Technical Report One

ASHRAE Standards 62.1-2010 and 90.1-2010

Father O'Connell Hall Renovation

The Catholic University of America

Washington, D.C

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Table of Contents

Executive Summery

The purpose of technical report one is to evaluate The Catholic University of America's Father O'Connell Hall Renovation is in compliance with ASHRAE Standards 62.1-2010, Sections 5 and 6, and Standard 90.1-2010.

Through the analysis of ASHRAE Standard 62.1-2010, it was found that Father O'Connell Hall is fully compliant. Ventilation systems meet the minimum requirements using seven different AHU's. System controls are compliant by using a building management system and utilizing various VFD's. Materials and waterproofing are undergoing current renovations to ensure proper sealant of the building enclosure. Standard 62.1 ensures proper insulation around ducts, pipes, etc. to prevent mold and other bacterial growth throughout the building. It also ensures that no contaminated air is recirculated and potential contaminants are exhausted directly outdoor. In order to prevent these contaminants from re-entering the building all supply air intakes are at a safe distance from exhausts or any outdoor source that has potential health risks.

Analysis of ASHRAE Standard 90.1-2010 showed that Father O'Connell Hall was not completely compliant. The building envelope did not meet minimum requirements because little or no insulation was used in the walls and roofs, although, vertical fenestration was much more efficient than the requirements of Standard 90.1. In addition, pumping efficiency was not met and further investigation needs to be done to understand why these efficiencies were low. It should be noted that Father O'Connell Hall had very low lighting power densities due to the use of LED lighting which could have a significant impact on over building energy usage. Additional, calculations will be done in technical report two.

Building Overview

Father O'Connell Hall is a 54,000 SF, 15 million dollar exterior and interior renovation on the campus of The Catholic University of America in Washington, DC. Father O'Connell Hall has three conjoined structures: the four story main building constructed in 1914, the three story east wing constructed in 1958, and the west wing constructed in 1962. The Hall is the third oldest building on campus; the renovation will preserve the historical Catholic culture which The Catholic University of America reflects in our nation's capital. Father O'Connell Hall will be used for administrative/Enrollment services, admissions, financial aid, and a banquet hall which will be used to hold special events. Undergraduate Admissions is important because it generates revenue for the school. The design sells the school while still reflection the rich historical tradition of The Catholic University of America and of the surrounding buildings.

The façade is primarily granite stone with Indiana limstone. The façade is broken up with a series of two story arched windows along the main building of the banquet hall, while the east and west wings use large rectangular on story windows. This closley represents a historic collegiate gothic style.

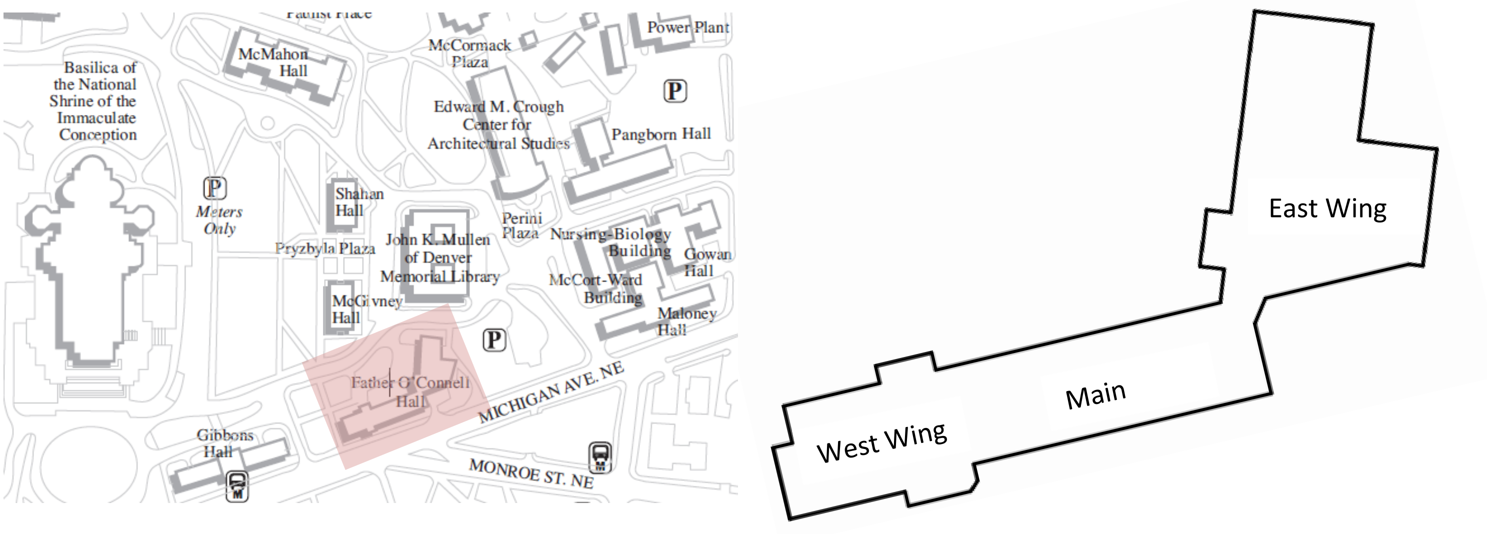

Figure 1: Father O'Connell Hall located on The Catholic University Campus.

Mechanical System Overview

Father O'Connell Hall is ventilated using seven air handling units, with one being 100% outdoor air. *Figure 1* below shows the zoning for each air handling units throughout the building. All New AHU's will be equipped with economizer cycle to maximize ventilation and reduce energy. The 100% outdoor air unit will also have an air-to-air plate exchanger as well as a wraparound heat pipe heat recovery exchanger to pre-condition supply air temperatures and further reduce energy consumption. Recirculation of this air is provided by fan powered boxes, VAV's, and air transfer ducts located in the plenum above the ceiling on the basement and first floors.

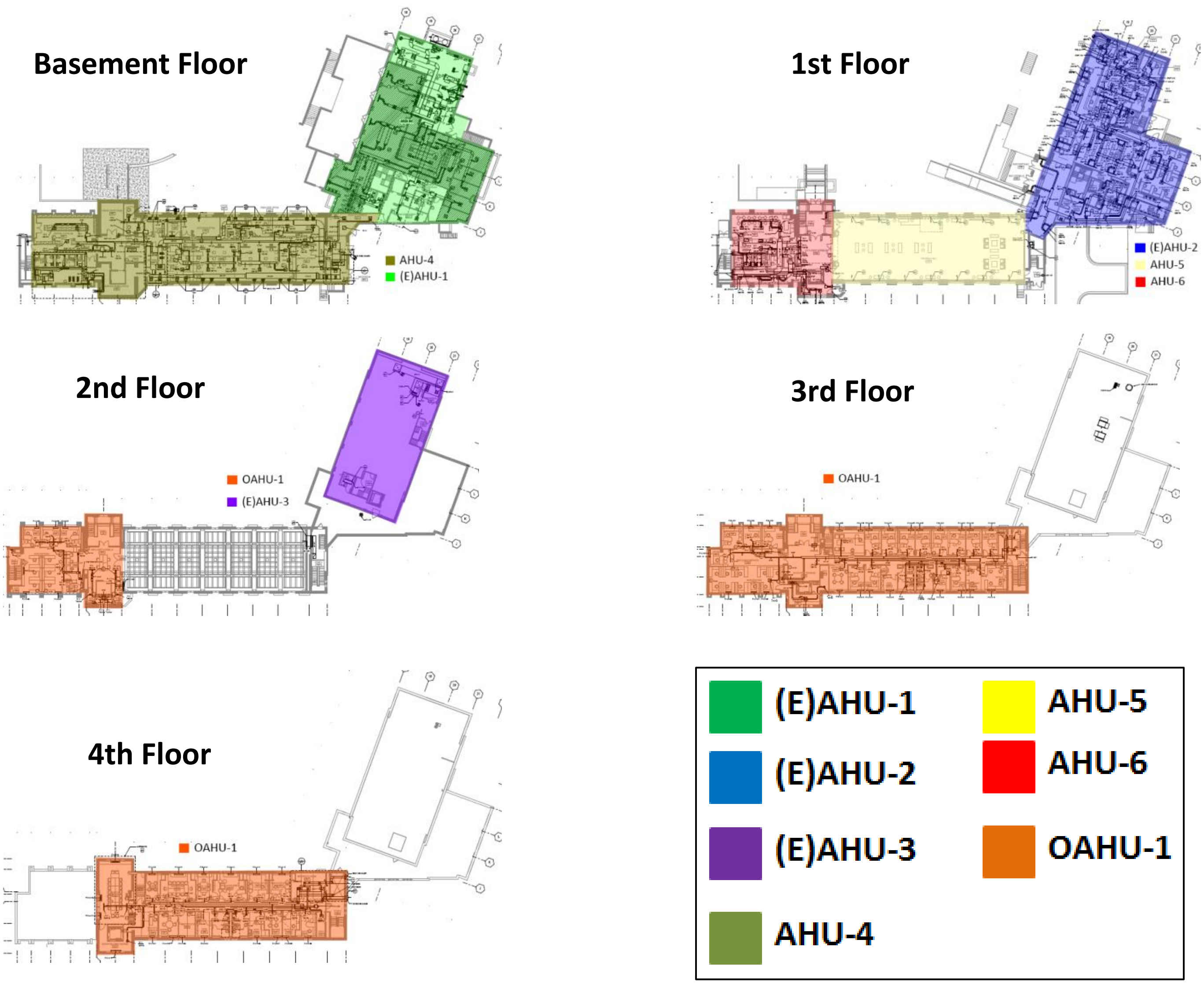

Figure 2: Air Handling Unit Zoning

Chilled Water System

Chilled water is provided from one 97.7 ton electric air-cooled chiller located on grade on the south side of east wing. Chilled water is provided directly to all AHU's and all FCU's located on floors 2 to 4. Chilled water flow delivered to all AHU's and FCU's is controlled by a proportional integral controller (PIC) control valve regulated by two chilled water pumps with VFD's. Additional cooling for two telecom rooms is provided by two ductless split system units.

Heating Hot Water System

Washington Gas Company provides a low pressure (2 psi), 2 inch gas pipe to two 500 MBH condensing pulse combustion boilers located on the basement level of the west wing. These boilers provide all hot water to the AHU's, FCU's, and reheat coils for the VAV's and Fan powered boxes. The hot water flow is controlled the same way as the chilled water system using three heat water pumps with VFD's. There are two additional existing boilers located in the east wing of the basement floor. These boilers provide heating to the small portion of the building that is not in the scope of this renovation. Information for this portion of the building is not available at this time.

ASHRAE Standard 62.1-2010 Analysis

Section 5: System and Equipment

5.1 Ventilation Air Distribution

Father O'Connell Hall meets design ventilation requirements by section 6 of Standard 62.1. AHU-4, AHU-5, and AHU-6 provide ventilation to the basement and first floor areas. Air transfer ducts, fan powered boxes, and variable air volume boxes are used to help ventilate these floors. Floors 2-4 are ventilated using a 100% outside air handling unit. Detailed calculations can be seen in appendix A.

5.2 Exhaust Duct Location

All exhaust ducts carrying potentially harmful contaminates from toilet or janitor rooms have a SMACNA seal class of C and a minimum negative pressurization of 2-inch wg. All exhaust is discharged at a safe distance above roof.

5.3 Ventilation System Controls

Father O'Connell Hall will be equipped with a Building Automated System (BAS). This system has occupied, unoccupied, and hand-off-auto operation modes that will control outside air dampers to ensure minimum ventilation requirements are met. All air handling units have a supply fan VFD that is controlled by the BAS.

5.4 Airstream Surfaces

Mold growth and erosion is avoided by using galvanized steel sheet metal that is in accordance of UL 181 ASTMC 1338 Standards.

5.5 Outdoor Air Intakes

Outside air louver intake for the 100% outside air handling unit is located on the fourth floor west wall of the main building. Outside air intake for AHU-6 and AHU-4 are located on the south wall of the basement level. AHU-5 has an air intake on the west wall of the main building on the basement level. All outside air intakes are located at least 15 feet from all exhaust outlets which exhaust class 3 air from toilet and janitor rooms. All intakes comply with ASHRAE Standard 62.1 Table 5-1 below. Details of louvers or louver shop drawings could not be located but specification requires bird screens and storm-proof to prevent entry of rain and snow.

TABLE 5-1 Air Intake Minimum Separation Distance

Object	Minimum Distance, ft (m)
Class 2 air exhaust/relief outlet (Note 1)	10 (3)
Class 3 air exhaust/relief outlet (Note 1)	15 (5)
Class 4 air exhaust/relief outlet (Note 2)	30 (10)
Plumbing vents terminating less than 3 ft (1 m) above the level of the outdoor air intake	10 (3)
Plumbing vents terminating at least 3 ft (1 m) above the level of the outdoor air intake	3 (1)
Vents, chimneys, and flues from combustion appliances and equipment (Note 3)	15 (5)
Garage entry, automobile loading area, or drive-in queue (Note 4)	15 (5)
Truck loading area or dock, bus parking/idling area (Note 4)	25 (7.5)
Driveway, street, or parking place (Note 4)	5 (1.5)
Thoroughfare with high traffic volume	25 (7.5)
Roof, landscaped grade, or other surface directly below intake (Notes 5 and 6)	1 (0.30)
Garbage storage/pick-up area, dumpsters	15 (5)
Cooling tower intake or basin	15 (5)
Cooling tower exhaust	25 (7.5)

Note 1: This requirements applies to the distance from the outdoor air intakes for one ventilation system to the exhaust/relief outlets for any other ventilation system.
Note 2: Minimum distance listed does not apply to laboratory fume hood exhaust air outlets. Separation criteria for fume hood exhaust shall be in compliance with NFPA 45[5] and ANSI/AIHA Z9.5.[6] Information on separation criteria for industrial environments can be found in the *ACGIH Industrial Ventilation Manual*[7] and in the *ASHRAE Handbook—HVAC Applications*.[8]
Note 3: Shorter separation distances shall be permitted when determined in accordance with (a) ANSI Z223.1/NFPA 54[9] for fuel gas burning appliances and equipment, (b) NFPA 31[10] for oil burning appliances and equipment, or (c) NFPA 211[11] for other combustion appliances and equipment.
Note 4: Distance measured to closest place that vehicle exhaust is likely to be located.
Note 5: Shorter separation distance shall be permitted where outdoor surfaces are sloped more than 45 degrees from horizontal or that are less than 1 in. (3 cm) wide.
Note 6: Where snow accumulation is expected, the surface of the snow at the expected average snow depth constitutes the "other surface directly below intake."

Figure 3: TABLE 5-1 ASHRAE Standard 62.1 Section 5

5.6 Local Capture of Contaminants

All contaminants that are generated by equipment are properly exhausted directly outside to avoid mixing into occupied spaces.

5.7 Combustion Air

Father O'Connell Hall has two condensing boilers located on the basement level. Both Boilers are vented directly to the outdoors. See *Figure 4* below.

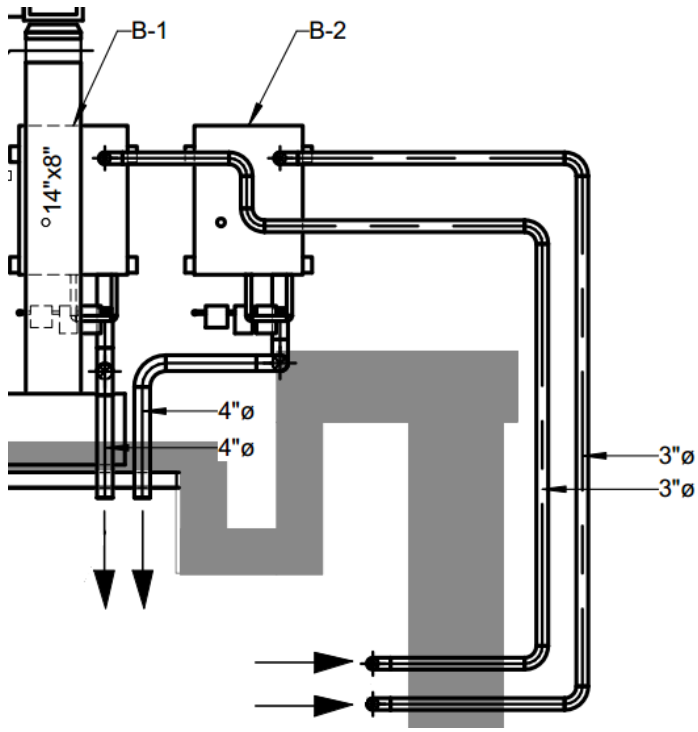

Figure 4: Boiler intake and exhaust vent from project documentation

5.8 Particulate Matter Removal

All AHU's will use pre-filters with a MERV 7 rating and a final filter with a MERV 13 rating upstream of the cooling coil. This complies with ASHRAE Standard 52.2 which requires a minimum filtration rating of MERV 6.

5.9 Dehumidification Systems

Father O'Connell Hall is specified to maintain a relative humidity of 50% throughout the building. Minimum supply air is greater than the maximum exhaust air, maintaining a positive pressure for the building as a whole. The building meets exfiltration requirements.

5.10 Drain Pans

Condensate drain pans have at least a 2 percent slope in the direction toward the drain connection. All sizes are large enough to collect from all cooling coils with a minimum depth of

2 inches deep. All other drain pans are to be designed and manufactured to according to ASHRAE Standard 62.1. See *Figure 5* below for a complete detail of a typical drain pan.

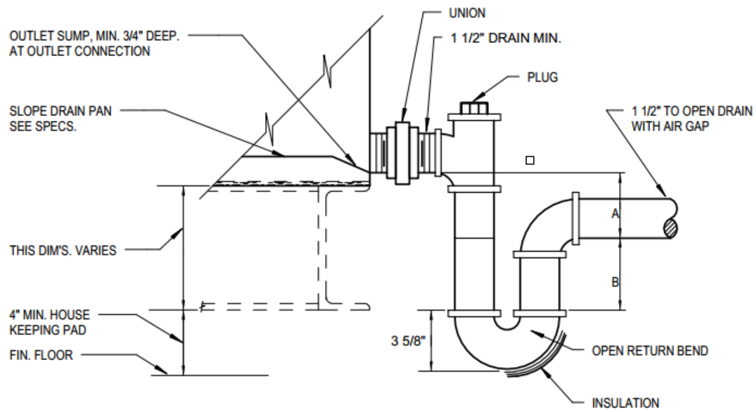

Figure 5: Drain Pan Detail

5.11 Finned-Tube Coils and Heat Exchangers

All finned-tube coils and heat exchangers have drain pans according to ASHRAE section 5.1. All Heat exchangers will have access doors at least 18 inches wide and are provided on both sides of coils. A pressure drop of less than 0.75 in. w.c. due to the access doors is not mentioned.

5.12 Humidifiers and Water-Spray Systems

Water used for humidity control originates directly from a potable source. Drip pans are located under the humidifier and there are no obstructions downstream. Therefore, Father O'Connell Hall complies with ASHRAE Standard 62.1 section 5.12.

5.13 Access for Inspection, Cleaning, and Maintenance

The following will be provided access doors for inspection, cleaning, and maintenance:

-Duct Filters
-Outdoor-air intakes and mixed-air plenums
-Control devices
-Volume dampers
-Duct silencers
-Turning vanes
-Drain pans
-Fire dampers

5.14 Building Envelope and Interior Surfaces

All exterior roofing and exterior walls will have appropriate waterproofing. *Figure 6* to the right shows a typical wall section indicating a fluid applied waterproofing membrane. Pipes will have a 125-mil-thick vapor barrier and waterproofing membrane to prevent condensation. All pipe and duct penetration will also have sufficient insulation and waterproof membrane.

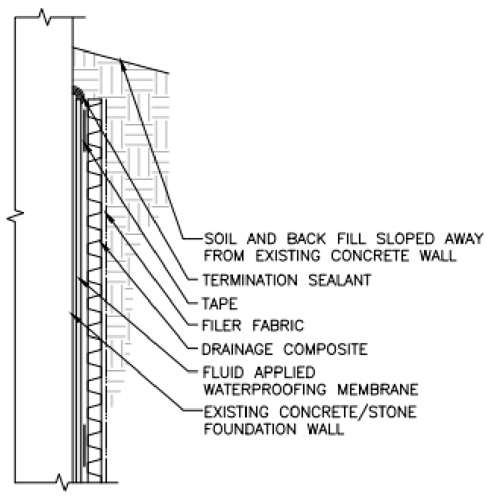

Figure 6: Typical Wall Section

5.15 Building Attached Parking Garages

This section does not apply because there are no parking garages. Vehicular exhaust is not a concern for this project.

5.16 Air Classification and Recirculation

Fan powered boxes are used to recirculate plenum air on the basement level and the 2nd level on the east building. Office space, storage rooms for dry materials, and corridors make up these spaces which all have class 1 air; therefore, it meets ASHRAE Standard 62.1 because class 1 air is permitted to be recirculated. All toilet and janitor closets have class 3 air and are directly exhausted to the outside. Some air transfer ducts are used to recirculate corridor air on floors 2-4.

5.17 Requirements for Buildings Containing ETS Areas

Father O'Connell Hall is a smoke free building; therefore, this section does not apply.

Section 6: Ventilation Rate Procedure Analysis

Air handling units 2,4,5,6 and 100% outside AHU (OAHU-1) were analyzed to estimate minimum outside air requirements for all spaces. Existing air handling units 1 and 3 were not able to be analyzed due to lack of information in the project documentation. AHU's 1 and 3 only provide ventilation for a small portion of the building which was not in the scope of this renovation.

Equation 6-1 in section 6.2.2.1 in ASHRAE Standard 62.1 was used to calculate breathing zone outdoor airflow (V_{bz}).

$$V_{bz} = (R_p \times P_z) + (R_a \times A_z)$$

Where: A_z = zone floor area: the net occupiable floor area of the ventilation zone ft^2

P_z = zone population: the number of people in the ventilation zone during typical usage. (this was determined from counting seats from furniture plans)

R_p = outdoor airflow rate required per person as determined from Table 6-1

R_a = outdoor airflow rate required per unit area as determined from Table 6-1

The zone outdoor airflow (Voz) is the outdoor air that must be provided to ventilate the zone.

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

Where E_z = zone distribution effectiveness which is found from table 6-2. E_z varied between 0.8,1, and 1.2 depending on how the air is distributed into the zone.

For 100% outside air systems the outdoor air intake flow (V_{ot}) is found by equation 6-4.

$$V_{ot} = \Sigma_{\text{all zones}} \times V_{oz}$$

The primary outdoor air fraction (Z_{pz}) is the minimum percent of ventilation air from the supply air. This is calculated from equation 6.5.

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

Where V_{pz} is the zone primary airflow.

Table 1 below is a summary of all five air handlers that were analyzed. Design CFM and Minimum OA CFM were taken from the project documentation and compared to ASHRAE 62.1 Min. OA CFM calculations based on the above formulas. Detailed spreadsheets used for these calculations are available in Appendix A.

Minimum Ventilation Rates				
Unit	Design CFM	Minimum OA CFM	ASHRAE 62.1 Min. OA CFM	Compliant (Y/N)
OAHU-1	1800	1800	1400	Y
(E)AHU-2	7790	1861	1171	Y
AHU-4	4100	1480	613	Y
AHU-5	8000	1480	1479	Y
AHU-6	3500	500	381	Y

Table 1: Minimum Ventilation Rates

ASHRAE 62.1 – 2010 Summary

After analyzing the ventilation system of Father O'Connell Hall, it has been determined that all spaces have met the minimum ventilation requirements required by ASHRAE 62.1. Seven air handling units, including one 100% outdoor air unit, and air transfer ducts exceed or meet the minimum ventilation requirements. In addition to minimum ventilation requirements, Father O'Connell Hall also complies with Section 5. This includes all materials and HVAC control systems. Father O'Connell Hall is currently undergoing renovation to install new waterproof membrane around the footing and windows to comply with section 5.14 building envelope and interior surfaces.

ASHRAE Standard 90.1-2010 Analysis

Section 5: Building Envelope

5.1.4 Climate

The Catholic University of America located in Washington, DC is in climate zone 4A as you can see from the *Figure 7* below. Table B-1 is found in Appendix B of ASHRAE Standard 90.1 and is used to determine building envelope requirements.

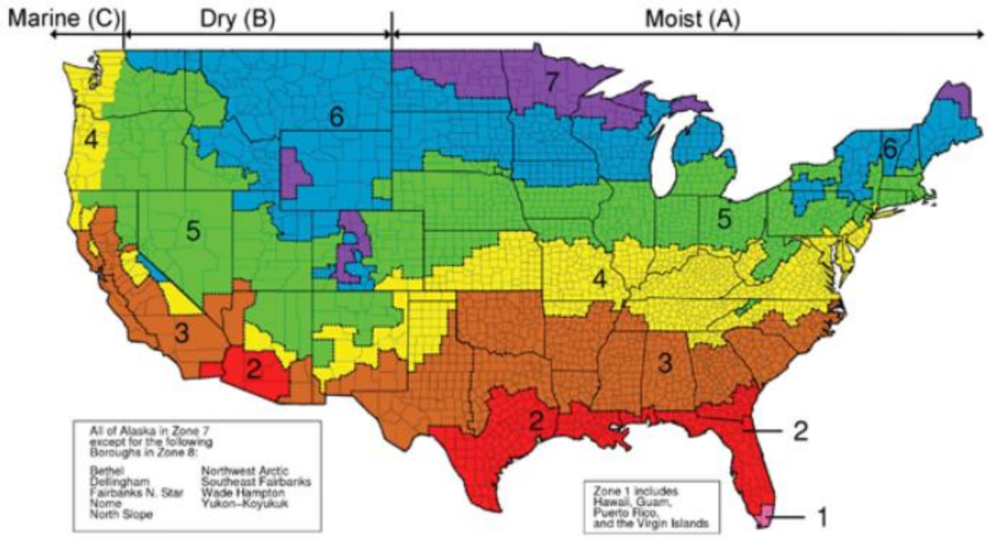

Figure 7: Climate Zones in the US from ASHRAE Table B-1

5.4 Mandatory Provisions

The exterior envelope of Father O'Connell hall is currently being renovated. Exterior limestone and granite joints are to be repointed. Coping stone is to be removed and reinstalled to install thru wall flashing. In addition, much of the exterior footer is to be excavated to in order to install water proofing. Windows and doors are specified to be sealed. *Figure 8* below is a detail of the window sealant. The entire building envelope is constructed with a continuous air barrier.

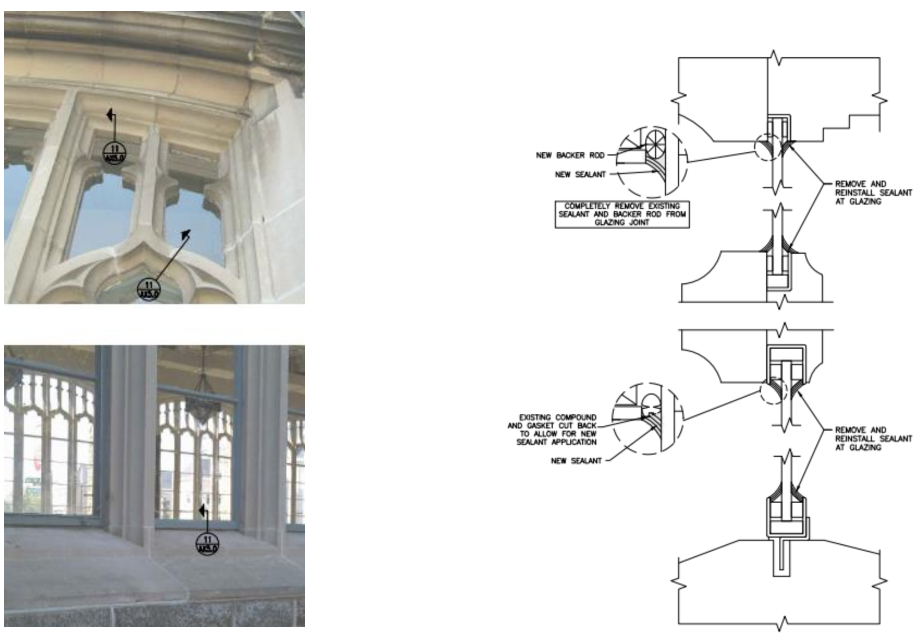

Figure 8: Sealant of existing windows detail from project documentation

5.5 Prescriptive Building Envelope

In order to determine compliance with building envelope requirements of ASHRAE Standard 90.1, the prescriptive building method was used. *Table 3* below shows a comparison of Father O'Connell Hall building envelope and requirements for nonresidential zone 4A. It was found that it does not comply with Standard 90.1. This is because the building was built in 1914 and no or very little insulation was used. This shows a potential for design improvements. In addition, the total vertical fenestration area must be less than 40% of the gross wall area. Table 2 below clearly indicates that Father O'Connell Hall complies. Fenestration calculations can be seen in *Table 2* below.

Vertical Fenestration Area				
Face	Glazing Area SF	Wall Area SF	Glazing %	Comply
North	2181	15,495	14.07551	Y
South	2201.7425	16,125	13.65422	Y
East	713.49	5,716	12.48233	Y
West	337.4175	3,670	9.193937	Y
Total	5433.65	41,006	13.25087	Y

Table 2: Fenestration Areas

Building Envelope for Nonresidential zone 4A							
Element	R-Value	Insulation Min. R-Value	U-Value	Max U-Value	SHGC	Max SHGC	Comply
Walls, Above Grade Mass	4.6*	9.5	0.217	0.104	-	-	N
Roofs, Built up roof East and West wing	9	20	0.095	0.048	-	-	N
Roofs, Built up roof main building	2.89*	20	0.346	0.048	-	-	N
Glazing, Nonmetal Framing East and West Wing	-	-	0.40	0.40	0.5	0.40	N
Glazing, Nonmetal Framing Main Building	-	-	0.60	0.40	0.5	0.40	N

* No insulation and overall R-Value was used

Table 3: Building Material R and U-Values

Section 6: Heating, Ventilating, and Air Conditioning

6.2 Compliance Paths

ASHRAE Standard 90.1 has two methods to evaluate equipment efficiency, the simplified approach option for HVAC systems and the mandatory provisions with prescriptive path. Father O'Connell Hall does not meet the height or gross area requirements of fewer than two stories and less than gross area of 25,000 ft^2; therefore, the mandatory provisions with prescriptive path must be used to evaluate equipment efficiency.

6.3 Simplified Approach Option for HVAC Systems

This section does not apply for reasons mentioned in Section 6.2.

6.4 Mandatory Provisions

Specifications indicate that all mechanical equipment must have manufacturer's label that states the requirements of ASHRAE Standard 90.1 is met; Therefore, minimum efficiencies will be must comply with section 6.4.

Each FCU, VAV, and Fan powered box will have its own thermostat for individual zone control. Room sensors have an accuracy of +/- 2 deg F while relative Humidity has an accuracy of +/- 5%. A combination of Direct Digital Control and Proportional Integral Derivative with a BAS system is used to keep the building at the desired set points.

6.5 Prescriptive Path

All AHU's are equipped with a mixed air economizer cycle. Heat recovery is used in the 100% outside air AHU by an air-to-air plate exchanger and a wraparound heat pipe heat recovery exchanger to reheat supply. During cooling season the leaving air temperature is maintained at 54 F dry bulb and 53.7 F wet bulb. During the heating season the leaving air temperature is maintained at 85 F. No motors with 5 or larger horsepower are used in Father O'Connell Hall so fan power limitation does not apply.

6.7 Submittals

Upon completion of the project, each contractor must submit normal cut sheets and shop drawings of all equipment. This includes control drawings, wire diagrams, dimensions, and

O&M manual. Submittals must be approved by authorities having jurisdiction prior to submitting them to the Architect.

Section 7: Service Water Heating

Washington Gas Company provides 2 psi gas to heat two 500 MBH condensing boilers for heating spaces. Domestic water heaters are used for heating domestic potable water. Hot-water supply boilers heated by gas that are greater than 4000 (btu/h)/gal are required to have a minimum efficiency of 78%. These boilers are rated at 91% (according to the manufacturer's website). All hot water piping is properly insulated. The heating hot water system is automatically enabled and disabled by the BMS time and season schedules.

Section 8: Power

Father O'Connell Hall complies with the National Electric Code for construction which requires a maximum voltage drop of 2% for feeders and a maximum voltage drop of 3% for branch circuits.

Section 9: Lighting

9.2 Compliance Path

Lighting and equipment can be examined by using the Building Area Method or the Space-by-Space Method. Due to time restraints the simplified building area method will be used to calculate interior lighting power allowance.

9.4 Mandatory Provisions

Father O'Connell Hall utilizes occupancy sensors to reduce the amount of energy consumption. Some types of rooms that have occupancy sensors include restrooms, storage, offices, and conference rooms. The rest of the lights are operated manually or by the building management system. Table 4 below summarizes the allowable power density levels as specified by ASHRAE Standard 90.1 by using the Building Area Method. Additional and more accurate results could be calculated at a later date using the Space-by-Space Method. Father O'Connell Hall uses many LED lights which use very little energy which could contribute to the low LPD calculated. Refer to Appendix B for full detailed calculations.

Lighting Power Densities					
Area Type	Std. 90.1 LPD (W/SF)	Building Area (SF)	Building (W)	Building LPD (W)	Comply
Office	0.9	60,000	36283	0.60	Y

Table 4: Lighting Power Densities calculated by using Building Area Method

Section 10: Other Equipment

Table 10.8B from ASHRAE Standard 90.1 states the minimum efficiency for all electric motors manufactured on or after December 19, 2010. According to Table 10.8, efficiency of the pumps does not comply with standard 90.1. A reason for this could be that the project documentation states that this is a minimum efficiency while Table 10.8B specifies efficiency for full load. Since the pumps have a VFD the efficiency might be much higher at full load. Another reason for this non-compliance is that pumps are generally oversized due to safety factors. *Table 4* below shows full calculations.

Minimum Pump Efficiency					
Unit	HP	Min. Efficiency	RPM	ASHRAE Std. 90.1 Efficiency	Comply
CHWP-1	7.5	72	1,750	89.5	N
CHWP-2	7.5	72	1,750	89.5	N
HHWP-1	1.5	57	1,750	84	N
HHWP-2	1.5	57	1,750	84	N
HHWP-3	1.5	57	1,750	84	N

Table 5: Minimum Pump Efficiency requirements for ASHRAE Standard 90.1

ASHRAE 90.1 – 2010 Summary

ASHRAE Standard 90.1 establishes minimum energy efficiency requirements for non-residential buildings. Standard 90.1 looks into building envelope and system equipment heavily to confirm a baseline energy efficient design.

Father O'Connell Hall did not comply with some sections of 90.1, mostly because of the building envelope. Little to none insulation was used causing the overall U-Value to be much higher than required. However, vertical fenestration did very well. Only 13.5% of the total building was found to be glazing. In addition, lighting power density was much lower than the requirements of standard 90.1. This has much to do with the use of LED lighting.

The mechanical equipment selection seemed to be very efficient, especially the gas condensing boilers. The chilled and hot water pumps were not compliant and must be investigated further to why the efficiency was not met. Additional, energy models will be investigated in technical report two to see how adding additional insulation to the walls and roofs will reduce energy usage.

References

ANSI/ASHRAE. (2010). Standard 62.1-2010, Ventilation for Acceptable Indoor Air Quality. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ANSI/ASHRAE. (2010). Standard 90.1-2010, Energy Standard for Buildings Except Low-Rise Residential Buildings. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

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Appendix A

(E)AHU-2

Room No.	Room Description	Az Floor area SF	Pz Zone population	Table 6.1 Space Type	P/100SQFT Occupant Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distribution effectiveness	Voz corrected OA cfm	Vpz Primary airflow to the zone	Max Zp Primary OA air fraction
E120	Office space	155	1	Office Space	5	0.0	5	0.06	5	9	0.8	18	200	0.09
E119	Office space	200	1	Office Space	5	0.0	5	0.06	5	12	0.8	21	410	0.05
EC117	Corridors	261	0	Corridors	0	0.0	0	0.06	0	16	0.8	20	340	0.06
E118	Office space	167	1	Office Space	5	0.0	5	0.06	5	10	0.8	19	210	0.09
E116	Conference/meeting	119	4	Conference/Meeting	50	0.0	5	0.06	20	7	1	27	90	0.30
E115	Conference/meeting	115	4	Conference/Meeting	50	0.0	5	0.06	20	7	1	27	90	0.30
E114	Conference/meeting	113	4	Conference/Meeting	50	0.0	5	0.06	20	7	1	27	90	0.30
E113	Conference/meeting	207	10	Conference/Meeting	50	0.0	5	0.06	50	12	1	62	200	0.31
	Corridors	210	0	Corridors	0	0.0	0	0.06	0	13	0.8	16	100	0.16
E102	Reception areas	933		Reception Areas	30	28.0	5	0.06	140	56	0.8	245	1600	0.15
	Other (storage, telecom closet	20	0	Storage	0	0.0	0	0.00	0	0	0.8	0	10	0.00
E108	Office space	980	11	Office Space	5	0.0	5	0.06	55	59	0.8	142	1050	0.14
E200	Other (storage, telecom closet	33	0	Storage	0	0.0	0	0.00	0	0	1	0	10	0.00
E111	Conference/meeting	800	70	Conference/Meeting	50	0.0	5	0.06	350	48	1	398	1600	0.25
EC102	Corridors	523	0	Corridors	0	0.0	0	0.06	0	31	0.8	39	310	0.13
E105	Other (storage, telecom closet	37	0	Storage	0	0.0	0	0.00	0	0	0.8	0	10	0.00
E104	Janitor closets, trash rooms, re	28	0	Janitor Closet	0	0.0	0	0.00	0	0	0.8	0	10	0.00
E106	Toilets, public	291	0	Toilet	0	0.0	0	0.00	0	0	0.8	0	50	0.00
E107	Toilets, public	222	0	Toilet	0	0.0	0	0.00	0	0	0.8	0	210	0.00
E100	Lobbies/Main entry lobbies (of	802		Main Entry Lobbies	10	8.0	5	0.06	40	48	0.8	110	1200	0.09
		6,216	106						710	335.1		1,171	7,790	0.31

AHU-4

Room No.	Room Description	Az Floor area SF	Pz Zone population	Table 6.1 Space Type	P/100SQFT Occupant Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distribution effectiveness Table 6.2	Voz corrected OA cfm	Vpz Primary airflow to the zone	Max Zp Primary OA air fraction
B000B	Enrollment Management	1697	30	Office Space	5	0.0	5	0.06	150	102	0.8	315	1740	0.18
B000A	Corridor	539	0	Corridors	0	0.0	0	0.06	0	32	0.8	40	200	0.20
B001	Central File	663	0	Office Space	5	0.0	5	0.06	0	40	0.8	50	200	0.25
B002A	Corridor	840	0	Corridors	0	0.0	0	0.06	0	50	0.8	63	310	0.20
B002	Toilet	71	1	Toilet	0	0.0	0	0.00	0	0	0.8	0	0	0.00
B003	Toilet	59	1	Toilet	0	0.0	0	0.00	0	0	0.8	0	0	0.00
B004	Janitor Closet	38	0	Janitor Closet	0	0.0	0	0.00	0	0	0.8	0	0	0.00
B006	Furniture Storage	283	0	Storage	0	0.0	0	0.00	0	0	0.8	0	140	0.00
B007	office	237	2	Office Space	5	0.0	5	0.06	10	14	0.8	30	180	0.17
B0011	Office	160	1	Office Space	5	0.0	5	0.06	5	10	0.8	18	160	0.11
B0012	Executive Office	184	1	Office Space	5	0.0	5	0.06	5	11	0.8	20	180	0.11
B0013	Project Room	384	2	Office Space	5	0.0	5	0.06	10	23	0.8	41	300	0.14
B0014	Corridor	150	0	Corridors	0	0.0	0	0.06	0	9	0.8	11	60	0.19
B0016	Storage	334	0	Storage	0	0.0	0	0.00	0	0	0.8	0	240	0.00
BC018	Corridor	324	0	Corridors	0	0.0	0	0.06	0	19	0.8	24	140	0.17
		5,963	38						180	310.68		613	3,850	0.25

AHU-5

Room No.	Room Description	Az Floor area SF	Pz Zone population	Table 6.1 Space Type	P/100SQFT Occupant Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distribution effectiveness Table 6.2	Voz corrected OA cfm	Vpz Primary airflow to the zone	Max Zp Primary OA air fraction
M101	The Great Hall	4572	200	Multi-Use Assembly (educational)	100	0.0	8	0.06	1500	274	1.2	1479	7750	0.19
		4,572	200						1500	274.32		1,479	7,750	0.19

AHU-6

Room No.	Room Description	Az Floor area SF	Pz Zone population	Table 6.1 Space Type	P/100SQFT Occupant Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distribution effectiveness Table 6.2	Voz corrected OA cfm	Vpz Primary airflow to the zone	Max Zp Primary OA air fraction
WC101	Corridor	272	0	Corridors	0	0.0	0	0.06	0	16	0.8	20	120	0.17
W102	Break Rooms	628	19	Break Rooms (general)	25	0.0	5	0.12	95	75	0.8	213	860	0.25
W103	Janitor closet	27	0	Janitor	0	0.0	0	0.00	0	0	0.8	0	0	0.00
W104	Toilet	57	1	Toilet	0	0.0	0	0.00	0	0	0.8	0	0	0.00
W105	Toilet	57	1	Toilet	0	0.0	0	0.00	0	0	0.8	0	0	0.00
W106	Catering Prep	732	4	Kitchen (cooking, food/bevera	20	0.0	8	0.12	30	88	0.8	147	1630	0.09
W106A	Storage	34	0	Storage	0	0.0	0	0.00	0	0	0.8	0	10	0.00
		1,807	25						125	179.52		381	2,620	0.25

OAHU-1

Room No.	Room Description	Az Floor area SF	Pz Zone population	Table 6.1 Space Type	P/100SQFT Occupant Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distribution effectiveness Table 6.2	Voz corrected OA cfm	Vpz Primary airflow to the zone	Max Zp Primary OA air fraction
W201	Meeting	103	4	Conference/Meeting	50	0.0	5	0.06	20	6	1	26	30	30
W202	Workstations	995	12	Office Space	5	0.0	5	0.06	60	60	1	120	120	120
W204	Office	146	1	Office Space	5	0.0	5	0.06	5	9	1	14	20	20
W205	Office	149	1	Office Space	5	0.0	5	0.06	5	9	1	14	20	20
W206	Office	146	1	Office Space	5	0.0	5	0.06	5	9	1	14	20	20
M200	2nd FL West Vestibule	543	4	Office Space	5	0.0	5	0.06	20	33	1	53	60	70
M201	Womens Toilet	66	1	Toilet	0	0.0	0	0.00	0	0	1	0	0	0
M202	Mens Toilet	66	1	Toilet	0	0.0	0	0.00	0	0	1	0	0	0
W300	Enrollment Services	346	0	Corridors	0	0.0	0	0.06	0	21	1	21	30	30
W301	Office	185	1	Office Space	5	0.0	5	0.06	5	11	1	16	20	20
W302	Office	147	1	Office Space	5	0.0	5	0.06	5	9	1	14	20	20
W303	Executive Office	185	1	Office Space	5	0.0	5	0.06	5	11	1	16	20	20
W304	Office	158	1	Office Space	5	0.0	5	0.06	5	9	1	14	20	20
W305	Workstations	849	10	Office Space	5	0.0	5	0.06	50	51	1	101	110	110
M300	3rd FL vestibule	452		Main Entry Lobbies	10	4.5	5	0.06	23	27	1	50	50	100
M301	IMG Room	162	1	Computer Lab (educational)	25	0.0	10	0.12	10	19	1	29	30	50
M301B	Storage	78	0	Storage	0	0.0	0	0.00	0	0	1	0	0	0
M305	Meeting	129	4	Conference/Meeting	50	0.0	5	0.06	20	8	1	28	30	30
M306	Office	159	1	Office Space	5	0.0	5	0.06	5	10	1	15	20	20
M307	Office	159	1	Office Space	5	0.0	5	0.06	5	10	1	15	20	20
M308	Files	117	0	Storage	0	0.0	0	0.00	0	0	1	0	0	0
M309	Mens Toilet	143	3	Toilet	0	0.0	0	0.00	0	0	1	0	0	0
M310	Womens Toilet	143	3	Toilet	0	0.0	0	0.00	0	0	1	0	0	0
M311	Files	116	0	Storage	0	0.0	0	0.00	0	0	1	0	0	0
M312	Office	153	1	Office Space	5	0.0	5	0.06	5	9	1	14	20	20
M313A	Asst Manager Office	140	2	Office Space	5	0.0	5	0.06	10	8	1	18	20	20
M313B	Work Study	243	4	Office Space	5	0.0	5	0.06	20	15	1	35	40	40
MC302	Corridors	950	0	Corridors	0	0.0	0	0.06	0	57	1	57	60	60
M302A	Files	86	0	Storage	0	0.0	0	0.00	0	0	1	0	0	0
M314	Office	162	1	Office Space	5	0.0	5	0.06	5	10	1	15	20	20
M315	Office	161	1	Office Space	5	0.0	5	0.06	5	10	1	15	20	20
M316	Office	175	1	Office Space	5	0.0	5	0.06	5	11	1	16	20	20

OAHU-1 Cont.

Room No.	Room Description	Az Floor area SF	Pz Zone population	Table 6.1 Space Type	P/100SQFT Occupant Density	Pz Calculate Occupants	Rp Table 6.1 cfm/person	Ra Table 6.1 cfm/sf	Pz*Rp People OA cfm	Az*Ra Area OA cfm	Ez Zone air distribution effectiveness Table 6.2	Voz corrected OA cfm	Vpz Primary airflow to the zone	Max Zp Primary OA air fraction
M317	Office	162	1	Office Space	5	0.0	5	0.06	5	10	1	15	20	20
M318	Office	161	1	Office Space	5	0.0	5	0.06	5	10	1	15	20	20
M319	Office	174	1	Office Space	5	0.0	5	0.06	5	10	1	15	20	20
M320	Office	162	1	Office Space	5	0.0	5	0.06	5	10	1	15	20	20
M321	Office	165	1	Office Space	5	0.0	5	0.06	5	10	1	15	20	20
M303	Reception/waiting	322	5	Reception Areas	30	0.0	5	0.06	25	19	1	44	50	70
M400	Events	783	20	Conference/Meeting	50	0.0	5	0.06	100	47	1	147	150	250
M401	Elevator Lobby/Waiting	219	6	Main Entry Lobbies	10	0.0	5	0.06	30	13	1	43	50	50
M402	Executive Assistant	104	1	Office Space	5	0.0	5	0.06	5	6	1	11	20	20
MC403	Corridors	993	0	Corridors	0	0.0	0	0.06	0	60	1	60	60	60
M404	Meeting	155	4	Conference/Meeting	50	0.0	5	0.06	20	9	1	29	30	30
M405	Furniture Storage	159	0	Storage	0	0.0	0	0.00	0	0	1	0	0	0
M406	Files	114	0	Storage	0	0.0	0	0.00	0	0	1	0	0	0
M407	Mens Toilet	143	1	Toilet	0	0.0	0	0.00	0	0	1	0	0	0
M408	Womens Toilet	143	1	Toilet	0	0.0	0	0.00	0	0	1	0	0	0
M409	Files	123	1	Storage	0	0.0	0	0.00	0	0	1	0	0	0
M411	Meeting	153	4	Conference/Meeting	50	0.0	5	0.06	20	9	1	29	30	30
M412	EM Techs	150	2	Office Space	5	0.0	5	0.06	10	9	1	19	20	20
M413	Office	178	1	Office Space	5	0.0	5	0.06	5	11	1	16	20	20
M414	Storage	77	0	Storage	0	0.0	0	0.00	0	0	1	0	0	0
M416	Executive Office	217	1	Office Space	5	0.0	5	0.06	5	13	1	18	20	20
M417	Executive Office	217	1	Office Space	5	0.0	5	0.06	5	13	1	18	20	20
M418	Executive Office	315	1	Office Space	5	0.0	5	0.06	5	19	1	24	30	30
M419	Executive Conference	153	6	Conference/Meeting	50	0.0	5	0.06	30	9	1	39	40	30
M420	Executive Conference	320	12	Conference/Meeting	50	0.0	5	0.06	60	19	1	79	80	80
M421	Meeting	188	4	Conference/Meeting	50	0.0	5	0.06	20	11	1	31	40	50
									663	747		1,410	1,600	1,800

Appendix B

Lighing Fixture	Watts/Fixture	# of Fixtures	Watts Used
BB	114	37	4218
CA	32	42	1344
DA1	40	52	2080
DA2	40	40	1600
DA3	40	43	1720
DB	42	20	840
DC1	32	31	992
FA	32	64	2048
FA1	32	32	1024
FB1	32	41	1312
FC1	32	29	928
FD	32	60	1920
FE	32	22	704
FF	17	37	629
FG	32	51	1632
FG1	32	40	1280
FJ	32	48	1536
LA	32	90	2880
LA1	32	84	2688
OWA	18	24	432
OWB	42	20	840
WA1	18	14	252
WA2	18	60	1080
WB	32	24	768
WC	32	16	512
WD	32	32	1024
Total			**36283**