



GRPE Working Group on VIAQ –  
Evaluation of test procedure  
“Draft Part IV of the Mutual Resolution (M.R.3) on Vehicle  
Interior Air Quality,,

Measurements and recommendations by OICA.  
October, 11th, 2024

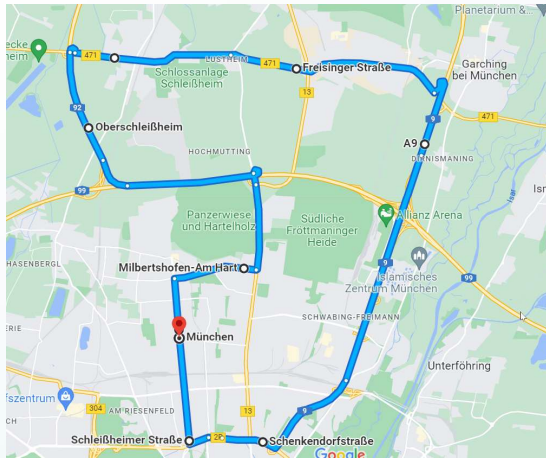


## BACKGROUND.

- Draft test procedure was tested during several measurements on public roads near Munich.
- The equipment for the measurements was placed in a 2018 BMW X3 vehicle.
- PM 2.5 sensors with measurement interval of 5 sec.
- CO<sub>2</sub> sensors with 10.000 ppm measurement range.
- Precision GPS sensor with recording interval of 5 sec.
- Two employees performed the measurements.

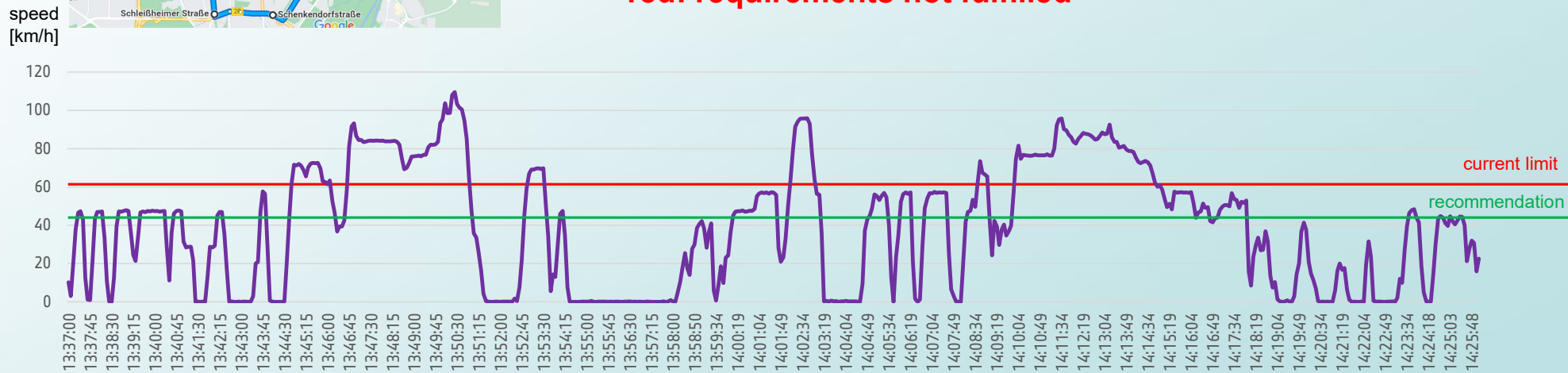


# RESULT OF ASSIGNED TRAFFIC PERCENTAGES.



Weather: calm, **dry**, temperature: **+ 15° C**, humidity: **62 %**  
atmospheric pressure: **96.0 kPa**, Test track length: 30 km  
**55% +/-10% urban traffic percentage < 60 km/h: → 74.3 %**  
**45% +/-10% outside city traffic percentage > 60km/h < 100km/h: → 25.7 %**  
measurement time (30 – 60 min): **49 min**

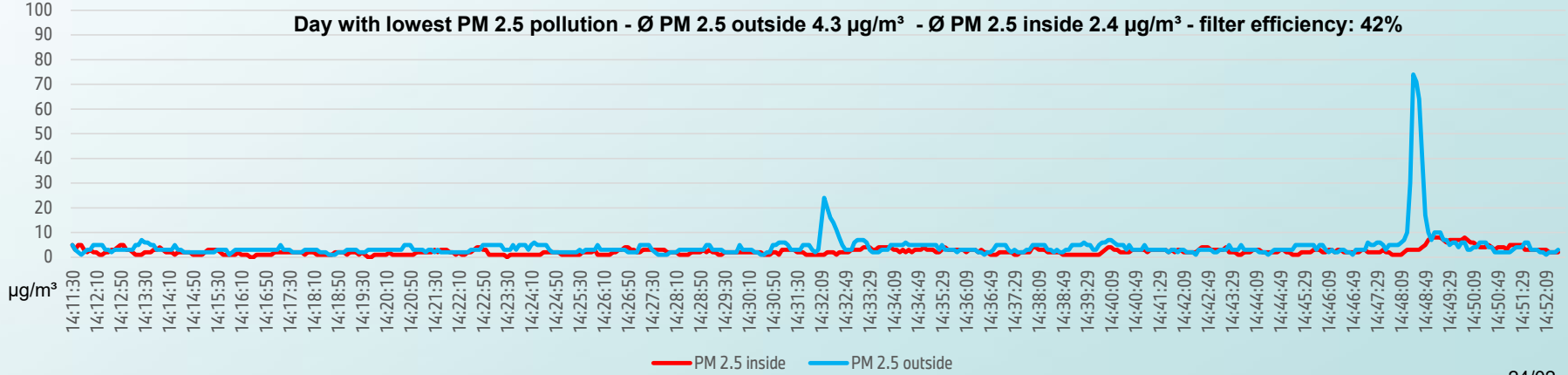
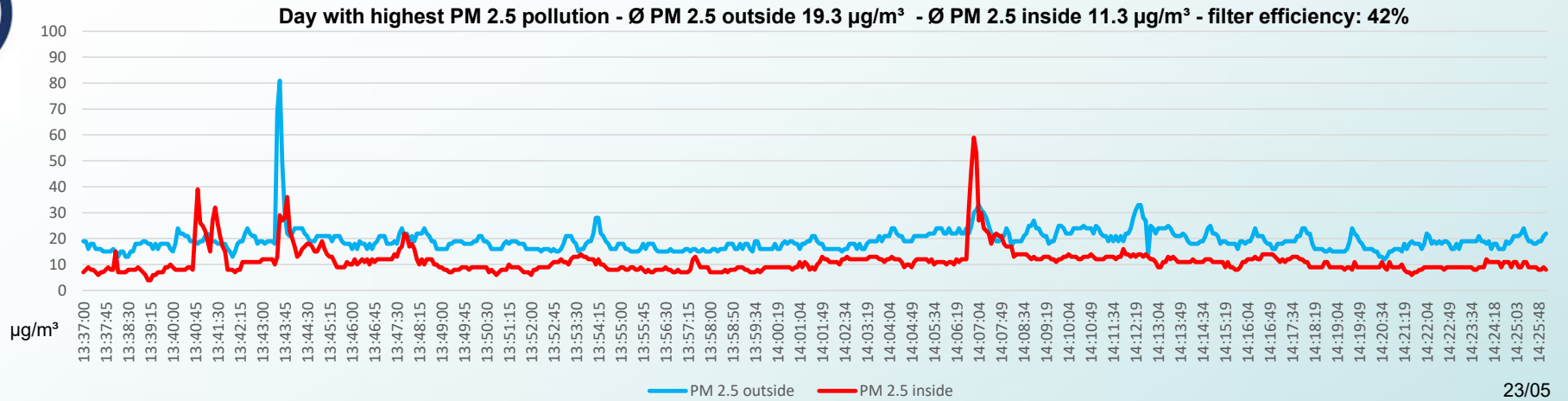
legend: **green: requirements fulfilled**  
**red: requirements not fulfilled**



→ traffic percentage limit exceeded. recommendation: change limits or required percentage



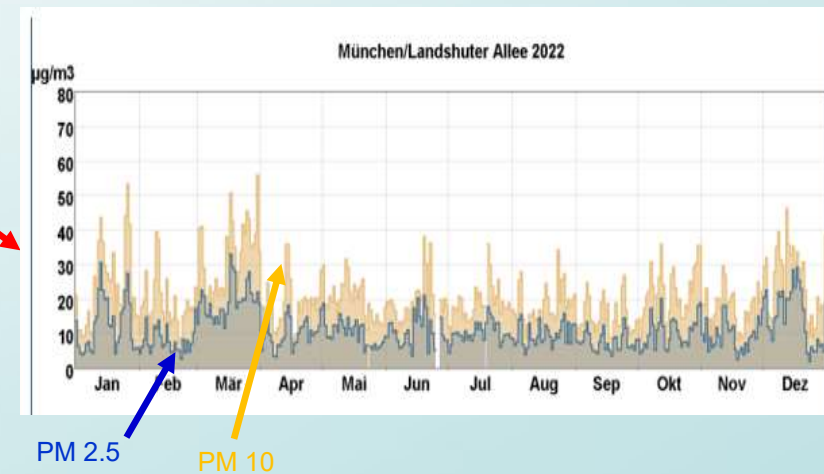
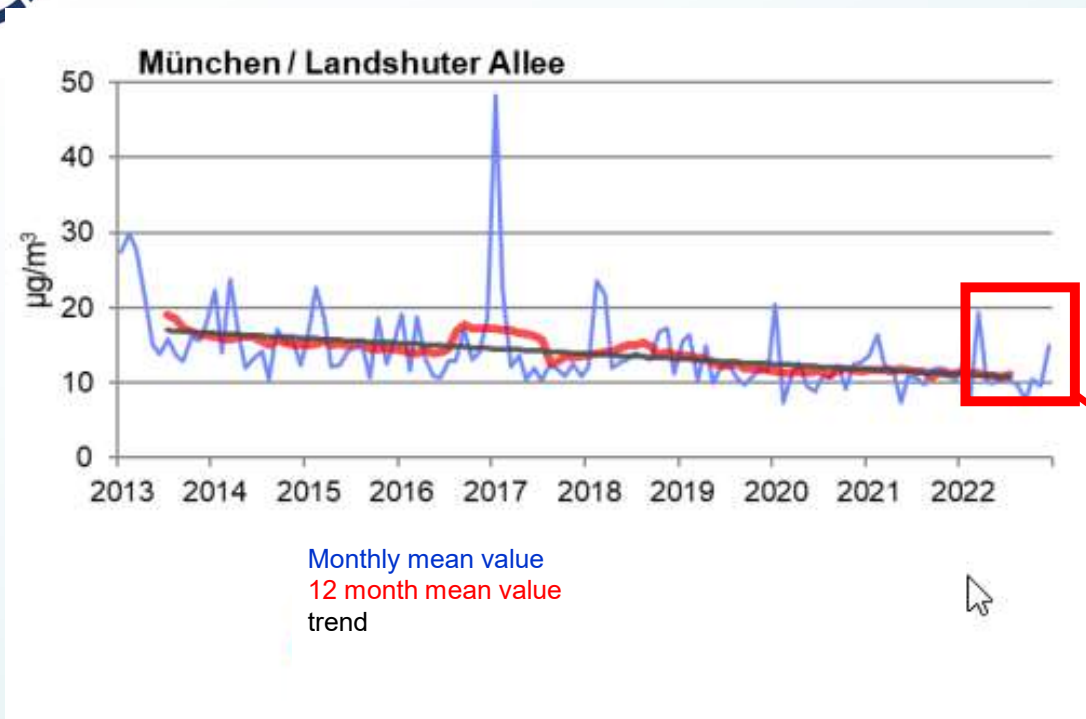
# RESULTS: PM 2.5 INSIDE AND OUTSIDE @ MAXIMUM/MINIMUM POLLUTION.



→ outside PM 2.5 concentration usually < 20 µg/m<sup>3</sup>  
→ Sensor PM 2.5 range: 0...500 µg/m<sup>3</sup>, maximum sensor tolerance: +- 10 µg/m<sup>3</sup>



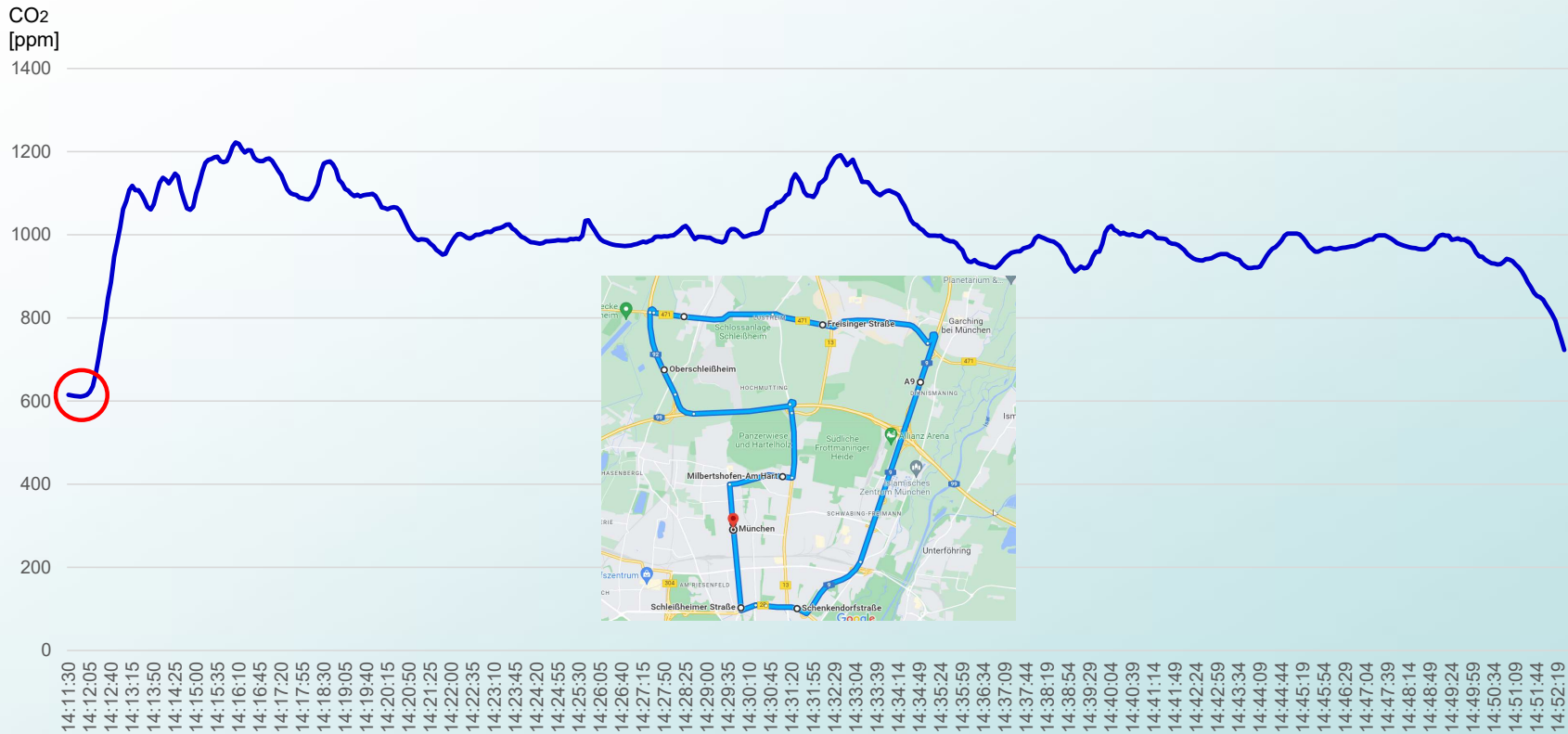
# PM 2.5 LONG-TERM MEASUREMENT @ MAIN ROAD MUNICH 2013 - 2023.



→ Long term PM 2.5 measurement in Munich shows decrease, mean value approximately 10 µg/m<sup>3</sup>



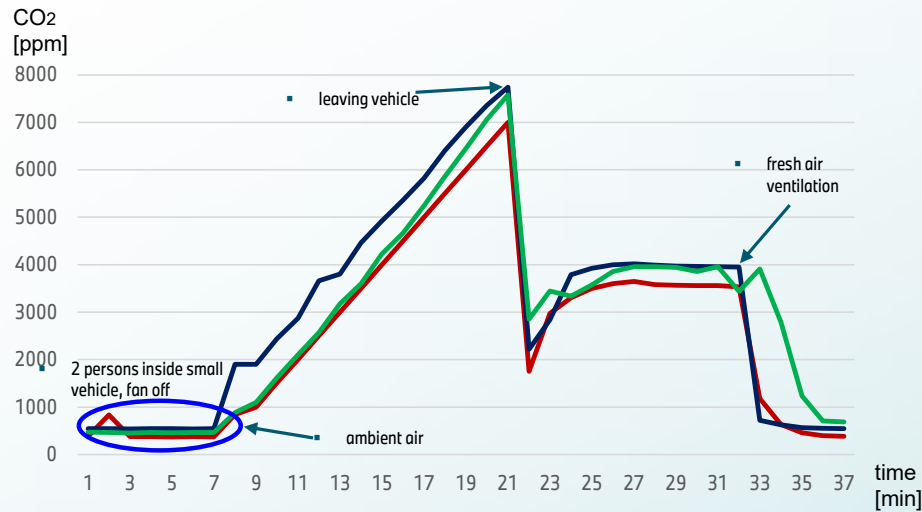
# CO<sub>2</sub> MEASUREMENT @ REAL DRIVING CONDITIONS.



- Mean value of 4 identical sensors inside the vehicle.
- 2 persons inside vehicle, A/C on, automatic air recirculation on.
- Unexpected ambient measurement value -> comparison of 3 different CO<sub>2</sub> sensors conducted.



# COMPARISON OF 3 CO<sub>2</sub> SENSORS @ PARKING, A/C OFF, FAN OFF.



3 sensors (Vaisala, Almemo, Senseair)

	Vaisala	Almemo	Senseair
accuracy [ppm]	40	100	50
accuracy [% of reading]	+ - 2	+ - 5	+ - 10
calibration uncertainty [ppm]	+ - 20	n.a.	n.a.
long term stability [ppm/ p.a.]	+ - 60	0, automatic compensation	n.a.
temperature dependance [% of reading], [ppm /K]	+ - 0,05	2	n.a.
sensor reading with ambient air @ comparison test	372	455	498
ambient (target 413 ppm) with maximum tolerances	285.....541	292.....534	322.....504
measurement within sensor tolerances	yes	yes	yes

- Sensors do not show equal results (ambient and tops), also a different response time is noticeable.
- Ambient air differs between: 372 ppm, 455 ppm and 498 ppm (target: 413±20 ppm)
- Ambient air measurement results are within the respectively sensors tolerance.
- What experience do you have? What is your measured city CO<sub>2</sub> ambient value?



## NOTICES AND RECOMMENDATIONS.

### **Long term PM 2.5 measurement in Munich show decrease, mean value approximately 10 $\mu\text{g}/\text{m}^3$**

- reduction of assigned PM 2.5 minimum (30  $\mu\text{g}/\text{m}^3$ ) recommended, e.g. 10  $\mu\text{g}/\text{m}^3$  (new WHO guideline)
- check measurement equipment tolerances

### **Assigned time intervals for specific speeds have not been reached**

- High speed of 60-100 km/h for 45% +/- 10% of test cycle is difficult to achieve
- reduce high speed contribution to e.g. 30% +/- 10%
- Definition of urban speed may also be changed to  $v < 50$  km/h e.g. 45 km/h (50 km/h city speed limit)

### **Different CO<sub>2</sub> sensors do not show equal results and also have different response times**

- Ambient air results were: 372 ppm, 455 ppm and 498 ppm (target: 413 +/- 20 ppm)
- Increase of ambient air tolerance is recommended (e.g. 420 +/- 100 ppm)
- Sensors 10% tolerance and/or +/- 100 ppm tolerance should be accepted





BACKUP.



# SPECIFICATIONS TEST VEHICLE PM SENSOR.



## Technical Index

Parameter	Index	unit
Range of measurement	0.3~1.0; 1.0~2.5; 2.5~10	Micrometer ( $\mu m$ )
Counting Efficiency	50%@0.3 $\mu m$ 98%@ $\geq 0.5\mu m$	
Effective Range (PM2.5 standard)	0~500	$\mu g/m^3$
Maximum Range (PM2.5 standard) *	$\geq 1000$	$\mu g/m^3$
Resolution	1	$\mu g/m^3$
Maximum Consistency Error (PM2.5 standard data)*	$\pm 10\%$ @100~500 $\mu g/m^3$ $\pm 10\mu g/m^3$ @0~100 $\mu g/m^3$	

## Typical Output Characteristic

Definition of axis Y: PM2.5 concentration , unit:  $\mu g/m^3$

Definition of axis X: number of samples, unit: time

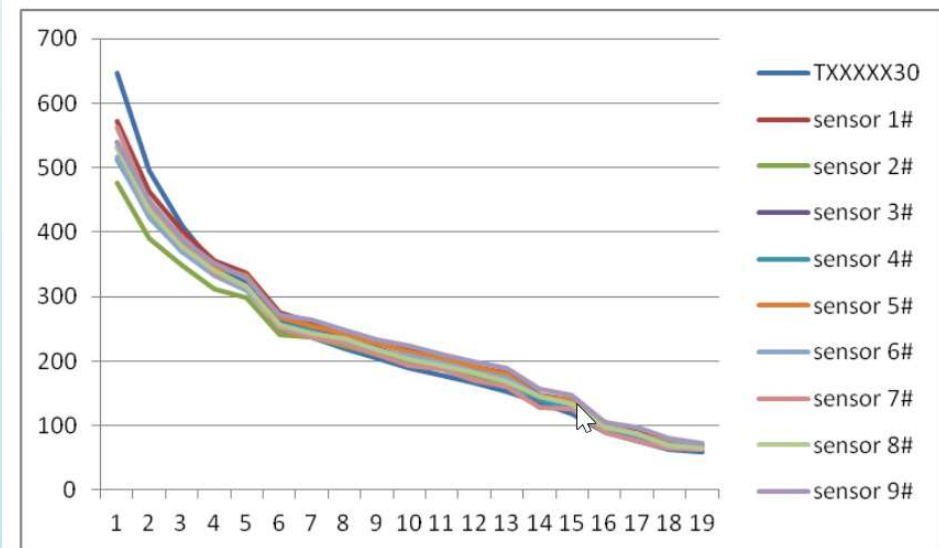


Figure 4-1 Consistency at 20°C



# SPECIFICATIONS TEST VEHICLE CO<sub>2</sub> SENSOR.



## World's most power efficient CO<sub>2</sub> sensor with NDIR technology

Compliant with HVAC and building standards, we now launch Senseair Sunlight – the world's most power efficient NDIR CO<sub>2</sub> sensor. Sunlight can be used in a wide range of applications but is optimal for battery and wireless applications or in places where you want to secure a reliable and secure sensor with long lifetime.

The module is designed for simple integration into products. The optical solid state design with no moving parts makes this sensor robust and resistant to vibrations.

With our automatic baseline correction Sunlight is maintenance-free, which means that you can mount and forget your sensor during its whole lifetime and it will still be accurate.

### Standard specification

Article No.	006-1-0100
Measured gas	Carbon dioxide (CO <sub>2</sub> )
Operating principle	Non-dispersive infrared
Measurement range (CO <sub>2</sub> )	400–5000ppm; extended range up to 10000ppm
Accuracy (CO <sub>2</sub> )	±50ppm ±3% of reading <sup>1,2</sup> (extended range ±10% of reading)
Average current	1–30µA
Measurement period	Default: 16s, 8 samples (adjustable by host)
Peak current	< 80mA
Power supply	3.05–5.5V <sup>3</sup>
Dimensions	34 x 21 x 12mm
Weight	5g
Life expectancy	> 15 years
Operating range	0–50 °C, 0–85% RH
Storage temperature	-40–70 °C
Serial communication	UART, I <sup>2</sup> C

### Key benefits

- Ultra Low Power consumption
- Compliant with ANSI/ ASHRAE Standard 62.1-2022
- Compliant with RESET grad B
- Compliant with WELL Building Standard® (WELL v2™)
- High Precision
- Robust
- Mass Production
- Self-correcting

Note 1: 15–35 °C, 0–80% RH, after 3 ABC (Automatic Baseline Correction) periods and default measurements settings.

Note 2: Specification is referenced to uncertainty of calibration gas mixtures (±1%).

Note 3: Unprotected against surges and reverse power supply polarity.