

Laboratory Evaluation Wicked Device – Air Quality Egg 2022 Model



Background

Three **Wicked Device – Air Quality Egg 2022 Model** (hereinafter **Air Quality Egg 2022 Model**) sensors were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (11/20/2021 to 1/19/2022) under ambient environmental conditions. Following field-testing, the same three units were evaluated in the South Coast AQMD Sensor Environmental Testing Chamber 2 (SENTEC-2) under controlled artificial aerosol concentration/size range, temperature, and relative humidity.

Air Quality Egg 2022 Model (3 units tested):

- Particle sensor: **optical; non-FEM (dual Plantower PMS5003)**
- Gas-phase sensor: **Electrochemical; non-FEM (Winsen ZE12A)**
- Each unit reports: CO (ppm), PM_{1.0}, PM_{2.5} and PM₁₀ (µg/m³)
- **Unit cost: \$671 (with offline data logging option)**
- Time resolution: 1-min
- Units IDs: 582f, 6c91, 6108



Reference instruments:

- PM_{2.5} instrument (**Teledyne T640x, San Diego, CA; hereinafter FEM T640x**); **cost: ~\$37,000**
- Time resolution: 1-min

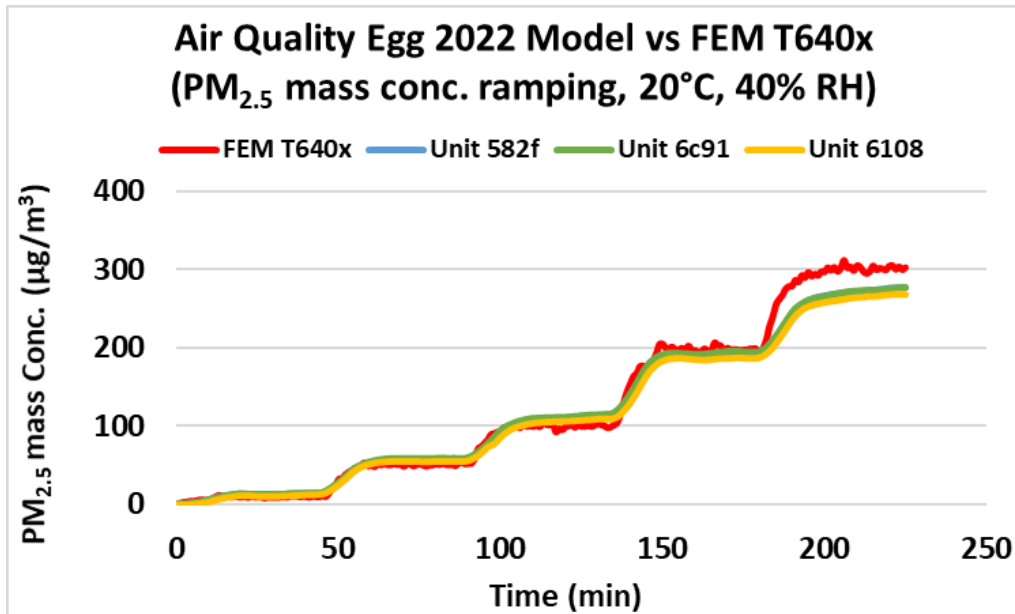


FEM T640x

PM_{2.5}

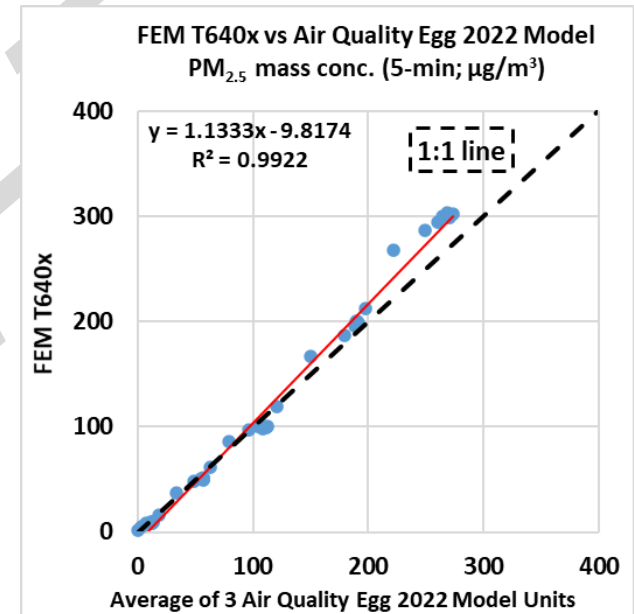
1. **FEM T640x vs Air Quality Egg 2022 Model**
2. **Accuracy, data recovery, and intra-model variability**
3. **Precision**
4. **Climate susceptibility**
5. **Discussion**

Air Quality Egg 2022 Model vs FEM T640x (PM_{2.5})



- The Air Quality Egg 2022 Model sensors tracked well with the concentration variation but overestimated PM_{2.5} at concentrations < 100 µg/m³ and underestimated PM_{2.5} at concentrations > 100 µg/m³, as compared to the FEM T640x in the concentration range of 0 - 300 µg/m³.

Coefficient of Determination



- The Air Quality Egg 2022 Model sensors showed very strong correlations with the FEM T640x PM_{2.5} mass conc. ($R^2 > 0.99$)

Air Quality Egg 2022 Model vs FEM T640x PM_{2.5} Accuracy

- Accuracy (20 °C and 40% RH)

Steady State #	Sensor Mean (µg/m ³)	FEM T640x (µg/m ³)	Accuracy (%)
1	12.4	9.1	63.9
2	57.0	50.4	86.8
3	110.6	99.3	88.6
4	190.6	197.5	96.5
5	271.0	301.6	89.9

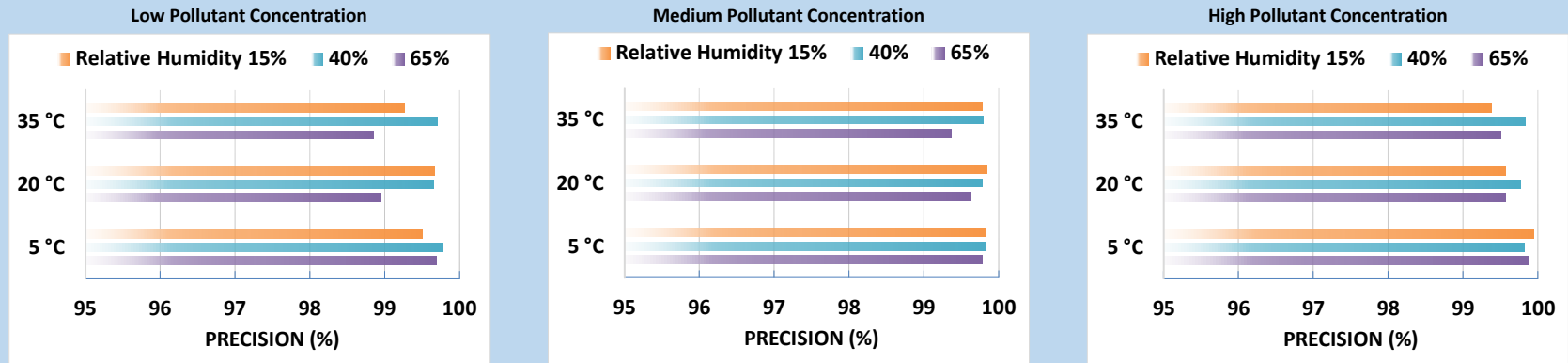
- The sensors showed higher accuracy at higher PM_{2.5} concentrations (from 63.9% at the lowest concentration to 96.5% at higher PM_{2.5} concentrations).

Air Quality Egg 2022 Model Data Recovery and Intra-model Variability

- Data recovery for PM_{2.5} measurements was 100% for all three units
- Low PM_{2.5} concentration variations were observed between the three units at 20° C and 40% RH, at low, medium and high PM_{2.5} concentrations as measured by the FEM T640x.

Precision: Air Quality Egg 2022 Model

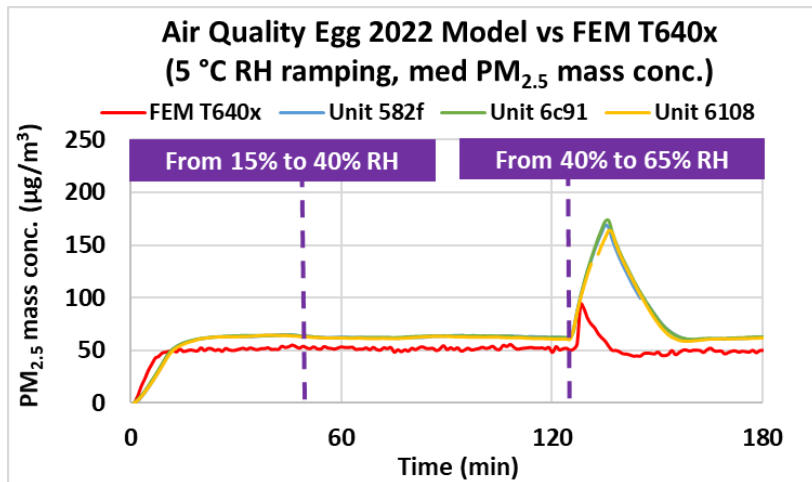
- Precision (effect of PM_{2.5} conc., temperature and relative humidity)



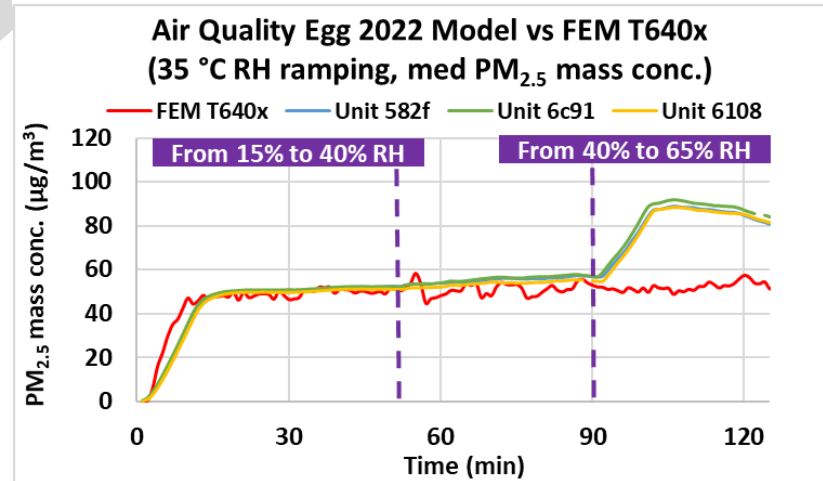
- Overall, Air Quality Egg 2022 Model sensors showed high precision for all the combinations of low, medium, and high PM_{2.5} conc., T, and RH.

Climate Susceptibility: Air Quality Egg 2022 Model

Low Temp - RH ramping
(medium conc.)



High Temp - RH ramping
(medium conc.)



Discussion: PM_{2.5}

- **Accuracy:** The three Air Quality Egg 2022 Model sensors showed accuracy ranged from 63.9% to 96.5%.
- **Precision:** The three Air Quality Egg 2022 Model sensors exhibited high precision during all tested PM_{2.5} conc., T, and RH conditions.
- **Intra-model variability:** Low PM_{2.5} measurement variations were observed among the three Air Quality Egg 2022 Model sensors at 20 °C and 40% RH.
- **Data Recovery:** Data recovery for PM_{2.5} measurements was 100% for all three units.
- **Bias:** N/A
- **Detection limit:** The detection limit cannot be estimated due to limitations in the chamber system design.
- **Response time:** Response time could not be studied due to the design of the chamber system. With a 1.6 m³ chamber volume, it was not possible to reach a high pollutant concentration within a short time.
- **Linear Correlation:** The three Air Quality Egg 2022 Model sensors showed very strong correlation/linear response with the corresponding FEM T640x PM_{2.5} measurement data ($R^2 > 0.99$).
- **Selectivity:** N/A for PM sensors test
- **Interferences:** N/A for PM sensors test
- **Note about PM_{1.0}:** The field evaluation compared the PM_{1.0} values reported from the Air Quality Egg 2022 Model sensors against the field GRIMM and T640 that reported PM_{1.0}. However, PM_{1.0} was not compared in this lab evaluation because at the time of lab testing (before March 2022) the lab T640x firmware upgrade to report PM_{1.0} was not finalized yet.

Discussion: PM_{2.5}

- **Measurement duration:** Air Quality Egg 2022 Model sensors report 1-min averaged values.
- **Measurement frequency:** Air Quality Egg 2022 Model sensors report 1-min averaged values. The obtained data was used as-is for calculation of statistics (e.g. data recovery, intra-model variability, mean, accuracy, precision), but condensed into 5-minute averages for linear correlation studies against the FEM T640x.
- **Sensor contamination and expiration:** Prior to the laboratory evaluation, the Air Quality Egg 2022 Model sensors were tested in the field for two months. The PM_{2.5} laboratory studies lasted for about 9 days with intermittent non-operating periods and a storage period of ~ 1 month. For PM_{2.5} measurements, all of the Air Quality Egg 2022 Model sensors maintained their functionalities and operated normally throughout the duration of the testing.
- **Concentration range:** Up to 1000 µg/m³ as suggested by the manufacturer. During the laboratory evaluation, the Air Quality Egg 2022 Model sensors were challenged with PM_{2.5} concentrations up to 300 µg/m³.
- **Drift:** N/A
- **Climate susceptibility:** During the lab studies, climate did not significantly impact precision. The sensors showed spiked concentration changes at the RH change points, especially at lower temperatures. The sensors showed enhanced PM_{2.5} concentrations at high RH values.
- **Response to loss of power:** Air Quality Egg 2022 Model sensors were powered through the entirety of the lab tests.