System Coefficients

Where Have We Been
and Where Are We Going?

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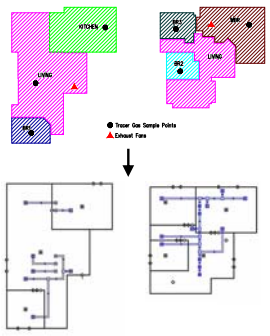
Tracer Gas Testing Sacramento January 2006

- Tracer gas test of production Building America house in Sacramento
- 2-story, 4 bedrooms, ~2600 square feet
- Tested two ventilation systems, with and without mixing via central air handler
- Results published by NREL (Bob Hendron) at IAQ 2007

CONTAM Modeling, Nov. 2006-Jan. 2007



Computer modeling used to replicate field testing (tune the model) and predict performance of systems not tested in the field

Expert Meeting, Dallas, January 2007

1. Presented:
   1. Tracer gas testing and results
   2. Calibrated model and results
   3. Coefficients ranging from 0.5 to 1.25 based on a reference of an exhaust-only system with a central AHU controlled by a thermostat only
2. Results:
   1. Committee wanted to see annual simulations, and a wider number of climates and house characteristics (leakage rates, ventilation systems, etc).

Expert Meeting, Long Beach, June 2007

1. Presented:
   1. First parametric study
   2. 3 climates, 3 enclosure leakage levels, 3 options for AHU, 2 options for AHU control, 2 options for duct leakage, 4 ventilation systems, ventilation rate 0-150% of 62.2
   3. Volume-weighted sources only
   4. Coefficients ranging from 1.0 to 2.0 based on a reference of a fully-ducted balanced ventilation system
2. Results:
   1. Committee wanted to see more climates, and had questions about how the various parameters affected the results

Expert Meeting, New York, January 2008

1. Presented:
   1. Second parametric study
   2. 5 climates, 3 enclosure leakage levels, 3 options for AHU, 2 options for AHU control, 2 options for duct leakage, 4 ventilation systems, ventilation rate 0-200% of 62.2
   3. Volume-weighted sources only
   4. Coefficients ranging from 1.0 to 2.0 based on a reference of a fully-ducted balanced ventilation system
   5. Comparison of exposure ratios from BSC's simulations to LBL's field testing & calculations
   6. Effect of AHU size
   7. Effect of parameters: climate, enclosure leakage, etc.
2. Results:
   1. Committee wanted no duct leakage, very leaky results, effect of sources in kitchens & bathrooms, and many more ventilation systems

Conference Calls, April-June 2008

1. April 18, 2008
   1. Revised simulation plan for third parametric study
2. June 10, 2008
   1. Presented third parametric study
   2. 8 climates, 4 enclosure leakage levels, 2 options for AHU, 2 options for AHU control, ~10 ventilation systems, ventilation rate 0-200% of 62.2
   3. Volume-weighted sources or kitchens & bathrooms sources
   4. Coefficients ranging from 1.0 to 2.0 based on a reference of a fully-ducted balanced ventilation system

Meeting, Salt Lake City, June 2008

1. Presented:
   1. Third parametric study
   2. 8 climates, 4 enclosure leakage levels, 2 options for AHU, 2 options for AHU control, 36 ventilation systems, ventilation rate 0-200% of 62.2
   3. Volume-weighted sources or kitchens & bathrooms sources
   4. Coefficients ranging from 1.0 to 2.0 based on a reference of a fully-ducted balanced ventilation system
2. Results:
   1. Committee wanted another enclosure leakage level (5 ach50), occupant-generated sources, and a few more ventilation systems

Conference Call, October 30 2008

1. Presented:
   1. Fourth parametric study
   2. 8 climates, 5 enclosure leakage levels, 2 options for AHU, 2 options for AHU control, ~12 ventilation systems, ventilation rate 0-200% of 62.2
   3. Volume-weighted sources, kitchens & bathrooms sources, or occupant-generated sources; also a combination of volume-weighted and occupant-generated
   4. Coefficients ranging from 1.0 to 2.0 based on a reference of a fully-ducted balanced ventilation system
2. Results:
   1. Participants wanted to see a sensitivity analysis of the effect of source scenario

Conference Call, December 12 2008

1. Presented:
   1. Sensitivity analysis
   2. 8 climates, 5 enclosure leakage levels, 2 options for AHU, 2 options for AHU control, ~12 ventilation systems, ventilation rate 0-200% of 62.2
   3. Different combinations of volume-weighted sources, kitchens & bathrooms sources, and occupant-generated sources
   4. Coefficients ranging from 1.0 to 2.0 based on a reference of a fully-ducted balanced ventilation system
2. Results:
   1. Participants disagree or need more information regarding appropriate assumptions for pollutant sources
   2. One additional ventilation system was requested

New System

- New ventilation system:
  - Two-point exhaust system
  - Exhaust points in hall bathrooms upstairs and downstairs
  - Without AHU, with AHU, and with AHU and minimum turnover

New System

- Results: 3.5 ach50, average of climates

Scenario A

Description	no central system	with central system	with min turnover
Single-point continuous exhaust from first floor common area	2.17	1.79	1.40
Single-point continuous exhaust from second floor master bathroom	2.88	2.15	1.45
Two-point continuous exhaust from 1st and 2nd floor hall bathrooms	2.30	1.87	1.39
Three-point continuous exhaust, 1/3 from each bathroom	2.25	1.72	1.26
Four-point continuous exhaust 1/4 from kitchen and each bathroom	2.00	1.61	1.26

New System

- Results: 3.5 ach50, average of climates

Scenario C

Description	no central system	with central system	with min turnover
Single-point continuous exhaust from first floor common area	2.10	1.87	1.76
Single-point continuous exhaust from second floor master bathroom	2.56	2.34	2.26
Two-point continuous exhaust from 1st and 2nd floor hall bathrooms	2.16	1.83	1.55
Three-point continuous exhaust, 1/3 from each bathroom	1.65	1.49	1.37
Four-point continuous exhaust 1/4 from kitchen and each bathroom	1.43	1.38	1.34

New System

- Results: 3.5 ach50, average of climates

Scenario E

Description	no central system	with central system	with min turnover
Single-point continuous exhaust from first floor common area	2.36	1.79	1.04
Single-point continuous exhaust from second floor master bathroom	3.46	2.08	0.82
Two-point continuous exhaust from 1st and 2nd floor hall bathrooms	2.55	1.94	1.08
Three-point continuous exhaust, 1/3 from each bathroom	2.71	1.80	0.95
Four-point continuous exhaust 1/4 from kitchen and each bathroom	2.45	1.73	0.94

Sensitivity Analysis

- Effect of mixing 3 “pure” scenarios in different ratios
- Pure scenarios:
  - A: Volume-weighted sources
  - C: Sources in kitchens & baths only
  - E: Occupant-generated sources only

Scenario	A	C	E
% K&B zones	25%	100%	0%
% Other zones	75%	0%	0%
% Occupants	0%	0%	100%

Sensitivity Scenarios

- Sensitivity scenarios:
  - F, G1 through G6

Scenarios as a mix of “pure” scenarios

Scenario	F	G1	G2	G3	G4	G5	G6
% VW	50	40	30	50	50	33	20
% K&B	0	10	20	10	20	33	20
% Occ.	50	50	50	40	30	33	60

Sensitivity Scenarios

- Sensitivity scenarios:
  - K&B have volume—how much?
  - 25% in K&B, 75% elsewhere

Scenario emissions by zones & occupants

Scenario	F	G1	G2	G3	G4	G5	G6
% K&B	13	20	28	23	33	41	25
% Other	38	30	23	38	38	25	15
% Occ.	50	50	50	40	30	33	60

Sensitivity Scenarios

- Sensitivity scenarios:
  - Occupants move around—where are their emissions?
  - 15% in K&B, 85% elsewhere

Total emissions by emission location

Scenario	F	G1	G2	G3	G4	G5	G6
% in K&B	20	28	35	29	37	46	34
% in Other	80	73	65	72	63	53	66

Scenario A

(25% in K&B, 75% in other zones, 0% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1.35	1.65	1.65
	not fully ducted	1.35	1.65	1.65
Exhaust	fully ducted	1.65	2	2
	not fully ducted	1.65	2	2
Balanced	fully ducted	1	1	1
	not fully ducted	1	1.35	1.35

Scenario C

(100% in K&B, 0% in other zones, 0% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1.65	2	2
	not fully ducted	2	2	2
Exhaust	fully ducted	1.35	1.65	1.65
	not fully ducted	2	2	2
Balanced	fully ducted*	1.35	1.35	1.35
	not fully ducted	1.35	1.65	2

*Any fully-ducted balanced system with returns from all K&B has a coefficient of 1.0

Scenario E

(0% in K&B, 0% in other zones, 100% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1	1	1
	not fully ducted	1	1.35	1.65
Exhaust	fully ducted	1	1.65	2
	not fully ducted	1	2	2
Balanced	fully ducted	1	1	1.35
	not fully ducted	1	2	2

Scenario F

(13% in K&B, 38% in other zones, 50% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1	1.35	1.35
	not fully ducted	1	1.35	1.65
Exhaust	fully ducted	1.35	2	2
	not fully ducted	1.35	2	2
Balanced	fully ducted	1	1	1.35
	not fully ducted	1	1.65	2

Scenario G1

(20% in K&B, 30% in other zones, 50% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1	1.35	1.35
	not fully ducted	1	1.35	1.65
Exhaust	fully ducted	1.35	1.65	2
	not fully ducted	1.35	2	2
Balanced	fully ducted	1	1	1.35
	not fully ducted	1	1.65	2

Scenario G2

(28% in K&B, 23% in other zones, 50% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1	1.35	1.35
	not fully ducted	1	1.35	1.65
Exhaust	fully ducted	1	1.65	2
	not fully ducted	1.35	2	2
Balanced	fully ducted	1	1	1.35
	not fully ducted	1	1.65	2

Scenario F

(13% in K&B, 38% in other zones, 50% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1	1.35	1.35
	not fully ducted	1	1.35	1.65
Exhaust	fully ducted	1.35	2	2
	not fully ducted	1.35	2	2
Balanced	fully ducted	1	1	1.35
	not fully ducted	1	1.65	2

Scenario G3

(23% in K&B, 38% in other zones, 40% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1	1.35	1.35
	not fully ducted	1	1.35	1.65
Exhaust	fully ducted	1.35	1.65	2
	not fully ducted	1.35	2	2
Balanced	fully ducted	1	1	1.35
	not fully ducted	1	1.65	2

Scenario G4

(33% in K&B, 38% in other zones, 30% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1	1.35	1.35
	not fully ducted	1.35	1.65	1.65
Exhaust	fully ducted	1.35	1.65	2
	not fully ducted	1.35	2	2
Balanced	fully ducted	1	1	1
	not fully ducted	1	1.65	2

Scenario G5

(41% in K&B, 25% in other zones, 33% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1	1.35	1.35
	not fully ducted	1.35	1.65	1.65
Exhaust	fully ducted	1.35	1.65	2
	not fully ducted	1.35	2	2
Balanced	fully ducted	1	1	1
	not fully ducted	1	1.65	2

Scenario G6

(25% in K&B, 15% in other zones, 60% from occupants)

Ventilation type	Ventilation ducting	With AHU		Without AHU
		With Min Turnover	Without Min Turnover	
Supply	fully ducted	1	1	1.35
	not fully ducted	1	1.35	1.65
Exhaust	fully ducted	1	2	2
	not fully ducted	1	2	2
Balanced	fully ducted	1	1	1.35
	not fully ducted	1	2	2

Scenarios G2, G5, G6

		Ventilation type	Ventilation ducting	With AHU		Without AHU
				With Min Turnover	Without Min Turnover	
Scenario	**G2**	Supply	fully ducted	1	1.35	1.35
% K&B	28		not fully ducted	1	1.35	1.65
% Other	23	Exhaust	fully ducted	1	1.65	2
% Occ.	50		not fully ducted	1.35	2	2
		Balanced	fully ducted	1	1	1.35
			not fully ducted	1	1.65	2
Scenario	**G5**	Supply	fully ducted	1	1.35	1.35
% K&B	41		not fully ducted	1.35	1.65	1.65
% Other	25	Exhaust	fully ducted	1.35	1.65	2
% Occ.	33		not fully ducted	1.35	2	2
		Balanced	fully ducted	1	1	1
			not fully ducted	1	1.65	2
Scenario	**G6**	Supply	fully ducted	1	1	1.35
% K&B	25		not fully ducted	1	1.35	1.65
% Other	15	Exhaust	fully ducted	1	2	2
% Occ.	60		not fully ducted	1	2	2
		Balanced	fully ducted	1	1	1.35
			not fully ducted	1	2	2