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Technical Report One

ASHRAE Standard 62.1 and Standard 90.1

Evaluations

SALK HALL ADDITION

The University of Pittsburgh, Pittsburgh

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Executive Summary

The Salk Hall Addition is designed as an 81,116 square foot expansion of the existing Salk Hall laboratory. Salk Hall serves as an educational and research facility for the Department of Health Sciences, the School of Pharmacy, and the School of Dental Medicine at the University of Pittsburgh. Existing Salk hall was evaluated to determine necessary or recommended infrastructure upgrades and renovations in order to establish a program for the new building. The university re-started the design process in September 2009 after reducing the scope and budget from a larger project that was initially studied in 2008. An analysis of the addition's designed mechanical equipment and systems is contained within this report.

Following this executive summary, there is a comparison of the proposed HVAC system, designed by Ballinger, to ASHRAE Standard 62.1 (2007) and ASHRAE Standard 90.1 (2007).

Section 5 of Standard 62.1, Systems and Equipment, is evaluated in order to check for general compliance. Section 5 specifies recommendations for the mechanical systems such as appropriate ventilation controls, indoor air quality criteria, minimum particulate matter removal guidelines, as well as other key health and safety performance characteristics. It is important to keep in mind that the building program is centered on its laboratories and their support spaces.

Section 6, of ASHRAE Standard 62.1, outlines two procedures which can be used to determine whether a building is receiving the appropriate amount of ventilation air. Calculations were performed according to the Ventilation Rate Procedure. The Ventilation Rate Procedure is a prescriptive procedure in which outdoor air intake rates are determined based on space type, occupancy level, and floor area. The appropriate design characteristics of each space were determined by referencing the construction documents; specifically the HVAC ductwork drawings, mechanical equipment schedules, and airflow flow diagrams. ASHRAE standard 62.1 does not address laboratories in the detail required to maintain a safe working environment. Compliance to The University of Pittsburgh's Laboratory Design Standard was also addressed in the discussion of appropriate ventilation rates.

In addition to determining compliance with ASHRAE Standard 62.1, ASHRAE Standard 90.1 (2007), Energy Standard for Buildings except Low-Rise Residential Buildings, was also evaluated. This standard measures energy efficiency in buildings with regard to the building's envelope, HVAC systems, and lighting and electrical systems. Appendix G of Standard 90.1 outlines the procedure for determining energy savings by comparing the proposed design to a baseline building with specified equipment performance characteristics. It is necessary to follow the prescriptive requirements of Appendix G in order to meet LEED (Leadership in Energy and Environmental Design) criteria.

The Salk Hall Addition hopes to earn a LEED certification. LEED specifies that ventilation rates must be compared to those of the International Mechanical Code as well as standard 62.1 and therefore these ventilation rates have also been included in the minimum ventilation rate calculations. Equipment performance and efficiencies will need to be evaluated upon purchase and/or installation.

The Salk Hall Addition was found to meet most of the criteria of ASHRAE Standard 62.1 and 90.1. The lighting power densities of the Salk Hall Addition do not meet the criteria set in section 9 of Standard 90.1. The allowable fan power per ASHRAE Standard 90.1 is lower than the BHP of the supply fans in each of the three air handling units. The ventilation rates per each conditioned area in the building do not comply with 100% of Standard 62.1's criteria. Most of these areas are laboratory support spaces which receive transfer air from the laboratory modules. Overall, the ventilation provided is much greater than the amount of outdoor air required. The University of Pittsburgh's laboratory design airflow standard is 6 ACH occupied and 4 ACH unoccupied.

All calculations and tables can be found in Appendix A of this report.

Mechanical System Summary of the Salk Hall Addition

All occupied areas are to be served with 100% outdoor air by a system of three manifolded air handling units. Each of the units is active and was designed with enthalpy energy recovery, humidifiers, and chilled water and steam preheat coils. A set of roof-mounted high-dilution exhaust fans, with redundancy, will provide the exhaust for this system.

The system is largely a variable air volume (VAV) system that will provide heating, ventilation, and air condition throughout the building. Phoenix venturi type laboratory control valves will be use in the laboratories and their support spaces. The system will include both constant and variable volume air settings for temperature control, as well as occupied and unoccupied settings to reduce energy consumption. The building's office suites, conference rooms, and lobby areas will use commercial grade variable air volume boxes with reheat.

The Peterson Event Center (PEC) Chilled Water Plant will provide chilled water, at 42°F, to the Salk Hall Addition. A new 1200 ton chiller, primary chilled water pump, and 1100 ton cooling tower will be added to the PEC chilled water plant. A decoupling bridge and tertiary pumping system will distribute chilled water to the Salk Hall Addition's air handling units and fan coil units. A process cooling water loop, at 85°F, was incorporated with the use of plate and frame heat exchangers to serve laboratory compressors and process loads throughout the building.

Campus steam, at 175 psi, from the Carrillo Steam Plant, is used after pressure reduction at the first floor of the Salk Hall Addition to serve AHU humidifiers, steam preheat coils, and the heat exchangers used for domestic and laboratory hot water.

A new Automated Logic, Inc. building automation system (BAS) will be provided for the Salk Hall Addition project. The Salk Hall Addition BAS will communicate over The University of Pittsburgh's campus Ethernet network to existing Automated Logic BAS servers. Existing computers utilizing a standard web browser will provide access to the BAS. The BAS will consist of a peer-to-peer network of individual control and monitoring systems. The new stand-alone BAS Direct Digital Control (DDC) controllers will be provided for each of the air handling units, energy recovery wheels, exhaust fans, supply fans, steam and condensate systems, heating hot water systems, building chilled water system, process cooling water system, Phoenix variable air volume air valves, Phoenix constant air volume (CAV) air valves, commercial-grade VAV boxes, commercial-grade CAV boxes, and miscellaneous terminal units.

Summary of Compliance with ASHRAE Standard 62.1

Section 5- Systems and Equipment

The Salk Hall Addition, a mechanically ventilated system, should comply with Section 5 of Standard 62.1, specifically subsections 2-17. The system generally complies with a majority of these prescriptive requirements.

Section 5.1 Natural Ventilation

The system is not naturally ventilated and therefore requires mechanical ventilation in order to achieve a quality standard. Windows are not operable in the building.

Section 5.2 Ventilation Air Distribution

The HVAC system in the Salk Hall Addition is that of a mechanically ventilated system and therefore the following subsections are applicable.

Section 5.2.1 Designing for Air Balancing

The laboratories and the majority of their support spaces are designed with variable air volume valves in which the supply air can be adjusted based on the space requirements. The laboratory VAV system is also designed to introduce make-up air when the fume hoods or biological safety cabinets are operating. The offices and conference rooms are designed with commercial grade VAV boxes that also can vary airflow into each space. Changes in occupancy are the governing factor in office and conference ventilation airflow rates. Areas with constant volume valves are those in which ASHRAE standard 62.1 does not specifically address, or are areas whose ventilation is based purely on the square footage of the space. These spaces include restrooms, corridors, or unique laboratory support spaces such as cold rooms.

Section 5.2.2 Plenum Systems

This section addresses concerns when ceiling or floor plenums are used both to recirculate return air and to distribute ventilation air to ceiling or floor terminal units. There is no recirculated air to any of the spaces within the building. Both the supply and exhaust systems are fully ducted. Supply air is handled by three identical air handlers while the exhausted air is pulled through the total energy recovery wheels and then is discharged at the roof by the four exhaust fans.

Section 5.2.3 Documentation

Air balancing and testing throughout the building is to be required after construction is completed. Appropriate testing to satisfy minimum requirements according to national standards for measuring and balancing will be performed prior to occupancy. The design documents state minimum ventilation rates for all applicable spaces as well as offsets and pressurization differentials in spaces that are not pressure neutral.

Section 5.3 Exhaust Duct Location

It is assumed that each laboratory and the majority of its support spaces contain potentially harmful chemicals. These spaces are directly exhausted through the roof. Under experimental conditions, fume hoods and biological safety cabinets serve to protect the occupants by containing potentially harmful chemicals or biological specimen. These units are directly exhausted from the top of each unit and supply diffusers are directed away from their intakes to ensure that the contaminants are not dispersed with the room air. Below is a chart that outlines the pressure breakdown among spaces.

Room Type	Pressurization with Respect to Adjacent Areas	Comments
Offices, Conference Rooms	Positive	
Laboratories	Negative	
Lab Linear Equip. Corridors	Positive	Relative to Labs
Lab Support Rooms	Negative	
Lab Personnel Corridors	Positive	
Mechanical Rooms	Negative	
Electrical Closets and Telephone Rooms	Neutral	
Elevator Machine Rooms	N/A	
Transformer and Switchgear Rooms	Neutral	

Section 5.4 Ventilation System Controls

A new Automated Logic, Inc. building automation system (BAS) will be provided for the Salk Hall Addition project. The Salk Hall Addition BAS will communicate over The University of Pittsburgh's campus Ethernet network to existing Automated Logic BAS servers. The system will maintain minimum ventilation airflows and will supply make-up air if fume hoods or biological safety cabinets are active. There are airflow measuring stations on each supply/exhaust shaft to monitor airflows.

Section 5.5.1 Resistance to Mold Growth

All airstream surfaces in the Salk Hall addition are exempt from this section due to exception 5.5.1.

a. Ductwork: G-90 galvanized steel.
    a. Supply ductwork is externally insulated with duct wrap where ducts are concealed and with rigid duct board where ducts are exposed in non-conditioned areas.
    b. Supply and return ducts are not insulated where exposed in air conditioned spaces.
    c. Type 304 stainless steel is used for dedicated connections to fume hoods and biological safety cabinets.

Section 5.5.2 Resistance to Erosion

All airstream surfaces in the Salk Hall addition are exempt from this section due to exception 5.5.2. The ducts are made out of G-90 galvanized steel.

Section 5.6.1 Outdoor Air Intake Location

Outdoor air will be drawn through wall louvers on the north side of the building into a double-wall accessible plenum. The OA intake and exhaust discharge are perpendicular to each other. Outdoor bypass make-up air will be introduced into the exhaust plenum through a modulating control damper to maintain constant stack discharge velocity for adequate dispersion of the exhaust air contaminants. The supply intake is sufficiently far enough away to comply with this section.

Section 5.6.2 Rain Entrainment

Water that penetrates the intake opening is removed through floor drains in the double wall plenum. There are four floor drains in the outdoor air intake plenum.

Section 5.6.3 Rain Intrusion

The only outdoor air handling equipment will be the exhaust fans that will be located on the roof. There are drains under the outdoor air intakes of these fans.

This design measure doesn't explicitly comply with this section but it is clear the design intent is sound.

Section 5.6.4 Snow Entrainment

The exhaust fans are designed to be elevated 2' above the roof. This will allow for building staff to maintain the OA intake clearance even during inclement weather.

Section 5.6.5 Bird Screens

The exhaust stacks that are located on the roof each have a ¼" wire mesh screen. This is an acceptable design feature to meet this section.

Section 5.7 Local Capture of Contaminants

Fume hoods and biological safety cabinets capture local contaminants in the laboratories and laboratory support spaces. These are directly exhausted through the roof after passing through a MERV 7 filter and the enthalpy energy recovery wheels located in each air handler. Fume hood exhaust airflow rates will be based on hoods with 100 feet per minute (fpm) average face velocity with a sash open height of 18". Sash stops will be used at the fume hoods so operators know that the 18" opening has been exceeded.

Section 5.8 Combustion Air

The emergency generator on the first floor has an outdoor air intake on the west side of the building and is exhausted directly to the roof.

Section 5.9 Particulate Matter Removal

MERV (minimum efficiency reporting value) 6 filters are required upstream of all cooling coils or other devices with wetted surfaces through which air is supplied to an occupied space. MERV 7 pre-filters are located on both the supply and exhaust side of the air distribution system. MERV 14 filters are downstream of the pre-filters on the supply side.

Section 5.10.1 Relative Humidity

Occupied space relative humidity shall be designed to be limited to 65% or less at peak conditions. Occupied spaces are designed as follows:

Room Type	Summer Dry Bulb (° F)	Max. Summer Relative Humidity (%)	Winter Dry Bulb (° F)	Min. Winter Relative Humidity (%)
Offices, Meeting Rooms, Conference Rooms	72	50	72	30
Laboratories	72	60	72	30
Lab Support Rooms	72	60	72	30
Lab Personnel Corridors	72	60	72	30
Tele-data Rooms	74	50	70	30
Lab Linear Equip. Corridor	74	60	74	30

Section 5.10.2 Exfiltration

The design minimum outdoor air intakes shall be greater than the design maximum exhaust airflow when the mechanical air-conditioning system is dehumidifying. The system is 100% outdoor air and therefore meets this section’s criteria.

Section 5.11.1 Drain Pan Slope

Drain pans are found to be pitched for positive drainage and sloped appropriately to comply with this section.

Section 5.11.2 Drain Outlet

The drain pan outlets are found to be in the center and have an integral auxiliary drain connection, which drains to a primary drain source.

Section 5.11.3 Drain Seal

All drains to be sealed in accordance with this section.

Section 5.11.4 Pan Size

Drain pans for the fan coil units and cooling coils are found to fit the equipment appropriately and are made of one single sheet without joints in order to prevent leakage.

Section 5.12 Finned-Tube Coils and Heat Exchangers

The hot water heating system will consist of two shell-and-tube LPS-to-hot water heat exchangers to heat. The chilled water system includes a plate and frame heat exchanger.

Section 5.12.1 Drain Pans

Drain pans in accordance with section 5.11 have been designed to be located beneath all dehumidifying cooling coil assemblies and all condensate producing heat exchangers.

Section 5.12.2 Finned-Tube Coil Selection for Cleaning

Each air handling unit has access doors prior to any section that could require cleaning or maintenance. This includes access to the cooling coils.

Section 5.13.1 Water Quality

All water used in the HVAC system is of a potable quality.

Section 5.13.2 Obstructions

Not applicable

Section 5.14 Access for Inspection, Cleaning, and Maintenance

The following components of the ventilation system are to be considered:

1. Outdoor Air Isolation Dampers
2. Pre & Final Filter Sections
3. Enthalpy Wheels
4. Supply Air Fans
5. Steam Preheat Coils
6. Humidifiers
7. Cooling Coils
8. Chilled Water Pumps

Section 5.14.1 Equipment Clearance

Each piece of equipment listed in section 5.14 has a clearance per each manufacturer's requirements.

Section 5.14.2 Ventilation Equipment Access

Access doors have been designed to allow for maintenance on each section of the three air handling units per piece of equipment listed in section 5.14.

Section 5.14.3 Air Distribution System

Access doors or panels have been provided in order to maintain and inspect the ventilation equipment and ductwork. The location of access doors for the air handling units can be found on the air handling unit schedule. Location of access panels on the ductwork can be found on the mechanical ductwork floor plans.

Section 5.15 Building Envelope and Interior Surfaces

The architectural specifications stipulate that all joints on the exterior of the building are to be sealed and that vapor barriers are to be placed within wall constructions.

Section 5.16 Buildings with Attached Parking Garages

Not applicable

Section 5.17 Air Classification and Recirculation

Air leaving each space or location shall be designated at an expected air-quality classification not less than shown in table 6-1or table 5-2.

Section 5.17.1 Classification

The following spaces are applicable to the recommendations of Table 6-1 and Table 5-2 of ASHRAE Standard 62.1 (2007).

Space	Air Class
Laboratory Hoods	4
University Laboratory	2
Break Rooms	1
Coffee Stations	1
Conference Rooms	1
Corridors	1
Storage	1

Office Space	1
Reception Areas	1
Tele-Data	1
Main Entry Lobbies	1
Electrical Equipment Rooms	1
Lobbies	1

Section 5.17.2.1 Air Cleaning

The exhaust air in the Salk Hall Addition is filtered through a MERV 7 filter before travelling through the enthalpy recovery wheel.

Section 5.17.2.2 Energy Recovery

The majority of the exhausted air in the Salk Hall Addition is class 2. The fume hoods and biological safety cabinets are not constantly operating and therefore the volume of class 4 air will vary depending on use. All exhaust air is treated with a MERV 7 filter before entering the energy recovery wheel. None of the exhaust air is recirculated in the building.

Section 5.17.2.3 Transfer

This section stipulates that when different air classes are returned through the same exhaust system, the highest air class must be designated for the mixture. For the Salk Hall addition, if fume hoods or biological safety cabinets are in operation, the exhausted air would be class 4.

Section 5.17.3 Recirculation Limits

Not applicable

Section 5.17.4 Documentation

Since there is no recirculation of air in the Salk Hall Addition, documentation of air class is not necessary.

Summary of Compliance with ASHRAE Standard 62.1

Section 6- Ventilation Rate Procedure

Within the Salk Hall Addition, three air handling units supply the building with 87,000 CFM with the entire volume being outdoor air. By tracing the supply ductwork to the appropriate diffusers in each conditioned space, the building was assessed per the Ventilation Rate Procedure according to ASHRAE Standard 62.1.

Air Handling Units and Total Airflow Rates (CFM)	
AHU-1	29,000 (100% OA)
AHU-2	29,000 (100% OA)
AHU-3	29,000 (100% OA)

6.2.2.1 Breathing Zone Outdoor Airflow

Most of the spaces within the building are classified according to Standard 62.1 as follows:

a. University Laboratory
b. Office Space
c. Conference Room
d. Corridor
e. Telephone/Data Entry
f. Storage Rooms
g. Reception Areas
h. Main Entry Lobbies

Equation 6-1 Breathing Zone Outdoor Airflow	$V_{bz} = R_p P_z + R_a A_z$

Breathing Zone Outdoor Airflow: V_{bz}	[CFM]
Outdoor Airflow Rate Required per Person: R_p	[CFM/Person]
Zone Population: P_z	[Number of People]
Outdoor Airflow Rate Required per Unit Area: A_z	[CFM/ft^2]
Zone Floor Area: A_z	[ft^2]

This equation applies to occupied breathing zones and therefore, storage spaces, closets, trash areas, etc. are listed but not taken into account. See attached tables in Appendix 1 for listing of rooms and required minimum airflow rates. The tables compare the minimum rates of Standard 62.1 and the minimum rates of IMC 2006. The spreadsheet selects whichever has the higher rate and sets that as the minimum airflow.

6.2.2.2 Zone Air Distribution Effectiveness

The zone air distribution effectiveness is determined using Table 6-2 in the Standard. In order to use this table, air distribution configurations must be selected based on ceiling and floor supply throughout the building. Since the Salk Hall Addition only supplies air from the ceiling, the zone air distribution effectiveness (E_z) was found to be 1.0 for both cool and warm air supply.

6.2.2.4 Zone Outdoor Airflow

Based on the Breathing Zone Outdoor Airflow section and the Zone Air Distribution Effectiveness, the Zone Outdoor Airflow (V_{oz}), can be calculated based on the following equation:

Equation 6-2 Zone Outdoor Airflow	$V_{oz} = V_{bz} / E_z$

6.2.4 100% Outdoor Air Systems

When one air handler supplies only outdoor air to one or more zones, the outdoor airflow intake flow (V_{ot}) shall be determined in accordance with the following equation:

Equation 6-4 Outdoor Air Systems	$V_{ot} = \Sigma_{all\ zones} V_{oz}$

6.2.6.1 Variable Load Conditions

The ventilation system has been designed to be capable of providing the required ventilation rates in the breathing zone whenever the zones served by the system are occupied, including full and part-load conditions.

6.2.7 Dynamic Reset

One or more motion/infrared occupancy sensors will be installed to serve individual temperature-controlled zones. When a zone is determined by the sensors to be occupied, the lights of the zone will be switched on and the air system will be indexed to occupied set points. When zone is determined to be unoccupied, the lights of the zone will be switched off and the air system will be indexed to unoccupied set points. Sensors will incorporate an adjustable delay to prevent too-frequent setting changes. This adjustment to supply air is in direct correlation to the ventilation air since the HVAC system is 100% outdoor air.

6.2.8 Exhaust Ventilation

Exhaust airflows shall be provided in accordance with Table 6-4 of Standard 62.1. These rates can be found in Appendix A.

Summary of Compliance with ASHRAE Standard 90.1

Section 5- Building Envelope

Section 5.1.2.1

Separate exterior building envelope requirements are specified for each of three categories of conditioned space:

a. The Salk Hall Addition qualifies for the nonresidential conditioned standards

Section 5.1.4 Climate

The Salk Hall Addition is located in Pittsburgh, Pennsylvania. According to table B-1 in Appendix B of the 2007 Standard, the climate classification is 5A. Summer design criteria for all areas will be 91°F dry bulb (assumed coincident with the design wet bulb) and 72°F wet bulb. The winter design criteria will be 3°F dry bulb (the ASHRAE Fundamentals 0.4 / 99.6% condition for Pittsburgh Pennsylvania) and 0 pounds water per pound of air humidity ratio.

Section 5.2.1 Compliance

The Salk Hall Addition must comply with sections 5.1 General, 5.4 Mandatory Provisions, 5.7 Submittals, as well as 5.8 Product Information and Installation Requirements. The building must also comply with section 5.5 Prescriptive Building Envelope Option or section 5.6 Building Envelope Trade-Off Option. Section 5.5 was found to be the easiest method for finding compliance and was the method chosen for analyzing the building.

Section 5.5 Prescriptive Building Envelope Option

Pitt Roof
Outside Air Resistance
Finish
3/8" Felt & Membrane
6" LW Concrete
Inside Surface Resistance
U=0.05048

Pitt Zinc Wall
Outside Air Resistance
4mm Aluminum Composite
3" Insulation
Air Space Resistance
5/8" Gypsum
Inside Surface Resistance
U=-.0713

Pitt Terracotta Wall
Outside Air Resistance
Steel Siding
8" HW Concrete
3" Insulation- High Density
3/4" Plaster
Inside Surface Resistance
U=-.084

Pitt Solar Ban 60 Windows	
Shading Coefficient	0.47
U Factor	0.5
Transmissivity	0.3196

Pitt Floor
12" LW Concrete
U=0.4219

ASHRAE Standard 90.1 specifies the required the maximum U-values:

Roof:	U=0.065	**COMPLY**
Walls:	U=0.084	**COMPLY**
Floor:	U=0.052	**COMPLY**
Windows:	U=0.57	**COMPLY**

Summary of Compliance with ASHRAE Standard 90.1

Section 6- HVAC

Section 6.1 General

The Salk Hall Addition's mechanical equipment serving the HVAC system will need to comply with the requirements of section 6.2.

Section 6.2 Compliance Paths

The Salk Hall Addition will need to comply with the following sections:

1. Section 6.1 General,
2. Section 6.4 Mandatory Provisions,
3. Section 6.5 Prescriptive Path,
4. Section 6.7 Submittals.

Section 6.4 Mandatory Provisions

The supply of heating and cooling energy to each zone shall be individually controlled by thermostatic controls responding to the temperature within the zone. Enclosed offices will be controlled in groups of three, unless the office has two exposures, in which the office will have a dedicated sensor. Each laboratory support room will have its own temperature sensor. There will be a temperature sensor approximately every 1,000 ft^2 in the laboratory modules. Thermostats controllable by occupants shall be installed 48 inches above floor.

The laboratory airflow control system will be based on Phoenix Controls Analog air valves with Automated Logic BAS DDC controllers performing the laboratory airflow and laboratory temperature control. Phoenix Controls CAV air valves will be utilized for fume hood exhaust service to maintain a constant face velocity across the fume hood opening. Phoenix Controls VAV supply air valves will be utilized to supply 100% outdoor makeup air to the laboratory and will be positioned to maintain airflow based on total exhaust flow minus the room offset airflow. The supply valve will be overridden to open further upon a need for more cooling. Phoenix Controls VAV general exhaust valves will maintain the room offset when the supply air valve is overridden open to supply more cooling to the laboratory .Generally, the valve and damper actuators serving the following components will be electric:

1. Control valves and dampers of AHUs;
2. Control dampers of fans and building air intakes and discharges;
3. Larger control valves in piping, such as those serving chillers; cooling towers, and heat exchangers;
4. Smoke dampers;
5. Smaller control valves, such as those serving terminal devices like reheat coils;
6. Air valves and VAV boxes.

The Salk Hall addition design criteria stipulates that duct insulation as well as piping insulation is protected from weather elements as well as vapors found within the building due to condensation. Per the design specifications, the ducts will be sealed appropriately and any piping will be thermally insulated as well. The ducts will be tested for leakage as per the specifications and will most likely be compliant with SMACNA *HVAC Air Duct Leakage Test Manual*.

Section 6.5 Prescriptive Path

The air handling units of the Salk Hall Addition do not include either air or water-side economizers. This does not comply with section 6.5.1 of the Standard.

BASELINE FAN POWER ACCORDING TO ASHRAE STANDARD 90.1_2007

SYSTEM	Typ. AHU Fan
Baseline Fan Brake Horsepower (Max)	
where bhp less than CFMS*.0013+A	54.83327669
CFM_s	32220
A = sum of (PD × CFMD/4131)	12.94727669
where:	
CFMD = the design airflow through each applicable device from Table 6.5.3.1.1B in cfm	32220
Fully ducted return and/or exhaust air systems- 0.5 in. w.c. CREDIT	0
Return and/or exhaust airflow control devices- 0.5 in. w.c CREDIT	0
Exhaust filters, scrubbers, or other exhaust treatment - CREDIT PD at fan system design condition	0.78
Particulate Filtration Credit: MERV 9 through 12- 0.5 in. w.c. CREDIT	0
Particulate Filtration Credit: MERV 13 through 15- 0.9 in. w.c. CREDIT	0.9
Particulate Filtration Credit: MERV 16 and greater - PD at clean filter	0
Carbon and other gas-phase air cleaners- PD at clean filter	0
Heat recovery device - CREDIT PD at fan system design condition	0.83
Evaporative humidifier/cooler- CREDIT PD at fan system design condition	0
Sound Attenuation Section- 0.15 in. w.c. CREDIT	0.15
Fume Hood Exhaust Exception (required if 6.5.3.1.1 Exception (c) is taken) - DEDUCT 1.0 in wc	-1
TOTAL Adjustments = PD	**1.66**
ALLOWABLE FAN POWER (KW)	**40.88917443**

The allowable fan power according to section 6.5.3.1 of the standard is 54.8 BHP per fan. This is higher than the scheduled BHP of 51.5 and therefore the system again does not comply with the requirements of section 6.5.

While the mechanical system does not need to include an exhaust air energy recovery system due to exception 6.5.7.2, fume hoods, each air handling unit includes an energy recovery enthalpy wheel that pre-treats the outdoor air supply.

Section 6.7 Submittals

Construction documents and specifications were presented to the owner in August of 2010.

Summary of Compliance with ASHRAE Standard 90.1

Section 7- Service Water Heating

The hot water heating system will consist of two shell-and-tube low pressure steam-to-hot water heat exchangers to heat. Each heat exchanger will be sized for 100% of load. Two primary system pumps will be provided, each with variable-frequency drives (VFDs) and each sized for 100% of load. VFDs will maintain the differential, supply versus return, pressure set point in the system. One or both pumps may operate to meet capacity for optimum energy use. Multiple secondary loops will be provided for the perimeter radiation. Each loop will consist of a three way mixing valve and hot water circulator pumps. This system will be constant volume. Reheat coils and other heating equipment will be provided with modulating two-way control valves located on the return side of each coil. In "end-of-run" situations there will be a bypass or 3-way control valves to ensure circulation. Valves will modulate to maintain room temperature at its set point.

The hot water system does not include a boiler and instead uses steam supplied from the campus plant. High pressure steam at a nominal pressure of 175 psig will be supplied by the campus system to the new building to serve space heating, humidification, autoclaves, domestic hot water, and laboratory hot water. The high pressure steam will be reduced in pressure on the first floor in two stages by a parallel 1/3 – 2/3 steam pressure reducing station to 60 psig and then to 15 psig.

Summary of Compliance with ASHRAE Standard 90.1

Section 9- Lighting

The lighting will be designed to provide task and ambient light to support visual needs, comfort, and security requirements of staff, students, and visitors. The design will include accent and effect lighting to reinforce the architectural design. Lighting equipment will be selected for energy efficiency and simplified lighting maintenance to minimize operating costs.

Lighting for the typical laboratory will be designed to provide visibility for typical paper-based and electronic tasks. Ambient lighting will be provided by direct fluorescent luminaires with a small up-light component that is less than 20%. In alcove areas, recessed fixtures will be used. Under cabinet task lighting will be provided where overhead cabinets are used

Individual offices will be illuminated with recessed 1' x 4' fluorescent luminaires. Fixtures shall be supplied with two ballast luminaires with dual switching to provide in-board, out-board, and full equal to 33%, 66%, and 100%. On/Off control will be by occupancy sensors with local overrides.

Corridor lighting will be achieved through the use of fluorescent luminaires. These luminaires will light floor and/or wall surfaces to achieve both corridor illumination and overall building aesthetic. Control will be via occupancy sensors except the emergency luminaires which will provide automatic switching to emergency lighting in the case of a power failure.

The design intent was to light each space as follows:

Interior Building Areas	Footcandles	Watts / Square Foot	ASHRAE Specified Watts/Square Foot
Circulation, Commons and Corridor Are	15-20 FC	1.0	0.5
Conference Room	30-50 FC	1.5	1.3
File/Copy/Mail	30 FC	1.2	1.1
*Office	35-50 FC	1.3	1.1
Pantry	20-30 FC	1.2	0.9
Toilet Room	30 FC	1.0	0.9
*Laboratory	50-75 FC	1.6	1.4

*Laboratory and offices lighting power densities include task lighting as per IESNA standards.

References

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Appendix A

Part I: Ventilation Rate Procedure

Ventilation Rate Procedure Calculation **Minimum Outdoor Air Requirements**

Az =	Zone Floor Area	
Pz =	Zone Population	
Rp =	Outdoor airflow required per person	(ASHRAE STANDARD 62.1-2004 Table 6-1)
Ra =	Outdoor airflow required per unit area	(ASHRAE STANDARD 62.1-2004 Table 6-1)
Ez =	Zone air distribution effectiveness	(ASHRAE STANDARD 62.1-2004 Table 6-2)
Vbz =	Breathing zone outdoor airflow	Vbz = RpPz + RaAz (ASHRAE STANDARD 62.1-2004 eq. 6-1)
Voz =	Zone outdoor airflow	Voz = Vbz / Ez (ASHRAE STANDEARD 62.1-2004 eq. 6-2)
Vot =	Outdoor air intake flow	Vot = sum of Voz (ASHRAE STANDARD 62.1-2004 eq. 6-4.)
Zp =	Zone primary outdoor air fraction	(ASHRAE STANDARD 62.1-2004)
Vpz =	Zone primary airflow	(ASHRAE STANDARD 62.1-2004)

AHU-1 THRU 3 **LABORATORY SYSTEM**

MINIMUM VENTILATION RATES (COOLING)

		ASHRAE Standard 62.1-2007 (Required by LEED NC v2.2 EQp1)								IMC 2006										
Rm No.	**Rm Name**	**Area (Az)**	**P** 1000 ft2	**Pz**	**Rp**	**Ra**	**Vbz**	**Ez**	**Voz**	**P** 1000 ft2	**Rp**	**Ra**	**Voz**	**Required Minimum Ventilatio**	Provided nimum C	Difference	4 ACH	6 ACH	10 ACH	Difference (6 ACH & Minimum
100	Elevator Lobby	415				0.06	25	1	25			0.05	21	25	250	225				
101	Vestibule	290				0.06	17	1	17			0.05	15	17	250	233				
103	Conference Room	620	50	31	6	0.06	223	1	223	*		*	620	620	300	-320				
104	Vending	170	20	3	11	0.06	48	1	48					48	150	102				
110	Café Storage	175				0.12	21	1	21					21	125	104				
111	Coffee	300	20	6	11	0.06	84	1	84					84	350	266				
112	Corridor	795				0.06	48	1	48			0.05	40	48	1050	1002				
113	Mechanical	1245				0.06	75	1	75					75	100	25				
115	Security	180	5	1	5	0.06	15	1	15	*		*	25	25	50	25				
116	MDF	170	5	1	5	0.06	14	1	14				24	24	50	26				
122	General Storage	200				0.06	12	1	12					12	150	138				
124	W	150	5	1	5	0.06	13	1	13				21	21	250	229				
125	M	150	5	1	5	0.06	13	1	13				21	21	250	229				
E-1	Existing 4th Floor Area	630				0.06	38	1	38					38	1050	1012				
200	Elevator Lobby	130				0.06	8	1	8			0.05	7	8	300	292				
204	Tele-Data	175	60	11	6	0.06	74	1	74				0	74	375	302				
205	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
206	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
207	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
208	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
209	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
210	Admin	360		1	5	0.06	27	1	27	7	20		50	50	275	225				
212	Office	130		3	5	0.06	23	1	23	7	20		18	23	60	37				
213	Office	130		3	5	0.06	23	1	23	7	20		18	23	60	37				
214	Conference Room	300	50	15	6	0.06	108	1	108	50	20		300	300	175	-125				
215	Corridor	350				0.06	21	1	21			0.05	18	21	290	269				
215B	Passage	200				0.06	12	1	12			0.05	10	12	640	628				
217	M. Restroom	150						1		*	*		225	225	250	25				
218	W. Restroom	150						1		*	*	*	225	225	250	25				
221	Break Room	595	25	15	10	0.06	184	1	184				0	184	550	366				
222	East Laboratory Control Zone, Lockers, Equipment Alcove, Fume Hood Alcove	3260	25	82	17	0.18	1972	1	1972				0	1972	3730	1758	2173	3260	5433	470
222C	GLP Lab	200	25	5	17	0.18	121	1	121				0	121	35	-86	120	180	300	-145
222D	Tissue Culture Alcove	95	25	2	17	0.18	57	1	57				0	57	35	-22	57	85.5	142.5	-50.5
222G	Cold Room	80						1					0	0	50	50				
222H	Dark Room	60						1					0	0	35	35				
222J	Virus Lab	100	25	3	17	0.18	61	1	61				0	61	35	-26	60	90	150	-55
223	West Laboratory Control Zone, Lockers, Protien Lab	3140	25	79	17	0.18	1900	1	1900				0	1900	3940	2040	2093	3140	5233	800
223B	Tissue Culture Alcove	210	25	5	17	0.18	127	1	127				0	127	35	-92	126	189	315	-154
223C	Microscopy Alcove	75	25	2	17	0.18	45	1	45				0	45	350	305	45	67.5	112.5	282.5
223F	Enviornmental Room	80						1					0	0	50	50	48	72	120	-22
223G	Mass Spec Lab	400	25	10	17	0.1818	243	1	243				0	243	160	-83	240	360	600	-200
224	Equipment Corridor	680				0.06	41	1	41			0.05	34	41	755	714				
224A	Glasswash	145						1					0	0	35	35				
225	Equipment Corridor	800				0.06	48	1	48			0.05	40	48	600	552				
2**	Commons	1910	150	287	5	0.06	1547	1	1547				0	1547	2000	453				
300	Elevator Lobby	130				0.06	8	1	8			0.05	7	8	300	292				
304	Tele-Data	175	60	11	6	0.06	74	1	74				0	74	375	302				
305	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
306	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
307	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
308	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
309	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
310	Admin	360		1	5	0.06	27	1	27	7	20		50	50	275	225				
312	Office	130		3	5	0.06	23	1	23	7	20		18	23	60	37				
313	Office	130		3	5	0.06	23	1	23	7	20		18	23	60	37				
314	Conference Room	300	50	15	6	0.06	108	1	108	50	20		300	300	175	-125				
315	Corridor	350				0.06	21	1	21			0.05	18	21	290	269				
317	M. Restroom	150						1		*	*		225	225	250	25				
318	W. Restroom	150						1		*	*		225	225	250	25				
321	Break Room	595	25	15	10	0.06	184	1	184				0	184	550	366				
322	East Laboratory Control Zone, Lockers, Equipment Alcove, Fume Hood Alcove	3300	25	83	17	0.18	1997	1	1997				0	1997	3935	1939	2200	3300	5500	635
322C	Tissue Culture	190	25	5	17	0.18	115	1	115				0	115	550	435	114	171	285	379
324A	Glasswash	145						1					0	0	35	35				
322D	Animal Surgery	95	25	2	17	0.18	57	1	57				0	57	35	-22	57	85.5	142.5	-50.5
322E	Microscopy Lab	190	25	5	17	0.18	115	1	115				0	115	35	-80	114	171	285	-136
322G	Cold Room	80						1					0	0	50	50				
322H	Dark Room	60						1					0	0	35	35				
322J	Histology Alcove	100	25	3	17	0.18	61	1	61				0	61	390	330	60	90	150	300
323	West Laboratory Control Zone, Lockers	3350	25	84	17	0.18	2027	1	2027				0	2027	4550	2523	2233	3350	5583	1200
323B	Tissue Culture	200	25	5	17	0.18	121	1	121				0	121	590	469	120	180	300	410
323C	Microscopy Alcove	75	25	2	17	0.18	45	1	45				0	45	35	-10	45	67.5	112.5	-32.5
323D	Animal Surgery	100	25	3	17	0.18	61	1	61				0	61	35	-26	60	90	150	-55
323F	Enviornmental Room	80						1					0	0	50	50	48	72	120	-22
323G	Equipment Room	190				0.06	11	1	11				0	11	35	24	114	171	285	-136
323H	Radio Isotope Lab	200	25	5	17	0.18	121	1	121				0	121	425	304	120	180	300	245
324	Equipment Corridor	665				0.06	40	1	40			0.05	33	40	755	715				
325	Equipment Corridor	800				0.06	48	1	48			0.05	40	48	600	552				
400	Elevator Lobby	130				0.06	8	1	8			0.05	7	8	300	292				
404	Tele-Data	175	60	11	6	0.06	74	1	74				0	74	375	302				
405	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
406	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
407	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
408	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
409	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
410	Admin	360		1	5	0.06	27	1	27	7	20		50	50	275	225				
412	Office	130		3	5	0.06	23	1	23	7	20		18	23	60	37				
413	Office	130		3	5	0.06	23	1	23	7	20		18	23	60	37				
414	Conference Room	300	50	15	6	0.06	108	1	108	50	20		300	300	175	-125				
415	Corridor	350		0		0.06	21	1	21			0.05	18	21	290	269				
417	M. Restroom	150						1		*	*		225	225	250	25				
418	W. Restroom	150						1		*	*		225	225	250	25				
421	Break Room	595	25	15	10	0.06	184	1	184				0	184	550	366				
422	East Laboratory Control Zone, Lockers, Equipment Alcove, Fume Hood Alcove	3300	25	83	17	0.18	1997	1	1997				0	1997	3770	1774	2200	3300	5500	470
422C	Procedure Rm	190	25	5	17	0.18	115	1	115				0	115	35	-80	114	171	285	-136
422D	Procedure Rm	95	25	2	17	0.18	57	1	57				0	57	35	-22	57	85.5	142.5	-50.5
422G	Cold Room	80						1					0	0	50	50				

422H	Dark Room	60						1					0	0	35	35				
422J	Procedure Rm	100	25	3	17	0.18	61	1	61				0	61	35	-26	60	90	150	-55
423	West Laboratory Control Zone, Lockers, Fume Hood Alcove	3350	25	84	17	0.18	2027	1	2027				0	2027	4350	2323	2233	3350	5583	1000
423B	Procedure Rm	200	25	5	17	0.18	121	1	121				0	121	35	-86	120	180	300	-145
423C	Microscopy	75	25	2	17	0.18	45	1	45				0	45	35	-10	45	67.5	112.5	-32.5
423F	Enviornmental Room	80						1					0	0	50	50				
423G	Equipment Room	190				0.06	11	1	11				0	11	35	24	114	171	285	-136
423H	Procedure Rm	190	25	5	17	0.18	115	1	115				0	115	50	-65	114	171	285	-121
424	Equipment Corridor	665				0.06	40	1	40			0.05	33	40	755	715				
424A	Glasswash	145						1					0	0	35	35				
425	Equipment Corridor	800				0.06	48	1	48			0.05	40	48	600	552				
500	Elevator Lobby	130				0.06	8	1	8			0.05	7	8	300	292				
504	Tele-Data	175	60	11	6	0.06	74	1	74				0	74	375	302				
505	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
506	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
507	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
508	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
509	Office	125		3	5	0.06	23	1	23	7	20		18	23	60	38				
510	Admin	360		1	5	0.06	27	1	27	7	20		50	50	275	225				
512	Office	130		3	5	0.06	23	1	23	7	20		18	23	60	37				
513	Office	130		3	5	0.06	23	1	23	7	20		18	23	60	37				
514	Conference Room	300	50	15	6	0.06	108	1	108	50	20		300	300	175	-125				
515	Corridor	350				0.06	21	1	21			0.05	18	21	290	269				
517	M. Restroom	150						1		*	*		225	225	250	25				
518	W. Restroom	150						1		*	*		225	225	250	25				
521	Break Room	595	25	15	10	0.06	184	1	184				0	184	550	366				
522	East Laboratory Control Zone, Lockers, Equipment Alcove, Fume Hood Alcove	3300	25	83	17	0.18	1997	1	1997				0	1997	3520	1524	2200	3300	5500	220
522C	Procedure Room	190	25	5	17	0.18	115	1	115				0	115	35	-80	114	171	285	-136
522D	Histology Alcove	120	25	3	17	0.18	73	1	73				0	73	35	-38	72	108	180	-73
522G	Cold Room	80						1					0	0	50	50				
522H	Hot Lab	60						1					0	0	35	35				
522J	Microscopy Lab	100	25	3	17	0.18	61	1	61				0	61	35	-26	60	90	150	-55
523	West Laboratory Control Zone, Lockers, Fume Hood Alcove	3350	25	84	17	0.18	2027	1	2027				0	2027	4350	2323	2233	3350	5583	1000
523B	Procedure Room	150	25	4	17	0.18	91	1	91				0	91	65	-26	90	135	225	-70
523C	Alcove	75	25	2	17	0.18	45	1	45				0	45	35	-10	45	67.5	112.5	-32.5
523F	Enviornmental Room	80						1					0	0	50	50	48	72	120	-22
523G	Equipment Room	190				0.06	11	1	11				0	11	200	189	114	171	285	29
523H	Procedure Room	190	25	5	17	0.18	115	1	115				0	115	35	-80	114	171	285	-136
524	Equipment Corridor	665				0.06	40	1	40			0.05	33	40	755	715				
524A	Glass Wash	145						1					0	0	35	35				
525	Equipment Corridor	680				0.06	41	1	41			0.05	34	41	600	559				

For 100% OA systems	Vot = Sum of Voz	Vot =	23207 cfm
	AHU-1 Thru 3 Min Supply cfm		48615 cfm

MINIMUM EXHAUST RATES PER TABLE 6-4		Area (ft^2)	# Units	Required Exhaust Rate cfm/ft^2	Required Exhaust Rate cfm/unit	Required Mini Exhaust Ra	ded Mini haust Ra	Difference
106	Recycling	52		1.00		52	150	98
107	Biological Waste	52		1.00		52	150	98
113	Chemical Wate	52		1.00		52	300	248
114	RA Waste	40		1.00		40	150	110
124	Women's Restroom	150	3		50	150	400	250
125	Men's Restroom	150	3		50	150	400	250
210	Admin	360		0.50		180	250	70
216	Janitor's Closet	31		1.00		31	75	44
217	Men's Restroom	150	3		50	150	350	200
218	Women's Restroom	150	3		50	150	350	200
222	East Laboratory Control Zone, Lockers, Equipment Alcove, Fume Hood Alcove	3260		1.00		3260	2320	-940
222C	GLP Lab	200		1.00		200	235	35
222D	Tissue Culture Alcove	95		1.00		95	235	140
222H	Dark Room	60		1.00		60	135	75
222J	Virus Lab	100		1.00		100	235	135
223	West Laboratory Control Zone, Lockers, Protien Lab	3140		1.00		3140	2420	-720
223B	Tissue Culture	208		1.00		208	235	27
223C	Microscopy Alcove	75		1.00		75	550	475
223G	Mass Spec Lab	400		1.00		400	360	-40
310	Admin	360		0.50		180	250	70
316	Janitor's Closet	31		1.00		31	75	44
317	Men's Restroom	150	3		50	150	350	200
318	Women's Restroom	150	3		50	150	350	200
322	East Laboratory Control Zone, Lockers, Equipment Alcove, Fume Hood Alcove	3300		1.00		3300	1885	-1415
322C	Tissue Culture	190		1.00		190	750	560
322D	Animal Surgery	95		1.00		95	235	140
322E	Microscopy	190		1.00		190	235	45
322H	Dark Room	60		1.00		60	1355	1295
322J	Histology Lab	100		1.00		100	590	490
323	West Laboratory Control Zone, Lockers	3350		1.00		3350	1370	-1980
323B	Tissue Culture	200		1.00		200	790	590
323C	Microscopy	75		1.00		75	235	160
323D	Animal Surgery	100		1.00		100	235	135
323H	Radio Isotope Lab	200		1.00		200	90	-110
410	Admin	360		0.50		180	250	70
416	Janitor's Closet	31		1.00		31	75	44
417	Men's Restroom	150	3		50	150	350	200
418	Women's Restroom	150	3		50	150	350	200
422	East Laboratory Control Zone, Lockers, Equipment Alcove, Fume Hood Alcove	3300		1.00		3300	2070	-1230
422C	Procedure Room	190		1.00		190	235	45
422D	Procedure Room	95		1.00		95	135	40
422H	Dark Room	60		1.00		60	135	75
422J	Procedure Room	100		1.00		100	235	135
423	West Laboratory Control Zone, Lockers, Fume Hood Alcove	3350		1.00		3350	1360	-1990
423B	Procedure Room	200		1.00		200	235	35
423C	Microscopy Alcove	75		1.00		75	235	160
423H	Procedure Room	190		1.00		190	250	60
510	Admin	360		0.50		180	250	70
516	Janitor's Closet	31		1.00		31	75	44
517	Men's Restroom	150	3		50	150	350	200
518	Women's Restroom	150	3		50	150	350	200
522	East Laboratory Control Zone, Lockers, Equipment Alcove, Fume Hood Alcove	3300		1.00		3300	1760	-1540
522C	Procedure Room	190		1.00		190	235	45
522D	Histology	120		1.00		120	235	115
522J	Microscopy	100		1.00		100	235	135
523	West Laboratory Control Zone, Lockers, Fume Hood Alcove	3350		1.00		3350	1875	-1475

523B	Procedure Room	150		1.00				150	265	115
523C	Alcove	75		1.00				75	235	160
523H	Procedure Room	190		1.00				190	235	45