New Science & Technology Center
The Chestnut Hill Academy

Philadelphia, PA

Technical Report 1:

ASHRAE Standard 62.1 Ventilation and Standard 90.1 Energy Design Evaluations

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Prepared for:
Dr. James D. Freihaut, PhD
Department of Architectural Engineering
The Pennsylvania State University

Prepared by:
David Klug
5th year Architectural Engineering Student
Mechanical Option

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Executive Summary

Technical report 1 includes evaluations of the Chestnut Hill Academy's New Science and Technology Center in accordance with ASHRAE Standards 62.1 and 90.1. The evaluation of Standard 62.1 includes sections 5 and 6, which deal with system and equipment requirements and ventilation rate calculations. Standard 90.1 sets minimum requirements for the building envelope, HVAC systems, service water heating, power, lighting, and electric motor efficiency.

The New Science and Technology Center meets the general requirements set forth by standard 62.1. In accordance with section 5, the HVAC system is equipped with sensors to monitor the indoor contaminant levels. If any space level breaches the control setpoint, the system alarm will sound and automatic measures will be taken to even the contaminant levels. Every lab has been fitted with exhaust vents as well. In accordance with section 6, the two AHU units supplying the building are capable of meeting the minimum outdoor air requirements. AHU-1 has a minimum requirement of 2,801 cfm and AHU-2 1,955 cfm. The units are sized for 6,300 cfm and 8,000 cfm, respectively.

The New Science and Technology Center meets the general requirements set forth by standard 90.1 The roof, floor, and wall insulations all meet the minimum requirements set by section 5. The plumbing and duct work has been insulated to meet the requirements of the standard as well. The building's electrical system was designed to meet the feeder and branch circuit voltage drops. The lighting compliance is also within the requirements set by the standard by 11%.

Building Summary

The New Science and Technology Center at the Chestnut Hill Academy is a two level building with a footprint area of 9,200 square feet and an aggregate area of 18,400 square feet on the two levels. The cost of construction is $9.6 million. The first and second levels are both occupied by classrooms and laboratories with the second level also containing a faculty office suite. The labs will be equipped to teach physics, biology, and chemistry classes, with a separate lab for robotics that will include a workshop area. The building will include a photovoltaic roof array and a wind turbine to harvest solar and wind energy. Both will be owner installed and operated. The adjacent parking lot and sidewalks will be paved with porous asphalt covering an uncompacted subgrade, providing better absorption back into the earth. It is the intent of the owner to achieve a LEED certified level once the construction of the building is completed in November of 2008. Floor plans are provided at the end of Appendix B

Mechanical System Summary

The New Science and Technology Center is planned to act as an addition to the already existing MEP infrastructure on campus. Power and water (domestic, heated, and fire suppression) will all be supplied from the central plant. A 480/277 V feeder will be run from the neighboring Inn building for the power supply. A 57.1 ton scroll chiller will be installed remotely for current use, with plans to upgrade to a 144.4 ton unit for use with future developments. The first and second levels will both be supplied by separate AHU's, AHU-1 and AHU-2, respectively. AHU-1 has a 6,300 CFM capacity and AHU-2 a 8,000 CFM capacity. Both are VAV units with an economizer and energy recovery in the form of a variable speed heat recovery wheel. The initial supply air setpoint from each AHU is 55°F. Once the zones are satisfied, the setpoint will be gradually adjusted to reduce energy use from heating and cooling. The air is supplied to the different zones using a single duct VAV system. The system is run on a user defined schedule with both occupied and unoccupied modes. During the occupied mode, the cooling setpoint is 74°F and the heating setpoint is 70°F. During the unoccupied mode, the cooling setpoint is raised to 85°F and the heating setpoint is dropped to 65°F. The system is also equipped to monitor zone CO_2 levels and override the damper controls to maintain a level of 500 PPM. Several exhaust fans are located in the labs to provide extra ventilation, if needed.

Standard 62.1-2007 Evaluation

Section 5 - Systems and Equipment

ASHRAE Standard 62.1 was developed to serve as a guide for determining the proper ventilation rates to control the indoor air quality of a building. It's procedures range from equipment placement to acceptable contaminant levels to required outdoor air ventilation rates. Section 5 of standard 62.1 deals directly with building systems and equipment.

Section 5 covers several topics, including mold growth, indoor contaminants, and outdoor air intake vent locations. According to the standard, all surfaces must be resistant to mold growth according to either the "Mold Growth and Humidity Test," from UL 181 or a comparable test. Contaminant levels inside the building must also meet the requirements of table 4-1 as shown below. As part of the LEED certification requirements, this project was developed with the proper equipment and controls to monitor the indoor air quality. If contaminant levels exceed the upper limit, the system is programmed to activate the alarm and begin to vent the building by increasing the outdoor air intake to the HVAC system. All materials and finishes inside of the building have also been designed as low emitting materials in accordance with LEED IEQ Credit 4.1. The robotics lab will also have a separate dust collection system that will be installed and operated by the owner to prevent contamination of the other zones. The lab facilities will have a chemical waste system which will pipe directly to a neutralization tank charged with limestone.

Table 4-1 from Standard 62.1

Contaminant	Long Term			Short Term		
	Concentration Averaging			Concentration Averaging		
	μg/m³	ppm		μg/m³	ppm	
Sulfur dioxide	80	0.03	1 year[b]	365	0.14	24 hours[b]
Particles (PM 10)	50	-	1 year[b]	150	-	24 hours[b]
Particles (PM2.5)	15	-	1 year[b]	65	-	24 hours[b]
Carbon monoxide	-	-	-	40,000 10,000	35 9	1 hour[b] 8hours[b]
Oxidants (ozone)	-	-	-	-	0.08 0.12	8 hours[b] 1 hour[b]
Nitrogen dioxide	100	0.053	1 year[b]	-	-	-
Lead	1.5	-	3 months[b]	-	-	-

b - annual arithmetic mean

Standard 62.1-2007 Evaluation

Section 5 - Systems and Equipment (cont)

Table 5-1 from the standard gives the minimum distance required for air intake locations from possible contaminants. As noted in the table below, the project meets all of the required distances. All of the lab prep areas are equipped with fumehood exhaust vents to avoid contamination of the indoor air. The exhausts connect to the exhaust air duct work, which then vents the exhaust air on the opposite side of the building from the outdoor air intake. The outdoor air intakes are also located on the building side that faces away from the surrounding buildings. This helps to limit the level of contaminants that enter the HVAC system from other buildings.

Table 5-1 from Standard 62.1

Air Intake Minimum Separation Distance		
Object	**Minimum Distance (ft)**	**Meets Requirements**
Significantly contaminated exhaust	15	YES
Noxious or dangerous exhaust	30	-
Vents, chimneys, and flues from combustion appliances and equipment	15	YES
Garage entry, automobile loading area, or drive in queue	15	YES
Truck loading area or dock, bus parking/idling area	25	YES
Driveway, street, or parking place	5	YES
Thoroughfare with high traffic volume	25	-
Roof, landscaped grade, or other surface directly below intake	1	YES
Garbage storage/pick-up area, dumpsters	15	YES
Cooling tower intake or basin	15	-
Cooling tower exhaust	25	-

Standard 62.1-2007 Evaluation

Section 6 - Procedures

Section 6 of Standard 62.1 deals with proper ventilation rates of indoor spaces. There are two different methods of determining if a system is compliant: either the IAQ or Ventilation Rate Procedure. For this evaluation, the Ventilation Rate Procedure was used to calculate the nominal outside air (V_{oz}) and the required outside air (V_{ot}). The table below compares the values for each with the maximum outdoor air capacity of each AHU.

Outdoor Air Requirements

	$\sum V_{oz}$ (cfm)	V_{ot} (cfm)	Max OA Supplied (cfm)
AHU-1	1,709	2,801	6,300
AHU-2	1,564	1,955	8,000

As we can see from the table, each AHU is easily capable of providing the required outdoor air intake levels. For AHU-1, the maximum primary outdoor air fraction (Z_p) was determined by the Commons and for AHU-2 it was determined by the biology lab. The values were 0.65 and 0.29, respectively. The Z_p for the Commons is high because the amount of outdoor air required is two thirds of the zone primary airflow. The population density used to determine V_{ou} was assumed to be 1.0, thus increasing the overall value of V_{ot} allowing for a greater supply of outdoor air. Attached in Appendix A is a chart listing the zones for each AHU and their respective characteristics (area, use, occupancy), how each zone was calculated, and a table comparing the results for each zone.

Standard 90.1-2007 Evaluation

ASHRAE Standard 90.1-2007 provides the minimum requirements for designing an energy efficient building. In my evaluation, I compared the building design to sections 5 through 9 of the standard. All of the requirements were determined using data from climate zone 4A. My results concluded that, overall, the building complies with the minimum requirements set forth by Standard 90.1.

Section 5 Compliance - Building Envelope

The objective of section 5 is to ensure that the building envelope is properly designed. Since the vertical fenestration area was calculated at 29% of the total gross wall area, the Prescriptive Building method was used for evaluation.

Wall Area (ft^2)	Glass Area (ft^2)	% Total Vertical Fenestration
6,242	1,812	29.0

Table 1 on the next page shows the minimum required insulation values and the design values for the building envelope. All of the values meet or exceed standard minimum requirements. All of the insulation is also required to meet ASTM C578 specifications for rigid cellular polystyrenne thermal insulation. The SOG, cavity walls, and roof insulation are specified as type IV, X, and VI, respectively. Table 2 Shows the requirements of ASTM C578 for each type.

Due to the number of interface joints between the various building envelope systems, air and moisture barriers were very important in the design. All flashing, joints, and seals on the walls, windows, and doors were designed to minimize the amount of air and moisture penetration. All connections include thermal breaks as well to limit a heat transfer short circuit. All spandrels are required to include a layer of R-19 insulation. The air barriers for all systems have a maximum air leakage rate of 0.004 cfm per square foot of wall area. All adjacent systems will be connected in a flexible matter to allow for thermal and moisture variations, as well as creep.

Standard 90.1-2007 Evaluation

Table 1 - Building Envelope Minimum Requirements

	Roof Insulation R-Value	Wall Insulation R-value	SOG Insulation R-Value	Fenestration U-Value	Fenestration SHGC
Minimum required value	20	13	NR	0.5	0.4
Design value	20	13	10.2	0.32	0.39

Reference from Table 5.5-4 from Standard 90.1

Table 2 - Insulation Properties

Insulation	Density (lb/ft^3)	R-Value per inch ($^oF\text{-}ft^2h/BTU$)	
		At 40^oF	At 75^oF
Type IV	1.6	5.4	5.0
Type X	1.6	5.4	5.0
Type VI	1.6	5.4	5.0

Referenced from Table 1 from ASTM C578

The SOG will have a two inch thick layer of type IV insulation below the concrete. All cavity walls will have 2-1/2" layer of type X. The roof will have two 2" layers of type VI for a total of 4" of insulation. All three types have maximum flame-spread and smoke-developed indices of 75 and 450, respectively.

Standard 90.1-2007 Evaluation

Section 6 - HVAC Compliance

Section 6 sets minimum requirements for HVAC equipment in a new building. The New Science & Technology Center is two stories and less that 25,000 ft^2 so the simplified approach option can be used.

For climate zone 4A an economizer is not required (Appendix B), yet one is still included in the design for higher efficiency. All seals have been designed to meet their respective class (A, B, or C). All seals have also been specified to be low emitting materials. The table below shows the minimum required insulation thickness for piping. The design thickness for all piping insulation meets the requirements. The outdoor air quantity is greater than the maximum 3000 cfm described for the simplified approach; however this meets the exception clause by the inclusion of an energy recovery system (heat wheel) in the design. The supply and return air ducts/plenum have all been insulated with 1-1/2" mineral fiber board or mineral fiber blanket. The outdoor air ducts/plenum has been insulated with the same materials but at 2" thick. All equipment, such as a boiler, are located in adjacent buildings or the service is supplied via the school's infrastructure. All motors are rated with Premium efficiency as defined by NEMA MG1.

Minimum Pipe Insulation Thickness

	Dual service heating/cooling	Heating hot water	CW supply/return		Condensate and equipment drain
Operating Temperature	40-200°F	< 200°F	-		<60°F
Pipe Size	<NPS-12	<NPS-12	<NPS-3	<NPS-12	All sizes
Min Required insulation thickness (in)	1.0	1.0	1.0	1.0	0.5
Design insulation thickness (in)	1.0	1.0	1.0	1-1/2	0.5

Referenced from Table 6.8.3 from Standard 90.1

Standard 90.1-2007 Evaluation

Section 7 - Service Water Heating Compliance

The service water heating for the New Science and Technology Center is provided from the already existing infrastructure on the school's campus. Any new equipment, piping, and controls have all be designed to meet the requirements. A Solaraide 4500 W, 120 gallon solar hot water heater will be owner installed and operated. The attached glycol pump will operate whenever the domestic hot water storage tank drops below 105ºF.

Section 8 - Power Compliance

All feeders are required to meet a maximum voltage drop of 2% and all branch circuits must meet a maximum voltage drop of 3% at design load. This was taken into account when designing the building systems. A GEPV-200-M solar array will be mounted on the roof and connected to the building electrical system. A 5% voltage drop is the maximum permitted for the assembly.

Section 9 - Lighting Compliance

The Building Area Method was used to calculate the interior lighting power allowance. Following are the four steps required for compliance:

1) From table 9.5.1 in Appendix B select a building area type and its associated lighting power density, or LPD. Using the school/university building area type the LDP is 1.2 W/ft^2.

2) Determine the gross lighted floor area in ft^2 of the building. The New Science & Technology Center is 18,400 ft^2.

3) Multiply the gross lighted floor area by the LPD.

   18,400 ft^2 x 1.2 W/ft^2 = 22,080 W

4) The installed interior lighting power must be less than the interior lighting power allowance. 19,569 W < 22, 080 W

Standard 90.1-2007 Evaluation

Lighting Compliance Table

LDP (W/ft^2)	Gross lighted floor area (ft^2)	Interior lighting power allowance (W)	Installed interior lighting allowance (W)
1.2	18,400	22,080	19,569

The above table shows the results of the installed interior lighting allowance compared with the interior lighting power allowance. As indicated, the installed lighting allowance is 11% below the maximum allowed.

An advanced lighting control system is to be installed for daylight harvesting. It will include on/off occupancy sensors with a 30 minute user adjustable time out. 4-button scene control override switches will be located in all of the classrooms and labs, as well as the conference room. The lighting level will be determined by the lowest light level signal for a given room. This system will help to reduce the energy usage due to the lighting system.

Discussion of Results

The Chestnut Hill Academy was looking to project an image of being environmentally responsible, as well as to create a top notch facility for the benefit of their students. The New Science & Technology Center was designed as a quality building. The center meets the minimum requirements set forth by standards 62.1 and 90.1. It will be able to reap the benefits of having properly designed systems.

References

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

•ANSI/ASHRAE/IESNA Standard 90.1-2007. Energy Standard for Buildings Except Low-Rise Residential Buildings. American Society of Heating, Refrigerating and Air-Conditioning Engineers. Atlanta, GA.

•Chestnut Hill Academy New Science & Technology Center Construction Documents. Lilley Dadagian Architects. Lexington, MA

•DiversiFoam Products. ASTM C 578-95 specifications for rigid cellular polystyrene thermal insulation. Rockford, MN http://www.diversifoam.com/cfproperties.htm

Appendix A

Standard 62.1 Tables and Sample Calculations

Table A-1

Level/Room	**Area** (Net SF)	**Calculated Population Basis** (SF/P)	**Occupancy Type**	**Calculated Population** (CP)
Second Level				
Chem./Biology Lab	1,070	50	Science Lab	21
Chem./Bio./Phy. Prep.	306	100	Office	3
Ind. Lab	170	50	Science Lab	3
Chem./Physics Lab	1,058	50	Science Lab	21
Office Suite	545	100	Office	5
Conference Room	196	15	Conference	13
Bio. Prep	127	50	Science Lab	3
Biology	1,092	50	Science Lab	22
Corridor	1,055	-	-	-
Second Level Totals	**4,564**			**92**
First Level				
Physics Lab	1,034	50	Science Lab	21
Phy. Prep.	210	100	Office	2
Ind. Phy. Lab	113	50	Science Lab	2
Robotics and Workshop	1,355	50	Science Lab	27
Porch	300	15	Lobbies	20
Commons	184	15	Lobbies	12
K-2 Lab	588	50	Science Lab	12
Prep	107	100	Office	1
3-5 Lab	618	50	Science Lab	12
Corridor	1,055	-	-	-
First Level Totals	**4,509**			**110**

Table A-1 lists each space in the building and it's respective area, estimated population, and occupancy type.

Appendix A

Standard 62.1 Tables and Sample Calculations

Ventilation Rate Calculation Procedure (section 6)

1) Calculate the breathing zone outdoor airflow

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

A_z = zone floor area (ft^2)

P_z = zone population

R_p = outdoor airflow rate required per person (table 6-1*)

R_a = outdoor airflow rate required per unit area (table 6-1*)

(* refers to Table 6-1 in Standard 62.1)

2) Calculate the zone air distribution effectiveness, E_z, from table 6-2

3) Calculate the zone outdoor airflow

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

4) Calculate the zone primary outdoor air fraction

$Z_p = V_{oz} / V_{pz}$ V_{pz} = zone primary airflow

5) Calculate the system ventilation efficiency, E_v, from table 6-3 or Appendix A of Standard 62.1

For Appendix A, $E_v = E_{vz} = 1 + X_s - Z_d$

where X_s is the average outdoor air fraction, $X_s = V_{ou} / V_{ps}$

and Z_d is the discharge outdoor air fraction, $Z_d = V_{oz} = V_{dz}$

6) Calculate the uncorrected outdoor air intake

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

D = occupancy diversity

7) Calculate the outdoor air intake flow

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

Appendix A

Standard 62.1 Tables and Sample Calculations

Sample Calculations (using AHU-2 and the biology lab)

1) Calculate the breathing zone outdoor airflow

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

$V_{bz} = (10 *22) + (0.18* 1092)$

$V_{bz} = 417$ CFM

2) Calculate the zone air distribution effectiveness, E_z, from table 6-2 on next page

$E_z = 1.0$

3) Calculate the zone outdoor airflow

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

$V_{oz} = 417 / 1$

$V_{oz} = 417$ CFM

4) Calculate the zone primary outdoor air fraction

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

$Z_p = 417 / 1450$

$Z_p = 0.29$

5) Calculate the system ventilation efficiency, E_v, from table 6-3 on next page

From tabe 6-3, use the maximum Z_p from all the spaces. In this case it is the biology lab for AHU-2 and the table gives us a value of 0.8

Appendix A

Standard 62.1 Tables and Sample Calculations

6) Calculate the uncorrected outdoor air intake

$V_{ou} = D \sum_{all\ zones}(R_p * P_z) + \sum_{all\ zones}(R_a * A_z)$ --> assume a diversity of 1.0

$V_{ou} = (1)(805) + (759)$

$V_{ou} = 1564$ CFM

7) Calculate the outdoor air intake flow

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

$V_{ot} = 1564 / 0.8$

$V_{ot} = 1955$ CFM

Table 6-2* Zone Distribution Effectiveness

Air Distribution Configuration	E_z
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air 15°F or more above Space temperature and ceiling return	0.8
Ceiling supply of warm air less than 15°F above Space temperature and ceiling return provided that the 150 fpm supply air jet reaches to within 4.5 ft of floor level	1.0
Floor supply of cool air and ceiling return provided that the 150 fpm supply jet reaches 4.5 ft or more above the floor	1.0
Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification	1.2
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7
Makeup supply drawn in on the opposite side of the room from the exhaust and/or return	0.8
Makeup supply drawn in near to the exhaust and/or return location	0.5

(* refers to tables in Standard 62.1)

Table 6-3*

System Ventilation Efficiency

Max (Z_p)	E_v
≤0.15	1.0
≤0.25	0.9
≤0.35	0.8
≤0.45	0.7
≤0.55	0.6
>0.55	Use Appendix A alternate calculation

Appendix A

Standard 62.1 Tables and Sample Calculations

Table A-2

	R_p	R_a	V_{bz}	E_z	V_{oz}	V_{pz}	Z_p	E_v	D	V_{ou}	V_{ot}
	(cfm/person)	(cfm/ft^2)	(cfm)		(cfm)	(cfm)				(cfm)	(cfm)
Second Level											
Chem./Biology Lab	10	0.18	403	1	403	1460	0.28	-	1		
Chem./Bio./Phy. Prep.	5	0.06	33	1	33	1400	0.02	-	1		
Ind. Lab	10	0.18	61	1	61	300	0.20	-	1		
Chem./Physics Lab	10	0.18	400	1	400	1680	0.24	-	1		
Office Suite	5	0.06	58	1	58	500	0.12	-	1		
Conference Room	5	0.06	77	1	77	275	0.28	-	1		
Bio. Prep	10	0.18	53	1	53	700	0.08	-	1		
Biology	10	0.18	417	1	417	1450	**0.29**	0.8	1		
Corridor	-	0.06	63	1	63	420	0.15	-	1		
							Total	0.8	1	1564	1955
									AHU 2 MAX OA (CFM)		8000
First Level											
Physics Lab	10	0.18	396	1	396	820	0.48	-	1		
Phy. Prep.	5	0.06	23	1	23	80	0.28	-	1		
Ind. Phy. Lab	10	0.18	40	1	40	100	0.40	-	1		
Robotics and Workshop	10	0.18	514	1	514	874	0.59	-	1		
Porch	5	0.06	118	1	118	2220	0.05	-	1		
Commons	5	0.06	71	1	71	110	**0.65**	0.61	1		
K-2 Lab	10	0.18	226	1	226	480	0.47	-	1		
Prep	5	0.06	11	1	11	140	0.08	-	1		
3-5 Lab	10	0.18	231	1	231	480	0.48	-	1		
Corridor	-	0.06	63	1	63	435	0.15	-	1		
							Total	0.61	1	1709	2801
									AHU 1 MAX OA (CFM)		6300

Table A-2 shows all of the calculated values required for each zone to find V_{ot}. E_z was determined using table 6-2 and is 1 for every space. E_v was calculated using table 6-3 for AHU-2. For AHU-1 the alternate calculation method listed in Appendix A of 62.1 (equations A-1 through A-3). Like stated before, the diversity, D, was assumed to have a value of 1 in order to increase the minimum requirements. The actual diversity is not known as the building is still under construction.

Appendix B

Standard 90.1 Tables reference from Standard 90.1

Table 6.5.1 Minimum System Size for Which an Economizer is Required

Climate Zones	Cooling Capacity for Which an Economizer is Required
1a, 1b, 2a, 2b, 3a, 4a	No economizer requirement
2b, 5a, 6a, 7, 8	≥135,000 Btu/h
3b, 3c, 4b, 5b, 5c, 6b	≥65,000 Btu/h

Table 6.4.4.2B Duct Seal Levels

Seal Level	**Sealing Requirement**
A	All transverse joints, longitudinal seams, and duct wall penetrations. Pressure-sensitive tape shall not be used as the primary sealant, unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification
B	All transverse joints, longitudinal seams. Pressure-sensitive tape shall not be used as the primary sealant, unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification
C	Transverse joints only

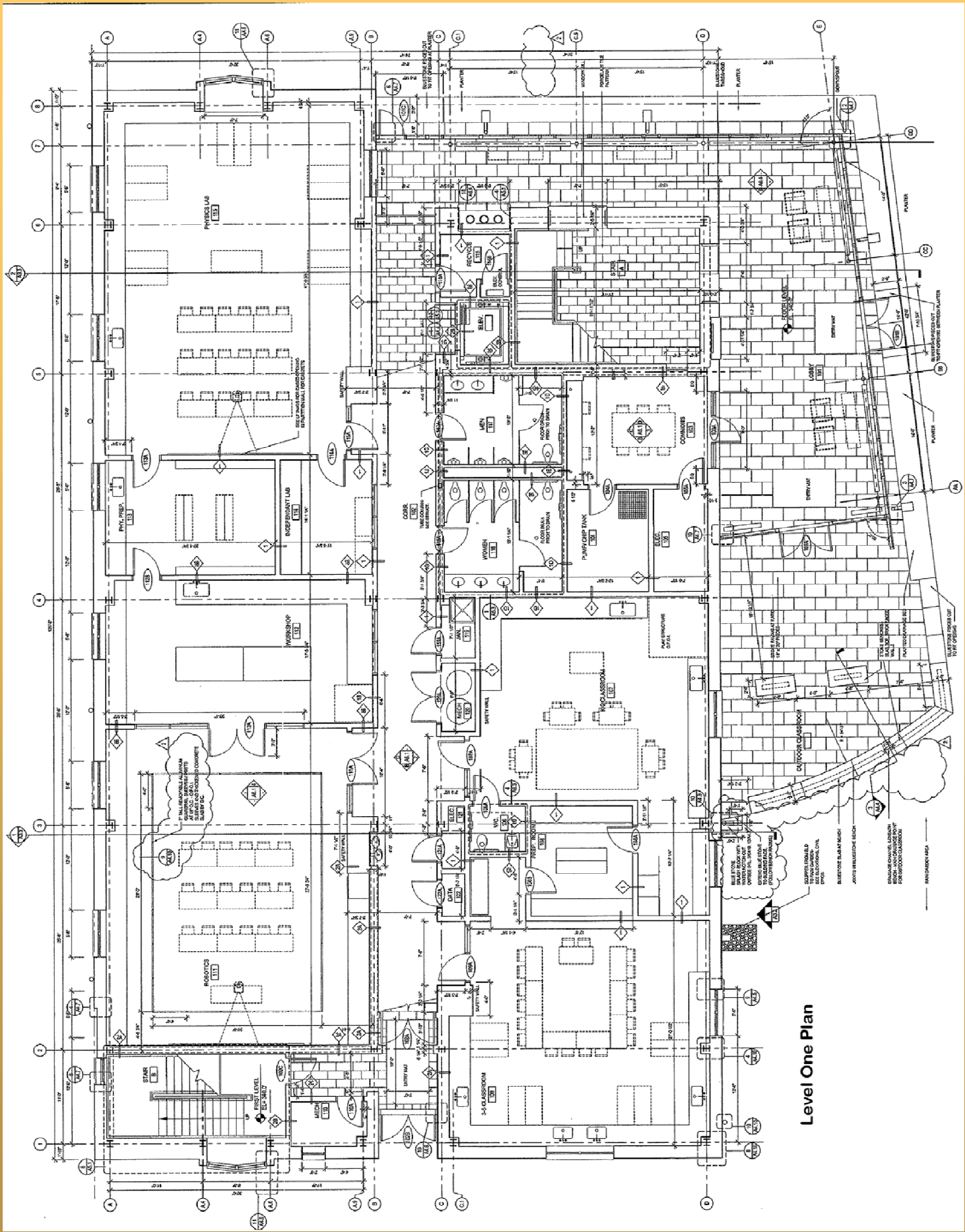
Appendix B

Standard 90.1 Tables

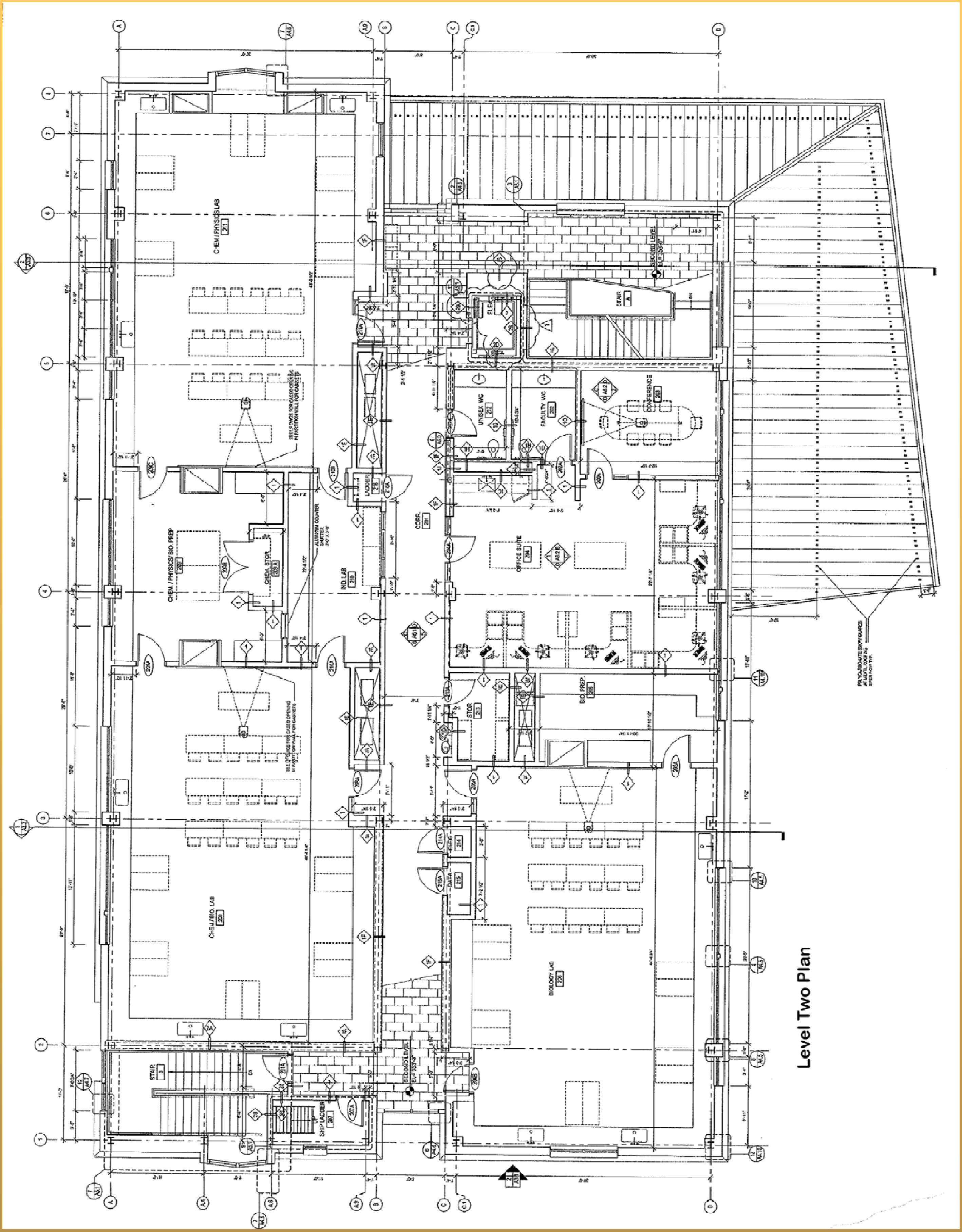
Table 9.5.1 Lighting Power Densities Using the Building Area Method

Building Area Type	LPD (w/ft^2)
Automotive facility	0.9
Convention center	1.2
Courthouse	1.2
Dining: bar lounge/leisure	1.3
Dining: cafeteria/fast food	1.4
Dining: family	1.6
Dormitory	1.0
Exercise center	1.0
Gymnasium	1.1
Health-care clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion picture theater	1.2
Multifamily	0.7
Museum	1.1
Office	1.0
Parking garage	0.3
Penitentiary	1.0
Performing arts theater	1.6
Police/fire station	1.0
Post office	1.1
Religious building	1.3
Retail	1.5
School/university	1.2
Sports arena	1.1
Town hall	1.1
Transportation	1.0
Warehouse	0.8
Workshop	1.4

Floor Plans



Floor Plans


Level Two Plan
CHEM / PHYSICS LAB
CHEM / PHYSICS/ BIO. PREP
CHEM. STOR
CORR.
CONFERENCE
UNISEX WC
FACULTY WC
OFFICE SUITE
BIO. PREP.
STOR.
CHEM./BIO. LAB
BIOLOGY LAB
STAIR
SHIP LADDER
LADDER
ELEV
SECOND LEVEL