

Mitigation Diagnostics for Schools & Large Buildings

Bill Brodhead
WPB Enterprises, Inc
www.wpb-radon.com

wmbrodhead@gmail.com
610 613-8004

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

How do you design an ASD system
for this 10 story building?



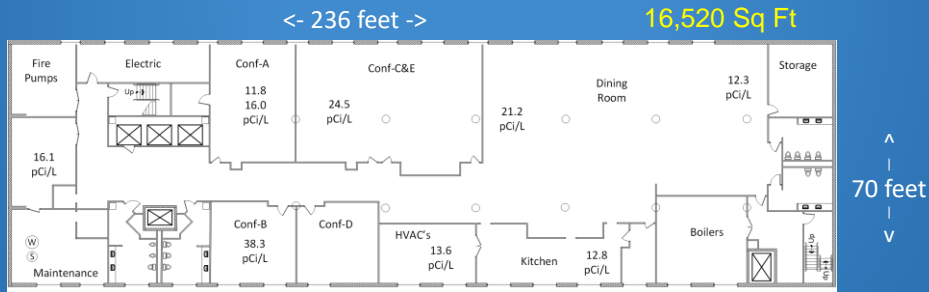
Lowest level
radon
12 to 24 pCi/L

Owner requests
no outside piping?

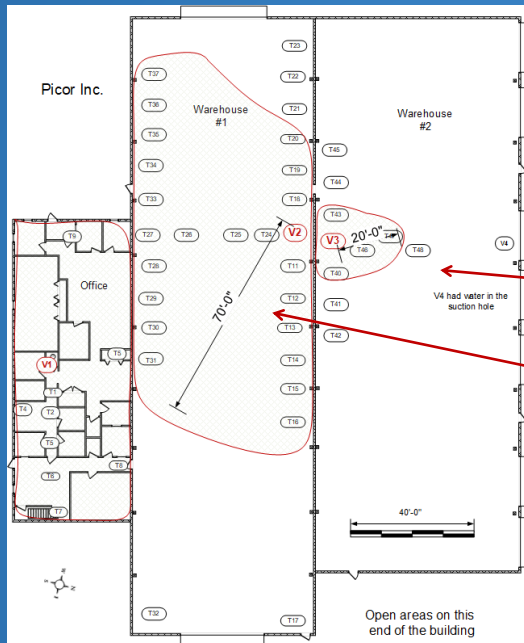
Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Important Commercial Building Questions:

- How old is the building? 1940 - 1950
- Was there any additions? No
- Are there construction drawings? No
- Does HVAC provide outdoor air? Yes but unknown
- Can it be fixed with outdoor air? No



Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium



Important PFE question

What is the PFE Area of Influence?
AOI

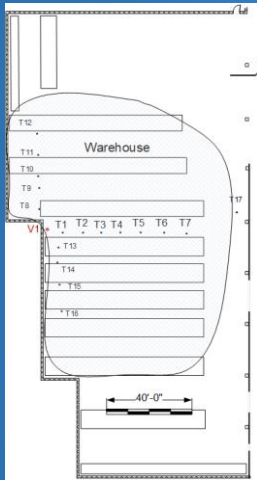
20 ft AOI @ V3
1,250 Sq Ft

70 ft AOI @ V2
15,000 Sq Ft

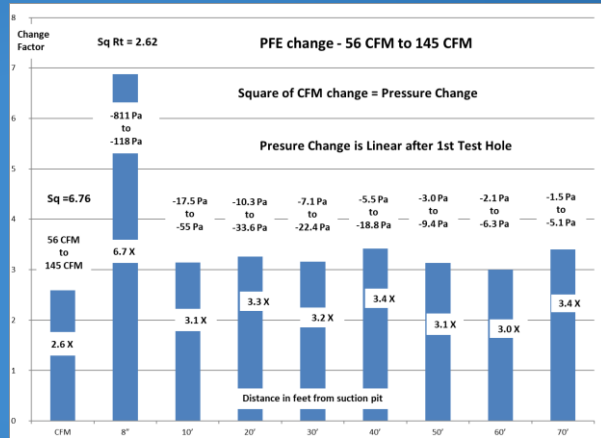
Need **twelve** V3 suction pits to cover **one** V2 suction pit

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Test Holes change uniformly as PFE test CFM changes



Note:
Square of
CFM change
equals
Pressure
Change



Square root of pressure change equals the CFM change

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

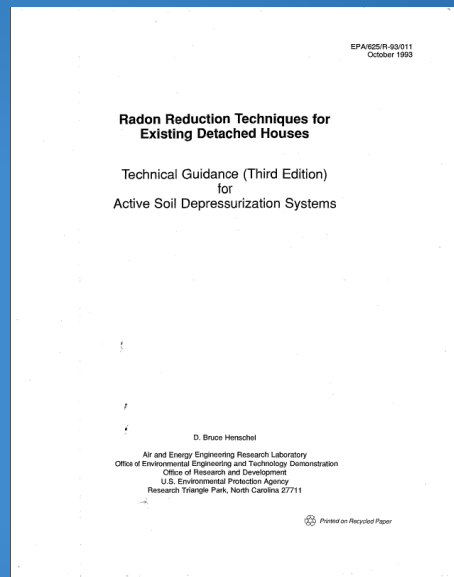
PFE began 30 years ago

EPA published:
Bruce Henschel's

Residential ASD
Technical Guidance

on
Pressure Field
Extension (PFE).

Residential PFE Concepts
are
the same for
Commercial Buildings



Thank you Bruce

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Main Difference:

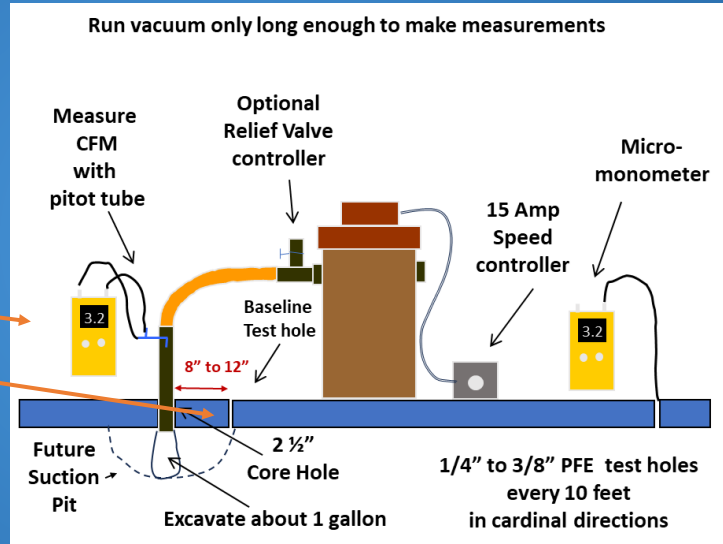
Residential: uses Suction pit PFE during installation

Commercial: makes Multi Pre-Installation PFE Tests

Commercial PFE:
Core 2.5"

Vacuum out
1 to 1.5 gallons

Measure CFM & Baseline Pressure = **Subslab Airflow Resistance**



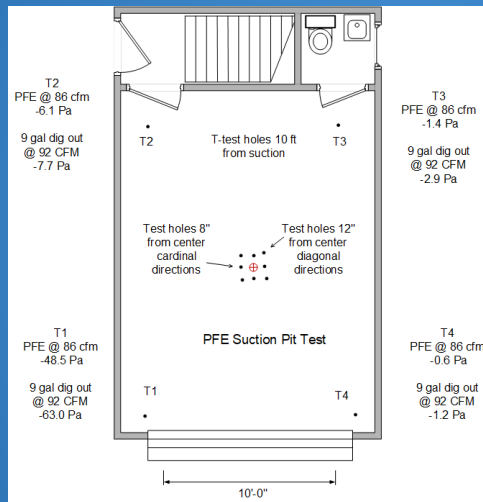
Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Which Baseline test hole distance best simulates a dug out suction pit?

8" out or 12" out?

The Test

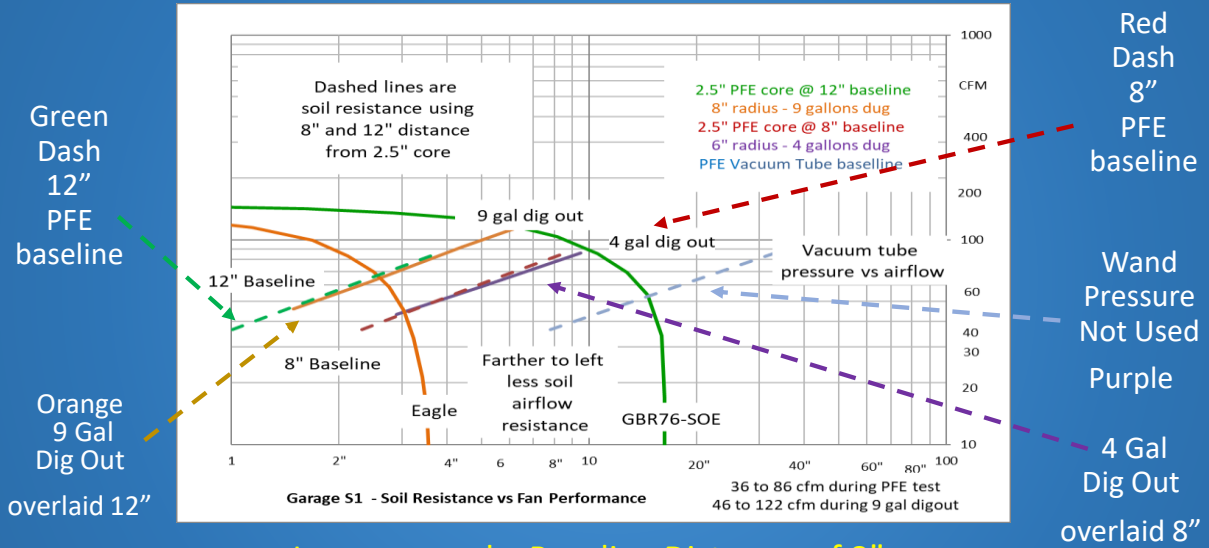
Measured 3 PFE Airflows with a pitot tube in a 2" riser pipe.



Measure Baseline Sub-Slab Pressure 8" & 12"

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Comparison of Garage PFE results vs Dug Out suction pit



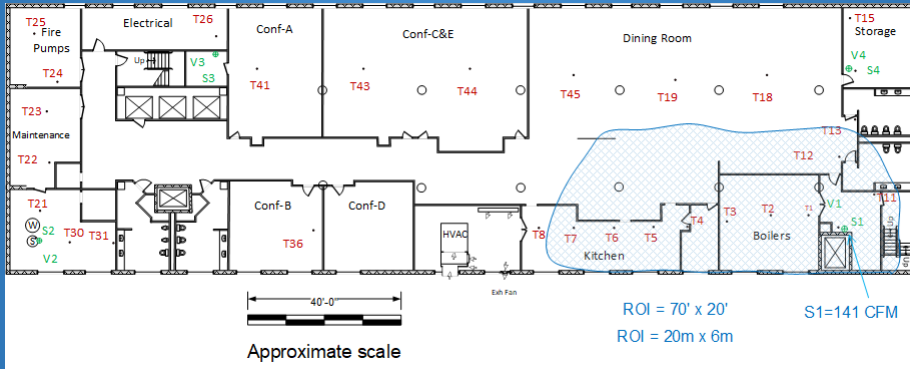
I recommend a Baseline Distance of 8"

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

10 Story Case Study S1 PFE

Vacuum off test holes +4 to +7 PA DR +20 Pa

Building pressure In to Out was -34 Pascals

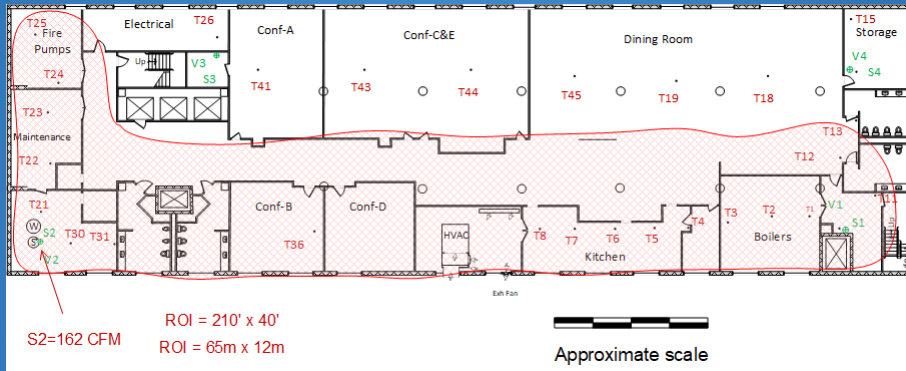


S1- 141 CFM & AOI 20' X 70'

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Case Study
S2 PFE

210 foot AOI
S2 used a sump pit for PFE test

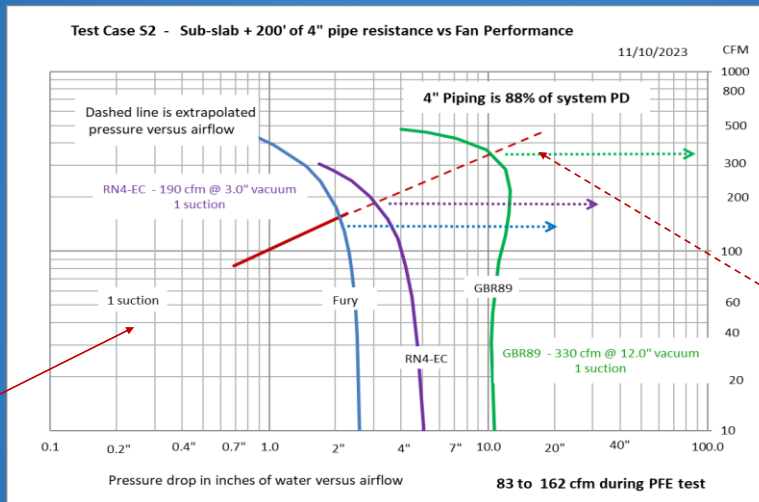


S2 airflow 162 CFM S1 airflow 141 CFM
8" Baseline only 0.28" SP - S1 0.52" SP

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Case Study
S2 PFE

Baseline Sub-Slab 0.28"
200 ft of 4" piping is 2.0" Pressure Drop



Solid Red is PFE test + piping

4" Piping is 88% of Total System airflow resistance

Dashed is extrapolated higher airflow

GBR89 can move 340 CFM versus 162 CFM during PFE Testing

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Case Study
S3 PFE

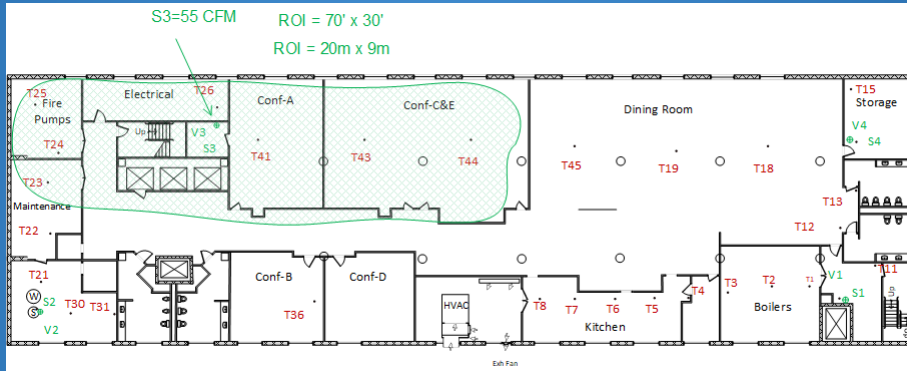
S2 AOI = 40' X 210' = 8400 ft²

vs

S3 AOI = 30' X 70' = 2100 ft²

4X different sq ft

Very Different Results



S2 = 55 CFM vs S3 = 162 CFM

3X different CFM

8" Baseline S2 = 6.4" SP vs S3 = 0.28" SP

20X different SP

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

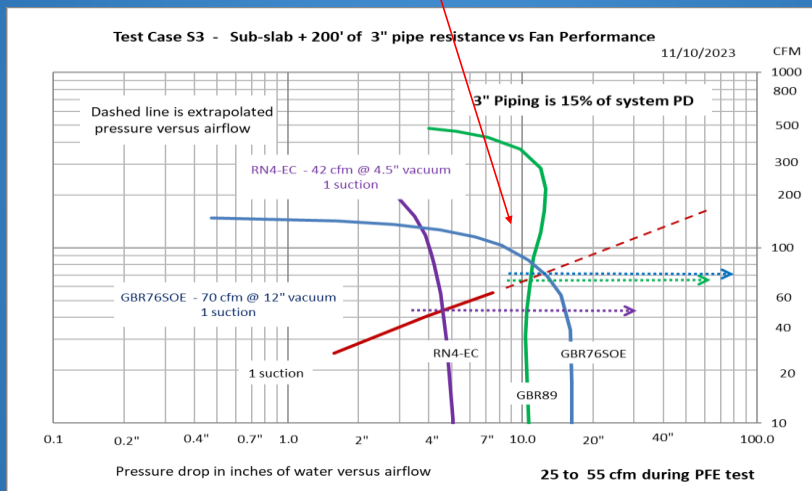
Case Study
S3
Fan & Piping Size

Big Difference in fan choice

GBR76 SOE = 300 watts

GBR89 = 1000 watts

S3 - Baseline = 6.0" SP
200 ft of 3" piping = 1.5" SP



3" Piping only 15% Total System Airflow Resistance

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

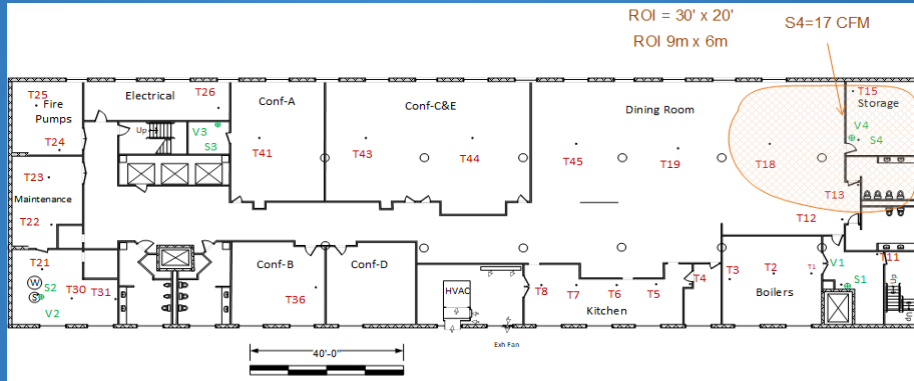
Case Study
S4 PFE

Airflow only
17 CFM

Baseline SP
11.6"

S4 20 X 30 ft AOI = 600 ft² @ 17 CFM
S3 30 X 70 ft AOI = 2100 ft² @ 55 CFM
S2 at 40 X 210 ft AOI = 8400 ft² @ 162 CFM

S4
14 X more
Sq Ft



S4 PFE did not reach across Dining Room

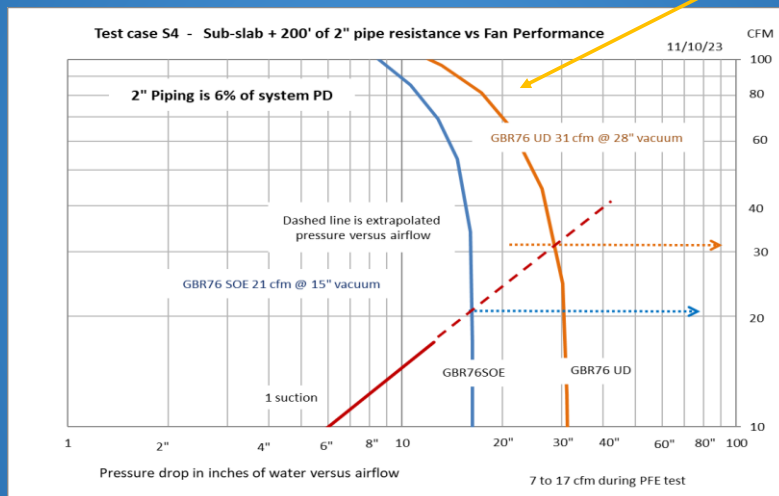
Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Case Study
S4 PFE

2" Piping is only
6%
of
Total
System
airflow
resistance

200 ft 3" pipe = 0.2" SP
200 ft 2" = 0.8" SP

High Vacuum
GBR76 UD
best choice



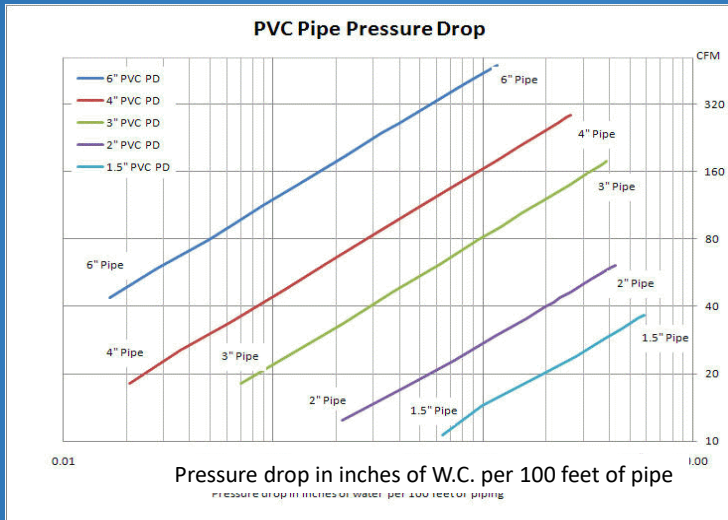
Fan speed is adjustable

Recommended Suction Pit Trenching Increase Airflow

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Piping Pressure Drop = $(((0.205 * \text{CFM} * \text{Pipe inch size}^{1.7})^{2.5}) * (\text{Total EF}/100))$

Critical to Calculate Piping Pressure Drop



Derived from 30 & 60 foot lengths of piping tested



Piping Pressure Drop Formula & chart at www.WPB-radon.com

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Critical to add equivalent feet for all fittings used

Pipe Size	Sweep 90°	Hard 90°	Sweep 45°	Angled 45°	Pipe Reducer	Open Inlet
2"	3'		2'			6.5'
3"	5'	14'	2'	4'	23'	21'
4"	6'	20'	3'	6'	16'	28'
6"	15'	26'	7'	11'	52'	40'

Fitting EF from 20' of Piping

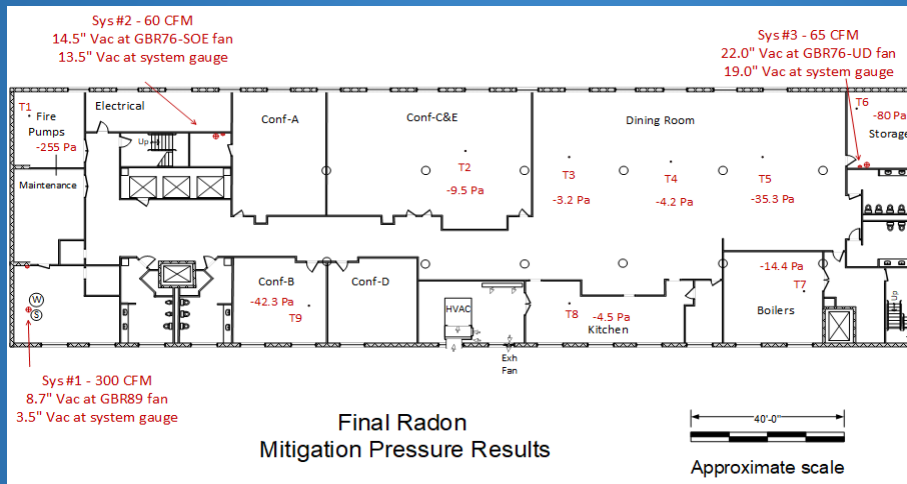


Angled Turn elbows have twice the pressure drop of sweeps

Formula for each fitting Equivalent Feet at CFM flow in Pressure Drop Paper

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

System #1 & #2 performance equaled PFE test at S2 & S3



S4 PFE
predicted
32 CFM
System #3
had
65 CFM
because of
trenching

Least sub-slab vacuum was - 3.2 Pa or - 0.013"

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium

Conference Papers on

Commercial PFE Testing
Calculating Piping Pressure Drop
Onsite Radon in Water Measurements
Elevation Influence

Available at:

www.wpb-radon.com

Bill Brodhead
WPB Enterprises, Inc
wmbrodhead@gmail.com
610 613-8004

Indoor Environments™ 2024 - Radon and Vapor Intrusion Symposium