Building Science Basics

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Some things building professionals need to understand

- Water causes problems in buildings
- Warm air is lighter than cold air
- Air leakage requires a hole AND an air pressure difference across the hole
- Warm air can hold more water than cold air
- About heat and energy transfer


1
Over 90% of building
problems are water related

Water Vapour/Humidity in Air

- Is not a problem until it is absorbed by or condenses in or on building materials

- Water that is liquid in one area of a building can be transported in vapour form to other areas of the building where it can condense and cause problems

Water vapour can come from

- Construction materials
- Cooking, cleaning, bathing and showers
- Respiration by people, plants and pets
- Humidifiers
- Plumbing problems
- Foundations
- Rain and snow entry

- Water as vapour (aka humidity) moves by diffusion and with air leakage

- In most building applications, moisture movement by diffusion is not critical – moisture movement from air leakage is the problem

High Humidity (i.e., water vapour) contributes to many water problems in buildings including

- Mould growth and related IAQ issues
- Rot, rust and deterioration of wood, metal and other construction materials
- Aesthetic damage to finishes and furnishings

- To control vapour related problems
  - Control relative humidity
    - Reduce sources
    - Dehumidify
  - Keep vulnerable surfaces and materials warm
  - Select non susceptible materials

Water as liquid can come from

- Rain
- Ground water
- Surface water
- Plumbing problems
- Condensation (on pipes or related to air leakage)
- Melting of ice and frost accumulations
  - Includes ice dams

- Water moves down by gravity and in any direction by capillarity
  - Control capillarity water with
    - good drainage
    - capillarity breaks
    - material selection (non porous/water resistant)
  - Control gravity with
    - good site and roof drainage and flashings
    - proper sequencing and shingling of material layers

Solid Water – Ice and Frost

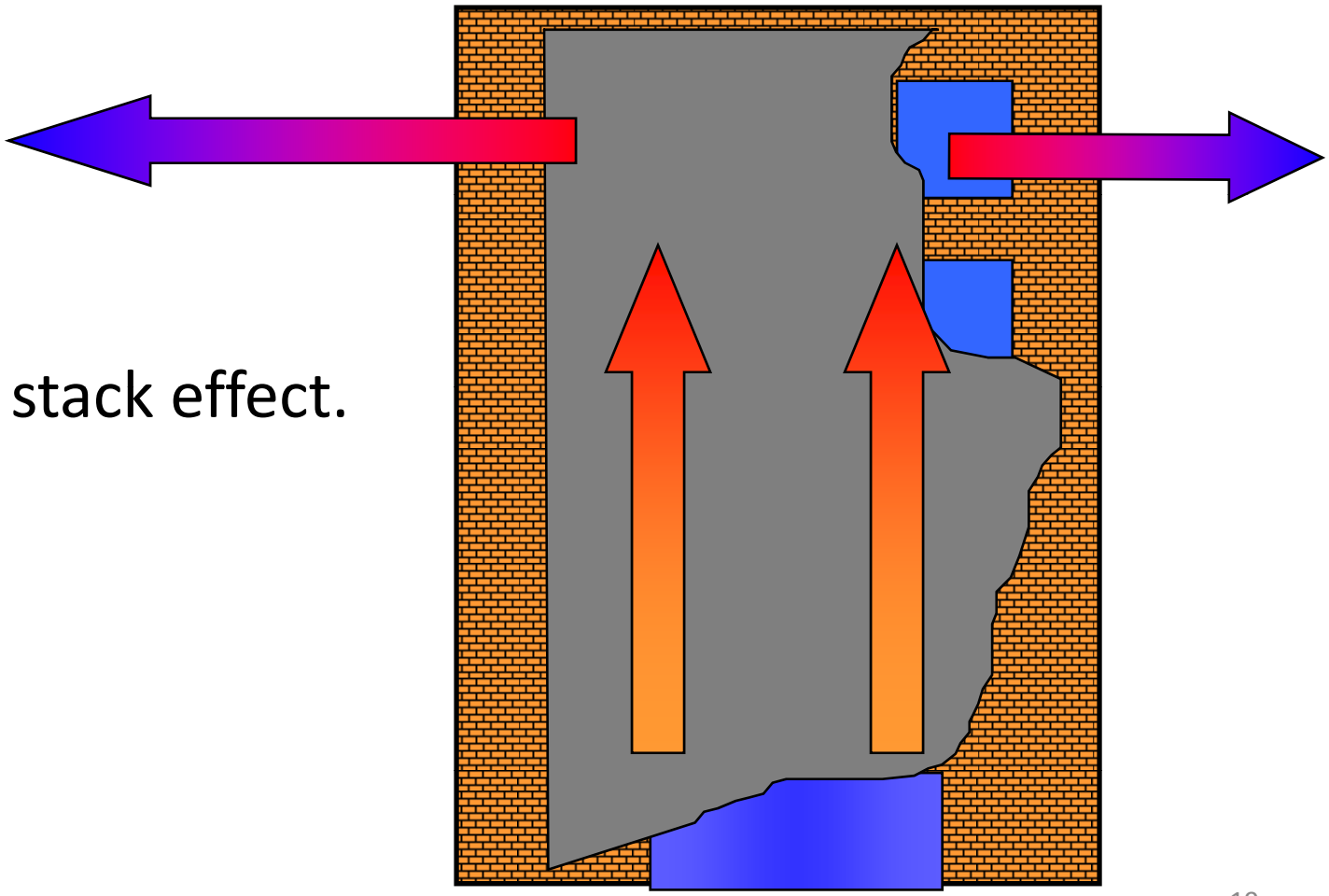
- Ice occurs when liquid water is cooled below freezing
- Frost occurs when air is cooled below both its dew point and freezing temperatures
  - Frost is usually related to air leakage

The problem with frost and ice

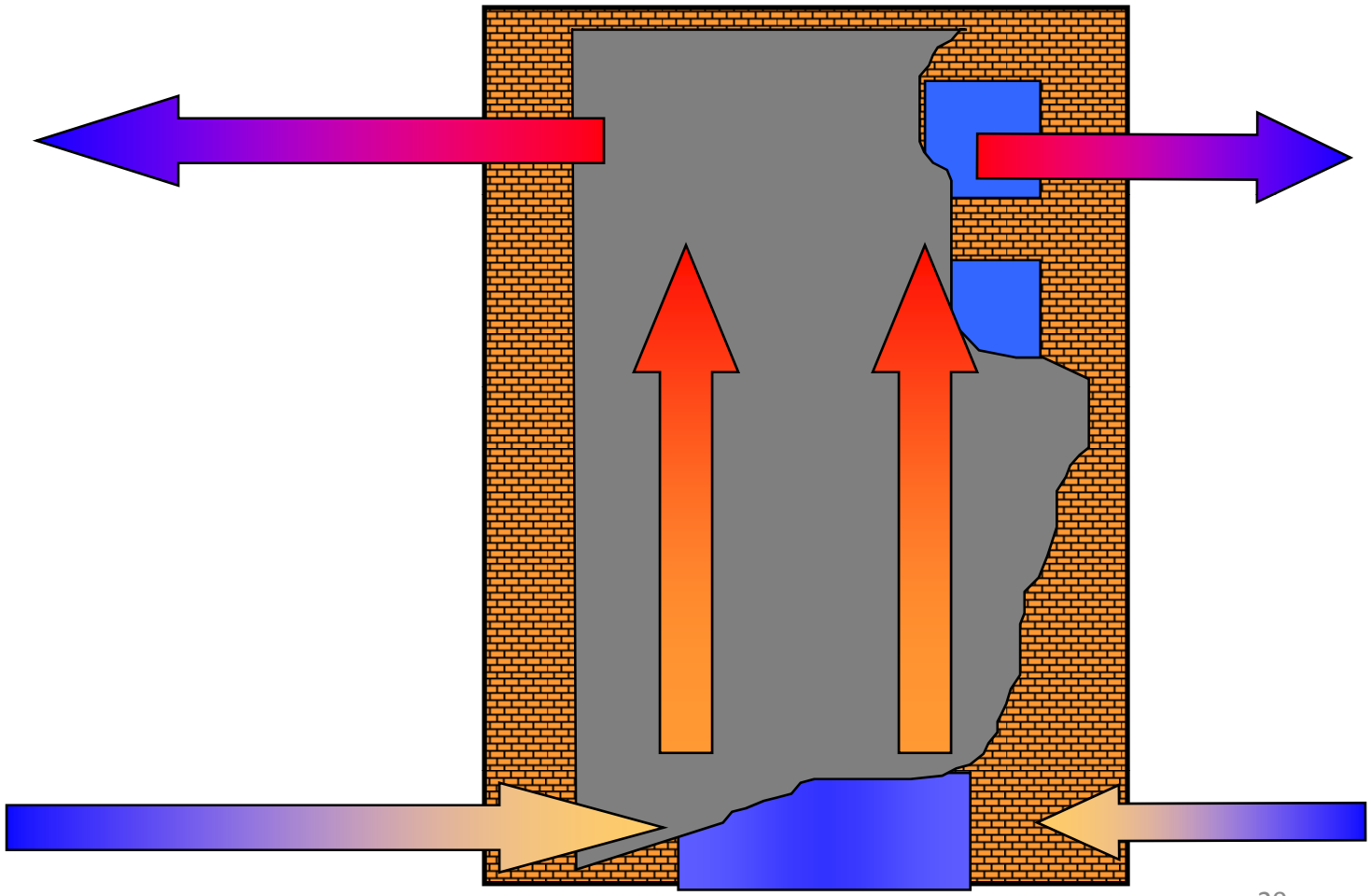
- Water which freezes in building materials can damage them, e.g., spalling masonry
- Frost and ice accumulations in insulations can significantly reduce R value
- Frost and ice accumulate until warm weather, then melt into water and move by gravity and capillarity


2
Warm Air Rises

The same pressure and leakage patterns occur in buildings.

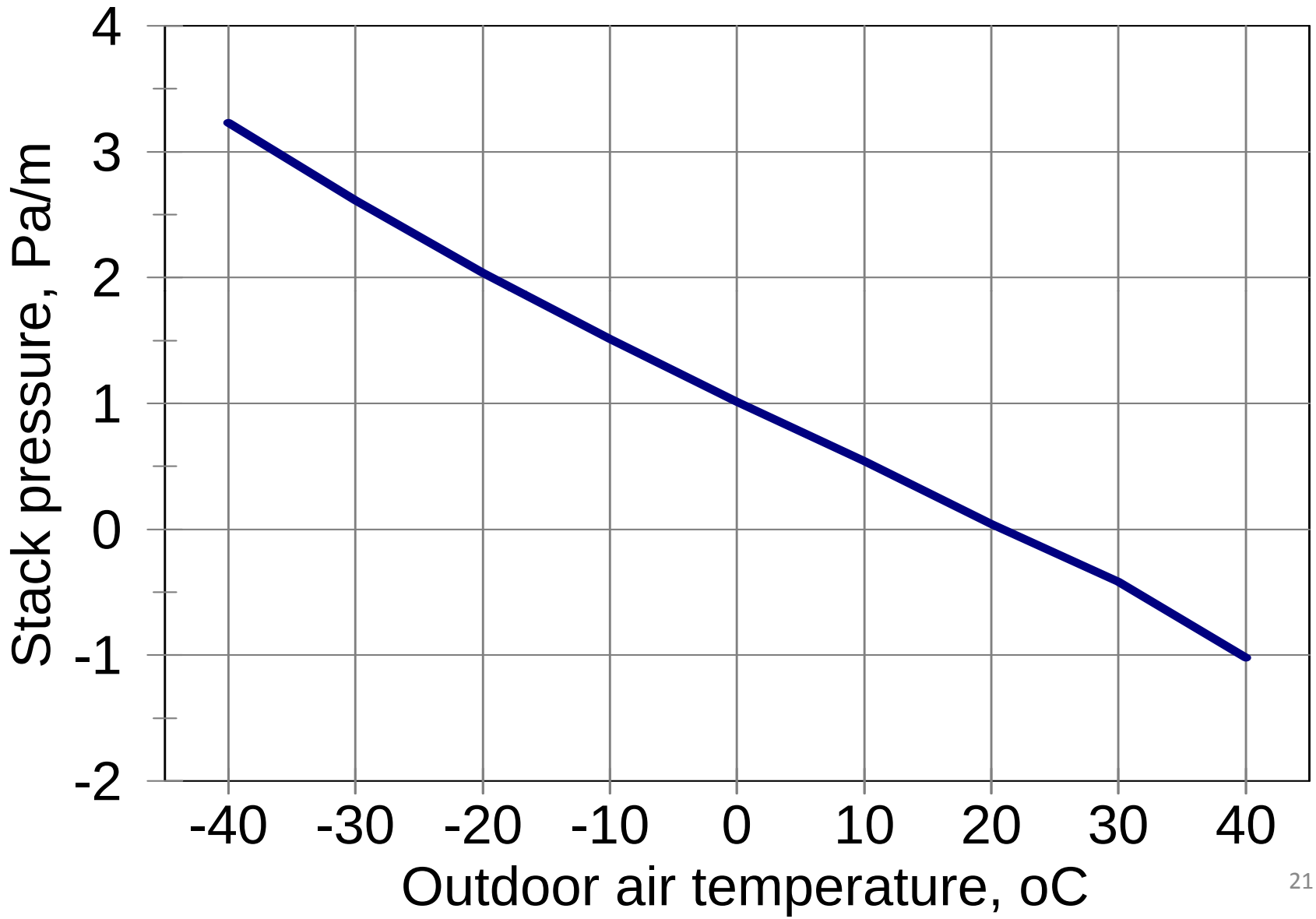


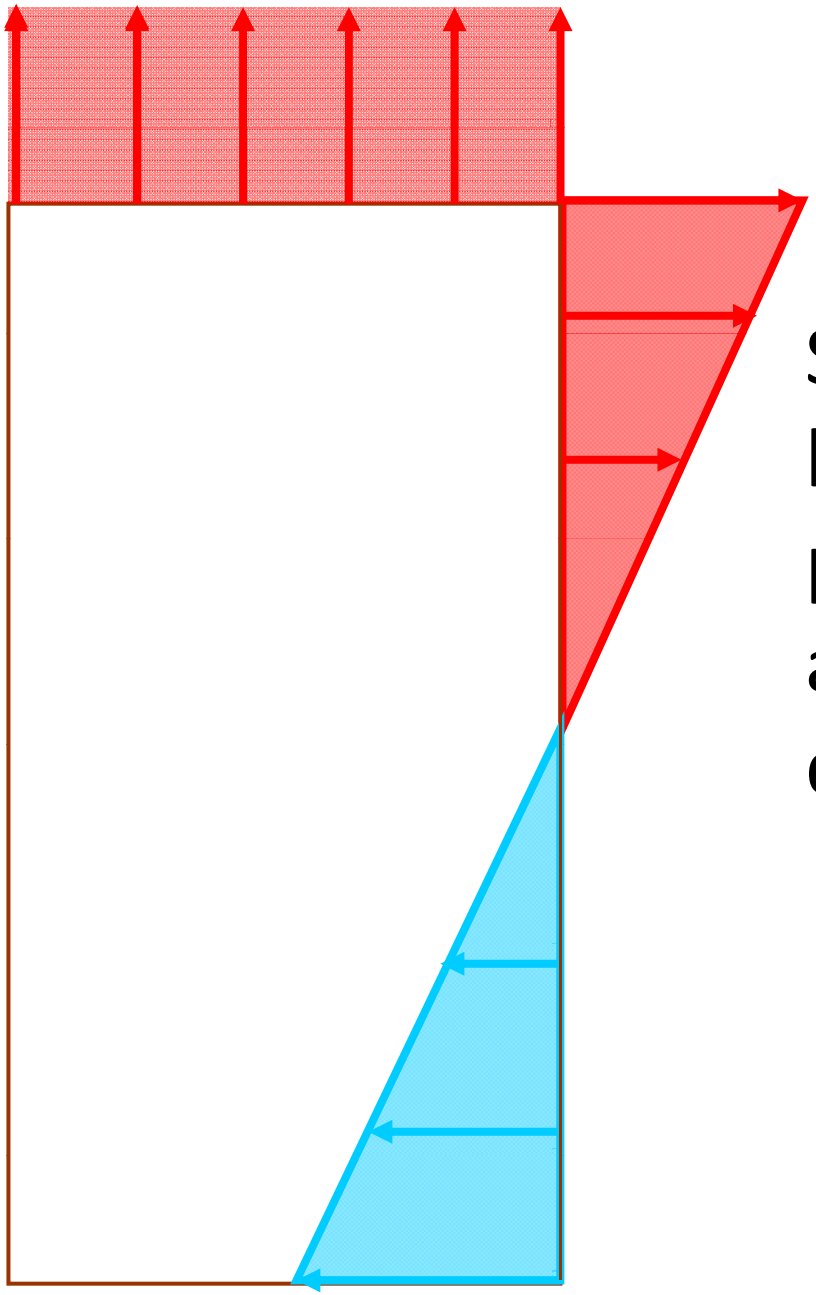
We call it stack effect.



Stack pressure differentials

Indoor Air Temperature +22oC





Stack pressure and leakage patterns and profiles in buildings are normally depicted like this.

3

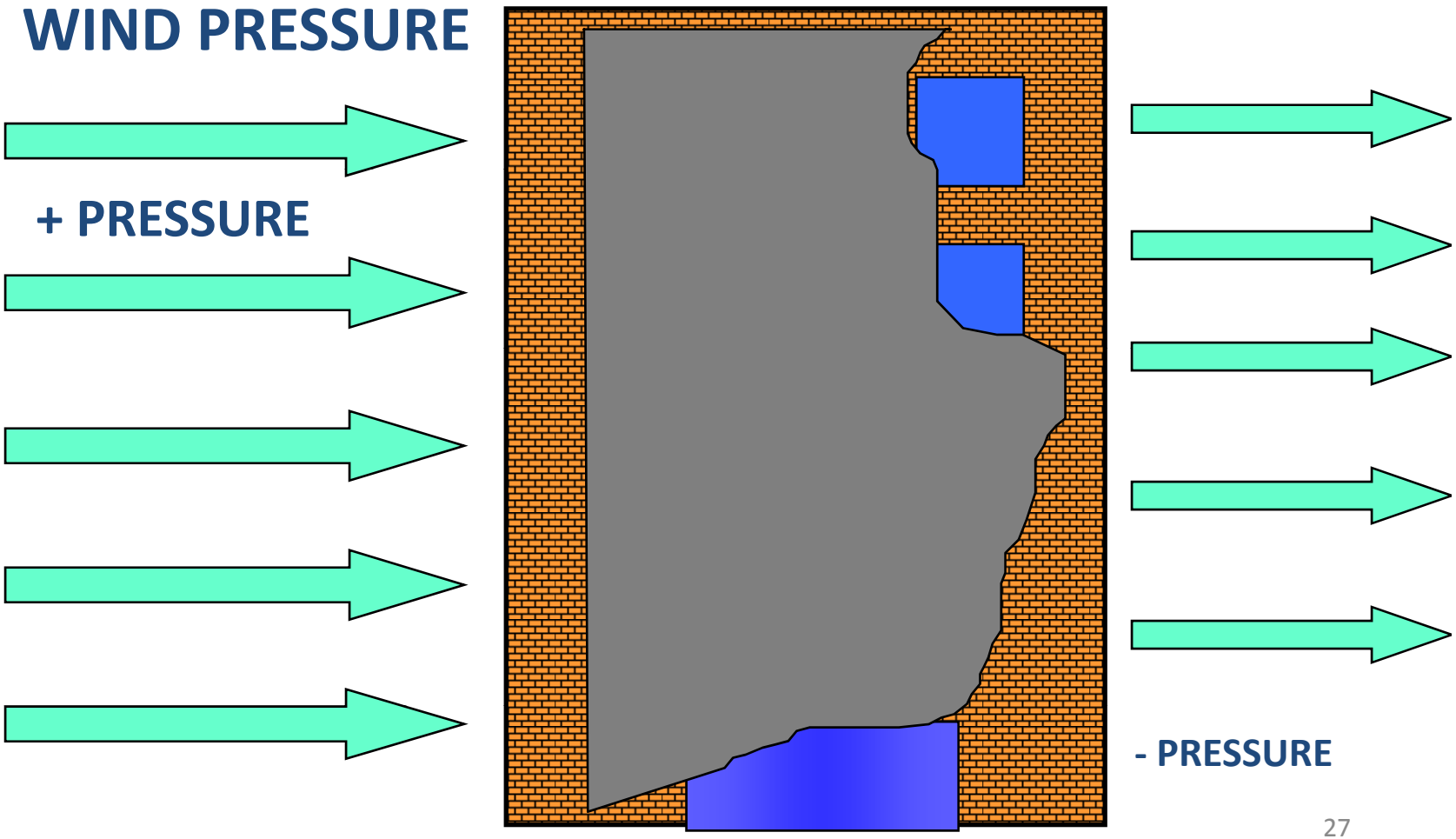
Air Leaks

if there is a hole AND a pressure difference

Ships have bilge pumps because …..

- All building envelopes have holes
- Stack effect, wind and a building's fan systems and chimneys create pressure differences across the building envelope

- Therefore all building envelopes experience air leakage


WIND PRESSURE
+ PRESSURE
- PRESSURE

Air leakage matters because

- It can affect occupant comfort and IAQ
- It increase the costs to heat and cool
- It can impact housekeeping costs
- Moisture in air can create water related problems in building envelopes

4

Heat, Energy and Insulation

Heat/Energy Transfer into, out of and within Buildings Occurs by

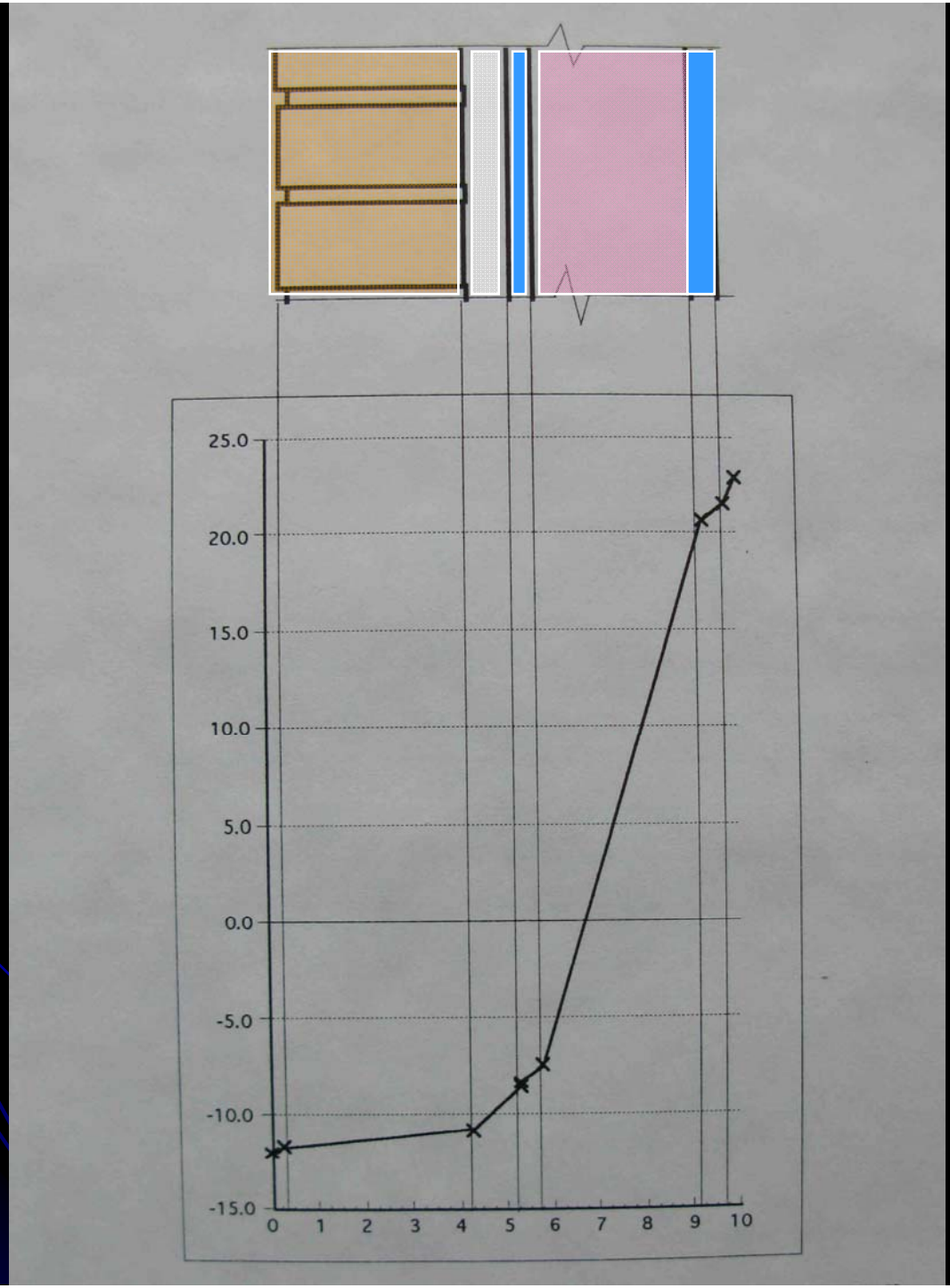
- Air transfer/air leakage
- Conduction
- Convection
- Radiation

With Conduction, Heat/Energy

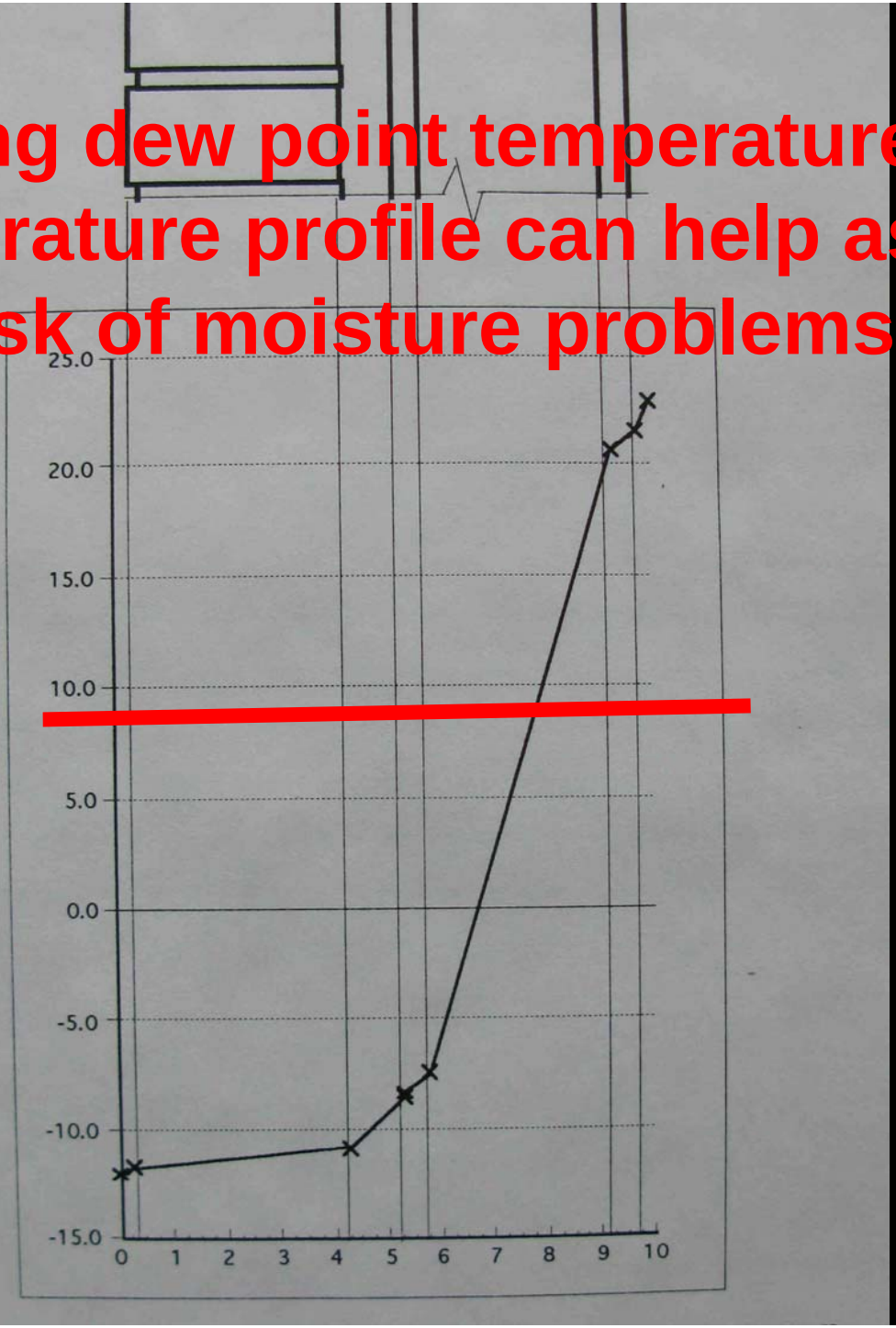
- Flows from hot to cold
- Heat/energy flow rate through a construction element depends on
  - Temperature difference across the element
  - Effective insulation level

Temperature Gradients

- The temperature at any point in an insulated assembly varies linearly from indoor temperature to outdoor temperature when plotted against R value
- We can plot temperature gradient against a wall profile


25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
0 1 2 3 4 5 6 7 8 9 10

Plotting dew point temperature on a temperature profile can help assess the risk of moisture problems



5
Air and Moisture

psychrometrics

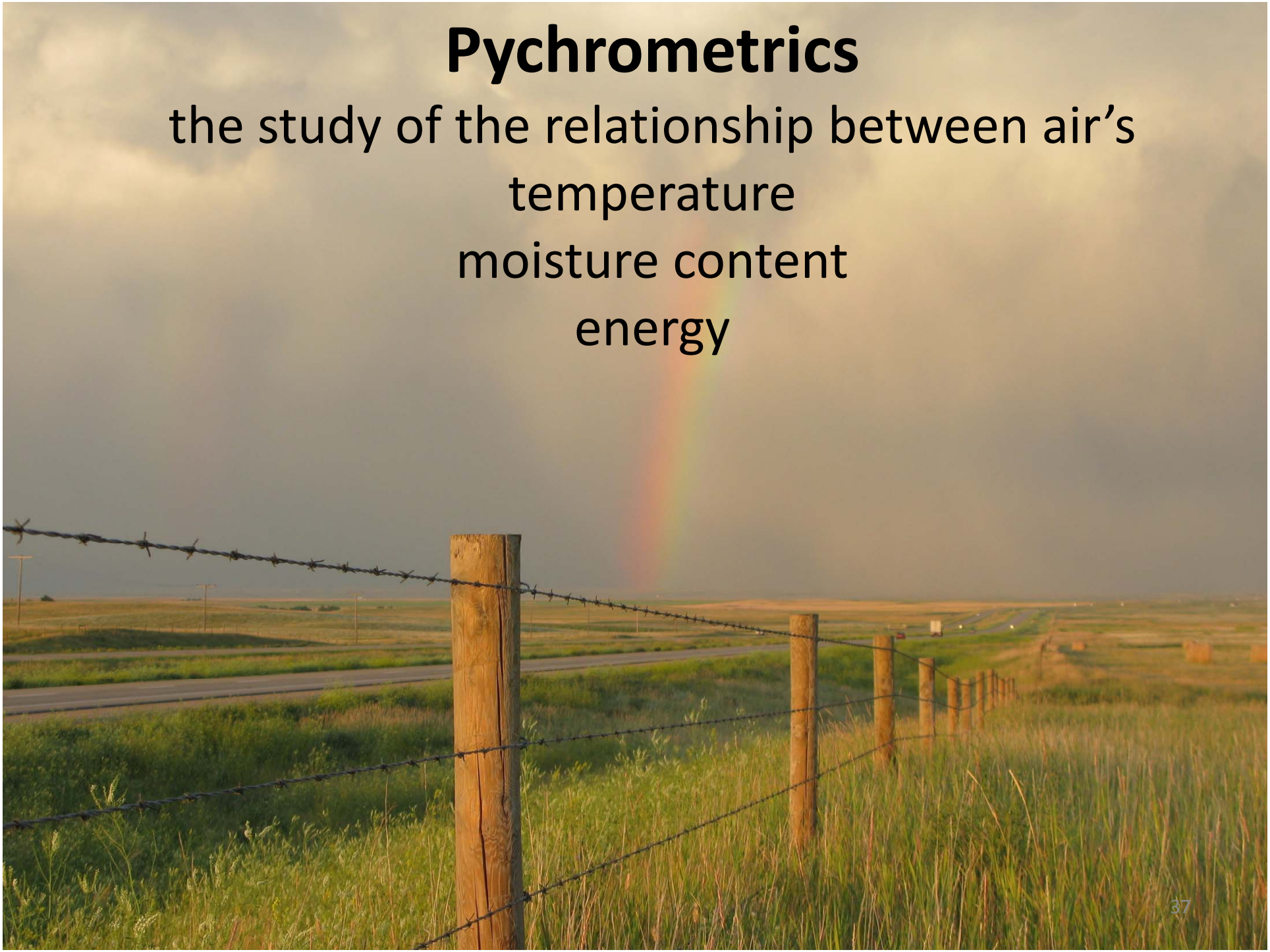
Pychrometrics

the study of the relationship between air's

temperature

moisture content

energy

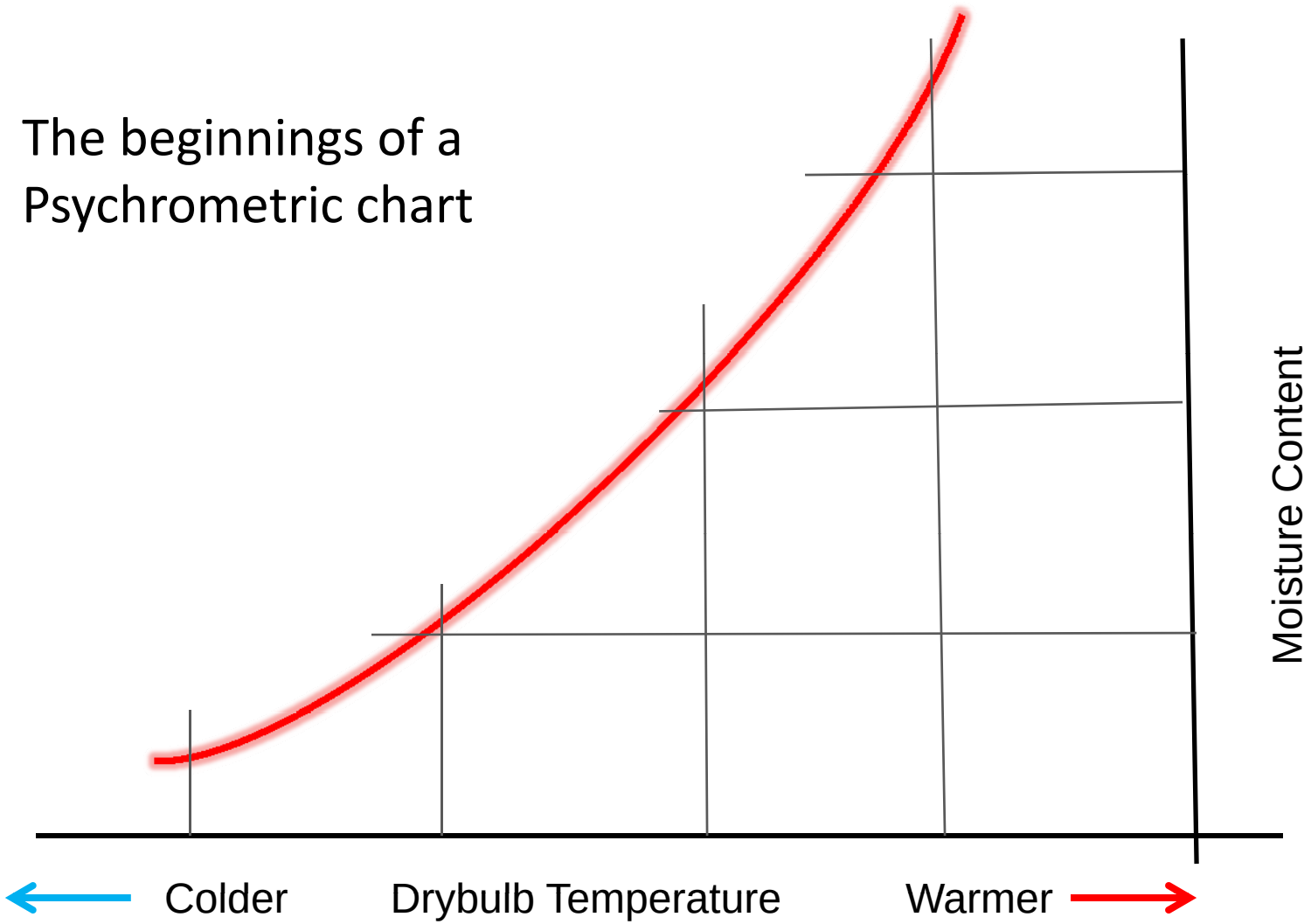


The amount of moisture that air <u>can</u> hold varies with temperature

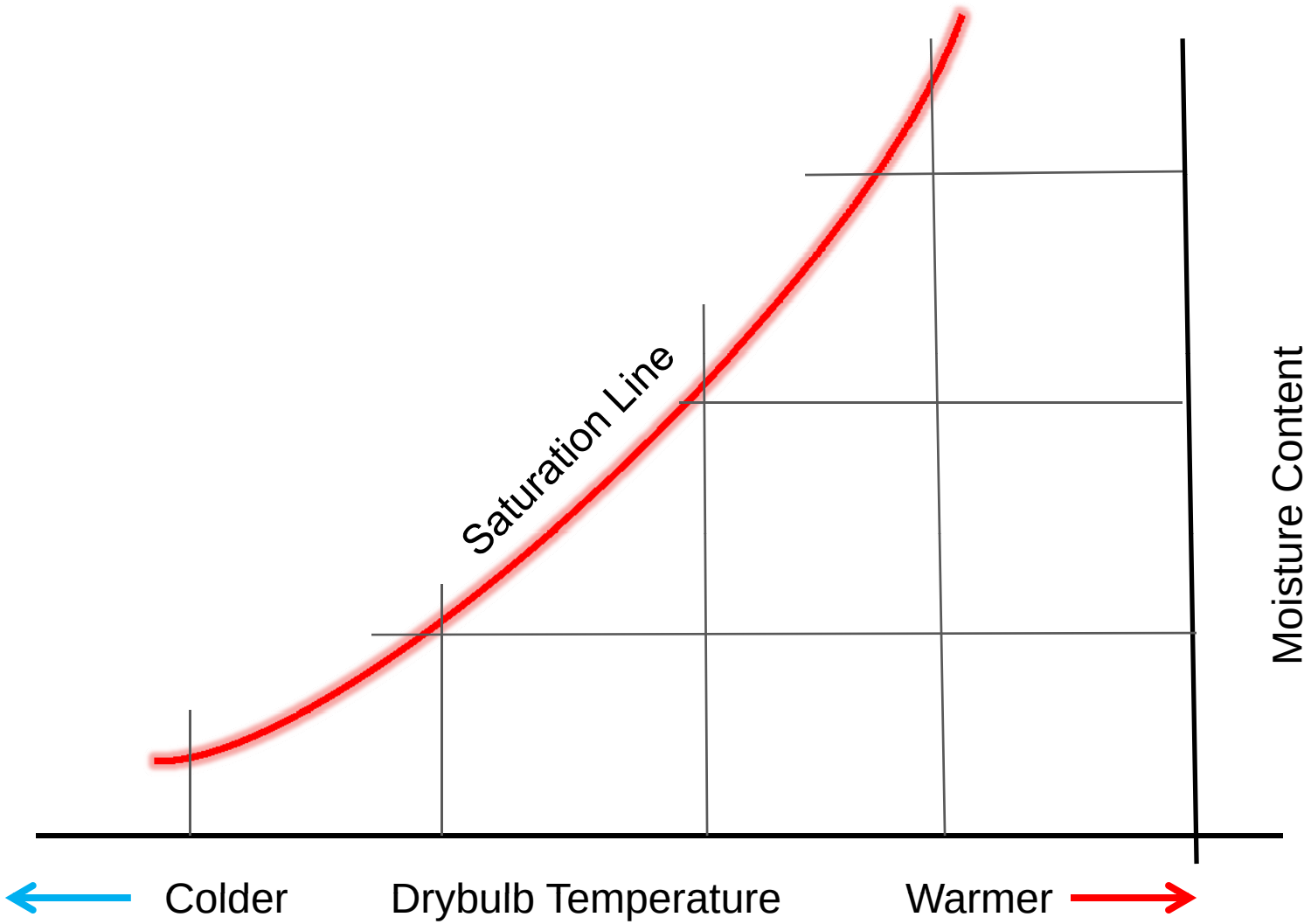
The warmer the air –
the more moisture it can hold

$10^{o}C$ change = +/- 2 X MC

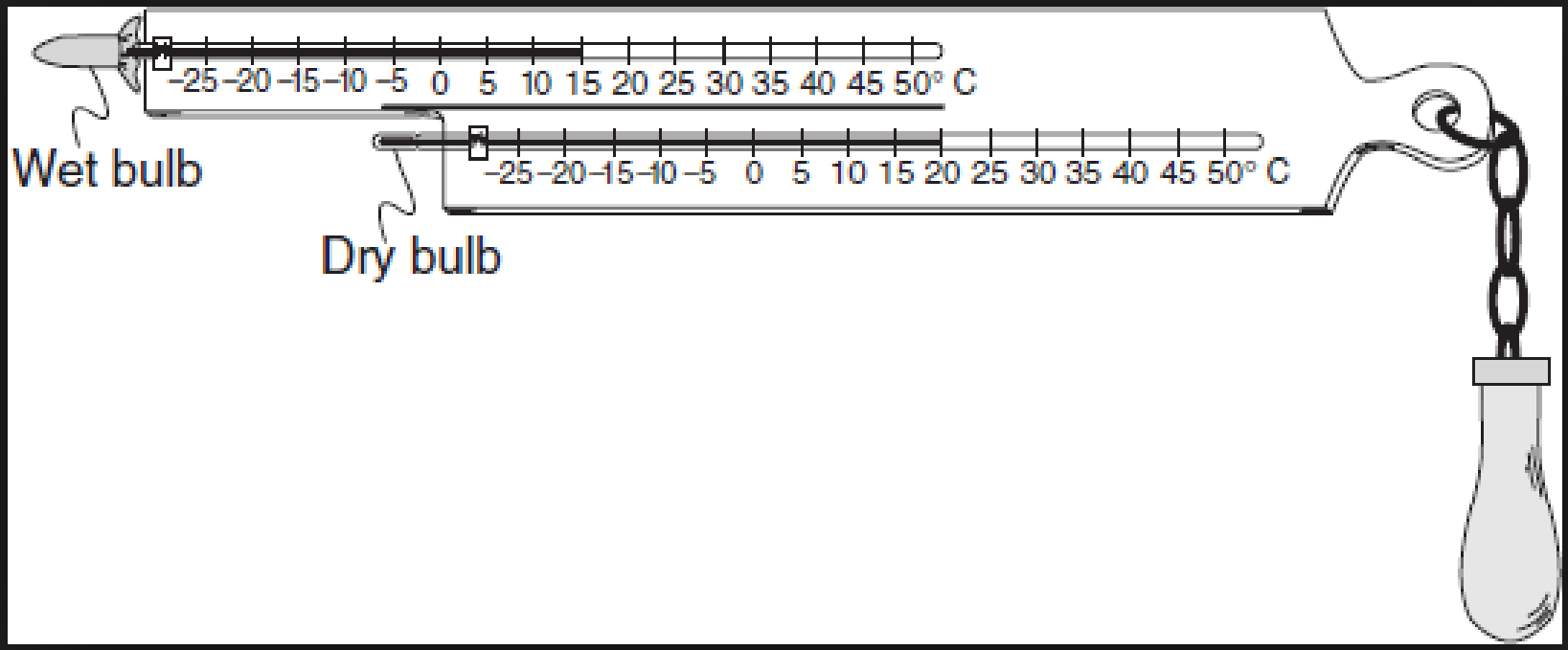
The beginnings of a
Psychrometric chart



The terms moisture content, absolute humidity and humidity ratio are used interchangeably


Saturation Line
Moisture Content
Colder
Drybulb Temperature
Warmer

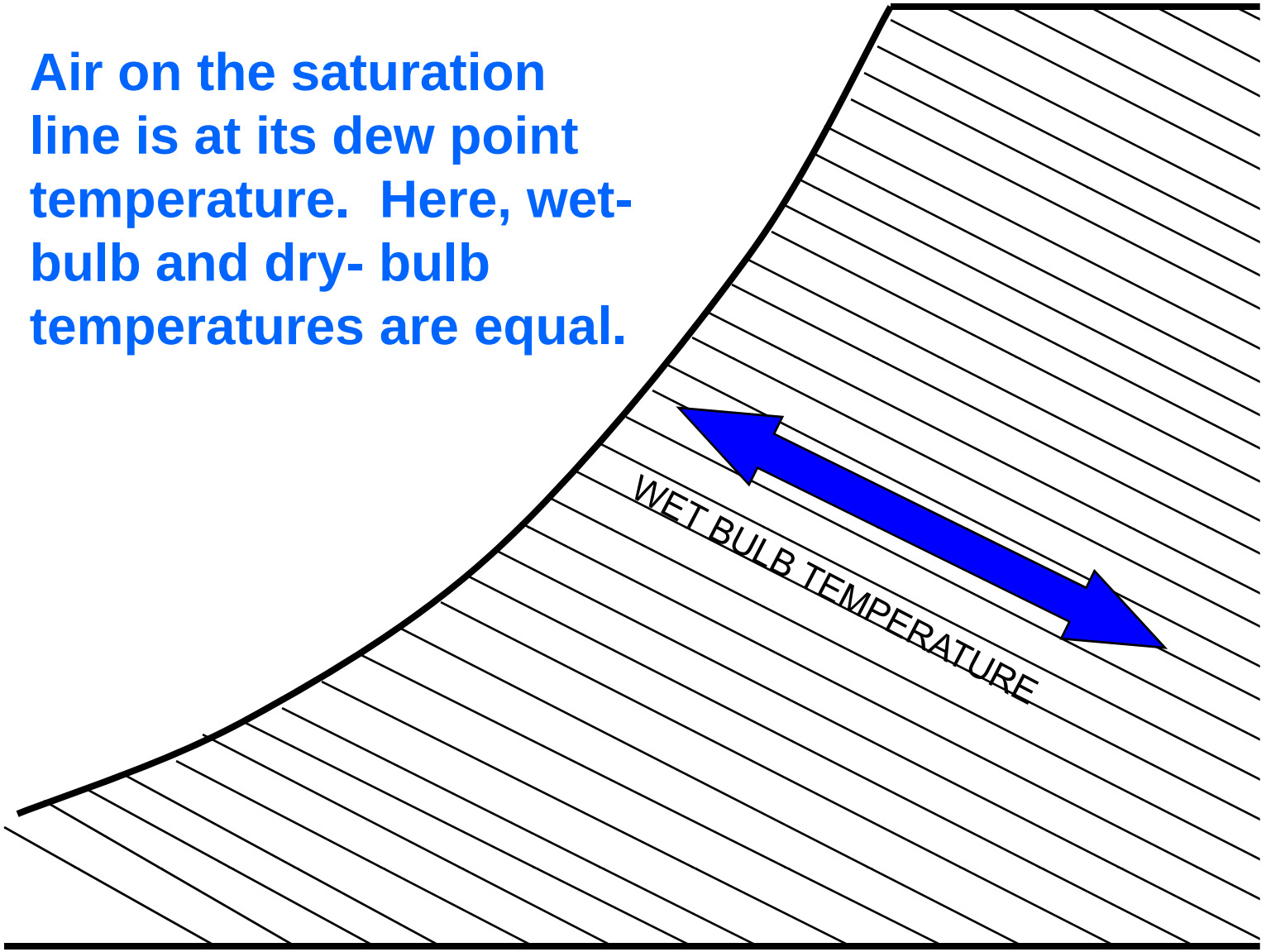
Wet and Dry Bulb Temperatures



Wet-bulb temperature (WBT) is affected by the moisture content of the air (evaporative cooling)

WET-BULB TEMPERATURE

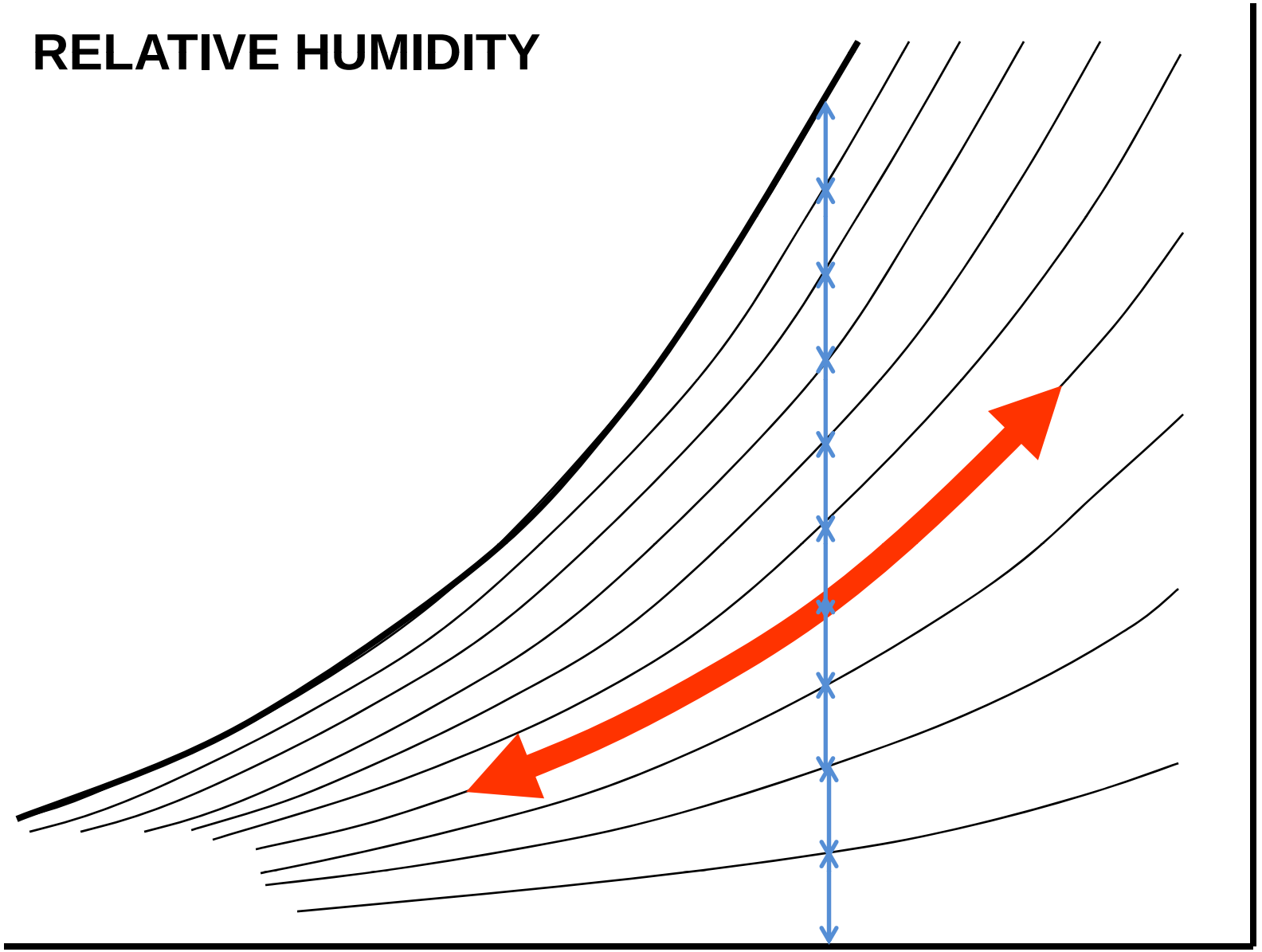
Air on the saturation line is at its dew point temperature. Here, wet-bulb and dry- bulb temperatures are equal.



RELATIVE HUMIDITY

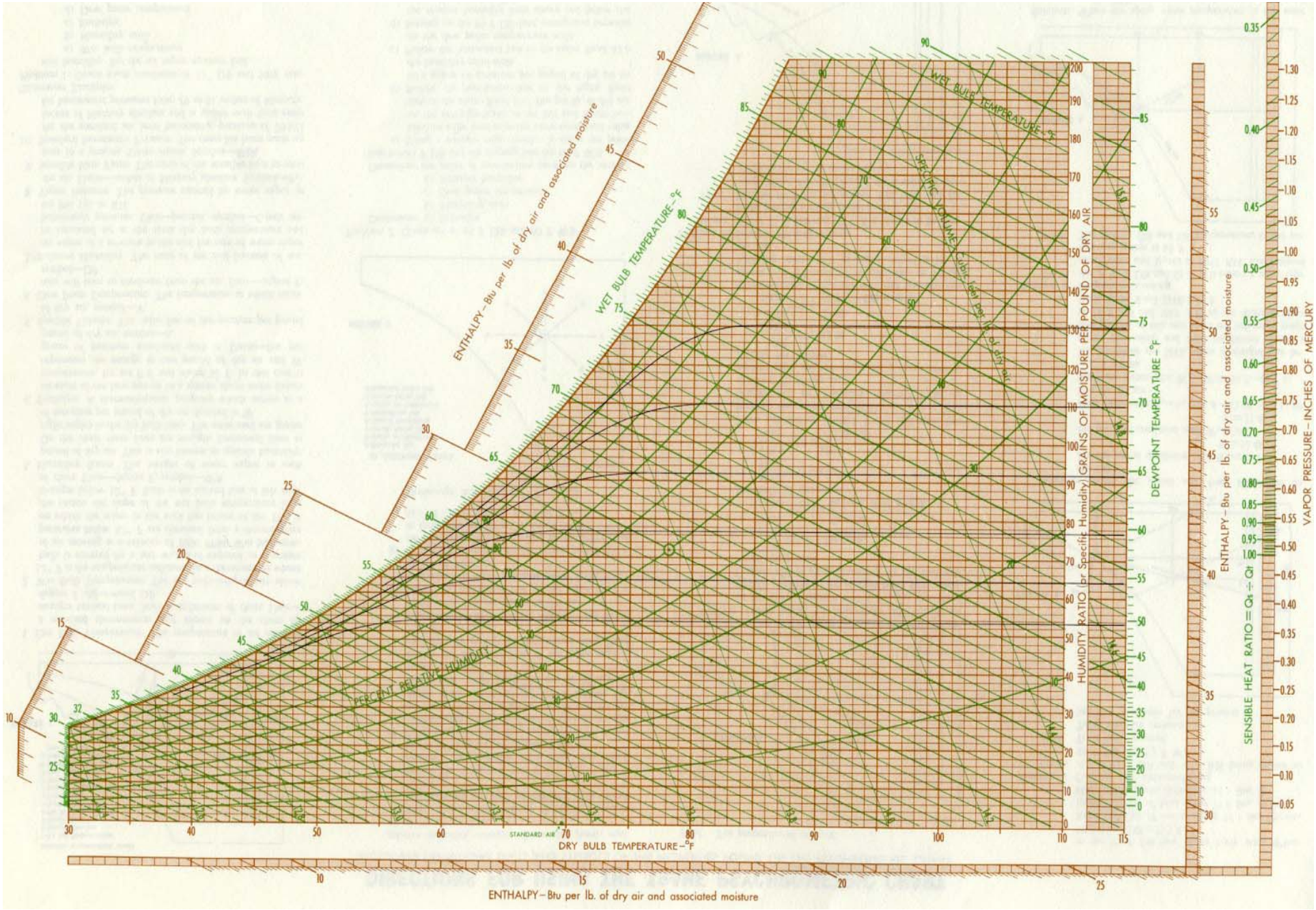
- Moisture present in air (i.e., its absolute humidity) **relative to** the maximum moisture capacity of air *at the same dry-bulb temperature*
- Expressed as a percentage

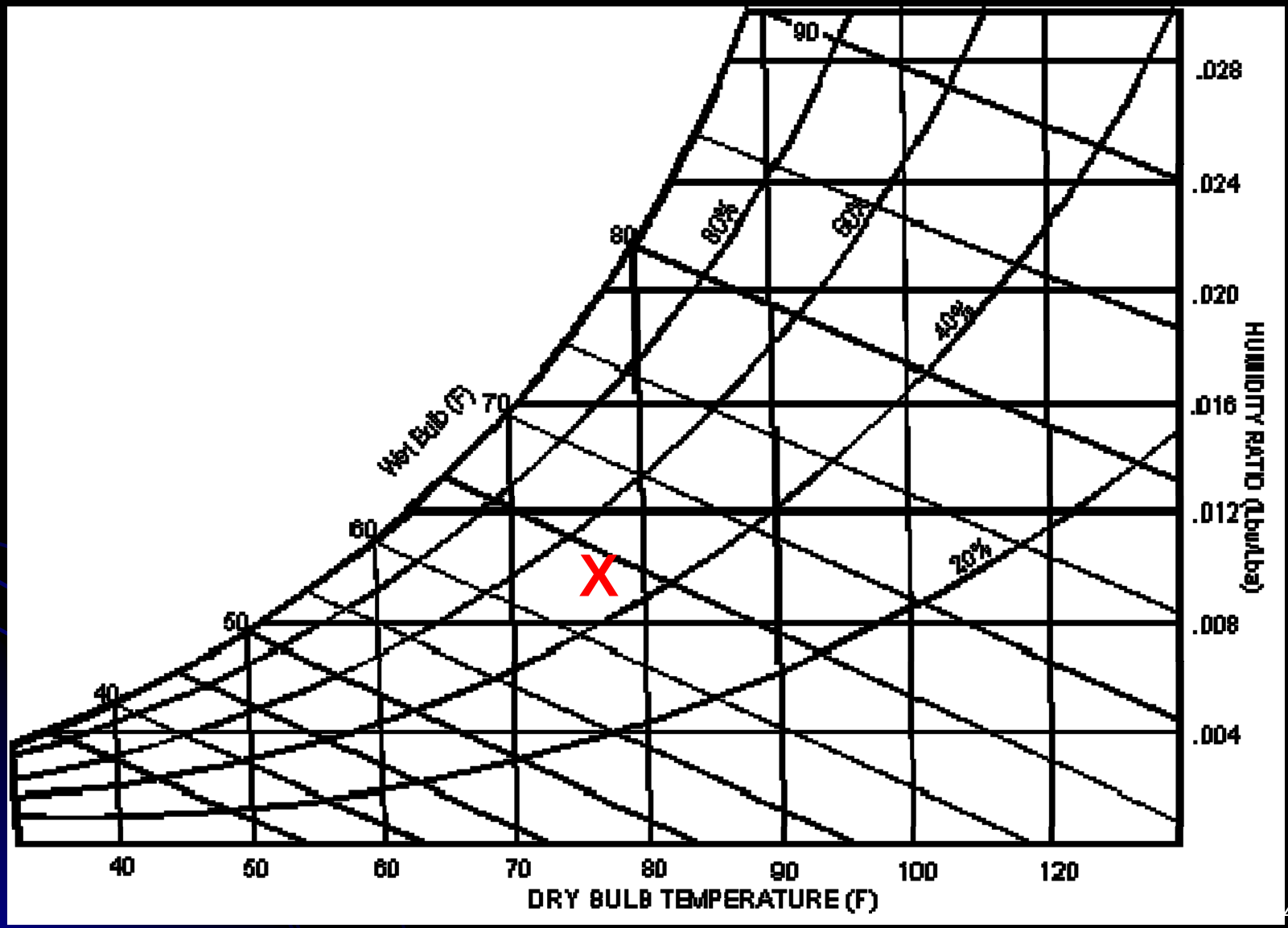
RELATIVE HUMIDITY

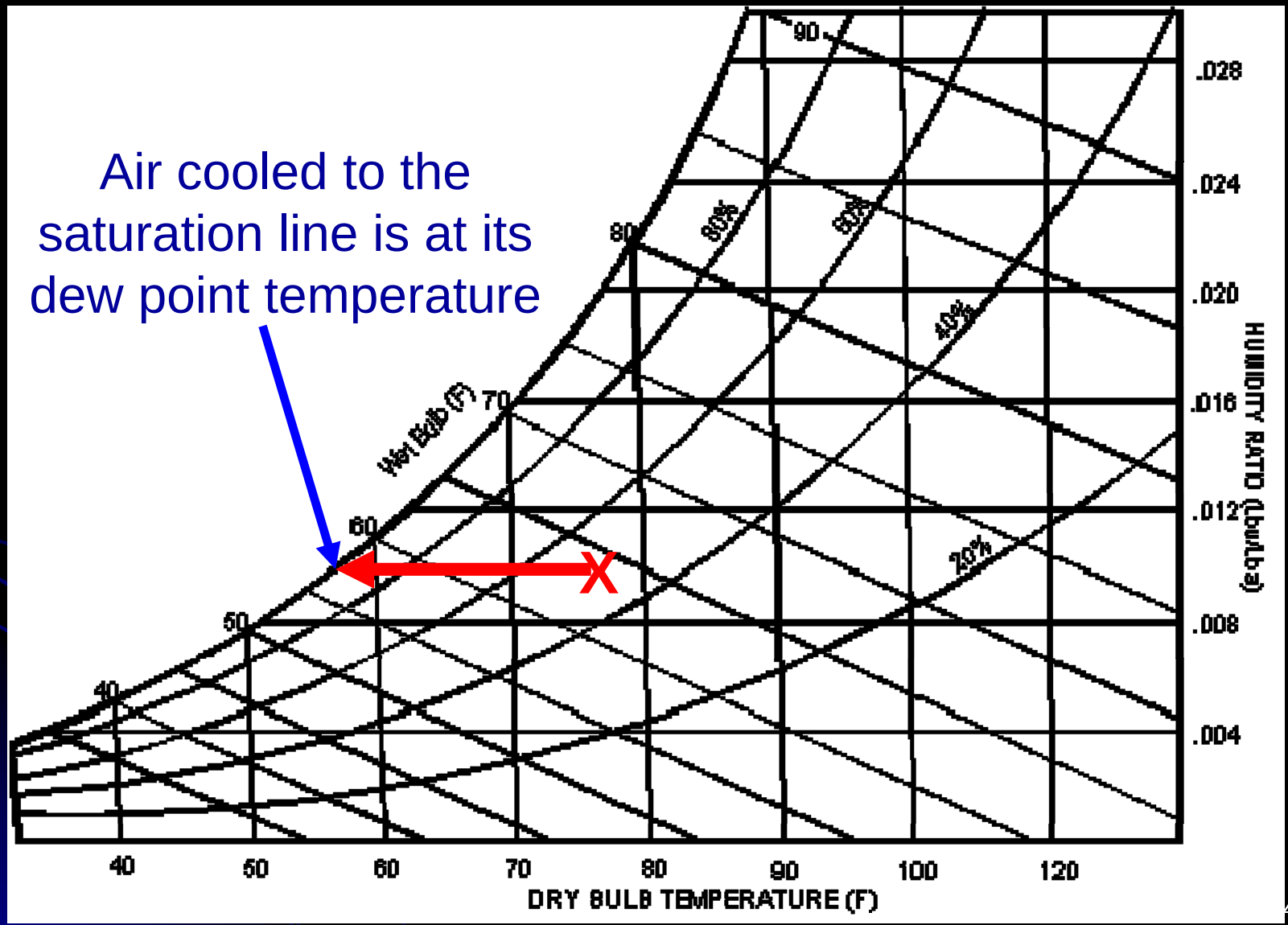


Knowing any two of these properties of a sample of air (DBT, WBT, RH, MC, dew point or saturation temperature), the other properties can be determined with the Psychrometric Chart

Other properties of air may also be plotted on the Psychrometric chart, including enthalpy (i.e., energy) and specific volume or density


ENTHALPY – Btu per lb. of dry air and associated moisture
WET BULB TEMPERATURE – °F
WET BULB TEMPERATURE – °F
SPECIFIC VOLUME (cubic feet per lb. of dry air)
PERCENT RELATIVE HUMIDITY
GRAINS OF MOISTURE PER POUND OF DRY AIR
HUMIDITY RATIO or Specific Humidity
DEWPOINT TEMPERATURE – °F
ENTHALPY – Btu per lb. of dry air and associated moisture
SENSIBLE HEAT RATIO = Qs ÷ Qt
VAPOR PRESSURE – INCHES OF MERCURY
STANDARD AIR
DRY BULB TEMPERATURE – °F
ENTHALPY – Btu per lb. of dry air and associated moisture


90
80
70
60
50
40
Wet Bulb (F)
80%
60%
40%
20%
X
.028
.024
.020
.016
.012
.008
.004
HUMIDITY RATIO (lbw/lba)
40
50
60
70
80
90
100
120
DRY BULB TEMPERATURE (F)


Air cooled to the saturation line is at its dew point temperature
X
Wet Bulb (F)
90
80
70
60
50
40
80%
60%
40%
20%
.028
.024
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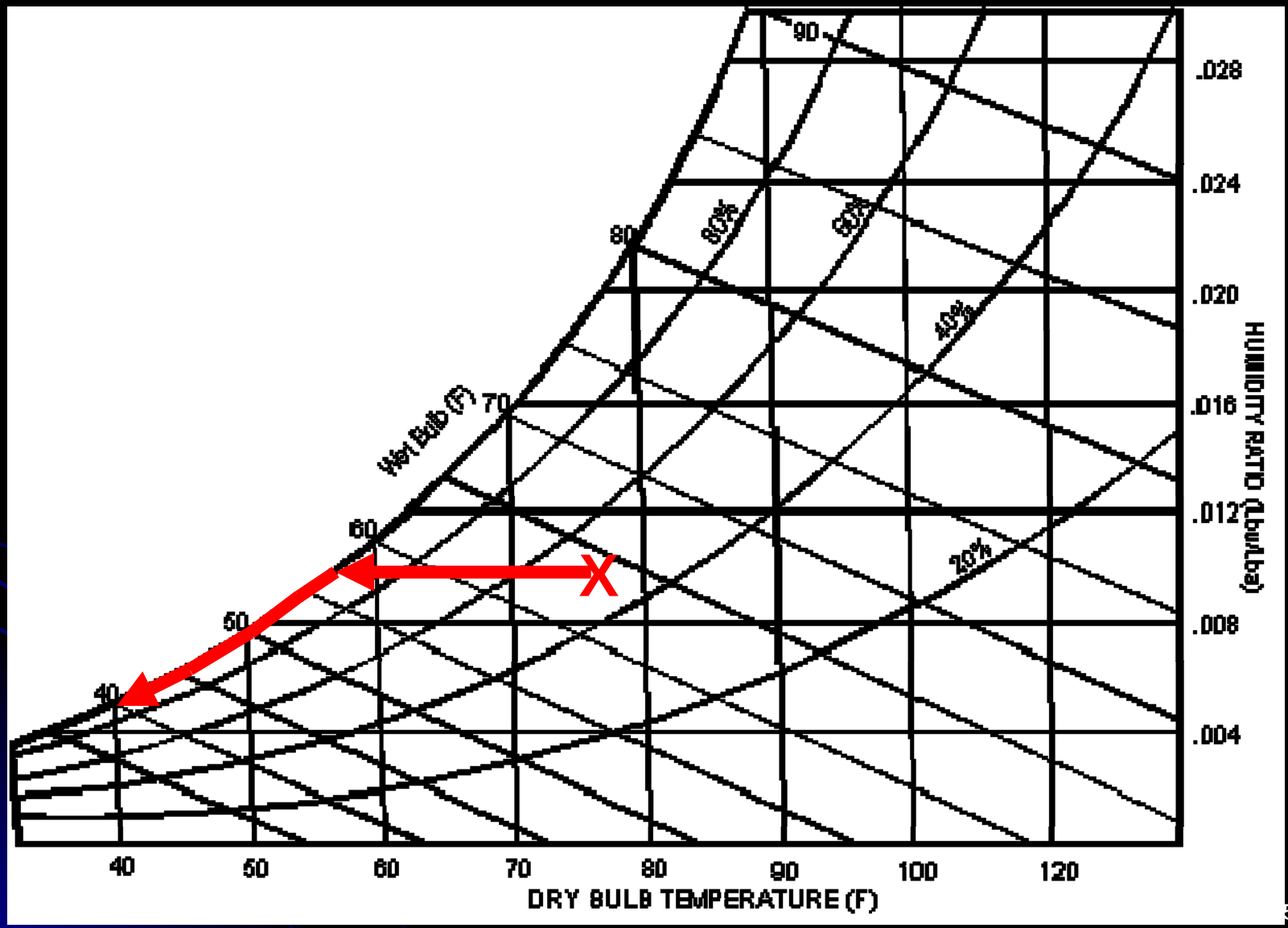
DRY BULB TEMPERATURE (F)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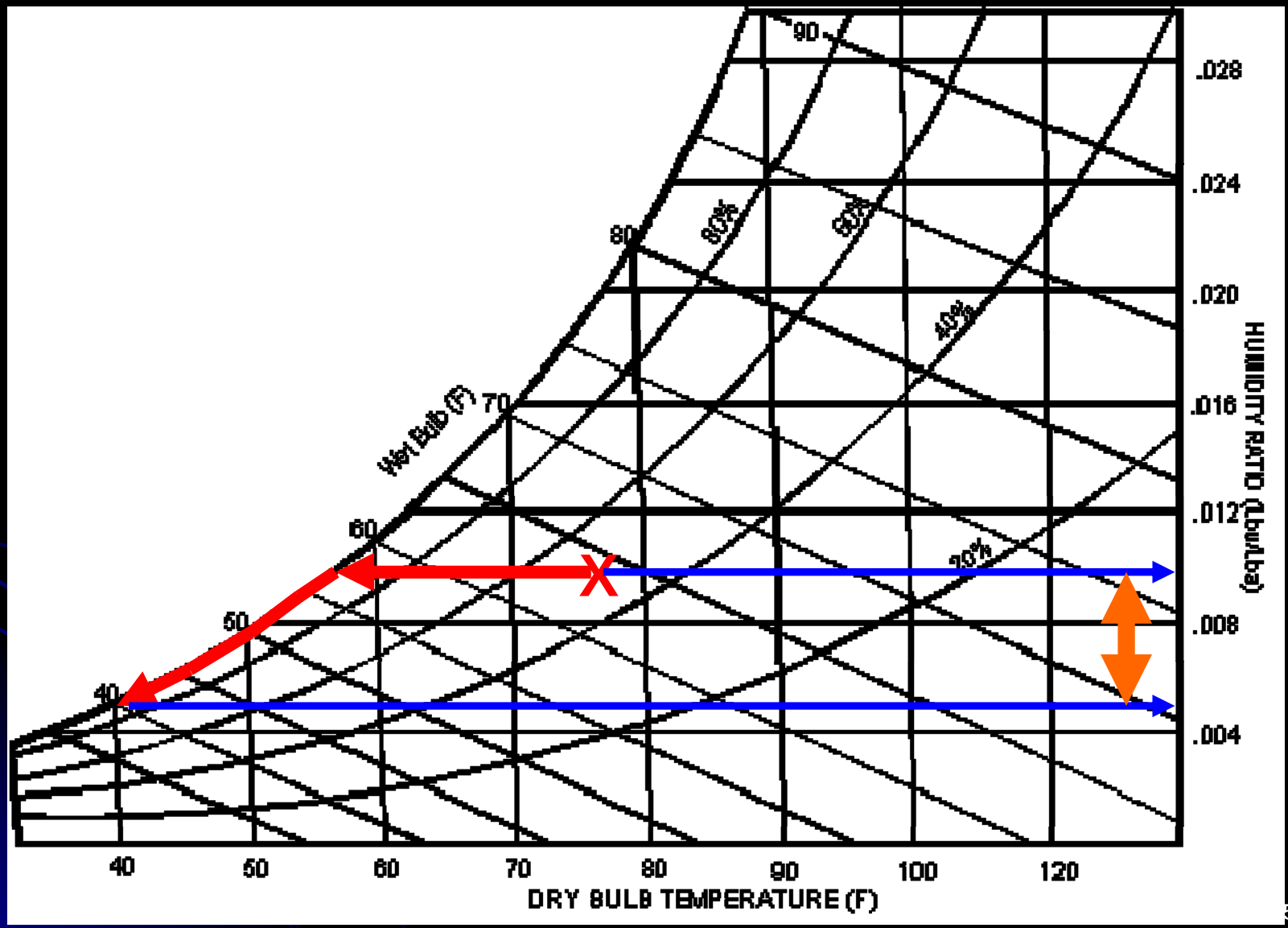
DRY BULB TEMPERATURE (F)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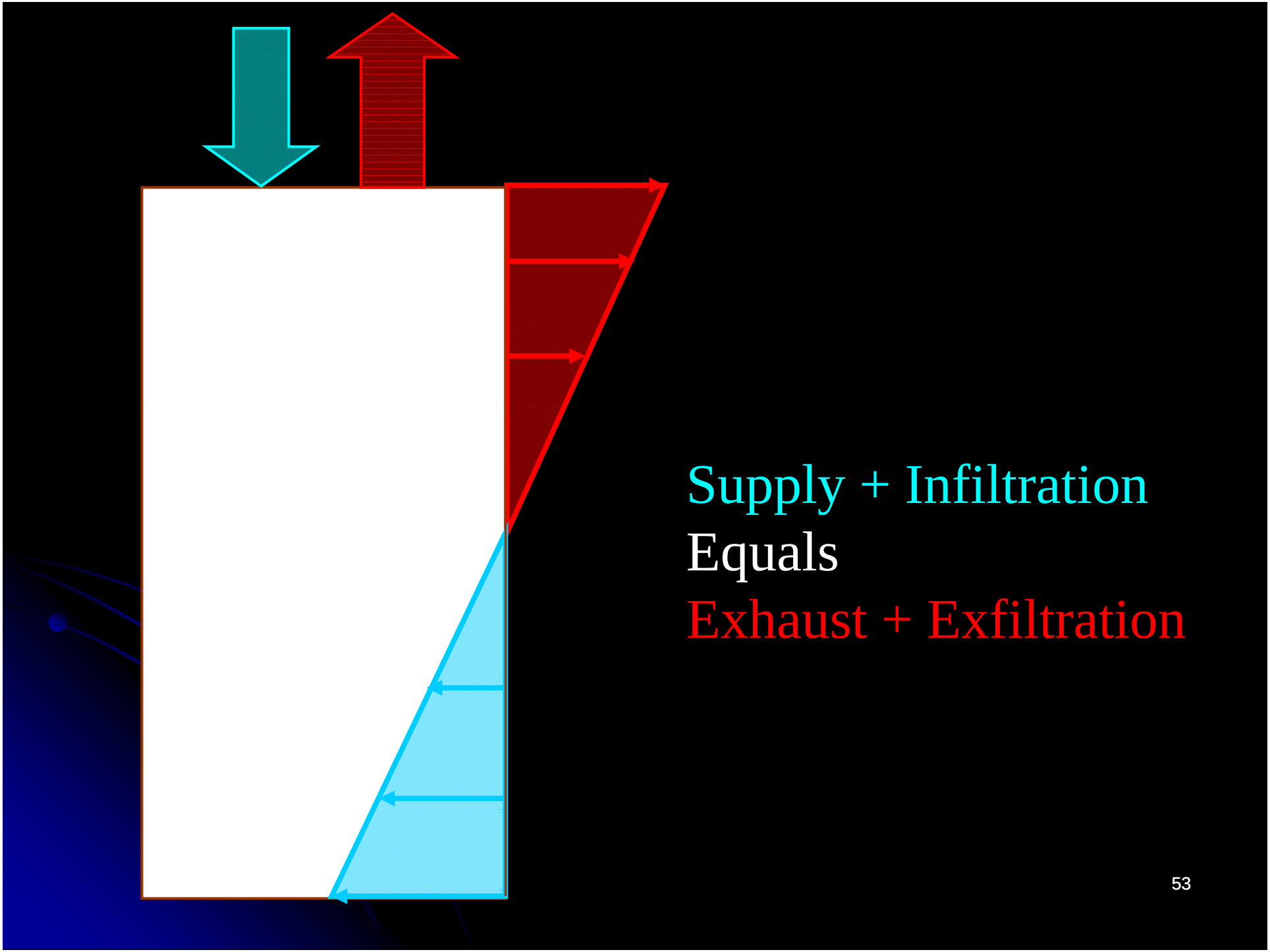
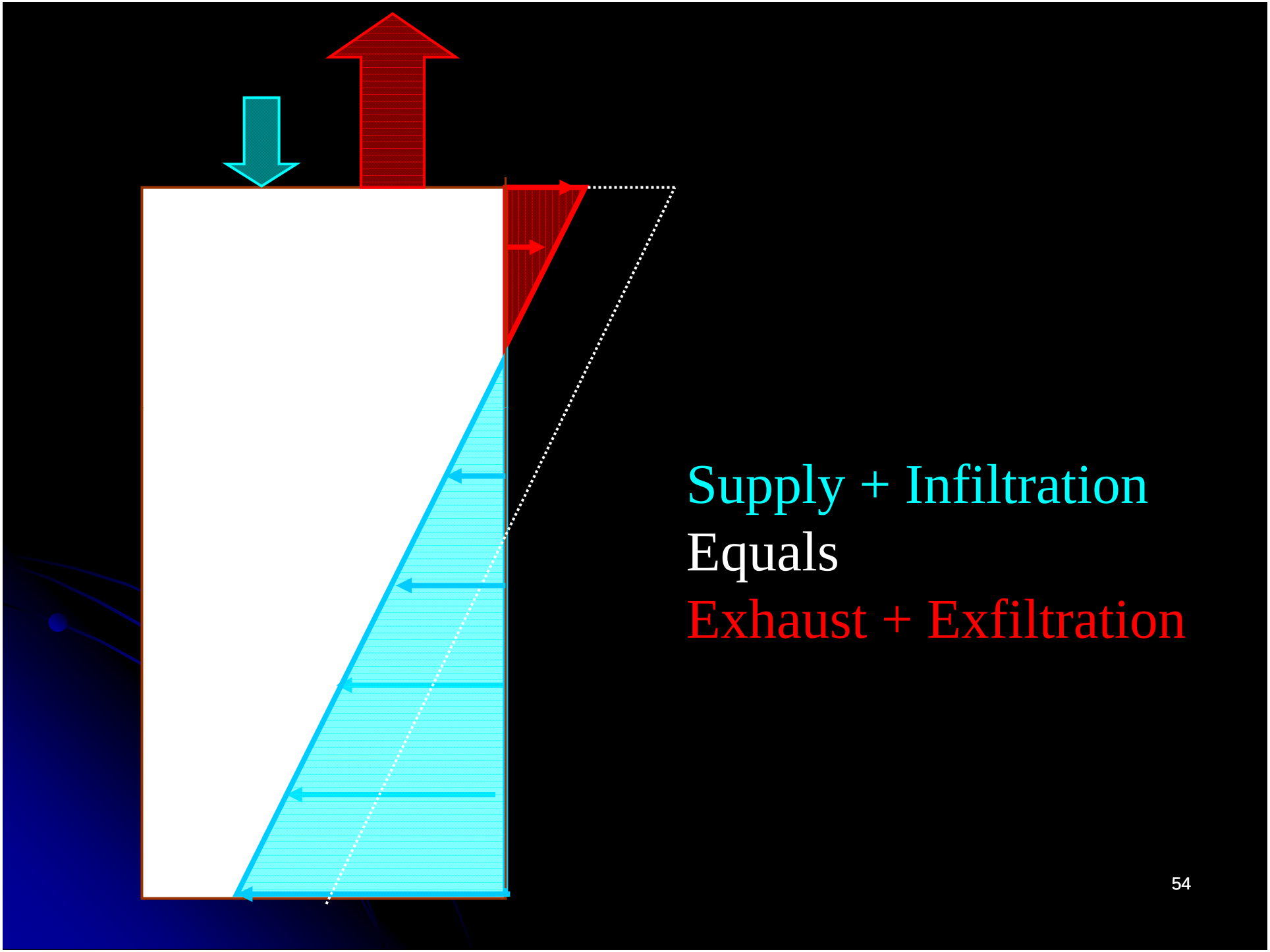
HUMIDITY RATIO (lbw/lba)
40
50
60
70
80
90
100
120
DRY BULB TEMPERATURE (F)

- Changing one thing in a building will probably impact some other aspects in the building – i.e., “the building acts as a system”

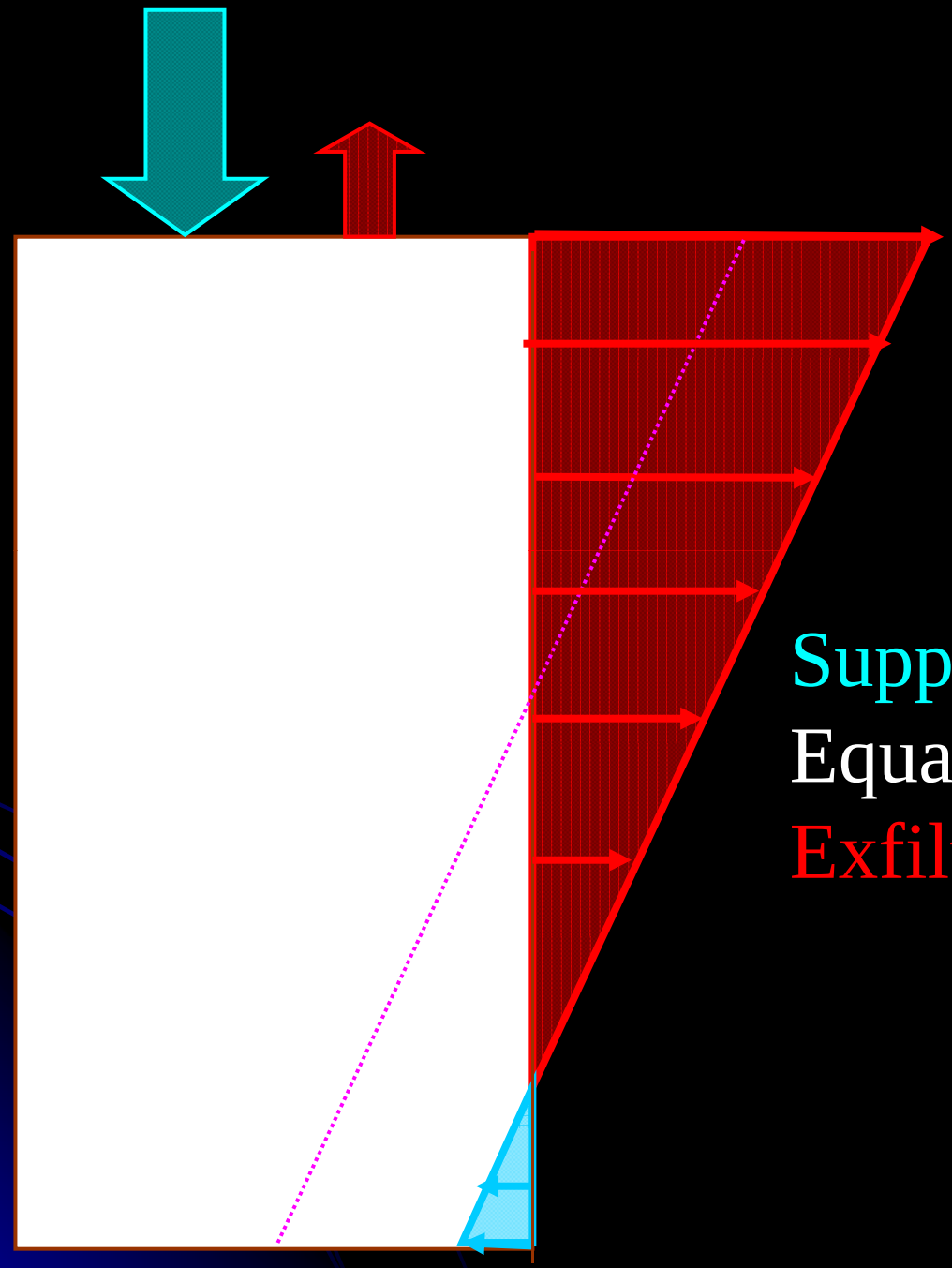
- **The art of building science is understanding how these various factors will interact**



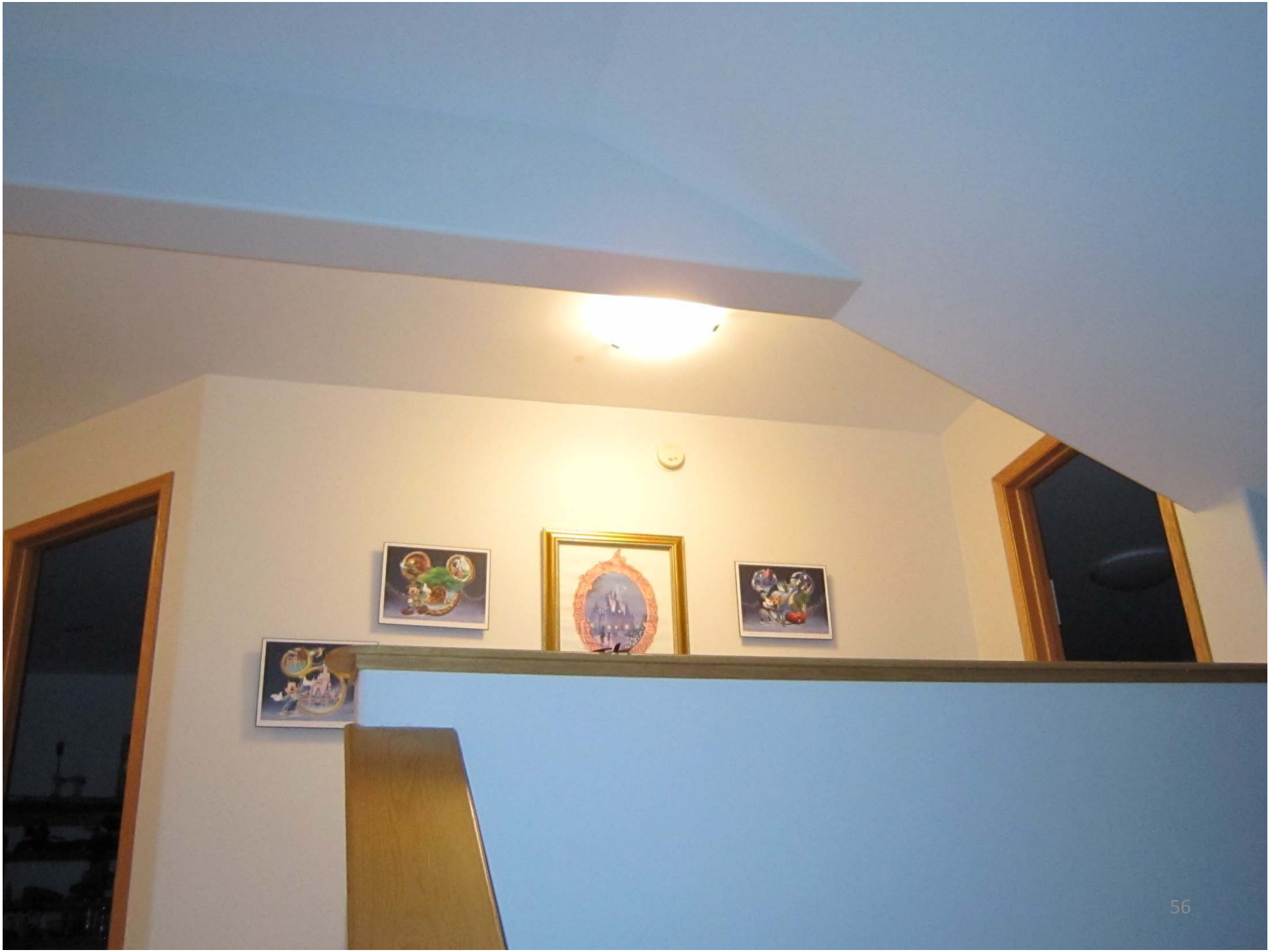
Supply + Infiltration
Equals
Exhaust + Exfiltration



Supply + Infiltration
Equals
Exhaust + Exfiltration



Supply + Infiltration
Equals
Exfiltration + Exhaust




CAUTION
Bears in Area
• Travel in a group
• Make lots of noise
• Keep small children with you


ENTRANCE
CLOSED


Questions