Technical Assignment 1

ASHRAE Standard 62.1

Indoor Air Quality Compliance Evaluation

CITY HOSPITAL – PHASE I
S.E. Pennsylvania

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Executive Summary

The Ventilation Rate Procedure and Indoor Air Quality described in ASHRAE Standard 62.1 is use as the basis for calculating the ventilation requirements and indoor air quality for City Hospital – Phase I. This report examines whether City Hospital – Phase I comply with ASHRAE Standard 62.1

Phase I is a 300,000 square foot state-of-the-art facility own and operate by City Hospital in southeast Pennsylvania. It houses support service, research facility, and a central utility plant in four levels with three levels below grade. The 205,000 square feet research facility has four levels with the lower three levels occupied by medical research spaces.

Medical research space accounted for 90% of the occupied zone in the building which cannot receive re-circulated air due to the threat of contamination from research spaces. Therefore the facility will be supplied with 100% outdoor air by four 100,000 air handling unites by means of variable air volume (VAV) system. In addition to indoor air quality, exhaust air filtration will be critically controlled due to the nature of research substance.

Air handling units 3 and 4 service Research Level C has been chosen for analysis. This decision was based upon the following considerations. Research Level B, C, and D share similar layout, and two air handling units with 100,000 CFM capacity serve each level.

Ventilation rates set forth by Standard 62.1 are determined for each space based on the usage, occupancy density, and square footage of these areas. After following the zone calculation procedure outlined in section 6.2.2, it was determined that air handling units are compliant with ASHRAE 62.1 – 2004 ventilation requirement. Each research level requires minimum 18,000 CFM of outdoor air and 121,800 CFM is supplied at design condition. The difference can be accounted for by assumptions made prior to analysis, and various source of exfiltration.

The study also verified that Phase I complies with Standard 62.1 Particulate Matter Removal with minimum 80% particulate filters for supply air, and 99.97% high efficiency particulate air (HEPA) filters at strategic locations. It ensured indoor air quality for occupant within the building as well as exhaust air quality.

All assumptions can be found on page 6 and all information was obtained from mechanical and architectural drawings as well as construction specifications.

Introduction

The intended purpose of ASHRAE 62.1 – 2004 is to reduce potential for adverse health effects arise from poorly designed mechanical system by specifying minimum ventilation rates and indoor air quality for occupied indoor space. This standard is applicable to all new building construction and renovation consisting of occupied indoor space. This report examines the ventilation rate and indoor air quality of City Hospital – Phase I, and verify whether the building complies with ASHRAE Standard 62.1 – 2004.

Project Background

City Hospital – Phase I is the first phase of a multiphase development. The entire project will eventually result in the construction of approximately one million square feet of research space, one million square feet of ambulatory care and clinical office space, and one million square feet of parking and support services.

Phase I is a four-level 300,000 square feet structure with three levels below grade. The building has essentially two sections. The west side of Phase I will contain a medical research facility and the east side will house a central utility plant. The research facility has a gross area of 205,000 square feet. Research Level-A accommodates a 30,000 square feet support service on street level, while the lower three levels, Research Level B, C, and D, will be fit out with state-of-the-art research spaces.

Figure 1 below shows the occupancy category breakdown for Phase I as prescribed by ASHRAE 62.1.

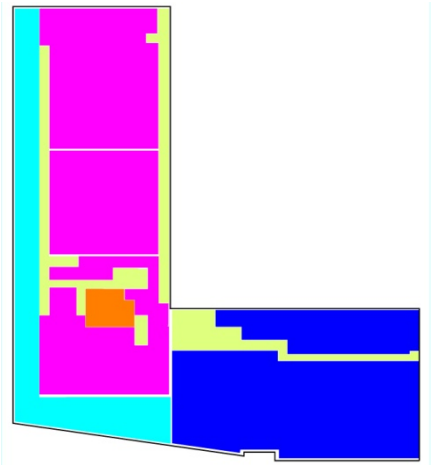

Figure 1

The three-level 95,000 square feet central utility plant is separated from the research building by a 48 foot, single-pour concrete shear wall. The central utility plant houses heating and cooling systems that will supply steam and chilled water to the research facility and well as future phases.

The challenge for a research space is to ensure that the contaminants will be contained and a highly controlled environment is achieved. Temperature must be maintained between 70°F and 74°F twenty-four hours a day, seven days a week. The mechanical system is planned to achieve proper conditions by using ceiling mounted force air distribution system.

The ventilation system for research facility comprised of four 100,000 CFM air handling units with variable frequency drives (VFD). They deliver 100% outdoor air to three of the four fit out levels via variable air volume (VAV) system. The four air handling units are demand based. Supply airflow will be cut back to 50% of design airflow when fume hoods operate at minimum sash height. The central utility plant uses two 24,000 CFM demand based makeup air units, and air conditioning units control temperature in each individual equipment room.

The chiller plant includes of one 2,000 ton steam turbine chiller and one 2,000 ton electric centrifugal chiller that produce 42°F water. These chillers provide chilled water to the air handling units, air conditioning units, as well as process chilled water loads.

The boiler plant includes four 800 horsepower duel fuel boilers with VFD that produce high pressure steam at 125 psig. The steam will be use to drive a steam turbine chiller, and provide building heating and research process loads.

The building's MEP infrastructure is expected to support Hospital's current activities as well as its future programs. Mechanical equipments will be added to the central utility plant in future phases for additional capacity. The project is expected to receive LEED Silver Certification.

Basis for Analysis

- Local outdoor air quality in southeast Pennsylvania shall be assumed acceptable for ventilation

- Smoking is not permitted on site

- Default occupancy density shall be used with actual occupant density is unknown

- Spaces that are not considered for ventilation include, but are not limited to:
  - Most mechanical equipment rooms
  - Elevator shafts
  - All Stairwells
  - Janitor closets and small storage closets

- Research C-Level has been chosen for analysis based upon the following considerations:
  - Research Levels B, C, and D are similar in configuration
  - Research Level C is completely fit out
  - Each level is serve by two 100,000 CFM air handling units with VFD

Zone Calculation

ASHRAE Standard 62.1 – 2004 Table 6 – 1 provides minimum ventilation rates for breathing zone and governs the design outdoor air requirements. Table 6 – 1 includes a list of occupancy categories and required minimum outdoor air rates per person and per square foot for those spaces.

Step One Determine the breathing zone outdoor airflow (V_{bz}) from Equation 6–1

$$V_{bz} = R_p P_z + R_a A_z$$

Where:
A_z = zone floor area: the net occupible floor area of the zone (ft^2)
R_z = zone population: the largest number of people expected to occupy the zone during typical hours
R_p = outdoor airflow rate required per person as determined from Table 6–1
R_a = outdoor airflow rate required per unit area as determined from Table 6–1

Step Two Determine the zone air distribution effectiveness (E_z) using Table 6–2

$$E_z = 1.0$$

Step Three Determine the design zone outdoor airflow (V_{oz}) from Equation 6–2:

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

Step Four Outdoor air intake flow (V_{ot}) for 100% Outdoor Air System from Equation 6–4:

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

To find the minimum outdoor air provided to each space, area of each type of space are summed. The following table illustrated space category, floor area, design occupant density, and outdoor air requirement from standard 62.1.

Space Category	R_p cfm/per	R_a cfm/sf	Occupant Density #/1000 sf	Exhaust Air cfm/sf	A_z sf	P_z people	R_p cfm	R_a cfm	V_{bz} cfm	V_{oz} cfm
Corridor	-	0.06	-	-	7,010	-	-	421	421	421
Lobby	5	2.50	10	-	1,000	10	50	2,500	2,550	2,550
Toilet	-	-	-	2	610	-	-	1,220	1,220	1,220
Locker Rm	-	-	-	0.5	720	-	-	360	360	360
Science Lab	10	0.18	25	1	31,320	783	7,830	5,638	13,468	13,468
Σ Voz										**18,018**

Indoor Air Quality

ASHRAE Standard 62.1 – 2004 Section 5.6 discuss outdoor air intake requirement. Two quantifiable parameters are studied.

Measures to Prevent Re-entry of Contaminated Air:

Air intake minimum separation distance from Table 5 – 1

Object	Minimum Distance (ft)	Approximate Distance (ft)	Standard 62.1 Compliant
Significantly contaminated exhaust	15	100	Yes
Noxious / dangerous exhaust	30	100	Yes
Vents / chimneys from combustion equipments	15	290	Yes
Garage entry, automobile loading area	15	n/a	-
Truck loading area, bus parking / idling area	25	50	Yes
Driveway, street	5	n/a	-
Thoroughfare w/ high traffic volume	25	160	Yes
Roof, landscape grade	1	2	Yes
Garbage storage / pickup area	15	35	Yes
Cooling tower intake	15	40	Yes
Cooling tower exhaust	25	40	Yes

Measures to Prevent Mold Growth:

Maximum relative humidity from Section 5.10.1

Space Type	Standard 62.1	Design		Std 62.1
	Max RH	Max RH	Min RH	Compliant
Research Type I	65	50	40	Yes
Research Type II	65	50	40	Yes
Research Type III	65	50	40	Yes
Equipment Wash	-	70	30	-

Discussion of Results

Air handler 3 & 4 service Research Level C are compliant with ASHRAE 62.1 – 2004. The two air handlers require to supply approximately 18,000 CFM. Together, they supply 121,000 CFM (Appendix A) and have a capacity of 200,000 CFM. The design ventilation rate is 6.5 times greater than the minimal outdoor airflow. Nevertheless, Z_p = 1 since 100% outdoor air is supply to each zone. The difference will be accounted by:

- Air handling units are demand based
- Airflow for indoor thermal comfort
- Makeup air for fume hood exhaust
- Exfiltration through elevator shafts
- Pressurization of mechanical distribution space

Several measurable areas of indoor air quality discussed in ASHRAE 62.1 section 5 are analyzed. The design satisfied the minimum separation for outdoor air intake to prevent contaminant re-entry, and maximum relative humidity to prevent mold growth. In addition, the building ventilation system employ minimum 80% particulate filter as well as 99.97% high efficiency particulate air (HEPA) filter at strategic locations. It satisfied ASHRAE 62.1 requirement of minimum efficiency reporting value (MERV) of 6 particulate filter, and curtail the risk of hazardous materials discharge to the outdoor.

Reference

2003 ASHRAE Handbook – HVAC Application. AHSRAE, Inc. Atlanta, GA. 2003.

ANSI/ASHRAE Standard 62.1 – 2004 – Ventilation for Acceptable Indoor Air Quality. AHSRAE, Inc. Atlanta, GA. 2004.

Appendix A

To find the total airflow for Research Level C, the design CFM of all supply variable air volume (VAV) box and their corresponding exhaust box are summed.

Box Number	Supply SV	Corresponding Exhaust EV	Corresponding Exhaust CEV
	CFM		
1	970	240	630
4	1,000	1,200	-
6	970	240	630
9	970	240	630
12	900	1,200	-
14	970	240	630
17	1,935	1,635	-
19	1,280	1,380	-
21	675	1,350	-
22	675	-	-
24	400	500	-
26	400	400	-
28	400	500	-
30	770	300	470
33	810	810	-
35	860	860	-
37	400	400	-
39	850	850	-
41	400	400	-
43	1,400	1,400	-

Box Number	Supply SV	Corresponding Exhaust EV	Corresponding Exhaust CEV
	CFM		
45	770	200	470
48	1,000	1,200	-
50	770	200	470
53	1,800	1,600	-
55	970	545	525
58	1,000	1,200	-
60	970	240	630
63	970	240	630
66	900	1,200	-
68	970	240	630
71	1,280	1,080	-
73	675	1,150	-
74	675	-	-
76	800	315	585
79	450	450	-
81	1,100	1,100	-
83	1,860	2,160	-
83A	300	-	-
85	750	750	-
87	300	300	-

Appendix A

Box Number	Supply SV	Corresponding Exhaust EV	Corresponding Exhaust CEV
	CFM		
89	525	-	-
90	475	375	-
92	1,500	-	-
92A	1,500	-	-
93	500	500	-
95	3,100	-	-
96	1,550	1,200	-
97	1,550	600	-
100	1,600	-	-
100A	2,700	-	-
101	250	150	-
103	1,200	-	-
104	1,200	-	-
105	1,200	-	-
106	200	-	-
107	3,900	-	-
108	4,400	-	-
109	900	-	-
110	1,500	-	-
111	1,800	-	-
112	1,100	-	-

Box Number	Supply SV	Corresponding Exhaust EV	Corresponding Exhaust CEV
	CFM		
113	5,400	-	-
114	600	1,200	-
115	800	-	-
117	2,500	2,500	-
119	3,200	3,200	-
121	950	320	630
124	1,100	1,200	-
126	950	320	630
129	950	340	630
132	675	675	-
133	1,100	1,200	-
135	950	320	-
138	1,280	1,380	-
140	1,800	1,100	-
142	970	240	630
145	1,100	1,200	-
147	970	240	630
3	2,200	2,400	-
152	325	125	-
154	720	920	-
156	1,300	1,500	-

Appendix A

Box Number	Supply SV	Corresponding Exhaust EV	CEV
	CFM		
158	1,100	1,200	-
160	970	240	630
163	2,200	2,400	-
165	970	240	630
168	675	775	-
170	1,800	1,200	-
172	1,280	1,380	-
174	1,100	1,200	-
175	1,020	390	630
179	200	200	-
181	1,020	390	630

Box Number	Supply SV	Corresponding Exhaust EV	CEV
	CFM		
184	1,020	390	630
187	1,100	1,200	-
189	1,020	390	630
192	600	700	-
194	1,250	1,550	-
195	970	340	630
199	1,300	1,200	-
201	1,300	1,200	-
203	970	350	630
205	2,100	2,000	-
TOTAL	**121,800**		**85,575**