MONGOMERY COLLEGE

ASHRAE Standard 62.1 and 90.1 Compliance

TECHNICAL ASSIGNMENT 1

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EXECUTIVE SUMMARY

Montgomery College New Science Center is a direct expansion to the East Science Center, located in Rockville Maryland. Each floor contains laboratories, classrooms, and offices. The new, bigger laboratories will allow the professors to conduct experiments they were unable to perform before and increasing the class size at the same time. In order to ensure quality of design ASHRAE Standards 62.1 and 90.1 -2007 were evaluated for compliance.

ASHRAE Standard 62.1-2007 sets the minimum ventilation rates and equipment requirements in order to prevent mold growth, re-entry of contaminants, and particulate filtration, promoting indoor air quality and a health environment for the predicted future occupants. Ensuring the New Science Center is properly ventilated is essential to providing a healthy and safe environment for the students and faculty that occupy the building. Ventilating the laboratories' contaminants is of highest importance when evaluating this standard. Laboratories are used for various experiments where chemicals, combustion, and other contaminants will pollute the air if the ventilation design does not meet standards.

ASHRAE Standard 90.1-2007 is used to establish minimum requirements for energy efficient design. Both building envelope and systems are assessed with this standard. Today energy consumption is becoming more and more of an issue and concern. Designing the building envelope properly reduces the thermal load by reducing infiltration, exfiltration, solar heat gain, and moisture therefore reducing the energy consumption on the building. Equipment efficiencies are also evaluated to meet minimum requirements. Increasing equipment efficiencies will adversely decrease the energy needed to power the heating, ventilation, and air-conditioning systems of the building.

The New Science Center is located in a mixed- humid environment increasing the complexity of the HVAC system. Both ASHRAE Standard 62.1 and 90.1 -2007 pertain to humid environments. Mold growth will need to be prevented by entry into the building (ASHRAE 90.1), equipment resistance, and exhaust systems (ASHRAE 62.1-2007).

In order to ensure compliance with ASHRAE Standard 62.1-2007, ventilation calculations were completed for each space based on the occupancy, space type, and area. Checking compliance with ASHRAE Standard 90.1-2007, was completed by conducting specification and drawing checks, lighting power density calculations and take-offs, and minor efficiency calculations.

The New Science Center compliance evaluation revealed lack of detail leading to uncertain compliance, potential infiltration problems. Many of the items were found to comply with the standards and in some instances surpass the suggested requirements.

MECHANICAL SYSTEM DESIGN

The mechanical system consists of a central air handling system, central chilled water system, a central hot water system, and a laboratory exhaust system. The central air handling system consists of two custom air handling units located on the roof. The units are manifolded together to operate in parallel.

Chilled and Hot Water Plant:

Both a satellite chilled water plant and a satellite hot water plant in the new Science Building is sized to provide the cooling and heating capacity for the West Loop respectively. The West Campus Loop consists of the New Science Center (building of discussion), Science East, Science West, Macklin Tower and Computer Science. The West Loop has three different operational modes. The entire West Loop can be served by the campus loop or the new satellite plant. Or the new satellite plant can serve only the New Science Center with the rest of the west loop served by the existing campus central water plant. Isolation valves are used in accomplishing each operation option. Each building will have local secondary pumps.

The new satellite plant will have its own expansion tank and fill line. The new expansion tank provides additional expansion capacity to supplement the existing expansion tank in the central plant.

Chilled Water System Design:

The existing 225 ton chiller with variable frequency speed control in Science East, associated cooling tower, and condenser pumps were retained. An additional two 550 ton electric centrifugal chillers with variable frequency drives will be added to the chilled water system for the expansion (New Science Center).

The three primary chilled water pumps have variable frequency drives, two duty pumps and one standby pump.

Two new induced draft- cross flow cooling towers, located on the roof, cool the chiller condenser water. The two towers in a two cell arrangement share a basin. Both towers have variable frequency drives for fan speed control. The two condenser water pumps are each sized for full flow of both towers. At ideal conditions the variable fan speed of the towers will reduce the condenser water temperature to allow the chillers to operate at peak efficiency.

Hot Water System Design:

Five ultra-high efficiency 3 million BTU hot water boilers are provided for the heating plant. 3 million is the input energy; each boiler can provide 2.61 million btus of heat at the minimum operating efficiency of 87%. The “fifth” boiler will only be used on peak demand days and will mainly serve as a back up boiler when heat recovery is working properly. Space has been allocated in the mechanical penthouse for a sixth boiler if one would be required to boost the capacity of the west hot water loop in the future.

Like the chilled water system pumps, the three main hot water loop distribution pumps have variable frequency drives, two duty pumps and one standby pump. There are no boiler pumps. The boilers are all piped in reverse return to balance out flows. Water always flows through all five boilers when there is a call for heat.

Air System Design:
The central air handling system consists of two roof top units manifolded together by a common discharge plenum. Each unit has dual fans and isolation dampers to isolate one unit from the rest of the system. There is no return fan because the pressure drop across the outside air section including the heat recovery coil is approximately equal to the pressure drop in the plenum return system. The return air damper will modulate to maintain the pressurization of the building. Because of the high percentage of outside air, due to the amount of lab exhaust, there is no relief in the unit. The only relief is required during economizer mode. This relief will be discharged from the building through the smoke exhaust fans.

A 12 ft wide corridor runs between the two units connecting them. The hot water and chilled mains that serve the unit run across the ceiling of the service corridor. At the end of the corridor, there is a mechanical room that houses the rest of the equipment in the custom penthouse. The air handler coils will be pulled into the service corridor for cleaning or removal.

The air handling unit consists of the following sections:

- Storm Louver
- Intake section
- Pre-filter for outside air
- Heat Recovery coil
- Return mixing box with inlet for return air with dampers and a pre- filter for the return air.
- Supply fan section with dual fans.
- 85% Supply air final filter
- Heating Coil
- Cooling Coil
- Isolation discharge dampers

- Discharge plenum.
- Requires access sections w/ 24" service doors.

Central Exhaust System Design:

The laboratory exhaust system consists of four high plume exhaust fans that are connected by a common plenum. The airflow through an individual fan is constant volume to maintain a constant discharge velocity out of the exhaust fan stack. The flow of exhaust air from the building is variable volume to minimize the amount of make-up air required at all times. To compensate, there is a make-up air damper in the exhaust plenum to mix enough outside air with the exhaust air from the building to maintain a constant exhaust flow rate. When the amount of make-up air exceeds the design flow rate through one whole fan, the exhaust fan with the longest run time shall shut off and the amount of make-up air will be varied accordingly to maintain a constant flow of exhaust air through the rest of the fans in operation. Of the four fans, one is a standby fan, in the event of a failure. The fan designations will be rotated based on run time.

The fans create a constant negative static pressure at the local exhaust plenum. Each main exhaust riser has a modulating damper that is normally 100% open. The damper modulates close to maintain the remote duct static pressure less than the maximum duct static pressure set point in the exhaust riser.

ASHRAE STANDARD 62.1

Section 5 Systems and Equipment

5.1 Natural Ventilation.

Natural Ventilation was not proposed in the mechanical system design.

5.2 Ventilation Air Distribution.

5.2.1 Designing for Air Distribution.

All equipment is designed with balancing capabilities as shown on Mechanical Drawings (Volume 2) including, balancing valves, flow sensors, volume control dampers, and variable frequency drives.

5.2.2 Plenum Systems.

No plenum area is designed to distribute both return air and ventilation air. The offices utilize the plenum for makeup air. For all general space ventilation air is supplied through hard duct systems. All laboratories use hard duct systems for both the supply and exhaust air, providing 100% outdoor air.

5.2.3 Documentation.

Section 230593 – Testing, Adjusting, and Balancing for HVAC, 1.3 Quality Assurance, specifies that air balancing and testing be approved by a member of the Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB). A guarantee is required on AABC/ NEBB forms stating that AABC/ NEEB will assist in completing requirements of the Contract Documents if the Testing Adjusting and Balancing (TAB) firm fails to comply with the Contract Documents. No assumptions were documented in any of the bid documents with respect to ventilation rates and air distribution.

5.3 Exhaust Duct Location.

All exhaust ducts are negatively pressurized.

5.4 Ventilation System Controls.

Building General Control system:

Each zone has a VAV box that varies the flow rate to the space. At a minimum flow (due either the ventilation minimum or the VAV box limitation), a hot water coil varies the leaving air temperature to maintain the space temperature. Each temperature zone has a thermostat and an occupancy sensor. The occupancy sensor notifies the building management system when a space is unoccupied. The building automated system can then reset the minimum flow rate (ventilation requirement) and adjust the space temperature to reduce the air flow rate in the space.

Pressurized Space Control System:

The pressurized systems are controlled in the same manner as the general building control system listed above. In order to maintain pressurization, an exhaust VAV box modulates based on the supply air flow rate to maintain the design flow rate offset in the space.

Teaching Lab (VAV fume hoods) Control System:

An independent lab control valve varies the flow rate from each hood based on sash position. The supply VAV box modulates from the minimum flow rate to the maximum flow rate based on temperature. The flow rate is increased if more air is required for fume hood make up than is required for conditioning the space. At minimum flow the control system is designed as the pressurized space control system, with thermostats and occupancy sensors that signal the building automated system, and an exhaust VAV box.

Organic Chem. Teaching Lab (2-position fume hood) Control System:

Fume Hoods are switched from design to standby mode by a switch on the wall. The flow rate through the hood is either at design flow or the standby flow rate depending on the hood position. The hood is constant volume so the sash velocity maintains relatively constant as the sash is lowered. The hoods are placed into standby mode at the conclusion of the lab.

The supply VAV box modulates from the minimum flow rate to the maximum flow rate based on temperature or make-up air requirements. The flow rate is increased if more air is required for fume hood make up than is required for conditioning the space which will be the case when the hoods are in use. At minimum flow the control system is designed as the pressurized space control system, with thermostats and occupancy sensors that signal the building automated system, and an exhaust VAV box.

Chemistry Teaching Lab (2-position fume hoods):

The chemistry teaching lab control system is designed the same as the organic chemistry lab with option of turning off the 6 foot hoods in the space when the hoods are not scheduled to be used. At this time the general exhaust valve will open and maintain the space pressurization.

5.5 Airstream Surfaces.

Exception to 5.5.1 and 5.5.2: Sheet metal and metal fasteners are used. All other surfaces comply with Underwriters Laboratory 181 as defined by the specifications 230.XXX.

5.6 Outdoor Air Intakes.

5.6.1 Location.

All intakes and exhausts are located on the roof. According to Table 5-1, the distance from the intake to the exhaust is set as a minimum of 30ft. The horizontal distance alone is 31'6" meeting the minimum requirement without taking into account the actual distance extended by any difference in elevation.

5.6.2 Rain Entrainment.

All louvers are based on AMCA performance according to the specifications.

5.6.3 Rain Intrusion.

Rain intrusion does not indicate that the standards are met. Specification state that the louvers were tested at 300fpm. The drawings at a specify 1,300 cfm through a 2'x2' louver resulting in 325 fpm. The louvers were not tested for the design airflow rate and therefore do not indicate compliance.

5.6.4 Snow Entrainment.

Both cleaning and drain requirements are met.

5.6.5 Bird Screens.

No screen was specified on drawings or specifications.

5.7 Local Capture of Contaminants.

All contaminates are ducted directly outdoors through the exhaust fans on the roof.

5.8 Combustion Air.

All fuel-burning appliances are provided with sufficient air for combustion and adequate removal of combustion products, in accordance with the manufacturer instructions.

5.9 Particulate Matter Removal.

Filters A- G have been specified to meet compliance with ASHRAE Standard 52.1 1992 and 52.2 1992. Filters H are specified to meet the latest version of IES-RP-CC001.3 Type A Filter. Therefore compliance with this standard (2007) is unspecified and uncertain.

5.10 Dehumidification Systems.

5.10.1 Relative Humidity.

The energy recovery units have a maximum of 60.16% relative humidity meeting the maximum of 65%.

5.10.2 Exfiltration.

The overall pressurization of the building is intended to always remain positive. Yet the minimum outdoor air flow rate is less than the maximum exhaust air flow rate at peak conditions.

5.11 Drain Pans.

5.11.1 Drain Pan Slope.

Slope of drip pans is not specified on construction documents.

5.11.2 Drain Outlet.

Drain outlet is indicated at the lowest part of the drain pan.

5.11.3 Drain Seal.

P traps are provided for equipment.

5.11.4 Pan Size.

Pan sizes are not specified.

5.12 Finned-Tube Coils and Heat Exchangers.

5.12.1 Drain Pans.

Drain pans have been indicated for under all cooling coils.

5.12.2 Finned Tube Coil Selection of Cleaning.

There are no finned-tube coils without adequate access space.

5.13 Humidifiers and Water-Spray Systems.

5.13.1 Water Quality.

Water for the New Science Center is provided by satellite water plants located on campus.

5.13.2 Obstructions.

All obstructions are located at the recommend distance or greater.

5.14 Access for Inspection, Cleaning, and Maintenance

5.14.1 Equipment Clearance.

Sufficient space is provided to each piece of equipment for maintenance and inspection without the need to remove any equipment.

5.14.1 Ventilation Equipment Access.

Ventilation equipment are equipped with convenient access where sizes for the respective equipment can be found in the specifications.

5.14.2 Air Distribution System.

Sufficient access has been specified for equipment that does not require the removal of nuts, bolts, screws, wedges or any other loose devices.

5.15 Building Envelope and Interior Surfaces.

5.14.3 Building Envelope.

All roofing, glazing/window/curtain wall system, exterior panels, and masonry walls have thermal and moisture protection. Masonry walls incorporate a cavity between the face brick and CMU back-up with a system of weeps to collect and drain any infiltrating moisture out of the wall. The metal building panels is part of a rain screen system that is self draining. The mechanical equipment is enclosed with a metal panel system. Sealants include both urethane and silicon based materials.

5.14.4 Condensation on Interior Surfaces.

Duct System	Insulation Type	Minimum Insulation Thickness
Supply - Concealed	I-3	2 inches
Supply - Exposed	I-2	1 inch
Supply - Outdoors	I-2	2 inches
Return - Concealed	I-3	1-1/2 inches
Return - Exposed	I-2	1 inch
Return - Outdoors	I-2	2 inches
Outside Air - Concealed	I-3	2 inches
Outside Air - Exposed	I-2	2 inches
Outside Air - Outdoors	I-2	2 inches
Sound Attenuators	I-2	1 inch
Field Fabricated Plenums, Casings	I-2	1 inch
Mixed Air - Concealed	I-3	1-1/2 inches
Mixed Air - Exposed	I-2	1 inch
Mixed Air - Outdoors	I-2	2 inches
Exhaust and Relief	I-2	1 inch

All duct systems are insulated as specified above meeting the requirements. No information on piping insulation could be found in the specifications or drawing set.

5.16 Building with Attached Parking Garages.

The New Science Center is not coupled with a parking garage.

5.17 Air Classification and Recirculation.

5.17.1 Classification.

Classification requirements can be met through Table 5-2 or 6-1. The laboratory hoods meet the requirement for both tables. More detail on table 6-1 requirements is discussed in the analysis of section 6.

5.17.2 Re-designation.

The class 4, laboratory air exhausted from the space, is 100% exhaust without recirculation. In addition any transfer air attains the classification of the most restrictive space. All air is directly exhausted from the laboratories that may have transferred from other spaces, and any air transferred from one general space to another are within the same classification specified on Table 5-2 ASHRAE 62.1.

5.17.3 Recirculation Limitations.

Class 4 Air (5.17.3.4) is the only classification that applies to the New Science Center.

5.17.4 Documentation.

The entire New Science Center was classified to meet the ASHRAE Standard 62.1 Tables 5-2 and 6-1 at a minimum.

5.18 Requirements for Buildings Containing ETS Areas and ETS-Free Areas.

The New Science Center is designed and intended to be a smoke free environment.

ASSUMPTIONS

Occupancy (Pz) and Area (Az) values from BurtHill take-off reports are correct.

Zone air distribution effectiveness (Ez) is 1.0.

The zone primary air floor (Vpz) is the amount of air being supplied through diffusers to each zone.

Occupancy diversity (D) is 1.0 to be conservative as the system population is not known.

Lab Recitations were assumed to be used as lecture classrooms and not for laboratory use.

Lab Preparations were designed as University Laboratories due to the chance of contaminates being used or prepared.

House Keeping was assumed to be used similar to Hotel/Motel Laundry Rooms without unit dwelling.

Bio Work Rooms were assumed to be used as office space due to the adjacent location to the offices and therefore and not be used similar to laboratories.

Animal Receiving and Holding were assumed as “Pet shops (animal areas)”.

Chemistry Oxbridge Room was assumed to be used similar to a lounge/lobby.

Chemical Storage Rooms were designed as University Laboratories due to contaminates stored.

Mechanical rooms, restrooms are exempt from the calculations since no outdoor air was supplied to those rooms.

Greenhouse was calculated similar to a warehouse and any hazardous material rooms were calculated similar to university/college labs due to lack of better alternatives available for ASHRAE 62.1.

PROCEDURE

ASHRAE 62.1-2007 carefully outlined the procedure to achieve the proper ventilation minimums in section 6. This procedure is summarized below. Refer to assumptions on previous page and Tables in Appendix A.

Step 1

The breathing zone outdoor air minimum flow rate (Vbz) is calculated using the equation:

$$Vbz = Rp*Pz + Ra*Az \qquad \text{(Equation 6-1)}$$

Az is the zone floor area.

Pz is the zone population.

Rp is the outdoor airflow rate required per person (ASHRAE 62.1 Table 6-1).

Ra is the outdoor airflow rate required per square foot (ASHRAE 62.1 Table 6-1).

In order to find the outdoor airflow rate for each space the area, population, and occupancy type must be known or determined. Once this information is collected the Rp and Ra values are found on ASHRAE 62.1 Table 6-1 based on the occupancy type. The equation is then used to calculate the Vbz for each space.

Step 2

The zone air distribution effectiveness (Ez) defined by the air distribution configuration in the ASHRAE 62.1 -2007 Table 6-2.

Step 3

The zone outdoor airflow (Voz) is calculated using the values found in steps 1 and 2.

$$Voz = Vbz/Ez \qquad \text{(Equation 6-2)}$$

This ventilation rate must be provided to the zone through the air distribution system.

Depending on what type of air handling unit (AHU) is used chose from steps 4, 5, and 6 in order to find the outdoor air intake flow rate (Voz). Only one procedure should be used per air handling unit, but a method for every AHU should be chosen for each respective air handling unit.

Step 4

For AHUs with siingle-zone systems, the outdoor air intake flow (Vot) is equal to the zone outdoor airflow (Voz):

Vot = Voz (Equation 6-3)

Step 5

For AHUs with 100% outdoor air the following equation is used

To calculate the outdoor air intake flow (Vot):

Vot = Σall zonesVoz (Equation 6-4)

Step 6a

For this application, the New Science Center, the Multiple-Zone recirculating Systems procedure applies. For AHUs supply a mixture of recirculated air and outdoor air to multiple zone, the following equation applies:

Zp =Voz/Vpz (Equation 6-5),

Vpz is the primary airflow to the zone.

Voz was calculated in step 3.

Step 6b

Using the value found in step 6a (Zp), determine the system ventilation efficiency according to ASHRAE 62.1 -2007 Table 6-3. Any Zp values above 0.55 should refer to Appendix A to complete the system ventilation efficiency assignment.

Appendix A procedure:

The system ventilation efficiency is defined as the minimum (Evz) zone ventilation efficiency.

Evz= 1+Xs-Zd

Xs is the average outdoor air fraction

Zd is the discharge outdoor air fraction

Xs = Vou/ Σ(Vpz)
Zd = Voz/ Vdz

The minimum Evz, zone ventilation efficiency, is then used as the Ev, system ventilation efficiency.

Step 7

Occupancy diversity can then be taken into account. Since the New Science Center is a university laboratory, the occupancy diversity is assigned to 1.0. This is a conservative measure with the assumption that at peak load the building will be at full occupancy in every space. In other designs the equation below is used:

D= Ps/ (Σall zones Pz) **(Equation6-7)**

Step 8

The uncorrected outdoor air intake (Vou) is calculated using the equation below to later determine the outdoor air intake flowrate incoorporating of the system efficiency.

Vou = D Σall zones (Rp•Pz) + Σ all zones (Ra•Apz) **(Equation 6-6)**

Step 9

The uncorrected outdoor air intake (Vou) is corrected using the system ventilation efficiency (Ev) to return the outdoor air intake (Vot).

Vot = Vou/Ev **(Equation 6-8)**

Step10

The outdoor air intake flow rates are then summed and compare to the supply air flow rates for each AHU.

CALCULATIONS

Step 1

Vbz = Rp*Pz + Ra*Az (Equation 6-1)

Vbz was calculated for each room based on the corresponding room area and occupancy use and the associated valves from the ASHRAE 62.1Table 6-1.

For example, one of the Environmental Science Laboratory Recitations would be categorized as a University/college Lab with 24 occupants at 1,296 square feet.

Vbz = [(10 cfm/person)*(24 people)] + [(0.18 cfm/ft2)*(1,296 ft2)]

Vbz = 240+233.28

Vbz = 473.28 cfm

Step 2

Ez was determined from ASHRAE 62.1 Table 6-3, as **1.0**. Since the air distribution method for the Montgomery College New Science Center is cool air distributed through the ceiling diffusers defined as air at a lower temperature than the room/space air.

Step 3

Voz = Vbz/Ez (Equation 6-2)

Following the above example for the Environmental Science Lab Recitation:

Voz = Vbz/Ez

Voz = 473.28 cfm/1.0

Voz = 473.28 cfm

Voz will equal Vbz for every space since every space supplies cool air from the ceiling, making Ez = 1.0 for every space. These calculations were calculated with an excel sheet found in Appendix A.

Steps 4 and 5 from the procedures listed above will be skipped for the Montgomery College New Science Center. Step 6 will be used since the New Science Center's HVAC system utilizes multiple-zone recirculation systems.

Step 6

Zp =Voz/Vpz **(Equation 6-5)**

Zp = 473.28 cfm / 1555.2 cfm

Zp =0.30 (zone primary outdoor air fraction)

The two air handling units that serve the New Science Center distribute the air into a common plenum. The air from both air handling units is then distributed to the spaces. Both units are sized identical to each other and not one unit supplies one space over the other.

For this example a floor by floor break down was completed as if a separate AHU served each floor. Realistically each AHU would be evaluated individually depending on the spaces it served.

Floor	Max (Zp)	Max (Zp)	Ev
Level 1	0.5	< 0.55	0.6
Level 2	0.48	< 0.55	0.6
Level 3	1.72	>0.55	Appendix A
Level 4	0.69	>0.55	Appendix A

ASHRAE 62.1 Appendix A Calculations:

Vdz = Vpz since there is no additional air supplied to the air that was supplied to the space from the air handling units. In addition since Vdz = Vpz, then Zp = Zd.

Floor 3:

Xs = Vou/ Σ(Vpz)
Xs = 6,128cfm/ 65,108cfm

Xs= 0.09

Zd = Voz/ Vdz

Evz= 1+Xs-Zd

The minimum Zd is 0.06 for the 3rd floor and therefore will be used to calculate the minimum Evz.

Evz (min) = 1+0.09+0.06 = 1.15

Evz (min) = Ev = 1.15

Floor 4:

$X_s = V_{ou} / \Sigma(V_{pz})$

X_s = 5,880 cfm/ 21,968 cfm

X_s= 0.27

$Z_d = V_{oz} / V_{dz}$

$E_{vz} = 1+X_s-Z_d$

The minimum Zd is 0.08 for the 4th floor and therefore will be used to calculate the minimum Evz.

E_{vz} (min) = 1+0.27+0.08

E_{vz} (min) = 1.35

E_{vz} (min) = E_v

E_v = 1.35

Step 7

Since the New Science Center is a university laboratory, the occupancy diversity becomes 1.0 since at peak load the building will be at full occupancy in every space.

Step 8

$V_{ou} = D\,\Sigma_{\text{all zones}}(R_p \cdot P_z) + \Sigma_{\text{all zones}}(R_a \cdot A_{pz})$ (Equation 6-6)

Floor 1:

V_{ou} = 1.0*(2,630) + (2,012)

V_{ou} = 4,642 CFM

Floor 2:

V_{ou} = 1.0*(3,245) + (3,098)

V_{ou} = 6,343 CFM

Floor 3:

V_{ou} = 1.0*(2,915) + (3,213)

V_{ou} = 6,128 CFM

Floor 4:

V_{ou} = 1.0*(2,715) + (3,165)

V_{ou} = 5,880 CFM

Step 9

Vot = Vou/Ev **(Equation 6-8)**

Floor 1:

Vot = 4,642 cfm / 0.60

Vot = 7,737 cfm

Floor 2:

Vot = 6,343 cfm / 0.60

Vot = 10,572 cfm

Floor 3:

Vot = 6,128 cfm / 1.15

Vot = 5328.69 cfm

Floor 4:

Vot = 5,880 cfm / 1.35

Vot = 4355.55 cfm

Step 10

∑ Vot = 7,737cfm + 10,572 cfm + 5329cfm +4355 cfm

∑ Vot = 27,993 cfm

ASHRAE STANDARD 90.1-2007

5. Building Envelope

The building envelope in section five is prescriptive to the climate zone and the compliance path. For this report the prescriptive path is followed. Looking at the mandatory provisions, one entrance is missing the required vestibule and compliance with NFRC 400 is not defined. The Montgomery College New Science Center is located in Rockville Maryland, climate zone 4A. Climate zone 4A is a mixed humid area. Each enclosing construction for the building can be evaluated for compliance on ASHRAE 90.1-2007s Table 5-5.4, where the building envelope is defined for climate zone 4A. Each wall meets compliance for the nonresidential space, with the exception of wall type 4. Wall type 4 was evaluated as a semi-heated wall, and met compliance.

The wall area consists of 38% metal framing vertical glazing. For climate zone 4A the corresponding maximum U-value is 0.50. Montgomery College New Science Center goes well below the maximum with a U-value of 0.29. The solar heat gain coefficient and for both the north and non-north is 0.28 under maximum 0.40 excluding the shading devices used to help minimize the solar heat gain into the building.

In conclusion, the building envelope meets the requirements with the exception of one vestibule. Pressurizing the building will help to counteract this unmet requirement.

6. Heating, Ventilating, and Air Conditioning

Additions to existing buildings:

Existing equipment does not need to meet requirements by exception and therefore was not checked for compliance. Additional HVAC equipment must all comply.

Controls:

Zone Thermostatic Controls – Zone controls are shown in the construction drawings

Dead Band – Space temperature sensors are used to communicate data to the Building Automation System in the project which can be set to have a dead band range of 5F. Drawings describe a +/-3 degree temperature range.

Setpoint Overlap Restriction – The band is +/- 3 degree F temperature band in occupied mode and a +/- 6 degree F band in unoccupied mode. This is to be programmed into the building automation system.

Off-Hour Controls – The building automation system is programmed to have time scheduling.

Automatic Shutdown - The BAS incorporates optimum start stop procedures. There are also occupancy sensors that will shut a system down if no occupants are sensed within 30 minutes. There is no indication that the system is tied into a manual or security override. There is indication that a web based application is considered to be tied into the campus system, possibly to be interfaced with the campus security system.

Setback Controls – Setback controls are included in the construction drawings.

Optimum Start Controls – Optimum start-stop controls are to be designed into the BAS software.

Zone Isolation – Zone dampers do not exist isolating each area into separate zones. Each floor is designed to be a zone. Life safety requirements prevent exhaust air from being shut off to the lab areas. The system is run 24 hours a day for life safety.

Ventilation System Controls:

Stair and Shaft Vents – There is no indication of stair and shaft dampers on control pages.

Gravity Hoods, Vents, and Ventilators – Motor operated dampers are shown on all outdoor air supply and exhaust systems.

Shutoff Damper Control – The system is capable of shutting down both outdoor air and exhaust.

Ventilation Fan Controls –There is start-stop control on the fans.

Ventilation Controls for High-Occupancy Areas – A106 Lecture classroom appears to be the only room needing DCV and it does not appear to have DCV. Most other spaces have less than 40 people per 1000 ft^2.

Equipment Efficiencies:

Water cooled centrifugal chiller 305 tons:

COP = 12/(KW/TON)/3.412 = 12/0.669/3.412 =5.257

According to ASHRAE 90.1 -2007 the COP for a water cooled centrifugal chiller needs to have a minimum of 6.10 for a standard chiller. The chillers on this project do not follow standard ARI 550/590 test condition. The chillers each operate with a condenser water flow rate of 2 gpm/ton, 42F leaving chilled water temperature, and 85F entering condenser-water temperature. Using Table 6.8.1J the adjusted required minimum COP becomes 5.11, which the designed chillers passes.

7. Service Water Heating

Additions to existing buildings:

Existing equipment does not need to meet requirements by exception and therefore was not checked for compliance. Additional HVAC equipment must all comply. Refer to Appendix B for calculations.

Piping Insulation:

There is little to no piping insulation details available on construction documents. Compliance is unsure.

Equipment Efficiency:

The 87% efficient hot water supply gas boiler meets the minimum 80% efficiency required.

8. Power

Both the feeders and branch circuits are within the respective 2% and 3% voltage drop at design load.

9. Lighting

The actual lighting power density for the New Science Center 92,788 Watts compared to the maximum of 99,427 Watts shows that the lighting requirements are met.

Occupancy Sensors are provided in all offices, laboratories, recitation, classrooms, conference rooms, and other associated support rooms.

The lighting control for the public areas, classrooms, laboratories, offices, and service spaces inside of the building shall be controlled by local switches and occupancy sensors which will operate directly with the fixture circuits without connection to a central lighting control network system. Classroom shall use dual technology type occupancy sensors and restrooms shall use ultrasonic type occupancy sensors. Offices and service space will have dual technology automatic wall switch sensors. Occupancy sensors shall have at least (2) contacts; one to control lights and the other for the BAS for HVAC control.

Lighting in the atrium shall include day-lighting control to adjust the lighting levels in conjunction with the available natural light. Metal Halide Lighting shall switch off or on in response to daylight penetration. Exterior lighting shall be controlled by the building BMS system with time clock control. The lighting control system shall be interconnected with the building management system to share the control capabilities. Lighting control for the Observatory shall include an architectural dimming system with preset capabilities. Multiple control stations shall be located in the space.

10. Electric Motor Efficiency

All major pumps and fans have variable frequency drive motors.

	Pumps	Fans
Horse Power	15	75
RPM	1,750	1,214
Poles	2	2
Minimum Efficiency	89.5	91.0

All fan and pump motor meet full-load efficiency minimum.

DISCUSSION OF RESULTS

ASHRAE Standard 62.1-2007, Section 6

As suspected, the Montgomery College New Science Center complies with ASHRAE 62.1 - 2007, section 6 as the amount of outdoor air of 94,280 cubic feet per minute is more than the 27,993 cubic feet per minute required. This large difference between the required and design supply airflow is due to the fact that the New Science Center used more stringent standards than the ASHRAE 62.1 standards. Standards more specific to laboratory design were used to calculate the outdoor air requirements.

ASHRAE Standard 62.1-2007, Section 5

Most of the requirements have been met for the ASHRAE 62.1 – 2007, section 5. The majority of the unmet requirements were not met due to lack of specification. The specification were not detailed enough to specify if ASHRAE 62.1 -2007 was met or not. These requirements were assumed to be met by the manufactures. Other unmet requirements were specified to meet ASHRAE 62.1 of previous years.

Overall the building will prevent mold growth, re-entry of contaminated air, and particulate filtration. The building envelope has superior moisture protection preventing any future mold growth by the use of vapor barriers, weep holes, and a self draining design. The mechanical equipment on the roof is enclosed to prevent mold growth within the system. The exhaust system goes beyond the minimum clearance from the supply, to prevent re-entry of contaminate air. And although the filters did not specify compliance with ASHRAE 2007 standards, there is very little recirculation of air throughout the building and the recirculated air mostly coming from the offices where contaminates are minimal.

ASHRAE Standard 90.1-2007

The New Science Center goes well beyond compliance for many of the requirements of ASHRAE 90.1-2007. A few requirements were unclear similar to the problem with ASHRAE 62.1-2007 compliance. More specific details on insulation and controls would need to be listed to meet compliance.

The New Science Center has well defined controls to maintain the building HVAC systems. The lighting power density is well within the maximum requirements. Equipment efficiencies exceed and excel past the minimum compliance.

The southeast entrance of the building does not indicate the required vestibule. The pressurization of the building will help to maintain the building's conditioning, similar to a vestibule. Previous version of ASHRAE 90.1 only required vestibules on the entrance of building in climate zone 1 and 2. The New Science Center is located in climate zone 4A, and therefore would have met requirements for ASHRAE 90.1-2004 and earlier versions. A vestibule with a seven foot clearance from the first set of door to the second would need to be added to meet ASHRAE 90.1-2007.

REFERENCES

ASHRAE. 2007, ANSI/ASHRAE, Standard 62.1 – 2007, Ventilation for Acceptable Indoor Air Quality. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc., Atlanta, GA. 2007.

ASHRAE. 2007, ANSI/ASHRAE, Standard 90.1 – 2007, Energy Standard for Building Except Low-Rise Residential Buildings. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc., Atlanta, GA. 2007.

APPENDIX A

ASHRAE 62.1 VENTILATION CALCULATIONS

Educational (Lab prep/ Labs Exhausted)
Accessory Storage Areas, Mechanical equipment room
Business
Educational (Classroom, Recitation)
Assembly (W/o fixed seats)

Room Information			Az	Pz	Rp	Ra	Rp*Pz	Az*Ra	Vbz	Ez	Voz	Vpz	Zp
Room Name	Occupancy Category	Room No.	SF	Occup.	(cfm/per)	(cfm/ft2)			CFM		CFM	CFM	
Lounge	Lobbies	A103	400 NSF		5	0.06	0	24	24	1	24	300	0.08
Vending	Lobbies	A110	168 NSF		5	0.06	0	10.08	10.08	1	10.08	126	0.08
Bio Tech Office	Office	A121a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Animal Receiving	Animal Areas	A121b	90 NSF		7.5	0.18	0	16.2	16.2	1	16.2	213.75	0.08
Animal Holding	Animal Areas	A121c	92 NSF		7.5	0.18	0	16.56	16.56	1	16.56	218.5	0.08
Green House	Warehouse	A122	744 NSF		0	0.06	0	44.64	44.64	1	44.64	558	0.08
Head House/ Storage	Storage Rooms	A122a	294 NSF		0	0.12	0	35.28	35.28	1	35.28	220.5	0.16
Biology Stock Room	Storage Rooms	B126	748 NSF		0	0.12	0	89.76	89.76	1	89.76	561	0.16
Classroom (30 seats)	Lecture Classroom	A105	713 NSF	30	7.5	0.06	225	42.78	267.78	1	267.78	552.046	0.49
Classroom (50 seats)	Lecture Classroom	A106	978 NSF	50	7.5	0.06	375	58.68	433.68	1	433.68	869.176	0.50
Classroom (30 seats)	Lecture Classroom	A107	635 NSF	30	7.5	0.06	225	38.1	263.1	1	263.1	533.17	0.49
Environmental Science Lab Recitation	Lecture Classroom	B124	642 NSF	24	7.5	0.06	180	38.52	218.52	1	218.52	458.964	0.48
Anatomy / Physiology Lab Recitation	Lecture Classroom	B140	642 NSF	24	7.5	0.06	180	38.52	218.52	1	218.52	458.964	0.48
Environmental Recitation	Lecture Classroom	B142	642 NSF	24	7.5	0.06	180	38.52	218.52	1	218.52	458.964	0.48
Biology Lab Preparation	University/college Labs	A121	532 NSF		10	0.18	0	95.76	95.76	1	95.76	1800	0.05
Environmental Science Lab	University/college Labs	B123	1,296 NSF	24	10	0.18	240	233.28	473.28	1	473.28	1555.2	0.30
Environmental Science Lab	University/college Labs	B125	1,296 NSF	24	10	0.18	240	233.28	473.28	1	473.28	1555.2	0.30
Volatile Chemistry Storage & Dispensary	University/college Labs	B132	119 NSF		10	0.18	0	21.42	21.42	1	21.42	142.8	0.15
Anatomy / Physiology Lab	University/college Labs	B139	1,296 NSF	24	10	0.18	240	233.28	473.28	1	473.28	1555.2	0.30
Anatomy / Physiology Lab	University/college Labs	B141	1,296 NSF	24	10	0.18	240	233.28	473.28	1	473.28	1555.2	0.30
General Biology Lab	University/college Labs	B143	1,296 NSF	24	10	0.18	240	233.28	473.28	1	473.28	1555.2	0.30
House Keeping	Laundry Rooms, central	A114	103 NSF		5	0.12	0	12.36	12.36	1	12.36	77.25	0.16
Server Room	Electrical Equipment Room	B127	188 NSF		0	0.06	0	11.28	11.28	1	11.28	141	0.08
IT Staging & Repair	University/college Labs	B129	307 NSF		10	0.18	0	55.26	55.26	1	55.26	230.25	0.24
Hazardous Material Waste	University/college Labs	B131	117 NSF		10	0.18	0	21.06	21.06	1	21.06	87.75	0.24
Hazardous Material Supply	University/college Labs	B133	117 NSF		10	0.18	0	21.06	21.06	1	21.06	87.75	0.24
Receiving	Shipping/Receiving	B134	604 NSF		0	0.12	0	72.48	72.48	1	72.48	453	0.16
Skeleton Closet	Storage Rooms	B138	167 NSF		0	0.12	0	20.04	20.04	1	20.04	125.25	0.16
Conference Room	Conference/meeting	A108	286 NSF	12	5	0.06	60	17.16	77.16	1	77.16	214.5	0.36
FIRST FLOOR TOTALS			15,908	315			2,630	2,012	4,642		4,642		

Room Information			Az	Pz	Rp	Ra	Rp*Pz	Az*Ra	Vbz	Ez	Voz	Vpz	Zp
Room Name	Occupancy Category	Room No.	SF	Occup.	(cfm/per)	(cfm/ft2)			CFM		CFM		
Bio Tech Office	Office Space	A202a	113 NSF	1	5	0.06	5	6.78	11.78	1	11.78	84.8	0.14
Bio Tech Office	Office Space	A206a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Part-Time Faculty Office	Office Space	A207a	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Bio Part-Time Faculty Office	Office Space	A207b	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Bio Part-Time Faculty Office	Office Space	A207c	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Bio Part-Time Faculty Office	Office Space	A207d	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Bio Faculty Office	Office Space	A208a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208b	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208c	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208d	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208e	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208f	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208g	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208h	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208i	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208j	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208k	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208l	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208m	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208n	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208o	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208p	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208q	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Faculty Office	Office Space	A208r	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Administrative Assistant	Office Space	A209	112 NSF	1	5	0.06	5	6.72	11.72	1	11.72	84	0.14
Bio Chair	Office Space	A210	237 NSF	1	5	0.06	5	14.22	19.22	1	19.22	177.8	0.11
Bio Receptionist	Reception Areas	A211	214 NSF	1	5	0.06	5	12.84	17.84	1	17.84	160.5	0.11
Bio Work Room	Office Space	A213	100 NSF		5	0.06	0	6	6	1	6	75	0.08
Process Room	University/college laboratories	A222a	100 NSF	1	10	0.18	10	18	28	1	28	75	0.37
Bio Tech Office	Office Space	B226a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Bio Study / Reference	Office Space	B229	367 NSF	12	5	0.06	60	22.02	82.02	1	82.02	275.3	0.30
Bio Tech Office	Office Space	B232a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Microbiology Genetics Recitation	Lecture classroom	A204	664 NSF	24	7.5	0.06	180	39.84	219.84	1	219.84	464.3	0.47
Environmental Recitation	Lecture classroom	B224	635 NSF	24	7.5	0.06	180	38.1	218.1	1	218.1	457.3	0.48
Biology Recitation	Lecture classroom	B228	638 NSF	24	7.5	0.06	180	38.28	218.28	1	218.28	458	0.48
Environmental Recitation	Lecture classroom	B234	623 NSF	24	7.5	0.06	180	37.38	217.38	1	217.38	454.4	0.48
Microbiology Lab Preparation	University/college laboratories	A202	985 NSF		10	0.18	0	177.3	177.3	1	177.3	1,800.00	0.10
Biology Lab Preparation	University/college laboratories	A206	524 NSF		10	0.18	0	94.32	94.32	1	94.32	1,800.00	0.05
Biology Lab Preparation	University/college laboratories	B226	525 NSF		10	0.18	0	94.5	94.5	1	94.5	1,800.00	0.05
Biology Lab Preparation	University/college laboratories	B232	525 NSF		10	0.18	0	94.5	94.5	1	94.5	1,800.00	0.05
Microbiology Lab	University/college laboratories	A203	1,285 NSF	24	10	0.18	240	231.3	471.3	1	471.3	3,600.00	0.13
Genetics Lab	University/college laboratories	A205	1,285 NSF	24	10	0.18	240	231.3	471.3	1	471.3	2,700.00	0.17
Biology Student / Facility Project Lab	University/college laboratories	A222	622 NSF	12	10	0.18	120	111.96	231.96	1	231.96	746.4	0.31
Cold Room	University/college laboratories	A222b	211 NSF	1	10	0.18	10	37.98	47.98	1	47.98	1,200.00	0.04
General Biology Lab	University/college laboratories	B223	1,281 NSF	24	10	0.18	240	230.58	470.58	1	470.58	1,537.20	0.31
General Biology Lab	University/college laboratories	B225	1,284 NSF	24	10	0.18	240	231.12	471.12	1	471.12	1,540.80	0.31
General Biology Lab	University/college laboratories	B227	1,299 NSF	24	10	0.18	240	233.82	473.82	1	473.82	1,558.80	0.30
General Biology Lab	University/college laboratories	B230	1,287 NSF	24	10	0.18	240	231.66	471.66	1	471.66	2,700.00	0.17
General Biology Lab	University/college laboratories	B231	1,282 NSF	24	10	0.18	240	230.76	470.76	1	470.76	2,700.00	0.17
General Biology Lab	University/college laboratories	B233	1,282 NSF	24	10	0.18	240	230.76	470.76	1	470.76	1,800.00	0.26
General Biology Lab	University/college laboratories	B235	1,281 NSF	24	10	0.18	240	230.58	470.58	1	470.58	1,800.00	0.26
Bio File Storage	Storage rooms	A212	100 NSF		0	0.12	0	12	12	1	12	75	0.16
SECOND FLOOR TOTALS			21,421	371			3,245	3,098	6,343		6,343	33,845	

Room Information			Az	Pz	Rp	Ra	Rp*Pz	Az*Ra	Vbz	Ez	Voz	Vpz	Zp
Room Name	Occupancy Catergory	Room No.	SF	Occup.	(cfm/per)	(cfm/ft2)			CFM		CFM		
Chem Tech Office	Office Space	A306a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Part-Time Faculty Office	Office Space	A307a	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Chem Part-Time Faculty Office	Office Space	A307b	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Chem Part-Time Faculty Office	Office Space	A307c	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Chem Part-Time Faculty Office	Office Space	A307d	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Chem Faculty Office	Office Space	A308a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308b	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308c	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308d	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308e	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308f	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308g	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308h	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308i	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308j	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308k	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308l	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308m	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308n	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308o	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308p	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Faculty Office	Office Space	A308q	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chem Admin	Office Space	A309	112 NSF	1	5	0.06	5	6.72	11.72	1	11.72	84	0.14
Chem Chair	Office Space	A310	237 NSF	1	5	0.06	5	14.22	19.22	1	19.22	177.8	0.11
Chem Receptionist	Reception Areas	A311	214 NSF	1	5	0.06	5	12.84	17.84	1	17.84	160.5	0.11
Chem Work Room	Office Space	A313	100 NSF		5	0.06	0	6	6	1	6	75	0.08
Chem Tech Office	Office Space	A322a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chemistry Oxbridge Room	Lobbies	B329	367 NSF	12	5	0.06	60	22.02	82.02	1	82.02	275.3	0.30
Tech Office	Office Space	B332a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Chemistry Recitation	Lecture Classroom	A304	701 NSF	24	7.5	0.06	180	42.06	222.06	1	222.06	473.2	0.47
Chemistry Recitation	Lecture Classroom	A306	632 NSF	24	7.5	0.06	180	37.92	217.92	1	217.92	457.3	0.48
Chemistry Recitation	Lecture Classroom	B324	635 NSF	24	7.5	0.06	180	38.1	218.1	1	218.1	127.1	1.72
Chemistry Lab Prep	University/college Laboratories	A322	620 NSF		10	0.18	0	111.6	111.6	1	111.6	744	0.15
Chemistry / Stock Room	University/college Laboratories	A322b	202 NSF		10	0.18	0	36.36	36.36	1	36.36	600	0.06
Chemistry Stock Room	University/college Laboratories	B326	642 NSF		10	0.18	0	115.56	115.56	1	115.56	770.4	0.15
Organic Chemistry Instrumentation	University/college Laboratories	B328	640 NSF		10	0.18	0	115.2	115.2	1	115.2	768	0.15
Chemistry Prep	University/college Laboratories	B332	502 NSF		10	0.18	0	90.36	90.36	1	90.36	602.4	0.15
Chem Lab Prep	University/college Laboratories	B334	525 NSF		10	0.18	0	94.5	94.5	1	94.5	630	0.15
Chemistry Student / Facility Project Lab & Prep	University/college Laboratories	A302	1,202 NSF		10	0.18	0	216.36	216.36	1	216.36	1,442.40	0.15
General Chemistry Lab	University/college Laboratories	A303	1,287 NSF	24	10	0.18	240	231.66	471.66	1	471.66	6,000.00	0.08
General Chemistry Lab	University/college Laboratories	A305	1,285 NSF	24	10	0.18	240	231.3	471.3	1	471.3	6,000.00	0.08
General Chemistry Lab	University/college Laboratories	B323	1,285 NSF	24	10	0.18	240	231.3	471.3	1	471.3	6,000.00	0.08
General Chemistry Lab	University/college Laboratories	B325	1,286 NSF	24	10	0.18	240	231.48	471.48	1	471.48	6,000.00	0.08
Organic Chemistry Lab	University/college Laboratories	B327	1,328 NSF	24	10	0.18	240	239.04	479.04	1	479.04	5,100.00	0.09
Organic Chemistry Lab	University/college Laboratories	B330	1,287 NSF	24	10	0.18	240	231.66	471.66	1	471.66	6,900.00	0.07
Organic Chemistry Lab	University/college Laboratories	B331	1,308 NSF	24	10	0.18	240	235.44	475.44	1	475.44	7,800.00	0.06
General Chemistry Lab	University/college Laboratories	B333	1,284 NSF	24	10	0.18	240	231.12	471.12	1	471.12	6,000.00	0.08
General Chemistry Lab	University/college Laboratories	B335	1,282 NSF	24	10	0.18	240	230.76	470.76	1	470.76	6,000.00	0.08
Chem File	Storage Rooms	A312	100 NSF		0	0.12	0	12	12	1	12	75	0.16
THIRD FLOOR TOTALS			21,523	331			2,915	3,213	6,128		6,128	65,108	

Room Information			Az	Pz	Rp	Ra	Rp*Pz	Az*Ra	Vbz	Ez	Voz	Vpz	Zp
Room Name	Occupancy Category	Room No.	SF	Occup.	(cfm/per)	(cfm/ft2)			CFM		CFM		
Phy/EE Tech Office	Office Space	A402a	98 NSF	1	5	0.06	5	5.88	10.88	1	10.88	73.5	0.15
Phy/EE Part-Time Faculty Office	Office Space	A407a	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Phy/EE Part-Time Faculty Office	Office Space	A407b	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Phy/EE Part-Time Faculty Office	Office Space	A407c	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Phy/EE Part-Time Faculty Office	Office Space	A407d	115 NSF	2	5	0.06	10	6.9	16.9	1	16.9	86.3	0.20
Phy/EE Faculty Office	Office Space	A408a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408b	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408c	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408d	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408e	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408f	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408g	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408h	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408i	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408j	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408k	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408l	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408m	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408n	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408o	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408p	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Faculty Office	Office Space	A408q	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Phy/EE Admin	Office Space	A409	112 NSF	1	5	0.06	5	6.72	11.72	1	11.72	84	0.14
Phy/EE Chair	Office Space	A410	237 NSF	1	5	0.06	5	14.22	19.22	1	19.22	177.8	0.11
Phy/EE Receptionist	Reception Areas	A411	214 NSF	1	5	0.06	5	12.84	17.84	1	17.84	160.5	0.11
Phy/EE Work Room	Office Space	A413	100 NSF		5	0.06	0	6	6	1	6	75	0.08
Phy/EE Tech Office	Office Space	A422a	100 NSF	1	5	0.06	5	6	11	1	11	75	0.15
Tech Office	Office Space	B427a	101 NSF	1	5	0.06	5	6.06	11.06	1	11.06	75.8	0.15
EE / Phy Oxbridge Room	Lobbies	B429	368 NSF	8	5	0.06	40	22.08	62.08	1	62.08	276	0.22
Astronomy Computer Lab	Computer Lab	A404	665 NSF	24	10	0.12	240	79.8	319.8	1	319.8	464.5	0.69
Engineering Science Computer	Computer Lab	B424	848 NSF	24	10	0.12	240	101.76	341.76	1	341.76	508.8	0.67
Engineering Science Computer Lab / Studio	Computer Lab	B425a	414 NSF	12	10	0.12	120	49.68	169.68	1	169.68	252	0.67
Engineering Science Computer	Computer Lab	B425b	855 NSF	24	10	0.12	240	102.6	342.6	1	342.6	510.5	0.67
Physics Recitation	Lecture Classroom	B432	630 NSF	24	7.5	0.06	180	37.8	217.8	1	217.8	456.1	0.48
Geosciences Lab Prep Room	University/college Laboratories	A402	768 NSF		10	0.18	0	138.24	138.24	1	138.24	921.6	0.15
Geosciences Reference / Workroom	University/college Laboratories	A402b	311 NSF		10	0.18	0	55.98	55.98	1	55.98	373.2	0.15
Lapidary / Power Tool Room	University/college Laboratories	A406	630 NSF		10	0.18	0	113.4	113.4	1	113.4	756	0.15
Physics Lab Prep Room	University/college Laboratories	A422	834 NSF		10	0.18	0	150.12	150.12	1	150.12	1,000.80	0.15
Physics Student Workroom	University/college Laboratories	B423a	414 NSF		10	0.18	0	74.52	74.52	1	74.52	496.8	0.15
Engineering Lab Shop	University/college Laboratories	B427	1,068 NSF		10	0.18	0	192.24	192.24	1	192.24	1,281.60	0.15
Engineering Prep Lab	University/college Laboratories	B428a	428 NSF		10	0.18	0	77.04	77.04	1	77.04	513.6	0.15
Engineering Student/Faculty Project Lab	University/college Laboratories	B428b	640 NSF		10	0.18	0	115.2	115.2	1	115.2	768	0.15
Astronomy / Physical Science Lab	University/college Laboratories	A403	1,287 NSF	24	10	0.18	240	231.66	471.66	1	471.66	1,544.40	0.31
Astronomy / Physical Science Lab	University/college Laboratories	A405	1,287 NSF	24	10	0.18	240	231.66	471.66	1	471.66	1,544.40	0.31
EE / Phy Lab	University/college Laboratories	B430	1,287 NSF	24	10	0.18	240	231.66	471.66	1	471.66	1,544.40	0.31
General Physics Lab	University/college Laboratories	B431	1,285 NSF	24	10	0.18	240	231.3	471.3	1	471.3	1,542.00	0.31
General Physics Lab	University/college Laboratories	B433	1,284 NSF	24	10	0.18	240	231.12	471.12	1	471.12	1,540.80	0.31
Geology / Collections Room	University/college Laboratories	B434	638 NSF	6	10	0.18	60	114.84	174.84	1	174.84	765.6	0.23
Geology / Meterology Lab	University/college Laboratories	B435	1,284 NSF	24	10	0.18	240	231.12	471.12	1	471.12	1,540.80	0.31
Phy/EE File	Storage Rooms	A412	100 NSF		0	0.12	0	12	12	1	12	75	0.16
Physics / Engineering Stock Room	Storage Rooms	B423b	855 NSF		0	0.12	0	102.6	102.6	1	102.6	641.3	0.16
Laptop Storage	Storage Rooms	B426a	99 NSF		0	0.12	0	11.88	11.88	1	11.88	74.3	0.16
Engineering Project Storage	Storage Rooms	B426b	312 NSF		0	0.12	0	37.44	37.44	1	37.44	234	0.16
FOURTH FLOOR TOTALS			21,713	297				3,165	5,880		5,880	21,968	

APPENDIX B

ASHRAE STANDARD 90.1 LIGHTING COMPLIANCE CALCULATIONS

Fixture	Floor 1	Floor 2	Floor 3	Floor 4	Roof	
CD1	61	51	47	50		
CD2	27	7	9	9		
CP1		3	3	3		
CP2						
D1	18	9	10	9		
FR1	151	199	205	202		
FR2	20	18	24	18		
FR3	15	40	38	37		
FR4	3	8	11	15		
FR6				14		
FR7	10	35	32	30		
FR9	25	13	13	13		
FS2	37	16	10	8	2	
FS3	33				12	
FW1	6	5	5	5		
FW3	4	8	8	8	8	
FW4						
LA						
LA1						
LC						
LD						
LD1						
LD2	6				25	
LS1	4	5	8	6		
LW3		2		2		
LW4					25	
MD1	29					
MDE						
MU1				12		
MUE						
PM1			6			
PM2			3			
UC1		33	26	29		
UC2			1	1		
Z					6	

	TOTAL	VOLT.	WATTS	POWER
CD1	209	277	32	6688
CD2	52	277	32	1664
CP1	9	277	26	234
CP2	1	277	52	52
D1	46	277	75	3450
FR1	757	277	56	42392
FR2	80	277	28	2240
FR3	130	277	56	7280
FR4	37	277	56	2072
FR6	14	277	56	784
FR7	107	277	28	2996
FR9	64	277	56	3584
FS2	73	277	56	4088
FS3	45	277	56	2520
FW1	21	277	56	1176
FW3	36	277	56	2016
FW4		277	56	0
LA		277	150	0
LA1		277	300	0
LC		277	LED	0
LD		120	LED	0
LD1		120	LED	0
LD2	31		LED	155
LS1	24	120	LED	120
LW3	4	277	LED	20
LW4	25	120	LED	125
MD1	29	277	70	2030
MDE		277		0
MU1	12	277	400	4800
MUE		277		0
PM1	6	277	70	420
PM2	3	277	70	210
UC1	88	120	14	1232
UC2	2	120	28	56
Z	6	277	64	384
			POWER TOTAL	92788 W

Room Type	90.1 Use Type	Net S.F.	90.1 P.D.	Watts
Animal Areas	lab	182 NSF	1.4	254.80
Astronomy / Physical Science Lab	lab	2,574 NSF	1.4	3603.60
Astronomy Computer Lab	classroom	665 NSF	1.4	931.00
Bio Administrative Assistant	office	112 NSF	1.1	123.20
Bio Chair	office	237 NSF	1.1	260.70
Bio Faculty Office	office	1,800 NSF	1.1	1980.00
Bio File Storage	active storage	100 NSF	0.8	80.00
Bio Part-Time Faculty Office	office	460 NSF	1.1	506.00
Bio Receptionist	office	214 NSF	1.1	235.40
Bio Study / Reference	office	367 NSF	1.1	403.70
Bio Tech Office	office	413 NSF	1.1	454.30
Bio Work Room	office	100 NSF	1.1	110.00
Biology Lab Preparation	lab	1,574 NSF	1.4	2203.60
Biology Recitation	classroom	638 NSF	1.4	893.20
Biology Student / Facility Project Lab	lab	622 NSF	1.4	870.80
Chem Admin	office	112 NSF	1.1	123.20
Chem Chair	office	237 NSF	1.1	260.70
Chem Faculty Office	office	1,700 NSF	1.1	1870.00
Chem File	active storage	100 NSF	0.8	80.00
Chem Lab Prep	lab	525 NSF	1.4	735.00
Chem Part-Time Faculty Office	office	460 NSF	1.1	506.00
Chem Receptionist	office	214 NSF	1.1	235.40
Chem Tech Office	office	200 NSF	1.1	220.00
Chem Work Room	office	100 NSF	1.1	110.00
Chemistry / Stock Room	active storage	202 NSF	0.8	161.60
Chemistry Lab Prep	lab	620 NSF	1.4	868.00
Chemistry Oxbridge Room	office	367 NSF	1.1	403.70
Chemistry Prep	lab	502 NSF	1.4	702.80
Chemistry Recitation	classroom	1,968 NSF	1.4	2755.20
Chemistry Stock Room	active storage	202 NSF	0.8	161.60
Chemistry Student / Facility Project Lab & Prep	office	620 NSF	1.4	868.00
Cold Room	lab	367 NSF	1.4	513.80
Conference/meeting	conference	502 NSF	1.3	652.60
EE / Phy Lab	office	701 NSF	1.4	981.40
EE / Phy Oxbridge Room	office	632 NSF	1.1	695.20
Electrical Equipment Room	electrical/mechanical	635 NSF	1.5	952.50
Engineering Lab Shop	lab	642 NSF	1.4	898.80
Engineering Prep Lab	lab	1,202 NSF	1.4	1682.80
Engineering Project Storage	active storage	211 NSF	0.8	168.80
Engineering Science Computer	classroom	1,703 NSF	1.4	2384.20
Engineering Science Computer Lab / Studio	lab	414 NSF	1.4	579.60
Engineering Student/Faculty Project Lab	lab	640 NSF	1.4	896.00
Environmental Recitation	classroom	1,258 NSF	1.4	1761.20
General Biology Lab	lab	8,996 NSF	1.4	12594.40
General Chemistry Lab	lab	10,278 NSF	1.4	14389.20
General Physics Lab	lab	2,569 NSF	1.4	3596.60
Genetics Lab	lab	1,285 NSF	1.4	1799.00
Geology / Collections Room	active storage	638 NSF	0.8	510.40
Geology / Meterology Lab	lab	1,284 NSF	1.4	1797.60
Geosciences Lab Prep Room	lab	768 NSF	1.4	1075.20
Geosciences Reference / Workroom	workshop	311 NSF	1.9	590.90
Lapidary / Power Tool Room	workshop	630 NSF	1.9	1197.00
Laptop Storage	active storage	99 NSF	0.8	79.20
Laundry Rooms, central	office	103 NSF	1.1	113.30
Lecture Classroom	classroom	4,252 NSF	1.4	5952.80
Lobbies	lobby	568 NSF	1.3	738.40
Microbiology Genetics Recitation	classroom	664 NSF	1.4	929.60
Microbiology Lab	lab	1,285 NSF	1.4	1799.00
Microbiology Lab Preparation	lab	985 NSF	1.4	1379.00
Office	office	100 NSF	1.1	110.00
Organic Chemistry Instrumentation	lab	640 NSF	1.4	896.00
Organic Chemistry Lab	lab	3,923 NSF	1.4	5492.20
Phy/EE Admin	office	112 NSF	1.1	123.20
Phy/EE Chair	office	237 NSF	1.1	260.70
Phy/EE Faculty Office	office	1,700 NSF	1.1	1870.00
Phy/EE File	active storage	100 NSF	0.8	80.00
Phy/EE Part-Time Faculty Office	office	460 NSF	1.1	506.00
Phy/EE Receptionist	office	214 NSF	1.1	235.40
Phy/EE Tech Office	office	198 NSF	1.1	217.80
Phy/EE Work Room	office	100 NSF	1.1	110.00
Physics / Engineering Stock Room	active storage	855 NSF	0.8	684.00
Physics Lab Prep Room	lab	834 NSF	1.4	1167.60
Physics Recitation	classroom	630 NSF	1.4	882.00
Physics Student Workroom	workshop	414 NSF	1.9	786.60
Process Room	office	100 NSF	1.1	110.00
Shipping/Receiving	active storage	604 NSF	0.8	483.20
Storage Rooms	active storage	1,209 NSF	0.8	967.20
Tech Office	office	201 NSF	1.1	221.10
University/college Labs	lab	7,672 NSF	1.4	10740.80
Warehouse	warehouse	744 NSF	0.9	669.60
Space by space totals		**82,856 NSF**		**110293.40**

APPENDIX C

NEW SCIENCE BUILDING - SPACE USE BREAKDOWN

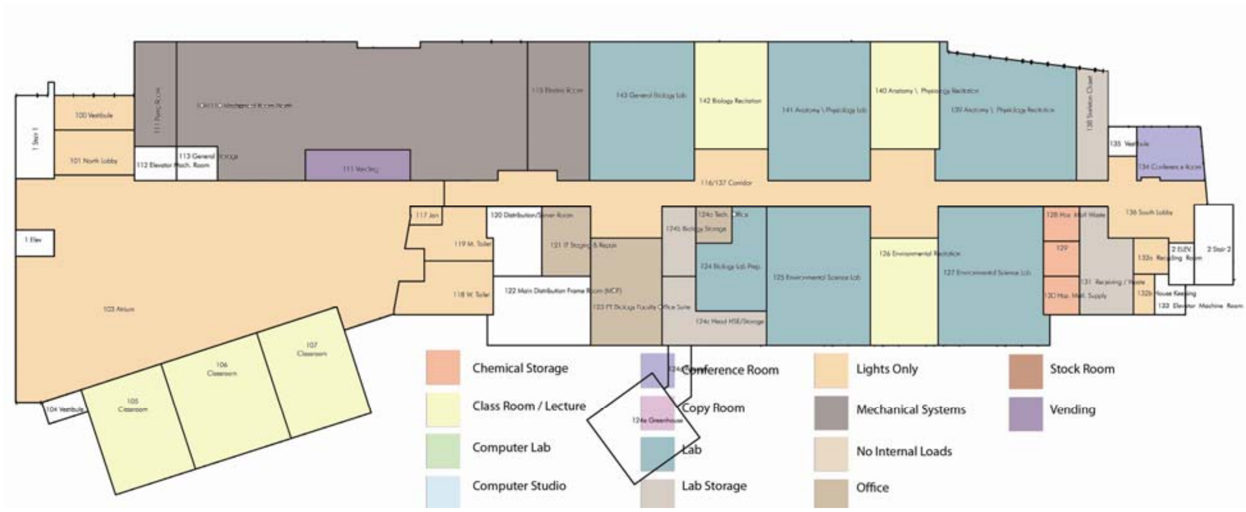

Figure 1.1 Level One Floor Plan

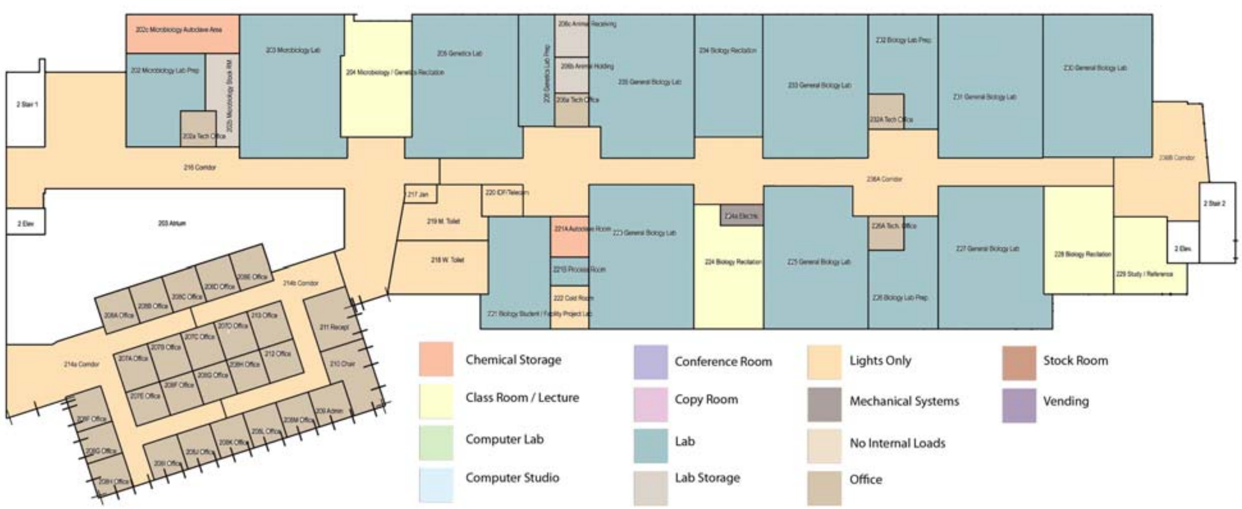

Figure 1.2 Level Two Floor Plan

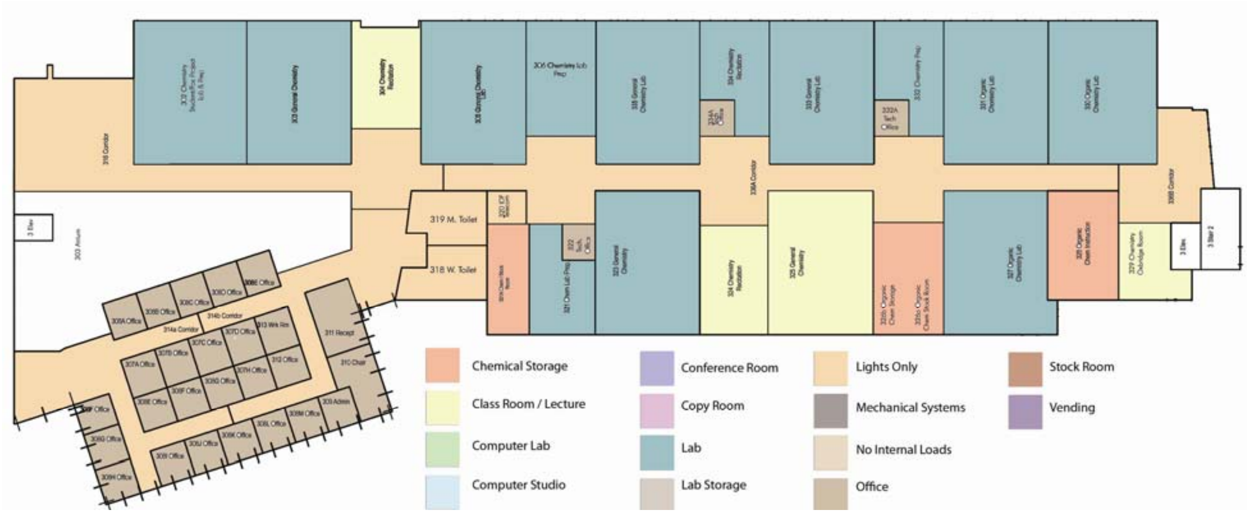

Figure 1.3 Level Three Floor Plan