

# Mechanical Technical Report One

## ASHRAE Standard 62.1 Ventilation and Standard 90.1 Energy Design Evaluations



HITT Contracting Headquarters  
2900 Fairview Park Drive, Falls Church, VA

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## Executive Summary

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standards 62.1-2007 and 90.1-2007 provide a basis of design for minimum ventilation requirements and ensure proper energy efficiency in buildings. This report analyzes in detail the HITT Contracting Headquarters building to the above standards. The HITT Contracting Headquarters is a 135,000 square foot office building located next to the Capital Beltway in Falls Church, Virginia. The building consists of a variety of spaces including office space, conference rooms, café space, a fitness center and covered, under building, parking.

The ASHRAE 62.1-2007 compliance analysis exposed two minor deficiencies in the building ventilation system. The first ASHRAE 62.1 requirement that was not met was the ASHRAE 62.1 Section 5.6.5 specification indicating that bird screens must be installed on outdoor air intakes. No such specification was found in the design documents or specifications. Aside from the bird screen requirement the building passed the minimum outdoor air ventilation requirements set forth in ASHRAE 62.1 Section 6.2 by a margin of over 40%. However, it failed to meet Section 6.2.8 Exhaust Ventilation in two building spaces. These spaces had exhaust systems, but they did not displace enough air as required.

The ASHRAE 90.1-2007 compliance analysis revealed one major deficiency in the building energy system. The lighting system failed to meet the standards provided in ASHRAE 90.1 Section 9 Lighting. The building exceeds the total maximum allowable wattage for lighting systems by 12%. ASHRAE 90.1 Sections 5, 6 and 7; building envelope, HVAC equipment and service water heating were all sufficient.

## Mechanical Systems Overview

The HITT Contracting Headquarters has (7) 50 Ton AAON air-cooled packaged rooftop units with energy recovery wheels serving the (4) occupied floors; three above ground and the cellar. Each above ground floor has a total of (2) units that serve the North and South sections respectively. Parallel, series, and shut-off Variable-Air-Volume (VAV) terminal units control the final supply temperature and flow to individual zones throughout the building. (3) split-system air-conditioning units provide air for loads in fitness and café spaces.

Powered Roof Ventilators (PRV) provide exhaust for restroom and locker spaces throughout the building. Additional exhaust for storage and trash rooms is provided by ceiling mounted exhaust fans. Exhaust fans also exist in entry rooms from the parking garage to expel harmful vapors that enter from the parking area.

## ASHRAE 62.1-2007 Overview

ASHRAE 62.1-2007 prescribes minimum requirements for outside ventilation air and indoor air quality in buildings. Sections 5 and 6 are applied below to HITT Contracting Headquarters in Falls Church, VA.

### ASHRAE 62.1 - Section 5

#### 5.2 Ventilation Air Distribution

##### 5.2.1 Designing for air balancing

Minimum ventilation airflow set forth in ASHRAE 62.1 - Section 6 must be met. Ventilation complies with ASHRAE 62.1-Section 6 so, in turn Section 5.2.1 is satisfied.

##### 5.2.2 Plenum Systems

Plenums are used to recirculate return air from the space, and has been accounted for in achieving the minimum ventilation airflow. Section 5.2.2 is satisfied.

##### 5.2.3 Documentation

Minimum requirements for air balance testing per the 2003 International Mechanical Code.

#### 5.3 Exhaust Duct Location

Exhaust ducts are negatively pressured relative to the spaces in which they pass so that they do not convey potentially harmful contaminants so that leaking does not affect the occupants. Section 5.3 is satisfied.

#### 5.4 Ventilation System Controls

The system includes an automatic control system included in the Building Management System (BMS) that enables the fan system to operate and maintain the airflow required in ASHRAE 62.1 - Section 6. Section 5.4 is satisfied.

#### 5.5 Airstream Surfaces

All airstream surfaces are made of sheet metal and are therefore pass ASHRAE 62.1 - Section 5.5 via exemption from Section 5.5.1 Resistance to Mold Growth and Section 5.5.2 Resistance and Erosion requirements.

## 5.6 Outdoor Air Intakes

### 5.6.1 Location

See Appendix A for requirements and results regarding outdoor air intake locations. The distances comply with the minimum distances stated in Section 5.6.3

### 5.6.2 Rain Entrainment

The system outdoor air intake is in accordance with Part D of ASHRAE 62.1 Section 5.6.2 Rain Entrainment. The outdoor air intake for the system consists of rain hoods on each RTU that are downward facing and must be sized for less than 500 fpm as per the calculation below. The RTU with the highest [CFM] was used to ensure compliance for all RTUs.

$$A_{\text{Opening}} = 25'' \cdot 100'' = 2500 \text{ in}^2 = 17.36 \text{ ft}^2$$

$$[\text{CFM}] \text{ of Outdoor Air intake} = 5150 [\text{CFM}]$$

$$\text{FPM}_{\text{Opening}} = [\text{CFM}] / \text{Area}_{\text{Opening}}$$

$$\text{FPM}_{\text{Opening}} = 5150 [\text{CFM}] / 17.36 \text{ ft}^2$$

$$\text{FPM}_{\text{Opening}} = 297 \text{ FPM} < 500 \text{ FPM}$$

Complies with ASHRAE 62.1- Section 5.6.2

### 5.6.3 Rain Intrusion

Air-handling and distribution equipment is designed to prevent rain intrusion into the airstream. The AAON rooftop units and COOK PRV comply with Section 58 of UL 1995. Section 5.6.3 is satisfied.

### 5.6.4 Snow Entrainment

The ventilation system complies with option A of Section 5.6.4 by providing suitable access doors to permit cleaning. Section 5.6.4 is satisfied.

### 5.6.5 Bird Screens

No bird screens are specified for AAON rooftop units. Section 5.6.3 is not satisfied.

### 5.7 Local Capture of Contaminants

The discharge from non-combustion equipment is ducted directly to the outdoors as specified in section 5.7. Section 5.7 is satisfied.

### 5.8 Combustion Air

No fuel burning appliances that do or do not require venting are present, Section 5.8 does not apply.

### 5.9 Particulate Matter Removal

Filters with a Minimum Efficiency Reporting Value (MERV) of 6 or greater are required upstream of the cooling coils or other devices. All units have a filter with a (MERV) of 13 installed after construction and therefore comply with ASHRAE 62.1-Section 5.9.

### 5.10 Dehumidification Systems

#### 5.10.1 Relative Humidity

Occupied space relative humidity must be a maximum of 65% when outdoor conditions are at the design humidification value of ~100%. The space satisfies this requirement through a design Sensible Heat Ratio of 0.70, meaning that at the design cooling load the outdoor air will be enough to lower the wet bulb temperature of the supply air.

#### 5.10.2 Exfiltration

The design minimum air intake is greater than the design maximum exhaust airflow during dehumidification, therefore complying with Section 5.10.2.

### 5.11 Drain Pans

Drain pans are packaged with RTUs and AC units and their slopes comply with ASHRAE 62.1 - Sections 5.11.1 to 5.11.4; Drain Pan Slopes, Outlet, Seal, and Pan Size respectively.

### 5.12 Finned-Tube Coils and Heat Exchangers

#### 5.12.1 Drain Pans

Drain pans that comply with section 5.11 are provided below all condensate producing heat exchangers in the system.

#### 5.12.2 Finned-Tube Coil Selection for Cleaning

No finned-tube coils are specified for any of the building systems. Section 5.12.2 is not applicable.

### 5.13 Humidifiers and Water-Spray Systems

#### 5.13.1 Water Quality

Steam generators in the locker room area utilize water from the building potable water supply and comply with Section 5.13.1.

#### 5.13.2 Obstructions

Applies to systems in which humidifiers are upstream of equipment that cannot be easily accessed. Not applicable to the steam generating system due to lack of obstructions. Section 5.13.2 is not applicable.

### 5.14 Access for Inspection, Cleaning and Maintenance

#### 5.14.1 Equipment Clearance

Equipment clearance complies with manufacturers requirements for inspection and maintenance. The AAON Rooftop unit manufacturer requirements are 48" on each side and an unobstructed top. The condensing units also meet their minimum requirements of 18" on each side. Section 5.14.1 is satisfied.

#### 5.14.2 Ventilation Equipment Access

Unobstructed access to ventilation equipment is provided via access doors and above ceiling tile. Section 5.14.2 is satisfied.

#### 5.14.3 Air Distribution Systems

Unobstructed access to the spaces A-H listed in Section 5.14.3 are provided via access doors, panels and above ceiling tile. Section 5.14.3 is satisfied.

### 5.15 Building Envelope and Interior Surfaces

#### 5.15.1 Building Envelope



The building envelope complies with Section 5.15 subsections one to three. The building has a weather barrier to prevent liquid water penetration into the envelope. Vapor retarder is applied to spaces below grade to prevent vapor water diffusion. Exterior joints and seams are caulked to prevent air leakage and limit infiltration.

#### 5.15.2 Condensation on Interior Surfaces

Condensation on interior surfaces including pipes and ducts is mitigated through the application of insulation on supply air ductwork and piping where condensation is possible.

### 5.16 Buildings with Attached Parking Garages

The interior parking garage on the cellar level follows option 3 of Section 5.16. This option provides that the attached parking garage must be designed to minimize migration of air from the attached parking garage into adjacent occupied spaces of the building. Areas that access the building from the parking garage have exhaust systems that operate when contaminants enter the space from the parking garage to keep the space free of vehicular exhaust.

### 5.17 Air Classification and Recirculation

#### 5.17.1 Classification

Return or exhaust air is classified into 4 classes based upon contaminant concentration ranging from 1 being the lowest to 4 being the highest. System air can be classified into this system, 5.17.1 is satisfied.

#### 5.17.2 Re-designation

A fraction of system return air is recirculated through spaces after flowing through an enthalpy heat exchanger and also mixing with fresh outdoor air and meets the prescribed requirements of Sections 5.17.2.1 Air Cleaning, 5.17.2.2 Energy Recovery and 5.17.2.3 Transfer for class 1 and 2 air. Air that is rated as class 3 or 4 is exhausted directly from the building, such as exhaust air from a pantry area that is rated as class 3. Section 5.17.2 is satisfied.

#### 5.17.3 Recirculation Limitations

##### 5.17.3.1 Class 1 Air

All class 1 air recirculated to space of any class or exhausted. Section 5.17.3.1 is satisfied.

#### 5.17.3.2 Class 2 Air

All class 2 air is recirculated to space of class 2 or 3 space or exhausted. Section 5.17.3.2 is satisfied.

#### 5.17.3.3 Class 3 Air

All class 3 air is directly exhausted from the space. Section 5.17.3.3 is satisfied.

#### 5.17.3.4 Class 4 Air

All Class 4 air in the system from print room is directly exhausted. Section 5.17.3.4 is satisfied.

#### 5.17.4 Documentation

Design documents do not show air class type of any other type of air than stated in ASHRAE 62.1-2007 Table 5-2. Section 5.17.4 is satisfied.

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

ETS areas have been specified in the building, Section 5.18 is not applicable.

## ASHRAE 62.1 –Section 6 Assumptions

The spaces calculated include floors one, two and the cellar levels. Calculations performed on these floors have a total of (5) rooftop units serving them along with (3) split-system AC units. The (2) rooftop units that serve third floor were not included in the detailed room-by-room calculation due to a space layout not being designed at the bid phase. This space is assumed to be similar to floors one and two of the building.

Zone air distribution effectiveness ( $E_z$ ) for exterior offices and conference rooms is 0.8 because of “ceiling supply of air than 15 degrees warmer than space air”

Zone air distribution effectiveness ( $E_z$ ) for interior offices and spaces is 1.0 because of “ceiling supply of cool air”

Furniture plans provided the actual people count for the values of the occupancy value ( $P_z$ )

Occupant diversity is assumed to be 1.0

Pantry spaces assumed to be office space for ventilation purposes, but have their own exhaust systems.

Electrical rooms and stairwells were excluded from the calculation.

## ASHRAE 62.1 – Section 6

### 6.2 Ventilation Rate Procedure

Below is a step-by-step explanation of the ventilation rate calculations described in Appendix B.

Find the zone supply air  $V_{pz}$  zone floor area  $A_z$  and the zone population  $P_z$  from the design documents.

Determine  $V_{bz}$  using Equation 6-1 below:

$$V_{bz} = R_p \cdot P_z + R_a \cdot A_z \text{ (Equation 6-1)}$$

$A_z$  = zone floor area (square feet)

$P_z$  = zone population (from architectural furniture plans)

$R_p$  = outdoor airflow rate per person (From Table 6.1)

$R_a$  = outdoor airflow rate per square foot (From Table 6.1)

Once  $V_{bz}$  has been found determine the Zone Air Distribution Effectiveness ( $E_z$ )

The assumption was made that  $E_z=0.8$  for exterior spaces and  $E_z=1.0$  for interior spaces due to the ceiling supply of hot air warmer than 15 degrees than room air and ceiling supply of cool air respectively.

Determine Zone Outdoor Airflow ( $V_{oz}$ ) using  $E_z$  and  $V_{bz}$

$$V_{oz} = V_{bz} / E_z \text{ (Equation 6-2)}$$

Next, Determine the Primary Outdoor Air Fraction  $Z_p$

$$Z_p = V_{oz} / V_{pz} \text{ (Equation 6-5)}$$

The worst case  $Z_p$  over all the zones under one system is used to determine the System Ventilation Efficiency ( $E_v$ ) using Table 6-3.

Outdoor Air Intake for the zone ( $V_{ot,zone}$ ) is then determined from  $V_{oz}$  and  $E_z$ .

$$V_{ot,zone} = V_{oz} / E_z \text{ (Assuming Diversity is 1.0)}$$

The final step is to sum all of the  $V_{ot,zone}$  to determine  $V_{ot,total}$  of the system.

$$\sum V_{ot,zone} = V_{ot, total}$$

See Appendix B for Ventilation Rate Procedure calculations for each Rooftop Unit and Split-System unit.

See Appendix C for Exhaust Ventilation Calculations.

Entire building comparison of  $\sum V_{oz}$  and  $V_{ot}$ :

$$\sum V_{oz}=10818 \text{ CFM} \quad V_{ot}=11898 \text{ CFM}$$

$$V_{ot} \text{ is } 110\% \text{ of } \sum V_{oz}$$

## ASHRAE 62.1 – Results and Conclusions

The results ASHRAE 62.1-2007 analysis for sections 5 and 6 conclude that the system fails for both sections 5 and 6. The building passes all of the requirements set forth in Section 5 except Section 5.6.5: Bird Screens. It was not noted in the mechanical specifications or cut sheets for the Rooftop unit that bird screens were to be provided.

Section 6 passed all of its outdoor air Ventilation Rate Procedure requirements set forth in Section 6.2 by a margin of over 40%. This was most likely due to the fact that 20 [CFM] per occupant was used in the design rather than the ASHRAE 62.1-2007 analysis of 5 [CFM] per occupant plus 0.06 [CFM] per square foot. Section 6 failed in Section 6.2.8 Exhaust Ventilation. The exhaust [CFM] did not meet the required exhaust [CFM] for two spaces. The reprographics room on the cellar level narrowly did not pass, and this could be due to the fact that the [CFM] per square foot value for printing rooms may have varied between ASHRAE 62.1-2007 and ASHRAE 62.1-2004. The other space to exceed the amount is the Loading dock, and it does so by a large margin. This could be because of air changes are greater in the loading dock area due to the overhead doors in that space.

## ASHRAE 90.1-2007 Overview

ASHRAE 90.1-2007 prescribes minimum requirements for the building envelope, HVAC systems, service water heating, power, lighting and electric motor efficiency. The sections below are applied below to HITT Contracting Headquarters in Falls Church, VA. The Virginia location falls into climate zone 5A.

### ASHRAE 90.1 – Section 5

#### 5.2 Compliance Paths (Building Envelope)

##### 5.2.1 Compliance

Option A: “Prescriptive Building Envelope Option” is used because the vertical fenestration area does not exceed 40% of the gross wall area for each space-conditioning category and skylight fenestration does not exceed 5% of the gross roof area. See window area calculations in Appendix D.

The Building envelope requirements for Climate zone 5 are found on Table 5.5-5 in ASHRAE 90.1-2007. The requirements vs. actual values can be found in Appendix E – Building Envelope Calculations. SHGC and U-Factor values were taken from architectural notes for fenestration and wall type details.

##### 5.5.3.1.1 High Albedo Roofs

This section does not apply to buildings in zone 5.

### ASHRAE 90.1 – Section 6

#### 6.2 Compliance Path (HVAC Systems)

##### 6.2.1 Compliance

Option B: Mandatory Provisions and Prescriptive path is chosen because the building does not meet the requirements of Option A: Simplified Approach Option due to building height and square footage requirements.

#### 6.4 Mandatory Provisions

#### 6.4.1.1 Minimum Equipment Efficiencies – Listed Equipment – Standard Rating and Operation Conditions

Minimum equipment efficiencies must be met for categories a-g in section 6.4.1.1. These include: Air conditioners and condensing units, heat pumps, water-chilling packages, packaged terminal and room air conditioners and heat pumps, furnaces, duct furnaces, and unit heaters, boilers and heat rejection equipment. Equipment data was taken from the mechanical design drawings and schedules. See Appendix F for Minimum Equipment Efficiencies calculations using the tables in Section 6.8.

### 6.5 Prescriptive Path

#### 6.5.3.1 Fan System Power Limitation

Option 1: maximum allowable nameplate motor hp was chosen. The rooftop unit calculations utilize the variable air volume equation of  $hp \leq CFM_S \cdot 0.0015$  whereas the exhaust fans utilize the constant volume  $hp \leq CFM_S \cdot 0.0011$  equation to calculate the maximum allowable hp for the fan.

Calculation Example:

Fan Type: Variable  
Fan HP = 25  
Fan [CFM] = 26400

$$hp \leq CFM \cdot x$$

$x = 0.0015$  for Variable systems and  $0.0011$  for Constant systems

$$hp \leq CFM \cdot 0.0015$$

$$25 \leq 26400 \cdot 0.0015$$

$$25 \leq 39.6$$

Complies with ASHRAE 90.1- Section 6.5.3.1

See Appendix G for fan power limitation calculations.

## ASHRAE 90.1 – Section 7

### 7.2 Compliance Paths (Service Water Heating)

7.2.1 Compliance shall be achieved by meeting the requirements of Sections 7.4 and 7.5

### 7.4 Mandatory Provisions

#### 7.4.2 Equipment Efficiency

All water heating equipment is required to meet the criteria in Table 7.8. See Appendix H for efficiency calculations for the four water heaters that are used in the building. Equipment efficiencies and standby losses are taken from the mechanical design documents and schedules.

### 7.5 Prescriptive Path

7.5.1 and 7.5.2 are not applicable. Spaces and water are not heated by gas or oil-fired boilers.

## ASHRAE 90.1 – Section 9

### 9.2 Compliance Paths (Lighting Systems)

#### 9.2.1 Lighting Systems and Equipment

Option A: Section 9.5 “Building Area Method” was chosen for the building as it is the more general approach to lighting system power density.

### 9.5 Building Area Method Compliance Path

Determine the building area types in Table 9.5.1 along with their LPD (watts per square foot), then determine building areas in square feet for each building area type. Listed below are the LPD values for the various building area types used in the calculation. Fixture wattages were taken from the architectural and mechanical bid drawings.

Office: 1 W/ft<sup>2</sup>

Corridors: 1 W/ft<sup>2</sup>

Lobby: 1.3 W/ft<sup>2</sup>

Conference: 1.3 W/ft<sup>2</sup>

Locker Room: 0.6 W/ft<sup>2</sup>



Exercise Center: 1 W/ft<sup>2</sup>  
Parking Garage: 0.3 W/ft<sup>2</sup>  
Storage: 0.8 W/ft<sup>2</sup>

See Appendix I for the associated Lighting Power Density calculations for the entire building using the Building Area Method.

## ASHRAE 90.1 – Results and Conclusions

The results of ASHRAE 90.1-2007 analysis for sections 5, 6, 7, and 9 conclude that the systems pass for sections 5, 6 and 7 and fail for section 9. The building easily passes the U-Factor and efficiency requirements in sections 5, 6, and 7, Building Envelope Compliance, Minimum Efficiencies, and Service Water Heating, respectively.

The failing section, Section 9, sets maximum allowable the lighting power density of building spaces. The building, as a whole, surpasses the maximum allowable wattage for the building spaces set forth in Section 9 by 12%. The majority of excess is in the building office space, where the allowable wattage is exceeded by 33.5% and is comprised of nearly 70% of the entire building floor area. The Building Area Method states that allowable wattages can be traded between spaces types as needed as long as the overall building is less than or equal to the total allowable wattage of all of the spaces combined. The reason for the 12% excess under ASHRAE 90.1-2007 is most likely due to higher maximum power densities in each space type. A simple calculation using this method in which the office and corridor space maximum watts per square foot is changed from the ASHRAE 90.1-2007 value of 1 watt per square foot to an older value of 1.1 watts per square foot puts the total allowable wattage very close to the actual total wattage.

## References

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

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

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### Appendix A – OA Intake Distances

Air Intake Minimum Separation Distance - ASHRAE 62.1 Section 5	Minimum Distance in Feet	Actual Distance in Feet
Object		
Significantly contaminated exhaust	15	15
Noxious or dangerous exhaust	30	N/A
Vents, chimneys, and flues from combustion appliances and equipment	15	31
Garage entry, automobile loading area, or drive-in queue	15	75
Truck loading area or dock, bus parking/idling area	25	75
Driveway, street, or parking place	5	5
Thoroughfare with high traffic volume	25	75
Roof, landscaped grade, or other surface directly below intake	1	>1
Garbage storage/pick-up area, dumpsters	15	78
Cooling tower intake or basin	15	N/A
Cooling tower exhaust	25	N/A

### Appendix B - Ventilation Rate Procedure

RTU 1-1 - 1st Floor South													
Room #	Room Name	Room Type	Az	Pz	Rp	Ra	Vbz	Ez	Voz	Ev	Vot	Vpz	Zp
1	Exterior Office	Office Space	160	1	5	0.06	15	0.8	18.75	0.9	21	440	0.04
2	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
3	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
4	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
5	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
6	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
7	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
8	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
9	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
10	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
11	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
12	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
13	Exterior Office	Office Space	155	1	5	0.06	15	0.8	18.75	0.9	21	280	0.07
14	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
15	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
16	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
17	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
18	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
19	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08

20	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
21	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
22	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
23	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
24	Exterior Office	Office Space	160	1	5	0.06	15	0.8	18.75	0.9	21	440	0.04
25	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	400	0.04
26	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	220	0.08
27	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
28	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
29	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
30	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
31	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
32	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
33	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
34	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	220	0.08
37	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
38	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
39	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
40	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
41	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
42	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15
43	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
44	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
45	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15

46	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
47	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
48	Interior Office	Office Space	155	1	5	0.06	15	1	15	0.9	17	95	0.16
49	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15
50	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15
51	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
52	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
53	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
54	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
55	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
56	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
57	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15
58	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15
59	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15
Open 1	Open Office	Office Space	346	24	5	0.06	328	1	328	0.9	364	2765	0.12
Open 2	Open Office	Office Space	155	11	5	0.06	148	1	148	0.9	164	1000	0.15
Open 3	Open Office	Office Space	312	22	5	0.06	298	1	298	0.9	331	2215	0.13
Conf 1	Conf.	Conf. Rm	160	8	5	0.06	50	1	50	0.9	56	950	0.05
Conf 2	Confere nce	Conf. Rm	160	8	5	0.06	50	1	50	0.9	56	1750	0.03
Lobby 1	Elevator Lobby	Lobby	160	0	5	0.06	10	1	10	0.9	11	1820	0.01
Corr 1	Corridor	Corridor	765	0	0	0.06	46	1	46	0.9	51	300	0.15
Total Area =	17520	ft <sup>2</sup>	Vpz Total =	22005	CFM	Actual Voa =	4600	CFM	Max Zp	0.16			
ΣVoz =	1851.75	CFM	Vot Total =	2058	CFM	46	% over ASHRAE 62.1-2007						

RTU 1-2 - 1st Floor North													
Room #	Room Name	Room Type	Az	Pz	Rp	Ra	Vbz	Ez	Voz	Ev	Vot	Vpz	Zp
1	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
2	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
3	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
4	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
5	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
6	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
7	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
8	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
9	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
10	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	360	0.05
11	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	440	0.04
12	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
13	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
14	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
15	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
16	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
17	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
18	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
19	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	340	0.05
20	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	300	0.06

21	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
22	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
23	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
24	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
25	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
26	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	130	0.13
27	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
28	Exterior Office	Office Space	135	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
29	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
30	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
31	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
32	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
33	Interior Office	Office Space	130	1	5	0.06	13	1	13	0.9	14	95	0.14
34	Interior Office	Office Space	130	1	5	0.06	13	1	13	0.9	14	95	0.14
35	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
36	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
37	Interior Office	Office Space	145	1	5	0.06	14	1	14	0.9	16	95	0.15
38	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	0	0.00
39	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
Open 1	Open Office	Office Space	1800	13	5	0.06	173	1	173	0.9	192	1065	0.16
Open 2	Open Office	Office Space	2410	17	5	0.06	230	1	230	0.9	256	1465	0.16
Open 3	Open Office	Office Space	1830	13	5	0.06	175	1	175	0.9	194	1200	0.15
Conf 1	Ext. Conf.	Conf. Rm	200	10	5	0.06	62	0.8	77.5	0.9	86	950	0.08
Conf 2	Conf.	Conf. Rm	720	36	5	0.06	224	1	224	0.9	249	1750	0.13



Pan 1	Pantry	Office Space	135	3	5	0.06	24	1	24	0.9	27	200	0.12
Pan 2	Pantry	Office Space	140	3	5	0.06	24	1	24	0.9	27	200	0.12
Priv 1	Privacy Room	Office Space	75	1	5	0.06	10	1	10	0.9	11	100	0.10
Stor 1	Storage	Storage	65	0	0	0.12	8	1	8	0.9	9	0	0.00
Stor 2	Storage	Storage	795	0	0	0.12	96	1	96	0.9	107	390	0.25
Corr 1	Corridor	Corridor	530	0	0	0.06	32	1	32	0.9	36	500	0.06
Corr 2	Corridor	Corridor	240	0	0	0.06	15	1	15	0.9	17	0	0.00
Corr 3	Corridor	Corridor	235	0	0	0.06	15	1	15	0.9	17	0	0.00
Corr 4	Corridor	Corridor	1105	0	0	0.06	67	1	67	0.9	74	800	0.08
Lobby 1	Lobby	Lobby	1345	1	5	0.06	86	0.8	107.5	0.9	119	2750	0.04
Lobby 2	Lobby	Lobby	400	1	5	0.06	29	1	29	0.9	32	650	0.04
Lobby 3	Lobby	Lobby	425	1	5	0.06	31	1	31	0.9	34	1930	0.02
Ent 1	Ent.	Lobby	230	1	5	0.06	19	1	19	0.9	21	0	0.00
Total Area =	18125	ft <sup>2</sup>	Vpz Total =		21260	CFM	Actual Voa =		4800	CFM	Max Zp		0.25
ΣVoz =	1999	CFM	Vot Total =		2221	CFM	48		% over ASHRAE 62.1-2007				

RTU 2-1 - 2nd Floor South													
Room #	Room Name	Room Type	Az	Pz	Rp	Ra	Vbz	Ez	Voz	Ev	Vot	Vpz	Zp
1	Exterior Office	Office Space	160	1	5	0.06	15	0.8	18.75	0.9	21	480	0.04
2	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
3	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
4	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
5	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
6	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
7	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
8	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
9	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06

10	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
11	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
12	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
13	Exterior Office	Office Space	155	1	5	0.06	15	0.8	18.75	0.9	21	280	0.07
14	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
15	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
16	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
17	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
18	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
19	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
20	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
21	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
22	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
23	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
24	Exterior Office	Office Space	160	1	5	0.06	15	0.8	18.75	0.9	21	440	0.04
25	Exterior Office	Office Space	160	1	5	0.06	15	0.8	18.75	0.9	21	400	0.05
26	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	220	0.08
27	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
28	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
29	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
30	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
31	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
32	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	270	0.06
33	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	220	0.08

34	Exterior Office	Office Space	130	1	5	0.06	13	0.8	16.25	0.9	18	250	0.07
35	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
36	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
37	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
38	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
39	Interior Office	Office Space	145	1	5	0.06	14	1	14	0.9	16	95	0.15
40	Interior Office	Office Space	145	1	5	0.06	14	1	14	0.9	16	95	0.15
41	Interior Office	Office Space	145	1	5	0.06	14	1	14	0.9	16	95	0.15
42	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15
43	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
44	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
45	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
46	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
47	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
48	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
49	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15
50	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15
51	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
52	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
53	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
54	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
55	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
56	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	95	0.15
57	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15

58	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15	
59	Interior Office	Office Space	135	1	5	0.06	14	1	14	0.9	16	95	0.15	
Open 1	Open Office	Office Space	346	5	20	5	0.06	308	1	308	0.9	342	2765	0.11
Open 2	Open Office	Office Space	155	0	8	5	0.06	133	1	133	0.9	148	1000	0.13
Open 3	Open Office	Office Space	312	0	18	5	0.06	278	1	278	0.9	309	2215	0.13
Conf 1	Training Room	Conf. Rm	540	8	5	0.06	73	0.8	91.25	0.9	101	1850	0.05	
Lobby 1	Elevator Lobby	Lobby	805	0	5	0.06	49	1	49	0.9	54	1700	0.03	
Corr 1	Corridor	Corridor	745	2	0	0.06	45	1	45	0.9	50	285	0.16	
Total Area =	18665	ft <sup>2</sup>	Vpz Total =		21230	CFM	Actual Voa =		4600	CFM	Max Zp		0.16	
ΣVoz =	1853	CFM	Vot Total =		2059	CFM	46		% over ASHRAE 62.1-2007					

RTU 2-2 - 2nd Floor North													
Room #	Room Name	Room Type	Az	Pz	Rp	Ra	Vbz	Ez	Voz	Ev	Vot	Vpz	Zp
1	Exterior Office	Office Space	200	1	5	0.06	17	0.8	21.25	0.9	24	160	0.13
2	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
3	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
4	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
5	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
6	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
7	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07
8	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
9	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	290	0.06
10	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	240	0.07

11	Exterior Office	Office Space	160	1	5	0.06	15	0.8	18.75	0.9	21	360	0.05
12	Exterior Office	Office Space	155	1	5	0.06	15	0.8	18.75	0.9	21	440	0.04
13	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
14	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
15	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
16	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
17	Exterior Office	Office Space	150	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
18	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
19	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
20	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	120	0.15
21	Exterior Office	Office Space	160	1	5	0.06	15	0.8	18.75	0.9	21	440	0.04
22	Exterior Office	Office Space	160	1	5	0.06	15	0.8	18.75	0.9	21	300	0.06
23	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
24	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
25	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
26	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
27	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
28	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
29	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	190	0.09
30	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
31	Exterior Office	Office Space	140	1	5	0.06	14	0.8	17.5	0.9	19	230	0.08
32	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	160	0.11
33	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15
34	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15

35	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15	
36	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15	
37	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15	
38	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.00	
39	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15	
40	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.00	
41	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15	
42	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.00	
43	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15	
44	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.00	
45	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15	
46	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.00	
47	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15	
48	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.00	
49	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15	
50	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.00	
51	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.15	
52	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	95	0.00	
Clo 1	Closet	Storage	90	1	5	0.06	11	1	11	0.9	12	95	0.12	
Open 1	Open Office	Office Space	238	5	17	5	0.06	229	1	229	0.9	254	1600	0.14
Open 2	Open Office	Office Space	870	6	5	0.06	83	1	83	0.9	92	465	0.18	
Open 3	Open Office	Office Space	143	5	10	5	0.06	137	1	137	0.9	152	1200	0.11
Open 4	Open Office	Office Space	870	6	5	0.06	83	1	83	0.9	92	465	0.18	
Open 5	Open Office	Office Space	240	5	17	5	0.06	230	1	230	0.9	256	1600	0.14
Conf 1	Conf.	Conf.	445	22	5	0.06	137	0.8	171.25	0.9	190	1710	0.10	

Conf 2	Conf.	Rm Conf. Rm	290	15	5	0.06	93	1	93	0.9	103	1100	0.08
Conf 3	Conf.	Conf. Rm	245	12	5	0.06	75	1	75	0.9	83	860	0.09
Conf 4	Conf.	Conf. Rm	170	9	5	0.06	56	1	56	0.9	62	650	0.09
Pan 1	Pantry	Office Space	335	7	5	0.06	56	1	56	0.9	62	665	0.08
Corr 1	Corridor	Corridor	118 0	0	0	0.06	71	1	71	0.9	79	340	0.21
Lobby 1	Elevator Lobby	Lobby	805	24	5	0.06	169	1	169	0.9	188	1700	0.10
Lobby 2	Lobby	Lobby	280	8	5	0.06	57	0.8	71.25	0.9	79	1175	0.06
Total Area =	19305	ft <sup>2</sup>	Vpz Total =		22755	CFM	Actual Voa =		4800	CFM	Max Zp		0.21
$\sum Voz =$	2384.25	CFM	Vot Total =		2649	CFM	48		% over ASHRAE 62.1-2007				

RTU C-2 - Cellar													
Room #	Room Name	Room Type	Az	Pz	Rp	Ra	Vbz	Ez	Voz	Ev	Vot	Vpz	Zp
Stor 1	Storage	Storage	295	0	5	0.06	18	1	18	0.9	20	220	0.08
Stor 2	Storage	Storage	1730	0	5	0.06	104	1	104	0.9	116	1275	0.08
Stor 3	Storage	Storage	2150	0	5	0.06	129	1	129	0.9	143	1570	0.08
4	Interior Office	Office Space	190	1	5	0.06	17	1	17	0.9	19	100	0.17
5	Interior Office	Office Space	160	1	5	0.06	15	1	15	0.9	17	100	0.15
6	Interior Office	Office Space	145	1	5	0.06	14	1	14	0.9	16	100	0.14
7	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	100	0.14
LAN 8	LAN Room	Office Space	350	2	5	0.06	31	1	31	0.9	34	3750	0.01
9	Exterior Office	Office Space	935	7	5	0.06	92	0.8	115	0.9	128	700	0.16
10	Interior Office	Office Space	165	1	5	0.06	15	1	15	0.9	17	100	0.15
11	Exterior Office	Office Space	145	1	5	0.06	14	0.8	17.5	0.9	19	100	0.18
12	Corridor	Corridor	970	0	5	0.06	59	1	59	0.9	66	400	0.15
13	Exterior Office	Office Space	690	5	5	0.06	67	0.8	83.75	0.9	93	2000	0.04
14	Exterior Office	Office Space	270	2	5	0.06	27	0.8	33.75	0.9	38	825	0.04

	Office	Space											
15	Exterior Office	Office Space	275	2	5	0.06	27	0.8	33.75	0.9	38	700	0.05
16	Exterior Office	Office Space	275	2	5	0.06	27	0.8	33.75	0.9	38	700	0.05
17	Exterior Office	Office Space	270	2	5	0.06	27	0.8	33.75	0.9	38	700	0.05
18	Exterior Office	Office Space	400	3	5	0.06	39	0.8	48.75	0.9	54	290	0.17
Conf 19	Conf. Rm	Conf.	230	2	5	0.06	24	1	24	0.9	27	1095	0.02
20	Interior Office	Office Space	225	2	5	0.06	24	1	24	0.9	27	180	0.13
21	Interior Office	Office Space	225	2	5	0.06	24	1	24	0.9	27	180	0.13
Corr 22	Corridor	Office Space	1080	0	5	0.06	65	1	65	0.9	72	802	0.08
Work 23	Work Room	Office Space	815	6	5	0.06	79	1	79	0.9	88	800	0.10
Stor 24	Storage	Storage	110	0	5	0.06	7	1	7	0.9	8	150	0.05
Stor 25	Storage	Storage	55	0	5	0.06	4	1	4	0.9	4	75	0.05
Corr 26	Corridor	Corridor	550	0	5	0.06	33	1	33	0.9	37	150	0.22
Stor 27	Storage	Storage	2235	0	5	0.06	135	1	135	0.9	150	1680	0.08
Stor 28	Storage	Storage	340	0	5	0.06	21	1	21	0.9	23	100	0.21
Open 29	Open Office	Office Space	155	3	5	0.06	25	1	25	0.9	28	120	0.21
30	Interior Office	Office Space	150	1	5	0.06	14	1	14	0.9	16	75	0.19
Conf 31	Conf. Rm	Conf.	195	1	5	0.06	17	1	17	0.9	19	900	0.02
Lock 32	Locker Rm	Locker Rm	165	1	5	0.06	15	1	15	0.9	17	250	0.06
33	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	550	0.03
34	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	550	0.03
35	Interior Office	Office Space	140	1	5	0.06	14	1	14	0.9	16	550	0.03
36	Interior Office	Office Space	145	1	5	0.06	14	1	14	0.9	16	550	0.03
37	Interior Office	Office Space	145	1	5	0.06	14	1	14	0.9	16	550	0.03
38	Interior	Office	140	1	5	0.06	14	1	14	0.9	16	550	0.00



Room #	Room Name	Room Type	Az	Pz	Rp	Ra	Vbz	Ez	Voz	Ev	Vot	Vpz	Zp	
39	Storage	Storage	870	1	5	0.06	58	1	58	0.9	64	1350	0.04	
40	Open Office	Office Space	130	1	5	0.06	13	1	13	0.9	14	400	0.03	
41	Open Office	Office Space	130	1	5	0.06	13	1	13	0.9	14	400	0.03	
42	Lounge	Office Space	505	4	5	0.06	51	1	51	0.9	57	0	0.00	
43	Storage	Storage	1550	0	5	0.06	93	1	93	0.9	103	1350	0.07	
Total Area =			18095	ft <sup>2</sup>	Vpz Total =		27087	CFM	Actual Voa =		5150	CFM	Max Zp	0.22
ΣVoz =			1615	CFM	Vot Total =		1794	CFM	51		% over ASHRAE 62.1-2007			

RTU AC-2 - Fitness Center														
Room #	Room Name	Room Type	Az	Pz	Rp	Ra	Vbz	Ez	Voz	Ev	Vot	Vpz	Zp	
Fitness	Fitness Room	Health Club/Weight Room	1355	14	20	0.06	362	0.8	452.5	1	453	3180	0.14	
Mens Locker	Mens Locker Rm	Office	435	2	5	0.06	37	1	37	1	37	450	0.08	
Womens Locker	Womens Locker Rm	Office	360	2	5	0.06	32	1	32	1	32	290	0.11	
Total Area =			2150	ft <sup>2</sup>	Vpz Total =		3920	CFM	Actual Voa =		3400	CFM	Max Zp	0.14
ΣVoz =			521.5	CFM	Vot Total =		522	[CFM	34		% over ASHRAE 62.1-2007			

AC-3 & AC-4 - Café														
Room #	Room Name	Room Type	Az	Pz	Rp	Ra	Vbz	Ez	Voz	Ev	Vot	Vpz	Zp	
Café 1	Lunch Rm	Cafeteria	1632	21	7.5	0.18	452	0.8	565	1	565	3180	0.18	
Pantry 3	Pantry	Office	325	2	5	0.06	30	1	30	1	30	450	0.07	
Total Area =			1957	ft <sup>2</sup>	Vpz Total =		3630	CFM	Actual Voa =		3400	CFM	Max Zp	0.18
ΣVoz =			595	CFM	Vot Total =		595	CFM	34		% over ASHRAE 62.1-2007			

### Appendix C – Exhaust Rate Calculations

Minimum Exhaust Rates		FT <sup>2</sup>	CFM/FT <sup>2</sup>	UNITS	CFM/UNIT	Req'd Exhaust [CFM]	Actual Exhaust [CFM]	PASS (Y/N)
	Occupancy							
EF-C-2	Shop	275	0.5			137.5	150	Yes
EF-C-3	Shop	270	0.5			135	150	Yes
EF-C-4	Printing	690	0.5	2	25	395	350	No
EF-C-5	Trash	85	1			85	150	Yes
EF-C-6	Storage	300	1.5			450	450	Yes
EF-C-7	Loading	1550	0.75			1162.5	200	No
EF-C-8	Wood Shop	630	0.5			315	350	Yes
EF-1	Restroom			24	50	1200	2600	Yes
EF-2	Restroom			24	50	1200	3000	Yes
EF-3	Locker Rm	795	0.5	8	50	797.5	1400	Yes
EF-4	Café Pantry	325	0.3	2	50	197.5	700	Yes

### Appendix D – Window Area Calculation

Window Area Calculation	Area (ft <sup>2</sup> )
Glazing Area	17967
Gross Wall Area	49505
% Glazing	36.29%

### Appendix E – Building Envelope Calculation

Section 5.2 - Building Envelope			Area	U-Factor	Required U-Factor	Pass/Fail
Opaque Elements						
Roof - Insulation Entirely Above Deck			41500	0.046	0.048	Pass
Walls - Above-grade			31136	0.05	0.09	Pass
Walls - Below-grade			6845	0.1	0.119	Pass
Floors - Slab-on-Grade Floors			1010	0.7	0.86	Pass
Fenestration Vertical Glazing	Area	U-Factor	SGHC	Required U-Factor	Required SGHC	Pass/Fail
Cellar level	16432	0.046	0.249	0.55	0.4	Pass
Floors 1-3	1535	0.49	0.697	0.55	0.4	Pass
Doors	402	0.49	0.697	0.8	0.4	Pass

### Appendix F – Minimum Equipment Efficiencies Calculations

Minimum Efficiencies - AHSRAE 90.1 Section 6					
	kBtu/hr	Actual EER	Minimum EER	Pass/Fail	System Type
RTU-C-2	746.8	11.1	9.5	Pass	Electronically Operated Unitary Air Conditioner & Condensing Units Single Package with Electric Resistance
RTU-1-1	670.1	11.1	9.5	Pass	
RTU-1-2	684.1	11.1	9.5	Pass	
RTU-2-1	670.1	11.1	9.5	Pass	
RTU-2-2	684.1	11.1	9.5	Pass	
RTU-3-1	685.2	11.1	9.5	Pass	
RTU-3-2	677.3	11.1	9.5	Pass	
AC-2	138.8	12.6	9.7	Pass	
AC-3	86.2	12.5	10.3	Pass	Air Conditioner & Condensing Units
AC-4	86.2	12.5	10.3	Pass	Split System with Electric Resistance

### Appendix G – Fan Power Limitation

Fan Power Limitation - ASHRAE 90.1 Section 6					
Fan Name	Fan Type	[CFM]	HP	CFM <sub>s</sub> ·x	Pass/Fail
RTU-C-2	Variable	26400	25	39.60	Pass
RTU-1-1	Variable	19850	20	29.78	Pass
RTU-1-2	Variable	22000	25	33.00	Pass
RTU-2-1	Variable	19850	20	29.78	Pass
RTU-2-2	Variable	22000	25	33.00	Pass
RTU-3-1	Variable	18300	20	27.45	Pass
RTU-3-2	Variable	20000	20	30.00	Pass
AC-2	Variable	4200	3	6.30	Pass
AC-3	Variable	2500	2	3.75	Pass
AC-4	Variable	2500	2	3.75	Pass
ERV-1	Variable	3400	5	5.10	Pass
EF-C-1	Constant	1085	0.33	1.19	Pass
EF-C-2	Constant	150	0.15	0.17	Pass
EF-C-3	Constant	150	0.15	0.17	Pass
EF-C-4	Constant	350	0.18	0.39	Pass
EF-C-5	Constant	150	0.15	0.17	Pass
EF-C-6	Constant	450	0.23	0.50	Pass
EF-C-7	Constant	200	0.21	0.22	Pass
EF-C-8	Constant	350	0.18	0.39	Pass
EF-C-9	Constant	350	0.18	0.39	Pass
EF-1-1	Constant	465	0.42	0.51	Pass
EF-1-2	Constant	465	0.42	0.51	Pass
EF-2-1	Constant	465	0.42	0.51	Pass
EF-2-2	Constant	465	0.42	0.51	Pass
EF-3-1	Constant	465	0.42	0.51	Pass
EF-3-2	Constant	465	0.42	0.51	Pass
EF-1	Constant	2600	0.5	2.86	Pass
EF-2	Constant	3000	0.75	3.30	Pass
EF-3	Constant	1400	0.33	1.54	Pass
EF-4	Constant	700	0.25	0.77	Pass

### Appendix H – Service Water Heating

Service Water Heating - AHSRAE 90.1 Section 7					
	kW	Volume (Gallons)	Actual Performance	Performance Required	Pass/Fail
EWH-1	18	119	551	401.8	Pass
EWH-2	4.5	66	93%	84%	Pass
EWH-3	4	30	95%	89%	Pass
EWH-4	4	30	95%	89%	Pass

### Appendix I – Lighting Power Density

Space Type	W/FT <sup>2</sup>	Area (FT <sup>2</sup> )	Allowable Wattage	Fixture Symbol	Fixture Description	Wattage	Number of Fixtures	Total Wattage	
Office	1	66915	66915	A	(2) 50W CFL	100	37	3700	
				B	(4) 54W T5 Indirect	216	264	57024	
				C	(1) 42W CFL Downlight	42	56	2352	
				C2	(1) 26W CFL Downlight	26	15	390	
				D	(1) 54W T5	54	16	864	
				G1	(2) 28W T5 Pendant	56	143	8008	
				G2	(4) 28W T5 Pendant	112	44	4928	
				G3	(6) 28W T5 Pendant	168	71	11928	
				AA	(2) 18W Pendant	36	4	144	
Corridors	1	6850	6850	C	(1) 42W CFL Downlight	42	80	3360	
				C2	(1) 26W CFL Downlight	26	52	1352	
				F	(1) 54W T5 Wall	54	8	432	

					Washer				
					K	(1) 35W Accentlight	35	9	315
					Z	(1) 42W CFL Downlight	42	18	756
					BB	(1) 42W CFL Wall Washer	42	2	84
							% Over=	-8.0%	6299
Lobby	1.3	4450	5785		C	(1) 42W CFL Downlight	42	29	1218
					J	(1) 35W Downlight	35	6	210
					E	(1) 12W/FT Cathode Cove	12	80	960
					V	(1) 20W Metal Halide	20	26	520
							% Over=	-49.7%	2908
Conf.	1.3	3355	4361.5		C	(1) 42W CFL Downlight	42	44	1848
					C-DIM	(1) 42W CFL Downlight	42	20	840
					F-DIM	(1) 54W T5 Wall Washer	54	5	270
					E	(1) 12W/FT Cathode Cove	12	50	600
					G1	(2) 28W T5 Pendent	56	4	224
					G2	(4) 28W T5 Pendent	112	1	112
					K	(1) 35W Accentlight	35	5	175
					BB	(1) 42W CFL Wall Washer	42	19	798
					DD	(2) 28W T5 Pendent	56	5	280
							% Over=	18.0%	5147
Locker Room	0.6	795	477		C	(1) 42W CFL Downlight	42	26	1092
							% Over=	128.9%	1092
Exercise Center	1	1355	1355		R	(1) 28W Pendent	28	28	784
							% Over=	-42.1%	784
Parking Garage	0.3	15500	4650		EX-H1	(1) 100W Metal Halide	100	9	900
					EX-H2	(1) 100W Metal	100	15	1500

				Halide				
				EX-J	(2) 17W Fluorescent	34	78	2652
						% Over=	8.6%	5052
Storage	0.8	9335	7468	M	(2) 32W T8 Industrial Fixture	64	86	5504
						% Over=	-26.3%	5504
				Total Allowable				97862
				Total Wattage				109825
				% Over Allowable				12%