Technical Report 1

ASHRAE Standard 62.1 Ventilation &
ASHRAE Standard 90.1 Energy Design Evaluations

EMD Serono Research Center - existing | Billerica, MA



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Executive Summary

The purpose of this report is to determine if the EMD Serono Research Center – existing building is in compliance with ASHRAE Standard 62.1-2007 and ASHRAE Standard 90.1-2007.

The EMD Serono Research Center – existing building is located in Billerica, MA. The building program contains management office, research and development laboratories, and vivarium rooms. Designed in 1999 and constructed in 2000, this building's HVAC design follows ASHRAE Standard 62.1 -1989 and ASHRAE Standard 90.1-1898.

The ASHRAE Standard 62.1-2007 analysis showed that the EMD Serono Research Center – existing building is entirely compliant with the requirement from section 5 and 6. This building was designed to prevent mold growth, prevent re-entry of contaminated air, and provide high quality indoor air to its occupants. Results of the ventilation rate requirement analysis in section 6 showed that the building's HVAC design goes beyond the ventilation requirement for all occupied spaces. With different air handling units for different types of space and with high efficiency filter, the HVAC design ensures contaminated air does not recirculate and transfer inside the building.

The ASHRAE Standard 90.1 analysis showed that this building is largely compliant with the standard. The only two areas that do not meet the requirement are building envelope and fan power limitation. However, none of the inadequacies are extremely large in terms of compliance and a few changes could be made for this building to meet the requirement for Standard 90.1

It was determined that the EMD Serono Research Center –existing building is entirely compliant with ASHRAE Standard 62.1-2007 and largely compliant with ASHRAE Standard 90.1-2007. The mechanical system design of the building provides excellent control over contaminated air and gives the building occupants healthy indoor air quality.

Building Summary

EMD Serono Research Center – existing lab building was constructed as the research and development building. This building has 2 stories, a basement, and a penthouse, with gross area of 56,700 square foot. The building program contains management office, research and development laboratories, and vivarium rooms. Mechanical rooms are located on the basement floor and in the penthouse. Vivarium facilities, research lab rooms, support rooms are located on both the 1st and 2nd floor.

Mechanical System Description

The building receives conditioned supply air from 3 air handling units (AHU). AHU-1 is located in the penthouse and supplies a total of 45,000 cfm conditioned outside air to research and development laboratory spaces in the building. The occupied spaces of the basement and administration offices on 1st and 2nd floor are conditioned by AHU-2 in the penthouse with 19,000 cfm total. The mechanical room in the basement and the vivarium rooms on the 1st floor are conditioned by AHU-3 which is located in the basement and supplies a total of 5,000 cfm.

One 350 ton centrifugal chiller is located in the basement. Two steam boilers and a boiler feed water pump is located in the penthouse. A 350 ton cooling tower and a 60 ton air cooled chiller are located on the roof adjacent to the penthouse.

ASHRAE Standard 62.1 – 2007

Section 5 Analysis

5.1 Natural Ventilation

The building utilizes mechanical ventilation system therefore section 5.1 natural ventilation does not apply

5.2 Ventilation Air Distribution

All spaces meet ventilation requirement. The variable air volume systems can be adjusted to meet and minimum ventilation air requirement.

5.3 Exhaust Duct Location

Exhaust ducts that convey potential harmful contaminants are negatively pressurized relative to space through which they pass. Therefore, meet 5.3 requirements.

5.4 Ventilation System Controls

The building has been designed to be controlled by a Direct Digital Control (DDC) system. The DDC system enables the fan system to operate whenever the spaces served are occupied. The system designed to maintain the minimum outdoor airflow as required by Section 6.

5.5 Airstream Surfaces

All ducts and fittings have sheet metal surfaces. Therefore, meet the requirement of section 5.5.

5.6 Outdoor Air Intakes

There are 2 outdoor air intakes. One outdoor air intake is located on the ground floor for AHU-3. Another outdoor air intake is located on the penthouse level for AHU-1 and

AHU-2. Despite the location of a cooling tower and several exhaust fans are on the penthouse level, outdoor air intakes comply with the minimum separation distances specified in Table 5-1 Air Intake Minimum Separation Distance from section 5.6.

5.7 Local Capture of Contaminants

All contaminants that are generated from the laboratory and vivarium spaces are ducted directly to exhaust fans on the roof.

5.8 Combustion

All combustion processes are provided with sufficient amounts of air. The emergency generator is enclosed in weather enclosure on the roof adjacent to the penthouse.

5.9 Particulate Matter Removal

The prefilters for AHUs have an average efficiency of 30% which is equate to a Minimum Efficiency Reporting Value (MERV) of approximately 7. Filters of AHU-1 and AHU-2 have average efficiency of 90% to 95%; filter for AHU-2 has minimum efficiency of 99.97%, which exceeds the requirements of section 5.9.

5.10 Dehumidification Systems

The building's general areas are designed to maintain a relative humidity of less than 55%, which meets the 65% relative humidity limit requirement. For humidity animal spaces, 70-40% relative humidity is designed in the winter and 58-35% relative humidity is designed for the summer. Humidity animal spaces are exempt from this section.

5.11 Drain Pans

Drains are provided from air handling units, air intake and other intake and exhaust plenums with traps. Traps have minimum size of 4", unless the static pressure requires additional trap depth. Drains discharge to nearest floor drain, janitor sink, roof or outdoor.

5.12 Finned Tube Coils and Heat Exchangers

The minimum distance between coils is 18 inches which complies with the requirements for section 5.12.

5.13 Humidifiers and Water-Spray Systems

Humidification is done with low pressure steam (10psig) from the steam boiler. Steam is filtered by softeners and brine filtration before deliver to the humidifier.

5.14 Access for Inspection, Cleaning, and Maintenance

Access doors are provided downstream of humidifier for visual verification of humidifier. No mechanical coupling is used in inaccessible location without access doors. Access door are 24” x24” in general and a minimum of 10”x18”. Access doors are sized to suit the access requirement to service the equipment and located individually.

5.15 Building Envelope and Interior Surfaces

The building envelope construction included vapor barrier to prevent water penetration into the building. Interior surfaces of pipes and ductwork are insulated to maintain a temperature close to the supply temperature, also prevent condensation on the surfaces.

5.16 Buildings with Attached Parking Garages

There is no attached parking garage for this project. Therefore, this section does not apply.

5.17 Air Classification and Recirculation

Return air from general office are classified as Air Class 1. Some of the Air Class 1 air is recirculated. The exhaust air from laboratories, tissue culture rooms, office area within the lab zone, vivarium area, cagewash, soiled holding area, and clean storage area are

classified as Air Class 2 to 4. None of the air from those rooms is recirculated, instead, 100% outside air supply and 100% exhaust air are utilized in those rooms.

5.18 Requirements for Buildings Containing ETS Areas and ETS-Free Areas

EMD Serono Research Center- existing lab building is a non-smoking facility, ETS – Free. Therefore, section 5.18 does not apply to this building.

Section 6 Analysis

Introduction

There are 3 air handling units (AHU) in this building. AHU-1 serves the research and development areas. AHU-2 serves the general non-lab related area such as lunch room, office, and conference room. AHU-3 serves the vivarium areas.

AHU-1 is variable air volume type with 100% outside air .AHU-3 is constant volume type with 100% outside air and 80% standby capacity. All lab areas and vivarium areas are 100% exhausted. The amount of air flow (cfm) is determined by the ventilation requirement and the thermal load requirement. When assuming thermal load dominates the quantity of supply air, AHU-1 and AHU-3 meet the ventilation requirement by ASHRAE section 6. Therefore, those units will not be analyzed for section 6.

AHU-2 is variable air volume type with return air fans recirculate office air back to the unit. It is selected for analysis due to this reason.

6.2 Ventilation Rate Procedure

Breathing Zone Outdoor Airflow (V_{bz}):

$$V_{bz} = R_p \times P_z + R_a \times A_z \quad \text{(Eq. 6-1)}$$

A_z: zone floor area: the net occupiable floor area of the zone (ft^2)

P_z: zone population: the largest number of people expected to occupy the zone during typical usage.

R_p: outdoor airflow rate required per person as determined from Table 6-1 (cfm/person)

R_a: outdoor airflow rate required per unit area as determined from Table 6-1 (cfm/ft^2)

Zone Air Distribution Effectiveness (E_z)

The spaces served by AHU 2 fit into the category of “ceiling supply of cool air” defined in Table 6-2 Zone Air Distribution Effectiveness. Therefore, for the purpose of these calculations, $E_z = 1$

Zone Outdoor Airflow (V_{oz})

The zone outdoor airflow is calculated using Equation 6-2 from the ASHRAE Standard which is shown below.

$$V_{oz} = V_{bz} / E_z \quad \text{(Eq. 6-2)}$$

With Ez = 1 Equation 6-2 is reduced to:

$$V_{oz} = V_{bz} \quad \text{(Eq. 6-5)}$$

Primary Outdoor Air Fraction:

$$Z_p = V_{oz}/V_{pz} \quad \text{(Eq. 6-5)}$$

Uncorrected Outdoor Air Intake:

$$V_{ou} = D\Sigma_{\text{all zones}} (R_p \times P_z) + \Sigma_{\text{all zones}} (R_a \times A_z) \quad \text{(Eq. 6-6)}$$

Where:

$D = P_s/\Sigma_{\text{all zones}} P_z$ (Eq. 6-7)

P_s = system population, total population in the area served by the system

Outdoor Air Intake:

$$V_{ot} = V_{ou}/E_v \quad \text{(Eq. 6-8)}$$

ASHRAE Standard 62.1 Findings

EMD Serono Research Center - existing AHU-2				
RESULTS				
	V_{tot}	Actual total supply air, cfm	15,500	
			Min, calculated	Actual
	V_{ot}	Outdoor air intake, V_{ou}/E_v, cfm	4,954	6,500
		Percent outdoor air intake, V_{ot}/V_{ps}	32.0%	41.9%

Table-1 AHU-2 system

From the ASHRAE 62.1 spreadsheet found in Appendix A, it can be seen that AHU-2 is in compliant with ASHRAE Standard 62.1 Section 6. AHU-2 serves occupied areas in the basement level, office, lobby, and reception areas in both level 1 and level 2. AHU-2 supplies 15,500 cfm supply air, 6,500 cfm of which are outside air. That led to 41.9% outdoor air to those areas, which exceed ASHRAE Standard 62.1. As shown in the Appendix A, rooms that served by AHU-2 exceeds ASHRAE ventilation requirement by an average of 162%.

EMD Serono Research Center – existing building is a research and development building. Used air from the lab and vivarium areas is highly contaminated. Having high ventilation rate for other general areas ensures contaminated air will purge out of the building in a timely manner in the case of air leakage. Therefore, improves indoor air quality in the building.

ASHRAE Standard 62.1 Conclusion

The EMD Serono Research Center – existing building is entirely compliant with ASHRAE Standard 62.1 -2007 Section 5 and 6.

By having 100% outside air and 100% exhausted air for both development and research area and vivarium area, contaminants will not be recalculated inside the building. And by having separate systems for general non-lab area, research and development areas, and vivarium areas, contaminated air will not be transferred to different part of the building. Filters with efficiency range from 90% to 99.97% are used in this building, which further improves the indoor air quality of this building.

The HVAC design of this building goes beyond the ventilation requirement in section 5. This means the designer has given a great effort on providing healthy indoor air quality to the occupants in the building.

ASHRAE Standard 90.1 – 2007

Introduction

The purpose of ASHRAE 90.1 is to provide minimum requirements for energy-efficient design of buildings.

Section 5 – Building Envelope

5.1.4 Climate Zone

The project is located at Billerica, Massachusetts. The climate zone of the project was determined to be Zone 5.

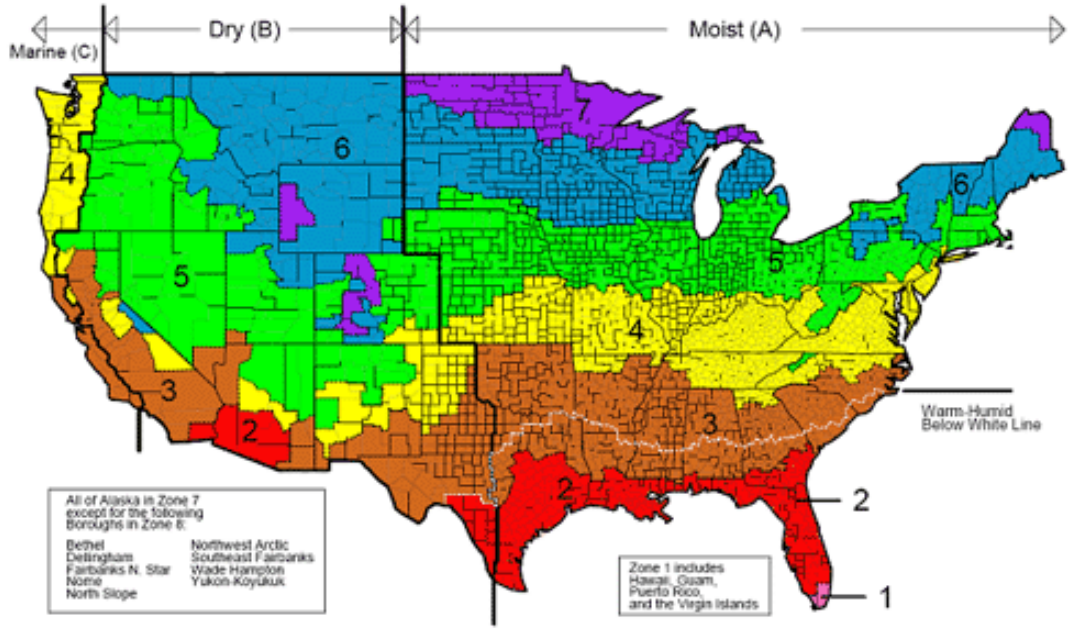

Figure 90.1- 5.1.4

5.2 Compliance Path

There are two compliance paths: prescriptive building envelope option and building envelop trade-off option. Prescriptive building envelope option was used for this analysis.

5.5 Prescriptive Building Envelope Option

Table-2 shows the calculation for fenestration percentage.

Fenestration Area				
Façade	**Gross Wall (sf)**	**Glass (sf)**	**Fenestration %**	**Complies**
East	6565	2542	38.7	**Yes**
South	10927	4082	37.4	**Yes**
West	4695	910	19.4	**Yes**
North	4274	2288	53.5	**No**
Total	26461	9822	37.1	**Yes**

Table-2 Fenestration Area

Section 5.5 stated that the fenestration area shall not exceed 40% of the gross wall area. As shown in Table-2, the overall building envelope has 37.1% fenestration area which complies with section 5.5.

Building Envelope Requirement				
Elements	**Description**	**Min R-Value**	**Building R-Value**	**Complies**
Roof	Insulation Above Deck	20	13.66	**No**
Wall, Above-Grade	Mass	11.4	12.4	**Yes**
Wall, Below-Grade	Mass	7.5	12.4	**Yes**
Floors	Mass	10.4	N/A	**N/A**
Slab on Grade	Unheated	NR	1.2	**NR**

Table-3 Building Envelope Requirement

Roof construction: 3” galvanized steel deck with 3” rigid insulation and roof membrane
Wall construction: 4” face brick, 2” air space, 2 ½” rigid insulation and ½” GWB sheathing.
Slab on Grade construction: 6” concrete slab

For the building envelope prescriptive approach, roof insulation does not compliant with requirement. Minimum R-value for slab-on-grade floors is not listed on Table 5.5-1 Building Envelope Requirement For Climate Zone 5 (A, B, C)* from section 5.5.

Section 6 – Heating Ventilating and Air Conditioning

6.2 Compliance Path

There are two compliance paths: Simplified Approach and Prescriptive Path in Mandatory Provisions.

In order to qualify for the Simplified Approach, the building needs to be two stories or fewer in height and with gross floor area less than 25,000 sf. The EMD Serono Research Center – existing building has a gross floor area of 56,700 sf, which does not qualify for the Simplified Approach. Therefore, Prescriptive path was used to analyze this building.

6.5 Prescriptive Path

The EMD Serono Research Center – existing building has a combination of variable air volume and constant air volume system. When checking fan power with ASHRAE Fan Power Limitation, the maximum design supply airflow rate to conditioned spaces served by the system was used.

Calculate the Allowable Horsepower for constant air volume:

$$\text{Allowable Horsepower} = \text{CFM} \times 0.0011$$

Calculate the Allowable Horsepower for variable air volume:

$$\text{Allowable Horsepower} = \text{CFM} \times 0.0015$$

In order to be compliant with ASHRAE Fan Power Limitation, the Allowable Horsepower needs to be greater than the Nameplate Motor Horsepower. The results for compliance are shown in the following page in Table-4.

Fan Power Limitation					
Unit	**Type**	**CFM**	**Allowable HP**	**Nameplate HP**	**Compliant**
AHU-1	VAV	45,000	67 ½	75 VSD	**No**
AHU-2	VAV	15,000	22 ½	25VSD	**No**
AHU-3	CAV	70,000	77	15	**Yes**
EX-1	VAV	20,000	30	25VSD	**Yes**
EX-2	VAV	20,000	30	25VSD	**Yes**
EX-3	CAV	7,000	7 5/7	7½	**Yes**
EX-4	CAV	1,000	1 1/9	1	**Yes**
EX-5	CAV	750	5/6	½	**Yes**
EX-6	CAV	800	7/8	½	**Yes**
HVU-1	CAV	3,000	3 1/3	5	**No**
HVU-2	CAV	1,000	1 1/9	3	**No**

Table-4 Fan Power Limitation

As shown in Table-4 most of the units compliant with ASHRAE Fan Power Limitation

6.8 Minimum Equipment Efficiency Tables

Chiller Minimum Efficiency Requirement Compliance					
Unit	**Description**	**KW/Ton**	**COP**	**COP requirement**	**Compliant**
ACCH-1	Air Cooled Chiller	1.24	2.84	2.80	**Yes**
CH-1	Centrifugal Chiller	0.56	6.28	6.02	**Yes**

Table-5 Fan Power Limitation

Cooling Tower Minimum Performance Requirement Compliance				
Unit	**Description**	**GPM/HP**	**Performance Required (GPM/HP)**	**Compliant**
CT-1	Cooling Tower	21	≥20.0	**Yes**

Table-6 Fan Power Limitation

Boiler Minimum Efficiency Requirement Compliance				
Unit	**Description**	**Efficiency**	**Minimum Efficiency Requirement**	**Compliant**
B-1	Steam Boiler	81%	75%	**Yes**
B-2	Steam Boiler	81%	75%	**Yes**

Table-7 Fan Power Limitation

All the chillers, boilers, and cooling tower meet the minimum efficiency required by section 6.8, see Table 4,5,6,7.

The Air Cooled Chiller is 60 ton and the centrifugal chiller is 350 ton. The cooling tower has a centrifugal fan with 1050 GPM at 50 BHP. Both boilers are gas-fired steam boiler: Boiler 1 has 175 boiler HP, boiler 2 has 50 boiler HP.

Section 7 – Service Water Heating

EMD Serono Research Center- existing building utilizes two gas-fired boilers that operated at a minimum fuel-to-water efficiency of 81%, which complies with the requirements of section7.

Section 8 – Power

Where circuits for power and lighting exceed 60'-0" for 120 volt circuits or 120'-0" for 277 volt circuits to the center of the load, #10 AWG wire or larger, circuit conductors are sized for a maximum 3% voltage drop at full circuit capacity. Therefore, meet section 8 requirement.

Section 9 – Lighting

There are two methods to calculate interior lighting power allowance: Lighting Power Densities Using the Building Area Method and Lighting Power Densities Using the Space-by-Space Method. Due to information availability, Lighting Power Densities Using the Building Area Method was used in this calculation.

Lighting Power Densities Using Building Area Method				
Building Area Type	**Building SF**	**W/ft^2**	**LPD (W/ft^2)**	**Compliant**
Pharmaceutical Research Development Lab	58,800	2	N/A	N/A

The EMD Serono Research Center-existing building is a pharmaceutical research and development lab building. The Table9.5.1 Lighting power Densities Using the Building Area Method listed in ASHRAE Standard 90.1 does not have building area type that are suitable for the this building. The closest LPD value for this type of area is Laboratory Space and Detailed Manufacturing Space under Table 9.6.1 Lighting Power Densities Using the Space-by-Space Method from ASHRAE Standard 90.1. The LPD value for laboratory space is 1.4W/ft^2 and 2.1 W/ft^2 for detailed manufacturing space. The lighting

density of this building is within the range of those LPD values and can therefore be considered acceptable.

ASHRAE Standard 90.1 Conclusion

The majority of the systems in the EMD Serono Research Center – existing building are in compliant with ASHRAE Standard 90.1-2007. The reasons for non-compliance are most likely due to the timeframe of the system design. The EMD Serono Research Center – existing building was designed in 1999 and its design follows ASHRAE Standard 90.1 – 1989, which has different requirements than ASHRAE standard 90.1 – 2007.

The methods that were used to determine the compliance of ASHRAE Standard 90.1-2007 are prescriptive path evaluation. This building largely complied with the requirements for Standard 90.1-2007. The two areas that did not meet the requirement are roof insulation from building envelope section and a few units from the fan power limitation section. However, none of the inadequacies are extremely large in terms of compliance and a few changes could be made for this building to meet the requirement for ASHRAE Standard 90.1-2007.

References

ASHRAE Standard 62.1 – 2007

ASHRAE Standard 90.1 – 2007

ASHRAE Handbook of Fundamentals

ASHRAE Handbook of HVAC Systems and Equipment

Appendix A

Following is the calculation for the outdoor airflow requirements of ASHRAE Standard 60.1-2007 section 6. (Both full table and simplified table are provided)

Full Table

EMD Serono Research Center - existing

AHU-2

RESULTS

V_{ot}	Actual total supply air, cfm	15,500	
		Min. calculated	Actual
V_{ot}	Outdoor air intake, V_{ot}/E_v, cfm	4,954	6,500
	Percent outdoor air intake, V_{ot}/V_{ot}	32.0%	41.9%
E_v	System ventilation efficiency	0.50	

65.0%

64.5%

ZONE LEVEL

Zones served by system	Room#	Room Name	Space type (select from pull-down list)	A_z	P_z	$V_{pz,max}$	V_{oz}	R_p	R_a	P_z*R_p	A_z*R_a	E_v	V_{oz}	Z_p	Design OA	
				Floor area of zone, ft²	Zone population, largest # of people expected to occupy zone	Maximum primary airflow to zone from air handler. In VAV systems, use the design value. cfm	The minimum value of the primary airflow to zone from air handler. In CAV systems, $V_{oz} = V_{pz,max}$. cfm	People outdoor air rate from Table 6.1, cfm/person	Area outdoor air rate from Table 6.1, cfm/ft²	Zone people OA calc (based on # of people)	Zone area OA calc (based on area ft²)	Zone air distribution effectiveness (refer toTable 6.2)	Zone OA corrected for zone air distribution effectiveness, cfm (Pz*Rp + Az*Ra)/Ez	Minimum Primary outdoor air fraction, V_{ot}/V_{oz}	Actual outside air cfm, based on 41.9% OA & max box position	% Ventilation in excess of code
Zone 1	B00	Corridor	Corridors	430	0	400	150	0.0	0.06	0	25.80	1.00	26	0.17	168	550.2%
Zone 2	B01	Exercise Room	Computer Lab.	360	9	500	225	10.0	0.12	90	43.20	1.00	133	0.59	210	57.4%
Zone 3	B02/03	Locker	Break rooms	335	9	200	125	5.0	0.06	45	20.10	1.00	65	0.52	84	28.8%
Zone 4	B06	Computer	Computer Lab.	335	0	100	125	10.0	0.12	0	40.20	1.00	40	0.32	42	4.3%
Zone 5	B07	Storage	Storage rooms	200	0	200	75	0.0	0.12	0	24.00	1.00	24	0.32	84	249.5%
Zone 6	B09	Files	Office space	1140	6	600	350	5.0	0.06	30	68.40	1.00	98	0.28	252	155.7%
Zone 7	B11	Library	Libraries	415	5	600	200	5.0	0.12	25	49.80	1.00	75	0.37	252	236.4%
Zone 8	B12	Lunch Room	Multi-use Assembly	1125	45	1000	650	7.5	0.06	338	67.50	1.00	405	0.62	419	3.5%
Zone 9	103	Reception	Reception areas	135	5	150	75	5.0	0.06	25	8.10	1.00	33	0.44	63	90.0%
Zone 10	104	RA/Tech	Office space	120	1	150	50	5.0	0.06	5	7.20	1.00	12	0.24	63	415.6%
Zone 11	105	MNGR Sci Office	Office space	135	1	200	75	5.0	0.06	5	8.10	1.00	13	0.17	84	540.2%
Zone 12	107	Assoc Office	Office space	115	1	150	50	5.0	0.06	5	6.90	1.00	12	0.24	63	428.6%
Zone 13	107	Assoc Office	Office space	115	1	150	50	5.0	0.06	5	6.90	1.00	12	0.24	63	428.6%

EMD Serono Research Center - existing

AHU-2

RESULTS

V_{ps}	Actual total supply air, cfm	15,500	
		Min, calculated	Actual
V_{ot}	Outdoor air intake, V_{ou} / E_v, cfm	4,954	6,500
	Percent outdoor air intake, V_{ot} / V_{ps}	32.0%	41.9%
E_v	System ventilation efficiency	0.50	

65.0%

64.5%

ZONE LEVEL

Zones served by system	Room#	Room Name	Space type (select from pull-down list)	A_z Floor area of zone, ft²	P_z Zone population, largest # of people expected to occupy zone	V_{pzd} Maximum primary airflow to zone from air handler. In VAV systems, use the design value. cfm	V_{pz} The minimum value of the primary airflow to zone from air handler. In CAV systems, V_{pz} = V_{pzd}, cfm	R_p People outdoor air rate from Table 6.1, cfm/person	R_a Area outdoor air rate from Table 6.1, cfm/ft²	$P_z R_p$ Zone people OA calc (based on # of people)	$A_z R_a$ Zone area OA calc (based on area ft²)	E_z Zone air distribution effectiveness (refer to Table 6.2)	V_{oz} Zone OA corrected for zone air distribution effectiveness, cfm (Pz*Rp + Az*Ra)/Ez	Z_p Minimum Primary outdoor air fraction, V_{oz} / V_{pz}	*Design OA* Actual outside air cfm, based on 41.9% OA & max box position	% Ventilation in excess of code
Zone 1	B00	Corridor	Corridors	430	0	400	150	0.0	0.06	0	25.80	1.00	26	0.17	168	550.2%
Zone 2	B01	Exercise Room	Computer Lab.	360	9	500	225	10.0	0.12	90	43.20	1.00	133	0.59	210	57.4%
Zone 3	B02/03	Locker	Break rooms	335	9	200	125	5.0	0.06	45	20.10	1.00	65	0.52	84	28.8%
Zone 4	B06	Computer	Computer Lab.	335	0	100	125	10.0	0.12	0	40.20	1.00	40	0.32	42	4.3%
Zone 5	B07	Storage	Storage rooms	200	0	200	75	0.0	0.12	0	24.00	1.00	24	0.32	84	249.5%
Zone 6	B09	Files	Office space	1140	6	600	350	5.0	0.06	30	68.40	1.00	98	0.28	252	155.7%
Zone 7	B11	Library	Libraries	415	5	600	200	5.0	0.12	25	49.80	1.00	75	0.37	252	236.4%
Zone 8	B12	Lunch Room	Multi-use Assembly	1125	45	1000	650	7.5	0.06	338	67.50	1.00	405	0.62	419	3.5%
Zone 9	103	Reception	Reception areas	135	5	150	75	5.0	0.06	25	8.10	1.00	33	0.44	63	90.0%
Zone 10	104	RA/Tech	Office space	120	1	150	50	5.0	0.06	5	7.20	1.00	12	0.24	63	415.6%
Zone 11	105	MNGR Sci Office	Office space	135	1	200	75	5.0	0.06	5	8.10	1.00	13	0.17	84	540.2%
Zone 12	107	Assoc Office	Office space	115	1	150	50	5.0	0.06	5	6.90	1.00	12	0.24	63	428.6%
Zone 13	107	Assoc Office	Office space	115	1	150	50	5.0	0.06	5	6.90	1.00	12	0.24	63	428.6%

EMD Serono Research Center - existing

AHU-2

RESULTS

V_{ot}	Actual total supply air, cfm	15,500		65.0%
		Min. calculated	Actual	
V_{ot}	Outdoor air intake, V_{ou}/E_v, cfm	4,954	6,500	
	Percent outdoor air intake, V_{ot}/V_{st}	32.0%	41.9%	64.5%
E_v	System ventilation efficiency	0.50		

ZONE LEVEL

Zones served by system	Room#	Room Name	Space type (select from pull-down list)	A_z Floor area of zone, ft²	P_z Zone population, largest # of people expected to occupy zone	V_{pzd} Maximum primary airflow to zone from air handler. In VAV systems, use the design value. cfm	V_{pz} The minimum value of the primary airflow to zone from air handler. In CAV systems, V_{pz} = V_{pzd}, cfm	R_p People outdoor air rate from Table 6.1, cfm/person	R_a Area outdoor air rate from Table 6.1, cfm/ft²	$P_z \cdot R_p$ Zone people OA calc (based on # of people)	$A_z \cdot R_a$ Zone area OA calc (based on area ft²)	E_z Zone air distribution effectiveness (refer to Table 6.2)	V_{oz} Zone OA corrected for zone air distribution effectiveness, cfm (Pz*Rp + Az*Ra)/Ez	Z_p Minimum Primary outdoor air fraction, V_{oz}/V_{pz}	Design OA Actual outside air cfm, based on 41.9% OA & max box position	% Ventilation in excess of code
Zone 14	108	Assoc Office	Office space	115	1	150	50	5.0	0.06	5	6.90	1.00	12	0.24	63	428.6%
Zone 15	109	Assoc Office	Office space	115	1	150	50	5.0	0.06	5	6.90	1.00	12	0.24	63	428.6%
Zone 16	110	Assoc Office	Office space	115	1	150	50	5.0	0.06	5	6.90	1.00	12	0.24	63	428.6%
Zone 17	111	Assoc Office	Office space	115	1	150	50	5.0	0.06	5	6.90	1.00	12	0.24	63	428.6%
Zone 18	112	Cubicles	Office space	690	4	600	225	5.0	0.06	20	41.40	1.00	61	0.27	252	309.8%
Zone 19	113	Office	Office space	160	1	200	75	5.0	0.06	5	9.60	1.00	15	0.19	84	474.5%
Zone 20	114	Office	Office space	160	1	300	100	5.0	0.06	5	9.60	1.00	15	0.15	126	761.7%
Zone 21	115	Office	Office space	150	1	200	75	5.0	0.06	5	9.00	1.00	14	0.19	84	499.1%
Zone 22	116	RA/Tech	Office space	165	1	100	50	5.0	0.06	5	9.90	1.00	15	0.30	42	181.4%
Zone 23	121	Lobby	Lobbies	1168	25	1000	375	5.0	0.06	125	70.08	1.00	195	0.52	419	115.0%
Zone 24	122	Corridor	Corridors	500	0	550	200	0.0	0.06	0	30.00	1.00	30	0.15	231	668.8%
Zone 25	124	Conference	Conference / meeting	430	22	500	225	5.0	0.06	110	25.80	1.00	136	0.60	210	54.4%
Zone 26	125	Office	Office space	160	1	200	75	5.0	0.06	5	9.60	1.00	15	0.19	84	474.5%

EMD Serono Research Center - existing

AHU-2

RESULTS

V_{tot}	Actual total supply air, cfm	15,500		65.0%
		Min. calculated	Actual	
V_{ot}	Outdoor air intake, V_{ou}/E_v, cfm	4,954	6,500	
	Percent outdoor air intake, V_{ot}/V_{ps}	32.0%	41.9%	64.5%
E_v	System ventilation efficiency	0.50		

ZONE LEVEL

				A_z	P_z	V_{pzd}	V_{pz}	R_p	R_a	$P_z R_p$	$A_z R_a$	E_z	V_{oz}	Z_p	Design OA	
Zones served by system	Room#	Room Name	Space type (select from pull-down list)	Floor area of zone, ft²	Zone population, largest # of people expected to occupy zone	Maximum primary airflow to zone from air handler. In VAV systems, use the design value. cfm	The minimum value of the primary airflow to zone from air handler. In CAV systems, V_{pz} = V_{pzd} . cfm	People outdoor air rate from Table 6.1, cfm/person	Area outdoor air rate from Table 6.1, cfm/ft²	Zone people OA calc (based on # of people)	Zone area OA calc (based on area ft²)	Zone air distribution effectiveness (refer to Table 6.2)	Zone OA corrected for zone air distribution effectiveness, cfm (Pz*Rp + Az*Ra)/Ez	Minimum Primary outdoor air fraction, V_{oz}/V_{pz}	Actual outside air cfm, based on 41.9% OA & max box position	% Ventilation in excess of code
Zone 27	126	Cubicles	Office space	435	3	600	200	5.0	0.06	15	26.10	1.00	41	0.21	252	512.2%
Zone 28	141	MNGR Sci Office	Office space	135	1	200	75	5.0	0.06	5	8.10	1.00	13	0.17	84	540.2%
Zone 29	142	Group Meeting	Conference / meeting	200	10	300	100	5.0	0.06	50	12.00	1.00	62	0.62	126	102.9%
Zone 30	135	Elec Room	Electrical equipment rooms	85	0	100	50	0.0	0.06	0	5.10	1.00	5	0.10	42	722.3%
Zone 31	136	Restroom	Break rooms	145	4	100	50	5.0	0.06	20	8.70	1.00	29	0.57	42	46.1%
Zone 32	137	Restroom	Break rooms	160	4	100	50	5.0	0.06	20	9.60	1.00	30	0.59	42	41.7%
Zone 33	138	File Room	Office space	85	1	50	50	5.0	0.06	5	5.10	1.00	10	0.20	21	107.6%
Zone 34	139	Tel/Data	Telephone / data entry	45	3	150	50	5.0	0.06	15	2.70	1.00	18	0.35	63	255.4%
Zone 35	203	Office	Office space	115	1	150	50	5.0	0.06	5	6.90	1.00	12	0.24	63	428.6%
Zone 36	204	Office	Office space	115	1	150	50	5.0	0.06	5	6.90	1.00	12	0.24	63	428.6%
Zone 37	205	Office	Office space	135	1	200	75	5.0	0.06	5	8.10	1.00	13	0.17	84	540.2%
Zone 38	206	Copy	Computer Lab.	90	1	150	50	10.0	0.12	10	10.80	1.00	21	0.42	63	202.4%
Zone 39	207	Office	Office space	116	1	150	50	5.0	0.06	5	6.96	1.00	12	0.24	63	425.9%

EMD Serono Research Center - existing

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RESULTS

V_{ot}	Actual total supply air, cfm	15,500	
		Min. calculated	Actual
V_{ot}	Outdoor air intake, V_{ou}/E_v, cfm	4,954	6,500
	Percent outdoor air intake, V_{ot}/V_{ot}	32.0%	41.9%
E_v	System ventilation efficiency	0.50	

65.0%

64.5%

ZONE LEVEL

Zones served by system	Room#	Room Name	Space type (select from pull-down list)	A_z Floor area of zone, ft²	P_z Zone population, largest # of people expected to occupy zone	V_{pzd} Maximum primary airflow to zone from air handler. In VAV systems, use the design value, cfm	V_{pz} The minimum value of the primary airflow to zone from air handler. In CAV systems, V_{pz} = V_{pzd}, cfm	R_p People outdoor air rate from Table 6.1, cfm/person	R_a Area outdoor air rate from Table 6.1, cfm/ft²	$P_z \cdot R_p$ Zone people OA calc (based on # of people)	$A_z \cdot R_a$ Zone area OA calc (based on area ft²)	E_z Zone air distribution effectiveness (refer to Table 6.2)	V_{oz} Zone OA corrected for zone air distribution effectiveness, cfm (Pz*Rp + Az*Ra)/Ez	Z_p Minimum Primary outdoor air fraction, V_{oz}/V_{pz}	*Design OA* Actual outside air cfm, based on 41.9% OA & max box position	% Ventilation in excess of code
Zone 40	208	Office	Office space	116	1	150	50	5.0	0.06	5	6.96	1.00	12	0.24	63	425.9%
Zone 41	209	Office	Office space	116	1	150	50	5.0	0.06	5	6.96	1.00	12	0.24	63	425.9%
Zone 42	210	Office	Office space	116	1	150	50	5.0	0.06	5	6.96	1.00	12	0.24	63	425.9%
Zone 43	211	Office	Office space	116	1	150	50	5.0	0.06	5	6.96	1.00	12	0.24	63	425.9%
Zone 44	213	Office	Office space	165	1	200	75	5.0	0.06	5	9.90	1.00	15	0.20	84	462.9%
Zone 45	214	Office	Office space	440	3	500	175	5.0	0.06	15	26.40	1.00	41	0.24	210	406.5%
Zone 46	216	Cubicles	Office space	785	4	200	250	5.0	0.06	20	47.10	1.00	67	0.27	84	25.0%
Zone 47	217	Office	Office space	165	1	150	50	5.0	0.06	5	9.90	1.00	15	0.30	63	322.2%
Zone 48	218	Cubicles	Office space	405	3	750	250	5.0	0.06	15	24.30	1.00	39	0.16	315	700.3%
Zone 49	223	lobby	Lobbies	1140	25	500	350	5.0	0.06	125	68.40	1.00	193	0.55	210	8.4%
Zone 50	233	Elec Room	Electrical equipment rooms	85	0	150	50	0.0	0.06	0	5.10	1.00	5	0.10	63	1133.4%
Zone 51	235	Elec Room	Electrical equipment rooms	75	0	150	50	0.0	0.06	0	4.50	1.00	5	0.09	63	1297.8%
Zone 52	236	Restroom	Break rooms	145	4	100	50	5.0	0.06	20	8.70	1.00	29	0.57	42	46.1%

EMD Serono Research Center - existing

AHU-2

RESULTS

V_{ot}	Actual total supply air, cfm	15,500		65.0%
		Min, calculated	Actual	
V_{ot}	Outdoor air intake, V_{ou}/E_v, cfm	4,954	6,500	
	Percent outdoor air intake, V_{ot}/V_{ps}	32.0%	41.9%	64.5%
E_v	System ventilation efficiency	0.50		

ZONE LEVEL

				A_z	P_z	V_{pzdsd}	V_{pz}	R_p	R_a	$P_z \cdot R_p$	$A_z \cdot R_a$	E_z	V_{oz}	Z_p	*Design OA*	
Zones served by system	Room#	Room Name	Space type (select from pull-down list)	Floor area of zone, ft²	Zone population, largest # of people expected to occupy zone	Maximum primary airflow to zone from air handler. In VAV systems, use the design value, cfm	The minimum value of the primary airflow to zone from air handler. In CAV systems, V_{pz} = V_{pzdsd}, cfm	People outdoor air rate from Table 6.1, cfm/person	Area outdoor air rate from Table 6.1, cfm/ft²	Zone people OA calc (based on # of people)	Zone area OA calc (based on area ft²)	Zone air distribution effectiveness (refer toTable 6.2)	Zone OA corrected for zone air distribution effectiveness, cfm (Pz*Rp + Az*Ra)/Ez	Minimum Primary outdoor air fraction, V_{oz}/V_{pz}	Actual outside air cfm, based on 41.9% OA & max box position	% Ventilation in excess of code
Zone 53	237	Restroom	Break rooms	120	3	100	50	5.0	0.06	15	7.20	1.00	22	0.44	42	88.9%
Zone 54	139	Tel/Data	Telephone / data entry	50	3	100	50	5.0	0.06	15	3.00	1.00	18	0.36	42	133.0%
Zone 55	222	Board Room	Conference / meeting	435	22	500	225	5.0	0.06	110	26.10	1.00	136	0.60	210	54.1%
Zone 56	224	Office	Office space	135	1	150	50	5.0	0.06	5	8.10	1.00	13	0.26	63	380.2%
Zone 57	242	Meeting	Conference / meeting	200	10	300	100	5.0	0.06	50	12.00	1.00	62	0.62	126	102.9%
TOTAL				15,673	258	15,500	6,675						2,477		6,500	

SYSTEM LEVEL

P_s	System population, maximum simultaneous # of occupants of space served by system	258	
D	Occupant diversity, ratio of system peak occupancy to sum of space peak	1.00	
V_{ou}	Uncorrected outdoor air intake, = $D*SR_p*P_s$	2,477	
Vot	**Actual total supply air, cfm**	**15,500**	
X_s	Mixing ratio at primary air handler of uncorrected outdoor air intake to system primary flow, = V_{ou}/V_{ps}	0.16	Not used in calculation

SYSTEM EFFICIENCY

Max Z_p	Maximum Z_p of all zones	0.62
Ev	System ventilation efficiency (from Table 6.3) based on Max Z_p	0.50
V_{ot}	**Calculated minimum outdoor air intake, V_{ou}/E_v, cfm**	**4,954**

Percent outdoor air intake = $V_{ot}/SVpztot$	**32.0%**

Simplified Table

EMD Serono Research Center - existing

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RESULTS

V_{tot}	Actual total supply air, cfm	15,500		65.0%
		Min, calculated	Actual	
V_{ot}	Outdoor air intake, V_{ot}/E_v, cfm	4,954	6,500	
	Percent outdoor air intake, V_{ot}/V_{pz}	32.0%	41.9%	64.5%
E_v	System ventilation efficiency	0.50		

ZONE LEVEL

Zones served by system	Room#	Room Name	Space type (select from pull-down list)	A_z Floor area of zone, ft^2	P_z Zone population, largest # of people expected to occupy zone	V_{pzmx} Maximum primary airflow to zone from air handler. In VAV systems, use the design value. cfm	V_{pz} The minimum value of the primary airflow to zone from air handler. In CAV systems, $V_{pz} = V_{pzmx}$. cfm	Z_p Minimum Primary outdoor air fraction, V_{oz}/V_{pz}	Design OA Actual outside air cfm, based on 41.9% OA & max box position	% Ventilation in excess of code
Zone 1	B00	Corridor	Corridors	430	0	400	150	0.17	168	550.2%
Zone 2	B01	Exercise Room	Computer Lab.	360	9	500	225	0.59	210	57.4%
Zone 3	B02/03	Locker	Break rooms	335	9	200	125	0.52	84	28.8%
Zone 4	B06	Computer	Computer Lab.	335	0	100	125	0.32	42	4.3%
Zone 5	B07	Storage	Storage rooms	200	0	200	75	0.32	84	249.5%
Zone 6	B09	Files	Office space	1140	6	600	350	0.28	252	155.7%
Zone 7	B11	Library	Libraries	415	5	600	200	0.37	252	236.4%
Zone 8	B12	Lunch Room	Multi-use Assembly	1125	45	1000	650	0.62	419	3.5%
Zone 9	103	Reception	Reception areas	135	5	150	75	0.44	63	90.0%
Zone 10	104	RA/Tech	Office space	120	1	150	50	0.24	63	415.6%
Zone 11	105	MNGR Sci Office	Office space	135	1	200	75	0.17	84	540.2%
Zone 12	107	Assoc Office	Office space	115	1	150	50	0.24	63	428.6%
Zone 13	107	Assoc Office	Office space	115	1	150	50	0.24	63	428.6%
Zone 14	108	Assoc Office	Office space	115	1	150	50	0.24	63	428.6%
Zone 15	109	Assoc Office	Office space	115	1	150	50	0.24	63	428.6%
Zone 16	110	Assoc Office	Office space	115	1	150	50	0.24	63	428.6%
Zone 17	111	Assoc Office	Office space	115	1	150	50	0.24	63	428.6%
Zone 18	112	Cubicles	Office space	690	4	600	225	0.27	252	309.8%
Zone 19	113	Office	Office space	160	1	200	75	0.19	84	474.5%
Zone 20	114	Office	Office space	160	1	300	100	0.15	126	761.7%
Zone 21	115	Office	Office space	150	1	200	75	0.19	84	499.1%
Zone 22	116	RA/Tech	Office space	165	1	100	50	0.30	42	181.4%
Zone 23	121	Lobby	Lobbies	1168	25	1000	375	0.52	419	115.0%
Zone 24	122	Corridor	Corridors	500	0	550	200	0.15	231	668.8%
Zone 25	124	Conference	Conference / meeting	430	22	500	225	0.60	210	54.4%

EMD Serono Research Center - existing

AHU-2

RESULTS

V_{tot}	Actual total supply air, cfm	15,500		65.0%
		Min, calculated	Actual	
V_{ot}	Outdoor air intake, V_{ou}/E_v, cfm	4,954	6,500	
	Percent outdoor air intake, V_{ot}/V_{pz}	32.0%	41.9%	64.5%
E_v	System ventilation efficiency	0.50		

ZONE LEVEL

Zones served by system	Room#	Room Name	Space type (select from pull-down list)	A_z Floor area of zone, ft^2	P_z Zone population, largest # of people expected to occupy zone	V_{pzmx} Maximum primary airflow to zone from air handler. In VAV systems, use the design value. cfm	V_{pz} The minimum value of the primary airflow to zone from air handler. In CAV systems, $V_{pz} = V_{pzmx}$. cfm	Z_p Minimum Primary outdoor air fraction, V_{oz}/V_{pz}	Design OA Actual outside air cfm, based on 41.9% OA & max box position	% Ventilation in excess of code
Zone 25	124	Conference	Conference / meeting	430	22	500	225	0.60	210	54.4%
Zone 26	125	Office	Office space	160	1	200	75	0.19	84	474.5%
Zone 27	126	Cubicles	Office space	435	3	600	200	0.21	252	512.2%
Zone 28	141	MNGR Sci Office	Office space	135	1	200	75	0.17	84	540.2%
Zone 29	142	Group Meeting	Conference / meeting	200	10	300	100	0.62	126	102.9%
Zone 30	135	Elec Room	Electrical equipment rooms	85	0	100	50	0.10	42	722.3%
Zone 31	136	Restroom	Break rooms	145	4	100	50	0.57	42	46.1%
Zone 32	137	Restroom	Break rooms	160	4	100	50	0.59	42	41.7%
Zone 33	138	File Room	Office space	85	1	50	50	0.20	21	107.6%
Zone 34	139	Tel/Data	Telephone / data entry	45	3	150	50	0.35	63	255.4%
Zone 35	203	Office	Office space	115	1	150	50	0.24	63	428.6%
Zone 36	204	Office	Office space	115	1	150	50	0.24	63	428.6%
Zone 37	205	Office	Office space	135	1	200	75	0.17	84	540.2%
Zone 38	206	Copy	Computer Lab.	90	1	150	50	0.42	63	202.4%
Zone 39	207	Office	Office space	116	1	150	50	0.24	63	425.9%
Zone 40	208	Office	Office space	116	1	150	50	0.24	63	425.9%
Zone 41	209	Office	Office space	116	1	150	50	0.24	63	425.9%
Zone 42	210	Office	Office space	116	1	150	50	0.24	63	425.9%
Zone 43	211	Office	Office space	116	1	150	50	0.24	63	425.9%
Zone 44	213	Office	Office space	165	1	200	75	0.20	84	462.9%
Zone 45	214	Office	Office space	440	3	500	175	0.24	210	406.5%
Zone 46	216	Cubicles	Office space	785	4	200	250	0.27	84	25.0%
Zone 47	217	Office	Office space	165	1	150	50	0.30	63	322.2%
Zone 48	218	Cubicles	Office space	405	3	750	250	0.16	315	700.3%
Zone 49	223	lobby	Lobbies	1140	25	500	350	0.55	210	8.4%
Zone 50	233	Elec Room	Electrical equipment rooms	85	0	150	50	0.10	63	1133.4%

EMD Serono Research Center - existing

AHU-2

RESULTS

V_{tot}	Actual total supply air, cfm	15,500		65.0%
		Min, calculated	Actual	
V_{ot}	Outdoor air intake, V_{ou}/E_v, cfm	4,954	6,500	
	Percent outdoor air intake, V_{ot}/V_{pz}	32.0%	41.9%	64.5%
E_v	System ventilation efficiency	0.50		

ZONE LEVEL

Zones served by system	Room#	Room Name	Space type (select fron pull-down list)	A_z Floor area of zone, ft^2	P_z Zone population, largest # of people expected to occupy zone	V_{pzmx} Maximum primary airflow to zone from air handler. In VAV systems, use the design value. cfm	V_{pz} The minimum value of the primary airflow to zone from air handler. In CAV systems, V_{pz} = V_{pzmx}. cfm	Z_p Minimum Primary outdoor air fraction, V_{oz}/V_{pz}	Design OA Actual outside air cfm, based on 41.9% OA & max box position	% Ventilation in excess of code
Zone 51	235	Elec Room	Electrical equipment rooms	75	0	150	50	0.09	63	1297.8%
Zone 52	236	Restroom	Break rooms	145	4	100	50	0.57	42	46.1%
Zone 53	237	Restroom	Break rooms	120	3	100	50	0.44	42	88.9%
Zone 54	139	Tel/Data	Telephone / data entry	50	3	100	50	0.36	42	133.0%
Zone 55	222	Board Room	Conference / meeting	435	22	500	225	0.60	210	54.1%
Zone 56	224	Office	Office space	135	1	150	50	0.26	63	380.2%
Zone 57	242	Meeting	Conference / meeting	200	10	300	100	0.62	126	102.9%
TOTAL				15,673	258	15,500	6,675		6,500	

SYSTEM LEVEL

P_s	System population, maximum simultaneous # of occupants of space served by system	258	
D	Occupant diversity, ratio of system peak occupancy to sum of space peak	1.00	
V_{ou}	Uncorrected outdoor air intake, = $D*SR_z*P_z$	2,477	
Vtot	**Actual total supply air, cfm**	**15,500**	
X_s	Mixing ratio at primary air handler of uncorrected outdoor air intake to system primary flow, = V_{ou}/V_{ps}	0.16	Not used in calculation

SYSTEM EFFICIENCY

Max Z_p	Maximum Z_p of all zones	0.62
Ev	System ventilation efficiency (from Table 6.3) based on Max Z_p	0.50
V_{ot}	**Calculated minimum outdoor air intake, V_{ou}/E_v, cfm**	**4,954**

Percent outdoor air intake = $V_{ot}/SVpztot$	**32.0%**