Laboratory Evaluation
RTI – MicroPEM $PM_{2.5}$ Sensor

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South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- Three **RTI MicroPEM** PM sensors that were previously evaluated for their performance in the field (deployment period: 02/10/2015 - 04/14/2015), under ambient weather conditions, have now been evaluated in the SCAQMD Chemistry Laboratory under controlled artificial aerosol concentration/size, temperature and relative humidity conditions.
- RTI MicroPEM (*3 units tested*):
  - ➢Particulate Matter sensors (optical; non-FEM)*
  - ➢Each unit measures: $PM_{2.5}$ (μg/m^3)
  - ➢Unit cost: ~$2,000
  - ➢Time resolution: 10 sec
  - ➢Units IDs: 60N, 65N, 72N

*The MicroPEM also allows for the collection of integrated $PM_{2.5}$ samples on a 25mm Teflon filter

- GRIMM (*reference method*):
  - ➢Optical particle counter (FEM)
  - ➢Uses proprietary algorithms to calculate total PM, $PM_{2.5}$, and PM_1 from particle number measurements
  - ➢Cost: ~$25,000 and up
  - ➢Time resolution: 1 min

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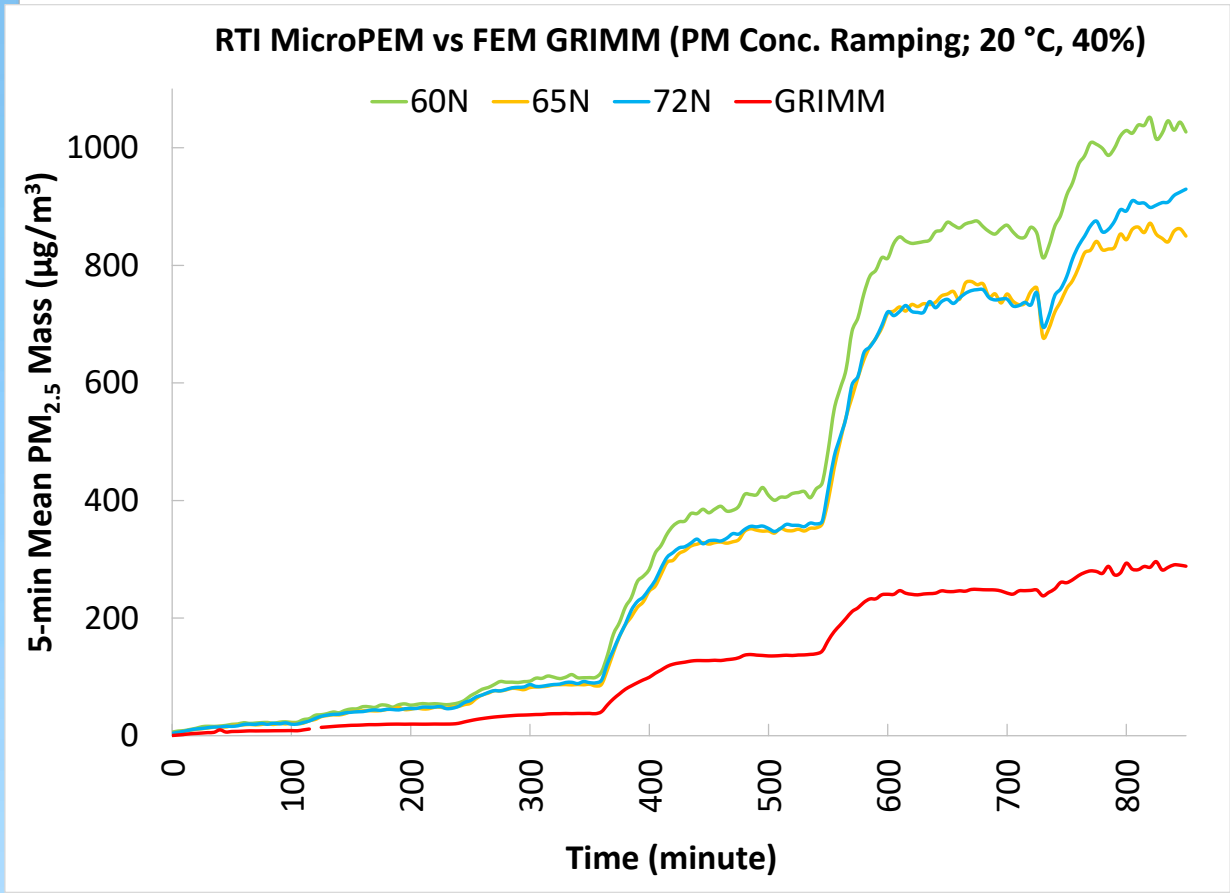
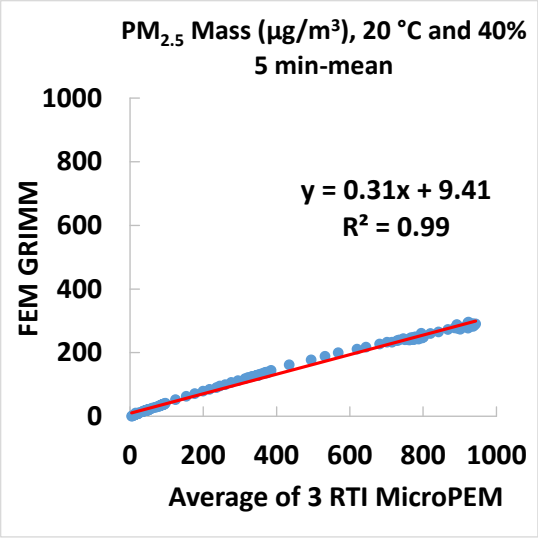
RTI MicroPEM vs FEM GRIMM ($PM_{2.5}$ mass; 5-min mean)



- Measurements from all three RTI MicroPEM sensors tracked very well the $PM_{2.5}$ (µg/m^3) variations (concentration ramping) recorded by the FEM GRIMM instrument at 20 °C and 40% RH.

Coefficient of Determination



- Measurements from all three RTI MicroPEM sensors showed excellent correlation with the corresponding FEM GRIMM $PM_{2.5}$ measurement data (R^2 = 0.99).
- However, the MicroPEMs largely overestimated (3 times) the FEM GRIMM $PM_{2.5}$ (slope = 0.31 and intercept = 9.41).

RTI MicroPEM vs FEM GRIMM ($PM_{2.5}$; 5-min mean)

- Accuracy (20 °C and 40% RH)

Steady State (#)	Sensor mean (µg/m³)	FEM GRIMM (µg/m³)	Accuracy (%)
1	20.2	8.9	-27.0
2	50.1	19.8	-53.0
3	91.3	37.8	-41.5
4	379.1	139	-72.7
5	727.1	241.2	-101.5

- Overall, the three RTI MicroPEM units showed accuracy (from -27.0% to -101.5%) for different $PM_{2.5}$ mass concentration levels over the range of 0 – 240 µg/m³. Low accuracy and overestimation was observed for RTI units compared to FEM GRIMM at 20 °C and 40% RH.

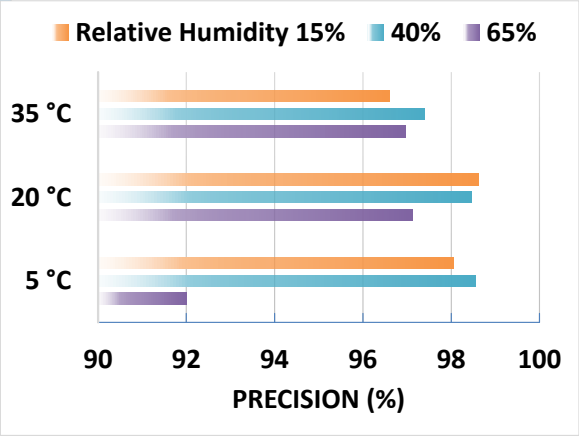
RTI MicroPEM Data Recovery & Intra-model Variability

- Data recovery for $PM_{2.5}$ mass concentration from all three units was 100%.
- Low $PM_{2.5}$ measurement variations were observed between the three units.

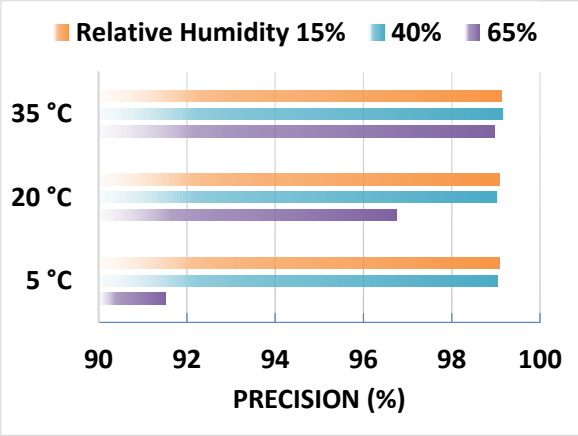
RTI MicroPEM vs FEM GRIMM ($PM_{2.5}$; 5-min mean)

- Precision (Effect of $PM_{2.5}$ conc.,Temperature and Relative Humidity)

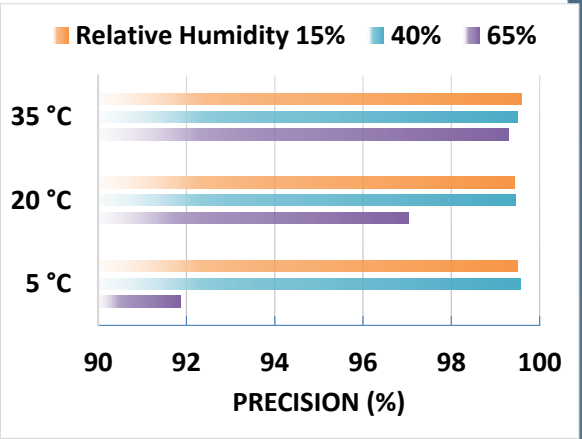
Low Conc.



Medium Conc.



High Conc.



- Overall, the three MicroPEMs and the FEM GRIMM showed high precision for almost all combinations of low, medium and high PM conc., temp and RH, except for the case of low temperature (5 °C) and high RH (65%) at all three PM concentration levels.

- FEM GRIMM precision was very high across all conditions.

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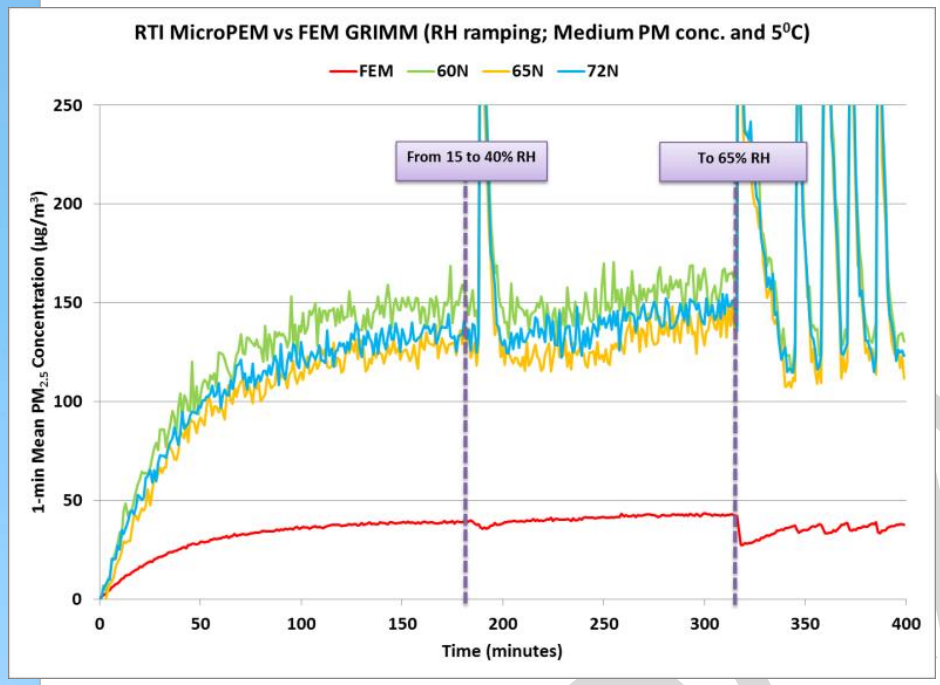
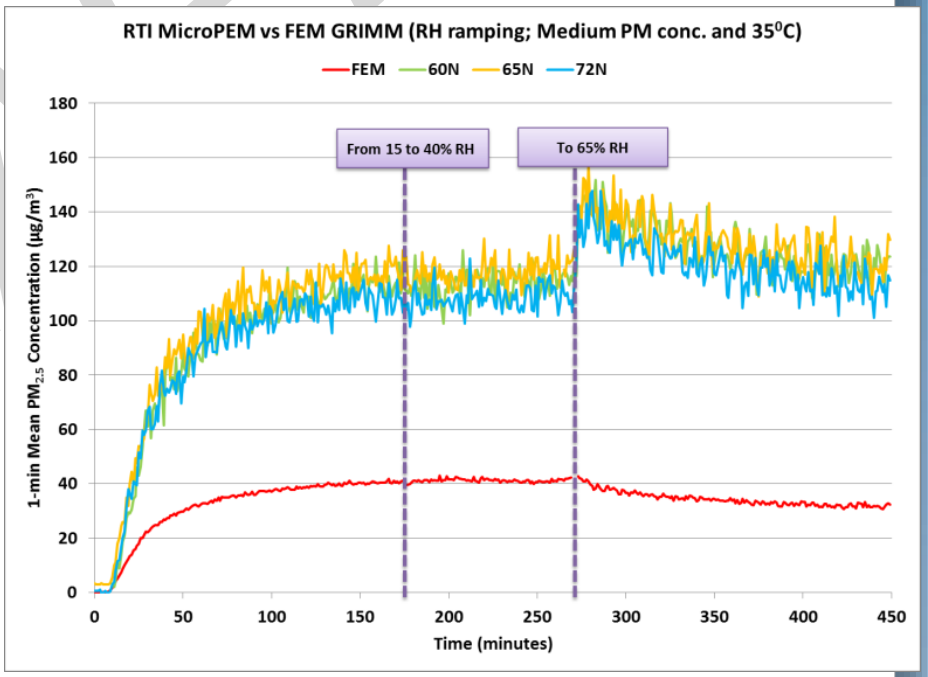
RTI MicroPEM Climate Susceptibility



Low Temp – RH ramping
(medium conc.)



High Temp – RH ramping
(medium conc.)

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Discussion

- **Accuracy**: Overall, the three RTI MicroPEM units showed accuracy (from -27.0% to -101.5%) for different $PM_{2.5}$ mass concentration levels over the range of 0 – 240 µg/m^3. Low accuracy and overestimation was observed for RTI units compared to FEM GRIMM at 20 °C and 40% RH. (refer to slide 4)
- **Precision**: High precision for all test combinations except at 5 °C and 65% for low, medium and high $PM_{2.5}$ (refer to slide 5)
- **Intra-model Variability**: Low $PM_{2.5}$ measurement variations were observed between the three units.
- **Data Recovery**: Data recovery for $PM_{2.5}$ mass concentration from all three units was 100%.
- **Linearity of sensor response**: MicroPEM sensors show excellent correlation/linear response with the corresponding FEM GRIMM $PM_{2.5}$ measurement data (R^2 = 0.99) (refer to slide 3)
- **Climate susceptibility**: From the lab studies, there is a clear and distinct Temperature and Relative Humidity effect on the sensor performance as this is realized by the $PM_{2.5}$ mass concentration measurement data both alone and relative to the corresponding FEM GRIMM data (refer to slides 6)

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