ASHRAE Standard 62.1 Compliance Report

(Rendering Courtesy of Clark-Nexsen)

William & Mary
Virginia Institute of Marine Science
Marine Research Building Complex
Seawater Research Laboratory

Gloucester Point, VA

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Executive Summary

This report investigates the compliance of William & Mary Virginia Institute of Marine Science Marine Research Building Complex Seawater Research Laboratory (VIMS Seawater Research Laboratory) with the Ventilation Rate Procedure of The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 62.1 with the 2006 Supplement. The use of Tables 6-1, 6-2, & 6-3, determined the use, outdoor air per square foot, outdoor air per person, ventilation efficiency and effectiveness.

The VIMS Seawater Research Laboratory is 1 story, 42,333 square foot research laboratory equaling 773,880 cubic feet that is supplied by two air handling units and four make-up air units, all supplying 100% outdoor air. The design supply airflow range for all supply air units is 21,960 cfm down to 3,295 cfm, for a total supply of 73,705 cfm.

As shown by the Building Systems Summary all air handling units and make-up air units comply with The 2004 ASHRAE Standard 62.1 and The 2006 Supplement. The supply air units were originally designed in accordance with The ASHRAE 2004 Standard 62.1 without The 2006 Supplement. The building systems still comply, mostly due to the over-sizing of the supply air units under The 2004 ASHRAE Standard 62.1.

The indoor air quality method can be applied once the particulate matter and the amount of noxious and dangerous vapors that are present in each zone are determined. Until then the assumption that all particulate matter, and noxious and dangerous vapors are completely exhausted either through the exhaust ducts or fume hoods.

Assumptions

Assumptions used in checking for compliance of ASHRAE Standard 62.1

- Regional outdoor air is acceptable per Section 4.
- The Dilution Factor of the Exhaust Air from Exhaust Fans is greater than that specified in Table F-2.
- Neglected air transfer between rooms due to ducted exhaust and. direct exhaust of every zone. Except janitor's closet which is accounted for by air transfer from the corridor
- Smoking will not be permitted within the building.
- Ozone Destruct Unit provides residual Ozone removal for all Ozone gas generated by the Ozone Generators.
- All air that contains noxious or dangerous particles, are properly exhausted through fume and relief hoods to filter system.
- The following table gives the design criteria for minimum outside air. These areas are to be continuously ventilated based on the values for each space provided in the table.

Seawater Research Laboratory			
Room	Area (sq. ft.)	Occupancy	Source
Main Entrance	231	0	Architect
Observation	788	0	Architect
Building Manager's Office	148	2	Architect
Building Engineer's Office	123	2	Architect
Fax/Copy	79	0	Architect
Kitchen	109	0	Architect
Conference	287	8	Architect
Exposure Lab 1	488	2	Architect
Exposure Lab 2	952	2	Architect
Toxicology Lab	3830	42	Estimated
Coral Reef Lab	231	0	Architect
Necropsy Lab	231	2	Architect
Lab A	921	2	Architect
Lab B	223	2	Architect
Vending	186	0	Architect
Vestibule	80	0	Architect
BSL - 1/2	6781	73	Estimated
BSL - 3	900	2	Architect
BSL - 3 Prep	403	1	Architect
BSL - 3 Entry	117	1	Architect
BSL - 3 Support	394	0	Architect
Gowning	121	1	Architect
Corridor	670	0	Architect
Mechanical	784	0	Architect
Electrical	151	0	Architect
Multi-purpose Lab	17484	190	Estimated
Radiation 1	323	1	Architect
Radiation 2	307	1	Architect
Shop	256	0	Architect
Toilet	61	0	Architect
Telecom	134	0	Architect
Storage	310	0	Architect

TABLE 1

Seawater Research Laboratory			
Area	Minimum Outdoor Air per Person	Minimum Outdoor Air per Square Foot	Source
Main Entrance	5	0.06	ASHRAE Standard 62.1
Observation	5	0.06	ASHRAE Standard 62.1
Building Manager's Office	5	0.06	ASHRAE Standard 62.1
Building Engineer's Office	5	0.06	ASHRAE Standard 62.1
Fax/Copy	5	0.06	ASHRAE Standard 62.1
Kitchen	5	0.06	Estimated
Conference	5	0.06	ASHRAE Standard 62.1
Exposure Lab 1	10	0.18	ASHRAE 2006 Supplement
Exposure Lab 2	10	0.18	ASHRAE 2006 Supplement
Toxicology Lab	10	0.18	ASHRAE 2006 Supplement
Coral Reef Lab	10	0.18	ASHRAE 2006 Supplement
Necropsy Lab	10	0.18	ASHRAE 2006 Supplement
Lab A	10	0.18	ASHRAE 2006 Supplement
Lab B	10	0.18	ASHRAE 2006 Supplement
Vending	--	0.06	ASHRAE Standard 62.1
Vestibule	--	0.06	ASHRAE Standard 62.1
BSL - 1/2	10	0.18	ASHRAE 2006 Supplement
BSL - 3	10	0.18	ASHRAE 2006 Supplement
BSL - 3 Prep	10	0.18	ASHRAE 2006 Supplement
BSL - 3 Entry	10	0.18	ASHRAE 2006 Supplement
BSL - 3 Support	10	0.18	ASHRAE 2006 Supplement
Gowning 1	10	0.18	ASHRAE 2006 Supplement
Gowning 2	10	0.18	ASHRAE 2006 Supplement
Corridor	--	0.06	ASHRAE Standard 62.1
Mechanical	--	0.06	Estimated
Electrical	--	0.06	ASHRAE Standard 62.1
Multi-purpose Lab	10	0.18	ASHRAE 2006 Supplement
Radiation 1	10	0.18	ASHRAE 2006 Supplement
Radiation 2	10	0.18	ASHRAE 2006 Supplement
Shop	10	0.18	ASHRAE Standard 62.1
Toilet	N/A	N/A	N/A
Telecom	--	0.06	Estimated
Storage	--	0.12	ASHRAE Standard 62.1

TABLE 2

Procedure

The ventilation rate procedure outlined in Section 6 is the basis of determining the proper ventilation of outdoor air for occupied spaces.

Variables used in the ASHRAE Standard 62.1 2004 Ventilation Rate Procedure:

A_z= *zone floor area*

P_z= *zone population*

R_a= *required outdoor airflow per square foot*

R_p= *required outdoor airflow per person*

V_{bz}= *outdoor airflow required in breathing zone*

E_z= *zone air distribution effectiveness*

V_{oz}= *required outdoor airflow to be distributed to the zone*

V_{ot}= *outdoor airflow required at the ventilation system outdoor air intake*

D= *occupant diversity – the ratio of the system population to the sum of the zone populations*

V_{ou}= *uncorrected outdoor air intake*

E_v= *system ventilation efficiency*

E_{vz}= *zone ventilation efficiency*

The following procedure was followed for checking the compliance of the VIMS Seawater Research Laboratory with the 2004 ASHRAE Standard 62.1 and 2006 Supplement:

Step 1: Properly divided and designated the building area into separate zones, based on the architectural layout and diffuser location.

Step 2: Assigned each zone an occupancy category from Table 6-1 that best matched each zone.

Step 3: Floor areas of each zone were values form the architectural drawings provided by Clark-Nexsen.

Step 4: Zone occupancies were values used from the architectural program. Zones that were unoccupied remained unoccupied, and occupancy density values were **<u>not</u>** used.

Step 5: Selected the required airflow per person, if available, from Table 6-1.

Step 6: Selected the required airflow per square foot, if available, from Table 6-1.

Step 7: Calculated breathing zone outdoor airflow using the following equation:

$$V_{bz}=R_pP_z+R_aA_z$$

Step 8: Selected the proper zone air distribution effectiveness from Table 6-2.

Step 9: Calculated the required zone outdoor airflow using the following equation:

$$V_{oz}=V_{bz}/E_z$$

Step 10: Calculated the outdoor air intake flow using the following equation:

$$V_{ot}=\sum_{all\ zones} V_{oz}$$

Step 15: Steps 1 through 14 are repeated for AHU-2.

Example Calculation (AHU-2)

Zone #1: Pre lab A_z=440 ft^2 P_z=2 people

Zone #2: Gown 1 A_z=121 ft^2 P_z=1 person

Zone #3: Gown 2 A_z=121 ft^2 P_z=1 person

Zone #4 BSL-3 A_z=1674 ft^2 P_z=1 person

For all zones Rp=10 cfm/person Ra=.18 cfm/ft^2 from Table 6-1

For all zones E_z=1.0 from Table 6-2

Zone #1:

V_{bz} = 10(2) + .18(440) = 99.2 cfm

V_{oz} = 99.2/1.0 = 99 cfm

Zone #2:

V_{bz} = 10(1) + .18(121) = 31.8 cfm

V_{oz} = 31.8/1.0 = 32 cfm

Zone #3:

V_{bz} = 10(1) + .18(121) = 31.8 cfm

V_{oz} = 31.8/1.0 = 32 cfm

Zone #4:

V_{bz} = 10(1) + .18(1674) = 311.3 cfm

V_{oz} = 311.3/1.0 = 311 cfm

V_{ot} = 99 + 32 + 32 + 311 = 474 cfm

Building Systems Summary

Overall

The VIMS Seawater Research Laboratory is divided into six major zones, each supplied with 100% outdoor air from either an air handler unit or make-up air unit. All units are variable air volume with variable frequency drives for fan speed control. Two of the major zones are supplied with separate air handlers, while the other four zones are supplied with make-up air units. All supply units are located on the roof. The total maximum supply airflow from all the units is 73705 cfm and the total minimum supply airflow from all the units is 42005 cfm. For zone layout and locations see Figures 1-6.

Air Handling Unit Schedule						
Item	Manufacturer	Type	Location	Area Served	Supply Fan	
					CFM	Min. OA CFM
AHU-1	Trane	VAV	Roof	Office & Dry Labs	18425	7215
AHU-2	Trane	VAV	Roof	BSL-3	3235	2280
MAU-1	Trane	VAV	Roof	BSL-1/2	13100	5825
MAU-2	Trane	VAV	Roof	Multi-Purpose Lab	21960	9760
MAU-3	Trane	VAV	Roof	Multi-Purpose Lab HB	9940	5440
MAU-4	Trane	VAV	Roof	Toxicology Lab	6485	3105

TABLE 3

All zones are ventilated with either a ducted or direct exhaust, with all exhaust ductwork being negatively pressurized in comparison with the surrounding air pressure in accordance with ASHRAE Standard 62.1-2004 Section 5.3. All noxious or dangerous vapors that are created in the labs are properly exhausted through filters, eliminating and potential health risks. The VIMS Chemistry Department was consulted to determine what measures that needed to be taken to minimize or remove any materials that have the potential of explosion. The following table shows the average rate of use of the most common solvents that will be used in the labs.

Monthly Average Use of Common Solvents	
Solvent	Rate of Use [L/month]
Chloroform	2
Acetonitrile	0.5
Acetone	4-5
Ether	1
Isopropanol	3
Butanol	1
Ethanol	2
Methanol	4
Methylchloride	3
Dichoroethane	0.2
Hydrochloric Acid	2
Acetic Acid	2-3
Nitric Acid	1

TABLE 4

The VIMS Seawater Research Laboratory HVAC system is controlled and monitored by DDC computer network, with controls supply fan speed of all the units, damper adjustments, humidifiers, cooling and heating coil valves, and the air to air energy recovery loop. The DDC network controls the equipment by monitoring zone air pressure and temperature, duct air temperature and pressure. These measures are taken to ensure that the indoor air quality of all the zones is safe and satisfactory by keeping the laboratory spaces negatively pressurized and the non-laboratory spaces positively pressurized.

AHU-1 (SEE APPENDIX A)

Air Handling Unit 1 supplies 18,425 cfm to the Main Entry, Observation Area, Building Manager's Office, Engineer's Office, Copy and Fax Room, Conference Room, Kitchen, Men's Toilet, Women's Toilet, Lab 115, Lab 116, Exposure Lab 1, Exposure Lab 2, Necropsy Lab, Coral Reef Lab, Service Corridor, Refrigerated Storage Wet and Dry, Shop Area, Radiation 1, Radiation 2, and Vending Area during peak load operation. This unit includes, preheat coil heated via. a 30% ethylene-glycol air to air coil energy recovery loop, from exhaust air energy. Also, included in Air Handling Unit 1 is a 500 lb/hr humidifier, heating coil, cooling coil, and supply fan. The laboratory zones supplied by this air handling unit are negatively pressurized, and the non-laboratory spaces are positively pressurized to prevent air form recirculating to other zones.

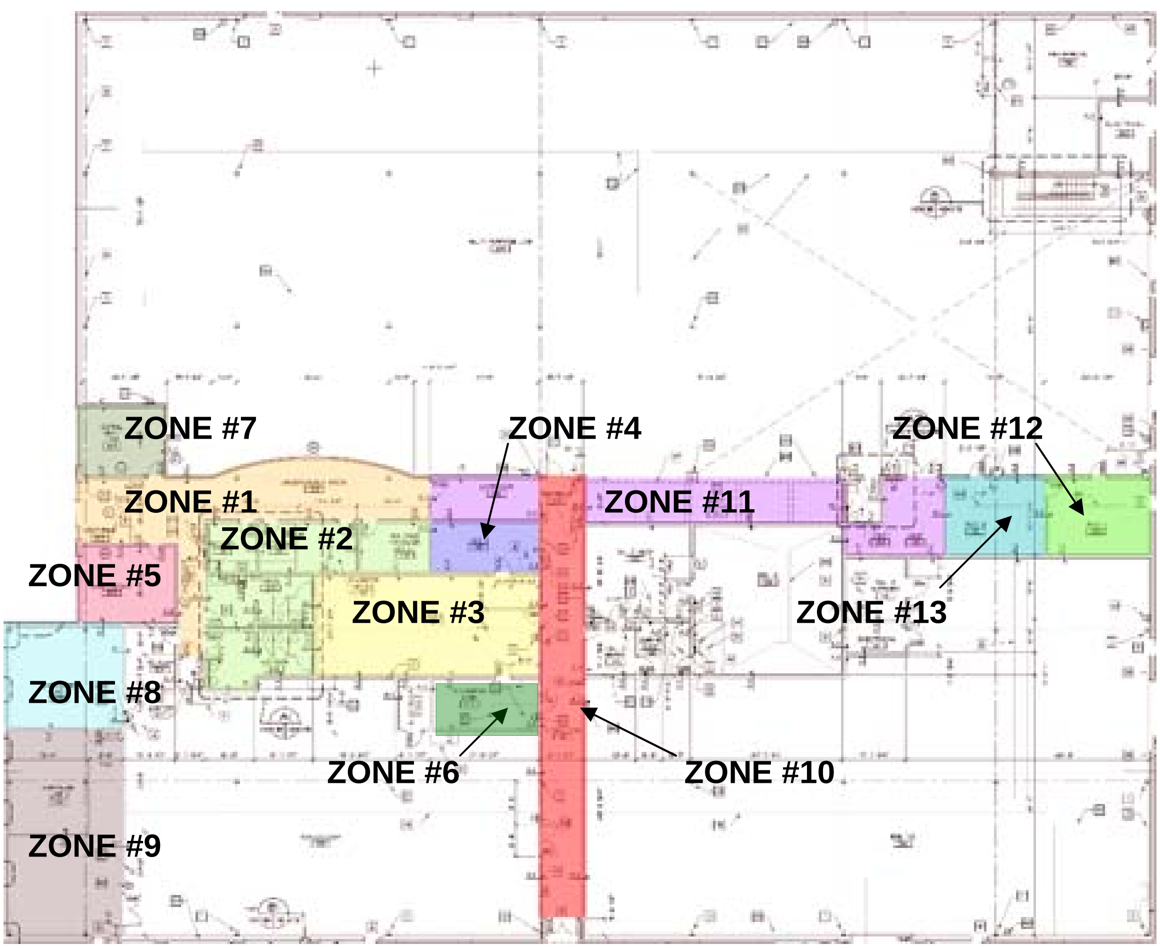

FIGURE 1

Calculations, according to The 2004 ASHRAE Standard 62.1, show that the zones supplied by AHU-1 require 1072 cfm of outdoor air which is 5% of designed airflow of 100% outdoor air. Therefore, AHU-1 does provide adequate outdoor air ventilation. The critical Z value is not relevant, for the fact that AHU-1 supplies 100% outdoor air.

AHU-2 (SEE APPENDIX B)

Air Handling Unit 2 supplies 3,295 cfm to the BSL-3 Lab, BSL-3 Prep, BSL-3 Entry, Gown 1, and Gown 2 during peak load operation. This unit includes a 88.3 lb/hr humidifier, preheat coil, heating coil, cooling coil, supply fan. All zones supplied by this air handling unit are negatively pressurized to prevent air from recirculating to other zones.

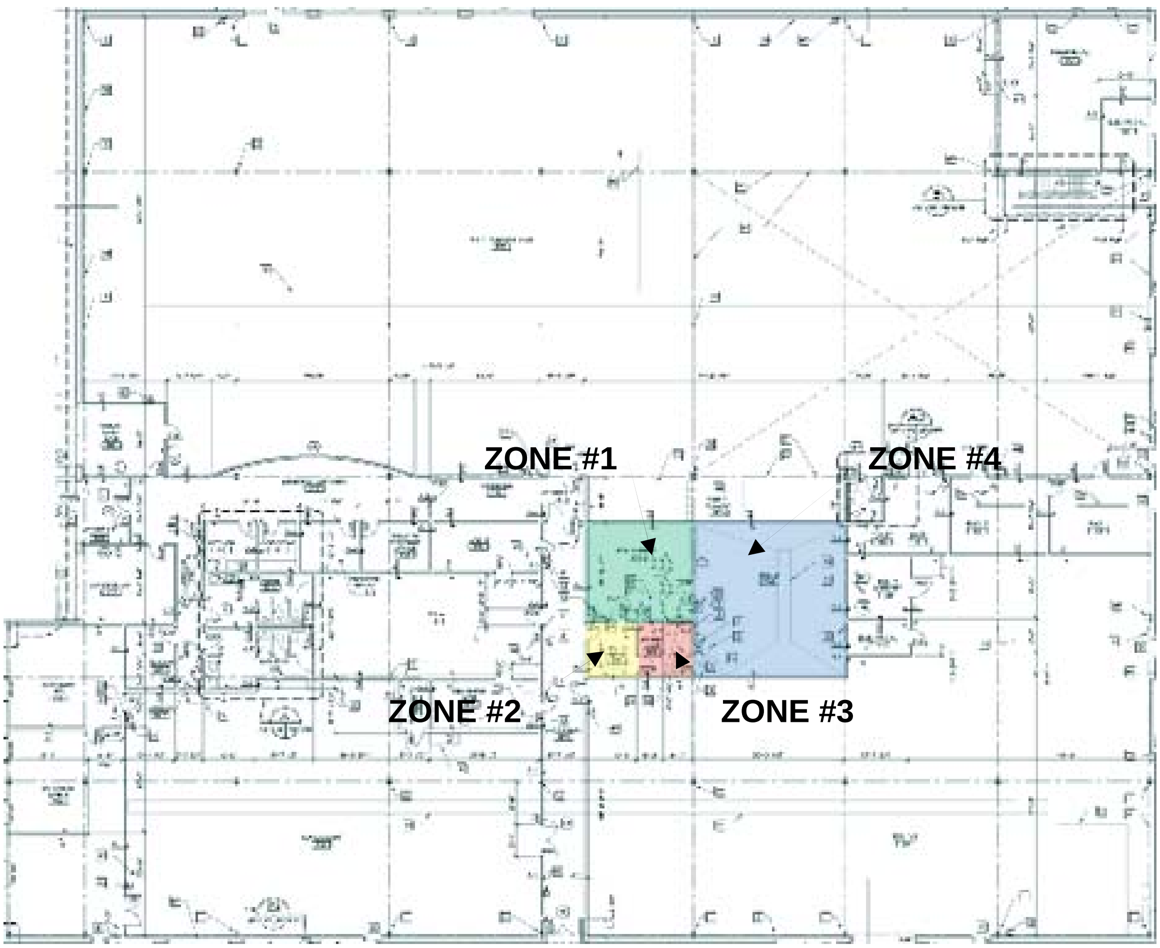

FIGURE 2

Calculations, according to The 2004 ASHRAE Standard 62.1, show that the zones supplied by AHU-2 require 474 cfm of outdoor air which is 21% of designed airflow of 100% outdoor air. Therefore, AHU-2 does provide adequate outdoor air ventilation. The critical Z value is not relevant, for the fact that AHU-2 supplies 100% outdoor air.

MAU-1 (SEE APPENDIX C)

Make-up Air Unit 1 supplies 13,100 cfm to the BSL-1/2 Lab during peak load operation. This unit includes a heating coil and supply fan. The population of this zone was estimated based on area ratios and the total amount of the remaining people from the building occupancy given by the architectural program. The zone supplied by this make-up air unit is negatively pressurized. The pressure level of the zone is controlled by an adjustable damper monitored by the building DDC system.

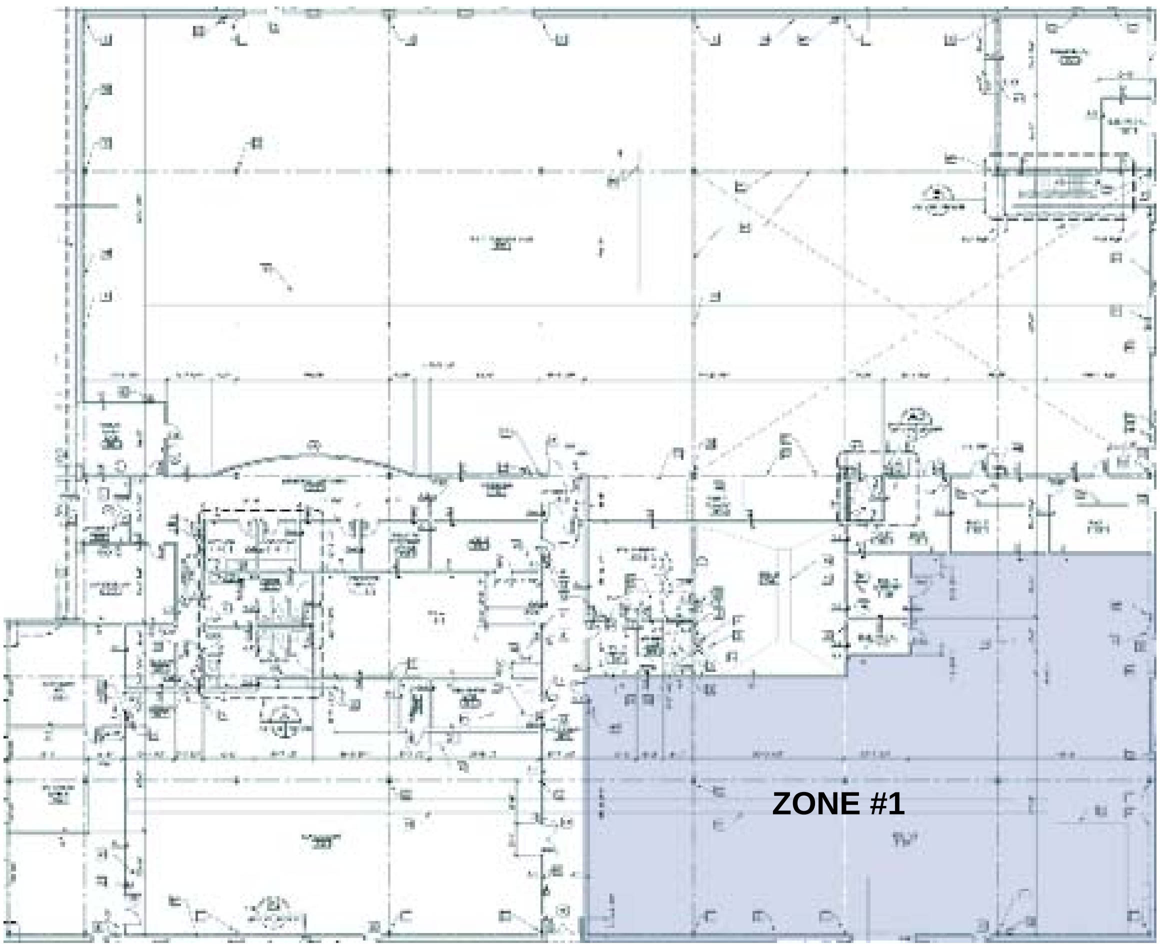

FIGURE 3

Calculations, according to The 2004 ASHRAE Standard 62.1, show that the zones supplied by MAU-1 require 1951 cfm of outdoor air which is 33% of designed airflow of 100% outdoor air. Therefore, MAU-1 does provide adequate outdoor air ventilation. The critical Z value is not relevant, for the fact that MAU-1 supplies 100% outdoor air.

MAU-2 (SEE APPENDIX D)

Make-up Air Unit 2 supplies 21,960 cfm to the Multi-purpose Lab during peak load operation. This unit includes a heating coil and supply fan. The population of this zone was estimated based on area ratios and the total amount of remaining people from the building occupancy given from the architectural program. The zone supplied by this make-up air unit is positively pressurized. The pressure level of the zone is controlled by an adjustable damper monitored by the building DDC system.

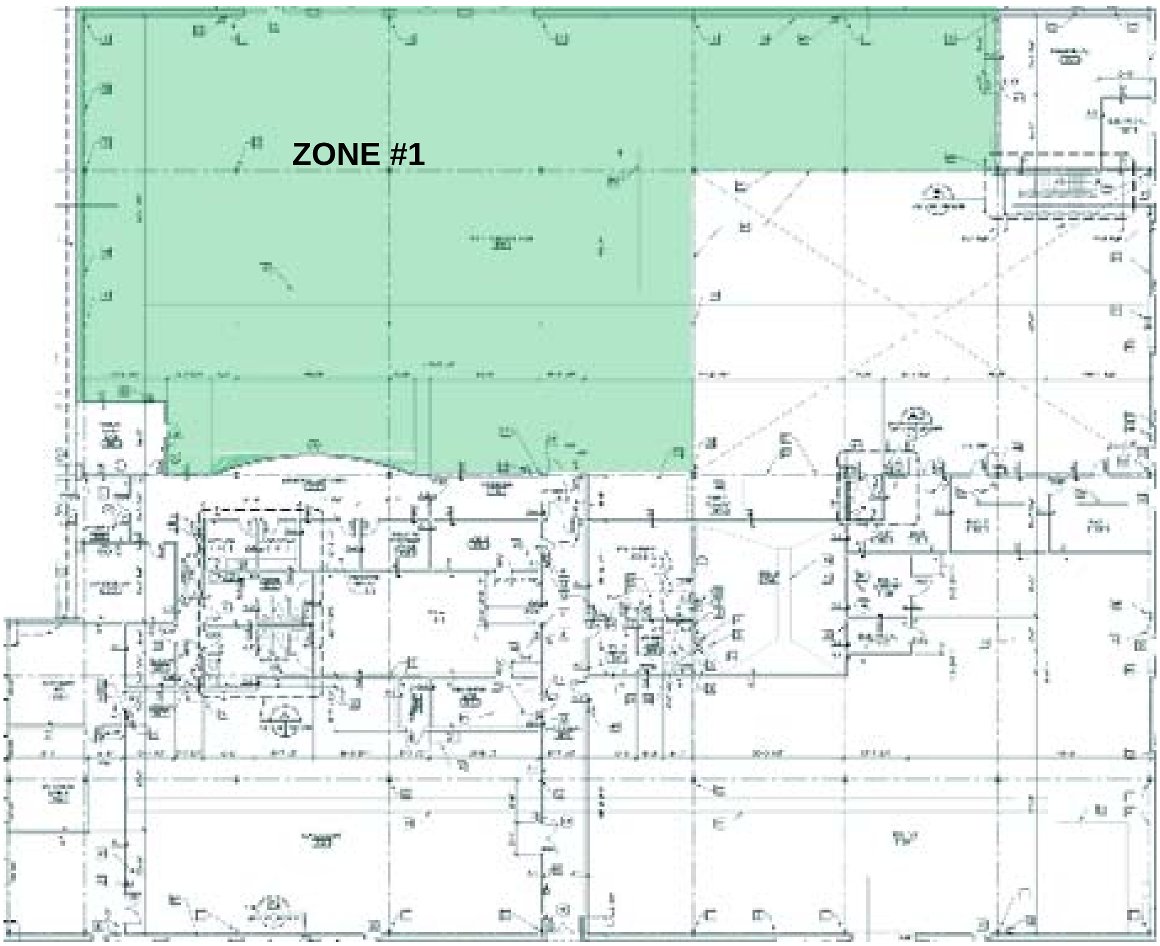

FIGURE 4

Calculations, according to The 2004 ASHRAE Standard 62.1, show that the zones supplied by MAU-2 require 5047 cfm of outdoor air which is 52% of designed airflow of 100% outdoor air. Therefore, MAU-2 does provide adequate outdoor air ventilation. The critical Z value is not relevant, for the fact that MAU-2 supplies 100% outdoor air.

MAU-3 (SEE APPENDIX E)

Make-up Air Unit 3 supplies 9,940 cfm to the High Bay above the Multi-purpose Lab. This unit includes a heating coil and supply fan. The population of this zone was estimated based on area ratios and the total amount of remaining people from the building occupancy given from the architectural program. The zone supplied by this make-up air unit is positively pressurized. The pressure level of this zone is controlled by an adjustable damper monitored by the building DDC system.

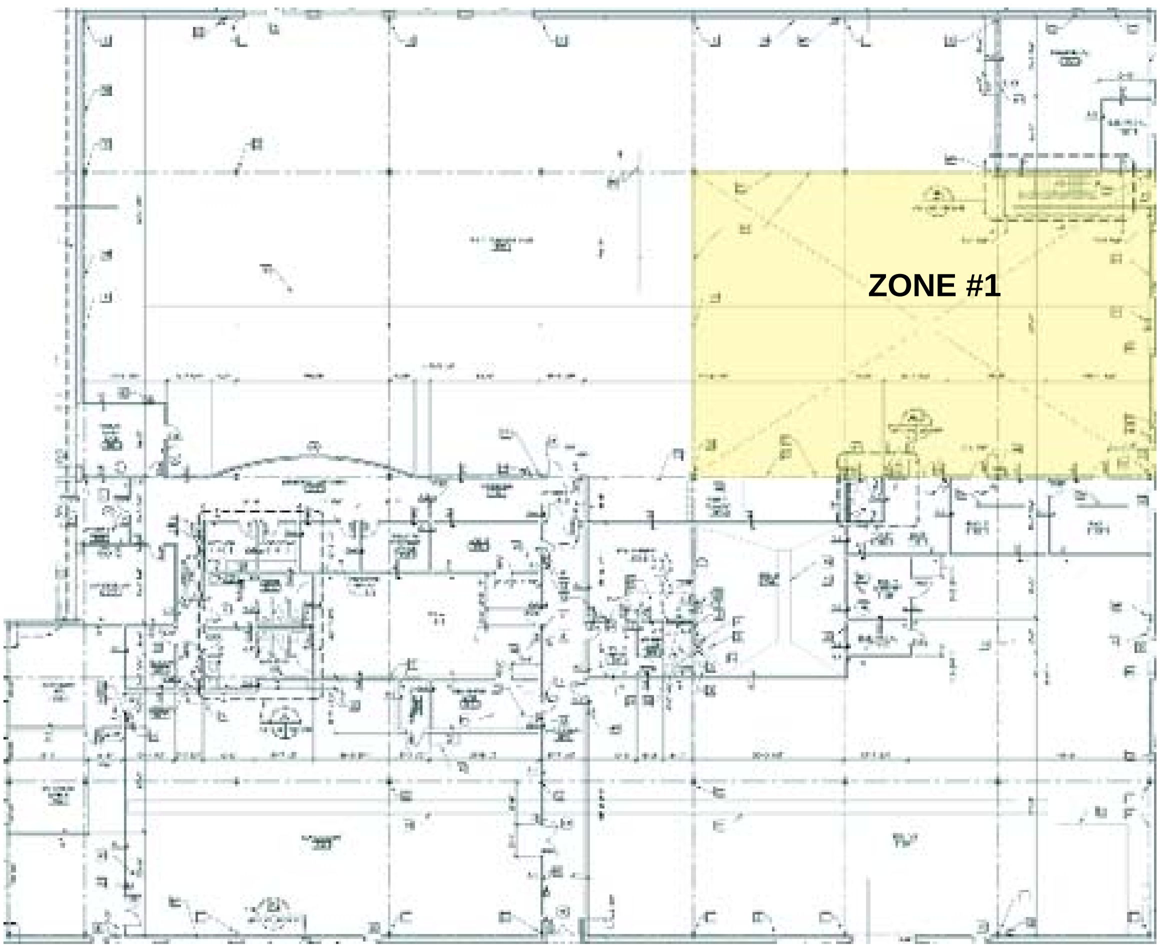

FIGURE 5

Calculations, according to The 2004 ASHRAE Standard 62.1, show that the zones supplied by MAU-3 require 398 cfm of outdoor air which is 7% of designed airflow of 100% outdoor air. Therefore, MAU-3 does provide adequate outdoor air ventilation. The critical Z value is not relevant, for the fact that MAU-3 supplies 100% outdoor air.

MAU-4 (SEE APPENDIX F)

Make-up Air Unit 4 supplies 6,985 cfm to the Toxicology Lab. This unit includes a heating coil and supply fan. The population of this zone was estimated based on area ratios and the total amount of remaining people from the building occupancy given from the architectural program. The zone supplied by this make-up air unit is positively pressurized. The pressure level of this zone is controlled by an adjustable damper monitored by the building DDC system.

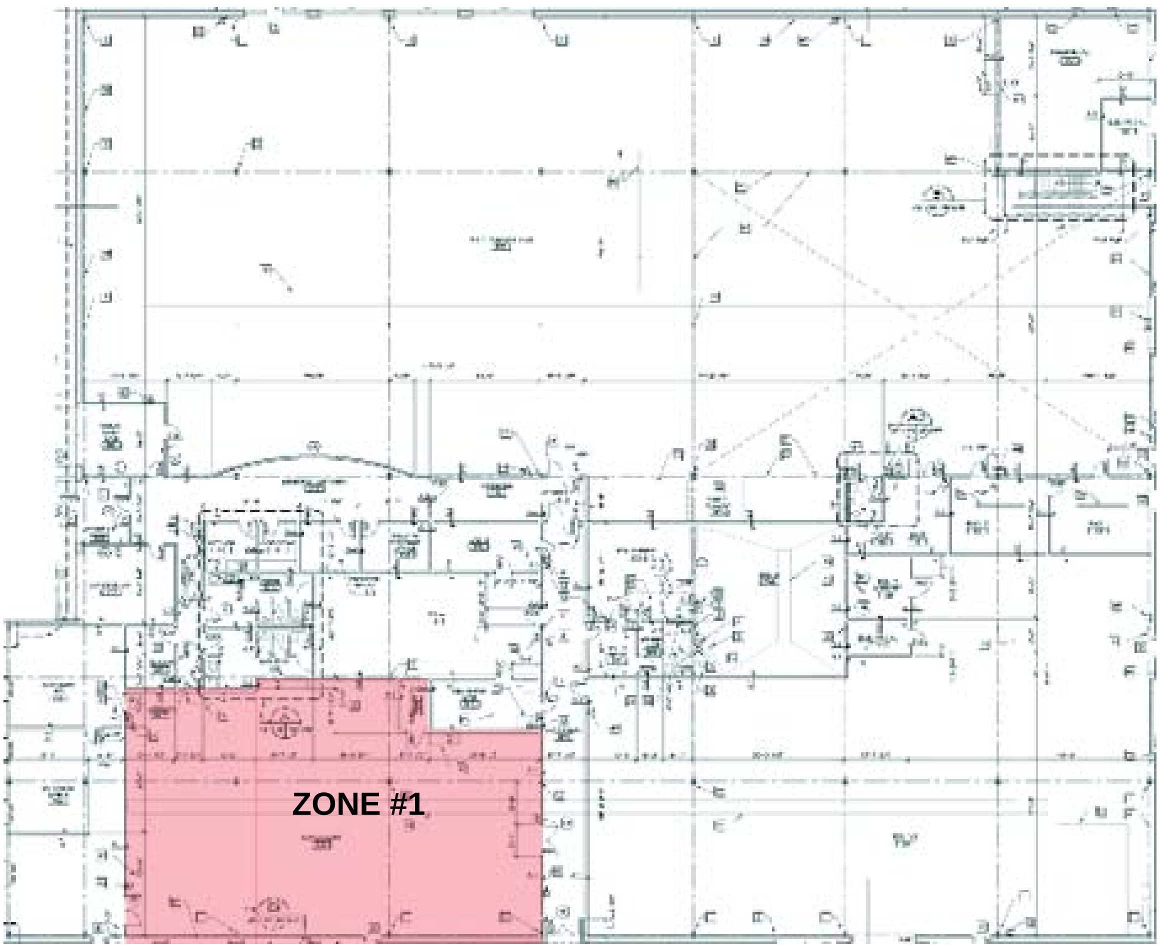

FIGURE 6

Calculations, according to The 2004 ASHRAE Standard 62.1, show that the zones supplied by MAU-4 require 1109 cfm of outdoor air which is 36% of designed airflow of 100% outdoor air. Therefore, MAU-4 does provide adequate outdoor air ventilation. The critical Z value is not relevant, for the fact that MAU-4 supplies 100% outdoor air.

CONCLUSION

As described in the Building System Summary, all six supply air units comply with The 2004 ASHRAE Standard 62.1 and The 2006 Supplement based on the stated assumptions. All units exceed the minimum outdoor air requirements and for good reasons. One reason being that there are noxious and dangerous vapors present in the labs, that in the event of a contaminant leak from one of the labs to a non-laboratory space the supply fan speed of the supply air units can be increased to contain the leak, by generating more pressure in the non-laboratory space as stated in the Building Systems Summary.

VENTILATION RATE VS. INDOOR AIR QUALITY

The Ventilation Rate Procedure, used in detail throughout this report, specifies a prescriptive method of achieving acceptable indoor air quality through air dilution and air ventilation. Through this methodology, know concentrations of harmful contaminants are to be below the levels stated by the United States Environmental Protection Agency National Air Quality Standards. The Ventilation Rate Procedure also includes an area component to dilute contaminants that are related to the floor area of a zone, and CO_2 concentrations generated by zone occupant densities.

The Indoor Air Quality Procedure, not used in the design of the VIMS Seawater Research Laboratory, is comprised of a performance methodology with a goal of obtaining acceptable indoor air quality through active control of known contaminants. The Indoor Air Quality Procedure requires measurements and subsequent suppression of known contaminants, while the Ventilation Rate Procedure can accommodate various contaminants. The Ventilation Rate Procedure does not account for specific zone contaminants such as noxious or dangerous vapor producing chemicals, where the Indoor Air Quality Procedure can prescribe a decrease of outdoor airflow to that specific zone if the contaminant levels are low enough.

The Ventilation Rate Procedure utilizes increased outdoor airflow rates to control or suppress the quantity of contaminants, while the Indoor Air Quality Procedure necessitates air cleaning and monitoring of contaminant sources. The extended monitoring of a zone under the Indoor Air Quality Procedure will create a greater cost for the equipment, initial testing, and follow testing, while the Ventilation Rate Procedure is more common and doesn't require any extra for testing and monitoring which generally leads to a lower cost. Both methods require that the minimum rates be maintained regardless of the load condition.

APPENDIX A: AHU-1

Initial Calculations for individual zones

OA rate per unit area for zone	Ra	cfm/sf
OA rate per person for zone	Rp	cfm/p
Floor Area of zone	Az	sf
Design population of zone	Pz	P
Unused OA req'd to breathing zone	Vbz	cfm
Unused OA requirement for zone	Voz	cfm

					Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Ra	cfm/sf	=			0.06	0.06	0.18	0.18	0.06	0.18
Rp	cfm/p	=			5	5	10	10	5	10
Az	sf	=			112	874	830	202	287	202
Pz	P	=			0	4	2	2	8	2
Vbz	cfm	=	Rpz Pz + Raz Az	=	6.72	72.44	169.4	56.36	57.22	56.36
Voz	cfm	=	Vbz/Ez	=	6.72	72.44	169.4	56.36	57.22	56.36

						Zone	Zone	Zone	Zone	Zone	Zone
Ra	cfm/sf	=			Zone 7	8	9	10	11	12	13
Rp	cfm/p	=			0.18	0.18	0.18	0.06	0.12	0.18	0.18
Az	sf	=			10	10	10	0	0	10	10
Pz	P	=			230	466	897	724	893	292	292
Vbz	cfm	=	Rpz Pz + Raz Az	=	2	2	2	0	0	1	1
Voz	cfm	=	Vbz/Ez	=	61.4	103.88	181.46	43.44	107.16	62.56	62.56
					61.4	103.88	181.46	43.44	107.16	62.56	62.56

Results

System Ventilation Efficiency	Ev				=	1
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm	=	Σall zones Voz	=	1041

APPENDIX B: AHU-2

Initial Calculations for individual zones

OA rate per unit area for zone	Ra	cfm/sf
OA rate per person for zone	Rp	cfm/p
Floor Area of zone	Az	sf
Design population of zone	Pz	P
Unused OA req'd to breathing zone	Vbz	cfm
Unused OA requirement for zone	Voz	cfm

Results

System Ventilation Efficiency	Ev	
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm

					Zone 1	Zone 2	Zone 3	Zone 4
Ra	cfm/sf	=			0.18	0.18	0.18	0.18
Rp	cfm/p	=			10	10	10	10
Az	sf	=			440	121	121	1674
Pz	P	=			2	1	1	1
Vbz	cfm	=	Rpz Pz + Raz Az	=	99.2	31.78	31.78	311.32
Voz	cfm	=	Vbz/Ez	=	99.2	31.78	31.78	311.32

Ev				=	1
Vot	cfm	=	Σall zones Voz	=	474.08

APPENDIX C: MAU-1

Initial Calculations for individual zones						Zone 1
OA rate per unit area for zone	Ra	cfm/sf	=			0.18
OA rate per person for zone	Rp	cfm/p	=			10
Floor Area of zone	Az	sf	=			6781
Design population of zone	Pz	P	=			73
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=	1950.58
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=	1950.58

Results						
System Ventilation Efficiency	Ev				=	1
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm	=	Σall zones Voz	=	1950.58

APPENDIX D: MAU-2

Initial Calculations for individual zones						Zone 1
OA rate per unit area for zone	Ra	cfm/sf	=			0.18
OA rate per person for zone	Rp	cfm/p	=			10
Floor Area of zone	Az	sf	=			17484
Design population of zone	Pz	P	=			190
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=	5047.12
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=	5047.12

Results						
System Ventilation Efficiency	Ev				=	1
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm	=	Σall zones Voz	=	5047.12

APPENDIX E: MAU-3

Initial Calculations for individual zones						Zone 1
OA rate per unit area for zone	Ra	cfm/sf	=			0.18
OA rate per person for zone	Rp	cfm/p	=			10
Floor Area of zone	Az	sf	=			1380
Design population of zone	Pz	P	=			15
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=	398.4
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=	398.4

Results						
System Ventilation Efficiency	Ev				=	1
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm	=	Σall zones Voz	=	398.4

APPENDIX F: MUA-4

Initial Calculations for individual zones						Zone 1
OA rate per unit area for zone	Ra	cfm/sf	=			0.18
OA rate per person for zone	Rp	cfm/p	=			10
Floor Area of zone	Az	sf	=			3830
Design population of zone	Pz	P	=			42
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=	1109.4
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=	1109.4

Results						
System Ventilation Efficiency	Ev				=	1
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm	=	∑all zones Voz	=	1109.4

WORKS CITED

2004 ASHRAE Standard 62.1. ASHRAE Incorporated. Atlanta, GA 2004.

2006 ASHRAE Standard 62.1 Supplement. ASHRAE Incorporated. Atlanta GA 2006.