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Building Science

Adventures In Building Science

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Ventilation Rates Are Based on Odor Control

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Ventilation Rates Are Based on Odor Control Health Science Basis for Ventilation Rates is Extremely Limited

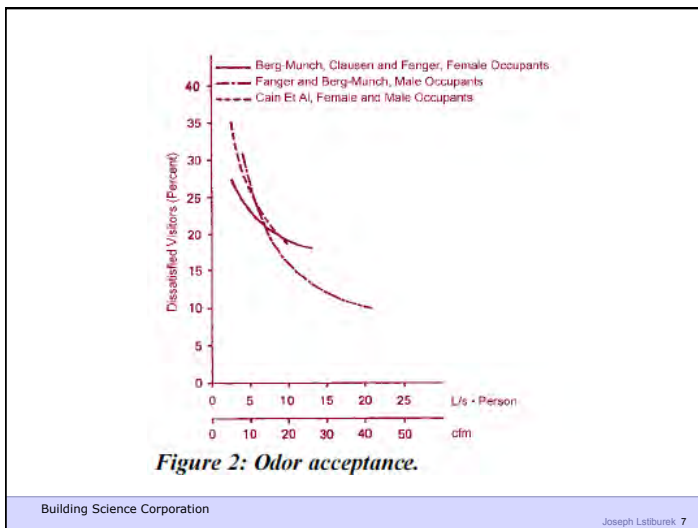
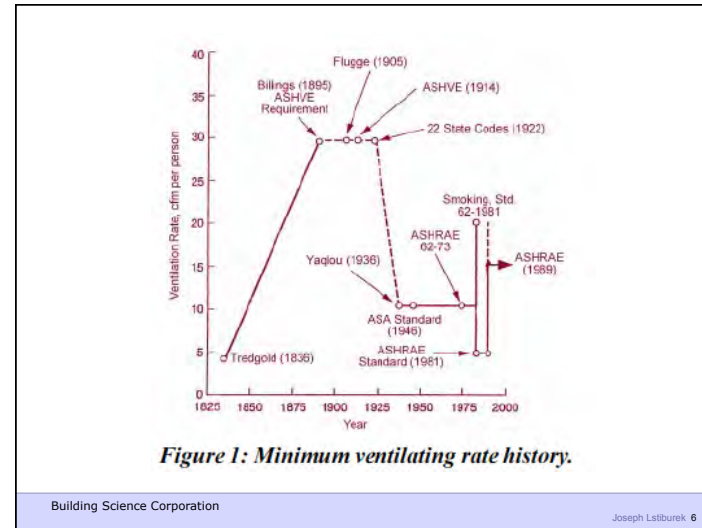
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Ventilation Rates Are Based on Odor Control Health Science Basis for Ventilation Rates is Extremely Limited Almost Nothing Cited Applies to Housing

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Ventilation Rates Are Based on Odor Control
 Health Science Basis for Ventilation Rates is
 Extremely Limited
 Almost Nothing Cited Applies to Housing
 The Applicable Studies Focus on Dampness

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House

2,000 ft²
3 bedrooms
8 ft. ceiling
Volume: 16,000 ft³

.35 ach	93 cfm
.30 ach	80 cfm
.25 ach	67 cfm
.20 ach	53 cfm
.15 ach	40 cfm

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House
 2,000 ft²
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		Ventilation Rates	
.35 ach	93 cfm	62 - 73	5 cfm/person 20 cfm
.30 ach	80 cfm		10 cfm/person 40 cfm
.25 ach	67 cfm	62 - 89	15 cfm/person 60 cfm
.20 ach	53 cfm	.35 ach	90 cfm
.15 ach	40 cfm	62.2 - 2010	7.5 cfm/person 50 cfm
		+ 0.01	
		62.2 - 2013	7.5 cfm/person 90 cfm
		+ 0.03	

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Office

Occupant Density		
15/1000 ft ² (67 ft ² /person)	62 - 89	15 cfm/person
5/1000 ft ² (200 ft ² /person)	62.1 - 2007	17 cfm/person

Correctional Facility Cell

Occupant Density		
20/1000 ft ² (48 ft ² /person)	62.1 - 2007	10 cfm/person

C.P. Yaglou
 Harvard School of Public Health
 1936
 1955

150 ft ³	→	20 cfm/person
300 ft ³	→	12 cfm/person

C.P. Yaglou
 Harvard School of Public Health
 1936
 1955

150 ft ³	→	20 cfm/person 18.75 ft ² 106 occupants
300 ft ³	→	12 cfm/person 37.5 ft ² 53 occupants

Experiment

470 ft ³	→	59 ft ²
200 ft ³	→	25 ft ²
100 ft ³	→	12 ft ²

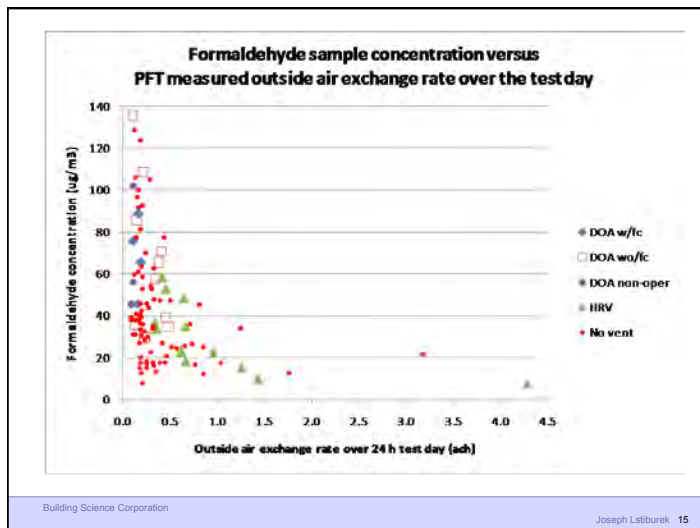
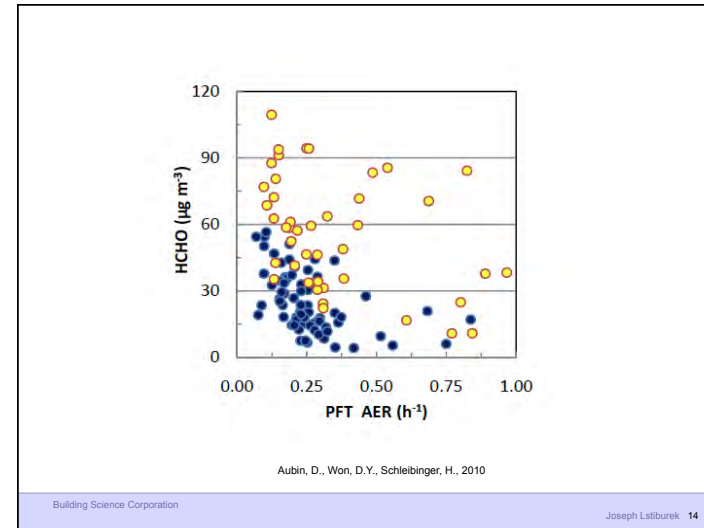
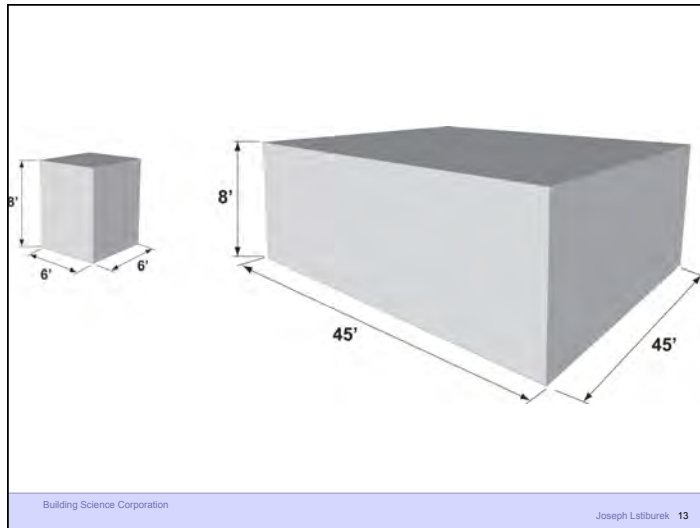


Table 1. Summary of the air changes rates measured during the winter 2009-10 season in Quebec City

Method	ACH (h ⁻¹)	ACH standard deviation (h ⁻¹)	number of measurements
SF ₆ tracer decay	0.27	0.12	77
perfluorocarbon tracer	0.32	0.22	37
blower door at 50 Pa	4.16	2.64	63

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Build Tight - Ventilate Right

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Build Tight - Ventilate Right
How Tight?
What's Right?

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Air Barrier Metrics

Material	0.02 l/(s-m ²) @ 75 Pa
Assembly	0.20 l/(s-m ²) @ 75 Pa
Enclosure	2.00 l/(s-m ²) @ 75 Pa
	0.35 cfm/ft ² @ 50 Pa
	0.25 cfm/ft ² @ 50 Pa
	0.15 cfm/ft ² @ 50 Pa

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Getting rid of big holes	3 ach@50
Getting rid of smaller holes	1.5 ach@50
Getting German	0.6 ach@50

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Best

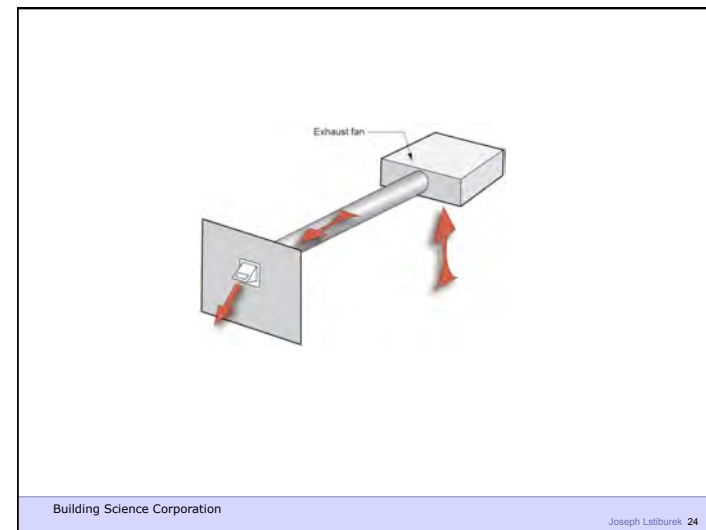
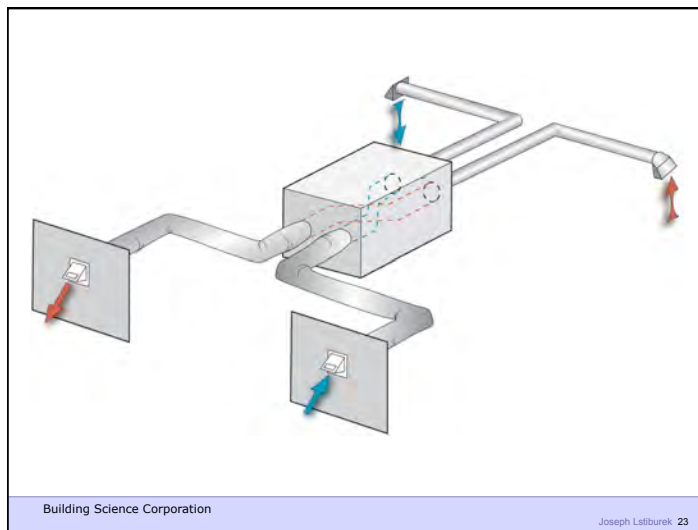
As Tight as Possible - with -
 Balanced Ventilation
 Energy Recovery
 Distribution and Mixing
 Source Control - Spot exhaust ventilation
 Filtration
 Material selection

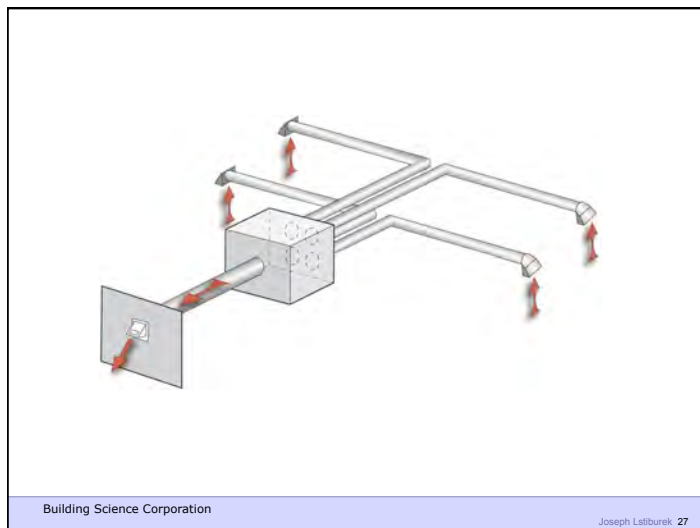
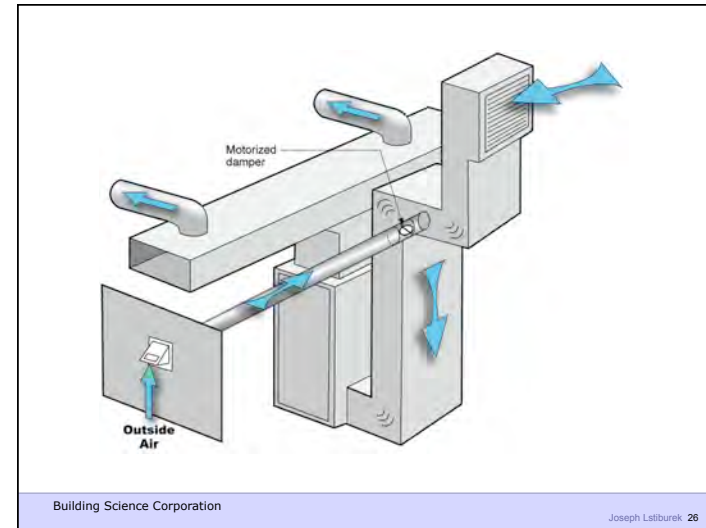
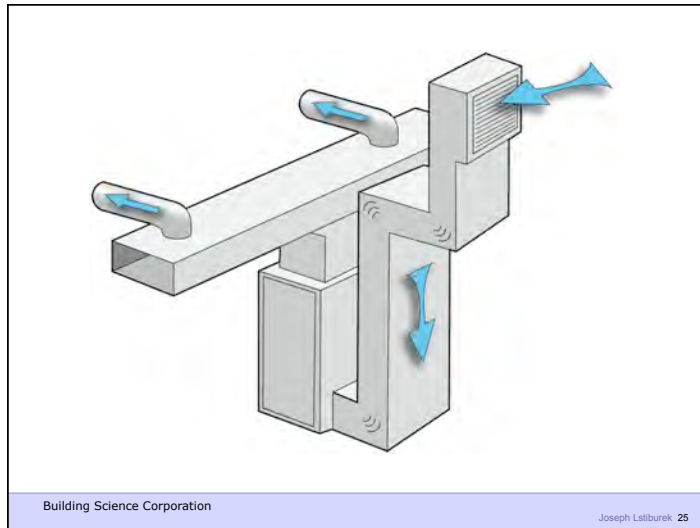
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Worst

Leaky - with - Nothing
 Spot Ventilation in Bathroom/Kitchen
 Exhaust Ventilation - with - No Distribution
 and No Mixing

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Cost	Exhaust	\$150
	Exhaust + Dist + Mix	\$200
	Supply + Dist + Mix	\$200
	Spot + Ex/Sup + Dist + Mix	\$500
	Balanced/HRV	\$1,250

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ASHRAE Standard 62.2 calls for 7.5 cfm per person plus 0.03 cfm per square foot of conditioned area

Occupancy is deemed to be the number of bedrooms plus one

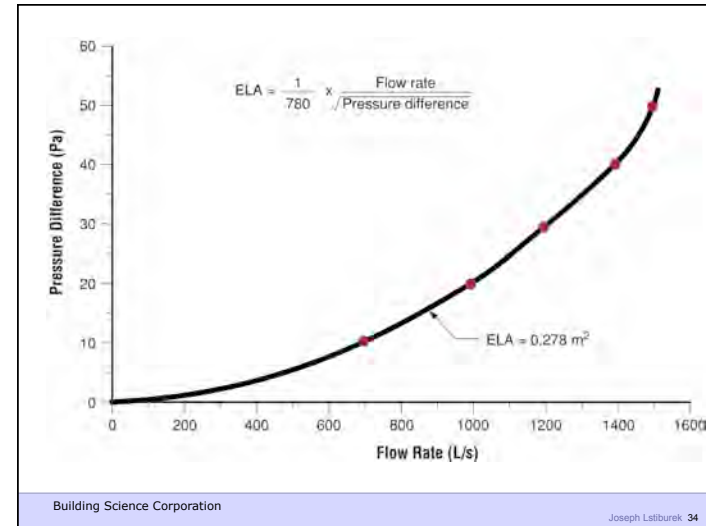
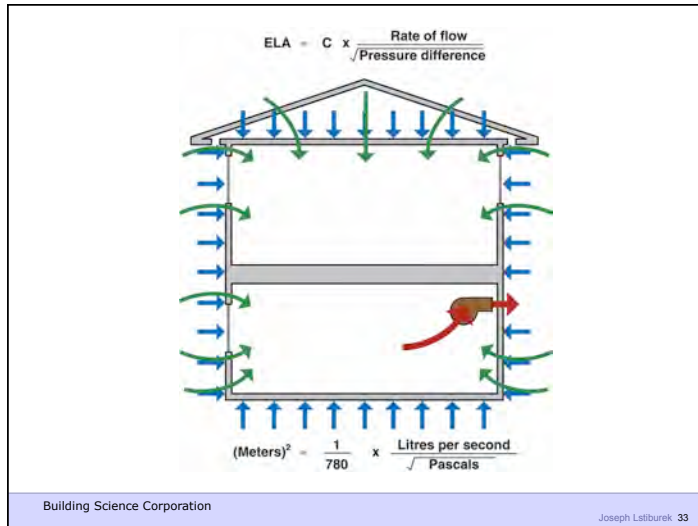
ASHRAE Standard 62.2 calls for 7.5 cfm per person plus 0.03 cfm per square foot of conditioned area

Occupancy is deemed to be the number of bedrooms plus one

Outcome is often bad – part load humidity problems, dryness problems, energy problems

The Cult of The Blower Door



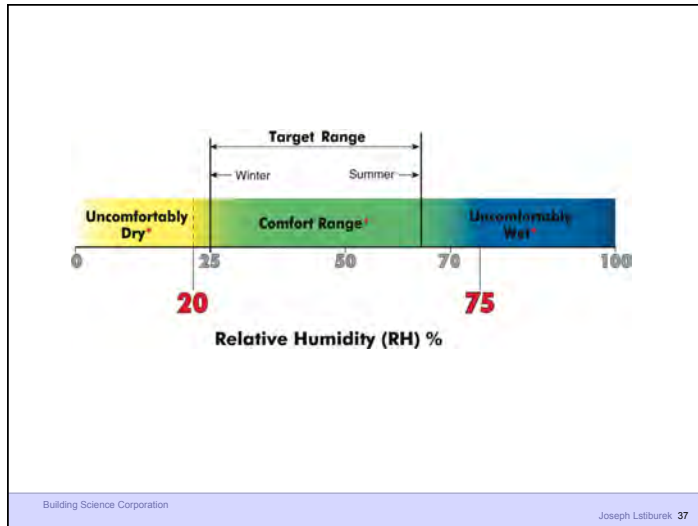


Blower Door Can't Get You The True ACH
On A Short Term Basis – Hour, Day, Week

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Don't Know Where The Holes Are
Don't Know The Type of Holes
Don't Know The Pressure Across The Holes

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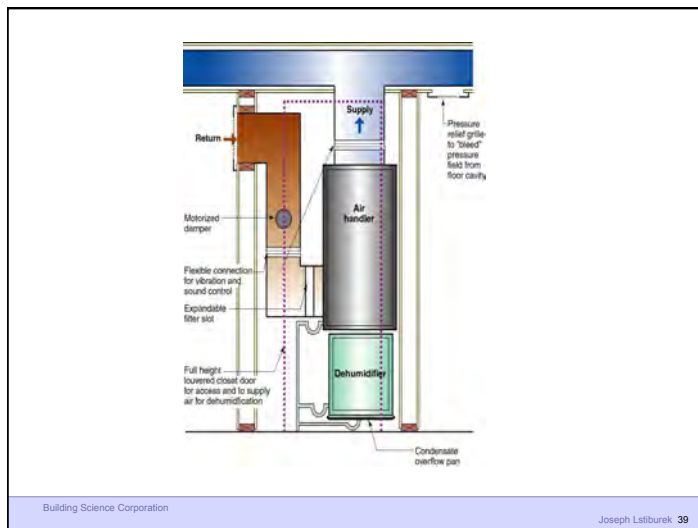


Recommended Range of Relative Humidity

Above 25 percent during winter

Below 70 percent during summer

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Barriers – Technology Dehumidification

Barriers – Cost

- Exhaust \$150
- Exhaust + Dist \$200
- Supply + Dist \$200
- Spot + Ex/Sup + Dist \$500
- Balanced/ER \$1,250
- Dehumidification \$250 to \$1,250

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Tracer Gas Testing
January 2006



- Tracer gas test of a production house in Sacramento
- 2-story, 4 bedrooms, ~2500 square feet
- Ventilation systems tested: supply and exhaust ventilation, with and without mixing via central air handler

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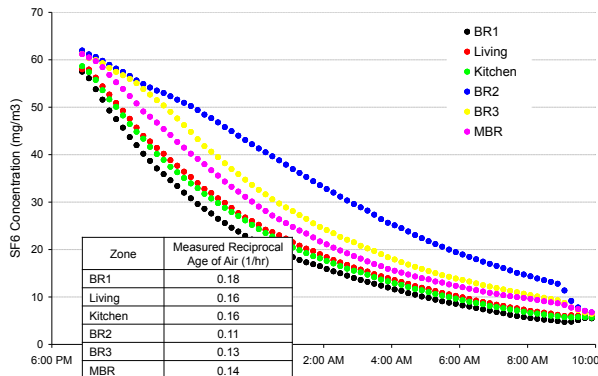
Floor Plan - 2 Story House



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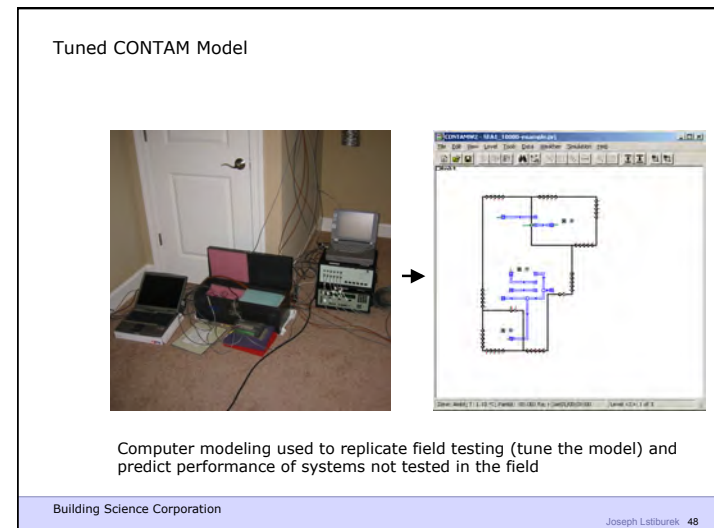
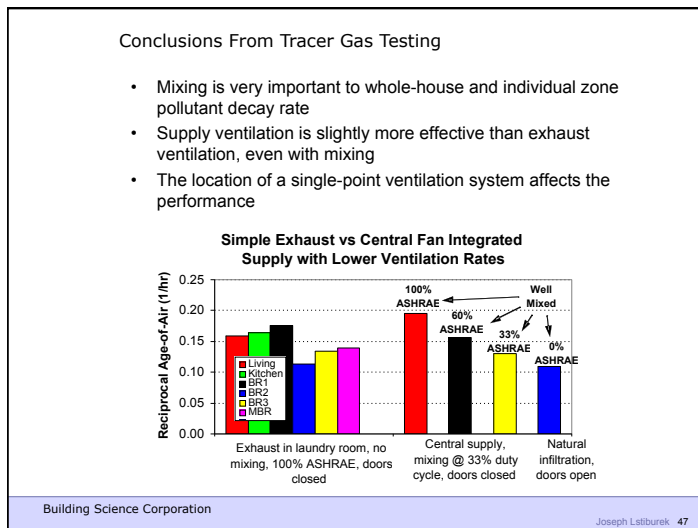
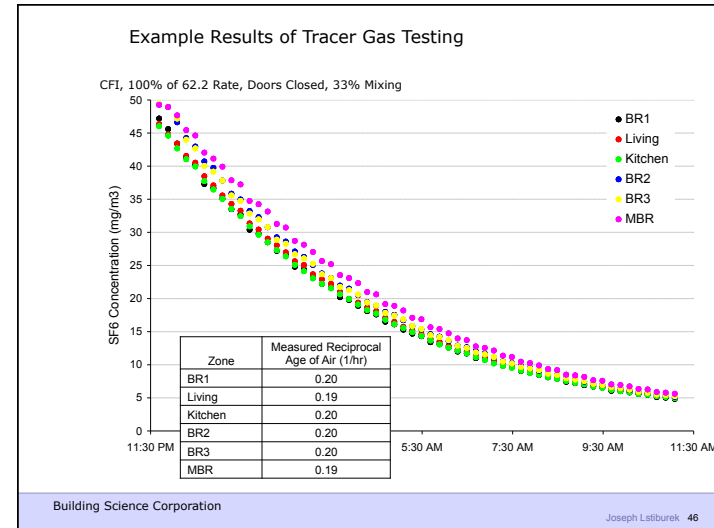
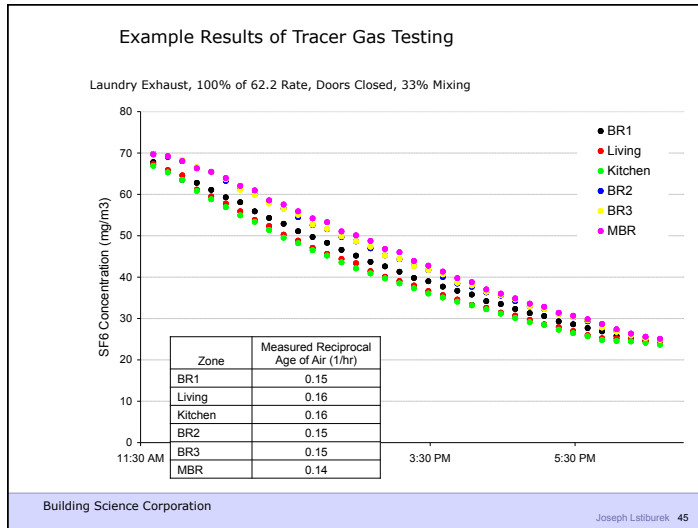
Example Results of Tracer Gas Testing

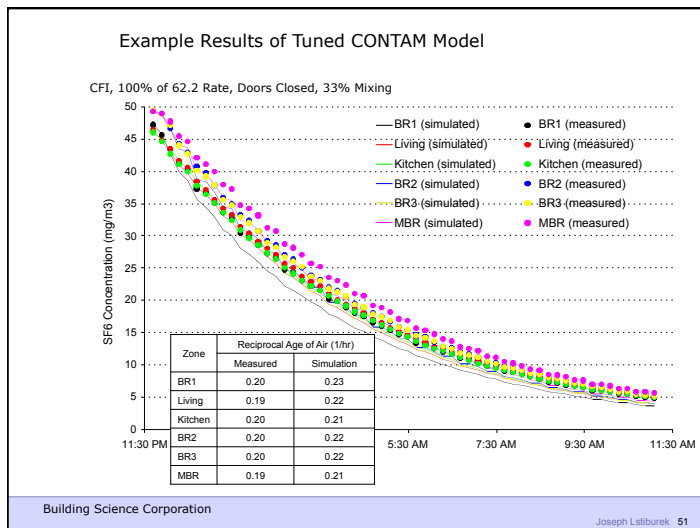
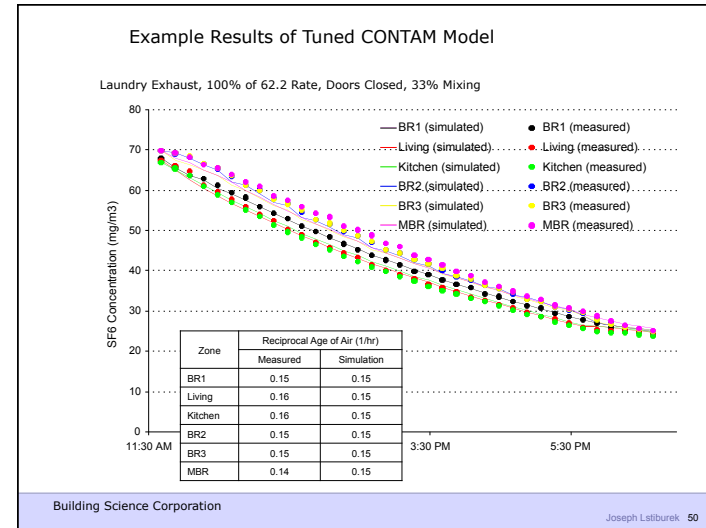
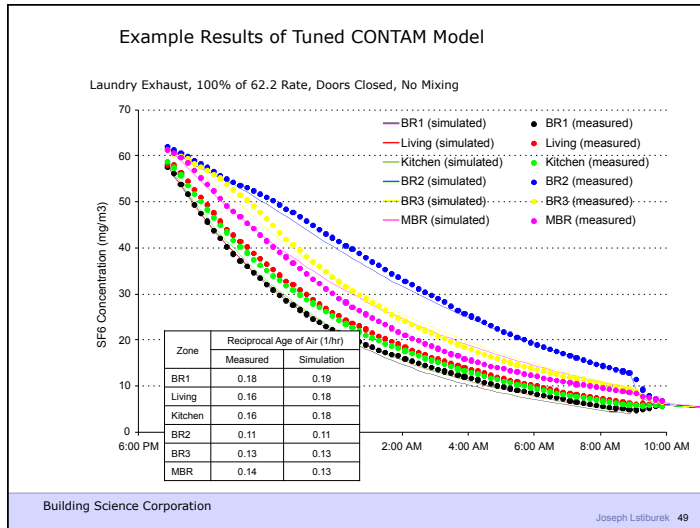
Laundry Exhaust, 100% of 62.2 Rate, Doors Closed, No Mixing



Zone	Measured Reciprocal Age of Air (1/hr)
BR1	0.18
Living	0.16
Kitchen	0.16
BR2	0.11
BR3	0.13
MBR	0.14

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Tuned CONTAM Model Applied to Other Systems

Systems Evaluated & Compared:

1. Exhaust ventilation, without central duct system
2. Supply ventilation, without central duct system
3. Exhaust ventilation, with central ducts, standard Tstat
4. Exhaust ventilation, with central ducts, Tstat with timer
5. Supply ventilation, with central ducts, Tstat with timer
6. Fully ducted balanced ventilation system, without central duct system

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$Q(v)$ = Ventilation Rate
 $Q(fan) = Q(v) \cdot C(s)$
 $C(s)$ = System Coefficient

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Airflow Ratios—All Simulations

System Type	Range	Approximate Median
Fully ducted balanced ventilation system, with or without central duct system	1.0	1.0
Non-fully ducted balanced ventilation, with central duct system, and central air handler unit controlled to a minimum runtime of at least 10 minutes per hour	0.9 to 1.1	1.0
Supply ventilation, with central duct system, and central air handler unit controlled to a minimum runtime of at least 10 minutes per hour	1.1 to 1.7	1.25
Exhaust ventilation, with central duct system, and central air handler unit controlled to a minimum runtime of at least 10 minutes per hour	1.1 to 1.9	1.25
Exhaust ventilation, with central duct system, and central air handler unit not controlled to a minimum runtime of at least 10 minutes per hour	1.0 to 1.8	1.5
Supply ventilation, without central duct system	1.4 to 1.9	1.75
Exhaust ventilation, without central duct system	1.3 to 2.6	2.0

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BSC 01 - 2013 calls for 7.5 cfm per person plus 0.01 cfm per square foot of conditioned area
 Occupancy is deemed to be the number of bedrooms plus one

 Occupant Rate + Building Rate

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$Q(v)$ = Fan Flow Rate
 $Q(fan) = Q(v) \cdot C(d)$
 $C(s)$ = System Coefficient

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Table 4.1
System Coefficient based on system type¹

System Type	Distributed	Not Distributed
Balanced	1.0	1.25
Not Balanced	1.25	1.5

¹ Where there is whole-building air mixing of at least 70% recirculation turnover each hour, the system coefficient may be reduced by 0.25.

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BSC 01-2013
Ventilation for New Low-Rise Residential Building
2,000 ft²
3 bedrooms

20 cfm + 30 cfm = 50 cfm

Mixed, Distributed, Balanced (MDB)
37.5 cfm

Not Mixed, Not Distributed, Not Balanced
75 cfm

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House
2,000 ft²
3 bedrooms
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Volume: 16,000 ft³

Ventilation Rates			
	.35 ach	93 cfm	
	.30 ach	80 cfm	62 - 73
	.25 ach	67 cfm	5 cfm/person 20 cfm
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	.15 ach	40 cfm	62 - 89
			15 cfm/person 60 cfm
			.35 ach 90 cfm
			62.2 - 2010
			7.5 cfm/person 50 cfm
			+ 0.01
			62.2 - 2013
			7.5 cfm/person 90 cfm
			+ 0.03
			BSC 01 - 2013
			7.5 cfm/person 37 cfm
			+ 0.01 (MBD) 75 cfm

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