%rh

Why, What & How

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Rotronic Instruments (UK) Ltd
Wednesday, 14th January 2015 CIBSE Webinar

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MEASUREMENT SOLUTIONS

Introducing myself

Rotronic Instruments
Sales, training and consultancy role

Forest Research
Regenerating brownfield land through novel decontamination technologies

C-Cure Solutions Ltd
Joint founder of spin-out aimed at commercialising charcoal technologies

PhD from Surrey University
Decontamination of mining sites by novel charcoals

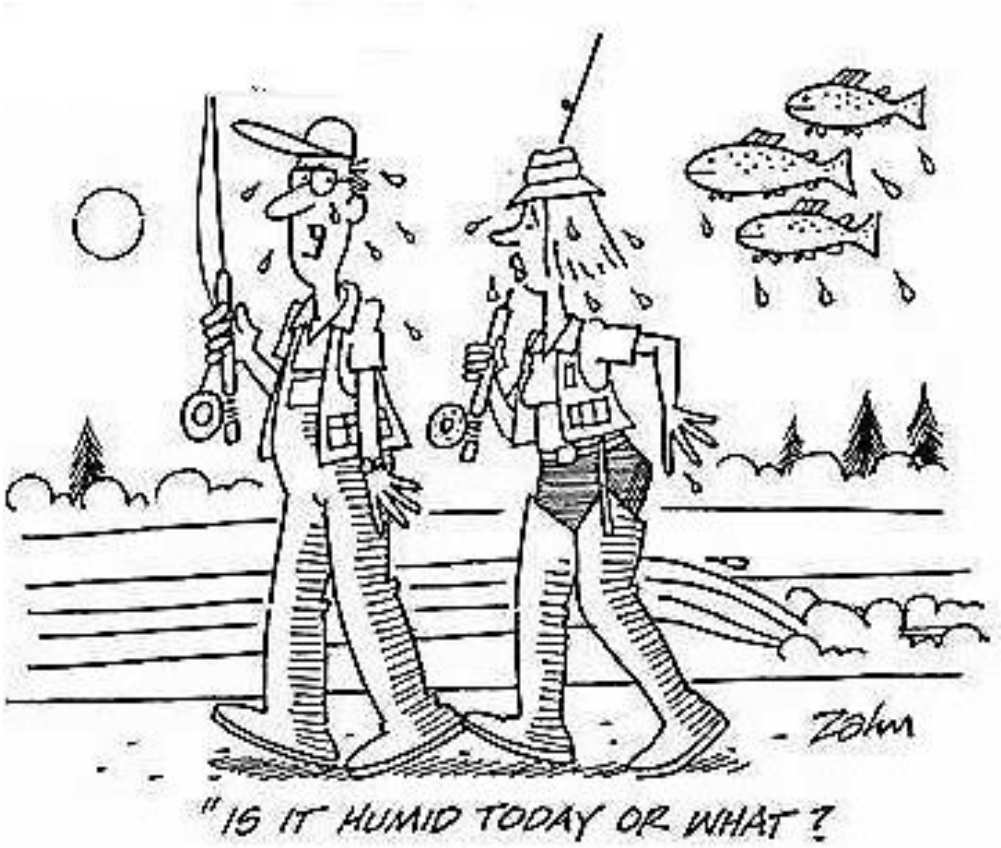
Contents

Why is humidity important (in buildings)

1. Human comfort
2. Human Health
3. Conservation
4. Energy

WHY IS HUMIDITY IMPORTANT

1. Human Comfort



Sweating = Evaporation

↓ *%rh makes you feel colder*

Human comfort

- Temperature
  - » *Radiated and Air*
- Humidity
- Air velocity

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WHY IS HUMIDITY IMPORTANT

2. Human Health

Dust Mites

- ↓ 50%rh is fatal
- ↑ %rh is worst

Pathogen Survival in Air

- 40-60%rh most lethal for viruses
- ↓ %rh is worst (winter)

Mould

- ↑ %rh & poor ventilation

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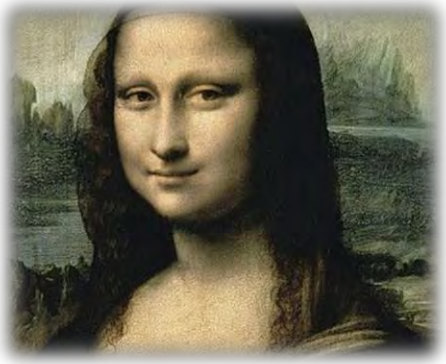
3. Conservation



Condensation

- *Mould & Rot*
- *Condensing on windows*

Heritage & Storage

- Museum artefacts
- Records

Reliability

- Maintaining equipment etc

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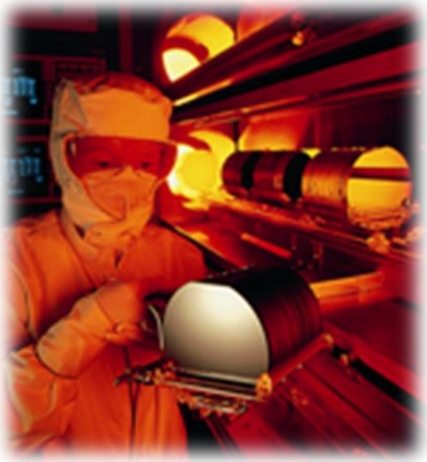
WHY IS HUMIDITY IMPORTANT

4. Energy & Efficiency



Building Control

- *Better measurements*
- *Intelligent control*
- *Sensitive products*

Process Control

- Save time and money
- Ensure consistent product

Regulation

- Ever increasing…

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What is humidity

1. States of matter

2. Relative Humidity

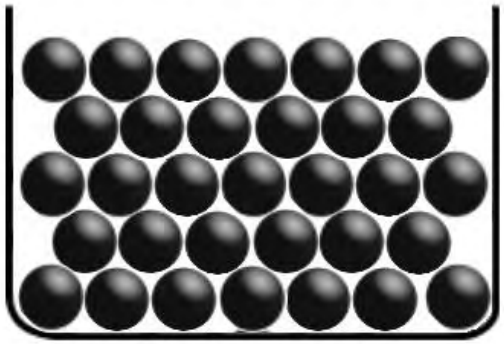
3. Other psychrometric parameters

1. States of Matter

Solid

- **Definite shape and volume**

Particles are closely packed and only vibrate

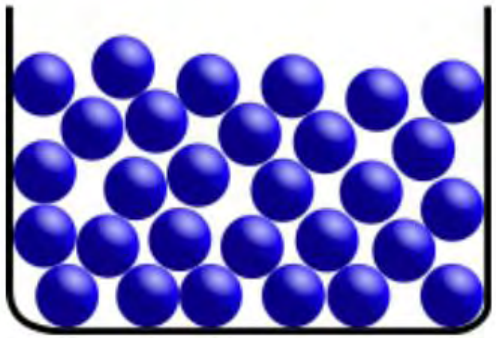


2. States of Matter

Liquid

- **Definite volume**

Particles flow to take shape of container

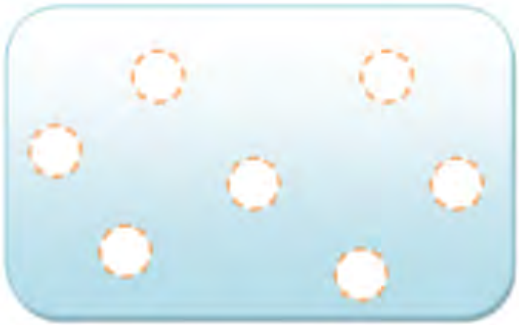


3. States of Matter

Gas (Water Vapour)

- **Neither volume or shape**

Particles will expand to fill a space

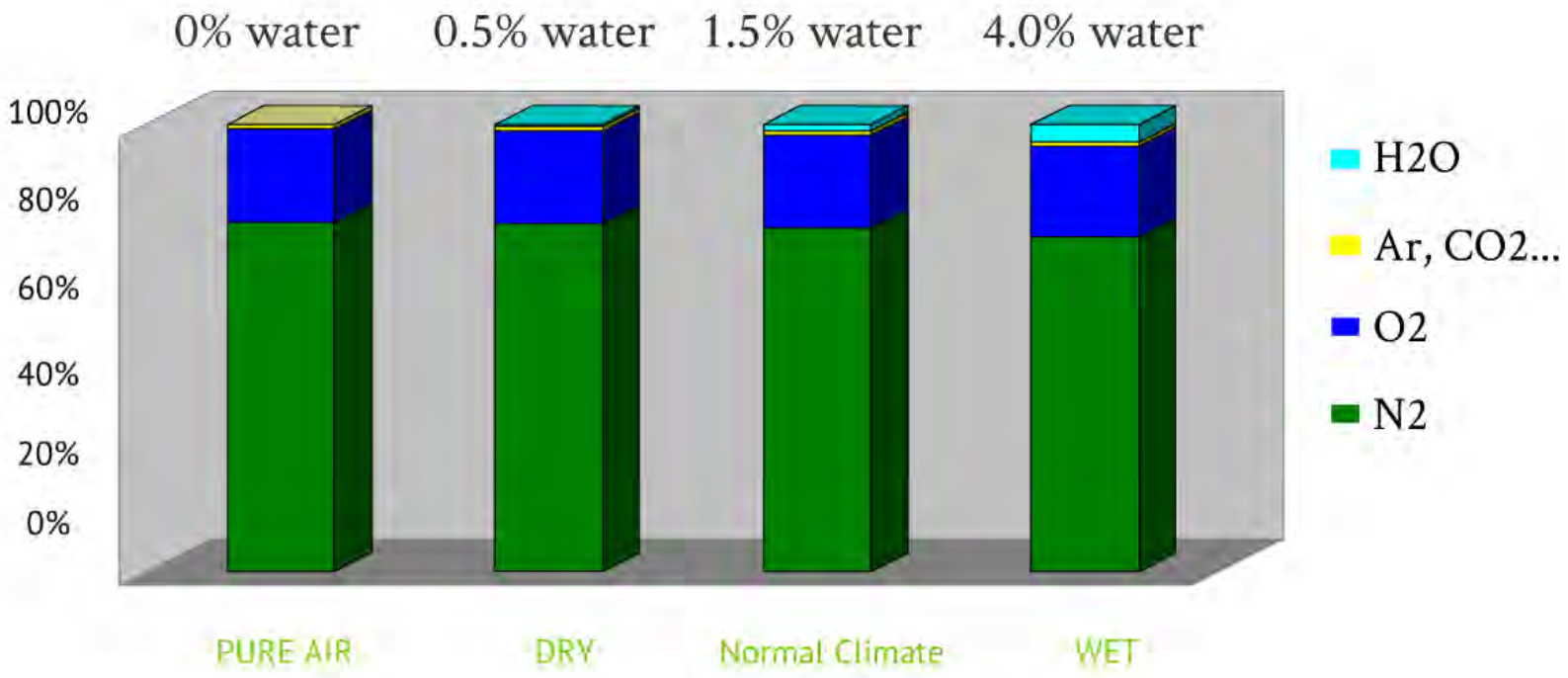


4. Dalton's Law of Partial Pressures

In a gas mixture such as room air the total pressure can be expressed as…

P(water) = vapour pressure

5. Composition of Air



Components of air (all in gas form)

% water vapour (by volume)

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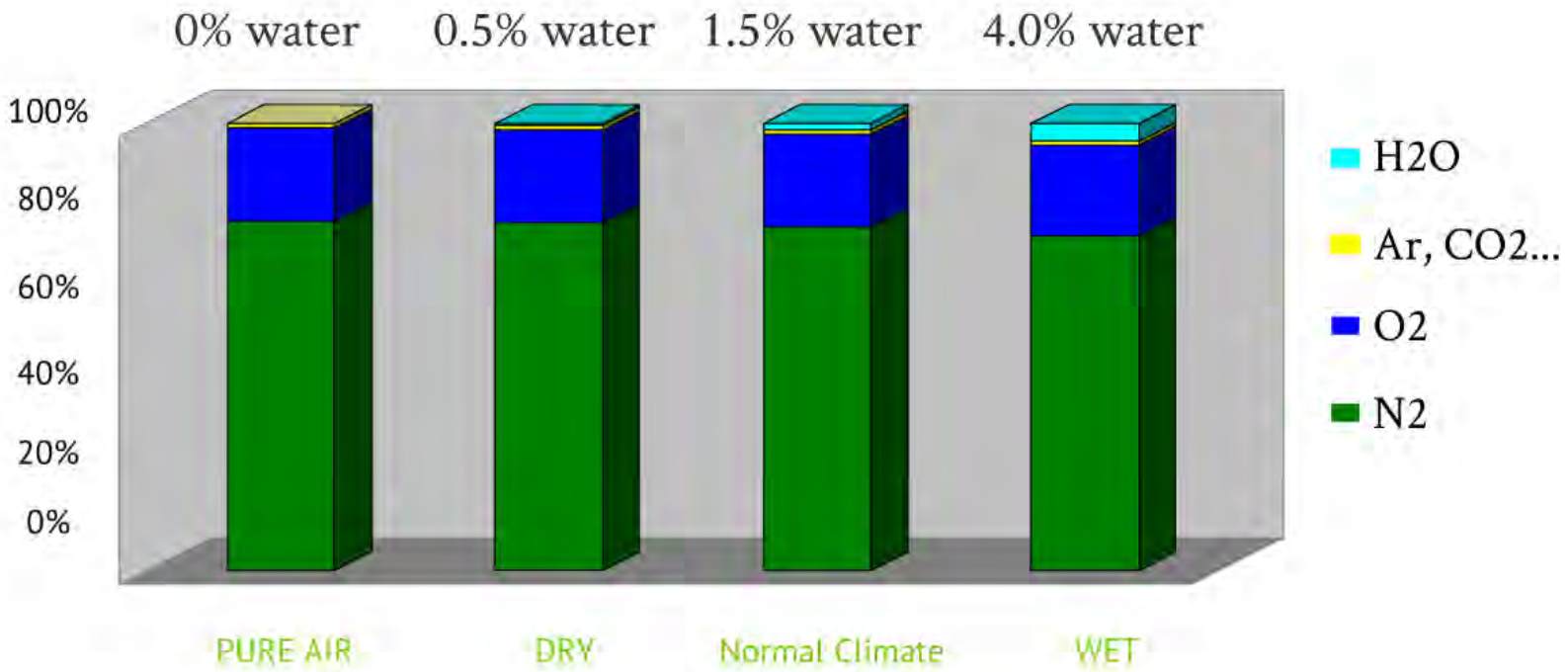
6. Composition of Air



0%rh **~12%rh** **~35%rh** **~95%rh**

(air at ~30 ˚C)

What about %rh?

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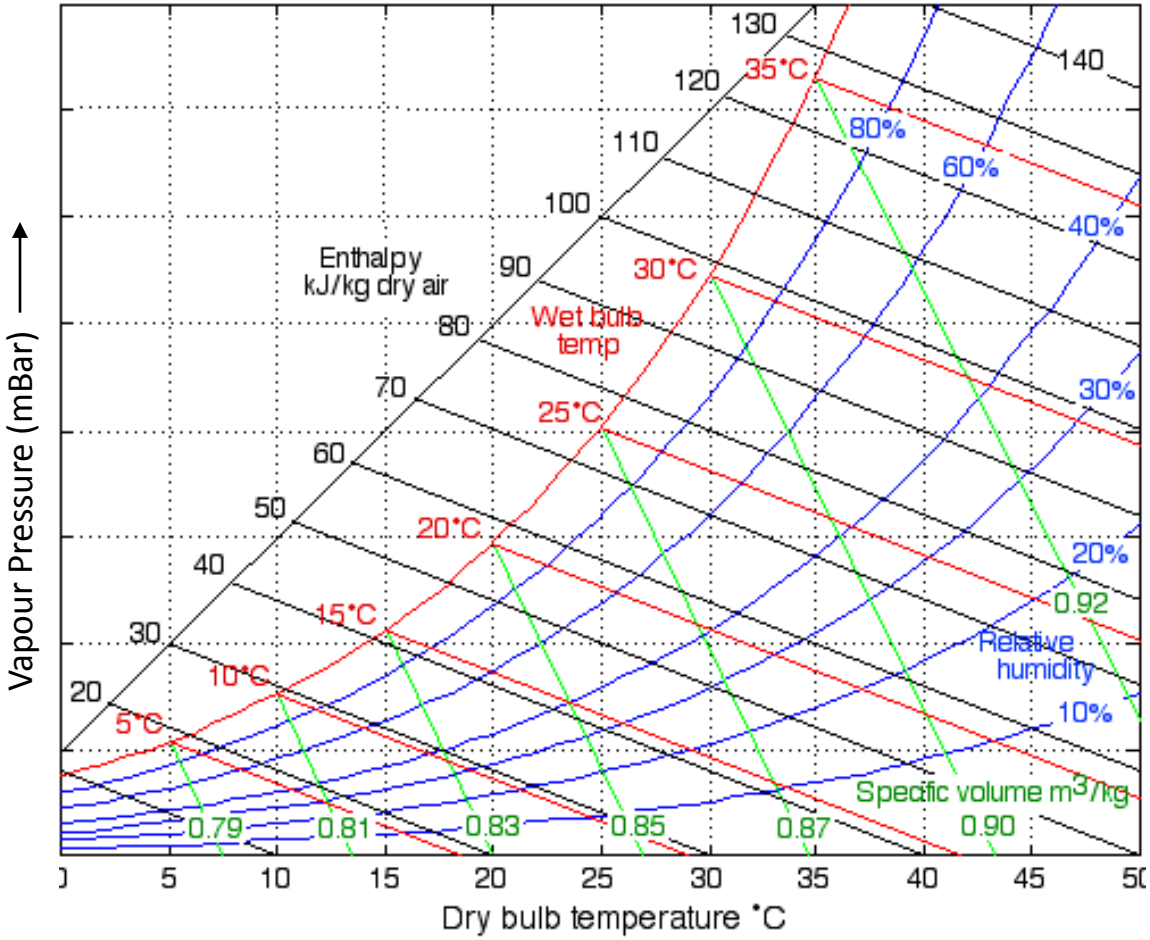
7. Recap!

- Water (H2O) in the gas phase is called VAPOUR
- Water vapour is transparent
- The amount of gas can be stated as a partial pressure
- Air typically holds ~1 - 4 % water vapour (10 - 40 mbar)
- AIR CAN ONLY HOLD A LIMITED AMOUNT OF WATER VAPOUR!

8. Last but not least

- Hotter air can support **more water vapour**
- When air can hold no more water it is **SATURATED**
- The partial pressure at this exact point is called the **SATURATION VAPOUR PRESSURE**

9. Psychrometric Charts



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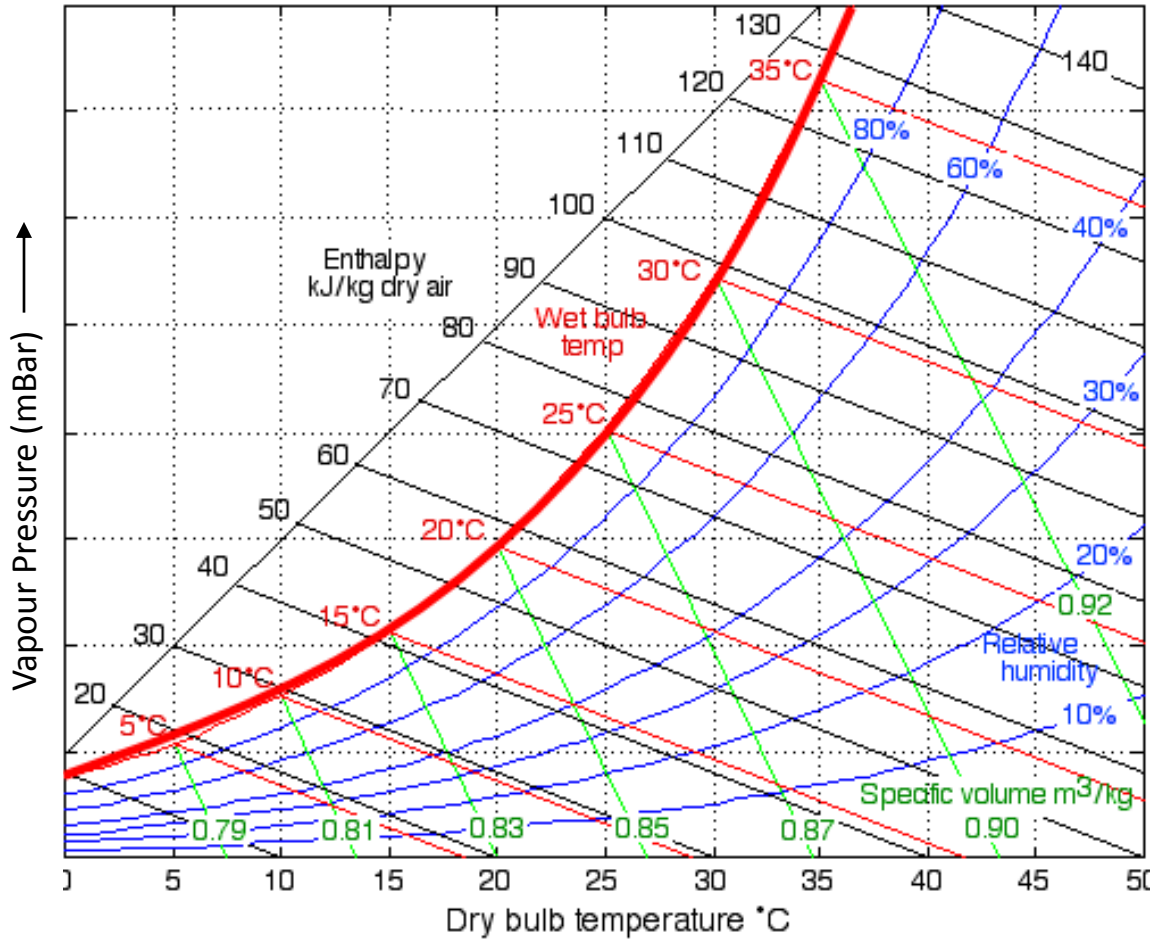
10. Psychrometric Charts



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11. So… Relative Humidity

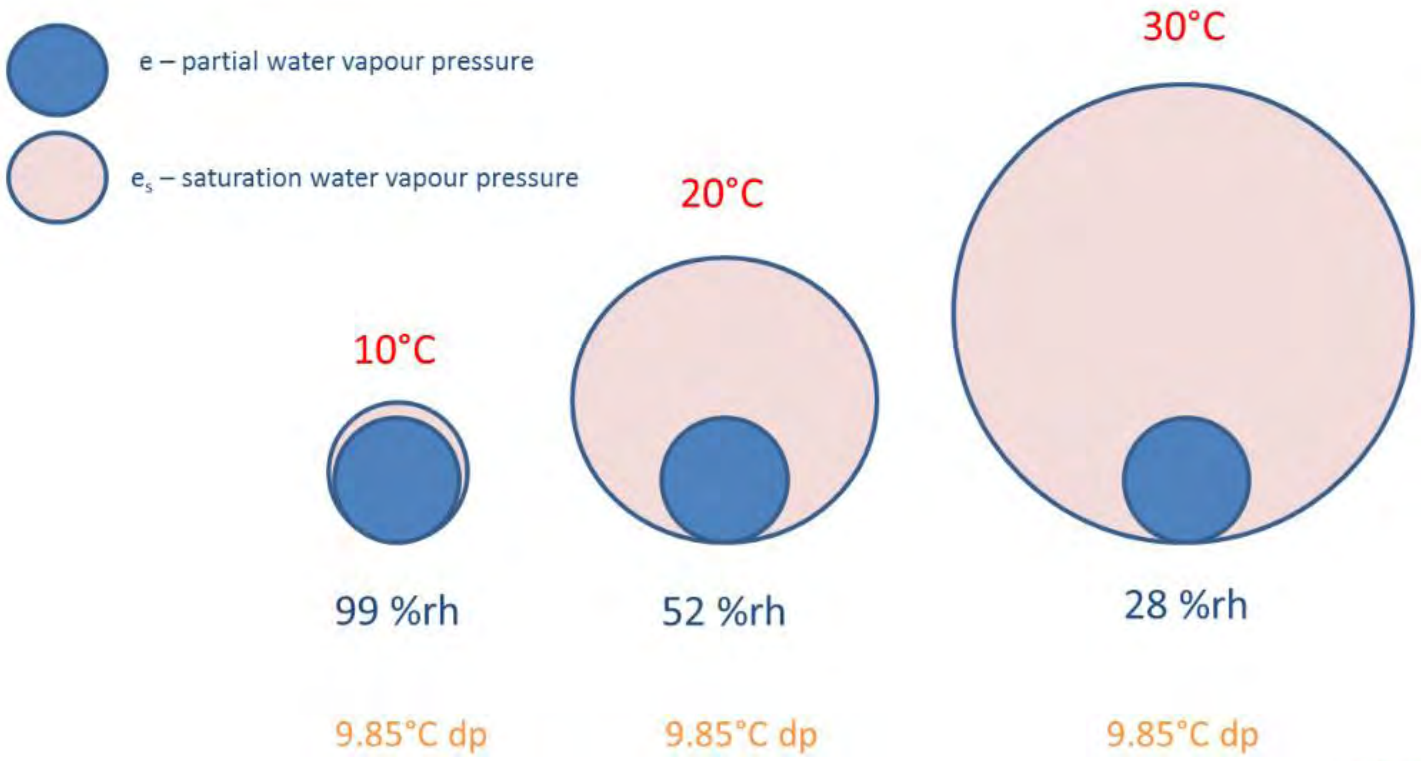
- The ratio of actual water vapour pressure against the saturation vapour pressure (in %)

I.e…

how much water vapour **is in the air**
compared to
how much water vapour **there could be in the air**

Relative humidity therefore is EXTREMELY temperature dependent!!

12. Effect of temperature



Same amount of water, different %rh

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13. Other parameters

- **Dew point**
  The temperature to which you need to cool a gas in order for saturation (condensation) to occur

- **Mixing ratio (absolute humidity)**
  Mass of vapour per unit mass of dry gas
  Dimensionless ratio although g/kg is often used

- **Wet Bulb**
  The temperature to which a thermometer covered with a wet ‘wick’ will cool (due to evaporation)

- **Enthalpy**
  Of the dry air and evaporated water

Measuring Humidity

1. Overview of instruments

2. Typical measurement problems

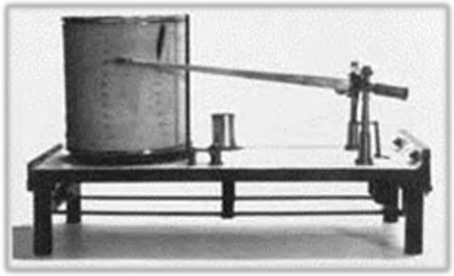
3. Best practice when taking measurements

1. Historic methods...

- **Mechanical**

  Horse Hair / Cat Gut!

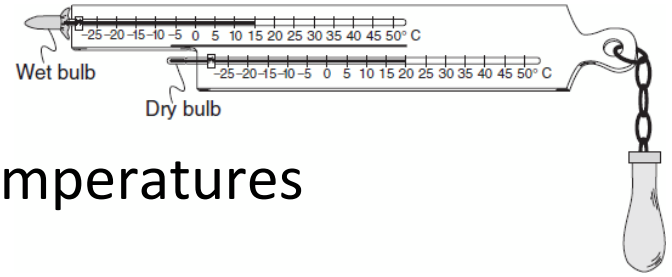
  - Poor accuracy
  - Poor repeatability
  - Slow response



- **Psychrometer**

  Measurement of wet and dry bulb temperatures

  - Still used in chamber control
  - Requires regular cleaning and service
  - Not reliable for building control



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2. Relative Humidity Sensors

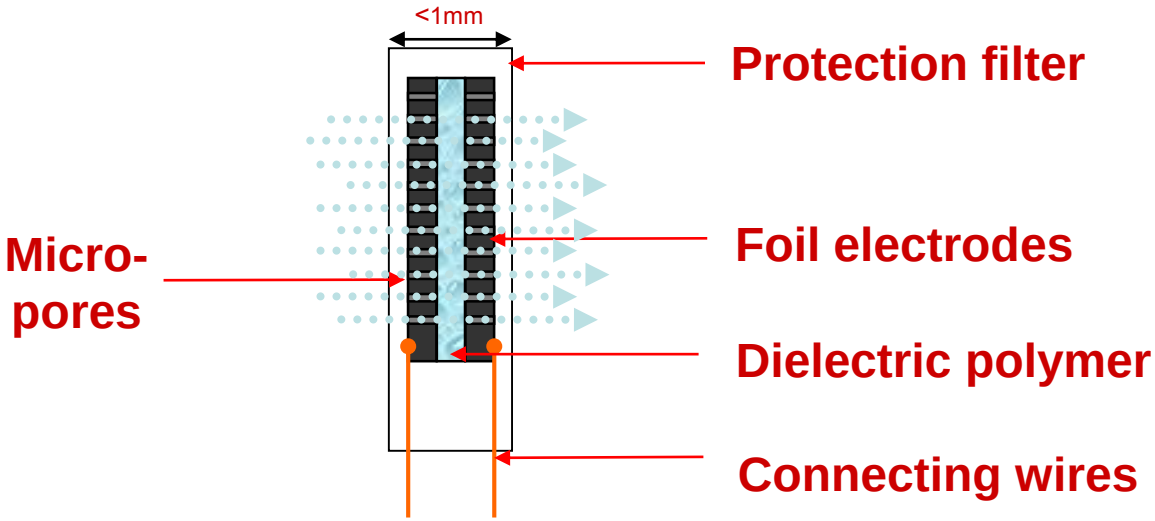
Very widely used

Highly practical

Based around variations in electrical properties of polymers

- Resistive or Capacitive

Factory adjusted to provide %rh measurements



3. Relative Humidity Sensors

- **Pros**

  Fast response

  Robust

  Wide operating range

  Low cost

- **Cons**

  Stability and repeatability

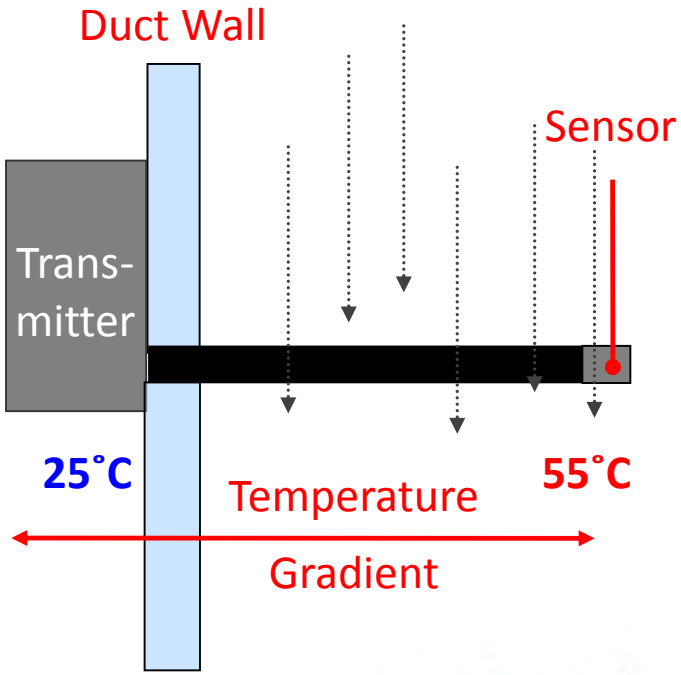
  Temperature dependence

  Drift

  Contamination effects

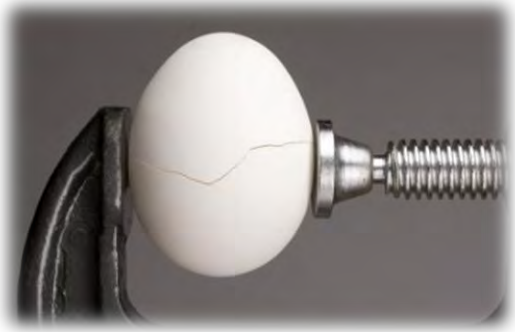
4. Typical Humidity Measurement Problems

- **Temperature Effects**
  - Calibration
  - Check instrument reflects the true application temperature
  - Stabilisation time
  - Stem conduction
  - Self heating
  - Temperature coefficients



5. Typical Humidity Measurement Problems

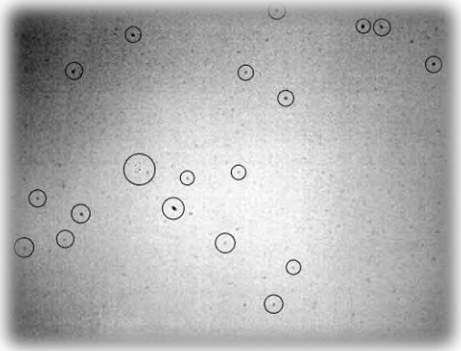
- **Pressure Effects**
  - Does not effect %rh
  - Some parameters are (eg. dew point)

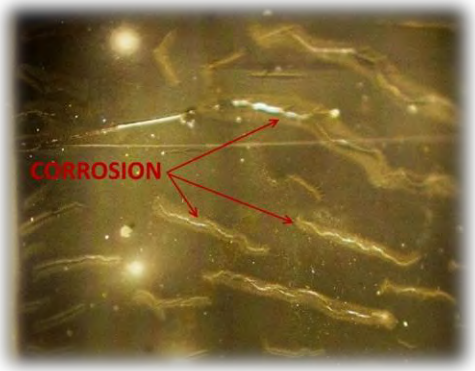


- **Drift**
  - ALL humidity sensors drift over time
  - Varies
    - Manufacturer
    - Filters
    - Application
    - Regular calibration

6. Typical Humidity Measurement Problems

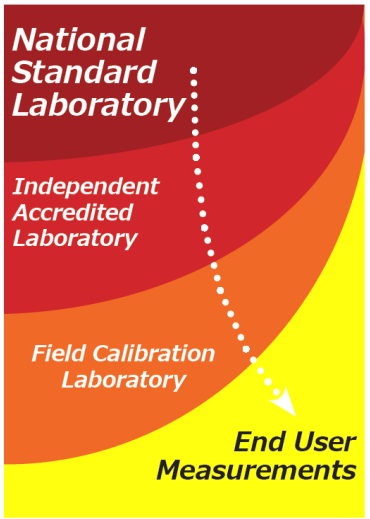
- **Contamination**
  - ➢ Particulate deposits
    - ❖Become part of the sensor
  - ➢ Chemical attack
    - ❖Solvents
    - ❖Atmospheric pollution
  - ➢ Filter maintenance
    - ❖Correct filters
    - ❖Regular replacement





7. Best Practice Notes

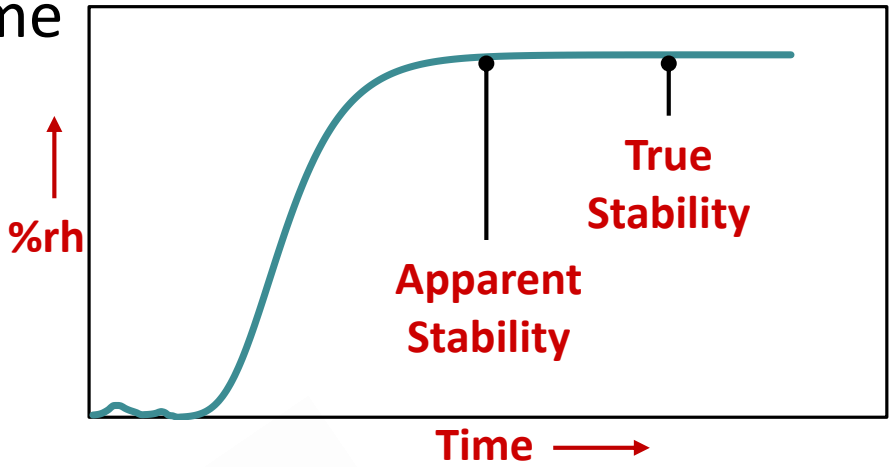
- Use quality reference instruments when commissioning with traceability to national standards



- Ensure good insertion and seal when measuring ducts

8. Best Practice Notes

- Ensure suitable stabilisation time
  - ❖ Log 30 minutes of data
  - ❖ Measure until stable
  - ❖ Consider both ˚C and %rh



- Ensure regular calibration of references and store carefully

- Loop check analogue systems for other errors

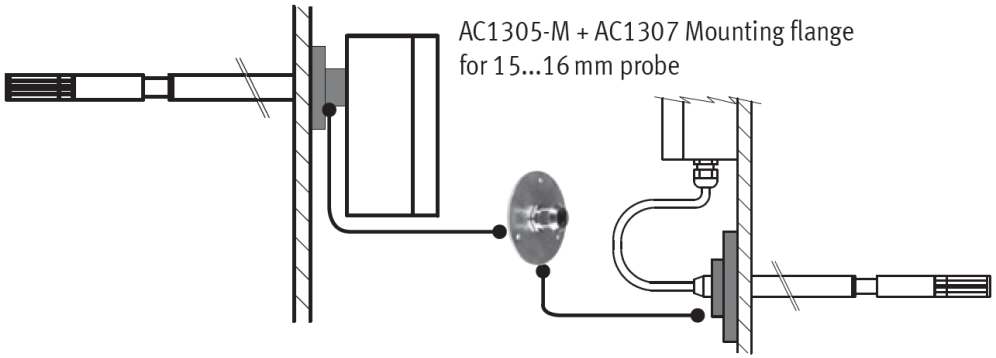
Controlling Humidity

1. Sensor locations

2. A note on accuracy

1. Sensor Locations

- Representative location with good air movement
- Avoid close proximity to;
  - ❖ Heaters
  - ❖ Cooling coils
  - ❖ Steam injectors
  - ❖ High air turbulence



- Install duct sensors into air flow (reduces stem conduction)
- Immerse sensors as much as possible

2. Sensor Locations

- Consider using temperature independent parameters

  Desired *condition* = *50%rh @ 23 ˚C*
  = *8.74 g/kg (mixing ratio)*

  Control hum and dehum system to 8.74 g/kg (independent of temp)
  Ensure room temp is 23 ˚C and %rh will be as required

- Outside air sensors
  - ❖ North facing wall
  - ❖ Mounted in a weather shield
  - ❖ Away from other heat / humidity sources

3. A note on accuracy

- Always consider accuracy and drift (what is best long term?)
- Measuring humidity is hard (3333x worse than temperature)
  - UK National Standards; ±0.1-1.0%rh vs ±0.0003 °C
- The very best %rh sensors claim ± 0.5%rh…±1.0%rh
- Temperature effects can be huge (~5%rh / 1.0°C error)
- As such close control for humidity is not easy!

Don’t forget…

Measuring humidity is all about temperature

Precision humidity measurement & control is not easy

Calibration is the only way to confirm performance

CIBSE Article on NPL Project

Rotronic White Paper on Modern Monitoring and Control

Thank You!

Any questions?

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