FLUKE®
Calibration

Fluke Calibration

Humidity Calibration

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Temperature & Humidity EMEA

5128A RHapid-Cal Introduction

The 5128A RHapid-Cal is a transportable humidity generator for calibrating RH probes and data loggers.

5128A RHapid-Cal Humidity Generator

RHapid-Cal Positioning

Compared to other portable humidity generators, the 5128A RHapid-Cal:

- Offers excellent stability and uniformity specs for accurate humidity probe calibration
- Provides rapid humidity and temperature stabilization for high calibration throughput
- Includes Fluke-backed specifications and accredited system calibration

Two-Pressure Generators

Thunder 2500

E&E Humor 20
w/ compressor

Fluke 5128A RHapid-Cal
Humidity Generator

Salts

Handheld Humidity
Meters

Rotronic
HygroPalm 23

Vaisala HM70

In the field, the 5128A provides more thorough, reliable multi-point calibrations than one-point spot checks using a handheld humidity meter

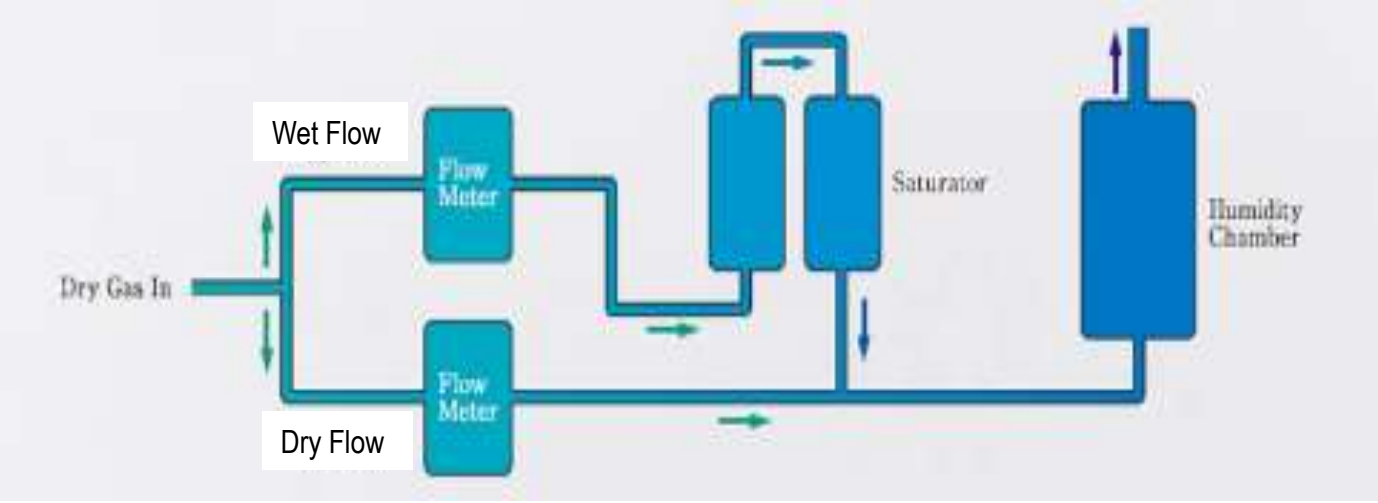
In the lab, the 5128A calibrates humidity probes faster and more economically than a two-pressure generator

Humidity Generator Technology Cont.

FLUKE® Calibration

Mixed-Flow Generator

- Uses a “split-stream” principle to control the system humidity
- Dry air stream is divided into two parts
- One stream is saturated (or partially saturated) with water vapor
- The other dry air stream is mixed in to achieve the desired humidity
- Humidity output depends on wet air humidity and the mixing ratio

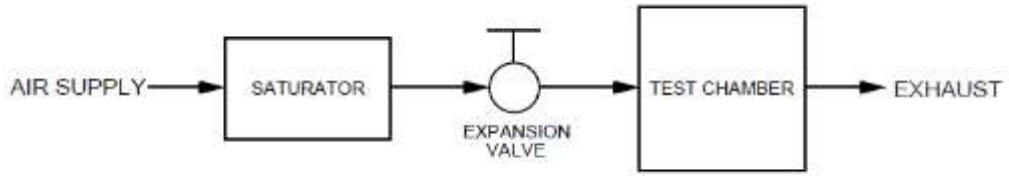


Mixed-Flow Humidity Generator Design
Diagram source: Shinyei

Humidity Generator Technology Cont.

Two-Pressure Generator

- Two chambers at the same temperature
- Saturator (first chamber): Air is saturated with water vapor at high pressure
- Test chamber (second): Air passes from Saturator to Test chamber (which is at a lower pressure)
- As the air reduces in pressure, relative humidity drops as well
- Relative humidity is given by the ratio of the two chamber pressures
- If the Test chamber pressure is set, get the desired relative humidity by varying the Saturation chamber pressure



Two-Pressure Generator Design
Diagram source: Thunder Scientific

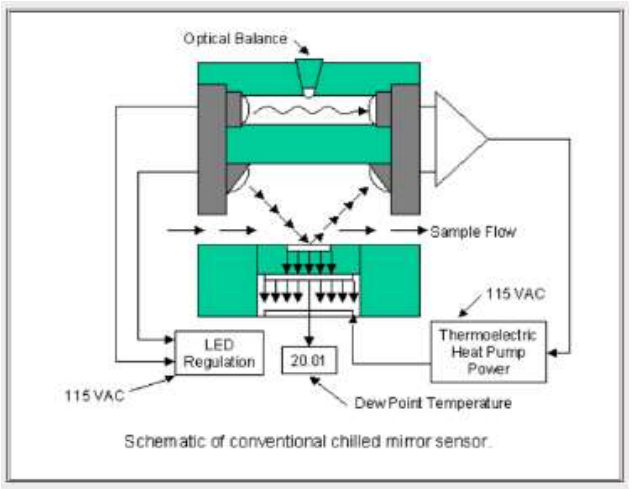
Humidity Generator Technology Comparison

	Mixed-flow Generator	Two-pressure Generator
Calibration speed	Fast humidity and temperature stabilization times Fluke 5128A: Typical six-point calibration takes two hours	Slower Thunder 1200: Typical six-point calibration takes more than three hours
Humidity specs	Good Fluke 5128A: Humidity accuracy: 1% (7–80% RH), 1.25% (80–95% RH) Humidity uniformity: 0.3% RH (18C to 28C)	Better Thunder 1200: Humidity accuracy: 0.5% Humidity uniformity: Not specified
Temperature specs	Good Fluke 5128A: Temperature accuracy: 0.2C (18C to 28C) Temperature uniformity: 0.12C (18C to 28C)	Better Thunder 1200: Temperature accuracy: 0.05C Temperature uniformity: 0.1C
Portability	Compact, single piece of equipment. For lab use or easy transport to the field.	Two large pieces of equipment with cart. Requires compressed air. Limited to lab use.
Chamber size	Good 1 to 2 liters typical	Better Thunder 1200: 3.5 liters
Price	More economical $30K to $35K	Expensive Thunder 1200 $50K, Thunder 2500 $90K

Humidity Generator Technology Cont.

Chilled Mirror Hygrometer Reference

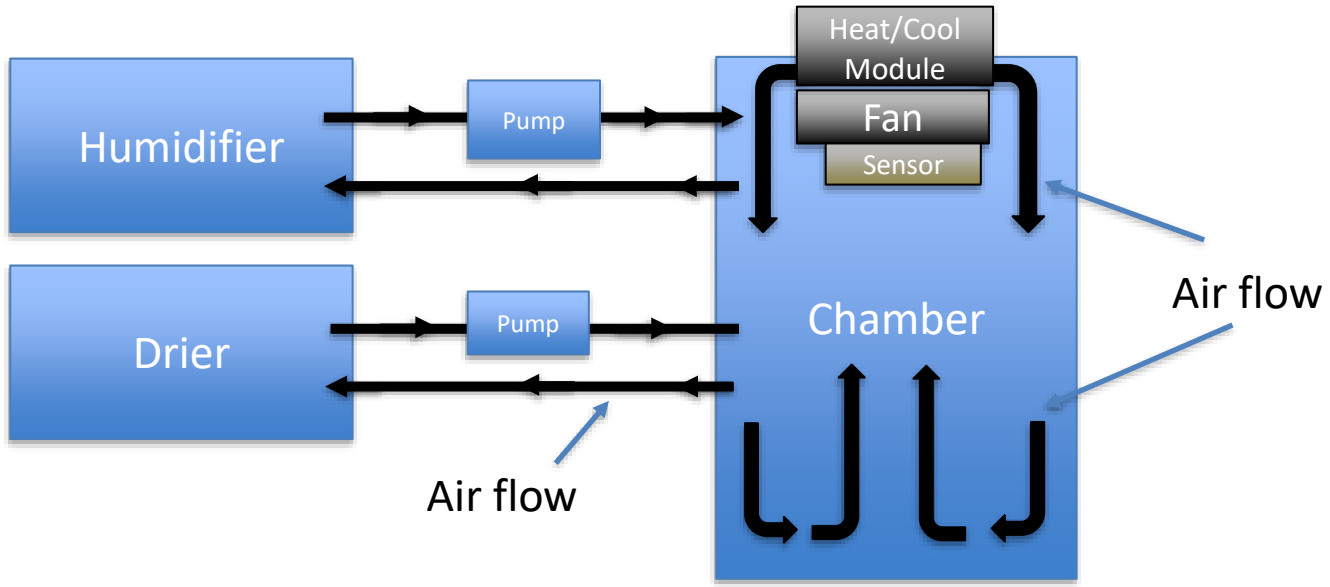
- Used as a reference to calibrate humidity generators
- Measures “dew point“ (temperature where dew forms on a surface)
- A reflective “mirror” surface is cooled until water begins to condense
- Mirror maintained at the dew point temperature (rate of dew condensation equals the rate of the dew evaporation)
- Pros: Best measurement capability, Highly stable, Works over broad humidity range
- Cons: Expensive $20K-$30K, Long stabilization time, Need very clean environment, High level of maintenance, Skilled operator needed



Chilled Mirror Hygrometer
Diagram source: Thunder Scientific

Fluke 5128A Mixed-Flow Humidity Generator System

Fluke Calibration 5128A Operation Diagram
Self-Contained System (provides own dry air)



- Closed-loop system provides excellent stability
- Uses less desiccant

5128A Feature Overview

FLUKE® Calibration

Display shows set points and actual temperature and humidity, plus the calculated dew point. Soft keys on the control panel make it easy to cycle through the command menu.

Mixing insert causes the air to circulate for better temperature and humidity uniformity inside the insert.

Desiccant cap provides easy, front-panel access to desiccant cartridge.

Sample In/Out port draws and returns gas to the working chamber. Used to measure the chamber's dew point with a chilled mirror instrument.

Fill inlet for filling the humidity generator with distilled water. Water level indicator shows the relative amount of water in the generator.

Chamber door provides access to the working chamber. Different door types are available.

Working chamber which holds the mixing insert. A unit under test can be placed directly in the working chamber without the mixing insert if the temperature and humidity are monitored with an external reference probe.

Target UUT Applications

FLUKE® Calibration

RH probes, meters & transmitters

Typical brands: many

- Characteristics
  - Must be long enough for 1” insertion through door
  - Generally 2-5% accuracy
- How to calibrate?
  - Insert up to 5 probes through ports in 5128A door
  - Select grommet to fit probe diameter snugly
  - Plug unused ports
- Solution to quote:
  - 5128A RHapid-Cal
  - Grommet kit
  - Extra desiccant(s) (optional)

RHapid-Cal Product Specifications

Chamber Humidity and Temperature Specifications				Status
1-year, 95% Confidence Level. Ambient temperature range of 18 – 28 °C < 80% RH				
Chamber Temperature Range	Chamber Humidity Range	Chamber Humidity Accuracy	Chamber Temperature Accuracy	Final pending test
18 to 23 °C	7 to 80 %RH	±1.0 %RH	±0.2 °C	
	>80 to 95 %RH	±1.25 %RH	±0.2 °C	
>23 to 28 °C	7 to 80 %RH	±1.0 %RH	±0.2 °C	
	>80 to H_{max}[1] %RH	±1.25 %RH	±0.2 °C	

Note 1: Hmax is the maximum humidity value at which the accuracy specification applies. Hmax is temperature dependent so it is calculated with the following formula: Hmax = 164 – 3*T. For example, to calculate Hmax at 25 °C, Hmax = 164 – 3*(25 °C) = 89 %RH

5128A Specifications Cont.

FLUKE® Calibration

Chamber Uniformity and Stability

Ambient Temperature Range: 23 °C ±3 °C [1]						
Chamber Temperature	Chamber Humidity Range		Chamber Temperature Uniformity [2]	Chamber Humidity Uniformity [2]	Chamber Humidity Stability [3]	Chamber Temperature Stability [3]
	Min % RH	Max % RH				
18 °C to 28 °C	7 % RH	See Chamber Operational Range Below	±0.12 °C	±0.3 % RH	±0.1 % RH	±0.05 °C
The following specifications are typical for chamber conditions shown [4]						
5 °C to <18 °C	15 % RH	See Chamber Operational Range Below	±0.5 °C	±1.5 % RH	±0.5 % RH	±0.5 °C
>28 °C to 30 °C	7 % RH		±0.2 °C	±0.6 % RH	±0.3 % RH	±0.2 °C
>30 °C to 35 °C	7 % RH		±0.3 °C	±0.9 % RH	±0.4 % RH	±0.3 °C
>35 °C to 40 °C	7 % RH		±0.5 °C	±1.5 % RH	±0.5 % RH	±0.5 °C
>40 °C to 50 °C	7 % RH		±0.5 °C	±1.5 % RH	±0.5 % RH	±0.5 °C

[1] For ambient conditions of 23°C ±5°C, multiply the specifications by 1.5.

[2] Defined as the uniformity of the Working Volume.

[3] Defined as 1-sigma standard deviation of measurement readings over a 5-minute span.

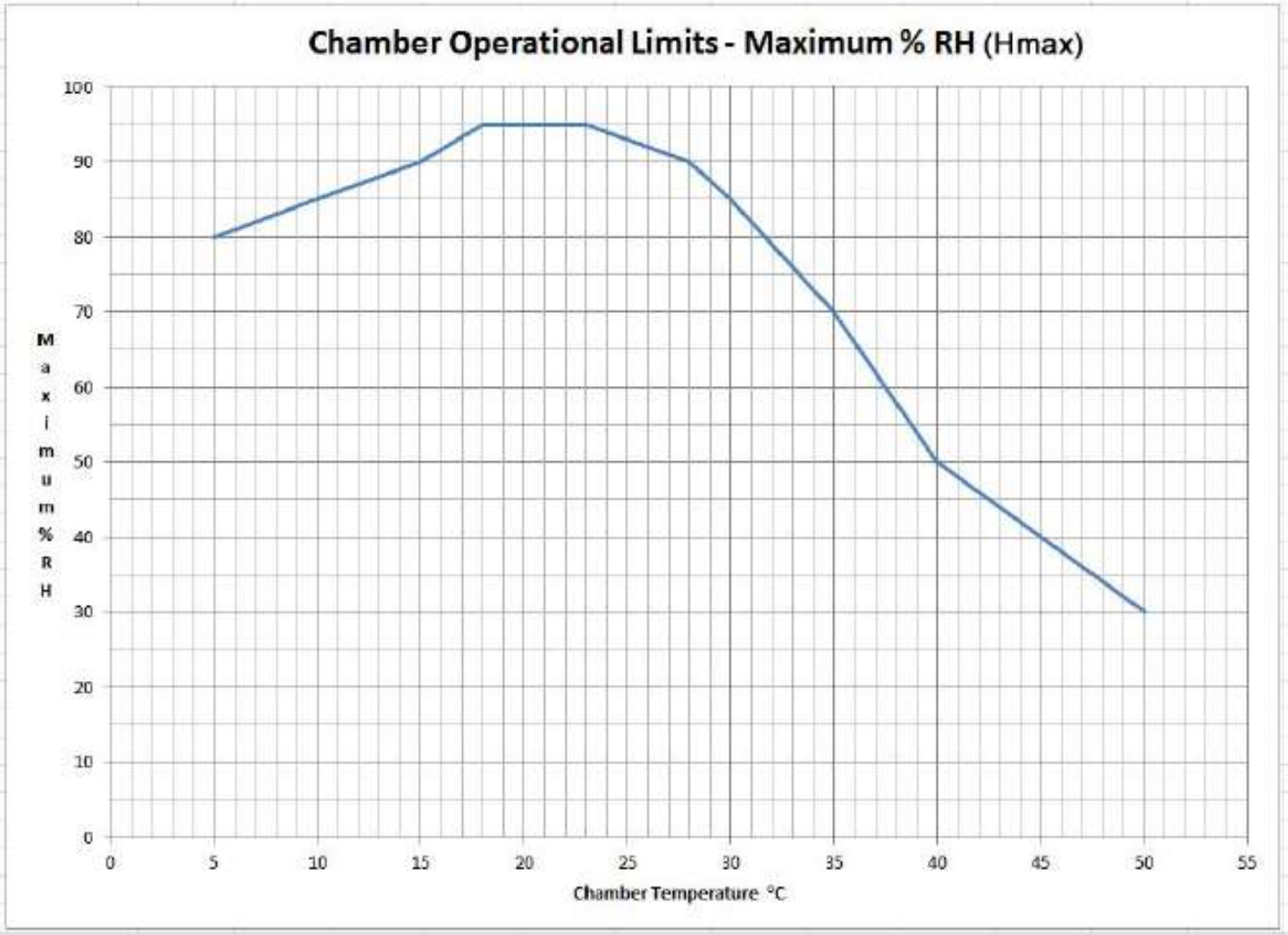
[4] Chamber humidity uniformity is listed for mid-level humidity settings. Lower humidity settings will give better uniformity while higher humidity settings will give worse uniformity.

5128A Specifications Cont.

FLUKE® Calibration

Chamber Operational Range – Maximum % RH

The chamber has operational range limits based on temperature and humidity settings. The table below shows the maximum % RH attainable at different temperatures.



Operational Specifications

Temperature rate of change – down	1.5 °C/minute (Typical)
Temperature rate of change – up	10 °C/minute (Typical)
Humidity rate of change – down	5 % RH/minute (Typical)
Humidity rate of change – up	10 % RH/minute (Typical)

Applications

- Oil & gas - research, exploration & production
- Power generation – fossil, hydro & nuclear plants
- Pharmaceutical & bio-tech – research & manufacturing
- Food & beverage – manufacturing plants
- Defence – cal labs
- Sensor – RTD, T/C & mechanical sensor manufacturing
- Other – semi-conductor, oceanography, pump & turbine efficiency, heat-meter, aerospace, marine, automotive & HVAC

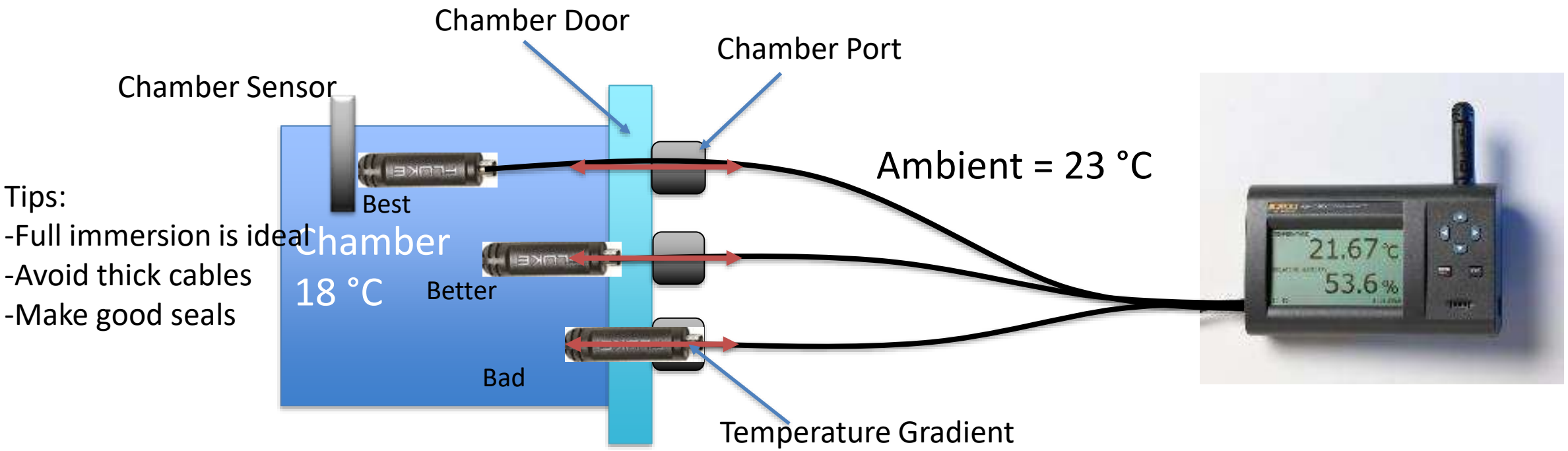
Keys for Successful Humidity Measurement

- Water vapor in gas diffuses quickly and evenly – this is good
- The main causes of humidity errors in a system are related to temperature
  - Temperature gradients don't diffuse quickly and evenly (stirring the air is helpful)
  - Remember: relative humidity indicates the percentage of saturation of air at a specific temperature
- Separate the measurement area from ambient (don't allow air leaks, ensure proper sensor immersion)
- Don't allow condensation to form
- Wait sufficient time - wait for stability and uniformity
- Correctly handle materials that absorb and emit water vapor (plastics, wood, foam, etc.)
- Use good materials for humidity measurement: Teflon, stainless steel

Tip: Typical humidity sensor required soak times: 10 to 60 minutes

Thermal Transfer Errors – Ideal Sensor Placement

- Two challenges:
  - Air is not a good thermal conductor
  - Some humidity sensors are very short and are designed for full immersion



Tips:
-Full immersion is ideal
-Avoid thick cables
-Make good seals

5128A Operators Manual Template

- Use as a guide to position DUT
- Specifications are guaranteed within the Working Area

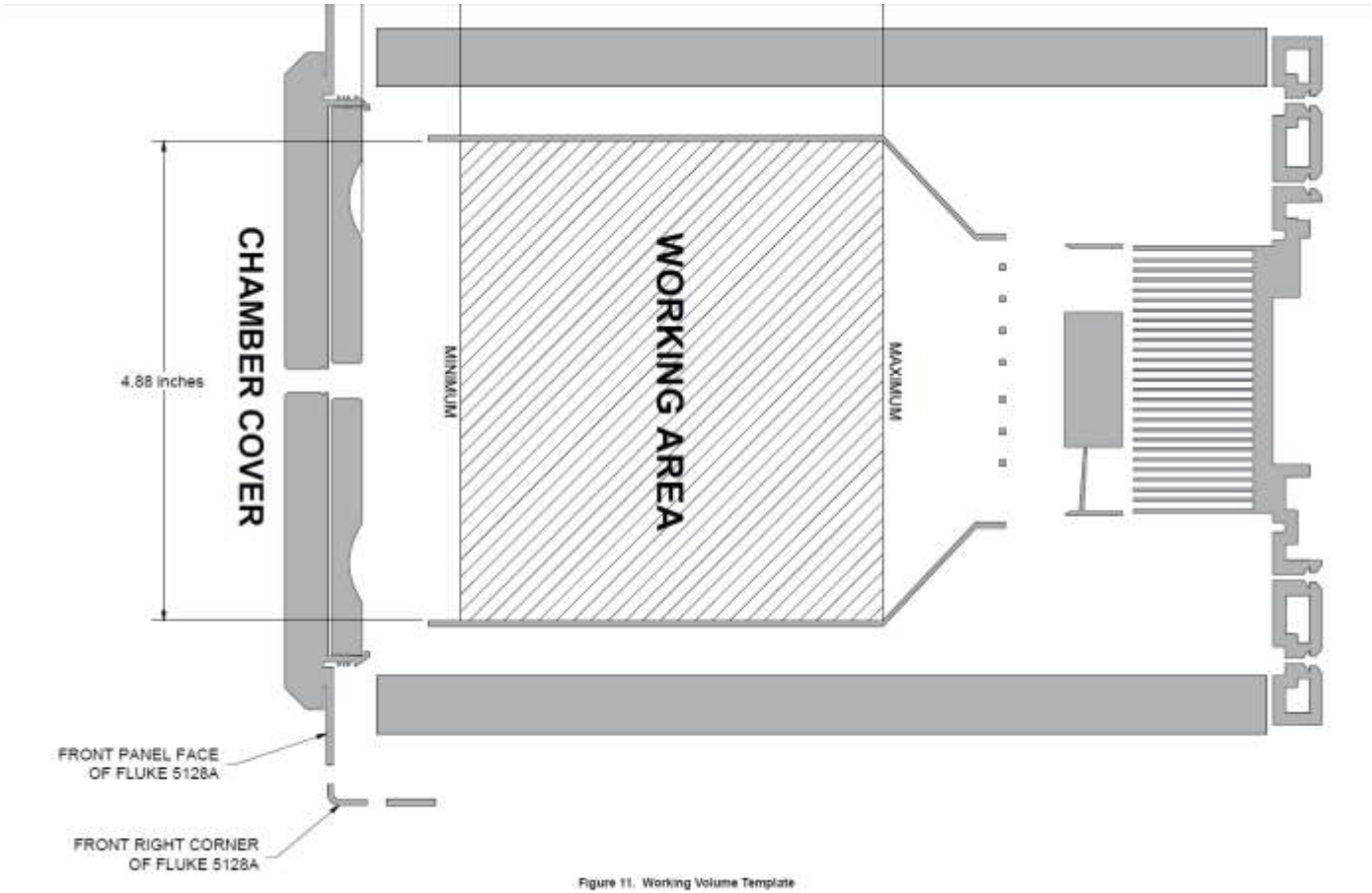


Figure 11. Working Volume Template

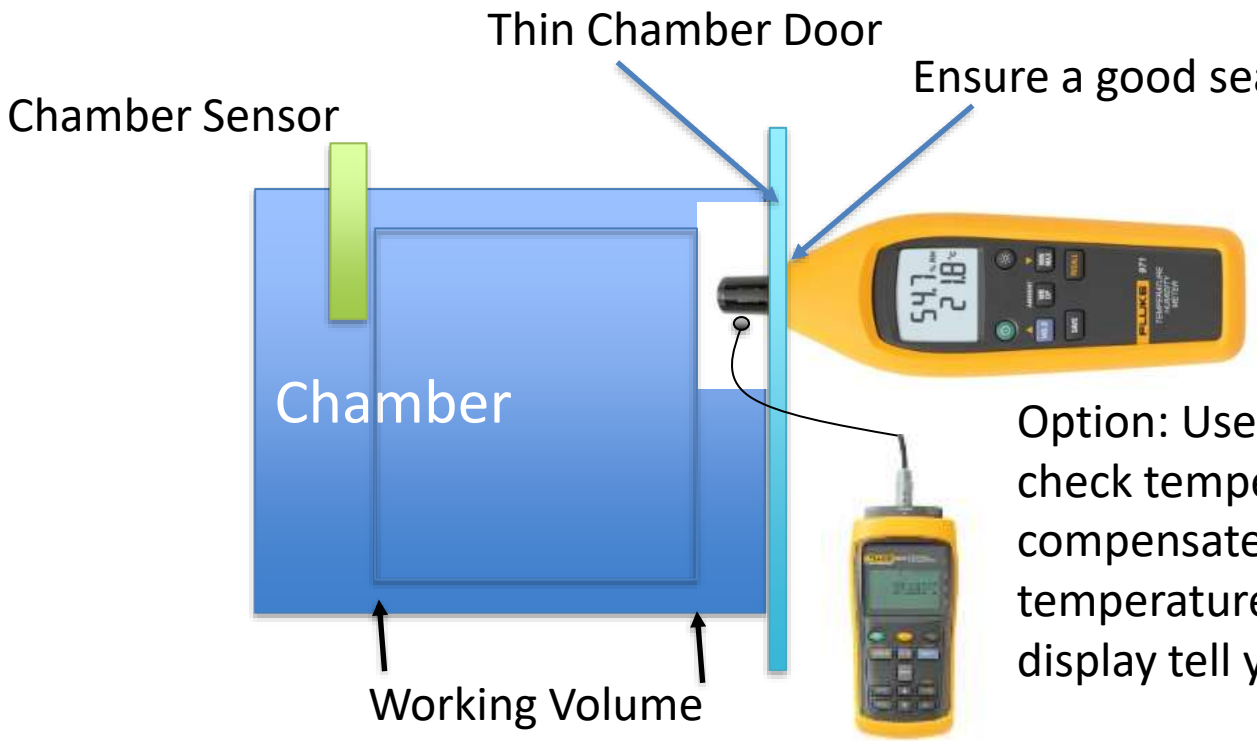
Really Short Sensors

- Understand the sensor design
  - Thermally isolated from meter body?
  - Thermally anchored to meter body?

Complete Immersion Design

Temperature Sensor

Partial Immersion Design



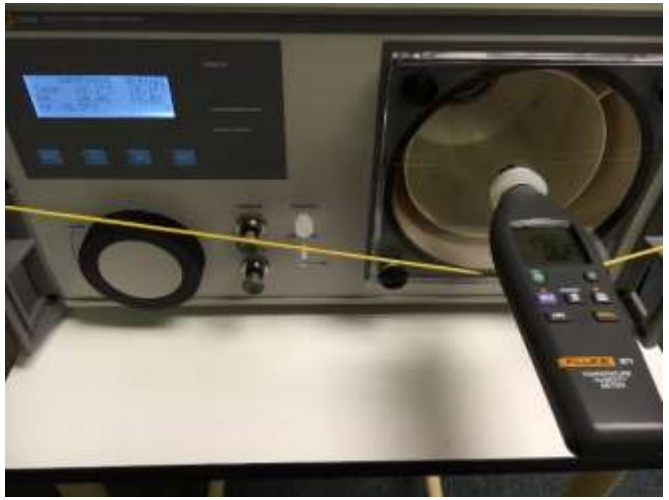
Option: Use an external temperature sensor to check temperature at DUT sensor location – compensate RH for delta°C – or – verify DUT temperature accuracy then let the temperature display tell you what is happening

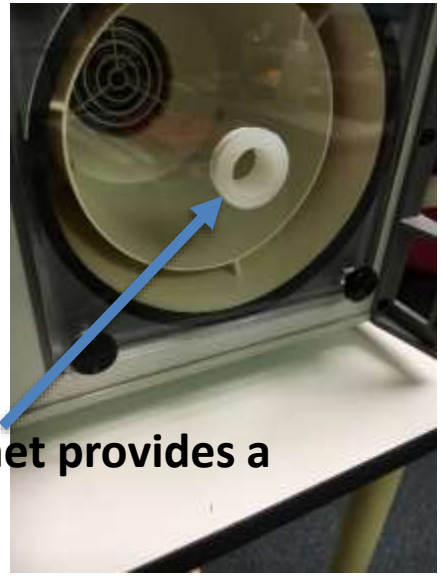
Full Immersion

- Pros
  - No concern about heat transfer from ambient
  - Verifies DUT operation over range of “ambient” temperatures
- Cons
  - Reduce number of DUTs
  - No mixing insert in chamber – may increase error
  - Requires user to map the chamber (mixing insert removed)

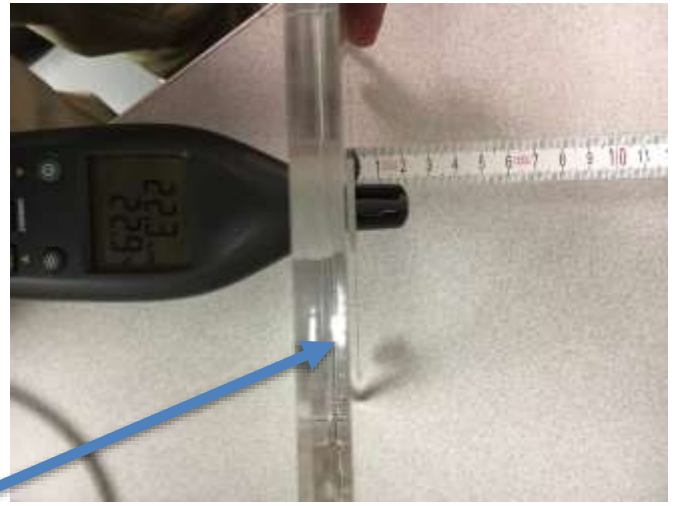
Insert Through Door

- Pros
  - Easier access to DUT
  - May accommodate more DUTs (higher capacity)
- Cons
  - Short DUT sensor doesn't extend to 5128A specified working area
  - Be careful of external temperature influence
  - Requires study of temperature gradients near the door
  - Requires customization of 5128A door

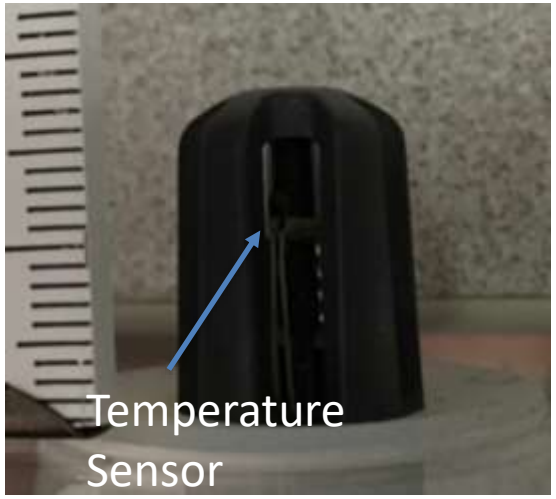




Grommet provides a seal

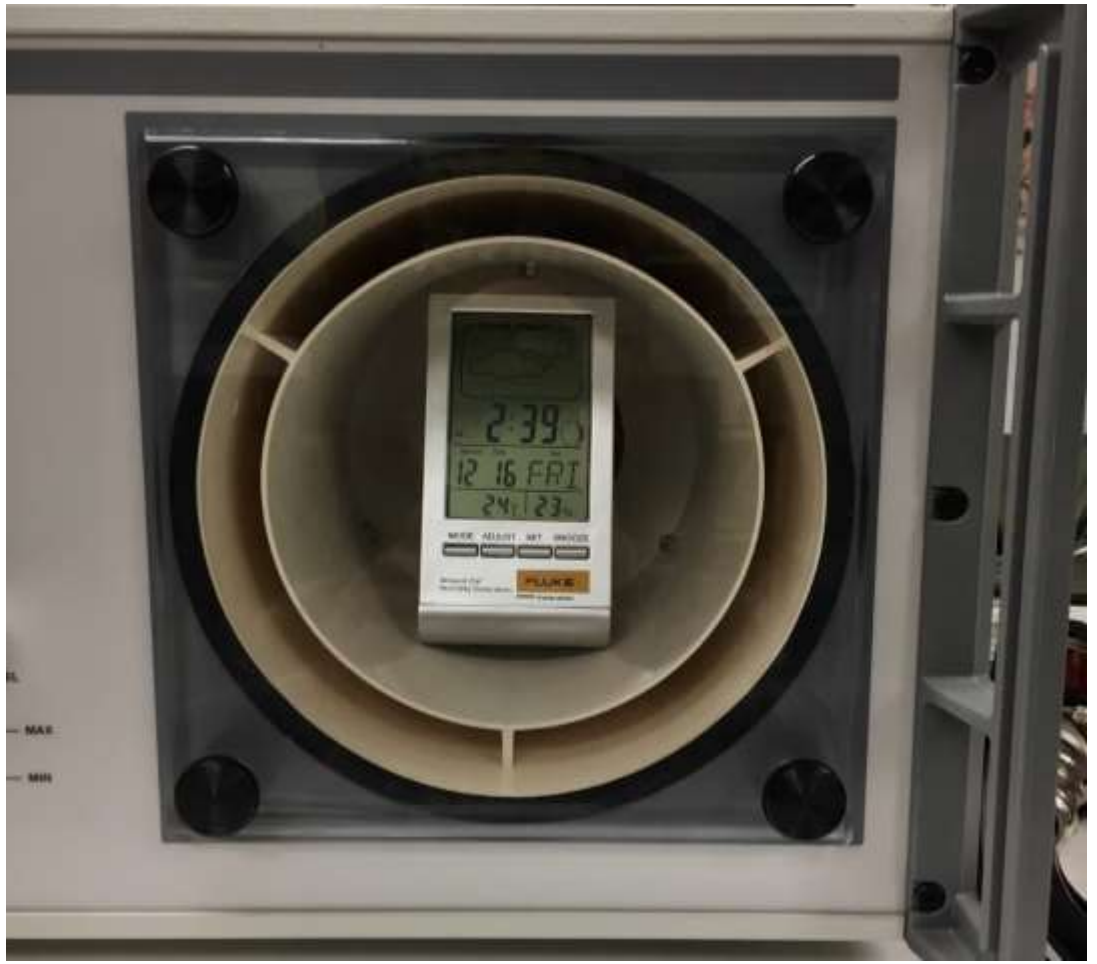


Thin door allows 2 cm of sensor immersion



Integrated Instruments – Sensor and Display

- Place entire instrument in chamber
- Use a small camera to read display for automation
- Consider impact on temperature uniformity
- Consider wattage/heat load
- Watch for radiant heat through the clear door



Take good care of the reference sensor/chamber

- The 5128A chamber sensor is fragile, handle it carefully
- Avoid exposure to volatile chemicals
- Keep the chamber clean
- Use only distilled water
- Keep the door on the chamber at all times
- May want to remove the sensor and pack it in foam for transport
- Monitor for drift using an external check standard

RH Sensor Calibration Methods

- Single-Point (Spot-Check) Calibration
  - Humidity sensor is checked at the existing room temperature and humidity
  - Often implemented when the DUT sensor cannot be moved (wall-mount transmitter)
  - Only valid for a very limited range about the check point
  - Consider the impact on traceability and risk of Out of Tolerance readings
  - May not identify problems at other temperature or humidity values
- Multi-Point Range Calibration
  - Humidity sensor is inserted into a humidity calibrator and checked at multiple humidity and temperature points to cover the required range of the instrument or the process
  - Consider both humidity and temperature range

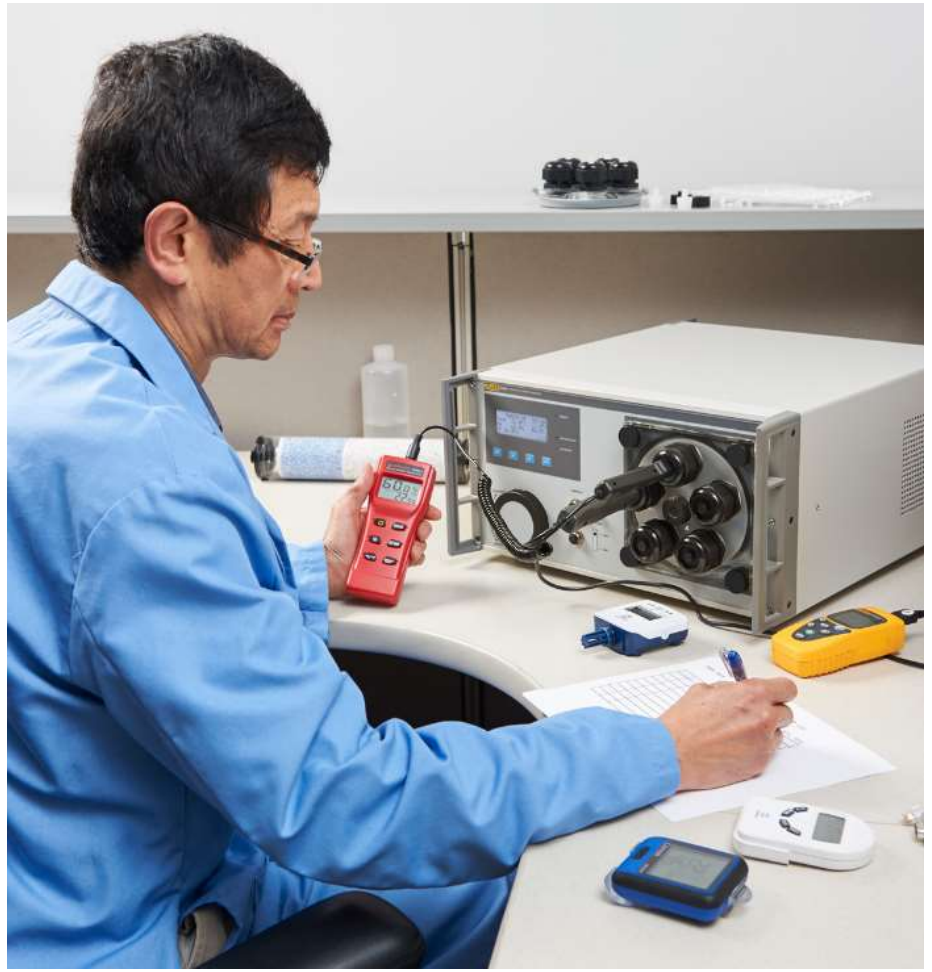
Calibration Sequence

Recommended calibration sequence to ensure fast, repeatable humidity sensor calibrations:

1. Follow the dew point - Do RH and temperature points with lower dew point first and ramp up to the higher dew point levels on each subsequent calibration step.

2. Do lower temperature calibration points first to minimize the probability of water vapor condensing inside the chamber.

Tip:
- When the dew point inside the 5128A chamber is greater than the ambient temperature, condensation can form on or near the chamber door.
- If condensation forms anywhere in the chamber, the relative humidity inside the chamber may be unknown.
- Condensation must always be removed from inside the chamber before calibrations are performed.



Calibration Process

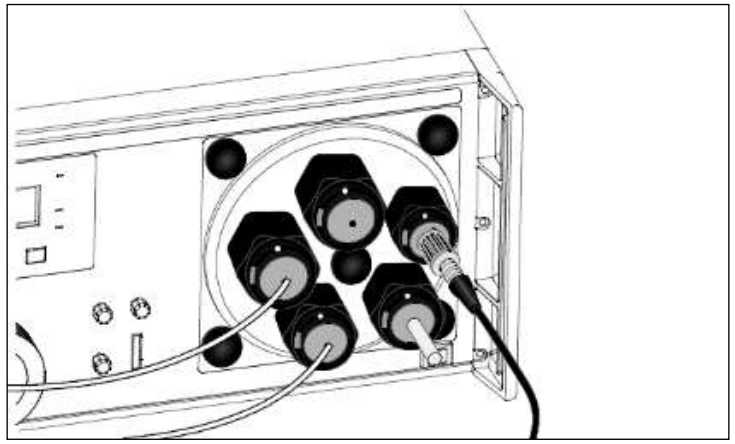
- Remove any condensation in the chamber
- Insert DUT probes through ports in 5128A door
- Select grommet to fit probe diameter snugly
- If necessary, add sealant material around the probe. Parafilm, Scotch™ Removable Adhesive Putty, or similar materials work well.
- Plug unused ports
- Set the chamber to the desired temperature and humidity set point
- Wait for chamber and UUT stabilization. The 5128A response time is normally much faster than the UUT.

External Reference Calibration Method

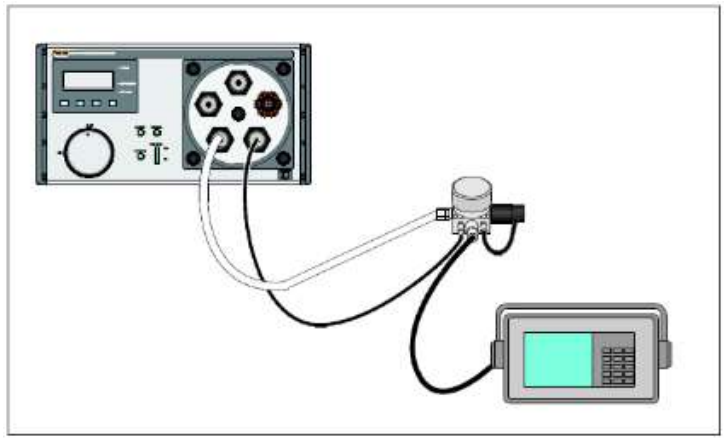
Reference chilled-mirror hygrometer

- Use as humidity reference for higher-accuracy workload
- High accuracy reference (0.1 °C dew point uncertainty) recommended for best result.
- Three configurations are described in the 5128A manual

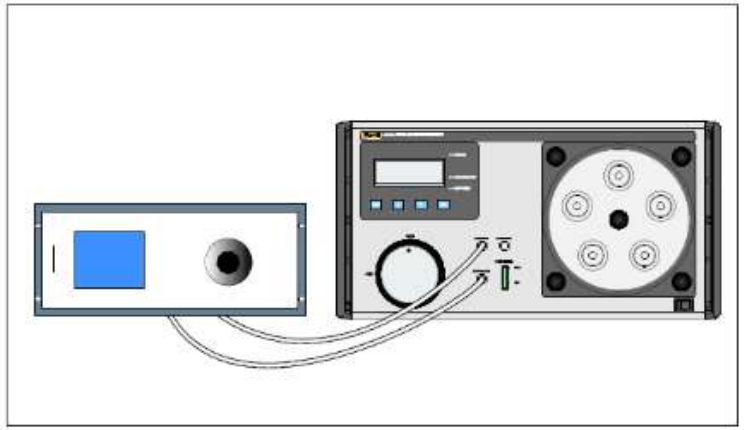
Remote Head
Chilled mirror sensor head inserted into the chamber
Reduces risk of condensation



Remote Head w/Pumped Air
Air pumped from the chamber to a remote chilled mirror sensor
Watch for condensation in tubing



Pump-Style
Air pumped from the chamber to the chilled mirror
Watch for condensation in tubing

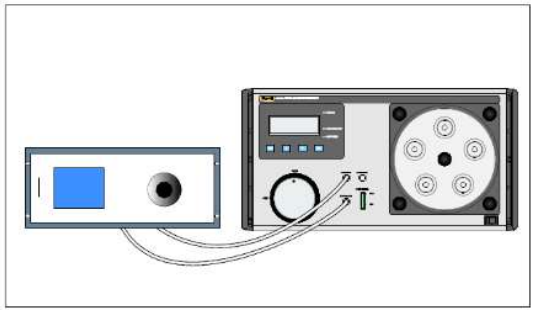


Calibrate the Fluke 1620A DewK Sensors

- DUT RH specification:
  - Model 2626-S: 2 %rh (20 to 70 %rh), (5128A TUR: 2.6)
  - Model 2626-H: 1.5 %rh (20 to 70 %rh), (5128A TUR: 1.9)
- DUT temperature specification:
  - Model 2626-S: 0.25 °C (15 to 35 °C), (5128A TUR: 1.6)
  - Model 2626-H: 0.125 °C (16 to 24 °C), (5128A TUR: 0.8)

5128A with standard
Square door, 5 ports

1524 with 5611T
thermistor probe.
System Accuracy: 0.015 °C
(TAR for 2626-H cal: 8.3)



Optional chilled mirror
hygrometer

5128A Specifications

- Confidence level of k=2.58 (99%)
- Specifications include all known uncertainties for 1-year interval
- System performance is specified
- Look at the footnotes!
- Warranted performance is fully disclosed – you know what you are getting

Humidity and Temperature Chamber Technical Specifications

The Product specifications describe the Absolute Instrumental Uncertainty of the Product. The Product specifications include stability, ambient temperature, and humidity (within specified limits), linearity, line regulation, the reference standard measurement uncertainty and long term stability of one year. The product specifications are provided at a 99 %, k=2.58, normally distributed level of confidence.

Chamber Specifications

One Year, Ambient Temperature Range 23 °C ±3 °C [1]			
Chamber Temperature Range	**Chamber Humidity Range**	**Humidity Specification**	**Temperature Specification**
18 °C to 23 °C	7 % to 80 % RH >80 % to 95 % RH	±1.0 % RH ±1.25 % RH	±0.2 °C ±0.2 °C
>23 °C to 28 °C	7 % to 80 % RH >80 % to H_{max} [2] % RH	±1.0 % RH ±1.25 % RH	±0.2 °C ±0.2 °C

[1] For ambient temperature range of 23°C ±5°C, multiply the specifications by 1.5.
[2] H_{max} is the maximum humidity value at which the specification applies. See Chamber Operational Range below for H_{max}.

Note

Specifications apply to the Working Volume shown in the Working Volume Template found at the end of the Operators Manual, and are referenced to the "Actual" reading on the Product display.

Chamber Uniformity and Stability

Ambient Temperature Range: 23 °C ±3 °C [1]						
Chamber Temperature	**Chamber Humidity Range**		**Chamber Temperature Uniformity [2]**	**Chamber Humidity Uniformity [2]**	**Chamber Humidity Stability [3]**	**Chamber Temperature Stability [3]**
	Min % RH	**Max % RH**				
18 °C to 28 °C	7 % RH	See Chamber Operational Range Below	±0.12 °C	±0.3 % RH	±0.1 % RH	±0.05 °C
The following specifications are typical for chamber conditions shown [4]						
5 °C to <18 °C	15 % RH	See Chamber Operational Range Below	±0.5 °C	±1.5 % RH	±0.5 % RH	±0.5 °C
>28 °C to 30 °C	7 % RH		±0.2 °C	±0.6 % RH	±0.3 % RH	±0.2 °C
>30 °C to 35 °C	7 % RH		±0.3 °C	±0.9 % RH	±0.4 % RH	±0.3 °C
>35 °C to 40 °C	7 % RH		±0.5 °C	±1.5 % RH	±0.5 % RH	±0.5 °C
>40 °C to 50 °C	7 % RH		±0.5 °C	±1.5 % RH	±0.5 % RH	±0.5 °C

[1] For ambient temperature range of 23°C ±5°C, multiply the specifications by 1.5.
[2] Defined as the uniformity of the Working Volume.
[3] Defined as 1-sigma standard deviation of measurement readings over a 5-minute span.
[4] Chamber humidity uniformity is listed for mid-level humidity settings. Lower humidity settings will give better uniformity while higher humidity settings will give worse uniformity.

Questions?