

Laboratory Evaluation Aeroqual AQY (v1.0)



Background

Three **Aeroqual AQY v1.0** sensors (units IDs: 1085, 1094, 1104) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (02/20/2020 to 04/22/2020) under ambient environmental conditions and have been evaluated in the South Coast AQMD Chemistry Laboratory under controlled artificial aerosol concentration/size range, temperature, and relative humidity. The same three Aeroqual AQY v1.0 units were tested both in the field (1st stage of testing) and in the laboratory (2nd stage of testing).

Aeroqual AQY v1.0 (3 units tested):

- Sensors: Ozone – Gas Sensitive Semiconductor (GSS);
- NO₂ – Gas Sensitive Electrochemical (GSE) (**non-FEM/non-FRM**);
- PM_{2.5} – Laser Particle Counter (LPC) (**non-FEM**), (model SDS011 by Nova Fitness)
- Each unit measures: O₃ (ppb), NO₂ (ppb), PM_{2.5} (μg/m³), T (°C), RH (%)
- **Unit cost: ~\$3,000 w/ modem** (\$4000 including 2-yr care package with cloud software and remote tech support)
- Time resolution: 1-min
- Units IDs: 1085, 1094, 1104
- Differences from AQY v0.5
 - Separate USB drive memory
 - New PCB board with sensor connector
 - Real time clock added
 - Mounting bracket for Ozone, NO₂ and PM_{2.5} sensors



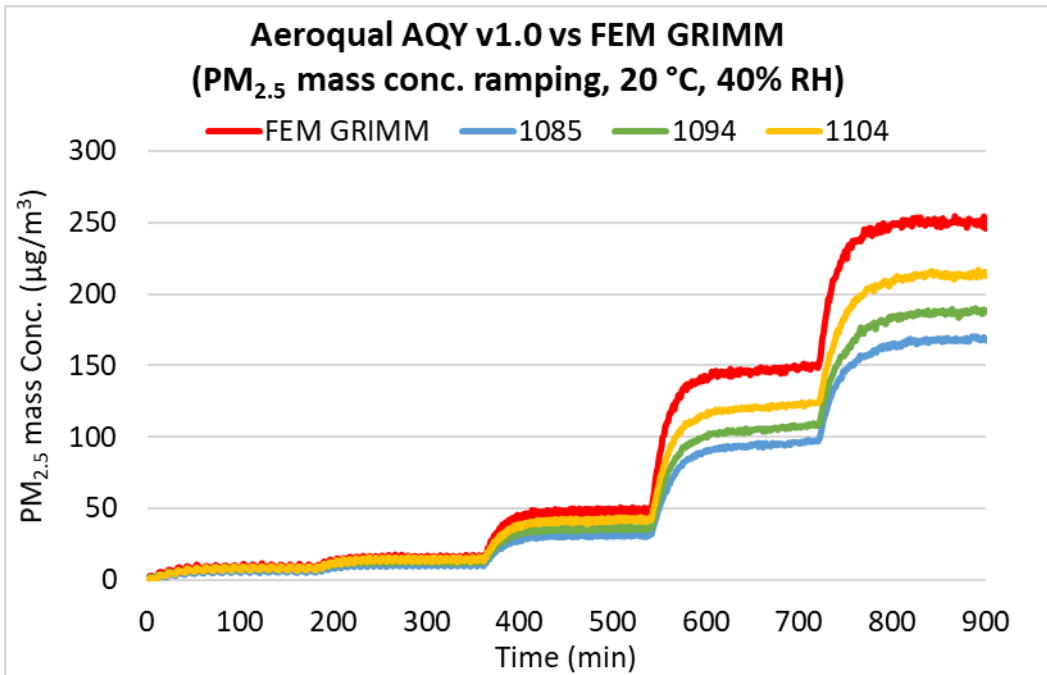
GRIMM (reference method):

- Optical particle counter
- **FEM PM_{2.5}**
- Uses proprietary algorithms to calculate PM_{1.0}, PM_{2.5}, and PM₁₀ mass conc. from particle number measurements
- **Cost: ~\$25,000**
- Time resolution: 1-min



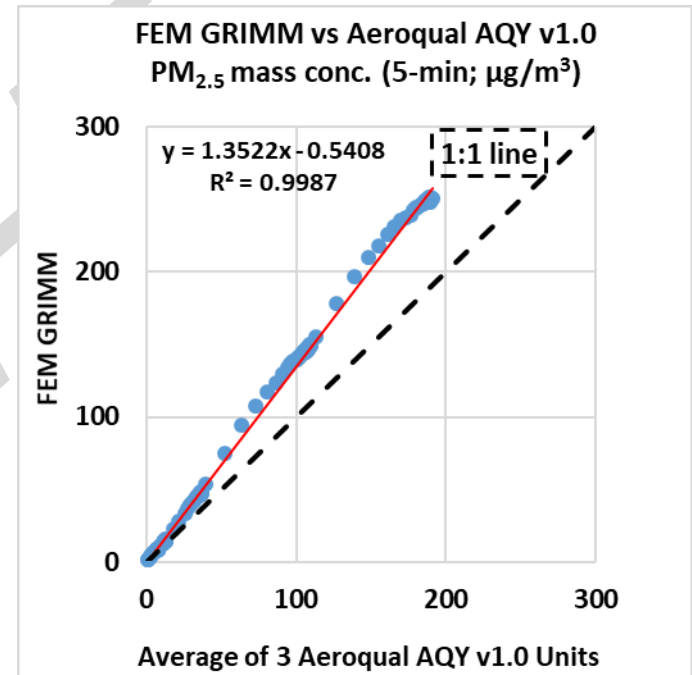
FEM GRIMM

Aeroqual AQY v1.0 vs FEM GRIMM (PM_{2.5} mass conc.)



- The Aeroqual AQY v1.0 sensors tracked well with the concentration variation as recorded by the FEM GRIMM in the concentration range of 0 - ~250 µg/m³.

Coefficient of Determination



- The Aeroqual AQY v1.0 sensors showed very strong correlations with the FEM GRIMM PM_{2.5} mass conc. ($R^2 > 0.99$)

Aeroqual AQY v1.0 vs FEM GRIMM PM_{2.5} Accuracy

- Accuracy (20°C and 40% RH)

Steady state #	Sensor Mean (µg/m ³)	FEM GRIMM (µg/m ³)	Accuracy (%)
1	7.3	8.7	84.3
2	12.7	14.8	85.4
3	36.6	48.1	76.1
4	109.4	149.4	73.3
5	190.3	250.3	76.0

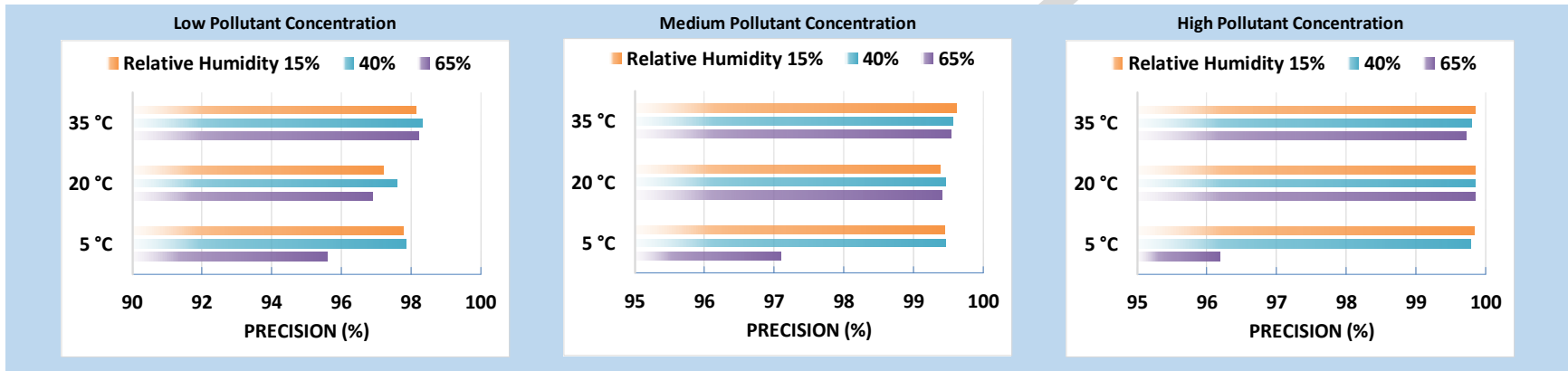
- The Aeroqual AQY v1.0 sensors underestimated FEM GRIMM PM_{2.5} mass concentration at 20 °C and 40% RH. The accuracy of the Aeroqual AQY v1.0 sensors was fairly constant (~73% to 85%) over the PM_{2.5} mass concentration range tested.

Aeroqual AQY v1.0: Data Recovery and Intra-model Variability

- Data recovery for PM_{2.5} mass concentration from all units was 100%
- Moderate PM_{2.5} measurement variations were observed between the Aeroqual AQY v1.0 sensors

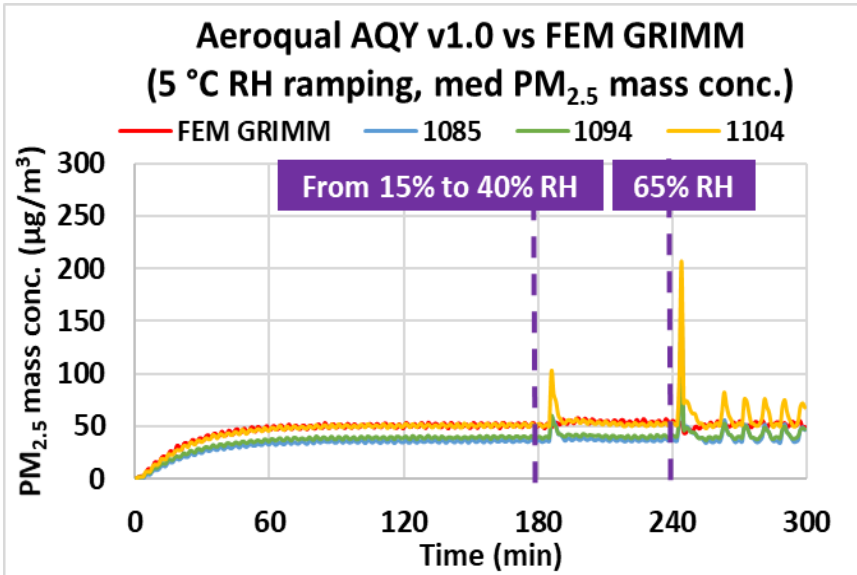
Aeroqual AQY v1.0 PM_{2.5}: Precision

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



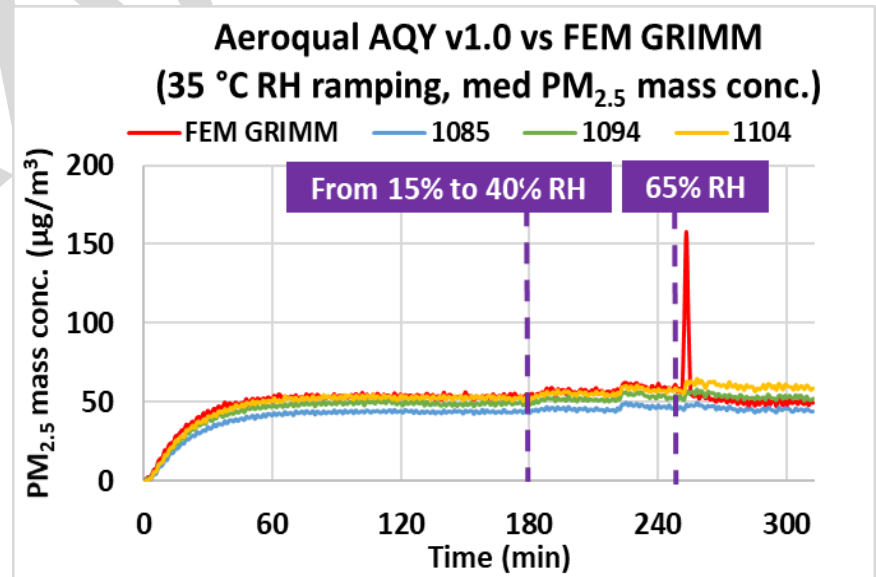
- Overall, the Aeroqual AQY v1.0 sensors showed high precision for all of the combinations of low, medium and high PM_{2.5} conc., T, and RH.
- Precision was relatively higher at higher PM_{2.5} mass concentrations.

Aeroqual AQY v1.0 PM_{2.5}: Climate Susceptibility



**Low Temp – RH ramping
(medium conc.)**

**High Temp – RH ramping
(medium conc.)**



Discussion

- **Accuracy:** Overall, the accuracy of the Aeroqual AQY v1.0 sensors was fairly constant (~ 73% to 85%) over the PM_{2.5} mass concentration range tested. The Aeroqual AQY v1.0 sensors underestimated PM_{2.5} measurements from FEM GRIMM in the laboratory experiments at 20 °C and 40% RH.
- **Precision:** The Aeroqual AQY v1.0 sensors showed high precision for all test combinations (PM concentrations, T and RH) for PM_{2.5} mass concentrations
- **Intra-model variability:** Moderate intra-model variability was observed among the Aeroqual AQY v1.0 sensors.
- **Data Recovery:** Data recovery for PM_{2.5} mass concentration was 100% from all Aeroqual AQY v1.0 units
- **Coefficient of Determination:** The Aeroqual AQY v1.0 sensors showed very strong correlation/linear response with the corresponding FEM GRIMM 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 Aeroqual AQY v1.0 sensors' precision; the sensors showed spiked conc. change at the RH change points at 5 °C and showed significant concentration variation at 5 °C/65% RH.