I&E INDUSTRIES & ENVIRONMENT

Calibrating 4500 Air Monitors in 60 Days

Lessons Learned: Where IAQ is not your basic IAQ anymore.

Ron McMahan | Sept 20, 2022

SAFER
GREENER
SMARTER

SGS

Agenda

- Indoor Air in Buildings, Not Just Industry, Becomes a True Exposure Risk
- CIHs Needed!
- Calibration
- Sum of the Impact to Calibration Accuracy
- Questions

Indoor Air in Buildings, Not Just Industry, Becomes a True Exposure Risk

IAQ’s role in indicating and reducing infectious transmission

Filtration

Particle measurements can indicate effectiveness of HVAC or standalone filters

IAQ’s role in indicating and reducing infectious transmission

Ventilation

Indoor carbon dioxide measurement can indicate adequate/optimal ventilation

IAQ’s role in indicating and reducing infectious transmission

Other considerations

Low-level carbon monoxide exposure

- Discussed for some time
- Avoided monitoring due to liability
- High exposure threshold of CO alarms
- Need for multi-unit monitoring to reduce possible malfunction effect
- Required action levels below 5 ppm

IAQ’s role in indicating and reducing infectious transmission

Other considerations

Volatile Organic Compounds (VOCs)

- Long known as a possible exposure risk
- Known carcinogenic compounds such as benzene and formaldehyde
- Measurement effective notification level without false alarms is difficult

IAQ’s role in indicating and reducing infectious transmission

Other considerations

Temperature and Relative Humidity

- Long been examined due to primary comfort
- Technology has been established

CIHs Needed!

With increased exposure risk from indoor air quality, the principles of Industrial Hygiene and EHS professionals are applicable.

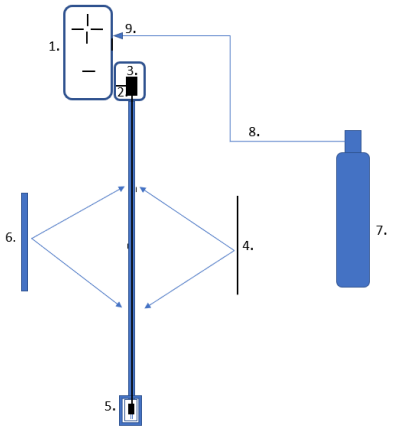
Processes and procedures to implement an effective IAQ program are critical

Defensible Data

What can you defend?

- Proof of calibration
- Calibration frequency (facts)
- Quality assurance documentation – proof of accuracy
- Elimination of false alarms
- IAQ instrument performance validation
- Cost effectiveness

Calibration



Calibration

Process

- Log into Fulcrum
- Scan sensor ID to insure location
- Record reference into Fulcrum
- Record reference into calibration platform
- Apply gas standard
- Auto log readings into Fulcrum
- Use calibration software to adjust accordingly
- Obtain updated readings
- Verify or redo, finalize calibration

Calibration Considerations

Carbon Monoxide (CO) and Carbon Dioxide (CO_2)

- Zero air extended (time vs nitrogen or background) against reference level
- Span certified test gas – How is it certified?
- Target action levels
  - CO - 5 PPM
  - CO_2 – 1000 PM

Calibration Considerations

Particulate Matter (PM 2.5)

- Zero by filter if able (Some validation with cal gas, but not accuracy)
- Field environment span difficult/often impractical, so reference single point
- Many PMs not calibratable since PM sensor manufacturer provides cal curves in microprocessor on board.
- Lower cost PM sensors do not count/account for PM 10 particles but use fixed ratio to calculate PM 10 PM 2.5
- Highly inaccurate for most sensors/ instruments

Calibration Considerations

Volatile Organic Compounds (VOCs)

- Includes hundreds if not thousands of compounds
- MOS sensors are the most widely used but inaccurate.
- PIDs are most relevant but limited to certain compounds; not formaldehyde at exposure levels.
- Specific formaldehyde sensors, guess at best; calibration is done by surrogates such as H_2S.

Calibration Considerations

Radon

- Where regulatory standards exist, radon is sketchy unless calibrated effectively or absorbent methods used.
- Most real-time radon sensors not mandated due to perceived market disparity

Calibration Considerations

Others

- Temperature
- Humidity
- Noise
- Light

Sum of the Impact to Measurement Uncertainty

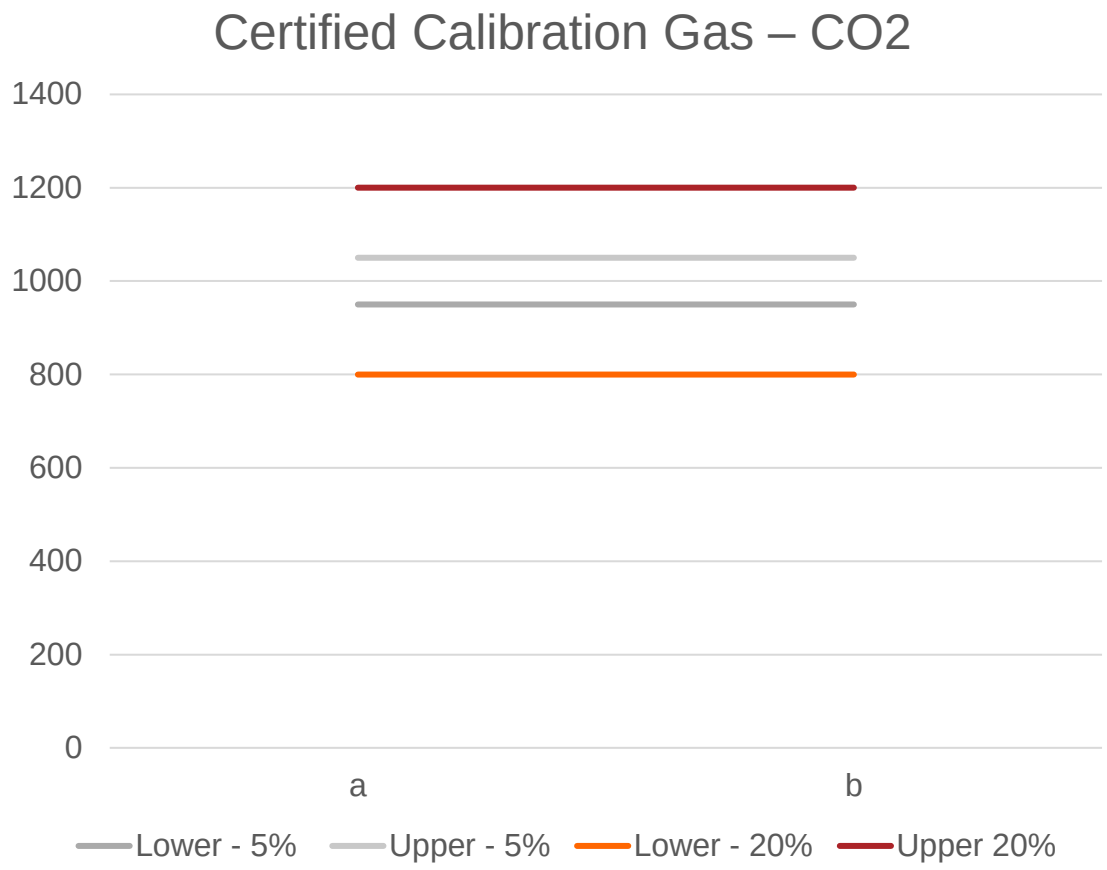
Challenges from Others

Sum of the Impact to Measurement Uncertainty

From Standards

- Test gas accuracy – certified?
- 5% to 20% plus or minus

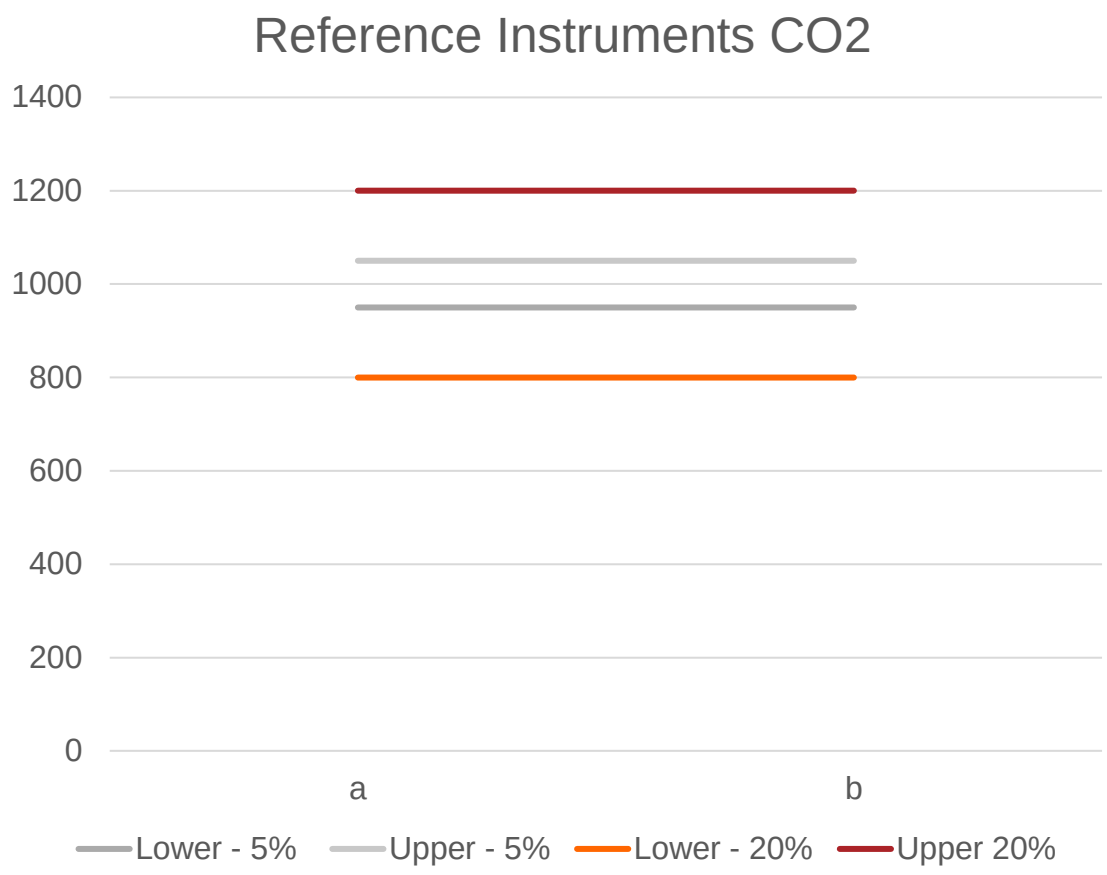
  1 ppm or……



Sum of the Impact to Measurement Uncertainty

By Reference

- Reference instruments calibrated against a standard
- Sum of impact caused by background using reference
- Absolute best case, +/- 5%, +/- 20%
- Particle make up (dust v/s other)



Sum of the Impact to Measurement Uncertainty

By Reference

- +/- 3%

Carbon Monoxide (IAQ Probe Model 982)

Sensor Type	Electro-chemical
Range	0 to 500 ppm
Accuracy[5]	±3% of reading or 3 ppm, whichever is great
Resolution	0.1 ppm
Response Time	<60 seconds to 90% step change

Carbon Dioxide (IAQ Probe Models 980 and 982)

Sensor Type	Dual-wavelength NDIR (non-dispersive infrared)
Range	0 to 5,000 ppm
Accuracy[6]	±3.0% of reading or ±50 ppm, whichever is greater
Resolution	1 ppm
Response Time	20 seconds

Temperature (IAQ Probe Models 980 and 982)

Sensor Type	Thermistor
Range	32 to 140°F (0 to 60°C)
Accuracy[3]	±1.0°F (0.5°C)
Resolution	0.1°F (0.1°C)
Response Time	30 seconds (90% of final value, air velocity at 400 ft/min [2 m/s])

Relative Humidity (IAQ Probe Models 980 and 982)

Sensor Type	Thin-film capacitive
Range	5 to 95% RH
Accuracy[4]	±3% RH
Resolution	0.1% RH
Response Time	20 seconds (for 63% of final value)

- +/- 10%

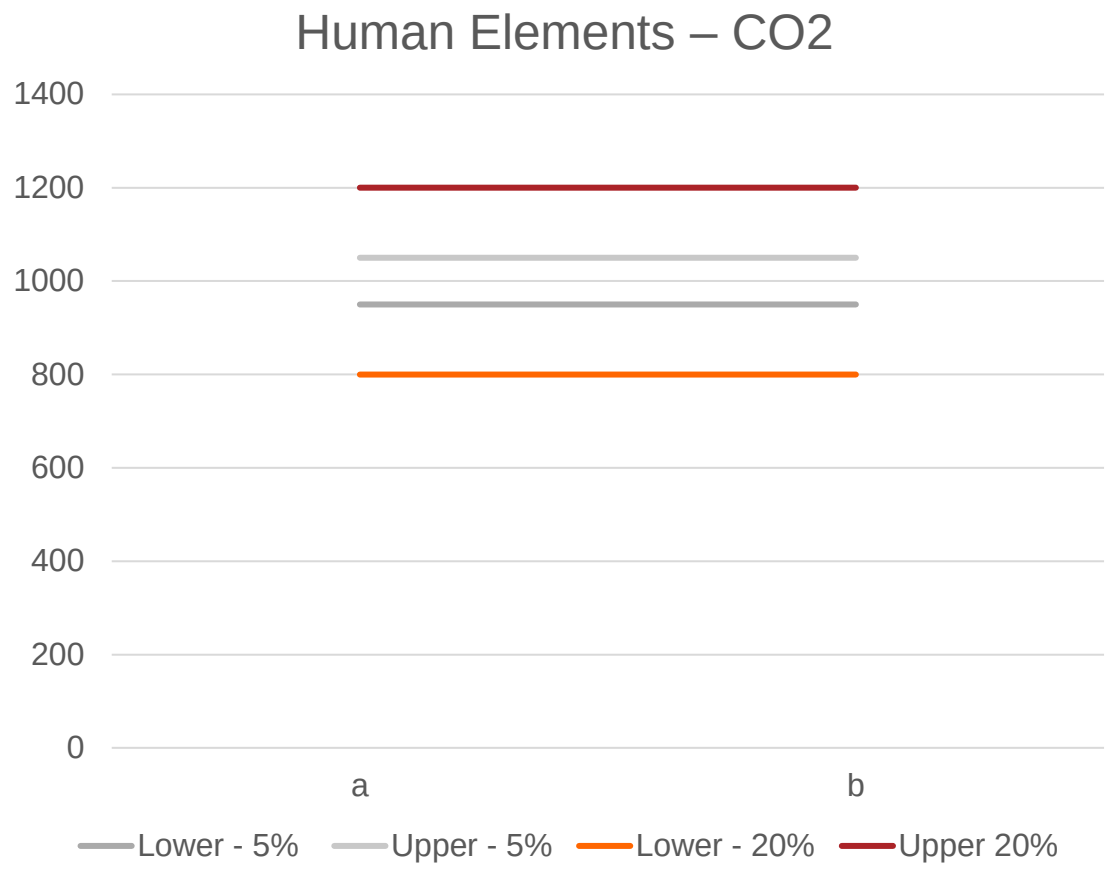
Technical Details | Optional Accessories | Resources | Reviews

Operating Principle	Counts individual particles using scattered laser light
Performance	
PM Range	PM1, PM2.5, PM4 and PM10
Concentration Range	0 - 1,000 µg/m3
Resolution	0.1 µg/m3 (display / serial output)
Sensitivity	High = 0.3 µm, Low = 0.5 µm
Accuracy	± 10%, to calibration aerosol

Sum of the Impact to Measurement Uncertainty

Inadvertent Influences

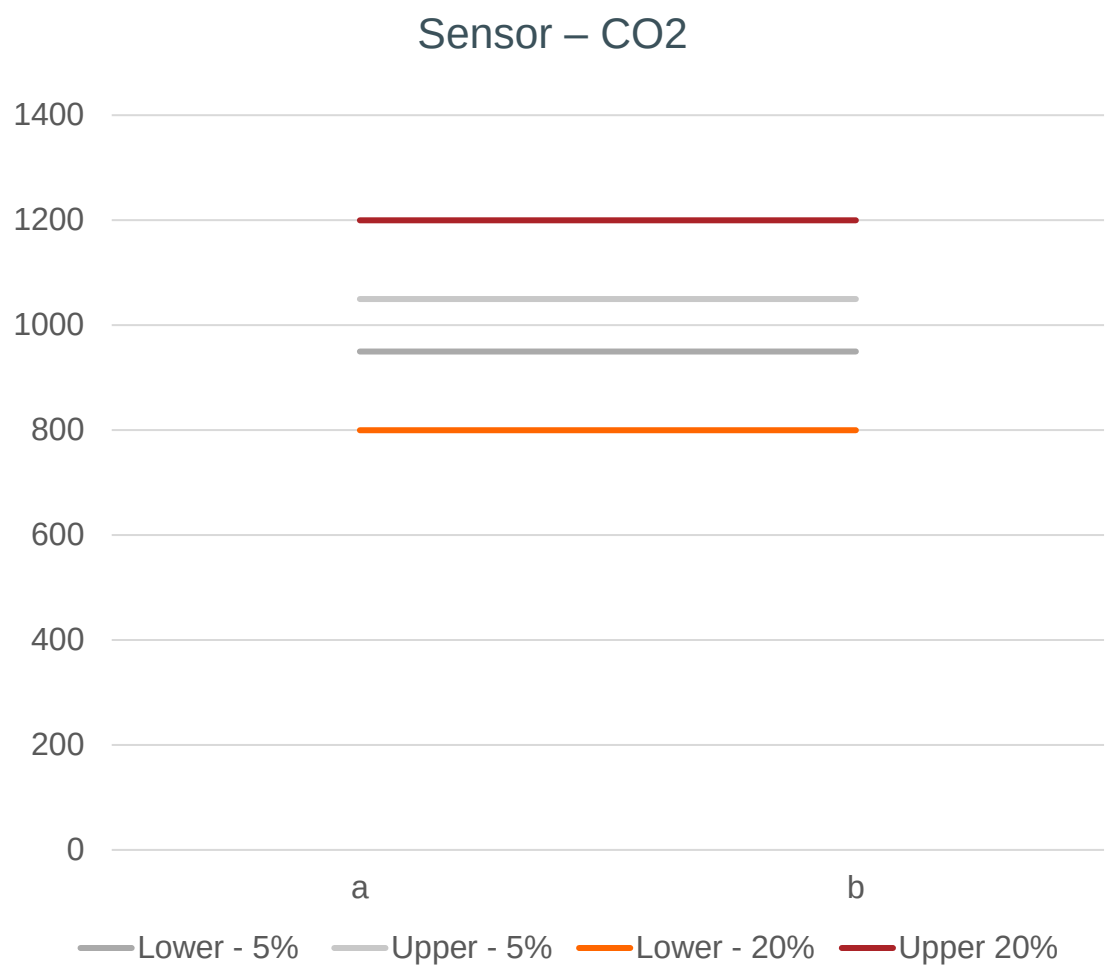
- Humans, leaks more and more – minimum 5%, +/- 20%
- Exhaled Breath Effect
- Human Error



Sum of the Impact to Measurement Uncertainty

By Sensor - Repeatability

- Cal enclosure
- Effects of any internal external dilution source
- Effect of flow/pressurization of sensor mechanism
- +/- 5% to +/- 20%



Sum of the Impact to Measurement Uncertainty

By Sensor - Repeatability

- Cal enclosure
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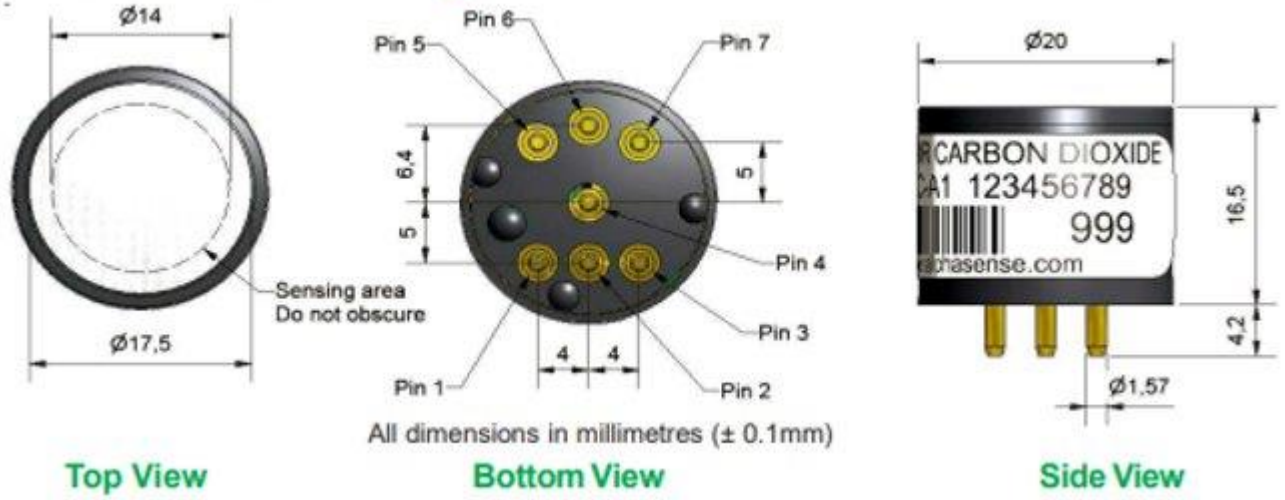
Figure 1 NDIR-A Schematic Diagram



KEY SPECIFICATIONS

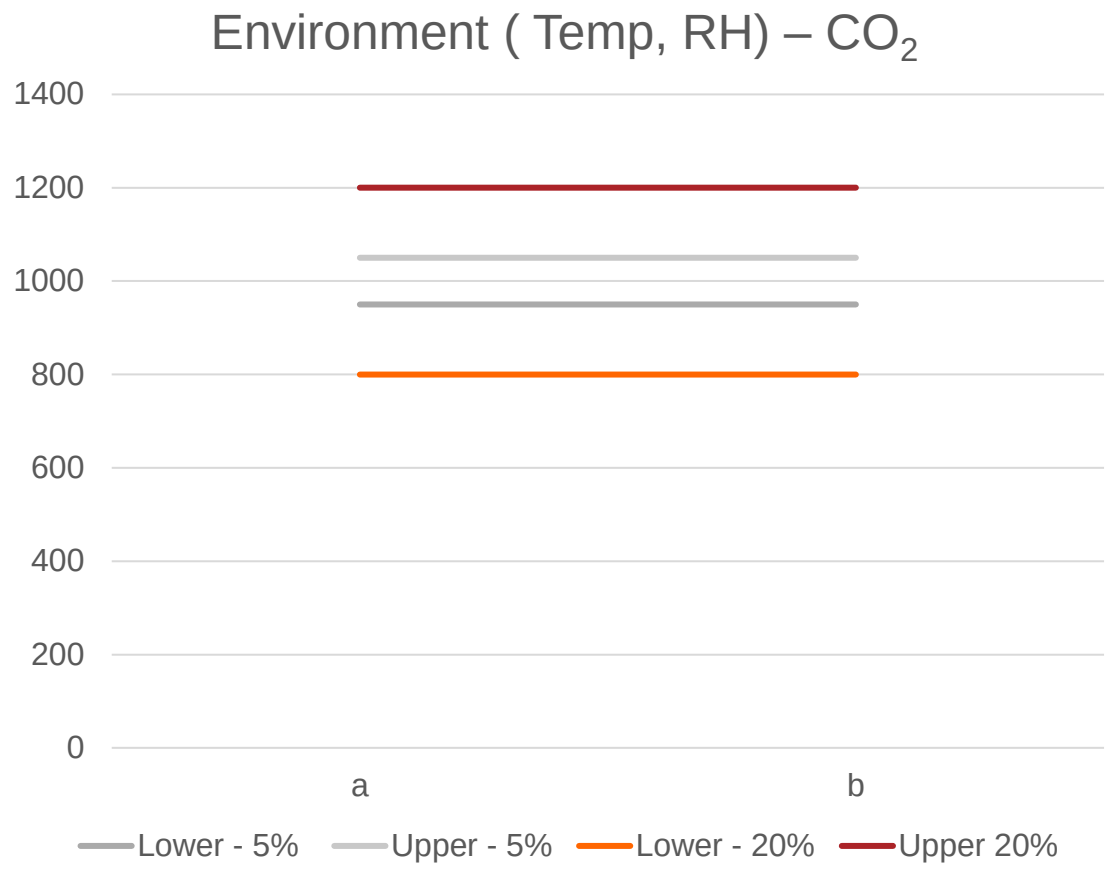
Temperature Signal	Integral thermistor (NTC, R_{25} = 3000 Ω B= 3450 K)
Operating Temperature Range	-20°C to +55°C (linear compensation from -10 to 40°C)
Storage Temperature Range	-40°C to +75°C
Humidity Range	0 to 95% rh non-condensing

TYPE*	Range (Application)	Accuracy (%FS, using universal linearisation coefficients)	Zero Resolution	Full Scale Resolution	Zero Repeatability	Full Scale Repeatability
IAQ	0 to 5000ppm (IAQ)	1	1ppm	15ppm	±10ppm	±50ppm

Sum of the Impact to Measurement Uncertainty

By Environmental Impact

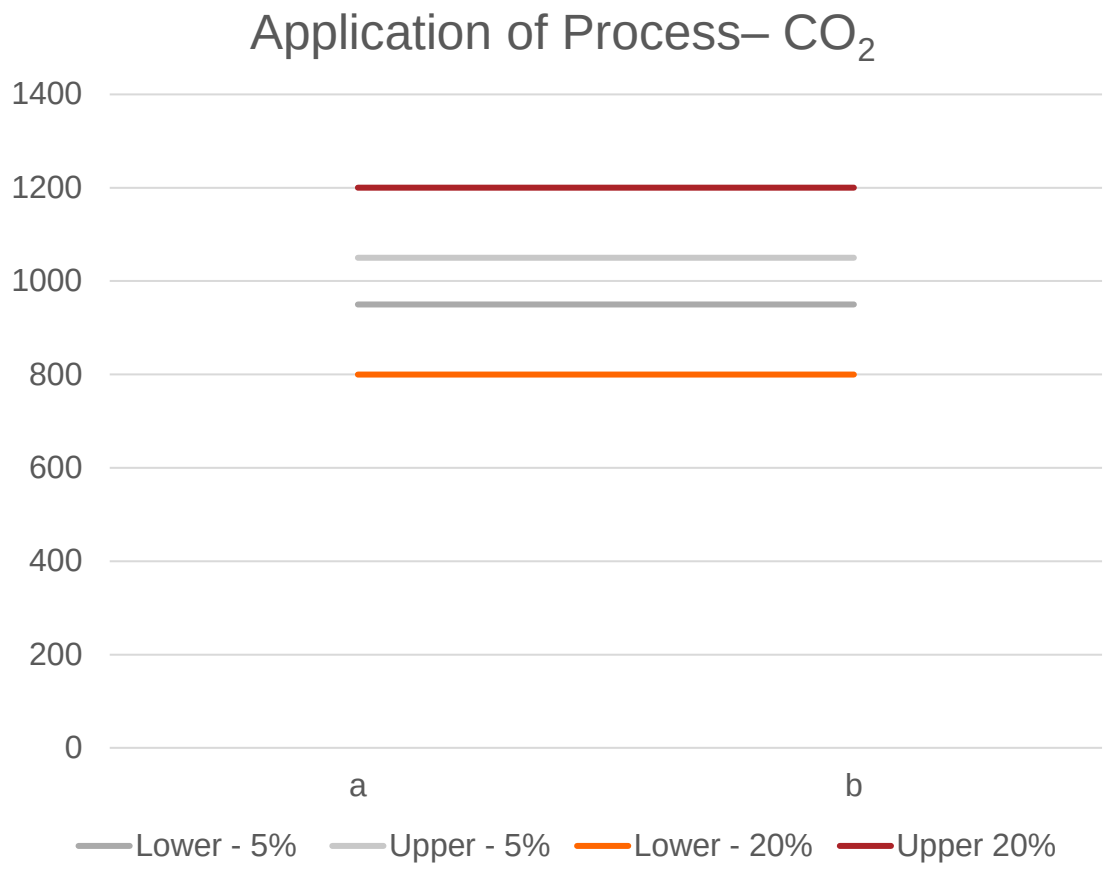
- Temperature Impact
- Corrective Algorithms
- +/- 5% to +/- 20%



Sum of the Impact to Measurement Uncertainty

By Process / Method

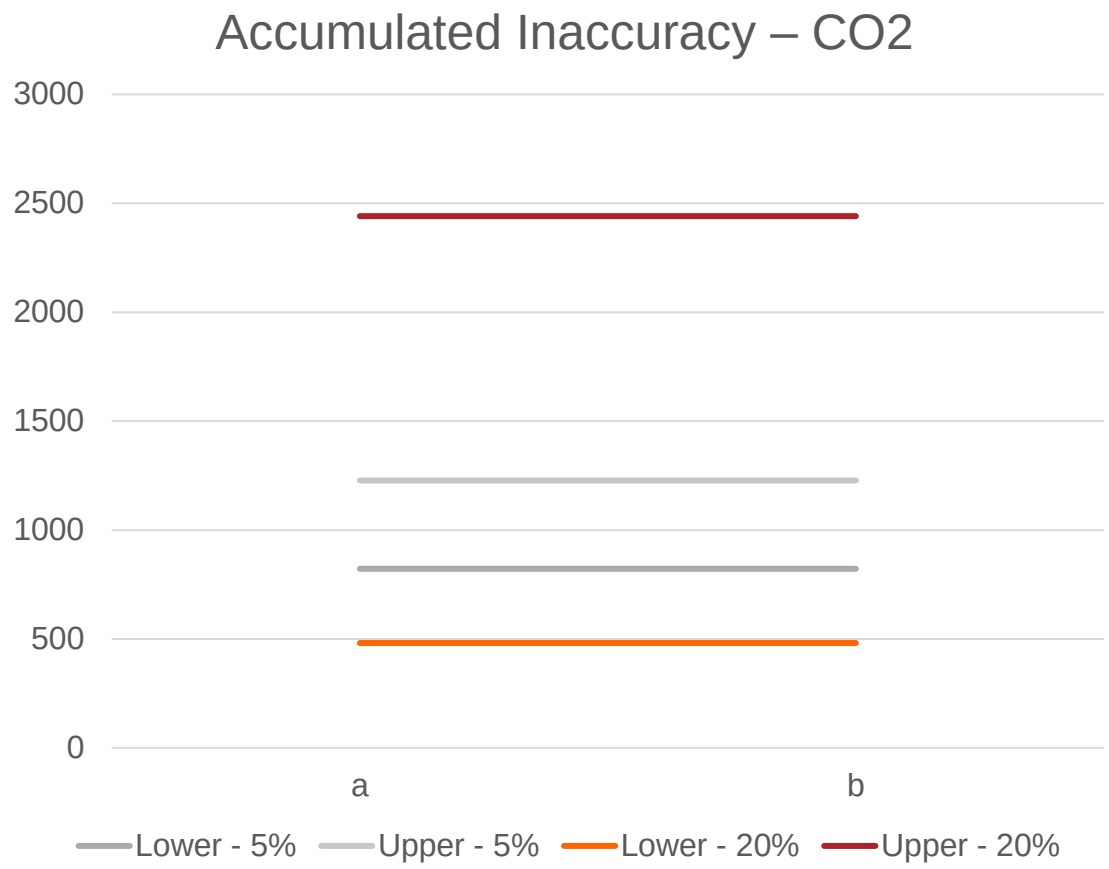
- Cal enclosure (Pressurization)
- Effects of any internal external dilution source
- Effect of flow/pressurization of sensor mechanism
- +/- 5% to +/- 20%



Sum of the Impact to Measurement Uncertainty

Accumulative Impact

- Validate accuracy attempt – worst/best case
- After all steps and considerations are complete, validation by a certified standard can confirm claim of Measurement Uncertainty at Target levels if performed properly
- For reference devices all impacts need to be considered



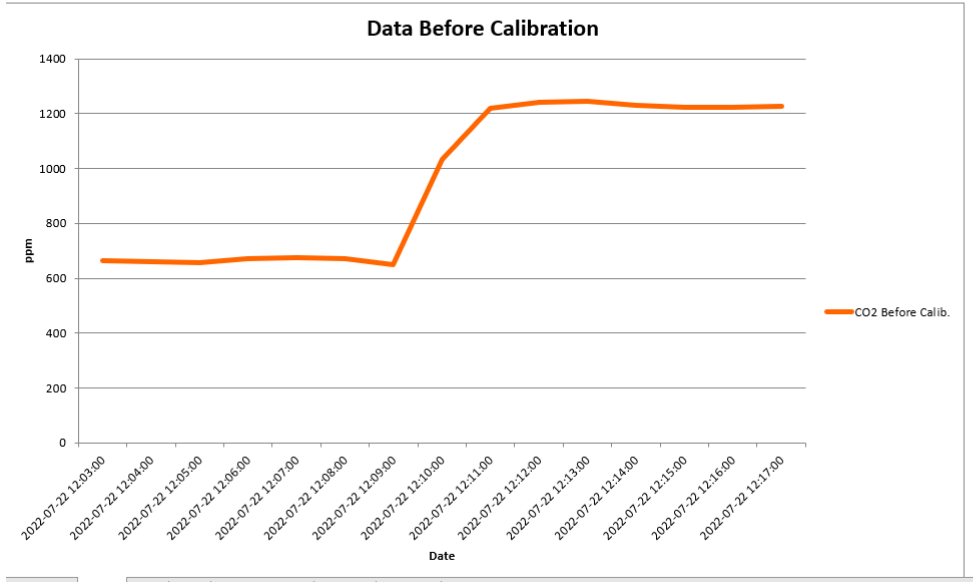
Documentation to Calibration Accuracy

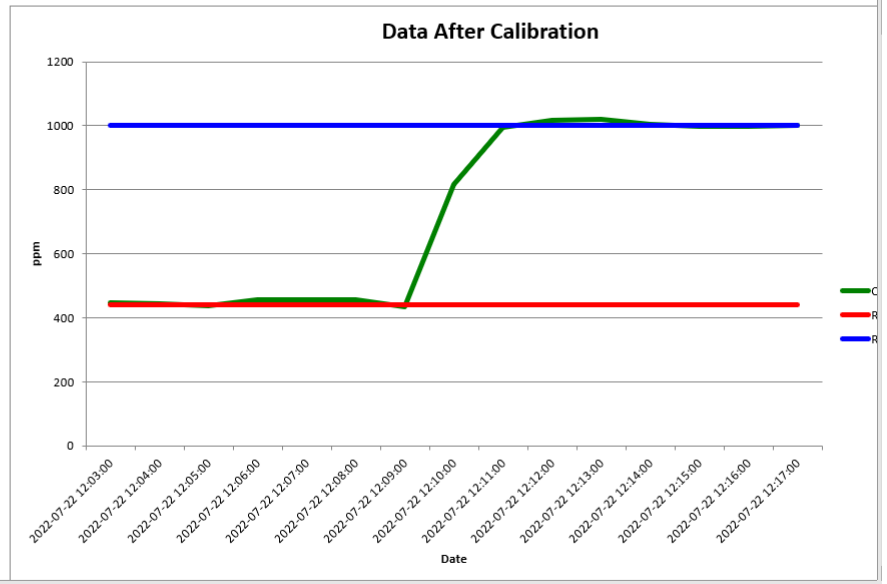
Documentation

	Ref1 (Low)	Ref2 (High)	Duration
Default Calibration Profile		1000	60
Calibration Profile executed	440	1000	15

	Start date (step 1)	End date (step 2)
Low Value	2022-07-22 12:03:41+00:00	2022-07-22 12:05:41+00:00
High Value	2022-07-22 12:14:41+00:00	2022-07-22 12:17:41+00:00

	We0	Sensitivity	Sensitivity2	Post Calibration Offset	Post Calibration Gain	ppb coeff
Initial parameters	1.025	0.1447	302.5394144	302.36652	0.59716	1
Calculated parameters	1.0183	0.2233	313.5459642	0	1	1



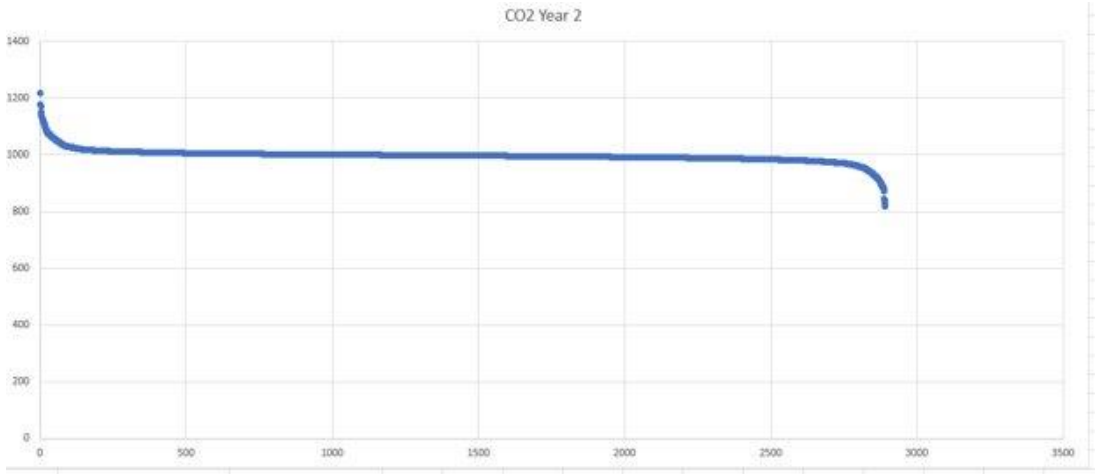


CO2 | CO | RH | Temperature | PM 10 | PM 2.5

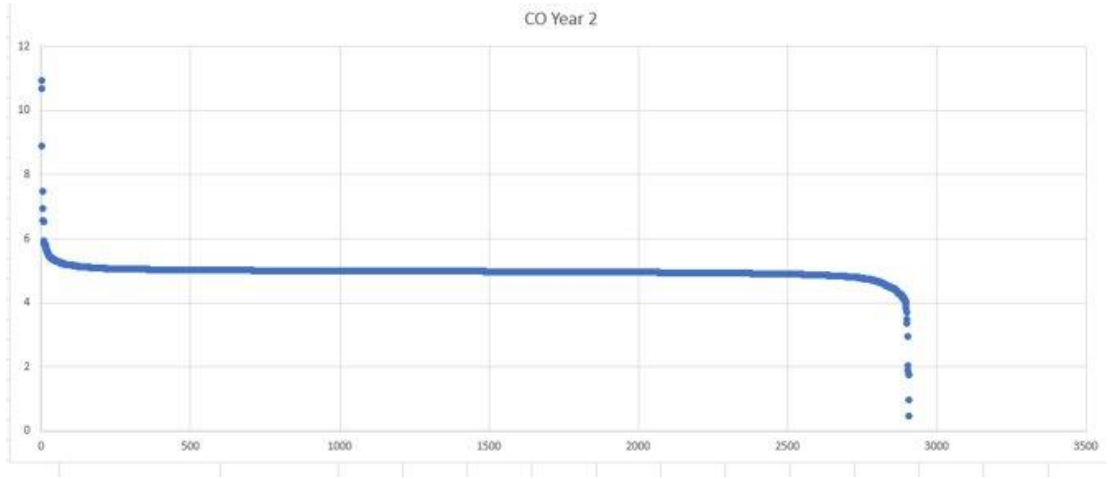
Documentation to Calibration Accuracy

Documentation

Column1	
Mean	997.0454964
Standard Error	0.421262566
Median	997.8515
Mode	1000
Standard Deviation	22.65437125
Sample Variance	513.2205367
Kurtosis	18.91840372
Skewness	0.353897694
Range	401.967
Minimum	816.836
Maximum	1218.803
Sum	2883455.575
Count	2892
Confidence Level(95.0%)	0.826005276



Column1	
Mean	4.961973222
Standard Error	0.005432945
Median	4.979
Mode	5
Standard Deviation	0.292976313
Sample Variance	0.08583512
Kurtosis	173.1166364
Skewness	2.615376713
Range	10.483
Minimum	0.454
Maximum	10.937
Sum	14429.41813
Count	2908
Confidence Level(95.0%)	0.010652812

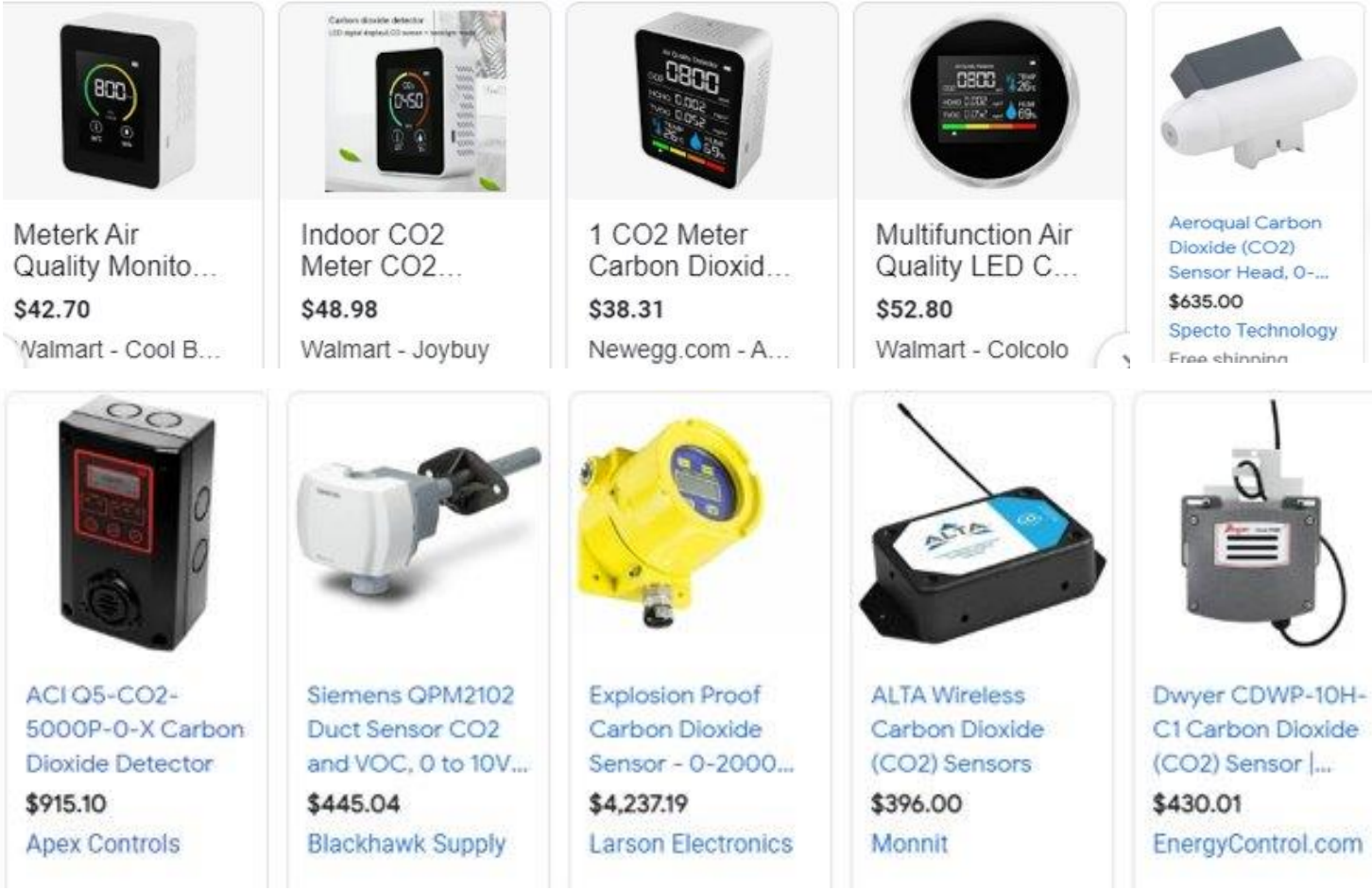


Sum of the Impact to Measurement Uncertainty

Challengers

- Last calibrated – documentation
- Any 3rd party validations
- Technical specifications
- Reverse challenge / side-by-side

AQM 65 Air Monitoring Station with Integrated Calibration



Lab Approach: Uncertainty Contribution and Action to Minimize/Eliminate

Documentation

Uncertainty Contributors

Department: GC
Field of Testing (FoT): GC-ECD/FID/NPD/PID: Volatile and Semi-Volatile Organic Compounds on Active Samplers

Contributors to Uncertainty	Representative and Applicable QC Data	Comments to Clarify Contributor Effects
Transportation/Storage/Handling		
shipping time, container, temperature	NA/FB	Usually no impact if recommended shipping conditions and holding times in referenced methods are followed. Field blanks can be an indication of some of these contributors.
lab storage time, conditions, temperature	NA/FB	Usually no impact if appropriate storage conditions and holding times are maintained. Field blanks can be an indication of some of these contributors.
contamination in lab storage areas	NA/FB	Usually no impact if appropriate storage conditions and holding times are maintained. Field blanks can be an indication of some of these contributors.
Laboratory Sub-sampling		
sample nonhomogeneity	NA	Not applicable to this FoT.
blending techniques	NA	Not applicable to this FoT.
sample size	NA	Not applicable to this FoT.
Sample Preparation		
volumetric glassware	NA	Not applicable to this FoT.
balance	NA	Not applicable to this FoT.
temperature	NA	Not applicable to this FoT.
dispensing device	BS/BSD	Pipettes and repipettors - tested daily to be within 2% of the true value. Same device is used for client samples.
desorption time	BS/BSD	Method recommended desorption time used. Same desorption time used for client samples.
sample extraction	BS/BSD	BS/BSD go through all sample preparation procedures.
media background	MB/BS/BSD	A MB/BS/BSD is analyzed with every batch of samples.
eluent background	EB/MB/BS/BSD	All lots of CS2 are analyzed before use, an EB is analyzed with every batch of samples. Same eluent is used for client samples.
Environmental & Measurement Conditions		
Light sensitivity	BS/BSD	BS/BSD will show any issues resulting from light sensitivity during sample preparation and analysis in the lab.
temperature/humidity variance	BS/BSD	BS/BSD will show any desorption issues due to temperature or humidity variations and any instrument drift.
Analysts		
different analysts	BS/BSD	BS/BSD results reflect variability due to different analysts on different days.
analyst training level and experience	BS/BSD	BS/BSD results reflect variability due to different analysts on different days.

Maybe IAQ plans and implementations should be required to be done by CIHs

Thank you!

Do you have any questions?
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