Fume Hood Performance Testing with Simultaneous Use of Both Nitrous Oxide and Sulfur Hexafluoride through a Single ASHRAE Standard 110 Ejector

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Alternate Titles…

The Dual Gas, One Ejector Study

Or

DG2E vs DG1E

The Motivating Force:

After December 31, 2011, ASHRAE 110-style tracer testing of fume hoods using SF6 will be illegal in California except when done **once** with **reduced face velocity** when the hood is unattended.

Review - 1

- We started seriously working on replacing SF6 in 2007. That work included the “Dual Gas – Dual Ejector [DG2E]” testing previously discussed here and at AIHce 2008 RT210

Review - 2

- Although that work showed a good correlation between SF6 and N2O, there were experimental problems that left many people unconvinced of N2O's suitability

Dual Gas – Dual Ejector Issues

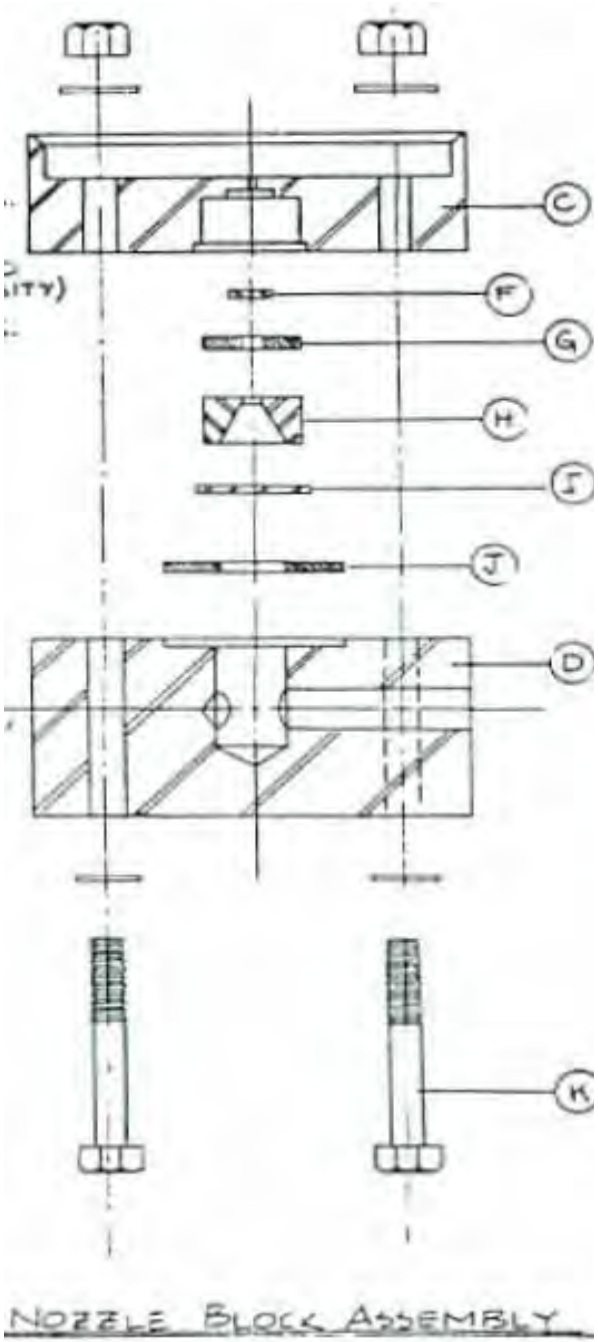
1. Plume Size: Using 4 lpm of each gas, the plumes were not the same.
2. Lateral Displacement: Using two ejectors side-by-side separated the two plumes ~15 cm and contributed to dissimilar results in the SF6 and N2O traces
3. Insufficient attention was paid to the drift in the background concentration of N2O

Issue: N2O Background Drift

- The concern with background drift is that we did not show that the amount of drift was low compared to the analytically significant value of 0.10 ppm
- To address this, we resolved to increase the resolution of our N2O area monitor. We reduced its span from 0-100 ppm to 0-5 ppm.

Issue: Plume Size

- It would be easy enough to adjust the ejector so that the plume size N2O would be the same as that of SF6 for equivalent flow; that just requires resizing the critical orifice.
- But that would not address errors from lateral displacement…



Issue: Lateral Displacement

- To eliminate the lateral displacement means using only one ejector: running both gasses through one orifice.
- This is difficult using 2-stage regulators. Instead, we used a pair of mass flow controllers.

Combined Approach - 1

- Both gasses would share the same ejector and be equally mixed in the same plume.
- Both gasses would flow at the same rate and have the same concentration in the plume
- The combined flow from the two gasses must create the same size plume as 4.0 lpm of SF6 alone

Combined Approach - 2

- After verifying that the mass flow controllers were stable and repeatable, we ran our “white box” tests to establish the required flow rates to get the “equivalent plume”:

SF6, lpm	N2O, lpm	Total lpm
2.665	2.665	5.33

Combined Approach - 3

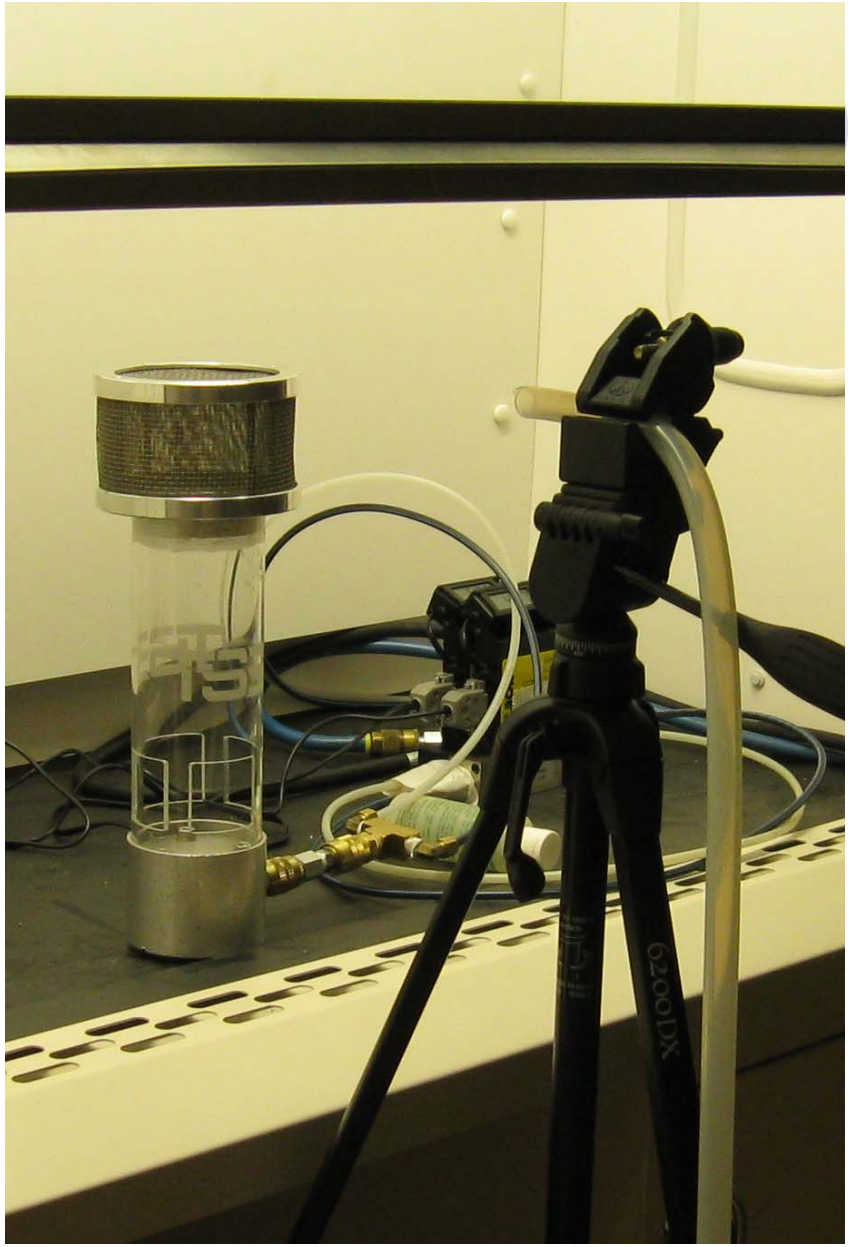
- Since neither gas would be able to flow at 4.0 lpm during these dual gas tests, results may have to be multiplied by 1.5x to compare to “regular” tests.
- We did not try to make this comparison: our point was to investigate the ability of N2O to behave like SF6 under conditions as similar as possible.

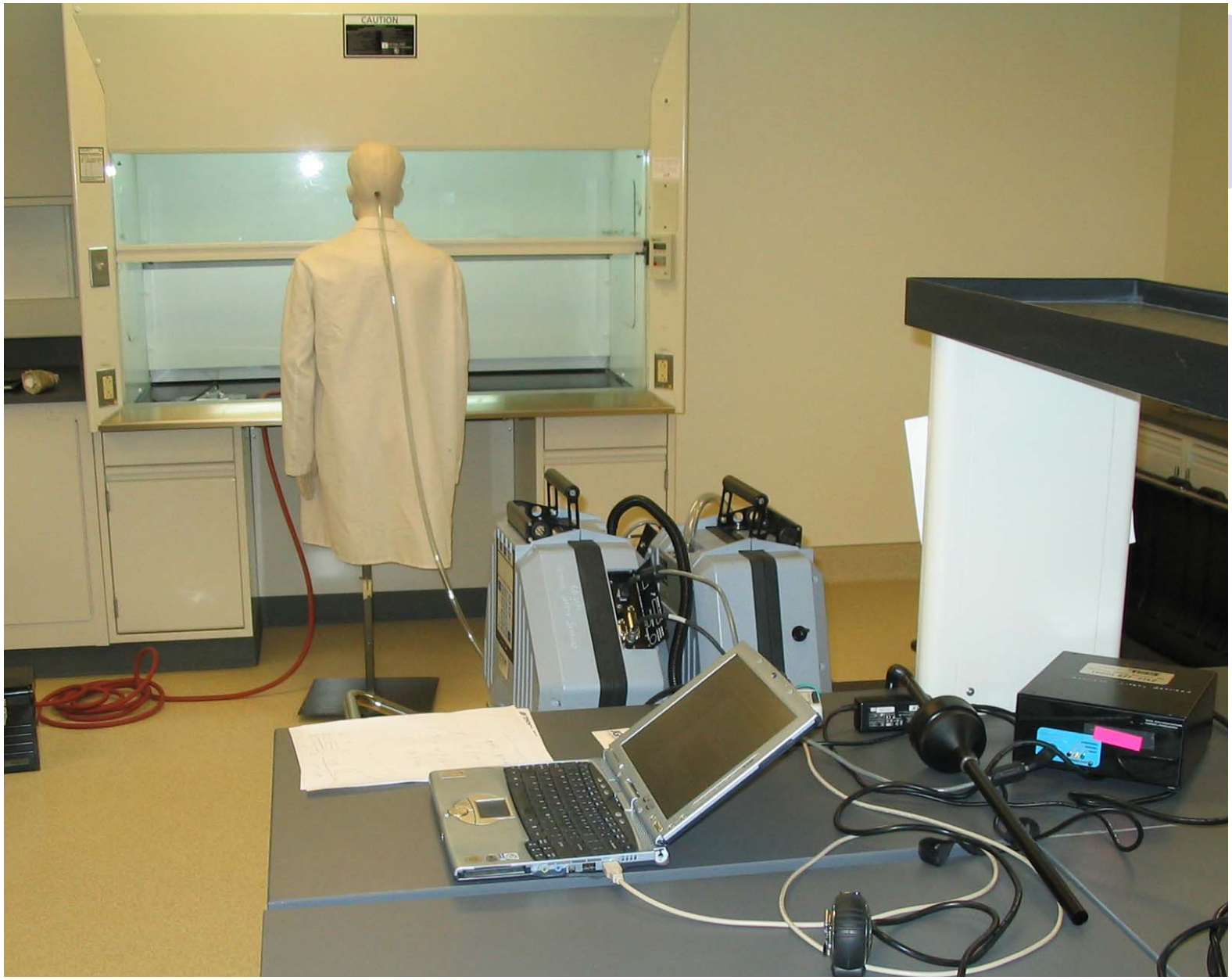
Field Testing - 1

- We are testing VAV fume hoods under unoccupied/reduced flow conditions: 60-70 fpm average face velocity.
- Single Gas tests: A fume hood must pass 4.0 AU 0.10 with SF6, then it must also pass 4.0 AU 0.10 with N2O.
- Dual Gas tests: If it passed the SG tests, it is subjected to dual gas testing.

Field Testing - 2

- Dual Gas tests:
  - 50 minutes in the center position only
  - Sample close to the face of the fume hood to be able to detect a leak.
  - Log background N2O concentration in lab




CAUTION

Results – Single Gas

- All 5 fume hoods tested so far have been newly-constructed from a single manufacturer, installed in operating laboratory spaces.
- The single-gas results are all comparable and all fume hoods passed

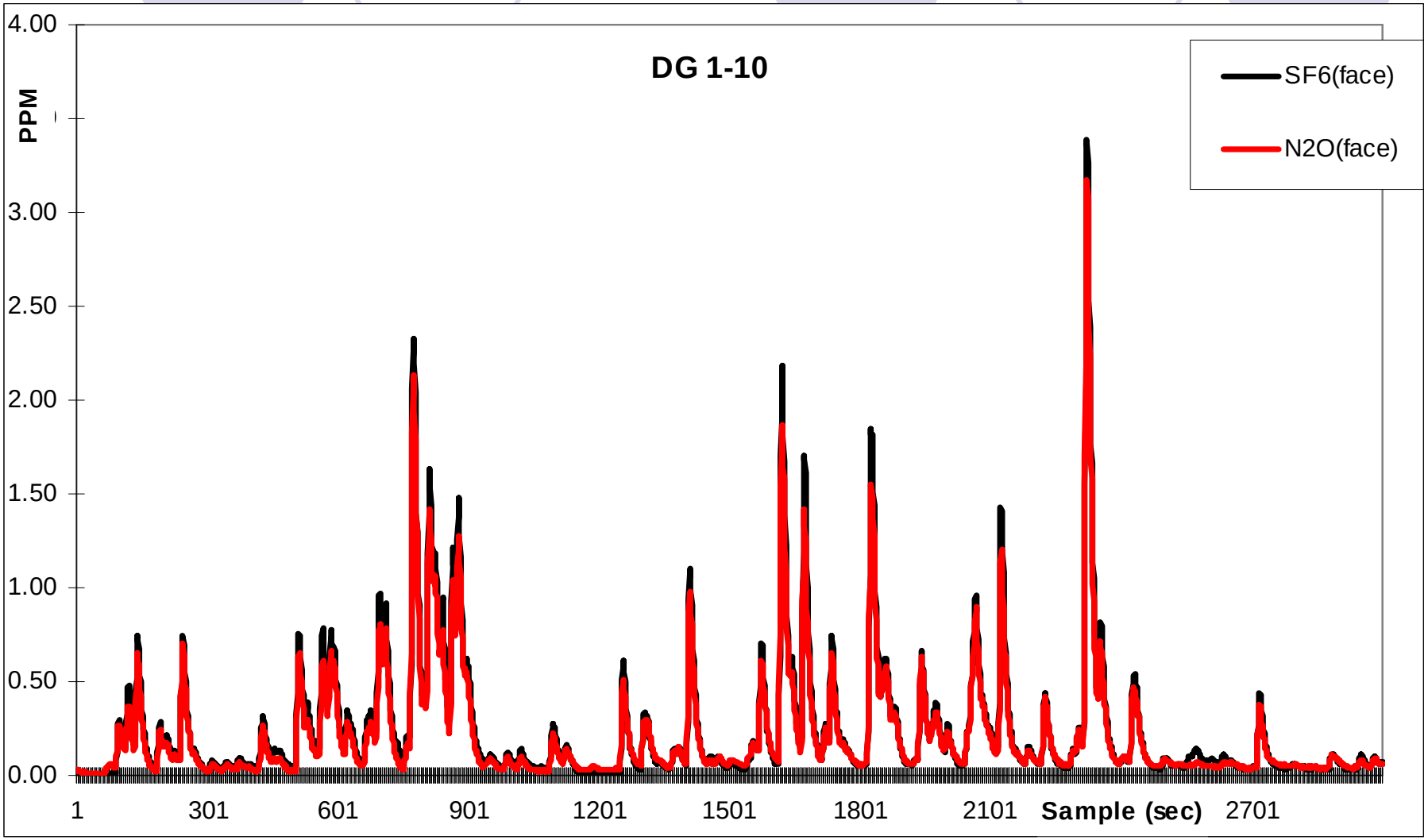
Results – Single Gas

	Peak Values, ppm		Average Values, ppm	
Fume Hood ID	SF6	N2O	SF6	N20
FH TSS003209	0.02	0.04	0.01	0.02
FH TSS005992	0.05	0.02	0.01	0.01
FH TSS005993	0.01	0.03	0.01	0.01
FH TSS005996	0.02	0.02	0.01	0.01
FH TSS006000	0.45	0.82	0.07	0.03

Results – DG1E - 1

- The results have been uniformly phenomenal.
- Plotting the SF6 and N2O concentrations together over the 50-minute interval shows the two lines to be virtually identical.

Results – DG1E - 2



Results – DG1E - 3

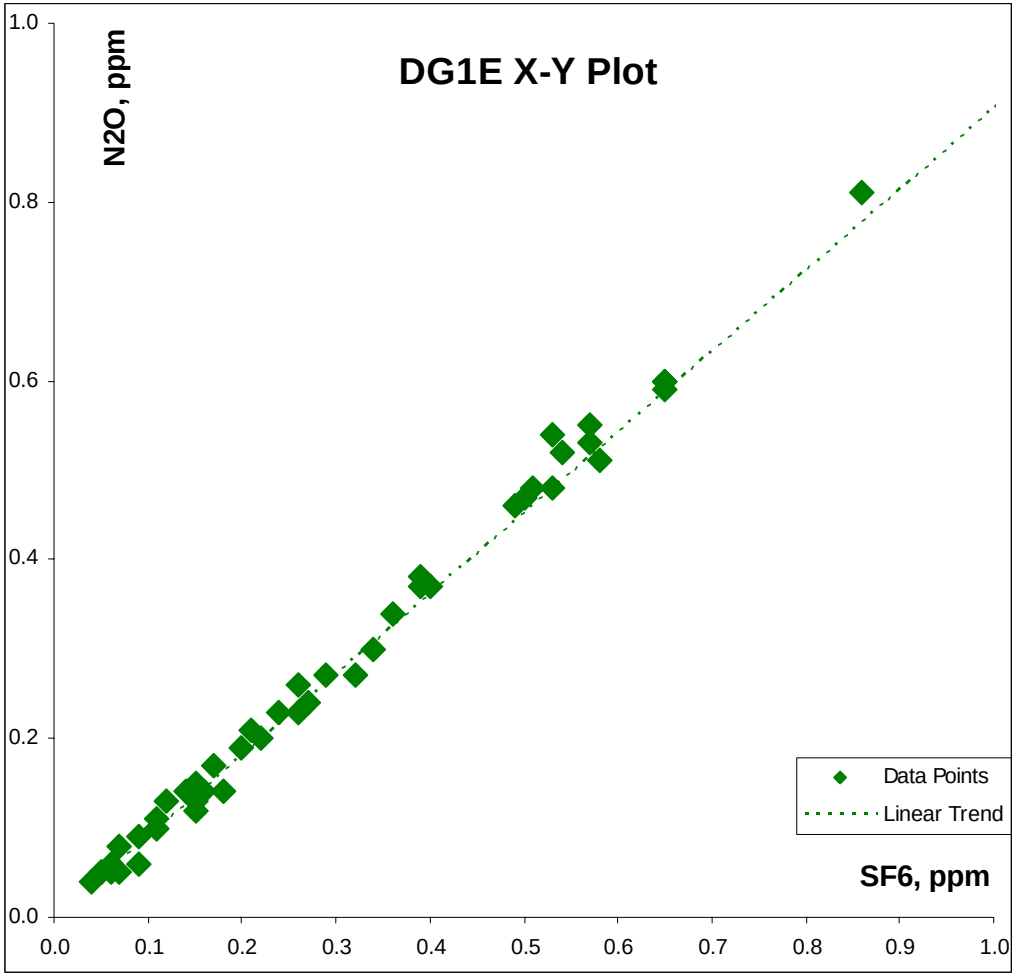
- Parsing the 50-minute DG1E sampling intervals into 10, successive 5-minute samples and comparing the average SF6 and N2O concentrations (like you would in a normal ASHRAE 110 test) shows excellent correlation:

Results – DG1E - 4

	Peak Values, ppm		Average Values, ppm	
Trial	**SF6**	**N2O**	**SF6**	**N20**
RFT SF6	0.02		0.01	
RFT N2O		0.04		0.02
DG 1	0.75	0.71	0.16	0.14
DG 2	0.77	0.65	0.18	0.14
DG 3	2.25	2.10	0.51	0.48
DG 4	0.53	0.44	0.09	0.06
DG 5	1.10	0.95	0.15	0.12
DG 6	2.16	1.82	0.32	0.27
DG 7	1.80	1.50	0.29	0.27
DG 8	3.35	3.13	0.34	0.30
DG 9	0.51	0.44	0.07	0.05
DG 10	0.41	0.34	0.04	0.04

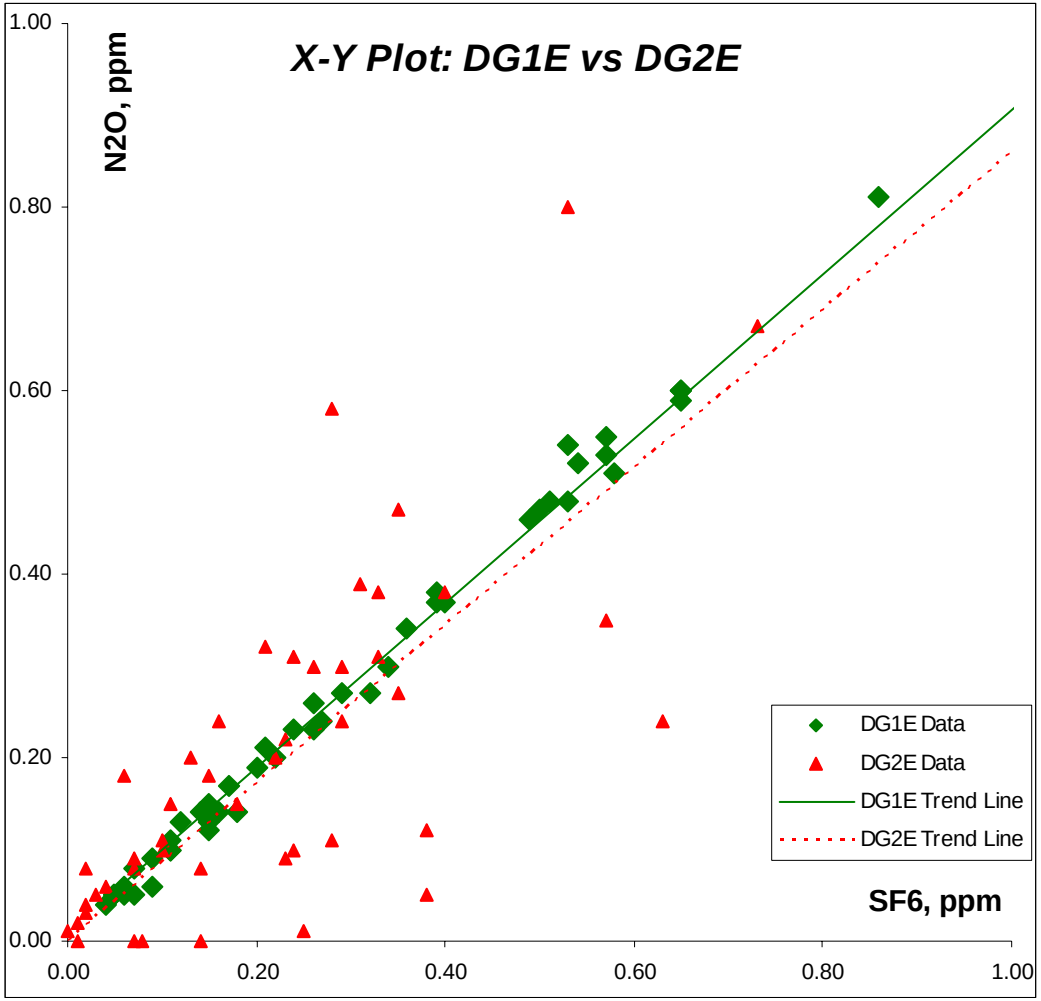
Results – DG1E - 5

- 99.7% Correlation



Results – DG1E - 6

- Compared to the DG2E test results

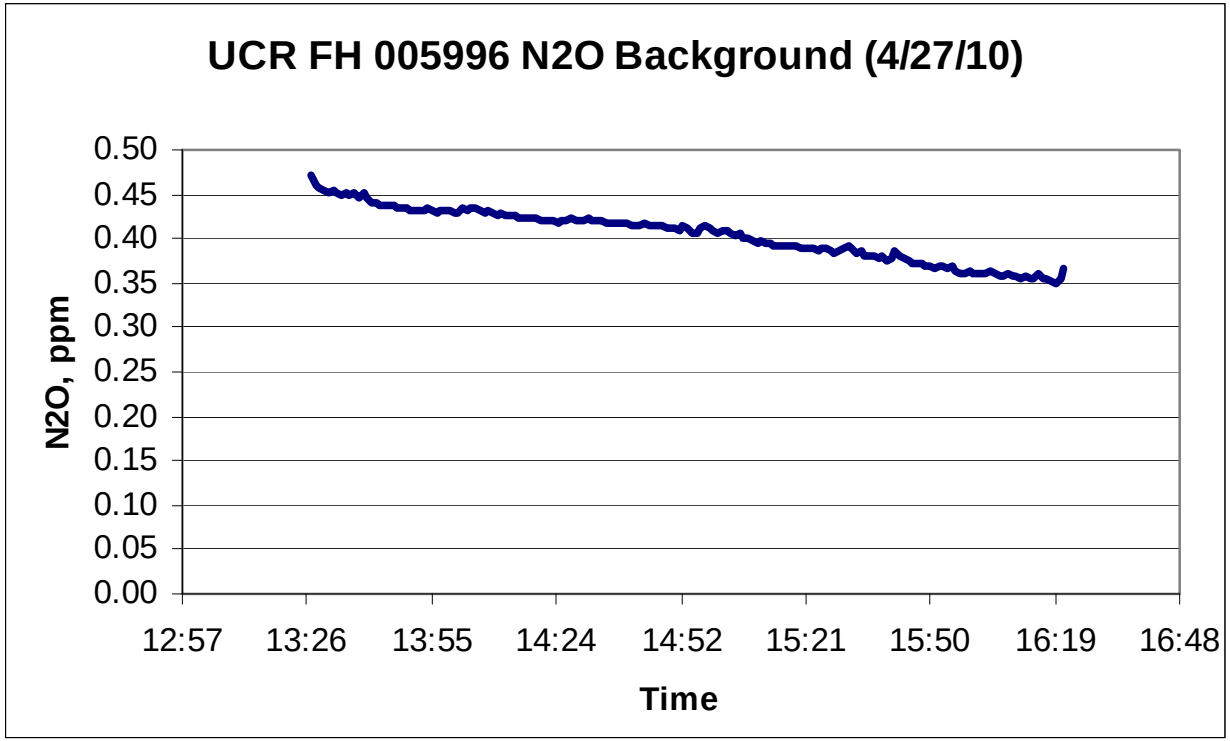


Results – Background N2O - 1

- Although the critical time period for ASHRAE 110 testing is five-minutes per location, we assume that the concentration should not change more than 0.03 ppm over a ten-minute interval.

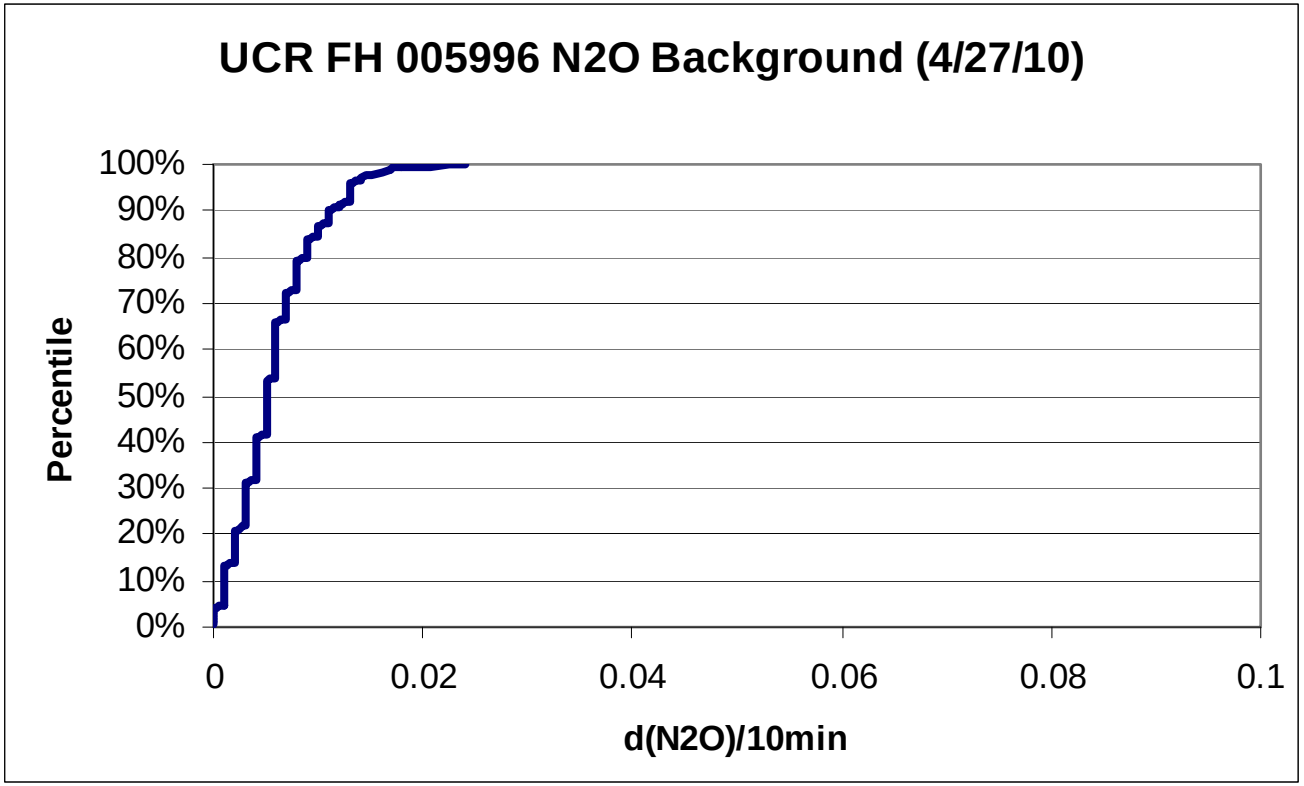
Results – Background N2O - 2

- This is typical and what we expect to see for N2O background drift:



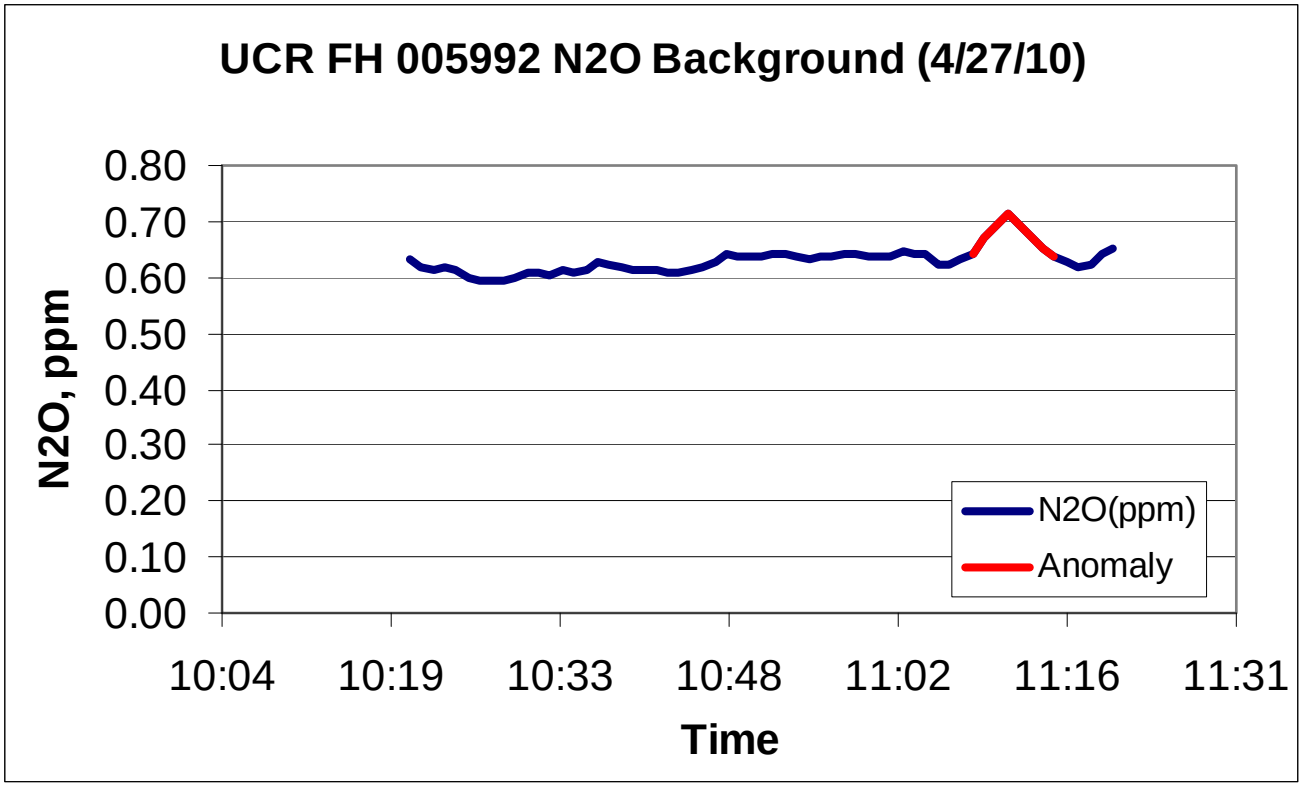
Results – Background N2O - 3

- Plotting that same data as d(N2O)/10min percentiles, the <=0.03ppm value is ~100%:



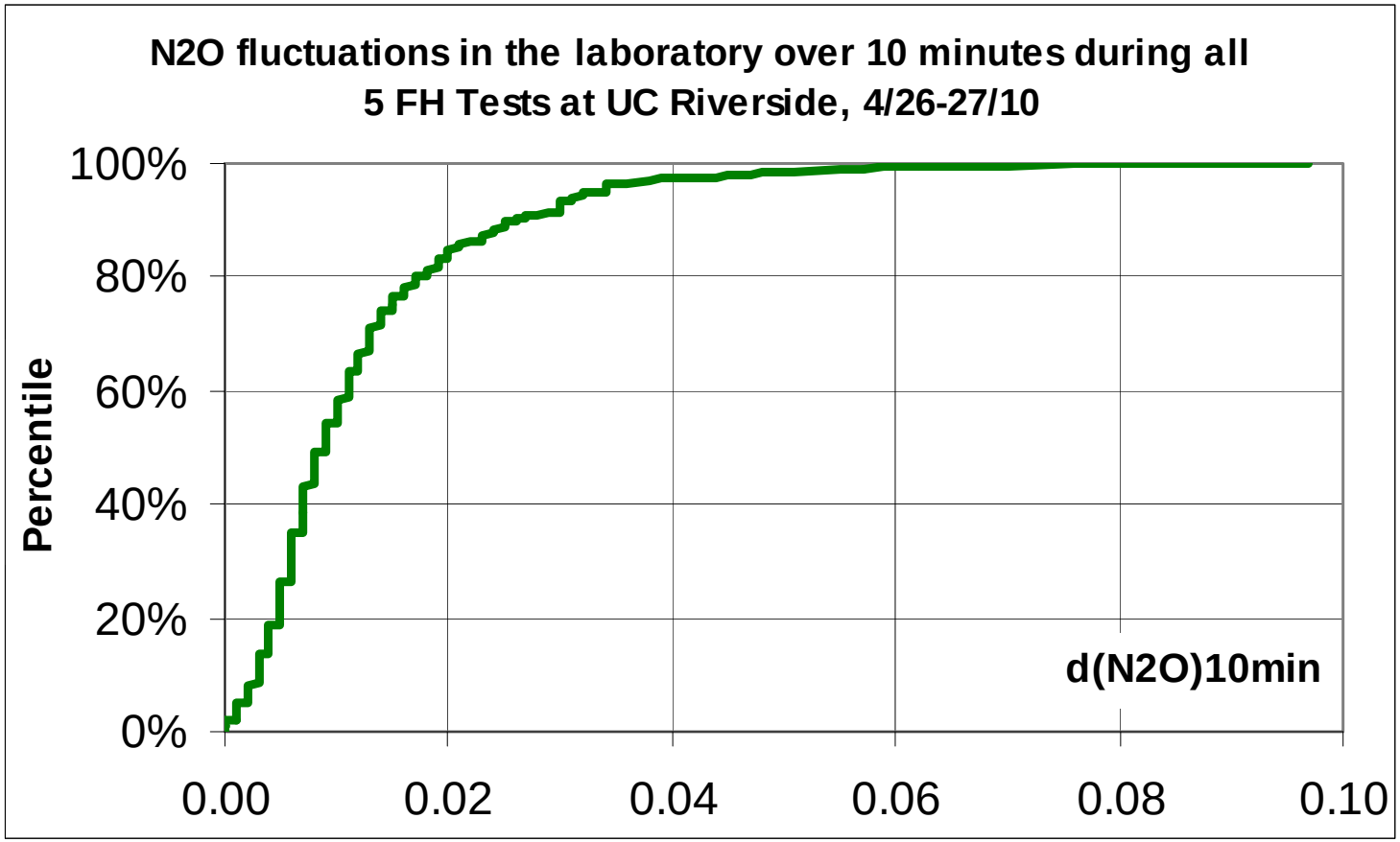
Results – Background N2O - 4

- Not all the data was perfect. Here was an anomalous spike in the N2O at one FH:

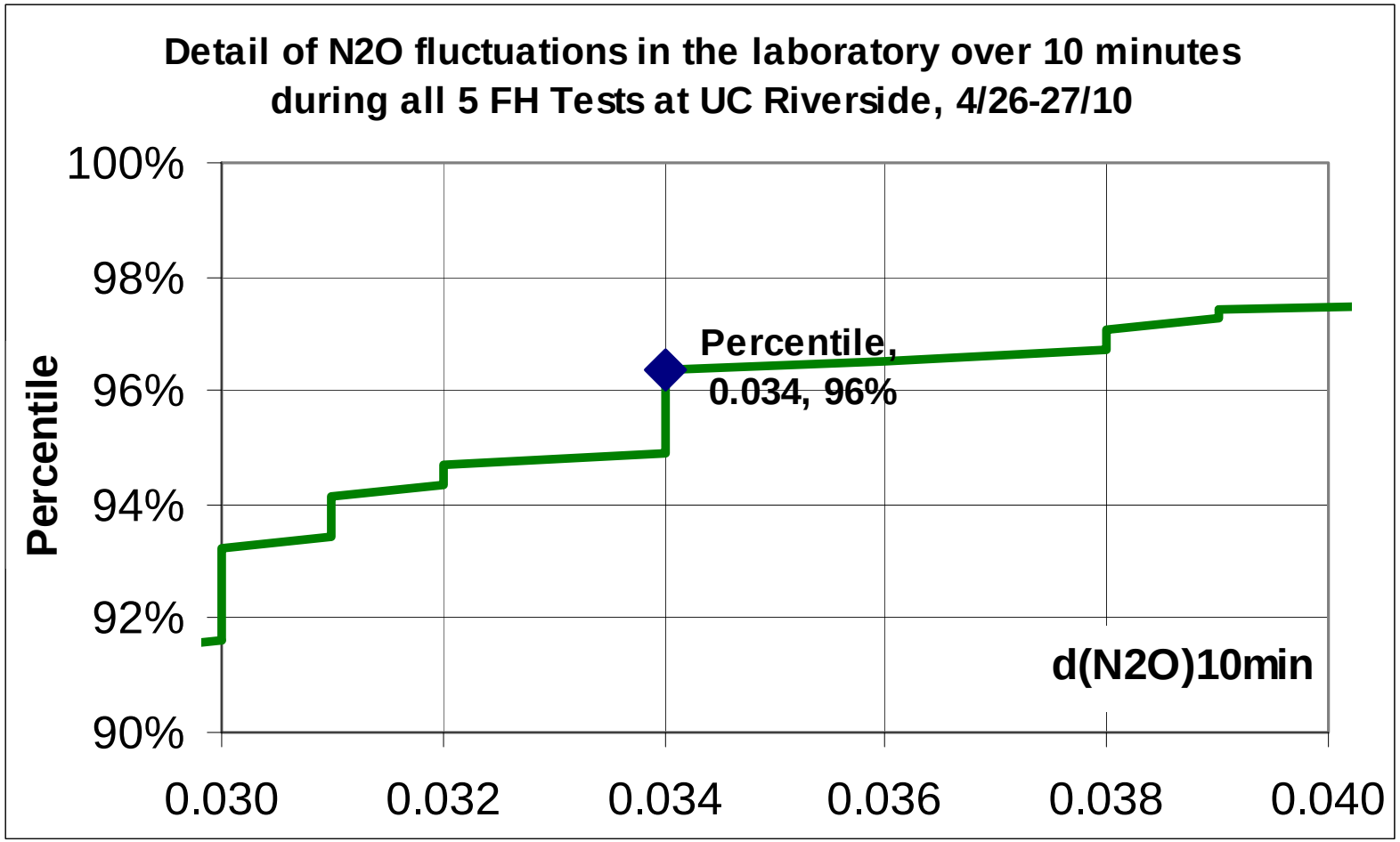


Results – Background N2O - 5

- Taking the data from all 5 fume hoods together:



Results – Background N2O - 5



Conclusions - 1

- In this ongoing study, we have already demonstrated that:
  - When ejected at the same time and place, and at the same flow rate, N2O can provide the same results as SF6 for the purposes of the ASHRAE 110 test. Our correlation was >99%
  - Background drift in N2O concentration can be monitored and managed to assure that final readings using N2O are not affected. Drift was <=0.03ppm 93% of the time.

Conclusions - 2

- Use of N2O in the ASHRAE 110 Standard requires some deviations:
  - Different MW from SF6
  - Potential change in release rate or resizing of orifice to achieve SF6-equivelent plume size
  - Rezeroing of detector due to atmospheric drift
  - Additional safety precautions:
    - EF survey, signage, area monitor, etc.

Conclusions - 2

- Provided these deviations are recognized and accommodated, N2O can detect leaks from the faces of fume hoods while significantly reducing our greenhouse gas emissions

Acknowledgements

- Larry Wong, CIH
  - University of California, Office of the President
- Russell Vernon, PhD
  - University of California, Riverside
- Gerhard Knutson, PE, PhD, CIH
  - Knutson Ventilation
- Ben Gonzales, PE, CSP
  - Technical Safety Services

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