

# AQ-SPEC

## Air Quality Sensor Performance Evaluation Center

### Evaluation Summary

#### Sensor Description

Manufacturer/Model:  
Atmotube/  
Pro

Pollutants:  
PM<sub>1.0</sub>, PM<sub>2.5</sub> and PM<sub>10</sub>  
mass concentration

Time Resolution:  
1-min

Type: Optical



#### Additional Information

##### Field evaluation report:

<http://www.aqmd.gov/aq-spec/evaluations/field>

##### Lab evaluation report:

<http://www.aqmd.gov/aq-spec/evaluations/laboratory>

##### AQ-SPEC website:

<http://www.aqmd.gov/aq-spec>

- Overall, the accuracy of the Atmotube Pro sensors fairly constant (84% to 98% and 86% to 98%) over the range of PM<sub>1.0</sub> and PM<sub>2.5</sub> mass concentration tested, respectively. Overall, the Atmotube Pro sensors overestimated GRIMM PM<sub>1.0</sub> measurements when PM<sub>1.0</sub> mass concentrations were > 100 µg/m<sup>3</sup> and overestimated PM<sub>2.5</sub> measurements from GRIMM in the laboratory experiments at 20 °C and 40% RH.
- The Atmotube Pro sensors exhibited high precision for all T/RH combinations and all PM concentrations.
- The Atmotube Pro sensors (IDs: E7E0, 05AB and 6C77) showed low to moderate intra-model variability for both the field and laboratory evaluations.
- Data recovery was ~94% and 100% from all units in the field and laboratory evaluations, respectively.
- For PM<sub>1.0</sub>, the Atmotube Pro sensors showed very strong correlations with the corresponding GRIMM data; and showed strong correlations with the ref. instruments from the field for PM<sub>2.5</sub> ( $0.79 < R^2 < 0.90$ ) and very strong correlations with GRIMM in the laboratory evaluations ( $R^2 > 0.99$  for PM<sub>1.0</sub> and PM<sub>2.5</sub>). For PM<sub>10</sub>, the sensors showed very weak correlations with the corresponding GRIMM and FEM BAM data ( $0.18 < R^2 < 0.26$ ).
- The same three Atmotube Pro units were tested both in the field (1<sup>st</sup> stage of testing) and in the laboratory (2<sup>nd</sup> stage of testing).

### Field Evaluation Highlights

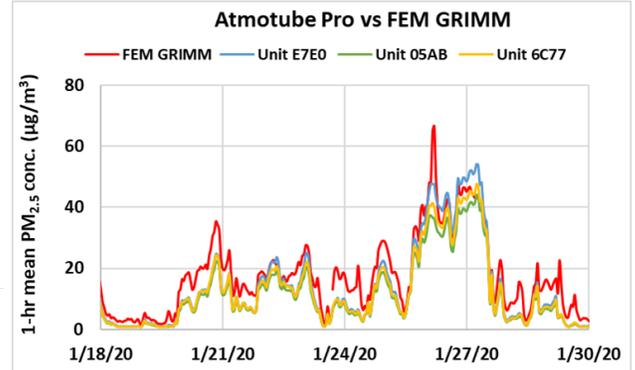
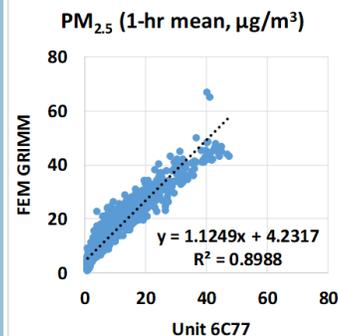
- Deployment period 01/07/2020 - 03/11/2020: the three Atmotube Pro sensors showed very strong, strong and very weak correlations with the corresponding ref. data for PM<sub>1.0</sub>, PM<sub>2.5</sub> and PM<sub>10</sub> mass concentrations, respectively.
- The units showed low intra-model variability and data recovery was ~ 94%.

1-hr mean, all ref. inst.

PM<sub>1.0</sub>: ~ 0.92

PM<sub>2.5</sub>:  $0.79 < R^2 < 0.90$

PM<sub>10</sub>:  $0.18 < R^2 < 0.26$



Coefficient of Determination ( $R^2$ ) quantifies how the three sensors followed the PM<sub>2.5</sub> concentration change by the reference instruments.

An  $R^2$  approaching the value of 1 reflects a near perfect agreement, whereas a value of 0 indicates a complete lack of correlation.

# Laboratory Evaluation Highlights

## Accuracy (PM<sub>2.5</sub>)

$$A (\%) = 100 - \frac{|\bar{X} - \bar{R}|}{\bar{R}} * 100$$

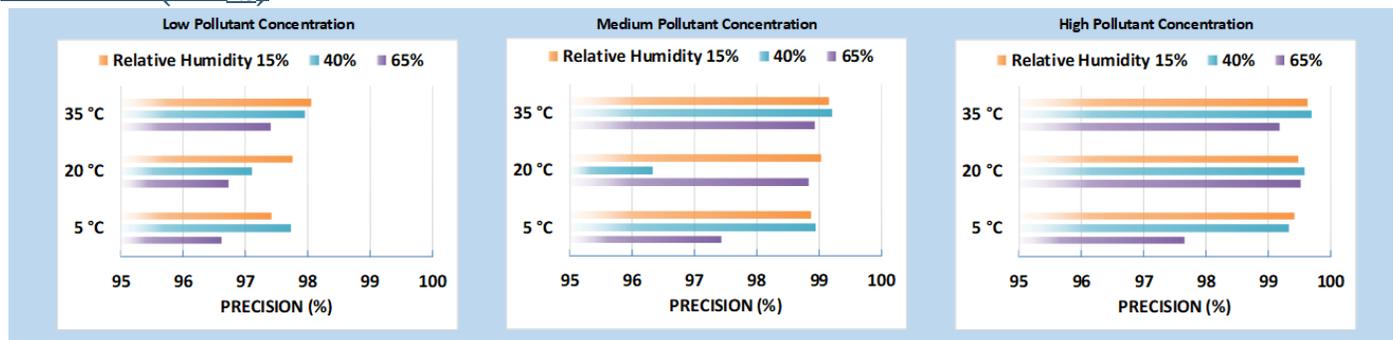
| Steady state # | Sensor Mean (µg/m <sup>3</sup> ) | FEM GRIMM (µg/m <sup>3</sup> ) | Accuracy (%) |
|----------------|----------------------------------|--------------------------------|--------------|
| 1              | 9.0                              | 8.4                            | 93.3         |
| 2              | 15.6                             | 13.7                           | 86.1         |
| 3              | 47.8                             | 45.3                           | 94.3         |
| 4              | 120.1                            | 117.7                          | 98.0         |
| 5              | 282.8                            | 261.5                          | 91.9         |

Accuracy was evaluated by a concentration ramping experiment at 20 °C and 40%. The sensor's readings at each ramping steady state are compared to the reference instrument.

A negative % means sensors' overestimation by more than two fold. The higher the positive value (close to 100%), the higher the sensor's accuracy.



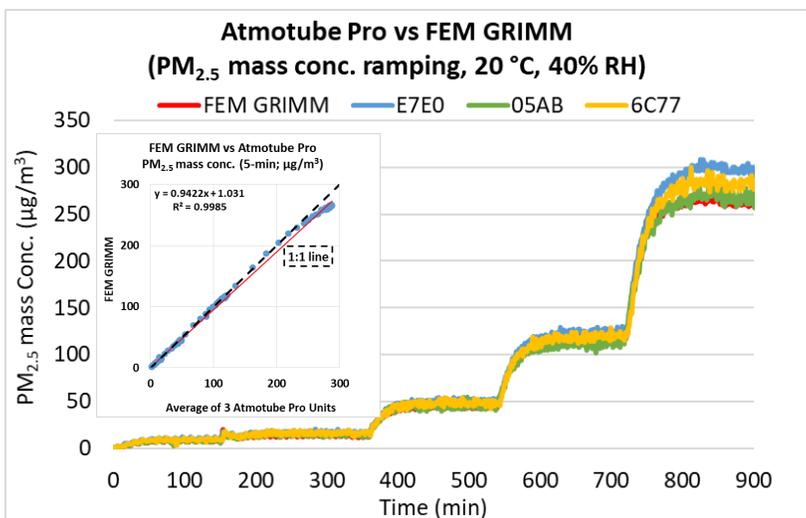
## Precision (PM<sub>2.5</sub>)



100% represents high precision.

Sensor's ability to generate precise measurements of PM<sub>2.5</sub> concentration at low, medium, and high pollutant levels were evaluated under 9 combinations of T and RH, including extreme weather conditions like cold and dry (5 °C and 15%) cold and humid (5 °C and 65%), hot and humid (35 °C and 65%), or hot and dry (35 °C and 15%).

## Coefficient of Determination



The Atmotube Pro sensors showed very strong correlations with the corresponding FEM PM<sub>2.5</sub> data ( $R^2 > 0.99$ ) at 20 °C/40% RH. For conc. ramping experiments of PM<sub>1.0</sub>, please see the lab report.

## Climate Susceptibility

From the laboratory studies, temperature and relative humidity had minimal effect on the Atmotube Pro sensors' precision. At the set-points of RH changes, the sensors reported spiked conc. changes for all PM levels at 5 °C and significant variation in concentration for all PM levels at 5 °C/65% RH.

## Observed Interferents

N/A



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