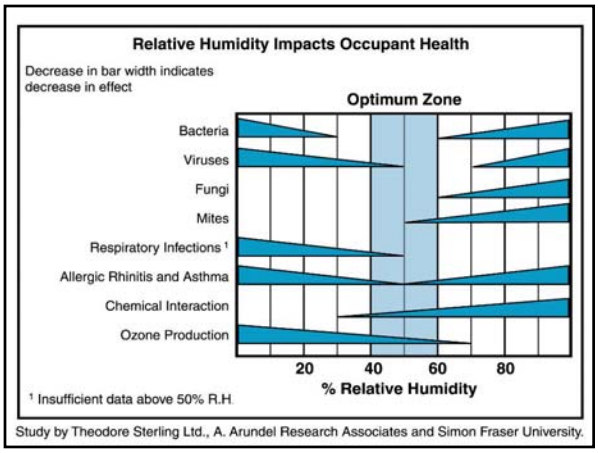
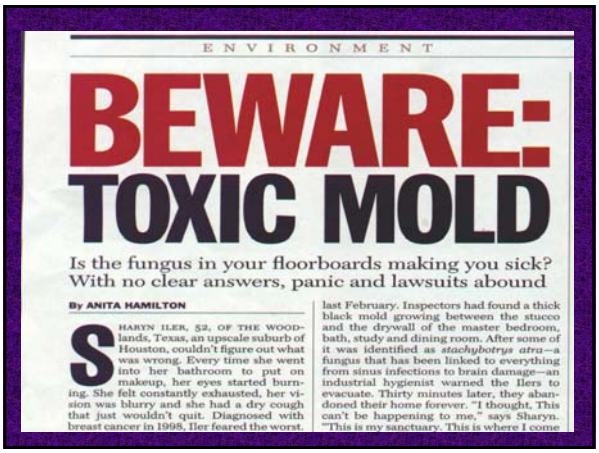
Welcome!

Natatorium Design:

better building and mechanical system performance.


Relative Humidity Impacts Occupant Health
Decrease in bar width indicates decrease in effect
Optimum Zone
Bacteria
Viruses
Fungi
Mites
Respiratory Infections 1
Allergic Rhinitis and Asthma
Chemical Interaction
Ozone Production
20
40
60
80
% Relative Humidity
1 Insufficient data above 50% R.H.
Study by Theodore Sterling Ltd., A. Arundel Research Associates and Simon Fraser University.



ENVIRONMENT

BEWARE: TOXIC MOLD

Is the fungus in your floorboards making you sick? With no clear answers, panic and lawsuits abound

By ANITA HAMILTON

SHARYN ILER, 52, OF THE WOODlands, Texas, an upscale suburb of Houston, couldn't figure out what was wrong. Every time she went into her bathroom to put on makeup, her eyes started burning. She felt constantly exhausted, her vision was blurry and she had a dry cough that just wouldn't quit. Diagnosed with breast cancer in 1998, Iler feared the worst.

last February. Inspectors had found a thick black mold growing between the stucco and the drywall of the master bedroom, bath, study and dining room. After some of it was identified as *stachybotrys atra*—a fungus that has been linked to everything from sinus infections to brain damage—an industrial hygienist warned the Ilers to evacuate. Thirty minutes later, they abandoned their home forever. "I thought, This can't be happening to me," says Sharyn. "This is my sanctuary. This is where I come

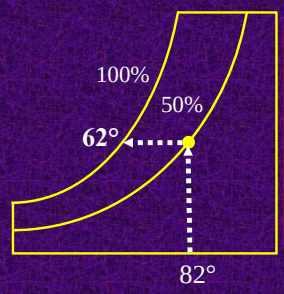
Design Issues

- Moisture Load calculation
- Condensation Control
- Pool Water Chemistry
- Exhaust Air
- Outdoor Air
- Air Distribution
- Duct Design
- Cooling
- Heating
- Energy recovery
- Mechanical dehumidification

Design Criteria #1: Establish the Space Dew Point

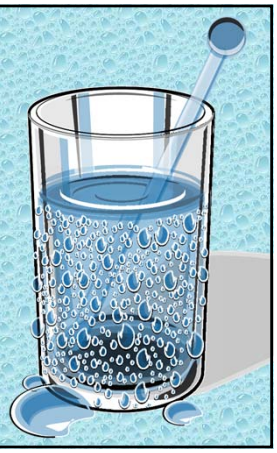
Everything vital to the pool is based on this value.

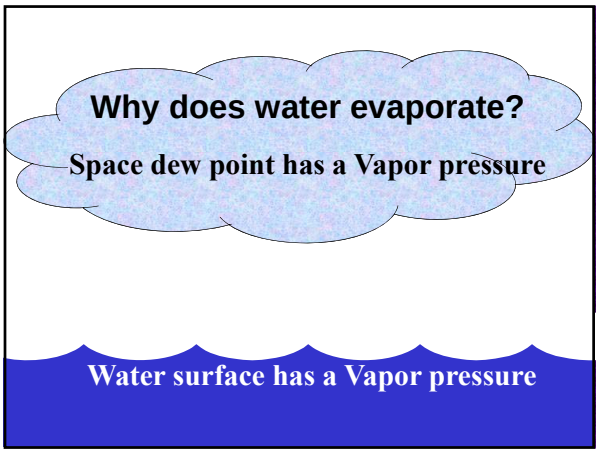
Dew Point

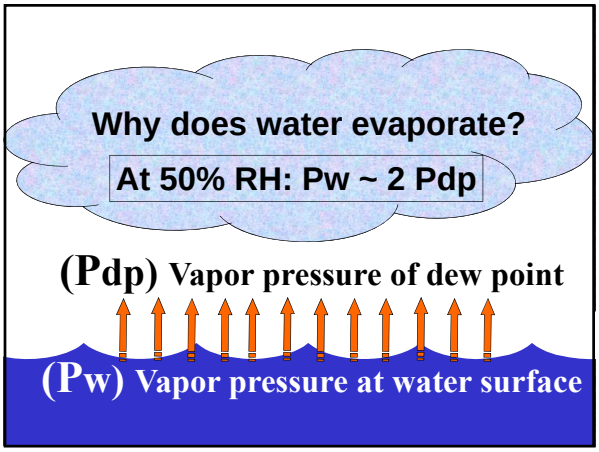


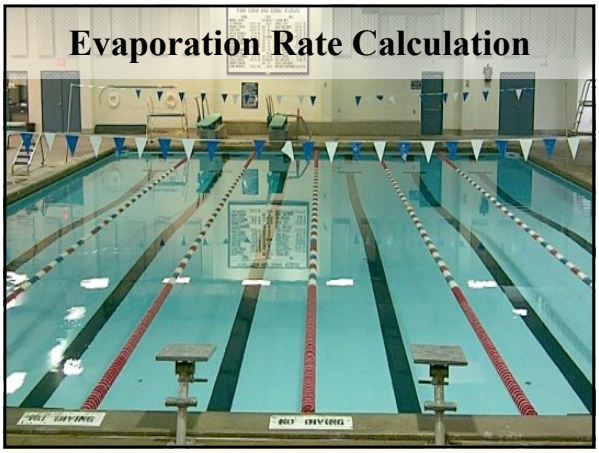
82°F 50%RH
= 62 °F DP
70°F 50%RH
= 50 °F DP

Any surface below 62°F will condense moisture




Why does water evaporate?
Space dew point has a Vapor pressure
Water surface has a Vapor pressure


Why does water evaporate?
At 50% RH: Pw ~ 2 Pdp
(Pdp) Vapor pressure of dew point
(Pw) Vapor pressure at water surface


Evaporation Rate Calculation

Evaporation Rate

Lb/h = 0.1 x A x ΔP x AF

- A: Water Area; ft^2
- ΔP: Δ Vapor pressure; inches Hg
- AF: Activity Factor (0.5 = Baseline)

Evaporation Rate

Lb/h = 0.1 x A x ΔP x AF

Typical calculation has 2 scenarios:

- AF = 0.5 and space @ 50% (night)
- AF = 1.0 and space @ 60% (active)

Typical Design Conditions

Pool Type	Air Temperature
Competition	78 to 85 °F
Diving	80 to 85 °F
Elderly Swimmers	84 to 90 °F
Hotel	82 to 85 °F
Physical Therapy	80 to 85 °F
Recreational	82 to 85 °F
Whirlpool/spa	80 to 85 °F

Typical Design Conditions

Pool Type	Water Temperature	Activity Factor
Competition	76 to 82 °F	0.65
Diving	84 to 88 °F	0.65
Elderly Swimmers	85 to 90 °F	0.8
Hotel	82 to 86 °F	0.8 – 1.0
Physical Therapy	90 to 95 °F	0.65
Recreational	80 to 85 °F	1.0
Whirlpool/spa	102 to 104 °F	1.0

Knowing the activity level in advance is important

Similar to a pool ?

Olympic Pool Example

Water Area : 165 ft x 70 ft, 11550 ft²	
Water Temperature	77º F
Air Temp and RH	79º F - 50%
Dew Point	58º F
Activity Factor	1.0
Evaporation Rate	**490 lb/h**
Heat Loss due to evaporation	**510,000 btu/h**

Olympic Pool Example

Water Area : 165 ft x 70 ft, 11550 ft²		
Water Temperature	77º F	77º F
Air Temp and RH	79º F - 50%	**82º F – 50%**
Dew Point	58º F	**62º F**
Activity Factor	1.0	1.0
Evaporation Rate	490 lb/h	**425 lb/h**
Heat Loss due to evaporation	510,000 btu/h	**450,000 btu/h**

Energy Consideration:

Higher Air Temperatures

Reduce evaporation

Rule of Thumb:
Air 2ºF warmer than water

Condensation Control

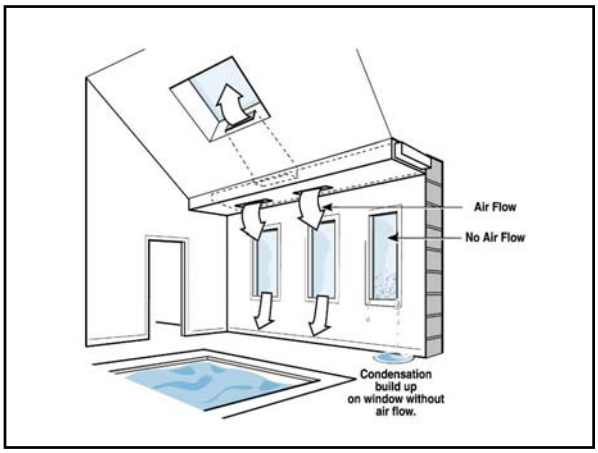
1) Indoor surface temperature control

Remember: 62 ºF DP

Expensive Windows……. aren't the answer.

- 85°F Space
- -10°F Outdoors
- A TRIPLE pane window has a 57 °F inner surface temperature.
- A double pane window has a 45 °F inner surface temperature.

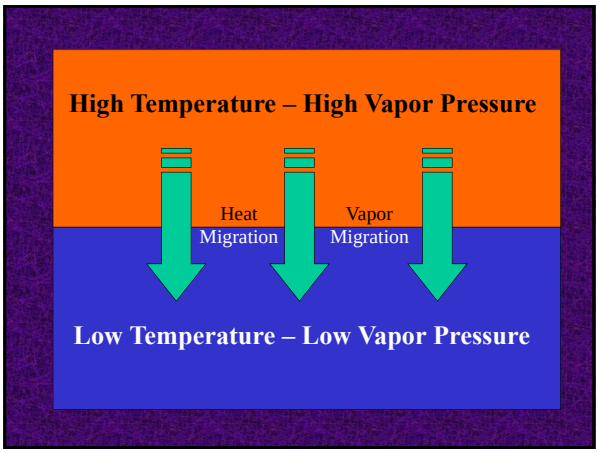
Room dew point = 62 °F

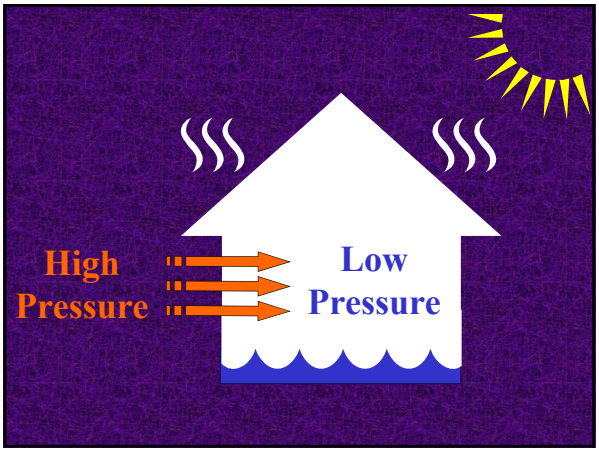


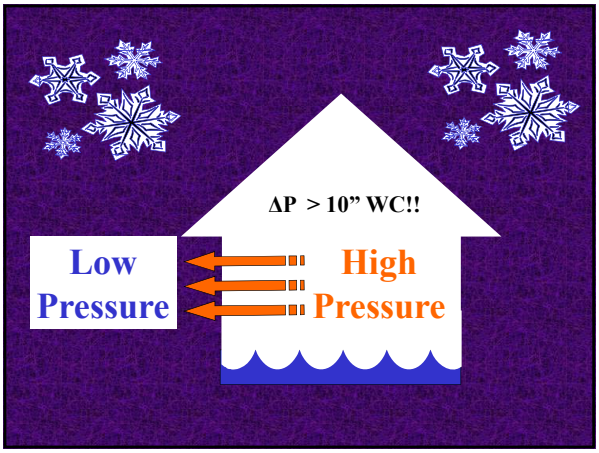
Condensation Control

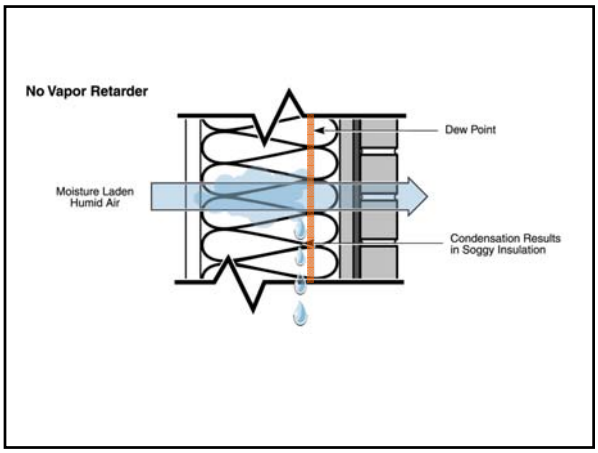
1) Inside surface temperature control

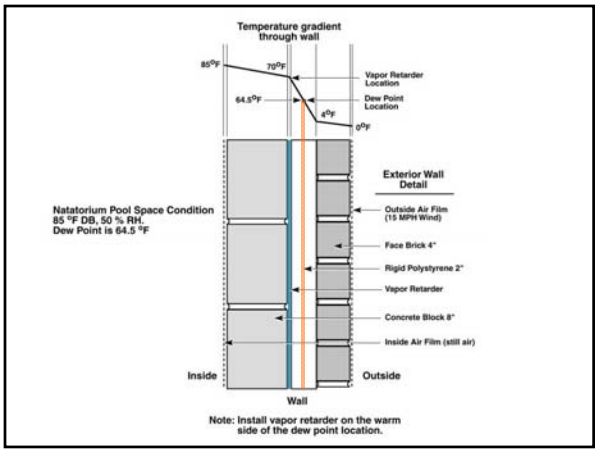
2) Moisture migration prevention

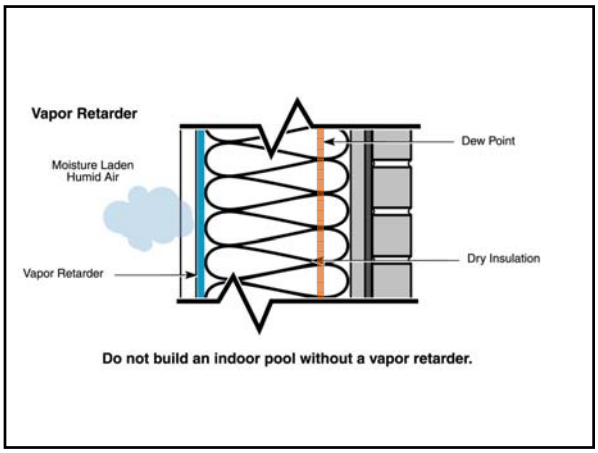

High Temperature – High Vapor Pressure
Heat Migration
Vapor Migration
Low Temperature – Low Vapor Pressure


High Pressure
Low Pressure


ΔP > 10" WC!!
Low Pressure
High Pressure


No Vapor Retarder
Dew Point
Moisture Laden Humid Air
Condensation Results in Soggy Insulation


Temperature gradient through wall
85°F
70°F
64.5°F
4°F
0°F
Vapor Retarder Location
Dew Point Location
Exterior Wall Detail
Natatorium Pool Space Condition
85 °F DB, 50 % RH,
Dew Point is 64.5 °F
Outside Air Film (15 MPH Wind)
Face Brick 4"
Rigid Polystyrene 2"
Vapor Retarder
Concrete Block 8"
Inside Air Film (still air)
Inside
Outside
Wall
Note: Install vapor retarder on the warm side of the dew point location.


Vapor Retarder
Moisture Laden
Humid Air
Dew Point
Dry Insulation
Vapor Retarder
Do not build an indoor pool without a vapor retarder.

DANGER KEEP OUT

Areas of Condensation Control

- Room dew point temperature control
- Inside surface temperature control
- Prevention of moisture migration through building materials

- ?
- ?
- ?

Areas of Condensation Control

- Room dew point temperature control
- Inside surface temperature control
- Prevention of moisture migration through building materials

- Mechanical Dehumidifier

Areas of Condensation Control

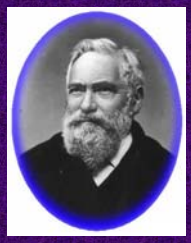
- Room dew point temperature control
- Inside surface temperature control
- Prevention of moisture migration through building materials

- Mechanical Dehumidifier
- Duct layout

Areas of Condensation Control

- Room dew point temperature control
- Inside surface temperature control
- **Prevention of moisture migration through building materials**
- Mechanical Dehumidifier
- Duct layout
- **Building Design**

"If There is a Pile of Manure in a Space. Do Not Try to Remove the Odor by Ventilation. <u>Remove the Pile of Manure"</u>



Pettenkofer (1858)

Pool water quality is the single biggest IAQ problem and it impacts the mechanical systems

Cause	Effect
• Under Chlorination	• Combined Chlorines (foul odor)
• High pH level or high total alkalinity	• Scale forming
• Low pH level or low total alkalinity	• Corrosion

Corrosion & the IAQ problem:

Off-gassed chloramines have a strong attraction to the airborne humidity.

Corrosion & the IAQ problem:

Chloramines = Corrosive Condensate

Addressing the IAQ problem:

Ultraviolet Light

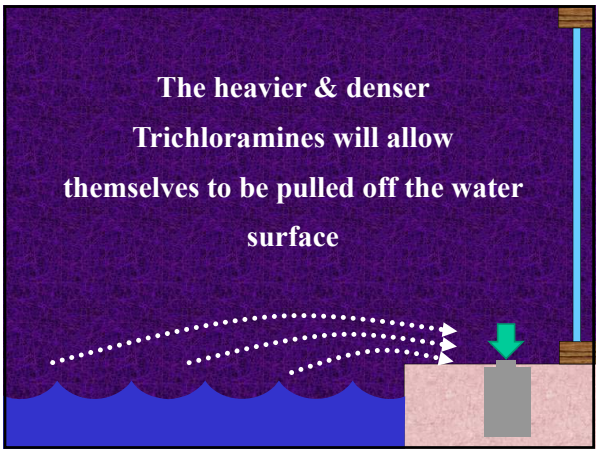
Reduces chloramines!

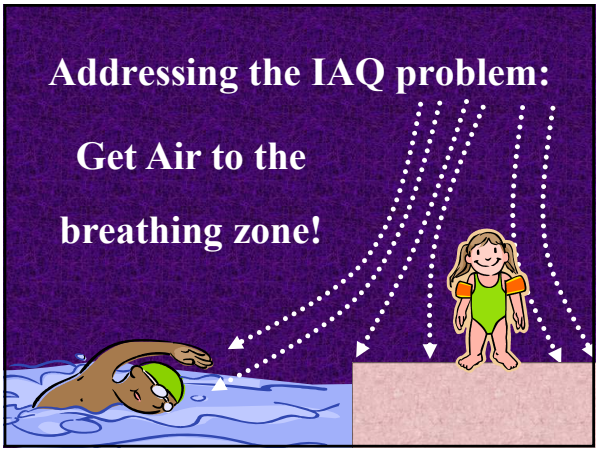
Addressing the IAQ problem:

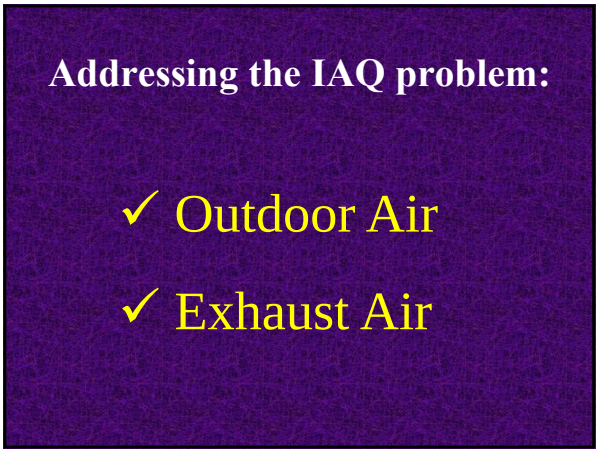
Trichloramines

4x heavier than air

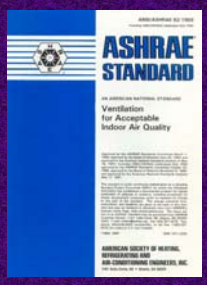
Source capture?


The heavier & denser
Trichloramines will allow
themselves to be pulled off the water
surface


Addressing the IAQ problem:
Get Air to the
breathing zone!


Addressing the IAQ problem:
✓ Outdoor Air
✓ Exhaust Air

Outdoor Air



Per Standard 62-2004:

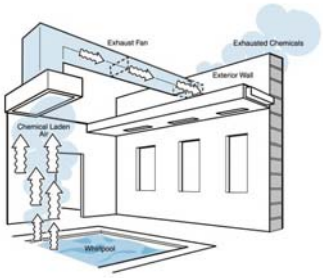
- 0.48 CFM per ft^2 of pool and (wet) deck area or

-7.5 CFM per spectator

Add Spectator OA CFM to baseline.

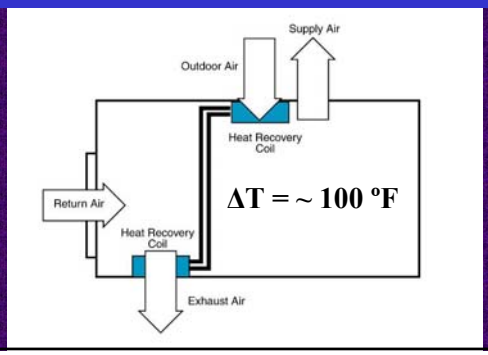
Water parks: Double the OA!

Exhaust Air



Per Chapter 4 Applications: 0.05 to 0.15" WC negative pressure.

Heat recovery



ΔT = ~ 100 ºF

The Art of Air Distribution

Air changes per ASHRAE

- 4 – 6 per hour in a natatorium
- 6 – 8 per hour in a spectator area
- 8 per hour (occupied) in a water park

Specify CFM needed to satisfy this requirement.

The Art of Air Distribution

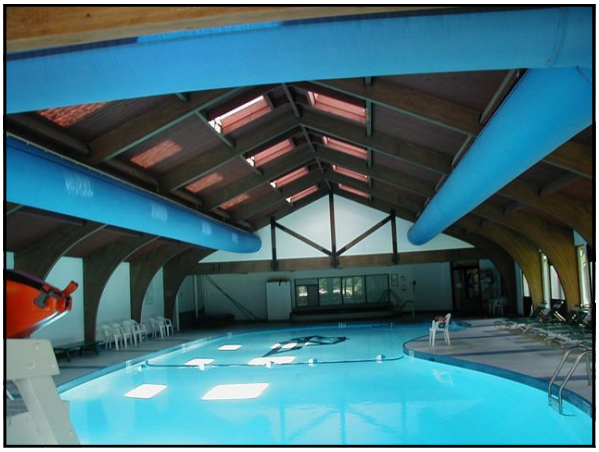
- Supply air to breathing zone!
- Supply air to where condensation is predictable
  - Exterior windows & Doors.
- Return location must complement supply duct layout.

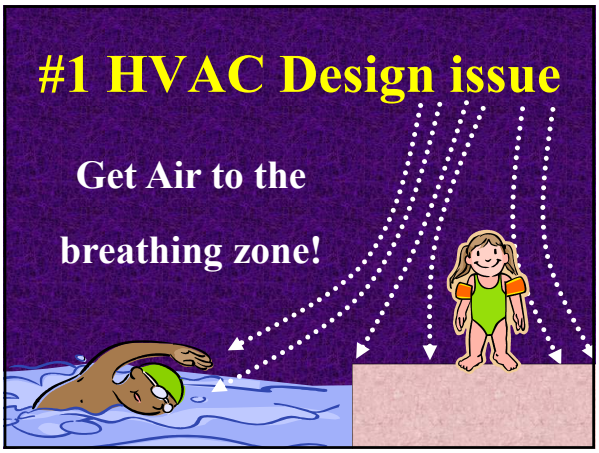
The Art of Duct Design

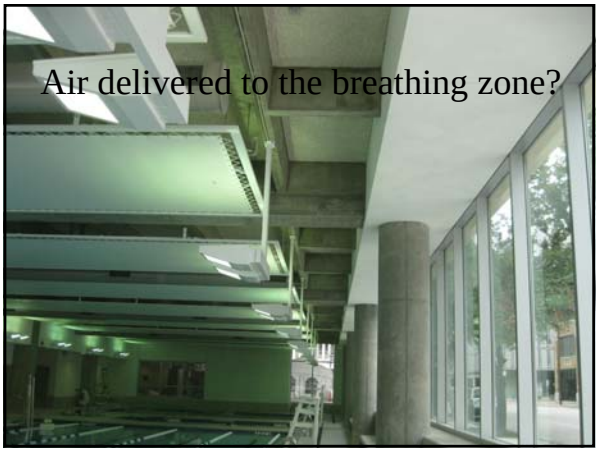
Duct Materials

- Galvanized – Aluminum – Fabric
- Avoid Stainless Steel!

Ensure proper throw and direction from all diffusers




#1 HVAC Design issue
Get Air to the
breathing zone!


Air delivered to the breathing zone?

Air delivered to the breathing zone?

Design Issues

- Moisture Load calculation
- Condensation Control
- Pool Water Chemistry
- Exhaust Air
- Outdoor Air
- Air Distribution
- Duct Design
- Cooling
- Heating
- Energy recovery
- Mechanical dehumidification

Heating and Cooling

The space is generally

10-15ºF warmer

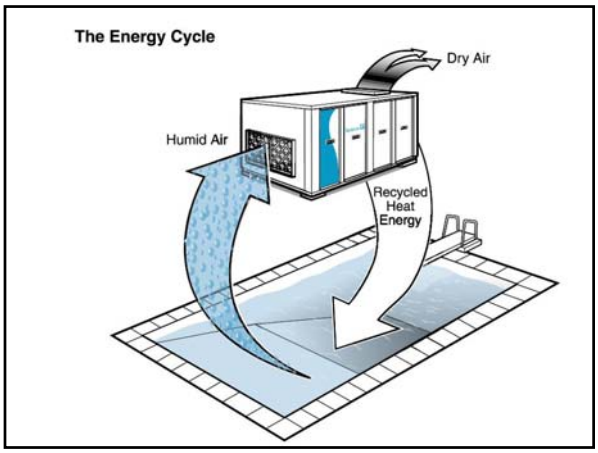
than a traditional room.

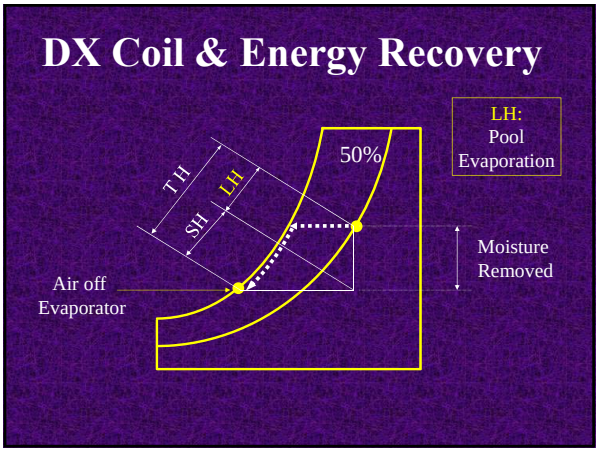
Heating and Cooling

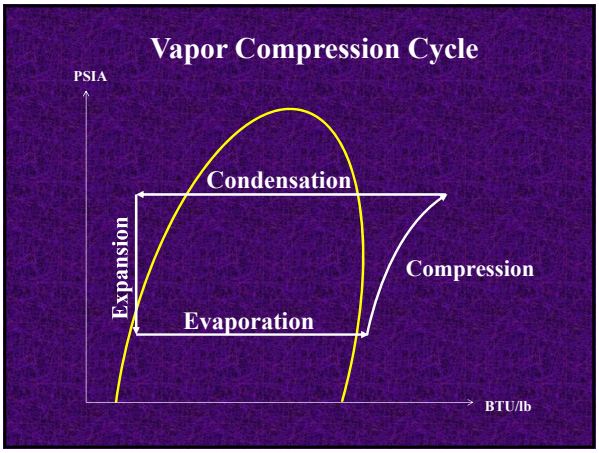
More btu/ft² heating

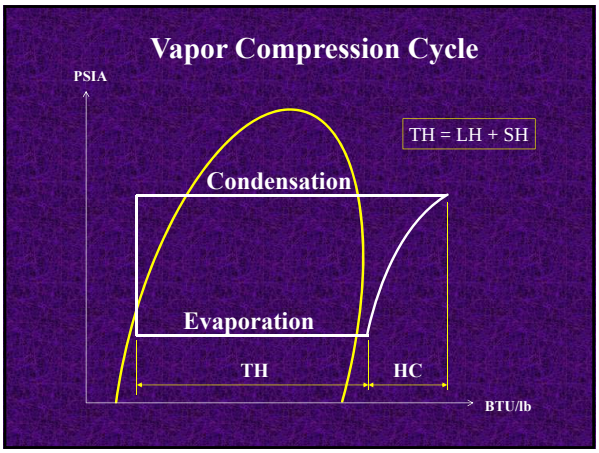
Less btu/ft² cooling

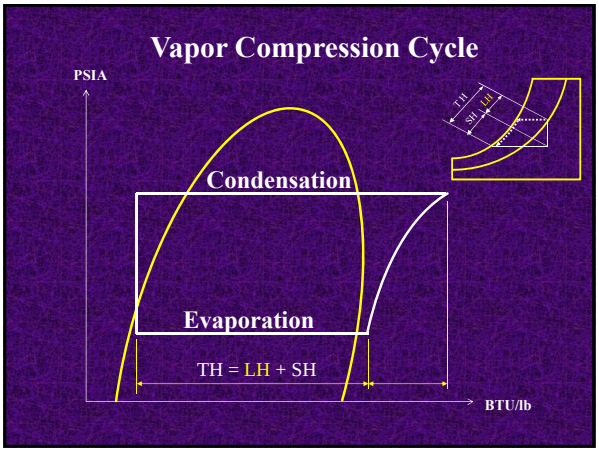
Don't forget Outdoor air in your load calculation. (~50% of heating load!)

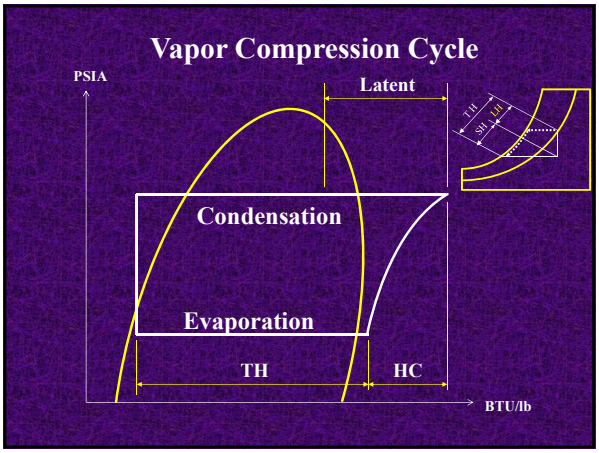

The Energy Cycle
Dry Air
Humid Air
Recycled Heat Energy

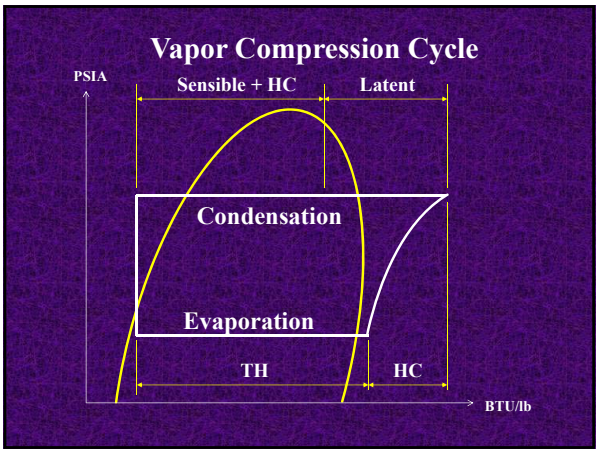

DX Coil & Energy Recovery
LH: Pool Evaporation
50%
TH
LH
SH
Moisture Removed
Air off Evaporator


Vapor Compression Cycle
PSIA
Condensation
Expansion
Compression
Evaporation
BTU/lb


Vapor Compression Cycle
PSIA
TH = LH + SH
Condensation
Evaporation
TH
HC
BTU/lb


Vapor Compression Cycle
PSIA
TH
SH
LH
Condensation
Evaporation
TH = LH + SH
BTU/lb


Vapor Compression Cycle
PSIA
Latent
TH
SH
LH
Condensation
Evaporation
TH
HC
BTU/lb



ARI Standard 910:

Efficient energy recycling means returning heat to where it came from by expending as little energy as possible.

Lb/h per system kW

Mechanical Room as Return Air Plenum

Locker Room as Return Air Plenum

Perhaps a good idea not to have things above the pool that need service….

….. stick with approved electrical devices…..

Thank You!