AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Laboratory Evaluation Report for

Sensirion SEN66

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Revision History

Version	Date	Note
0	09/03/2026	Original issued report

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The laboratory evaluation was conducted in an AQ-SPEC environmental chamber with simulated pollutant and interferent concentrations that were generated from nebulizer solutions, dust dispensers, and/or gas dilution calibrators. Generated environments may not be able to fully replicate the conditions that may be experienced under ambient settings. The sensor assembly, installation, and use can also impact the reliability of the products evaluated by the AQ-SPEC program.

South Coast AQMD makes no claim, warranty, or guarantee that these devices will or will not work when operated by other users for their specific applications.

South Coast AQMD's AQ-SPEC aims at providing information to and for the benefit of the public to make informed purchasing decisions on air quality sensors. In accordance with this mission, the general policy of the Governing Board of the Agency is to exclude all commercial advertising and promotional material, including links which provide exclusive private or financial benefit to commercial, non-public enterprises and which do not promote or enhance a public benefit to the general public. As a Government Agency, the South Coast AQMD neither endorses nor supports individual private commercial enterprises through testing of products by AQ-SPEC or through providing links to the sites of such commercial enterprises.

Report Role	Name	Date Completed
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Section 1: Background

Three **Sensirion SEN66** sensors (units IDs: 4B48, DE98, F981) were evaluated in an AQ-SPEC environmental chamber under controlled temperatures, humidities, and volatile organic compound (VOC) concentrations.

Note: *The Sensirion SEN66 reports VOC index. For the purpose of estimating error metrics, the VOC index values were converted to ppb values by the manufacturer prior to data analysis.*
Reference in the plots refers to the Thermo 55i reference instrument unless otherwise noted.

Sensirion SEN66

Thermo 55i

Section 2: Manufacturer Specs (VOC)

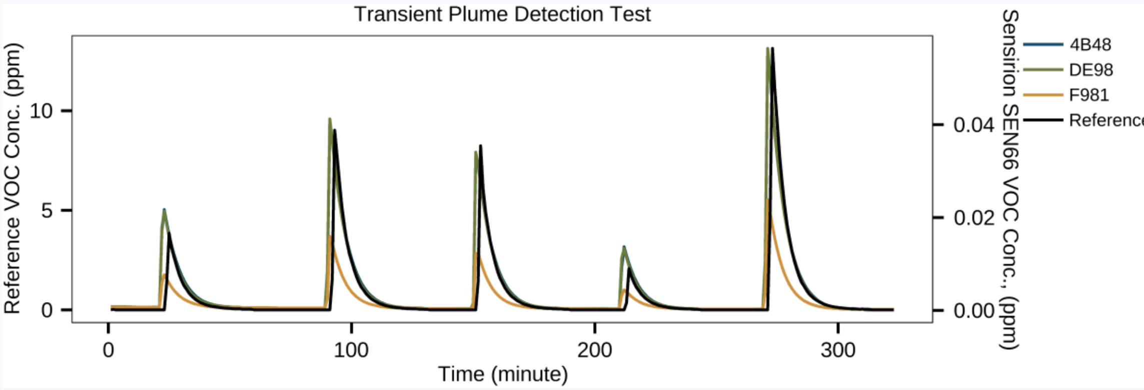
Parameter	Sensor: Sensirion SEN66 (raw sensor is Sensirion SEN66)	Reference Instrument*: Thermo 55i
Pollutant	Total VOC (hereinafter referred to as "VOC")	CH_4 and non-methane hydrocarbons
Cost	$62	~$25,000
Weight	0.04 pounds	50 pounds
Dimensions (LxWxD)	2.15 x 0.95 x 0.83 inches	23 x 16.75 x 8.62 inches
Power	3.6 VDC	115 - 240 VAC
Battery	No	No
Data transmission	Serial/USB to PC via SensorBridge (as-tested)	Ethernet, serial, analog output
Internal memory	No	Yes (>20,000 total records)
Operating temperature range	14 to 122 degrees F	59 to 95 degrees F
Operating RH range	0 to 90%	N/A
Product website	https://sensirion.com/products/catalog/SEN66	https://www.thermofisher.com/order/catalog/product/55I
Operating principle	Metal Oxide	Flame Ionization Detection
Time resolution	1-second	70 seconds
Concentration range	NA (0-500 VOC Index)	0 – 50 ppm

*There is also an Agilent 6890N GC-FID that is used as a supplemental VOC reference instrument; additional results with the GC-FID can be found at the end of the report.

Section 3: VOC

Section 3.1: Transient Plume Detection

Sensirion SEN66 vs Thermo 55i Reference



Interpretation:
- The Sensirion SEN66 sensors responded to 100% of the VOC peaks.
- The Sensirion SEN66 sensors detected the peaks at nearly the same time as the Thermo 55i reference; the apparent difference is due to different sampling times of the sensors vs. the Thermo 55i reference instrument.

Section 3: VOC

Section 3.2: Initial Concentration Ramp

Section 3.2.1: Data Recovery

Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	Unit 4B48	Unit DE98	Unit F981
VOC, low conc. ramp	99.9%	99.9%	99.9%
VOC, high conc. ramp	99.9%	99.9%	99.9%

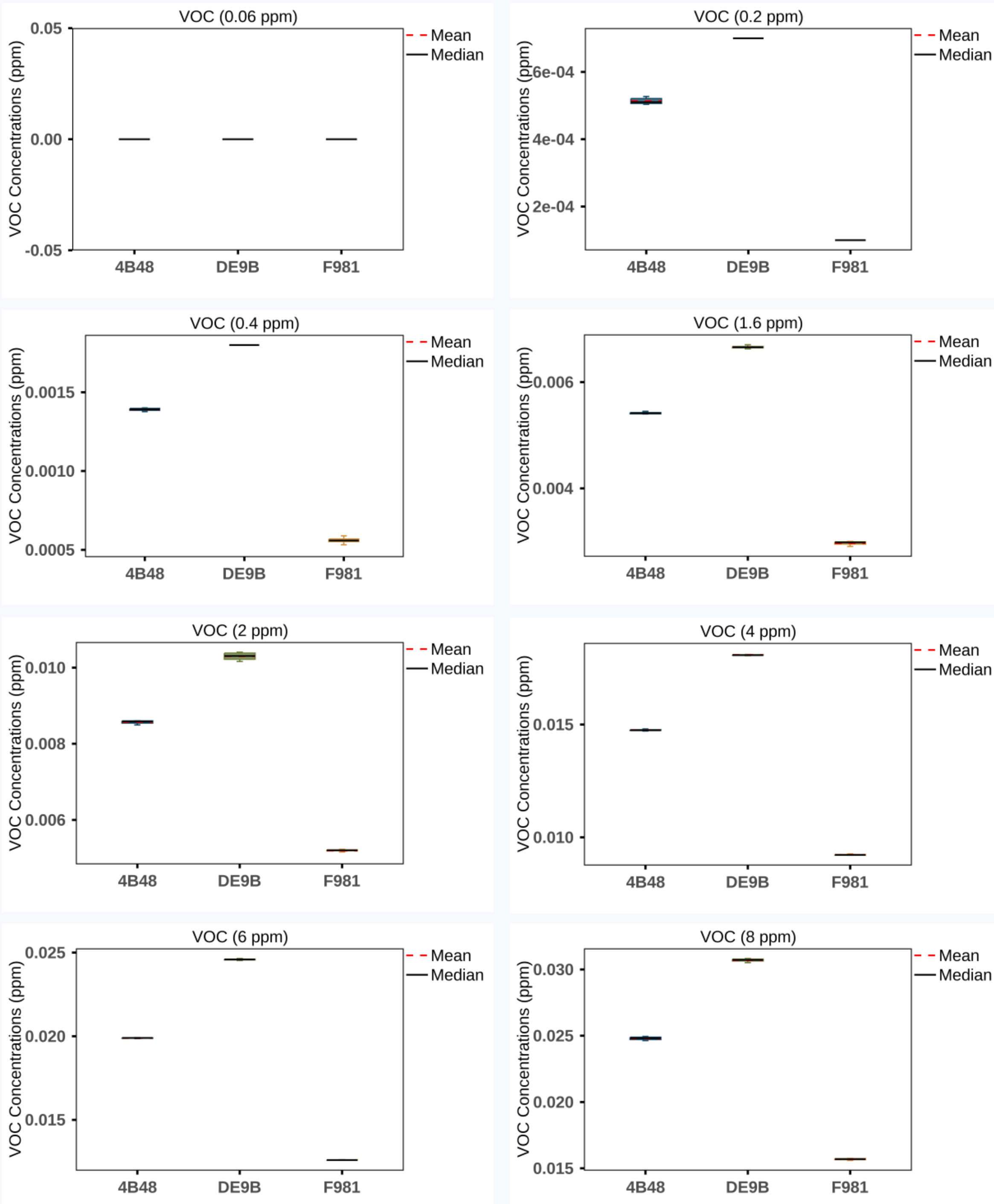
Section 3.2.2: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using 20 measurements from each steady-state period.

Test VOC Concentration (ppm)	Absolute intra-model variability (ppm)	Relative intra-model variability (%)
0.06	0	N/A
0.20	0.0003	70.14
0.40	0.0006	50.58
1.60	0.0019	37.42
2.00	0.0026	32.40
4.00	0.0045	31.93
6.00	0.0060	31.76
8.00	0.0076	31.86

Section 3: VOC

Section 3.2.2: Intra-Model Variability – Box Plots



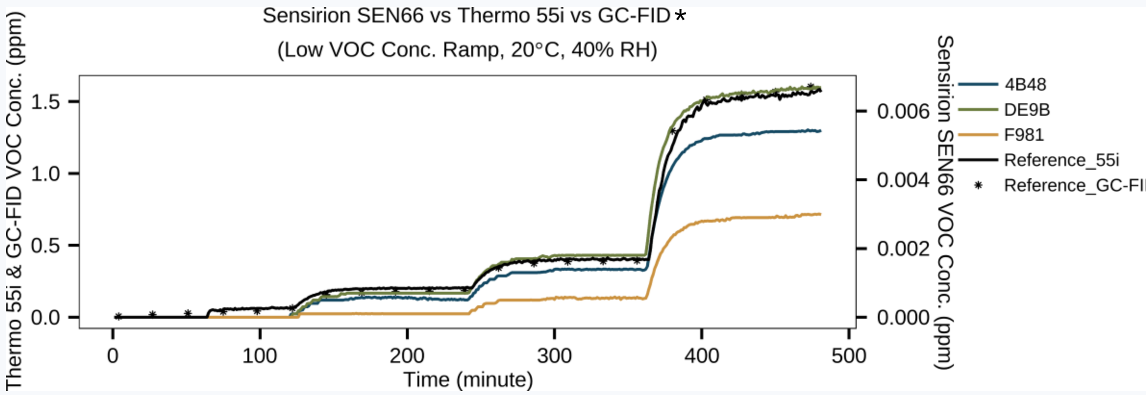
Section 3: VOC

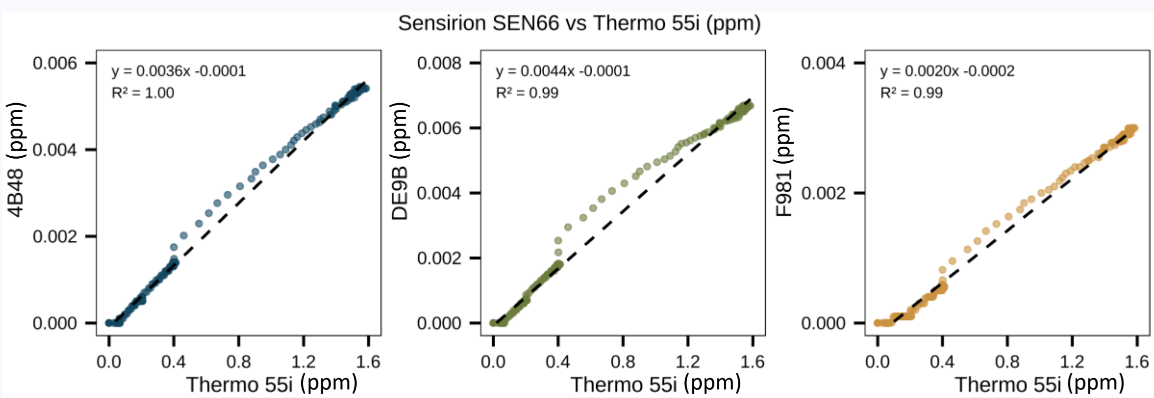
Section 3.2.3: Linearity (R^2) – Low Conc. Ramp

Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, readings flagged by the sensor, and invalid data points were eliminated from the data-set.

A summary of the mean R^2 between the sensor and reference instruments across all units tested.

Parameter	Time Resolution	Sensirion SEN66 (mean ± SD)
VOC, low conc. ramp	1-minute	0.99 ± 0.006





Interpretation:

- The Sensirion SEN66 sensors showed very strong correlation with the corresponding Thermo 55i reference instrument ($R^2 \geq 0.99$) for a VOC mixture containing equal concentrations of 1,3 butadiene, benzene, ethane and tetrachloroethylene, from 0.06 to 1.6 ppm (low concentration ramp), at 20°C and 40% RH.

*There is also an Agilent 6890N GC-FID that is used as a supplemental VOC reference instrument; additional results with the GC-FID can be found at the end of the report.

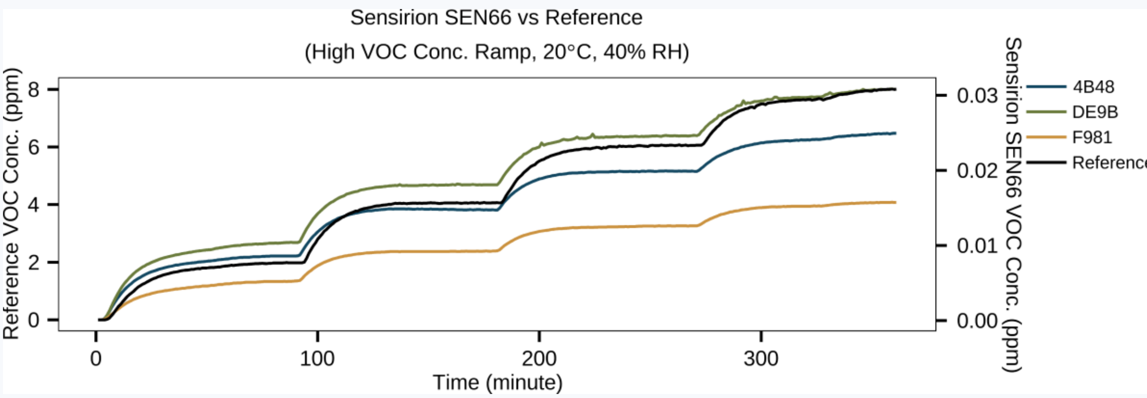
Section 3: VOC

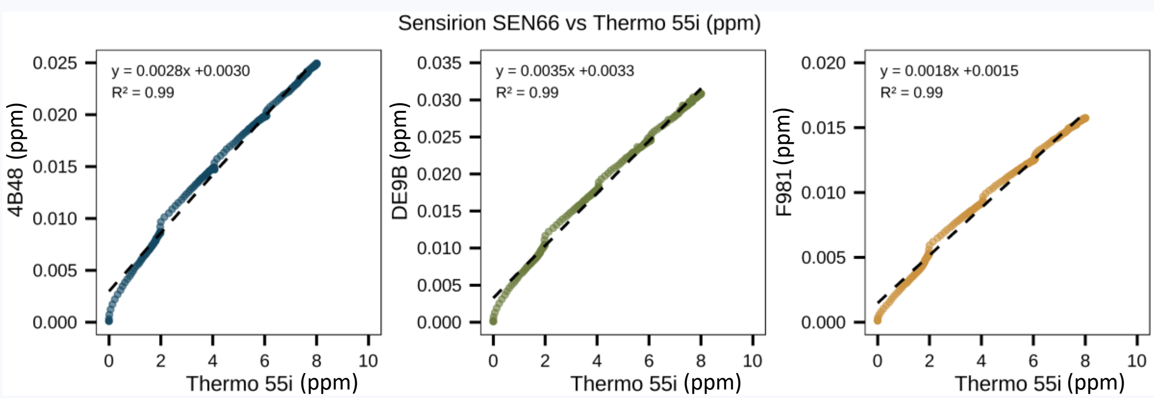
Section 3.2.3: Linearity (R^2) – High Conc. Ramp

Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, readings flagged by the sensor, and invalid data points were eliminated from the data-set.

A summary of the mean R^2 between the sensor and reference instruments across all units tested.

Parameter	Time Resolution	Sensirion SEN66 (mean ± SD)
VOC, high conc. ramp	1-minute	0.99 ± 0.00





Interpretation:

- The Sensirion SEN66 sensors showed very strong correlations with the corresponding Thermo 55i reference instrument (R^2 = 0.99) for a VOC mixture containing equal concentrations of 1,3 butadiene, benzene, ethane and tetrachloroethylene, from 2 to 8 ppm (high concentration ramp), at 20°C, 40% RH.

Section 3: VOC

Section 3.3: Effect of Temperature and Humidity

Section 3.3.1: Normal and Extreme Conditions

Section 3.3.1.1: Data Recovery

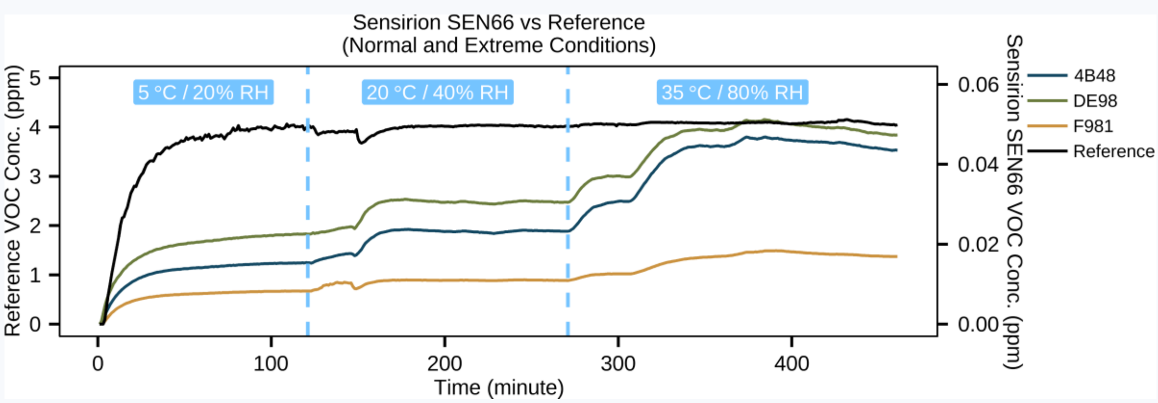
Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	Unit 4B48	Unit DE98	Unit F981
VOC	99.9%	99.9%	99.9%

Section 3.3.1.2: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using 20 measurements from each steady-state period.

Condition	T (°C)	RH (%)	Absolute intra-model variability (ppm)	Relative intra-model variability (%)
Cold/dry	5	20	0.0071	46.23
Baseline	20	40	0.0099	45.85
Hot/humid	35	80	0.0167	46.18



Interpretation:

- The Sensirion SEN66 sensors' VOC readings increased from cold/dry condition to hot/humid condition.

Section 3: VOC

Section 3.3.2: RH interference

Section 3.3.2.1: Data Recovery

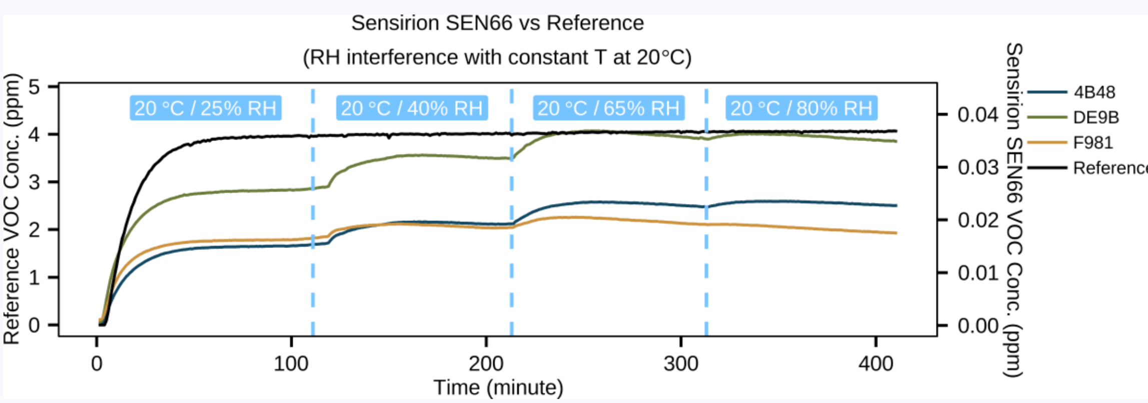
Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	Unit 4B48	Unit DE98	Unit F981
VOC	99.9%	99.9%	99.9%

Section 3.3.2.2: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using 20 measurements from each steady-state period.

RH (%) (T constant at 20° C)	Absolute intra-model variability (ppm)	Relative intra-model variability (%)
25	0.0058	30.47
40	0.0074	32.08
65	0.0086	33.34
80	0.0090	35.50



Interpretation:

- The Sensirion SEN66 sensors' VOC readings increased as RH increased from 25% to 80% at constant temperature at 20° C, except for Unit F981's VOC readings which decreased at RH above 40%.

Section 3: VOC

Section 3.3.3: T interference at constant RH

Section 3.3.3.1: Data Recovery

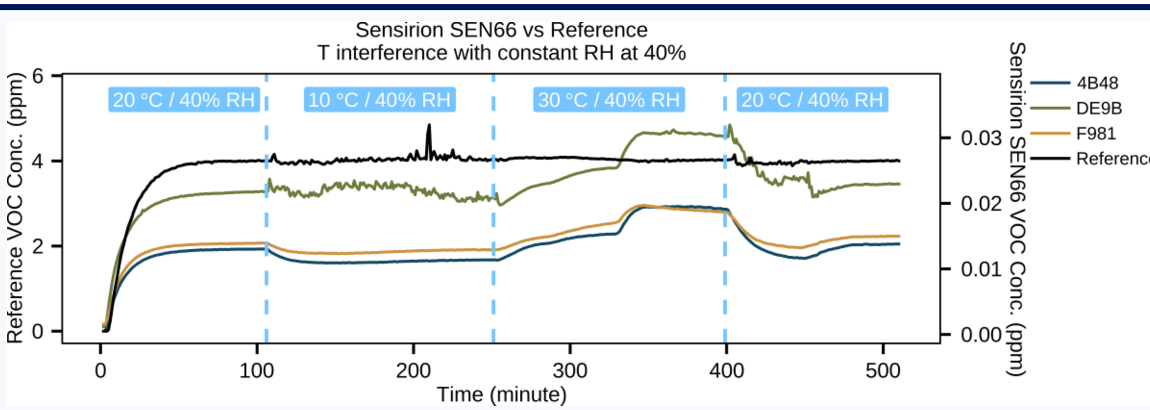
Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	Unit 4B48	Unit DE98	Unit F981
VOC	99.9%	99.9%	99.9%

Section 3.3.3.2: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using 20 measurements from each steady-state period.

T (°C) (RH constant at 40%)	Absolute intra-model variability (ppm)	Relative intra-model variability (%)
20	0.0048	29.56
10	0.0050	33.47
30	0.0066	28.80
20	0.0050	28.91



Interpretation:

- The Sensirion SEN66 sensors' VOC readings seemed to change in the same direction as temperature, i.e. the sensors' VOC reading increased as temperature increased and vice versa.

Section 3: VOC

Section 3.3.4: T interference at constant absolute humidity (AH)

Section 3.3.4.1: Data Recovery

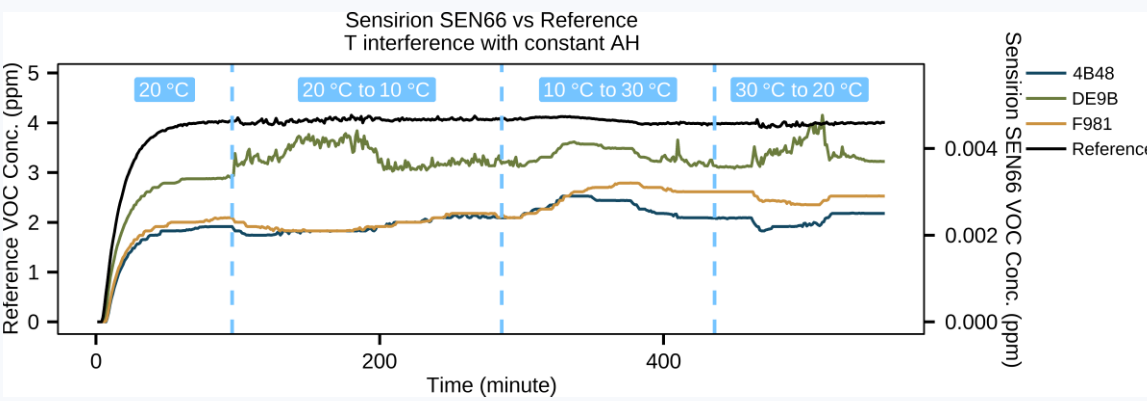
Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	Unit 4B48	Unit DE98	Unit F981
VOC	99.9%	99.9%	99.9%

Section 3.3.4.2: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using 20 measurements from each steady-state period.

T (°C) (AH constant at 0.007 kg/m³)	Absolute intra-model variability (ppm)	Relative intra-model variability (%)
20	0.0006	22.83
10	0.0007	25.15
30	0.0006	20.76
20	0.0006	20.47



Interpretation:

- It is unclear from this test what was the impact of T at constant AH on the VOC readings reported by the Sensirion SEN66 sensors.

Section 3: VOC

Section 3.4: Effect of Gaseous Interferents

Section 3.4.1: Ozone Interference

Section 3.4.1.1: Data Recovery

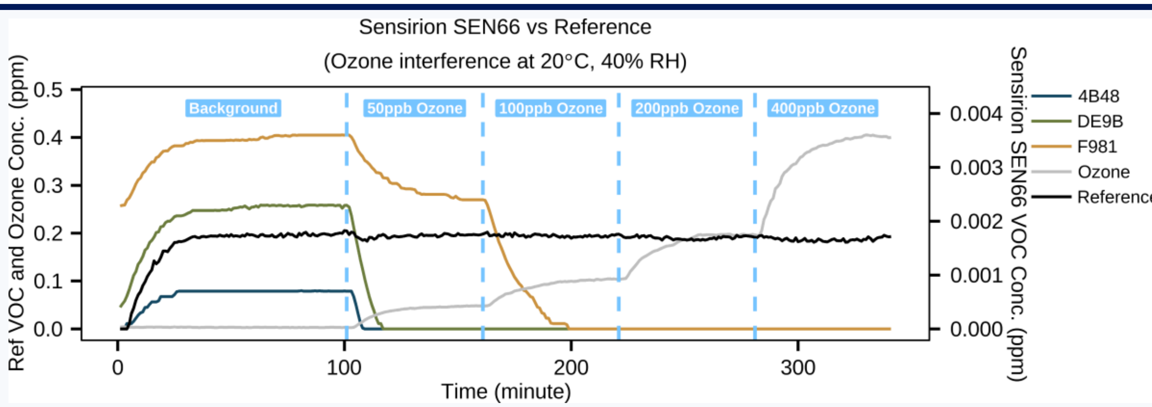
Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	Unit 4B48	Unit DE98	Unit F981
VOC	99.9%	99.9%	99.9%

Section 3.4.1.2: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using 20 measurements from each steady-state period.

O_3 (ppb) (At constant 0.2 ppm of VOC)	Absolute intra-model variability (ppm)	Relative intra-model variability (%)
background	0.0015	66.01
50	0.0014	173.21
100	0	NA
200	0	NA
400	0	NA



Interpretation:

- The Sensirion SEN66 sensors' VOC readings measured were very sensitive to any O_3 concentrations; the sensors' VOC readings decreased to ~ 0 when O_3 was introduced, except for Unit F981, which VOC readings decreased to 0 after 100ppb ozone is introduced.

Section 3: VOC

Section 3.4.2: CO Interference

Section 3.4.2.1: Data Recovery

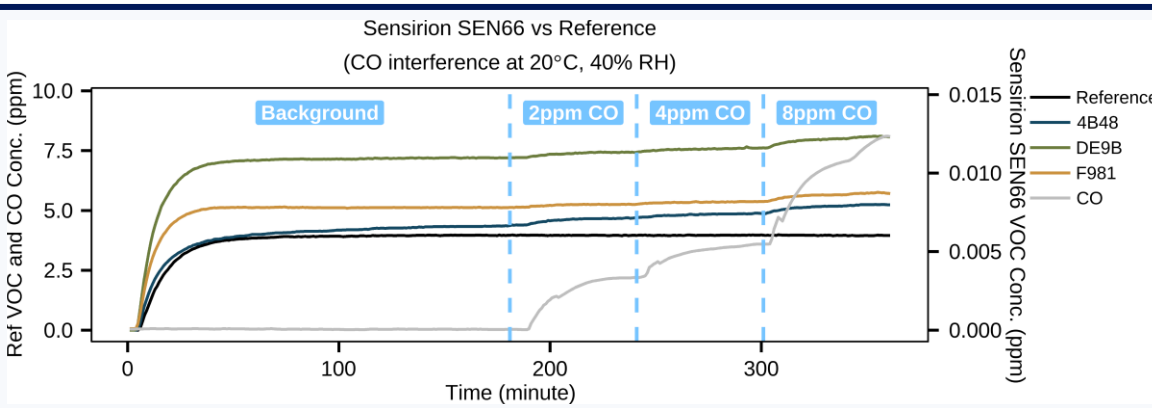
Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	Unit 4B48	Unit DE98	Unit F981
VOC	99.9%	99.9%	99.9%

Section 3.4.2.2: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using 20 measurements from each steady-state period.

CO (ppm) (At constant 4 ppm of VOC)	Absolute intra-model variability (ppm)	Relative intra-model variability (%)
background	0.0023	26.59
2	0.0022	25.15
4	0.0022	24.51
8	0.0023	23.92



Interpretation:

- The Sensirion SEN66 sensors' VOC readings increased slightly as CO concentrations increased from background level to 8ppm.

Section 3: VOC

Section 3.4.3: CO_2 Interference

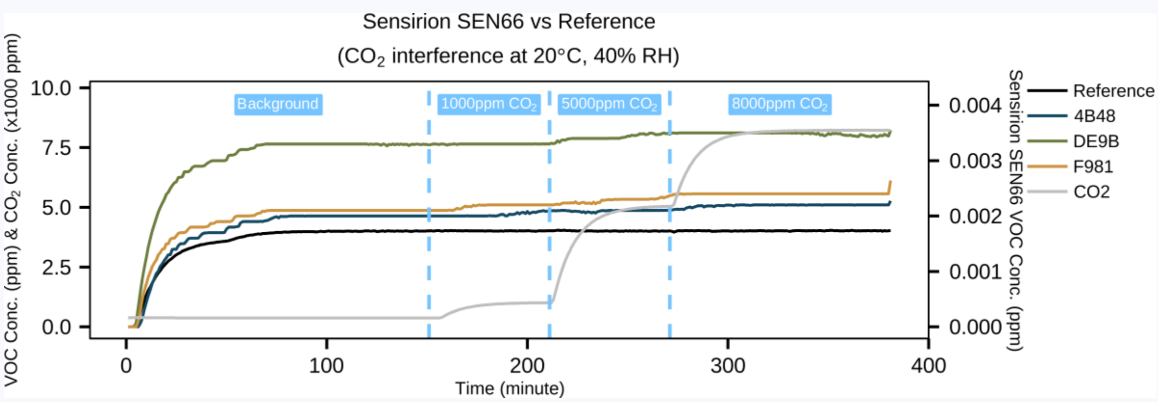
Section 3.4.3.1: Data Recovery

Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	Unit 4B48	Unit DE98	Unit F981
VOC	99.9%	99.9%	99.9%

Section 3.4.3.2: Intra-Model Variability

CO_2 (ppm) (At constant 4 ppm of VOC)	Absolute intra-model variability (ppm)	Relative intra-model variability (%)
background	0.0007	29.18
1000	0.0007	26.91
5000	0.0007	28.17
8000	0.0007	25.94



Interpretation:

- The Sensirion SEN66 sensors' VOC readings increased slightly as CO_2 concentrations increased from background level to 8000ppm.

Section 3: VOC

Section 3.5: Outdoor Simulation

Section 3.5.1: Data Recovery

Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

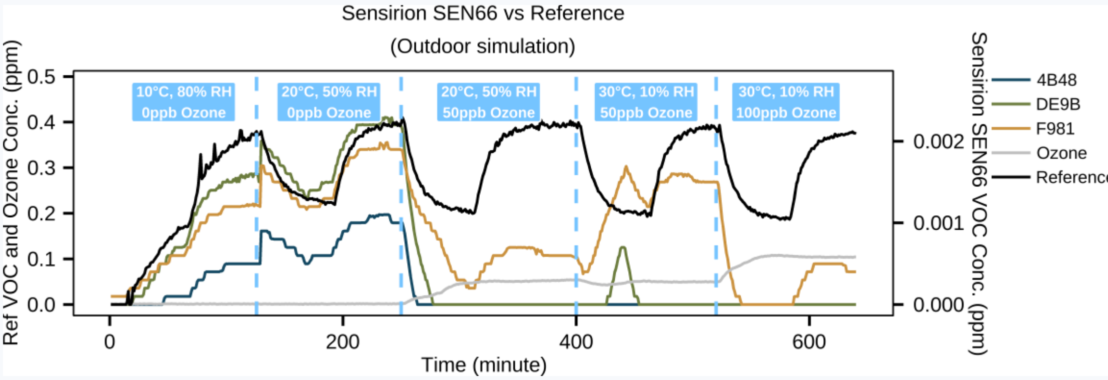
Parameter	Unit 4B48	Unit DE98	Unit F981
VOC	99.9%	99.9%	99.9%

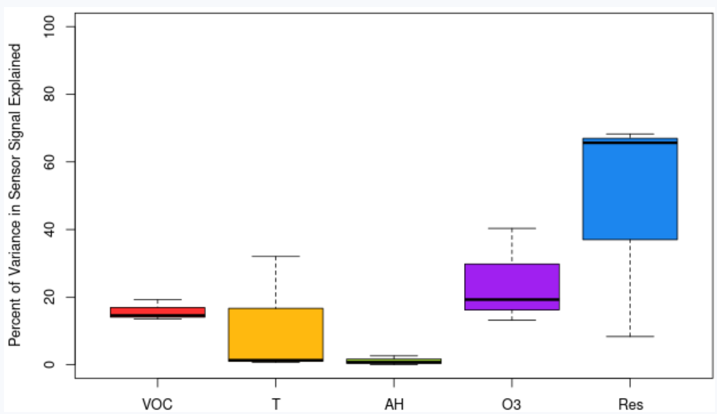
Section 3.5.2: Intra-Model Variability

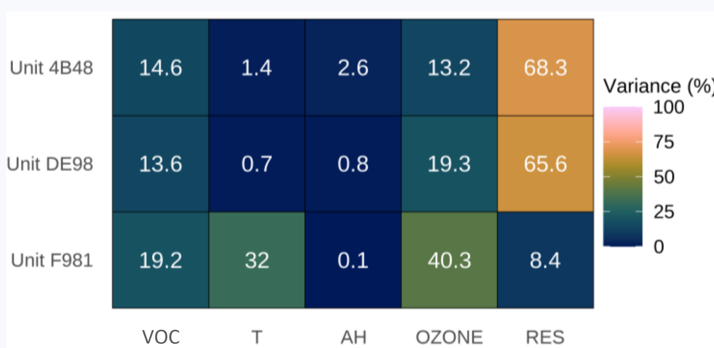
Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using 20 measurements from each steady-state period.

Step	VOC (ppm)	T (°C)	RH (%)	O_3 (ppb)	Absolute intra-model variability (ppm)	Relative intra-model variability (%)
1	0.2	10	80	0	0.0003	68.27
2	0.4	10	80	0	0.0005	49.62
3	0.2	20	50	0	0.0004	40.98
4	0.4	20	50	0	0.0006	35.25
5	0.2	20	50	50	0.0002	173.21
6	0.4	20	50	50	0.0003	173.21
7	0.2	30	10	50	0.0008	135.77
8	0.4	30	10	50	0.0009	173.21
9	0.2	30	10	100	0.0000	NA
10	0.4	30	10	100	0.0003	173.21

Section 3.5.3: ANOVA Statistical Test







Interpretation:

- **Ozone** explained ~ 13-40% of the Sensirion SEN66 sensors' VOC readings, followed by **VOC** (~ 14-19%), while **Temperature** (except for Unit F981), explained a small percentage (~0-2%) of the variance.

Notes:

- "VOC" is the Thermo 55i reference VOC monitor reading
- "AH" is the absolute humidity and is used instead of RH in ANOVA due to multicollinearity between RH and T
- "RES" is the residual, or variance that is not explained by the other variables

Section 3: VOC

Section 3.6: Final Concentration Ramp

Section 3.6.1: Data Recovery

Basic QA/QC procedures such as removal of duplicate records was performed. Nulls, negatives, out of instrument bounds as specified by the manufacturer, and values flagged as invalid by the sensor were considered invalid. Data recovery was calculated as the percent of valid readings through the entire evaluation.

Parameter	Unit 4B48	Unit DE98	Unit F981
VOC, low conc. ramp	99.9%	99.9%	99.9%
VOC, high conc. ramp	99.9%	99.9%	99.9%

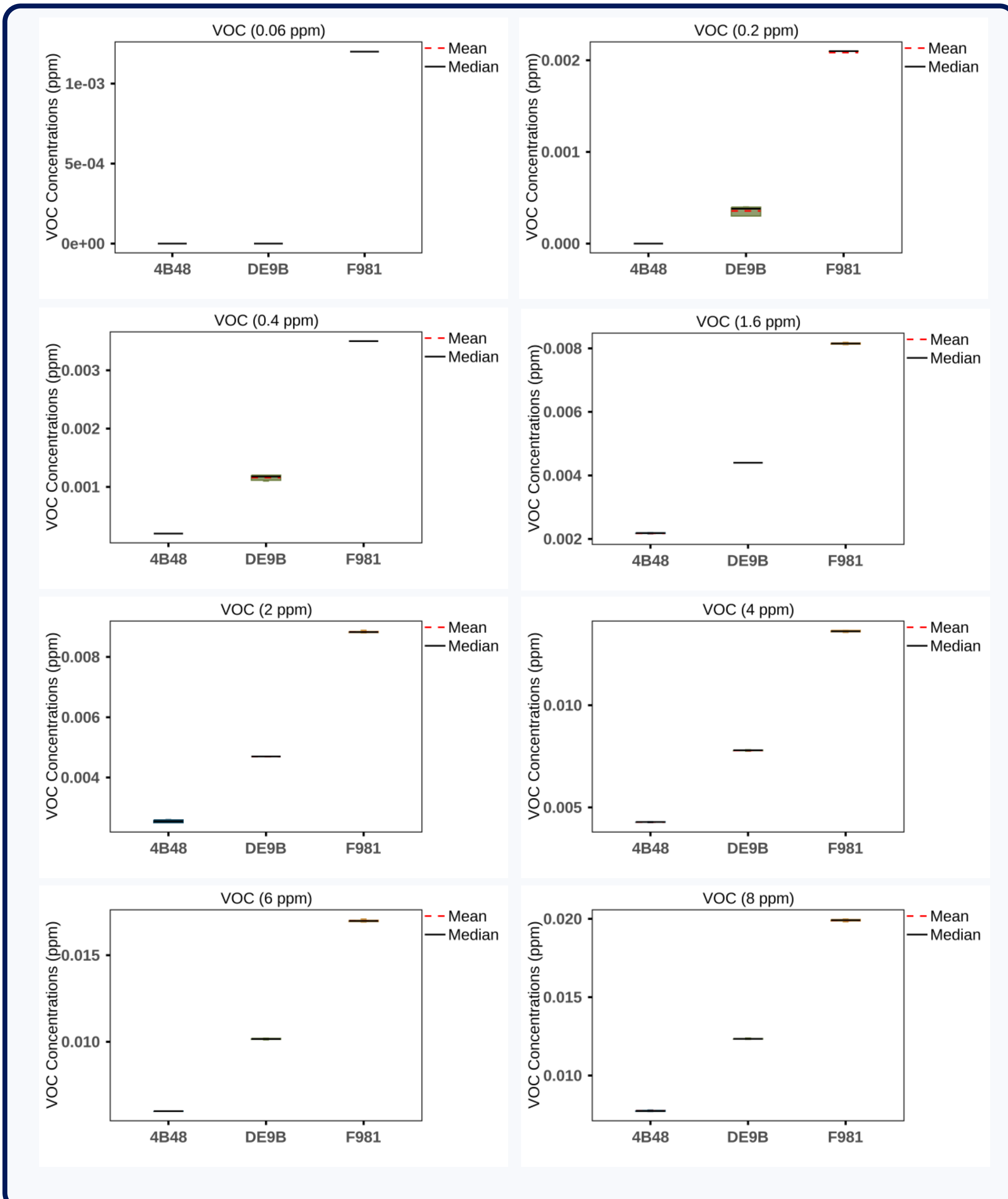
Section 3.6.2: Intra-Model Variability

Absolute intra-model variability was calculated as the standard deviation of the mean values of the sensors. Relative intra-model variability was calculated as the absolute intra-model variability divided by the sensor grand mean. Calculations were performed using 20 measurements from each steady-state period.

Test VOC Concentration (ppm)	Absolute intra-model variability (ppm)	Relative intra-model variability (%)
0.06	0.0007	173.21
0.2	0.0011	137.03
0.4	0.0017	104.77
1.6	0.0030	61.48
2	0.0032	59.59
4	0.0047	55.11
6	0.0055	50.20
8	0.0061	46.09

Section 3: VOC

Section 3.6.2: Intra-Model Variability – Box Plots



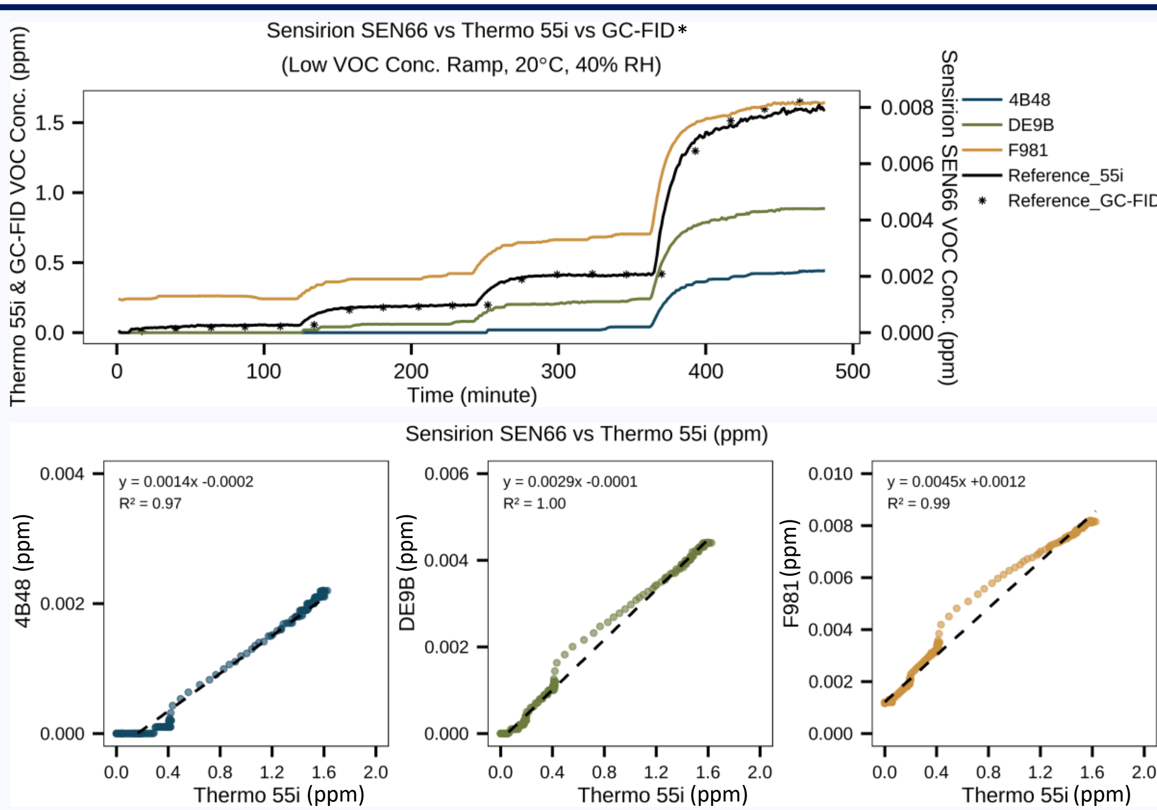
Section 3: VOC

Section 3.6.3: Linearity (R^2) – Low Conc. Ramp

Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, readings flagged by the sensor, and invalid data points were eliminated from the data-set.

A summary of the mean R^2 between the sensor and reference instruments across all units tested.

Parameter	Time Resolution	Sensirion SEN66 (mean ± SD)
VOC, low conc. ramp	1-minute	0.99 ± 0.015



Interpretation:

- The Sensirion SEN66 sensors showed very strong correlation with the corresponding Thermo 55i reference instrument ($0.97 < R^2 < 1.00$), for a VOC mixture containing equal concentrations of 1,3 butadiene, benzene, ethane and tetrachloroethylene, from 0.06 to 1.6 ppm (low concentration ramp), at 20°C and 40% RH.

*There is also an Agilent 6890N GC-FID that is used as a supplemental VOC reference instrument; additional results with the GC-FID can be found at the end of the report.

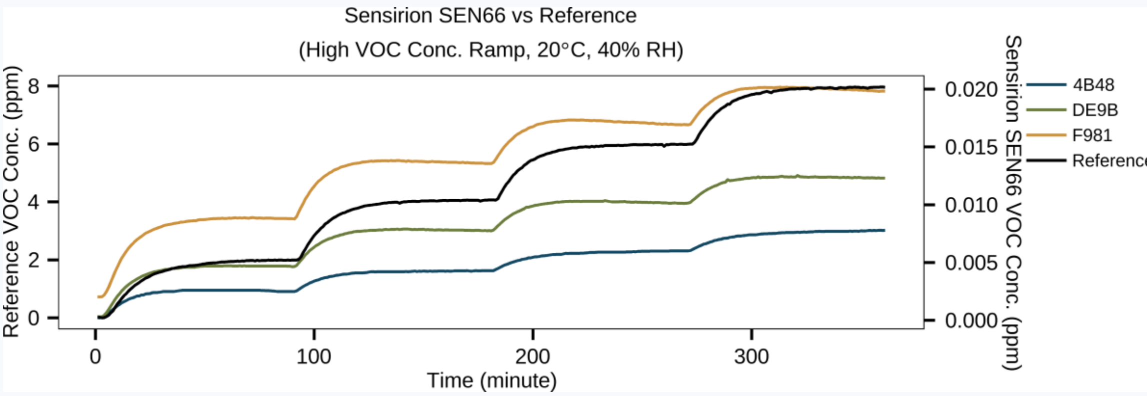
Section 3: VOC

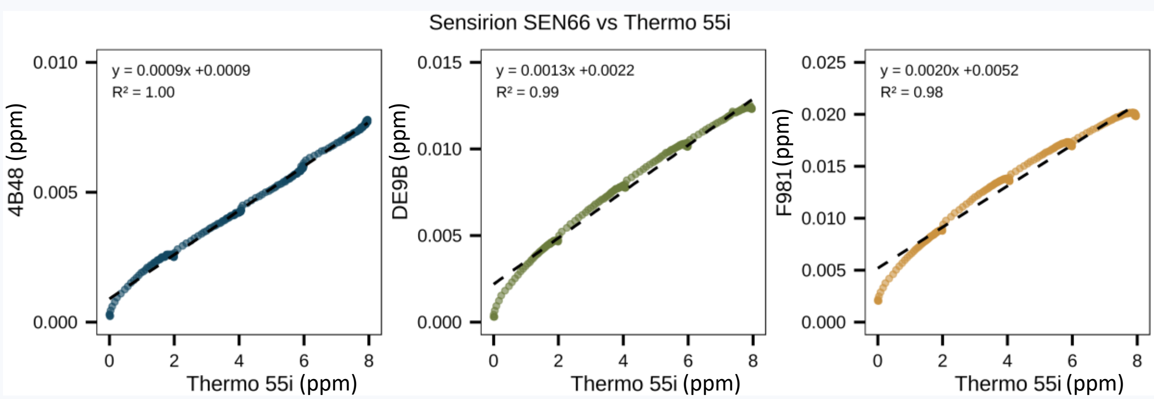
Section 3.6.3: Linearity (R^2) – High Conc. Ramp

Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, readings flagged by the sensor, and invalid data points were eliminated from the data-set.

A summary of the mean R^2 between the sensor and reference instruments across all units tested.

Parameter	Time Resolution	Sensirion SEN66 (mean ± SD)
VOC, high conc. ramp	1-minute	0.99 ± 0.01





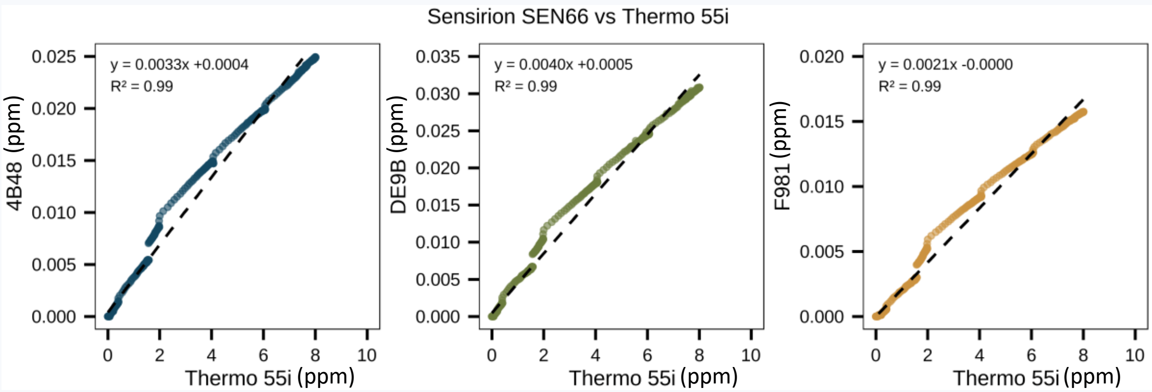
Interpretation:

- The Sensirion SEN66 sensors showed very strong correlations with the corresponding Thermo 55i reference instrument ($0.98 < R^2 < 1.00$) for a VOC mixture containing equal concentrations of 1,3 butadiene, benzene, ethane and tetrachloroethylene, from 2 to 8 ppm (high concentration ramp), at 20°C, 40% RH.

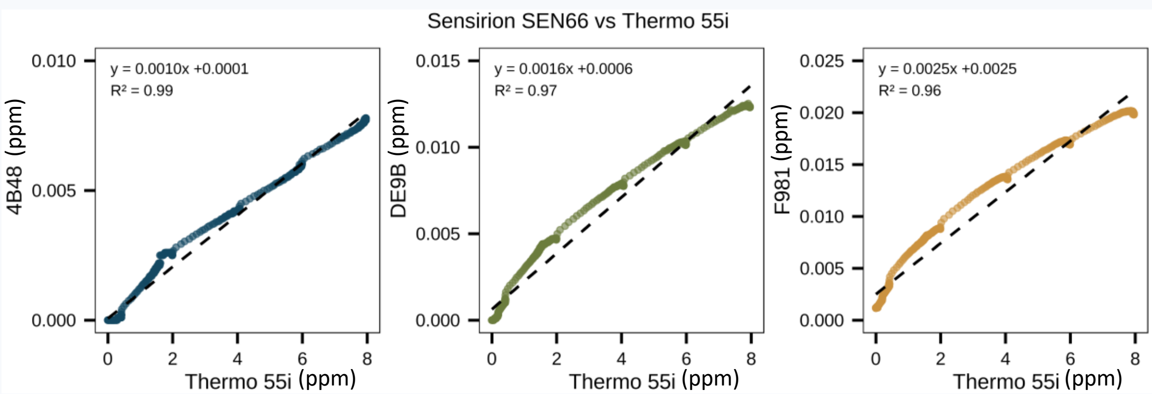
Section 3: VOC

Section 3.6.4: Short-Term Sensor Response Change

Initial Concentration Ramp



Final Concentration Ramp



Interpretation:

- Short-term sensor response change is characterized as the change in reference-sensor regression between the initial and final concentration ramping experiments
- Combining data from both low and high concentration ramps of the VOC blend, the slope of the final concentration ramp was lower (except for unit F981), suggesting that the Sensirion SEN66 sensors on average became less sensitive to unit changes in VOC concentrations compared to the initial concentration ramp.

Section 4: Summary Metrics

		Initial VOC Concentration Ramp							
		0.06 ppm VOC	0.2 ppm VOC	0.4 ppm VOC	1.6 ppm VOC	2 ppm VOC	4 ppm VOC	6 ppm VOC	8 ppm VOC
Sensirion SEN66	**Average***	0	0.0004	0.0012	0.0050	0.0080	0.0140	0.0190	0.0237
	SD*	0	0	0	0	0.0001	0	0	0.0001
	CV (RSD, %)	N/A	0.54	1.20	0.56	0.67	0.17	0.09	0.35
	Absolute IMV*	0	0.0003	0.0006	0.0019	0.0026	0.0045	0.0060	0.0076
	Relative IMV (%)	N/A	70.14	50.58	37.42	32.40	31.93	31.76	31.86
Thermo 55i	**Average***	0.06	0.20	0.40	1.56	1.97	4.06	6.06	7.96
	SD*	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.04
	CV (RSD, %)	3.88	0.84	0.73	0.76	0.67	0.17	0.12	0.51
Sensirion SEN66 vs Thermo 55i	**Pearson R^2**	0.99 to 1.00				0.99			
	Slope	0.0020 to 0.0044				0.0018 to 0.0035			
	Intercept*	-0.0002 to -0.0001				0.0015 to 0.0033			
	MBE*	-0.063	-0.203 to -0.202	-0.403 to -0.401	-1.556 to -1.553	-1.962 to -1.956	-4.049 to -4.040	-6.043 to -6.031	-7.942 to -7.927
	$nMBE_{mean}$	-1	-1 to -0.997	-0.999 to -0.996	-0.998 to -0.996	-0.997 to -0.995	-0.998 to -0.996	-0.998 to -0.996	-0.998 to -0.996
	MAE*	0.063	0.202 to 0.203	0.401 to 0.403	1.553 to 1.556	1.956 to 1.962	4.040 to 4.049	6.031 to 6.043	7.927 to 7.942
	$nMAE_{mean}$	1	0.997 to 1	0.996 to 0.999	0.996 to 0.998	0.995 to 0.997	0.996 to 0.998	0.996 to 0.998	0.996 to 0.998
	RMSE*	0.063	0.202 to 0.203	0.401 to 0.403	1.553 to 1.557	1.956 to 1.962	4.040 to 4.049	6.031 to 6.043	7.927 to 7.942
	$nRMSE_{mean}$	1.001	0.997 to 1	0.996 to 0.999	0.996 to 0.998	0.995 to 0.997	0.996 to 0.998	0.996 to 0.998	0.996 to 0.998

*Units in ppm

Section 4: Summary Metrics

		Final VOC Concentration Ramp							
		0.06 ppm VOC	0.2 ppm VOC	0.4 ppm VOC	1.6 ppm VOC	2 ppm VOC	4 ppm VOC	6 ppm VOC	8 ppm VOC
Sensirion SEN66	Average*	0.0004	0.0008	0.0016	0.0049	0.0054	0.0086	0.0110	0.0133
	SD*	0	0	0	0	0	0	0	0.0001
	CV (RSD, %)	0.06	6.96	1.20	0.45	0.76	0.29	0.25	0.30
	Absolute IMV*	0.0007	0.0011	0.0017	0.0030	0.0032	0.0047	0.0055	0.0061
	Relative IMV (%)	173.21	137.03	104.77	61.48	59.59	55.11	50.20	46.09
Thermo 55i	Average*	0.05	0.20	0.41	1.59	1.98	4.05	5.98	7.95
	SD*	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01
	CV (RSD, %)	2.79	0.89	0.64	0.73	0.39	0.20	0.27	0.15
Sensirion SEN66 vs Thermo 55i	Pearson R^2	0.97 to 1.00				0.98 to 1.00			
	Slope	0.0014 to 0.0045				0.0009 to 0.0020			
	Intercept*	-0.0001 to 0.0012				0.0009 to 0.0052			
	MBE*	-0.054 to -0.053	-0.196 to -0.194	-0.414 to -0.411	-1.592 to -1.586	-1.980 to -1.974	-4.048 to -4.039	-5.970 to -5.959	-7.942 to -7.930
	$nMBE_{mean}$	-1 to -0.98	-1 to -0.989	-1 to -0.992	-0.999 to -0.995	-0.999 to -0.996	-0.999 to -0.997	-0.999 to -0.997	-0.999 to -0.998
	MAE*	0.053 to 0.054	0.194 to 0.196	0.411 to 0.414	1.586 to 1.592	1.974 to 1.980	4.039 to 4.048	5.959 to 5.970	7.930 to 7.942
	$nMAE_{mean}$	0.98 to 1	0.989 to 1	0.992 to 1	0.995 to 0.999	0.996 to 0.999	0.997 to 0.999	0.997 to 0.999	0.998 to 0.999
	RMSE*	0.053 to 0.054	0.194 to 0.196	0.411 to 0.414	1.586 to 1.592	1.974 to 1.980	4.039 to 4.048	5.959 to 5.970	7.930 to 7.942
	$nRMSE_{mean}$	0.98 to 1	0.989 to 1	0.992 to 1	0.995 to 0.999	0.996 to 0.999	0.997 to 0.999	0.997 to 0.999	0.998 to 0.999

*Units in ppm

Summary Metrics Guide

Average:	mean of individual sensor means at a given steady-state concentration; the grand mean
SD:	mean of individual sensor standard deviations (σ; measure of variation of the values about its mean) at a given steady-state concentration
CV (RSD):	mean of individual sensor coefficient of variations (relative standard deviation; the ratio of the standard deviation to the mean, expressed as a percentage) at a given steady-state concentration
Absolute IMV	intra-model variability expressed in absolute terms; standard deviation of individual sensor means at a given steady-state concentration
Relative IMV	intra-model variability expressed in relative terms; the ratio of the *Absolute IMV* to the *Average* at a given-steady-state concentration
SDL	estimated lower limit of detection of the sensors; calculated from the sensor vs. GC-FID reference regression line following ICH guidelines in *Validation of Analytical Procedures: Text and Methodology Q2(R1),* 2005
Pearson R^2:	the squared value of the Pearson correlation coefficient; the square of the covariance of the reference and sensor measurements divided by the product of their standard deviations (a value from 0 to 1)
Slope:	change in the sensor's value per unit increase in the reference monitor's value
Intercept:	the sensor's predicted value when the reference monitor observes zero
MBE:	mean bias error; mean of the differences between reference and sensor measurements at a given steady-state concentration
$nMBE_{mean}$:	mean bias error normalized with respect to the reference mean value at a given steady-state concentration
MAE:	mean absolute error; mean of the absolute differences between reference and sensor measurements at a given steady-state concentration
$nMAE_{mean}$:	mean absolute error normalized with respect to the reference mean value at a given steady-state concentration
RMSE:	root mean square error; the square root of the average squared differences between reference and sensor measurements at a given steady-state concentration
$nRMSE_{mean}$:	root mean square error normalized with respect to the reference mean value at a given steady-state concentration

Appendix: GC-FID VOC Results

Three **Sensirion SEN66** sensors (units IDs: 4B48, DE98, F981) were evaluated in an AQ-SPEC environmental chamber under controlled temperatures, humidities, and volatile organic compound (VOC) concentrations. In addition to the Thermo 55i continuous VOC reference instrument, there was an Agilent 6890N GC-FID (coupled with an Entech 7100A preconcentrator) that served as a supplemental reference instrument. The supplemental reference instrument measured concentrations of each of the 4 species in the VOC blend test gas, was used as a check on the Thermo 55i reference instrument and to determine the sensor lower limit of detection, or SDL.

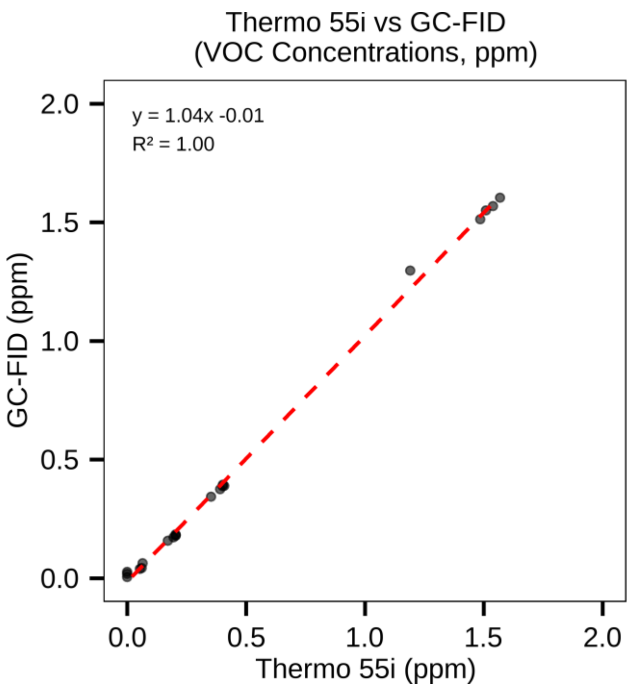
Sensirion SEN66

Agilent 6890N GC-FID

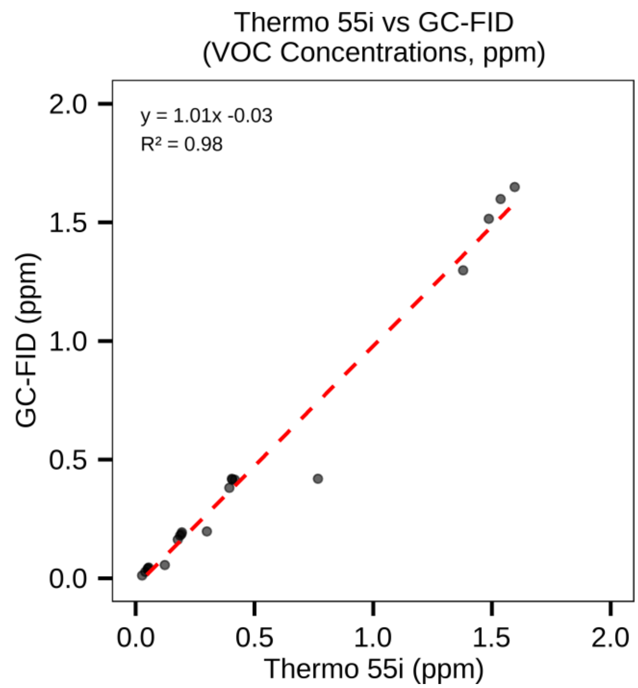
Parameter	Sensor: Sensirion SEN66 (raw sensor is Sensirion SEN66)	Reference Instrument: Agilent 6890N GC-FID
Pollutant	Total VOC (hereinafter referred to as “VOC”)	Speciated VOC
Cost	$62	~$44,000 (plus ~$65,000 for the preconcentrator)
Weight	0.04 pounds	108 pounds
Dimensions (LxWxD)	2.15 x 0.95 x 0.83 inches	19.7 x 22.8 x 21.6 inches
Power	3.6 VDC	115 - 240 VAC
Battery	No	No
Data transmission	Serial/USB to PC via SensorBridge (as-tested)	Ethernet, serial, analog output
Internal memory	No	No
Operating temperature range	14 to 122 degrees F	59 to 95 degrees F
Operating RH range	0 to 90%	5% to 95%
Product website	https://sensirion.com/products/catalog/SEN66	https://www.agilent.com/cs/library/specifications/Public/5989-3290EN.pdf
Operating principle	Metal Oxide	Flame Ionization Detection
Time resolution	1-second	22 minutes (with preconcentrator and sequence specific to current method)
Concentration range	NA (0-500 VOC Index)	< 2 ppm per current method

Appendix: GC-FID VOC Results

Beginning of Evaluation



End of Evaluation



Interpretation:

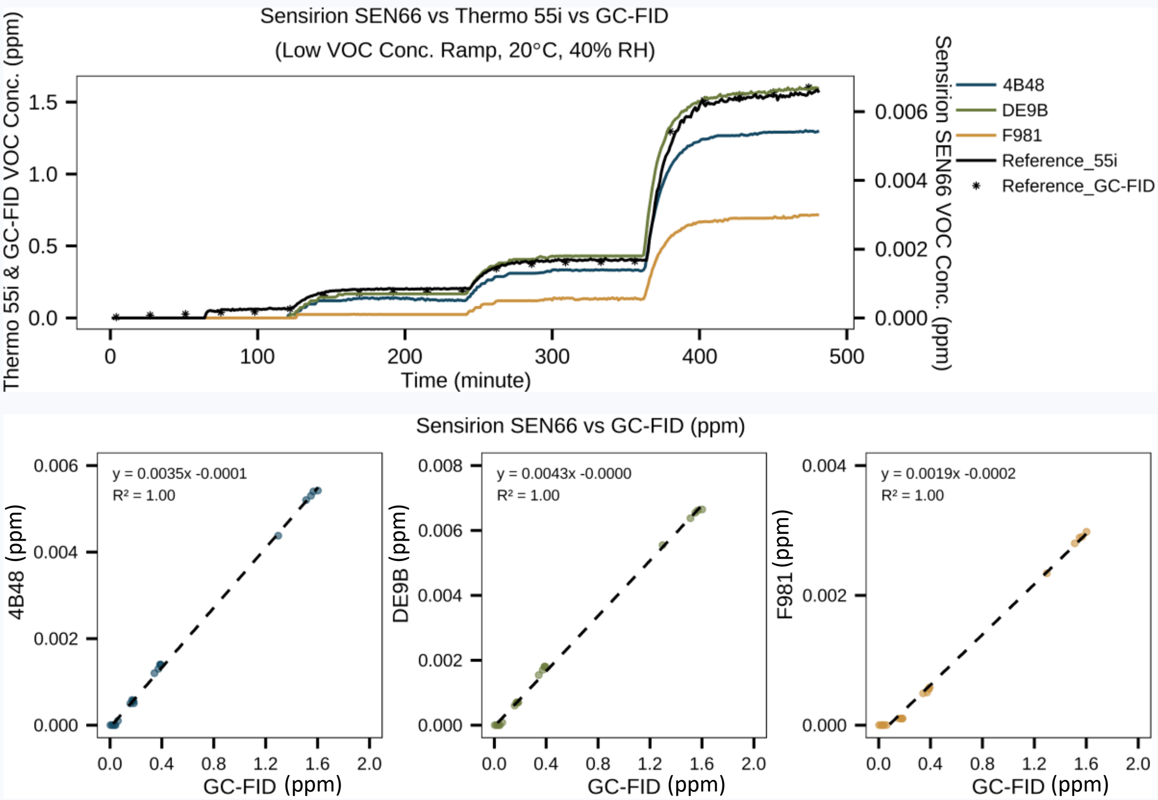
- Very strong correlations between the Thermo 55i and GC-FID (0.98 < R^2 < 1.00).
- The two reference instruments reported similar VOC concentrations at both the beginning and the end of evaluation.

Appendix: GC-FID VOC Results

Linearity (R^2) – Initial Low Conc. Ramp

Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, readings flagged by the sensor, and invalid data points were eliminated from the data-set.

A summary of the mean R^2 between the sensor and reference instruments across all units tested.



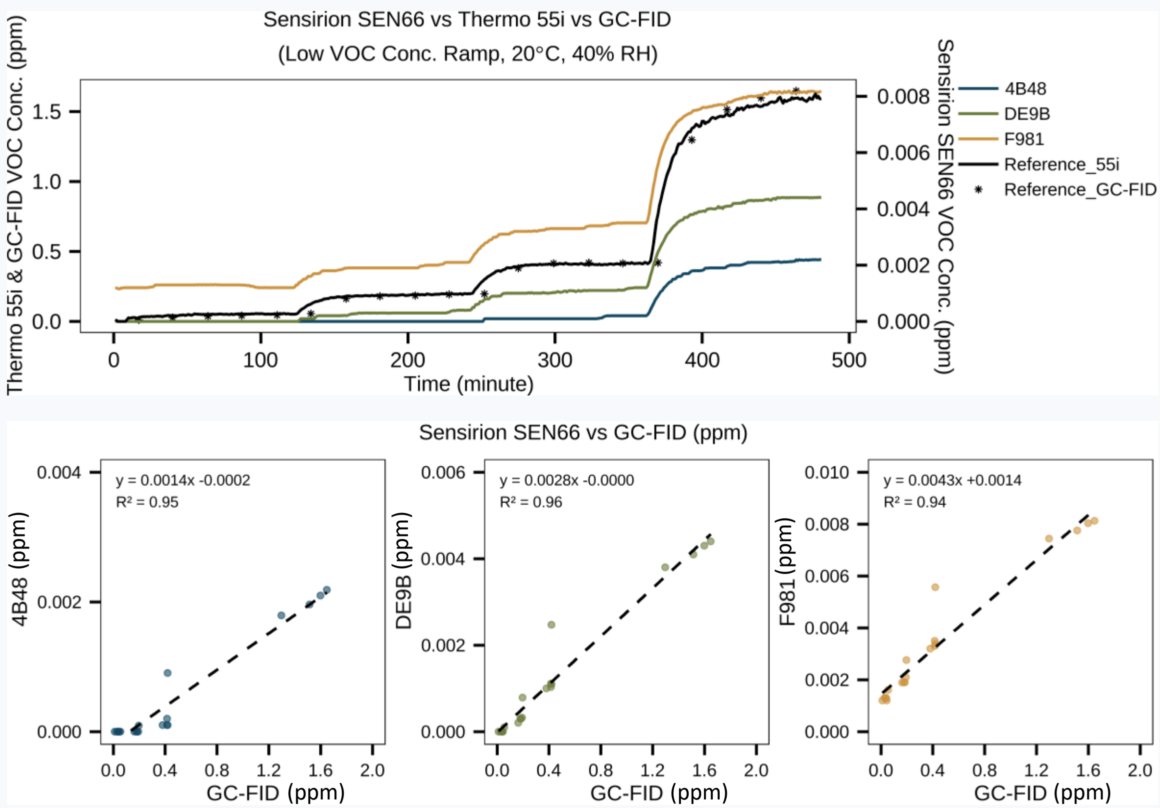
SDL, ppm	Unit 4B48: 0.02-0.06 Unit DE9B: 0.02-0.08 Unit F981: 0.04-0.13

Appendix: GC-FID VOC Results

Linearity (R^2) – Final Low Conc. Ramp

Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values, readings flagged by the sensor, and invalid data points were eliminated from the data-set.

A summary of the mean R^2 between the sensor and reference instruments across all units tested.



SDL, ppm	Unit 4B48: 0.13-0.46 Unit DE9B: 0.12-0.41 Unit F981: 0.14-0.48