Ventilation for Acceptable Indoor Air Quality 62.1-2010

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RMH GROUP

What Is ASHRAE Standard 62.1?

- The Industries Ventilation Standard
  - Consensus Standard
  - Standard of Care
  - Used in NFPA 5000 Building Construction and Safety Code
  - LEED Requirement
- 2009 IMC – Ventilation system efficiency may be calculated by Appendix A (62.1-2004)

History of the Standard

- 1905 Flugge 30 cfm
- 1936 Yaglou 10 cfm
- 1973 First Issued office 15 cfm/p
- 1981 Lower Rates office 5 cfm/p
- 1989 Higher Rates office 20 cfm/p
- 1999 Little Change office 20 cfm/p
- 2001 More Mandatory Language office 20 cfm/p
- 2004 Key Changes office 17 cfm/p
- 2007 Appendix H office 17 cfm/p
- 2010 Dropped Smoking office17 cfm/p

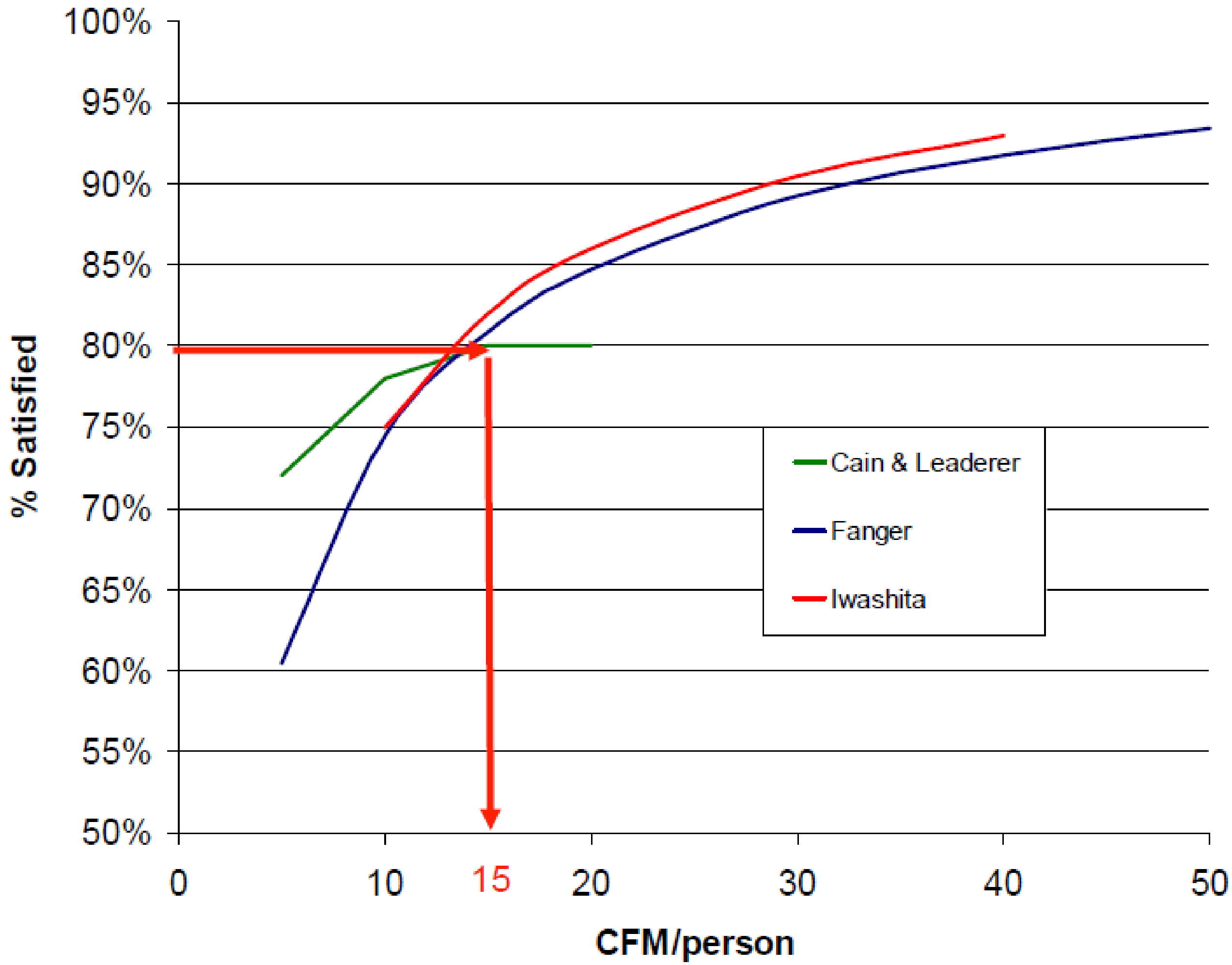
Acceptable Indoor Air Quality What Is It?

- Standard 62: “Air in which there is no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction.”

How Much Ventilation?

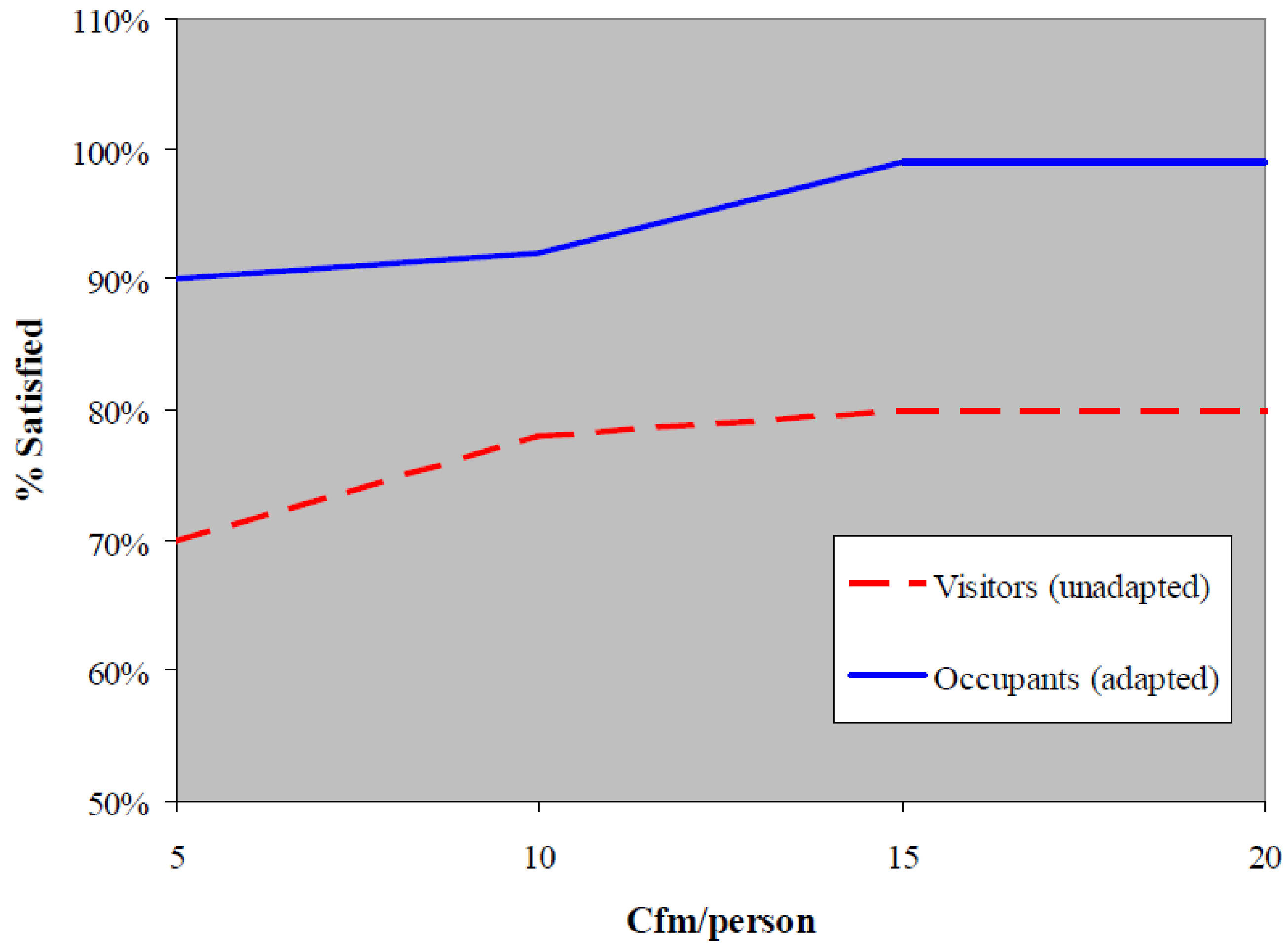
- Unknown
- Chamber studies
  - Limited to body odor (olf)
- Medical evidence
  - No “evidence based” studies
- Rule of thumb evidence

Chamber Body Odor Studies
Impact of ventilation rate on "visitors"



From ASHRAE presentation by Steve Taylor

Body Oder Studies
Cain & Leaderer



From ASHRAE presentation by Steve Taylor

Cain & Leaderer 1983

- For nonsmoking occupancy, 47 combinations of temperature, humidity, ventilation rate and occupancy density were examined. Odor level depended entirely on ventilation rate per person irrespective of the number of persons in the chamber.
- For both smoking and nonsmoking conditions, a combination of high temperature (78°F) and humidity (r.h. > 70 %) exacerbated the odor problem

Recent Studies

- Hillsborogh County Schools
  - March 2011 Engineered Systems
  - 9th largest district in US
  - 7.5 cfm/student
- 2 California Studies ongoing
- Anticipate ventilation rate changes

62.1 New in 2010

- PM2.5 non-attainment areas require air cleaning
- Smoking spaces no longer covered by the standard
- Air intake separation distances revised
- Deletes requirements for health care spaces
- Revises IAQ procedure to make it more robust
- Most natural ventilation systems now require mechanical systems for when natural vent cannot be used (thermal comfort, noise, security)

Fun Facts

- Means to balance the system to achieve minimum airflow.
- Design documentation to state ventilation rate and air distribution assumptions.
- Controls to enable the fan to operate whenever the spaces served are occupied.
- VAV systems with fixed OA dampers must comply at minimum supply airflow.
- MERV 6 filters upstream of all coils or other devices with wetted surfaces.

Two paths to compliance

- Ventilation Rate Procedure
  - Most commonly used method
  - Lookup table (simple) or Appendix A (complex)
  - Need zone air distribution effectiveness
  - LEED requires this method
- Indoor Air Quality Procedure
  - Design to maintain specific contaminant levels
  - Mass Balance Analysis
  - Methods used in similar buildings
  - Validation by contaminant monitoring

Single duct systems such as VAV reheat

Multiple paths: Fan powered VAV and Dual duct

Ventilation Rate Procedure

TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/person	L/s•person	cfm/ft^2	L/s•m^2		#/1000 ft^2 or #/100 m^2	cfm/person	L/s•person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Day room	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Classrooms (ages 5-8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3		65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150	8	4.0	1

Ventilation Rate Procedure

GENERAL NOTES FOR TABLE 6-1

1 **Related Requirements:** The rates in this table are based on all other applicable requirements of this standard being met.

2 **Smoking:** This table applies to no-smoking areas. Rates for smoking-permitted spaces must be determined using other methods. See Section 6.2.9 for ventilation requirements in smoking areas.

3 **Air Density:** Volumetric airflow rates are based on an air density of 0.075 lb_{da}/ft^3 (1.2 kg_{da}/m^3), which corresponds to dry air at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C). Rates may be adjusted for actual density but such adjustment is not required for compliance with this standard.

4 **Default Occupant Density**: The default occupant density shall be used when actual occupant density is not known.

5 **Default Combined Outdoor Air Rate (per person)**: This rate is based on the default occupant density.

6 **Unlisted Occupancies:** If the occupancy category for a proposed space or zone is not listed, the requirements for the listed occupancy category that is most similar in terms of occupant density, activities and building construction shall be used.

Ventilation Rate Procedure

TABLE 6-2
Zone Air Distribution Effectiveness

Air Distribution Configuration	E_z
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return.	0.8
Ceiling supply of warm air less than 15°F (8°C) above space temperature and ceiling return provided that the 150 fpm (0.8 m/s) supply air jet reaches to within 4.5 ft (1.4 m) of floor level. **Note**: For lower velocity supply air, $E_z = 0.8$.	1.0
Floor supply of cool air and ceiling return provided that the 150 fpm (0.8 m/s) supply jet reaches 4.5 ft (1.4 m) or more above the floor. **Note**: Most underfloor air distribution systems comply with this proviso.	1.0
Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification	1.2
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7

Classroom Example

Single zone 2010

- High School classroom 35’x35’ 30 people
- $V_{bz} = R_pP_z + R_aA_z$ V_{bz} = Breathing Zone OA
- 10 cfm /person 10 * 30 = 300 cfm
- 0.12 cfm/ft^2 0.12 * 35 * 35 = 147 cfm
- 300 + 147 = 447 cfm
- Zone outdoor airflow $V_{oz} = V_{bz}/E_z$
- 447 /1 = 447 cfm or 14.9 cfm/person

Short-Term Conditions

- Peak occupancy of short duration
- Ventilation interrupted for a short period of time
- $T = 3V / V_{bz}$
- V = Volume of ventilation zone
- + Zone outdoor air flow

Example Private Office

- 230 Sq Ft, 9 ft ceiling Work station and 2 guest chairs
-

  $T = 3V/ V_{bz} = 9*230*9/(3*5 +230 *0.06) = 3.6$ hrs
- Assume guests present 1/3 of time
- Design occupancy = 1 + (2 * 1/3) = 1.7

Multiple-Zone Recirculating Systems

- For each zone:
  - $V_{bz} = R_p P_z + R_a A_z$ Just like previous example
  - $V_{oz} = V_{bz}/E_z$ Just like previous example

Multiple-Zone Recirculating Systems

- Primary outdoor air fraction Zp
- $Z_{pz} = V_{oz}/V_{pz}$ (For each zone)
- V_{oz} - zone outdoor airflow
- V_{pz} - minimum zone primary airflow (supply air)

Uncorrected Outdoor Air Intake

- $V_{ou} = D\Sigma_{all\ zones}R_pP_z + \Sigma_{all\ zones}\ R_aA_z$
  - V_{ou} - uncorrected outdoor air intake
  - D - occupant diversity = $P_s / \Sigma_{all\ zones}\ P_z$
  - P_s -total population of area served by the system
  - P_z - largest number of people in the zone

System Ventilation Efficiency

TABLE 6-3
System Ventilation Efficiency

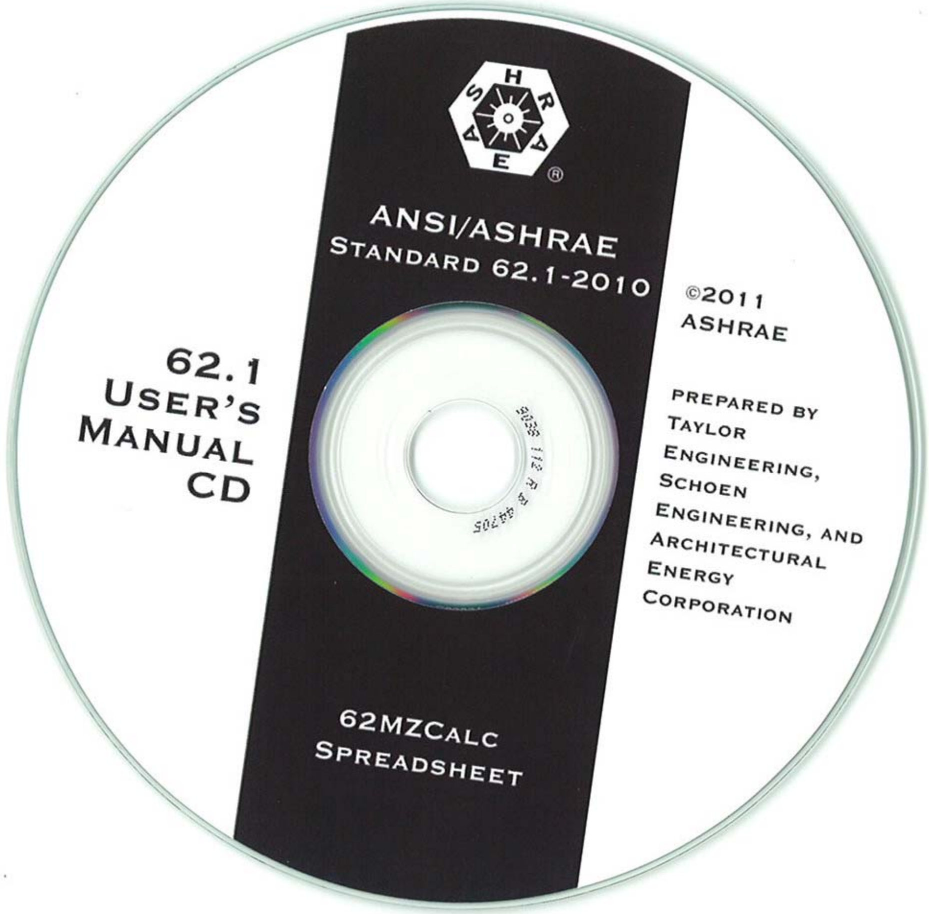
Max (Z_p)	E_v
≤ 0.15	1.0
≤ 0.25	0.9
≤ 0.35	0.8
≤ 0.45	0.7
≤ 0.55	0.6
> 0.55	Use Appendix A

1. "Max Z_p" refers to the largest value of Z_p, calculated using Equation 6-5, among all the zones served by the system.
2. For values of Z_p between 0.15 and 0.55, one may determine the corresponding value of E_v by interpolating the values in the table.
3. The values of E_v in this table are based on a 0.15 average outdoor air fraction for the system (i.e., the ratio of the *uncorrected outdoor air intake* V_{ou} to the total *zone primary airflow* for all the zones served by the air handler). For systems with higher values of the average outdoor air fraction, this table may result in unrealistically low values of E_v and the use of Appendix A may yield more practical results.

Outdoor Air Intake

- $V_{ot} = V_{ou}/E_v$
- V_{ot} - design outdoor air intake flow
- V_{ou} - uncorrected outdoor air intake
- E_v - ventilation efficiency from Table 6-3 or Appendix A

62MZCalc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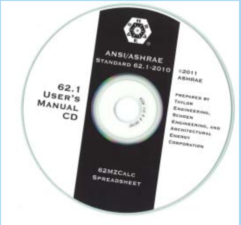
62MZCalc
Spreadsheet

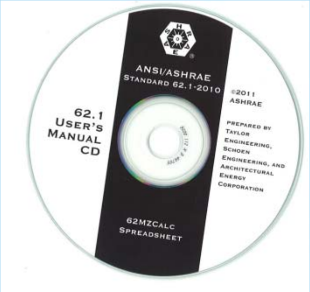
62MZCALC

	B	C	D	F	G	H	J	K	L	M	O	P	Q
1	**Building:** Delete Zone												
2	**System Tag/Name:**												
3	**Operating Condition Description:** Add Zone												
4	**Units (select from pull-down list)**	IP											
5				w/o diversity			w/ diversity						
6	**Inputs for System**	**Name**	**Units**	**System**		**Diversity**	**System**				**Check Figures**		
7	Floor area served by system	*As*	sf	3,000				Default entry has been overridden.					
8	Population of area served by system	*Ps*	P	300	*D*		300	Default entry has been overridden.			100.0	P/1000 sf	
9	Design primary supply fan airflow rate	Vpsd	cfm	10,000			10,000	Default entry has been overridden.			3.33	cfm/sf	
10	OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.06							0.06	ave cfm/sf	
11	OA req'd per person for system area (Weighted average)	Rps	cfm/p	5.0							5.00	ave cfm/p	
12	Percent increase in Vbz over minimum required			0%									
14	**Inputs for Potentially Critical zones**							**Potentially Critical Zones**					
15	Zone Name Show Values per Zone	*Zone title turns purple italic for critical zone(s)*						***Conf Rm***	**Office**	**Break Room**	**Totals/averages**		
16	Zone Tag							**RM 101**	**RM 102**	**New zone ID**			
17	Occupancy Category		Select from pull-down list:					**Conference/ meeting**	**Office space**	**Office space**			
18	Floor Area of zone	*Az*	sf					400	160		560	total sf	
19	Design population of zone	*Pz*	P	(default value listed; may be overridden)				20	2	0	22	total P	
20	Design total supply to zone (primary plus local recirculated)	Vdzd	cfm					750	350		1,100	total cfm	
21	Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A:										
22	Frac. of local recirc. air that is representative of system RA	*Er*									1.00	average	
23	**Inputs for Operating Condition Analyzed**												
24	Percent of total design airflow rate at conditioned analyzed	Ds	%	**May need to manually edit Ds:**			11%	100%	100%	100%	100%	average	
25	Air distribution type at conditioned analyzed		Select from pull-down list:					CS	CS	CS			
26	Zone air distribution effectiveness at conditioned analyzed	*Ez*				Show codes for Ez		1.00	1.00	1.00	1.00	average	Primary airflow rate to zones
27	Primary air fraction of supply air at conditioned analyzed	*Ep*									1.00	average	1100 cfm
34	**Results**												
35	System Ventilation Efficiency	*Ev*					**1.00**						
36	Outdoor air intake required for system	*Vot*	cfm				**711**						
37	Outdoor air per unit floor area	*Vot/As*	cfm/sf				**0.24**						
38	Outdoor air per person served by system (including diversity)	*Vot/Ps*	cfm/p				**2.4**						
39	Outdoor air as a % of design primary supply air	Ypd	%				**7%**						
40													



62MZCALC

Detailed Calculations											
Initial Calculations for the System as a whole											
System primary supply air flow at conditioned analyzed	*Vps*	cfm	=	Vpsd Ds	=	1100					
Uncorrected OA intake flow req'd for system	*Vou*	cfm	=	Rps *Ps* + Ras As	=	1680					
Uncorrected OA req'd as a fraction of primary SA	*Xs*		=	*Vou / Vps*	=	1.53					
Initial Calculations for individual zones											
Area outdoor air rate	Ra	cfm/sf					0.06	0.06	0.06		
People outdoor air rate	Rp	cfm/p					5.00	5.00	5.00		
Total supply air to zone (at condition being analyzed)	*Vdz*	cfm		Vdzd Ds			750	350	0	1100	
Primary airflow to zone (at condition being analyzed)	*Vpz*	cfm	=	*Vdz Ep*	=		750	350	0	1100	
Breathing zone outdoor airflow	*Vbz*	cfm	=	*Rp Pz + Ra Az*	=		124	20	0	144	
Zone outdoor airflow	*Voz*	cfm	=	*Vbz / Ez*	=		124	20	0	144	
Fraction of zone supply not directly recirc. from zone	*Fa*		=	*Ep + (1-Ep) Er*	=		1.00	1.00	1.00		
Fraction of zone supply from fully mixed primary air	*Fb*		=	*Ep*	=		1.00	1.00	1.00		
Fraction of zone OA not directly recirc. from zone	*Fc*		=	*1-(1-Ez)(1-Ep)(1-Er)*	=		1.00	1.00	1.00		
OA fraction required in the supply air to the zone	Zd		=	*Voz / Vdz*	=		0.17	0.06	0.00	0.17	Maximum Zd
OA fraction required in the primary air to the zone	*Zpz*		=	*Voz / Vpz*	=		0.17	0.06	0.00	0.17	Maximum *Zpz*
System Ventilation Efficiency											
Zone Ventilation Efficiency (App A Method)	*Evz*		=	*(Fa+FbXs-FcZpzEp)/Fa*	=		2.36	2.47	2.53		
System Ventilation Efficiency (App A Method)	*Ev*		=	min (*Evz*)	=	**2.36**					
System Ventilation Efficiency (Table 6.3 Method)	*Ev*		=	Value from Table 6.3	=	0.98					
Minimum outdoor air intake airflow											
Outdoor Air Intake Flow required to System	*Vot*	cfm	=	*Vou / Ev*	=	**711**					
OA intake req'd as a fraction of primary SA	Y		=	*Vot / Vps*	=	**0.65**					
Outdoor Air Intake Flow required to System (Table 6.3 Method)	*Vot*	cfm	=	*Vou / Ev*	=	1706					
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		=	*Vot / Vps*	=	1.55					
OA Temp at which Min OA provides all cooling											
OAT below which OA Intake flow is @ minimum		Deg F	=	{(Tp-dTsf)-(1-Y)*(Tr+dTrf)}/Y	=	46					



DYNAMIC RESET

- VRP procedure gives the peak rate based on worst case assumptions (design)
- Reset based on
  - Occupancy: time of day
  - Occupancy sensors
  - Carbon dioxide
  - Air distribution efficiency
  - Multiple space equation solved dynamically
  - Economizer reset of VAV minimums

Dynamic Reset

- Air Distribution Efficiency
  - If min OA determined in heating mode, OA can be reduced during cooling due to a higher Ez
  - Solve equations in appendix A dynamically based on zone and system flows to reset zone minimums and outdoor airflow.
  - OA economizer reset of VAV Box minimum
- Don’t drop below the area outdoor air rate R_a.
- Economically limited to high-density occupancies.

Demand Controlled Ventilation

- CO_2.
  - Time averaging to reduce zone population is not allowed
- Constant Volume with no air flow measurement
  - At CO_2 max, damper positioned to admit Vot design occupancy
  - At ambient CO_2 levels set minimum to admit required air quantity with no occupants Vat
  - Linear reset between CO_2max and CO_2 ambient

Demand Controlled Ventilation

- CO_2 sensor location:
  - In the breathing zone
  - Typically adjacent to the temp sensor
  - 44” AFF
  - Return air sensing doesn’t work
- Sensor type
  - Infrared
  - Accuracy +- 75 PPM

Constant Volume W/O air flow measurement

- Calculate Vot at design occupancy rate
- Calculate Vot with no occupants call it Vat
- Reset min OA damper position from Vat to Vot as CO_2 varies from 400 (ambient) to 800 (calculated or arbitrary setpoint)

- Damper positions set in conjunction with balancer

Constant volume with air flow measurement

- Solve equations A-H dynamically to reset the required min OA qty
- Can't reduce the number of occupants using time averaging
- Can reset zone effectiveness based on supply air temperature

Multiple Zone Systems

- ASHRAE Research 1547TRP is working on it
- “Old” method in 2004 handbook

Learning More

- Read the standard
- 2010 Handbook is available
- ASHRAE ALI courses

Questions