

Joseph Lstiburek, Ph.D., P.Eng
John Straube, Ph.D., P.Eng

Building Science

Moisture

presented by www.buildingscience.com

Moisture and Buildings

- Moisture is involved in almost all building envelope performance problems
 - In-service Durability
- Examples:
 - rot,
 - corrosion,
 - mould (IAQ)
 - termites, (!),
 - staining
 - etc.

Building Science 2008

Heat Air and Moisture No.2/78

Moisture Damage

- Damage caused by
 - Very high humidity for a long time
 - Wet (100%RH) for a shorter time
- Time required depends
 - on material
 - Temperature
 - Higher temperature accelerates process

Building Science 2008

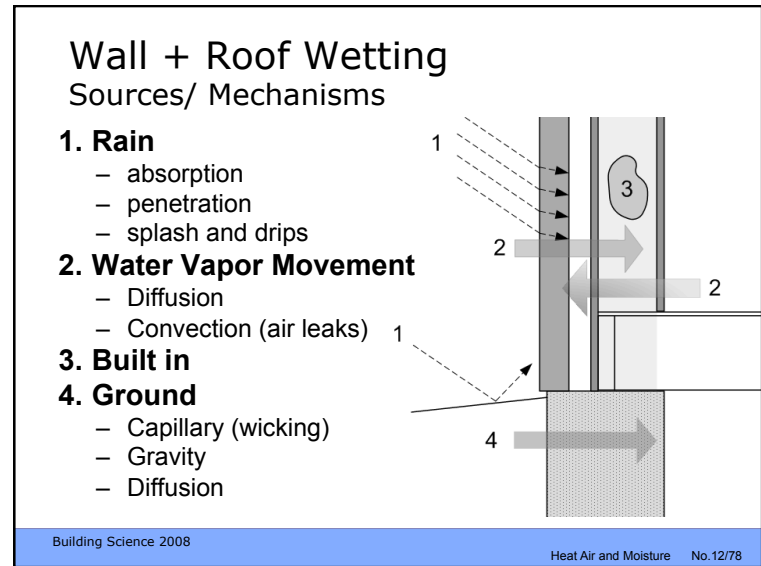
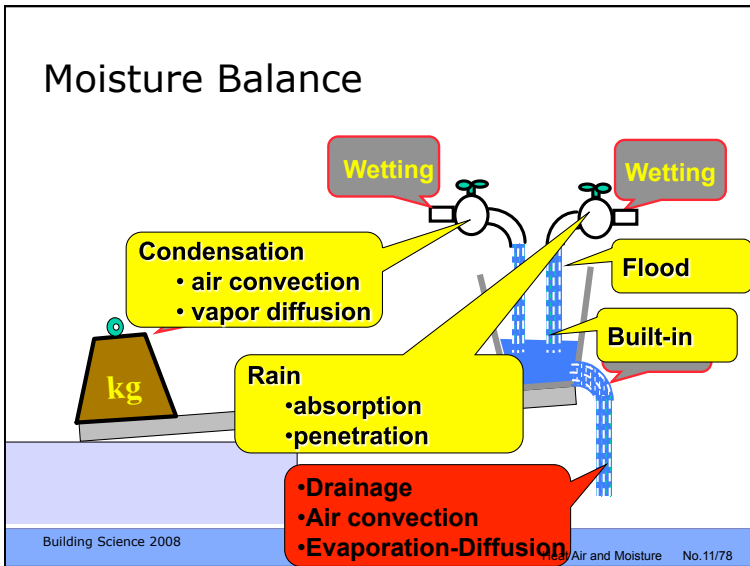
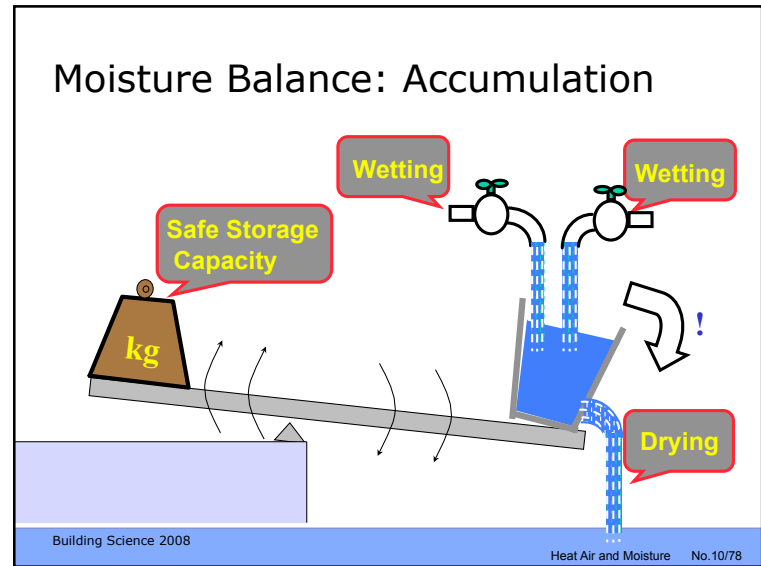
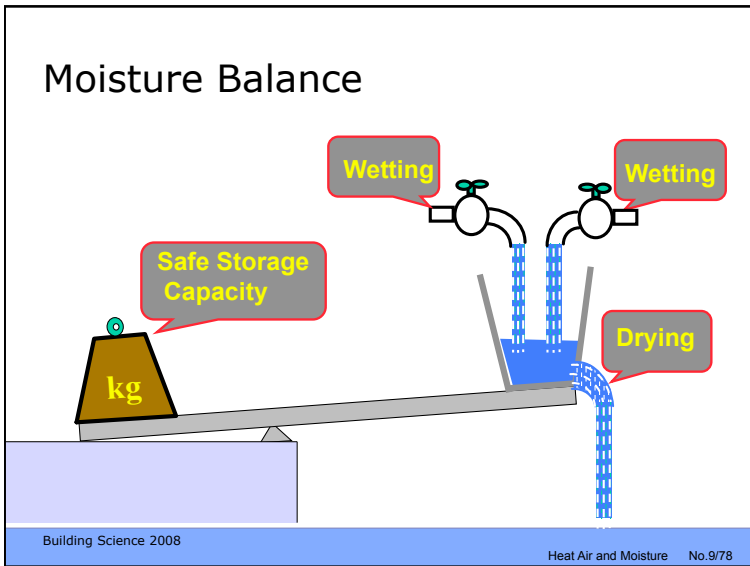
Heat Air and Moisture No.3/78





Moisture Control

- Moisture-related Problems
 1. **Moisture** must be available
 2. There must be a route or **path**
 3. There must be a **force** to cause movement
 4. The material must be **susceptible** to damage
- Theory:
 - eliminate any one for complete control
- Practice:
 - control as many as possible



Wall + Roof Drying Sinks and Mechanisms

1. Surface Evaporation

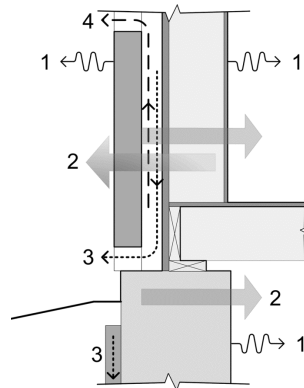
- Wicking to surface

2. Vapor Movement

- i) Diffusion
- ii) Convection

3. Drainage

4. Intentional Convection = Ventilation Drying



Note above and below grade

Ventilation Drying

•Ventilation provides drying to the exterior

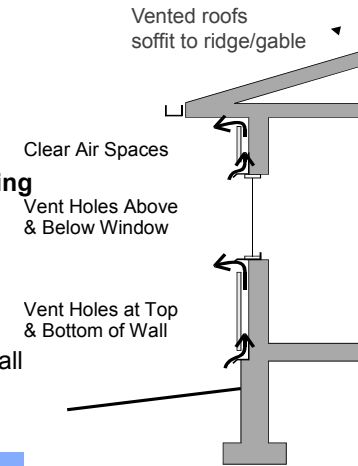
•Can be important for:

1. vapor impermeable cladding

- metal panels
- most roofing

2. systems which retain rainwater

- Improves survivability of small rain leaks and condensation

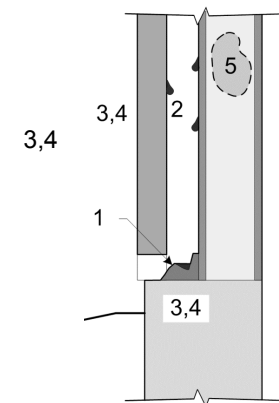


Storage

- Bridges gap in time between wetting and drying
- **How much moisture** for **how long** before damage
- **Safe** storage: safe against what?
 - mold, rot, freeze-thaw, corrosion
- Basic mechanisms
 - **A**bsorbed into materials= capillary pores (*bound liquid*)
 - **A**dsorbed to materials = sorption (*vapor*)
 - pools and puddles (*free liquid*)

Moisture Storage in Assemblies

1. Trapped / undrained
 - Liquid or solid
2. Surface tension
3. Adsorbed
4. Absorbed
5. Vapor
 - small



Design Choices

- Either **avoid wetting**
- Or, **provide enough drying** to accommodate wetting
- Depending on the **storage provided**

The balance has shifted over time

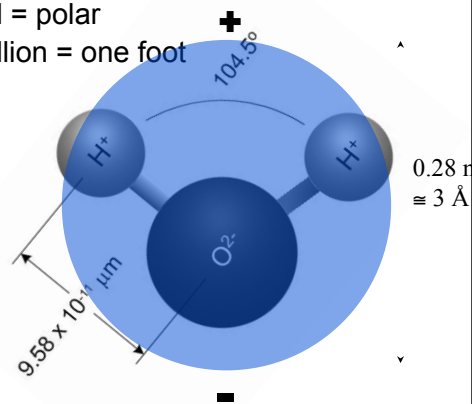
- **Amount of storage** has changed over last 100 yrs
 - e.g. steel stud, vs wood stud vs concrete block
 - 1: 10 : 100+
- Wetting is usually less
- Drying is often much less

Design Solutions

- Balance wetting, drying, and storage
- Practical Rules
 - Provide a **continuous** plane of **rain** control including each enclosure detail
 - Provide **continuous air barriers** and **insulation** to control condensation problems
 - Allow **drying** of built-in and accidental moisture – beware drying retarders

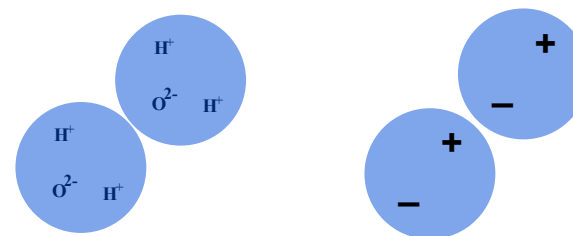
The Water Molecule

- Asymmetrical = polar
- Small: one billion = one foot



The Polar Molecule

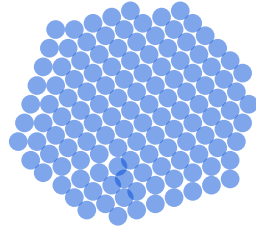
- Hydrogen end is “more” positive
- Oxygen end is “more” negative



Water: Liquid vs Vapor

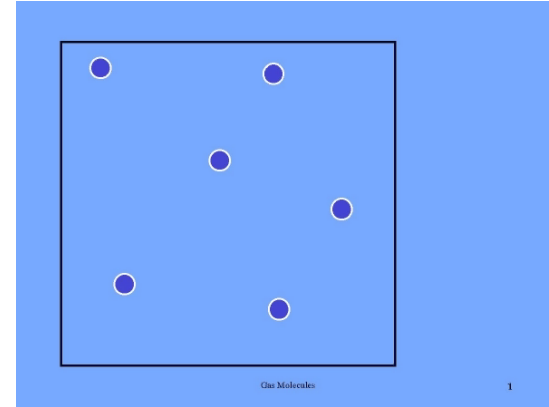
- Vapor is a single molecule
- Liquid is molecular clumps, 60 or more
- Tyvek vs asphalt

Vapor



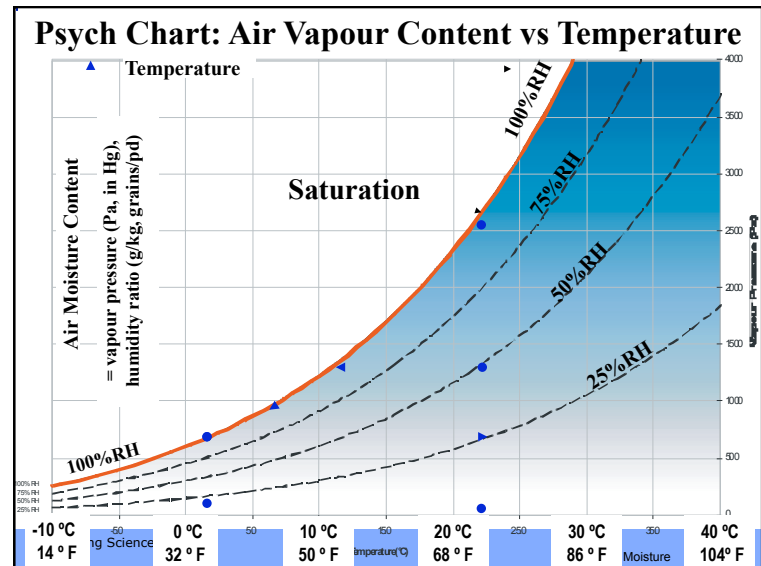
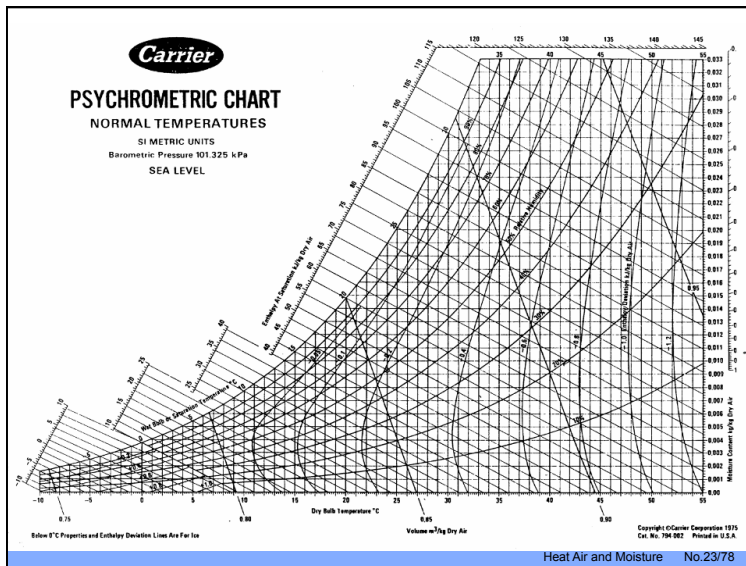
Liquid

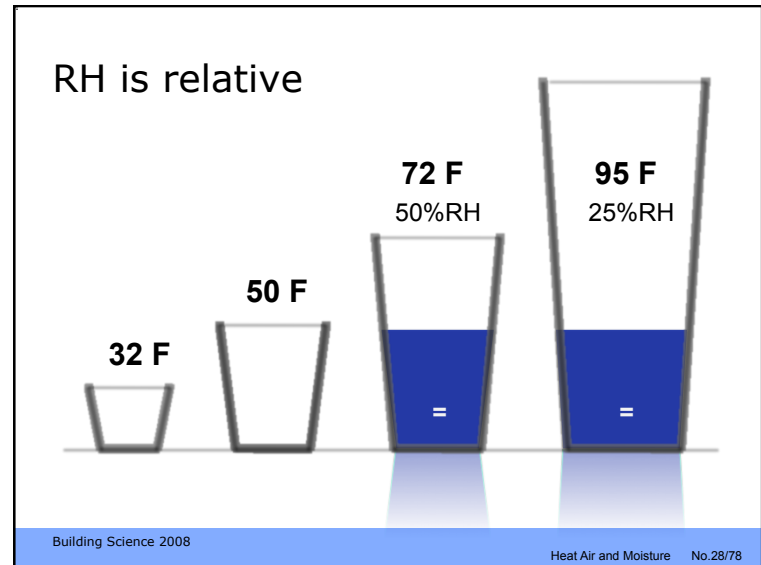
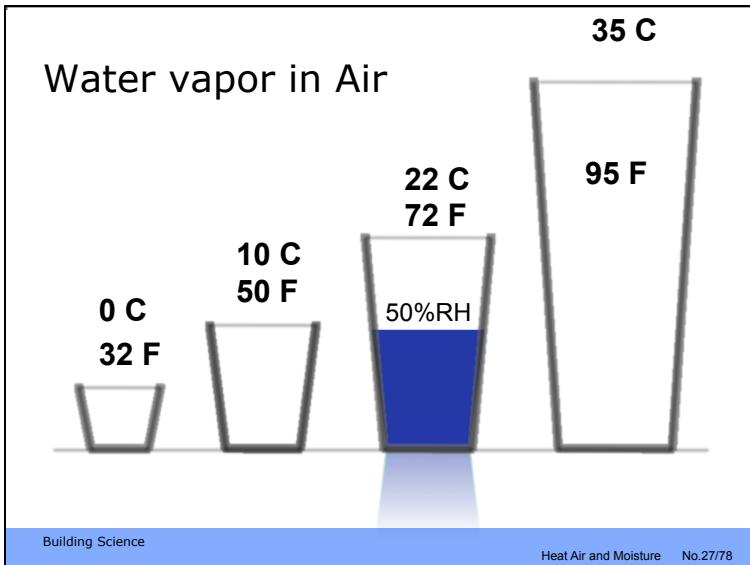
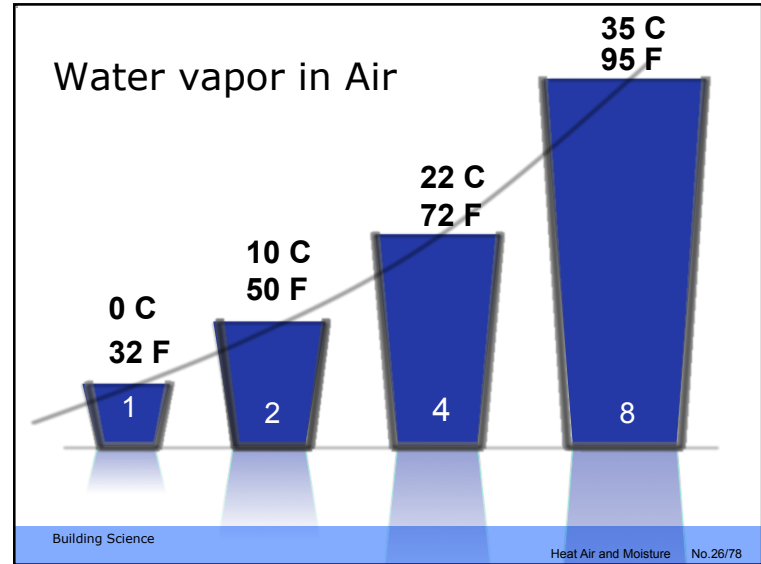
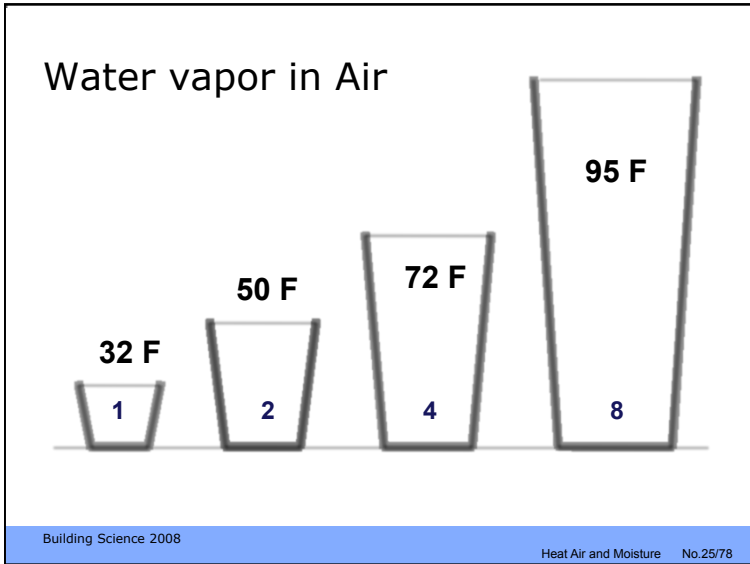
Moisture as a Gas (water vapor)

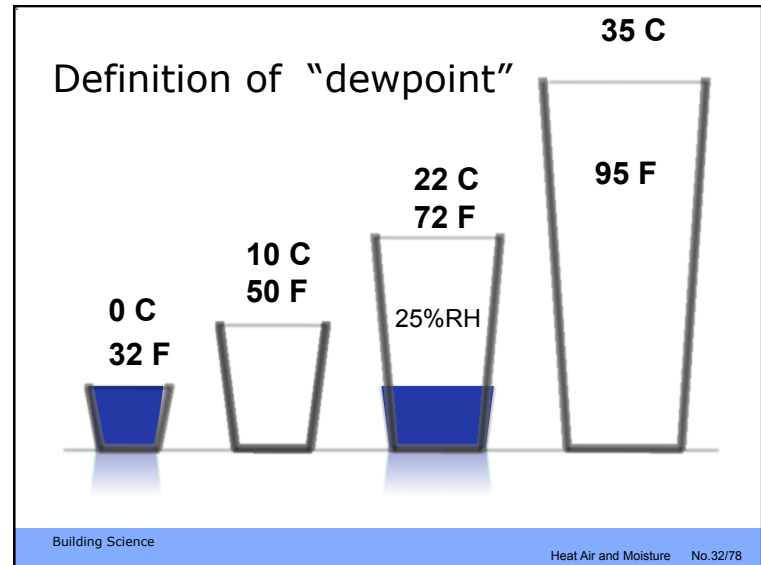
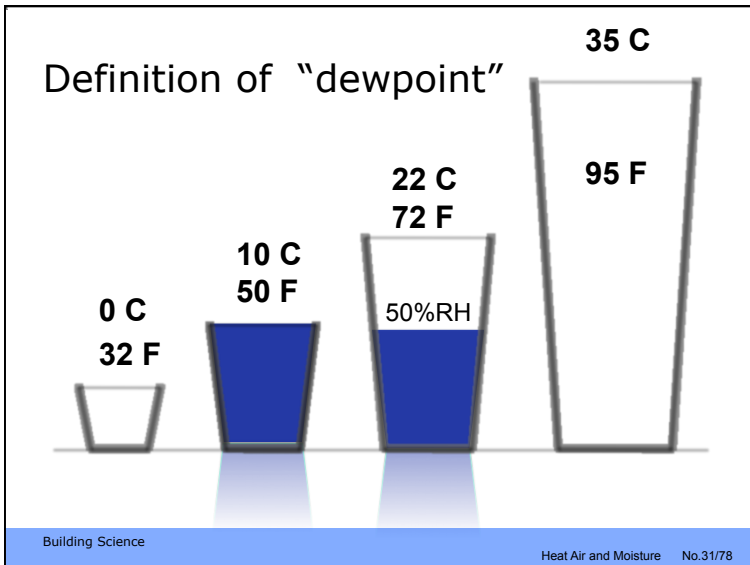
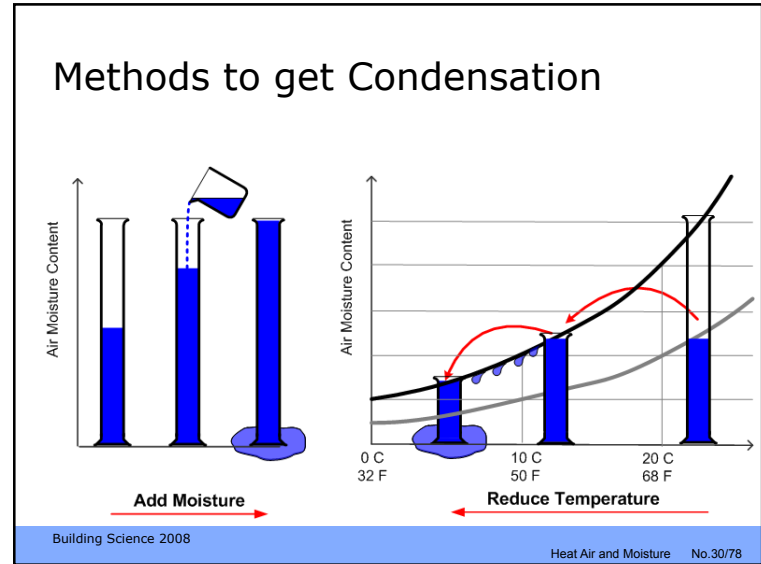
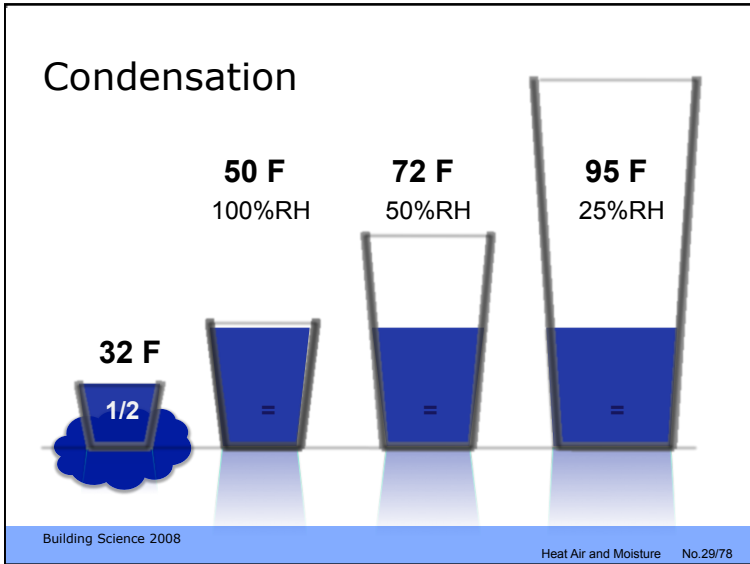


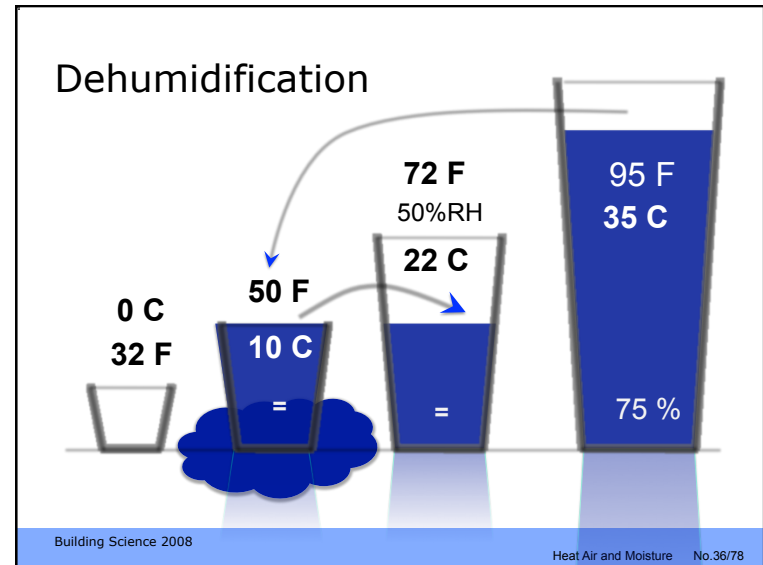
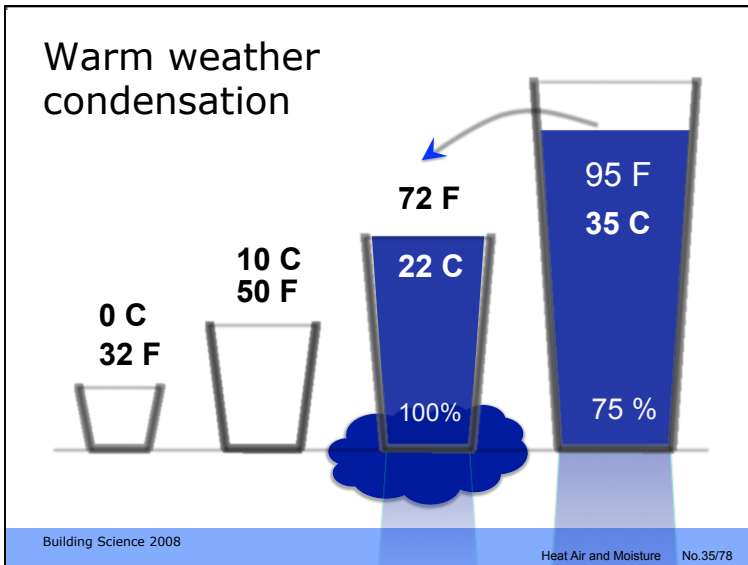
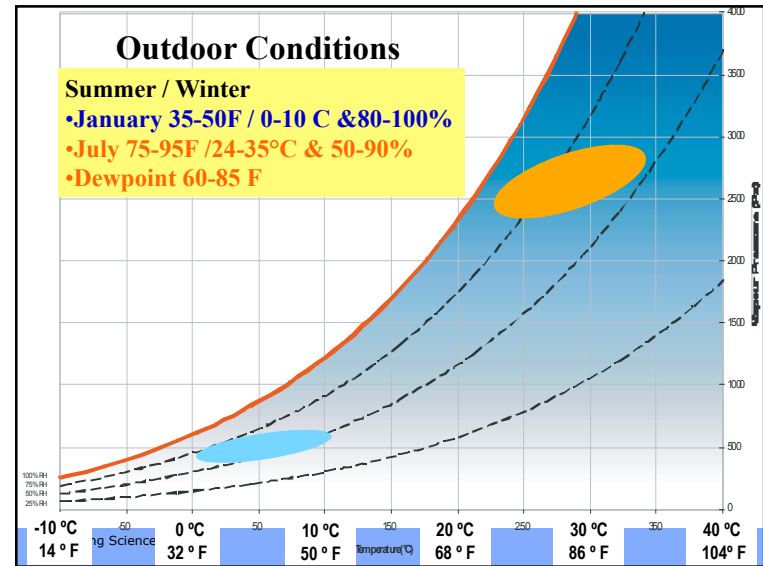
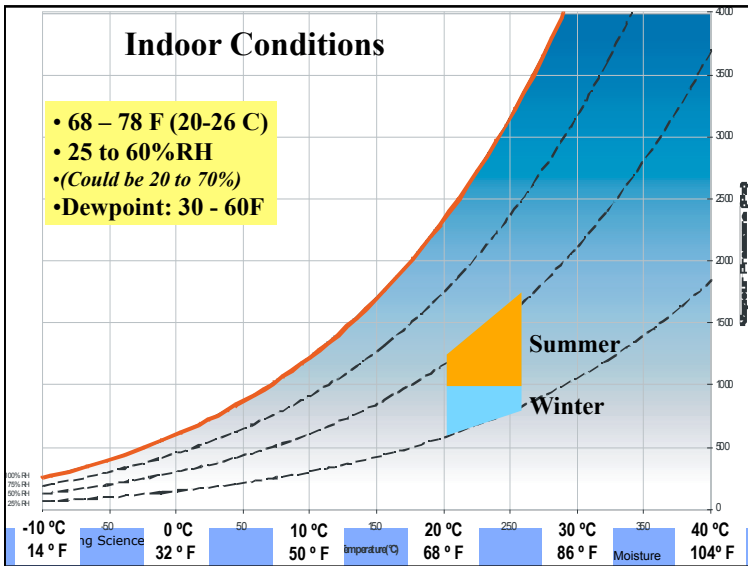
Gas Molecules

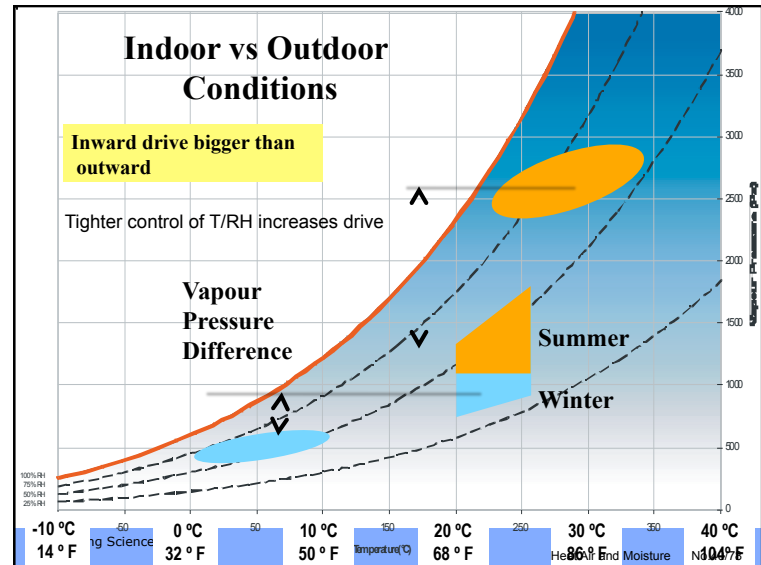
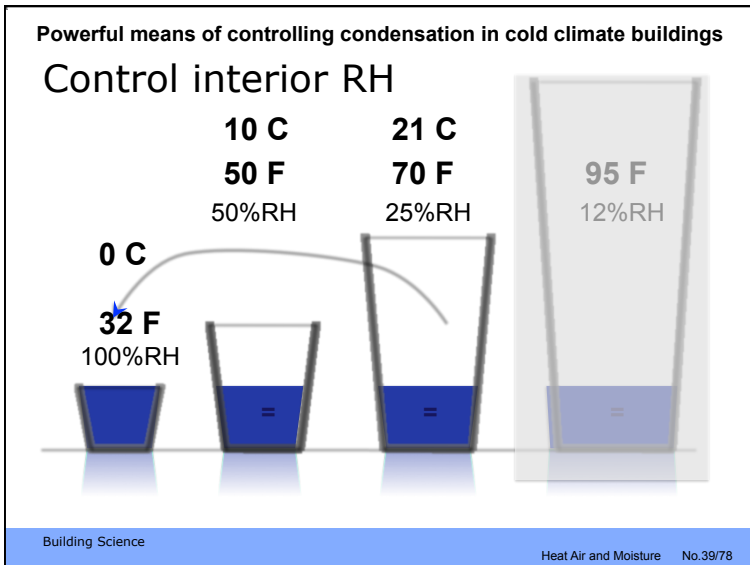
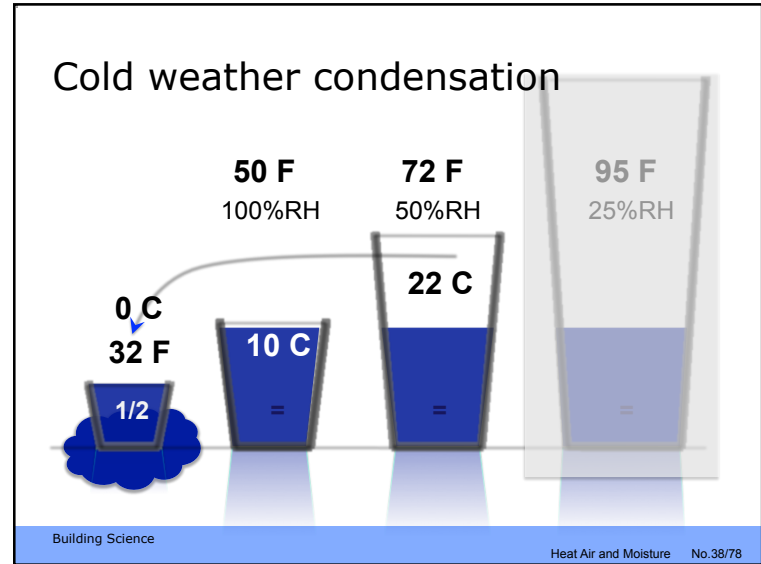
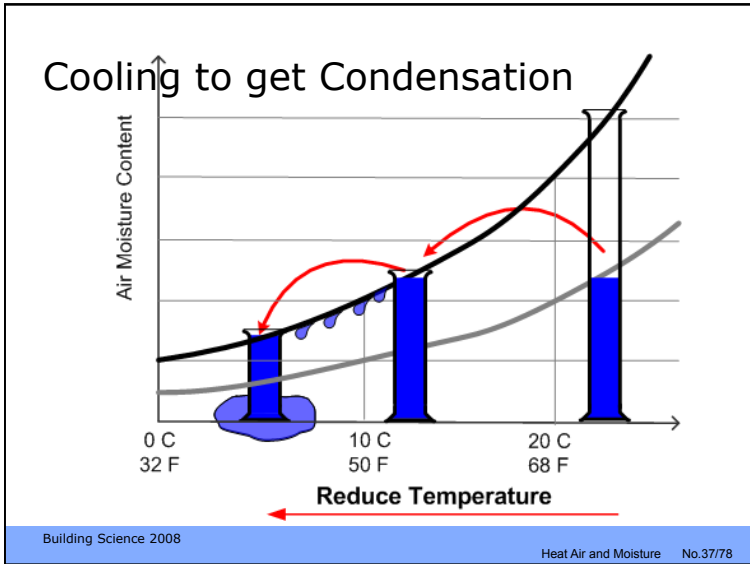
1

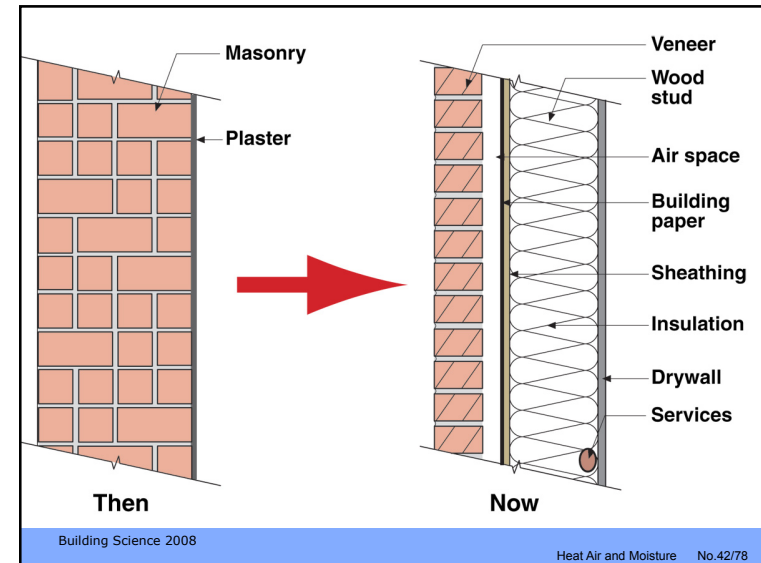
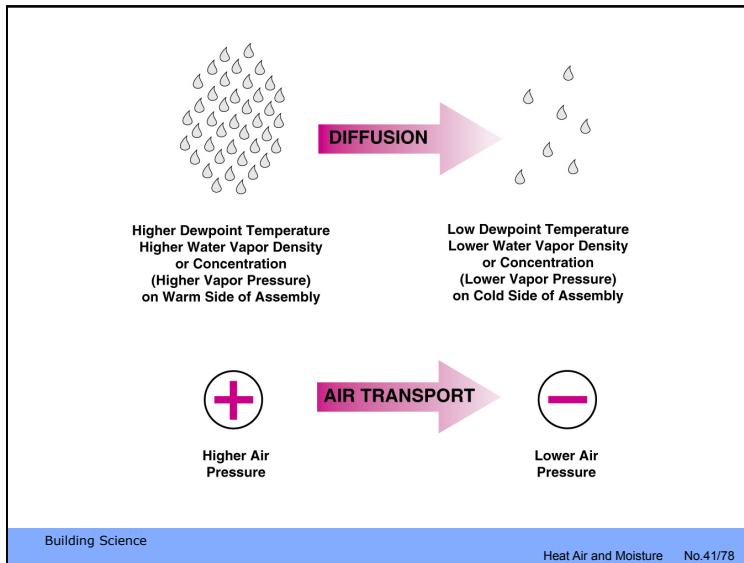












Water Vapour Transport

- Vapour Diffusion (like heat conduction)
 - more to less vapour
- Air Convection (like heat convection)
 - more to less air pressure
 - flow through cracks and holes
 - vapour is along for the ride

Vapour Diffusion

- Slow process – through open pores
- Some materials allow easy diffusion
 - Many, very open pores
 - e.g. batt, gypsum, cellulose, etc.
- Many materials slow/retard diffusion
 - small pored materials
 - e.g., concrete, brick, stone
- Some stop, or practically stop it
 - crystals, or micropore
 - e.g., many plastics (poly), metals, glass

