PITTSBURGH MINING RESEARCH DIVISION

Contamination Ingress and Purging for Built-in-Place RA

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Pittsburgh, PA

DEPARTMENT OF HEALTH & HUMAN SERVICES · USA
CDC Workplace Safety and Health
NIOSH

Outline

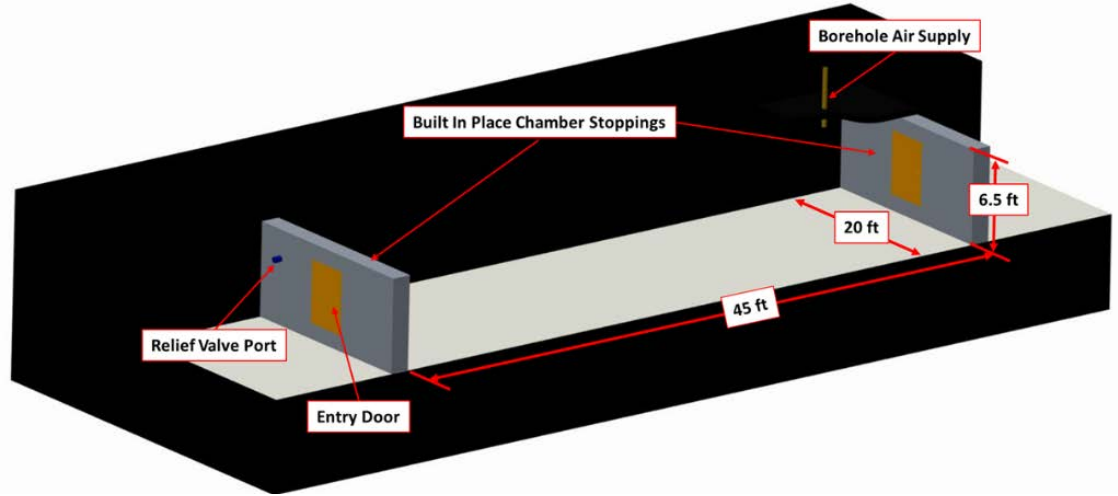
- Why use built-in-place RA?
- Why perform contamination ingress testing?
- Summary of contamination ingress testing
- Why is purging important?
- Purge testing

Advantages of BIP Refuge Alternatives

(Assuming the use of protected compressed air line or borehole)

- Quicker and easier to prepare and operate
- Store more equipment
- Provide more space per occupant
- Increase likelihood communication system will survive
- Better chance of surviving a secondary explosion than a tent-type mobile RA
- Psychological advantages

NIOSH Built-In-Place (BIP) Refuge Alternative (RA) Research Area



Contaminants such as CO can cause health effects

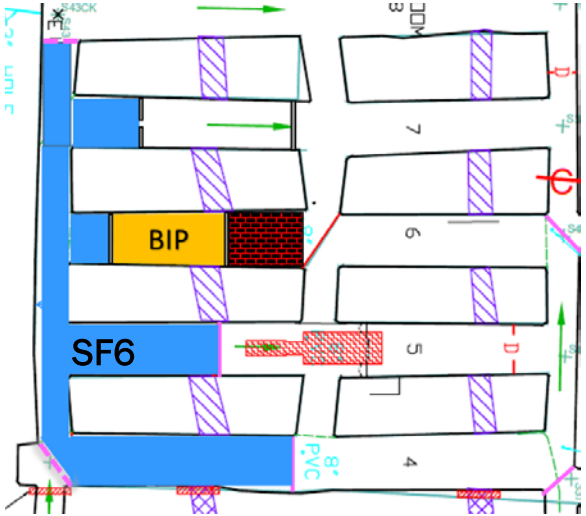
CO Exposure

Concentration (ppm)	Symptoms
35	Headache and dizziness within six to eight hours of constant exposure.
100	Slight headache in two to three hours.
200	Slight headache within two to three hours; loss of judgment.
400	Frontal headache within one to two hours.
800	Dizziness, nausea, and convulsions within 45 min; insensible within 2 hours.
1,600	Headache, tachycardia, dizziness, and nausea within 20 min; death in less than 2 hours.
3,200	Headache, dizziness, and nausea in five to ten minutes. Death within 30 minutes.
6,400	Headache and dizziness in one to two minutes. Convulsions, respiratory arrest, and death in less than 20 minutes.
12,800	Unconsciousness after 2–3 breaths. Death in less than three minutes.

10,000 ppm CO

Contamination Ingress Testing in BIP RA

NIOSH is performing contamination ingress research to determine the concentration of CO that would exist in a BIP RA due to miners entering after a catastrophic event.



Contamination Ingress Testing Results

(without mine air flow)

Test	Outside BIP SF6 Concentration (ppb)	Inside BIP SF6 Concentration (ppb)	Contamination Factor
W/ Air Supply 5 Subjects	172.5	1.16	0.67%
W/O Air Supply 5 Subjects	146.6	1.48	1.01%
W/ Air Supply 15 Subjects	145.6	2.48	1.70%
W/O Air Supply 15 Subjects	200.1	2.85	1.42%

10,000 ppm CO

Coal Pillar

Coal Pillar

10,000 ppm CO

Coal Pillar

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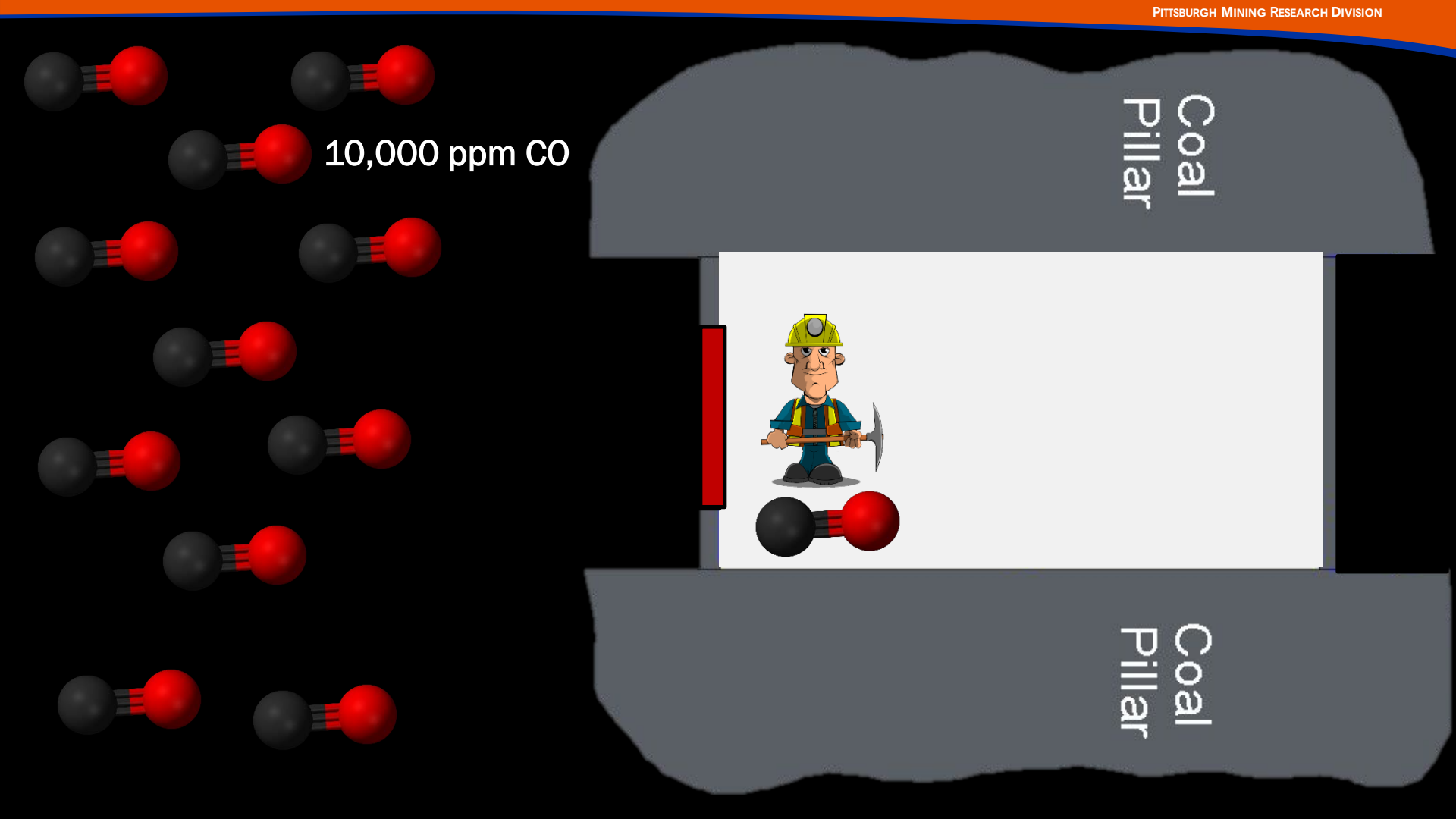
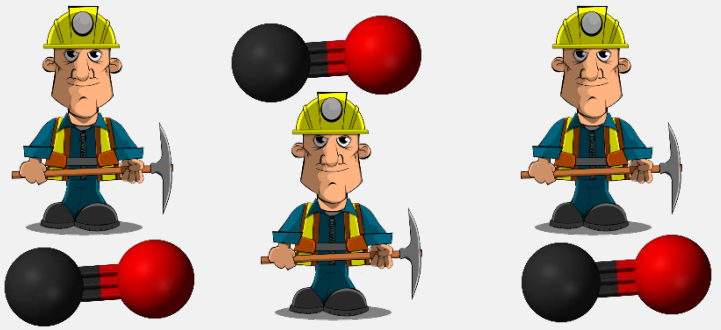
10,000 ppm CO



10,000 ppm CO

Coal Pillar

About 170 ppm CO for 15 miners



Coal Pillar

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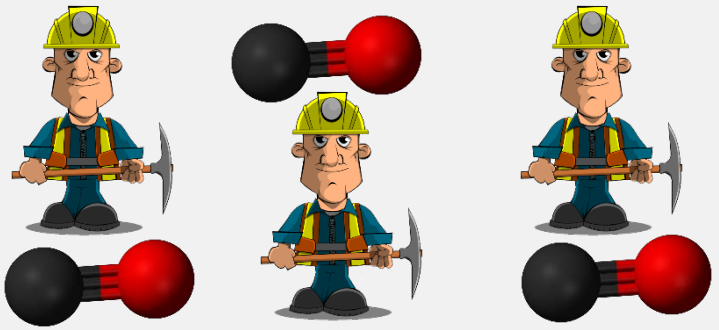
About 170 ppm CO for 15 miners



100	Slight headache in two to three hours.
200	Slight headache within two to three hours; loss of judgment.

Summary

- 5 and 15 person tests resulted in contamination factors of 0.67% to 1.70% with and without air supply (no mine air flow)
  - Contamination can result in hazardous atmosphere inside BIP RA

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  - Contamination can result in hazardous atmosphere inside BIP RA

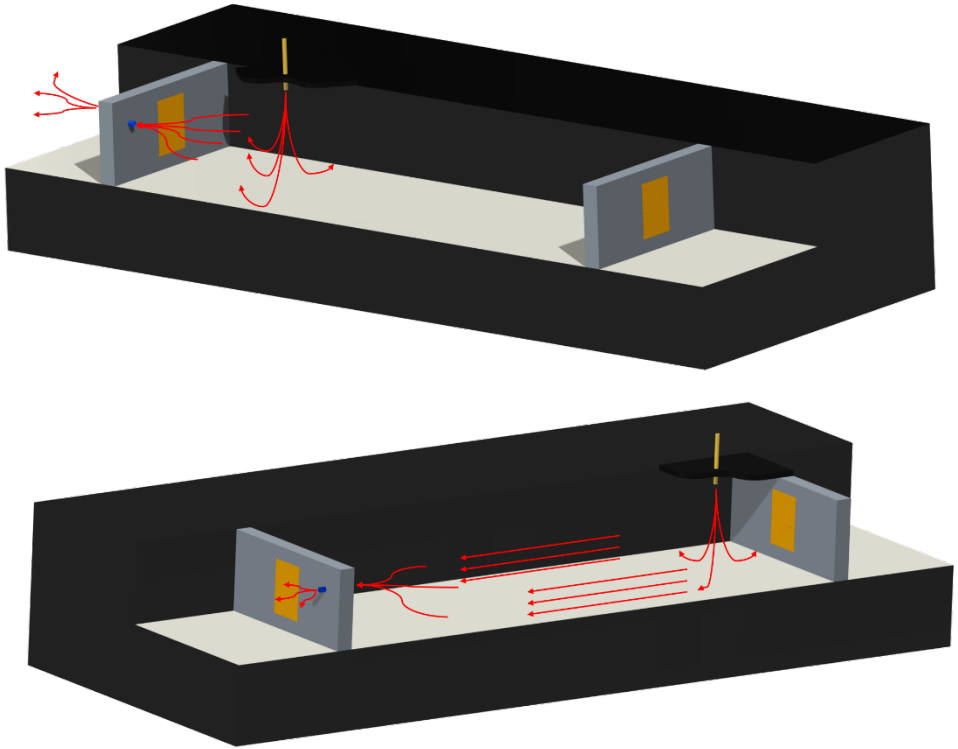
- Ongoing contamination ingress tests
  - 30 person test with and without air supply
  - Contamination prevention strategies will be investigated (strip curtains, door bladder)

Purge Testing in BIP RA

- Once contaminant (CO) has entered an RA, purging is required to reduce the contaminant to safe levels
- NIOSH is performing BIP RA purging research to determine:
  - Time required to purge for various ventilation system layouts
  - If ventilation system layout creates “dead areas”

Variety of Conditions

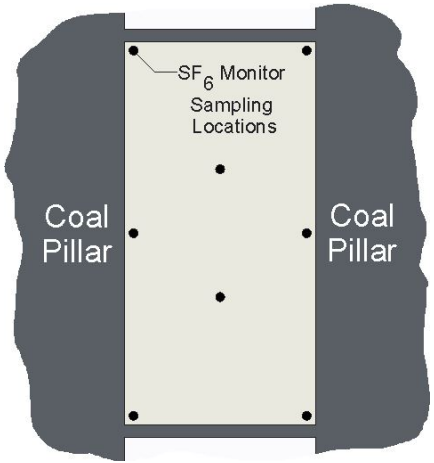
- Variety of ventilation designs
  - 60-person rectangular BIP
    - Mandated square footage
    - Mandated flow rate
    - Higher flow rates
  - Sizes and airflows used at mines

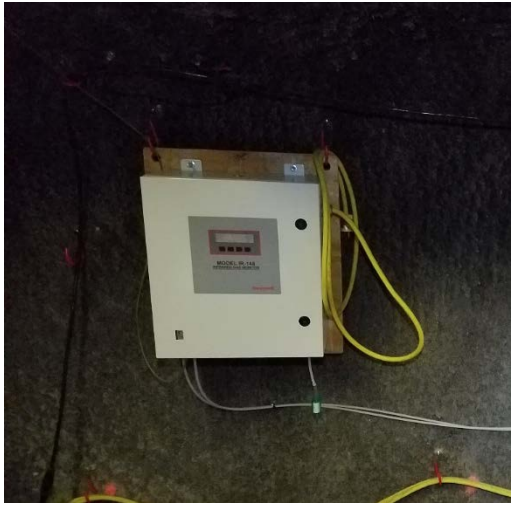


Air Supply System Connected to Borehole

Test setup simulates purging of CO-contaminated air using SF_6 monitors at several locations inside the BIP RA

Injection of SF_6

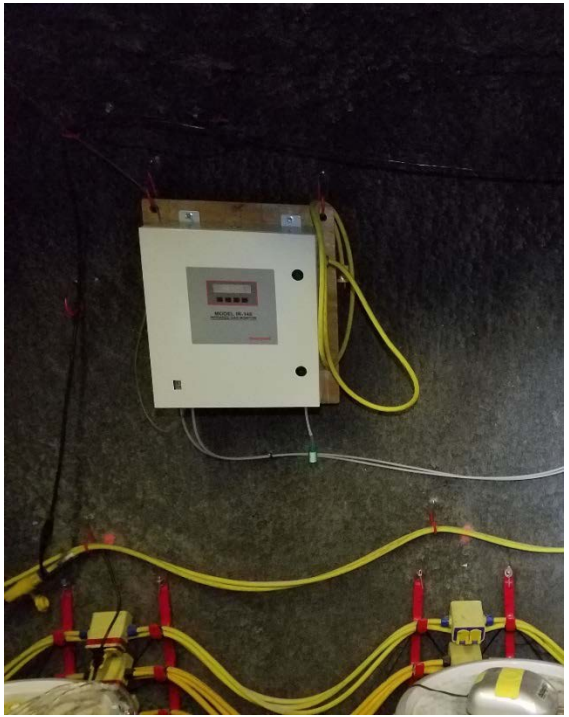




Real time monitoring of SF_6 concentration

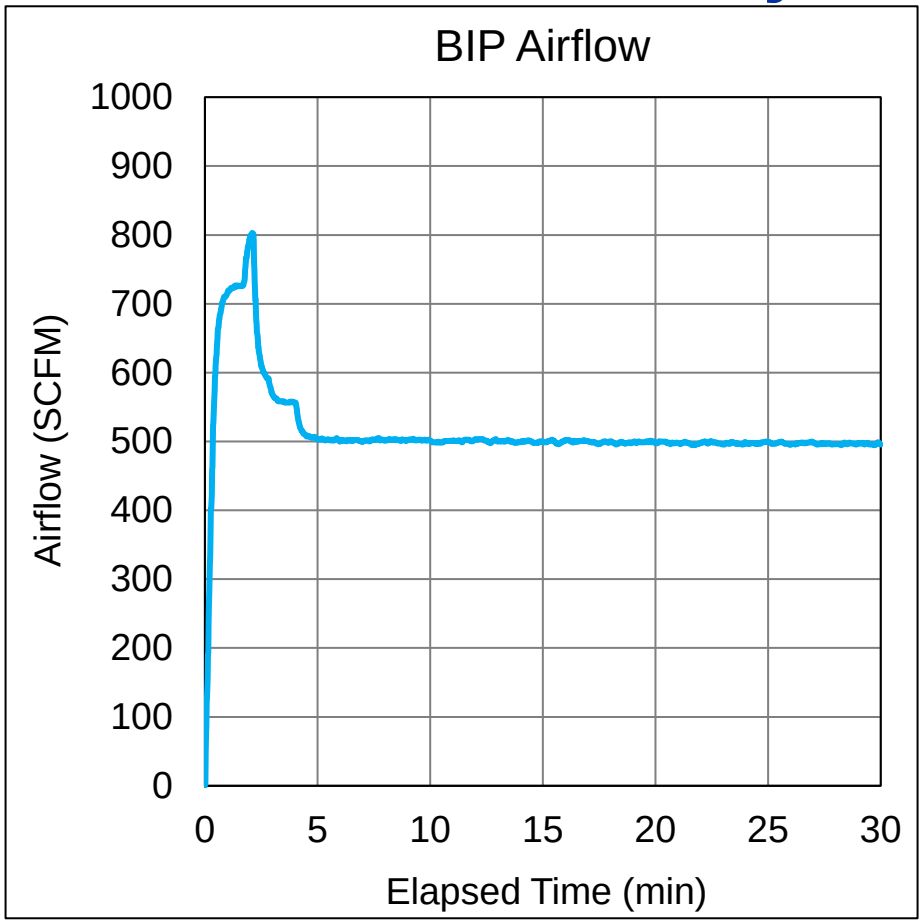
Purge Testing Setup

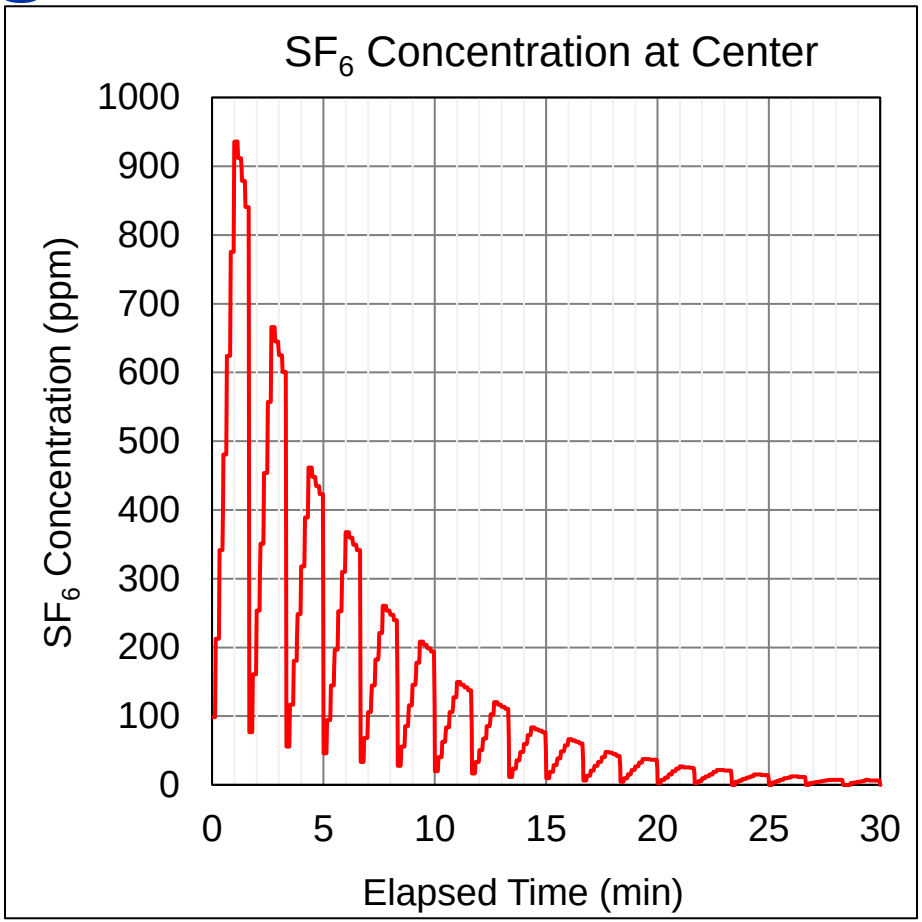
Sampling tubes in BIP RA



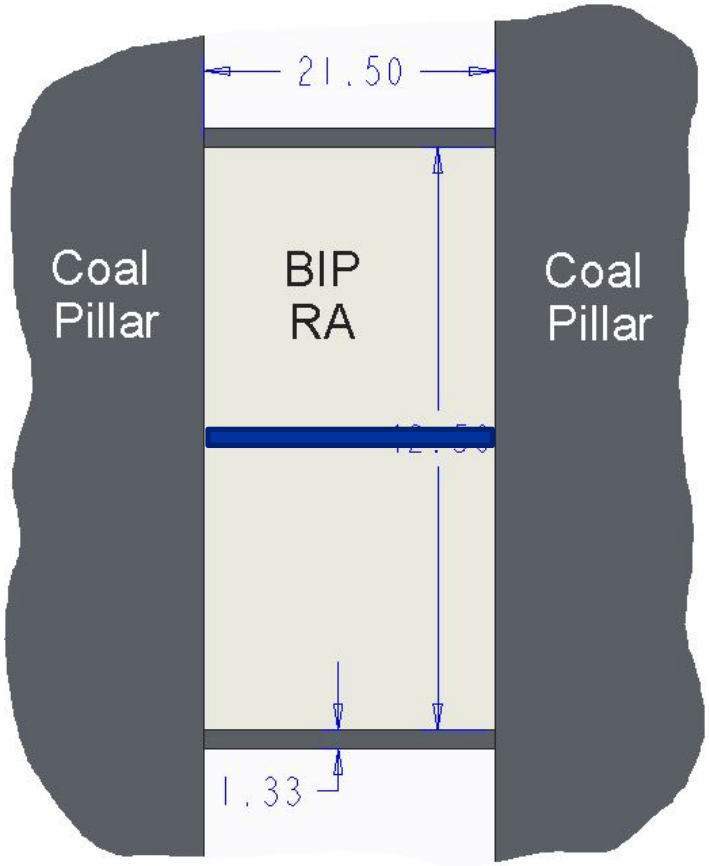
Real-time SF_6 concentration monitor
(Maximum concentration – 1000 ppm)

Preliminary Purge Test Results





BIP RA Setup

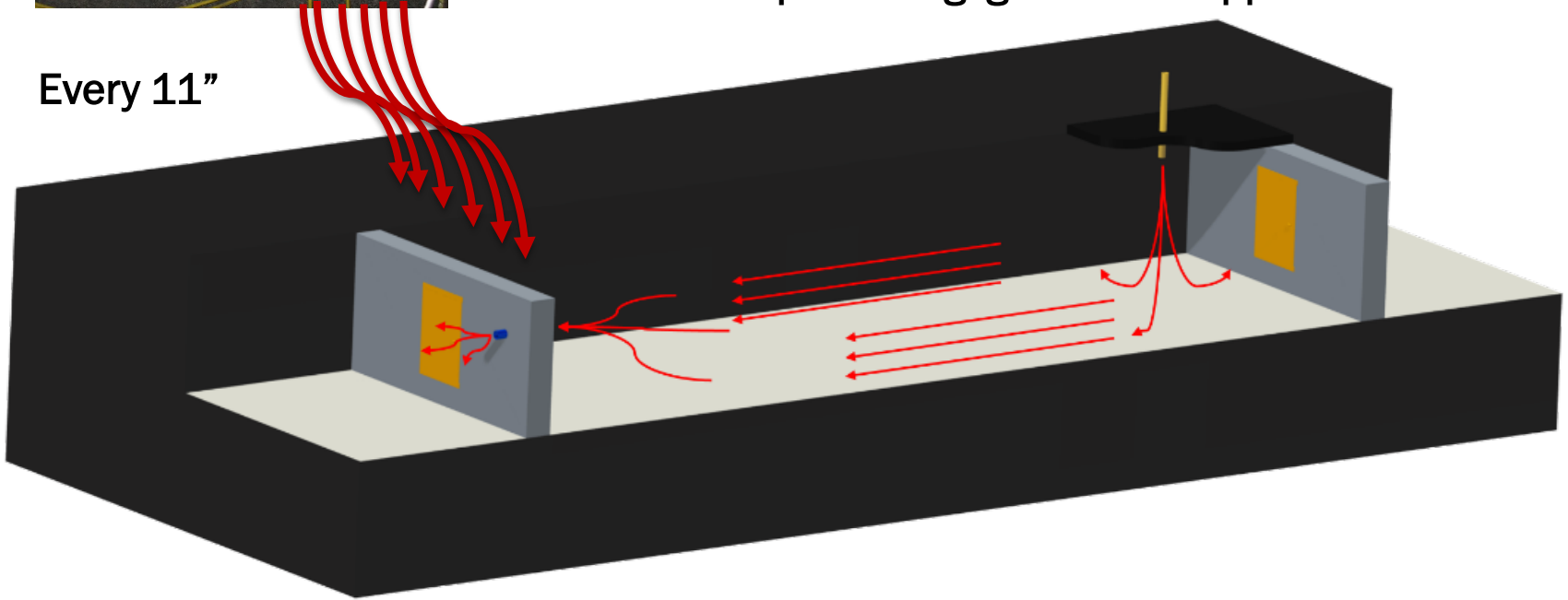


Concentration variation with height of sampling location

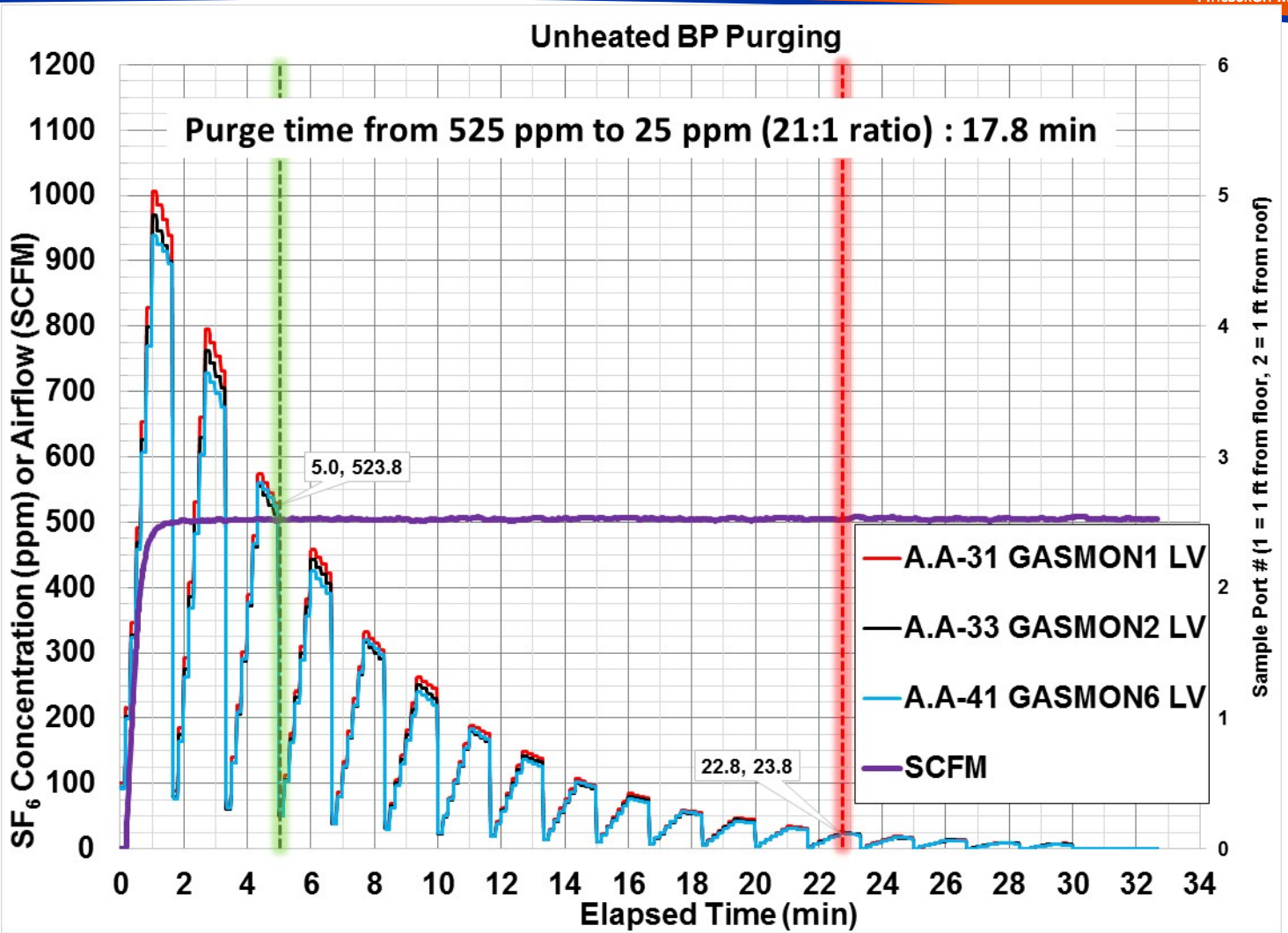
SF_6 conc.

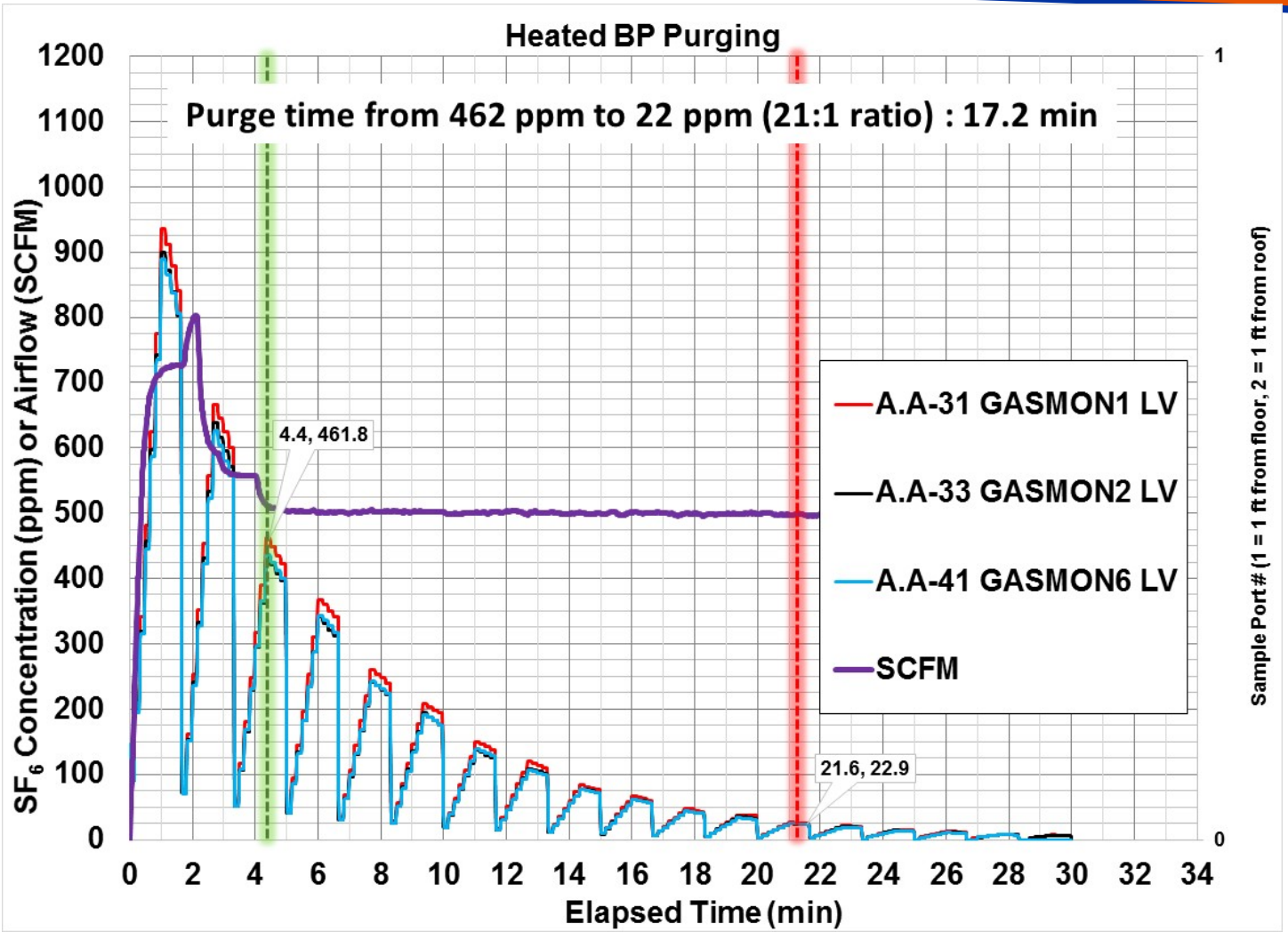
- Maximum spread 100 ppm at 900 ppm
- Maximum spread 25 ppm at 600 ppm
- Maximum spread negligible at 100 ppm

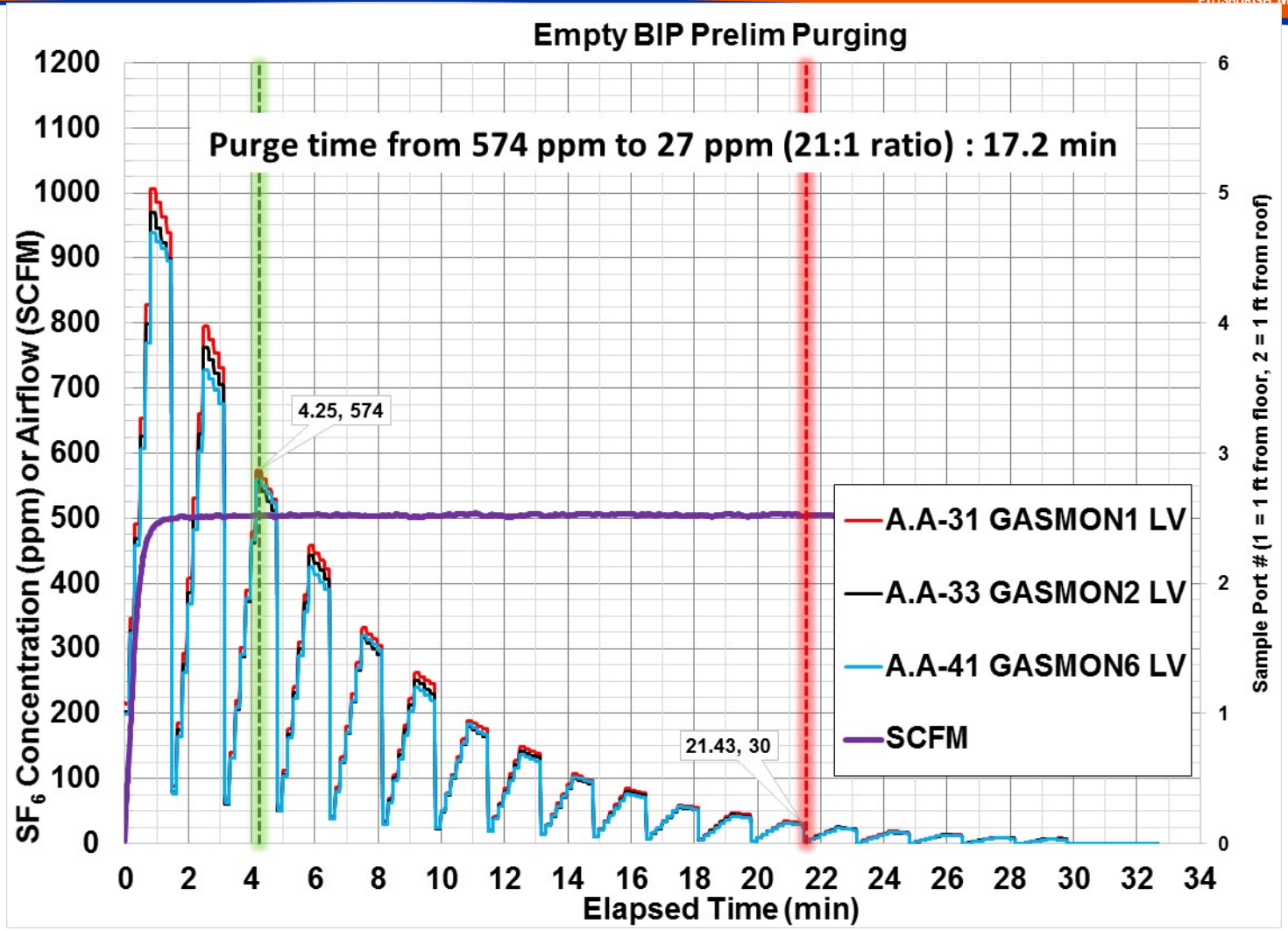
Every 11”



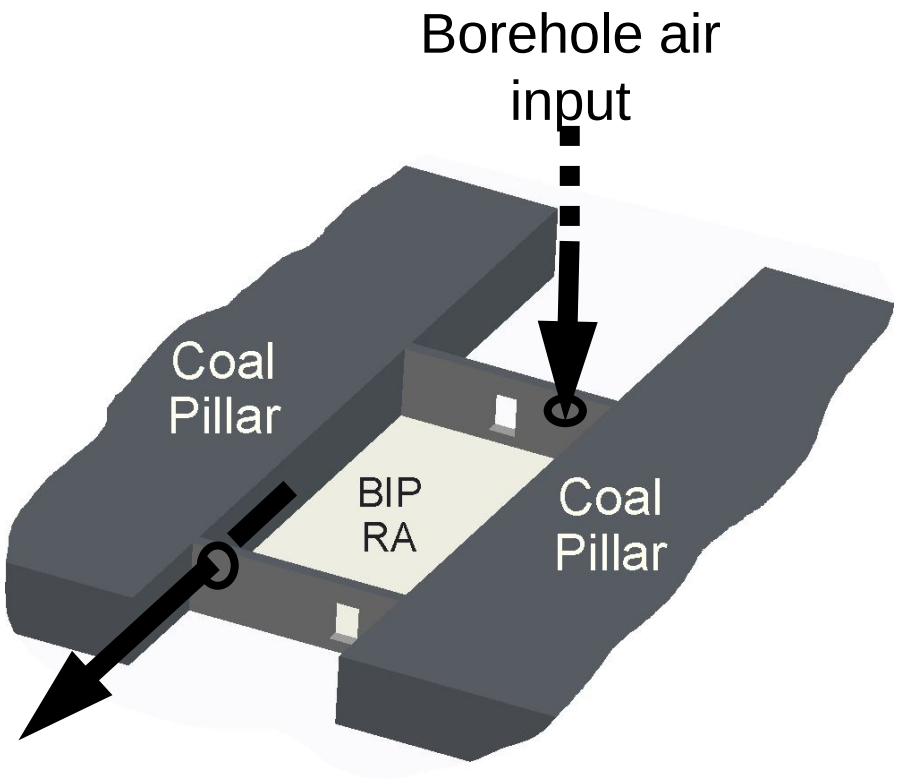
Does the presence of barrel people or heat affect purging time

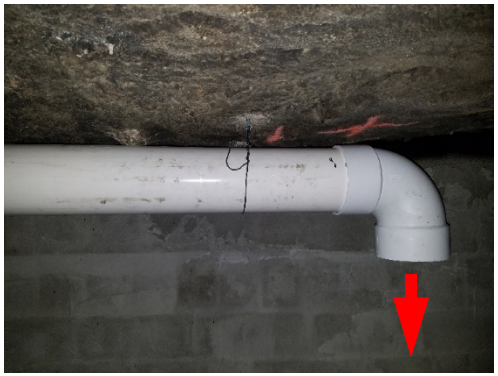

Unheated BP Purging
Purge time from 525 ppm to 25 ppm (21:1 ratio) : 17.8 min
5.0, 523.8
22.8, 23.8
A.A-31 GASMON1 LV
A.A-33 GASMON2 LV
A.A-41 GASMON6 LV
SCFM
SF6 Concentration (ppm) or Airflow (SCFM)
Sample Port # (1 = 1 ft from floor, 2 = 1 ft from roof)
Elapsed Time (min)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
0
1
2
3
4
5
6
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34

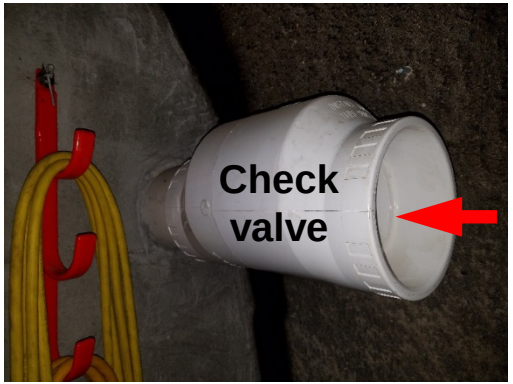

Heated BP Purging
Purge time from 462 ppm to 22 ppm (21:1 ratio) : 17.2 min
SF6 Concentration (ppm) or Airflow (SCFM)
Elapsed Time (min)
Sample Port # (1 = 1 ft from floor, 2 = 1 ft from roof)
4.4, 461.8
21.6, 22.9
A.A-31 GASMON1 LV
A.A-33 GASMON2 LV
A.A-41 GASMON6 LV
SCFM
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
1
0


Empty BIP Prelim Purging
Purge time from 574 ppm to 27 ppm (21:1 ratio) : 17.2 min
4.25, 574
21.43, 30
A.A-31 GASMON1 LV
A.A-33 GASMON2 LV
A.A-41 GASMON6 LV
SCFM
SF6 Concentration (ppm) or Airflow (SCFM)
Sample Port # (1 = 1 ft from floor, 2 = 1 ft from roof)
Elapsed Time (min)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
0
1
2
3
4
5
6
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34

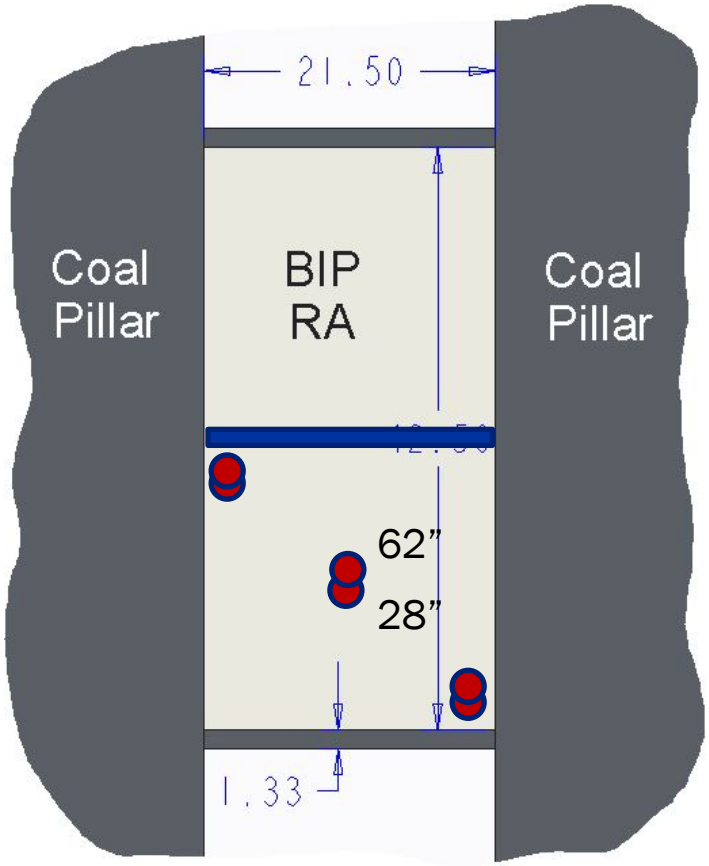
Tests were conducted to evaluate purging performance for borehole-ventilated BIP RAs for various piping system layouts



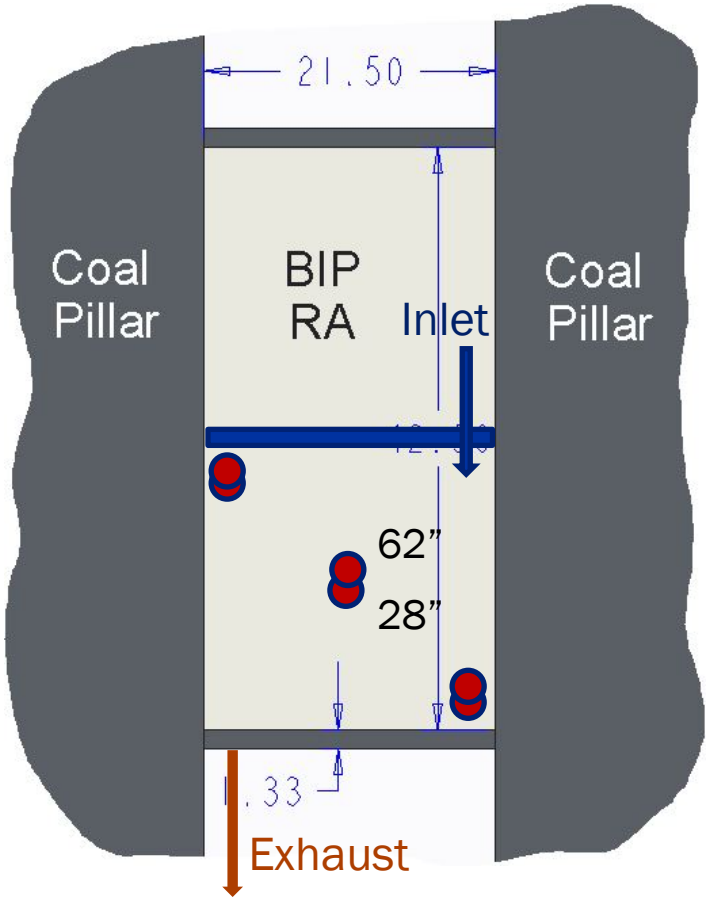


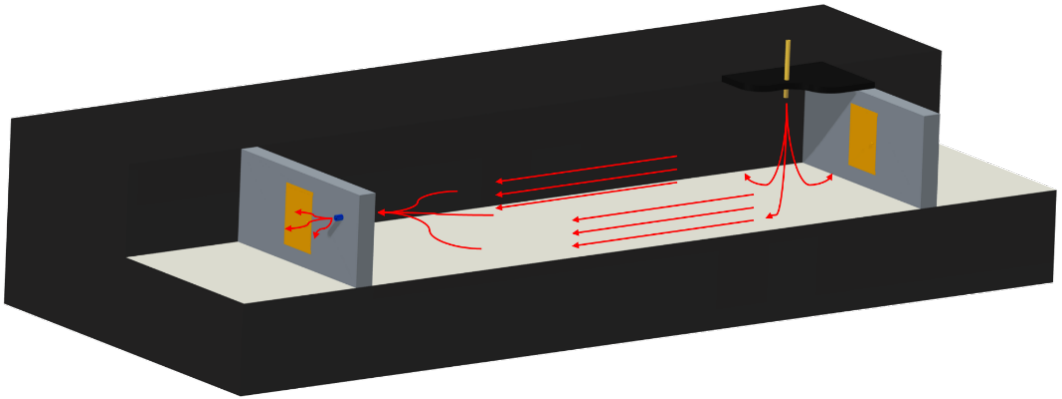


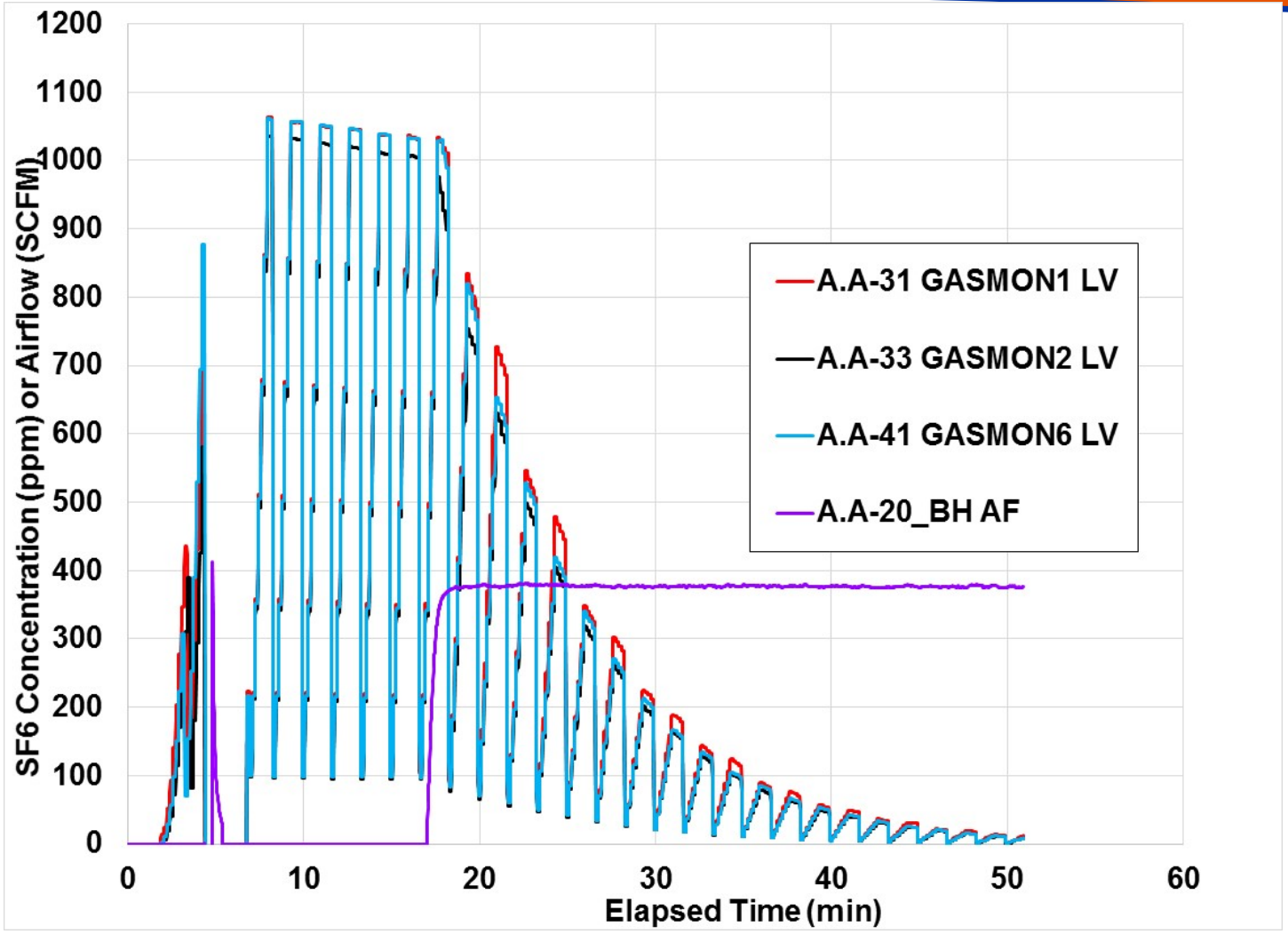
BIP RA Setup



30-persons BIP RA





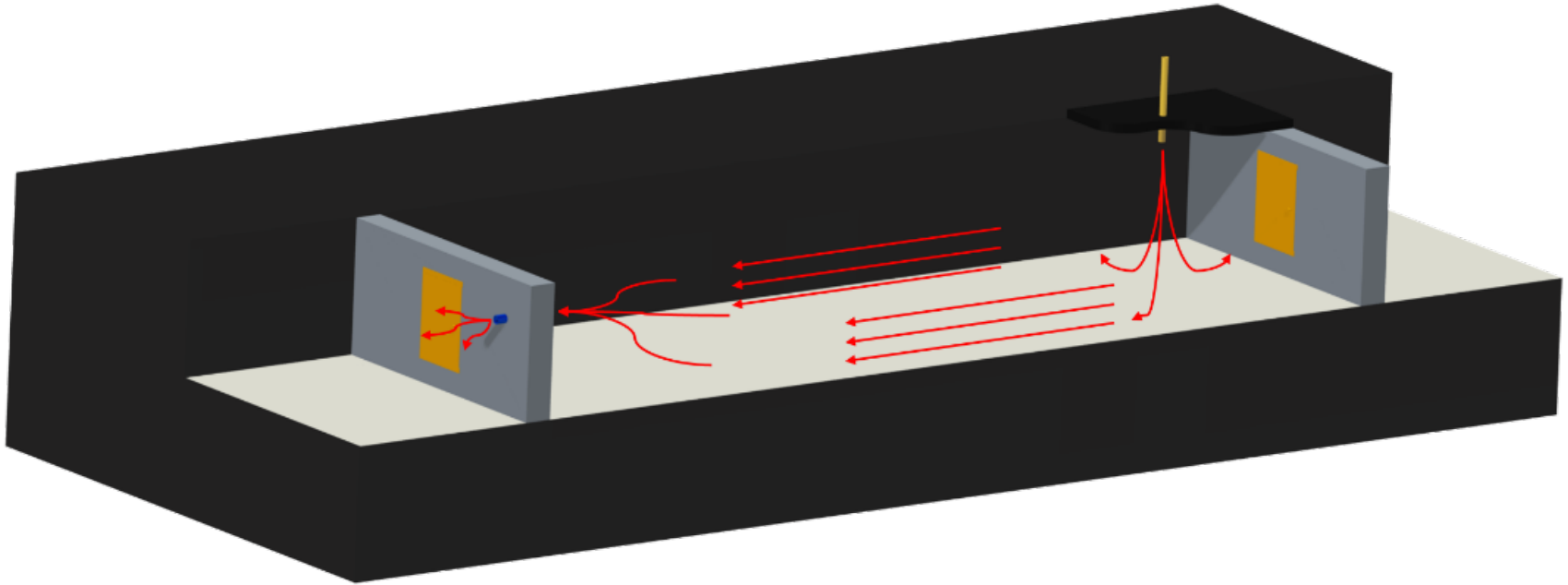

SF6 Concentration (ppm) or Airflow (SCFM)
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
Elapsed Time (min)
A.A-31 GASMON1 LV
A.A-33 GASMON2 LV
A.A-41 GASMON6 LV
A.A-20_BH AF

30-persons BIP RA

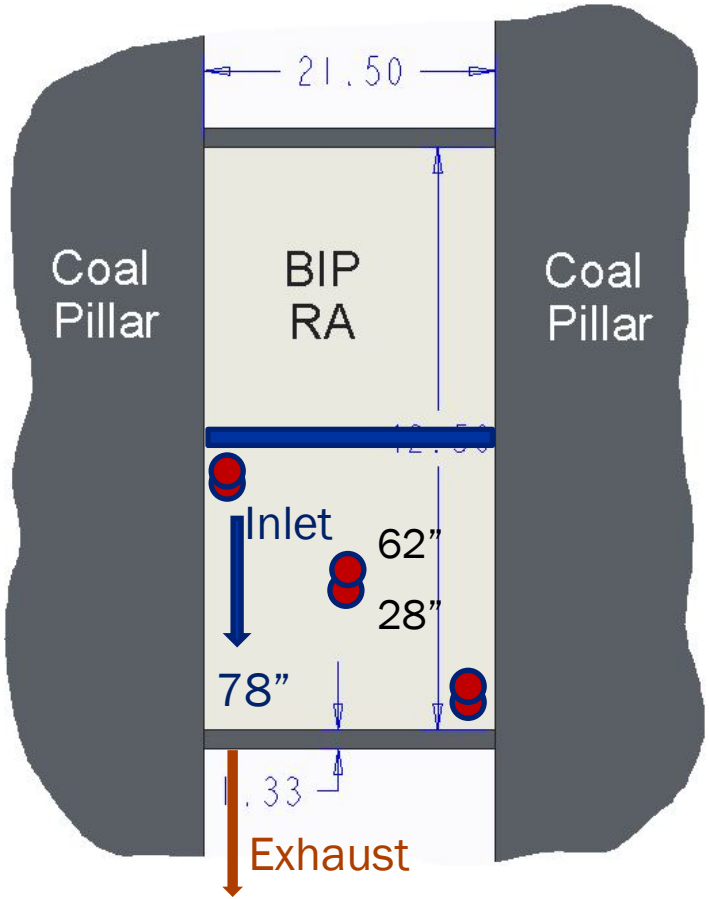
Airflow: 375+20 scfm

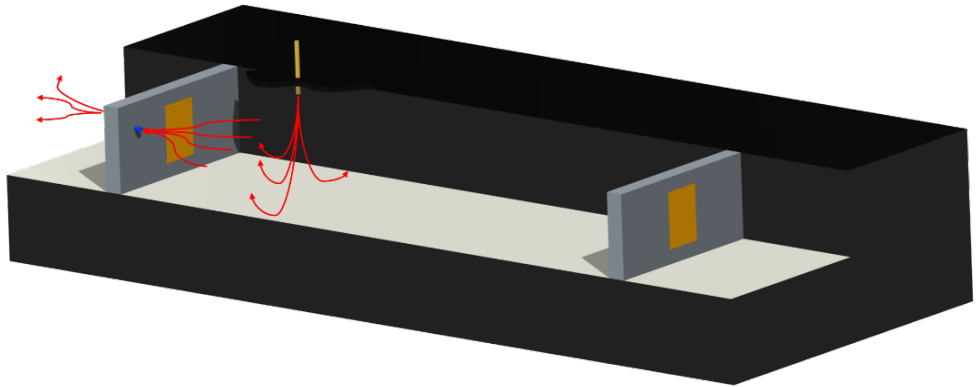
SF_6 concentration from 700 to 25 ppm

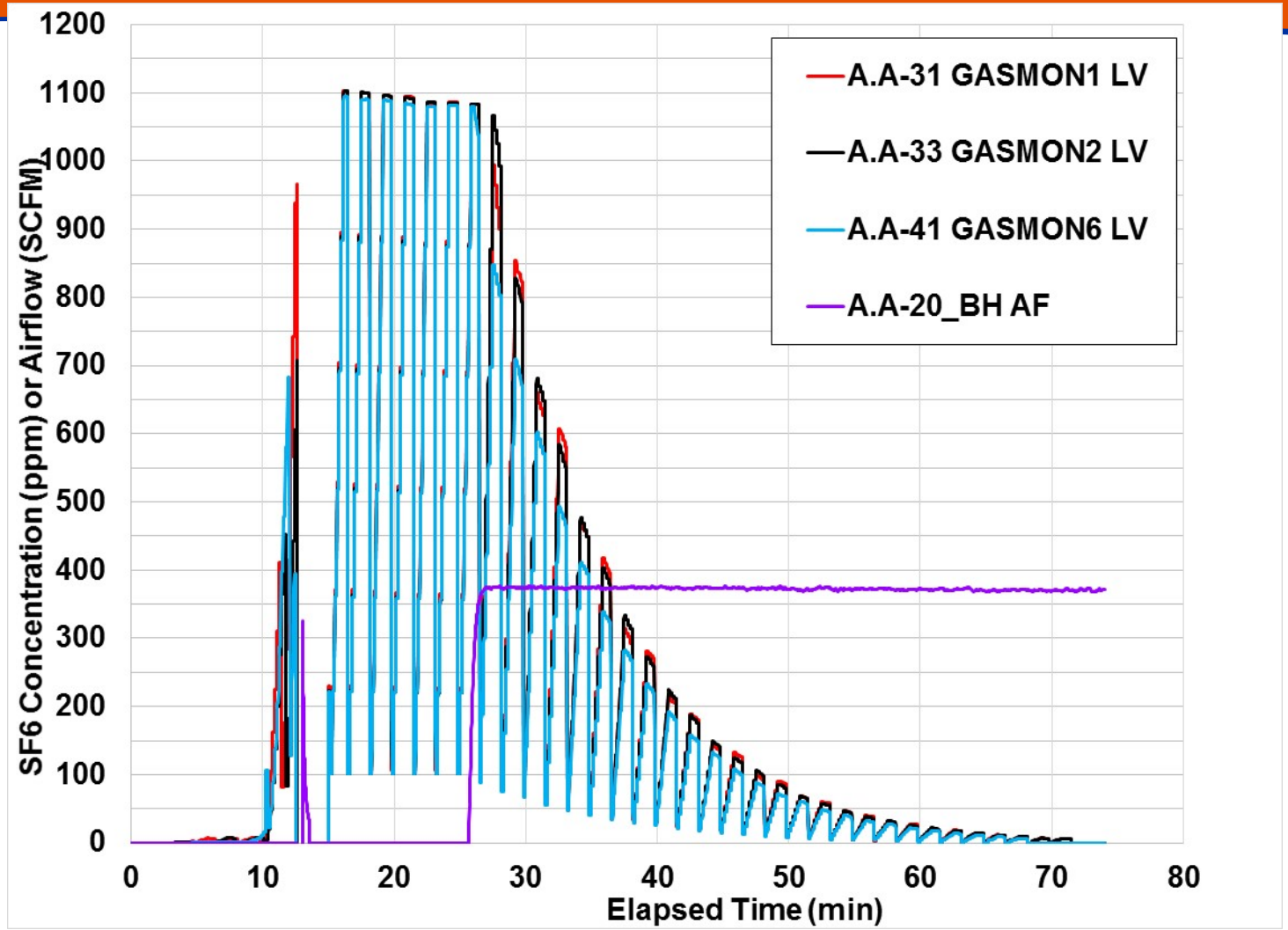
Time: 1469 ± 35 s (24 min 30 s)



30-persons BIP RA





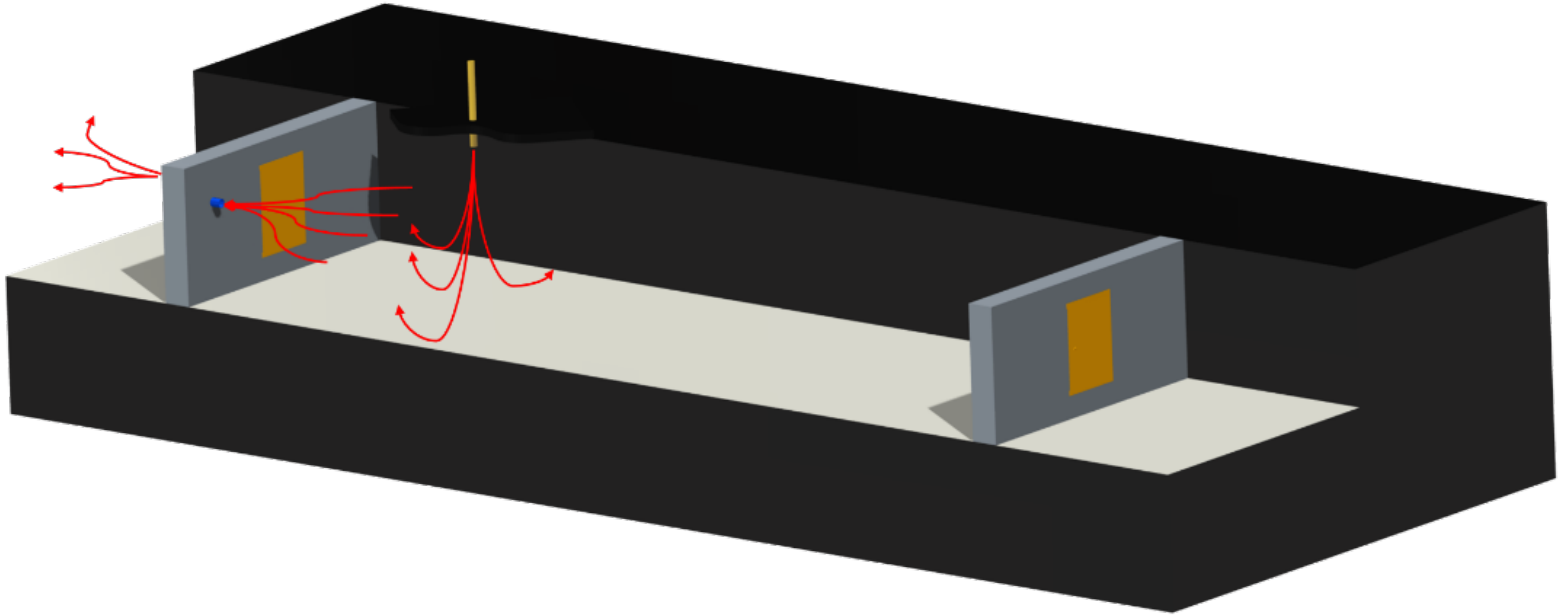

A.A-31 GASMON1 LV
A.A-33 GASMON2 LV
A.A-41 GASMON6 LV
A.A-20_BH AF
SF6 Concentration (ppm) or Airflow (SCFM)
Elapsed Time (min)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
0
10
20
30
40
50
60
70
80

30-persons BIP RA

Airflow: 375±20 scfm

SF_6 concentration from 700 to 25 ppm

Time: 1715 ± 188 s (28 min 35 s)



Summary

- Test Setup
  - The presence of barrel people (heated or unheated) did not have a significant effect
  - Height of sampling port did not affect reading
  - Good repeatability

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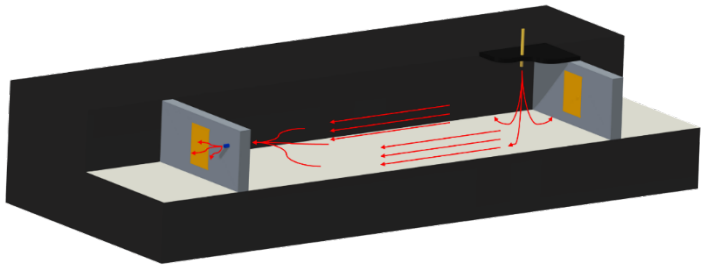
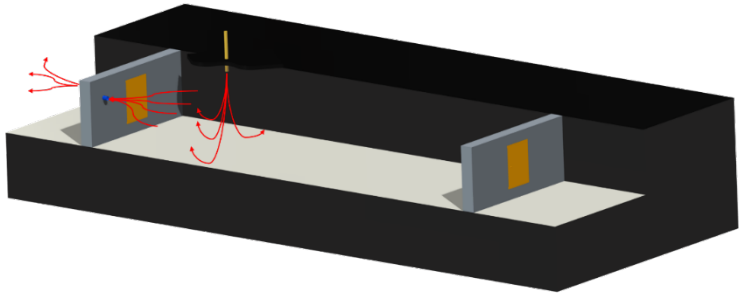
  - The presence of barrel people (heated or unheated) did not have a significant effect
  - Height of sampling port did not affect reading
  - Good repeatability
- **Design 1 resulted in less purge time than design 2 in a square 30-person BIP RA setup at locations of sampling ports**



Design 1



Design 2

Summary

- Test Setup
  - The presence of barrel people or temperature did not have a significant effect
  - Height of sensor was not significant
  - Good repeatability
- Design 1 resulted in less purge time than design 2 in a square 30-person BIP RA setup at locations of sampling ports
- Ongoing research
  - 60 person BIP RA
  - Different ventilation designs will be evaluated
  - Different quantities of airflow (all above the mandated)

Thank you!!
Questions???

James Noll

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