Interpreting Humidity Instrument Specifications

Helping you make a better measurement.

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MEASUREMENT SOLUTIONS

Webinar Presenters & Humidity Experts

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Agenda & Learning Objectives

- Examine the metrological meaning of Accuracy
- See how specifications use the term Accuracy
- Looking beyond "Accuracy"
  - Initial performance
  - Long Term Drift (performance after a period of time)
  - Measurements away from the calibration temperature points
- How to compare instruments

What is Accuracy?

Choose the best answer:

A. The closeness of a measurement to the true value

B. Closeness of agreement between a measured quantity value and a true quantity value of a measurand

C. the condition or quality of being true, correct, or exact; freedom from error or defect; precision or exactness; correctness

D. A numerical indication of the overall performance of an instrument during the manufacturer’s recommended calibration interval

Accurate Definition of Accuracy

The VIM (BIPM - International vocabulary of metrology – Basic and general concepts and associated terms)

“closeness of agreement between a measured quantity value and a true quantity value of a measurand”

Bureau international des poids et mesures

Accurate Definition of Accuracy

"closeness of agreement between a measured quantity value and a true quantity value of a measurand"

- **Measurand** - quantity intended to be measured
- **Measured Quantity Value** - quantity value representing a measurement result
- **True Quantity Value** - quantity value consistent with the definition of a quantity
- **Quantity Value** - number and reference together expressing magnitude of a quantity, for example 5 °C, 543 meters

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What does NIST say?

TN1297 Appendix D (reference to VIM)

- "closeness of the agreement between the result of a measurement and the value of the measurand"

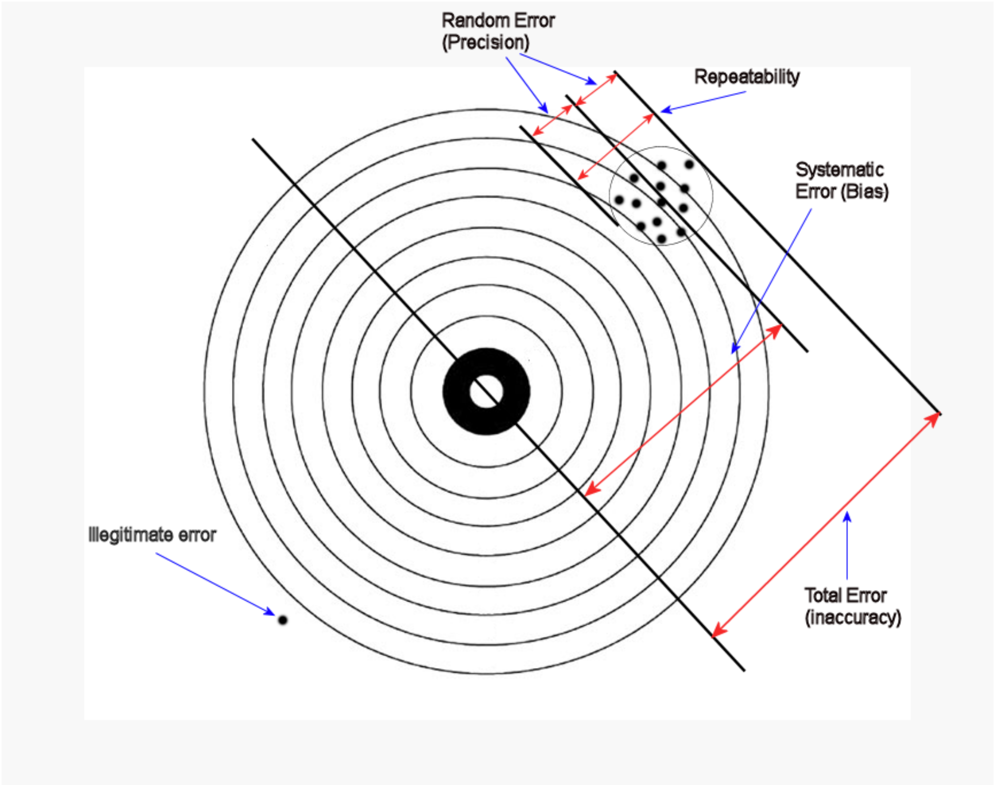
NIST Comments:

- Accuracy is a qualitative concept
- One should not use accuracy quantitatively, that is, associate numbers with it; numbers should be associated with measures of uncertainty instead.

National Institute of Standards and Technology
U.S. Department of Commerce

Common Misconceptions

- Accuracy specification covers everything.
- The other values on the data sheet are all included in the accuracy specification.
- Instrument says accuracy is +/-1% RH then I can expect the error to be less than 1% RH when I send it in for calibration next year.
- The instrument can be used at any temperature and still has an accuracy of 1% RH.



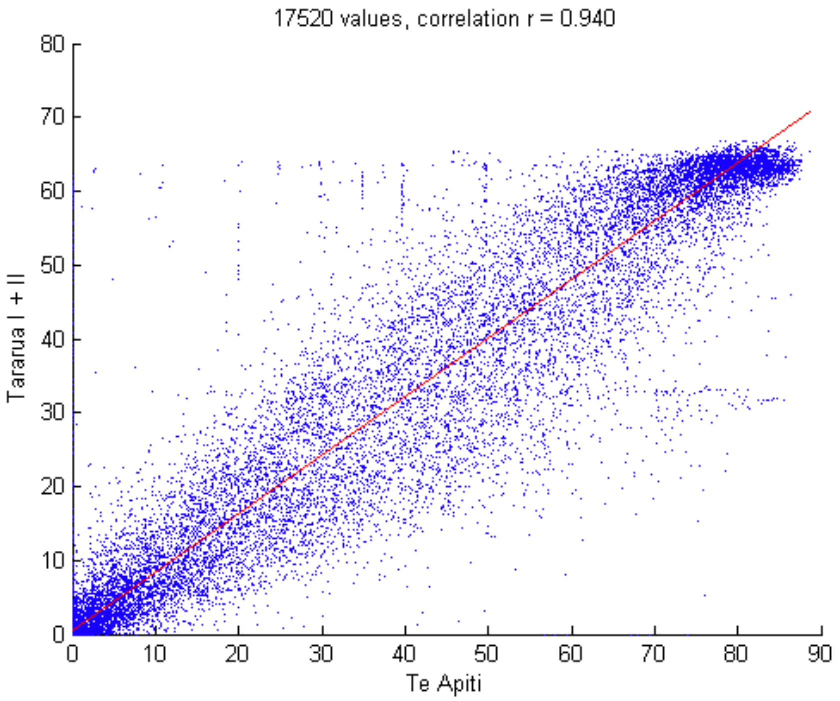
$$U = k\sqrt{u1^2 + u2^2 + u3^2 + u4^2 + u5^2 \ldots\ldots}$$

What does the accuracy specification mean?

Manufacturing limit of difference between the Unit Under Test and the Reference

- Typically includes
  - Linearity
  - Repeatability
  - Hysteresis

- Typically ignores
  - Reference uncertainty
  - Long term drift



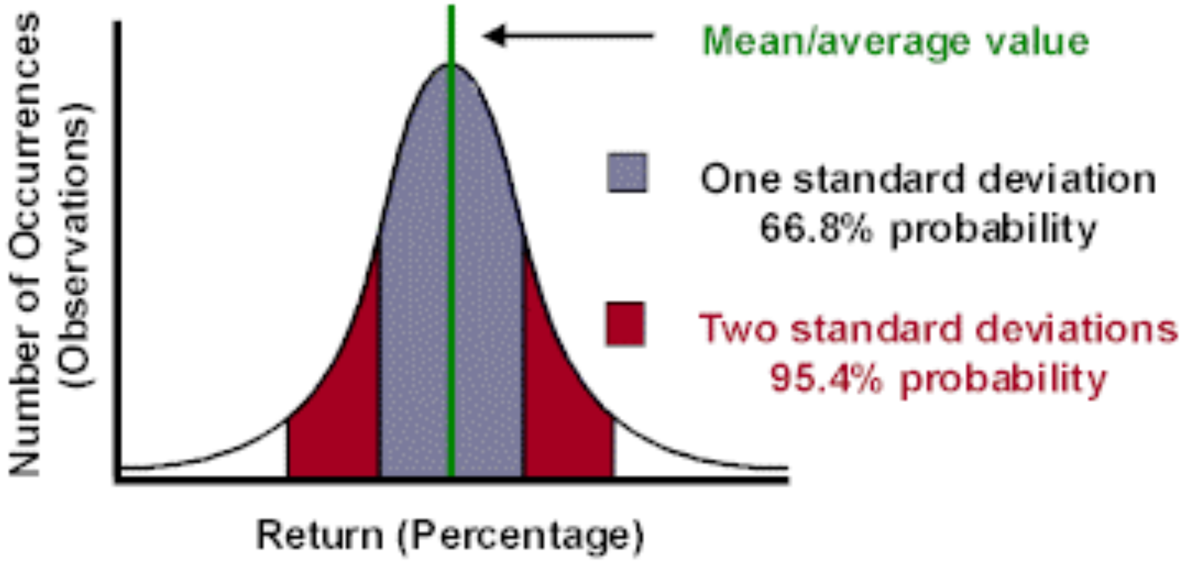
Comments & Questions

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

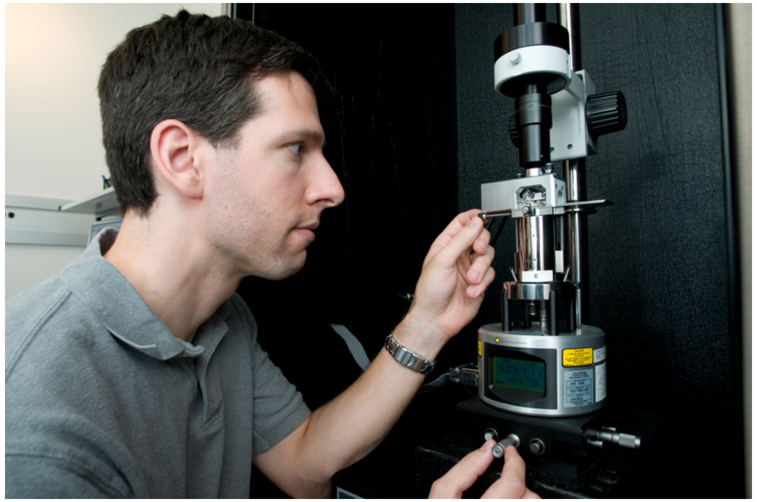
Looking Beyond Accuracy

- Other key parameters
  - Calibration uncertainty
  - Long term drift
  - Temperature compensation

- Often need to look beyond the webpage specifications
  - Data sheets
  - Product/User manuals
  - Ask the manufacturer
  - Calibration certificate



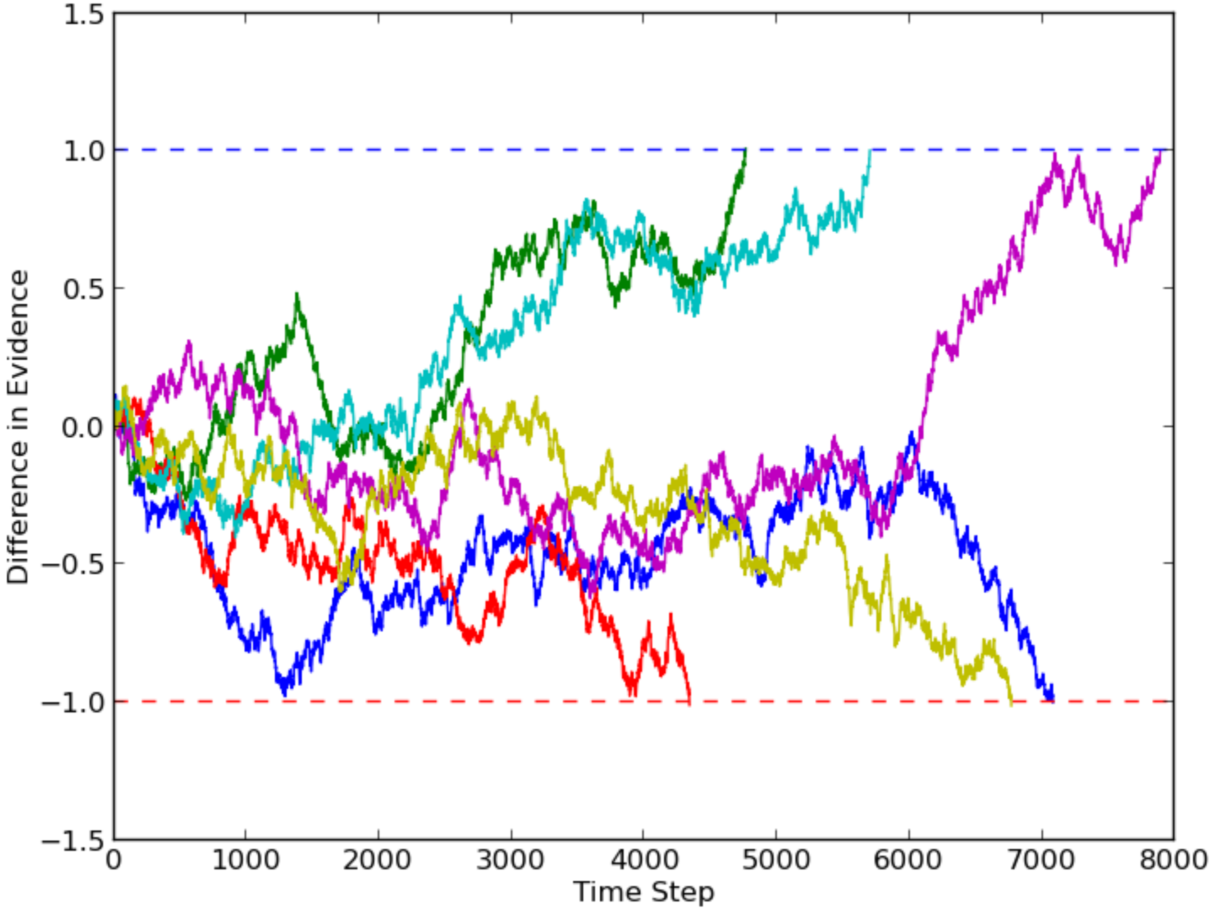
Calibration Uncertainty



- Provides context to “Accuracy” specification.
- Every measurement has uncertainty (even NIST)
- A key part of the traceability of a measurement
- It is the indication of how the accuracy of measurements have degraded through the chain of calibrations going back to NIST and essentially back to SI.

Drift

- All instruments will drift but not all by the same amount
- Not always on the datasheet



Common Causes of Drift in Relative Humidity

Particulate

- **Dust** - Slowing down of response time (increase hysteresis)
- **Salts** - Create a salt solution on sensor surface increases local humidity
- **Protection** - mechanical filters

Vapor

- **Outgassing of products** in chambers may effect dielectric in sensors, or cause delamination.
- **Protection** - high quality sensors tested for the chemical

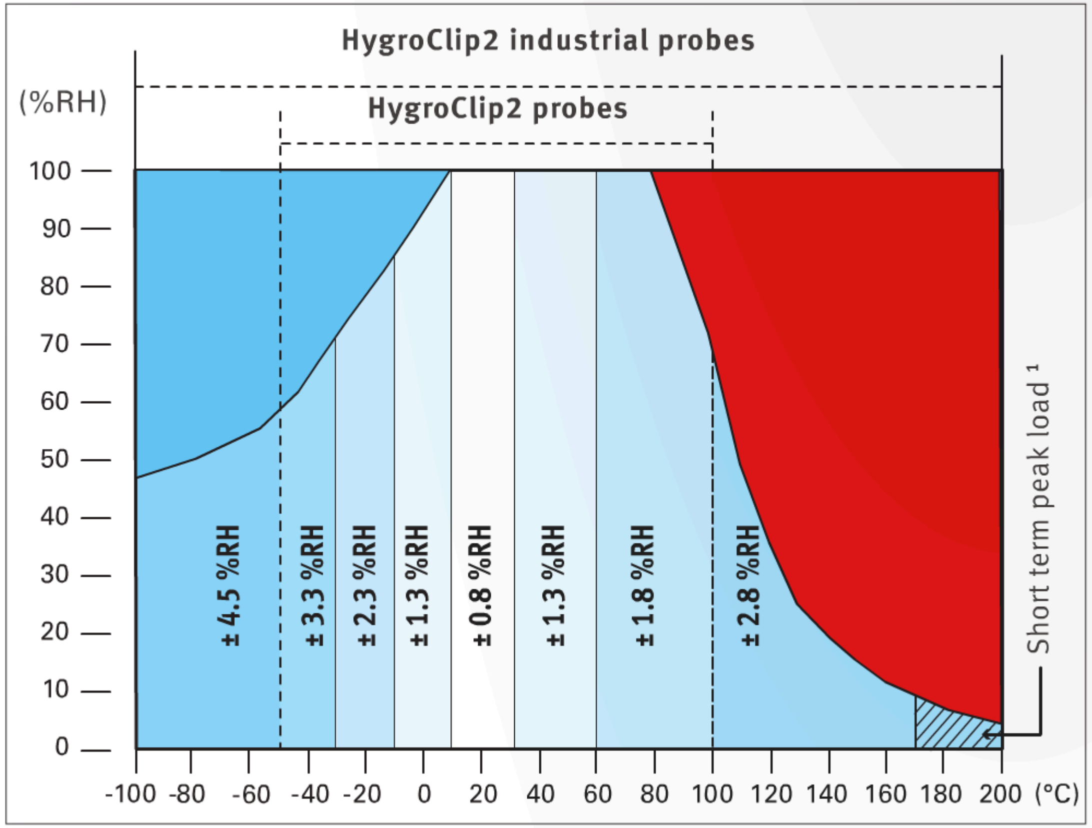
Drift in RH Sensors Caused by Chemicals

- Chemical resistance guides
  - Specify allowable concentrations of chemicals
  - Found in user manuals

Pollutant	Formula	Allowed Concentration Continuous Operation	
		ppm	mg/m^3
Acetic acid	CH_3COOH	800	2000
Acetone	CH_3COOH_3	3300	8000
Ammonia	NH_3	5500	4000
2-Butanone (MEK)	$C_2H_5COCH_3$	3300	8000
Chlorine	Cl_2	0.7	2
Ethanol	C_2H_5OH	3500	6000
Ethyl acetate	CH_3COOC_2H	4000	15000
Ethylene glycol	$HOCH_2CH_2OH$	1200	3000
Ethylene oxide	C_2H_4O	3	
Formaldehyde	HCHO	2400	3000
Hydrochloric acid	HCl	300	500
Hydrogen sulfide	H_2S	350	500
Isopropanol	$(CH_3)_2CHOH$	4800	12000
Methanol	CH_3OH	3500	6000
Nitrogen oxides	NO_X	5	9
Ozone	O_3	0.5	1
Petrol			150000
Sulfur dioxide	SO_2	5	13
Toluene	$C_6H_5CH_3$	1300	5000
Xylene	$C_6H_5(CH_3)_2$	1300	5000

Temperature Compensation

- Specifications usually provide accuracy at a single temperature or small range (+/-5 °C)
- Error increases outside of this range
- Examples:
  - +0.02%RH per Kelvin dependent on the process and electronics temperature (for a deviation of 25 °C)
  - At -20…+40 °C ±(1.0 + 0.008 x reading)
  - At -40…+180 °C ±(1.5 +0.015 x readings)



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Sample Specifications for 65 %RH at 23 °C

Specification	Instrument A	Instrument B	Instrument C	Instrument D
Accuracy		±0.8 %RH		
Accuracy Includes: - Non-linearity - Hysteresis - Repeatability	±1 %RH			±1.3 %RH + 0.003 *mv (± 1.495 %RH)
Measurement Uncertainty Includes: - Non-linearity - Hysteresis - Repeatability - Calibration Uncertainty			±1 %RH + 0.007 * mv (± 1.46 %RH)	
Calibration Uncertainty	±1 %RH	±0.5 %RH		
Annual Drift		< 1 %RH		

Normalizing Specifications

Instrument A

Parameter	U	Distribution	Divisor	Standard Uncertainty	Comment
Accuracy (Linearity, Repeatability, Hysteresis)	1	Rectangular	1.732	0.577	From Data Sheet
Calibration Uncertainty	1	Normal	2	0.500	From Data Sheet
Annual Drift	1	Rectangular	1.732	0.577	From Historical Data Sheet
			Combined Uncertainty	0.957	
			Expanded Uncertainty k=2	**±2.0 %RH**	

Instrument B

Parameter	U	Distribution	Divisor	Standard Uncertainty	Comment
Accuracy	0.8	Rectangular	1.732	0.462	From Data Sheet
Calibration Uncertainty	0.5	Normal	2	0.250	From Calibration Certificate
Annual Drift	1	Rectangular	1.732	0.577	From Data Sheet
			Combined Uncertainty	0.780	
			Expanded Uncertainty k=2	**±1.6 %RH**	

Instrument C

Parameter	U	Distribution	Divisor	Standard Uncertainty	Comment
Measurement Uncertainty (Linearity, Repeatability, Hysteresis, Calibration Uncertainty)	1.46	Normal	2	0.730	From Data Sheet
Annual Drift	1	Rectangular	1.732	0.577	Best Estimate
			Combined Uncertainty	0.9307	
			Expanded Uncertainty k=2	**±1.9 %RH**	

Instrument D

Parameter	U	Distribution	Divisor	Standard Uncertainty	Comment
Accuracy (Linearity, Repeatability, Hysteresis)	1.5	Rectangular	1.732	0.863	From Data Sheet
Calibration Uncertainty	0.6	Normal	2	0.300	From Associated Calibrator Data Sheet
Annual Drift	1	Rectangular	1.732	0.577	Best Estimate
			Combined Uncertainty	1.081	
			Expanded Uncertainty k=2	**±2.2 %RH**	

Takeaways

1. The Accuracy Specification does not provide the whole picture of instrument performance, especially for long term performance (1 Year).
2. Data Sheets are only the beginning to understanding instrument performance, they do not always contain all the information required to make an informed decision.
3. The most important value of instrument performance is the 1 year performance value.

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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

Traceability – What is it and How to Achieve it?

Thursday, January 14th 1:00PM EST

Register at www.rotronic-usa.com/humidity-webinars

Takeaways

- How does traceability affect the measurements that we take?
- How can I prove traceability of my measurements?
- How can I ensure that my suppliers are actually providing traceable calibration results?

Helping you make a better humidity measurement – and more.

Transmitters, portable meters and loggers for:

- Humidity
- Carbon Dioxide
- Low Dew Point
- Water Activity
- Differential Pressure
- Monitoring systems for cGMP
- ISO 17025 calibrations (humidity and temperature)

Post webinar survey

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