Laboratory Evaluation
UniTec Sens-IT CO

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South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

Three **Sens-IT** CO sensors that were previously field-tested at the SCAQMD Rubidoux fixed ambient monitoring station (07/01/2015 to 07/31/2015) under ambient weather conditions, have now been evaluated in the SCAQMD Chemistry Laboratory under controlled CO concentration, temperature, and relative humidity.

- Sens-IT (*3 units tested*):
  - Gaseous sensors: Metal-oxide (non-FRM)
  - Unit measures: CO (0.1 – 80 ppm)
  - Unit cost: ~$2200
  - Time resolution: 1-min
  - Units IDs: U197, U247, U245

- SCAQMD FRM instrument:
  - CO (EC 9830T, American Ecotech, Providence, RI)
  - Instrument Cost: ~$7,000
  - Time resolution: 1-min

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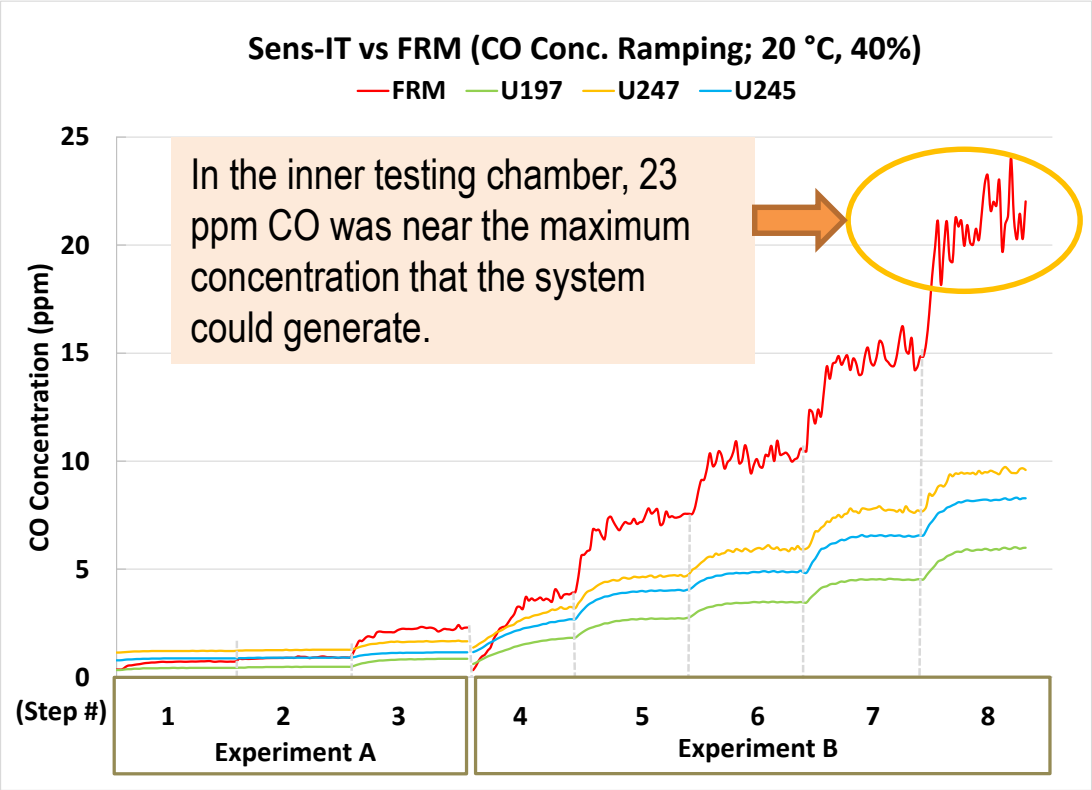
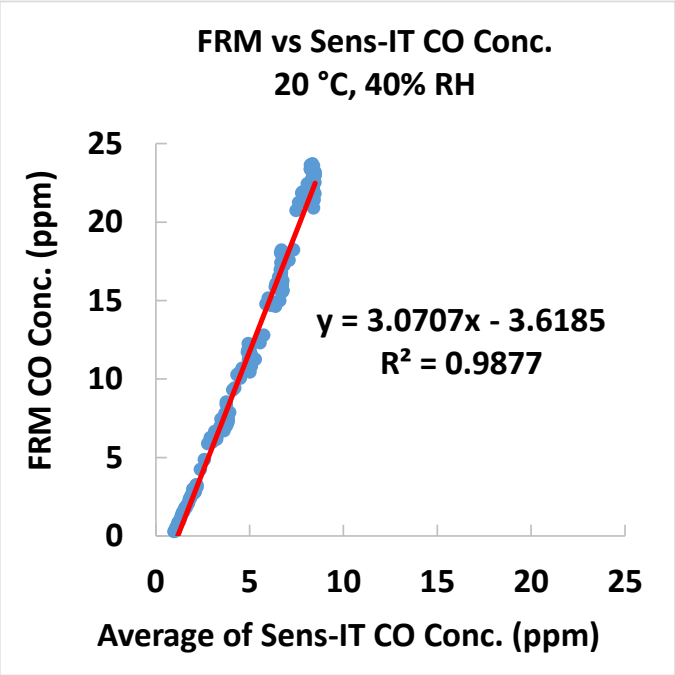
Coefficient of Determination: Sens-IT vs FRM





- At baseline, the FRM instrument measured CO concentration to be 0.34 ppm, whereas the three Sens-IT sensors recorded the 0.37, 1.16, and 0.80 ppm, respectively.
- At low (<1.5 ppm) CO concentrations, the three Sens-IT units did not track the increasing FRM CO concentrations. For the CO concentration ranging from 1.5 to 25 ppm, the three Sens-IT units tracked well with the FRM CO concentration changes ($R^2 > 0.98$).

Sens-IT CO Accuracy

- Accuracy (20 °C and 40% RH)

Steady State (#)	Sensor mean (ppm)	FRM (ppm)	Accuracy (%)
1	1.2	2.4	50.0
2	3.8	7.6	50.0
3	5.1	11.4	44.7
4	6.7	16.7	40.1
5	8.4	23.0	36.5

- For CO concentrations ranging from 0 to 23 ppm, the three Sens-IT units showed low to low to medium accuracy compared to the FRM at 20 °C and 40% RH. Accuracy ranges from 36.5 – 50.0%.

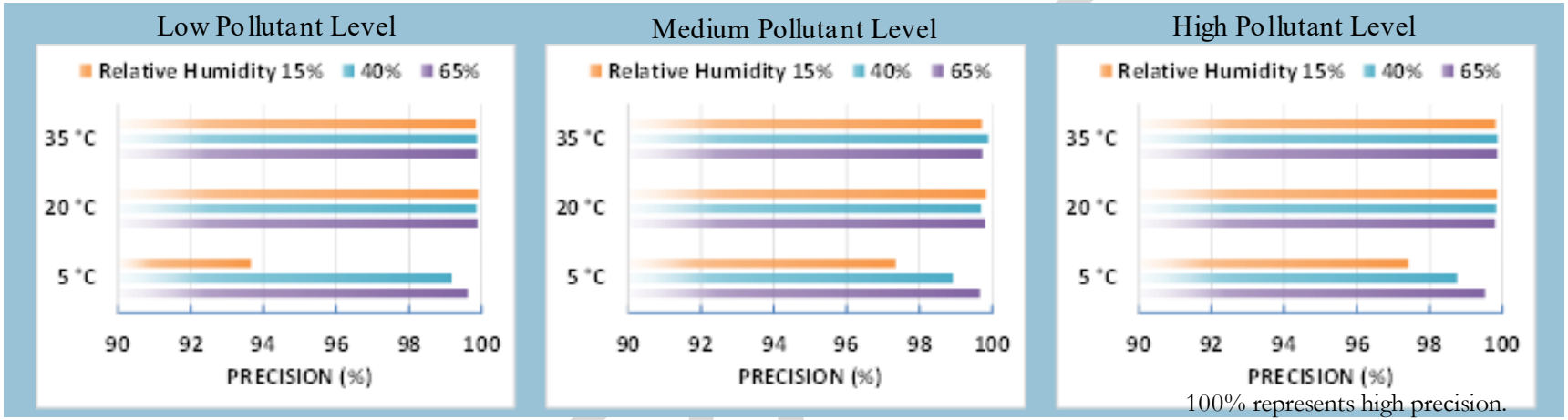
Sens-IT CO Data Recovery & Intra-model Variability

- Data recovery from U197, U247, and U245 was 100% for all units.
- High intra-model variability was observed among the three Sens-IT units at 20 °C and 40% RH at 2, 8, and 16 ppm CO (measured by FRM).

Note: After a closer look at the data, the three sensors correlated each other very well ($R^2 > 0.99$). Despite the high intra-model variability, sensor average is used in calculating evaluation parameters, such as precision, accuracy, coefficient of determination.

Sens-IT Precision

- Precision (Effect of CO conc.,temperature and relative humidity)



- Overall, the Sens-IT CO units showed good precision under most conditions, except for 5 °C and 15%.
- FRM's precision was high across all conditions.

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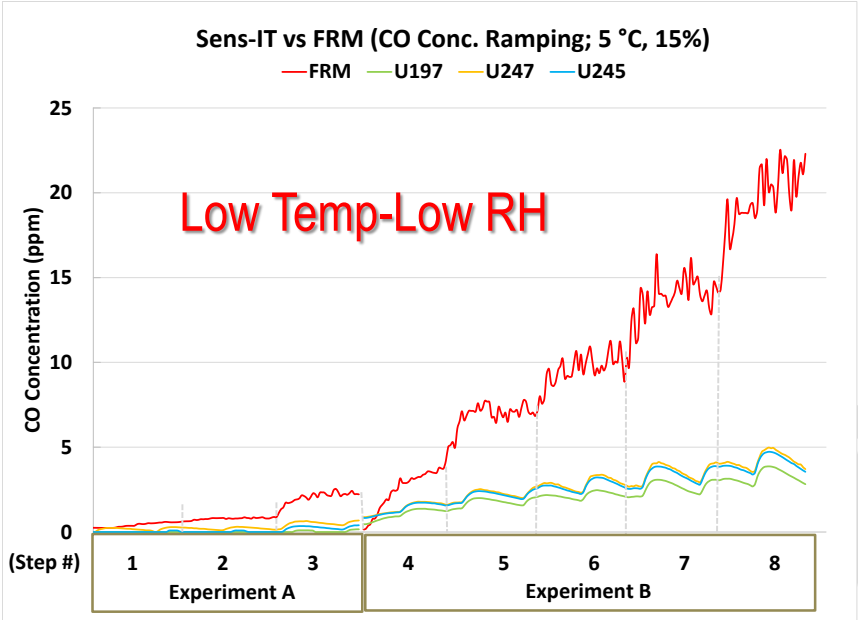
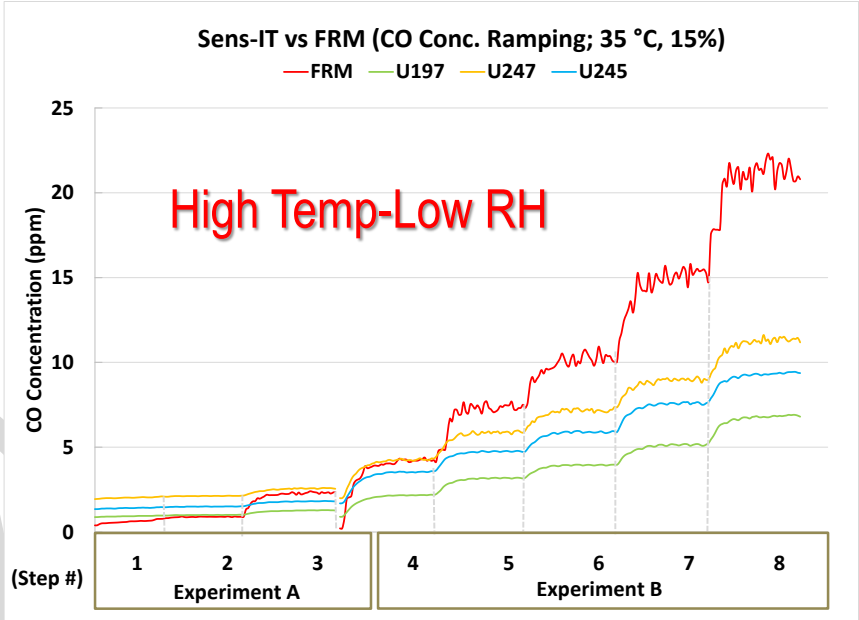
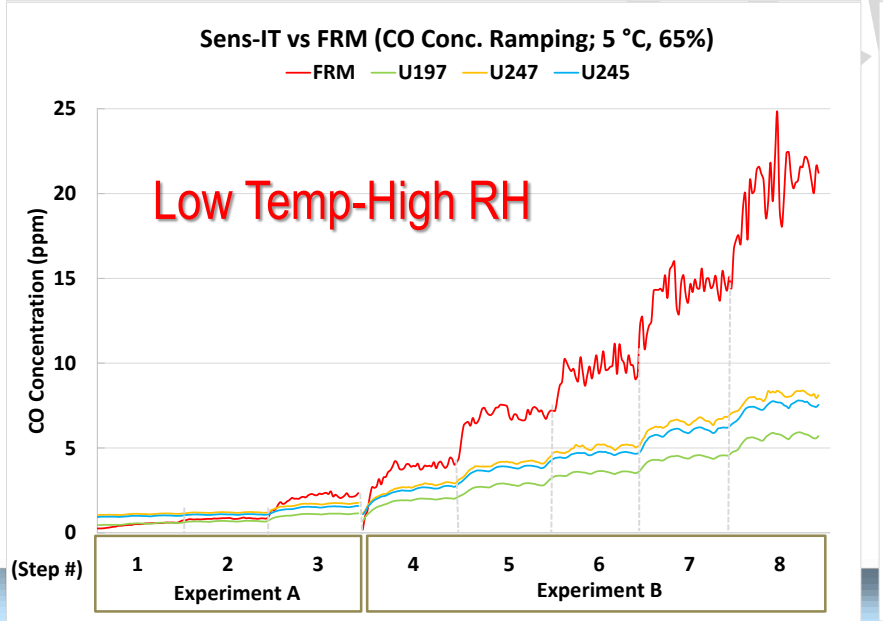
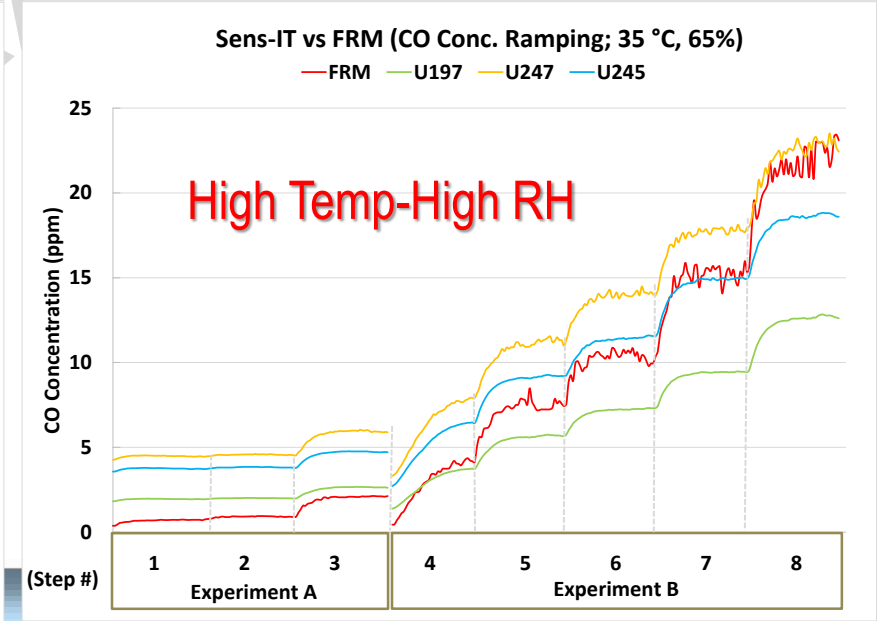
Sens-IT CO Climate Susceptibility









Discussion

- **Accuracy**: For CO concentrations ranging from 0 to 23 ppm, the three Sens-IT sensors showed low accuracy compared to the FRM at 20 °C and 40% RH. Accuracy ranges from 36.5 – 50.0%.(refer to slide 4).
- **Precision**: Overall, the three Sens-IT sensors showed good precision for most combinations of low, medium and high CO conc., T, and RH. At 5 °C and 15% RH, the three units had the lowest precision. (refer to slide 5)
- **Intra-model variability**: High intra-model variability was observed among the three Sens-IT units at 20 °C and 40% RH. (refer to slide 4)
- **Data recovery**: Data recovery from the three SensIT sensors was 100%. (refer to slide 4)
- **Baseline:** The Sens-IT units reported baselines from 0.5 to 5 ppm, depending on the weather conditions. The higher the T and RH, the higher their baselines values were. (refer to slide 6)
- **Linearity of sensor response**: Sens-IT sensors showed good linear correlation with the corresponding FRM CO measurements ($R^2 > 0.98$) at 20 °C and 40% RH. (refer to slide 3)
- **Concentration range**: Manufacturer specifies that Sens-IT CO sensors measure CO concentrations in the range of 0-80 ppm. During the laboratory evaluation, Sens-IT Sensors were challenged with CO concentrations up to 23 ppm. (refer to slide 3)
- **Climate susceptibility**: The three Sens-IT units were sensitive to temperature and relative humidity. Under the same CO concentration, the Sens-IT units measured higher CO values at higher the T and RH. Sens-IT units' baseline values were also affected. The increase in T and RH resulted the baseline values to increase from 0.5 ppm (5 °C, 15%) to 4.5 ppm (35 °C, 65%). (refer to slide 6)

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