

Environmental Measurement for Healthy Homes: A Quick Overview

Kevin Kennedy



Disclosures:

I have no conflicts of interest to disclose.

I will discuss measurement instruments
and use photos of some brand-name
instruments for illustration purposes only



The home walk through is the most important part of any healthy home assessment for health and safety risks

Use your 5(6) best assessment tools:

Look

Listen

Smell

Touch

Taste

Common Sense



Thorough assessment by a trained, knowledgeable professional

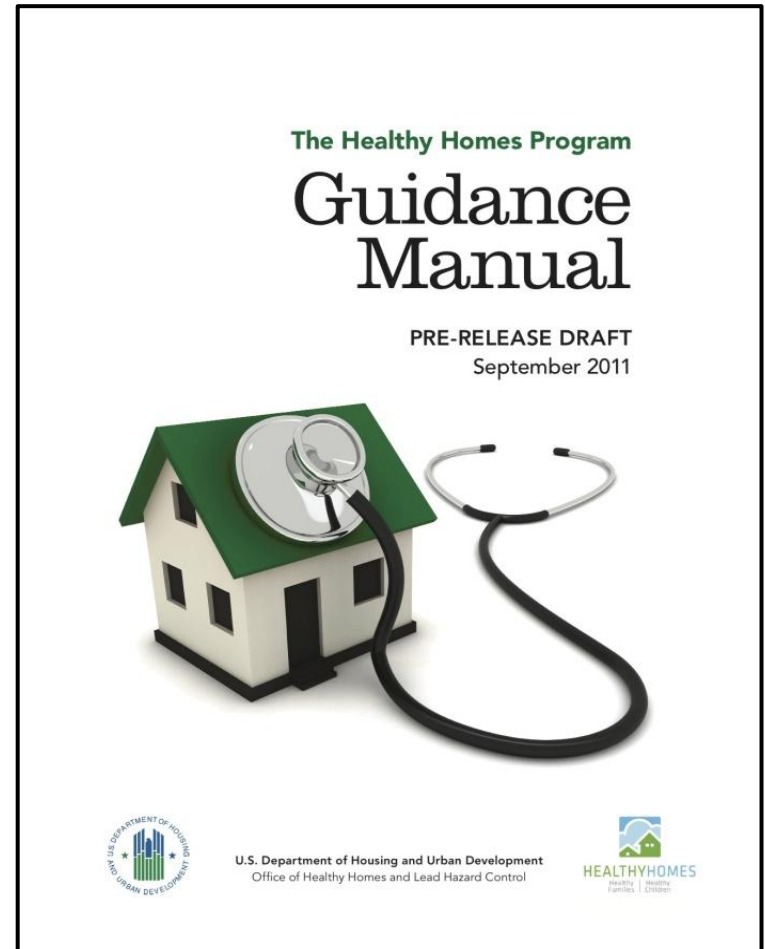
Communicate with your client about best healthy home practices



Healthy Home Guidance Manual

- Chapter 1 Introduction
- Chapter 2 Community Involvement
- Chapter 3 Program Design
- **Chapter 4 Assessment**
- Chapter 5 Intervention Strategies
- Chapter 6 Program Evaluation
- Chapter 7 Sustainability

https://www.hud.gov/sites/documents/HHPGM_FINAL_CH1.PDF



There are excellent healthy home assessment protocol development tools

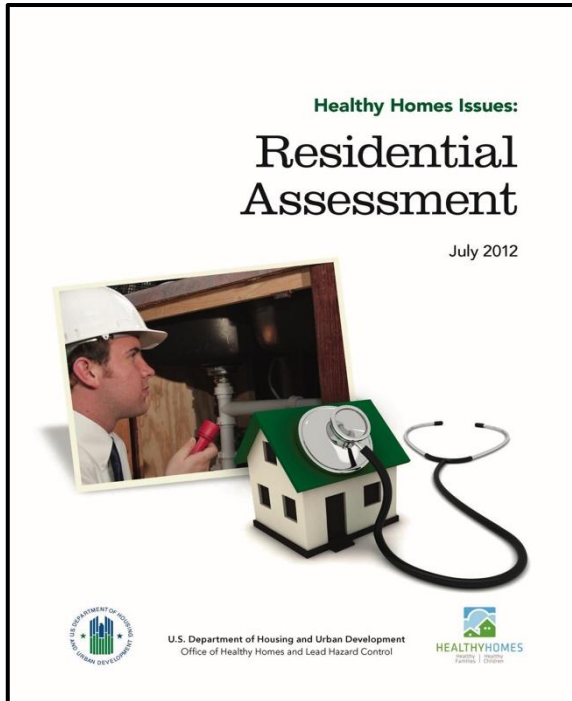


Table 3. Overview of Assessment Strategies for Selected Residential Hazards

Residential Hazard	Assessment Strategy				
	Visual Assessment	Occupant Survey	Environmental Sampling		Building Performance Testing
			Dust	Air	
Biological Hazards					
Dust mite allergens	X ^a		X ¹	X	
Cockroach allergens	X ^a	X	X ¹	X	
Rodent allergens	X ^a		X ²	X ²	
Pet allergens	X ^a	X	X ²	X ²	
Mold	X ^a	X ³	X ²	X ²	
Bacterial endotoxins	X ^a		X	X	
Chemical Hazards					
Pesticides	X	X ⁴	X ²	X ²	
Carbon monoxide	X	X ³		X	X
VOCs, including formaldehyde	X ^a	X ⁴		X	X
Lead			X		
Radon				X	
Particulate Matter (e.g., PM _{2.5})				X	
NO ₂				X	
Structural Hazards					
Structural defects	X	X ³			
Excess moisture	X	X ³			X ⁷
Poor ventilation	X			X	X
Unhygienic conditions	X	X			
Carbon dioxide (CO ₂ , fresh air indicator)				X	X
Slip, trip, fall hazards	X				
Un-cleanable surfaces	X				
Missing/malfunctioning safety devices (e.g., smoke and CO alarms)	X	X			
Behavioral Hazards					
Cigarette smoking/2nd- & 3rd-hand smoke	X	X		X	
Poor safety practices (e.g., no childproofing)	X	X			
Lack of supervision of children		X			
Unsafe use of products and appliances	X	X ⁴			

Use measurement tools, when necessary, to:

Provide baseline and visual representation of issues for occupants

Verify hazard identification and assist with interpretation of environmental conditions

**Remember,
association does not equal causation**



There are six basic measurements techniques that every healthy home assessor should be familiar with



Tool	What it measures:	Est. Price
Infrared thermometer	Surface temperature of objects	\$30 - \$300
Combustible gas meter	Combustible gases, including: natural gas (methane), propane, gasoline	\$200 - \$1000
Carbon monoxide detector	Presence of any carbon monoxide gas	\$50 - \$400
Moisture meters	Moisture content in building materials	\$100 - \$1500
Vapor generator / air flow indicator	Direction of air current	\$50 - \$750
Specialty Thermo-hygrometer Psychrometer	Air temperature, relative humidity, dew pt. Temperature, probe for water temp.	\$200 - \$1000



Environmental Measurement – Advanced



Particle Counters



Multi-sensor IAQ Measurements



**Thermographic
cameras**



**Chemicals & VOC
Sampling Devices**



Your instruments must be maintained and a service record kept (it's a liability issue). Develop a log

Instrument Maintenance Activity Log

Date	Instrument	Description of Activity	Status	Initials
10/5/05	Multi-Rae	Yearly Cleaning & Calibration	OK	
		REPAIRED VOC AMPLIFIER		
10/11/05	IAQ 10760	REPLACED BATTERIES	OK	
	IAQ 10767	REPLACED BATTERIES	OK	
10/11/05	Multi-Rae	RE-ACTIVATED VOC LOG	OK	
		* MULTI RAE WAS NOT SAVING VOC READINGS		
10/18/05	Multi-Rae	REPLACED OLD PID LAMP	OK	
		* WAS NOT WORKING → CAUSED SPAN GAS ERROR		
12/30/05	RK1 - Eagle	Got Back from OHA Yearly Maintenance & Calibration	OK	



Quality Assurance –

Field instruments should be tested and pass a “bump” test before they are used in the field. This information needs to be documented. If they fail the test, calibrate.

Fail again, DO NOT USE.

Instrument Calibration & Check Form

Operator's Name(s): _____ Date: _____
 Barometric Pressure: _____

On-Site Gas Measurement

Instrument / ID #:	Parameter	Zero Chk	Chk Std Conc.	Measured Value	% Rec.	Accept. Range	P / F	Comments	Operator Init.
IAQ Calc- Model # 8760									
ID # 24396	Temp.	NA	Ref-			+/- 1°F			
	RH	NA	Ref-			+/- 3%			
	CO2		1000 ppm	ppm		950 - 1050			
ID # 24397	Temp.	NA	Ref-			+/- 1°F			
	RH	NA	Ref-			+/- 3%			
	CO2		1000 ppm	ppm		950 - 1050			
Multi-Gas Detector (circle which one was calibrated)									
ID # 28349 or 28350	CO		35 ppm	ppm		31.5 - 38.5			
	TVOC		10.0* ppm	ppm		9.0 - 11.0			
	NO2		5.0 ppm	ppm		4.5 - 5.5			
	LEL		50%	%		45 - 55			
CO Detectors									
Gas Alert (yellow)	CO		35 ppm	ppm		31.5 - 38.5			
Gas Alert	CO		35 ppm	ppm		31.5 - 38.5			
Laser Particle Counter									

Instrument Calibration & Check Form

Operator's Name(s): _____ Date: _____
 Barometric Pressure: _____

On-Site Gas Measurement

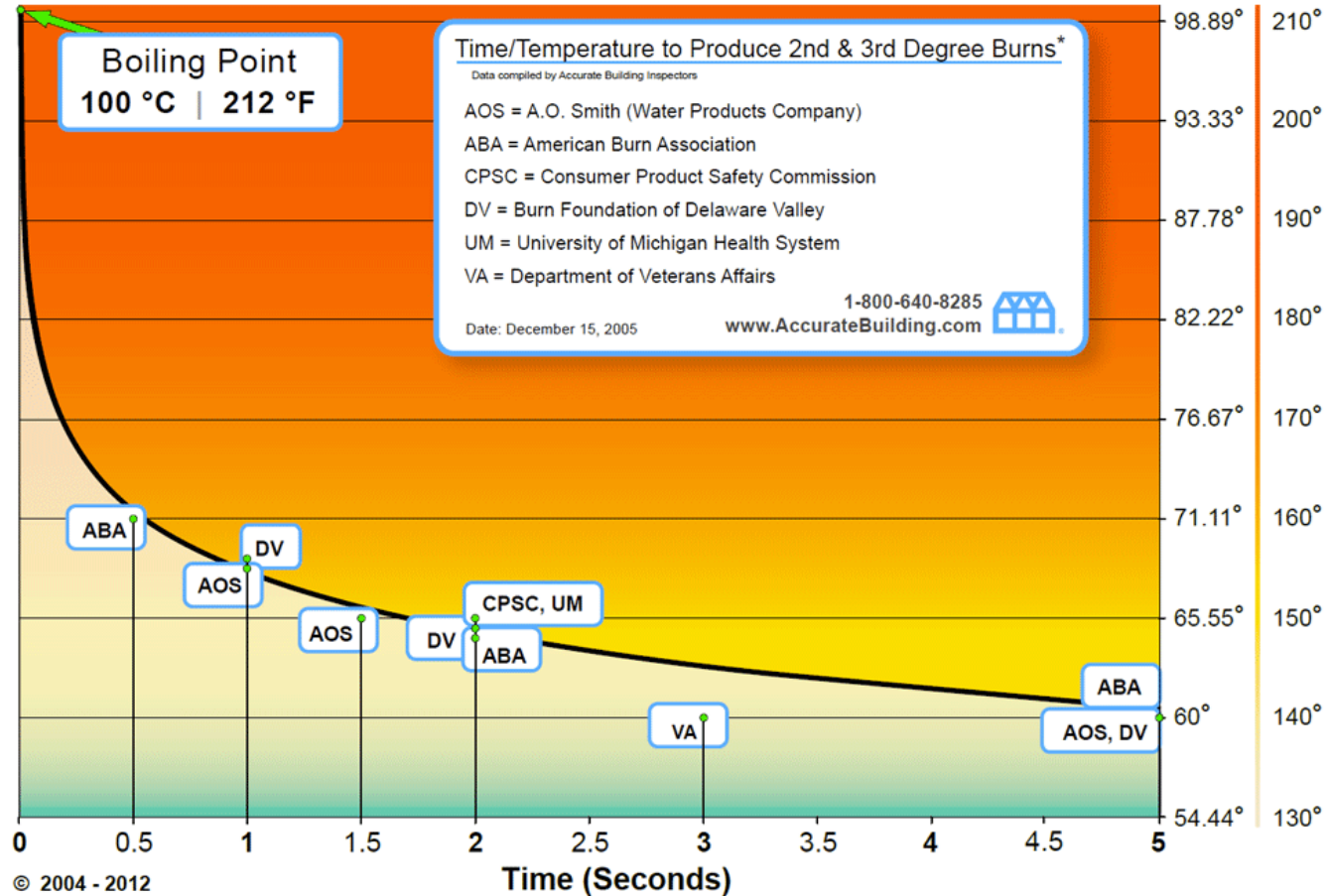
Instrument / ID #:	Parameter	Zero Chk	Chk Std Conc.	Measured Value	% Rec.	Accept. Range	P / F	Comments	Operator Init.
IAQ Calc- Model # 8760									
ID # 24396	Temp.	NA	Ref-			+/- 1°F			
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	CO2		1000 ppm	ppm		950 - 1050			
ID # 24397	Temp.	NA	Ref-			+/- 1°F			
	RH	NA	Ref-			+/- 3%			
	CO2		1000 ppm	ppm		950 - 1050			
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	LEL		50%	%		45 - 55			
CO Detectors									
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Water Temperature Testing

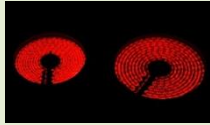


Hot Water Burn & Scalding Graph



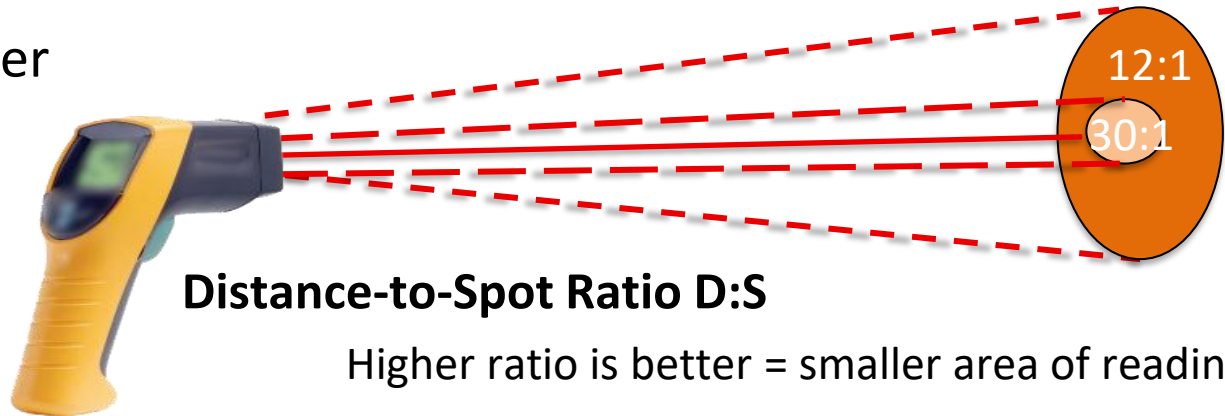
Infrared thermometers

Type of
data?



Surface
Temperature (°F)

- Surface temperature of walls
- Surface temperature where walls meet floors
- Supply vs. return register temperature



Combustible gas meter – measuring combustible gases in the air

Type of Data?



sound



light

PPM

concentration



These do not ID gases!!

Combustible gas meters are commonly used to check for gas leaks

Often referred to as “sniffing”



Carbon Monoxide Devices:

There is a difference between these



Alarm



Monitor



Detector



Carbon Monoxide (CO) Detector

Type of data:
Concentration in parts per million (ppm)



Warranted to accurate for 5 years. Simply activate and use until end of service life

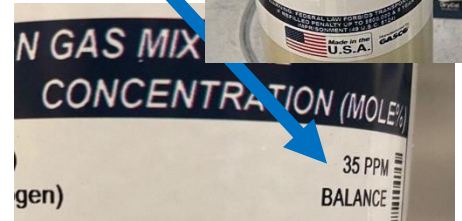
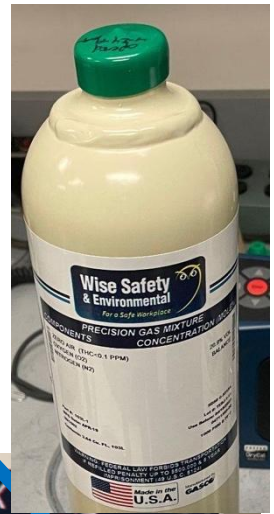


Can be checked and calibrated at the office using reference gas prior to going to the home



Most multi-sensor devices measure CO

Use a reference gas for bump tests



Measuring carbon monoxide (CO)

quick check of exhaust

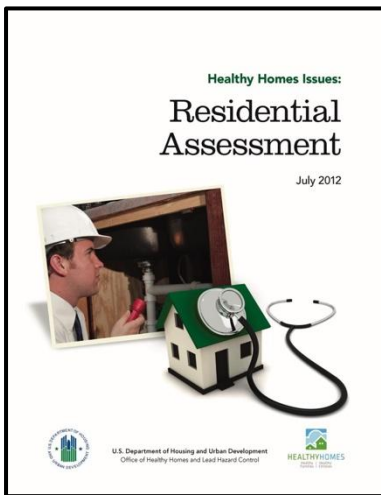


Some CO detectors can log data for longer-term monitoring over several days



These are selected standards and guidelines for carbon monoxide (CO)

Table from Residential Assessment,
HUD OLVCHH, 2012 pg. 47



Standard	Agency & Purpose
9 ppm	EPA's National Ambient (outdoor) Air Quality Standard—8-hr average (<i>Federal Register</i> , August 1, 1994) World Health Organization's outdoor air limit—8-hr average
≤11 ppm	Health Canada's Exposure Guideline for Residential Indoor Air—acceptable short-term exposure range, 8-hr average
≤25 ppm	Health Canada's Exposure Guideline for Residential Indoor Air—acceptable short-term exposure range, 1-hr average
30 ppm	Lowest CO level that UL and CSA allow home CO alarms to display, must not alarm in less than 30 days
35 ppm	EPA's National Ambient (outdoor) Air Quality Standard—1-hr average (<i>Federal Register</i> , August 1, 1994)
50 ppm	OSHA's 8-hr time-weighted average exposure for workers (29 CFR 1910.1000, Table Z-1) EPA's Significant Harm Level for ambient CO per 8 hr time-weighted average (40 CFR Part 51.151)
70 ppm	UL and CSA false alarm resistance point at 60 minutes (1 hr) of exposure Level at or above which UL and CSA home CO alarms must go off when exposed for 60–240 minutes (1–4 hrs)
75 ppm	EPA's Significant Harm Level for ambient CO per 4 hr time-weighted average (40 CFR Part 51.151)
125 ppm	EPA's Significant Harm Level for ambient CO per 1 hr (40 CFR Part 51.151)
150 ppm	Level at or above which UL approved CO alarms must go off within 10–50 minutes of exposure
200 ppm	NIOSH ceiling concentration for workers at which immediate evacuation is recommended (NIOSH, 1972). (Air free) Level of CO allowed inside water heater flue by ANSI standard
400 ppm	Level at or above which UL approved home alarms must go off within 4–15 minutes of exposure (Air free) Level of CO allowed inside furnace flue by ANSI standard
800 ppm	(Air free) Level of CO allowed inside oven flue by ANSI standard

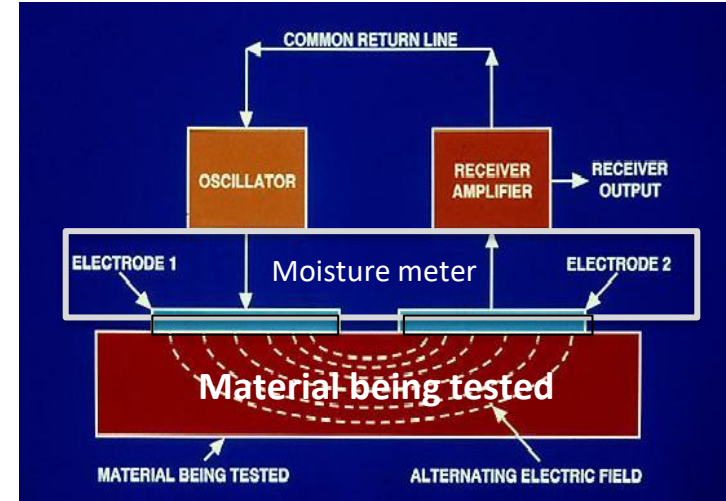
Moisture Meters – measure moisture content in materials

Type of data:

% Wood Moist. Equiv. (%WME)

Rel. Scale (0 - 100, 0 - 1000)

- Impedance type
 - capacitance



- Pin type
 - resistance



- Combination units
 - Resistance and capacitance in one

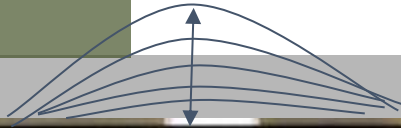


Framing



Framing

Drywall



Impedance (Capacitance)

Read ½" - 4" into
material depending
on meter and accuracy



Pin (resistance)

Read ⅛" - ½" into
material depending on
meter and accuracy



Wood material



Moisture content of wood

low  **0.1 ~ 14%**

Normal wood moisture

medium  **14 ~ 18%**

Damp wood

high  **> ~ 18%**

Wood saturated with moisture - will grow mold

Healthy Indoors Training, LLC Lawrence, Kans

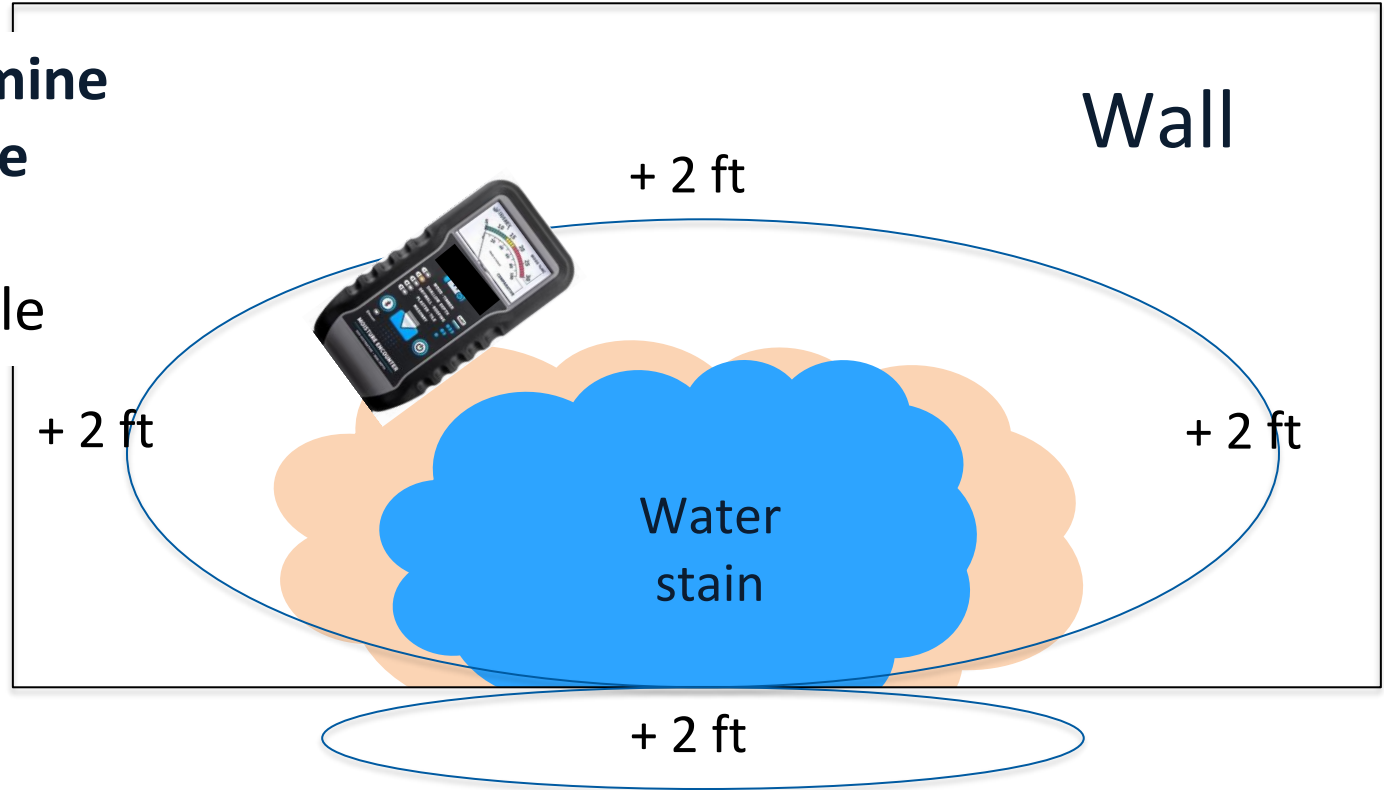
2 scales:
- %WME
- Comparative



Diagnostic technique – use a moisture meter to “map” or “survey” a water stain

Trying to determine
the extent of the
damage

-What isn't visible



What's behind that wall?

10.1



%
9.6

What's behind that wall?



98.1



%
99.6

What's behind that wall?



**Vapor generator/
airflow indicator**

**Type of
data**



**Direction of
air flow**

**Can visualize room and
house airflow and circulation**



Smoke = Chemical SDS

Safety Data Sheets

Material Safety Data Sheet 

For use with Retrotec's Air Current Tester
Emergency Phone Number (24 hours) CHEMTREC 800-424-9300
Outside US: 761-827-5887

SECTION 1 - IDENTIFICATION
PRODUCT NAME: Titanium Tetrahydride
COMMON NAME OR SYNONYM: Titanium Tetrachloride (TiCl₄)
SPECIES CATALOG NUMBER: VHS-001

SECTION 2 - HAZARD IDENTIFICATION
Hazardous: Yes
Corrosive: Yes
Flammable: No
Toxic: Yes
Irritant: Yes
Hazardous to the Environment: No

SECTION 3 - COMPOSITION / INGREDIENTS
CAS# 7550-45-0
EINECS 231-100-0
VOLUME 10ml

SECTION 4 - FIRST AID MEASURES
General: Remove contaminated clothing, wash thoroughly before reuse.
Eye: Flush with water for at least 15 minutes, occasionally lifting upper and lower eyelids.
Skin: Remove contaminated clothing and flush with water thoroughly. Rub alcohol. Move to fresh air. Get medical attention immediately. Ingestion: Get immediate medical attention immediately. If the patient is conscious, give large quantities of water. Do not induce vomiting.

SECTION 5 - FIRE FIGHTING MEASURES
Flash Point: Not applicable.
Extinguishing media: Carbon Dioxide or Dry Chemical. Do not use water or foam.
Special Hazards and Procedure: Contact with water may evolve flammable hydrogen gas.

Anbotek 安博检测
Product Safety Anbotek Testing

Report No. SZR170717007001

SAFETY DATA SHEETS

Sample Description: WIND INDICATOR REPLACEMENT CARTRIDGE
Model Number: CIRC-INC
Applicant: CHONGCHING UNITED TECHNOLOGY INC.
Address: 23-18 SOUTH TOWER OF CENTURY EMPEROR, NO.38 JIANXIN ROAD, JIANGBEI CHONGQING, 400020 CHINA

Reviewed by: 
Shen Chen Laboratory manager
Leo Li Laboratory director

CIRRUS Wind Indicator

CIRRUS Wind Indicator

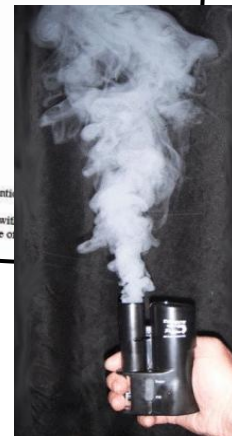
SAFETY DATA SHEET (SDS)
MATERIAL SAFETY DATA SHEET (MSDS)

SECTION 1 - IDENTIFICATION
Product Name: Look Solutions Fog Fluid
Look Solutions Haze Fluid
Product Label: Tiny Fluid
Quick Fog
Regular Fog
Slow Fog
Cryo Fog
Unique Fluid
Manufacturer: Look Solutions
Buenos Aires 33
30989 Gehrden
Germany
Phone: +49-5108-912210
Distributor: Look Solutions USA, Ltd.
10210 Governor Lane Blvd. #2008-B
Williamsport, MD 21795
U.S.A.
Phone: (646) 300-0520

SECTION 2 - HAZARD IDENTIFICATION
None. Not classified as hazardous materials (CFR49) or as dangerous goods (IATA/ICAO).

SECTION 3 - COMPOSITION / INGREDIENTS
Contains one or more of the following:
Triethylene Glycol CAS# 112-27-6
Monopropylene Glycol CAS# 57-55-6
Dipropylene Glycol CAS# 110-98-5
Dememineralized Water CAS# 7732-18-5

SECTION 4 - FIRST AID MEASURES
General: No Special Procedure
Eye: Flush With Water. Obtain Medical Attention.
Skin: Wash Off With Water.
Ingestion: Do Not Induce Vomiting. Rinse Mouth with Water. Obtain Medical Attention in Case of



Consider leaving a copy with the occupants



Kitchen Exhaust / Hood / Fan



Capture Efficiency

Diagnostics – Smoke spillage

- 2 minutes for water heaters & furnaces in heating mode
- 5 minutes for furnaces not in heating mode



Green Jobs Training Center



Healthy Indoors Training, LLC Lawrence, Kansas

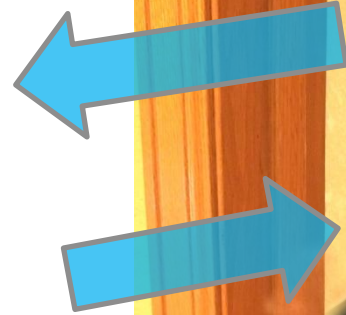


Room Pressures – return air path

- Determine airflow direction
- Indicate evidence of (+/-) pressure



Air Handler = Off?
Direction?
Air Handler = On?
Direction?



Thermo-hygrometers (temperature/relative humidity gauge)

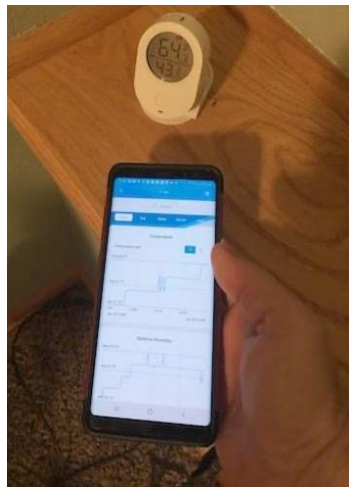
Type of
data

Air Temperature (°F)
Relative Humidity (%)



Low-cost
thermohygrometers

Low-cost Temperature and
RH monitor and datalogger



Send to occupant. Place in different rooms, maybe move them every few days. You arrive and read the data via Bluetooth (set it up before you send it)



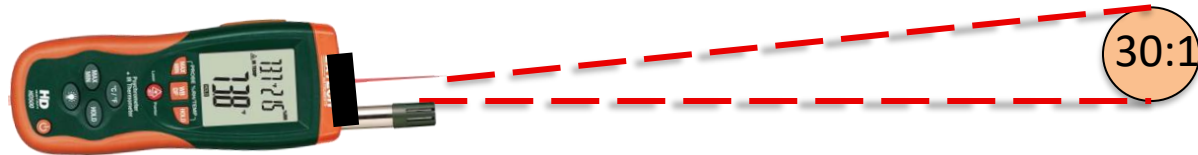
Digital Psychrometer (data logging) Advanced thermo-hygrometer

Type of data

Ambient Air Temperature (°F)
Wet Bulb Air Temperature (°F)
Dew point Air Temperature (°F)
Relative Humidity (%)
Absolute Humidity (%)



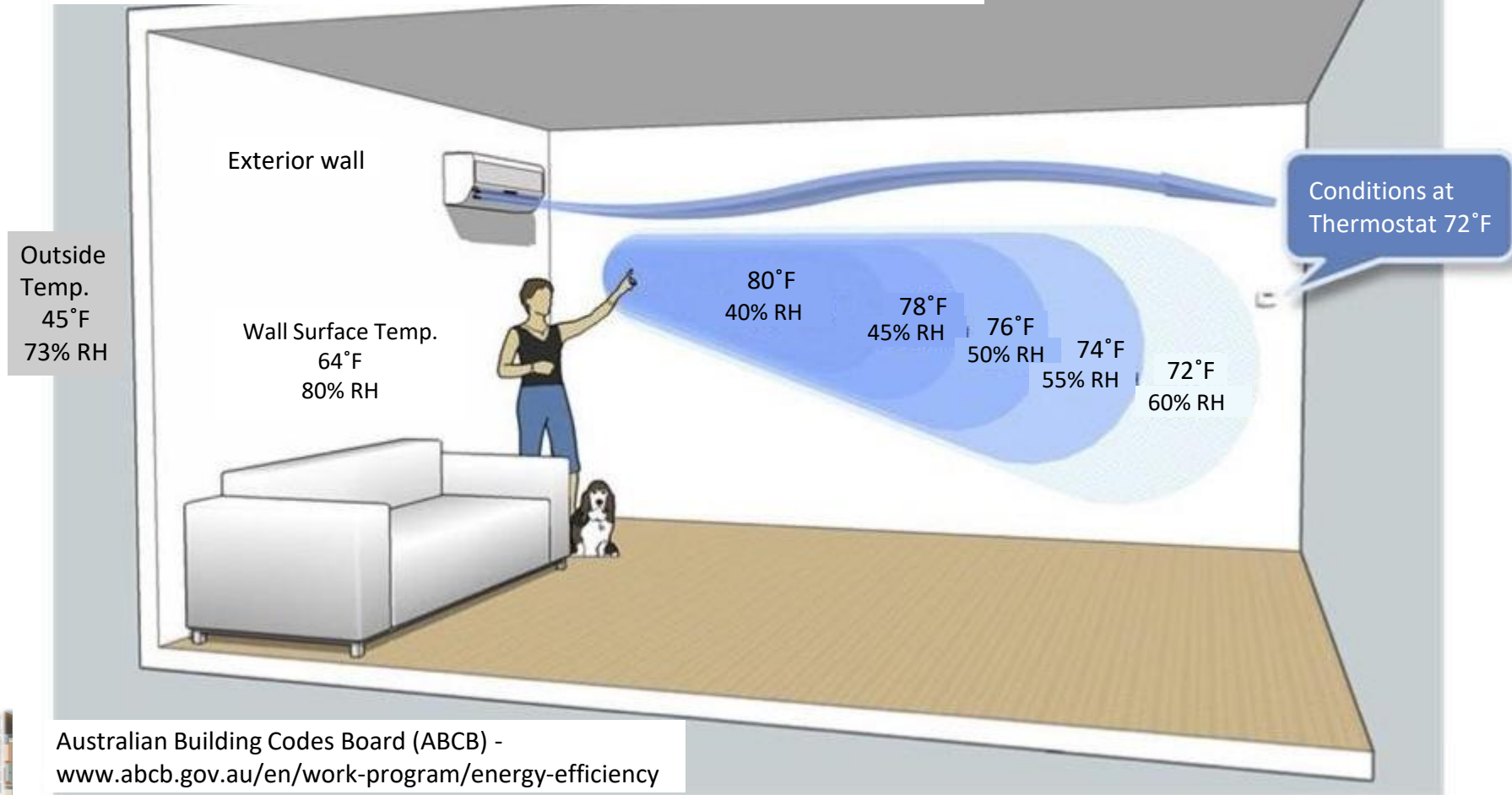
Some have built-in IR thermometer



Can set reading for dew pt. temp. and use the IR Thermometer to check surface temperatures around damp rooms



Relative humidity is highly dynamic



...but look at all the mold

54% rh... should be no problem!

Problem: the dew point is close to..

...the surface temperature...

...so rh **at the surface** is over 90%

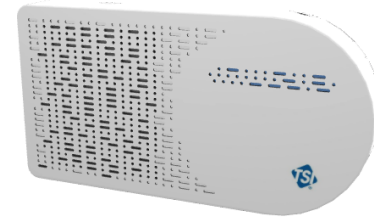
Relative humidity (RH) varies with temperature, so cooler areas can have a higher RH just because of temperature difference



IAQ Monitors

- Homeowner = \$100 - \$500
- Professional = \$1,000 - \$3,000
- Professional - top end = \$5,000 - \$10,000

- Carbon Monoxide
- Carbon Dioxide
- TVOC Total Volatile Organic Compounds
- Particulates
- Temperature & Humidity



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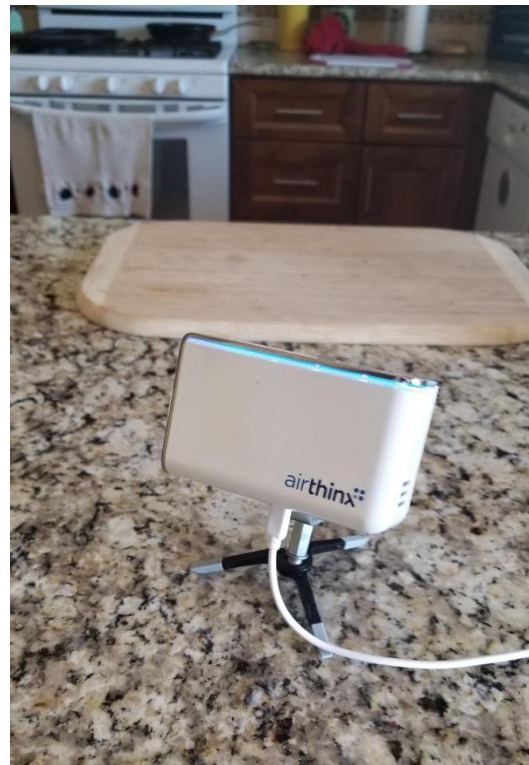
Is it calibrated? How do you know it is operating correctly.



There's a lot of confusion about how to use IAQ monitors effectively.

- Where should it go?
- How long should it be there?
- How would you get the data?
- How much time represents exposure
- What do you do if a result is out of range

*If you had a doctor visit that was 3 minutes –
do you feel it would be a thorough evaluation?*



AQ-SPEC

Air Quality Sensor Performance Evaluation Center

www.aqmd.gov/aq-spec

Sensors

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Dylos - DC1700-PM



2B Technologies - POM



Acrobatic - Smart Citizen Kit



FabLab - Smart Citizen Kit V2.1



Footbot



PurpleAir PA-II



PurpleAir PA-I-Indoor



HabitatMap - AirBeam



HabitatMap - AirBeam2



RTI - MicroPEM



SainSmart - Pure Morning P3



Edimax - EdiGreen Home



Aeroqual - S500 (O3 0-0.15)



Aeroqual - S500-PM



Hanvon-N1



IQAir - AirVisual Pro



Samsung S&C - SY-D5-DK3



Sensirion - Nubo



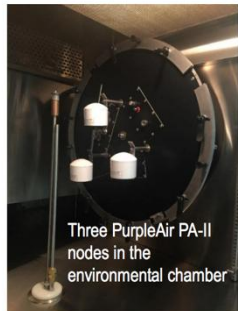
AQ-SPEC

Air Quality Sensor Performance Evaluation Center

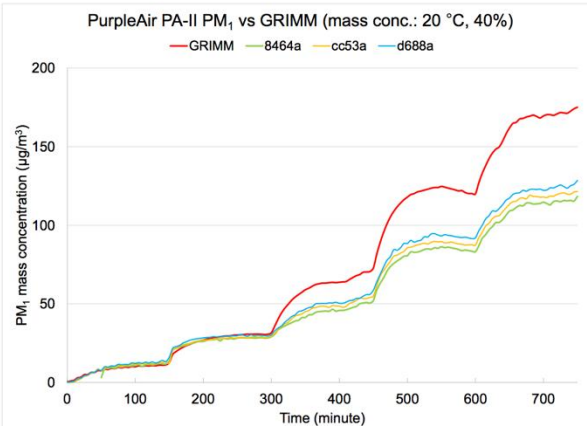
www.aqmd.gov/aq-spec

Evaluation results guideline

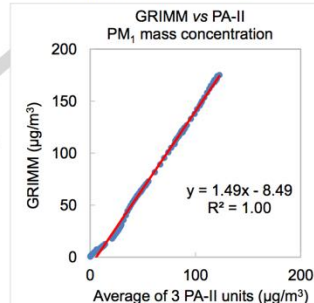
- PurpleAir PA-II vs GRIMM PM₁ mass concentration
- PurpleAir PA-II vs GRIMM PM_{2.5} mass concentration
- PurpleAir PA-II vs APS vs GRIMM PM₁₀ mass concentration



PA-II vs GRIMM (PM₁ mass; 5-min mean)



Coefficient of Determination



- Over the full PM₁ concentration range tested (0-175 µg/m³), the three PA-II sensors tracked well with the concentration variation recorded by GRIMM.
- PA-II sensors showed very strong correlations with GRIMM PM₁ mass conc. ($R^2 > 0.99$) between 0-175 µg/m³.
- PA-II sensors underestimated the GRIMM PM₁ mass conc.

<https://www.purpleair.com/map?opt=1/mAQI/a10/cc0#3.37/34.08/-100.5>

Healthy Indoors Training, LLC Lawrence, Kansas

Thanks for listening!

Contact me anytime here:

Kevin Kennedy

kkennedy740@gmail.com

<https://www.Healthyindoorstraining.com>

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