## 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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**Prepared For:** 

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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.

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## **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 1<sup>st</sup> and 2<sup>nd</sup> 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 1<sup>st</sup> and 2<sup>nd</sup> 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 1<sup>st</sup> 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.

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<sub>bz</sub>):

 $V_{bz} = R_p x P_z + R_a x A_z$  (Eq. 6-1)

 $A_z$ : zone floor area: the net occupiable floor area of the zone (ft<sup>2</sup>)

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

R<sub>p</sub>: outdoor airflow rate required per person as determined from Table 6-1 (cfm/person)

R<sub>a</sub>: outdoor airflow rate required per unit area as determined from Table 6-1 (cfm/ft<sup>2</sup>)

Zone Air Distribution Effectiveness (E<sub>z</sub>)

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,  $E_z = 1$ 

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Zone Outdoor Airflow (Voz)

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

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

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

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

Primary Outdoor Air Fraction:

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

Uncorrected Outdoor Air Intake:

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

Where:

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

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

Outdoor Air Intake:

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

### **ASHRAE Standard 62.1 Findings**

EMD Se AHU-2 RESULTS	erono I	Research Center	- existing	
RESCETS	$V_{tot}$	Actual total supply air, cfm	15,500	
			Min, calculated	Actual
	V <sub>ot</sub>	Outdoor air intake, V <sub>ou</sub> /E <sub>v</sub> , cfm	4,954	6,500
		Percent outdoor air intake, V <sub>ot</sub> /V <sub>ps</sub>	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.

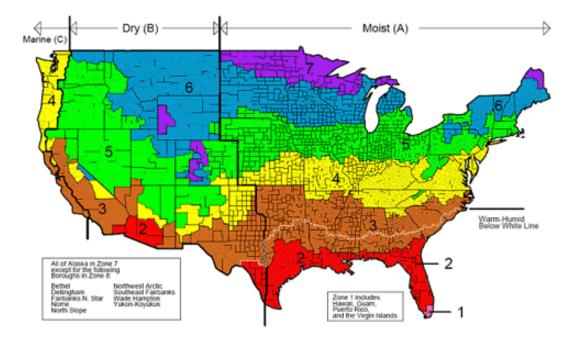


Figure 90.1- 5.1.4

#### **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

	Fe	nestration A	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 shows the calculation for fenestration percentage.

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 E	nvelope Requi	irement	
Elements	Description	Min R-Value	<b>Building R-Value</b>	Complies
Roof	Insulation	20	13.66	No
	Above Deck			
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  $\frac{1}{2}$ " rigid insulation and  $\frac{1}{2}$ " 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:

Allowable Horsepower = CFM  $\times$  0.0011

Calculate the Allowable Horsepower for variable air volume:

Allowable Horsepower = 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 Limitatio	n	
Unit	Туре	CFM	Allowable HP	Nameplate HP	Compliant
AHU-1	VAV	45,000	67 1⁄2	75 VSD	No
AHU-2	VAV	15,000	22 1/2	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	71⁄2	Yes
EX-4	CAV	1,000	1 1/9	1	Yes
EX-5	CAV	750	5/6	1/2	Yes
EX-6	CAV	800	7/8	1/2	Yes
HVU-1	CAV	3,000	3 1/3	5	No
HVU-2	CAV	1,000	1 1/9	3	No
		Table	A Fan Power Limitatio	n	

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	<b>Efficienc</b>	y Requ	irement Compliand	ce
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

C	ooling Tower I	Minimum	Performance Requirement Comp	liance
Unit	Description	GPM/HP	Performance Required (GPM/HP)	Compliant
CT-1	Cooling Tower	21	≥20.0	Yes

Table-6 Fan Power Limitation

	Boiler M	linimum Eff	iciency 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 Powe	er Densities Using	g Building	Area Method	
Building Area Type	Building SF	W/ft <sup>2</sup>	LPD (W/ft <sup>2</sup> )	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<sup>2</sup> and 2.1 W/ft<sup>2</sup> 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**

### SHIYUN CHEN | ADVISOR: DR. BAHNFLETH

$V_{a}$ Accorditationally according         State Signature state         State Signate         State Sign	EMD :	Serono Ke	EMD Serono Research Center - existing AHU-2	existing													
Image: consist of the state	HESULT		Actual total supply air. ofm Outdoor air intake. <i>Y1 E</i> ofm Percent outdoor air intake. <i>Y1 Y</i> System ventilation efficiency	15,500 Min, calculated 4,954 32.0% n.5n	Actual 6.500 41.9%	65.0% 64.5%											
Protection         Termination	ZONE LE	VEL			, <sup>4</sup>	Р.	V and at	×. *	в,		×	1.	Ε,	r.,	Z,	Design DA	
Bio         Controle         Controle         400         0         400         700         75         700         75         700         75         700         75         700         75         700         75         700         75         700         75         700         75         700         75         700         75         700         75         700         700         75         700         700         75         700         700         700         75         700         700         75         700         700         75         700         700         75         700         700         75         700         700         75         700 <t< th=""><th>Zones served b<b>j</b> system</th><th>Room</th><th>Room Name</th><th></th><th>loor area of zone, ft²</th><th>Zone population, largest # of people expected to occupg zone</th><th></th><th>The minimum value of the primarg airflow to zone from air handler. In CAY systems, V, = V, efm</th><th></th><th></th><th>Zone people OA calc [based on # of people]</th><th>Zone area DA calc (based on area ft²)</th><th></th><th>Zone OA corrected for zone air distribution effectivenes s, cfm [Pz<sup>-</sup>Fp•</th><th>Minimum Primary outdoor air fraction, <i>Y, I.Y.</i></th><th></th><th>X Ventilation in excess of code</th></t<>	Zones served b <b>j</b> system	Room	Room Name		loor area of zone, ft²	Zone population, largest # of people expected to occupg zone		The minimum value of the primarg airflow to zone from air handler. In CAY systems, V, = V, efm			Zone people OA calc [based on # of people]	Zone area DA calc (based on area ft²)		Zone OA corrected for zone air distribution effectivenes s, cfm [Pz <sup>-</sup> Fp•	Minimum Primary outdoor air fraction, <i>Y, I.Y.</i>		X Ventilation in excess of code
B01         Enertie Floor         Compute List.         300         30         210         101         130         103         210	Zone 1	B00	Corridor	Corridors	430	0	400	150	0.0	90:0	0	25.80	100	26	0.17	168	550.2%
B02001         Looker         Beakrooms         335         9         2000         VES         60         66         65         60         65         60         66         67         60         66         67         60         66         67         60         66         67         60         67         60         67         60         67         60         67         60         67         60         67         60         67         60         67         60         67         60         67         60 <td>Zone 2</td> <td>BOI</td> <td>Exercise Room</td> <td>Computer Lab.</td> <td>360</td> <td>o</td> <td>500</td> <td>225</td> <td>10.0</td> <td>0.12</td> <td>30</td> <td>43.20</td> <td>100</td> <td>133</td> <td>0.59</td> <td>210</td> <td>57.4%</td>	Zone 2	BOI	Exercise Room	Computer Lab.	360	o	500	225	10.0	0.12	30	43.20	100	133	0.59	210	57.4%
Biol         Compute         Compute <thcompute< th=""> <thcompute< th=""> <thcomp< td=""><td>Zone 3</td><td>B02/03</td><td>Locker</td><td>Break rooms</td><td>335</td><td>6</td><td>200</td><td>125</td><td>5.0</td><td>90.0</td><td>45</td><td>20.10</td><td>1.00</td><td>65</td><td>0.52</td><td>84</td><td>28.8%</td></thcomp<></thcompute<></thcompute<>	Zone 3	B02/03	Locker	Break rooms	335	6	200	125	5.0	90.0	45	20.10	1.00	65	0.52	84	28.8%
Bit         Storage         St	Zone 4	BOG	Computer	Computer Lab.	336	0	100	126	10.0	0.12	0	40.20	1.00	0+	0.32	42	4.3%
Bigs         Files         Officespace         140         6         600         350         50         006         50 <td>Zone 5</td> <td>B07</td> <td>Storage</td> <td>Storage rooms</td> <td>200</td> <td>0</td> <td>200</td> <td>75</td> <td>0.0</td> <td>0.12</td> <td>0</td> <td>24.00</td> <td>100</td> <td>24</td> <td>0.32</td> <td>84</td> <td>249.5%</td>	Zone 5	B07	Storage	Storage rooms	200	0	200	75	0.0	0.12	0	24.00	100	24	0.32	84	249.5%
EffLukayLukayLukayHaile45 $50$ $600$ $200$ $50$ $0.12$ $26$ $100$ $75$ $0.27$ $262$ $262$ B12LunchRoomMultureMulture $125$ $45$ $000$ $650$ $75$ $0.06$ $238$ $57.90$ $100$ $065$ $0.22$ $262$ $103$ FeceptionReceptionReception areas $135$ $57$ $100$ $265$ $200$ $205$ $260$ $100$ $262$ $262$ $262$ $104$ FadrechOfficespace $120$ $10$ $125$ $500$ $006$ $256$ $8.00$ $100$ $232$ $0.44$ $623$ $104$ FadrechOfficespace $120$ $10$ $15$ $10$ $100$ $250$ $100$ $100$ $250$ $100$ $260$	Zone 6	808	Files	Office space	1140	9	600	350	5.0	90:0	30	68.40	100	38	0.28	252	155.7%
BL2         Unrichfoom         Multi-use Assembly         125         45         100         650         75         0.06         335         67.50         100         405         632         413           103         Peception         Assembly         125         5         100         75         0.05         25         8.10         100         405         0.24         633           104         Peception         Reception areas         135         15         150         0.05         25         8.10         100         133         0.44         633         143           104         Pereption         Reception areas         135         150         150         0.05         25         8.10         100         123         0.44         633         143           105         MARFICIA         Otice space         155         150         0.05         5         720         100         12         0.44         633         143           105         Assocotice         155         1         206         5         100         100         12         0.44         633         14           107         Assocotice         155         10         106	Zone 7	BII	Library	Libraries	415	2	600	200	5.0	0.12	25	49.80	100	75	0.37	252	236.4%
103         Reception         135         150         1	Zone 8	B12	Lunch Room	Multi-use Assembly	1125	45	1000	650	7.5	90:0	338	67.50	1.00	405	0.62	419	3.5%
Zone 10         TeA/Tech         Difficespace         TO	Zone	103	Reception	Reception areas	135	2	150	75	5.0	90.0	25	8.10	1.00	33	0.44	63	30.0%
Zone 11         105         MNGR Sci Office         135         1         200         75         5.0         0.06         5         8.10         100         13         8.1           Zone 12         107         Associative         115         1         150         5.0         0.06         5         8.0         100         12         8.4         8.1		104	RA/Tech	Office space	120	-	150	50	5.0	90:0	2	7.20	1.00	12	0.24	63	415.6%
Zone 12         107         Assocotifie         Diffeespace         115         150         150         150         150         150         120         12         124         633           Zone 13         107         Assocotifie         Diffeespace         115         11         150         50         0.06         55         6.90         100         12         0.24         6.33		105	MNGR Sci Office	Office space	135	-	200	75	5.0	0.06	5	8.10	1.00	13	0.17	84	540.2%
Zone 13         107         Assoc Office         Diffice space         115         1         150         50         50         0.06         5         6.30         100         12         0.24         6.3		107	Assoc Office	Office space	115	-	150	50	5.0	90:0	ß	6.30	1.00	12	0.24	83	428.6%
		107	Assoc Office	Office space	115	-	150	50	5.0	90:0	5	6.30	1.00	12	0.24	83	428.6%

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#### SHIYUN CHEN | ADVISOR: DR. BAHNFLETH

AHU-2		AHU-2	0													
RESULTS		Actual total supply air, cfm	15,500 Min, calculated	Actual	65.0%											
	*	Uutdoor air intake. <i>Y I.E.</i> . cfm Percent outdoor air intake. <i>Y I.V</i>	32.0%	41.9%	64.5%											
	ε,	System ventilation efficiency	0.50													
ZONE LEVEL	VEL															
				. <del>4</del>	Р.	V orbed	r.,	в,	в,	P. R.	A. R.	Ε.		z,	Design DA	
Zones served by system	Room	Room Name	Space type [select from pull-down list]	Floor area of zone, ft²	Zone population, largest # of people ezpected to occupg zone	Masimum primary airflow to zone from air handler. In VAV systems, use the design value. ofm	The minimum value of the primary airflow to zone from air handler. In CAV systems, $V_{\mu\nu} = V_{\mu\nu\nu}$ . cfm	People outdoor air rate from Table 6.1, cfmłperso n	Area outdoor air rate from Table 6.1, cfm/ft*	Zone people OA calc (based on # of people)	Zone area OA calc (based on area ft²)	Zone air distributi on effective ness (refer toTable 6.2)	Zone OA corrected for zone air distribution effectivenes s. cfm Az <sup>-</sup> Ra)/Ez	Minimum Primary outdoor air fraction,	Actual outside air cfm. based on 41.9% DA & mar bor position	x Ventilation in excess of code
Zone 1	B00	Corridor	Corridors	430	0	400	150	0.0	90.0	0	25.80	1.00	26	0.17	168	550.2%
Zone 2	B01	Exercise Room	Computer Lab.	360	o	500	225	10.0	0.12	8	43.20	1.00	133	0.59	210	57.4%
Zone 3	B02/03	Locker	Break rooms	335	o	200	125	5.0	90:0	45	20.10	1.00	65	0.52	84	28.8%
Zone 4	90E	Computer	Computer Lab.	335	0	100	125	10.0	0.12	0	40.20	1.00	40	0.32	4	4.335
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	9	600	350	5.0	90:0	30	68.40	1.00	8	0.28	252	155.7%
Zone 7	BII	Library	Libraries	415	a	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	90:0	338	67.50	1.00	405	0.62	419	3.5%
Zone 9	103	Reception	Reception areas	135	2	150	75	5.0	90:0	25	8.10	1.00	33	0.44	63	30.0%
Zone 10	104	RA/Tech	Office space	120	٠	150	50	5.0	90.06	5	7.20	1.00	12	0.24	8	415.6%
Zone 11	105	MNGR Soi Office	Office space	135	-	200	75	5.0	90:0	5	8.10	1.00	13	0.17	84	540.2%
Zone 12	107	Assoc Office	Office space	115	-	150	50	5.0	90.06	5	6.30	1.00	12	0.24	8	428.6%
Zone 13	40.7	Access Others		ų		1	1									

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### SHIYUN CHEN | ADVISOR: DR. BAHNFLETH

RFSIII TS																
	V.u.	Actual total supply	15,500													
		air, ofm	Min. calculated	Actual	65.0%											
	¥	Outdoor air intake.	4,954	6,500												
		V., IE., ofm	~ 0 66	A1 9~												
		intake. V., IV.,			64.5%											
	ε,	System ventilation efficiency	0.50													
ZONE LEVEL	VEL															
				, 4,	Р.	V med	۲.,	в,	в,	P. 'R.	A. R.	E.	r	z.	Design DA	
Zones			Space type	Floor area of	Zone population.	Maximum primary airflow to zone from	The minimum value of the primary airflow	People outdoor air rate	Area outdoor	Zone people	Zone area	Zone air distributi on	Zone OA corrected for zone air	Minimum Primarg outdoor	Actual outside air	X
bj	Room	Room Name	[select from pull-down list]	zone, ft <sup>z</sup>	people people expected to occupy zone	air handler. In YAV systems, use the design value. cfm	to zone from air handler. In CAV systems, <i>Y</i> ,, = <i>Y</i> ,,, cfm	from Table 6.1, cfmłperso n	air rate from Table 6.1, cfm/ft²	(based on a of people)	(based on area ft <sup>2</sup> )	ness ness (refer toTable 6.2)	effectivenes s. cfm (P2'Bp • Az'Ba)/Ez	fraction.	the max box the max box position	in ercess of code
Zone 14	108	Assoc Office	Office space	115	-	150	50	5.0	90:0	2	6.30	100	12	0.24	63	428.6%
Zone 15	109	Assoc Office	Office space	15	-	150	50	5.0	90:0	2	6.30	1.00	5	0.24	8	428.6%
Zone 16	110	Assoc Office	Office space	115	۰	150	50	5.0	90.0	2	6.30	100	12	0.24	8	428.6%
Zone 17	E	Assoc Office	Office space	115	-	150	50	5.0	90:06	5	6.30	100	12	0.24	3	428.6%
Zone 18	112	Cubicles	Office space	630	4	600	225	5.0	90:0	20	41.40	100	61	0.27	252	309.8%
Zone 19	113	Office	Office space	160	-	200	75	5.0	90:0	5	9.60	100	15	0.19	84	474.5%
Zone 20	114	Office	Office space	160	۰	300	100	5.0	90:0	5	9.60	1.00	15	0.15	126	75137
Zone 21	115	Office	Office space	150	-	200	75	5.0	90:0	5	9.00	1.00	4	0.19	84	438.15
Zone 22	116	RA/Tech	Office space	165	٢	100	50	5.0	90:0	5	9.90	100	15	0:30	42	181.4%
Zone 23	121	Lobby	Lobbies	1168	25	1000	375	5.0	90.0	125	70.08	1.00	195	0.52	419	115.0%
Zone 24	122	Corridor	Corridors	500	0	550	200	0.0	90:06	0	30.00	1.00	30	0.15	231	668.8%
Zone 25	124	Conference	Conference / meeting	430	22	500	225	5.0	90:0	110	25.80	100	136	09'0	210	54.4%
Zone 26	ave		000100000	ţeu			;	;	~~~	,			,		;	

#### SHIYUN CHEN | ADVISOR: DR. BAHNFLETH

RESULTS <i>V</i> Actual total supply 15,500 ai <i>cim</i> Min. calculated <i>V</i> Outdoor air intake, 4,954 <i>V</i> I. <i>V</i> 12, cim Percent outdoor air 32.0% intake, <i>V</i> I. <i>V</i> 2.0% E., Sastem ventilation 0.50 efficiency Zones		Actual 6.500	85.0%											
<ul> <li>Y., Outdoor air intake.</li> <li>Y., I.E., ofm Percent outdoor air intake.</li> <li>Y., I.Y.,</li> <li>E. System ventilation efficiency</li> </ul>		la al	2009											
Y IE., cfm       Percent outdoor air intake. Y I Y       E., System ventilation efficiency	-													
intake. V., I.V., E., System ventilation efficiency		41.9%												
E, Sąstem ventilation efficiency			64.5%											
	*		Р.	V and	r.,	в,	в,	P. 'R',	A. R.	Ε,	¥	z,	Design DA	
served Room\$ Room Name Space type Space type Space type Space throm by pull-down list)		Floor area of la zone, ft²	∠one population. largest ≢ of people erpected to					∠one people OA calc (based on	Zone area OA calc (based on area ft²)	Zone air distributi on effective ness (refer	Zone OA corrected for zone air distribution effectivenes s. cfm	Minimum Primary outdoor air fraction,	Actual outside air ofm, based on 41.9% OA & mar bor	x Yentilation in excess of code
		ŏ		use the design value. cfm	France Comments	crimitperso (	6.1, cfm/ft*	people)		toTable 6.2)	(Pz'Rp • Az'Ra)/Ez		position	
Zone 27 126 Cubicles Diffice space		435	8	600	200	5.0	0.06	ß	26.10	1.00	41	0.21	262	512.2%
Zone 28 141 MNGR Sci Office Dffice space		135	-	200	75	5.0	90.0	a	8.10	1.00	13	21:0	84	540.2%
Zone 29 142 Group Meeting Conference / meeting		200	10	300	100	5.0	90.0	50	12.00	1.00	62	0.62	126	102.9%
Zone 30 135 Elec Room equipment rooms		85	0	100	50	0.0	90.0	0	5.10	1.00	5	0.10	42	722.3%
Zone 31 136 Restroom Break rooms		145	4	100	50	5.0	90:0	20	8.70	100	23	0.57	42	46.1%
Zone 32 137 Restroom Break rooms		160	4	100	50	5.0	90.0	20	9.60	1.00	30	0.59	42	41.7%
Zone 33 138 File Room Office space		85	-	50	50	5.0	90.0	a	5.10	1.00	10	0.20	21	107.6%
Zone 34 t39 Tel/Data Telephone / data		45		150	50	5.0	90:0	5	2.70	1.00	8	0.35	8	255.4%
Zone 35 203 Diffice Diffice space		115	-	150	50	5.0	90.0	2	6.90	100	12	0.24	8	428.6%
Zone 36 204 Office Office space		115	-	150	50	5.0	90:0	a	6.90	1.00	12	0.24	ß	428.6%
Zone 37 205 Diffice Diffice space		135	-	200	75	5.0	90.0	2	8.10	100	13	0.17	84	540.2%
Zone 36 Copy Computer Lab.		30	-	120	20	10.0	0.12	9	10.80	100	51	0.42	8	202.4%
Zone 39 207 Office Diffice space		118	-	150	50	5.0	90:0	ß	6.96	100	2	0.24	8	425.3%

### SHIYUN CHEN | ADVISOR: DR. BAHNFLETH

EMI	O Serono R	EMD Serono Research Center - existing AHU-2	existing													
	RESULTS	Actual total supply air. cim Dutdoor air intake. $Y \perp I \in .$ cim Percent outdoor air intake. $Y \perp I Y \perp$ Sistem ventilation efficiency	15,500 Min, calculated 4,954 32,0% 0,50	Actual 6,500 41.3%	65.0% 64.5%											
				. ¥	Ъ.	V orbed	<i>*.</i>	в,	в,	P. R.	A. R.	£.		Z,	Design DA	
by a system	s Boome	Room Name	Space type [select from pull-down list]	Floor area of zone, ft <sup>z</sup>	zone population, largest # of people expected to occupg zone	Mazimum primarg airflow to zone from air handler. In VAV systems, use the design value. cfm	The minimum value of the primarg airflow to zone from air handler. In CAY systems, $V_{\mu\nu} =$	People outdoor air rate from Table 6.1, f cfmfperso n	Area Area outdoor air rate from Table 6.1, cfm/ft <sup>2</sup>	zone people OA calc (based on a of people)	Zone area OA calc (based on area ft²)	Zone air distributi on effective ness (refer toTable 6.2)	Zone OA corrected for zone air distribution effectivenes s, cfm A2 <sup>-</sup> Ra)/Ez	Minimum Primary outdoor air fraction,	Actual outside air cfm, based on 41.9% OA i & max box position	X Ventilation in excess of code
Zone 40	+0 208	Office	Office space	116	-	150	50	5.0	9.06	ß	6.36	1.00	12	0.24	8	425.3%
Zone 41	41 209	Office	Office space	116	-	150	50	5.0	9.0E	a	6.96	1.00	12	0.24	83	425.9%
Zone 42	42 210	Office	Office space	116	-	150	50	5.0	9.06	2	6.36	1.00	12	0.24	63	425.3%
D Zone 43	43 211	Office	Office space	116	-	150	50	5.0	0.06	2	6.96	1.00	12	0.24	63	425.3%
Zone 44	41 213	Office	Office space	165	-	200	75	5.0	9.0E	Ω	9.90	1.00	15	0.20	84	462.9%
Zone 45	45 214	Office	Office space	440	3	500	175	5.0	9.06	5	26.40	1.00	41	0.24	210	406.5%
Zone 46	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	47 217	Office	Office space	165	-	150	50	5.0	0.06	5	9.90	1.00	5	0.30	63	322.2%
Zone 48	48 218	Cubicles	Office space	405	9	750	250	5.0	0.06	£	24.30	1.00	33	0.16	315	700.3%
Zone 49	49 223	lobby	Lobbies	1140	25	500	350	5.0	9.0E	125	68.40	1.00	193	0.55	210	8.4%
Zone 50	50 233	Elec Room	Electrical equipment rooms	85	0	150	50	0.0	9.06	0	5.10	1.00	2	0.10	63	1133.4%
Zome 51	230	Elec Foom	Electrical equipment rooms	22	0	150	00	0.0	90.06	0	4.50	1.00	ø	0.03	8	1237.8%
Zone 52	52 236	Restroom	Break rooms	145	4	100	50	5.0	90.0	20	8.70	1.00	29	0.57	42	46.1%
				Ī				Í	ĺ		Ī	Í	Ī	Ī		e

EMD S AHU-2	Serono Re	EMD Serono Research Center - existing AHU-2	existing													
RESULTS	5 V.u	Actual total supply	15,500		and and											
		air. crm	Min, calculated	Actual	90.0%											
	, r.	V., IE., ofm		000'0												
		Percent outdoor air intake. V., IV.,	32.0%	41.9x	64.5%											
	ε.	System ventilation efficiency	0.50													
ZONE LEVEL	IVEL															
				۶.	Р.	V and	<i></i>	в,	в,	P. R.	A. R.	Ε.	*	z.	Design DA	
Zones served by system	Room	Room Name	Space type (select from pull-down list)	Floor area of zone, ft²	Zune population, largest <b>#</b> of people expected to occupy zone	Mazimum primary airflow to zone from air handler. In VAV systems. use the design value. cfm	The minimum value of the primarg airflow to zone from air handler. In CAV systems. V., = V.,	People outdoor air rate from Table 6.1, cfmlperso n	Area Area outdoor air rate from Table 6.1, cfm/fr <sup>z</sup>	Zume people OA calc (based on people)	Zone area OA calc (based on area ft²)	Zone air distributi on effective ness (refer to Table 6.2)	Zone OA currected for zone air distribution effectivenes s, cfm Az'Ra)/Ez	Minimum Primary outdoor air fraction,	Actual outside air cfm. based on 41.9% DA & mar bor position	x Ventilation in ercess of code
Zone 53	237	Restroom	Break rooms	120	e	100	20	5.0	0.06	ħ	7.20	1.00	8	0.44	45	88.3%
Zone 54	139	Tel/Data	Telephone / data entry	20	e	100	50	5.0	90.0	£	3:00	100	8	0.36	42	133.0%
Zone 55	222	Board Room	Conference / meeting	435	22	500	225	5.0	90.0	01	26.10	1.00	136	0.60	210	24,45
Zone 56	224	Office	Office space	135	-	150	50	5.0	0.06	2	8.10	1.00	13	0.26	8	380.2%
Zone 57	242	Meeting	Conference / meeting	200	10	300	100	5.0	90:0	8	12.00	100	62	0.62	126	102.3%
TOTAL				15,673	258	15,500	6,675						2.477		6,500	

#### SYSTEM LEVEL

2,	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	
Ver	Uncorrected outdoor air intake, = D *SR *P,	2,477	-
Viot	Actual total supply air, cfm	15,500	
х,	Mixing ratio at primary air handler of uncorrected outdoor air intake to system primary flow, = $V_{ev}/V_{ze}$	0.16	Not used in calculation

#### SYSTEM EFFICENCY

Var	Calculated minimum outdoor air intake, V <sub>ex</sub> /E <sub>v</sub> , cfm	4,954
Εv	System ventilation efficiency (from Table 6.3) based on Max Z <sub>p</sub>	0.50
Max Z <sub>p</sub>	Maximum $Z_p$ of all zones	0.62

Percent outdoor sir intake = V<sub>er</sub>SVpztot 32.0%

## **Simplified Table**

#### EMD Serono Research Center - existing

#### AHU-2

RESULTS	$V_{set}$	Actual total supply air, cfm	15,50)	
			Min, calculated	Actual
	V et	Outdoor air intake, V <sub>au</sub> /E <sub>v</sub> , cfm	4,954	6,500
		Percent outdoor air intake, $V_{gr}/V_{pr}$	32.0%	41.9%
	Ev	System ventilation efficiency	0.50	

65.0%

64.5%

#### ZONE LEVEL

LONELLEN		1								
				A:	Ρ.	V <sub>powe</sub>	V <sub>F</sub>	Z,	Design O.A	
Zones served by system	Room#	Room Name	Space type (select fron pull- down list)	Floor area of zone, ft <sup>2</sup>	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, $V_{pe} =$ $V_{pene}$ cfm	Minimum Primary outdoor air fraction, $V_{ec}/V_{pc}$	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	Compute: 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	658.8%
Zone 25	124	Conference	Conference / meeting	430	22	500	225	0.60	210	54.4%

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#### EMD Serono Research Center - existing

#### AHU-2

RESULTS					
	Vat	Actual total supply air, cfm	15,500		65.0%
			Min, calculated	Actual	
	V <sub>et</sub>	Outdoor air intake, V <sub>eu</sub> /E <sub>v</sub> , cfm	4,954	6,500	
		Percent outdoor air intake, V <sub>oc</sub> V <sub>22</sub>	32.0%	41.9%	64.5%
		mane, e av p			04.376
	Ev	System ventilation efficiency	0.50		

#### ZONE LEVEL

ZONE LE	VEL									
				A ;	P:	V pune	V <sub>F</sub>	Ζ,	Design O.A	
Zones served by system	Room≠	Room Name	Space type (select fron pull- down list)	Floor area of zone, ft <sup>2</sup>	Zone population, largest # of people expected to occupy zone	Maximum primary airflow to zone from air haadler. In VAV systems, use the design value. cfm	The minimum value of the primary airflow to zone from air handler. In CAV systems, V <sub>pc</sub> = V <sub>pute</sub> , cfm	Minimum Primary outdoor air fraction, $V_{ec}/V_{pc}$	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	Lobbes	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 – EXISITING | BILLERICA | MA 29

#### EMD Serono Research Center - existing

#### AHU-2

RESULTS	-		1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 -	1	
	Vat	Actual total supply air, cfm	15,500		65.0%
			Min, calculated	Actual	
	Vat	Outdoor air intake, V <sub>eu</sub> /E <sub>v</sub> , cfm	4,954	6,500	
		Percent outdoor air intake, $V_{ee}V_{pi}$	32.0%	41.9%	64.5%
	Ev	System ventilation efficiency	0.50		

#### ZONE LEVEL

ZONE LEV	EL									
				A ;	Ρ;	Vpant	V <sub>Fi</sub>	Ζ,	Design OA	
Zones served by system	Koom#	Room Name	Space type (select fron pull- down list)	Floor area of zone, ft <sup>2</sup>	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, $V_{pz} =$ $V_{pzper}$ cfm	Minimum Primary outdoor air fraction, $V_{ec}/V_{pc}$	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	\$8.9%
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

Ρ.	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	_
Ver	Uncorrected outdoor air intake, = D*SR.*P.	2,477	-
Viot	Actual total supply air, cfm	15,500	
Х,	Mixing ratio at primary air handler of uncorrected outdoor air intake to system primary flow, = $V_{ev}/V_{ze}$	0.16	Not used in calculation

#### SYSTEM EFFICIENCY

$\operatorname{Max} Z_p$	Maximum $Z_p$ of all zones	0.62
Εv	System ventilation efficiency (from Table 6.3) based on Max $Z_p$	0.50
Vat	Calculated minimum outdoor air intake, V <sub>ex</sub> /E <sub>v</sub> , cfm	4,954