Ft. Detrick Defense Medical Logistics Center

Frederick, MD

ASHRAE 62.1 Ventilation Analysis

Technical Assignment 1

Prepared for: Dr. William Bahnfleth
Prepared by: Domenica Ferraro, Mechanical Option

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Executive summary

The purpose of this report is to determine Ft. Detrick Defense Medical Logistics Center's compliance with ASHRAE 62.1-2007. First, the systems of Ft. Detrick are compared to the design requirements in Section 5. The building mostly complies, but the louvers oz/(ft^2 free area) is too large. Also, the design does not include drain pans, moisture removal devices, rain intrusion prevention, or snow entrainment.

The second part of this report applies the ventilation rate procedure found in Section 6 to the mechanical systems in Ft. Detrick. The results of this evaluation show which systems in the building supply an adequate amount of outdoor air according to the standard. Ft. Detrick is a three story office building and contains two air handling units (AHUs) on each floor and an extra emergency unit on the second floor for a total of seven units. The units are variable volume and serve multiple zones with a mixture of outdoor and return air.

The amount of outdoor air needed is controlled by the critical space. This is the zone in each system with the highest outdoor air fraction, Z_p. The highest Z_p is then used to calculate the minimum zone ventilation efficiency, E_{vz}. The sum of the nominal outdoor air intakes, $\sum V_{oz}$, is divided by this factor, thus increasing the required flow. This value is the total design outdoor air intake, V_{ot}, and is compared to the actual outdoor air intake flow to determine compliance. The actual values are from Ft. Detrick's mechanical design documents as provided by Baker and Associates. Based on assumptions made and equations and values taken from ASHRAE 62.1-2007, AHU-1 fails to comply and the other six AHUs comply.

Mechanical Design Overview

Fort Detrick Defense Medical Logistics Center is a three-story office building with a rectangular footprint on all floors. It contains six air handling units (AHU-1 through AHU-6) that are on during regular operation and one emergency air handling unit (AHU-7) that runs by generator power. All units supply a mixture of outdoor and recirculated air to multiple zones. Each floor has 2 mechanical rooms, one on the north end and one on the south end, where an air handling unit is housed. The emergency unit is on the south end of the second floor and serves the Joint Operations Command (JOC) office area if the power to AHU-4 goes out. There is a separate mechanical room located on the south end of the first floor that houses the boilers, chillers, and pumps.

All AHUs are controlled by variable frequency drives (VFDs) and distribute air through variable air volume (VAV) hot-water reheat boxes. In this design, each zone is controlled individually by adjusting the airflow. Spaces not served by the air handlers include stairwells, vestibules, mechanical rooms, communications rooms, and restrooms. Stairwells, vestibules, and mechanical rooms are heated only and are served by electric cabinet unit heaters. Communication rooms house servers and other electrical equipment. They are cooled only and are served by air conditioning units in each room. Restrooms are heated and cooled by transfer air.

The chiller plant contains two rotary screw water cooled chillers at 220 tons each, which supply AHU-1 through AHU-6 with chilled water. AHU-7 is self contained. The chillers are also controlled by VFDs on the pumps. Condenser water is evaporatively cooled via two induced draft cooling towers, each with two speed fans. Chillers and towers are linked to permit either tower to serve either chiller.

The boiler plant includes two gas-fired hot water boilers at 2160 MBH each, which provide hot water to AHU-1 through AHU-6, VAV reheat coils, and unit heaters. The hot water is distributed using a reverse return loop on each floor. The boilers have modulating burners that are each sized for 65% of the peak load. The boilers, too, are controlled by VFDs on the pumps.

Compliance with ASHRAE 62.1 Section 5

Louvers are not in the vicinity of any potential contaminants, including the parking lot, the main road, and the cooling towers. Louver controls are located in the corresponding mechanical room. According to the specifications, the louvers are designed for a maximum of 0.2 oz/(ft^2 free area), which does not meet ASHRAE's required maximum of 0.01 oz/(ft^2 free area). Also, the drawings do not show drain pans or any moisture removal device. The louvers are designed with birdscreens, but no rain intrusion prevention or snow entrainment is specified. Ventilation air from the AHU is ducted directly to VAV boxes and can be balanced by a thermostat in each zone. Once construction is completed, testing and balancing of the airflow will be performed in accordance with AABC MN-1, NEBB TABES, or SMACNA HVACTAB.

Rooms in the building that require an exhaust system are the restrooms, locker rooms, and janitor closets. These rooms are clustered together at the same location on every floor. A main vertical exhaust duct serves these spaces and is negatively pressurized. The branch on each floor converges into the vertical exhaust main which connects to an exhaust fan in the attic. After passing through the fan, the exhaust air is ducted up through a rooftop relief ventilator.

The building is designed to be resistant to mold growth and erosion per UL 181. The AHUs contain MERV 7 pre-filters and MERV 13 primary filters to ensure particulate matter removal. Both factors are in compliance with ASHRAE 62.1-2007.

Section 6 Overview and Assumptions

Compliance with ASHRAE 62.1-2007 is determined using the Ventilation Rate Calculation Procedure in Section 6. Only zones served by AHU-1 through AHU-7 are analyzed. A table of variables used in the calculation, their definitions, their units of measure, and where they are referenced in the calculation can be found in Appendix A. Spreadsheets summarizing the calculation for each AHU are in Appendix B. The critical zone for each unit is highlighted. Space characteristics including floor area, function, occupancy, and zone expected primary airflow were obtained from the design documents provided by Baker and Associates.

The zone air distribution effectiveness (E_z) is determined by using Table 6-2. Since all AHUs are configured to supply cool air above the ceiling, E_z was set at 1.0 for all calculations. The system ventilation efficiency (E_v) cannot be determined by using Table 6-3 if the maximum primary outdoor air fraction (Z_p) is greater than 0.55. Since the maximum Z_p value for AHU-1 and AHU-6 is greater than 0.55, Appendix A of ASHRAE 62.1-2007 is used to determine E_v for all AHUs to maintain consistency and accuracy. In this procedure, E_v is equal to the lowest calculated value of the zone ventilation efficiency (E_{vz}). This occurs in the same zone that has the maximum Z_p. To determine E_{vz}, Equation A-1 was used for all AHUs because they all provide ventilation air that is a mixture of outdoor air and recirculated air. In Equation A-1, the discharge outdoor air fraction (Z_d) was assumed to be equal to Z_p. The occupant diversity (D) is used to account for variations in population within a zone. This is assumed to be equal to 1.0, which means that each zone is filled to capacity all the time.

ASHRAE 62.1-2007 Compliance

To comply with ASHRAE 62.1-2007, the total design outdoor air intake (V_{ot}) obtained from the calculation in Appendix B must be less than or equal to the actual outdoor air intake. The actual outdoor air intake was taken from the air handling unit schedule in the design documents. The following table summarizes Ft. Detrick's compliance with ASHRAE 62.1-2007.

Section 6 Compliance Summary

AHU	Maximum Z_p	Nominal OA ($\sum V_{oz}$)	Total Design OA Intake (V_{ot})	OA Supplied	Comply
1	0.58	2843	4566	4460	NO
2	0.53	1733	2951	4210	YES
3	0.52	2235	3589	4975	YES
4	0.36	2092	2704	4550	YES
5	0.33	2120	2686	4670	YES
6	0.56	2584	4438	4985	YES
7	0.18	376	394	450	YES

The minimum outdoor air required for AHU-1 per ASHRAE 62.1 exceeds the actual outdoor air supplied by 106 cfm, so it is not in compliance with the standard. Note that in the ventilation rate spreadsheet for AHU-1, the critical zone is a storage room. The critical zone is where maximum Z_p and minimum E_v occur. Since a storage facility likely will not be occupied 100% of the time, the designer may have assumed that supplying that space with 58% outdoor air was not critical. Also note that out of the seven AHUs, four of the critical zones are storage spaces. It may be worth investigating if reducing the amount of outdoor airflow to the building's many storage spaces would result in an energy savings.

It is clear that Z_p (and thus E_v) has a great impact on V_{ot}. Since E_z=1.0, V_{ot} is just the total nominal outdoor air divided by E_v. In all cases, the minimum outdoor air increased.

Appendix A – Definition of Variables

Definition of Variables

Variable	Units	Definition	ASHRAE 62.1 Reference
A_z	ft^2	Room Area	-
E_v	-	System Ventilation Efficiency (use minimum E_{vz} value)	Equation A-3
E_{vz}	-	Zone Ventilation Efficiency	Equation A-1
E_z	-	Zone Air Distribution Effectiveness	Table 6-2
P_z	people	Maximum Design Occupancy	-
R_a	cfm/ft^2	Outdoor airflow rate required per unit area	Table 6-1
R_p	cfm/person	Outdoor airflow rate required per person	Table 6-1
V_{bz}	cfm	Zone outdoor airflow required in breathing zone	Equation 6-1
V_{dz}	cfm	Minimum expected discharge airflow ($V_{ps}=V_{dz}$ in this calculation)	-
V_{ps}	cfm	Total expected primary airflow ($\sum V_{pz}$, $V_{ps}=V_{dz}$ in this calculation)	-
V_{pz}	cfm	Zone expected primary airflow	-
V_{ot}	cfm	Total design outdoor air intake	Equation 6-8
V_{ou}	cfm	Total uncorrected outdoor air intake	Equation 6-6
V_{oz}	cfm	Zone (nominal) uncorrected outdoor airflow	Equation 6-2
X_s	-	Average outdoor air fraction (V_{ou}/V_{ps})	-
Z_d	-	Discharge outdoor air fraction ($Z_d=Z_p$ in this calculation)	-
Z_p	-	Primary outdoor air fraction ($Z_d=Z_p$ in this calculation)	Equation 6-5

Appendix B – Ventilation rate summaries

AHU-1 Potentially Critical Zones

Zone	Room #	Room Name	P_z	A_z	R_p	R_a	V_{bz}	E_z	V_{oz}	V_{pz}	Z_p (Z_d)	X_s	E_v	V_{ot}
1-01	134	Open Office Exterior	10	733	5	0.06	94	1	94	500	0.19	0.20	1.01	
1-02	133	Storage	0	720	0	0.12	86	1	86	150	0.58	0.20	0.62	
1-02	132	Storage	0	104	0	0.12	12	1	12	50	0.25	0.20	0.95	
1-02	131	Storage	0	197	0	0.12	24	1	24	50	0.47	0.20	0.73	
1-03	134	Open Office Exterior	5	662	5	0.06	65	1	65	750	0.09	0.20	1.11	
1-04	134	Open Office Exterior	3	465	5	0.06	43	1	43	450	0.10	0.20	1.10	
1-05	134	Open Office Exterior	4	662	5	0.06	60	1	60	700	0.09	0.20	1.11	
1-06	134	Open Office Exterior	13	1040	5	0.06	127	1	127	600	0.21	0.20	0.99	
1-06	128	Corridor	0	197	0	0.06	12	1	12	50	0.24	0.20	0.96	
1-07	135	Office Interior	1	164	5	0.06	15	1	15	100	0.15	0.20	1.05	
1-07	136	Office Interior	1	165	5	0.06	15	1	15	100	0.15	0.20	1.05	
1-08	134	Open Office Exterior	5	662	5	0.06	65	1	65	750	0.09	0.20	1.11	
1-09	134	Open Office Exterior	11	979	5	0.06	114	1	114	600	0.19	0.20	1.01	
1-10	129	Classroom	28	794	10	0.12	375	1	375	700	0.54	0.20	0.66	
1-11	107	Corridor	0	578	0	0.06	35	1	35	100	0.35	0.20	0.85	
1-11	119	File Storage	0	96	0	0.12	12	1	12	50	0.23	0.20	0.97	
1-11	120	Storage	0	96	0	0.12	12	1	12	50	0.23	0.20	0.97	
1-11	130	Storage	0	197	0	0.12	24	1	24	50	0.47	0.20	0.73	
1-11	127	File Storage	0	136	0	0.12	16	1	16	50	0.33	0.20	0.87	
1-11	122	Receiving	0	350	0	0.12	42	1	42	350	0.12	0.20	1.08	
1-12	108	Alcove	0	69	7.5	0.18	12	1	12	400	0.03	0.20	1.17	
1-12	109	Corridor	0	173	0	0.06	10	1	10	50	0.21	0.20	0.99	
1-13	113	Office Interior	1	154	5	0.06	14	1	14	100	0.14	0.20	1.06	
1-13	116	Office Interior	1	154	5	0.06	14	1	14	100	0.14	0.20	1.06	
1-14	110	Small Conference	6	114	5	0.06	37	1	37	125	0.29	0.20	0.90	
1-15	106	Large Conference	18	362	5	0.06	112	1	112	400	0.28	0.20	0.92	
1-16	106	Large Conference	18	362	5	0.06	112	1	112	400	0.28	0.20	0.92	

1-17	117	Open Office Exterior	6	931	5	0.06	86	1	86	660	0.13	0.20	1.07	
1-17	112	Storage	0	96	0	0.12	12	1	12	50	0.23	0.20	0.97	
1-17	114	Storage	0	169	0	0.12	20	1	20	50	0.41	0.20	0.79	
1-18	111	Small Conference	5	109	5	0.06	32	1	32	125	0.25	0.20	0.95	
1-19	105	Extra Large Conference	42	839	5	0.06	260	1	260	1000	0.26	0.20	0.94	
1-20	104	Large Conference	18	358	5	0.06	111	1	111	400	0.28	0.20	0.92	
1-21	105	Extra Large Conference	55	1107	5	0.06	341	1	341	1200	0.28	0.20	0.91	
1-22	104	Large Conference	18	358	5	0.06	111	1	111	400	0.28	0.20	0.92	
1-23	117	Open Office Exterior	6	1031	5	0.06	92	1	92	1200	0.08	0.20	1.12	
1-24	117	Open Office Exterior	18	1231	5	0.06	164	1	164	750	0.22	0.20	0.98	
1-25	117	Open Office Exterior	3	442	5	0.06	42	1	42	450	0.09	0.20	1.11	
1-26	118	Office Interior	1	159	5	0.06	15	1	15	250	0.06	0.20	1.14	
			297	17215			2843		2843	14310				4566
							V_{ou}			V_{ps}				

AHU-2 Potentially Critical Zones

Zone	Room #	Room Name	P_z	A_z	R_p	R_a	V_{bz}	E_z	V_{oz}	V_{pz}	Z_p (Z_d)	X_s	E_v	V_{ot}
2-01	152	Office Exterior	1	204	5	0.06	17	1	17	200	0.09	0.12	1.03	
2-02	151	Open Office Exterior	4	662	5	0.06	60	1	60	700	0.09	0.12	1.03	
2-03	153	Office Interior	1	152	5	0.06	14	1	14	100	0.14	0.12	0.98	
2-03	161	Office Interior	1	114	5	0.06	12	1	12	100	0.12	0.12	1.00	
2-03	162	Office Interior	1	140	5	0.06	13	1	13	100	0.13	0.12	0.99	
2-04	151	Open Office Interior	6	741	5	0.06	74	1	74	600	0.12	0.12	1.00	
2-04	154	Corridor	0	114	0	0.06	7	1	7	50	0.14	0.12	0.98	
2-05	141	Office Interior	1	96	5	0.06	11	1	11	100	0.11	0.12	1.01	
2-05	150	Office Interior	1	96	5	0.06	11	1	11	100	0.11	0.12	1.01	
2-06	168	Copy	1	94	5	0.06	11	1	11	325	0.03	0.12	1.09	
2-07	163	Office Interior	1	114	5	0.06	12	1	12	100	0.12	0.12	1.00	
2-07	164	Office Interior	1	135	5	0.06	13	1	13	100	0.13	0.12	0.99	
2-07	165	Office Interior	1	143	5	0.06	14	1	14	100	0.14	0.12	0.98	
2-08	101	Lobby	2	902	5	0.06	64	1	64	525	0.12	0.12	1.00	
2-09	175	Office Interior	1	140	5	0.06	13	1	13	100	0.13	0.12	0.99	
2-09	188	Office Interior	1	140	5	0.06	13	1	13	100	0.13	0.12	0.99	
2-09	189	Office Interior	1	140	5	0.06	13	1	13	100	0.13	0.12	0.99	
2-10	160	Storage	0	152	0	0.12	18	1	18	50	0.36	0.12	0.76	
2-10	166	Storage	0	333	0	0.12	40	1	40	75	0.53	0.12	0.59	
2-10	167	Storage	0	324	0	0.12	39	1	39	75	0.52	0.12	0.60	
2-11	183	Open Office Interior	4	822	5	0.06	69	1	69	800	0.09	0.12	1.03	
2-11	159	Alcove	0	100	7.5	0.18	18	1	18	400	0.05	0.12	1.08	
2-11	183	Open Office Interior	10	1279	5	0.06	127	1	127	750	0.17	0.12	0.95	
2-13	183	Open Office Interior	8	1105	5	0.06	106	1	106	630	0.17	0.12	0.95	
2-14	183	Open Office Interior	20	1324	5	0.06	179	1	179	800	0.22	0.12	0.90	
2-15	183	Open Office Interior	14	1242	5	0.06	145	1	145	800	0.18	0.12	0.94	
2-16	177	Office Exterior	1	167	5	0.06	15	1	15	300	0.05	0.12	1.07	
2-16	178	Office Exterior	1	143	5	0.06	14	1	14	175	0.08	0.12	1.04	
2-17	176	Small Conference	6	110	5	0.06	37	1	37	125	0.29	0.12	0.83	
2-18	179	Office Exterior	1	151	5	0.06	14	1	14	175	0.08	0.12	1.04	
2-18	180	Office Exterior	1	154	5	0.06	14	1	14	175	0.08	0.12	1.04	
2-18	181	Office Exterior	1	154	5	0.06	14	1	14	175	0.08	0.12	1.04	
2-19	182	Office Exterior	1	236	5	0.06	19	1	19	300	0.06	0.12	1.06	
2-20	183	Open Office Exterior	4	768	5	0.06	66	1	66	975	0.07	0.12	1.05	
2-21	183	Open Office Interior	14	1114	5	0.06	137	1	137	700	0.20	0.12	0.92	
2-22	183	Open Office Exterior	5	764	5	0.06	71	1	71	900	0.08	0.12	1.04	

2-23	183	Open Office Interior	14	1034	5	0.06	132	1	132	650	0.20	0.12	0.92	
2-24	187	Office Interior	1	101	5	0.06	11	1	11	100	0.11	0.12	1.01	
2-25	101	Lobby	2	1084	5	0.06	75	1	75	600	0.13	0.12	1.00	
2-25	102	Alcove	0	77	7.5	0.18	14	1	14	400	0.03	0.12	1.09	
2-25	103	Corridor	0	246	0	0.06	15	1	15	50	0.30	0.12	0.82	
2-26	185	Office Interior	1	140	5	0.06	13	1	13	100	0.13	0.12	0.99	
2-26	186	Office Interior	1	140	5	0.06	13	1	13	100	0.13	0.12	0.99	
2-27	184	Office Exterior	1	144	5	0.06	14	1	14	150	0.09	0.12	1.03	
2-28	155	Server	0	317	5	0.06	19	1	19	400	0.05	0.12	1.07	
			136	17852			1733		1733	14430				2951
							V_{ou}			V_{ps}				

AHU-3 Potentially Critical Zones

Zone	Room #	Room Name	P_z	A_z	R_p	R_a	V_{bz}	E_z	V_{oz}	V_{pz}	Z_p (Z_d)	X_s	E_v	V_{ot}
3-01	228	Office Interior	1	99	5	0.06	11	1	11	75	0.15	0.14	0.99	
3-01	229	Office Interior	1	114	5	0.06	12	1	12	75	0.16	0.14	0.98	
3-02	231	Open Office Interior	14	1041	5	0.06	132	1	132	800	0.17	0.14	0.97	
3-03	231	Open Office Exterior	3	461	5	0.06	43	1	43	600	0.07	0.14	1.07	
3-04	231	Open Office Exterior	6	960	5	0.06	88	1	88	1000	0.09	0.14	1.05	
3-05	231	Open Office Exterior	2	416	5	0.06	35	1	35	400	0.09	0.14	1.05	
3-06	231	Open Office Interior	15	1009	5	0.06	136	1	136	600	0.23	0.14	0.91	
3-06	225	Corridor	0	168	0	0.06	10	1	10	50	0.20	0.14	0.94	
3-07	231	Open Office Interior	3	382	5	0.06	38	1	38	200	0.19	0.14	0.95	
3-08	231	Open Office Exterior	6	960	5	0.06	88	1	88	1000	0.09	0.14	1.05	
3-09	231	Open Office Interior	15	1361	5	0.06	157	1	157	800	0.20	0.14	0.94	
3-10	250	Office Interior	1	99	5	0.06	11	1	11	75	0.15	0.14	0.99	
3-11	232	Classroom	23	661	10	0.12	309	1	309	600	0.52	0.14	0.62	
3-12	226	Storage	0	517	0	0.12	62	1	62	125	0.50	0.14	0.64	
3-13	233	File Storage	0	637	0	0.12	76	1	76	200	0.38	0.14	0.76	
3-14	206	Office Interior	1	92	5	0.06	11	1	11	75	0.14	0.14	1.00	
3-14	207	Office Interior	1	92	5	0.06	11	1	11	75	0.14	0.14	1.00	
3-14	208	Office Interior	1	92	5	0.06	11	1	11	75	0.14	0.14	1.00	
3-15	209	Office Interior	1	140	5	0.06	13	1	13	75	0.18	0.14	0.96	
3-15	210	Office Interior	1	140	5	0.06	13	1	13	75	0.18	0.14	0.96	
3-16	211	Open Office Interior	11	1210	5	0.06	128	1	128	1000	0.13	0.14	1.01	
3-17	203	Office Interior	1	132	5	0.06	13	1	13	100	0.13	0.14	1.01	
3-17	204	Office Interior	1	154	5	0.06	14	1	14	100	0.14	0.14	1.00	
3-17	205	Office Interior	1	154	5	0.06	14	1	14	100	0.14	0.14	1.00	
3-18	211	Open Office Exterior	3	576	5	0.06	50	1	50	720	0.07	0.14	1.07	
3-19	211	Open Office Exterior	4	768	5	0.06	66	1	66	960	0.07	0.14	1.07	
3-20	211	Open Office Interior	24	1902	5	0.06	234	1	234	1200	0.20	0.14	0.94	
3-21	211	Open Office Interior	14	1189	5	0.06	141	1	141	800	0.18	0.14	0.96	
3-21	221	Alcove	0	74	7.5	0.18	13	1	13	400	0.03	0.14	1.11	
3-22	211	Office Exterior	4	607	5	0.06	56	1	56	720	0.08	0.14	1.06	

3-23	211	Open Office Interior	12	1221	5	0.06	133	1	133	800	0.17	0.14	0.97	
3-24	218	Office Interior	1	97	5	0.06	11	1	11	75	0.14	0.14	0.99	
3-24	219	Office Interior	1	91	5	0.06	10	1	10	75	0.14	0.14	1.00	
3-24	220	Office Interior	1	91	5	0.06	10	1	10	75	0.14	0.14	1.00	
3-25	213	Office Exterior	1	195	5	0.06	17	1	17	150	0.11	0.14	1.03	
3-25	214	Office Exterior	1	135	5	0.06	13	1	13	135	0.10	0.14	1.04	
3-26	212	Office Exterior	1	236	5	0.06	19	1	19	300	0.06	0.14	1.07	
3-27	215	Office Exterior	1	136	5	0.06	13	1	13	135	0.10	0.14	1.04	
3-27	216	Office Exterior	1	135	5	0.06	13	1	13	135	0.10	0.14	1.04	
3-27	217	Office Exterior	1	224	5	0.06	18	1	18	225	0.08	0.14	1.06	
3-28	239	Small Conference	10	202	5	0.06	62	1	62	200	0.31	0.14	0.83	
3-29	201	Lobby	1	648	5	0.06	44	1	44	200	0.22	0.14	0.92	
3-29	238	Vending	0	71	5	0.06	4	1	4	250	0.02	0.14	1.12	
3-29	265	Copy	1	71	5	0.06	9	1	9	325	0.03	0.14	1.11	
			191	19760			2235		2235	16155				3589
							V_{ou}			V_{ps}				

AHU-4 Potentially Critical Zones

Zone	Room #	Room Name	P_z	A_z	R_p	R_a	V_{bz}	E_z	V_{oz}	V_{pz}	Z_p (Z_d)	X_s	E_v	V_{ot}
4-01	253	Storage	0	129	0	0.12	15	1	15	50	0.31	0.13	0.82	
4-01	254	Copy	1	82	5	0.06	10	1	10	200	0.05	0.13	1.08	
4-01	255	Alcove	0	172	7.5	0.18	31	1	31	400	0.08	0.13	1.06	
4-01	257	Corridor	0	279	0	0.06	17	1	17	100	0.17	0.13	0.97	
4-01	283	File Storage	0	273	0	0.12	33	1	33	100	0.33	0.13	0.81	
4-02	293	Small Conference	6	114	5	0.06	37	1	37	125	0.29	0.13	0.84	
4-03	290	Office Interior	1	137	5	0.06	13	1	13	100	0.13	0.13	1.00	
4-03	291	Office Interior	1	137	5	0.06	13	1	13	100	0.13	0.13	1.00	
4-03	292	Office Interior	1	162	5	0.06	15	1	15	100	0.15	0.13	0.99	
4-04	284	Office Exterior	1	187	5	0.06	16	1	16	175	0.09	0.13	1.04	
4-04	285	Office Exterior	1	187	5	0.06	16	1	16	275	0.06	0.13	1.07	
4-04	286	Office Exterior	1	206	5	0.06	17	1	17	180	0.10	0.13	1.04	
4-04	287	Office Exterior	1	206	5	0.06	17	1	17	275	0.06	0.13	1.07	
4-05	288	Office Exterior	1	319	5	0.06	24	1	24	360	0.07	0.13	1.07	
4-06	289	Office Exterior	1	201	5	0.06	17	1	17	200	0.09	0.13	1.05	
4-07	294	Open Office Interior	13	1824	5	0.06	174	1	174	1200	0.15	0.13	0.99	
4-08	294	Open Office Exterior	6	777	5	0.06	77	1	77	960	0.08	0.13	1.05	
4-09	294	Open Office Interior	23	1738	5	0.06	219	1	219	1200	0.18	0.13	0.95	
4-10	294	Open Office Exterior	6	960	5	0.06	88	1	88	1200	0.07	0.13	1.06	
4-11	294	Open Office Interior	19	1850	5	0.06	206	1	206	1000	0.21	0.13	0.93	
4-11	296	Storage	0	150	0	0.12	18	1	18	50	0.36	0.13	0.77	
4-12	295	Office Interior	1	93	5	0.06	11	1	11	75	0.14	0.13	0.99	
4-13	202	Medium Conference	15	305	5	0.06	93	1	93	300	0.31	0.13	0.82	
4-14	260	Conference Room	8	240	5	0.06	54	1	54	300	0.18	0.13	0.95	
4-15	261	Conference Room	8	240	5	0.06	54	1	54	300	0.18	0.13	0.95	
4-16	258	JOC Lobby	0	71	0	0.06	4	1	4	50	0.09	0.13	1.05	
4-16	259	Joint OPS / Sipernet	7	1236	5	0.06	109	1	109	775	0.14	0.13	0.99	

4-17	259	Joint OPS / Sipernet	10	1390	5	0.06	133	1	133	800	0.17	0.13	0.97	
4-18	263	Snack/Copy	1	69	7.5	0.18	20	1	20	550	0.04	0.13	1.10	
4-19	251	Open Office Exterior	7	960	5	0.06	93	1	93	1000	0.09	0.13	1.04	
4-20	251	Open Office Interior	14	1041	5	0.06	132	1	132	600	0.22	0.13	0.91	
4-21	262	Office Interior	1	140	5	0.06	13	1	13	100	0.13	0.13	1.00	
4-21	264	Office Interior	1	91	5	0.06	10	1	10	75	0.14	0.13	0.99	
4-22	251	Open Office Exterior	5	768	5	0.06	71	1	71	800	0.09	0.13	1.04	
4-23	251	Open Office Interior	17	1118	5	0.06	152	1	152	800	0.19	0.13	0.94	
4-24	251	Open Office Exterior	2	416	5	0.06	35	1	35	400	0.09	0.13	1.05	
4-25	251	Open Office Exterior	2	349	5	0.06	31	1	31	400	0.08	0.13	1.06	
			182	18617			2092		2092	15675				2704
							V_{ou}			V_{ps}				

AHU-5 Potentially Critical Zones

Zone	Room #	Room Name	P_z	A_z	R_p	R_a	V_{bz}	E_z	V_{oz}	V_{pz}	Z_p (Z_d)	X_s	E_v	V_{ot}
5-01	328	Open Office Exterior	6	775	5	0.06	77	1	77	900	0.09	0.12	1.04	
5-02	328	Open Office Interior	16	1132	5	0.06	148	1	148	900	0.16	0.12	0.96	
5-03	328	Open Office Exterior	2	396	5	0.06	34	1	34	450	0.08	0.12	1.05	
5-04	328	Open Office Exterior	4	496	5	0.06	50	1	50	600	0.08	0.12	1.04	
5-05	328	Open Office Exterior	6	973	5	0.06	88	1	88	1125	0.08	0.12	1.04	
5-06	328	Open Office Interior	12	1325	5	0.06	140	1	140	900	0.16	0.12	0.97	
5-07	328	Open Office Interior	9	952	5	0.06	102	1	102	500	0.20	0.12	0.92	
5-08	329	Storage	0	23	0	0.12	3	1	3	50	0.06	0.12	1.06	
5-08	330	File Storage	0	207	0	0.12	25	1	25	75	0.33	0.12	0.79	
5-08	331	Storage	0	42	0	0.12	5	1	5	50	0.10	0.12	1.02	
5-09	328	Open Office Interior	15	1237	5	0.06	149	1	149	900	0.17	0.12	0.95	
5-10	325	Workroom	0	370	5	0.06	22	1	22	300	0.07	0.12	1.05	
5-11	311	Small Conference	8	168	5	0.06	50	1	50	400	0.13	0.12	0.99	
5-12	304	Open Office Interior	18	1229	5	0.06	164	1	164	1000	0.16	0.12	0.96	
5-13	304	Open Office Interior	12	1224	5	0.06	133	1	133	1000	0.13	0.12	0.99	
5-14	304	Open Office Exterior	6	966	5	0.06	88	1	88	1125	0.08	0.12	1.04	
5-15	304	Open Office Interior	12	1090	5	0.06	125	1	125	1000	0.13	0.12	0.99	
5-16	304	Open Office Interior	9	1040	5	0.06	107	1	107	1000	0.11	0.12	1.01	
5-17	304	Open Office Exterior	4	662	5	0.06	60	1	60	675	0.09	0.12	1.03	
5-18	304	Open Office Interior	11	1349	5	0.06	136	1	136	1000	0.14	0.12	0.98	
5-19	304	Open Office Interior	8	1251	5	0.06	115	1	115	900	0.13	0.12	0.99	
5-19	312	Alcove	0	51	7.5	0.18	9	1	9	400	0.02	0.12	1.10	
5-20	305	Office Exterior	1	204	5	0.06	17	1	17	400	0.04	0.12	1.08	
5-21	306	Office Exterior	1	161	5	0.06	15	1	15	150	0.10	0.12	1.02	
5-21	307	Office Exterior	1	180	5	0.06	16	1	16	225	0.07	0.12	1.05	

5-22	308	Office Exterior	1	161	5	0.06	15	1	15	150	0.10	0.12	1.02	
5-22	309	Office Exterior	1	103	5	0.06	11	1	11	130	0.09	0.12	1.03	
5-22	310	Office Exterior	1	97	5	0.06	11	1	11	130	0.08	0.12	1.04	
5-24	301	Lobby	1	541	5	0.06	37	1	37	400	0.09	0.12	1.03	
5-23	337	Office Interior	1	140	5	0.06	13	1	13	100	0.13	0.12	0.99	
5-25	336	Small Conference	6	115	5	0.06	37	1	37	150	0.25	0.12	0.87	
5-26	375	Office Interior	1	88	5	0.06	10	1	10	100	0.10	0.12	1.02	
5-26	302	Office Interior	1	159	5	0.06	15	1	15	100	0.15	0.12	0.97	
5-27	303	Medium Conference	15	296	5	0.06	93	1	93	350	0.27	0.12	0.86	
			189	19203			2120		2120	17635				2686
							V_{ou}			V_{ps}				

AHU-6 Potentially Critical Zones

Zone	Room #	Room Name	P_z	A_z	R_p	R_a	V_{bz}	E_z	V_{oz}	V_{pz}	Z_p (Z_d)	X_s	E_v	V_{ot}
6-01	352	Open Office Interior	16	938	5	0.06	136	1	136	900	0.15	0.15	0.99	
6-02	352	Open Office Exterior	2	396	5	0.06	34	1	34	450	0.08	0.15	1.07	
6-03	352	Open Office Exterior	4	492	5	0.06	50	1	50	600	0.08	0.15	1.06	
6-04	352	Open Office Interior	15	1320	5	0.06	154	1	154	900	0.17	0.15	0.97	
6-05	352	Open Office Exterior	6	960	5	0.06	88	1	88	1125	0.08	0.15	1.07	
6-06	352	Open Office Exterior	6	964	5	0.06	88	1	88	1125	0.08	0.15	1.07	
6-07	352	Open Office Interior	14	1307	5	0.06	148	1	148	900	0.16	0.15	0.98	
6-08	359	File Storage	0	189	0	0.12	23	1	23	75	0.30	0.15	0.84	
6-08	361	Classroom	42	1191	10	0.12	563	1	563	1000	0.56	0.15	0.58	
6-09	362	Storage	0	35	0	0.12	4	1	4	50	0.08	0.15	1.06	
6-09	363	Copy	1	71	5	0.18	18	1	18	350	0.05	0.15	1.09	
6-10	356	Alcove	0	118	7.5	0.12	14	1	14	400	0.04	0.15	1.11	
6-10	357	File Storage	0	194	0	0.06	12	1	12	75	0.16	0.15	0.99	
6-10	358	Corridor	0	132	0	0.06	8	1	8	75	0.11	0.15	1.04	
6-11	355	Small Conference	6	122	5	0.06	37	1	37	150	0.25	0.15	0.90	
6-12	360	File Storage	0	189	0	0.12	23	1	23	75	0.30	0.15	0.84	
6-12	377	Office Interior	1	92	5	0.06	11	1	11	100	0.11	0.15	1.04	
6-12	376	Storage	0	95	0	0.12	11	1	11	50	0.23	0.15	0.92	
6-13	385	Open Office Interior	12	1288	5	0.06	137	1	137	1000	0.14	0.15	1.01	
6-14	385	Open Office Interior	16	1226	5	0.06	154	1	154	1000	0.15	0.15	0.99	
6-15	384	Office Exterior	1	231	5	0.06	19	1	19	400	0.05	0.15	1.10	
6-16	385	Open Office Exterior	4	632	5	0.06	58	1	58	675	0.09	0.15	1.06	
6-17	379	Office Exterior	1	136	5	0.06	13	1	13	175	0.08	0.15	1.07	
6-17	380	Office Exterior	1	136	5	0.06	13	1	13	175	0.08	0.15	1.07	
6-17	385	Open Office Exterior	1	189	5	0.06	16	1	16	175	0.09	0.15	1.05	
6-18	381	Office Exterior	1	136	5	0.06	13	1	13	175	0.08	0.15	1.07	
6-18	382	Office Exterior	1	136	5	0.06	13	1	13	175	0.08	0.15	1.07	

6-18	383	Office Exterior	1	136	5	0.06	13	1	13	175	0.08	0.15	1.07	
6-19	385	Open Office Interior	14	1192	5	0.06	142	1	142	750	0.19	0.15	0.96	
6-20	385	Open Office Interior	14	1272	5	0.06	146	1	146	1000	0.15	0.15	1.00	
6-21	304	Open Office Exterior	4	800	5	0.06	68	1	68	1125	0.06	0.15	1.08	
6-22	385	Open Office Interior	16	806	5	0.06	128	1	128	500	0.26	0.15	0.89	
6-23	304	Open Office Interior	14	1385	5	0.06	153	1	153	1000	0.15	0.15	0.99	
6-24	385	Open Office Exterior	6	772	5	0.06	76	1	76	900	0.08	0.15	1.06	
			220	19278			2584		2584	17800				4438
							V_{ou}			V_{ps}				

AHU-7 Potentially Critical Zones

Zone	Room #	Room Name	P_z	A_z	R_p	R_a	V_{bz}	E_z	V_{oz}	V_{pz}	Z_p (Z_d)	X_s	E_v	V_{ot}
4-14	260	Conference Room	8	240	5	0.06	54	1	54	300	0.18	0.14	0.95	
4-15	261	Conference Room	8	240	5	0.06	54	1	54	300	0.18	0.14	0.95	
4-16	258	JOC Lobby	0	71	0	0.06	4	1	4	50	0.09	0.14	1.05	
4-16	259	Joint OPS/Sipernet	7	1236	5	0.06	109	1	109	775	0.14	0.14	0.99	
4-17	259	Joint OPS/Sipernet	10	1390	5	0.06	133	1	133	800	0.17	0.14	0.97	
4-18	263	Snack/Copy	1	69	7.5	0.18	20	1	20	550	0.04	0.14	1.10	
			34	3246			376		376	2775				394
							V_{ou}			V_{ps}				