Validation of the Use of Carbon Dioxide and Sulfur Hexafluoride as a Tracer Gas in Determining Air Change Rates in a Single-Zone Space with Fewer Than 10 Air Changes per Hour

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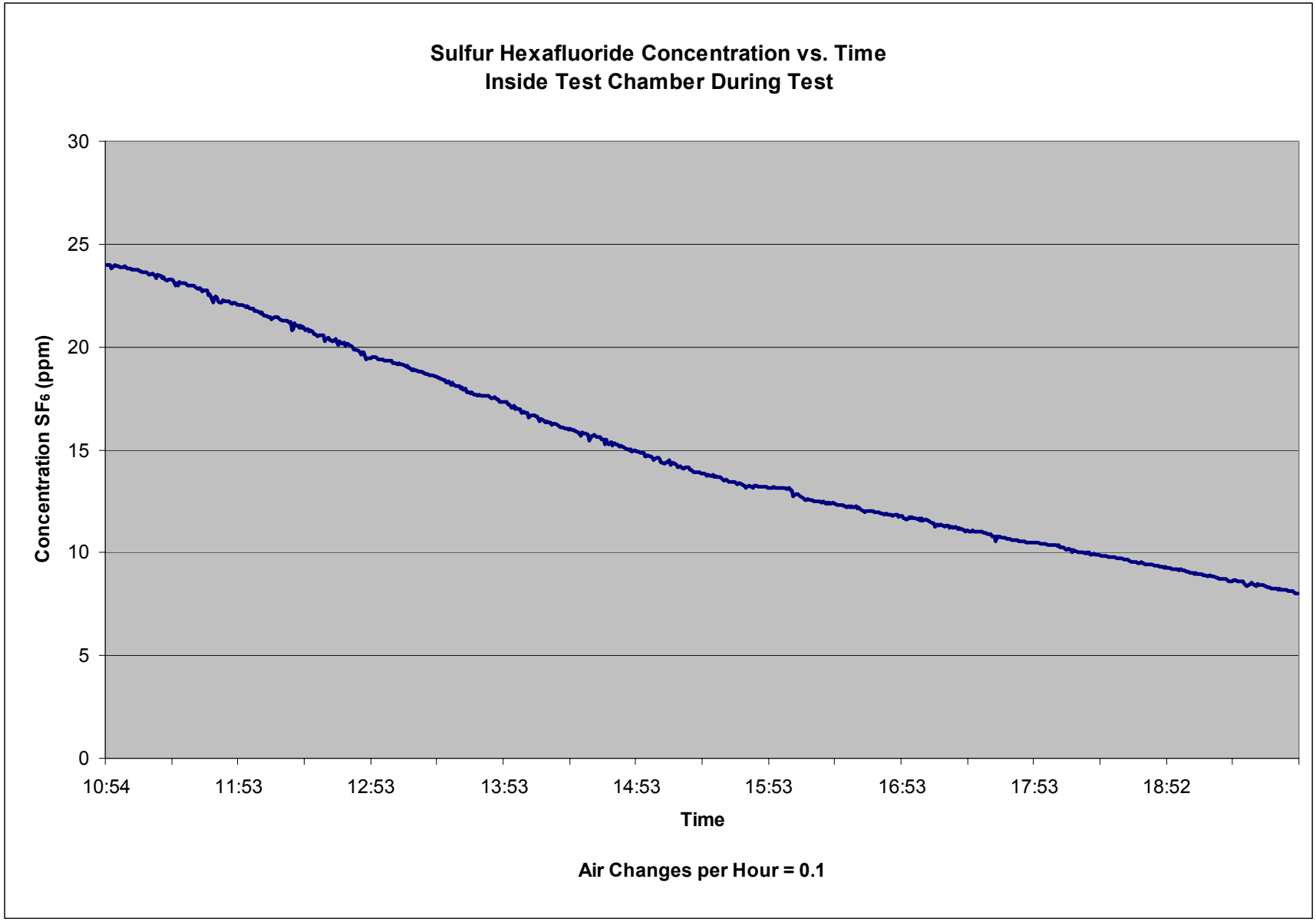
Introduction

- ASTM Method E741 is a standardized method used to measure the air change rate of a single-zone space using a tracer gas
- The method describes several tracer gases; two commonly used gases are carbon dioxide (CO_2) and sulfur hexafluoride (SF_6)
- This presentation will compare the effectiveness of these two gases using the ASTM method

ASTM E741

- Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution (2000)
- Concentration Decay Method used
  - Background measurements taken
  - Tracer gas introduced
  - Uniform concentration established
  - Concentration measured over time
  - Linear regression performed; air change rate is equal to slope of regression line

ASTM Method E741-00, Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution. American Society of Testing and Materials, 2000.


Sulfur Hexafluoride Concentration vs. Time
Inside Test Chamber During Test
Concentration SF6 (ppm)
30
25
20
15
10
5
0
10:54
11:53
12:53
13:53
14:53
15:53
16:53
17:53
18:52
Time
Air Changes per Hour = 0.1

Sulfur Hexafluoride

- Advantages:
  - Extremely low background levels (ppb)
  - Easily detectable with proper equipment; very little gas needed in many cases
  - Non-toxic (PEL = 1000 ppm) and inert
- Disadvantages:
  - Gas is expensive (approx. $1100/35 lb. cylinder)
  - Gas is not always readily available
  - Detection equipment is expensive (approx. $35,000)

Carbon Dioxide

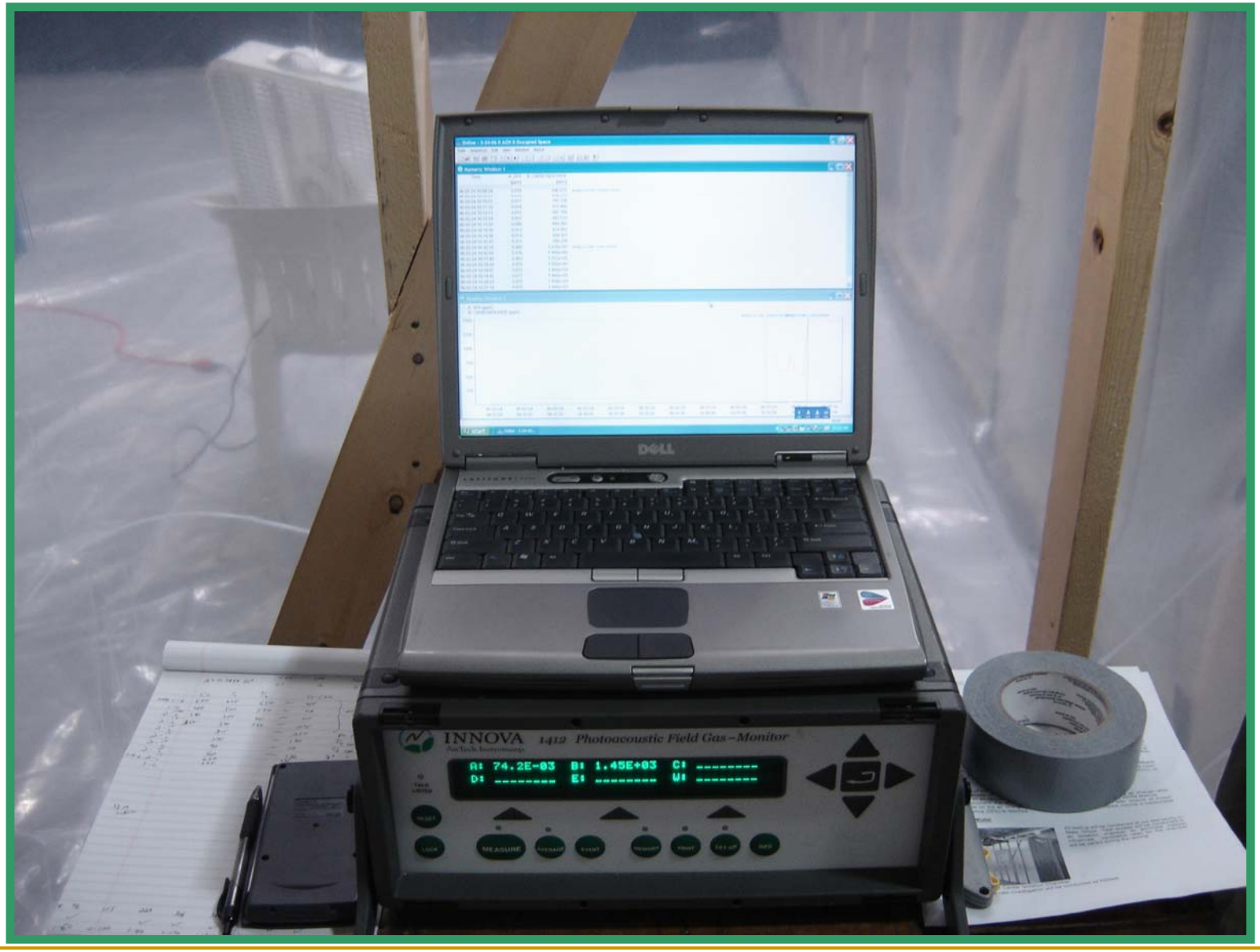
- Advantages:
  - Gas is cheap
  - Gas is easy to procure
  - Detection equipment is comparatively cheap and easy to obtain
- Disadvantages:
  - High background levels; large amounts of gas needed to overcome
  - Potential confounding sources of gas (e.g. human exhalation, combustion sources)

Solutions to Disadvantages

- Carbon Dioxide
  - Eliminate as many potential sources of CO_2 as possible during testing
  - Perform testing while space is unoccupied
  - Account for background CO_2 by subtracting from measured concentrations
- Sulfur Hexafluoride
  - Money

Our Studies

- ASTM method used during 18 chamber and field studies
- SF_6 and CO_2 concentrations measured for each test (though not always simultaneously)
- SF_6 detection: Innova 1412 Multi-Gas Monitor
- CO_2 detection: TSI Q-Trak and Innova 1412
- Air change rates ranged from <0.1 to 10 air changes per hour (ACH)
- All CO_2 calculations performed at levels well above background


DELL
INNOVA
1412 Photoacoustic Field Gas-Monitor
A: 74.2E-03 B: 1.45E+03 C: --------
D: -------- E: -------- U: --------
MEASURE

Results – 0 to 2 Air Changes per Hour

- 12 tests performed
- SF_6 air change rates ranged from <0.1 to 1.2 ACH
- CO_2 air change rates ranged from <0.1 to 0.9 ACH
- SF_6 results averaged 14% higher result than CO_2
- Differences between SF_6 and CO_2 ranged from 0 to 0.3 ACH, averaging 0.1

Results – 2 to 6 Air Changes per Hour

- 2 tests performed
- SF_6 air change rates ranged from 5.0 to 5.5 ACH
- CO_2 air change rates ranged from 2.6 to 3.1 ACH
- SF_6 results averaged 46% higher result than CO_2
- Difference between SF_6 and CO_2 result was 2.4 ACH for both tests

Results – 6 to 10 Air Changes per Hour

- 4 tests performed
- SF_6 air change rates ranged from 7.7 to 11.5 ACH
- CO_2 air change rates ranged from 5.1 to 7.7 ACH
- SF_6 results averaged 31% higher result than CO_2
- Differences between SF_6 and CO_2 ranged from 1.7 to 3.8 ACH

Conclusions

- SF_6 air change rates averaged 21% higher than CO_2 air change rates
- As air change rates increased, CO_2 and SF_6 results tended to separate
- At higher air change rates, SF_6 may produce more reliable results because of:
  - Faster response time of detection equipment
  - Less tracer gas necessary

Recommendations

- For general use, both SF_6 and CO_2 tracer gases will provide adequate results for air change rate using the ASTM method
- For purposes of modeling exposures, both tracer gases will provide acceptable results at lower air change rates; caution should be used as air change rates increase
- For precision measurement, or at high air change rates, use SF_6 to reduce the potential error of confounding factors

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Thank you!

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