How Can Low-Cost IAQ Monitors Benefit Builders and Contractors

Joe Medosch
Determine if your home is impacting your health!
Special Thanks

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HVAC School
www.hvacrschool.com/

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Team Leader, ROCIS Initiative
www.ROCIS.org

Brett Singer and Woody Delp
Lawrence Berkley Laboratory
Low-Cost IAQ (Indoor Air Quality) Monitors

• Options for contractors
• Less options for builders
• General overview of monitors and accuracy
• Criteria for monitoring IAQ
• Inherent challenges with low-cost devices
• Third Party evaluations and standard for monitors
• What is next for IAQ monitors and improving IAQ
Occupant is the IAQ Receptor
What are you breathing?

10’ x 10’ x 4’

3000 gallons of air every day.

Animation source: http://noticing.co/how-insects-breathe/#
The Original IAQ Monitors

Foobot
*PM 2.5, Temperature, Humidity, Total VOCs, Carbon Dioxide*

uHoo
*PM 2.5, Temperature, Humidity, Total VOCs, Carbon Dioxide, CO, Ozone, NO2, Barometric Pressure*
Multiple devices

Bluetooth

WiFi

PM 2.5

4G

Personal

Radon

EEBA

4G

Hayward SCORE
Consumer IAQ Monitors

Trend Indicators
What do you want to use the IAQ monitor for?

- Measure what conditions?
- Where in the house?
- How long is it measuring? When?
- How will you get the data or share it?
- How will you know what occurred in the home?
  - cooking / showers

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

at that time

Trend Indicators

in that location
IAQ Monitor =
**Consumer IAQ Monitors**

**Blood Test Results**

<table>
<thead>
<tr>
<th>Blood Test</th>
<th>Result</th>
<th>Normal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBCs (billion/L)</td>
<td>8.00</td>
<td>3.5 to 10.5</td>
</tr>
<tr>
<td>Neutrophils (%)</td>
<td>62</td>
<td>40 to 70</td>
</tr>
<tr>
<td>Lymphocytes (%)</td>
<td>28</td>
<td>25 to 45</td>
</tr>
<tr>
<td>Monocytes (%)</td>
<td>10</td>
<td>2 to 8</td>
</tr>
<tr>
<td>Eosinophils (%)</td>
<td>1</td>
<td>1 to 5</td>
</tr>
<tr>
<td>Basophils (%)</td>
<td>0</td>
<td>0 to 1</td>
</tr>
<tr>
<td>RBCs (trillion/L)</td>
<td>3.84</td>
<td>4.3 to 5.7</td>
</tr>
<tr>
<td>Hb (g/dL)</td>
<td>11.7</td>
<td>13 to 17</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>37</td>
<td>37 to 52</td>
</tr>
<tr>
<td>Platelets (billion/L)</td>
<td>262</td>
<td>150 to 450</td>
</tr>
</tbody>
</table>

**IAQ Monitor Results**

![IAQ Monitor Result](image)
Multiple devices that measure multiple conditions

- Temperature & Humidity - some Dew Point
- CO – carbon monoxide - ppm
- Radon - pCi/L
- PM Particle count/mass – PM 1, 2.5, 10
- tVOC – total volatile organic compounds
  - Formaldehyde
- CO2 - carbon monoxide – **have a direct CO2 sensor**
- Ozone
- Air Pressure / Barometer
- Ambient light – lux and or Sound - dBA
Multiple devices that measure multiple conditions

- **Temperature & Humidity** - some Dew Point
- CO – carbon dioxide - ppm
- Radon - pCi/L
- **PM Particle count/mass** – PM 1, 2.5, 10
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  - Formaldehyde
- **CO2 - carbon dioxide** – **have a direct CO2 sensor**
- Ozone
- Air Pressure / Barometer
- Ambient light – lux and or Sound - dBA

These Are Most Consistent & Stable Readings
Data – what do you get and how?
This report displays our findings about the air quality in your home, and offers recommendations to help you make informed decisions about your family's health, comfort and safety. If you have additional questions, please visit www.airadviceforhomes.com.

### HEALTH

#### Particles

**Health Concerns**
- Particles are generally a cause for concern when daily average levels are above 10 ug/m³.
- Particles are known to trigger asthma and allergy symptoms. At levels above 35 ug/m³, they can harm normally healthy adults by causing emphysema and diminished lung capacity. Children, the elderly, and pregnant women are more susceptible.

**What We Found In Your Home**
- Particle levels were between 11-35 ug/m³.

**Potential Causes**
- Particles can build up to unhealthy levels due to three primary causes:
  - **Activities in the home**
  - **Presence of excessive particulate sources**
  - **Heating and cooling system issues**

**Recommended Actions**
- Replace filters or upgrade filtration system
- Inspect and clean duct work
- Use the exhaust fan during cooking
- Install UV light in cooling coil to prevent mold

#### Chemicals

**Health Concerns**
- Chemical pollutants are generally a cause for concern when average levels are above 500 ug/m³ (micrograms per cubic meter of air). Chemical pollutants are known to trigger asthma and allergy symptoms. At moderate levels, eyes and nasal passages can be irritated. Some people can experience nausea and headaches. At very high levels, they can even affect normally healthy adults by overworking the liver and kidneys. Children, the elderly, and pregnant women are more susceptible.

**What We Found In Your Home**
- Chemical pollutant levels were between 501-3000 ug/m³.

**Potential Causes**
- Levels can build up in your home's air due to usage of chemical products and heating/cooling system issues:
  - **Sources**: Off-gassing from building materials, carpeting, furniture and other synthetic materials, fuel fumes, painted products and air treatments, personal care products, household products such as paint, glue, and plastic
  - **Possible heating & cooling issues**: Lack of fresh air introduced into home (either inadequate mechanical ventilation or none present), no chemical pollutant removal equipment

**Recommended Actions**
- Install an energy efficient ventilation device, such as a heat or energy recovery ventilator (ERV or HVR)
- Install a VOC reduction device such as a photocatalytic oxidizer (PCO)
- Minimize use of VOC sources such as air fresheners, open cleaning fluids, or candles

#### Carbon Dioxide

**Health Concerns**
- Carbon dioxide (CO₂) levels above 750 ppm (parts per million) are a cause for concern. At higher levels, CO₂ inside a home can contribute to what the EPA terms "sick building syndrome," which leads to fatigue, headache, breathing difficulties, nausea, dried eyes and itchy skin. At even higher levels, CO₂ can cause asphyxiation as it replaces oxygen in the blood. CO₂ poisoning, however; is very rare. The U.S. EPA recommends a maximum concentration of CO₂ of 1500 ppm (0.1%) for continuous exposure.

**What We Found In Your Home**
- Carbon dioxide levels were below 750 ppm.

**Potential Causes**
- Elevated carbon dioxide levels can occur in the home due to source causes, home heating & cooling system issues, or both:
  - **Sources**: 'Tight' (well weatherized and energy-efficient) home construction without adequate ventilation, common human & household activity (breathing, and burning candles, gas, wood, or other combustion)
  - **Possible heating & cooling issues**: Lack of supplied fresh air (no ventilation), malfunctioning ventilation, ventilation shut off by occupant, HVAC equipment needs repair or service

**Recommended Actions**
- Use the exhaust fan during cooking
- Inspect combustion sources, such as fireplaces, gas heaters, or gas stoves, for proper ventilation

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*a* Source: American Lung Association, Environmental Protection Agency (EPA), Indoor Air Quality Association.

*b* Source: European Union (EU); Leadership in Energy & Environmental Design (LEED); Environmental Protection Agency (EPA).

*c* Source: EPA, Minnesota Dept of Health.
IAQ Monitors – Data 1, 2, 3...

• The device measures the data...

• Where is it stored?
  • On the device?
  • In the cloud?
  • Do you own the data if you terminate the contract?

• Who has access to the data – Manufacturer?
  • GEO location!
What is an AQ – Manufacturer's Air Quality Index

Index Score Number

AIR QUALITY SCORE

Air quality score

78

GOOD

CO₂ 87

AQ 70

EEBA
Same Sensor – different readings

- Most use same sensors – Plantower or Honeywell
  - May be customized for each manufacturer
- Sensor is integrated with the device
  - Soldering and additional electronics
- Typically only one sensor – accuracy can be questionable
- Sensors can get clogged with what you're measuring
Same Sensor – different readings

- Some devices try to self correct
- This could cause the sensor to drift over time

Example

Resistive Sensor

Device overtime exposed to extreme temperatures, humidity and dust

Impacting the physical conditions of the sensor.

Potentially becoming clogged over time

Accuracy has been compromised

Algorithm can attempt to compensate based on the average readings over time from their internal studies.

Your device may drift differently
Same Sensor – different readings

- Some devices try to self correct
- This could cause the sensor to drift over time

Example

CO2

Relative humidity is based on an outdoor baseline

CO2

Device has a baseline of 400 ppm and measures the increase and decrees of CO2

CO2

Algorithm after 7 days: It will assume the lowest value is Outdoors

CO2

Now it shifts the baseline and all the reading Shift Down

CO2

7 days later the process is readjusted: Always comparing the last 7 days to the baseline.

This average may not be your conditions

7 day average is 450 ppm

Prefer non-dispersive NDIR sensor
# AQ-SPEC

Air Quality Sensor Performance Evaluation Center

www.aqmd.gov/aq-spec

<table>
<thead>
<tr>
<th>Sensors</th>
<th>AQ-SPEC Home</th>
<th>Evaluations</th>
<th>Submit a Sensor</th>
<th>Special Projects</th>
<th>Resources</th>
<th>Sensor News</th>
<th>Conference 2017</th>
<th>Workshops</th>
<th>FAQs</th>
<th>AQ-SPEC Advisory Board</th>
<th>About Us</th>
<th>Contact</th>
</tr>
</thead>
</table>

[Images of various air quality sensors]

[Links to sensor specifications and resources]
Evaluation results guideline

- PurpleAir PA-II vs GRIMM PM$_1$ mass concentration
- PurpleAir PA-II vs GRIMM PM$_{2.5}$ mass concentration
- PurpleAir PA-II vs APS vs GRIMM PM$_{10}$ mass concentration

Over the full PM$_1$ concentration range tested (0-175 µg/m$^3$), the three PA-II sensors tracked well with the concentration variation recorded by GRIMM.

PA-II vs GRIMM (PM$_1$ mass; 5-min mean)

- PA-II sensors showed very strong correlations with GRIMM PM$_1$ mass conc. ($R^2 > 0.99$) between 0-175 µg/m$^3$.
- PA-II sensors underestimated the GRIMM PM$_1$ mass conc.
**RESET™**

The intent of the RESET™ Air Test Procedure for Accredited Monitors is to:

- Evaluate monitor quality via a singular, standardized test protocol
- Standardization of the test methodologies and protocols as outlined, ensuring consistent replicability in laboratories, irrespective of geographic location.

**Accredited monitors**

- A Grade = Reference
- B Grade = Commercial
- C Grade = Consumer

- Particulate Matter 2.5 (PM2.5)
- Total Volatiles Organic Compounds (TVOC)
- Carbon Dioxide (CO2)
- Temperature
- Humidity

[www.reset.build/](http://www.reset.build/)
RESET™

RESET™ Air Accredited Monitors are defined and categorized by both Grade and Type. Monitor Grade defines the performance, accuracy and data reporting proficiency of a monitoring device. Monitor Type defines the “fit for purpose” scenarios applicable to each Grade and serves to define appropriate deployment of monitoring devices.

The RESET™ Air Accredited Monitor Grades include:

**Grade A:** Calibration Grade monitors. Monitors that are used for the calibration of Grade B and C monitors. Grade A monitors are typically (but not exclusively) handheld and are primarily utilized for project commissioning, site audits, and pollutant source detection.

**Grade B:** Commercial Grade monitors. Grade B monitors provide actionable, indoor air quality data at scale within buildings, balancing performance and cost while reliably enabling building automation and providing occupants with high-quality data.

**Grade C:** Consumer Grade monitors. Grade C monitors are affordable to the average user or “citizen scientist”. Primarily utilized for personal data gathering or non-scientific purposes.

www.reset.build/
Contractors
What do want to use the IAQ monitor for?

- Measure what conditions? General conditions or ???

- Where in the house? Set a schedule for clients to relocate the monitor and document location & time
  - more than 1 monitor?

- How long is it measuring? When? 3 work days + weekend min. 2 weeks +

- How will you get the data or share it? Send report / share data

- How will you know what occurred in the home?
  - windows open? / cooking / showers Clients keep a journal?
Role of the contractor and role of the device

• Do you let the client see the measurements?
  - does a device have a display?
  - is it better to hide this information or let them see it?

• What is the data really mean as actionable items
  - are there thresholds for these readings

• What are these devices telling you?
  - conditions and materials in the home,
  - their habits
Role of the contractor and role of the device

This is the ultimate engagement tool.

It is useless unless you the contractor fully engage the client.

The success of the IAQ monitor is dependent on the contractor – more than the device, or the client.

Recommended - share one with technicians and staff.
AWAIR Omni

Front indicator lights display conditions.
Fully customizable

Includes internal battery
Same device multiple measurements
The M5200 IAQ Monitor from AirAdvice
A Complete Report in **30 Minutes**

- Plug in the power cord.
- An email is sent to the Technician in 30 minutes.
- **Test for Opportunities on Every Call!**
The AirAdvice 30- min. *FlashReport*

- Particles
- VOCs
- CO2
- Temperature
- Relative Humidity
- CO
What are you breathing?

*Lawrence Berkley Labs (LBL) MERV 8-13

Air Leakage / Infiltration = Exposure pathway
HUMAN HAIR
50-70 μm (microns) in diameter

PM_{2.5}
Combustion particles, organic compounds, metals, etc.
< 2.5 μm (microns) in diameter

- SARS-CoV-2 0.06-0.14 μm
- Bacteria 0.5-2 μm
- Blood cell 7.5 μm

PM_{10}
Dust, pollen, mold, etc.
< 10 μm (microns) in diameter

FINE BEACH SAND
90 μm (microns) in diameter

Effects of PM_{2.5}

- Enter through nose and mouth
- Nose irritation
- Larger particles are deposited through coughing and sneezing
- Throat irritation
- Cardiovascular disease
- Lung tissues and even lung cancer
- PM_{2.5} particles are able to penetrate deep into the lung, causing lung and heart tissues
FURNACE AND HVAC SYSTEM FILTERS

Furnace and HVAC filters work to filter the air only when run only when heating or cooling is needed (usually less than half the year). In order to get more filtration, the system would have to run more frequently, which may not be practical in many cases since longer run times increase energy cost and less control during the cooling season.

- Furnace Filter
- Portable Air Cleaners
- Furnace and HVAC Filters
Air Handler Intervention

CASE STUDY: Indoor Air Quality Interventions
Chris Guignon, evolveEA

Source: Linda Wigington

16x25x1 MERV 12

20x25x4 MERV 13
24/7 Air Handler w High MERV Filter

1) Using existing 1” pleated filter

2) Return drop modification
   w/ turning vanes
   4”, 20”x 25” MERV 13 filter

Dylos particles ≥0.5 μm

CASE STUDY: Indoor Air Quality Interventions
Chris Guignon, evolveEA

Source: Linda Wigington
Energy Audit

• Actually an energy penalty
• Typically Exhaust only
• Follow ASHRAE 62.2 X

Healthy Home Assessment

• Balanced Ventilation has significant improvements including a reduction in respiratory triggers such as formaldehyde and other VOCs, airborne mold and phthalates, carbon dioxide as well as radon and fewer asthma/respiratory symptoms.
• And associated with lower dust mite levels.
Handheld IAQ Monitors
Virtual or Remote Diagnostics

Govee 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 sent it)
Digital Radon Detector

**AirThings Corentium Home Model**

- **Accuracy (±5%)** (plus or minus 0.14 pCi/L)
- **Precision (2.7 pCi/L):** Short term (7 days): 80+% after 1 week, Long term: 90+% after 1 month
- LCD display short term 1 day and 7 days, and long term 1 year average
- Radon Gas Sampling Method: Passive radon diffusion chamber
- Radon Gas Detection Method: Alpha spectrometry using digital detector technology
- Readout in pCi/L
- Designed in Europe, and tested in Japan
- Unaffected by humidity, electromagnetic interference and dust
- Not universally accepted in Real Estate Transactions
Low Level CO Alarm – Perfect Gift

Low-Level Carbon Monoxide Monitor - These are Carbon Monoxide detectors that can detect and alarm at levels at 5 ppm. Other units detect when above 70ppm for 4+ hours.

Ultra Low Level Display Time: 5 ppm within 1 minute
Low Level Visual Alert Time: 9 ppm within 10 minutes, 25 ppm within 2 minutes
Low Level Audible Alert Time: 15 ppm within 60 minutes
Low Level Alarm Time: 25 ppm within 30 minutes
Mid Level Alarm Time: 50 ppm within 15 minutes
High Level Alarm Times: 100 ppm within 5 minutes; 150 ppm within 3 minutes
Visual Alert and Alarm Signals: Current CO level detected and flashing Red Alarm LED
Display Resolution: 1 PPM
Display Accuracy: ±15%, plus ±2% each succeeding year, or 5 PPM, whichever is greater, from 20 to 500 PPM @ 50% RH, 72F ±5F
Particulate and VOC / Formaldehyde Meters

Particulate Counter

FM200: Formaldehyde Meter

Measures Volatile Organic Compounds and $\text{CH}_2\text{O}/\text{HCHO}$ Concentrations in Real Time

VFM200: VOC/Formaldehyde Meter
Carbon Dioxide (CO₂) Meters
BuildingDoctors.com

- Comprehensive Energy Audits
- Your Report or Treatment Plan
- Energy Efficient Upgrades
- Third Party Verification

GET THE BEST INDOOR AIR QUALITY
MAKE YOUR HOUSE MORE COMFORTABLE
HELP THE ENVIRONMENT
REDUCE COSTS
HAZARDS THAT AFFECT YOUR HOME’S HEALTH & INDOOR AIR QUALITY

Did you know that according to the EPA, your indoor air might be two to five times more polluted than the air outside? This is because many homes have structural issues which allow airborne contaminants to accumulate inside the home.

Even if you give your house a deep clean on a regular basis, there could be problem areas in your house which harm your IAQ and waste valuable energy. For example:

- Air leaks let outside pollutants seep into the home
- Poor ventilation keeps stale air indoors
- Ductwork leaks let dust into your HVAC system
- Excess indoor humidity causes mold growth
- Crawl space issues send musty air throughout the home

For a truly healthy home, it’s important to uncover these types of issues at the source and make targeted improvements which improve indoor air quality, comfort, and energy efficiency.

HOW TO MAKE YOUR HOME A HEALTHY HOME

With Total Home Performance, creating a healthy home is simple. We offer a wide range of services that work together to make your home healthier inside and out.

Here are some key home improvements we recommend if you’re looking to boost overall home health.
Does your house have:

Active and/or recent leaks?
- Yes
- No
- I don’t know

Visible or suspected mold?
- Yes
- No
- I don’t know

Wall-to-wall carpet?
- Yes
- No
- I don’t know

A crawlspace?
- Yes
- No
- I don’t know

Forced air heating/cooling?
- Yes
- No
- I don’t know

Frequent indoor or outdoor pest treatment?
- Yes
- No
- I don’t know
Builders
Sensor Integration

- Works with Apple HomeKit
- Works with IFTTT

![iRobot](image)
![NETATMO](image)
![wemo](image)
![SmartThings](image)
![hue](image)
![alexa](image)
![EEBA](image)

![Hayward Score](image)
You Can Only Control If You Measure the Conditions.

If you Measure the Conditions... Can You Control the Conditions
Sensor Integration

Air Purifiers
New & Unique

HAVEN™ Central Air Monitor

by TZOA® In-duct monitor integrates with any HVAC system to track indoor air quality

CENTRAL AIR CONTROLLER
To control HVAC system fan during air quality events and ensure regular circulation

OTHER EQUIPMENT
Automatically triggers ventilation or filtration during AQ events

AH Control

Indoor Stand Alone Device
Haven Central IAQ Monitor

Current Status

HVAC Fan: Active

PM: Good
5 µg/m³

VOC: Fair
240 µg/m³

RH: 25%

Filtration (Particles): Good
Ventilation (Chemicals): Fair

History

Timeframe:
Last week
From 06-15-2020, 10:00 AM To 06-22-2020, 10:00 AM

Graphs showing recent airflow readings and particulate matter in the air.
Sensor Integration CONNECTED IAQ SYSTEM
Sensor Integration

Panasonic

Cosmos Command Center

Cosmos HQ
Monitors system operations in real-time, receives alerts and recommendations, and automates processes efficiently.

Cosmos Indoor Air Quality Monitor
Constantly monitors indoor air quality levels to determine when outside the normal range. Color-coded LED lights provide instant air quality reading.

Cosmos Communication Modules
Provides communication for signal reliability among Cosmos components.

Mobile App
Provides data on your home's indoor air quality in an easy-to-read dashboard, you'll know when something is wrong, and how Cosmos resolves it automatically.
COVID-19 Zappers

CAUTION
**uHoo Virus Index**

The ‘uHoo Virus Index’ is a patent pending technology that uses the power of air quality data to help you know **how to deactivate viruses** in your home/workplace and how your air quality affects your health and immune system. Optimize your air quality so you can **deactivate viruses**, if they’re present.
Responsive Purification
Designed to help optimize indoor environmental conditions, DARWIN Home Wellness Intelligence uses advanced algorithms and machine learning methods to monitor and improve indoor air quality. Air monitoring sensors passively test air quality in real-time and automatically turns on the heating and cooling system to provide you with fresh air exactly when you need it.
Readings
- Temperature
- Humidity
- Dew Point
- TVOCs
- Formaldehyde
- CO2 Carbon dioxide
- CO Carbon monoxide
- NO2 Nitrogen dioxide
- PM 1.0, 2.5, 10
- Ozone
- Air Pressure / Barometer
- Ambient light - lux
- Sound - dBA
- Local Whether

Sensor
- Self Calibration
- Factory Calibration
- Passive or fan assist

Connectivity
- 3G / 4G / 5G
- WiFi
- Bluetooth / range
- Collects data if not connected to cloud
- Phone app
- Web access
- Cloud storage
- Integrates w/ other devices
- API

Power
- 120v
- Portable - internal battery
- Portable - works off a battery pack
- USB power

Active Spread Sheet

<table>
<thead>
<tr>
<th>Type</th>
<th>Contractor</th>
<th>Commercial / Residential</th>
<th>Residential / Maybe small commercial applications</th>
<th>Personal Portable monitor</th>
<th>Residential</th>
<th>Consumer</th>
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</thead>
<tbody>
<tr>
<td>Esta Price for unit (as of June 2020)</td>
<td>$1,200</td>
<td>$899</td>
<td>$289</td>
<td>$149</td>
<td>$149</td>
<td>$300</td>
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<tr>
<td>Monthly / annual service fee</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Visual Display</td>
<td>Minimal - Connectivity and Alert single color</td>
<td>Full color display</td>
<td>No</td>
<td>Yes - minimal - can be changed</td>
<td>Yes - minimal - can be changed</td>
<td></td>
</tr>
<tr>
<td>Display can be turned OFF</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Readings
- Temperature
- Humidity
- Dew Point
- TVOCs
- Formaldehyde
- CO2 Carbon dioxide

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Yes</th>
<th>Range - 0-99°C</th>
<th>Resolution - 0.1°C</th>
<th>Maximum Error - ±0.5°C</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Humidity</th>
<th>Yes</th>
<th>Range - 0-99%RH</th>
<th>Resolution - 0.1%RH</th>
<th>Maximum Error - ±2%RH</th>
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</table>

<table>
<thead>
<tr>
<th>Dew Point</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>No</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>TVOCs</th>
<th>Yes</th>
<th>PPM</th>
<th>Effective Range - 1-300ppm of HCHO</th>
<th>Sensitivity - 0.15 - 0.5 Rs (10ppm of HCHO) Rs (air)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Formaldehyde</th>
<th>No</th>
<th>CH2O Sensor</th>
<th>Effective Range - 0-1 ppm</th>
<th>Resolution - 0.001 ppm/m3</th>
<th>Maximum Error - &lt; 9% FS</th>
</tr>
</thead>
</table>

| CO2 Carbon dioxide | Yes | Effective Range - 0-3000 ppm | CO2: 400 - 10,000 ppm | Yes | 0 to 4000 ppm, +/-75 ppm |

link - https://bit.ly/36t1jPZ
Conclusions

- All chemicals matter
- All particulates matter
- All homes matter
- All occupants matter

Thank You
joemedosch@gmail.com
More information go to bpi.org/HHP

Download the full PowerPoint PDF - bpi.org/hhp
Video Recording is on EEBAs YouTube site

https://www.youtube.com/playlist?list=PL18eaEJUabuVXShxYBZw5Ym1bt9AlMv2p
or
https://www.youtube.com/playlist?list=PL18eaEJUabuWTrFvqC1-NhSjFPSnZtWLo