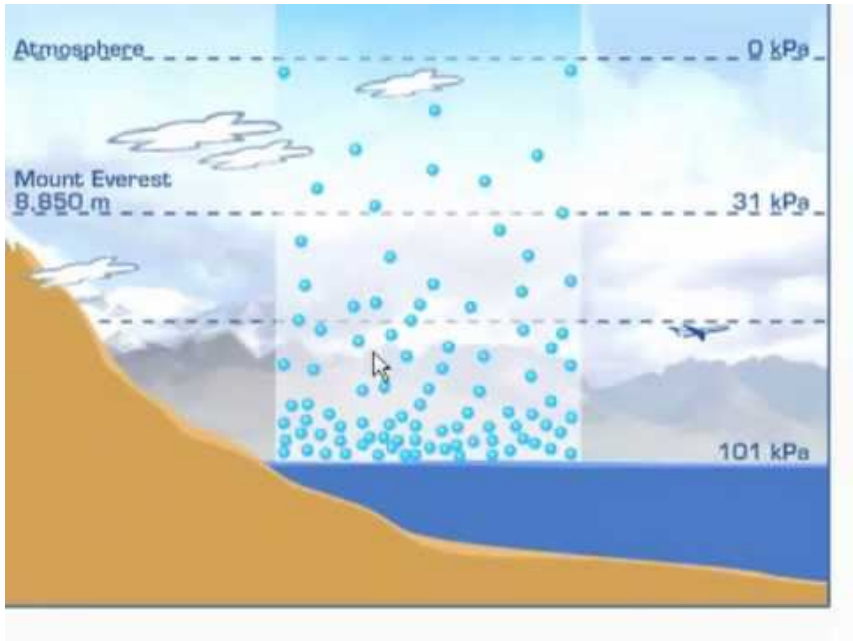
Understanding Stack Affect

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



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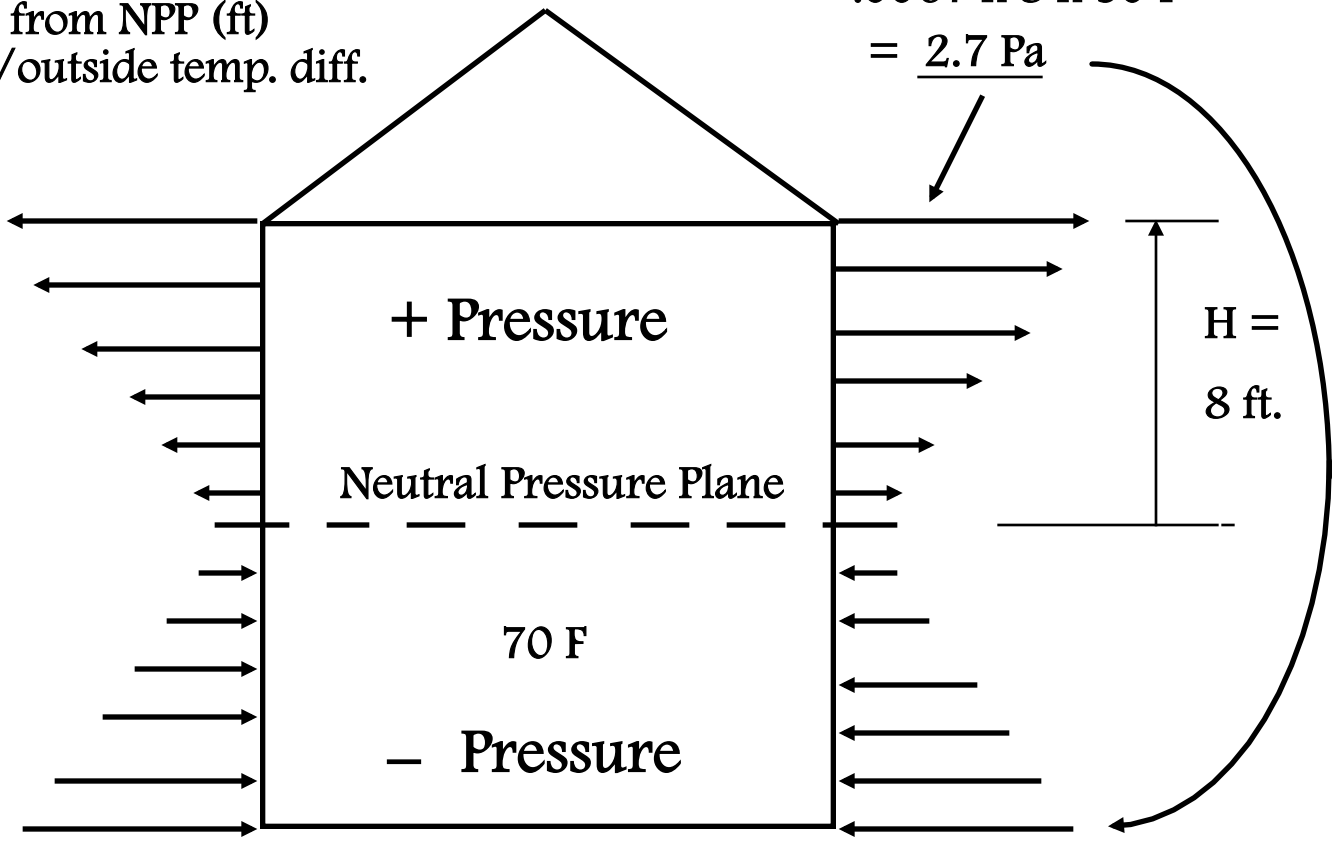
STACK EFFECT

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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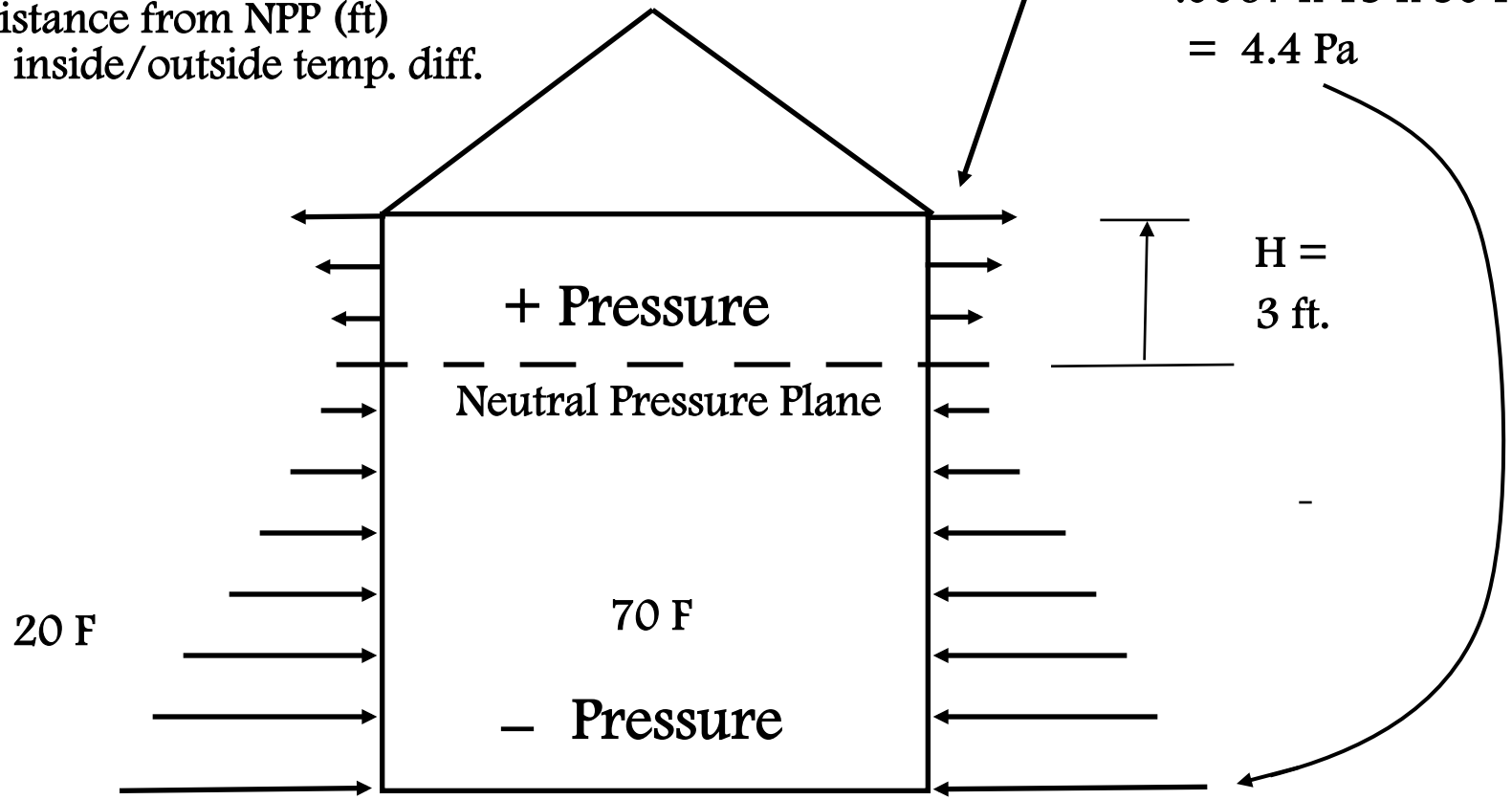
STACK EFFECT

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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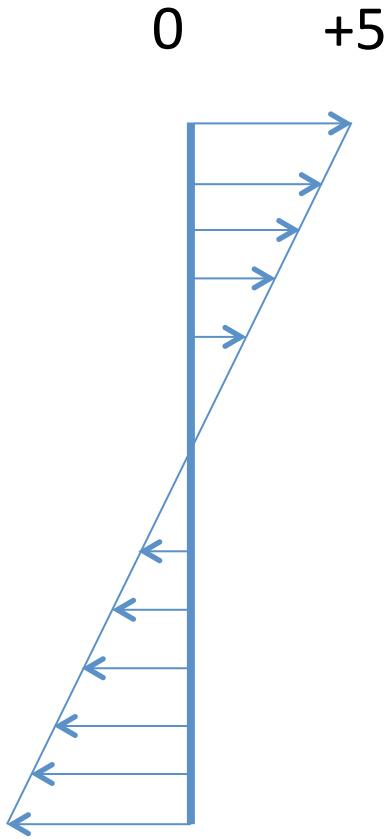
Baseline Pressures

SIDE ELEVATION



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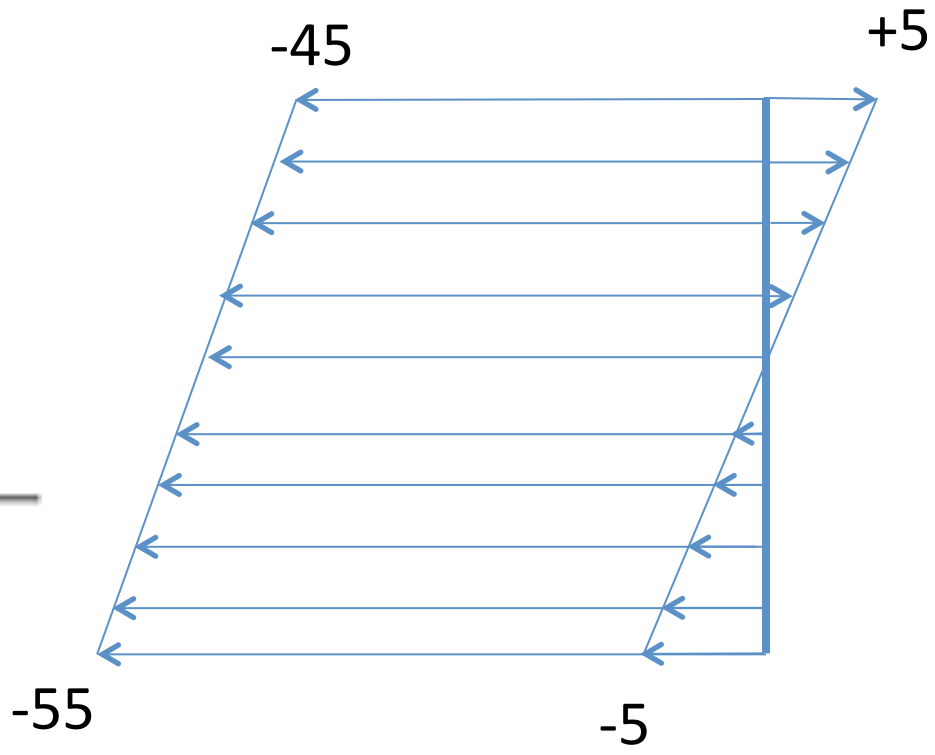
-50 Pa Induced Pressure

SIDE ELEVATION



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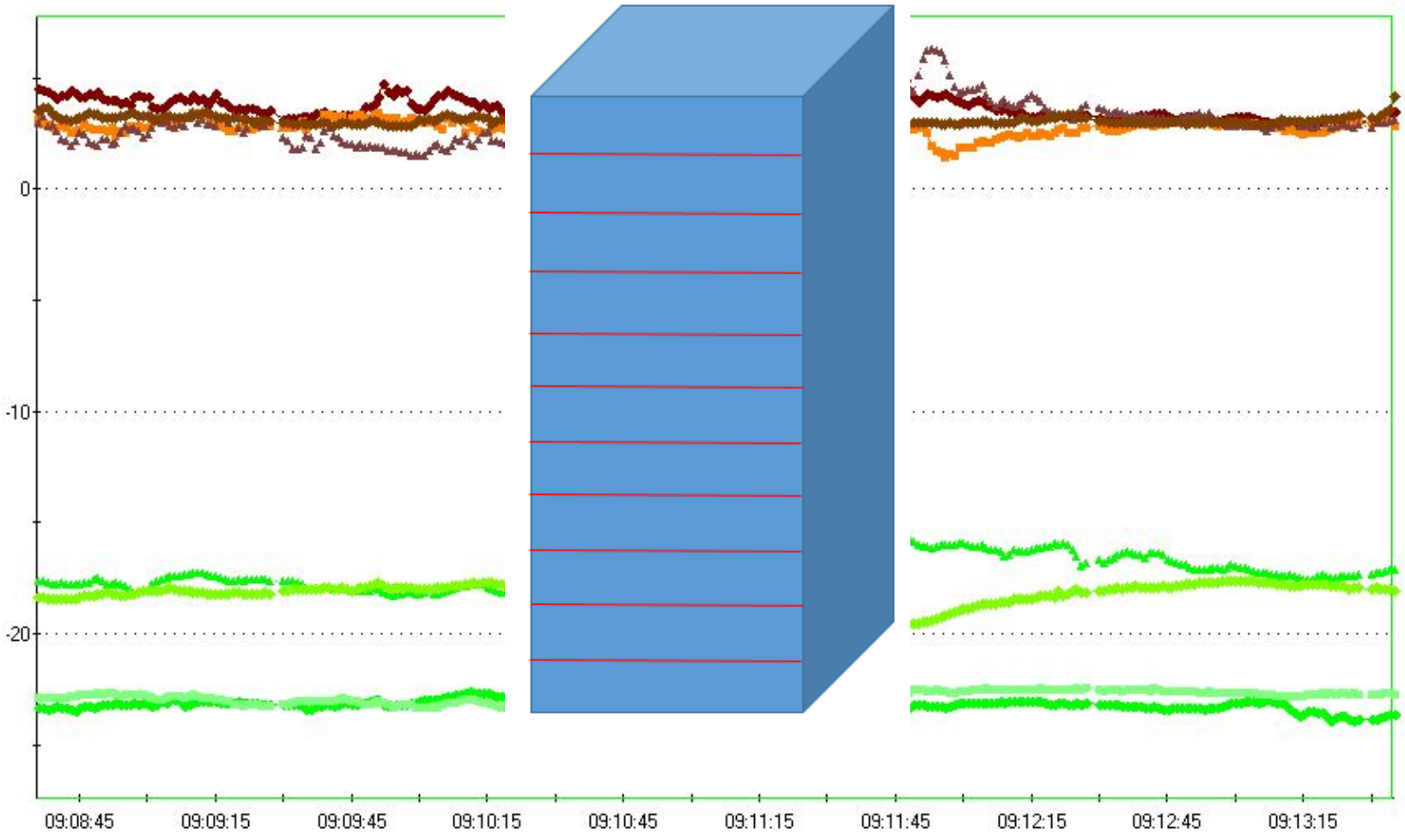
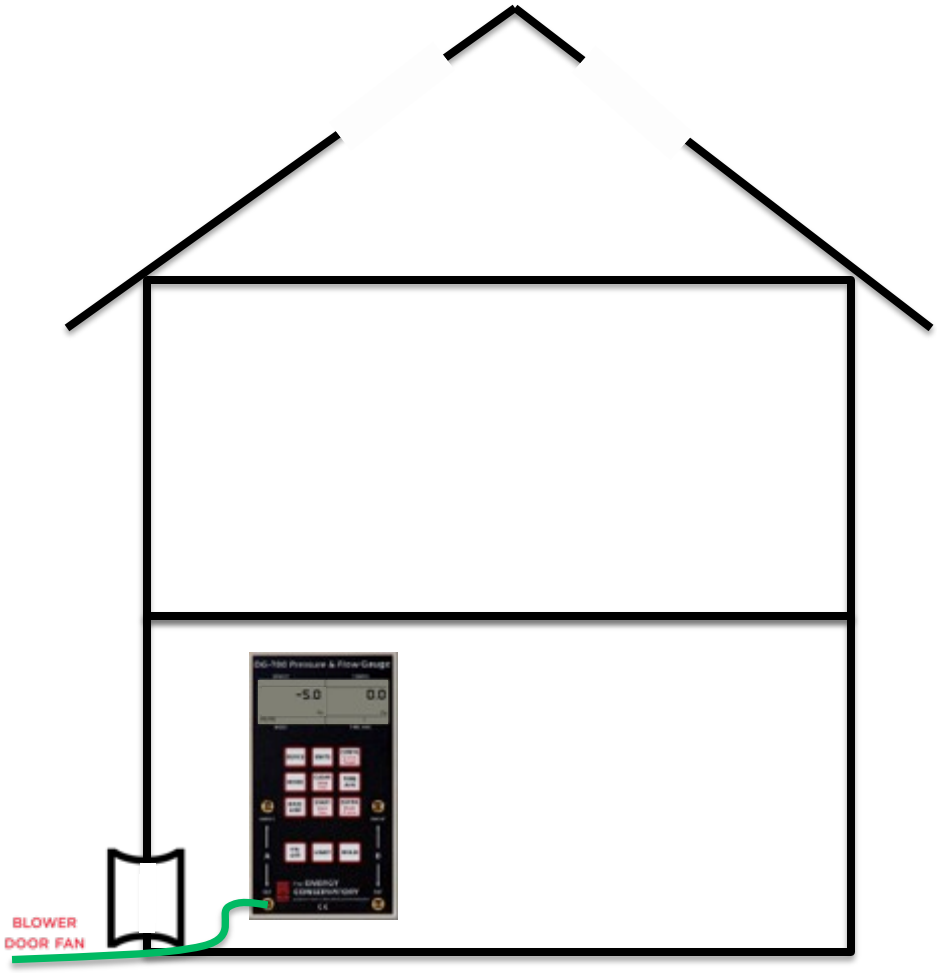
Understanding Pressures





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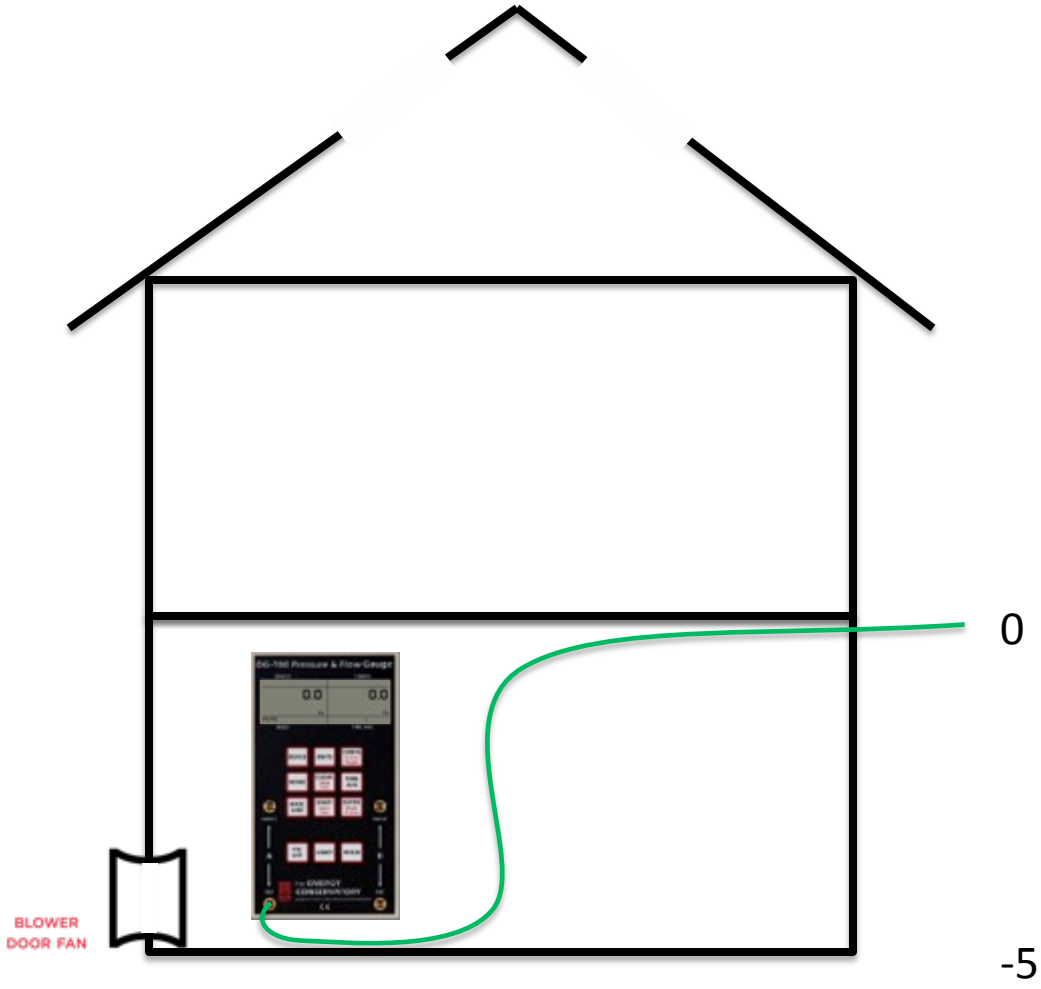

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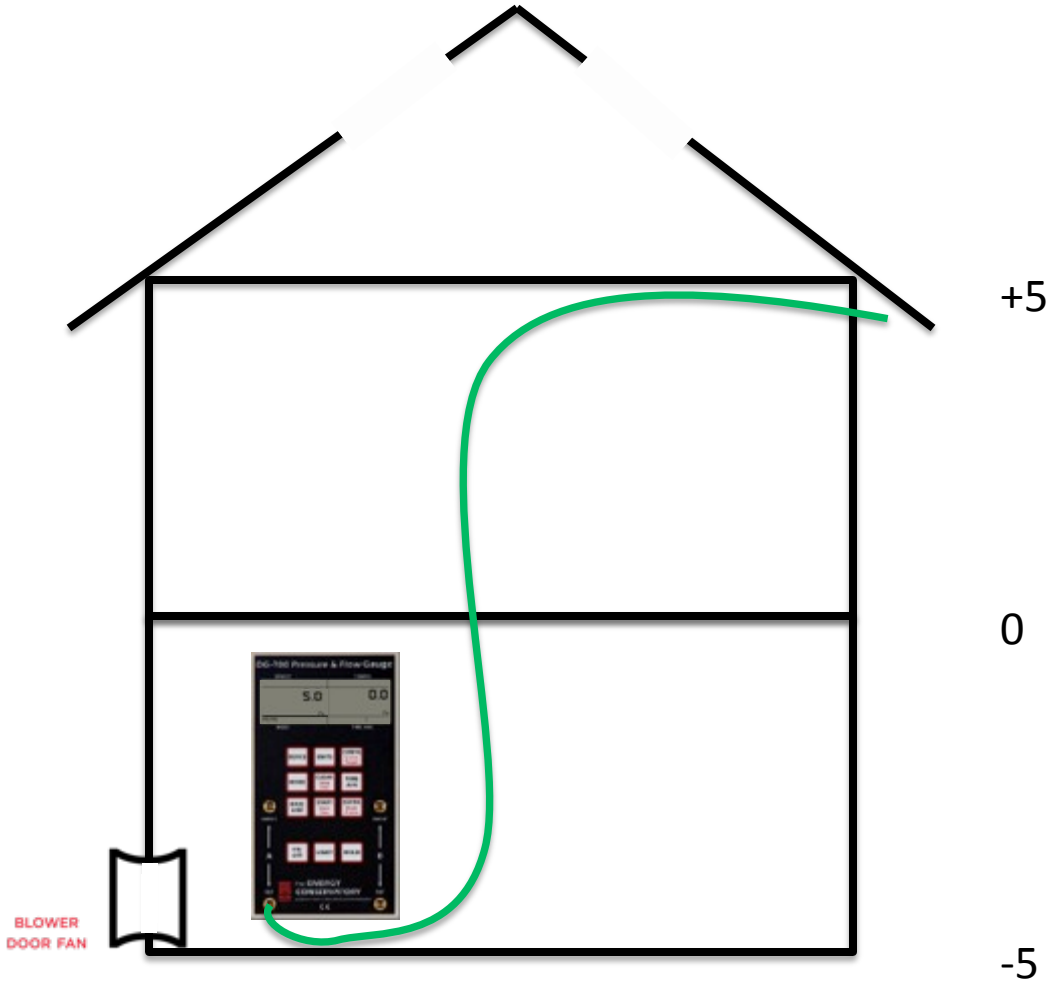
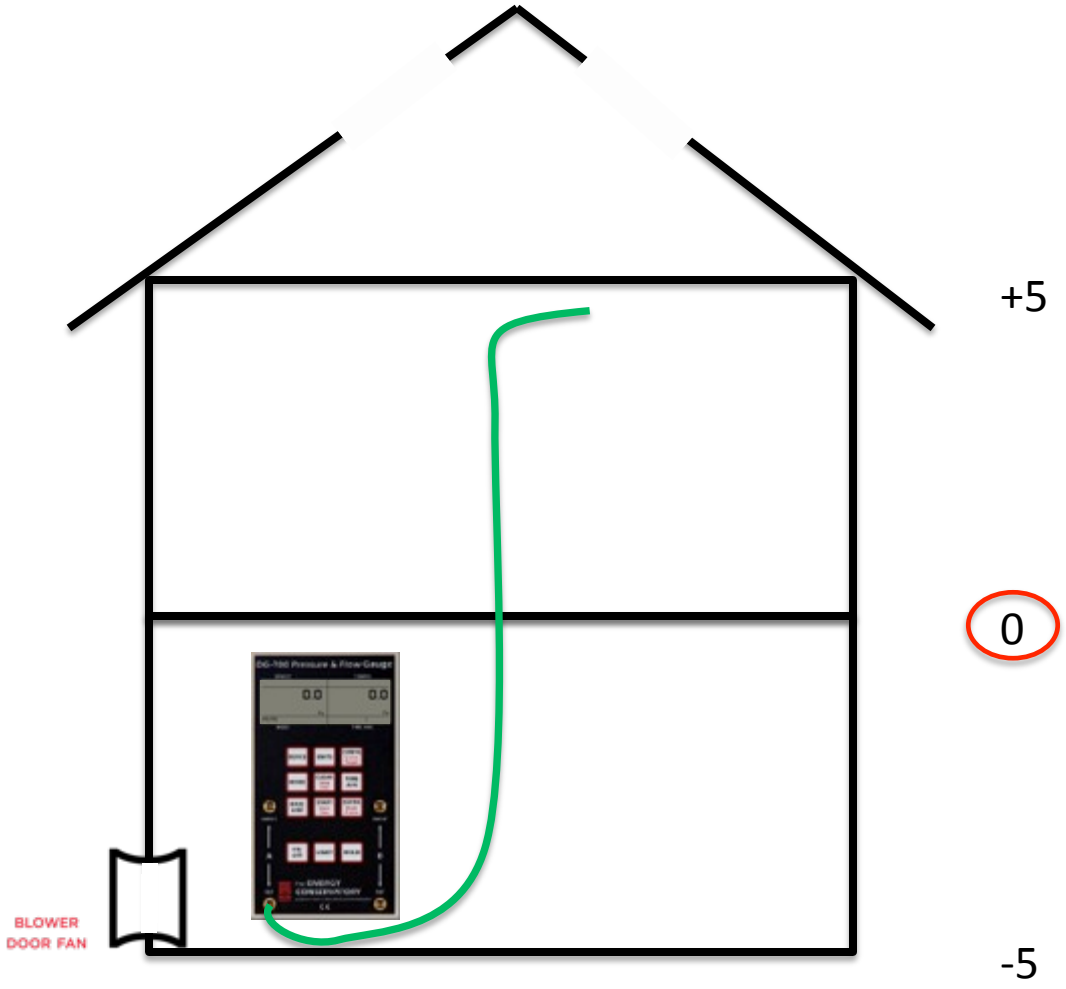

+5
0
-5
BLOWER
DOOR FAN


+5
0
-5
BLOWER
DOOR FAN

Wind Effect

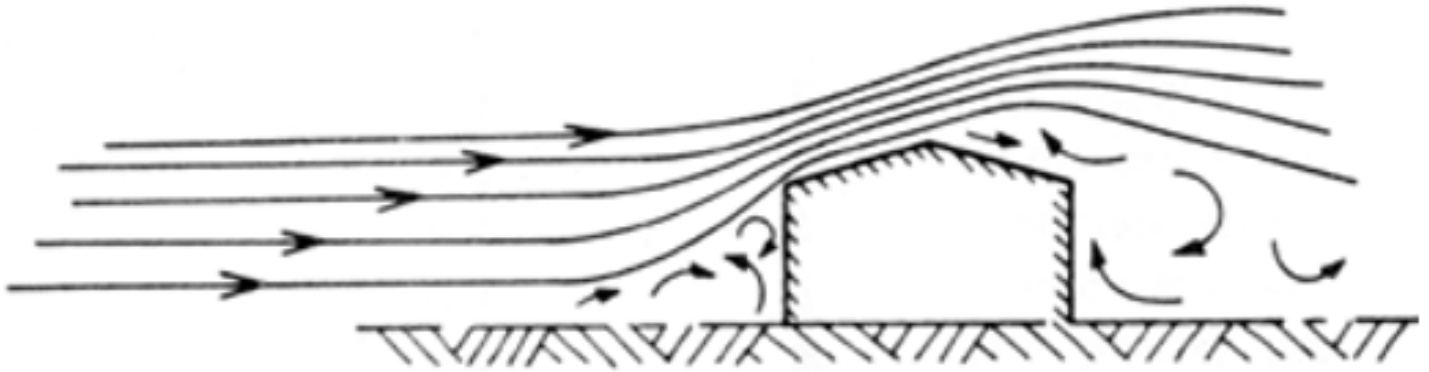


Figure 20 Flow lines around a simple building shape

CMHC Research - Canadian Building Digests

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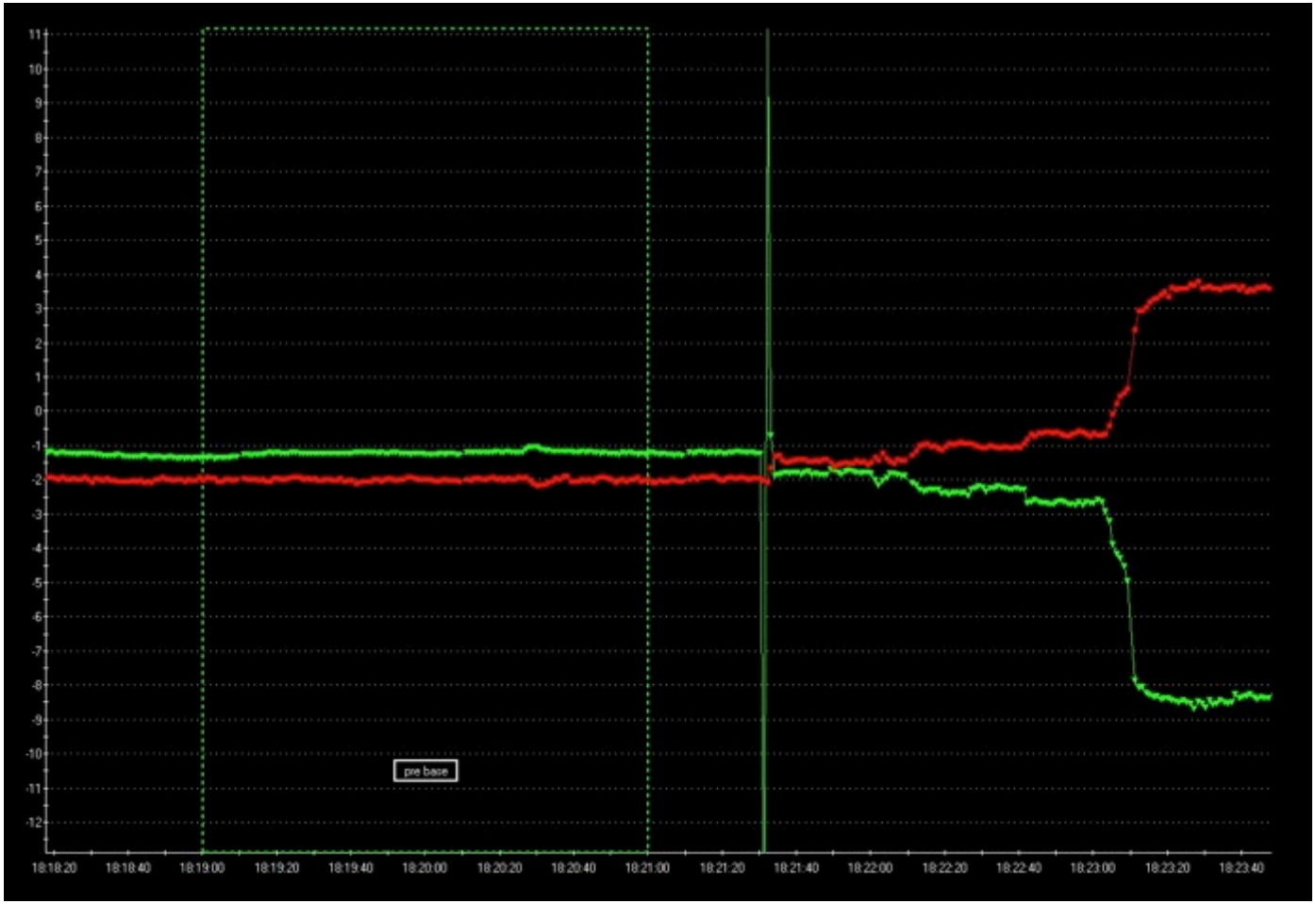
Wind Effect



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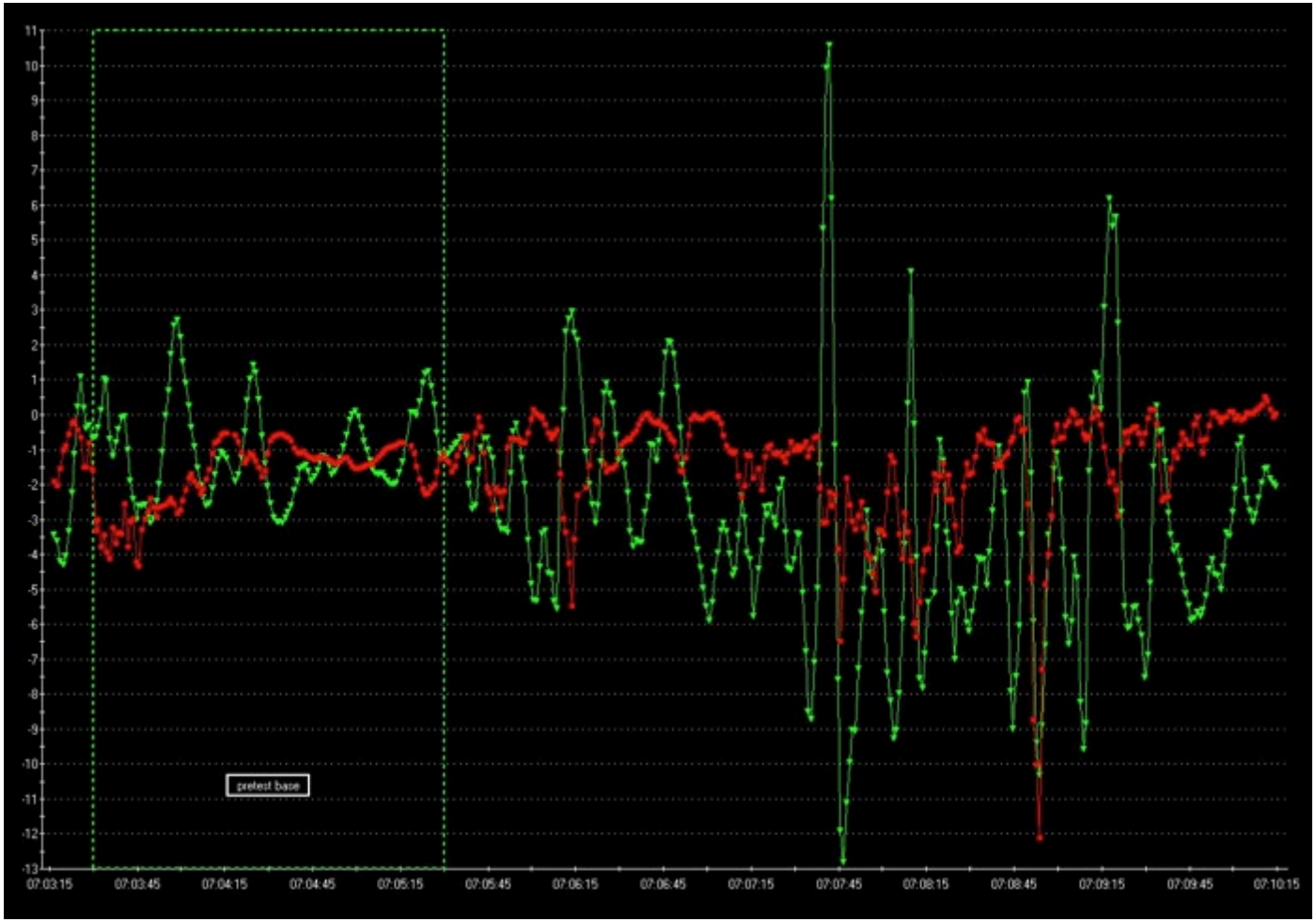
Wind Effect



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Wind Effect

» Problems caused by wind

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Solution?

- Seal and insulate rim joist from the outside
- Replace vented vinyl soffit material with rigid sheet material sealed at edges and seams

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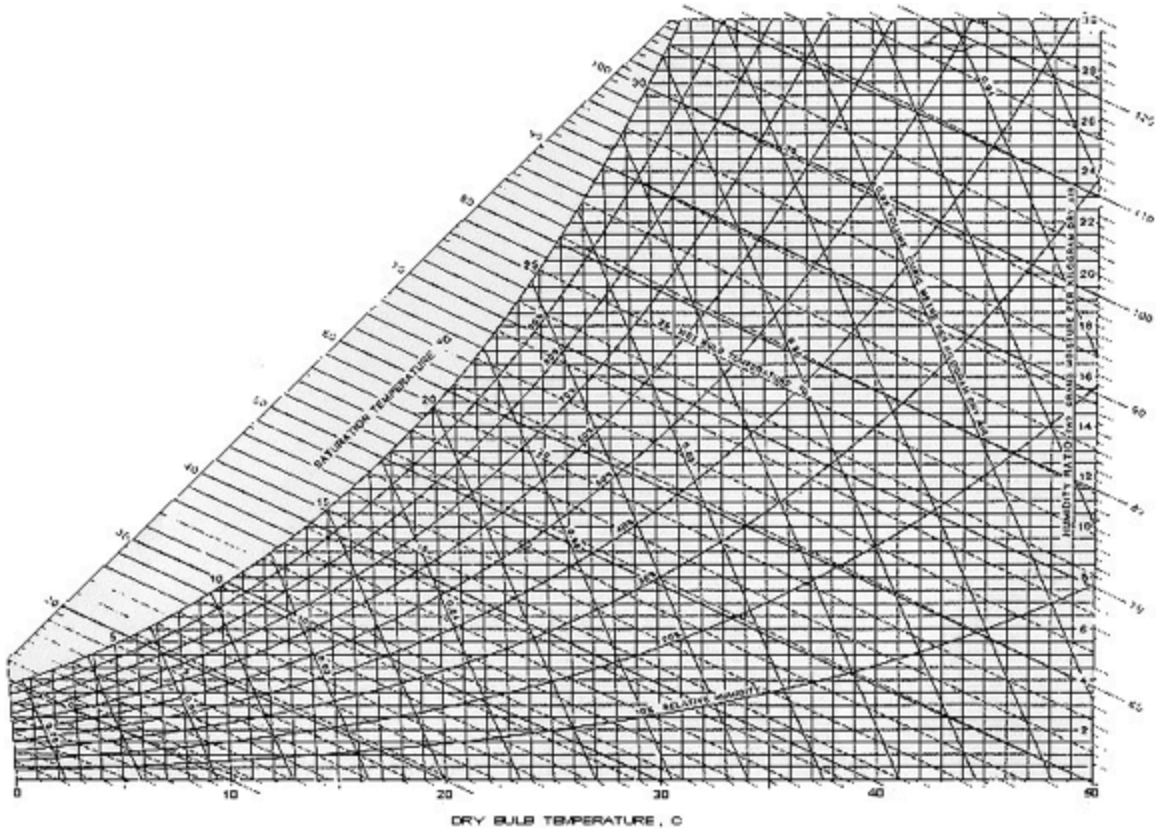
Mechanical Effect

- Pressures caused by:
  - Chimneys of natural draft appliances
    - Fireplace = 300 CFM
  - Exhaust devices
  - Air handler fan and door closure
  - Air handler fan and duct leaks to outside

Ability to of air to carry heat and moisture



Psychrometric Chart

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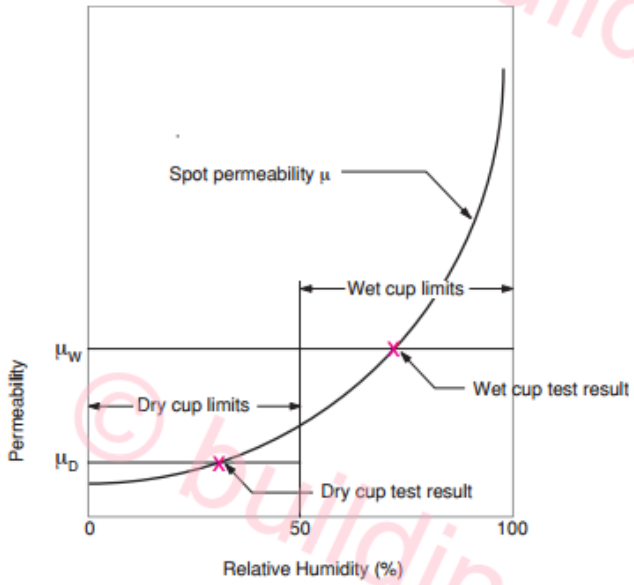
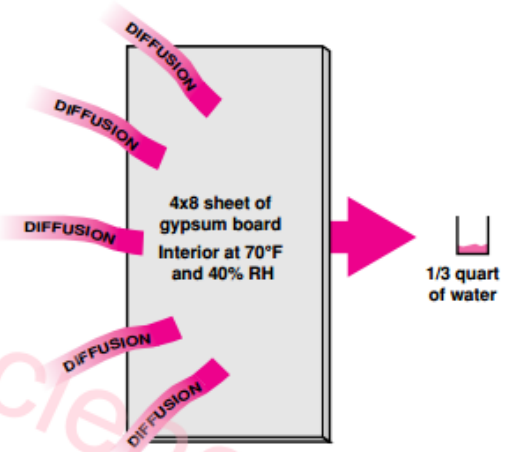
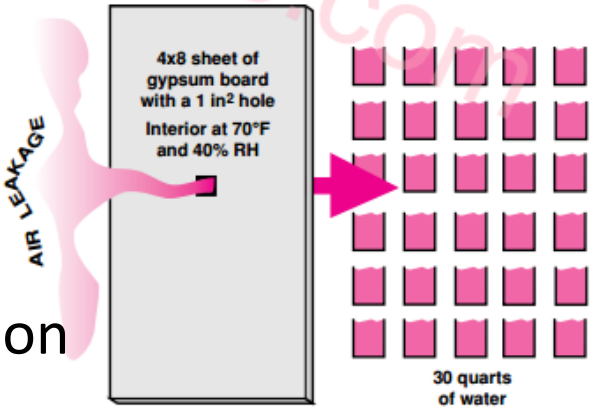
Ability of air to carry heat and moisture







Moisture transfer over a heating season

Ability of air to carry heat and moisture

- BTU's coming out of a register
  = 1.07 x CFM x ΔT where:

  CFM = air coming out of register
  ΔT = temperature difference between the air coming out of the register and air in the center of the room

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Diagnostic Tools

- Eyes, ears, nose, touch - observation
- Basic hand tools, ladders, tarps, respirator
- Flash light, small mirror and camera
- Pad of paper or computer (tablet)
- Thermometer, RH, dew point
- Moisture meters
- Blower door, smoke puffer, infrared camera
- Something to measure supply register and exhaust fan flow

Asking the Right Questions

- A homeowner interview can give critical information:
  - defining the issue as precisely as possible
  - setting expectations

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Questions - Defining the Issue

- Room is too cold in winter
  - Always too cold?
    - Only at night
    - Only on cloudy days
    - Only during extreme temperatures
  - Is the floor cold?
  - Are the walls cold?
  - Is it drafty?
  - Is it too cold right now?
  - Do you pull shades at night?
  - Do you open shades during the day?
  - Is the door always closed?
  - Do you set back the thermostat at night?
  - Which room is the warmest?

After the Interview

- Observe – walk inside and outside of the general area of the room
- Hypothesize – what do you think the problem is
- Prove your hypothesis – what tests are needed?
  - Temperatures – center of warm and cold rooms, temperature in floor cavities
  - Blower door and IR
  - Measure register airflow and temperature
    - Problem room
    - Warmest room

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Case Study #1
Dripping from attic through a bathroom ceiling

- Problem occurred after insulation was added to attic – total 18” blown FG

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Case Study #1
Dripping from attic through a bathroom ceiling

- A moisture problem always suggests 4 questions
  - **the source**
  - **the path**
  - **the moisture form**
  - **the driving / pulling force**

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Case Study #1
Dripping from attic through a bathroom ceiling

- **the source**
  - Four teenagers
  - Basement concrete block shower with hot water drip

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Case Study #1
Dripping from attic through a bathroom ceiling

- **the path**
  - Plumbing from basement to attic
  - Dropped soffit with recessed light

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Case Study #1
Dripping from attic through a bathroom ceiling

- **the moisture form**
  - Bulk water splashing onto concrete block
  - Vapor from showers
  - Condensate in attic

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Case Study #1
Dripping from attic through a bathroom ceiling

- **the driving / pulling force**
  - Capillary action - concrete block
  - Stack effect moves air to attic
  - Heat from recessed lights increases flow of air
  - Air handler on during a shower pressurize the bathroom

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Case Study #1
Dripping from attic through a bathroom ceiling

- Why did problem occur when attic was insulated?
  - Attic is colder and more condensation occurs
  - Longer, colder temperatures followed by a warm front

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Case Study #1
Dripping from attic through a bathroom ceiling

- Testing required to solve problem
  - Blower door and IR
- Solutions:
  - Seal bypasses
  - Bath fan / ventilation system
  - Fix hot water leak

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Case Study #2
Attic Moisture Investigation

- Both moisture source and path are not at all obvious

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Case Study #2
Attic Moisture Investigation

- 1250 ft² 1979 slab on grade town house
- February - 20º outside
- Down flow sealed combustion furnace
  - Sub slab supplies
  - Returns in attic
  - Natural draft water heater
  - Combustion air intake runs through the attic
- 2 bath fans used frequently, 20 and 60 CFM
- Bedroom and bathroom have wet ceiling
- Space heater and dehumidifier used in bedroom to limit mold growth
  - concrete that bedroom duct

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Case Study #2
Attic Moisture Investigation

Source

- No humidifier – very few plants
- Normal amount of cooking
- Water heater drafts under worst case
- One person living there
- Marshland in back yard – unlimited source

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Case Study #2
Attic Moisture Investigation

» Source

	BR 1	BR 2	LR	BR2 duct	LR duct
Temperature	68	73	69	64	73
dew point	51	49	48	54.5	62
RH	59	47	47	65	64

Case Study #2
Attic Moisture Investigation

Path

- Moisture into the house
  - Through slab
  - Sub slab ducts are plastic with metal elbows and risers
- Moisture into attic
  - Bypasses – standard for 1979
  - Fresh air intake
  - Return duct in attic

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Case Study #2
Attic Moisture Investigation

Form

- Vapor
  - From soil into house
  - From house into attic
- Condensation
  - In sub slab ducts
  - In fresh air intake in attic
  - In return duct in attic
- Frost
  - Entire attic roof and wall sheathing
- Ice
  - In fresh air intake in attic
  - In return duct in attic

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Case Study #3
Attic Moisture Investigation

Driving force

- Stack effect
  - Air movement into attic through bypasses
  - Air out though the fresh air intake
- Convection
  - Current in return / supply ducts
- Vapor pressure
  - From sub slab ducts into house
- Capillary action
  - Through concrete slab

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Case Study #4
Attic Moisture Investigation

Solutions

- Purchase an industrial dehumidifier or
- Solve multiple issues:
  - Remove carpet and seal floor
  - Aeroseal ducts or fill with concrete and add new ducts across ceiling or in attic
  - Seal attic bypasses
  - Sealed combustion water heater and eliminate combustion air duct
  - Install continuous ventilation
  - Use dehumidifier as needed

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Questions?

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