Laboratory Evaluation

Redspira
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\textsubscript{2.5} and PM\textsubscript{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\textsubscript{2.5}, FEM PM\textsubscript{10}
- Uses proprietary algorithms to calculate total PM\textsubscript{1.0}, PM\textsubscript{2.5} and PM\textsubscript{10} mass conc. from particle number measurements
- Cost: ~$35,000
- Time resolution: 1-min
• 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)

<table>
<thead>
<tr>
<th>Steady state #</th>
<th>Sensor Mean (PM$_{2.5}$, µg/m$^3$)</th>
<th>FEM T640x (PM$_{2.5}$, µg/m$^3$)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14.7</td>
<td>11.4</td>
<td>71.0</td>
</tr>
<tr>
<td>2</td>
<td>66.9</td>
<td>52.3</td>
<td>72.1</td>
</tr>
<tr>
<td>3</td>
<td>108.4</td>
<td>104.0</td>
<td>95.7</td>
</tr>
<tr>
<td>4</td>
<td>145.5</td>
<td>144.4</td>
<td>99.3</td>
</tr>
<tr>
<td>5</td>
<td>275.1</td>
<td>282.6</td>
<td>97.4</td>
</tr>
</tbody>
</table>

- 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.)

Redspira vs FEM T640x
(5 °C RH ramping, Med PM$_{2.5}$ mass conc.)

Redspira vs FEM T640x
(35 °C RH ramping, Med PM$_{2.5}$ mass 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.