Field Evaluation
Elitech Temtop PMD 351
From 04/23/2021 to 06/22/2021, three Elitech Temtop PMD 351 (hereinafter Temtop PMD 351) sensors were deployed at the South Coast AQMD stationary ambient monitoring site in Rubidoux and were run side-by-side with Federal Equivalent Method (FEM) instruments measuring the same pollutants.

**Temtop PMD 351 (3 units tested):**
- Particle sensor: optical; non-FEM (Temtop PMS16)
- Each unit reports: PM$_{1.0}$, PM$_{2.5}$ and PM$_{10}$ ($\mu$g/m$^3$)
- Also reports PM$_4$, and TSP ($\mu$g/m$^3$)
- Unit cost: ~$960
- Time resolution: 1-min
- Units IDs: 10003, 60001, 80001

**GRIMM (reference instrument):**
- Optical particle counter (FEM PM$_{2.5}$)
- Measures PM$_{1.0}$, PM$_{2.5}$, and PM$_{10}$ ($\mu$g/m$^3$)
- Cost: ~$25,000 and up
- Time resolution: 1-min

**Teledyne API T640 (reference instrument):**
- Optical particle counter (FEM PM$_{2.5}$)
- Measures PM$_{1.0}$, PM$_{2.5}$ and PM$_{10}$ ($\mu$g/m$^3$)
- Cost: ~$21,000
- Time resolution: 1-min
Data validation & recovery

- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery from all units was ~ 100% for all PM measurements

Temtop PMD 351; intra-model variability

- Absolute intra-model variability was ~ 1.20, 1.48 and 1.68 µg/m³ for PM_{1.0}, PM_{2.5} and PM_{10}, respectively (calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was ~ 11.1%, 9.6% and 6.4% for PM_{1.0}, PM_{2.5} and PM_{10}, respectively (calculated as the absolute intra-model variability relative to the mean of the three sensor means)
Data recovery for PM$_{1.0}$ from GRIMM and T640 was ~ 100%.

Strong correlations between the reference instruments for PM$_{1.0}$ measurements ($R^2$ ~ 0.88) were observed.
Reference Instruments: PM$_{2.5}$
FEM GRIMM and FEM T640

- Data recovery for PM$_{2.5}$ from FEM GRIMM and FEM T640 was ~ 100%.
- Very strong correlations between the reference instruments for PM$_{2.5}$ measurements ($R^2$ ~ 0.90) were observed.
Reference Instruments: PM$_{10}$  
GRIMM and T640

- Data recovery for PM$_{10}$ from GRIMM and T640 was ~ 100%.
- Strong correlations between the reference instruments for PM$_{10}$ measurements ($R^2$ ~ 0.88) were observed.
The Temtop PMD 351 sensors showed strong correlations with the corresponding GRIMM data ($0.73 < R^2 < 0.76$).

Overall, the Temtop PMD 351 sensors overestimated the PM$_{1.0}$ mass concentrations as measured by GRIMM.

The Temtop PMD 351 sensors seemed to track the PM$_{1.0}$ diurnal variations as recorded by GRIMM.
The Temtop PMD 351 sensors showed strong correlations with the corresponding FEM GRIMM data (0.70 < $R^2$ < 0.75).

Overall, the Temtop PMD 351 sensors overestimated the PM$_{2.5}$ mass concentrations as measured by FEM GRIMM.

The Temtop PMD 351 sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM GRIMM.
The Temtop PMD 351 sensors showed very weak to weak correlations with the corresponding GRIMM data (0.26 < $R^2 < 0.33$).

Overall, the Temtop PMD 351 sensors underestimated the PM$_{10}$ mass concentrations as measured by GRIMM.

The Temtop PMD 351 sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by GRIMM.

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**Elitech Temtop PMD 351 vs GRIMM**

- **GRIMM**
- **Unit 10003**
- **Unit 60001**
- **Unit 80001**

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PM$_{10}$ (5-min mean, $\mu g/m^3$)

- **Unit 10003**
  - $y = 0.5423x + 14.211$
  - $R^2 = 0.328$

- **Unit 60001**
  - $y = 0.4305x + 16.105$
  - $R^2 = 0.2737$

- **Unit 80001**
  - $y = 0.5003x + 16.152$
  - $R^2 = 0.2664$

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**PM$_{10}$ (5-min mean, $\mu g/m^3$)**

- **Unit 10003**
- **Unit 60001**
- **Unit 80001**
The Temtop PMD 351 sensors showed strong correlations with the corresponding GRIMM data ($0.74 < R^2 < 0.76$)

- Overall, the Temtop PMD 351 sensors overestimated the PM$_{1.0}$ mass concentrations as measured by GRIMM
- The Temtop PMD 351 sensors seemed to track the PM$_{1.0}$ diurnal variations as recorded by GRIMM
The Temtop PMD 351 sensors showed strong correlations with the corresponding FEM GRIMM data ($0.71 < R^2 < 0.75$).

Overall, the Temtop PMD 351 sensors overestimated the PM$_{2.5}$ mass concentrations as measured by FEM GRIMM.

The Temtop PMD 351 sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM GRIMM.
The Temtop PMD 351 sensors showed very weak to weak correlations with the corresponding GRIMM data (0.27 < $R^2$ < 0.35).

Overall, the Temtop PMD 351 sensors underestimated the PM$_{10}$ mass concentrations as measured by GRIMM.

The Temtop PMD 351 sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by GRIMM.
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The Temtop PMD 351 sensors seemed to track the PM$_{1.0}$ diurnal variations as recorded by GRIMM.
The Temtop PMD 351 sensors showed strong correlations with the corresponding FEM GRIMM data (0.73 < R² < 0.75).

Overall, the Temtop PMD 351 sensors overestimated the PM$_{2.5}$ mass concentrations as measured by FEM GRIMM.

The Temtop PMD 351 sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM GRIMM.

\[ y = 0.4999x + 5.4449 \quad R^2 = 0.7481 \]

\[ y = 0.3965x + 5.8307 \quad R^2 = 0.7354 \]

\[ y = 0.5017x + 5.6906 \quad R^2 = 0.7434 \]
The Temtop PMD 351 sensors showed very weak correlations with the corresponding GRIMM data ($0.21 < R^2 < 0.26$).

Overall, the Temtop PMD 351 sensors underestimated the PM$_{10}$ mass concentrations as measured by GRIMM.

The Temtop PMD 351 sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by GRIMM.
The Temtop PMD 351 sensors showed moderate to strong correlations with the corresponding T640 data (0.68 < R² < 0.71).

Overall, the Temtop PMD 351 sensors overestimated the PM₁₀ mass concentrations as measured by T640.

The Temtop PMD 351 sensors seemed to track the PM₁₀ diurnal variations as recorded by T640.
The Temtop PMD 351 sensors showed strong correlations with the corresponding FEM T640 data ($0.70 < R^2 < 0.74$).

Overall, the Temtop PMD 351 sensors overestimated the PM$_{2.5}$ mass concentrations as measured by FEM T640.

The Temtop PMD 351 sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM T640.
Temtop PMD 351 vs T640 (PM$_{10}$; 5-min mean)

- Temtop PMD 351 sensors showed weak correlations with the corresponding T640 data ($0.39 < R^2 < 0.46$)
- Overall, the Temtop PMD 351 sensors underestimated the PM$_{10}$ mass concentrations as measured by T640
- The Temtop PMD 351 sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by T640
The Temtop PMD 351 sensors showed moderate to strong correlations with the corresponding T640 data ($0.68 < R^2 < 0.72$).

Overall, the Temtop PMD 351 sensors overestimated the PM$_{1.0}$ mass concentrations as measured by T640.

The Temtop PMD 351 sensors seemed to track the PM$_{1.0}$ diurnal variations as recorded by T640.
The Temtop PMD 351 sensors showed strong correlations with the corresponding FEM T640 data (0.71 < R^2 < 0.75).

Overall, the Temtop PMD 351 sensors overestimated the PM_{2.5} mass concentrations as measured by FEM T640.

The Temtop PMD 351 sensors seemed to track the PM_{2.5} diurnal variations as recorded by FEM T640.

\[ y = 0.5903x + 6.3432 \]
\[ R^2 = 0.7446 \]

\[ y = 0.4648x + 6.8643 \]
\[ R^2 = 0.7172 \]

\[ y = 0.5995x + 6.5338 \]
\[ R^2 = 0.7378 \]
The Temtop PMD 351 sensors showed weak correlations with the corresponding T640 data ($0.40 < R^2 < 0.48$).

Overall, the Temtop PMD 351 sensors underestimated the PM$_{10}$ mass concentrations as measured by T640.

The Temtop PMD 351 sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by T640.
The Temtop PMD 351 sensors showed moderate to strong correlations with the corresponding T640 data (0.68 < $R^2$ < 0.72).

Overall, the Temtop PMD 351 sensors overestimated the PM$_{1.0}$ mass concentrations as measured by T640.

The Temtop PMD 351 sensors seemed to track the PM$_{1.0}$ diurnal variations as recorded by T640.
Temtop PMD 351 vs FEM T640 (PM$_{2.5}$; 24-hr mean)

- The Temtop PMD 351 sensors showed strong correlations with the corresponding FEM T640 data ($0.77 < R^2 < 0.79$)
- Overall, the Temtop PMD 351 sensors overestimated the PM$_{2.5}$ mass concentrations as measured by FEM T640
- The Temtop PMD 351 sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM T640
Temtop PMD 351 vs T640 (PM$_{10}$; 24-hr mean)

- The Temtop PMD 351 sensors showed weak to moderate correlations with the corresponding T640 data (0.46 < $R^2$ < 0.52)
- Overall, the Temtop PMD 351 sensors underestimated the PM$_{10}$ mass concentrations as measured by T640
- The Temtop PMD 351 sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by T640
## Summary

<table>
<thead>
<tr>
<th>Average of 3 Sensors, PM₁₀</th>
<th>Temtop PMD 351 vs GRIMM &amp; T640, PM₁₀</th>
<th>GRIMM &amp; T640 (PM₁₀, μg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>Intercept</td>
</tr>
<tr>
<td>5-min</td>
<td>0.68 to 0.75</td>
<td>0.52 to 0.70</td>
</tr>
<tr>
<td>1-hr</td>
<td>0.69 to 0.76</td>
<td>0.52 to 0.70</td>
</tr>
<tr>
<td>24-hr</td>
<td>0.68 to 0.76</td>
<td>0.53 to 0.71</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average of 3 Sensors, PM₂₅</th>
<th>Temtop PMD 351 vs FEM GRIMM &amp; FEM T640, PM₂₅</th>
<th>FEM GRIMM &amp; FEM T640 (PM₂₅, μg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>Intercept</td>
</tr>
<tr>
<td>5-min</td>
<td>0.71 to 0.74</td>
<td>0.41 to 0.60</td>
</tr>
<tr>
<td>1-hr</td>
<td>0.72 to 0.75</td>
<td>0.40 to 0.60</td>
</tr>
<tr>
<td>24-hr</td>
<td>0.74 to 0.78</td>
<td>0.40 to 0.62</td>
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<tr>
<td>5-min</td>
<td>0.27 to 0.46</td>
<td>0.43 to 0.82</td>
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<tr>
<td>1-hr</td>
<td>0.28 to 0.48</td>
<td>0.41 to 0.81</td>
</tr>
<tr>
<td>24-hr</td>
<td>0.21 to 0.51</td>
<td>0.32 to 0.75</td>
</tr>
</tbody>
</table>

¹ Mean Bias Error (MBE): the difference between the sensors and the reference instruments. MBE indicates the tendency of the sensors to underestimate (negative MBE values) or overestimate (positive MBE values).

² Mean Absolute Error (MAE): the absolute difference between the sensors and the reference instruments. The larger MAE values, the higher measurement errors as compared to the reference instruments.

³ Root Mean Square Error (RMSE): another metric to calculate measurement errors.
The three Temtop PMD 351 sensors’ data recovery from all units was ~ 100% for all PM measurements.

The absolute intra-model variability was ~ 1.20, 1.48 and 1.68 µg/m³ for PM₁₀, PM₂.₅ and PM₁₀, respectively.

Strong correlations between GRIMM and T640 for PM₁₀ (R² ~ 0.88, 1-hr mean); very strong correlations between FEM GRIMM and FEM T640 for PM₂.₅ (R² ~ 0.90, 1-hr mean) and strong correlations between GRIMM and T640 for PM₁₀ (R² ~ 0.88, 1-hr mean) mass concentration measurements.

PM₁₀ mass concentrations measured by the Temtop PMD 351 sensors showed moderate to strong correlations with the corresponding GRIMM and T640 data (0.68 < R² < 0.76, 1-hr mean). The sensors overestimated PM₁₀ mass concentrations as measured by GRIMM and T640.

PM₂.₅ mass concentrations measured by the Temtop PMD 351 sensors showed strong correlations with the corresponding FEM GRIMM and FEM T640 data (0.71 < R² < 0.75, 1-hr mean). The sensors overestimated PM₂.₅ mass concentrations as measured by FEM GRIMM and FEM T640.

PM₁₀ mass concentrations measured by the Temtop PMD 351 sensors showed very weak to weak correlations with the corresponding GRIMM and T640 data (0.27 < R² < 0.48; 1-hr mean). The sensors underestimated PM₁₀ mass concentrations as measured by GRIMM and T640.

No sensor calibration was performed by South Coast AQMD Staff prior to the beginning of this test.

Laboratory chamber testing is necessary to fully evaluate the performance of these sensors under known aerosol concentrations and controlled temperature and relative humidity conditions.

All results are still preliminary.