Laboratory Evaluation

Redspira

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

Three **Redspira** sensors (units IDs: 0083, 0084, 0085) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (10/29/2020 to 12/25/2020) under ambient environmental conditions. During laboratory testing, Redspira Unit 0084 was unable to connect to the internet for necessary data transmission and was excluded from laboratory testing. The two remaining units (units IDs: 0083 and 0085) were evaluated in the AQ-SPEC Sensor Environmental Testing Chamber-2 (SEnTeC-2) under controlled artificial aerosol concentration/size range, temperature, and relative humidity.

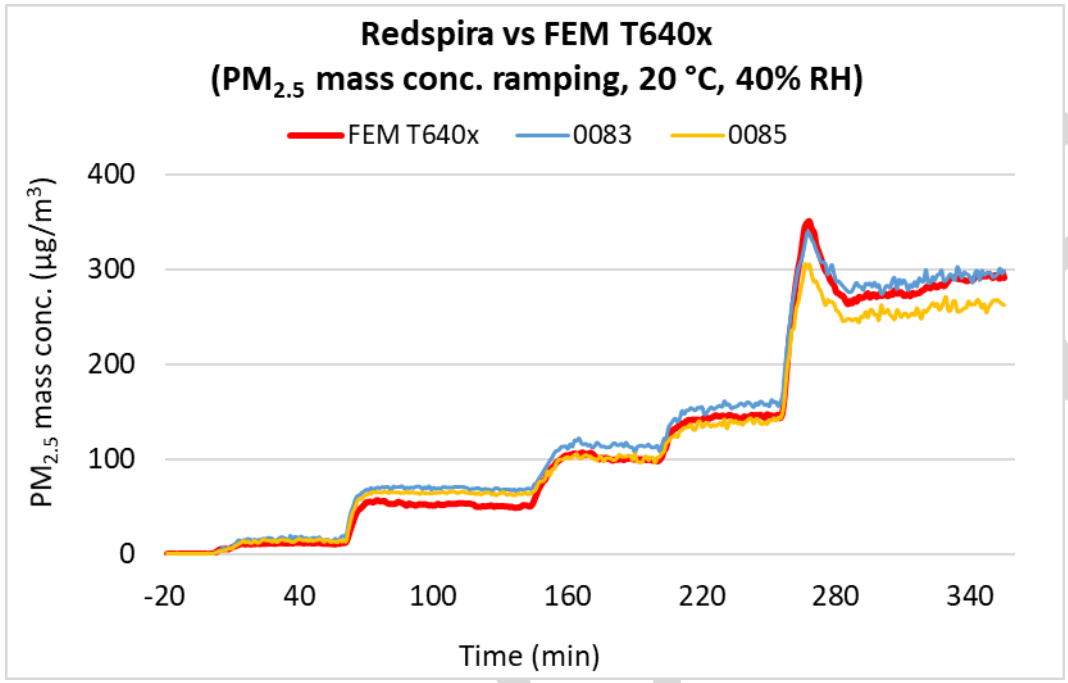
Redspira (*2 units tested*):

- Particle sensor: optical; non-FEM (PMS5003, Plantower)
- Each unit reports: $PM_{2.5}$ and PM_{10} ($\mu g/m^3$), temperature (°C) and RH (%)
- Unit cost: $180
- Time resolution: 1-min
- Units IDs: 0083, 0085

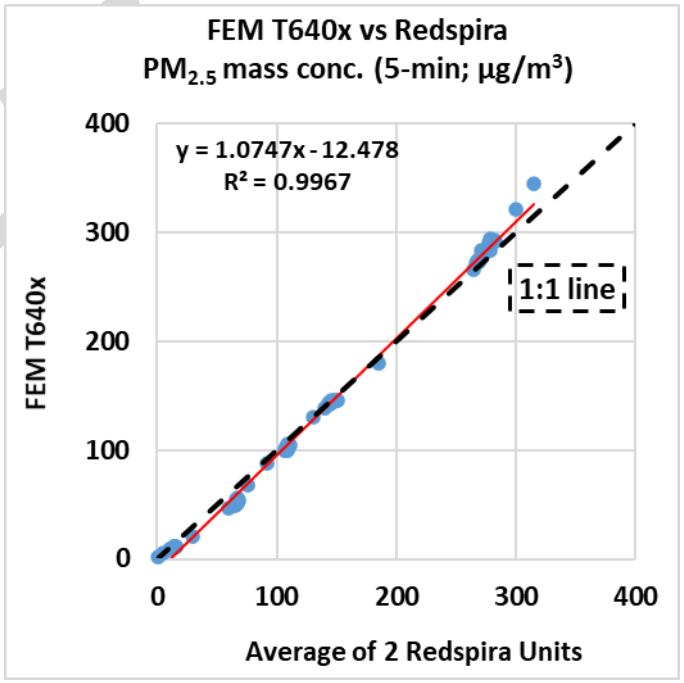
Teledyne API T640x (reference method)

- 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

Redspira vs FEM T640x ($PM_{2.5}$ mass conc.)



Coefficient of Determination



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

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

Redspira vs FEM T640x $PM_{2.5}$ Accuracy

- Accuracy (20°C and 40% RH)

Steady state #	Sensor Mean ($PM_{2.5}$, µg/m³)	FEM T640x ($PM_{2.5}$, µg/m³)	Accuracy (%)
1	14.7	11.4	71.0
2	66.9	52.3	72.1
3	108.4	104.0	95.7
4	145.5	144.4	99.3
5	275.1	282.6	97.4

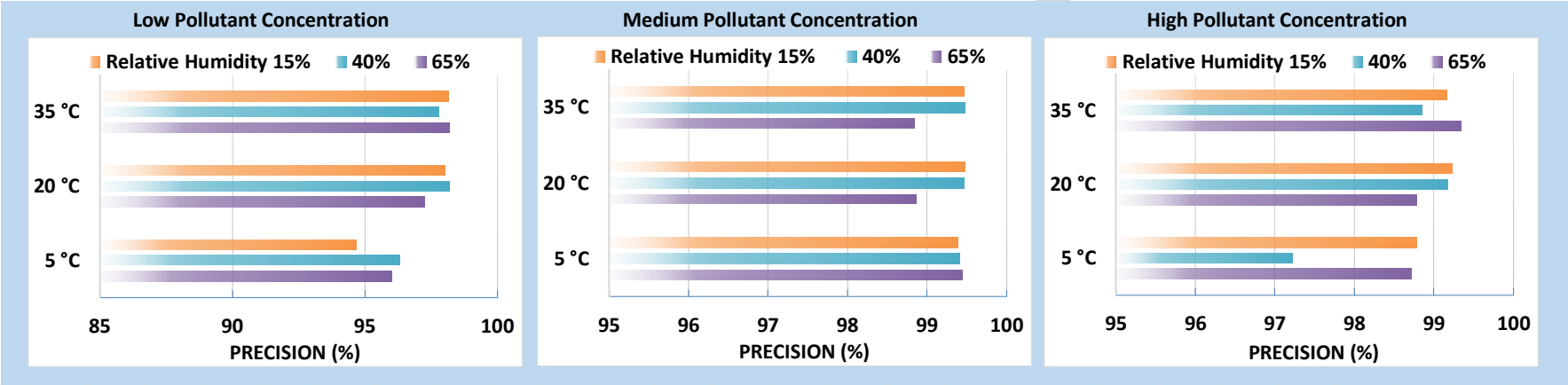
- Overall, the Redspira sensors overestimated the FEM T640x $PM_{2.5}$ mass concentration at 20°C and 40% RH. The accuracy of the Redspira sensors increased (~ 71% to 99%) with increasing $PM_{2.5}$ mass concentrations

Redspira 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 Redspira sensors

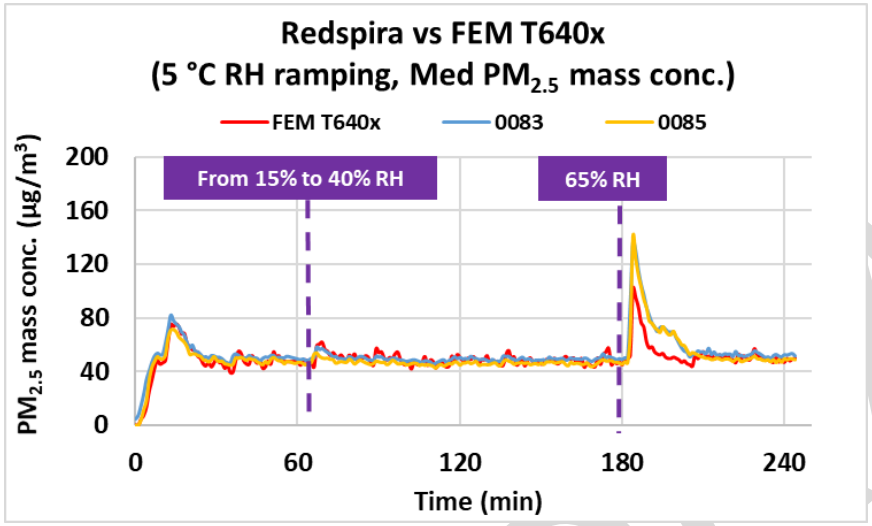
Redspira $PM_{2.5}$: Precision

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



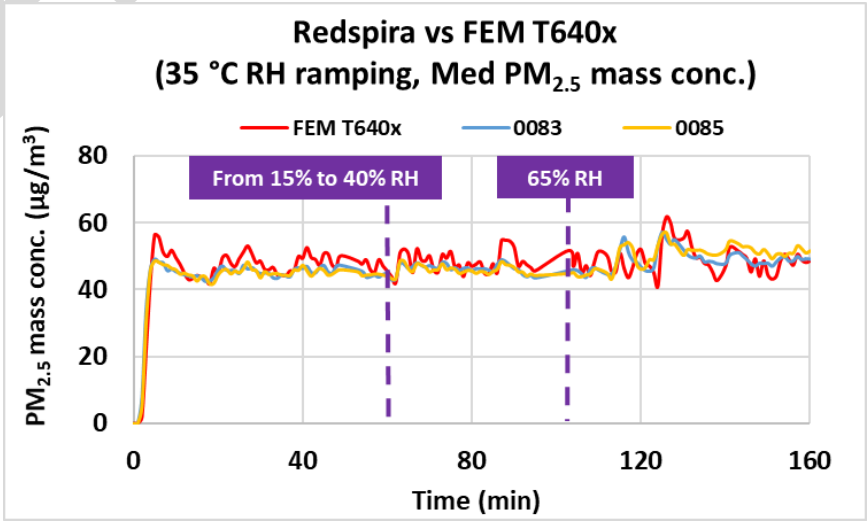
- Overall, the Redspira sensors showed high precision for all the combinations of low, medium and high $PM_{2.5}$ conc., T, and RH.

Redspira $PM_{2.5}$: Climate Susceptibility



Low Temp – RH ramping (medium conc.)

High Temp – RH ramping (medium conc.)



Discussion

- **Accuracy**: Overall, the Redspira sensors overestimated the FEM T640x $PM_{2.5}$ mass concentration at 20°C and 40% RH. The accuracy of the Redspira sensors increased (~ 71% to 99%) with increasing $PM_{2.5}$ mass concentrations.
- **Precision**: The Redspira 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 Redspira sensors.
- **Data Recovery:** Data recovery for $PM_{2.5}$ mass concentration was 100% for all units
- **Coefficient of Determination**: The Redspira 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 Redspira sensors; the sensors showed some small spiked conc. changes at RH change points.