ASHRAE Standard 62
Ventilation Report
Technical Assignment #1

Calvert Memorial Hospital
Prince Frederick, MD

Prepared By: Holly Mawritz
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ASHRAE Standard 62 Ventilation Report
Calvert Memorial Hospital
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Executive Summary

In this report, Calvert Memorial Hospital, located in Prince Frederick, Maryland, will be analyzed using ASHRAE Standard 62-2001, and Addendum *n* of the standard. ASHRAE Standard 62-2001 is used to determine if the building spaces produce the required ventilation rates to zones of diverse use and occupancy. These ventilation requirements are very important in distributing clean air to all of the building spaces. These provisions are even more important when dealing with health care facilities that must contend with waste materials, diseases, odors, and other contaminants.

Calvert Memorial Hospital a 6 floor, 185,000 square foot building contains 14 air handling units, 2 roof top units, and numerous heat pumps. In my evaluation, I will be analyzing 33,683 square feet of building space (2 of the 6 floors) which include 2 of the 14 air-handlers along with a large area of heat pumps. The air handlers cover approximately 13,816 square feet, with the rest of the space being conditioned by heat pumps located in each individual patient room. The two air handling units, Air Handling Unit #3 and Air Handling Unit #4, are rated at 4000 cfm and 11,100 cfm respectively. You will find that in the Air Handling Unit Summary the air handlers meet the requirements of the ASHRAE Standard 62-2001 code. However, the values implemented in the calculations may have discrepancies with the present calculations due to incorrect measurements and/or unclear airflows of air devices.

Assumptions:

- Table 6.1 of ASHRAE Standard 62-2001 Addendum n was used to determine the minimum ventilation rates in the occupant breathing zone. When those values were not sufficient, Table E-1* of Appendix E of the standard was used. The following cfm/ft2 values were not provided, therefore were calculated with the present values:
  - Patient Rooms: ((10 people / 1000 ft^2) x (25 cfm / person)) = 0.25 cfm/ft^2
  - Recovery and ICU: ((20 people / 1000ft^2) x (15 cfm / person)) = 0.3 cfm/ft^2
  - Rooms served by Air Handling Unit #3 & #4 such as the Consult, Work/Nurse Station, and Clean Utility assumed the values of an Office Space.
  - Rooms served by Air Handling Unit #4 such as the Nourishment room and Meds. space assumed values of a Science Laboratory, and the ICU Waiting Rooms will assume values of Booking/Waiting.
- The Zone Air Distribution Effectiveness (E_z) was determined using Table 6.2 of the standard. Ez was chosen to be 1.0 due to a ceiling supply and return air scheme.
- Stairways, elevators, mechanical rooms, and electrical rooms are not included in these calculations.
- Space loads were determined by flow rates (cfm) on drawing sets produced in 1976, therefore there may be discrepancies in the room load values. Proper documentation of these flow rates are to be calculated in further analysis of the building spaces.
- Private toilet rooms are located in the patient rooms and also some of the Intensive Care Unit rooms. These spaces are given small amounts of supply air, but then are exhausted directly to the outdoors; therefore, these rooms have been omitted from the Z_{crit} calculation.
- The patient room heat pumps are only evaluated to see if proper ventilation is allotted to each space. Therefore, the Z_{crit} value was not used in the evaluation.

Procedure:

ASHRAE Standard 62-2001 Addendum n provided the basis of this report by determining whether or not the building spaces met the standard ventilation criteria. The breathing zone outdoor airflow parameter was first discovered by utilizing the zone floor area, zone population, outdoor airflow rate required per person and the outdoor airflow rate required per square foot. Table 6.1, Minimum Ventilation Rates In Breathing Zones, and Appendix E, Table E-1*, Ventilation Rates for Health Care Facilities, provided the appropriate values for the required outdoor airflow per person and per square foot. The occupancies of the spaces were also able to be determined by Table 6.1. ASHRAE requirements for minimum OA (cfm) were determined by the cfm/ft^2 or cfm/person values prescribed from the above-mentioned table. The uncorrected OA values were then calculated. The designed OA values were taken from the drawings and implemented in the table. After these values were summed, the system OA supply was determined. The uncorrected outdoor air fraction of the system, denoted by X, was then calculated by dividing the sum of the OA flow for the system by the total design supply air. The Multiple Spaces Equation is then incorporated to find the Y value which describes the corrected OA fraction of the system. The final results from the calculations were then compared to the design ventilation of the building.

Sample Calculations:

For this sample calculation, I will use data from the Constant Volume Air Handling Unit #3 Calculation:

The critical space of the air-handler was from the Isolation Room on the 3rd floor.

- $Z_{crit} = 0.67$
- Square Footage = 189 ft^2
- Maximum Occupancy = 0.3 people / ft^2
- Maximum No. People = 4 people
- OA / Person = 15 cfm / person
- Diversity = 0.72
- Uncorrected OA = 0.72 x (15cfm / person) x (4 people) = 629 cfm
- Air flow from drawings = 175 cfm

Implementing the Multiple Spaces Equation:

- $Y = X / (1+X-Z)$ where,

  $Y = V_{ot} / V_{st}$ = corrected fraction of outdoor air in system
  $X = V_{on} / V_{st}$ = uncorrected fraction of outdoor air in system supply
  $Z = (V_{oc} / V_{sc})$ = fraction of outdoor air in critical space. The critical space is that space with the greatest required fraction of outdoor air in the supply to this space.

- $Y = (0.22) / (1 + 0.22 – 0.67)$

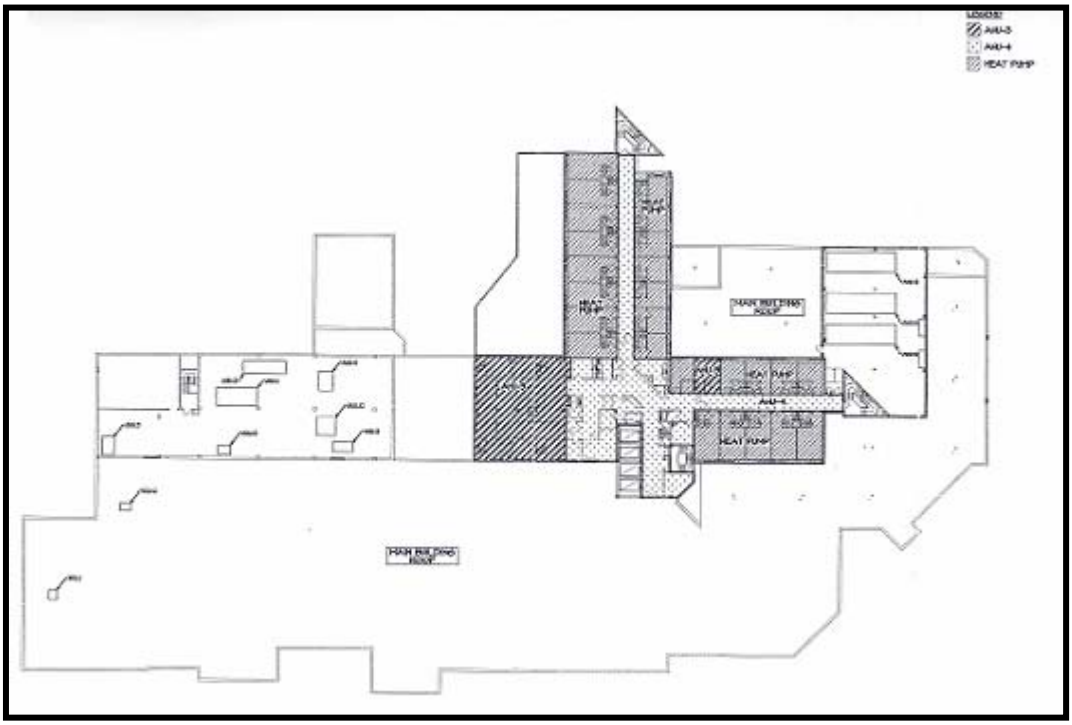
- $Y = 0.43$ ➔ corrected fraction of outdoor air in system

Design OA flow rate = 2910 cfm
ASHRAE Standard 62-2001 Required OA flow rate = 1257 cfm (43% of design OA)
Note: The Air Handler is rated for 4000 cfm.

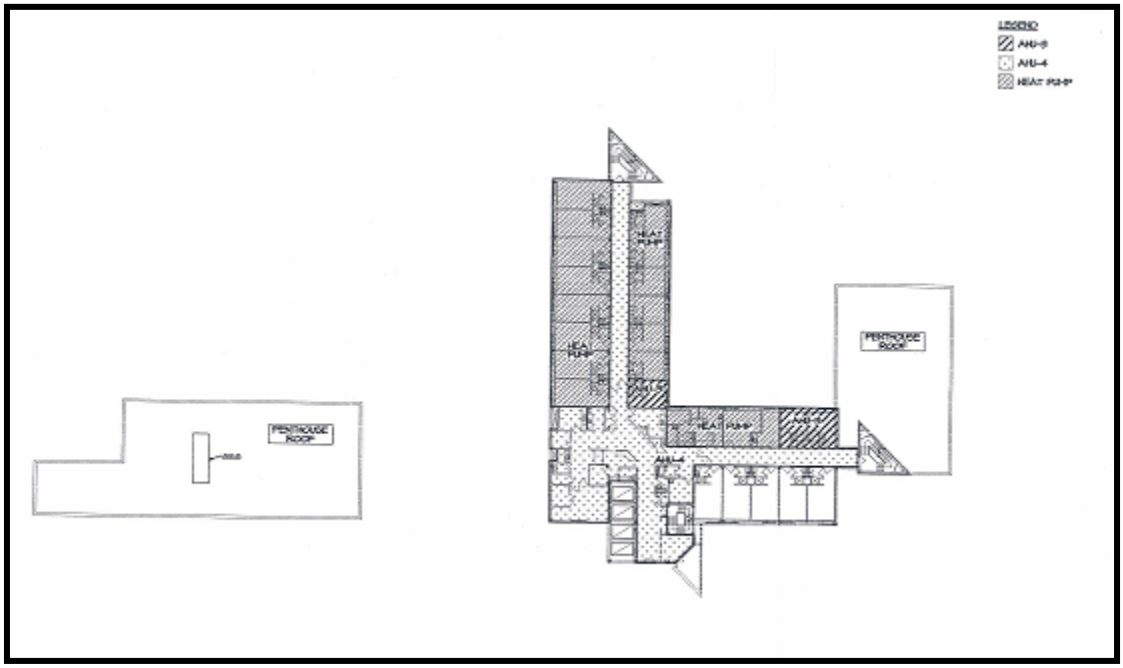
AHU #3 **does satisfy ASHRAE Standard 62-2001!!**
(Values may be slightly skewed due to error in calculations and/or assumptions.)

System and Building Summary:

The air handling units serve the following areas on the following floor plans:



2nd Floor AHU Distribution Plan



3rd Floor AHU Distribution Plan

Air Handling Unit #3 (See Appendix A):

Air Handling Unit #3 **does** comply with the ASHRAE Standard 62-2001 ventilation requirements. Some of the spaces evaluated were multiplied by a diversity factor due to the critical space that was calculated. This critical space, $Z_{crit,}$ was found in the Isolation Room on the 3rd floor with a value of 0.67 which was obtained using a diversity factor of 0.72. The combined air flow rates to the spaces are 2910 cfm. The ventilation required by ASHRAE is 1257 cfm which is only 42% of the OA intake of the system. This shows that the hospital is bringing in more than double the ventilation OA required by the standard. An explanation of this excess OA supply stems from the system being a constant volume system. A constant volume system means that the primary flow to the zone from the air handler is equivalent to the minimum value of the primary airflow to zone from air handler. Due to the air handling unit operating at constant volume and having a rated capacity of 4000 cfm, this unit uses excessive amounts of outside air. This type of operation does not provide for efficient energy operation, although it is more than sufficient for the ASHRAE Standard 61-2001 ventilation requirements. (See Appendix A for tabular calculation.)

Air Handling Unit #4 (See Appendix B):

Air Handling Unit #4 **does** comply with the ASHRAE Standard 62-2001 ventilation requirements. The critical space, Z_{crit} value, was obtained from the Elevator / Waiting area. The critical value was 0.68 with a diversity factor of 0.4. This diversity was then used in other critical spaces served by the air handler. The air flow to the spaces sums to be 4200 cfm. The ventilation required by ASHRAE is 1523 cfm which is 36% of the designed outdoor airflow to the spaces. Along with AHU #3, this system is operating at constant volume. It is rated for 11,100 cfm. It is clear that this air handler is also bringing in more than double the ventilation air required by the standard. Again, this implies the same kind of inefficient energy operations as Air Handing Unit #3.

Heat Pumps (See Appendix C & D):

Approximately one-third of Calvert Memorial Hospital is equipped with heat pumps which are located in each patient room of the hospital on the 2^{nd} – 5^{th} floors. These heat pumps are both concealed ceiling mounted units and exterior wall units. The heat pumps either reject (cooling mode) or collect (heating mode) heat from the central condenser water loop. They reject heat to two cooling towers.

It has been proposed to remove all of the existing heat pumps from the patient rooms. They will be replaced with all overhead variable air volume air handling units serving single air terminal units with reheat coils for individual zone control. This would not only minimize the amount of equipment to be maintained but also provide a more flexible system to be used in the future.

These heat pumps are installed in each room separately. Between the 2^{nd} and 3^{rd} floors, there are 2 kinds of patient rooms. One type of room is 125 square feet and there are 22 rooms of this size and load. The second type of room is 325 square feet in area and there are 26 rooms of this size and load. To discover if the ventilation rates for the two types of patient rooms are efficient, I performed the ASHRAE Standard 62-2001 ventilation calculation procedure. The Z_{crit} value was omitted from the calculation because only the individual space supplied by the heat pump was evaluated for proper ventilation requirements. The 182 square foot rooms were designed for 165 cfm. ASHRAE only required 47% of the outdoor air supplied to the rooms which resulted in 78 cfm. The other rooms that are 325 square feet require a space airflow of 200 cfm each. The required ventilation by ASHRAE was 59% of that value, which is 118 cfm. Therefore, the heat pumps **pass** the ASHRAE Standard 62-2001 for required ventilation.

Appendix A:

Air Handling Unit #3 Table of Values Used in Calculation:

Floor	Space	Space Type	Floor Area (sqft)	Estimated Occupancy (people)	Maximum Occupancy (people/1000sqft)	Maximum Occupancy (people)	Outdoor Air Requirements (cfm/person)	Outdoor Air Requirements (cfm/sqft)	Design Supply (cfm)	Calculated Ventilation (cfm)	Z Critical
2nd	Soiled Utility	Janitor/Trash/Rec	114	0	0	0	0	0	80	0	NA
2nd	ICU #6	Recovery & ICU	126	2	20	3	15	0.3	180	83	0.46
2nd	Toilet	Private Toilet	45	0	0	0	0	0	60	0	NA
2nd	ICU #5	Recovery & ICU	126	2	20	3	15	0.3	180	83	0.46
2nd	Toilet	Private Toilet	45	0	0	0	0	0	60	0	NA
2nd	ICU #4	Recovery & ICU	195	2	20	4	15	0.3	180	83	0.46
2nd	Toilet	Private Toilet	45	0	0	0	0	0	60	0	NA
2nd	ICU #3	Recovery & ICU	195	2	20	4	15	0.3	180	83	0.46
2nd	Toilet	Private Toilet	45	0	0	0	0	0	60	0	NA
2nd	ICU #2	Recovery & ICU	126	2	20	3	15	0.3	180	83	0.46
2nd	Toilet	Private Toilet	45	0	0	0	0	0	60	0	NA
2nd	ICU Isolation	Recovery & ICU	189	2	20	4	15	0.3	180	117	0.65
2nd	Toilet	Private Toilet	45	0	0	0	0	0	60	0	NA
2nd	Consult	Office Space	95	3	2	1	5	0.06	125	11	0.09
2nd	Work/Nurse	Office Space	637	4	2	2	5	0.06	800	59	0.07
2nd	Clean Utility	Office Space	179	0	2	1	5	0.06	230	16	0.07
3rd	ICU Isolation	Recovery & ICU	189	2	20	4	15	0.3	175	117	0.67
3rd	Toilet	Private Toilet	45	0	0	0	0	0	60	0	NA
	Totals:		2486	21		29			2910	735	

Air Handling Unit #3 Calculation Table:

ZONE LEVEL		Soiled Utility	ICU #6	ICU Toilet	ICU #5	ICU Toilet	ICU #4	ICU Toilet	ICU #3
	Zones served by system	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
	Space type (select from pull-down list)								
Az	Floor area of zone, ft2	114	126	45	126	45	126	45	126
Pz	Zone population, largest # of people expected to occupy zone	0	3	0	3	0	3	0	3
Ra	Area outdoor air rate from Table 6.1, cfm/ft2	0	0.3	0	0.3	0	0.3	0	0.3
Rp	People outdoor air rate from Table 6.1, cfm/person	0	15	0	15	0	15	0	15
Pz*Rp		0	45	0	45	0	45	0	45
Az*Ra		0	37.8	0	37.8	0	37.8	0	37.8
Ez	Zone air distribution effectiveness, Table 6.2	1	1	1	1	1	1	1	1
Voz	Outdoor airflow to the zone corrected for zone air distribution effectiveness, (Pz*Rp + Az*Ra)/Ez, cfm	0	83	0	83	0	83	0	83
Vpz	Primary airflow to zone from air handler. In VAV systems, use the design value. cfm	80	180	60	180	60	180	60	180
Vpzm	The minimum value of the primary airflow to zone from air handler. In CAV systems, Vpzm = Vpz.cfm	80	180	60	180	60	180	60	180
Zp	Primary outdoor air fraction, Voz/Vpzm	0.00	0.46	0.00	0.46	0.00	0.46	0.00	0.46
SYSTEM LEVEL									
Ps	System population, maximum simultaneious # of occupants of space served by system	21							
D	Occupant diversity, ratio of system peak occupancy to sum of space peak occupancies, = Ps/ΣPz	0.72							
Vou	Uncorrected outdoor air intake, = D*ΣRp*Pz +ΣRa*Az,	629							
Xs	Mixing ratio at primary air handler of uncorrected outdoor air intake to system primary flow, = Vou/Vps	0.22	Not used in calculation						
SYSTEM EFFICIENCY									
Max Zp	Max Zp	0.67							
Ev	System ventilation efficiency, Table 6.3 based on maxZp	0.50							
				Percent outdoor air intake					
Vot	Minimum outdoor air intake, Vou/Ev, cfm	1257		48%	= Vot/Sum of Vpz				

Appendix A (Cont'd):

ICU Toilet	ICU #2	ICU Toilet	ICU Isol	ICU Toilet	Consult	Work/Nurs	Clean Util	Isolation-3rd	Toilet
Zone 9	Zone 10	Zone 11	Zone 12	Zone 13	Zone 14	Zone 15	Zone 16	Zone 17	Zone 18
					Office spac	Office spac	Office space		
45	126	45	189	45	95	637	179	189	45
0	3	0	4	0	1	4	1	4	0
0	0.3	0	0.3	0	0.06	0.06	0.06	0.3	0
0	15	0	15	0	5	5	5	15	0
0	45	0	60	0	5	20	5	60	0
0	37.8	0	56.7	0	5.7	38.22	10.74	56.7	0
1	1	1	1	1	1	1	1	1	1
0	83	0	117	0	10.7	58.22	15.74	117	0
60	180	60	180	60	125	800	230	175	60
60	180	60	180	60	125	800	230	175	60
0.00	0.46	0.00	0.65	0.00	0.09	0.07	0.07	0.67	0.00

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Appendix B:

Air Handling Unit #4 Table of Values Used in Calculation:

Floor	Space	Space Type	Floor Area (sqft)	Estimated Occupancy (people)	Maximum Occupancy (people/1000sqft)	Maximum Occupancy (people)	Outdoor Air Requirements (cfm/person)	Outdoor Air Requirements (cfm/sqft)	Design Supply (cfm)	Calculated Ventilation (cfm)	Z Critical
2nd	Corridor	Corridor	2286	0	0	0	0.06	0.06	800	137	0.17
2nd	Clean Utility	Office Space	132	0	5	1	0.06	5	230	14	0.06
2nd	ICU Waiting	Booking/Waiting	83	4	50	4	0.06	7.5	120	42	0.35
2nd	Elevator Lobby	Lobbies	223	5	50	12	0.06	5	150	38	0.26
2nd	Nurse Office	Office Space	81	2	5	1	0.06	5	160	10	0.06
2nd	Treatment	Office Space	132	2	10	2	0.25	25	210	83	0.40
2nd	Nourishment	Science Laborator	75	1	25	2	0.18	10	60	24	0.39
2nd	Nurse Station	Office Space	130	3	5	1	0.06	5	100	23	0.23
2nd	Meds.	Science Laborator	52	0	25	2	0.18	10	70	20	0.28
2nd	Elevator/Waiting	Lobbies	424	2	50	22	0.06	5	200	76	0.36
3rd	Corridor	Corridor	2286	0	0	0	0.06	0.06	800	137	0.17
3rd	Clean Utility	Office Space	132	0	5	1	0.06	5	230	14	0.06
3rd	ICU Waiting	Booking/Waiting	83	4	50	5	0.06	7.5	120	42	0.35
3rd	Elevator Lobby	Lobbies	223	5	50	12	0.06	5	150	38	0.26
3rd	Nurse Office	Office Space	81	2	5	1	0.06	5	160	10	0.06
3rd	Treatment	Office Space	132	2	10	2	0.25	25	210	83	0.40
3rd	Nourishment	Science Laborator	75	1	25	2	0.18	10	60	24	0.39
3rd	Nurse Station	Office Space	130	3	5	1	0.06	5	100	23	0.23
3rd	Meds.	Science Laborator	52	0	25	2	0.18	10	70	20	0.28
3rd	Elevator/Waiting	Lobbies	424	2	50	22	0.06	5	200	76	0.36
	Totals		7236	38		95			4200	934	

Air Handling Unit #4 Calculation Table:

ZONE LEVEL		Corridor-2	Clean Utility-2	ICU Waiting-2	Elev. Lobby-2	Nurse Office-2	Treatment-2	Nourishment-2	Nurse Station-2	Meds.-2	Elevator/ W
	Zones served by system	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone '
	Space type (select from pull-down list)	Corridors	Office space	Booking/waiting	Lobbies	Office space	Office space	Science laborato	Office space	Science la	Lobbies
Az	Floor area of zone, ft2	2286	132	83	223	81	132	75	130	52	
Pz	Zone population, largest # of people expected to occupy zone	0	1	4	12	1	2	2	1	2	
Rp	People outdoor air rate from Table 6.1, cfm/person	0	5	7.5	5	5	25	10	5	10	
Ra	Area outdoor air rate from Table 6.1, cfm/ft2	0.06	0.06	0.06	0.06	0.06	0.25	0.18	0.06	0.18	
Pz*Rp		0	5	30	60	5	50	20	5	20	
Az*Ra		137.16	7.92	4.98	13.38	4.86	33	13.5	7.8	9.36	
Ez	Zone air distribution effectiveness, Table 6.2	1	1	1	1	1	1	1	1	1	
Voz	Outdoor airflow to the zone corrected for zone air distribution effectiveness, (Pz*Rp + Az*Ra)/Ez, cfm	137	13	35	73	9.86	83	33.5	12.8	29.36	
Vpz	Primary airflow to zone from air handler. In VAV systems, use the design value. cfm	800	230	120	150	160	210	60	100	70	
Vpzm	The minimum value of the primary airflow to zone from air handler. In CAV systems, Vpzm = Vpz. cfm	800	230	120	150	160	210	60	100	70	
Zp	Primary outdoor air fraction, Voz/Vpzm	0.17	0.06	0.29	0.49	0.06	0.40	0.56	0.13	0.42	
SYSTEM LEVEL											
Ps	System population, maximum simultaneous # of occupants of space served by system	38									
D	Occupant diversity, ratio of system peak occupancy to sum of space peak occupancies, = Ps/ΣPz	0.40									
Vou	Uncorrected outdoor air intake, = D*ΣRp*Pz +ΣRa*Az,	761									
Xs	Mixing ratio at primary air handler of uncorrected outdoor air intake to system primary flow, = Vou/Vps	0.18	Not used in calculation								
SYSTEM EFFICIENCY											
Max Zp	Max Zp	0.68									
Ev	System ventilation efficiency, Table 6.3 based on maxZp	0.50									
				Percent outdoor air intake							
Vot	Minimum outdoor air intake, Vou/Ev, cfm	1523		38%	= Vot/Sum of Vpz						

Appendix C:

Heat Pump Values (Patient Rooms of 125 ft^2) for Calculation:

Floor	Space	Space Type	Floor Area (sqft)	Estimated Occupancy (people)	Maximum Occupancy (people/1000sqft)	Maximum Occupancy (people)	Outdoor Air Requirements (cfm/person)	Outdoor Air Requirements (cfm/sqft)	Design Supply (cfm)	Calculated Ventilation (cfm)	Z Critical
2nd & 3rd	Patient Room	Patient Room	125	1	10	1	25	0.25	165	78	NA
	Totals:		125	1		1			165	78	

Heat Pump (Patient Rooms of 125 ft^2) Calculation Table:

ZONE LEVEL		Patient Room			
	Zones served by system	Zone 1			
	Space type (select from pull-down list)				
Az	Floor area of zone, ft2	182			
Pz	Zone population, largest # of people expected to occupy zone	1			
Ra	Area outdoor air rate from Table 6.1, cfm/ft2	0.25			
Rp	People outdoor air rate from Table 6.1, cfm/person	25			
Pz*Rp		25			
Az*Ra		45.5			
Ez	Zone air distribution effectiveness, Table 6.2	1			
Voz	Outdoor airflow to the zone corrected for zone air distribution effectiveness, (Pz*Rp + Az*Ra)/Ez, cfm	71			
Vpz	Primary airflow to zone from air handler. In VAV systems, use the design value. cfm	165			
Vpzm	The minimum value of the primary airflow to zone from air handler. In CAV systems, Vpzm = Vpz. cfm	165			
Zp	Primary outdoor air fraction, Voz/Vpzm	0.00			
SYSTEM LEVEL					
Ps	System population, maximum simultaneous # of occupants of space served by system	1			
D	Occupant diversity, ratio of system peak occupancy to sum of space peak occupancies, = Ps/ΣPz	1.00			
Vou	Uncorrected outdoor air intake, = D*ΣRp*Pz +ΣRa*Az,	71			
Xs	Mixing ratio at primary air handler of uncorrected outdoor air intake to system primary flow, = Vou/Vps	0.43	Not used in calculation		
SYSTEM EFFICIENCY					
Max Zp	Max Zp	0.00			
Ev	System ventilation efficiency, Table 6.3 based on maxZp	0.90			
				Percent outdoor air intake	
Vot	Minimum outdoor air intake, Vou/Ev, cfm	78		47%	= Vot/Sum of Vpz

Appendix D:

Heat Pump Values (Patient Rooms of 325 ft^2) for Calculation:

Floor	Space	Space Type	Floor Area (sqft)	Estimated Occupancy (people)	Maximum Occupancy (people/1000sqft)	Maximum Occupancy (people)	Outdoor Air Requirements (cfm/person)	Outdoor Air Requirements (cfm/sqft)	Design Supply (cfm)	Calculated Ventilation (cfm)	Z Critical
2nd & 3rd	Patient Room	Patient Room	325	1	10	1	25	0.25	200	118	NA
	Totals:		325	1		1			200	118	

Heat Pump (Patient Rooms of 325 ft^2) Calculation Table:

ZONE LEVEL		Patient Room			
	Zones served by system	Zone 1			
	Space type (select from pull-down list)				
Az	Floor area of zone, ft2	325			
Pz	Zone population, largest # of people expected to occupy zone	1			
Ra	Area outdoor air rate from Table 6.1, cfm/ft2	0.25			
Rp	People outdoor air rate from Table 6.1, cfm/person	25			
Pz*Rp		25			
Az*Ra		81.25			
Ez	Zone air distribution effectiveness, Table 6.2	1			
Voz	Outdoor airflow to the zone corrected for zone air distribution effectiveness, (Pz*Rp + Az*Ra)/Ez, cfm	106			
Vpz	Primary airflow to zone from air handler. In VAV systems, use the design value. cfm	200			
Vpzm	The minimum value of the primary airflow to zone from air handler. In CAV systems, Vpzm = Vpz. cfm	200			
Zp	Primary outdoor air fraction, Voz/Vpzm	0.00			
SYSTEM LEVEL					
Ps	System population, maximum simultaneous # of occupants of space served by system	1			
D	Occupant diversity, ratio of system peak occupancy to sum of space peak occupancies, = Ps/ΣPz	1.00			
Vou	Uncorrected outdoor air intake, = D*ΣRp*Pz +ΣRa*Az,	106			
Xs	Mixing ratio at primary air handler of uncorrected outdoor air intake to system primary flow, = Vou/Vps	0.53	Not used in calculation		
SYSTEM EFFICIENCY					
Max Zp	Max Zp	0.00			
Ev	System ventilation efficiency, Table 6.3 based on maxZp	0.90			
				Percent outdoor air intake	
Vot	Minimum outdoor air intake, Vou/Ev, cfm	118		68%	= Vot/Sum of Vpz

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