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Verification and Validation of the Mobile Protection Factor Test Capability

Steven Yurechko

RESEARCH AND TECHNOLOGY DIRECTORATE

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When performing protection factor testing in alternate chambers, aerosol sampling must be conducted to verify that the chambers can provide the necessary challenge concentrations as stated in the 1992 *Joint Service Standardization Agreement for Fit Factor Testing of Military Masks*. A total of four mobile air beam chamber configurations were identified to support protection factor testing in the field. It was determined that all chamber configurations satisfy the requirements set forth in the 1992 Joint Service Standard for protection factor testing.

15. SUBJECT TERMS

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PREFACE

The work described in this report was conducted as part of the FY19 Innovative Development of Employee Advanced Solutions (IDEAS) initiative at the U.S. Army Combat Capabilities Development Command Chemical Biological Center (CCDC CBC; Aberdeen Proving Ground, MD). The work was started in August 2019 and completed in December 2019.

The use of either trade or manufacturers' names in this report does not constitute an official endorsement of any commercial products. This report may not be cited for purposes of advertisement.

This report has been approved for public release.

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- Dr. Terrence D'Onofrio, for his statistical analysis of gathered data;
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- Mr. Doug Wilke, for his expertise on generating custom components to ensure the success of the test enclosure.

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EXECUTIVE SUMMARY

When protection factor (PF) testing is conducted in a new location, verification tests must be performed in order to satisfy the requirements set forth in the 1992 Joint Service Standard* for conducting PF testing. These requirements are as follows:

- **Requirement 1**: chamber concentration must remain between 20 and 40 mg/m^3;
- **Requirement 2**: chamber concentration deviation must be less than 10% over a 15 min duration; and
- **Requirement 3**: chamber concentration deviation must be less than 5% wherever a mask would be tested.

Four air beam structure configurations were identified to act as potential PF chambers in the field and were tested to these requirements. These configurations were as follows:

- **Configuration 1**: small chamber with no exhaust;
- **Configuration 2**: small chamber with exhaust;
- **Configuration 3**: large chamber with no recirculation; and
- **Configuration 4**: large chamber with recirculation and aerosol dissemination control.

The table summarizes the results of this verification and validation study and demonstrates that each configuration could be used to conduct PF testing and meet the 1992 Joint Service Standard.

Table. Statistical Data Analysis of Tested Enclosure Configurations

Configuration Number	Requirement 1	Requirement 2	Requirement 3
1	99.9% chance of being within 20–40 mg/m^3	99.9% chance of less than 10% concentration deviation	99.9% chance of less than 5% concentration deviation
2	99.9% chance of being within 20–40 mg/m^3	99.9% chance of less than 10% concentration deviation	99.9% chance of less than 5% concentration deviation
3	99.9% chance of being within 20–40 mg/m^3	99.9% chance of less than 10% concentration deviation	99.9% chance of less than 5% concentration deviation
4	99.9% chance of being within 20–40 mg/m^3	99.9% chance of less than 10% concentration deviation	99.9% chance of less than 5% concentration deviation

**Joint Service Standardization Agreement for Fit Factor Testing of Military Masks*. Joint Logistics Commanders, Joint Panel on Chemical and Biological Defense, 1 October 1991; Memorandum of Agreement, January 1992; UNCLASSIFIED Specification.

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VERIFICATION AND VALIDATION OF THE MOBILE PROTECTION FACTOR TEST CAPABILITY

1. INTRODUCTION

Protection factor (PF) testing is routinely used as a way to quantify respirator performance while the respirator is worn by an end user in an aerosol environment. Each user dons a respirator and performs a series of exercises within an aerosol chamber that are designed to stress the seal of the mask on the user's face. The resulting ratio of the aerosol concentration in the chamber to the aerosol that infiltrated the mask during the exercises is referred to as the PF score, and it is then compared to respirator performance requirements.

$$PF = \frac{\text{Challenge concentration}}{\text{In-mask concentration}} \tag{1}$$

These tests are routinely performed in aerosol test chambers that have been validated to meet the aerosol chamber requirements set forth in the 1992 *Joint Service Standardization Agreement for Fit Factor Testing of Military Masks** (JS Standard; Appendix C). In order to perform these tests for customers, volunteers must be recruited to act as test subjects. Historically, it has been difficult to recruit volunteers and even more difficult to recruit end users (such as pilots, ground troops, etc.) because of scheduling conflicts and the burden of traveling.

To address this issue, a mobile air beam PF chamber was created so that personnel from the U.S. Army Combat Capabilities Development Command Chemical Biological Center (CCDC CBC; Aberdeen Proving Ground, MD) could take the PF capability directly to the customer or end user for testing. This test chamber would ease the burden of test subjects, customers, and end users traveling to CCDC CBC for testing while maintaining the same level of capability and accuracy that the fixed-site chamber provides. Before testing is performed in other locations or chambers, verification and validation testing must be conducted to ensure that the aerosol concentration levels meet the JS Standard. The requirements for aerosol concentration from the 1992 JS Standard are as follows:

- **Requirement 1**: chamber concentration must remain between 20 and 40 mg/m^3;
- **Requirement 2**: chamber concentration deviation must be less than 10% over a 15 min duration; and
- **Requirement 3**: chamber concentration deviation must be less than 5% wherever a mask would be tested.

**Joint Service Standardization Agreement for Fit Factor Testing of Military Masks*. Joint Logistics Commanders, Joint Panel on Chemical and Biological Defense, 1 October 1991; Memorandum of Agreement, January 1992; UNCLASSIFIED Specification.

Four configurations of air beam aerosol test chambers have been created to meet the needs of customers that are not able to travel for PF testing. These chambers may be rapidly mobilized and deployed to conduct PF tests on site while still providing the same testing capability offered by other aerosol PF test facilities.

This report details the verification and validation procedures that were conducted on each air beam chamber configuration to ensure that the aerosol concentration profiles adhere to the requirements set forth in the 1992 JS Standard.

2. AIR BEAM CHAMBER DESCRIPTION

PF test chambers rely on the combination of an enclosure, an aerosol generator, and mixing fans to generate the necessary concentration profiles required for testing. Generally, it is hard to achieve uniform mixing of the aerosol in these configurations because the locations of the mixing fans and the aerosol generator vary within the enclosure.

Air beam test enclosures require a blower (to keep the structure inflated) as well as an aerosol generator, but because of their unique aerosol distribution method, they do not require mixing fans. Figure 1 shows the air beam test chamber that has been inflated using a blower system.

Figure 1. Air beam test enclosure.

Rather than inject aerosol directly into the chamber from the generator, aerosol is injected into the blower that keeps the structure inflated, as shown in Figure 2.

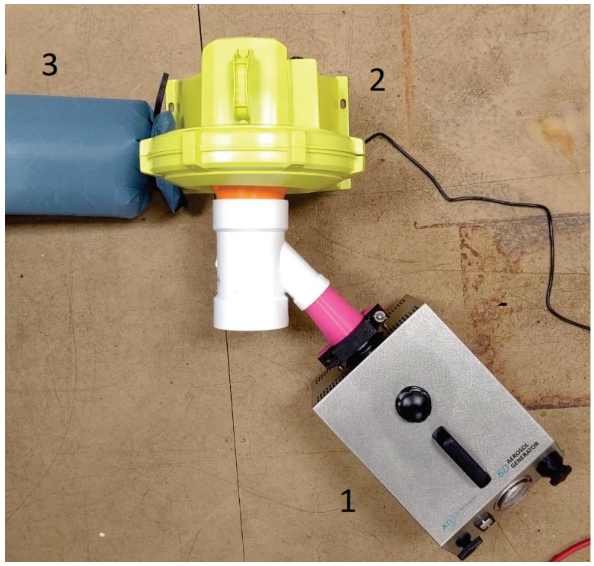


Figure 2. Aerosol distribution system. Components include (1) aerosol generator, (2) blower fan to inflate air beam, and (3) pathway to air beam structure.

This aerosol travels inside the air beam structure and is then introduced to the chamber through the use of strategically placed, commercially available directional air nozzles (1/2 in. opening). The aerosol movement through the air nozzles is driven by the overpressure created by the chamber blower, shown in Figure 3.

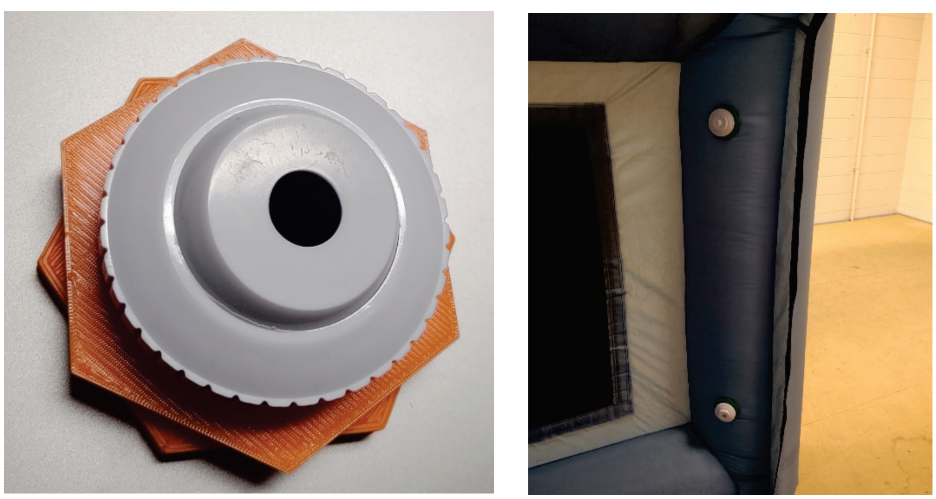


Figure 3. Air nozzles (left) were installed on air beam inside of enclosure (right).

The combination of the blower fan mixing, the travel distance throughout the air beam structure, and the final injection into the chamber ensure that the aerosol is properly mixed and meets the JS Standard requirement.

3. AIR BEAM CONFIGURATION DESCRIPTIONS

Multiple air beam structures were purchased and modified for PF testing based on the anticipated environment and test subject capacity required for a particular test. Four configurations were selected as part of this validation effort, and details are provided here.

3.1 Configuration 1: Small Chamber without Exhaust

The small chamber (Figure 4) consists of a 13 × 8 × 7 ft air beam structure with an accompanying 750 W blower fan for inflating the chamber and an optional 350 W blower for exhaust (not used in this configuration).

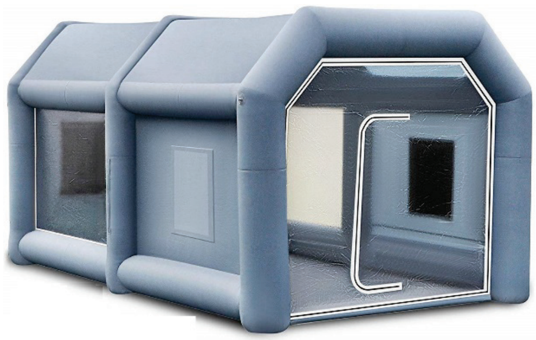


Figure 4. Small air beam enclosure.

A total of 10 air nozzles are installed on this configuration. Two nozzles are installed on each corner air beam column at heights of 4.5 and 1 ft, and one nozzle is installed on each middle air beam column at a height of 4.5 ft (Figure 5).

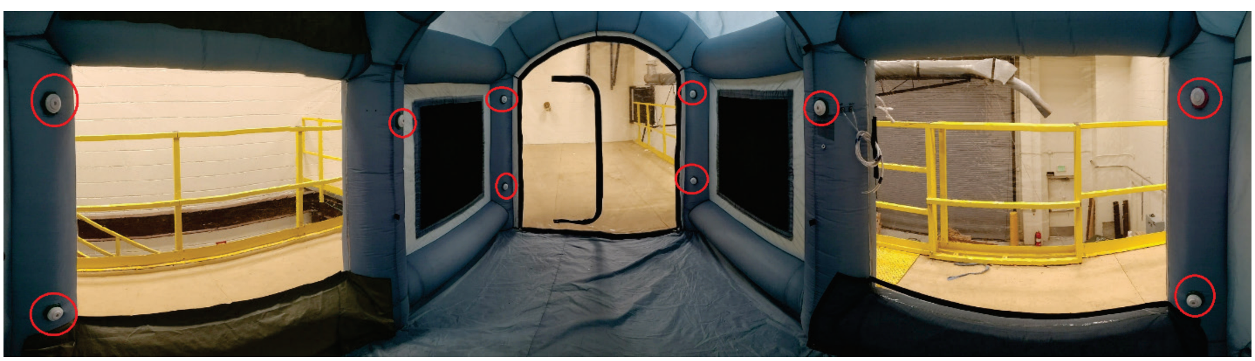


Figure 5. Panoramic view of installed air nozzles (circled in red) within small enclosure.

Because air is introduced to the enclosure from the air nozzles, a pressure relief mechanism is required for the enclosure; otherwise, it would inflate similar to a balloon. This pressure buildup is relieved through two low-airflow-resistance carbon mesh panels on each side of the enclosure. The airflow through these panels may be increased or decreased by opening or closing the cover material, respectively (Figure 6). For this configuration, both carbon mesh panels were left fully open. Because aerosol is purging to outside of the enclosure, it is recommended that this configuration be used outdoors.

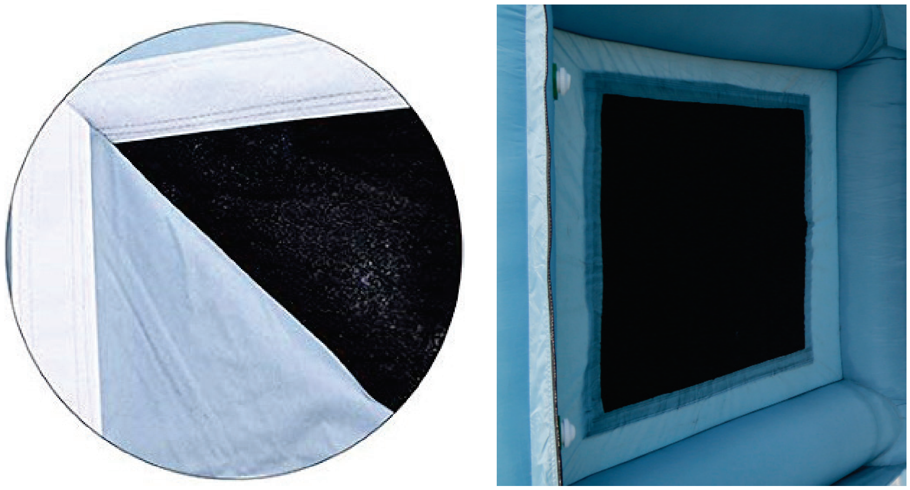


Figure 6. Adjustable carbon mesh side panel, opened (left) and closed (right).

3.2 Configuration 2: Small Chamber with Exhaust

In this configuration, the same chamber is used as for Configuration 1; however, a customized exhaust system prevents aerosol from escaping from the enclosure. This configuration is ideal if the enclosure is to be used indoors and there is concern of the test aerosol propagating throughout the space where it is deployed. The exhaust system uses the included 350 W blower with an attached high-efficiency particulate air (HEPA) filter to purge air from the enclosure at a rate similar that for the airflow entering the structure from the air nozzles (Figures 7 and 8).

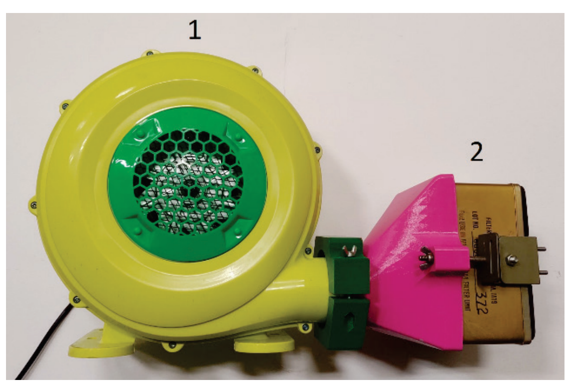


Figure 7. Small chamber exhaust system: (1) 350 W blower and (2) HEPA particulate filter.

Figure 8. Small chamber exhaust location (left) and blower attached to exhaust system (right).

While in this configuration, the carbon mesh panels on the sides of the enclosure were left open.

3.3 Configuration 3: Large Chamber without Exhaust

The large chamber consists of a 26 × 13 × 10 ft air beam structure (Figure 9) with an accompanying 950 W blower for inflating the chamber, an optional 350 W blower for exhaust (not used in this configuration), and a wall partition that may be used to section off a small portion of the enclosure. The wall partition was used in this configuration.

Figure 9. Large air beam enclosure.

Two air nozzles were installed on each air beam column inside the enclosure at heights of 5 and 2 ft, for a total of 12 nozzles (Figure 10). The large chamber has four carbon mesh panels. The two panels on the side of the enclosure were left fully open, while the two panels at the back of the chamber leading to the partitioned section of the enclosure were fully closed. Because aerosol is purged to the enclosure exterior, it is recommended that this configuration be used outdoors.

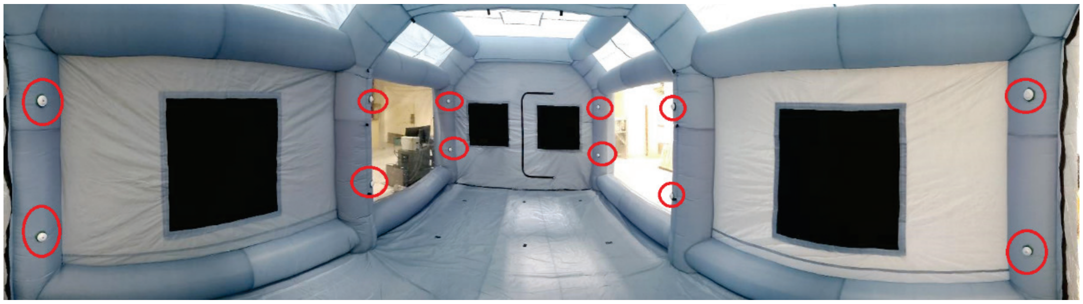


Figure 10. Panoramic view of installed air nozzles (circled in red) within large enclosure.

3.4 Configuration 4: Large Chamber with Aerosol Recirculation and Concentration Control

In this configuration, the large chamber is used with a recirculation system and software to control the aerosol concentration within the chamber and also to prevent the enclosure from inflating. The recirculation system is composed of the 950 W air beam blower and a custom return-air fitting that allows for simultaneous aerosol injection, as shown in Figure 11. This configuration is ideal for use when a particular challenge concentration must be maintained to meet customer needs.

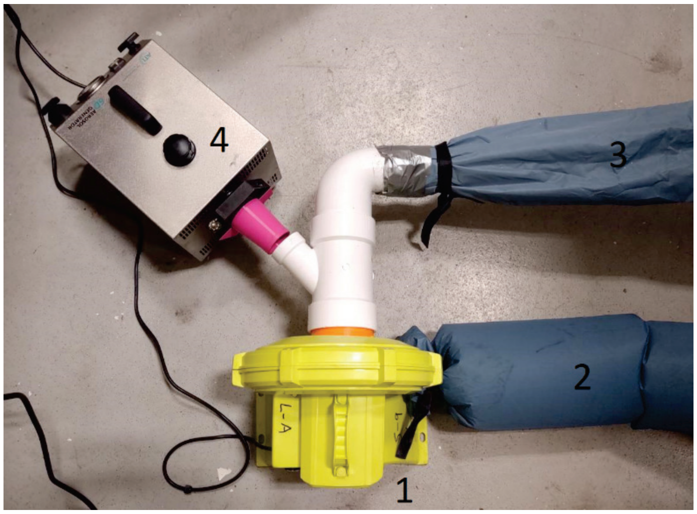


Figure 11. Large enclosure recirculation setup: (1) 950 W blower, (2) positive-pressure airflow to air beam structure, (3) negative-pressure return air from partitioned section of structure, and (4) aerosol generator.

The large enclosure is separated by a wall partition that has two carbon mesh panels. These panels were each opened halfway, so that air would be able to pass freely between the segregated sections of the enclosure (Figure 12).

Figure 12. Large chamber wall partition with mesh panels opened halfway.

When the 950 W blower is engaged, positive-pressure air inflates the chamber and allows air to flow from the installed air nozzles into the main section of the enclosure. However, because the return airflow rate from the blower is larger than the total airflow from the 12 air nozzles inside the main enclosure section, a pressure differential is created. This differential forces air to travel through the carbon mesh panels, from the main section to the partitioned section of the enclosure. The air in the partitioned section is then pulled back into the blower by a tube (Figure 13), from which it is expelled back into the airframe, thereby creating the recirculation loop.

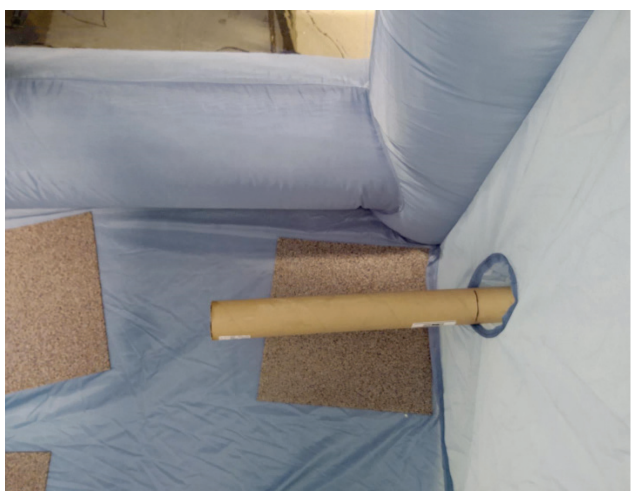


Figure 13. Return air tube to blower.

A LabVIEW program (National Instruments; Austin, TX) was created to automatically maintain the desired concentration level within the enclosure. Although the enclosure slowly loses aerosol concentration to the outside environment through losses in the air beam itself, if there were no control in the closed-loop recirculation system, the aerosol level would quickly exceed the required level set forth in the 1992 JS Standard. This program automatically turns the aerosol generator on and off to maintain a relatively stable aerosol concentration at the desired set point, as shown in Figure 14.

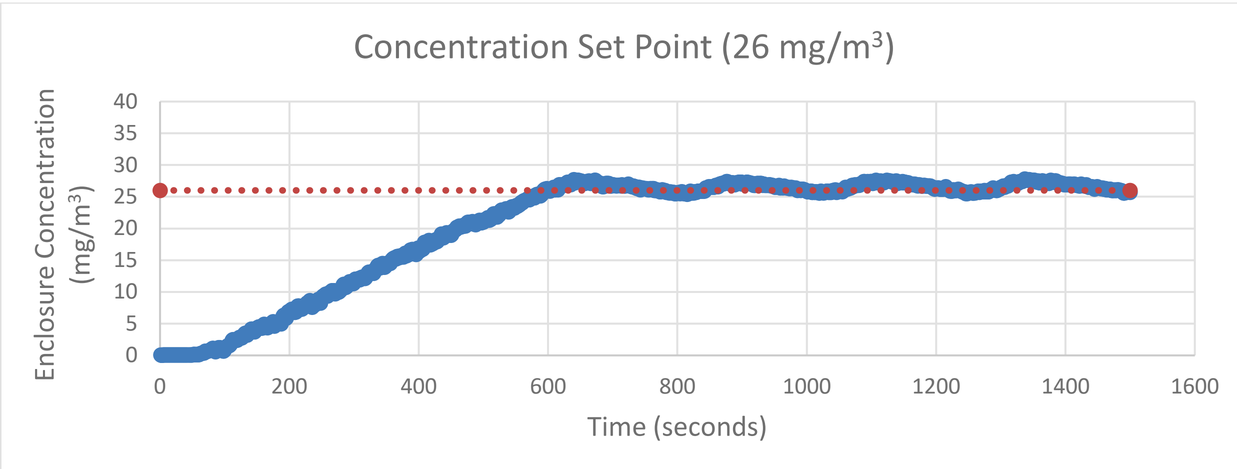


Figure 14. Example of Configuration 4 aerosol concentration recirculation control.

4. SUPPORTING EQUIPMENT

4.1 ATI TDA-6D Laskin Nozzle Aerosol Generator

The TDA-6D aerosol generator (Figure 15) from Air Techniques International (ATI; Owings Mills, MD) is a small, lightweight Laskin nozzle generator that has the compressor built in. It may be used with a wide variety of simulant oils to produce aerosol, but the most common oils are polyalphaolefin (PAO) and corn oil. The poly-dispersed particle size of the aerosol produced by this generator has a range of 0.4–0.6 mass median aerosol diameter, which is the size needed to satisfy the requirement in the 1992 JS Standard. PAO was used exclusively for all of the testing performed for this technical report.

Figure 15. ATI TDA-6D Laskin nozzle generator.

4.2 TSI DustTrak II 8530

The DustTrak II 8530 aerosol monitor (TSI Incorporated; Shoreview, MN), shown in Figure 16, is a desktop battery-operated, data-logging, single-channel, light-scattering laser photometer that gives real-time aerosol mass readings and collects gravimetric samples. It uses a sheath air system that isolates the aerosol in the optics chamber to keep the optics clean for improved reliability and low maintenance. Concentration values are recorded per second.

Figure 16. TSI DustTrak II 8530 aerosol monitor.

4.3 TSI Laser Photometer 8587A

The model 8587A laser photometer (Figure 17) uses a 30 mW laser to illuminate and collect the scattered light from airborne particles to produce a voltage peak that may be used with data acquisition software. An internal valve allows switching between upstream and downstream sampling. Because of its portability and wide dynamic range, it also is used in HEPA filter scanning systems to measure the penetration efficiencies of large, high-efficiency filter assemblies.

Figure 17. TSI model 8587A laser photometer.

5. METHODS

5.1 Testing Methodology

Each configuration was tested to the spatial uniformity concentration requirements as stated in the 1992 JS Standard for fit factor testing. The standard does not specifically state how to collect or analyze data to verify the requirements, so a sampling procedure was generated by a PF subject matter expert (SME) to evaluate the enclosure configurations.

A total of seven trials were conducted on each enclosure configuration. A trial included five steps, which were defined as follows:

1. Inflate the enclosure.
2. Engage aerosol generator and allow chamber to ramp in concentration for 15 min.
3. Conduct 15 min static sample in center of enclosure.
4. Conduct point-to-point sampling inside enclosure (30 s per identified location).
5. Disengage aerosol generator and deflate enclosure.

To determine whether each configuration for both the small and large enclosure met the special uniformity requirement, a chamber sampling scheme had to be determined. To accomplish this, an SME identified (based on experience and historical data of past PF chambers) the locations within the small and large enclosure that would adequately represent where testing would be conducted. These locations are represented in Figure 18 for the small and large enclosures, respectively. Additional details are provided in Appendix A.

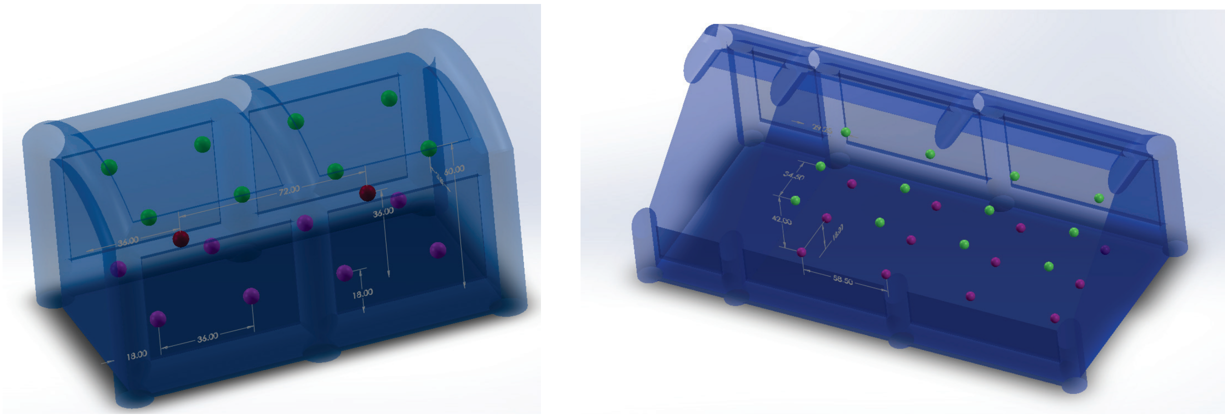


Figure 18. Sample locations for small (left) and large (right) enclosures.

5.2 Data Collection and Statistical Analysis

To verify Requirement 1, the DustTrak II 8530 aerosol monitor was used to collect concentration data throughout the verification. For all of the values collected, the system evaluated whether the concentration level was within 20 and 40 mg/m^3. This was measured for all positions in all configurations.

For Requirement 2, the DustTrak II 8530 aerosol monitor was placed in the direct center of the test enclosure. After an initial 15 min ramp duration, the DustTrak II was set to sample for 15 min. When this was completed, the average concentration value during the 15 min sample was calculated, and then the percent deviations for individual values collected during this time were compared to the calculated average. A process capability analysis was then conducted to calculate the expected percentage of nonconforming results.

To evaluate Requirement 3, an SME for respiratory protection used the DustTrak II 8530 system to sample each predetermined location for 30 s. Once that was completed, the average concentration at each location was calculated and compared to the overall concentration average that was observed during the sampling. The percent deviation of each location was then calculated and compared to the requirement. The percent deviation by location could also be presented graphically, as shown in Figure 19 and as part of the data supplement in Appendix B. A process capability analysis was then conducted to calculate the expected percentage of nonconforming results.

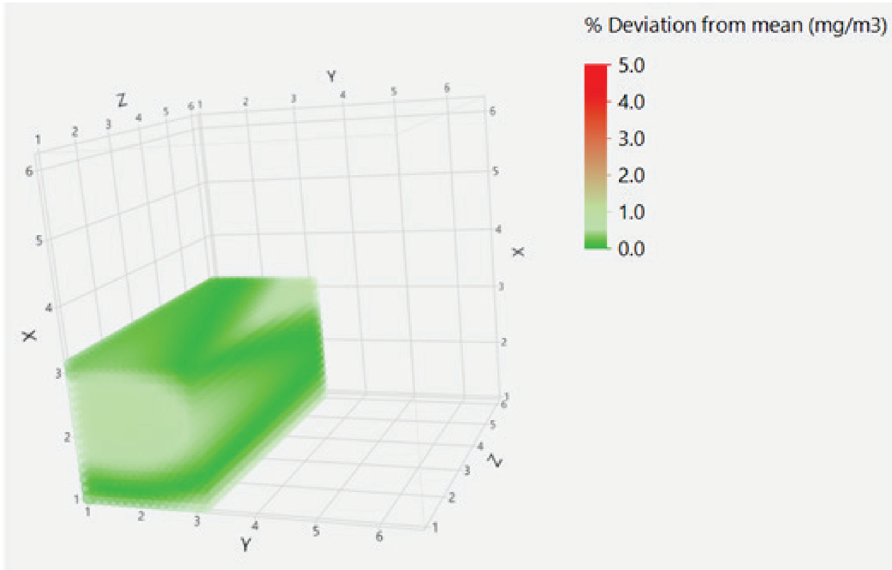


Figure 19. Graphical depiction of percent deviation for concentrations within enclosure.

6. RESULTS AND CONCLUSIONS

The following tables summarize the condensed data that were collected for this validation. All raw data may be found in Appendix B.

Table 1 represents the overall statistical analysis of the seven trials that were performed for each of the tested configurations to meet the 1992 JS Standard aerosol concentration requirements.

Table 1. Statistical Data Analysis of Tested Enclosure Configurations

Configuration Number	Requirement 1	Requirement 2	Requirement 3
1	99.9% chance of being within 20–40 mg/m^3	99.9% chance of less than 10% concentration deviation	99.9% chance of less than 5% concentration deviation
2	99.9% chance of being within 20–40 mg/m^3	99.9% chance of less than 10% concentration deviation	99.9% chance of less than 5% concentration deviation
3	99.9% chance of being within 20–40 mg/m^3	99.9% chance of less than 10% concentration deviation	99.9% chance of less than 5% concentration deviation
4	99.9% chance of being within 20–40 mg/m^3	99.9% chance of less than 10% concentration deviation	99.9% chance of less than 5% concentration deviation

Table 2 is the total data summary for Requirement 1, for all of the configurations tested. This data was compiled from all of the aerosol samples collected (one sample per second) during the trials conducted for Requirements 2 and 3.

Table 2. Data from Configurations to Support Requirement 1

Configuration	Trial Number	Number of Aerosol Data Points Collected	Percentage of Data Points between 20 and 40 mg/m^3
1	1	1440	100
	2	1440	100
	3	1440	100
	4	1440	100
	5	1440	100
	6	1440	100
	7	1440	100
2	1	1440	100
	2	1440	100
	3	1440	100
	4	1440	100
	5	1440	100
	6	1440	100
	7	1440	100
3	1	1620	100
	2	1620	100
	3	1620	100
	4	1620	100
	5	1620	100
	6	1620	100
	7	1620	100
4	1	1620	100
	2	1620	100
	3	1620	100
	4	1620	100
	5	1620	100
	6	1620	100
	7	1620	100

Table 3 summarizes the data that were collected to verify each testing configuration against Requirement 2 of the JS Standard. Over the course of each 15 min trial, a total of 900 concentration data points were recorded. The average concentration of the trial was calculated, the minimum and maximum of the data set were identified, and then the percent differences were calculated and compared with the values in Requirement 2.

Table 3. Data Summary for Requirement 2

Configuration	**Trial Number**	**Concentration (mg/m^3)**			**Deviation Range (%) –10% to +10% Required**
		Average during Trial	**Minimum Recorded**	**Maximum Recorded**	
1	1	32.26	31.5	33.2	–2.35 to +2.92
	2	32.83	32.4	33.2	–1.32 to +1.12
	3	32.78	32.3	33.4	–1.45 to +1.90
	4	32.97	32.5	33.3	–1.24 to +1.19
	5	33.59	33.0	34.2	–1.20 to +1.53
	6	32.39	32.0	32.9	–1.19 to +1.59
	7	33.07	32.5	33.6	–1.73 to +1.60
2	1	32.78	32.4	33.3	–1.17 to +1.57
	2	32.4	32	32.8	–1.22 to +1.24
	3	32.59	32.1	33.1	–1.52 to +1.55
	4	32.62	32	33.1	–1.91 to +1.46
	5	32.15	31.5	32.8	–2.03 to +2.02
	6	32.54	32.1	33	–1.36 to +1.40
	7	31.91	31.5	32.4	–1.29 to +1.54
3	1	35.81	33.7	38.4	–5.90 to +7.22
	2	29.61	28.1	30.7	–5.11 to +3.67
	3	29.34	27.7	30.5	–5.60 to +3.94
	4	29.9	28.3	31.1	–5.35 to +4.01
	5	29.3	27.6	30.6	–5.18 to +4.43
	6	30.26	29.3	30.9	–3.17 to +2.12
	7	29.82	28	31.1	–6.11 to +4.29
4	1	25.42	24.7	26.4	–2.82 to +3.87
	2	26.08	25.2	26.9	–3.38 to +3.13
	3	26.68	26	27.4	–2.54 to +2.71
	4	26.59	25.9	27.5	–2.58 to +3.44
	5	26.79	25.8	28	–3.68 to +4.54
	6	27	25.9	28	–4.08 to +3.69
	7	26.86	25.9	28.1	–3.58 to +4.61

Table 4 summarizes the data to verify Requirement 3 of the JS Standard. A total of 540 concentration data points were recorded for Configurations 1 and 2, and 720 data points were recorded for Configurations 3 and 4. These numbers were based on the number of sample locations that were determined for each configuration (18 for Configurations 1 and 2, and 24 for Configurations 3 and 4). Each location was sampled for 30 s, and then the average concentration was calculated. The minimum and maximum average concentrations per trial were then compared with the total average observed for the trial, and percent differences were calculated. These percentages were then compared with the values in Requirement 3.

Table 4. Summary Data for Requirement 3

Configuration	Trial Number	Concentration (mg/m^3)			Deviation Range (%) –5 to +5 Required
		Average during Trial	Minimum Average Recorded	Maximum Average Recorded	
1	1	32.76	32.4	33.02	–1.08 to +0.79
	2	33.28	33.1	33.46	–0.61 to +0.55
	3	33.57	33.3	34.017	–0.83 to +1.33
	4	33.52	33.3	33.98	–0.60 to +1.39
	5	33.59	33.3	33.81	–0.81 to +0.64
	6	32.96	32.7	33.48	–0.76 to +1.60
	7	33.75	33.4	34.08	–0.94 to +0.98
2	1	32.78	32.45	32.98	–1.01 to +0.61
	2	33.07	32.93	33.47	–0.42 to +1.21
	3	33.2	33.12	33.33	–0.25 to +0.39
	4	33	32.76	33.12	–0.74 to +0.36
	5	32.86	32.75	33.037	–0.32 to +0.53
	6	32.89	32.773	33.08	–0.35 to +0.58
	7	32.38	32.21	32.47	–0.51 to +0.29
3	1	32.34	31.81	33.12	–1.64 to +2.42
	2	31.71	31.42	31.86	–0.90 to +0.49
	3	31.03	30.88	31.273	–0.48 to +0.79
	4	30.6	30.39	30.77	–0.70 to +0.54
	5	30.69	30.48	30.92	–0.68 to +0.77
	6	31.2	30.75	31.46	–1.43 to +0.87
	7	31.19	30.57	31.44	–1.96 to +0.83
4	1	25.34	24.82	25.86	–2.02 to +2.05
	2	25.83	25.27	26.25	–2.19 to +1.63
	3	26.83	26.103	27.5	–2.70 to +2.52
	4	26.71	26.03	27.143	–2.55 to +1.61
	5	26.76	26.26	27.18	–1.86 to +1.59
	6	26.47	25.56	27.14	–3.43 to +2.55
	7	26.75	25.95	27.37	–2.99 to +2.33

At the conclusion of the trials conducted, it was found that each configuration of the tested enclosures would meet the concentration requirements stated in the 1992 JS Standard and should be considered for use when PF testing is required at locations other than CCDC CBC. All raw data for these trials are provided in Appendix B.

ACRONYMS AND ABBREVIATIONS

ATI	Air Techniques International
CBC CCDC	Chemical Biological Center Combat Capabilities Development Command
HEPA	high-efficiency particulate air
JS Standard	*Joint Service Standardization Agreement for Fit Factor Testing of Military Masks*
PAO	polyalphaolefin
PF	protection factor
SME	subject matter expert

Blank

APPENDIX A

ENCLOSURE SAMPLING LOCATIONS

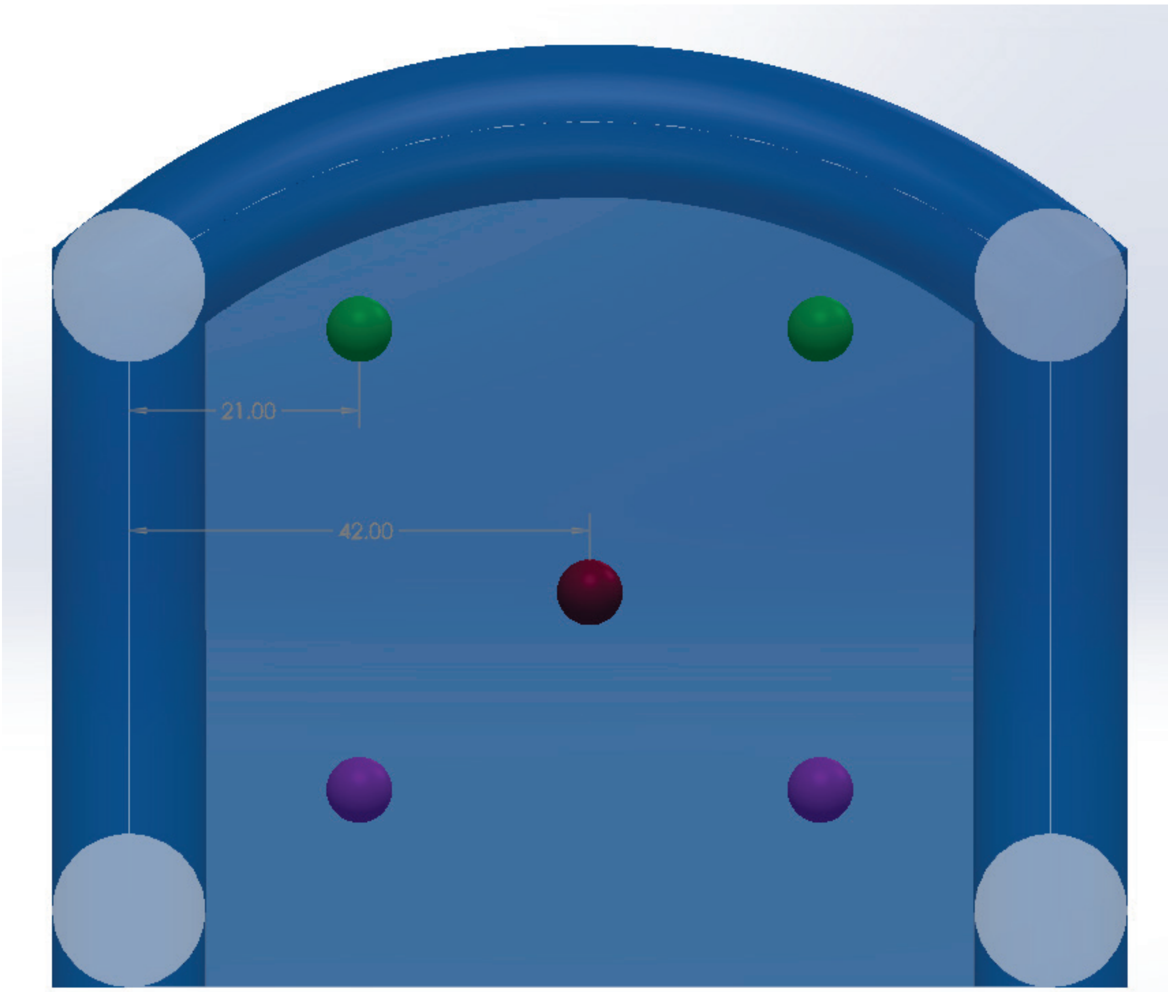


Figure A-1. Small enclosure: front view.

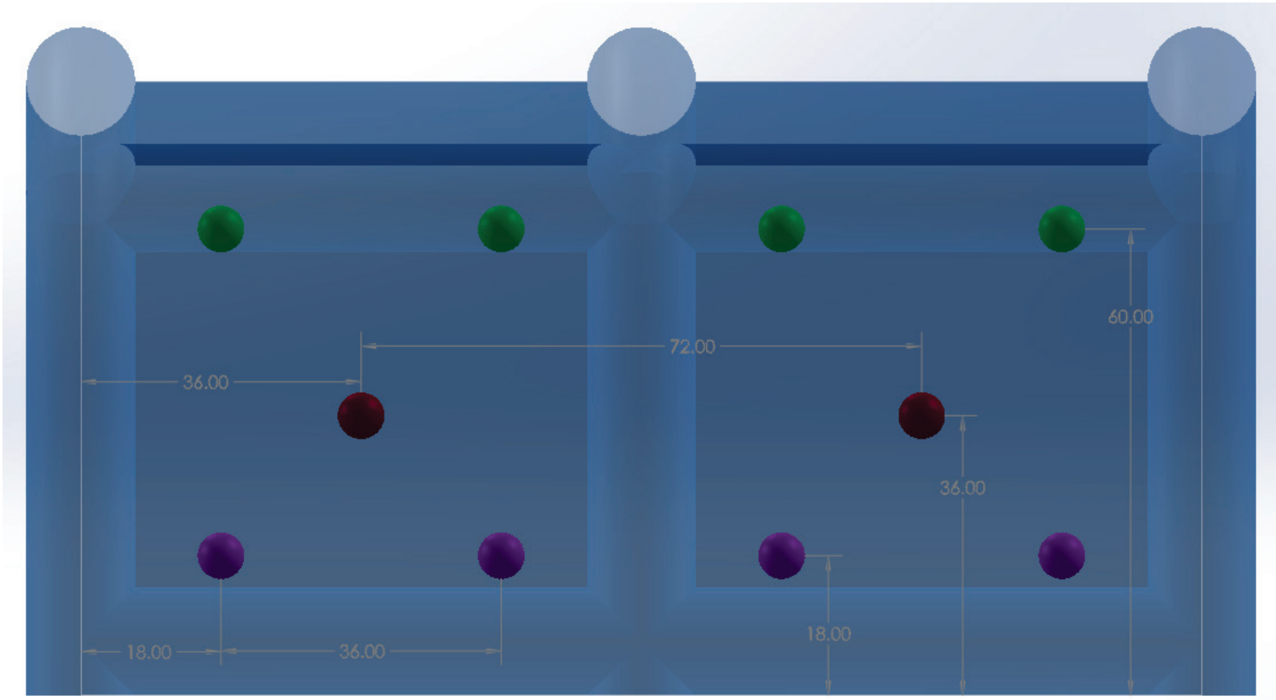


Figure A-2. Small enclosure: side view.

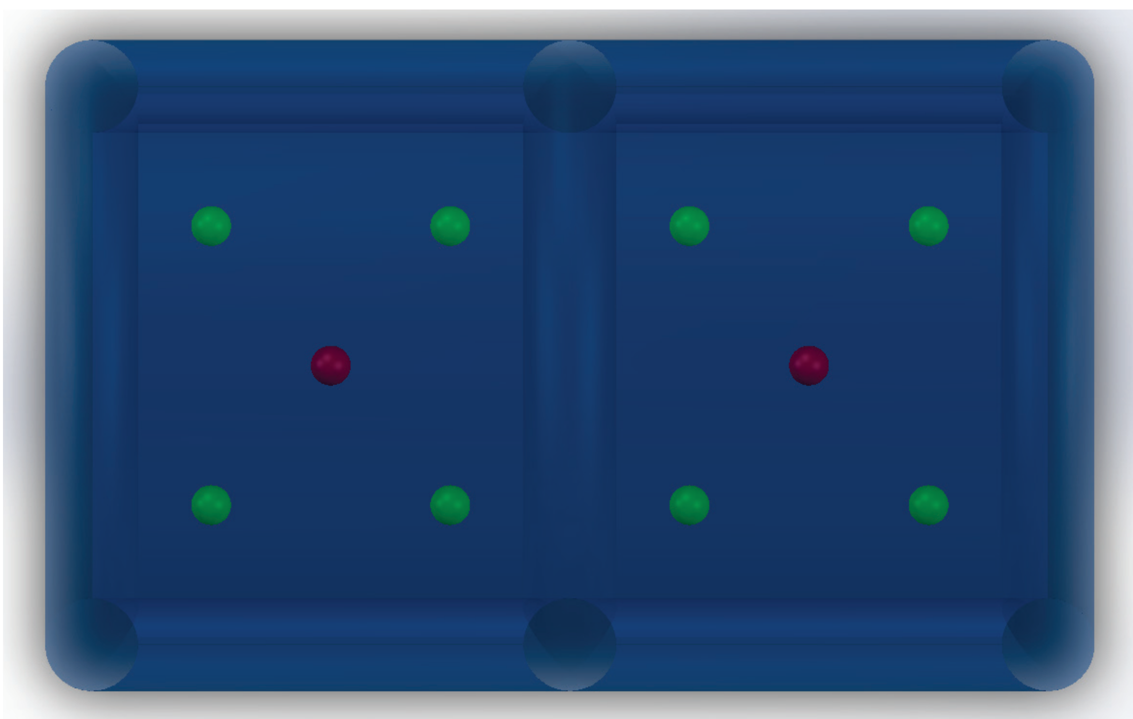


Figure A-3. Small enclosure: top view.

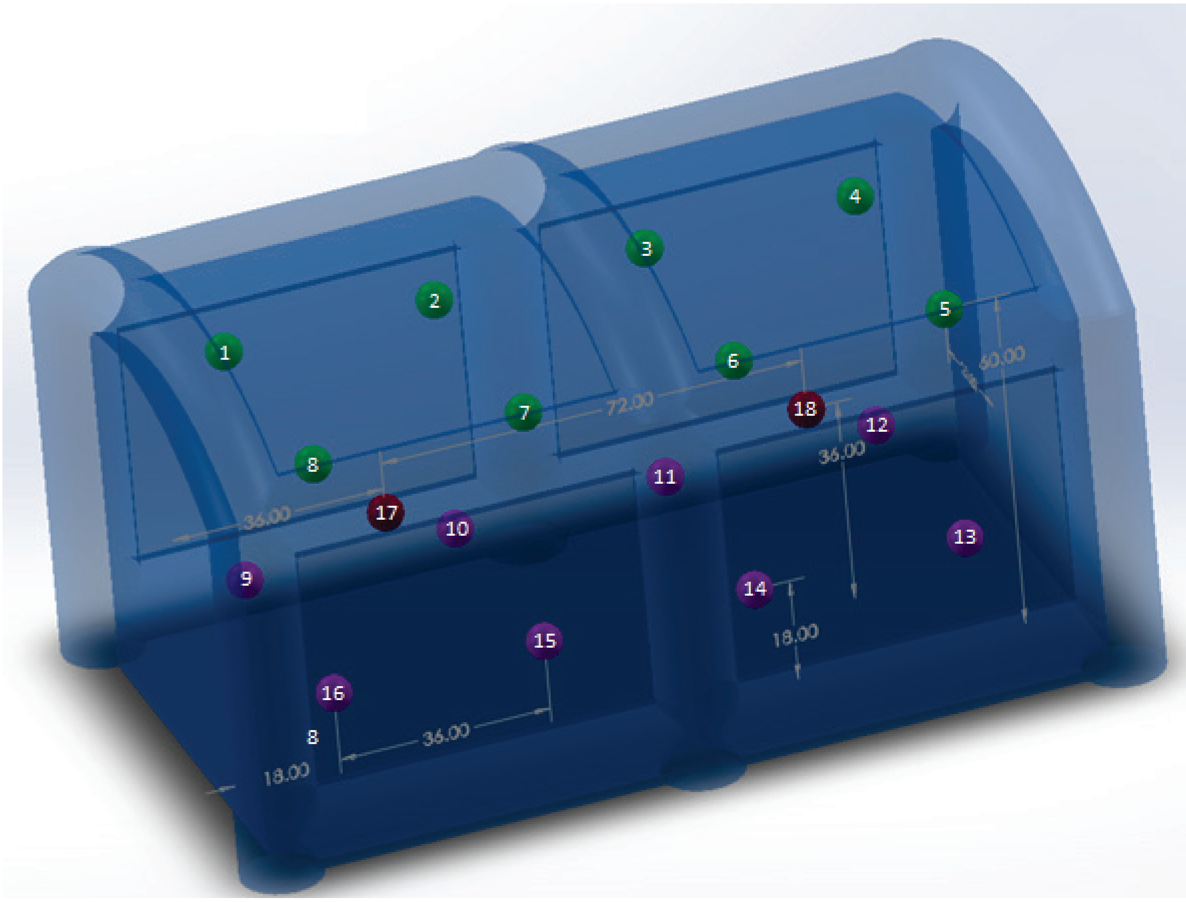


Figure A-4. Small enclosure: 3-D representation.
Note: numbers indicate order in which each location was sampled.

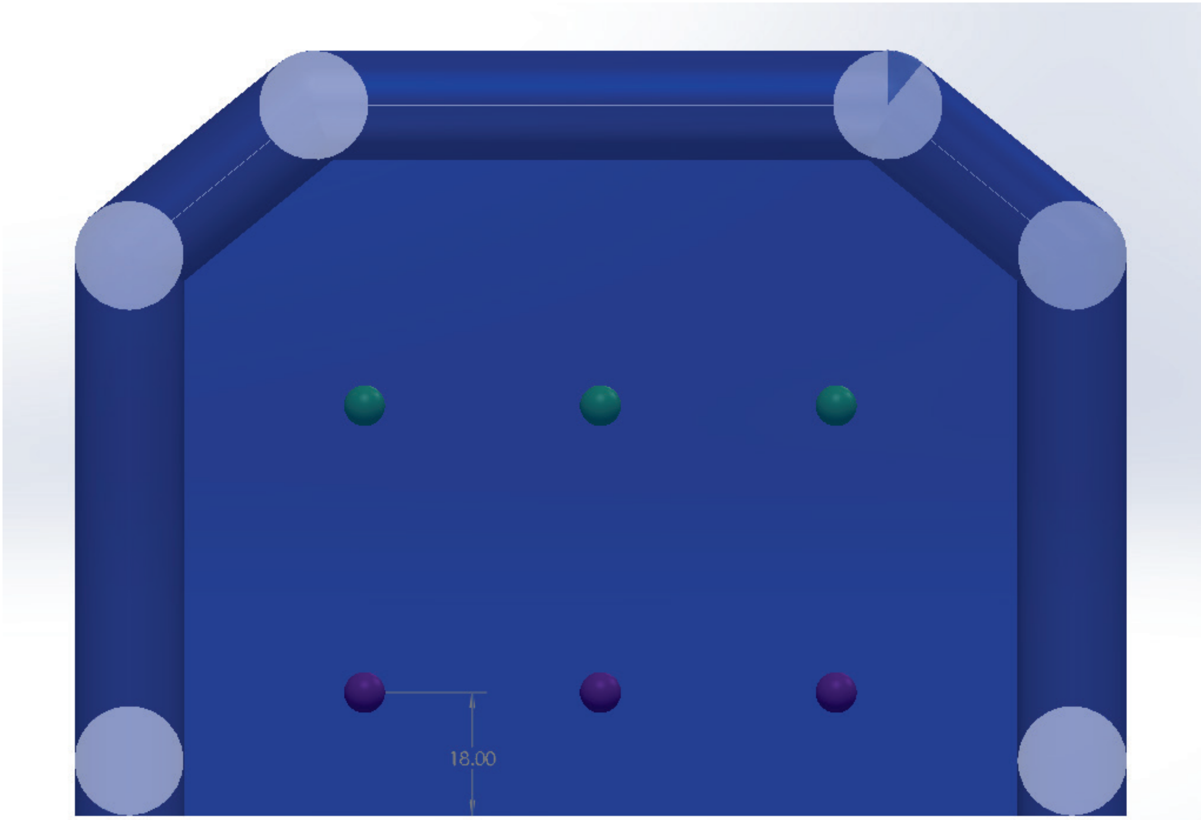


Figure A-5. Large enclosure: front view.

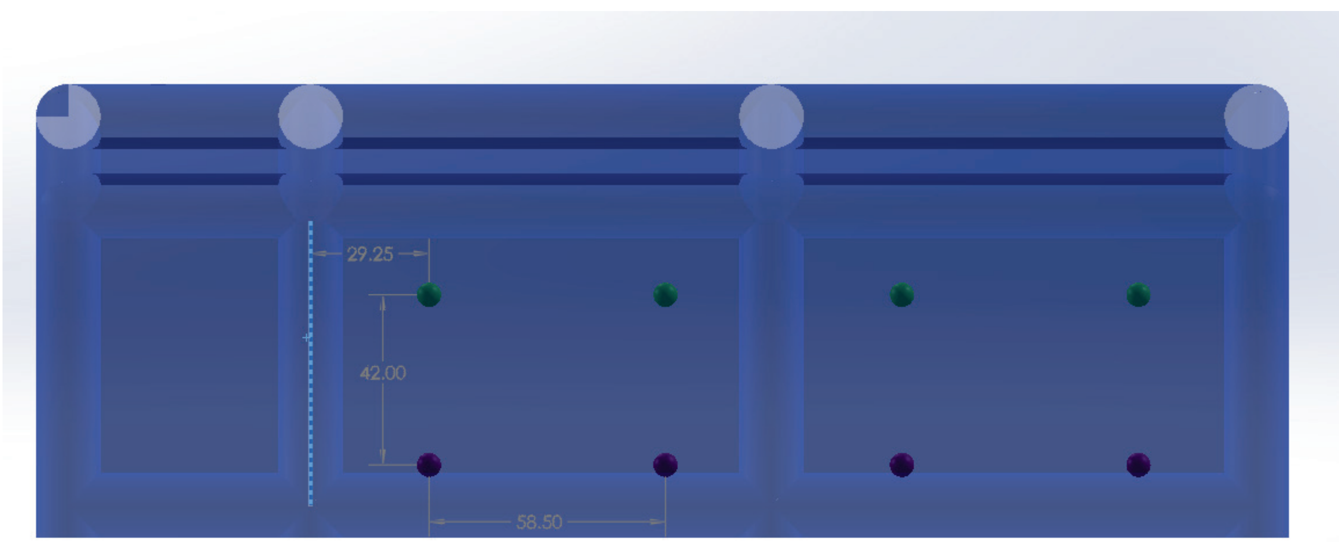


Figure A-6. Large enclosure: side view.

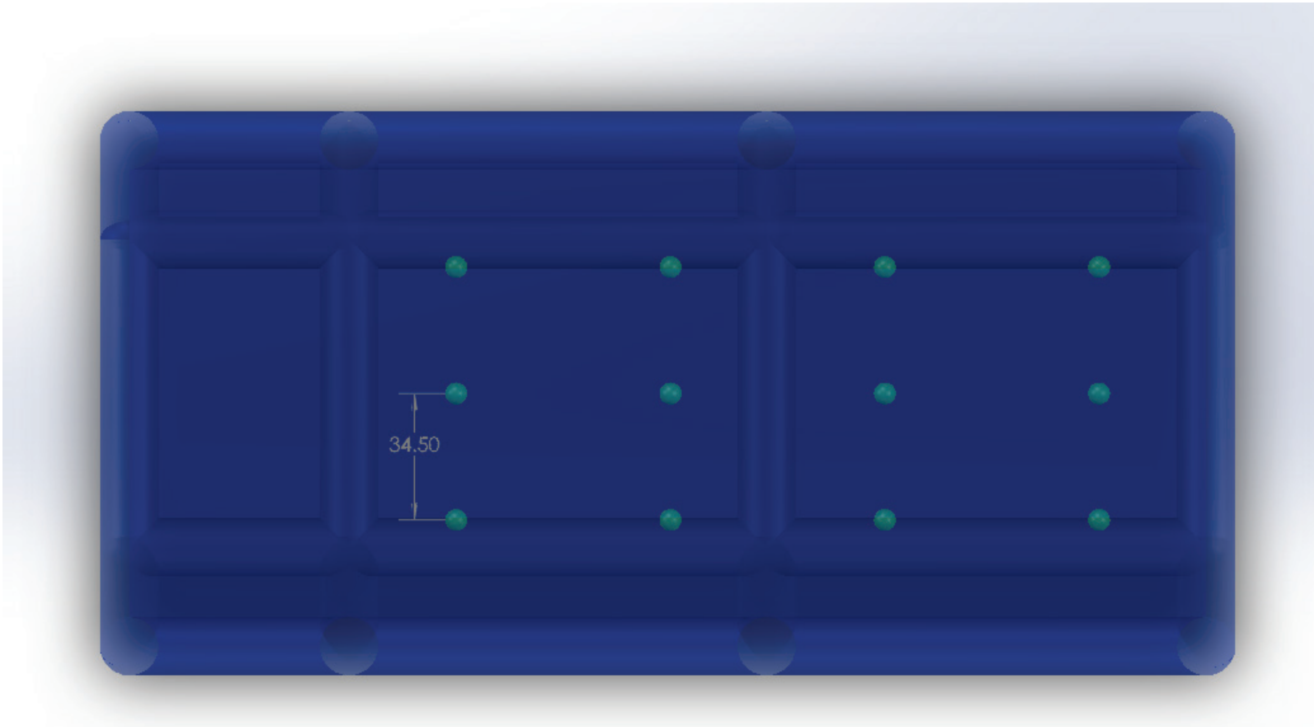


Figure A-7. Large enclosure: top view.

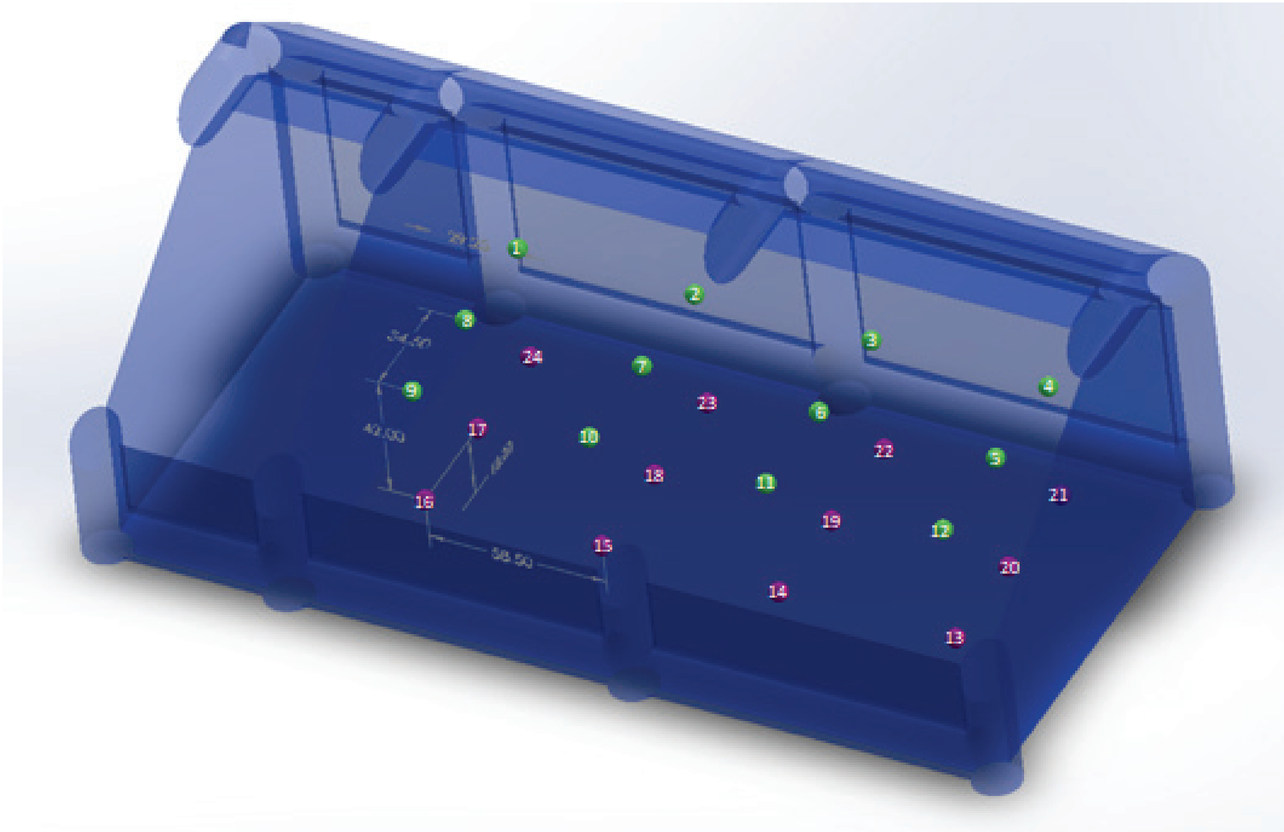


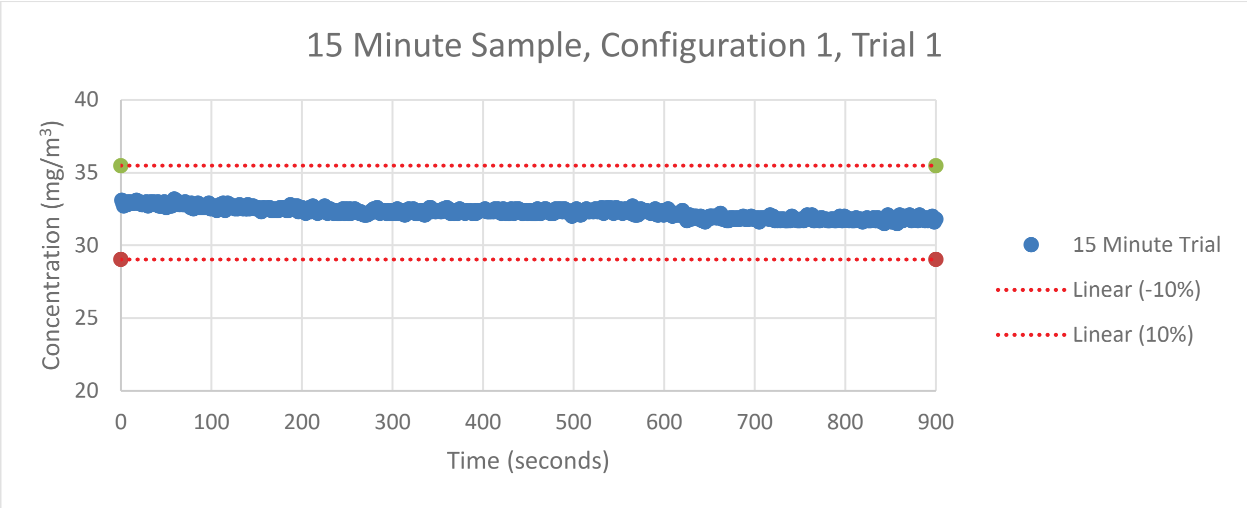
Figure A-8. Large enclosure: 3-D representation.
Note: numbers indicate order in which each location was sampled.

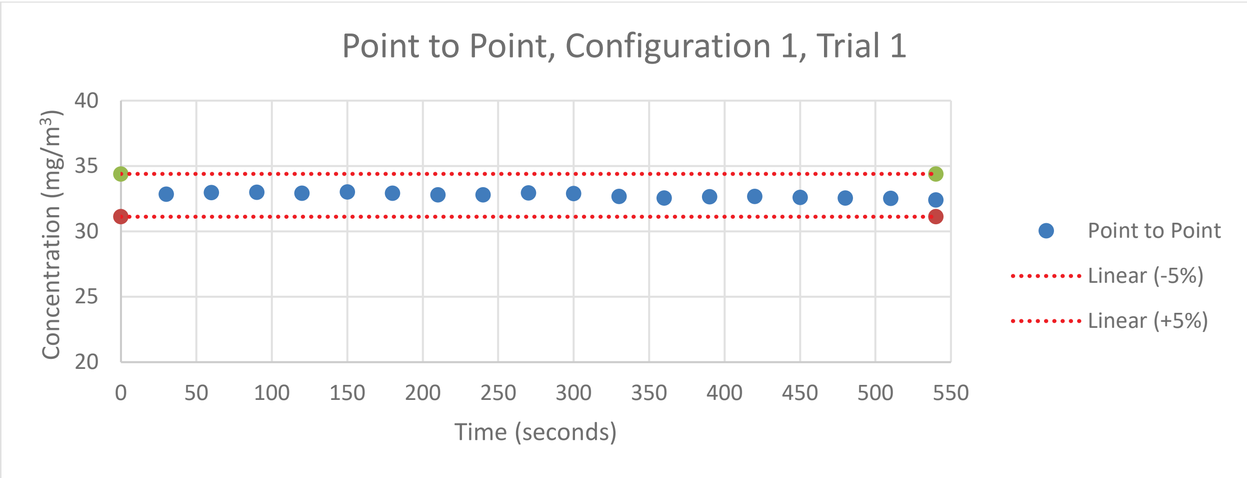
APPENDIX B

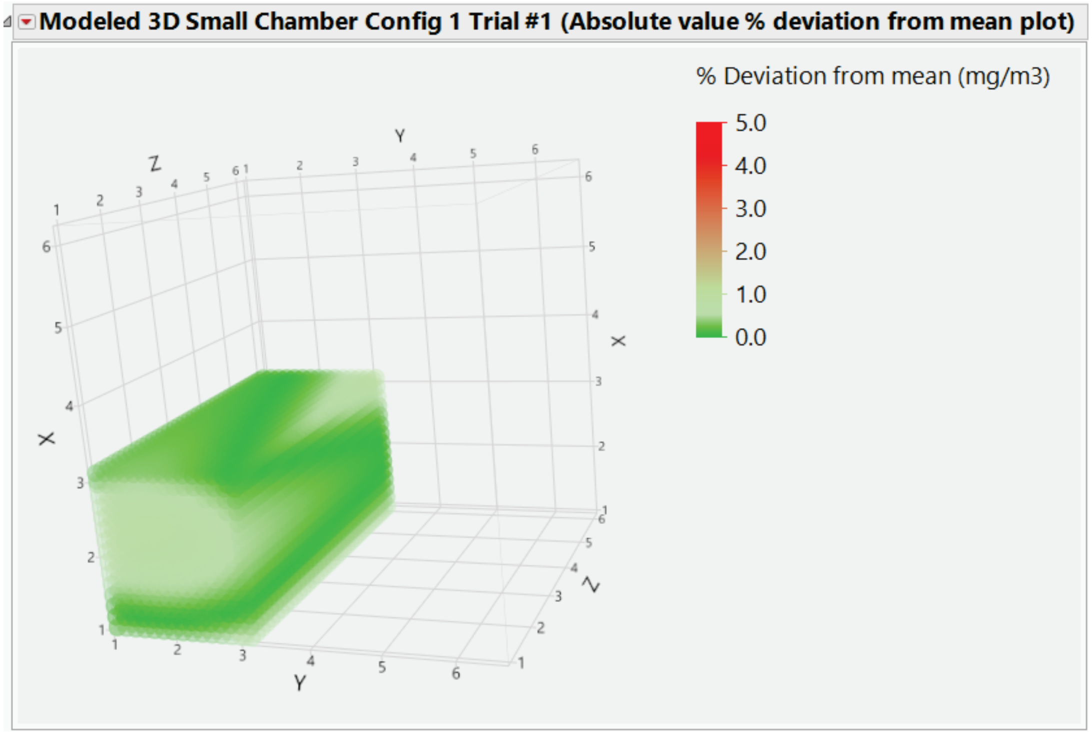
ENCLOSURE CONFIGURATION RAW DATA GRAPHS AND ENCLOSURE CONCENTRATION DISTRIBUTIONS

B.1 CONFIGURATION 1: TRIALS 1–7

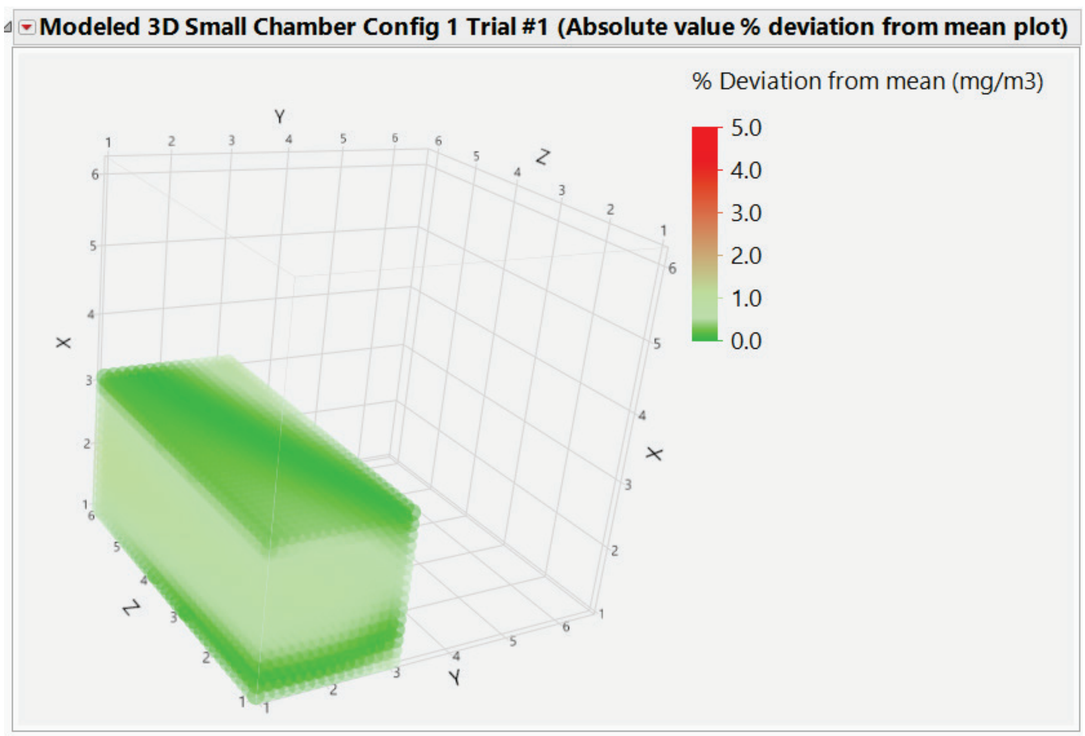
B.1.1 Configuration 1, Trial 1





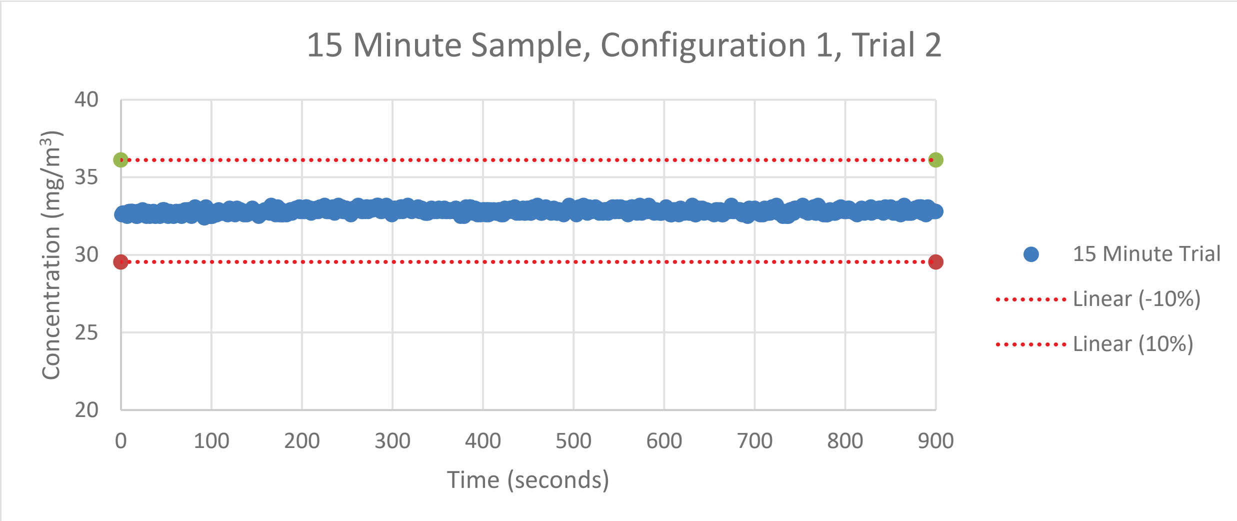


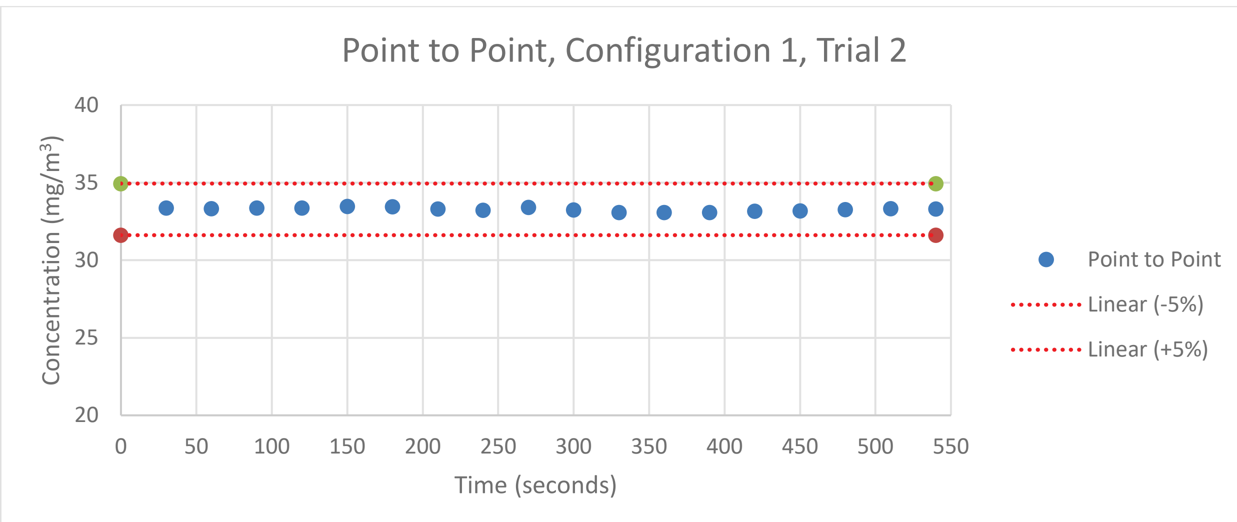
Point-to-point sampling, front-right view.

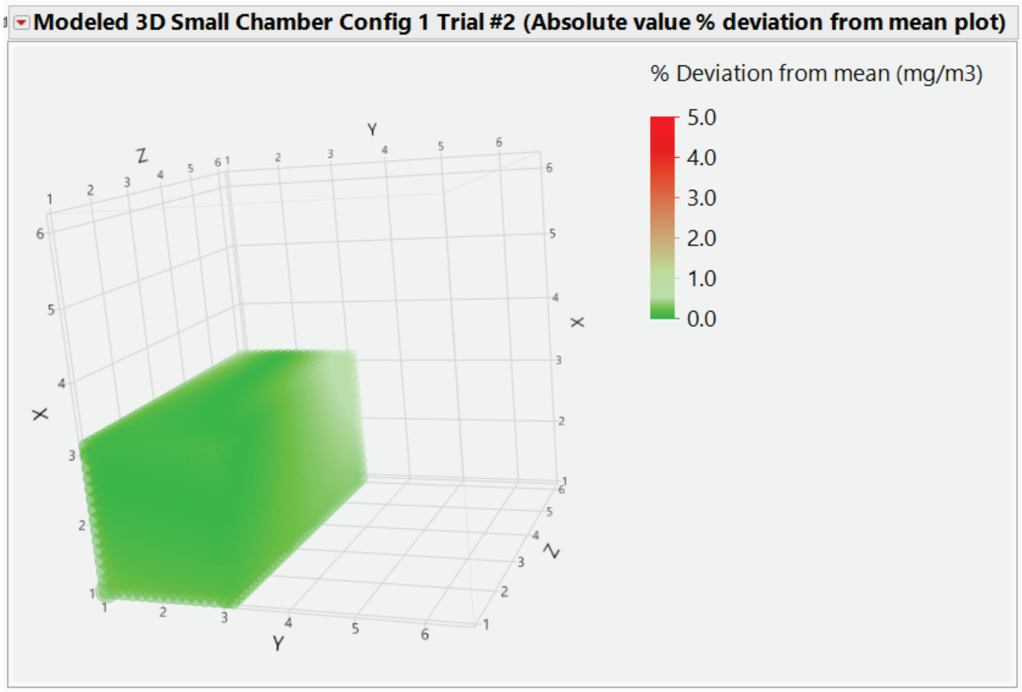


Point-to-point sampling, front-left view.

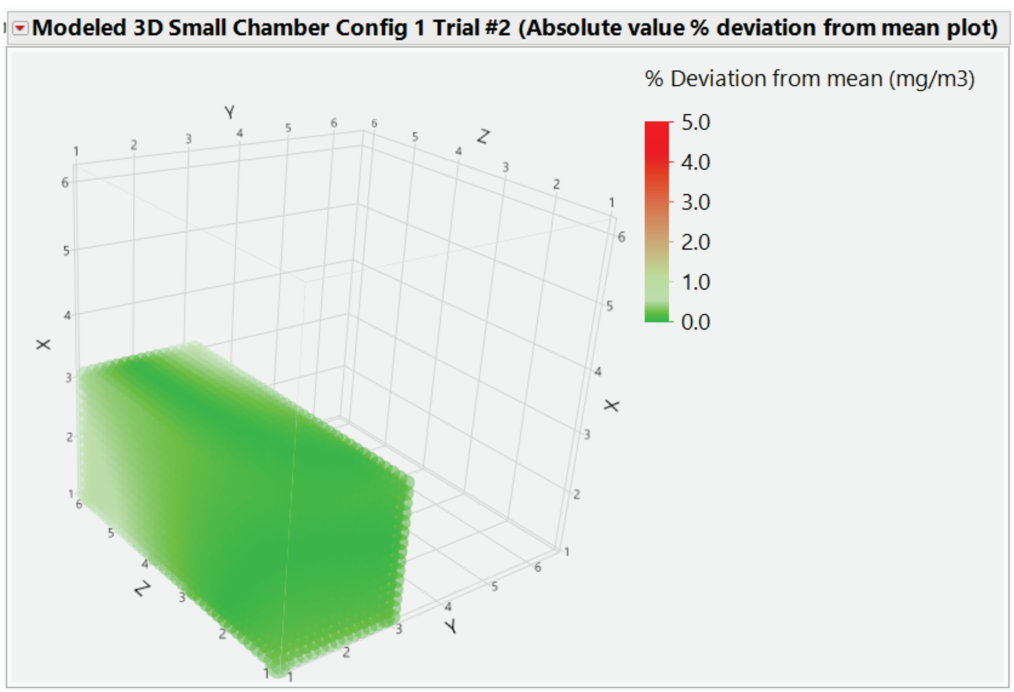
B.1.2 Configuration 1, Trial 2





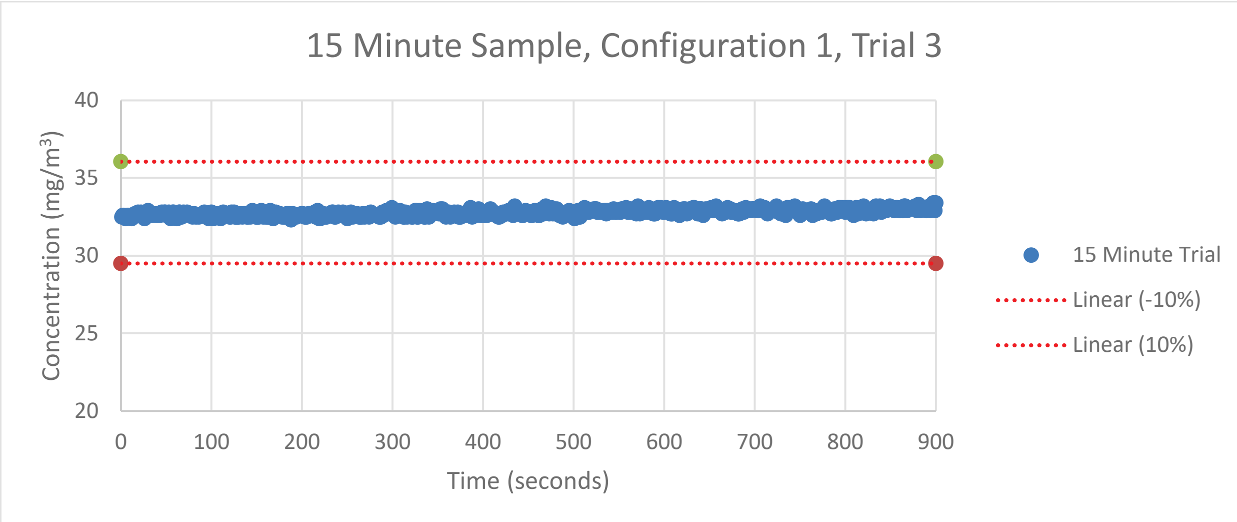


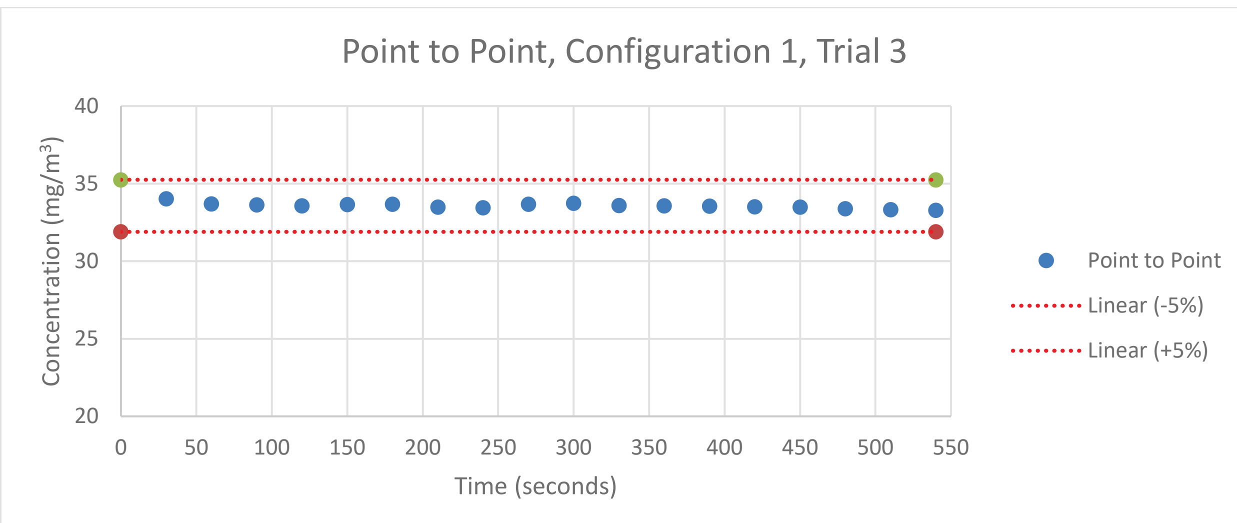
Point-to-point sampling, front-right view.

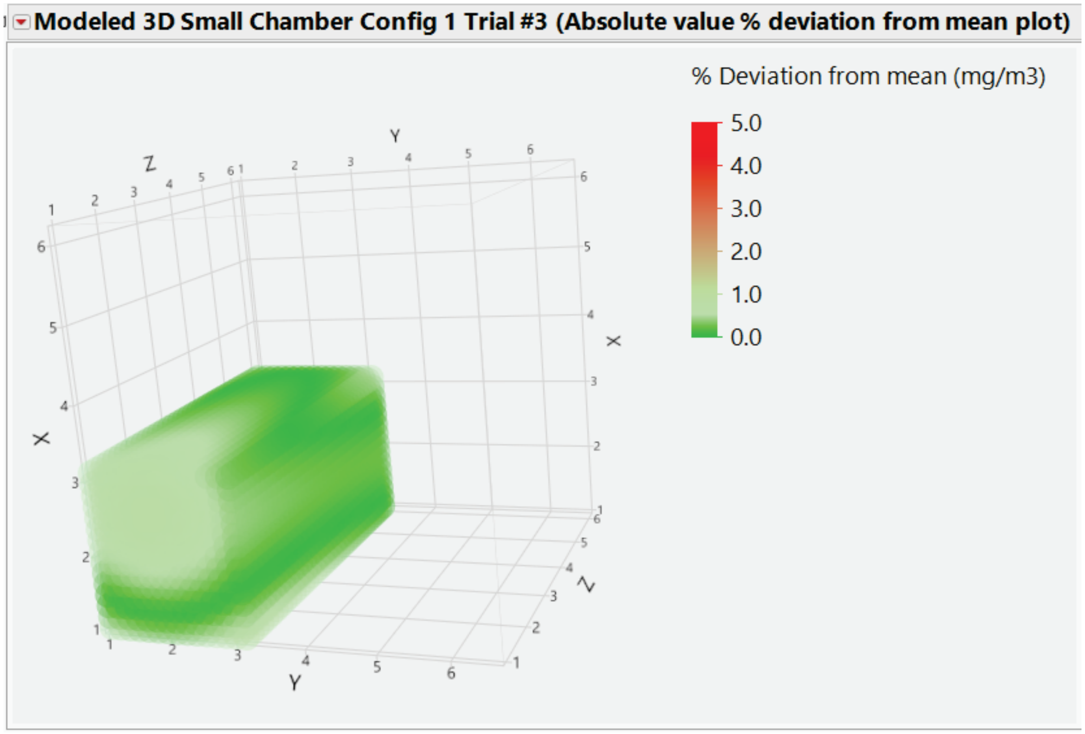


Point-to-point sampling, front-left view.

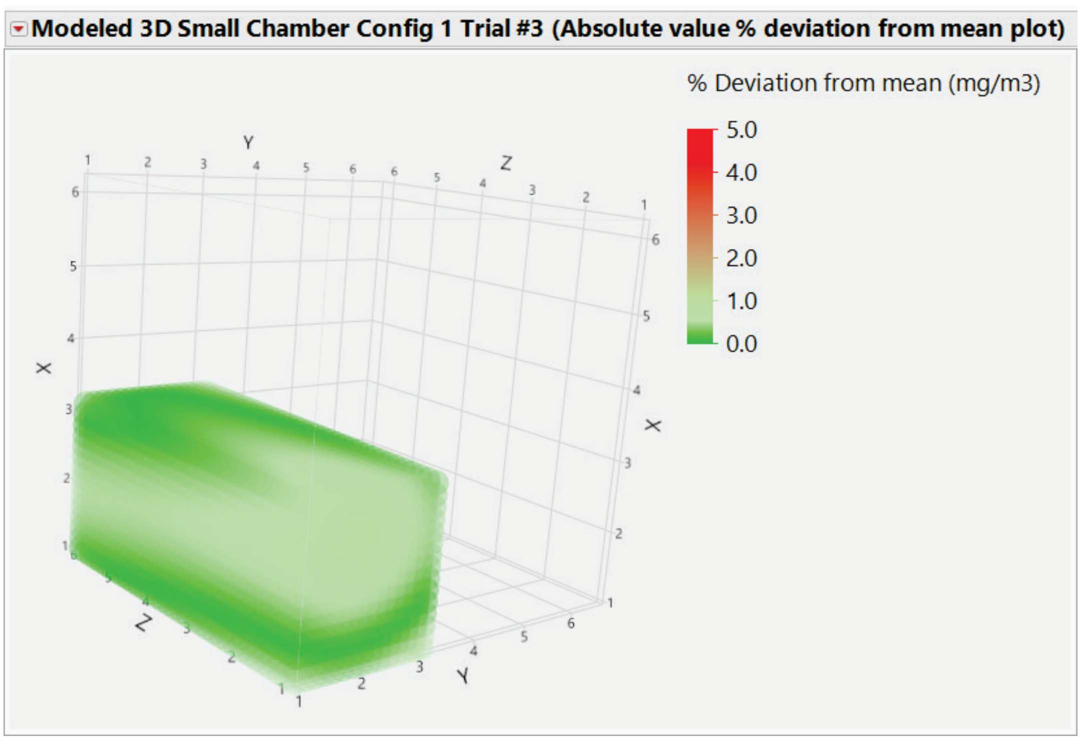
B.1.3 Configuration 1, Trial 3





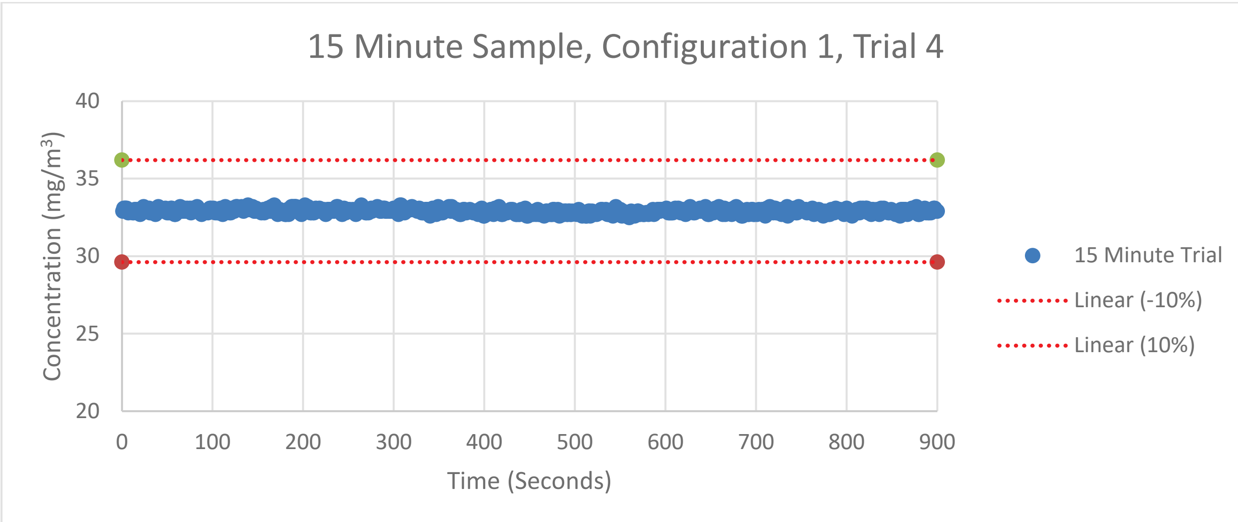


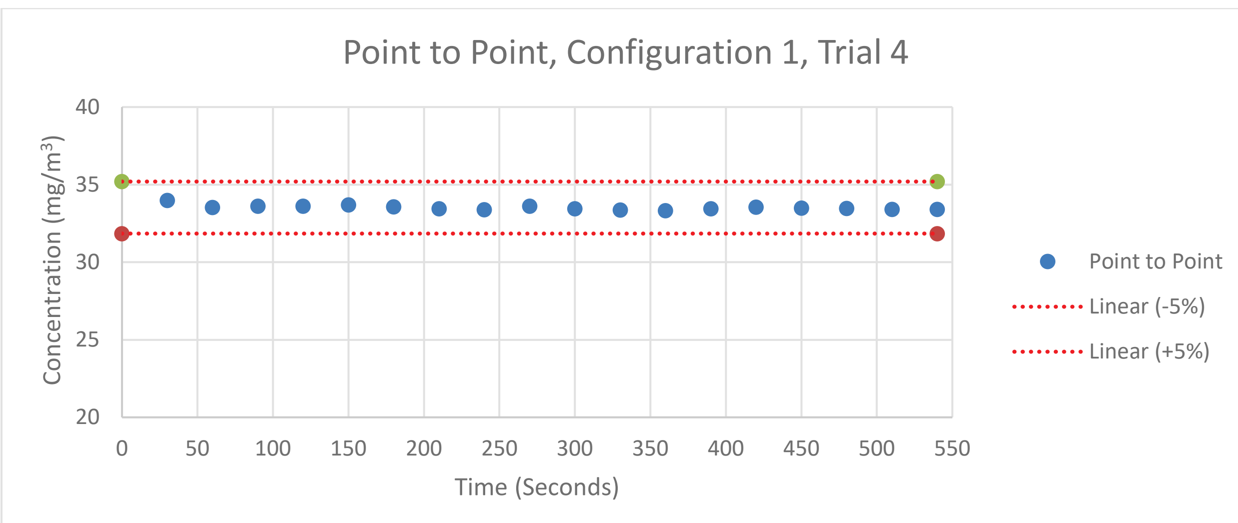
Point-to-point sampling, front-right view.

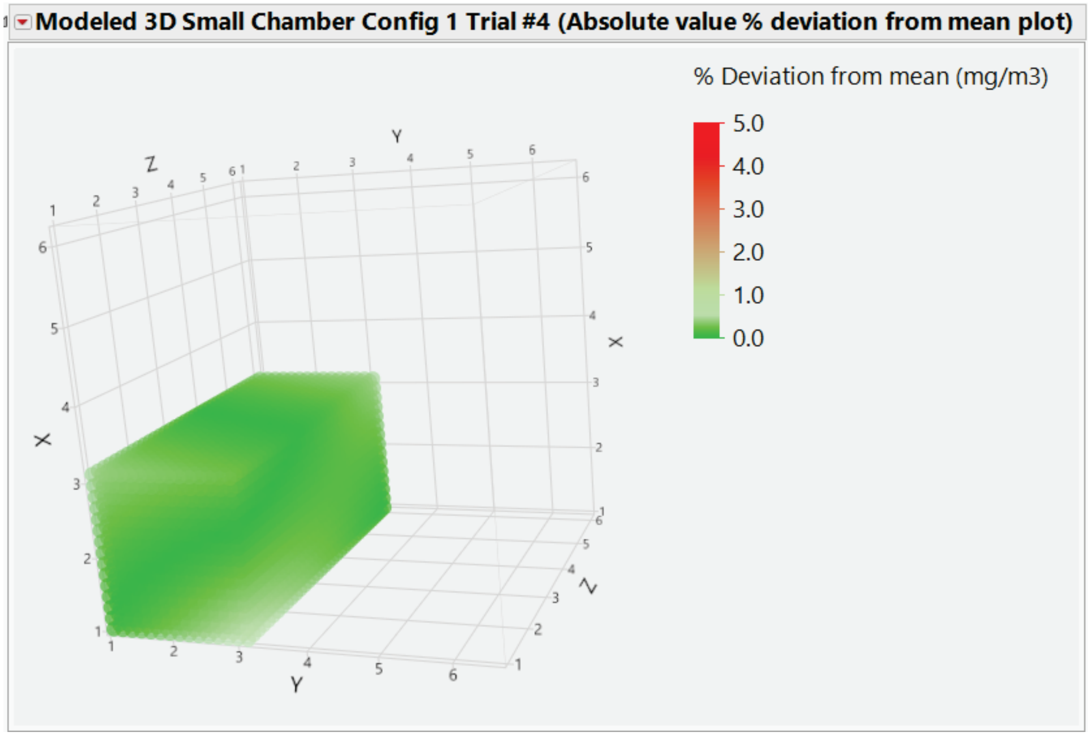


Point-to-point sampling, front-left view.

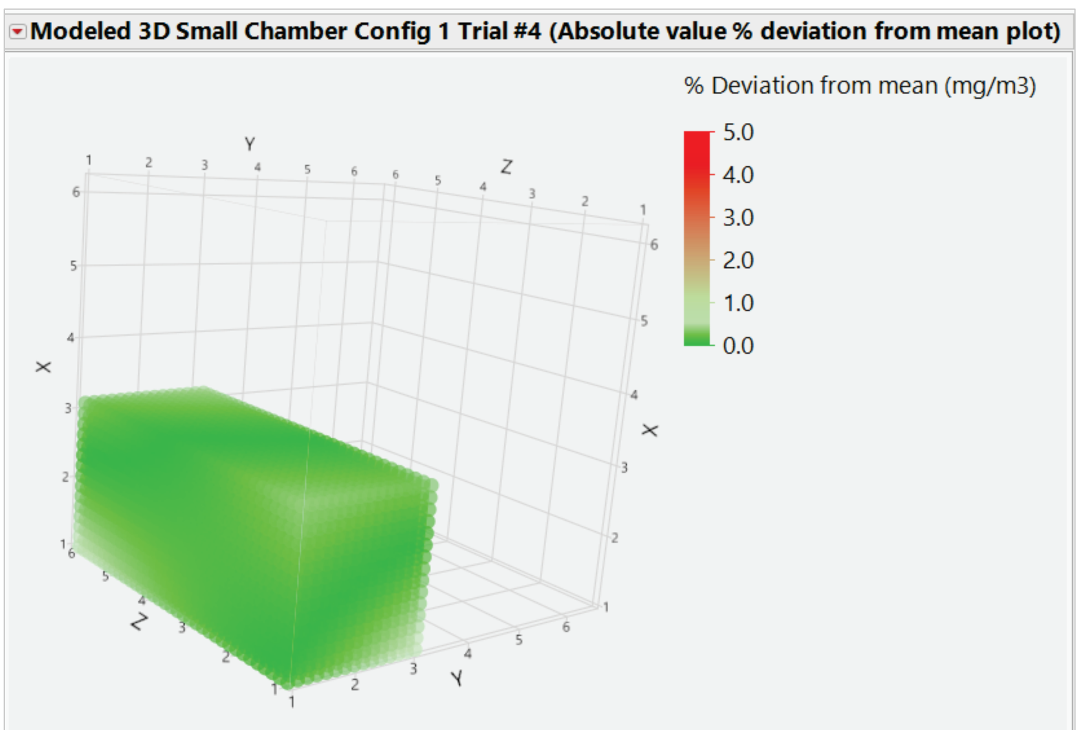
B.1.4 Configuration 1, Trial 4





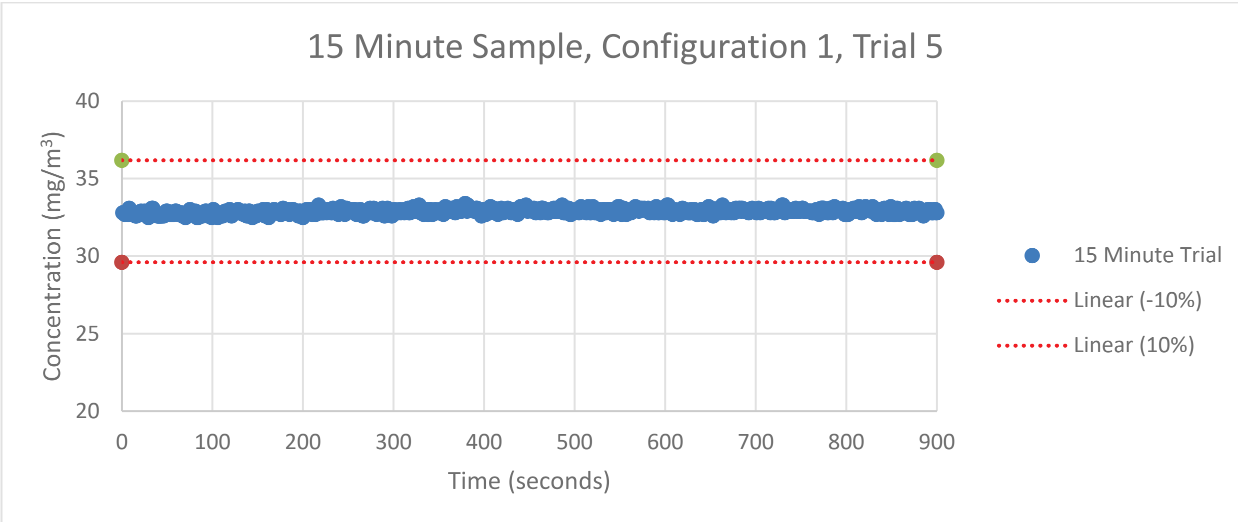


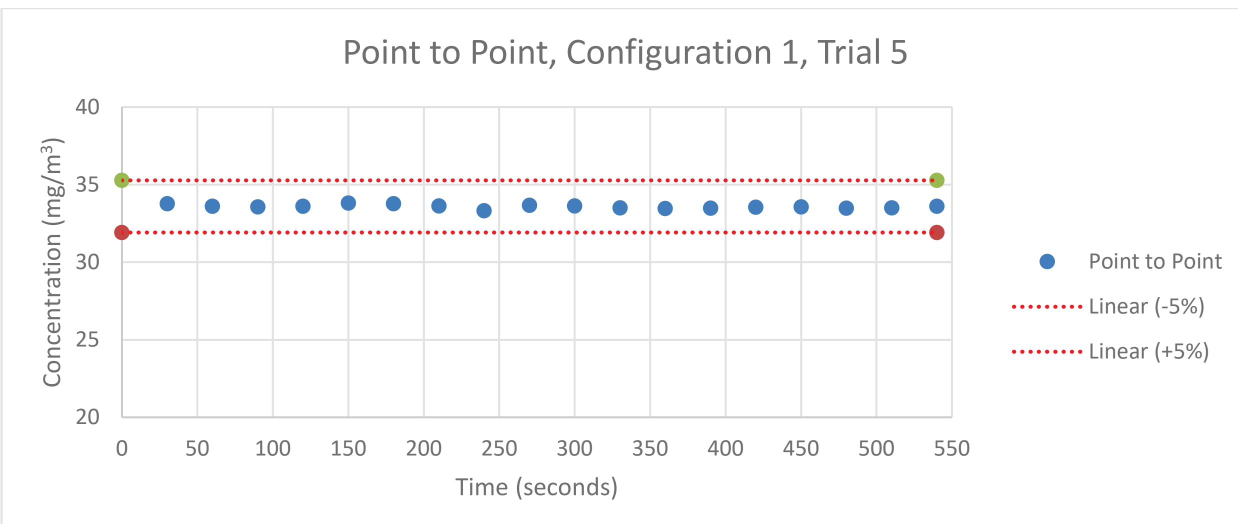
Point-to-point sampling, front-right view.

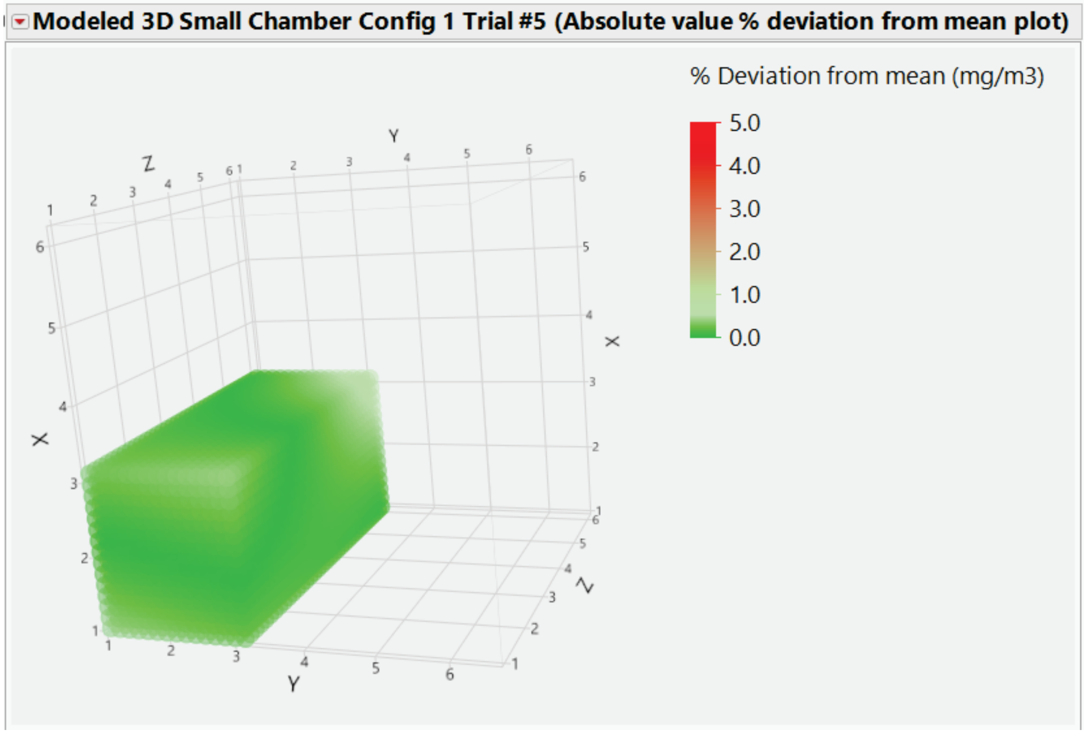


Point-to-point sampling, front-left view.

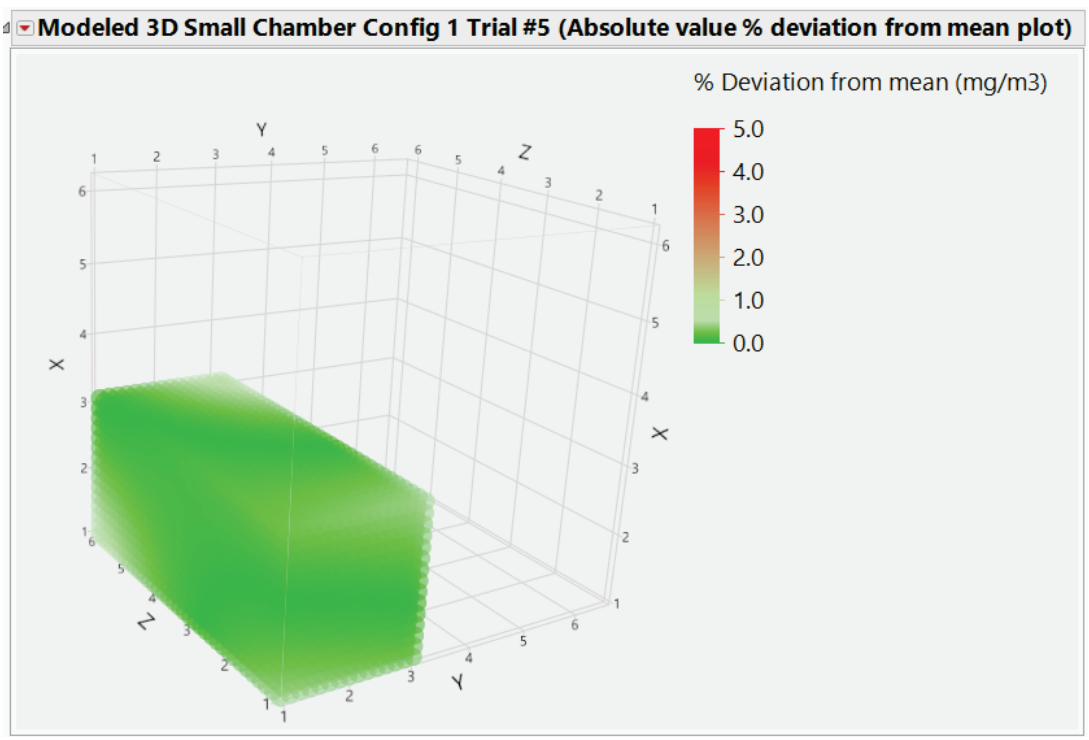
B.1.5 Configuration 1, Trial 5





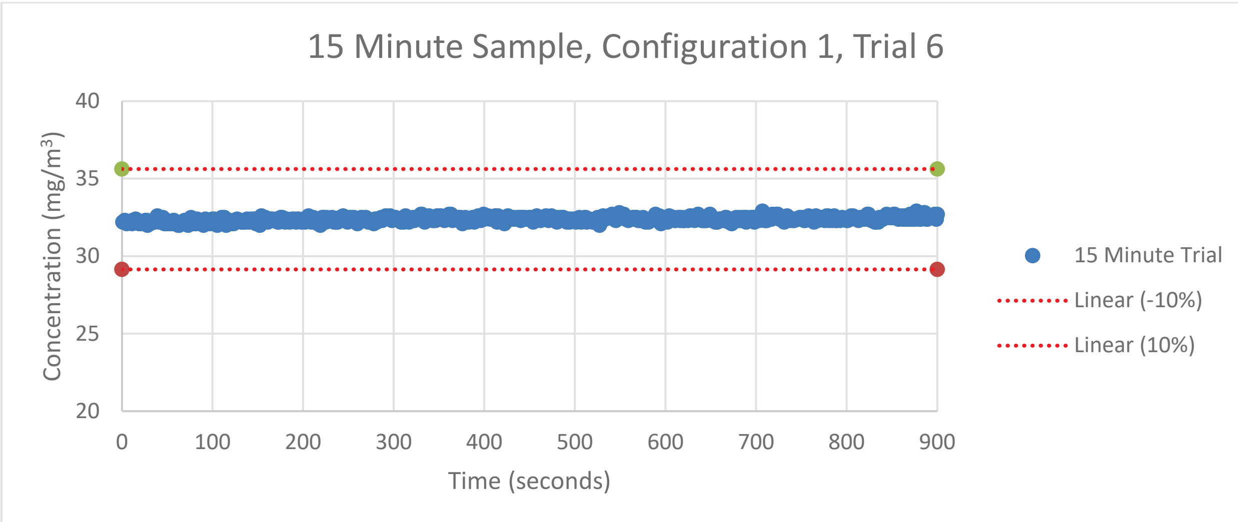


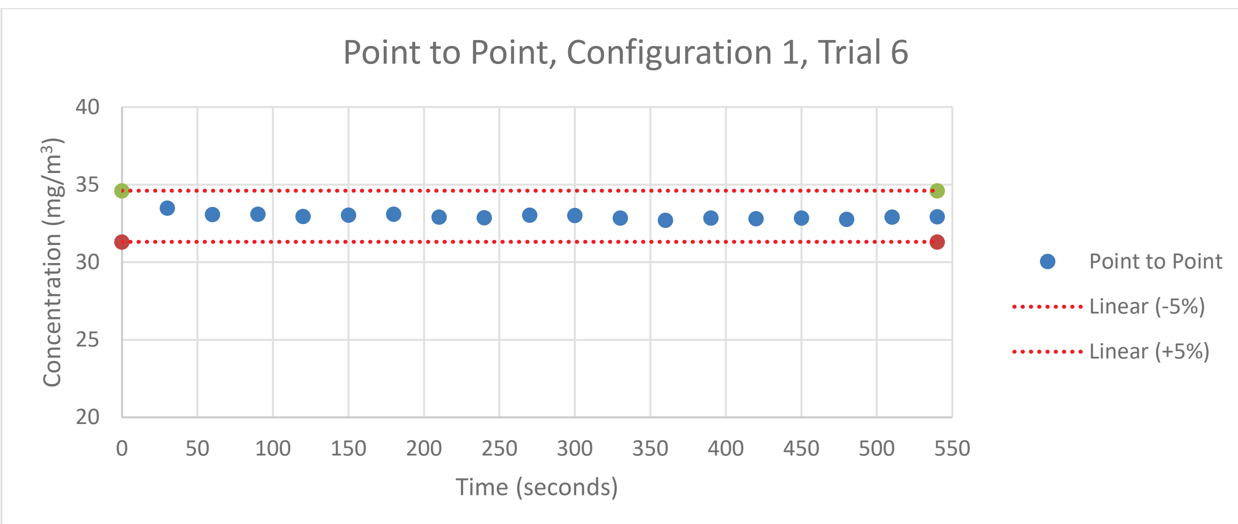
Point-to-point sampling, front-right view.

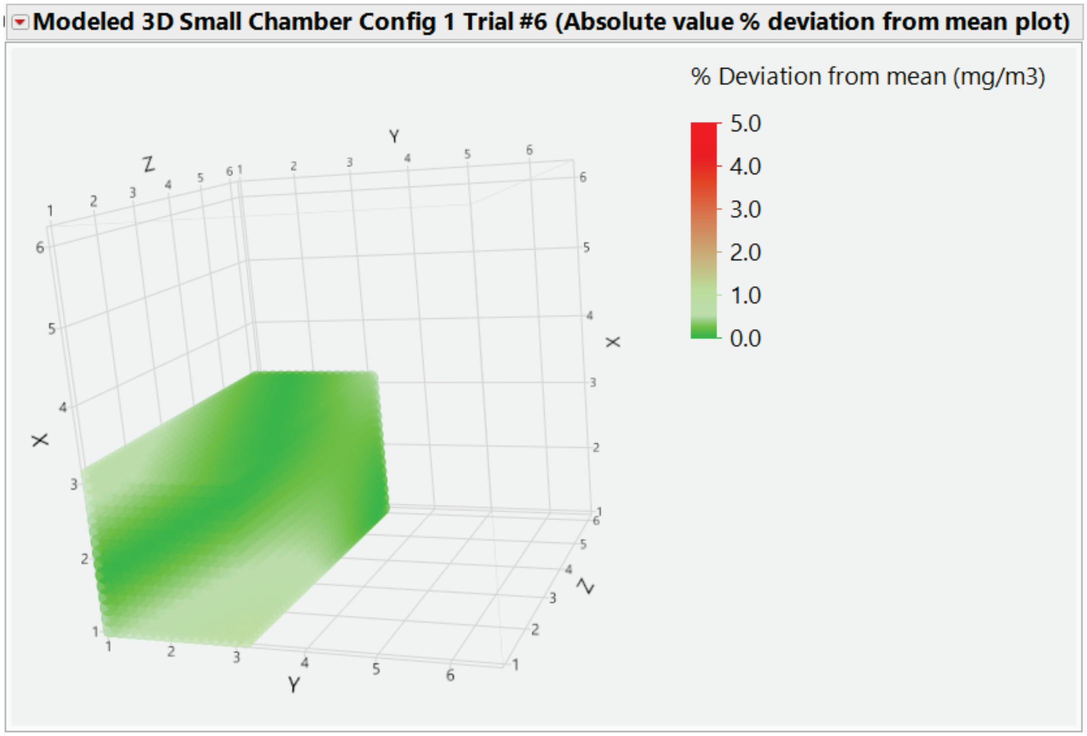


Point-to-point sampling, front-left view.

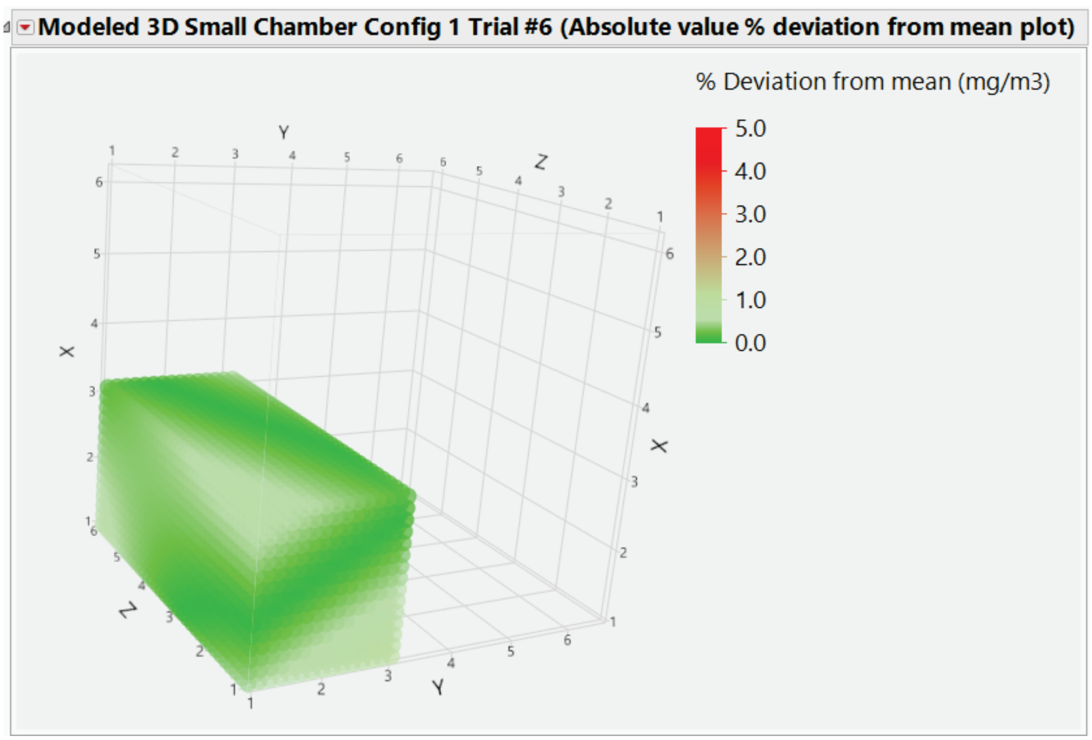
B.1.6 Configuration 1, Trial 6





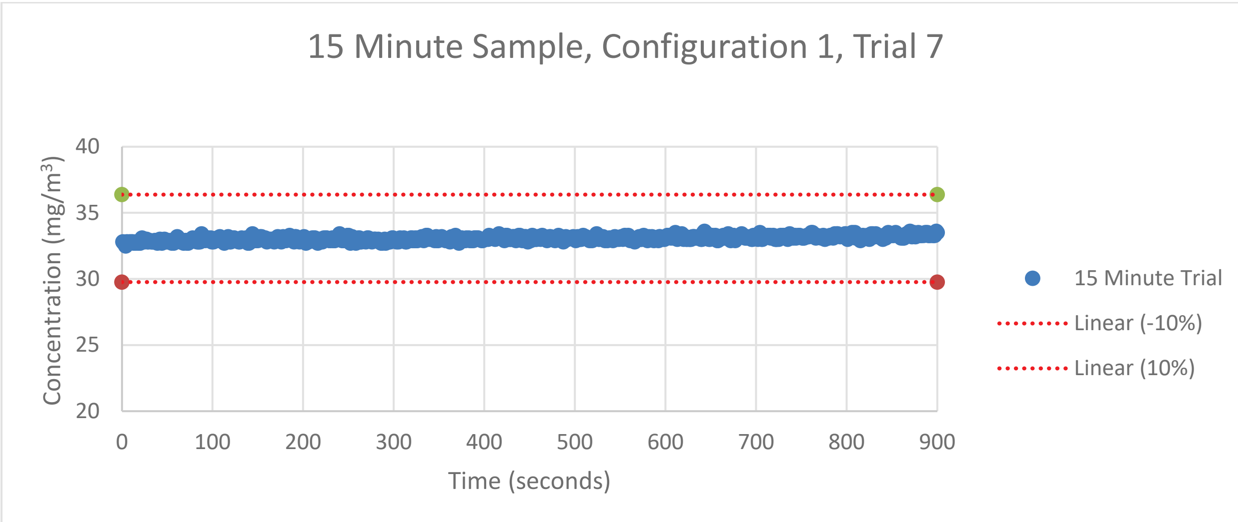


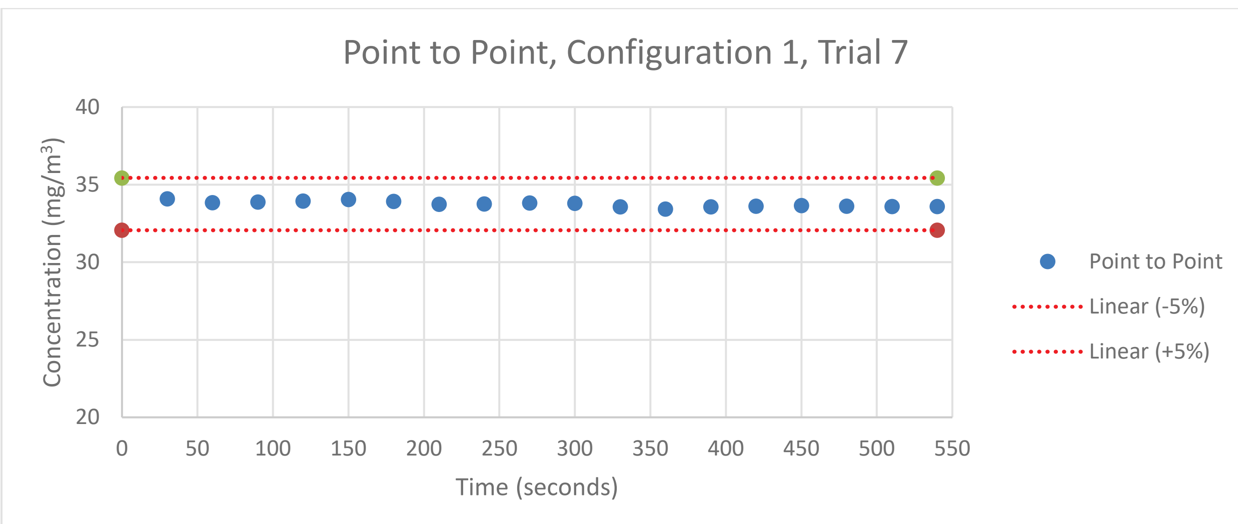
Point-to-point sampling, front-right view.

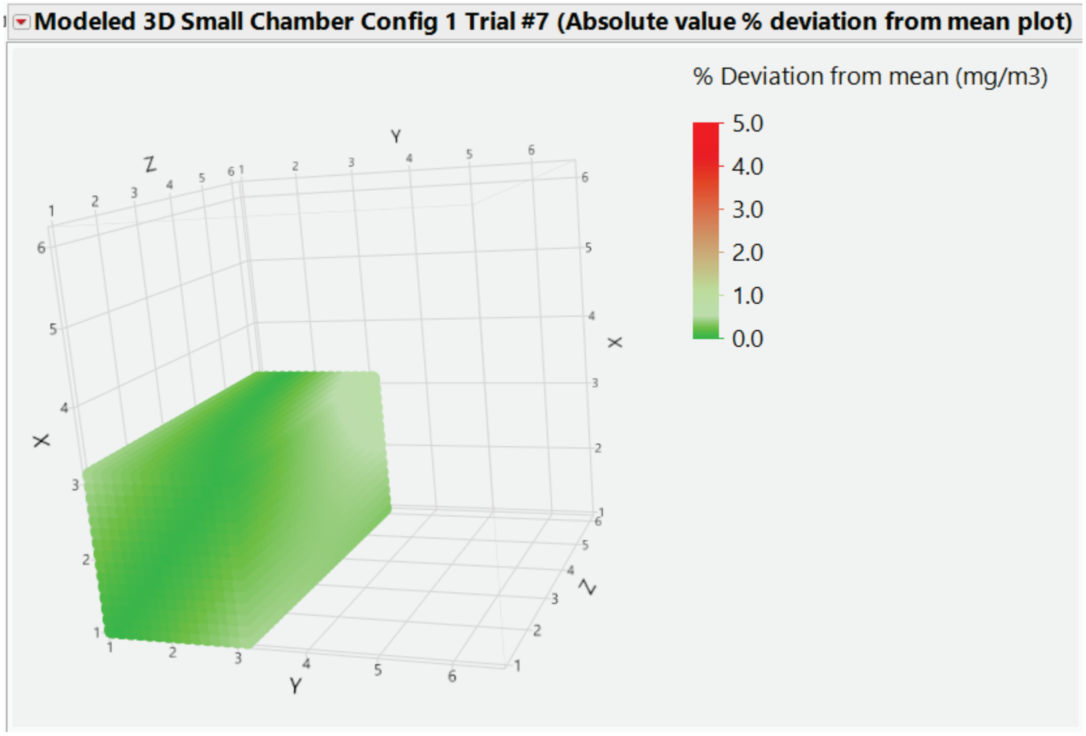


Point-to-point sampling, front-left view.

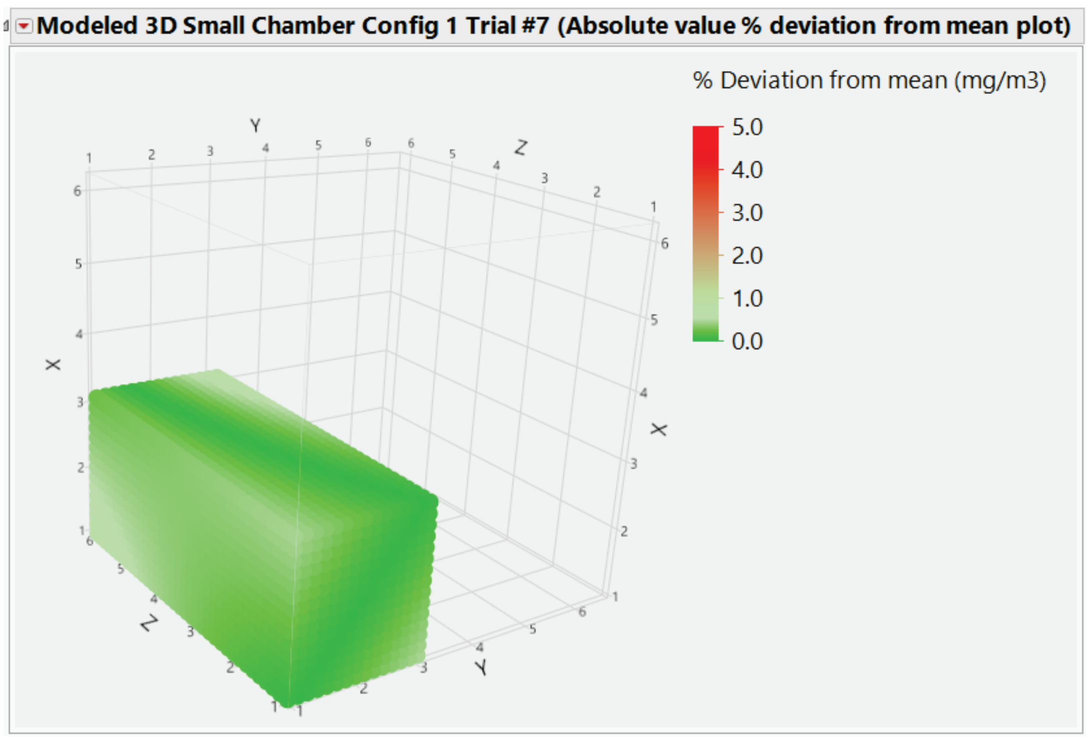
B.1.7 Configuration 1, Trial 7







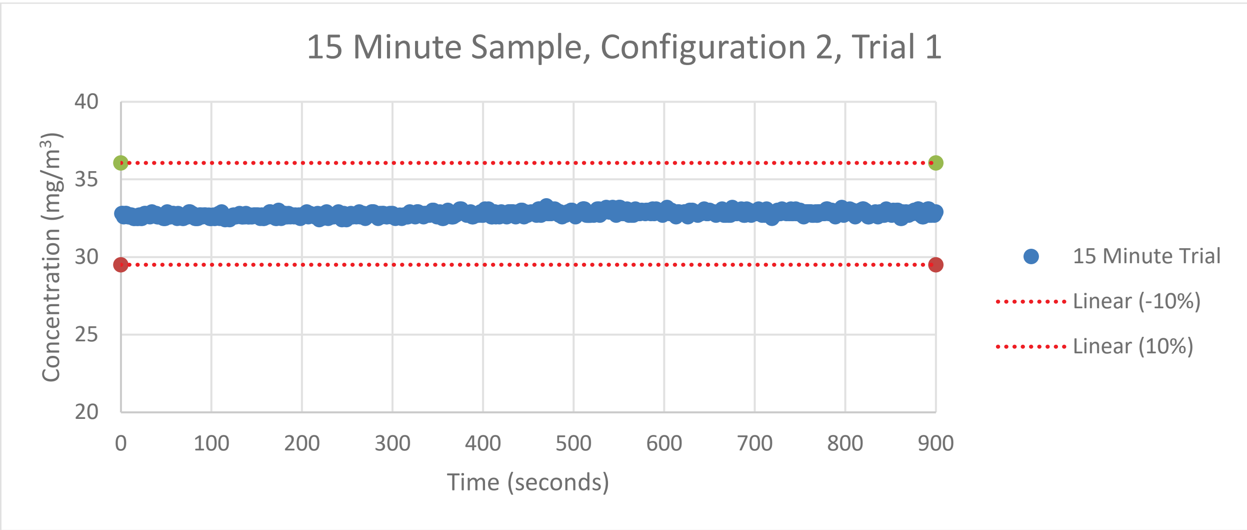
Point-to-point sampling, front-right view.

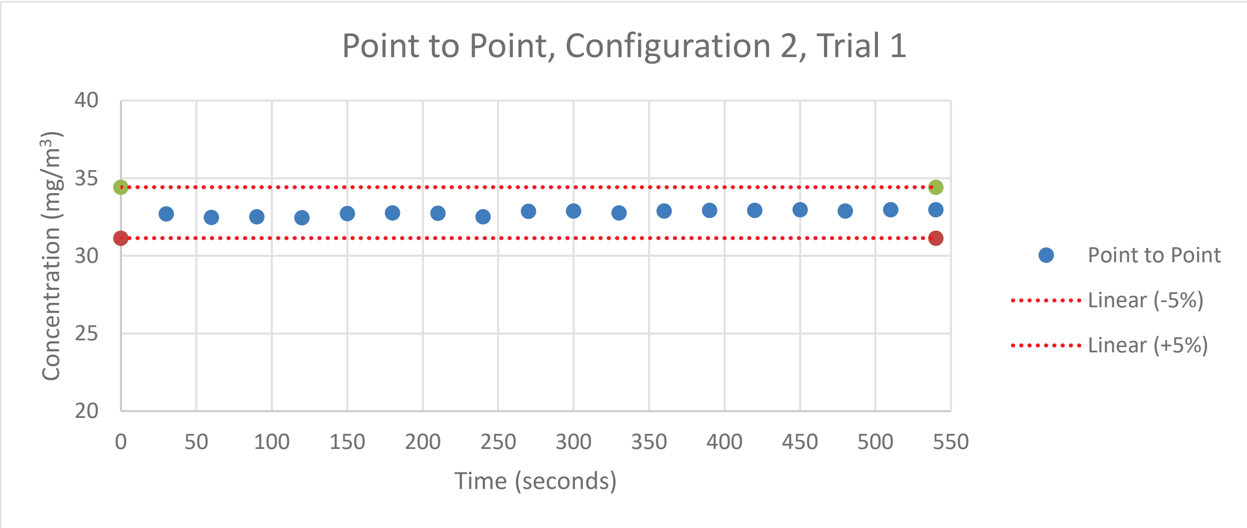


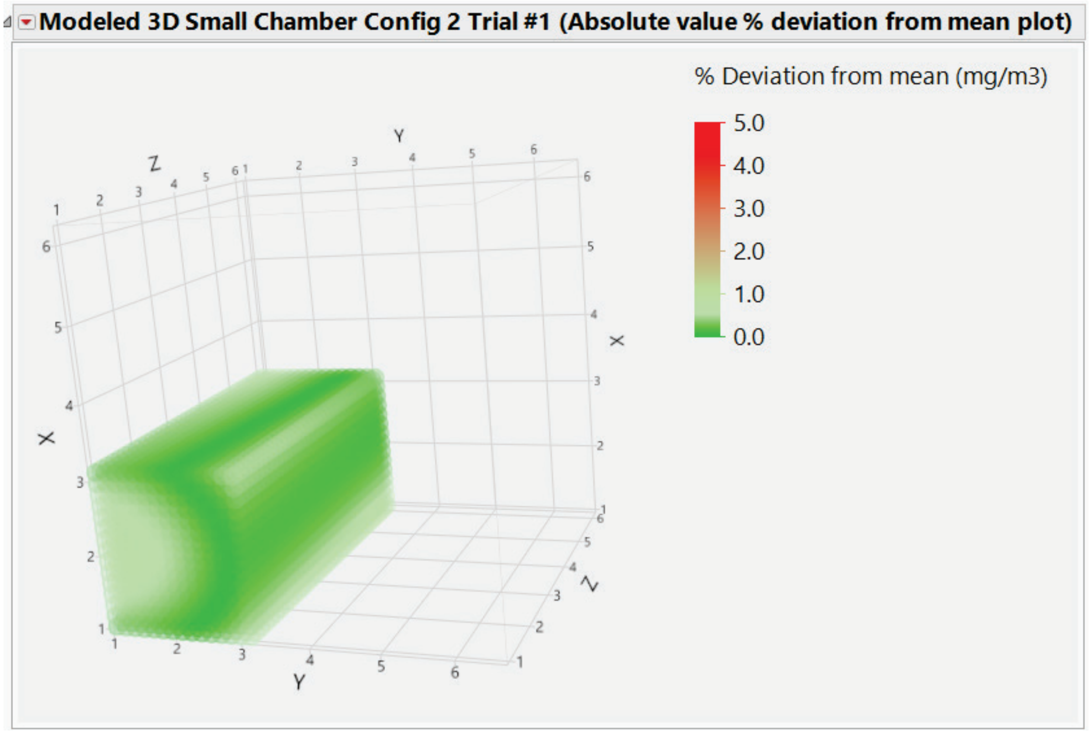
Point-to-point sampling, front-left view.

B.2 CONFIGURATION 2: TRIALS 1–7

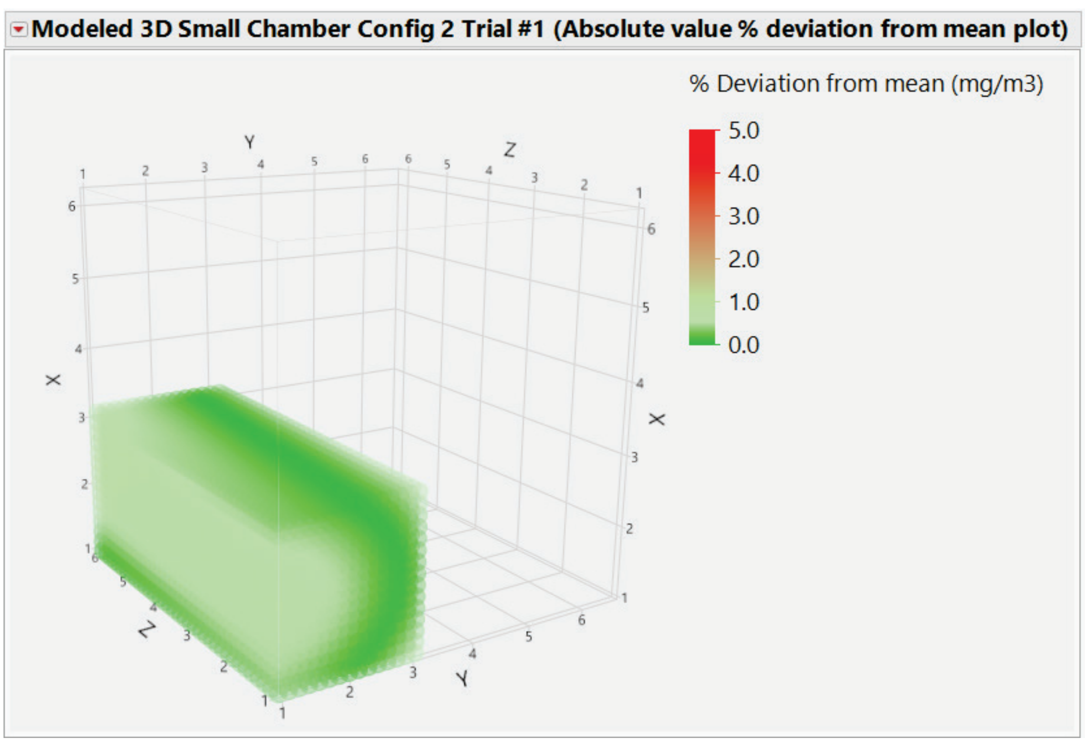
B.2.1 Configuration 2, Trial 1





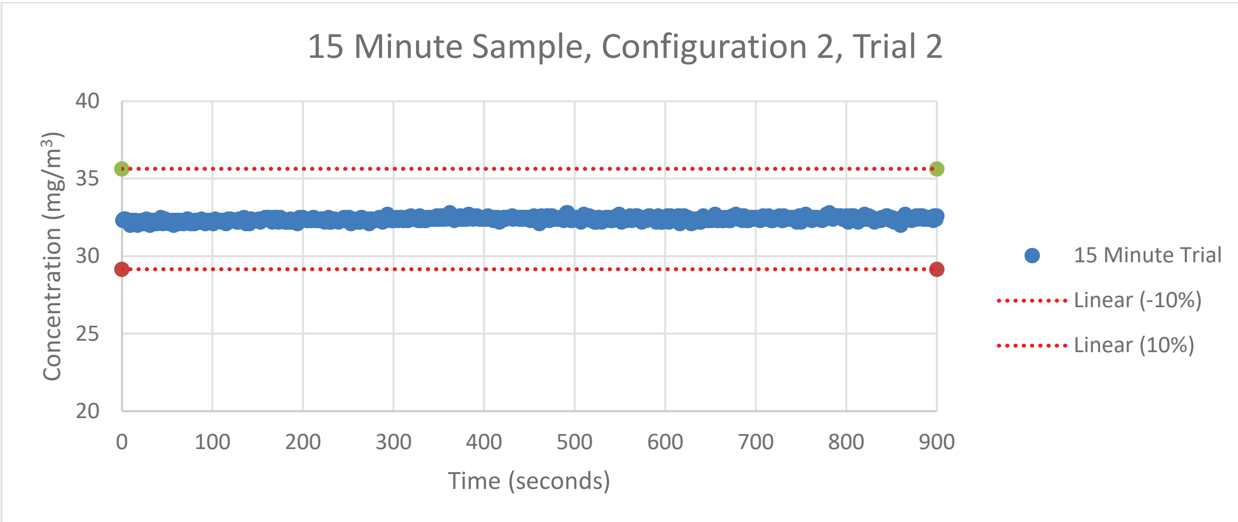


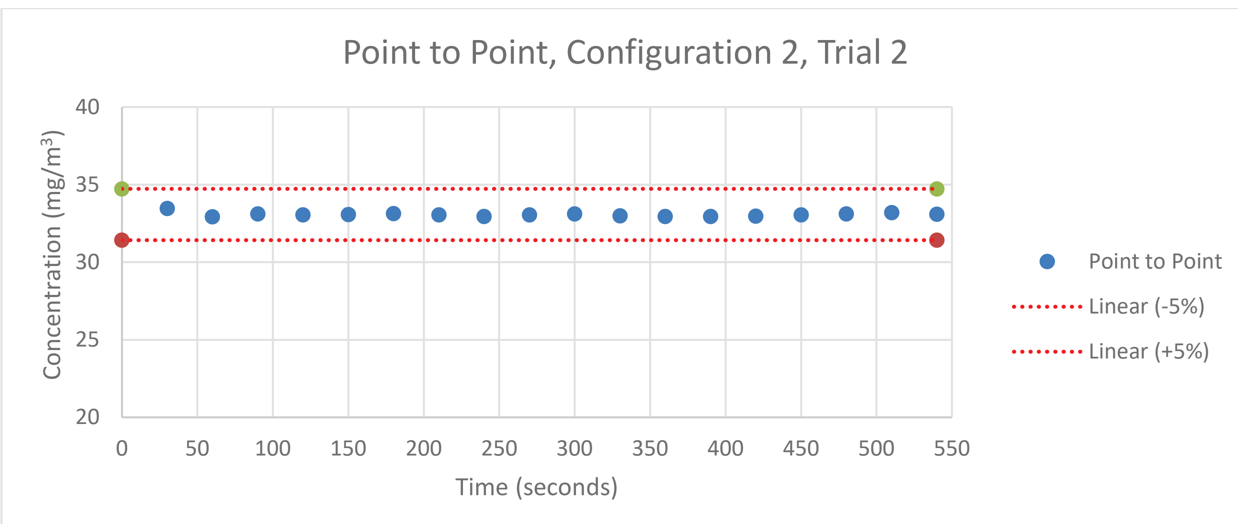
Point-to-point sampling, front-right view.

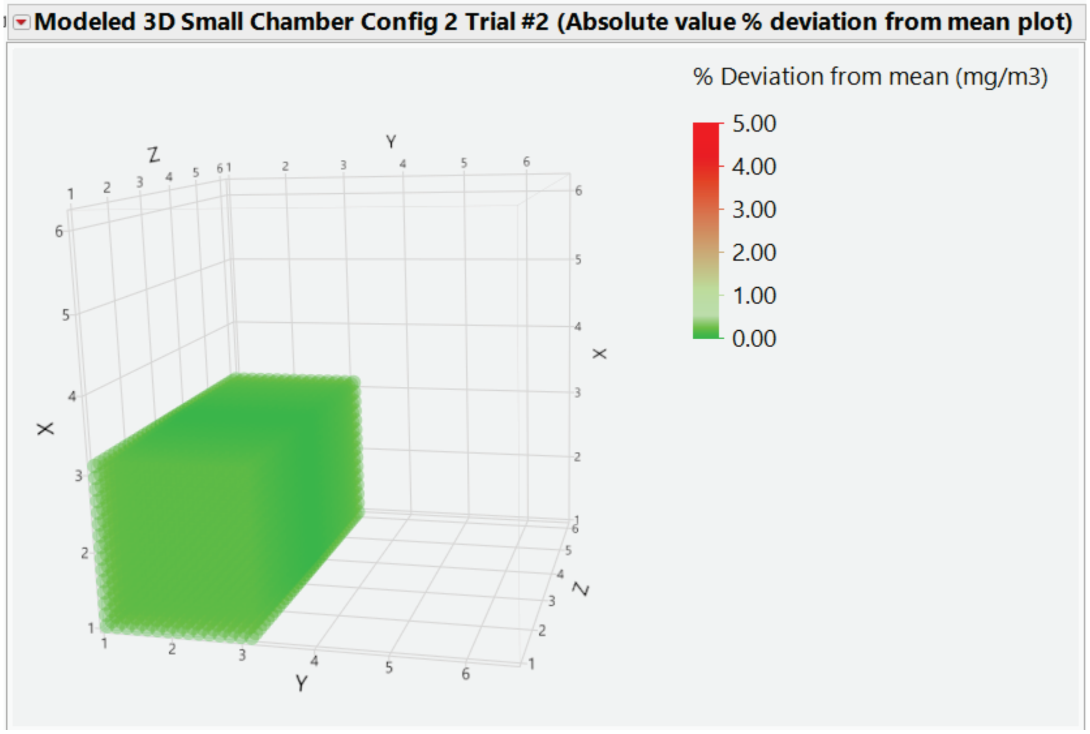


Point-to-point sampling, front-left view.

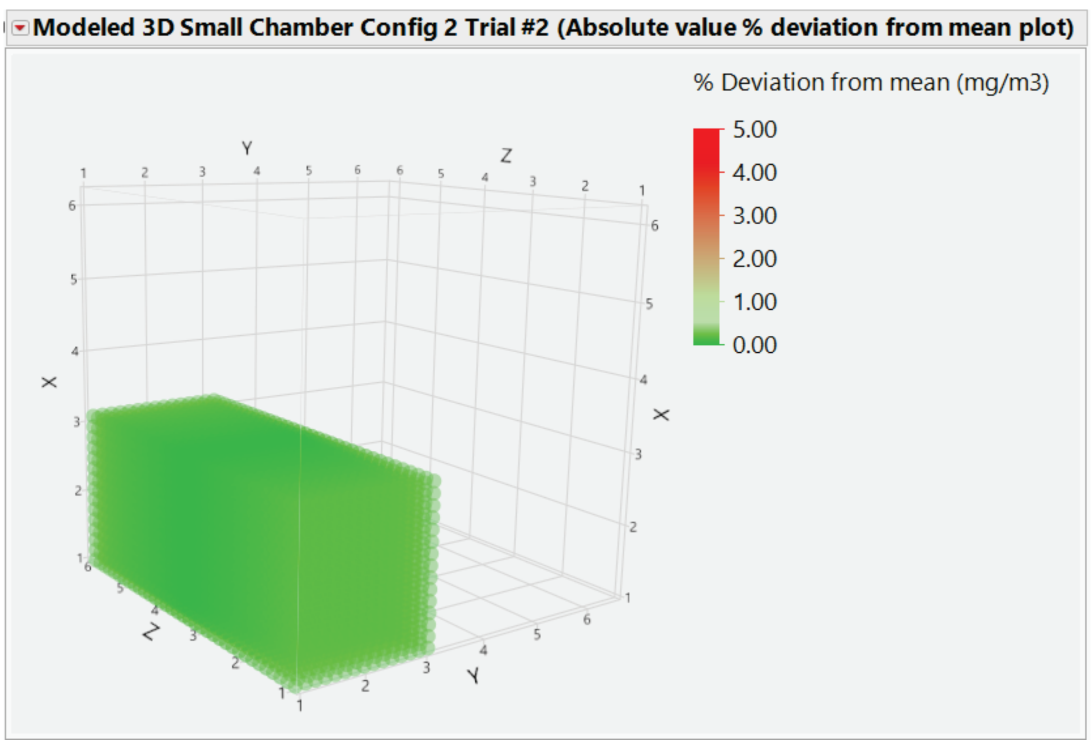
B.2.2 Configuration 2, Trial 2





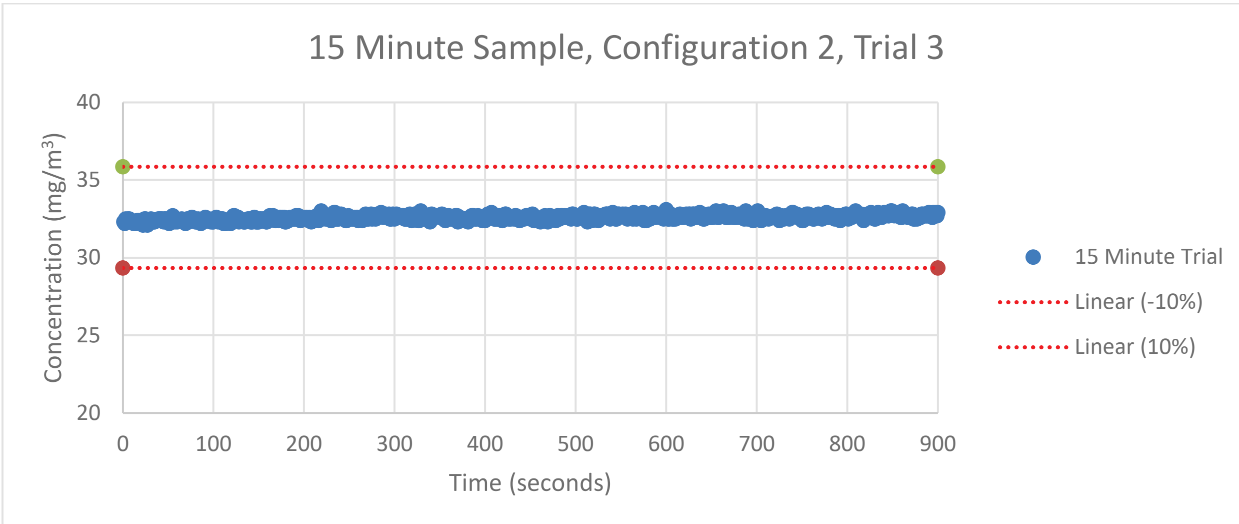


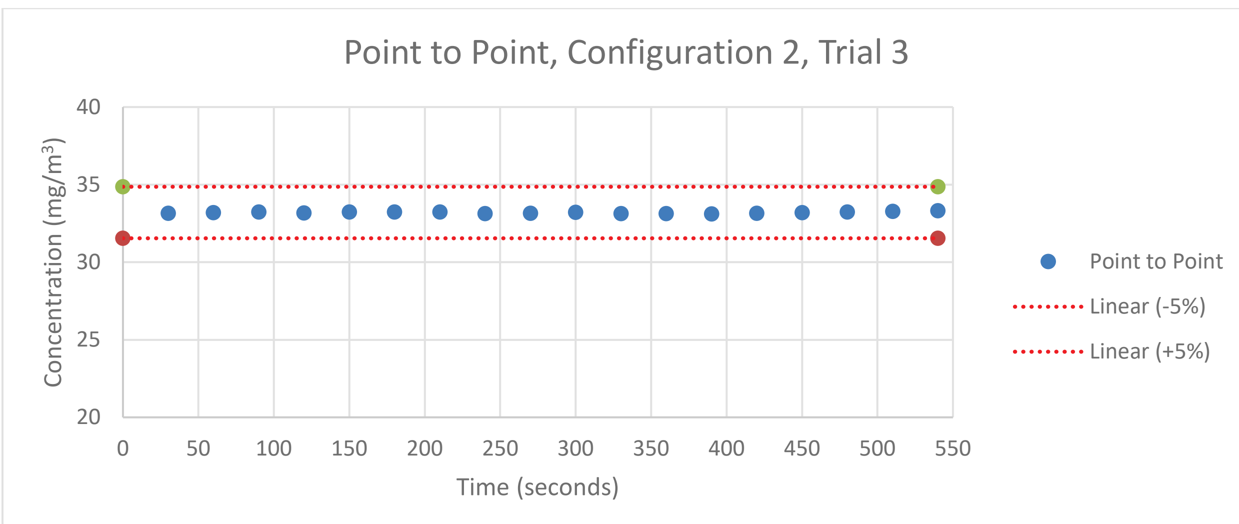
Point-to-point sampling, front-right view.

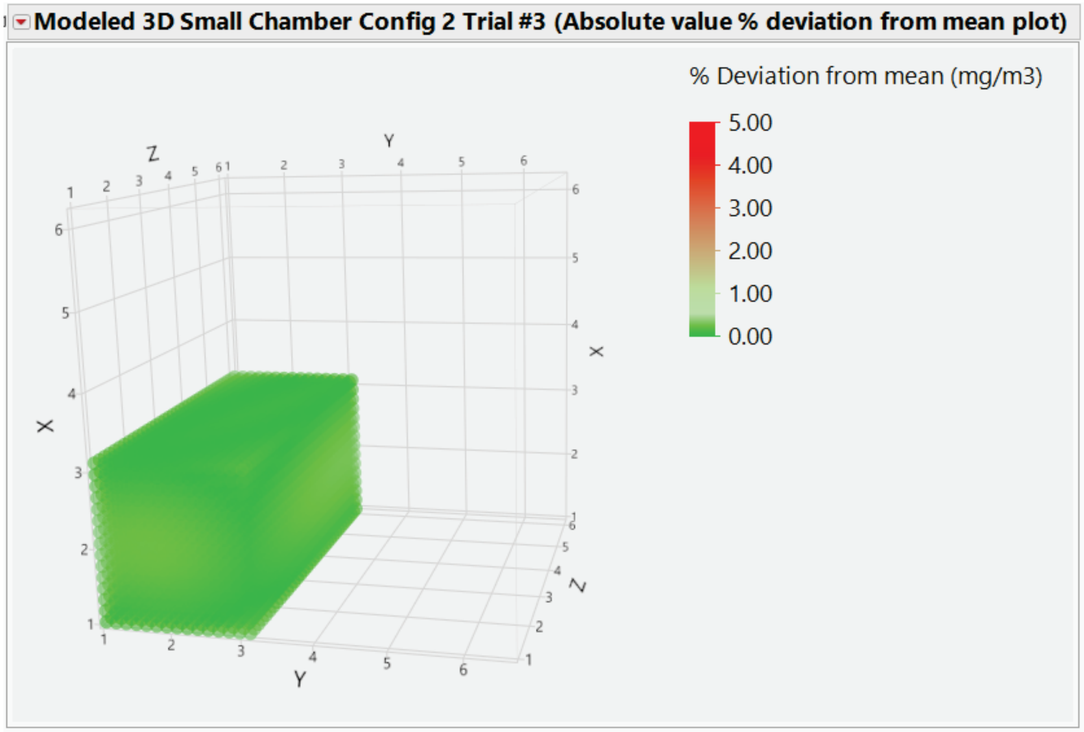


Point-to-point sampling, front-left view.

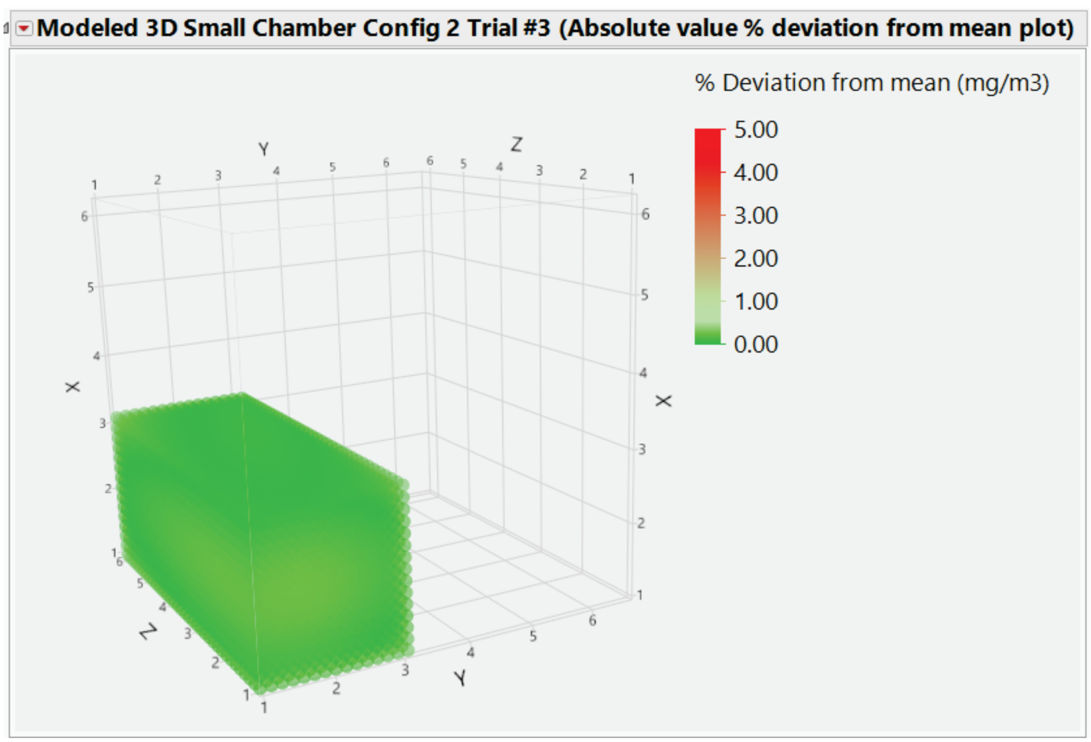
B.2.3 Configuration 2, Trial 3





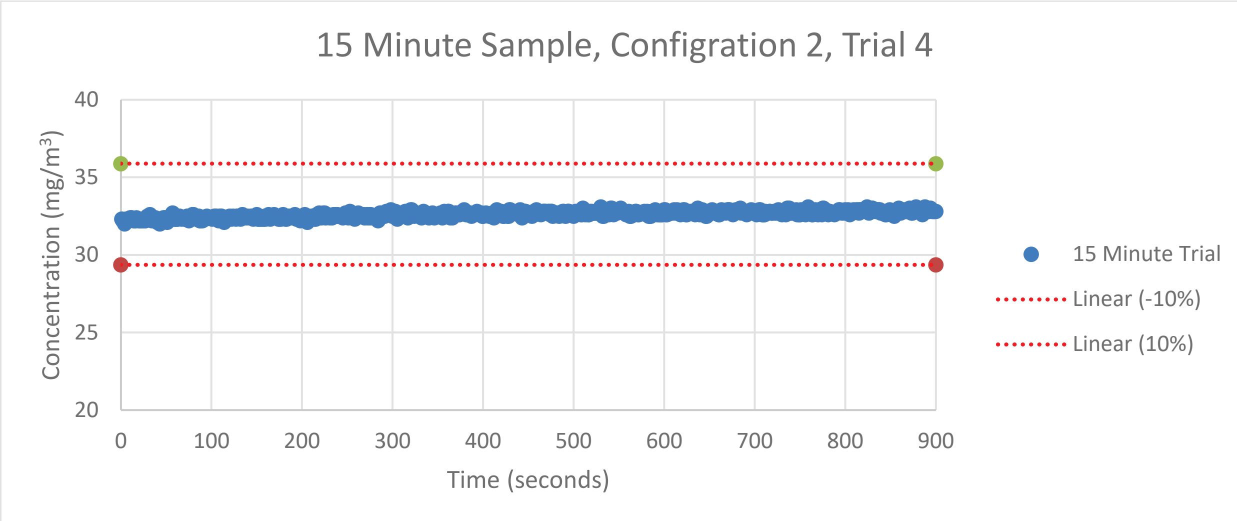


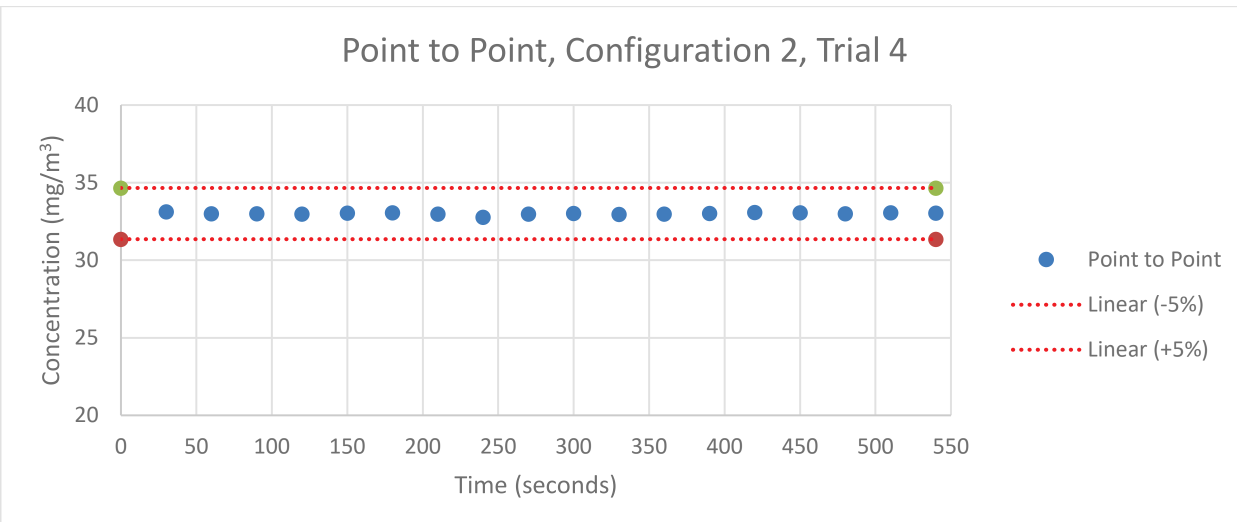
Point-to-point sampling, front-right view.

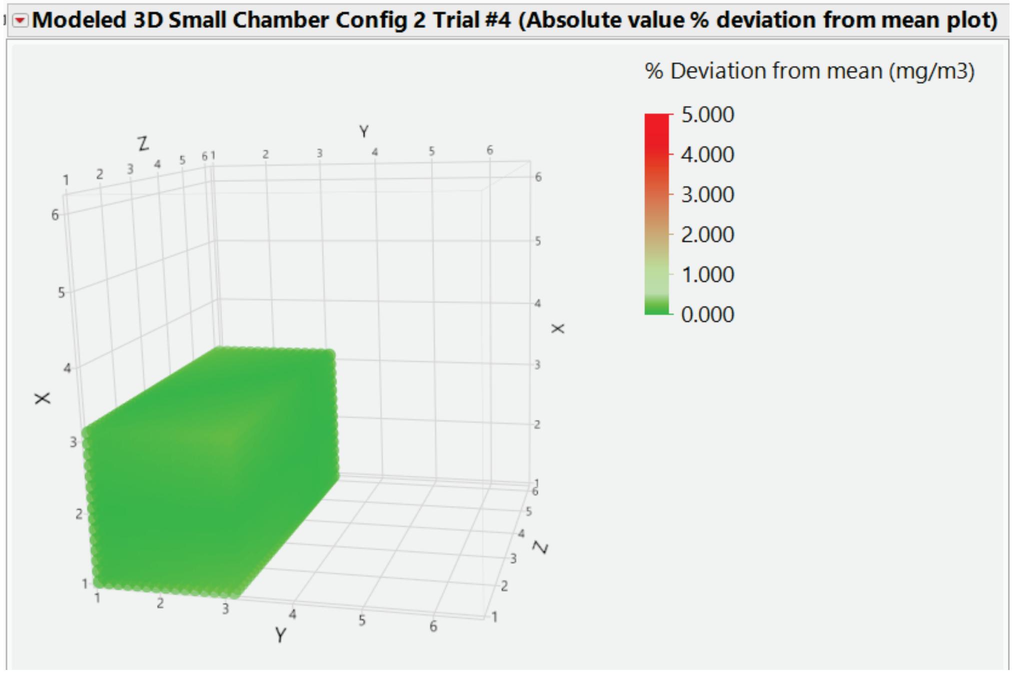


Point-to-point sampling, front-left view.

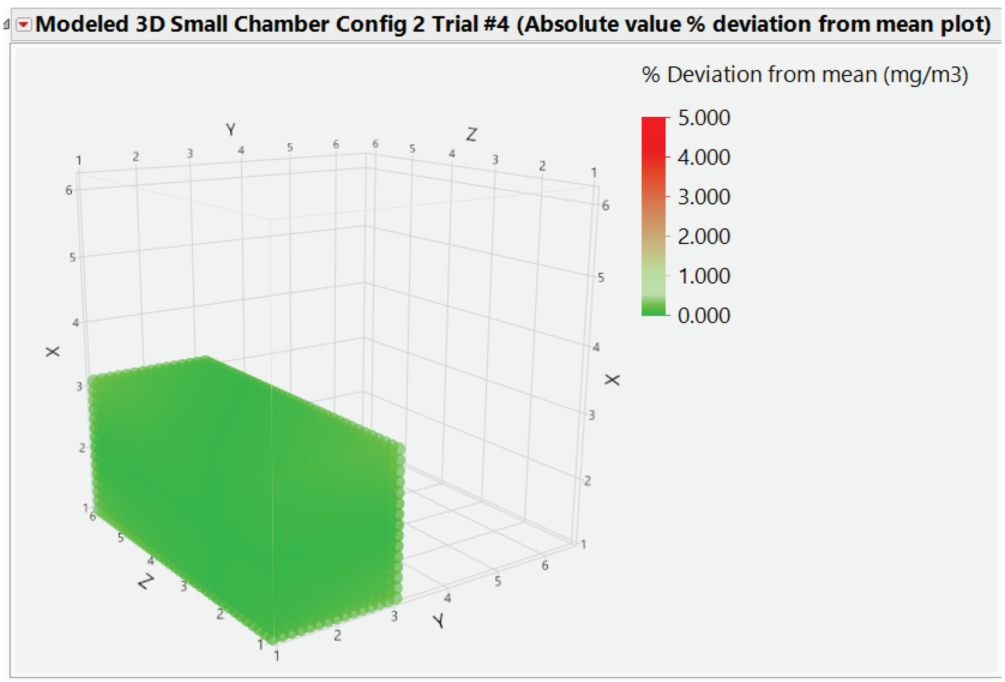
B.2.4 Configuration 2, Trial 4





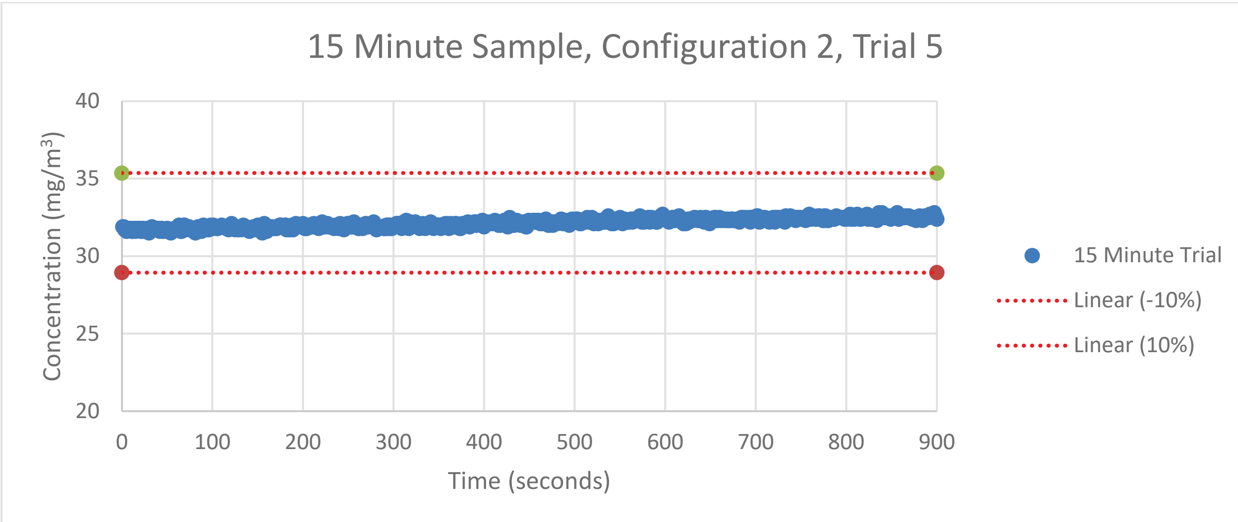


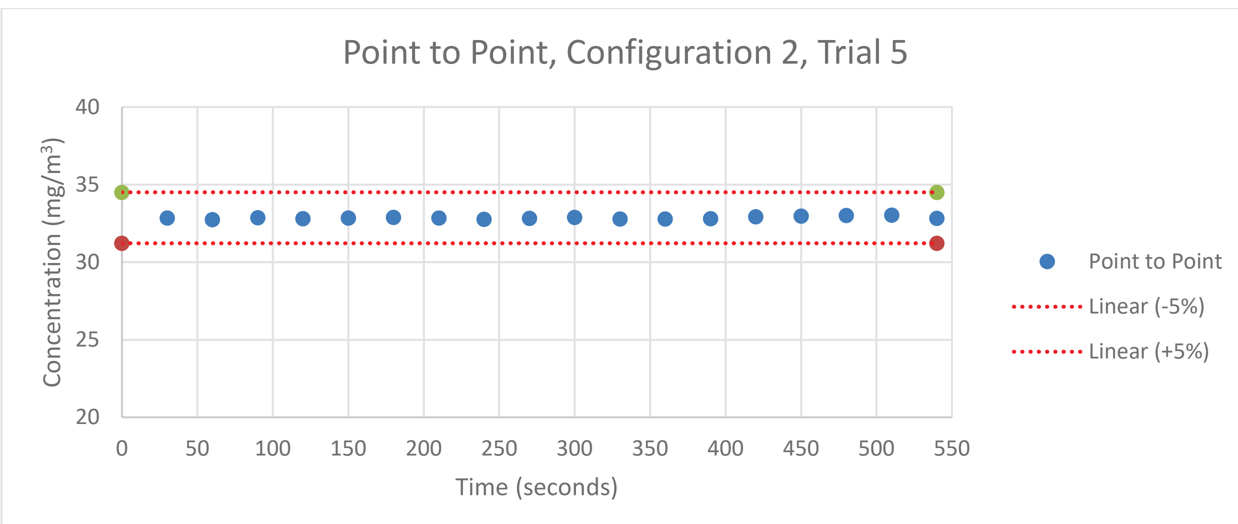
Point-to-point sampling, front-right view.

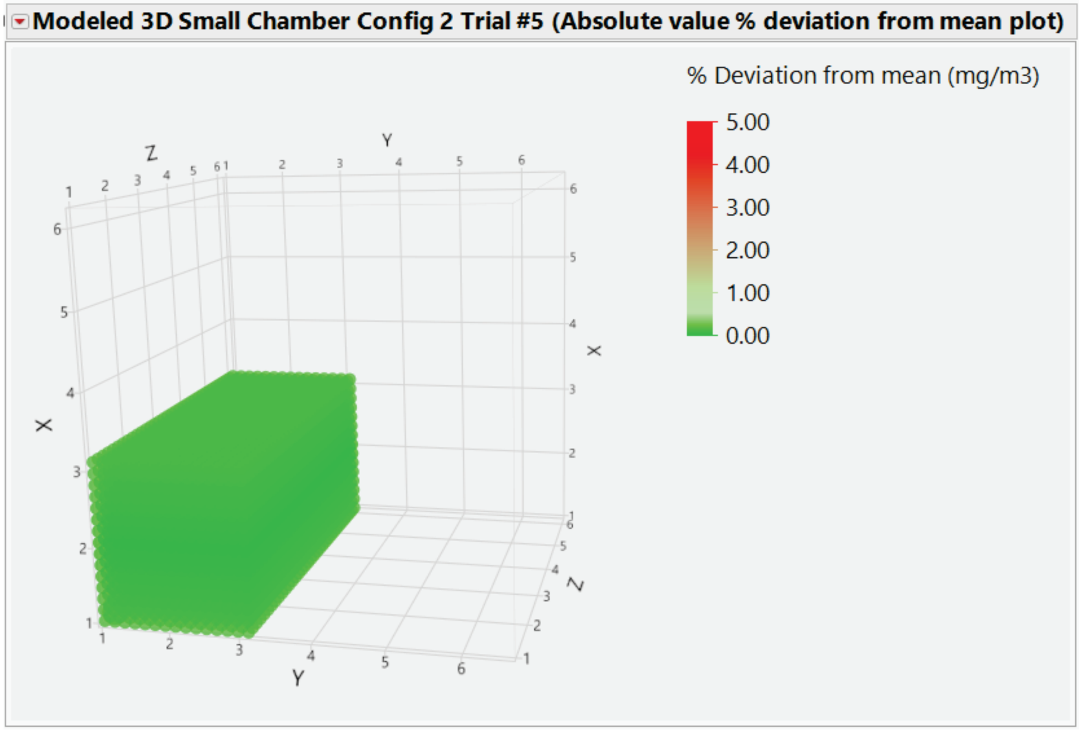


Point-to-point sampling, front-left view.

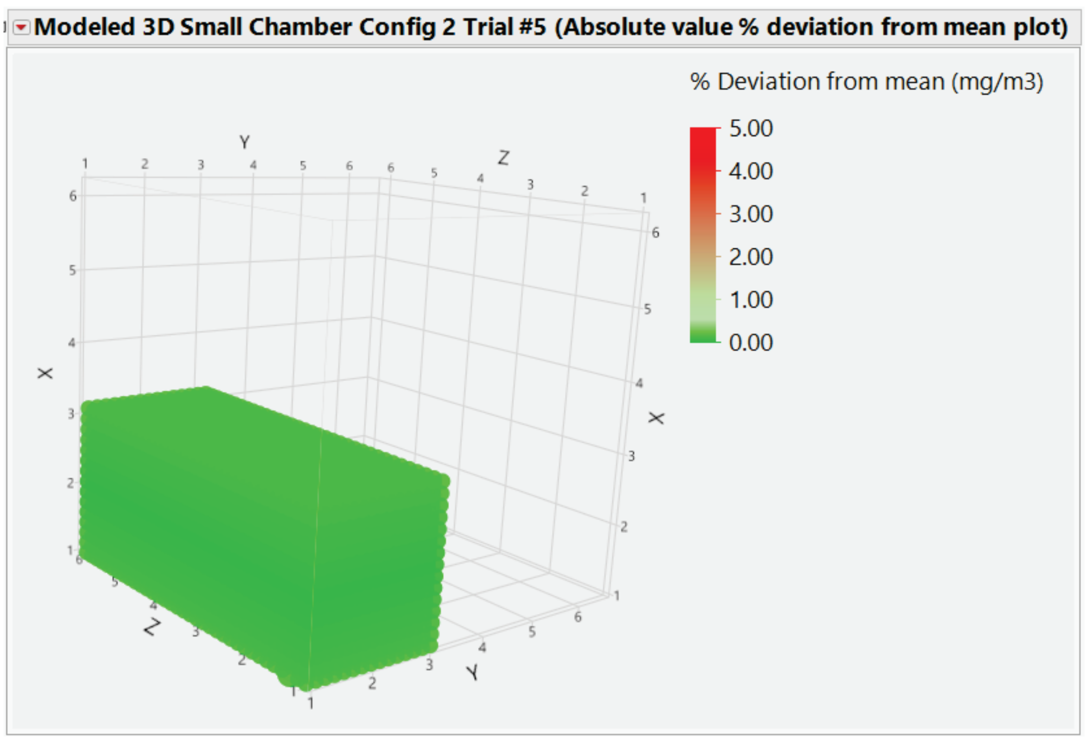
B.2.5 Configuration 2, Trial 5





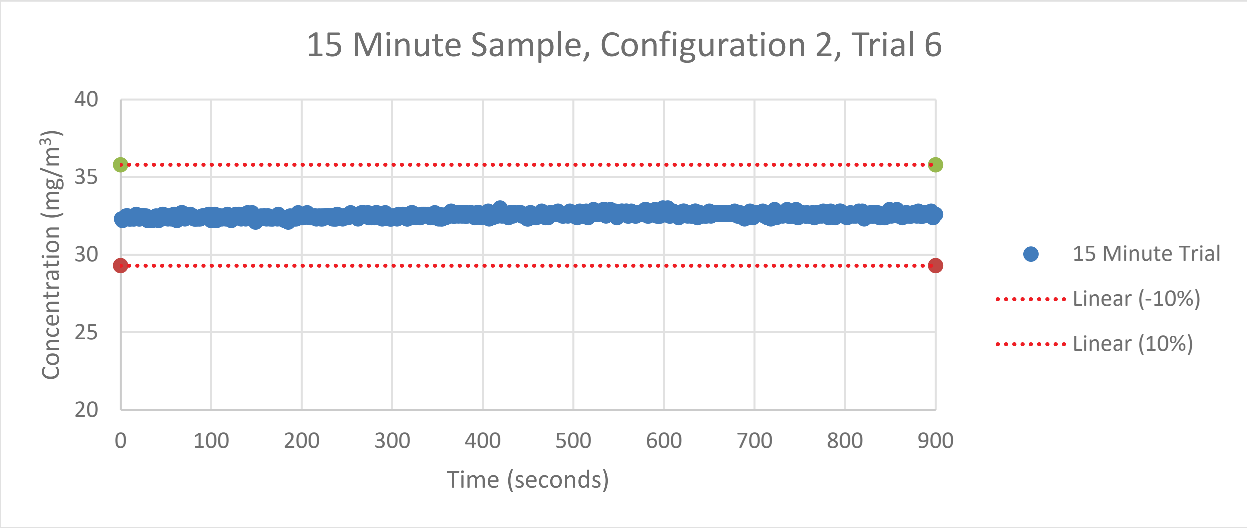


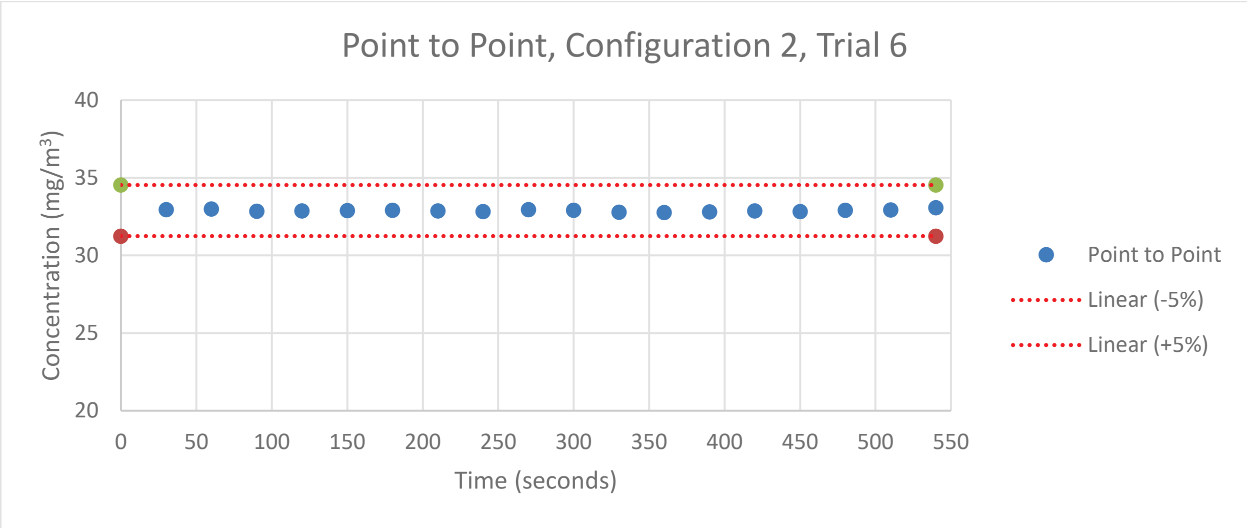
Point-to-point sampling, front-right view.

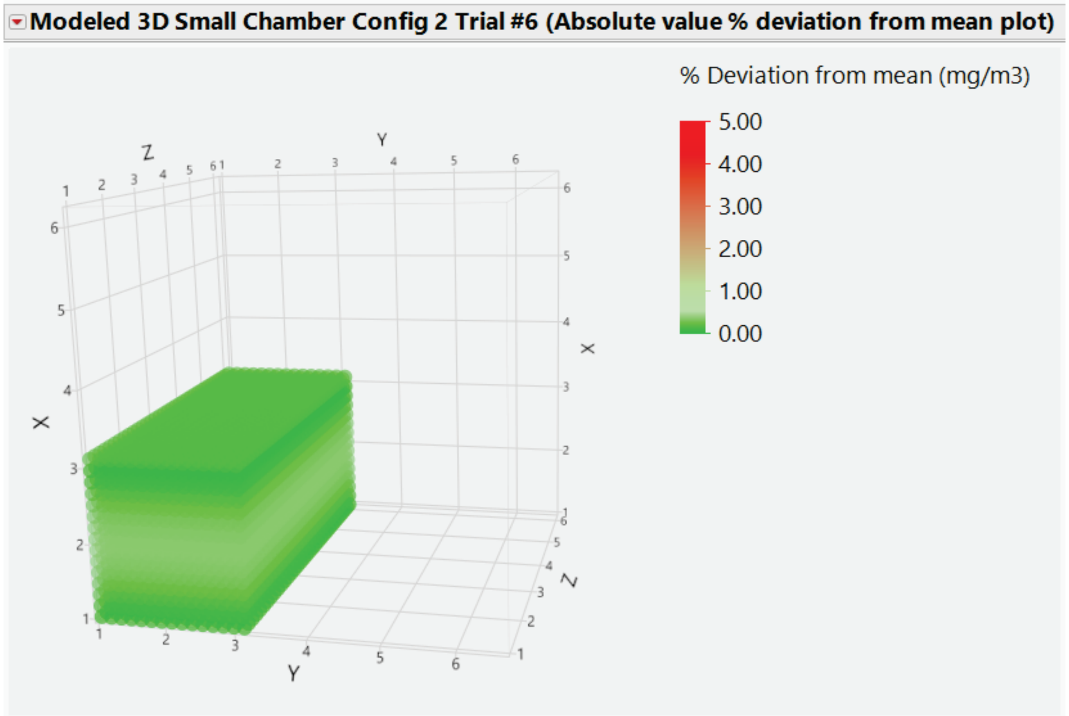


Point-to-point sampling, front-left view.

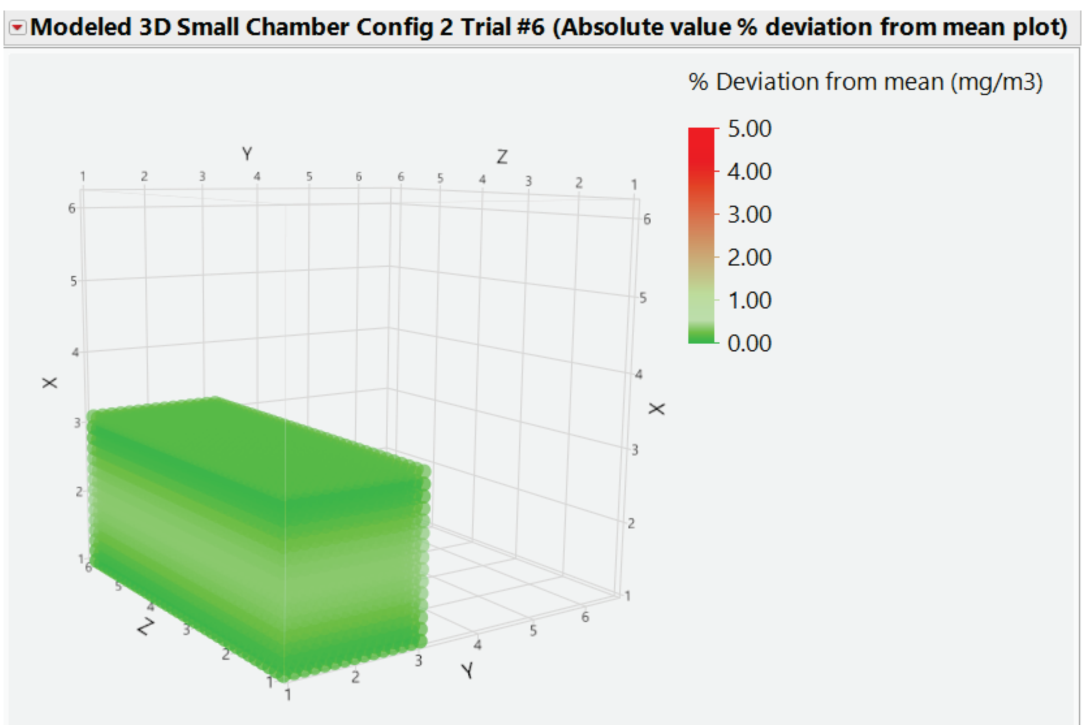
B.2.6 Configuration 2, Trial 6





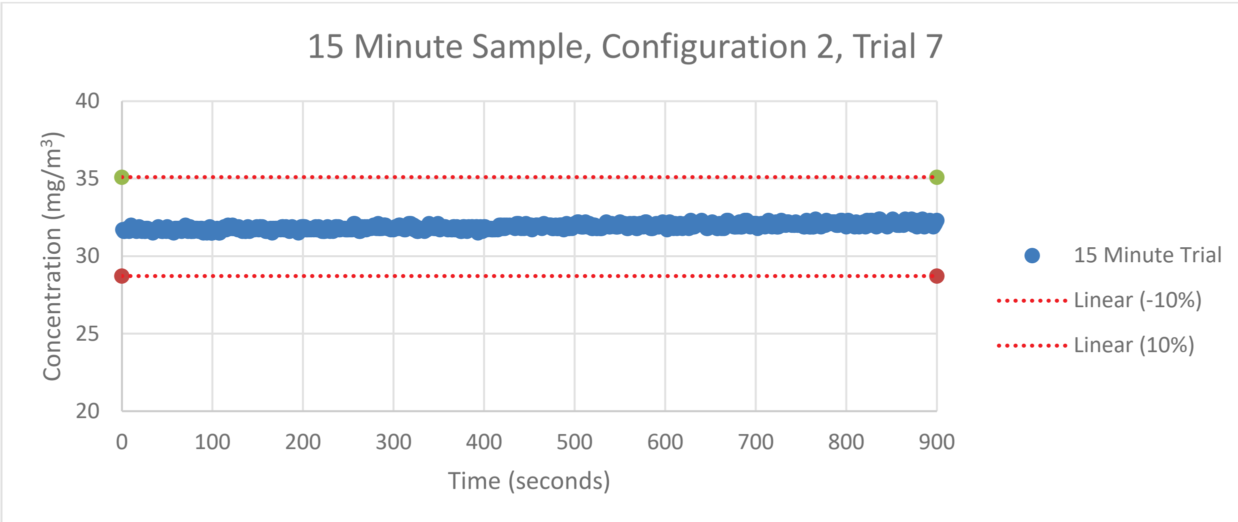


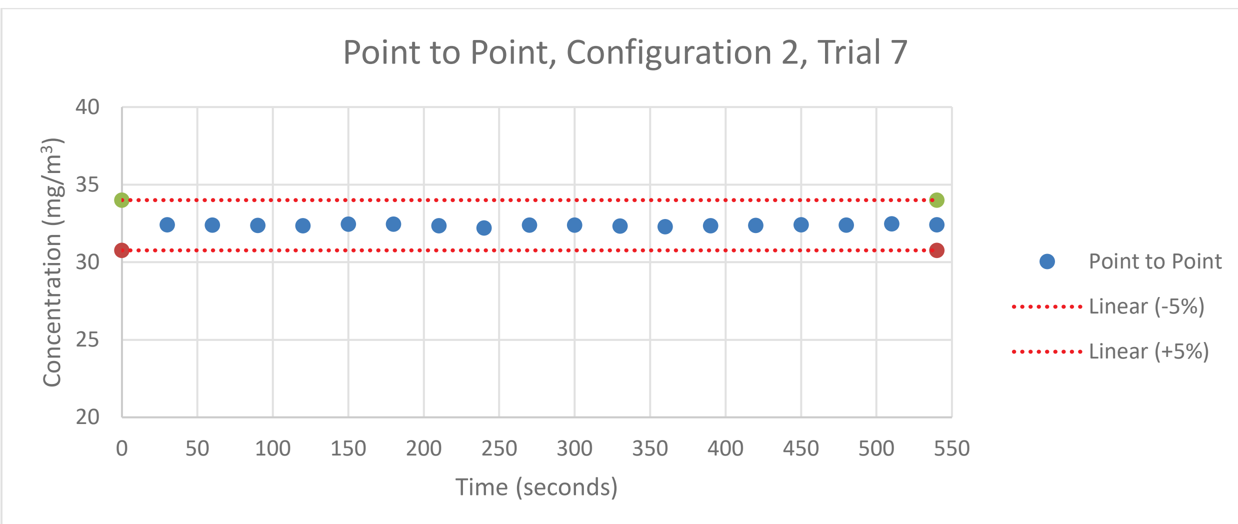
Point-to-point sampling, front-right view.

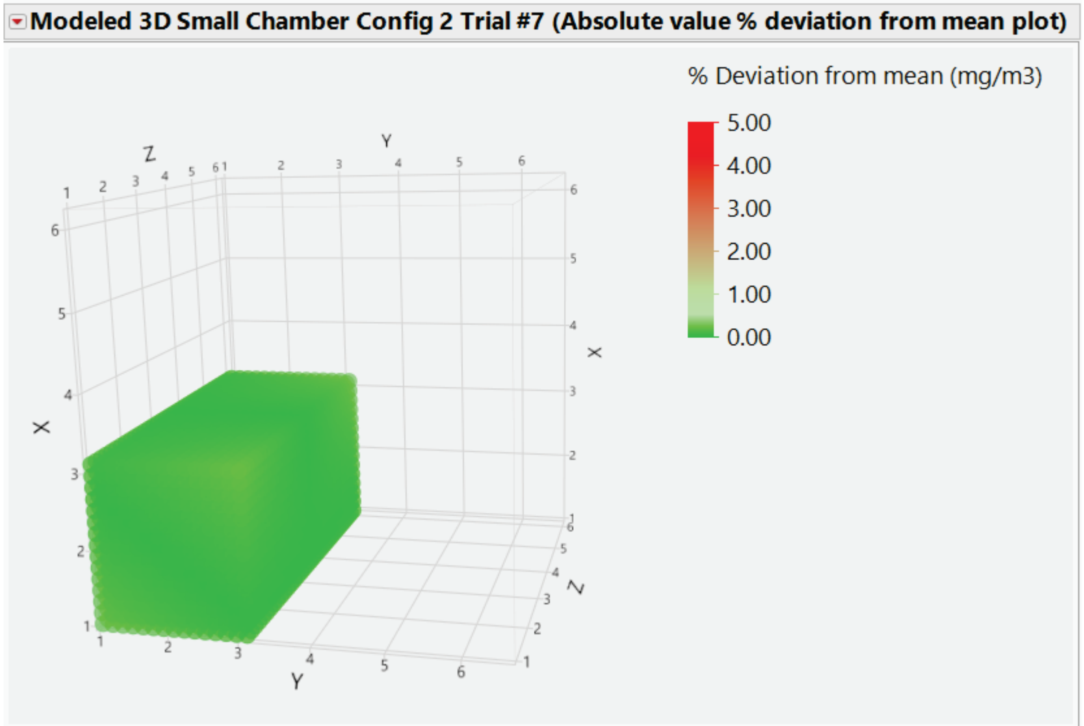


Point-to-point sampling, front-left view.

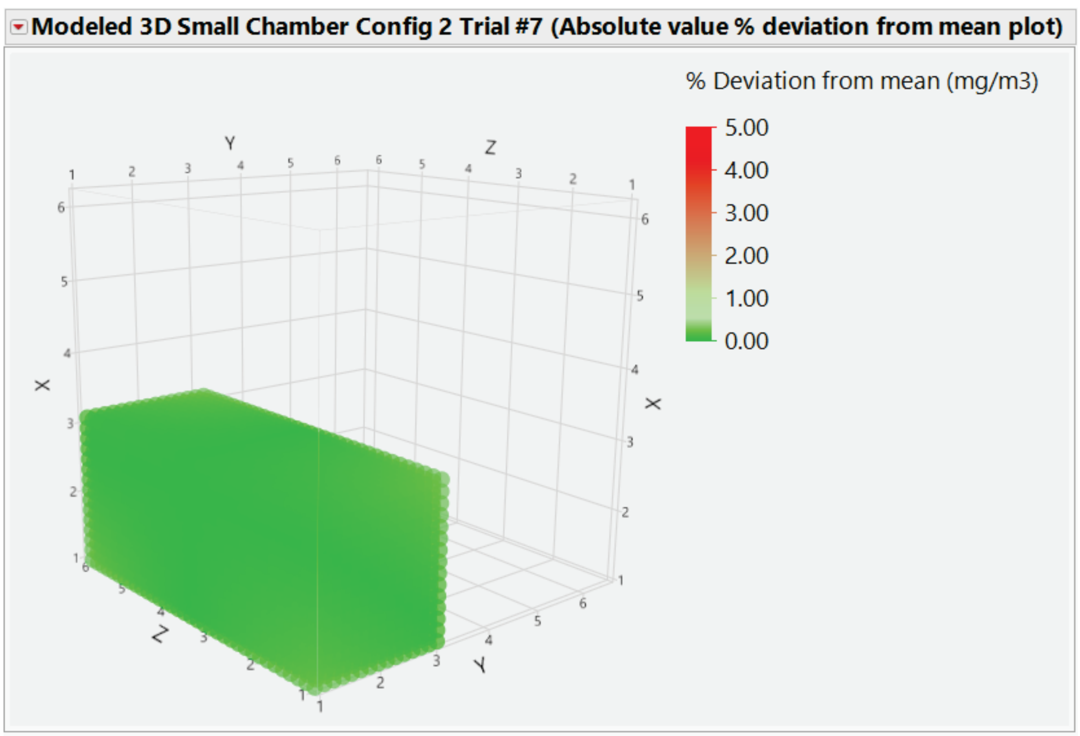
B.2.7 Configuration 2, Trial 7







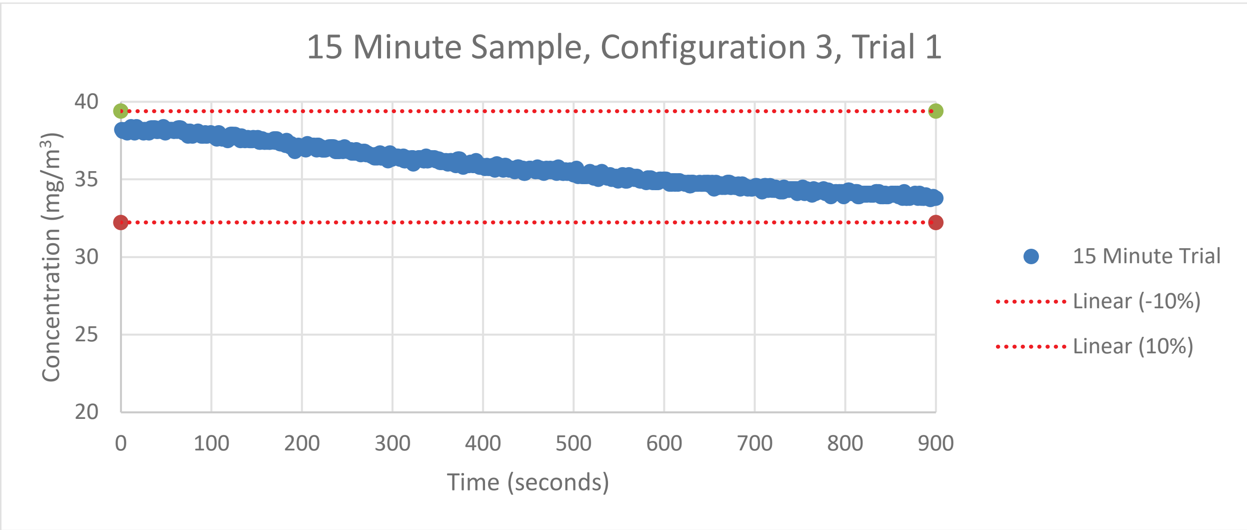
Point-to-point sampling, front-right view.

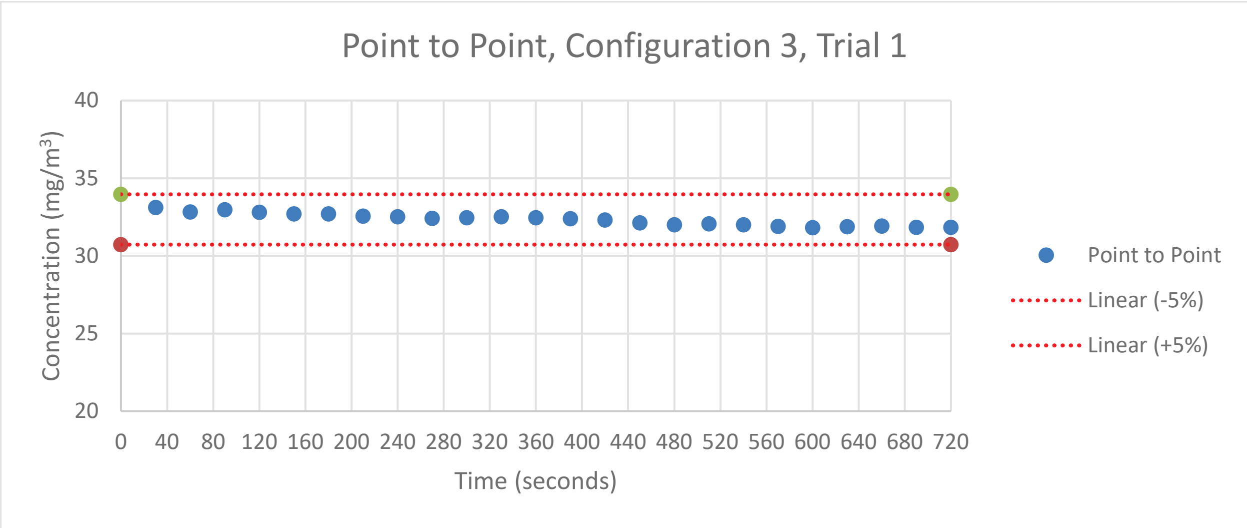


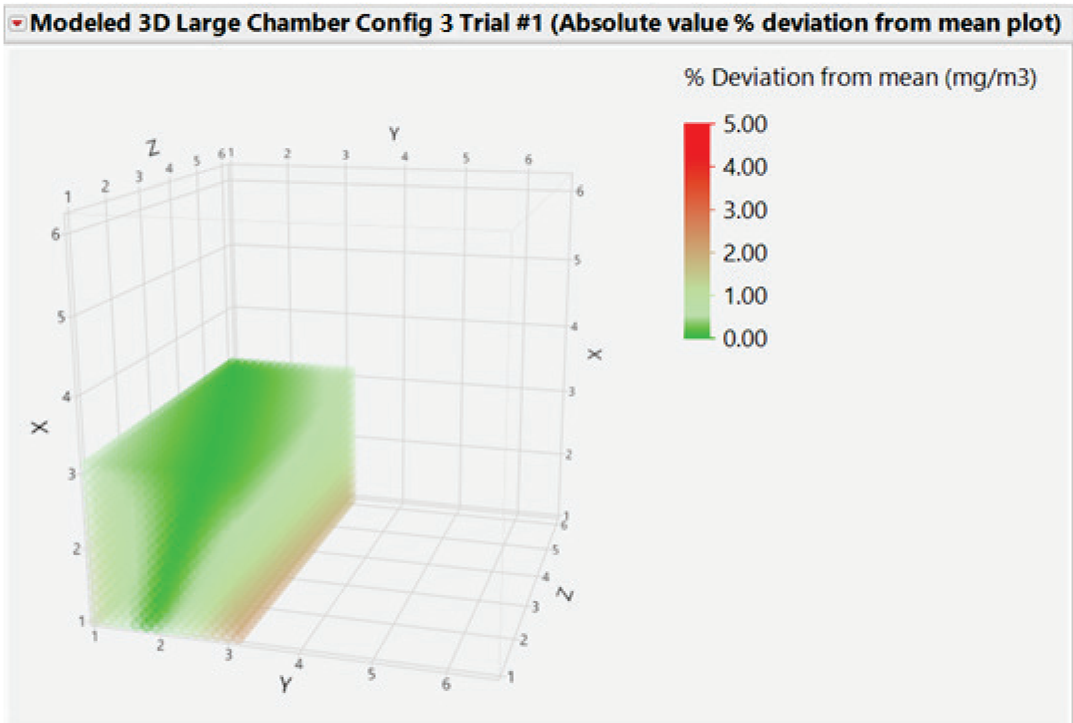
Point-to-point sampling, front-left view.

B.3 CONFIGURATION 3: TRIALS 1–7

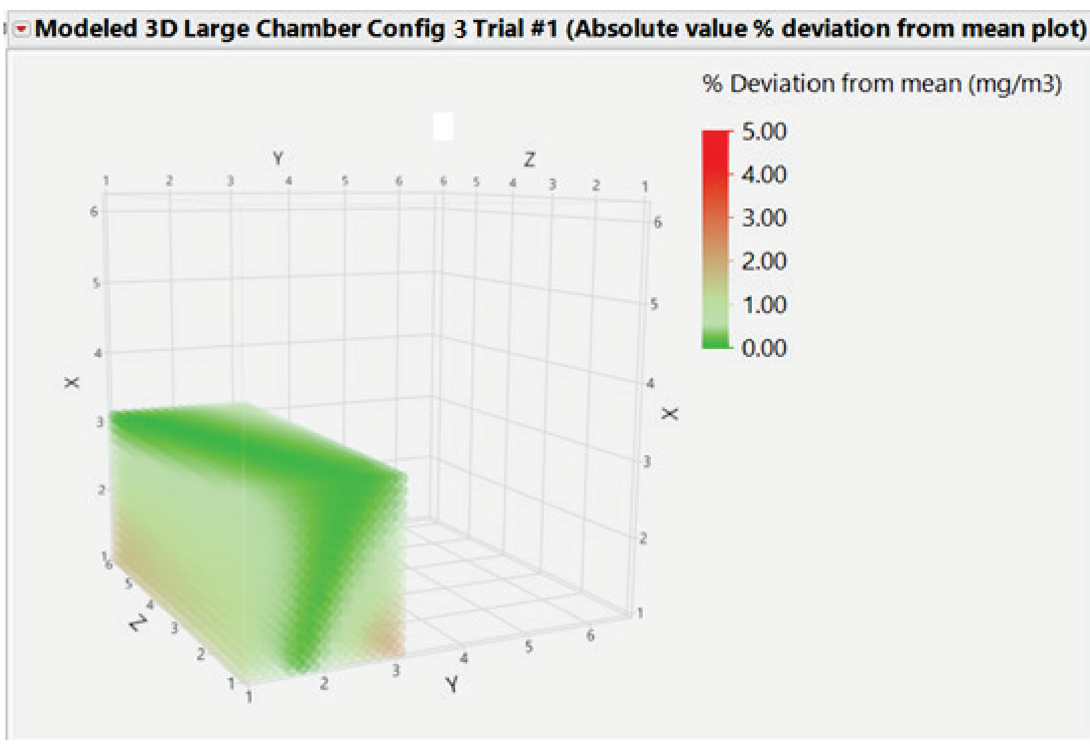
B.3.1 Configuration 3, Trial 1





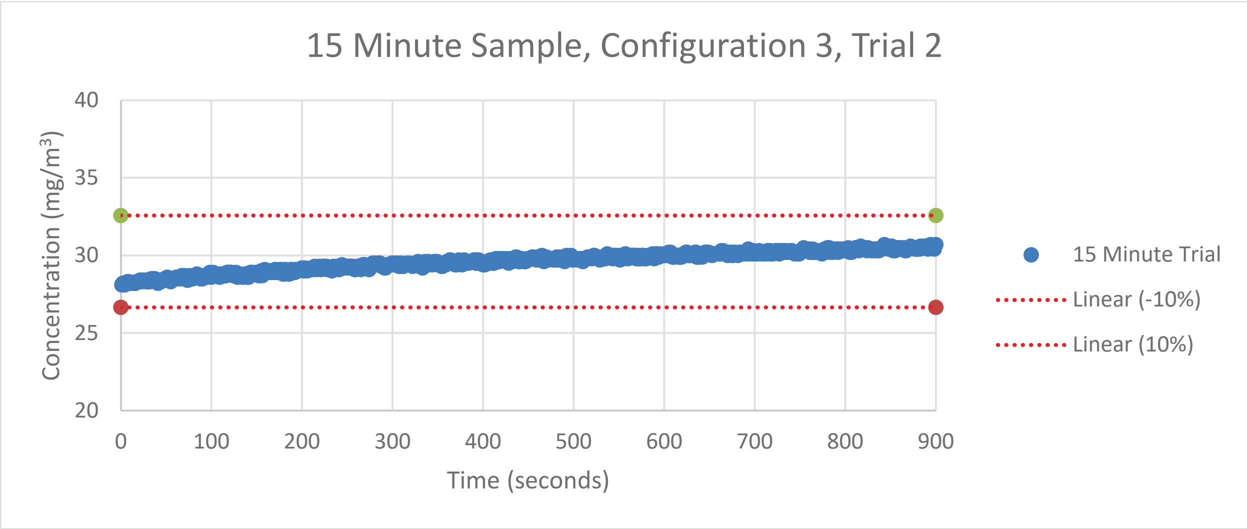


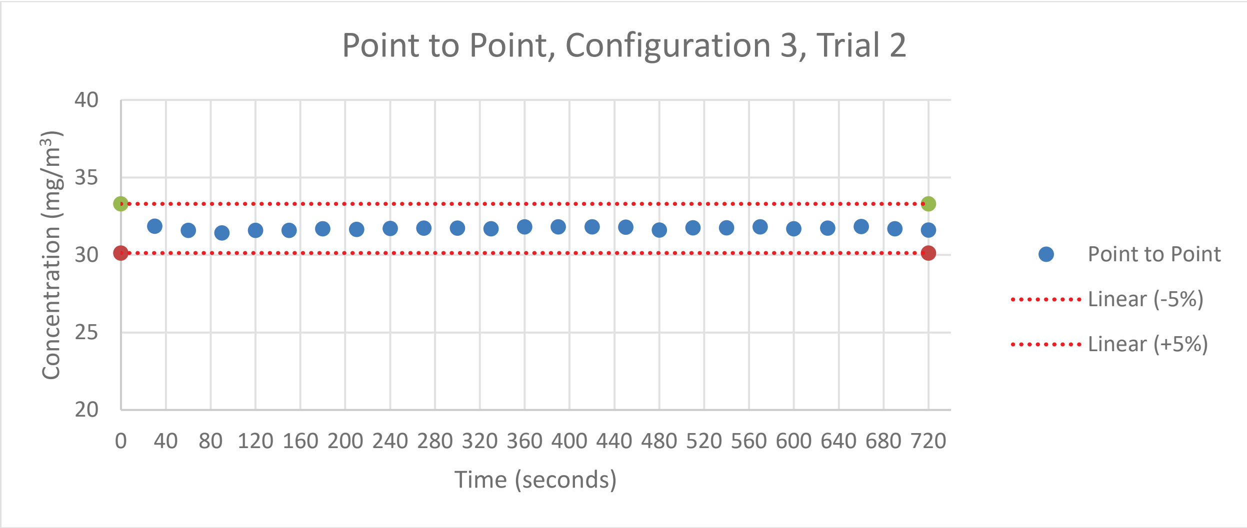
Point-to-point sampling, front-right view.

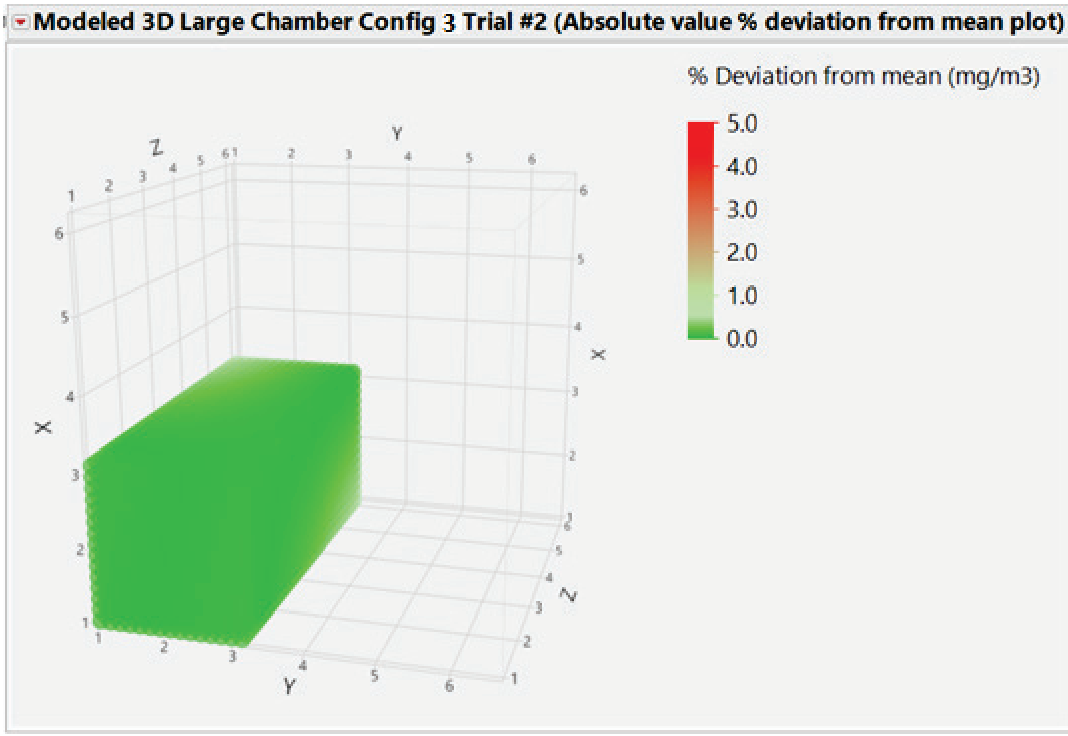


Point-to-point sampling, front-left view.

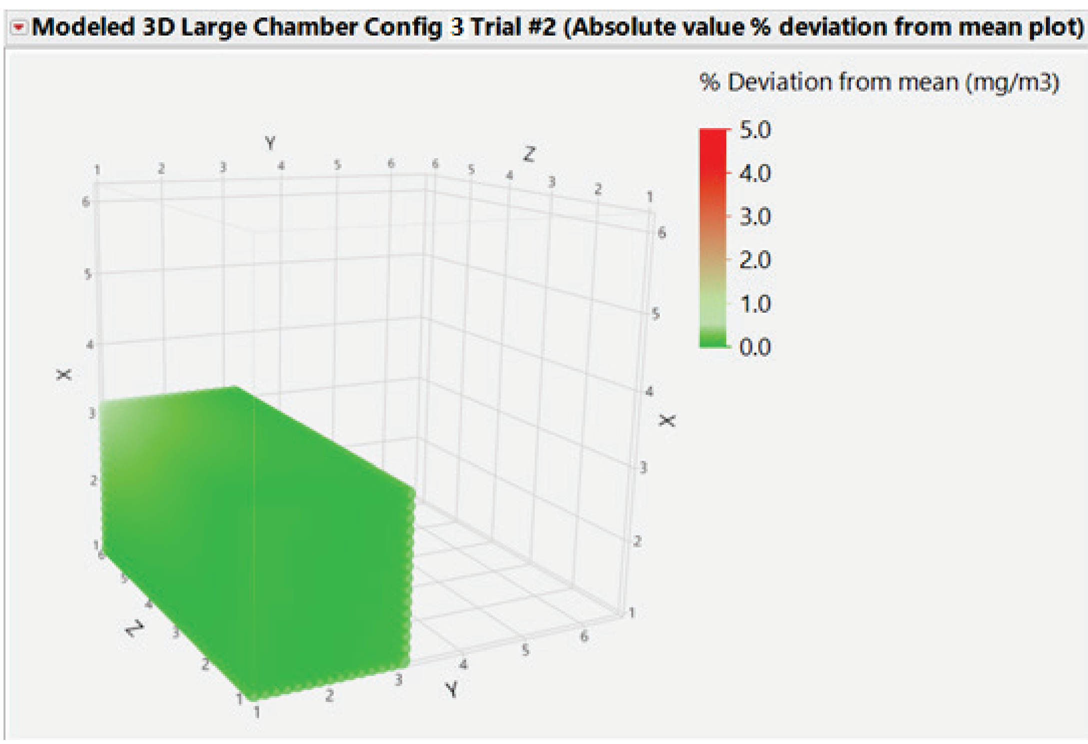
B.3.2 Configuration 3, Trial 2







Point-to-point sampling, front-right view.



Point-to-point sampling, front-left view.

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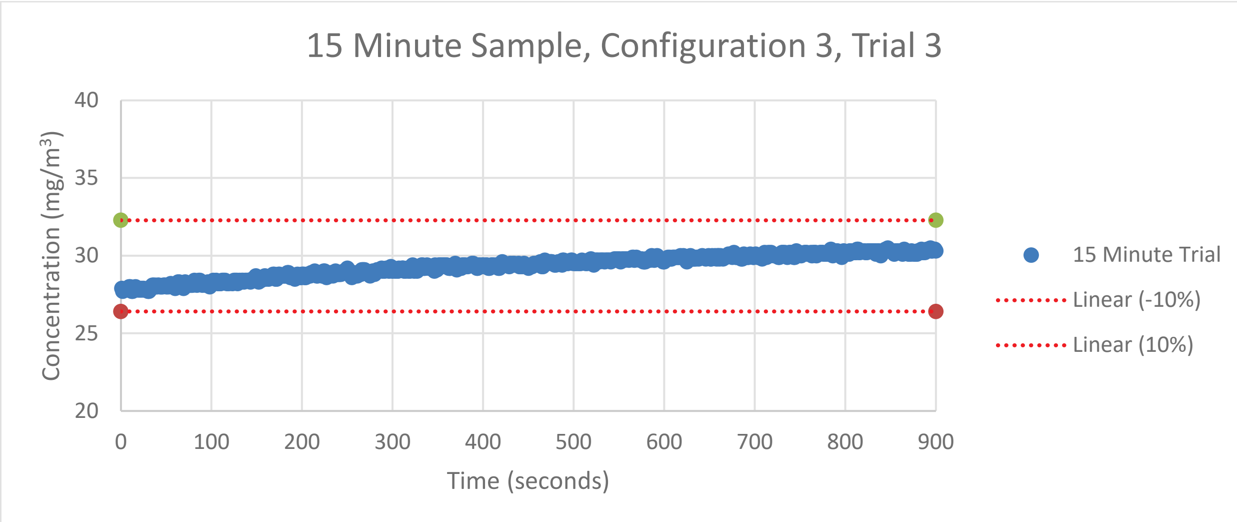
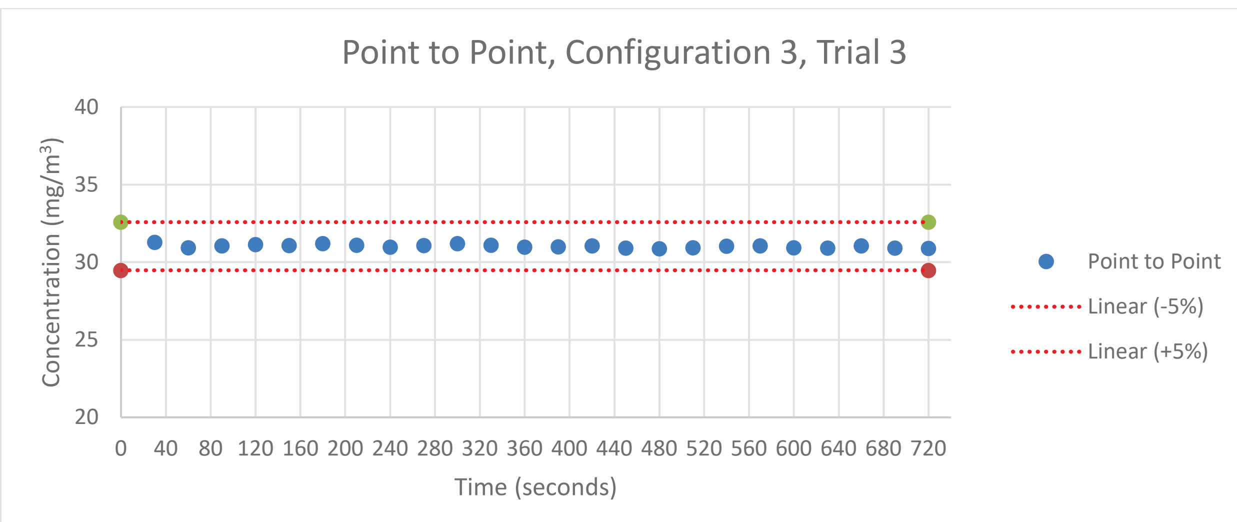
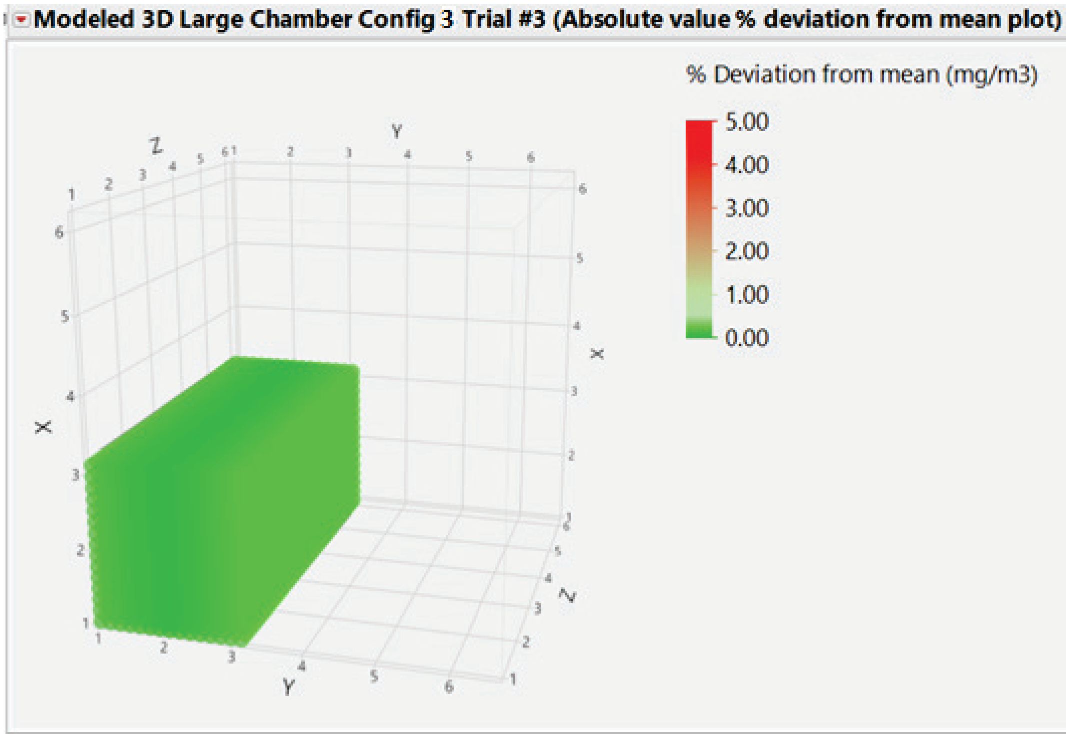
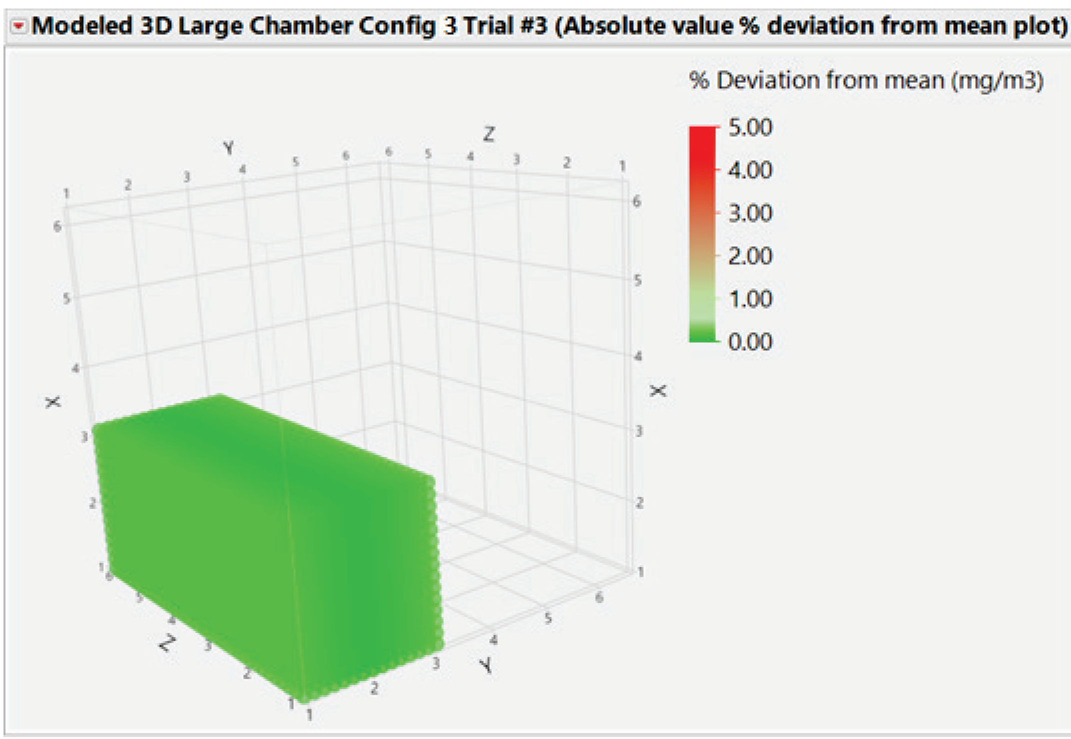






Point-to-point sampling, front-right view.



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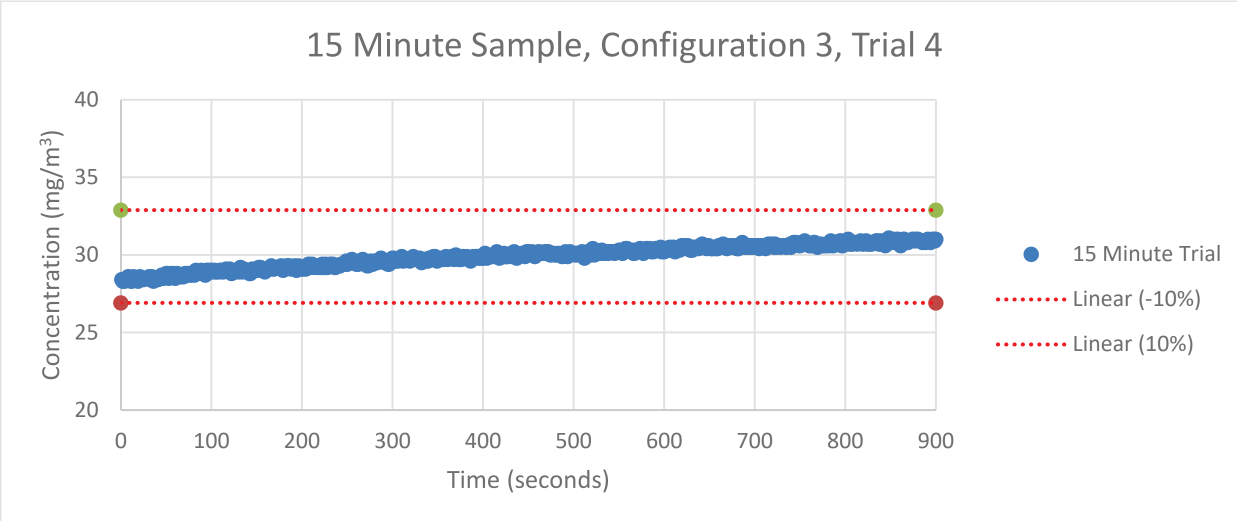

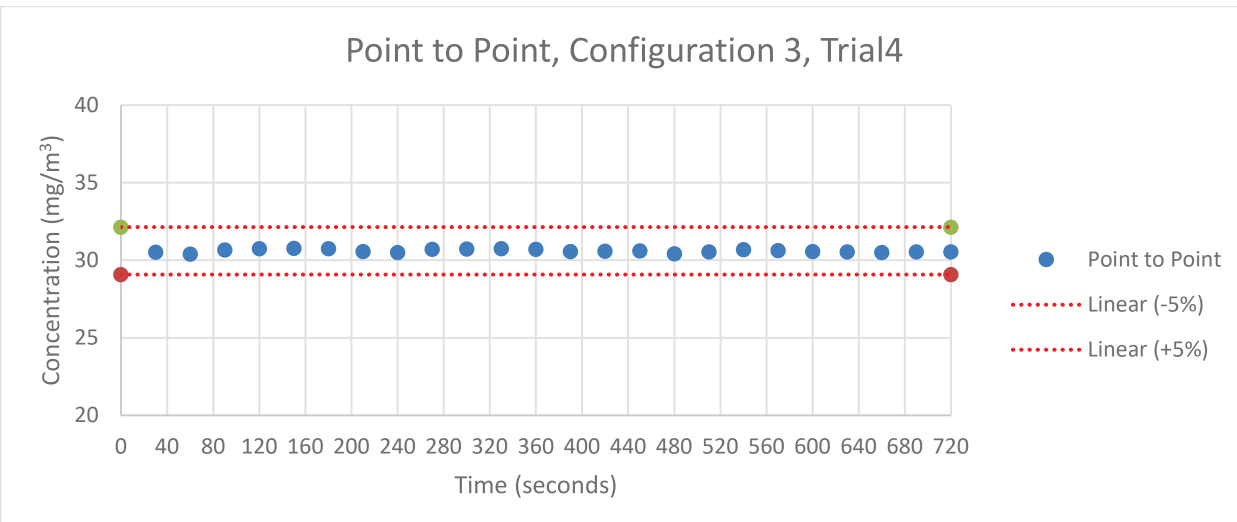

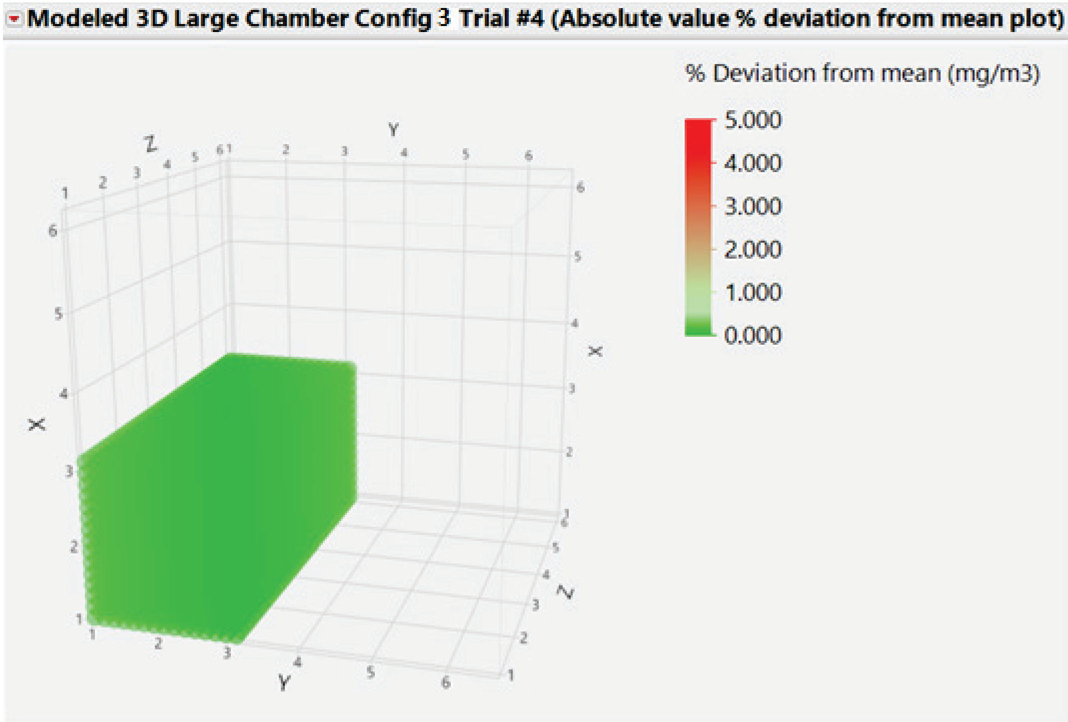

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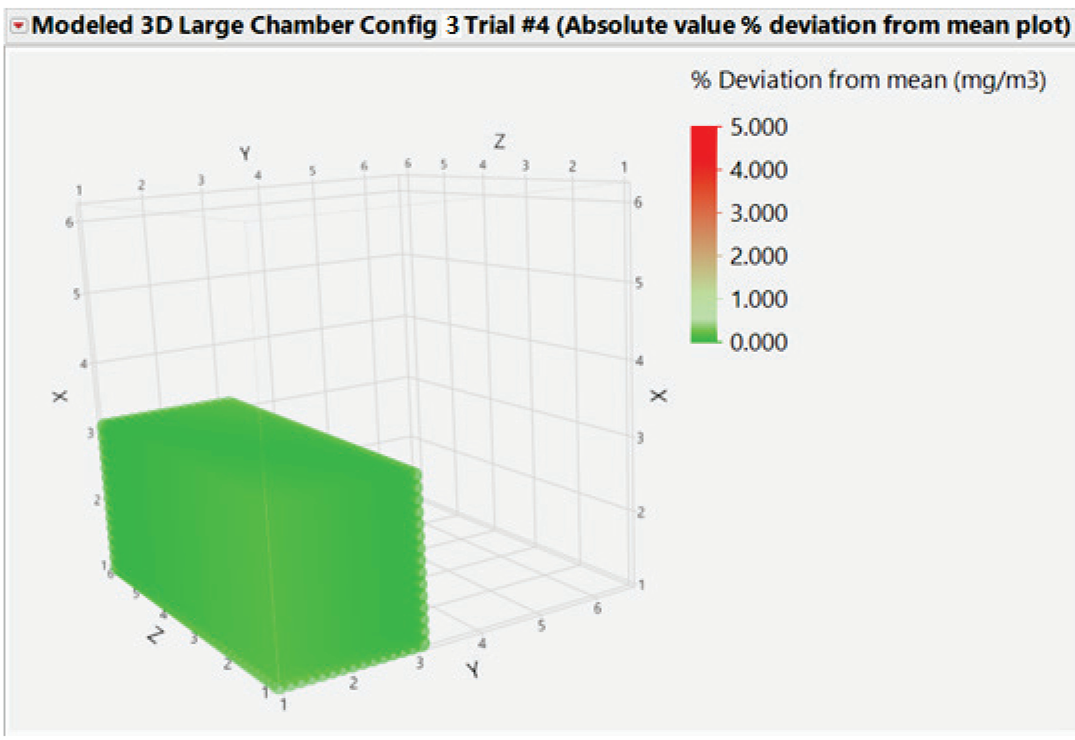
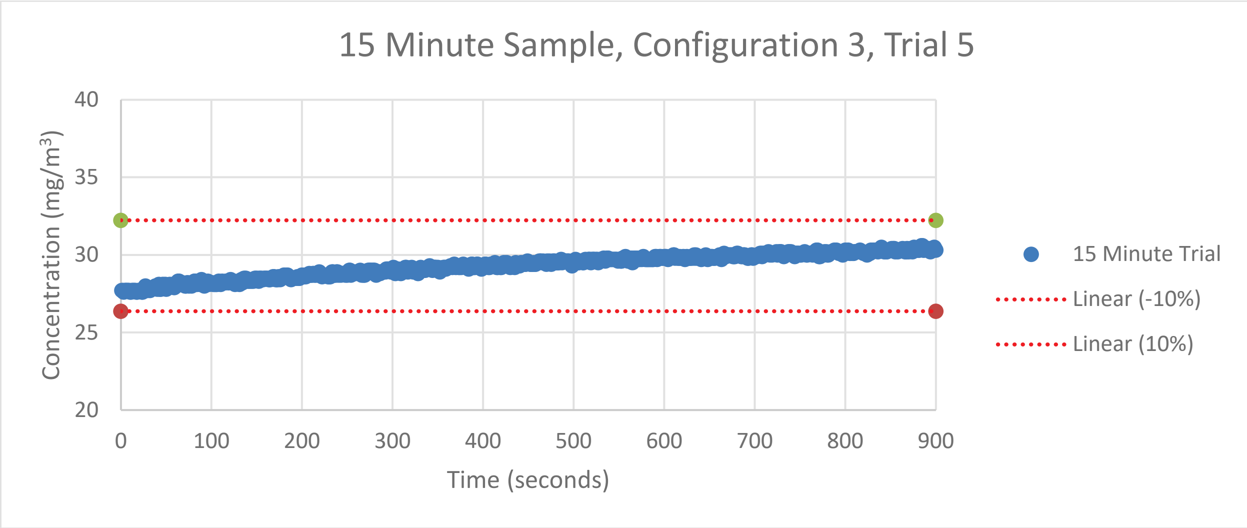
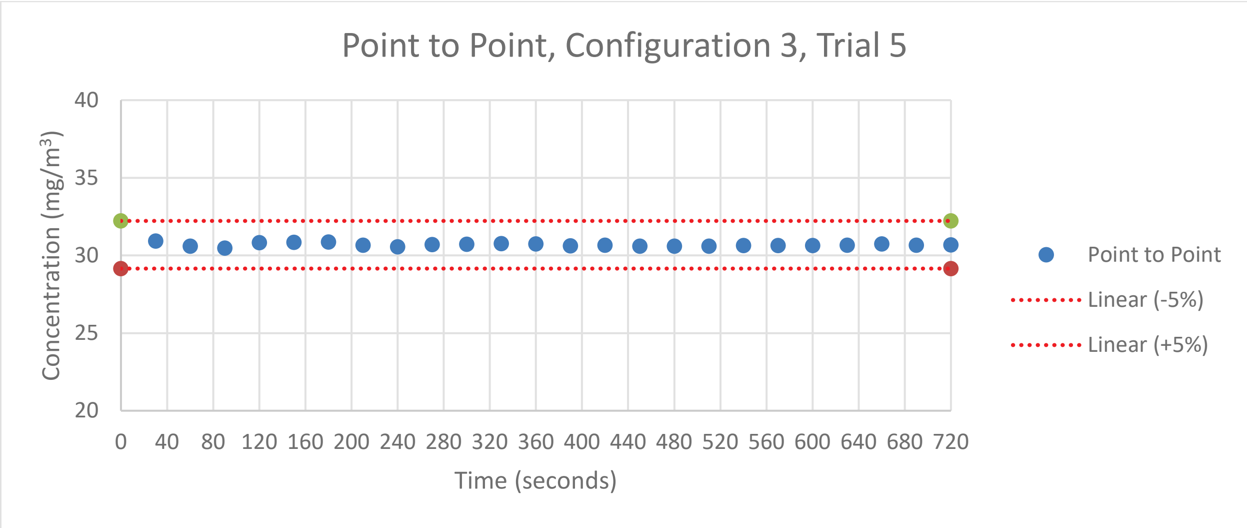
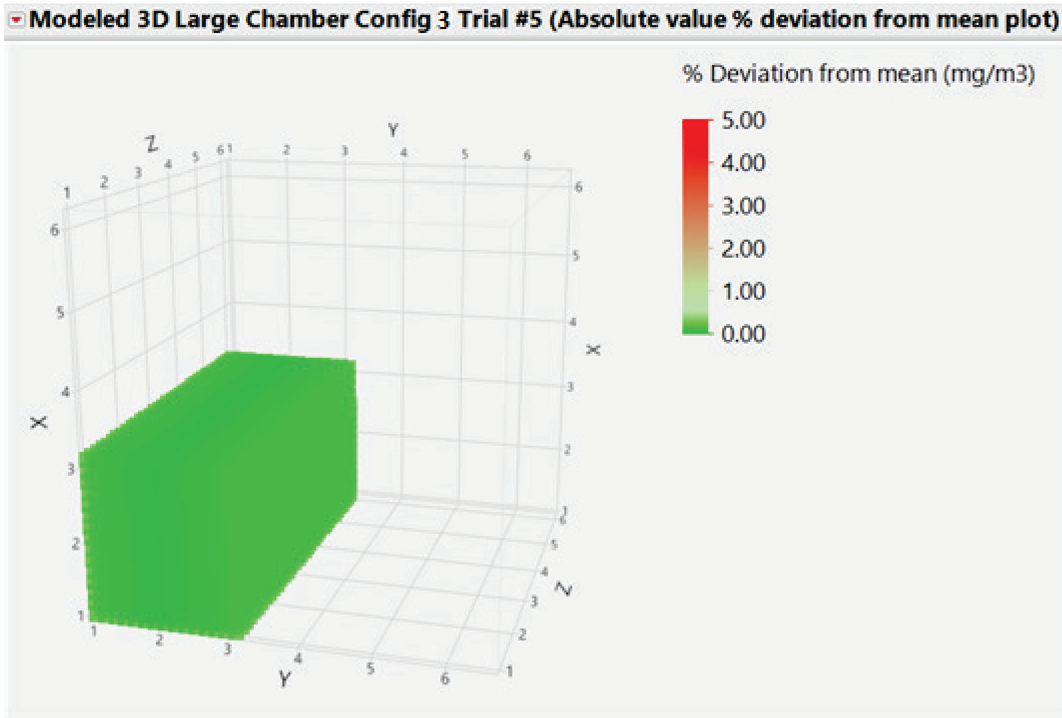


Point-to-point sampling, front-left view.

B.3.5 Configuration 3, Trial 5







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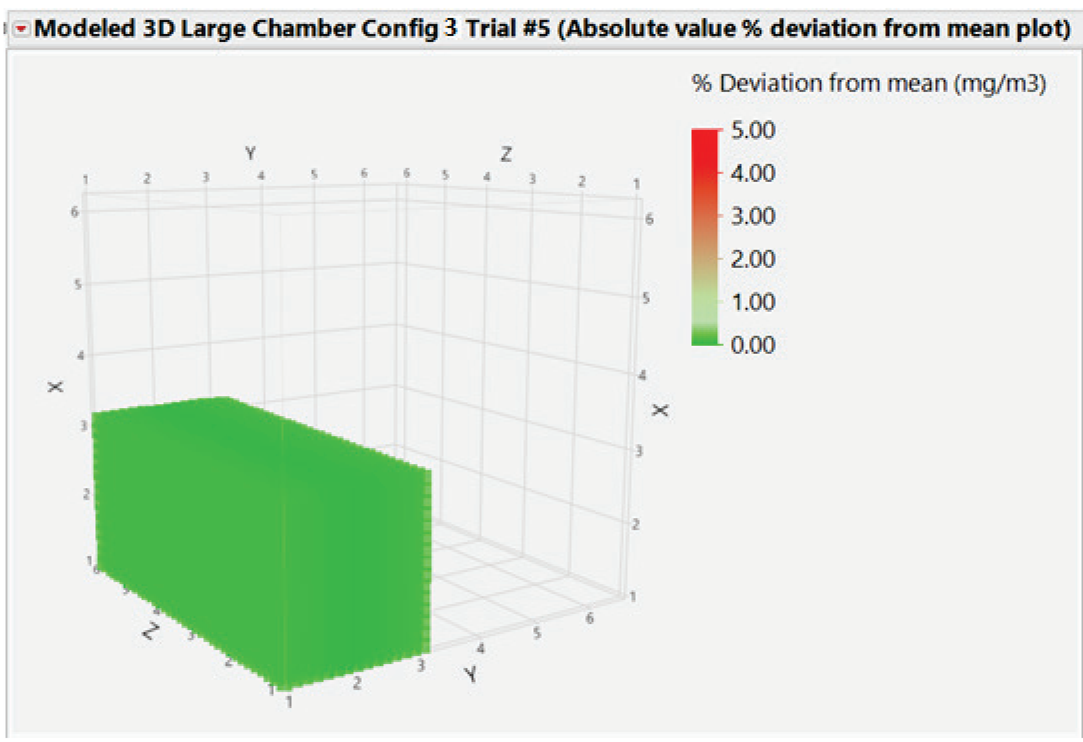
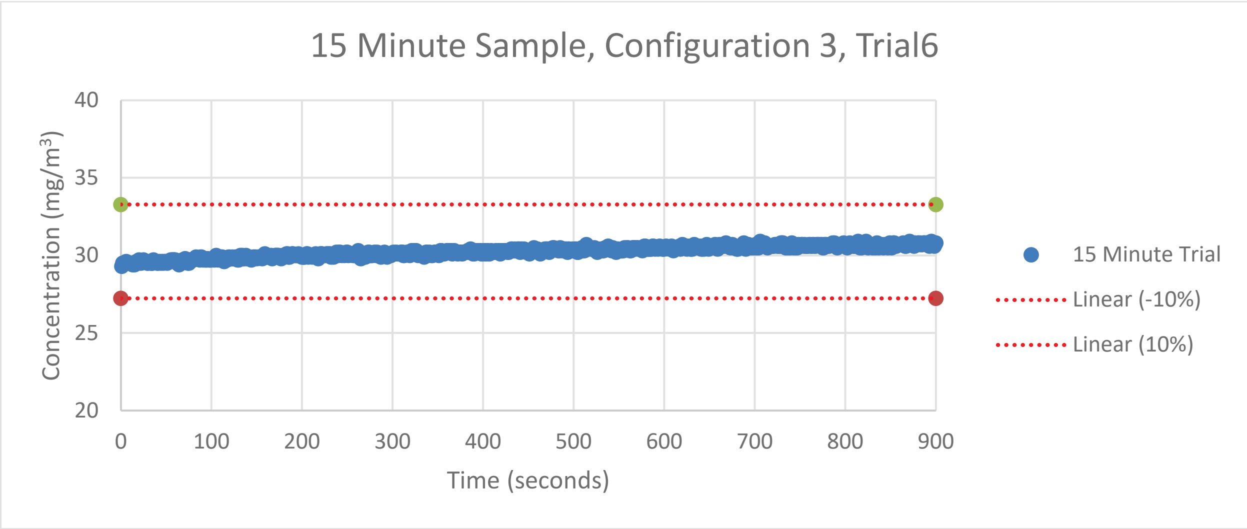
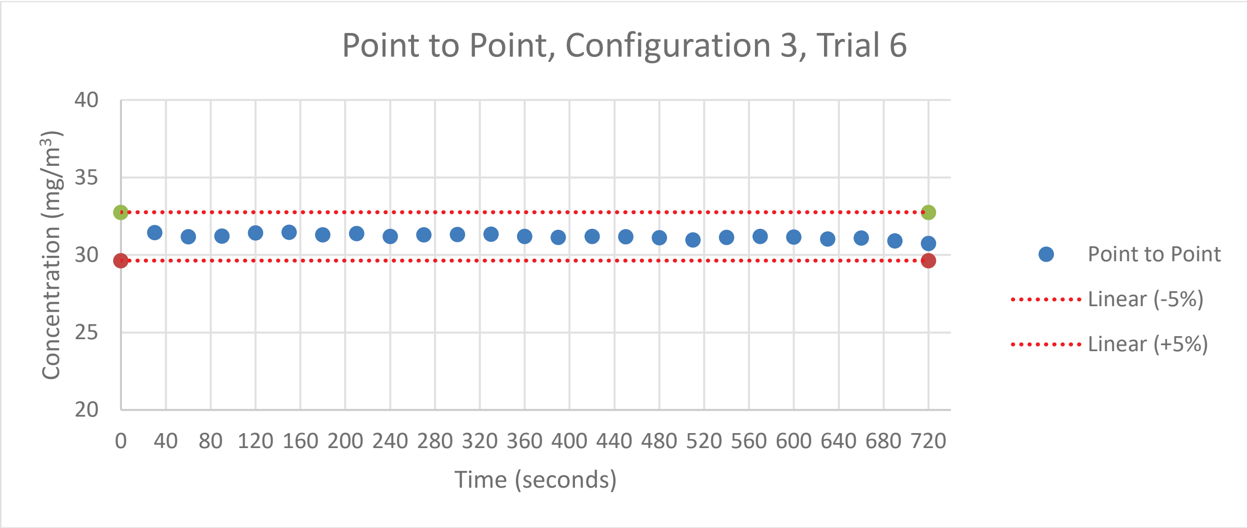
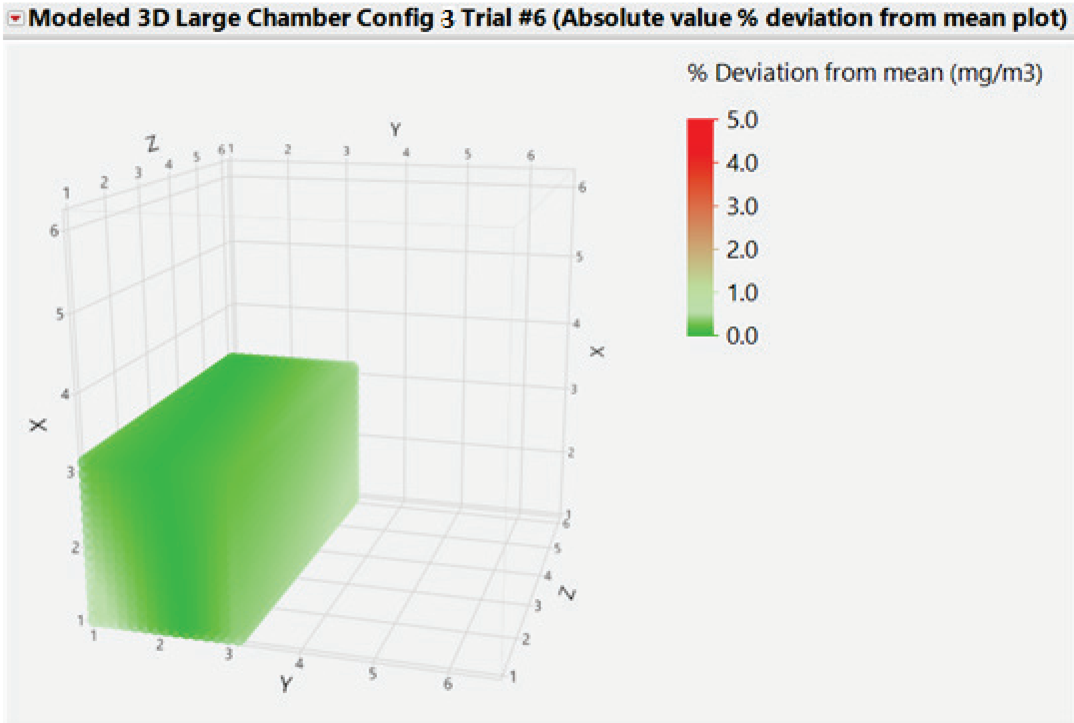


Point-to-point sampling, front-left view.

B.3.6 Configuration 3, Trial 6







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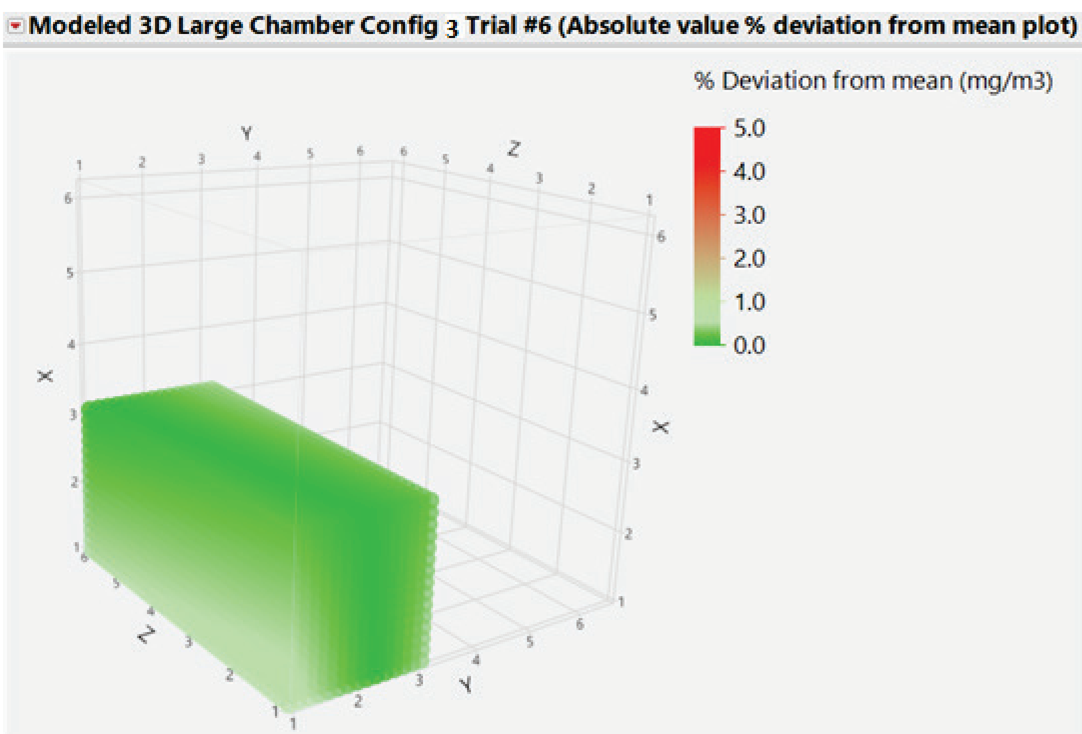
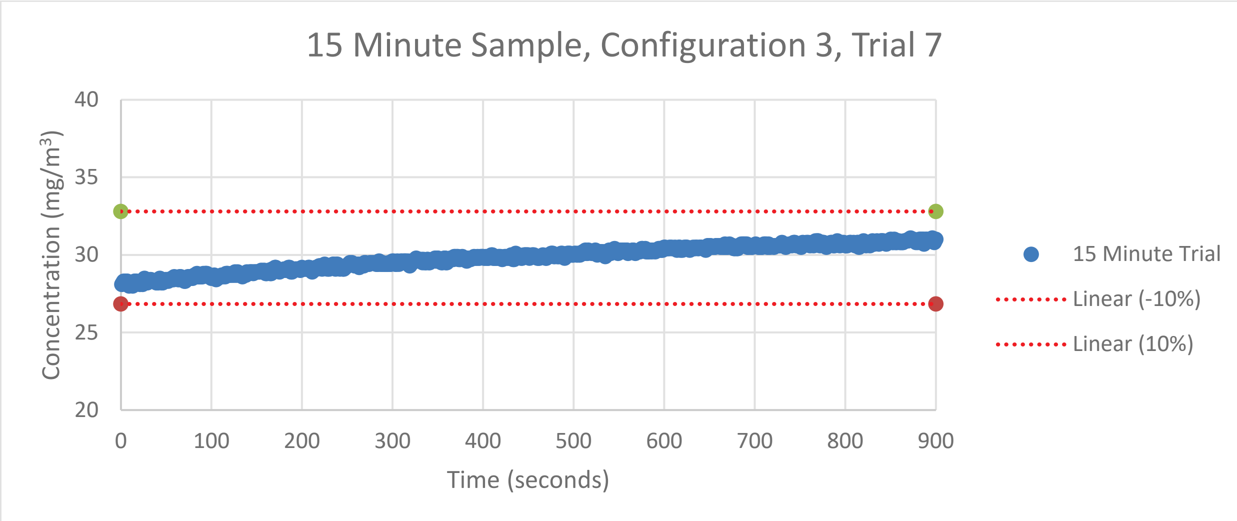
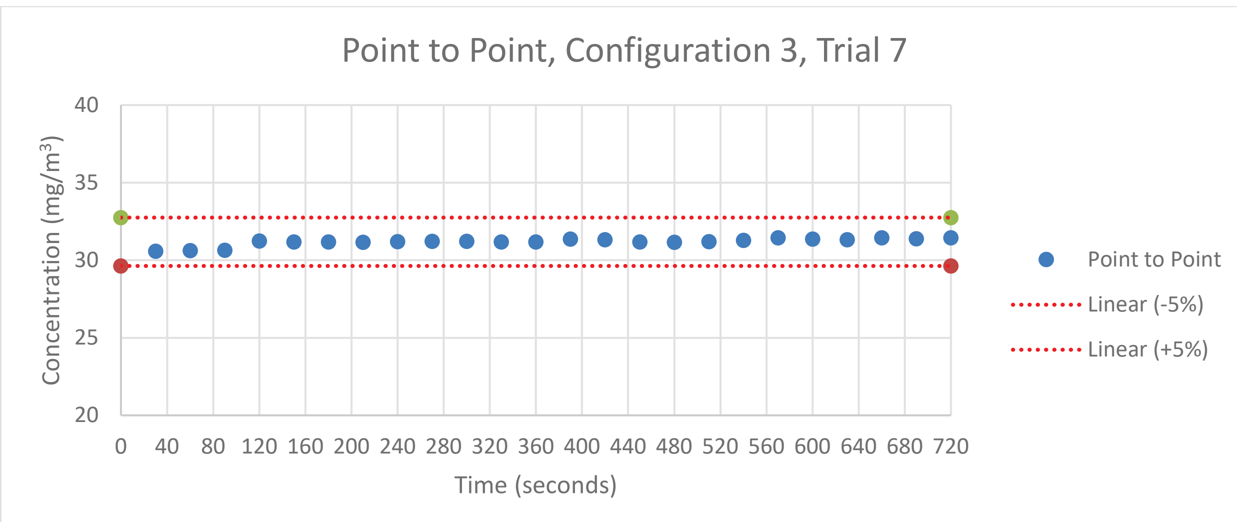
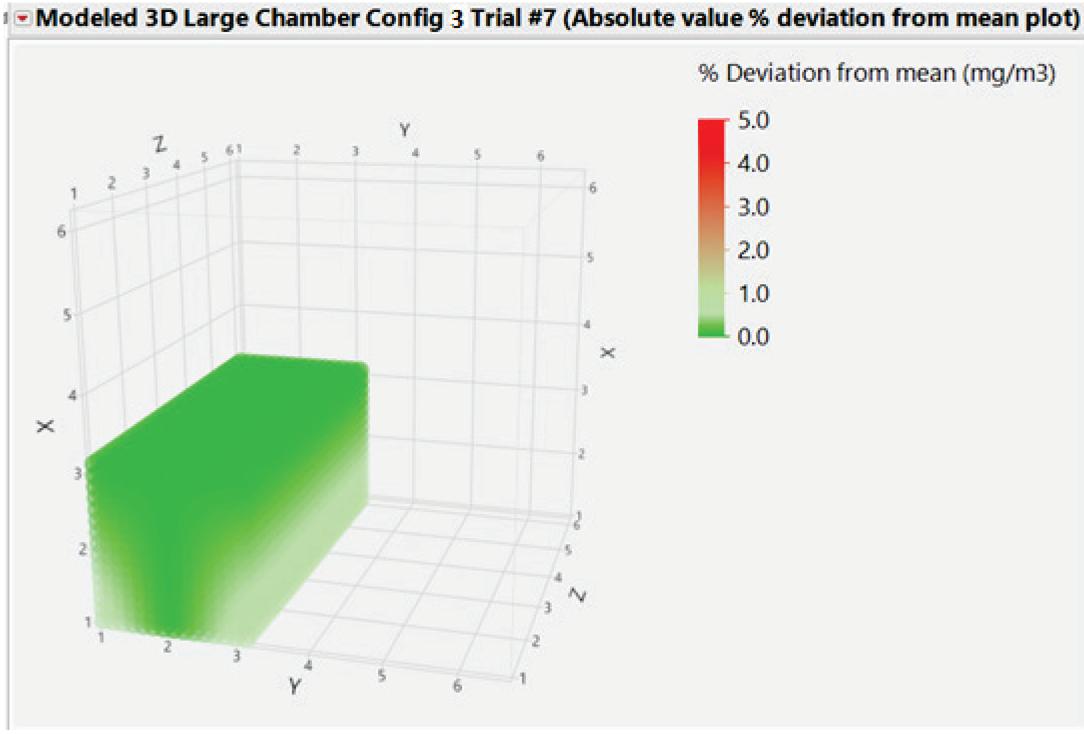


Point-to-point sampling, front-left view.

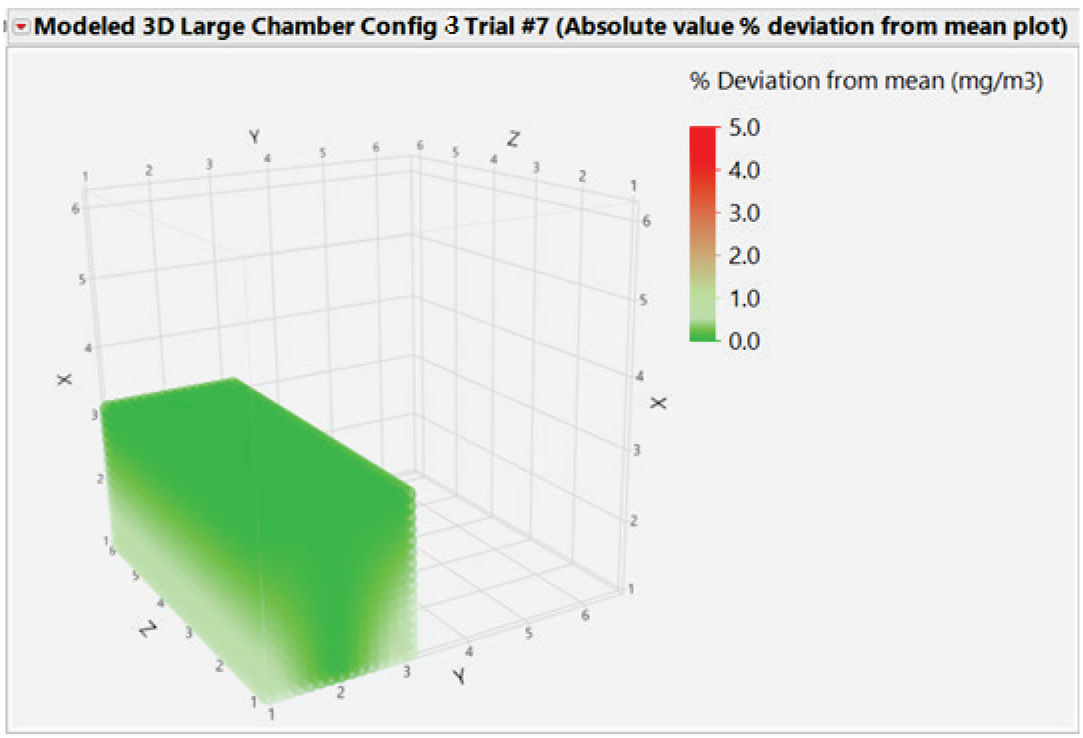
B.3.7 Configuration 3, Trial 7







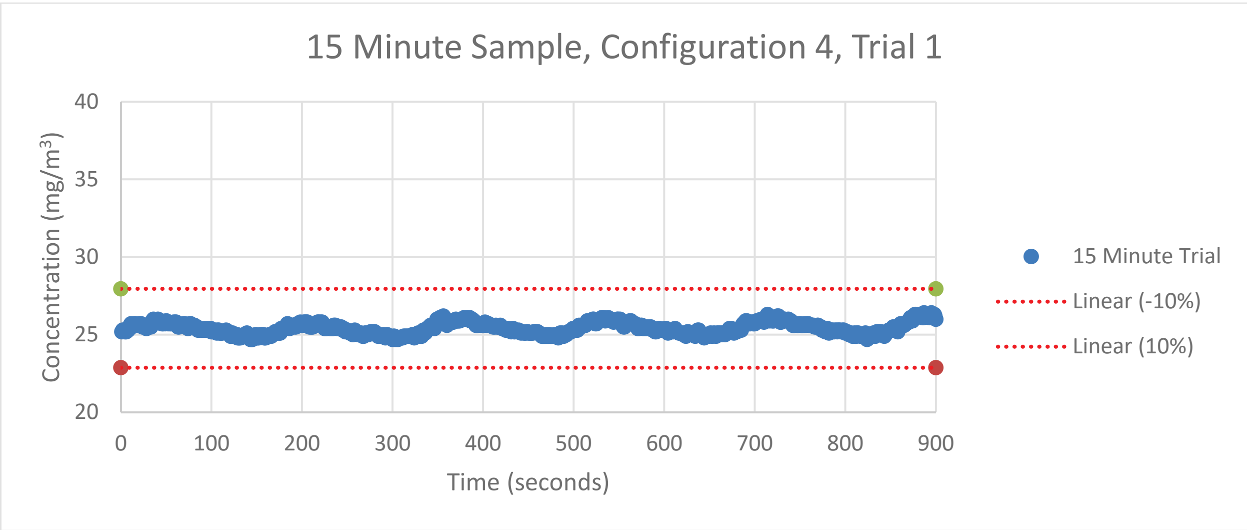
Point-to-point sampling, front-right view.

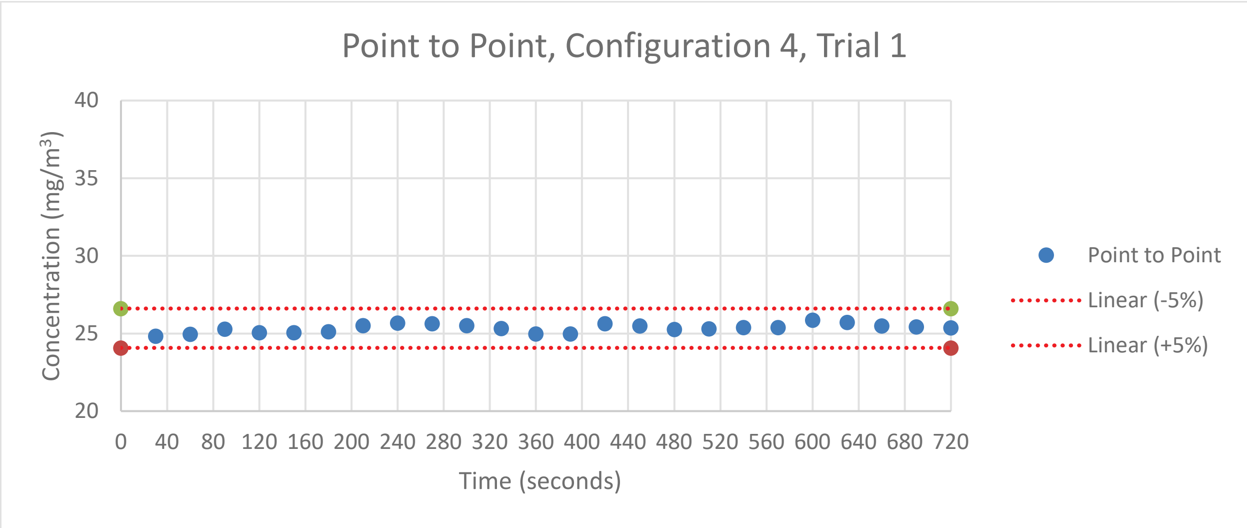


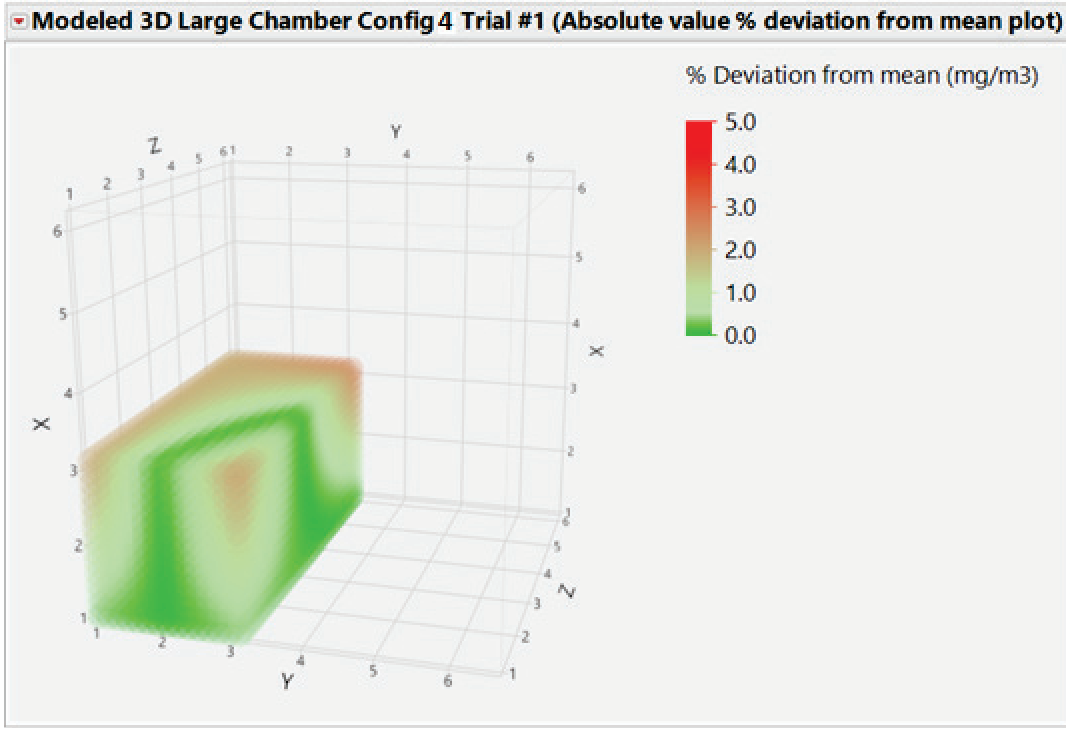
Point-to-point sampling, front-left view.

B.4 CONFIGURATION 4: TRIALS 1–7

B.4.1 Configuration 4, Trial 1







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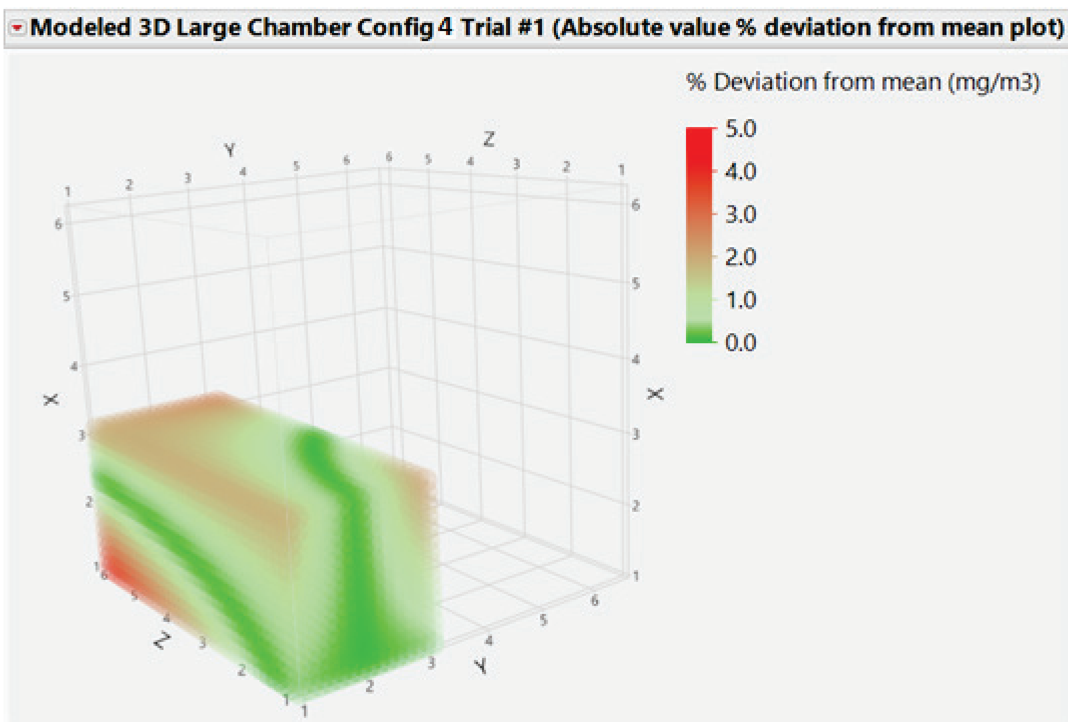
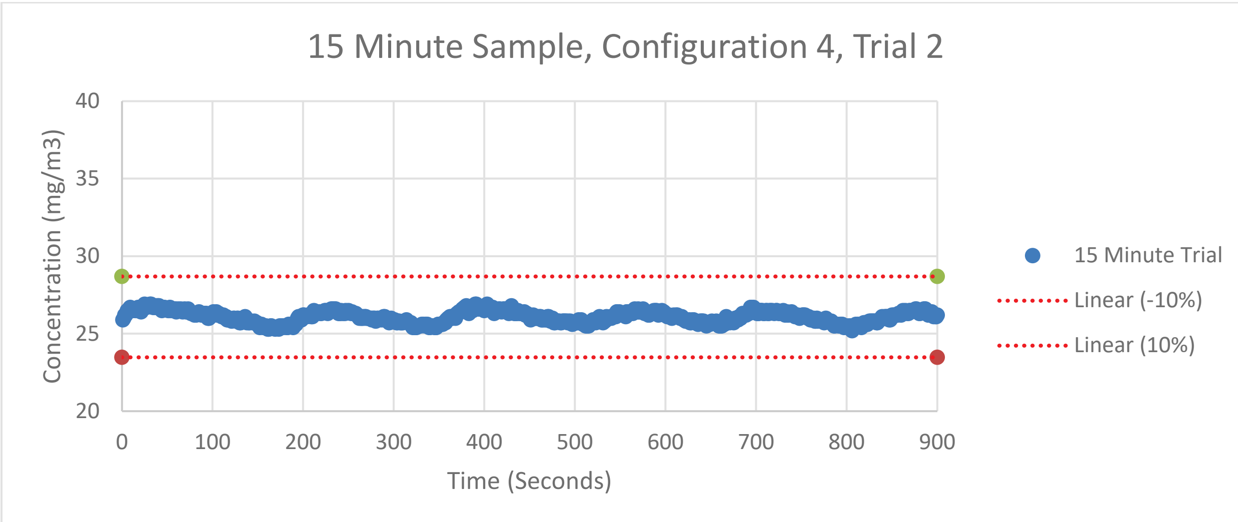
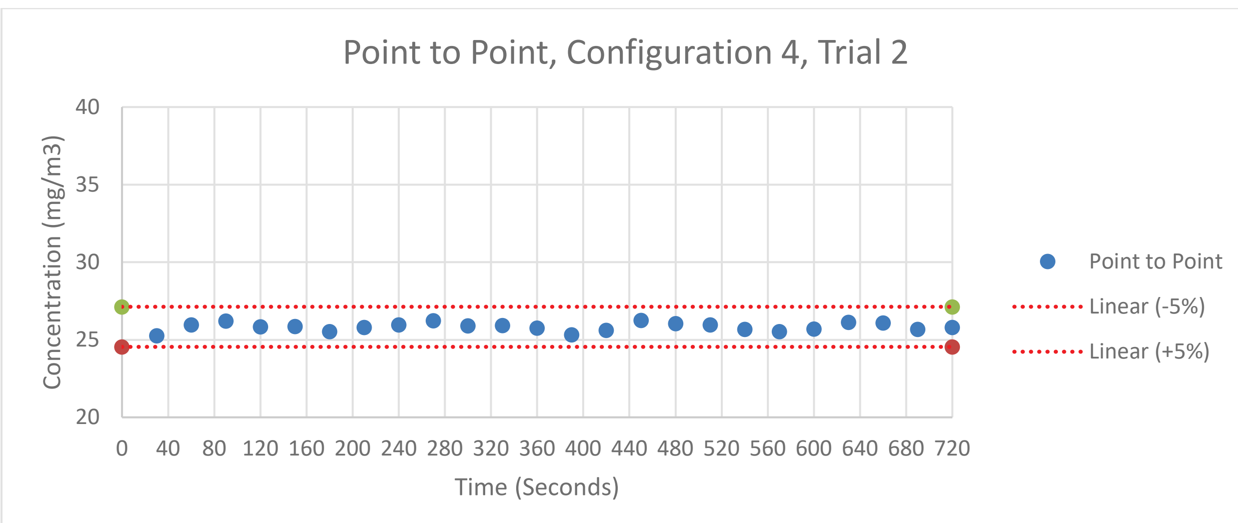
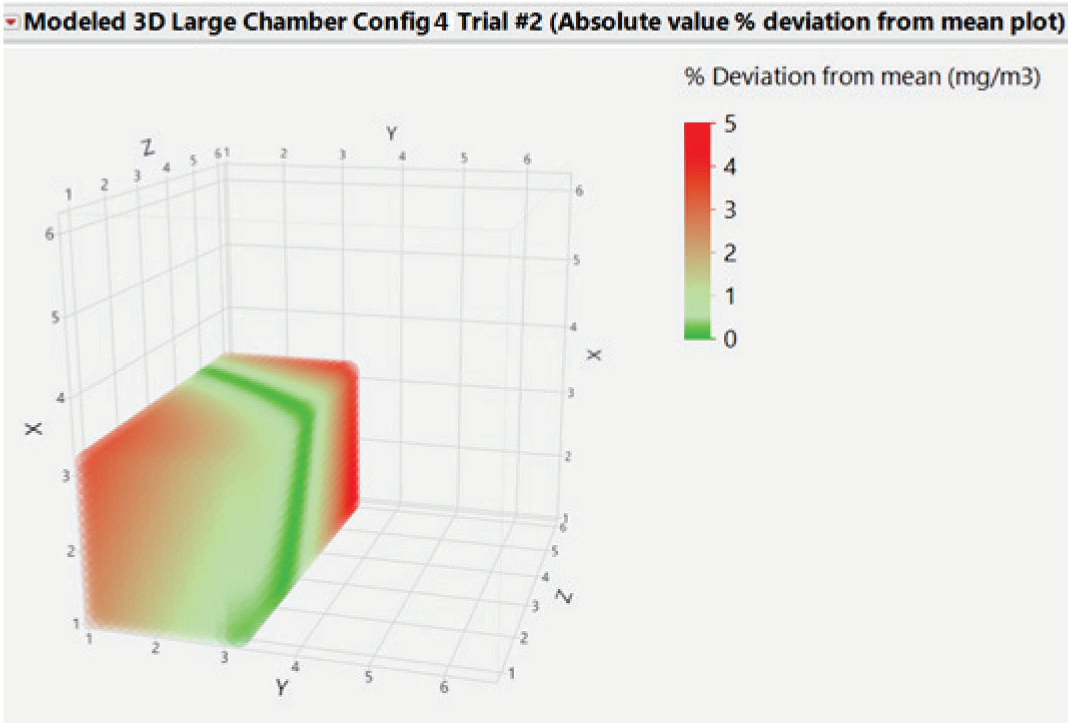


Point-to-point sampling, front-left view.

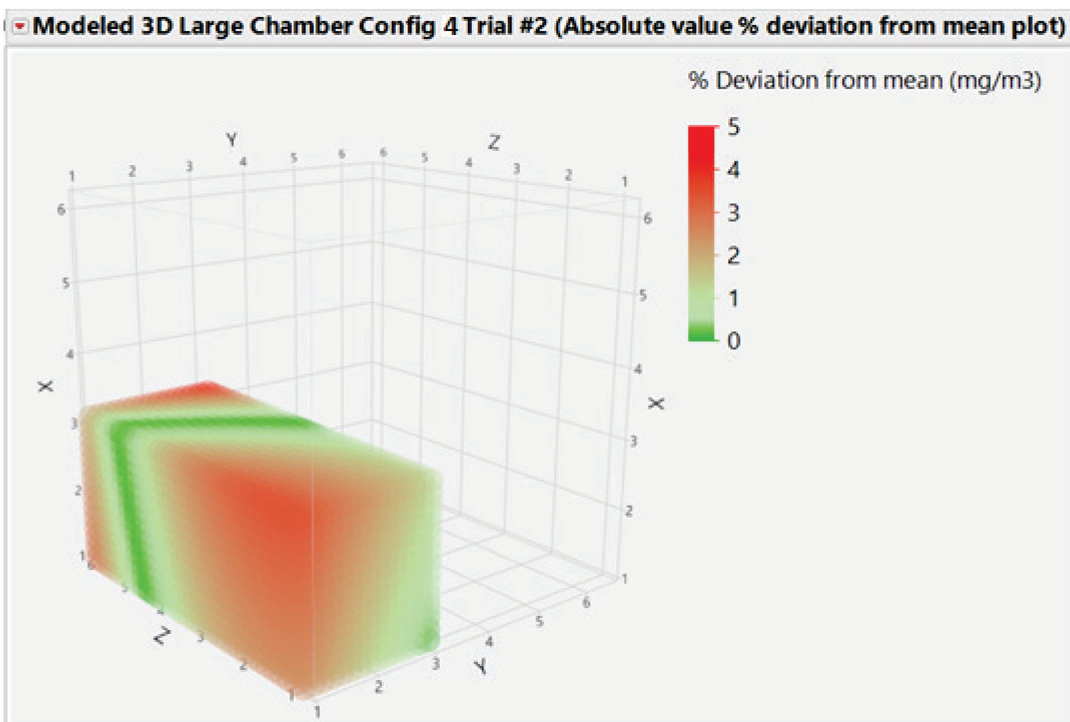
B.4.2 Configuration 4, Trial 2







Point-to-point sampling, front-right view.



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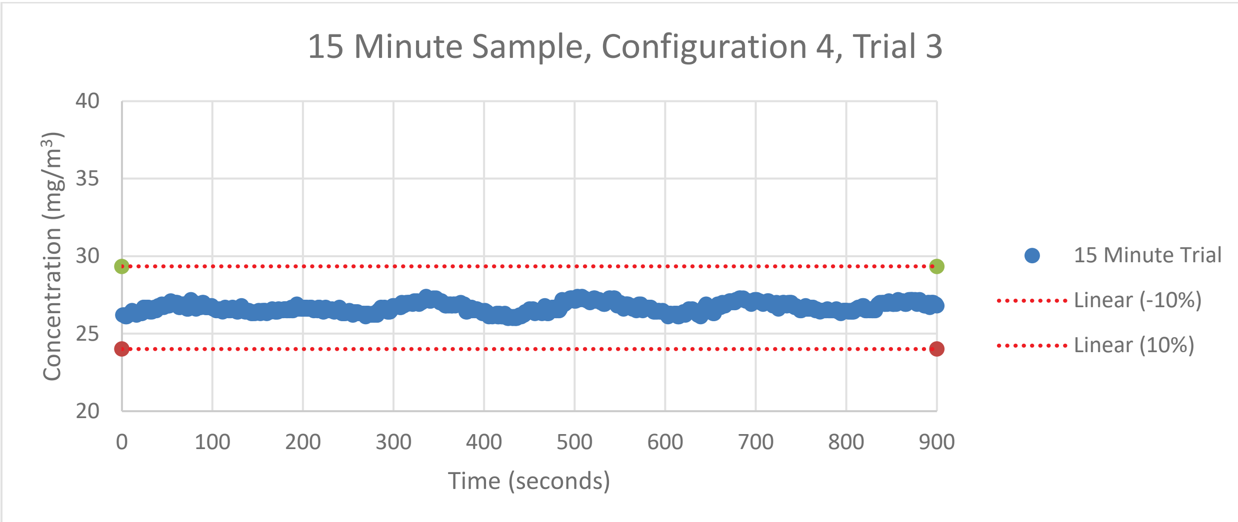

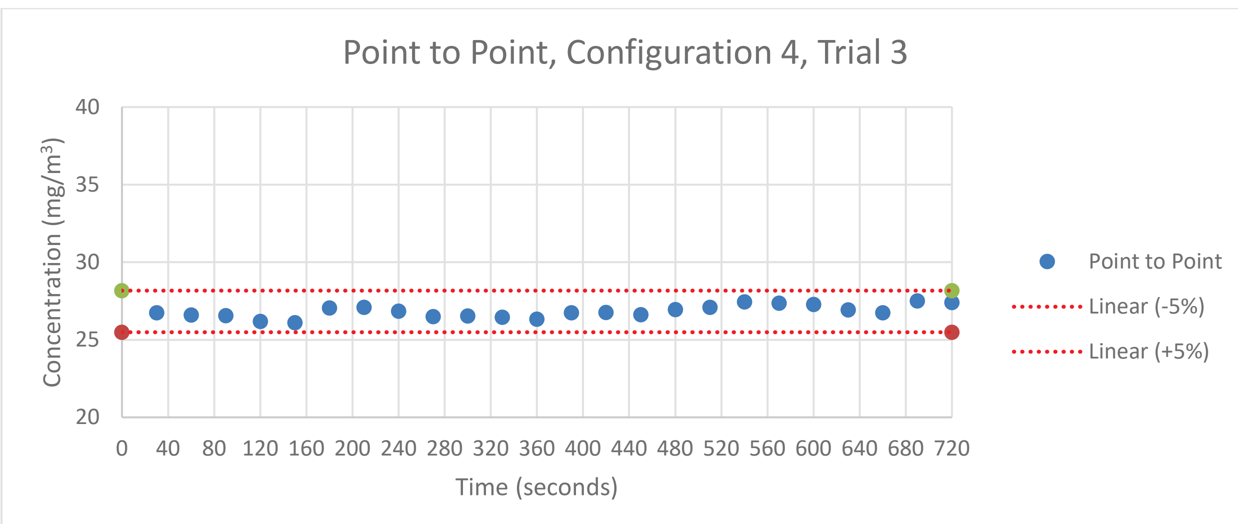

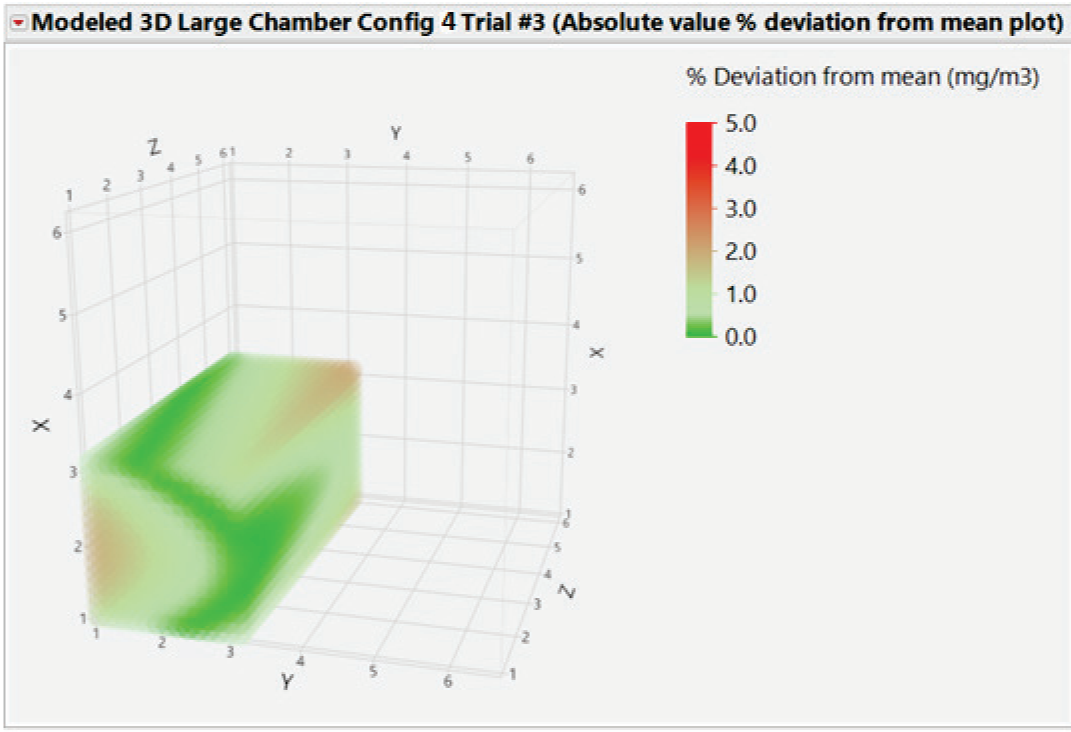

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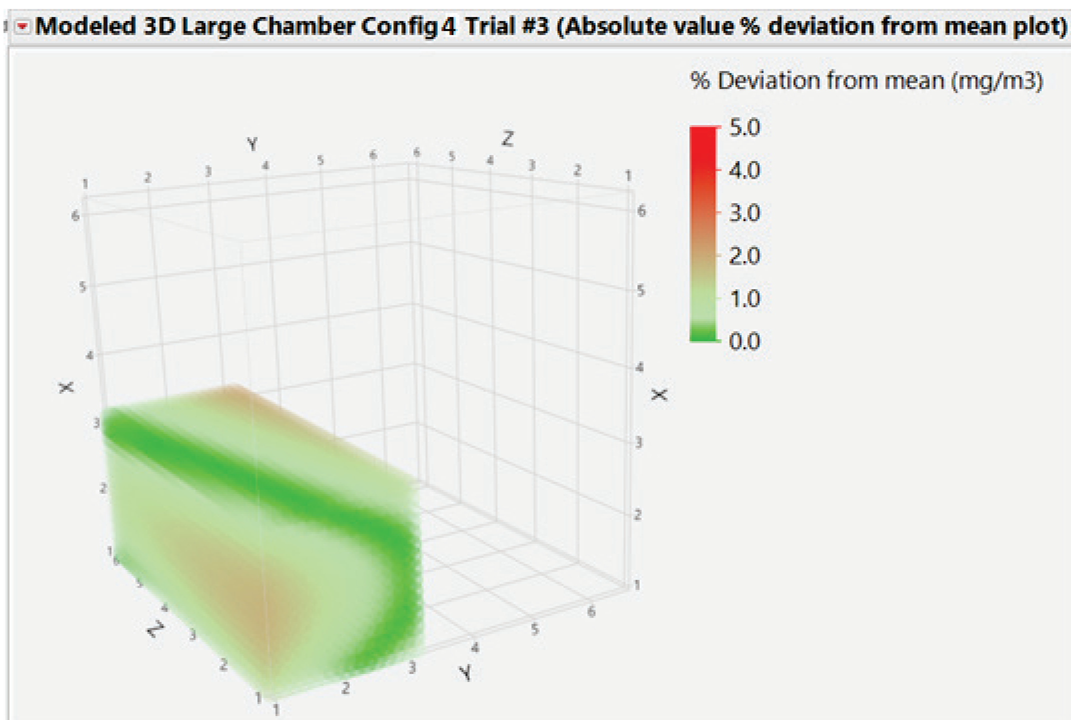

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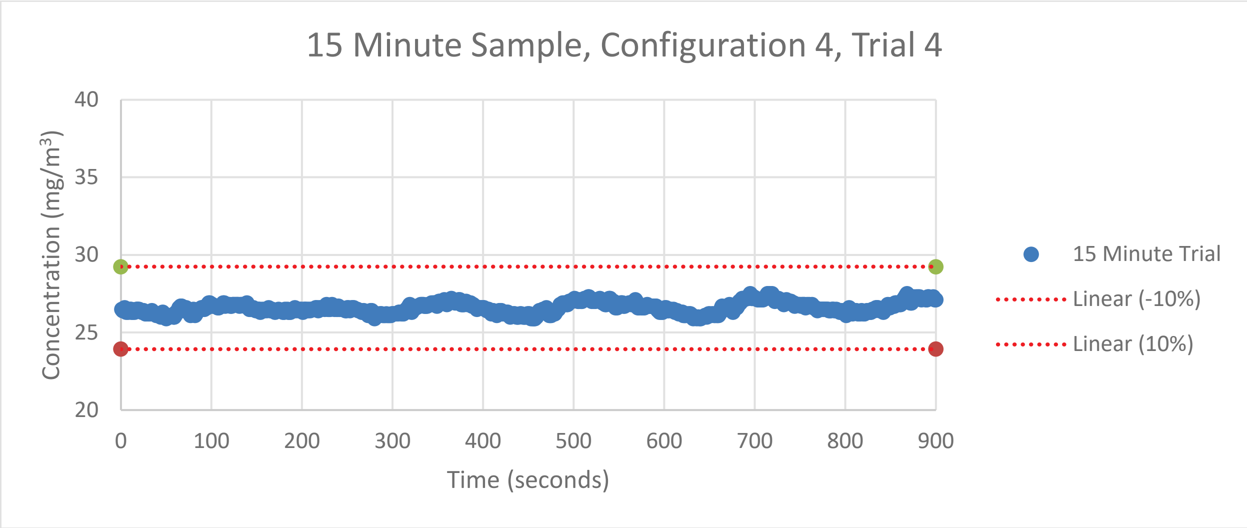
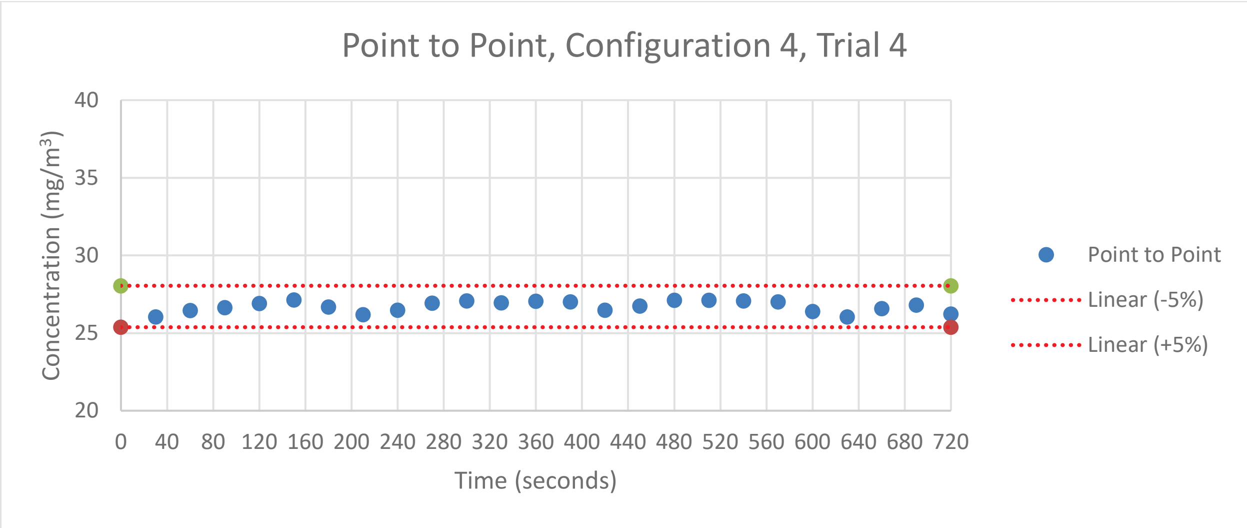
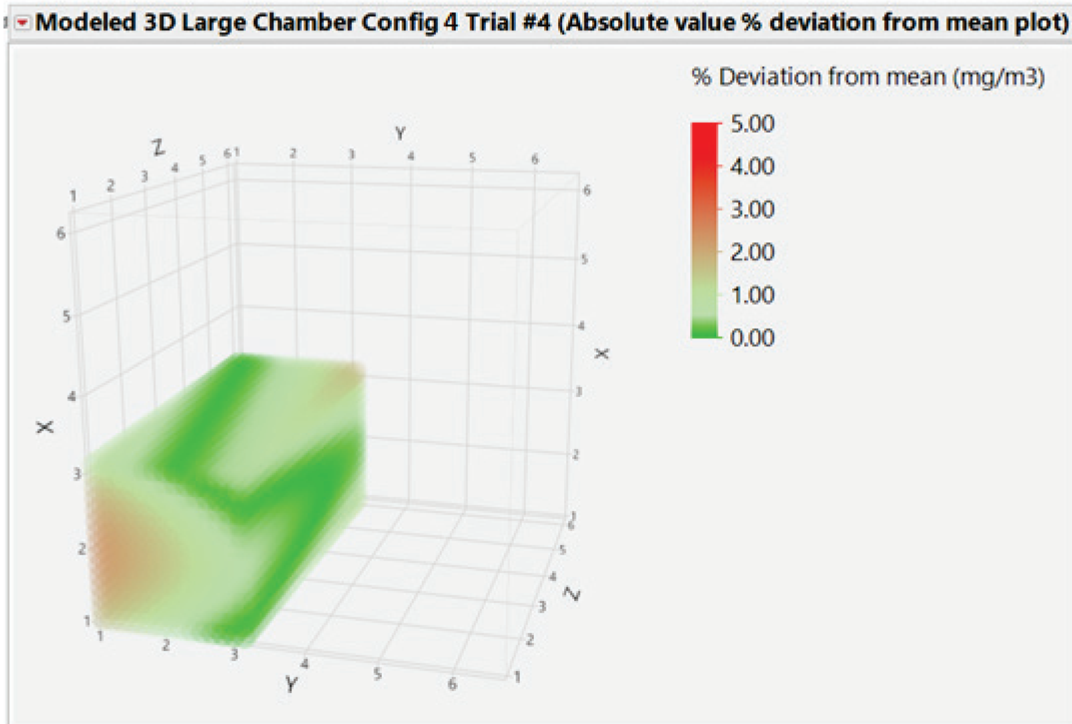
B.4.4 Configuration 4, Trial 4







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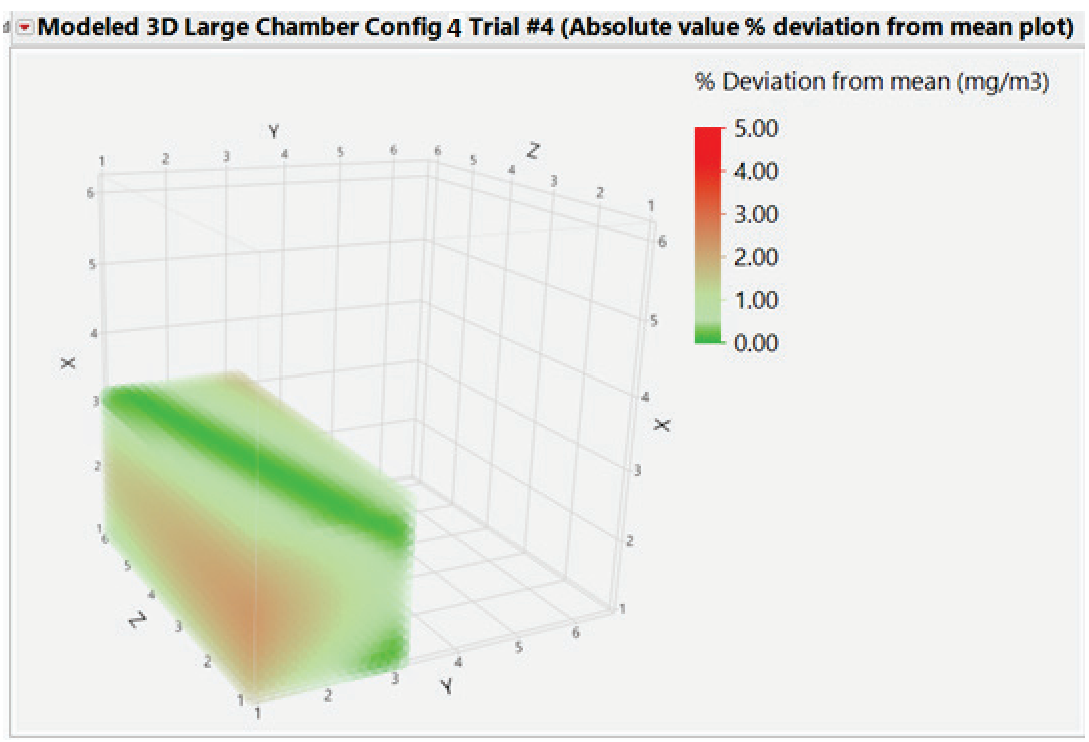
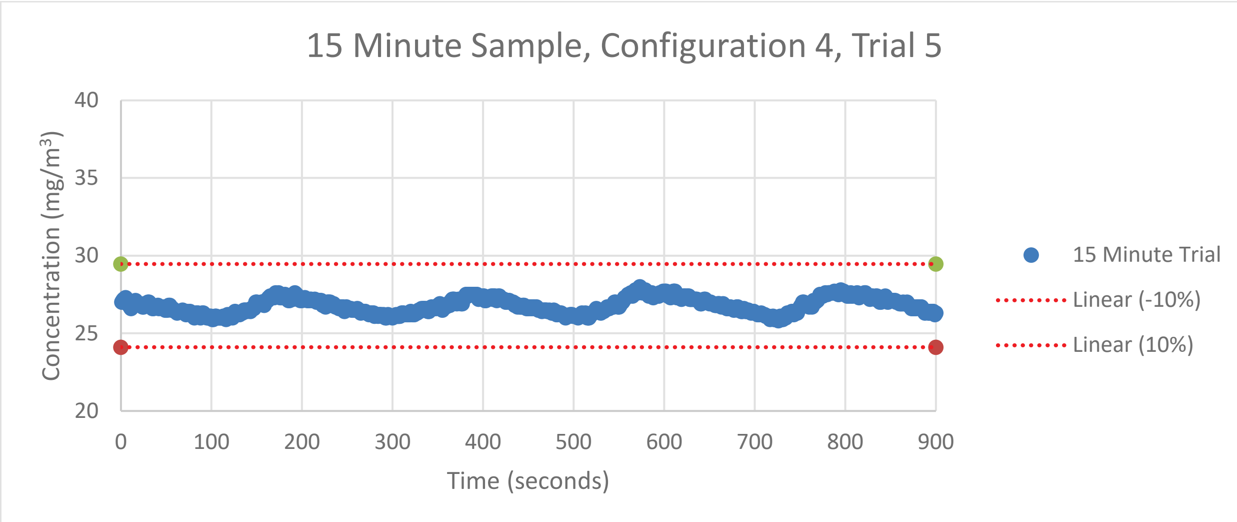
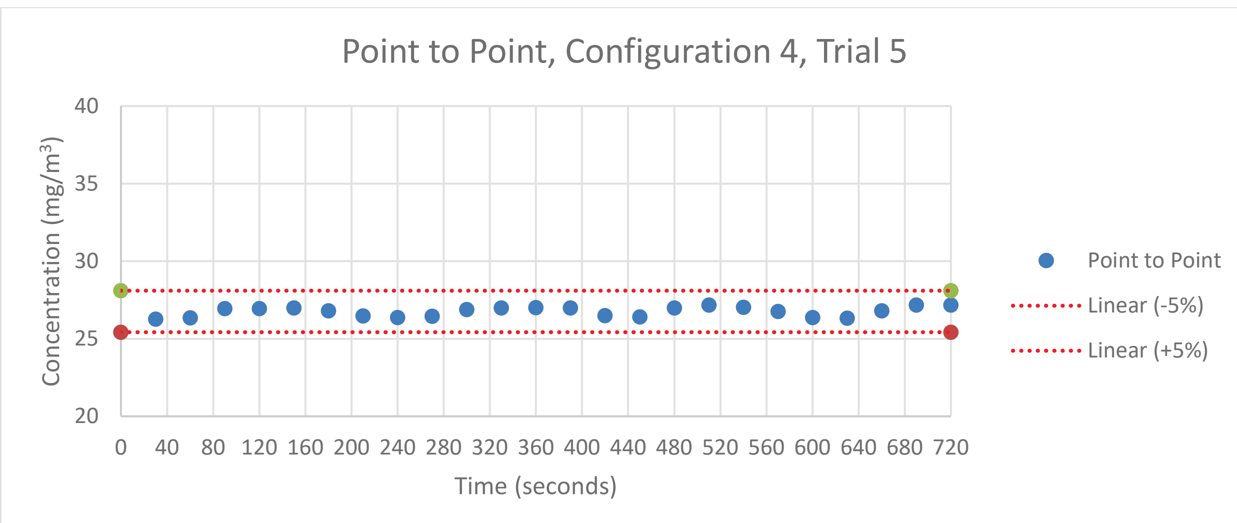
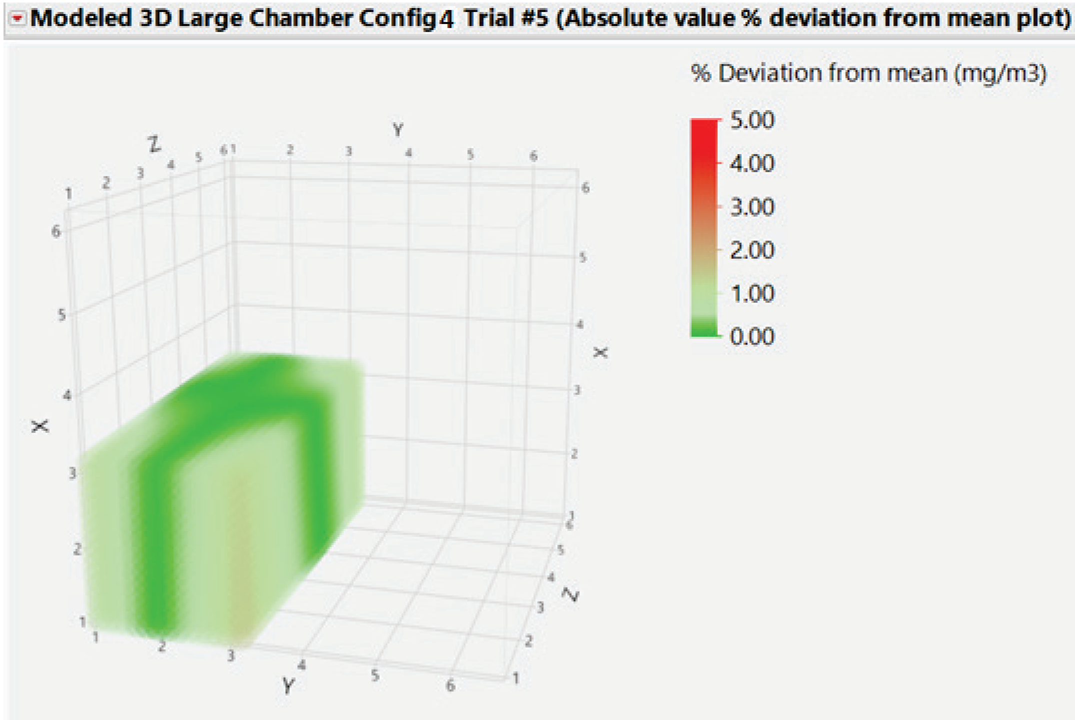


Point-to-point sampling, front-left view.

B.4.5 Configuration 4, Trial 5







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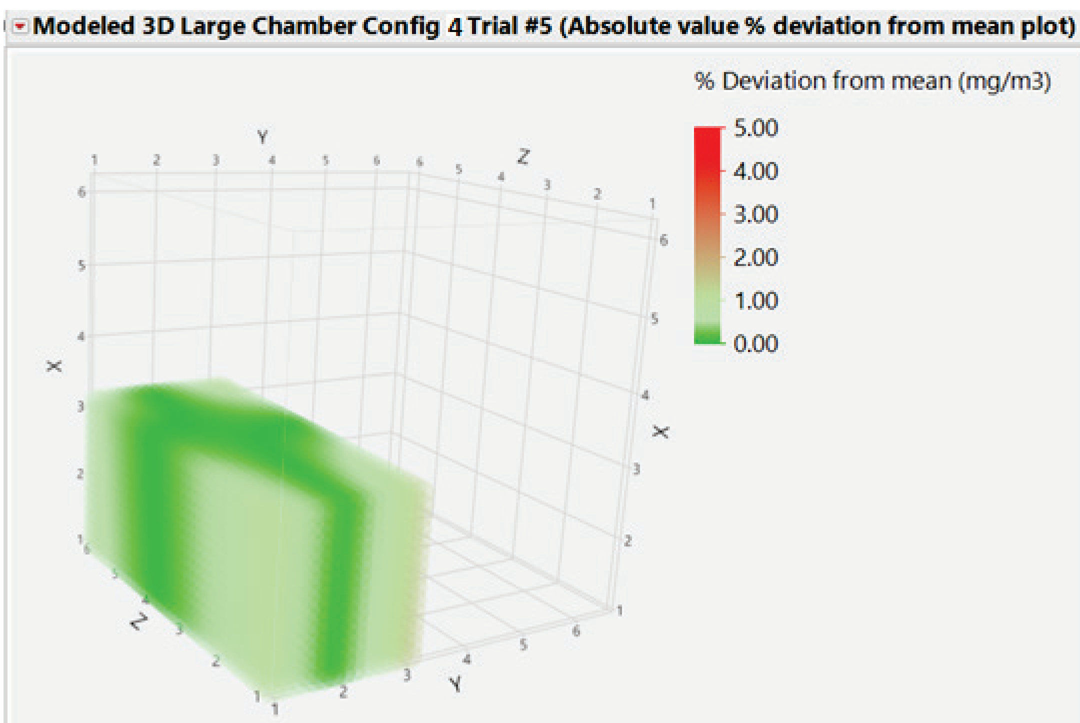
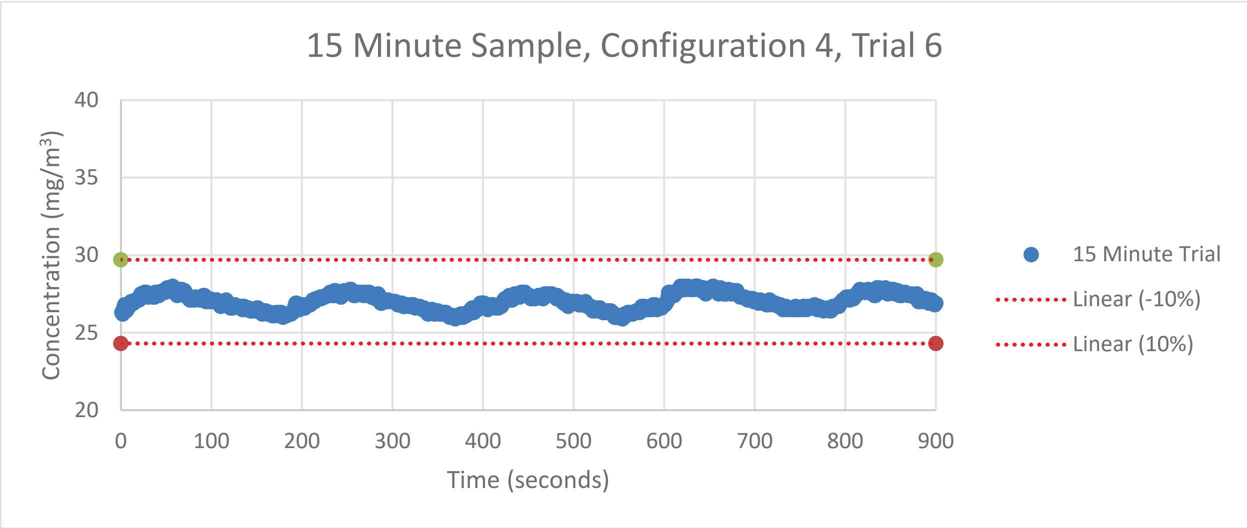
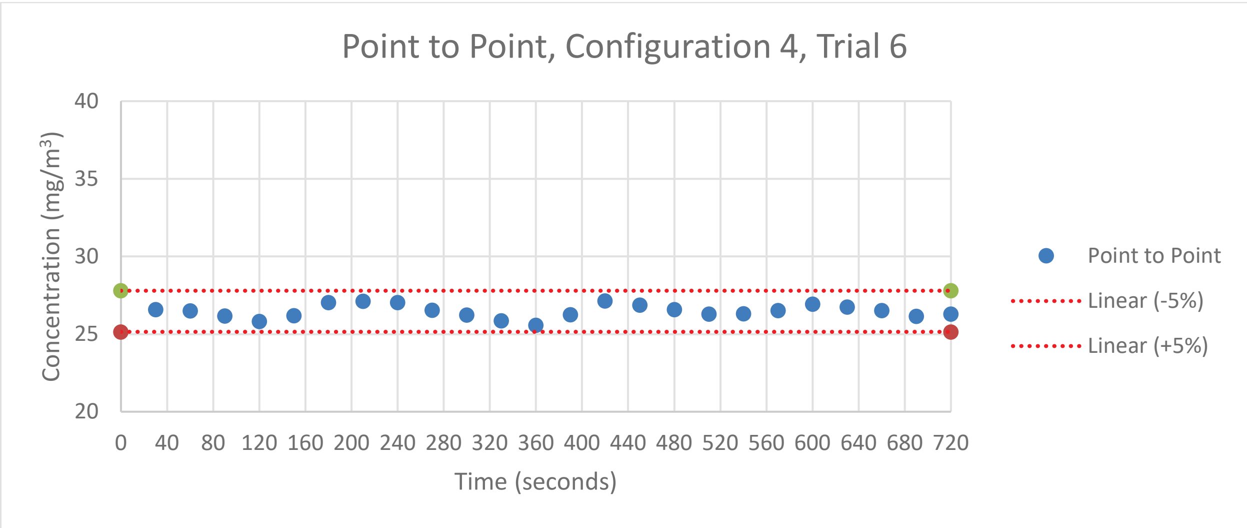
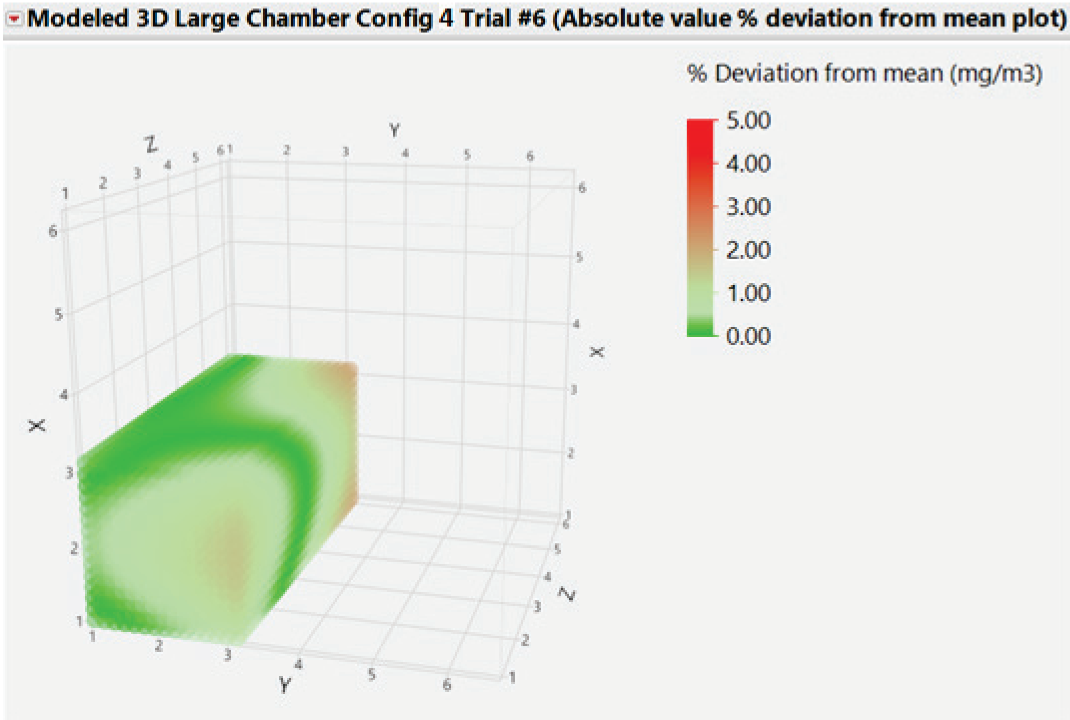


Point-to-point sampling, front-left view.

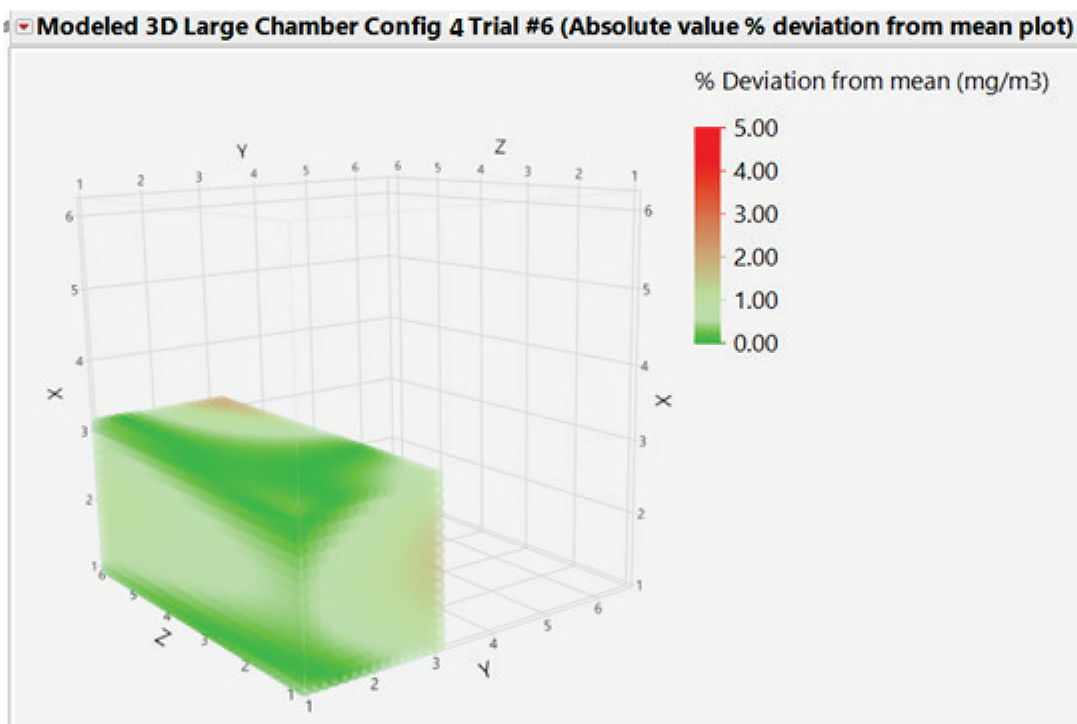
B.4.6 Configuration 4, Trial 6





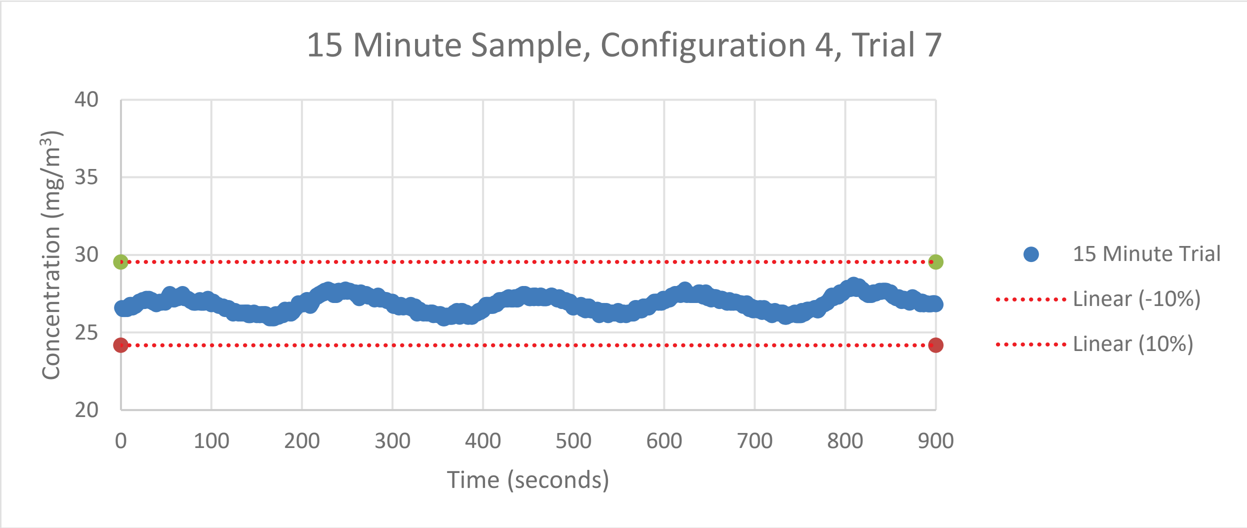


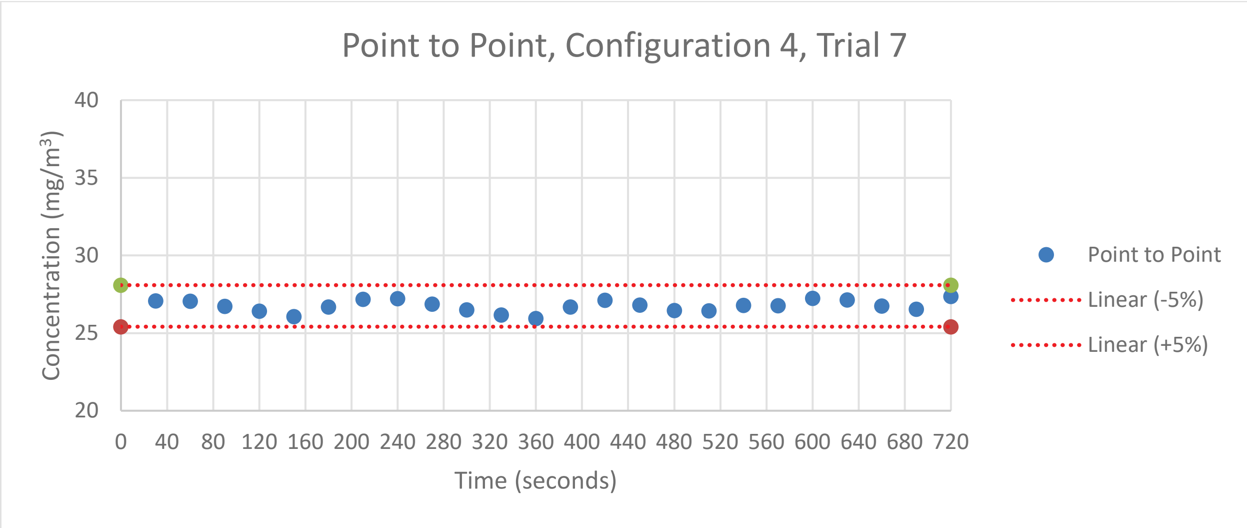
Point-to-point sampling, front-right view.

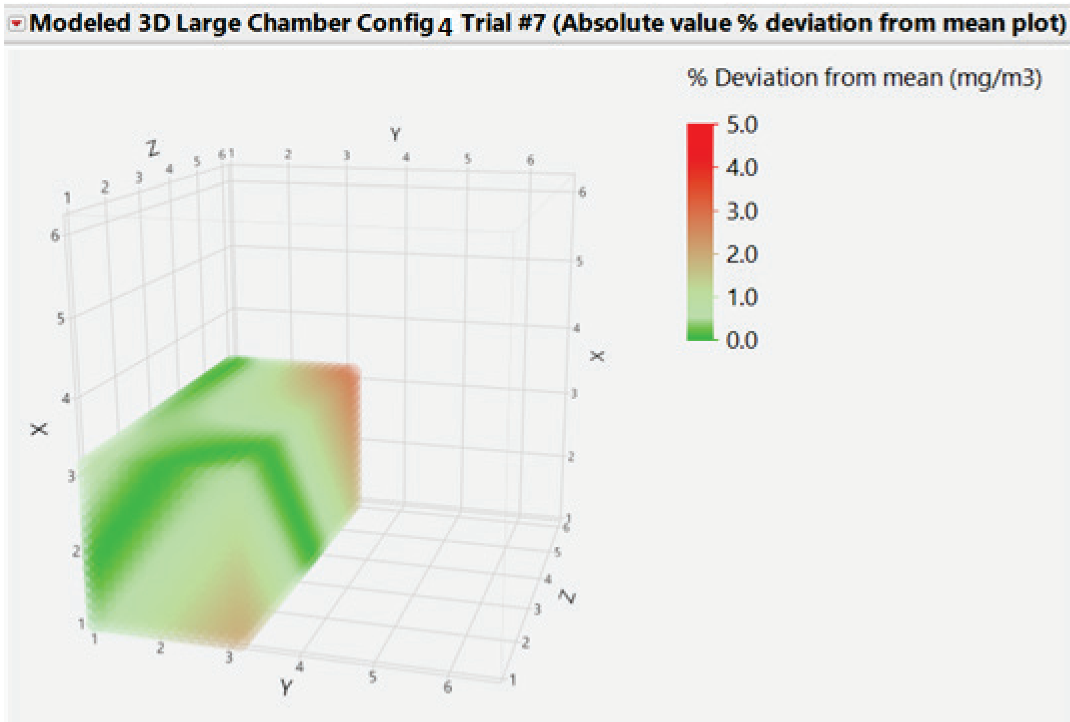


Point-to-point sampling, front-left view.

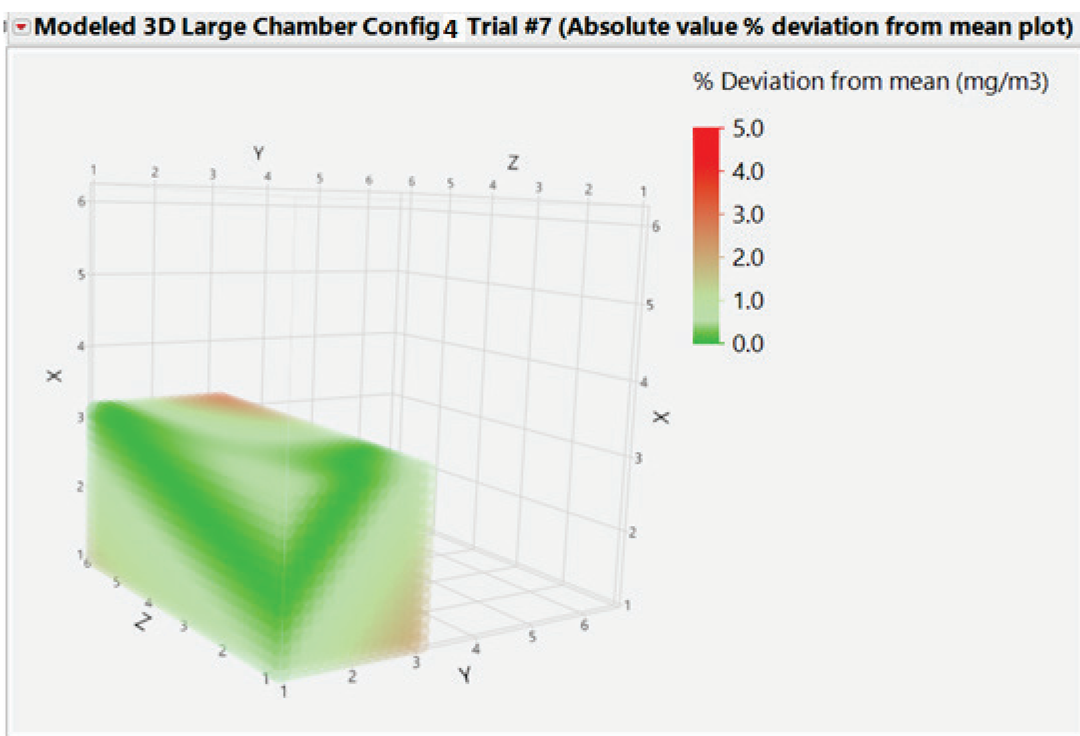
B.4.7 Configuration 4, Trial 7







Point-to-point sampling, front-right view.



Point-to-point sampling, front-left view.

APPENDIX C

MEMORANDUM: JOINT SERVICE STANDARDIZATION AGREEMENT FOR FIT FACTOR TESTING OF MILITARY MASKS

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HEADQUARTERS US ARMY MATERIEL COMMAND
5001 EISENHOWER AVE., ALEXANDRIA, VA. 22333-0001

DEPARTMENT OF THE NAVY
DEPUTY CHIEF OF NAVAL OPERATIONS (LOGISTICS)
WASHINGTON, DC 20350-2000

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE LOGISTICS COMMAND
WRIGHT-PATTERSON AFB, OHIO 45433-5001

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SYSTEMS COMMAND
ANDREWS AFB, WASHINGTON, DC 20334-5000

JOINT LOGISTICS COMMANDERS
JOINT PANEL ON CHEMICAL AND BIOLOGICAL DEFENSE

SMCCR-CO

10 JAN 1992

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Joint Service Standardization Agreement for Fit Factor Testing of Military Masks

As the representatives for the four Services' chemical-biological research and development matters, we endorse the enclosed Memorandum of Agreement as a joint service standardized test methodology.

Use of this test methodology during the research and development of military masks by Program Managers, project engineers, equipment developers, and industry will enhance our overall CBD capability.

J. A. VAN PROOYEN
Brigadier General, USA
Commanding
U.S. Army Chemical Research, Development and Engineering Center

R. A. TIEBOUT
Major General, USMC
Commanding General
Marine Corps Research Development and Acquisition Command

JAMES F. ROBBINS, GM-15
Director, Air Base Operability
Aeronautical Systems Division
Air Force Systems Command

STANLEY HERMAN, GM-15
Director, Ship Survivability Subgroup
Naval Sea Systems Command

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