

Georgetown University New Science Center

ASHRAE Standard 62.1 and 90.1 Compliance Report



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GEORGETOWN UNIVERSITY NEW SCIENCE CENTER

ASHRAE Standard 62.1 and 90.1 Compliance Report

Executive Summary

The New Science Complex is a 154,000 SF research facility being built on the Georgetown University Campus in Washington, DC. The building is to house the Physics, Biology, and Chemistry departments. It will consist primarily of labs, classrooms, offices, and conference rooms. Each floor will have lounges and common areas to encourage interdisciplinary interaction and research. The building stands five stories above grade and is designed to achieve LEED Silver Certification. This report analyzes the building's compliance with ASHRAE Standard 62.1-2007 and ASHRAE Standard 90.1-2007 to ensure proper ventilation and energy efficiency requirements are met.

ASHRAE Standard 62.1 provides the minimum ventilation rates and indoor air quality to provide a safe, comfortable environment for building occupants. The nature of this building demands careful analysis of this standard due to the chemicals and associated contaminants that will be used in the laboratories throughout the buildings. Compliance to this standard is critical in allowing teachers and students to carry out experiments and classes effectively. The building's ventilation air is supplied by a VAV Dedicated Outdoor Air System. It consists of four 50,000 CFM Air Handling Units located in the mechanical penthouse on top of the building. This is the system being analyzed in this report. To ensure proper ASHRAE 62.1 compliance, this report contains ventilation calculations that were performed for each space in the building. Ventilation requirements are based on occupancy, size, and usage type of a space. The New Science Center was found to be compliant with Section 5 and 6 of ASHRAE Standard 62.1-2007.

ASHRAE Standard 90.1 provides minimum energy-efficiency requirements for buildings. Requirements must be met for the building envelope and systems. This will help reduce pollution and save the owner in energy costs. Since this building is intended to become LEED Silver Certified, ASHRAE 90.1 energy performance ratings must be met and exceed. This report contains analysis of equipment specifications, equipment efficiencies, and building power densities for compliance with ASHRAE 90.1-2007, and was found to be compliant with most of the standard. There were, however, a few minor variations from the requirements, such as the supply air fan efficiencies. These may have been caused by assumptions made during the design of these systems.

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ASHRAE Standard 62.1 Section 5 Analysis

Section 5.1 Natural Ventilation

Natural Ventilation is not used as a primary ventilation system for this building. This section is not applicable to the New Science Center.

Section 5.2 Ventilation Air Distribution

Ventilation requirements of ASHRAE 62.1 Section 6 are met. Detailed analysis can be found in the “ASHRAE 62.1 Section 6 Analysis” section of this report.

A plenum system is used for the supply distribution air. Since this is a Dedicated Outdoor Air System, there is not any return air used in the supply air and all spaces will receive proper ventilation airflow through the plenum system.

Air balancing and testing procedures are included in the Contract Documents. However, ventilation design assumptions are not provided.

Section 5.3 Exhaust Duct Location

All exhaust ducts are negatively pressurized to prevent contaminant leakage into occupied spaces.

Section 5.4 Ventilation System Controls

Direct Digital Controls are used to adjust airflow of VAV boxes based on minimum ventilation requirements described in ASHRAE 62.1-2007 Section 6. Minimum ventilation airflow of teaching labs, offices, and core spaces are based on a time-of-day occupancy schedule. Research labs use occupancy sensors and a time-of-day occupancy schedule to determine minimum airflow required.

Section 5.5 Airstream Surfaces

All mold and erosion resistance requirements are met by using sheet metal surfaces and metal fasteners on air distribution equipment and ductwork.

Section 5.6 Outdoor Air Intakes

Air intakes for the four AHUs are located on the roof of the building. Minimum separation requirements are met as specified in ASHRAE 62.1-2007 Table 5-1. Bird screens and deflection baffles to keep out rain and snow are specified in the Contract Documents.

Section 5.7 Local Capture of Contaminants

Contaminants in laboratory spaces are captured by fume hoods and exhausted directly outside at the roof of the building.

Section 5.8 Combustion Air

Combustion products of the emergency generator are vented directly outside of the building. During operation, the generator is provided sufficient amount of air to allow for complete combustion. There are no boilers to require combustion.

Section 5.9 Particulate Matter Removal

All filters upstream of cooling coils are specified for MERV 7 rating or greater, exceeding the minimum MERV 6 rating required by this section.

ASHRAE 62.1 Air Filter Compliance			
Unit	Pre-Filter	Final Filter	Compliance
AHU-1	MERV 7	MERV 14	Yes
AHU-2	MERV 7	MERV 14	Yes
AHU-3	MERV 7	MERV 14	Yes
AHU-4	MERV 7	MERV 14	Yes

Section 5.10 Dehumidification Systems

The maximum allowed relative humidity in occupied spaces according to this section is 65% at design conditions. The New Science Center's Building Automation System will monitor the humidity at two points per floor, and adjust the system to maintain a setpoint of 30% RH.

Section 5.11 Drain Pans

All water producing devices are to have a drain pan to collect condensate. The slope of the pans are to meet the minimum 1/8" required per this section. P-traps are used and are to be manually prime filled prior to system start-up to create the initial seal and prevent air ingestion.

Section 5.12 Finned-Tube Coils and Heat Exchangers

All cooling coils are to have an 18 gauge aluminum, stainless steel, or plastic drain pan under the entire length of the coil per Contract Documents. All coils meet the minimum access space requirement of 18".

Section 5.13 Humidifiers and Water Spray Systems

Steam humidifiers are located at all four AHUs. Steam is supplied from Georgetown University's steam plant. Humidifiers are located according to manufacturer's recommended absorption distances.

Section 5.14 Access for Inspection, Cleaning, and Maintenance

All ventilation equipment is laid out to provide sufficient access for maintenance, cleaning, and inspection.

Section 5.15 Building Envelope and Interior Surfaces

At the exterior walls and roof, a weather barrier is used to prevent water penetration, and a vapor retarder is used to prevent vapor diffusion. All seams are to be properly sealed during construction to limit infiltration of moisture and pollutants.

All piping carrying fluids at 60°F or less are insulated with fibrous glass insulation with a factory-applied retardant vapor barrier jacket. Thicknesses range from 1"-1.5" depending on the fluid temperature.

All ducts are to have fibrous glass duct wrap with a foil-kraft flame-resistant vapor barrier ranging from 1"-3" thicknesses depending on duct shape and location.

Section 5.16 Buildings with Attached Parking Garages

The New Science Center is attached to the Leavey Parking Garage to the north. Occupied spaces are positively pressurized to limit infiltration of vehicular exhaust from this parking garage, as required in this section.

Section 5.17 Air Classification and Recirculation

The New Science Center does not use any recirculated air, therefore all exhaust air is vented directly outside regardless of air classification.

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

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

ASHRAE Standard 62.1 Section 6 Analysis

Section 6 of ASHRAE Standard 62.1 2007 provides proper procedure for calculating sufficient minimum ventilation requirements for buildings.

Ventilation Rate Procedure

Step 1 - Breathing zone outdoor airflow (V_{bz})

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

A_z = zone floor area [ft²]

P_z = zone population

R_p = outdoor airflow rate required per person [cfm/person] (ASHRAE 62.1 2007 Table 6-1)

R_a = outdoor airflow rate per unit area [cfm/ft²] (ASHRAE 62.1 2007 Table 6-1)

Step 2 - Zone outdoor airflow (V_{oz})

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

E_z = zone air distribution effectiveness (ASHRAE 62.1 2007 Table 6-2)

The New Science Center uses “ceiling supply of cool air”, therefore will have an $E_z = 1$

Step 3 - 100% Outdoor air system

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

Step 4 - Primary Outdoor Air Fraction

$$Z_p = V_{oz}/V_{pz}$$

V_{pz} = minimum supply airflow in VAV system [cfm]

Step 5 - Uncorrected Outdoor Air Intake

$$V_{ou} = D \sum_{\text{all zones}} (R_p \cdot P_z) + \sum_{\text{all zones}} (R_a \cdot A_z)$$

$$\text{Where: } D = P_s / \sum_{\text{all zones}} P_z$$

$D = 1$, since the whole building is treated as one zone**.

Step 5 - Outdoor Air Intake

$$V_{ot} = V_{ou}/E_v$$

****Note:** All four AHUs feed into plenum spaces which supply all spaces of the building, therefore there are not any dedicated “zones” used for each air handler unit. This is beneficial when utilizing proper staging to allow for the minimum number of AHUs to be running at one time to meet the loads of the whole building.

Standard 62.1 Conclusions

The New Science Center is fully compliant of ASHRAE Standard 62.1-2007 Section 5. This was expected since it is such a large, high profile project. The majority of Section 5 compliance is addressed in the specifications of the contract documents.

According to ASHRAE 62.1-2007 Section 6, The New Science Center will require minimum ventilation airflow of 32,464 CFM. Since this building is a Dedicated Outdoor Air System this requirement will be easily met and exceeded. The building is equipped with four 50,000 CFM Air Handling Units. It is noted in the contract documents that these are sized for 15% additional capacity to account for future growth. The minimum ventilation rate will be met with only one AHU operating. For this system, supply airflow and AHU staging are based on thermal load requirements, not ventilation.

A large part of ASHRAE 62.1 requirements is based on assumptions regarding space usage and occupancy. The contract documents do not contain a list of the assumptions used by the mechanical designers of the system, but since this is a DOAS system, ventilation rates will be well over what is required by this standard.

ASHRAE Standard 90.1 Analysis

ASHRAE 90.1 provides minimum energy efficiency requirements for buildings.

Section 5 Building Envelope

Section 5.1.4 Climate

The New Science Center is located in Washington, DC. This is a part of Climate Zone 4A of ASHRAE 90.1, shown to the left in yellow.

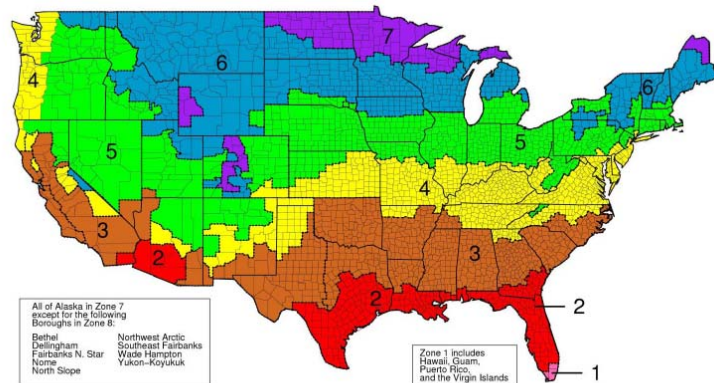


Figure 90.1-1

Section 5.5 Prescriptive Building Envelope Option

The window to wall ratio of the New Science Center is 34 % which meets the required is 40% for Climate Zone 4A.

The New Science Center's envelope complies with Section 5 of ASHRAE 90.1 2007.

Section 6 Heating, Ventilating, and Air Conditioning

Section 6.2 - Compliance Paths

ASHRAE provides two different compliance paths based on the size of the building. They are the Simplified Approach Option and the Mandatory Provisions. The Simplified Approach Option requires the building to be two stories or fewer in height and to have a gross square area of less than 25,000 ft². The New Science Center has five floors and a gross floor area of approximately 154,000 SF; therefore it must be analyzed using the Mandatory Provisions path (Section 6.4).

Section 6.4 - Mandatory Provisions.

The New Science Center uses direct digital controls and a building automation system to manage control sequences and monitor the conditions/load requirements throughout the building. Teaching labs, offices, and core area occupancy is based on a time-of-day schedule. Research lab occupancy is based on both time-of-day schedule and occupancy sensors. During unoccupied hours in research labs, if the occupancy sensor is activated, the space will revert to occupied mode until the sensor detects no occupancy for 30 minutes. All four AHUs are operated with optimal start controls.

The New Science Center uses chilled water and steam supplied from a campus plant. Chillers and boilers are not used; therefore these efficiency requirements are not applicable to this building.

The table below shows that all piping insulation meets minimum thickness requirements.

ASHRAE 90.1 HVAC Piping Insulation Compliance								
Piping	Fluid Temp [°F]	Insulation Thickness - Designed (Required)					Insulation Conductivity [Btuh-in/Hr-°F-SF at Mean Temperature °F]	Compl
		<1"	1"- <1.5"	1.5"- <4"	4"- <8"	8"+		
HEATING SYSTEMS								
Steam & Hot Water								
High press./temp.	351 +	2.5 (2.5)	3.0 (3.0)	3.0 (3.0)	4.0 (4.0)	4.0 (4.0)	.32 (.32-.34)	Yes
Med. press./temp	251-350	1.5 (1.5)	2.5 (2.5)	3.0 (3.0)	3.0 (3.0)	3.0 (3.0)	.29 (.29-.32)	Yes
Low press./temp.	201-250	1.5 (1.5)	1.5 (1.5)	2.0 (2.0)	2.0 (2.0)	2.0 (2.0)	.27 (.27-.30)	Yes
Low temp	141-200	1.0 (1.0)	1.0 (1.0)	1.0 (1.0)	1.5 (1.5)	1.5 (1.5)	.25 (.25-.29)	Yes
low temp	105-140	1.0 (0.5)	1.0 (0.5)	1.0 (1.0)	1.0 (1.0)	1.0 (1.0)	.22 (.22-.28)	Yes
COOLING SYSTEMS								
Chilled Water	40-60	1.0 (0.5)	1.0 (0.5)	1.5 (1.0)	1.5 (1.0)	1.5 (1.0)	0.22 (.22-.28)	Yes

Section 6.5 Prescriptive Path

For ASHRAE Climate Zone 4A, an economizer is not required in the system design.

The New Science Center does not meet the Fan System Power Limitation set in this section of ASHRAE 90.1. The two supply fans in each air handling unit add up to a total of 100 horsepower, exceeding the maximum allowable for the airflow they supply.

ASHRAE 90.1 Fan Compliance					
Unit No.	CFM	Speed Control	As designed motor HP	Required max motor HP	Compliance
AHU-1 (supply)	54,402	Variable	2@50 (100 total)	81.6	No
AHU-2 (supply)	54,402	Variable	2@50 (100 total)	81.6	No
AHU-3 (supply)	54,402	Variable	2@50 (100 total)	81.6	No
AHU-4 (supply)	54,402	Variable	2@50 (100 total)	81.6	No
AHU-1 (exhaust)	54,402	Variable	2@40 (80 total)	81.6	Yes
AHU-2 (exhaust)	54,402	Variable	2@40 (80 total)	81.6	Yes
AHU-3 (exhaust)	54,402	Variable	2@40 (80 total)	81.6	Yes
AHU-4 (exhaust)	54,402	Variable	2@40 (80 total)	81.6	Yes
F-12	9,000	Constant	7.5	9.9	Yes

The New Science Center uses a VAV fume hood exhausts and VAV supply boxes capable of reducing exhaust and makeup air volume to 50% less of design values as required by ASHRAE 90.1.

Section 6.7 Submittals

HVAC system balancing and commissioning is to take place after all equipment is installed and connected. This will take place as the building is being reviewed to achieve LEED Silver certification and is required for ASHRAE 90.1.

Section 7 Service Water Heating

Heating for the New Science Center is provided from a district steam plant of Georgetown University. High Pressure Steam enters the building, is converted to Low Pressure Steam, and goes through one of three shell-and-tube heat exchangers to heat the water used for the heating and preheating throughout the building.

Section 8 Power

All feeders and branch circuits are within the required maximum 2% and 3% voltage drops at design load.

Section 9 Lighting

The maximum interior lighting power density required by ASHRAE 90.1 for a School/University building is 1.2W/sf. Using the Building Area Method described in Section 9, the New Science Center's lighting power densities are summarized in the table below. Appendix B contains detailed calculations of the interior lighting loads. The New Science Center complies with Section 9 of ASHRAE Standard 90.1.

ASHRAE 90.1 Lighting Compliance Summary			
Floor	As-designed Power Density [W/sf]	ASHRAE Power Density [W/sf]	Compliance
1st	0.32	1.20	Yes
2nd	1.11	1.20	Yes
3rd	0.81	1.20	Yes
4th	0.83	1.20	Yes
5th	0.82	1.20	Yes

Standard 90.1 Conclusions

The New Science Center met and exceeded the majority of the requirements of ASHRAE Standard 90.1-2007. The only noncompliance found was the power used by the supply fan motors of the four main Air Handling Units. Fan motor power is limited by the amount of airflow they put out. This issue may be resolved in the near future, since the building is still being constructed. It may be due to misinterpretation of the standard or something overlooked in this analysis due to the complexity of the system.

The New Science Center is an advanced research lab with many energy intensive applications. It is designed to allow the essential laboratory equipment and systems to perform correctly while maintaining an energy efficient design, which is the biggest challenge in designing a building of this nature.

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 Compliance								
Room Name	Room No.	Az SF	Occupancy Category	Occupancy density [#/1000sf]	Pz Occupancy	Rp [cfm/per]	Ra cfm/ft2	Vbz=Voz CFM
Loading Dock	100L	8429	Warehouse	0	0	0	0.06	505.74
Mechanical Room	100J	3756	Storage rooms	0	0	0	0.12	450.72
Fire Pump Room	155	155	Storage rooms	0	0	0	0.12	18.6
Maintenance Office	154	157	Office space	5	1	5	0.06	14.42
Electrical Room	100I	1967	Electrical eqpt rooms	0	0	0	0.06	118.02
Electrical Room	100M	94	Electrical eqpt rooms	0	0	0	0.06	5.64
PRV Station Room	100N	182	Storage rooms	0	0	0	0.12	21.84
Field Work Storage	153	252	Storage rooms	0	0	0	0.12	30.24
Waste Storage	151C	124	Storage rooms	0	0	0	0.12	14.88
Waste Storage	151D	81	Storage rooms	0	0	0	0.12	9.72
Vestibule	151	152	Corridors	0	0	0	0.06	9.12
Cylinder Storage	151A	149	Storage rooms	0	0	0	0.12	17.88
Cylinder Storage	151B	150	Storage rooms	0	0	0	0.12	18
Loading Dock Office	146	124	Office space	5	1	5	0.06	12.44
Corridor	100H	243	Corridors	0	0	0	0.06	14.58
Bio Waste Storage	149	193	Storage rooms	0	0	0	0.12	23.16
Custodial Equipment	144	119	Storage rooms	0	0	0	0.12	14.28
Recycling Building Waste	147	391	Storage rooms	0	0	0	0.12	46.92
Custodial Supply	142	154	Storage rooms	0	0	0	0.12	18.48

Room Name	Room No.	Az SF	Occupancy Category	Occupancy density [#/1000sf]	Pz Occupancy	Rp [cfm/per]	Ra cfm/ft2	Vbz=Vo z CFM
Lounge	140	480	Break rooms	25	12	5	0.06	88.8
Corridor	100G	696	Corridors	0	0	0	0.06	41.76
Physics Research	152	579	Office space	5	3	5	0.06	49.74
Corridor	100E	643	Corridors	0	0	0	0.06	38.58
Storage	143A	158	Storage rooms	0	0	0	0.12	18.96
Mechanical Room	143	577	Storage rooms	0	0	0	0.12	69.24
Autoclave	141A	102	Office space	5	1	5	0.06	11.12
Storage	138A	101	Storage rooms	0	0	0	0.12	12.12
Glass Washing	141	317	Office space	5	2	5	0.06	29.02
Elevator Service Room	138	79	Elevator machine rooms	0	0	0	0.12	9.48
Stock Control/ Dispensing	139	1195	Storage rooms	0	0	0	0.12	143.4
Jan Closet	135B	38	Storage rooms	0	0	0	0.12	4.56
Computational Area	128	265	Computer lab	25	7	10	0.12	101.8
Physics Research Support	124	257	Office space	5	2	5	0.06	25.42
Shared Office	122	215	Office space	5	2	5	0.06	22.9
Office (Grad Students)	116	390	Office space	5	2	5	0.06	33.4
Chemical Solvent Storage	139A	357	Storage rooms	0	0	0	0.12	42.84
Corridor	100A	2389	Corridors	0	0	0	0.06	143.34
Tel/Data	125	108	Electrical eqpt rooms	0	0	0	0.06	6.48
Emerg Elec Room	127	98	Electrical eqpt rooms	0	0	0	0.06	5.88

Room Name	Room No.	Az	Occupancy Category	Occupancy density [#/1000sf]	Pz	Rp	Ra	Vbz=Voz
		SF			Occupancy	[cfm/per]	cfm/ft2	CFM
Physics Research	123	799	Office space	5	4	5	0.06	67.94
Physics Teaching Grad	115	981	University/College Labs	25	25	10	0.18	426.58
Lab Entry	100D	177	Corridors	0	0	0	0.06	10.62
Physics Teaching Intro	119	1710	Lecture classroom	65	112	7.5	0.06	942.6
Demo/ Prep	117	250	Classrooms	35	9	10	0.12	120
Physics Upper Level	113	1343	Lecture classroom	65	88	7.5	0.06	740.58
Vestibule	100B	233	Corridors	0	0	0	0.06	13.98
Physics Lounge	101	538	Break rooms	25	14	5	0.06	102.28
Physics Lecture	109	1382	Lecture classroom	65	90	7.5	0.06	757.92
Elec Room	105	110	Electrical eqpt rooms	0	0	0	0.06	6.6
Elec Room Opt Standby	107	102	Electrical eqpt rooms	0	0	0	0.06	6.12
Demo/Prep	111	255	Classrooms	35	9	10	0.12	120.6
Lab Entry	100C	178	Corridors	0	0	0	0.06	10.68
Biochem Teaching	236	1261	Lecture classroom	65	82	7.5	0.06	690.66
Instrument Room	236B	221	Storage rooms	0	0	0	0.12	26.52
Confocal Microscope Room	236A	108	Office space	5	1	5	0.06	11.48
NMR Suite Private	240A	367	University/College Labs	25	10	10	0.18	166.06
NMR Suite General	240	539	University/College Labs	25	14	10	0.18	237.02
Lobby	200B	1299	Lobbies	150	195	5	0.06	1052.94
Chem Instrumentation	234	1020	University/College Labs	25	26	10	0.18	443.6

Room Name	Room No.	Az	Occupancy Category	Occupancy density [#/1000sf]	Pz	Rp	Ra	Vbz=Voz
		SF			Occupancy	[cfm/per]	cfm/ft2	CFM
Analytical Methods	230	929	Lecture classroom	65	61	7.5	0.06	513.24
Support/Storage	230A	102	Storage rooms	0	0	0	0.12	12.24
Jan Closet	232	102	Storage rooms	0	0	0	0.12	12.24
Storage	236C	49	Storage rooms	0	0	0	0.12	5.88
Vestibule	200C	226	Corridors	0	0	0	0.06	13.56
Seminar Room East	239	1061	Lecture classroom	65	69	7.5	0.06	581.16
BDF Room	228	88	Electrical eqpt rooms	0	0	0	0.06	5.28
Recitation	221	420	Lecture classroom	65	28	7.5	0.06	235.2
Entry	219	200	Main entry lobbies	10	2	5	0.06	22
Corridor	200A	2598	Corridors	0	0	0	0.06	155.88
Office	219B	98	Office space	5	1	5	0.06	10.88
Emerg Elec Room	227	17	Electrical eqpt rooms	0	0	0	0.06	1.02
Tel/ Data	225	137	Electrical eqpt rooms	0	0	0	0.06	8.22
Chem Support	217B	111	Office space	5	1	5	0.06	11.66
Entry	217	201	Main entry lobbies	10	2	5	0.06	22.06
Sem Room	215	123	Office space	5	1	5	0.06	12.38
Office	217C	99	Office space	5	1	5	0.06	10.94
Stock Room	213	362	Storage rooms	0	0	0	0.12	43.44
Office	211A	74	Office space	5	1	5	0.06	9.44
Gen Chem 1	219A	1423	University/College Labs	25	36	10	0.18	616.14

Room Name	Room No.	Az	Occupancy Category	Occupancy density [#/1000sf]	Pz	Rp	Ra	Vbz=Voz
		SF			Occupancy	[cfm/per]	cfm/ft2	CFM
Gen Chem 2	217A	1395	University/College Labs	25	35	10	0.18	601.1
Gen Chem Prep	231A	663	University/College Labs	25	17	10	0.18	289.34
Entry	211	189	Main entry lobbies	10	2	5	0.06	21.34
Recitation	209	503	Lecture classroom	65	33	7.5	0.06	277.68
Gen Chem 3	211B	1392	University/College Labs	25	35	10	0.18	600.56
Elec Room	207	129	Electrical eqpt rooms	0	0	0	0.06	7.74
Tissue Culture	201C	98	University/College Labs	25	3	10	0.18	47.64
Opt Standby Elec Room	205	18	Electrical eqpt rooms	0	0	0	0.06	1.08
South Lounge	202	294	Break rooms	25	8	5	0.06	57.64
Bio Support	201A	88	Office space	5	1	5	0.06	10.28
Entry/Support	201	186	Office space	5	1	5	0.06	16.16
Bio Research	201B	1434	University/College Labs	25	36	10	0.18	618.12
Bio Teaching	381A	1187	University/College Labs	25	30	10	0.18	513.66
Bio Teaching Support	371B	829	Office space	5	5	5	0.06	74.74
Ind Study Lab	381	288	Computer lab	25	8	10	0.12	114.56
Café	300G	562	Lobbies	150	85	5	0.06	458.72
Office	375	118	Office space	5	1	5	0.06	12.08
Vestibule	300E	129	Corridors	0	0	0	0.06	7.74
Office	373	118	Office space	5	1	5	0.06	12.08
Bio Teaching	371A	1209	University/College Labs	25	31	10	0.18	527.62

Room Name	Room No.	Az	Occupancy Category	Occupancy density [#/1000sf]	Pz	Rp	Ra	Vbz=Voz
		SF			Occupancy	[cfm/per]	cfm/ft2	CFM
Ind Study Lab/ Comp Space	371	292	University/College Labs	25	8	10	0.18	132.56
Corridor	300C	1345	Corridors	0	0	0	0.06	80.7
Bio Teaching	361	1252	University/College Labs	25	32	10	0.18	545.36
Office	357	118	Office space	5	1	5	0.06	12.08
Office	355	108	Office space	5	1	5	0.06	11.48
Bio Teaching Support	353A	647	Office space	5	4	5	0.06	58.82
Bio +4 Cold Room	349C	101	University/College Labs	25	3	10	0.18	48.18
Sem Room	349B	80	Office space	5	1	5	0.06	9.8
Corridor	349	204	Corridors	0	0	0	0.06	12.24
Jan Closet	349A	73	Storage rooms	0	0	0	0.12	8.76
Bio Teaching	353	1332	Lecture classroom	65	87	7.5	0.06	732.42
Vestibule	300D	198	Corridors	0	0	0	0.06	11.88
Office	347	127	Office space	5	1	5	0.06	12.62
Office	345	131	Office space	5	1	5	0.06	12.86
Office	343	144	Office space	5	1	5	0.06	13.64
Office	341	144	Office space	5	1	5	0.06	13.64
Corridor	300B	1810	Corridors	0	0	0	0.06	108.6
Physics Research Support	333	173	Office space	5	1	5	0.06	15.38
Conference Room East	351	552	Conference/meeting	50	28	5	0.06	173.12
Bio Teaching Comp	339	754	Lecture classroom	65	49	7.5	0.06	412.74

Room Name	Room No.	Az	Occupancy Category	Occupancy density [#/1000sf]	Pz	Rp	Ra	Vbz=Voz
		SF			Occupancy	[cfm/per]	cfm/ft2	CFM
Physics Research	333B	1066	University/College Labs	25	27	10	0.18	461.88
Autoclave	331	91	Office space	5	1	5	0.06	10.46
Physics Research Support	333A	130	University/College Labs	25	4	10	0.18	63.4
Dark Room	329	99	University/College Labs	25	3	10	0.18	47.82
Tissue Culture	323D	122	University/College Labs	25	3	10	0.18	51.96
Chem Res Support	323C	98	Office space	5	1	5	0.06	10.88
Emerg Elec Room	327	17	Electrical eqpt rooms	0	0	0	0.06	1.02
Tel/ Data	325	117	Electrical eqpt rooms	0	0	0	0.06	7.02
Chem Research Support	353A	112	Office space	5	1	5	0.06	11.72
Chem Research Support	323	222	Office space	5	2	5	0.06	23.32
Counter Room	319A	105	Office space	5	1	5	0.06	11.3
Special Procedure Room	319B	117	University/College Labs	25	3	10	0.18	51.06
Equip Room	319	261	Storage rooms	0	0	0	0.12	31.32
Equip Room	301E	99	Storage rooms	0	0	0	0.12	11.88
Equip Room	301D	99	Storage rooms	0	0	0	0.12	11.88
Office	324	178	Office space	5	1	5	0.06	15.68
Office	322	172	Office space	5	1	5	0.06	15.32
Office	320	172	Office space	5	1	5	0.06	15.32
Office	318	172	Office space	5	1	5	0.06	15.32
Office	316	172	Office space	5	1	5	0.06	15.32

Room Name	Room No.	Az	Occupancy Category	Occupancy density [#/1000sf]	Pz	Rp	Ra	Vbz=Voz
		SF			Occupancy	[cfm/per]	cfm/ft2	CFM
Chem Research Lab	323B	2161	University/College Labs	25	54	10	0.18	928.98
Bio Research Lab	301A	3665	University/College Labs	25	92	10	0.18	1579.7
Office	314	130	Office space	5	1	5	0.06	12.8
Dark Room	311A	137	University/College Labs	25	4	10	0.18	64.66
Procedure Room	311B	116	Office space	5	1	5	0.06	11.96
Office	312	130	Office space	5	1	5	0.06	12.8
Office	310	172	Office space	5	1	5	0.06	15.32
Office	308	172	Office space	5	1	5	0.06	15.32
Office	306	172	Office space	5	1	5	0.06	15.32
Office	304	172	Office space	5	1	5	0.06	15.32
South Lounge	302	301	Break rooms	25	8	5	0.06	58.06
Corridor	300A	987	Corridors	0	0	0	0.06	59.22
Cylinder Closet	309	28	Storage rooms	0	0	0	0.12	3.36
Equip Room	311	223	Storage rooms	0	0	0	0.12	26.76
Tis Cult Rm	301C	178	University/College Labs	25	5	10	0.18	82.04
Elec Room Opt Standby	305	18	Electrical eqpt rooms	0	0	0	0.06	1.08
Elec Room	307	129	Electrical eqpt rooms	0	0	0	0.06	7.74
4 Deg Cold Room	301B	79	University/College Labs	25	2	10	0.18	34.22
Microbial Growth & Harv	301	329	University/College Labs	25	9	10	0.18	149.22
Bio Research Lab	301A	3665	University/College Labs	25	92	10	0.18	1579.7

Room Name	Room No.	Az	Occupancy Category	Occupancy density [#/1000sf]	Pz	Rp	Ra	Vbz=Voz
		SF			Occupancy	[cfm/per]	cfm/ft2	CFM
Vestibule	400D	136	Corridors	0	0	0	0.06	8.16
North Lounge	400F	612	Break rooms	25	16	5	0.06	116.72
North Lounge	400E	563	Break rooms	25	15	5	0.06	108.78
Conf Room East	451	552	Conference/meeting	50	28	5	0.06	173.12
West Lounge	400C	270	Break rooms	25	7	5	0.06	51.2
Shared Office	434	260	Office space	5	2	5	0.06	25.6
Jan Closet	435A	14	Storage rooms	0	0	0	0.12	1.68
Physics Research	439	823	University/College Labs	25	21	10	0.18	358.14
Physics Research	433B	1106	University/College Labs	25	28	10	0.18	479.08
Physics Research Support	433	172	Office space	5	1	5	0.06	15.32
Office	432	105	Office space	5	1	5	0.06	11.3
Office	430	179	Office space	5	1	5	0.06	15.74
Office	428	172	Office space	5	1	5	0.06	15.32
Office	426	130	Office space	5	1	5	0.06	12.8
Office	424	130	Office space	5	1	5	0.06	12.8
Office	422	172	Office space	5	1	5	0.06	15.32
Office	420	172	Office space	5	1	5	0.06	15.32
Office	418	171	Office space	5	1	5	0.06	15.26
Office	416	170	Office space	5	1	5	0.06	15.2
Office	414	130	Office space	5	1	5	0.06	12.8

Room Name	Room No.	Az	Occupancy Category	Occupancy density [#/1000sf]	Pz	Rp	Ra	Vbz=Voz
		SF			Occupancy	[cfm/per]	cfm/ft2	CFM
Sem Room	431	104	Office space	5	1	5	0.06	11.24
Physics Research Support	433A	115	Office space	5	1	5	0.06	11.9
Chem Research Support	429	226	Office space	5	2	5	0.06	23.56
Chem Research Support	429A	98	Office space	5	1	5	0.06	10.88
Elec Room	427	17	Electrical eqpt rooms	0	0	0	0.06	1.02
Tel/ Data	425	117	Electrical eqpt rooms	0	0	0	0.06	7.02
Chem Support	423A	114	Office space	5	1	5	0.06	11.84
Chem Research Support	423	224	Office space	5	2	5	0.06	23.44
Cylinder Closet	421	30	Storage rooms	0	0	0	0.12	3.6
Bio Research Small	419C	191	University/College Labs	25		10	0.18	34.38
Bio Research Support	419	263	Office space	5	2	5	0.06	25.78
Bio Equip	419B	97	Storage rooms	0	0	0	0.12	11.64
Bio Equip	401D	98	Storage rooms	0	0	0	0.12	11.76
Chem Tech Desk	423D	347	Computer Lab	25	9	10	0.12	131.64
Chem Research	423B	1801	University/College Labs	25	46	10	0.18	784.18
Bio Research Small	419A	707	University/College Labs	25	18	10	0.18	307.26
Bio Research Small	401A	2997	University/College Labs	25	75	10	0.18	1289.46
Office	412	130	Office space	5	1	5	0.06	12.8
Office	410	172	Office space	5	1	5	0.06	15.32
Office	408	172	Office space	5	1	5	0.06	15.32

Room Name	Room No.	Az	Occupancy Category	Occupancy density [#/1000sf]	Pz	Rp	Ra	Vbz=Voz
		SF			Occupancy	[cfm/per]	cfm/ft2	CFM
Office	406	172	Office space	5	1	5	0.06	15.32
Office	404	172	Office space	5	1	5	0.06	15.32
South Lounge	402	302	Lobbies	150	25	5	0.06	143.12
Injection Room	411A	137	University/College Labs	25	4	10	0.18	64.66
4 Deg Cold Room	411B	99	University/College Labs	25	3	10	0.18	47.82
Bio Freezer Room	411	211	University/College Labs	25	6	10	0.18	97.98
Microscope Room	401C	227	Office space	5	2	5	0.06	23.62
Elec Room Opt Standby	405	18	Electrical eqpt rooms	0	0	0	0.06	1.08
Elec Room	407	129	Electrical eqpt rooms	0	0	0	0.06	7.74
Tissue Culture	401B	192	University/College Labs	25	5	10	0.18	84.56
Equip Room	401	224	Storage rooms	0	0	0	0.12	26.88
Computational Area	561	1212	Computer Lab	25	30	10	0.12	445.44
Chair Storage	563A	101	Storage rooms	0	0	0	0.12	12.12
Kichenette	561	149	Break rooms	25	4	5	0.06	28.94
Conf Room West	550	1021	Conference/meeting	50	20	5	0.06	161.26
North Lounge	500D	357	Break rooms	25	9	5	0.06	66.42
Conf Room East	551	552	Conference/meeting	50	28	5	0.06	173.12
Tech Desks	539	455	Computer Lab	25	12	10	0.12	174.6
West Lounge	500E	272	Break rooms	25	7	5	0.06	51.32
Chem Research	521C	4007	University/College Labs	25	100	10	0.18	1721.26

Room Name	Room No.	Az SF	Occupancy Category	Occupancy density [#/1000sf]	Pz Occupancy	Rp [cfm/per]	Ra cfm/ft2	Vbz=Voz CFM
Office	534	352	Office space	5	2	5	0.06	31.12
Office	532	172	Office space	5	1	5	0.06	15.32
Office	530	172	Office space	5	1	5	0.06	15.32
Office	528	172	Office space	5	1	5	0.06	15.32
Office	524	265	Office space	5	2	5	0.06	25.9
Office	522	172	Office space	5	1	5	0.06	15.32
Office	520	172	Office space	5	1	5	0.06	15.32
Office	518	171	Office space	5	1	5	0.06	15.26
Office	516	170	Office space	5	1	5	0.06	15.2
Jan Closet	533	77	Storage rooms	0	0	0	0.12	9.24
Bio-Safety Room	521E	222	Office space	5	2	5	0.06	23.32
Sem Room	531	96	Office space	5	1	5	0.06	10.76
Chem Research Support	523	224	Office space	5	2	5	0.06	23.44
Procedure Room	521D	98	Office space	5	1	5	0.06	10.88
Emerg Elec Room	527	17	Electrical eqpt rooms	0	0	0	0.06	1.02
Tel/ Data	525	117	Electrical eqpt rooms	0	0	0	0.06	7.02
Chem Research Support	521B	233	Office space	5	2	5	0.06	23.98
Chem Research Support	521	224	Office space	5	2	5	0.06	23.44
Autoclave	519	68	Office space	5	1	5	0.06	9.08
Synthesis	521H	111	Office space	5	1	5	0.06	11.66

Room Name	Room No.	Az	Occupancy Category	Occupancy density [#/1000sf]	Pz	Rp	Ra	Vbz=Voz
		SF			Occupancy	[cfm/per]	cfm/ft2	CFM
Cylinder Closet	517	69	Storage rooms	0	0	0	0.12	8.28
Chem Instrument Room	521G	272	Storage rooms	0	0	0	0.12	32.64
Atomic Force Microscope	521F	98	Computer Lab	25	2	10	0.12	31.76
Bioinformatics Room	501A	171	Office space	5	1	5	0.06	15.26
Bio Research Small	501A	2997	University/College Labs	25	75	10	0.18	1289.46
Office	514	130	Office space	5	1	5	0.06	12.8
Office	512	130	Office space	5	1	5	0.06	12.8
Office	510	172	Office space	5	1	5	0.06	15.32
Office	508	172	Office space	5	1	5	0.06	15.32
Office	506	172	Office space	5	1	5	0.06	15.32
Office	504	172	Office space	5	1	5	0.06	15.32
Corridor	500B	874	Corridors	0	0	0	0.06	52.44
Corridor	500A	681	Corridors	0	0	0	0.06	40.86
Dissection Room	511C	160	Office space	5	1	5	0.06	14.6
Bio Equip	511D	97	Storage rooms	0	0	0	0.12	11.64
Bio Equip	511	224	Storage rooms	0	0	0	0.12	26.88
Environment Room	511A	90	University/College Labs	25	3	10	0.18	46.2
Bio Equip	511B	105	Storage rooms	0	0	0	0.12	12.6
Elec Room	507	129	Electrical eqpt rooms	0	0	0	0.06	7.74
Elec Room Opt Standby	505	18	Electrical eqpt rooms	0	0	0	0.06	1.08

Room Name	Room No.	Az SF	Occupancy Category	Occupancy density [#/1000sf]	Pz Occupancy	Rp [cfm/per]	Ra cfm/ft2	Vbz=Voz CFM
Bio Equip	501C	90	Storage rooms	0	0	0	0.12	10.8
Bio Equip	501B	96	Storage rooms	0	0	0	0.12	11.52
Bio Equip	501	224	Storage rooms	0	0	0	0.12	26.88
South Lounge	502	295	Break rooms	25	8	5	0.06	57.7

TOTAL

23464 CFM

Appendix B

ASHRAE 90.1 Lighting Compliance												
Fixture	Voltage	Watts/ Fixture	1st floor		2nd floor		3rd floor		4th floor		5th floor	
			Qty	Power	Qty	Power	Qty	Power	Qty	Power	Qty	Power
RA	277	48	27	1,296	45	2,160	84	4,032	77	3,696	72	3,456
RB	277	56	27	1,512	24	1,344	13	728	12	672	17	952
RD	277	32	46	1,472	55	1,760	54	1,728	50	1,600	50	1,600
RE-4	277	32	1	32		0	20	640	4	128		0
RE-8	277	64	8	512	38	2,432	26	1,664	13	832	1	64
RG	277	32	15	480	11	352	2	64	2	64	4	128
RH	277	28	1	28	16	448		0		0	2	56
RJ	277	84	8	672		0		0		0		0
RM	277	32	3	96	3	96	7	224	3	96	3	96
RN	277	70		0	9	630	8	560		0		0
FS1	277	64	65	4,160	69	4,416	18	1,152	8	512	6	384
FS2	277	64	5	320		0		0		0		0
FS4	277	56	8	448	8	448	8	448	8	448	2	112
FS7	277	42	2	84	2	84	4	168	2	84		0
FS8	277	70		0		0	13	910		0		0
FR1	277	32	2	64		0		0		0		0
FR2	277	150		0	18	2,700		0		0		0
FR3	277			0	2	0		0		0		0
DPA1	277	42		0		0		0		0	6	252

Fixture	Voltage	Watts/ Fixture	1st floor		2nd floor		3rd floor		4th floor		5th floor	
			Qty	Power	Qty	Power	Qty	Power	Qty	Power	Qty	Power
DPC	277	32	6	192		0	19	608	24	768	14	448
GA	277	2	26	52	36	72	32	64	37	74	35	70
GB	277	32		0		0	3	96		0	22	704
GC	277	32	10	320		0	8	256	7	224	11	352
LPA	277	192	15	2,880	18	3,456	21	4,032	22	4,224	21	4,032
LPA1	277	192	15	2,880	18	3,456	21	4,032	22	4,224	21	4,032
LPB	277	32	15	480	6	192	23	736	17	544	20	640
LPC	277	64	38	2,432	25	1,600	71	4,544		0		0
LPD	277	28		0		0	8	224		0		0
LPF	277	64		0	12	768	6	384	6	384	18	1,152
LSA	277	32		0		0		0		0	4	128
LBA	277	32		0	15	480		0		0		0
LWA	277	28		0		0		0		0	4	112
LWB	277	56	4	224	4	224	4	224	4	224	4	224
Total Lighting Power [W]:			20,636		27,118		27,518		18,798		18,994	
Lighting Power Density [W/sf]:			0.32		1.11		0.81		0.83		0.82	