

Laboratory Evaluation

APT MINIMA



Background

Three **Applied Particle Technology MINIMA** (hereinafter **APT MINIMA**) sensors (units IDs: BW28, BW29, BW31) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (10/30/2020 to 12/29/2020) under ambient environmental conditions and have been evaluated in the AQ-SPEC Sensor Environmental Test Chamber (SENTEC-2) under controlled artificial aerosol concentration/size range, temperature, and relative humidity. The same three APT MINIMA units were tested both in the field (1st stage of testing) and in the laboratory (2nd stage of testing).

APT MINIMA (3 units tested):

- Particle sensor: **optical; non-FEM (PMSA003 by Plantower)**
- Each unit reports: $PM_{1.0}$, $PM_{2.5}$ and PM_{10} ($\mu\text{g}/\text{m}^3$)
- **Unit cost: \$995 (hardware only)**
- Time resolution: 1-min
- Units IDs: BW28, BW29, BW31

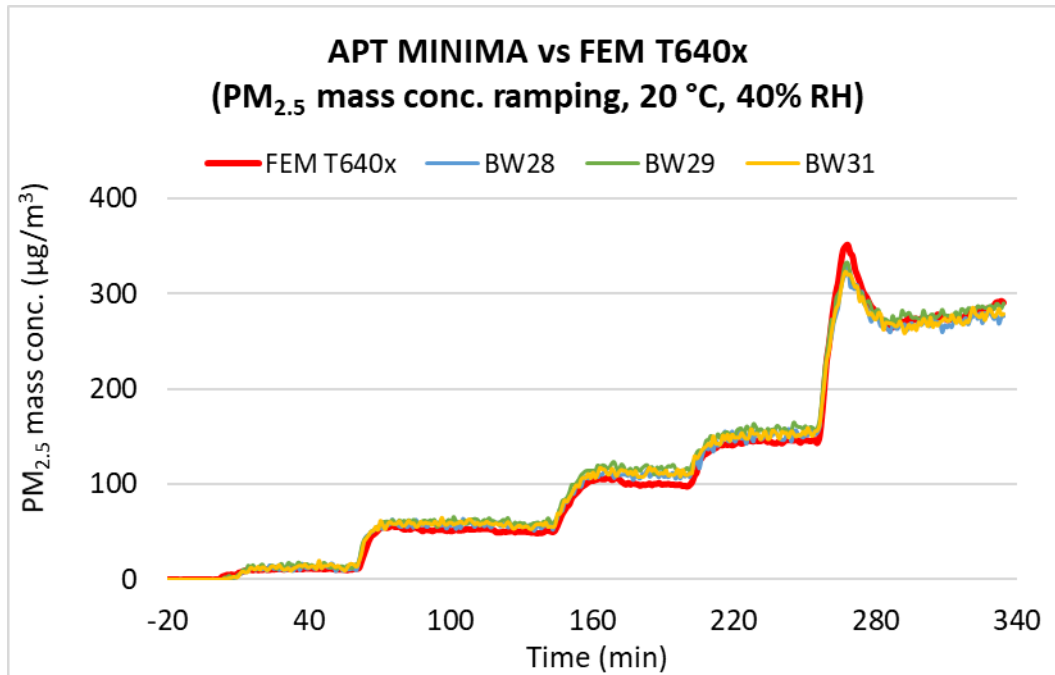


Teledyne API T640x (reference method)

- Optical particle counter
- **FEM $PM_{2.5}$, FEM PM_{10}**
- Uses proprietary algorithms to calculate total $PM_{1.0}$, $PM_{2.5}$ and PM_{10} mass conc. from particle number measurements
- **Cost: ~\$35,000**
- Time resolution: 1-min

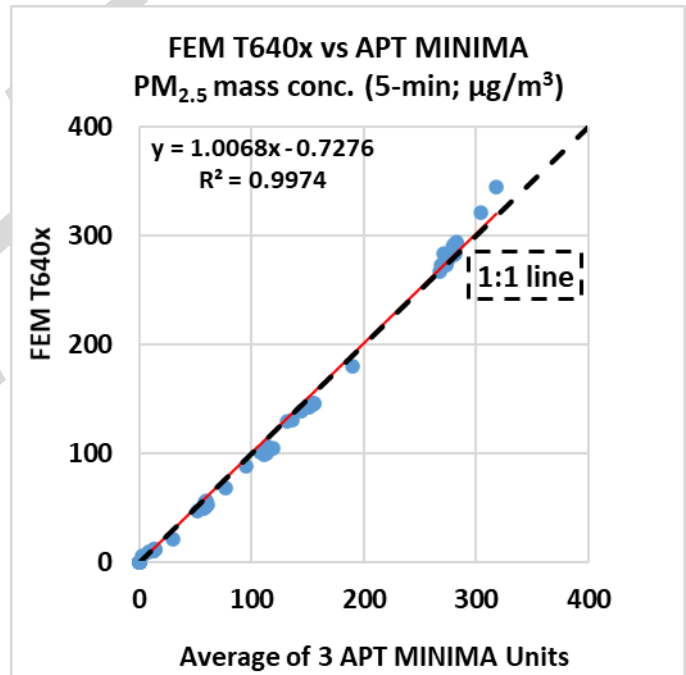


APT MINIMA vs FEM T640x (PM_{2.5} mass conc.)



- The APT MINIMA sensors tracked well with the concentration variation as recorded by the FEM T640x in the concentration range of 0 - ~300 µg/m³.

Coefficient of Determination



- The APT MINIMA sensors showed very strong correlations with the FEM T640x PM_{2.5} mass conc. ($R^2 > 0.99$)

APT MINIMA vs FEM T640x PM_{2.5} Accuracy

- Accuracy (20°C and 40% RH)

Steady state #	Sensor Mean (PM _{2.5} , µg/m ³)	FEM T640x (PM _{2.5} , µg/m ³)	Accuracy (%)
1	13.3	11.3	82.2
2	57.1	50.4	86.6
3	112.4	100.1	87.7
4	154.5	145.6	93.9
5	280.9	291.9	96.2

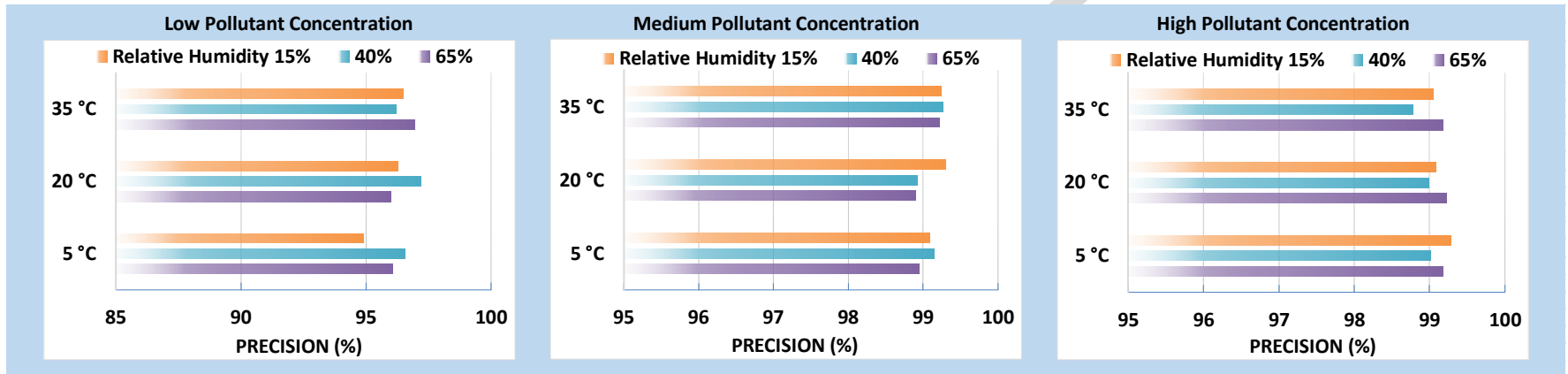
- Overall, the APT MINIMA sensors overestimated the PM_{2.5} mass concentration as measured by the FEM T640x at 20 °C and 40% RH. The accuracy of the APT MINIMA sensors increased (~ 82% to 96%) with increasing PM_{2.5} mass concentrations.

APT MINIMA Data Recovery and Intra-model Variability

- Data recovery for PM_{2.5} mass concentration was 100% from all sensors.
- Low PM_{2.5} measurement variations were observed between the APT MINIMA sensors

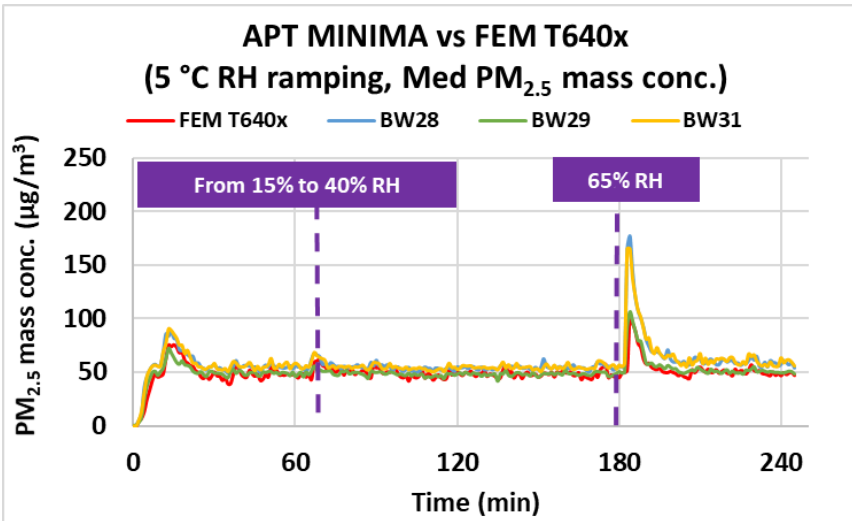
APT MINIMA PM_{2.5}: Precision

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

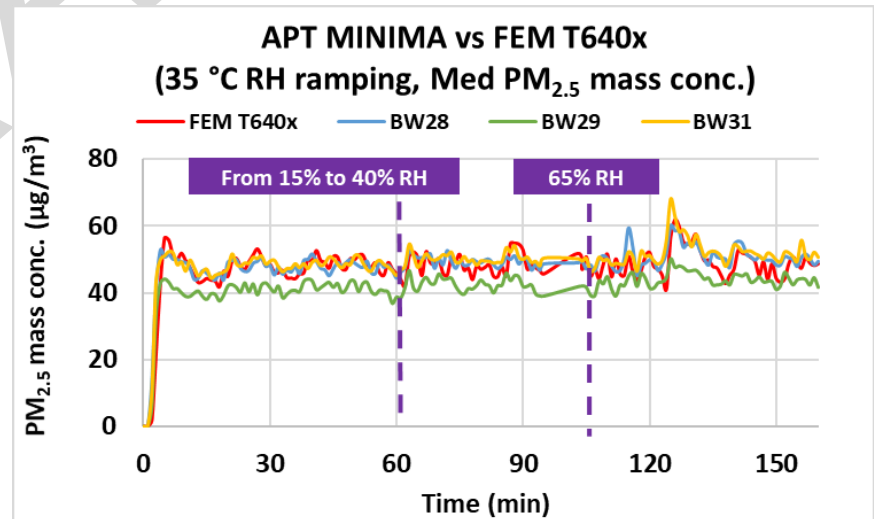


- Overall, the APT MINIMA sensors showed high precision for all the combinations of low, medium and high PM_{2.5} conc., T, and RH.
- Precision increases as PM concentration increases.

APT MINIMA PM_{2.5}: Climate Susceptibility



High Temp – RH ramping
(medium conc.)



Low Temp – RH ramping
(medium conc.)

Discussion

- **Accuracy:** Overall, the accuracy of the APT MINIMA sensors increased from ~ 82% to 96% as PM_{2.5} conc. increased over the tested concentration range. Overall, the APT MINIMA sensors overestimated PM_{2.5} measurements from FEM T640x in the laboratory experiments at 20 °C and 40% RH.
- **Precision:** The APT MINIMA sensors showed high precision for all test combinations (PM concentrations, T and RH) for PM_{2.5} mass concentrations.
- **Intra-model variability:** Low intra-model variability was observed among the APT MINIMA sensors.
- **Data Recovery:** Data recovery for PM_{2.5} mass concentration was 100% for all units
- **Coefficient of Determination:** The APT MINIMA sensors showed very strong correlation/linear response with the corresponding FEM T640x PM_{2.5} measurement data ($R^2 > 0.99$).
- **Climate susceptibility:** For most of the temperature and relative humidity combination, the climate condition had minimal effect on the APT MINIMA sensors; the sensors showed some small spiked conc. changes at RH change points