AQ-SPEC

Air Quality Sensor Performance Evaluation Center

Sensor Description

Manufacturer/Model:
MetOne ES-405

Pollutants:
$PM_{1.0}$ (only analyzed from field evaluation), $PM_{2.5}$, and PM_{10} 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

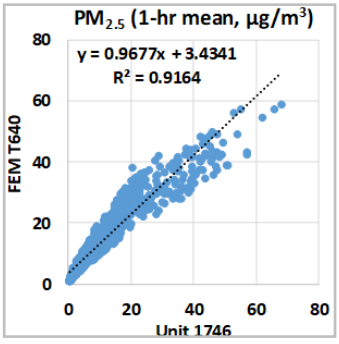
Evaluation Summary

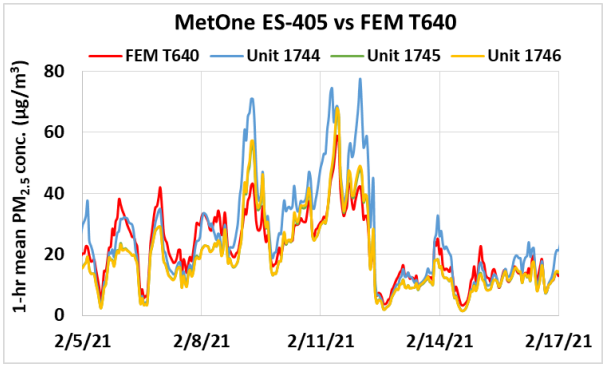
- The accuracy of the MetOne ES-405 sensors for $PM_{2.5}$ was 35.9% to 49.1% and for PM_{10} was 40.9% to 71.8% in the lab. The MetOne ES-405 sensors underestimated $PM_{2.5}$ compared to the T640x in the lab and underestimated PM_{10} compared to the T640x and APS in the lab.
- The MetOne ES-405 sensors exhibited high precision for all conc., T/RH combinations for $PM_{2.5}$. Precision for PM_{10} mass conc. cannot be determined due to the inherent variability of the test dust used.
- The MetOne ES-405 sensors showed low to moderate intra-model variability for $PM_{2.5}$ and moderate intra-model variability for PM_{10} in the lab.
- Data recovery in the field was ~ 100% from the two units tested.
- MetOne ES-405 sensors showed strong to very strong correlations with GRIMM and T640 in the field for both $PM_{1.0}$ (R^2: 0.84-0.91) and $PM_{2.5}$ (0.80-0.92), moderate to very strong correlations with reference instruments in the field for PM_{10} (R^2: 0.78-0.92), and very strong correlations with the reference instruments in the laboratory studies ($R^2 > 0.98$ for $PM_{2.5}$ and PM_{10}).
- All of the same MetOne ES-405 units were tested both in the field (1st stage of testing) and in the laboratory (2nd stage of testing) against reference PM instruments.

Field Evaluation Highlights

- Deployment period 12/24/2020 - 02/24/2021: the three MetOne ES-405 sensors showed strong to very strong correlations with the $PM_{1.0}$ and $PM_{2.5}$ mass concentration as recorded by GRIMM and T640, and moderate to very strong correlations with the corresponding GRIMM, T640, and BAM data for PM_{10}.
- The units showed data recovery was ~100%.

1-hr mean, all ref. inst.
$PM_{1.0}$: $0.84 < R^2 < 0.93$
$PM_{2.5}$: $0.64 < R^2 < 0.93$
PM_{10}: $0.71 < R^2 < 0.96$





Coefficient of Determination (R^2) quantifies how the two sensors followed the $PM_{1.0}$, $PM_{2.5}$, or PM_{10} 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 ($PM_{2.5}$)

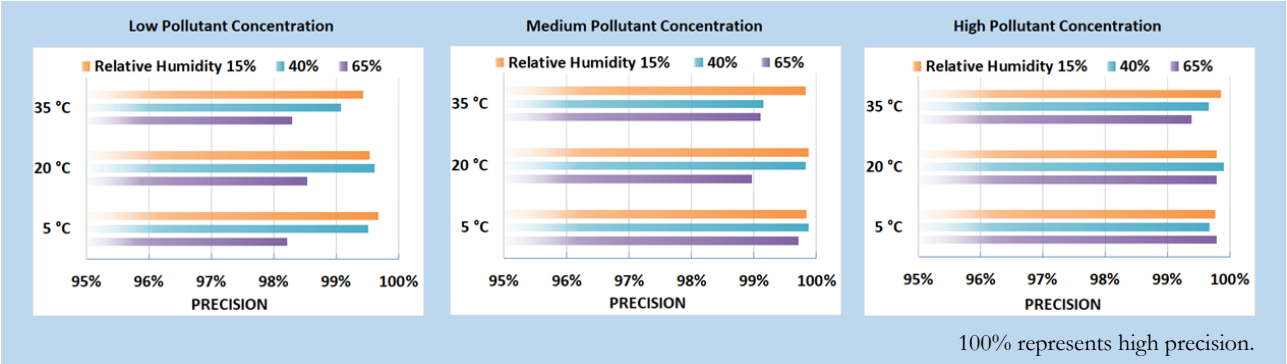
$$A\ (\%) = 100 - \frac{|\bar{X} - \bar{R}|}{\bar{R}} * 100$$

Steady state #	Sensor Mean (µg/m³)	FEM T640x (µg/m³)	Accuracy (%)
1	4.19	9.05	46.3%
2	23.34	47.50	49.1%
3	45.93	97.71	47.0%
4	78.22	196.31	39.8%
5	106.34	296.41	35.9%

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.

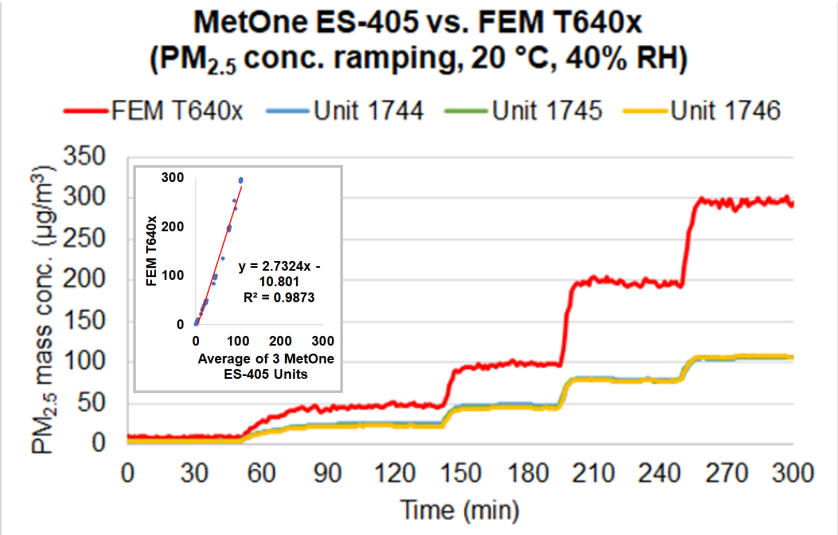
Precision ($PM_{2.5}$)



100% represents high precision.

Sensor's ability to generate precise measurements of $PM_{2.5}$ 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 MetOne ES-405 sensors showed very strong correlations with the corresponding FEM $PM_{2.5}$ data ($R^2 > 0.98$) at 20 °C and 40% RH.

At the time of testing, the reference monitor did not report $PM_{1.0}$. For conc. ramping experiments of PM_{10}, please see the lab report.

Climate Susceptibility

From the laboratory studies, temperature and relative humidity had minimal effect on the MetOne ES-405 sensors' precision.

Observed Interferents

N/A