Relative Humidity & Dew Point, The Basics

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Webinar Presenters & Humidity Experts

Bruce McDuffee

Michael Boetzkes

David Love

Agenda & Takeaways

Agenda

- Why RH & Dew Point
- Relative Humidity Theory
- Dew Point Theory
- Make a Better Measurement

Takeaways

- Knowledge helps avoid poor processes
- Temperature & RH
- Pressure & Dew Point
- Know what your sensor is measuring

Why RH & Dew Point?

- 90% of humidity instrument's sensors react to RH or dew point.
- RH sensors are problematic because of sensitivity to temperature variances.
- Dew point is the least understood parameter.

RH

T_d

Other Parameters

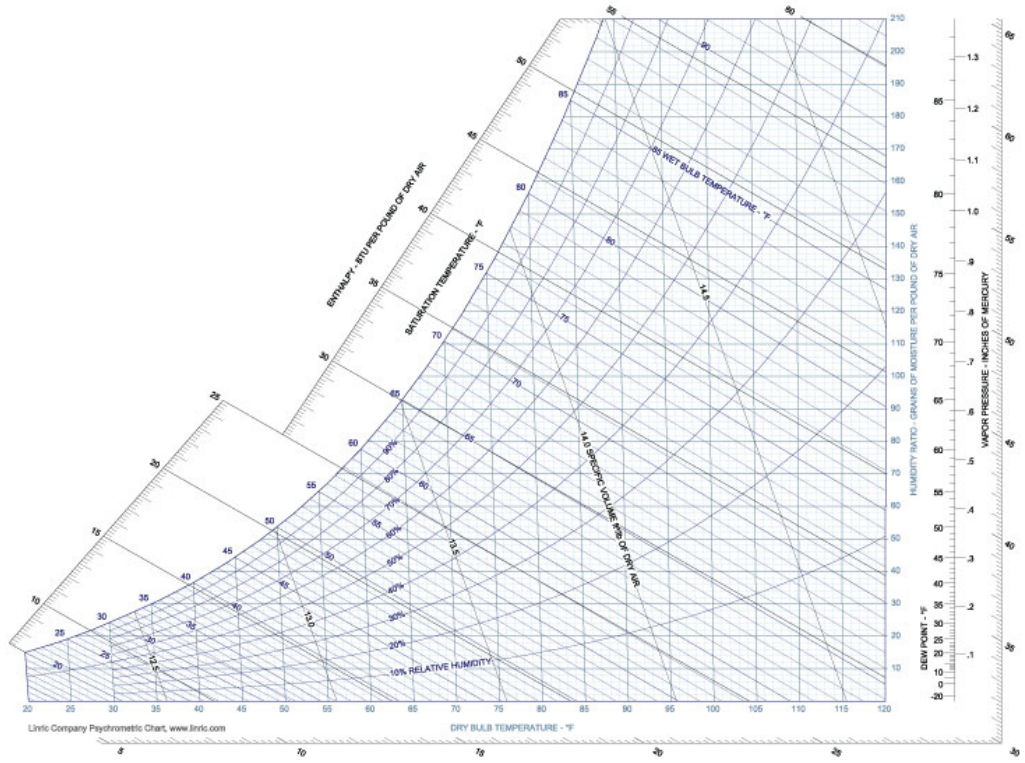
Mixing ratio

Absolute humidity

Vapor pressure

Frost point Enthalpy

ppm_v Wet bulb



www.rotronic-usa.com/humidity-academy/humidity-measurement-tools/

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Relative Humidity Theory

Takeaway for better measurement:

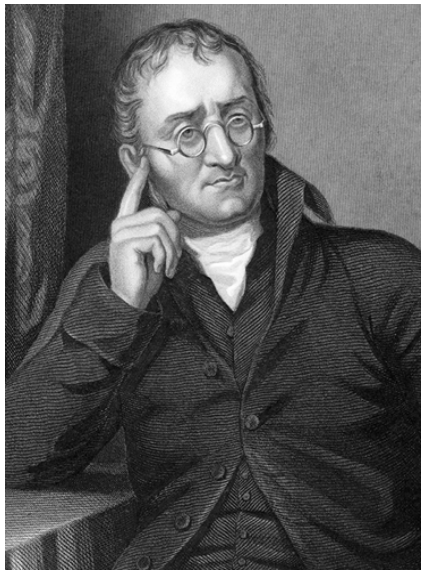
- Temperature must be uniform and representative.
- As temperature rises, RH decreases.
- As temperature goes lower, RH increases.
- As pressure in a closed container increases, RH increases
- As pressure in a closed container decreases, RH decreases

Partial Pressure of Water Vapor (p)

aka vapor pressure

Dalton's Law of Partial Pressures:

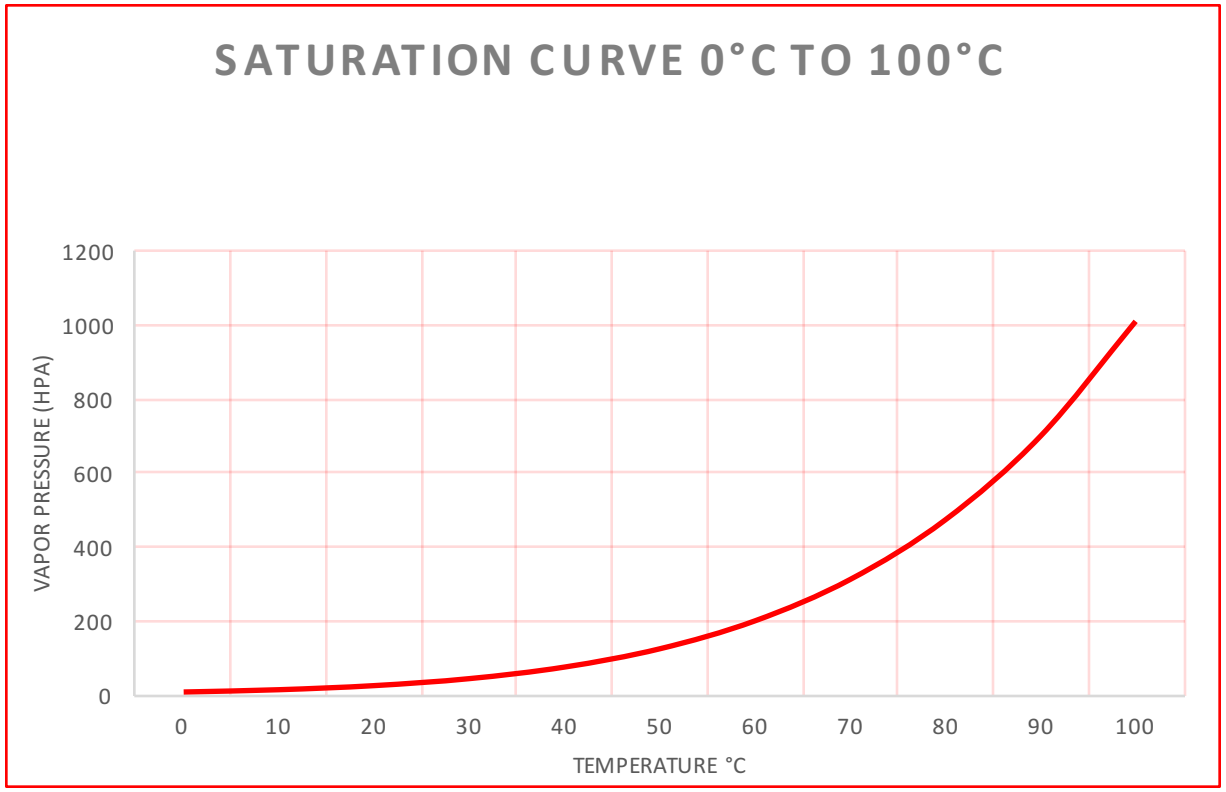
- *The total pressure of a gas mixture is equal to the sum of the partial pressures of the individual gas components.*



John Dalton

$$P_t = P_1 + P_2 + P_3 + \ldots P_n$$

Saturation Vapor Pressure (p_s)



The saturation vapor pressure is the pressure of a vapor when it is in equilibrium with the liquid phase. It is solely dependent on the temperature. As temperature rises the saturation vapor pressure rises as well. - CMMAP.org

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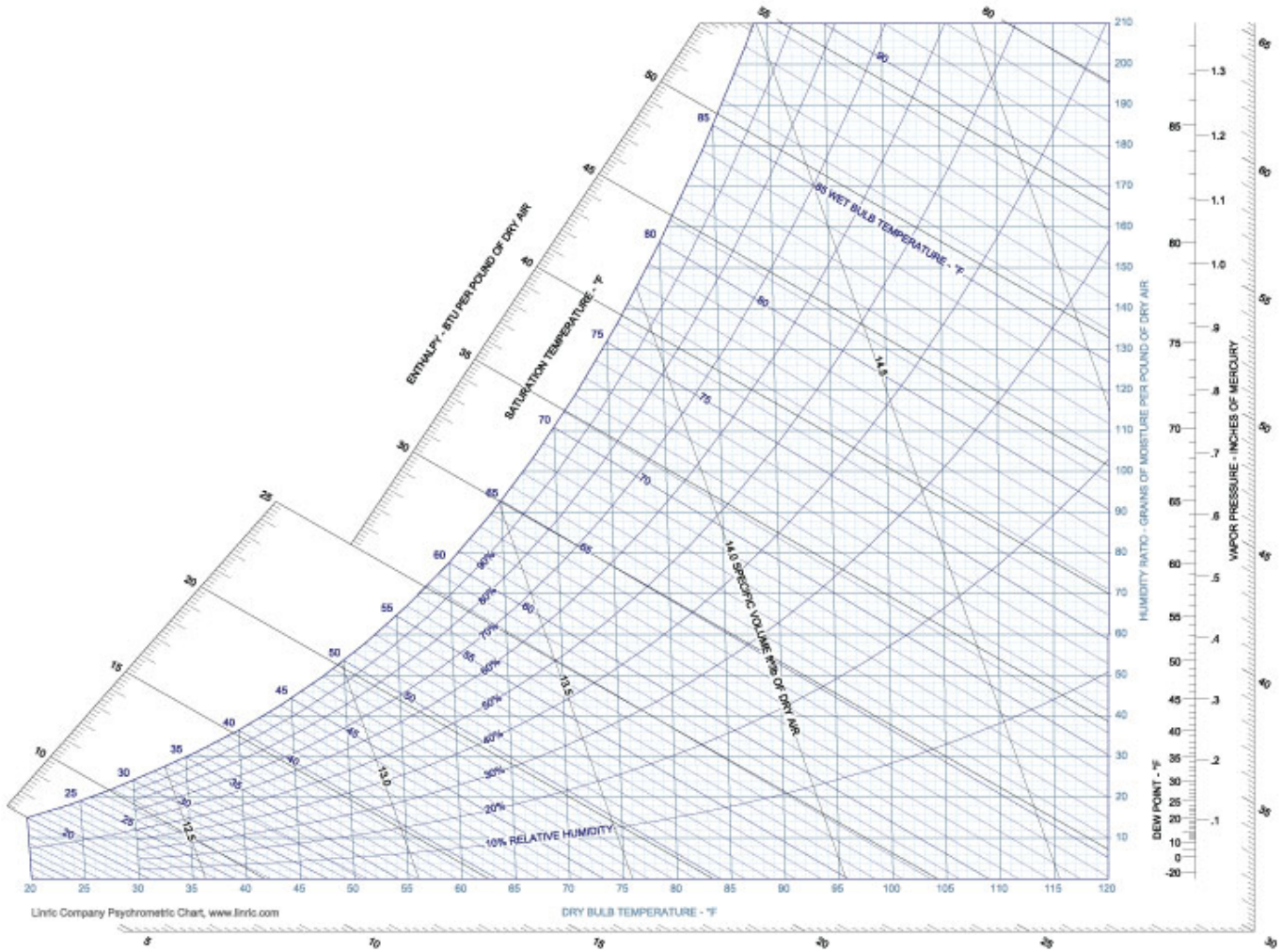

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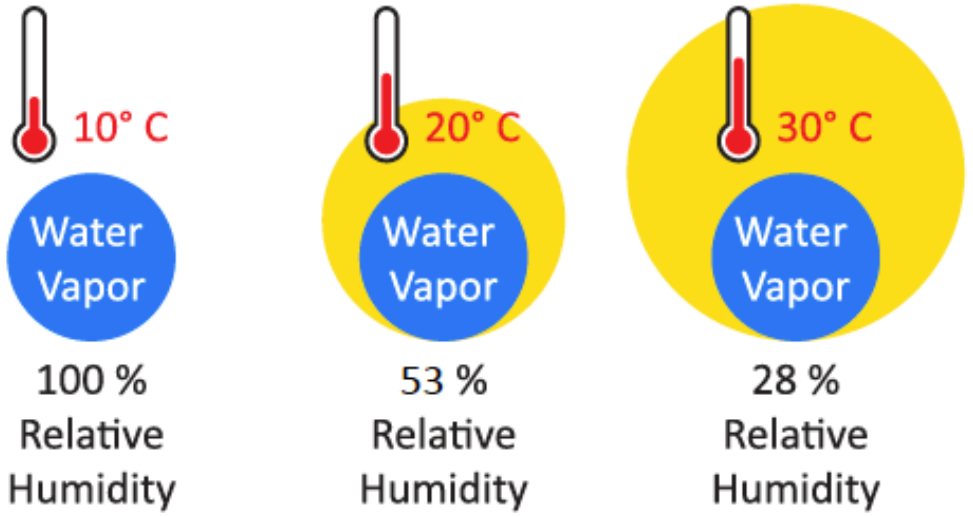
Relative Humidity

$RH = p/p_s$

p=partial pressure
p_s=saturation pressure



p=12.3 hPa
p_s=12.3 hPa

p=12.3 hPa
p_s=23.4 hPa

p=12.3 hPa
p_s=42.4 hPa

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Why is temperature so critical?

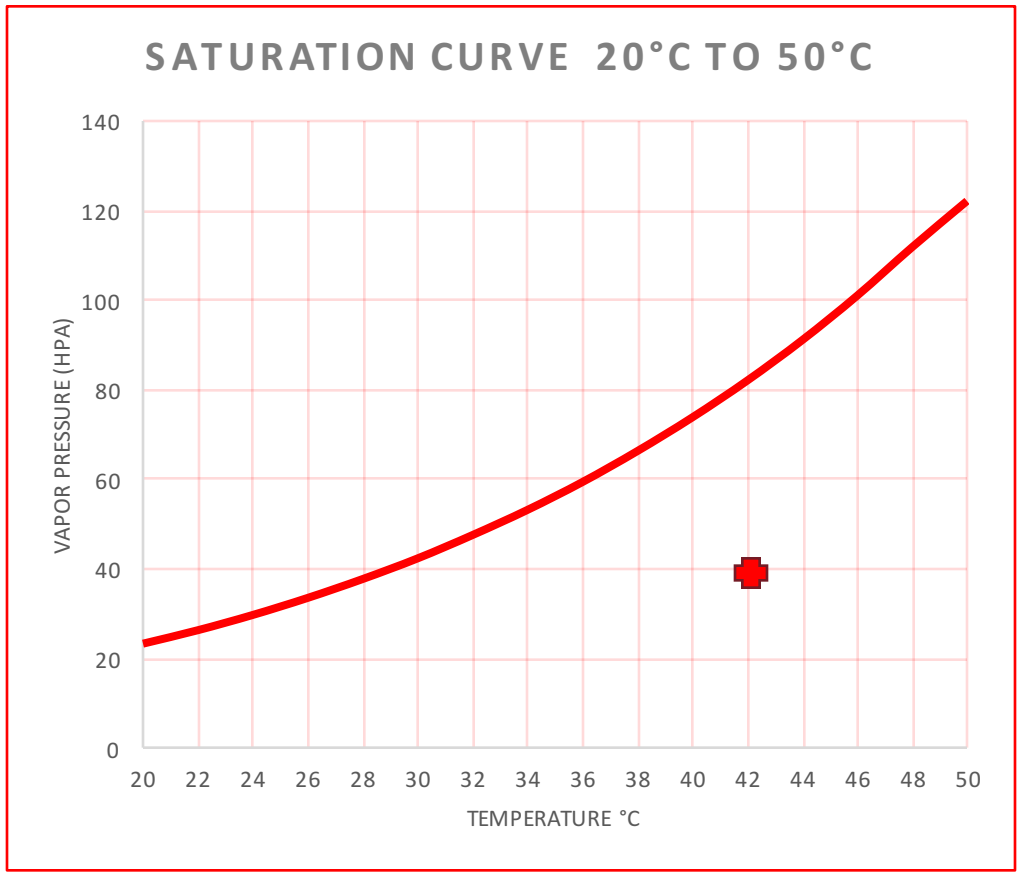
- p (partial pressure) does not change as the temperature changes.
- p_s does change as temperature changes

$$RH = p/p_s$$

p=partial pressure
p_s=saturation pressure

T	p	p_s	RH	△
40℃	40 hPa	73.8 hPa	54.2%	
39℃	40 hPa	69.9 hPa	57.2%	+ 3.0%
41℃	40 hPa	77.8 hPa	51.4%	- 2.8%
38℃	40 hPa	66.3 hPa	60.3%	+ 6.1%
42℃	40 hPa	82 hPa	48.8%	- 5.4%

Temperature Effects



T = 42°C
p = 40 hPa
p_s = ?
RH = ?

Increase T = 50°C
p =
p_s = ?
RH = ?

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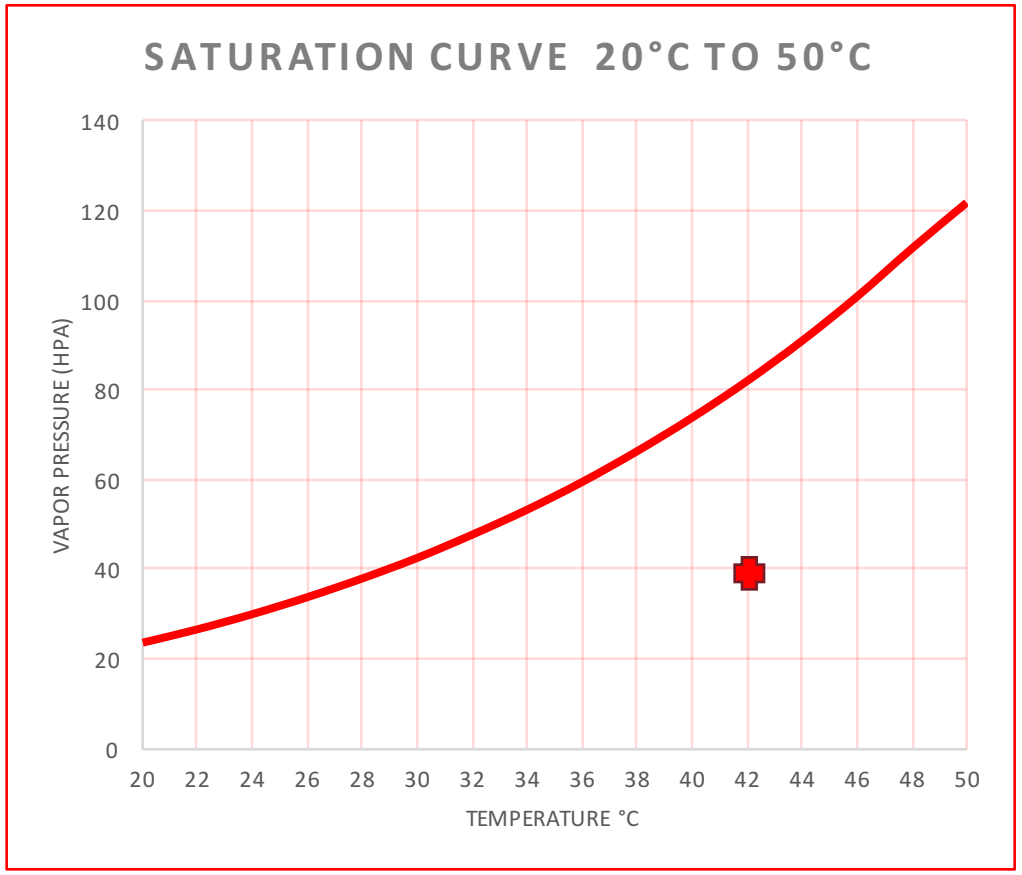
RH and Pressure (closed container)

- p (partial pressure) does change as the pressure changes.
- p_s does not change as pressure changes.

$$RH = p/p_s$$

p=partial pressure
p_s=saturation pressure

Pressure Effects (closed container)



T = 42°C
p = 40 hPa
p_s = 80 hPa
RH = 50%
Pressure = 1013 hPa

Increase P 2x = 2026 hPa
T = 42°C
p =
p_s = ?
RH = ?

Hint: Dalton's Law

$$P_t = P_1 + P_2 + P_3 + \ldots P_n$$

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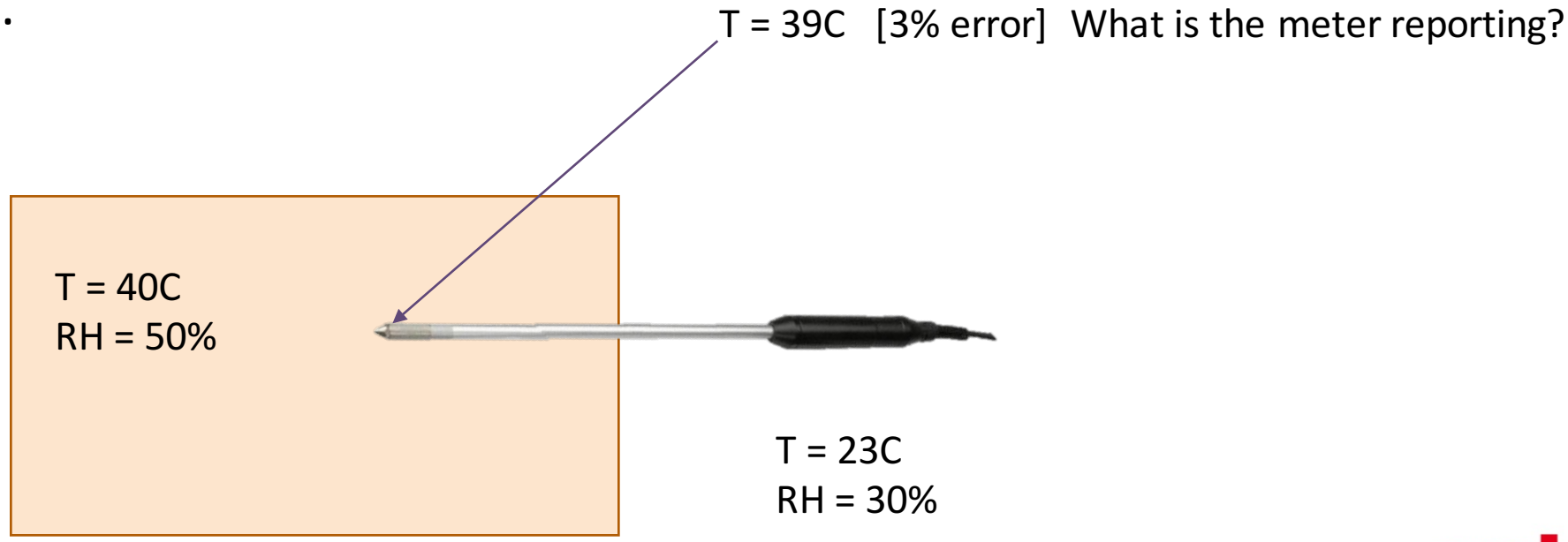
The RH Measurement Challenge

- Non-representative sources of heat or cold
- Non-uniform temperature between measurement device and gas being measured.



Comments & Questions

Please type your questions into the chat box at the lower left portion of your screen.

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Dew Point Theory

Takeaway for better measurement:

- Know if your instrument is measuring or calculating.
- Know what the calculation is based on; pressure or ambient, dew or frost.
- Pressure differences will change the measurement.

Definition of Dew Point Temperature

- Dew point temperature is the temperature at which water vapor will begin to condense.
- The temperature at which a moist gas is saturated over a plane surface of pure liquid water.

Takeaway – Dew point temperature does not change as temperature changes.

What about Frost Point?

- The temperature at which a moist gas is saturated over a plane surface of pure ice.

Note – Dew point is lower than frost point (by about 4C at -40).

Dew Point & Pressure

- As pressure increases, dew point temperature goes up towards saturation.
- As pressure decreases, dew point temperature drops.

PSI	Dew point	Frost point
90	-41.1C	-37.6C
100	-40C	-36.6C
110	-39.1C	-35.8C

When to use Dew Point?

- Goal is to avoid condensation
- Very dry application (< 10% RH)
- Compressed air systems

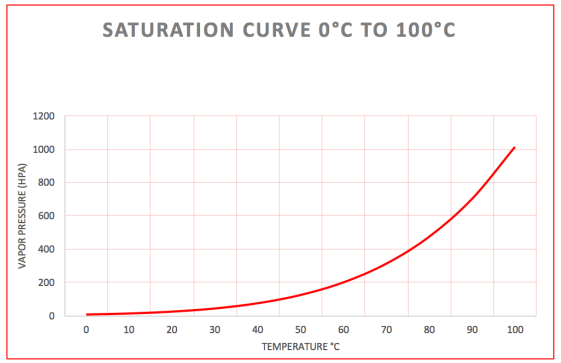
Takeaways for a Better Measurement

RH Requires Uniform Temperature

- RH sensors are very sensitive to temperature.
- Measurement probe must be uniform temperature.
- Measurement point must be representative.

$$RH = p/p_s$$

p=partial pressure
p_s=saturation pressure

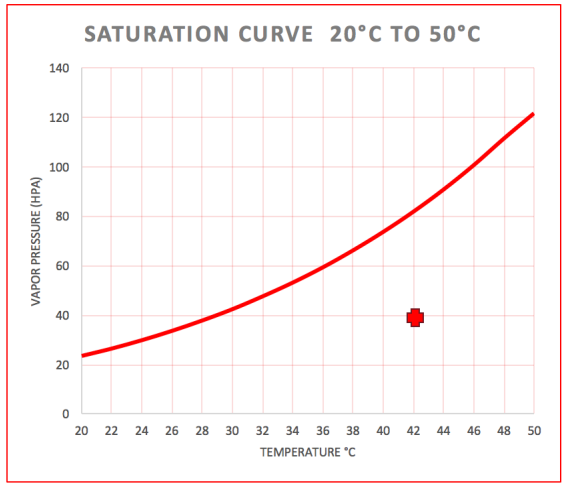


Relative Humidity – Rules of Thumb

- As temperature increases, RH decreases
- As temperature decreases, RH increases

In a closed container:

- As pressure increases, RH increases
- As pressure decreases, RH decreases



Dew Point

- Dew point changes with pressure.
- Dew point does not change with temperature.
- Ensure pressure is consistent with point of interest.
- Use dew point when condensation is a concern or in very dry gas.

Comments & Questions

If we don't get to your question today, we'll respond via email after the webinar.

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Humidity Academy

- Resources for making a better measurement
  - Psychrometric charts
  - Technical notes
  - Humidity calculator
  - Application notes
  - more

www.rotronic-usa.com/humidity-academy

Next Webinar

Pros and Cons of Humidity Measurement Technologies

- Thursday, September 17th
- Register at www.rotronic-usa.com/humidity-webinars
- We'll cover these humidity measurement technologies;
  - chilled mirror
  - resistive
  - capacitive
  - psychrometer (wet-bulb/dry-bulb)
  - mechanical
  - metal oxide

Helping you make a better humidity measurement – and more.

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- HVAC humidity, temperature, CO2, diff-press
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- Data loggers for mapping and monitoring
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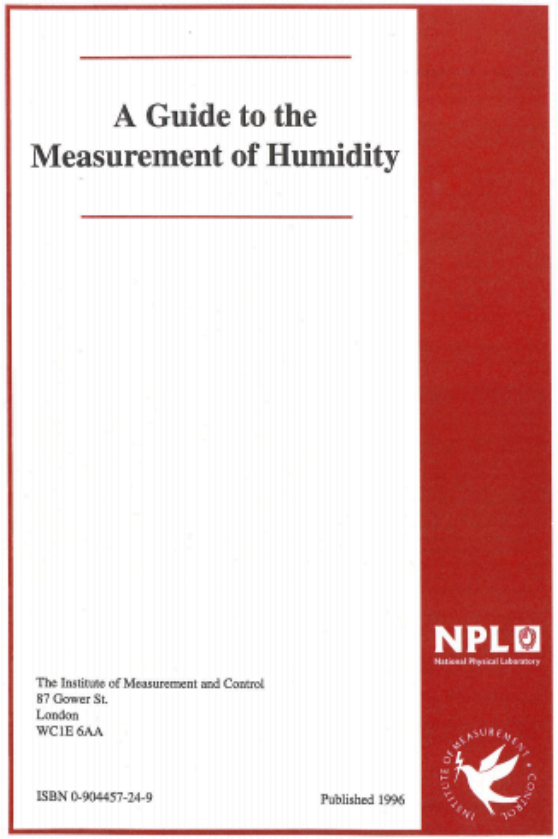

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