2018 AHRAE STUDENT DESIGN COMPETITION - DESIGN CALCULATIONS
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1. EXECUTIVE SUMMARY

This report is submitted by a team from British Columbia Institute of Technology for 2018 ASHRAE student design competition (Design Calculations). The objective of the competition is to perform the design calculations to correctly size the variable air volume HVAC system for a four-story, 70,000 ft^2 mixed used complex north of Istanbul, Turkey near Arnavutkoy. The facility features retail, office spaces, a restaurant, and a hotel.

The introduction section of the report deals with the owner project requirements and key parameters such as the climate zone, weather, building envelope and zoning. The Design considerations sections shows the compliance with the latest editions of ASHRAE Standard 55, 62.1, and 90.1 as per the owner requirements. Additionally, NFPA 96 was considered for commercial kitchen exhaust and fire suppression system. In the load calculation section of the report the heating and cooling load were done via TRACE 700, a software package by Trane Inc. The results obtained from Trace 700 were verified with manual calculations in Excel. The System Selection section provides a detailed description of the system selected based on the load calculation results. The Duct design section of the report outlines the steps taken in sizing the ducts, diffusers etc. The layout of the ducts are appended at the end of the report. Finally, the Energy analysis section covers the annual energy consumption and life cycle cost analysis of the selected system.

Analysis of Arnavutkoy weather revealed that the climate zone is warm and humid and it's classified as 3A. The building envelope properties for climate zone 3A were selected based on the OPR and building drawings. However the building envelope of the walls due to its irregular geometry needed a mathematical approach. Zoning was conducted based on the amount of VAV boxes (thermostats) used, thus the area of the zoning was controlled to be less than 1000ft^2 to achieve maximum thermal comfort. Spaces with similar occupancy, lighting, plug loads and temperature requirements were grouped into a single zone. These zones were subsequently used for load calculations.

The total system peak loads for the building, based on the calculations done in TRACE 700 are 656 MBH for cooling and 439 MBH for heating. These load calculations were done by assigning 4 air handling units (AHU), 1 rooftop unit (RTU) and 2 makeup air units (MAU) to the building. Each AHU was assigned to one floor, the RTU was assigned to the dining room and the MAU's were assigned to the two commercial kitchens. This was decided by considering the design requirements, low first cost and efficiency. The building primary system is a water chiller and a boiler.

The energy analysis was also performed for annual energy consumption in eQuest. The annual energy consumption for electricity is 1,031,200 kWh and 2,994.3 kWh for natural gas. Turkey has a huge geographical advantage to use solar energy and future installation of PV panels for renewable energy was also considered.

A 50-year life cycle cost analysis of the building system priced the initial system cost at $0.8 million and operation and maintenance at $6.5 million, resulting in the total price for the system over 50 years to be at $7.3 million.

2. Table of Contents

3. TABLES & FIGURES

4. Introduction

4.1. Owner Project Requirements

The Owner Project Requirements (OPR) outlines the main goals, requirements and details that must be met by the project. Some of the main highlights from the OPR are:

- Calculate heating and cooling loads.
- Design the Heating, Ventilation and Air Conditioning (HVAC) system for the building.
- Demonstrate compliance with the latest editions of ASHRAE Standards 55 (2017), 62.1 (2013), and 90.1 (2016).
- HVAC system must use a Variable Air Volume (VAV) system for all spaces.
- The interior conditions as noted in *Table 1* must be maintained.

	Office & Administrative Support Spaces	Restaurant	Retail	Lodging	IT support spaces
Occupancy	7 am - 6 pm Mon-Fri 8 am - 1 pm Sat	7 am - 10 pm Mon - Fri	9 am – 10pm Mon–Sat 11am-7pm Sun	24 hours/ day 365 days/year	
Summer DB	73.4°F	73.4°F	73.4°F	78.8°F	73.4°F
Summer RH	50%	50%	50%	55%	50%
Winter DB	70°F	70°F	70°F	73.4°F	73.4°F
Sound	NC 35	NC 30	NC 30	N/A	N/A

Table 1 - Design Requirements

4.2. Weather & Climate Zone

Due to the limited information available, the climate zone of Arnavutkoy is difficult to determine. Therefore, the climate zone information from Istanbul, which is a city 10 kilometers away from Arnavutkoy, is used. According to ASHRAE Standard 90.1 Istanbul is a 3A climate zone. This implies that the weather is warm and humid. To validate the previous statement, the weather data of Arnavutkoy was plotted.

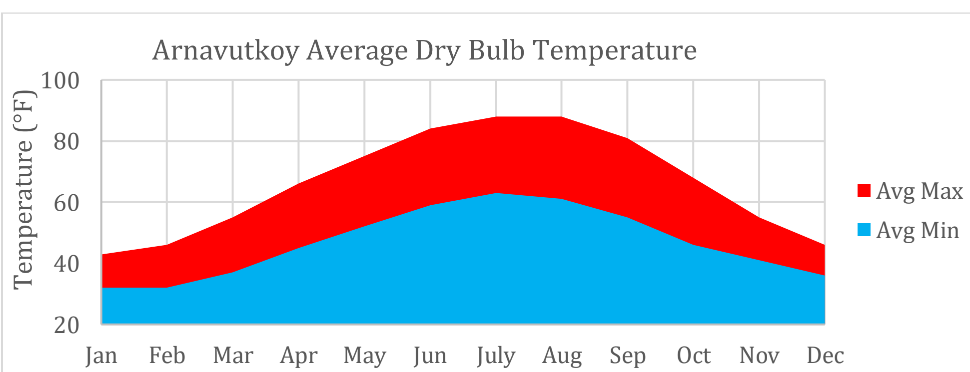


Figure 1 - Arnavutkoy Average Temperatures

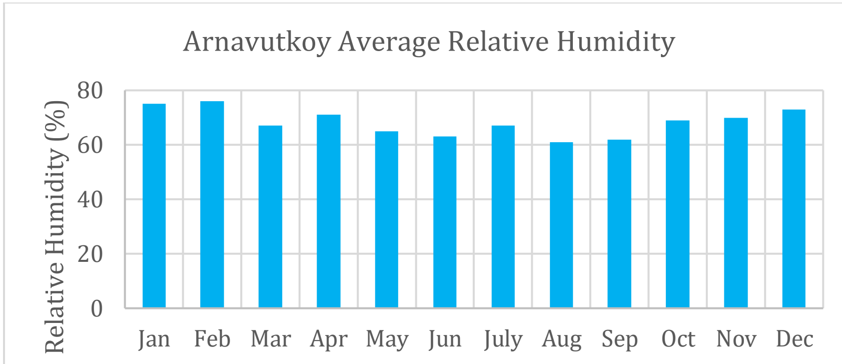


Figure 2 - Arnavutkoy Average Relative Humidity

Figures 1 and Figure 2 show the average monthly temperatures and the average monthly relative humidity respectively. From the figures, it can be determined that the peak outdoor conditions in summer as compared to the indoor conditions shown in Table 1 are warm and humid. Therefore, climate zone 3A is a safe assumption.

Based on the OPR, the exterior design conditions should be based on the ASHRAE 2% criteria, heating 99%, evaporation 1% and dehumidification 1% for the climate of Istanbul Turkey. Furthermore, 2017 ASHRAE Fundamentals Handbook was used to determine the heating and cooling degree days as shown in Table 2 below.

Climate Zone	HDD65 (annual)	CDD50 (annual)
3A	3260	4258

Table 2 – Climate Zone Information

4.3. Building Envelope

The building envelope requirements (i.e. insulation values) for climate Zone 3A are defined in both ASHRAE Standard 90.1 and 189.1(Design of High- Performance Green Buildings). Since ASHRAE Standard 189.1 supersedes 90.1, therefore ASHRAE Standard 189.1 (Appendix E, table E-3) was used to determine the maximum u-values for the building envelope. However, the u-values in the standard are determined for plain walls, not the triangular shaped walls shown in Figure 3 (left). Therefore, a mathematical approach was used to simplify the triangular shaped structure to a multiple layered wall with uniform material (Figure 3).

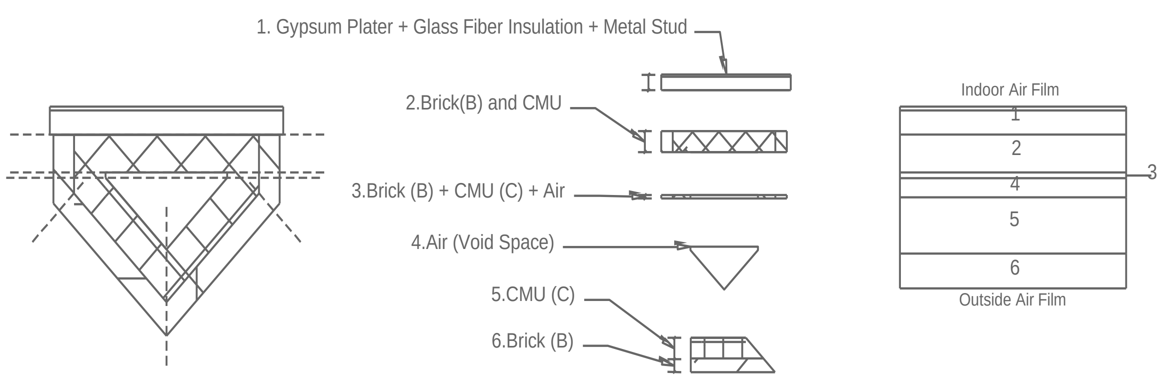
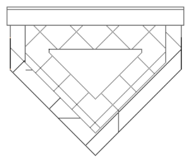


Figure 3 - Layer Break Down

Type 1:



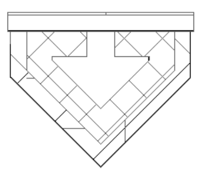
Metal stud wall calculation	R_tot = a*R_T1 +b*R_T3			a=0.5
				b=0.5
Space of the metal stud and insulation	insulation	99.63%		
	Metal stud	0.37%		

Wall Type 1 Configuration	Thk	Frame	Insulation	R_T3
		R (ft^2 F h / Btu)		
Outside Air Film	-	0.17	0.17	0.17
Brick (B)	5.250	0.578	0.578	0.578
CMU	5.750	4.025	4.025	4.025
Air	2.875	1.038	1.038	1.038
B+C+Air+C+B	0.875	0.004	0.004	0.004
B+C+B	5.688	0.028	0.028	0.028
Metal Stud		0.008	0.000	1.923
Glass Fiber Insulation	3.625	0.000	14.500	
Gypsum Plaster	0.625	0.390	0.390	0.390
Indoor Air Film	-	0.680	0.680	0.680
Total		6.921	21.413	8.836

R_T1	21.248
R_T2	1.923
R_TOT	15.042
U_TOT	0.066

Figure 4 - Type 1 Masonry Wall Calculations

Type 2:



Wall Type 2 Configuration	Thk	Frame	Insulation	R_T3
		R (ft^2 F h / Btu)		
Outside Air Film	-	0.170	0.170	0.170
Brick (B)	5.25	0.578	0.578	0.578
CMU	5.75	4.025	4.025	4.025
Air	2.875	1.038	1.038	1.038
B+C+Air+C+B	0.875	0.004	0.004	0.004
B+C+Air+C+B	5.6875	0.054	0.054	0.054
Metal Stud		0.008	0.000	1.923
Glass Fiber Insulation	3.625	0.000	14.500	
Gypsum Plaster	0.625	0.390	0.390	0.390
Indoor Air Film	-	0.680	0.680	0.680
Total		6.947	21.439	8.863

R_T1	21.275
R_T2	1.923
R_TOT	15.069
U_TOT	0.066362

Figure 5 - Type 2 Masonry Wall Calculations

Figure 4 and 5 show the calculated U-values for the 2 slightly different type of walls. To calculate the U-values, the total R-value (R_TOT) is required. The R-value is calculated by the summation of the weighted averages of the metal studs/joists and insulation according to their proportions in the assembly. Finally, the U-value is calculated by dividing 1 by R_TOT.

For the remainder of the building envelope (roof, doors and windows), the U-values were obtained from the Trace library since the load calculations were done via Trace 700. The U-values from the standard are used as a maximum limit. The U-values, as shown in Table 3, obtained via the mathematical model and Trace 700 fall within the limits of the ASHRAE Standard 189.1.

Assembly	Max U-Value Standard 189.1 (Btu/hr-ft^2-^{0}F)	Details	Calculated U-Value (Btu/hr-ft^2-^{0}F)
Windows	≤0.45	Trace 700: Double glazed, fixed windows	0.29
Doors	≤0.54	Trace 700: Generic Door	0.29
Roof	≤0.041	Trace700: 8” HW conc. 6” Ins	0.041
Walls	≤0.123	Figure 3 and Figure	0.0667

Table 3 - Building Envelope Values

4.4. Zoning

An appropriate Zoning technique takes various factors into consideration. Therefore, to maximize the efficiency, cost and thermal comfort, the following rules were determined.

- Zoning is done by considering the perimeter and core of the building.
- The depth of the perimeter can't be more than 15 feet from the exterior wall.
- Area of the zone must be less than 1000 ft^2.
- Where possible, only 1 side of the zone is exposed to solar heat.
- Based on the OPR, "spaces of similar occupancy shall be considered as a single zone based on ASHRAE Standard 62.1".

The depth of the perimeter was determined by ASHRAE Standard 90.1. The area of the zone was decided to be less than 1000 ft^2 because the zoning is done based on how many VAV boxes (thermostats) will be used. Therefore, the area had to be controlled to achieve maximum thermal comfort.

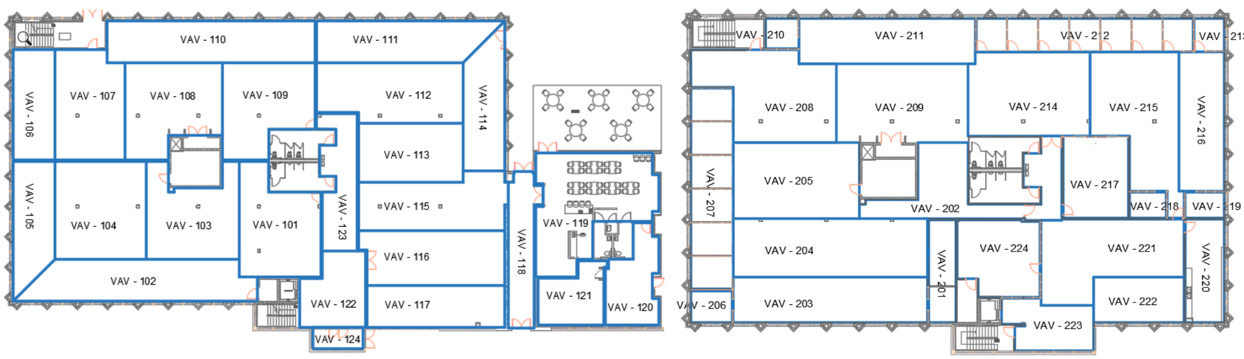


Figure 6 - Zoning - Floor 1 (left) - Floor 2 (right)

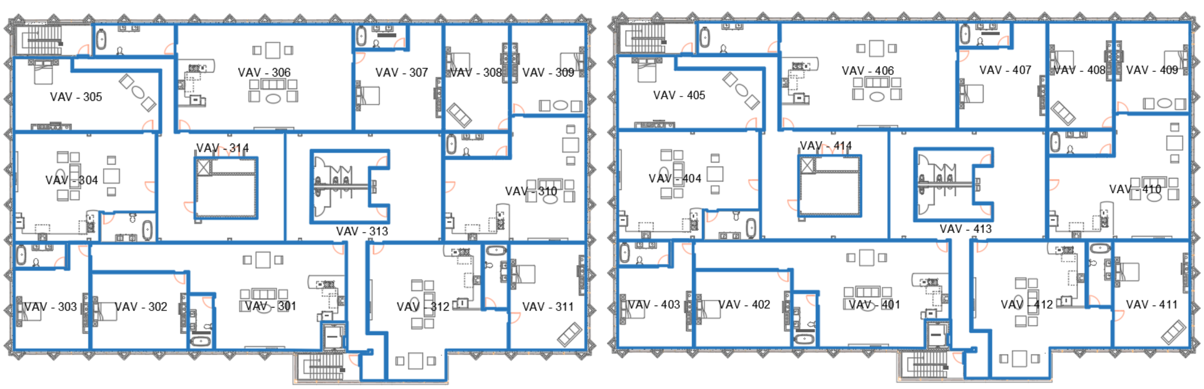


Figure 7 - Zoning - Floor 3 (left) - Floor 4 (right)

5. Design Considerations

5.1. ASHRAE Standard 55

ASHRAE Standard 55 determines the thermal environmental conditions for human occupancy in a building, which are affected by air speed, clothing insulation, temperature, humidity, metabolic rate and radiant temperature. To test the compliance with standard 55 following assumptions were made.

- Thermal conditions will be determined for level 2(Office Space).
- Occupants are wearing a normal shirt, normal trousers, jacket, underwear, socks and boots.
- The HVAC system will maintain design air humidity and temperature.
- Relatively small temperature difference exists between the surfaces of the enclosure.
- Walls have a high emittance, ε.

Input	Values
Metabolic Rate	1.1
Clothing Insulation	1.01
Indoor Summer Design Temperature	73.4°F
Indoor Winter Design Temperature	70°F
Relative Humidity	50%
Emissivity	1

Table 4 - Thermal Comfort Assumptions

5.1.1. Calculating Parameters

i. *Operative Temperature (OT) Range*

$$t_{min,Icl} = \frac{(I_{cl} - 0.5clo)t_{min,1.0clo} + (1.0clo - I_{cl})t_{min,0.5clo}}{0.5clo}$$

$$t_{max,Icl} = \frac{(I_{cl} - 0.5clo)t_{max,1.0clo} + (1.0clo - I_{cl})t_{max,0.5clo}}{0.5clo}$$

I_{cl} = clothing insulation value, clo
t_{min} = lower temperature limit, °F
t_{max} = upper temperature limit, °F

Using the graph shown in Figure 8 below, minimum and maximum temperature for 0.5 and 1.0 clo can be determined at a relative humidity of 50%. These values can be used to obtain the operative temperature range by using the equations above.

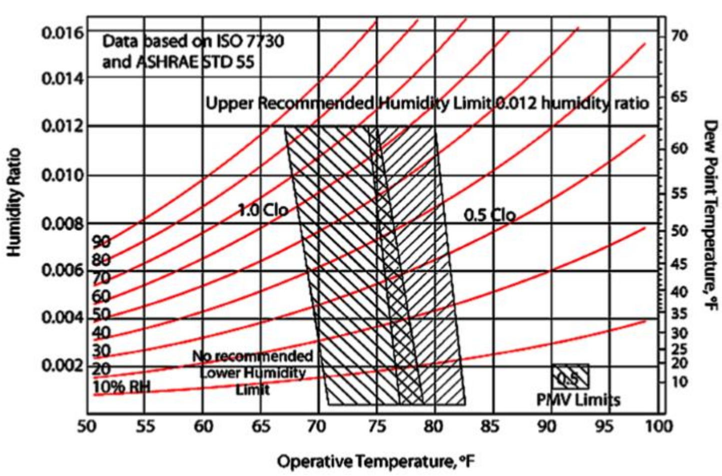


Figure 8 - Standard 55 Graphical method

ii. *Maximum acceptable air velocity*

$$V = 31375.7 - 857.295t_a + 5.86288t_a^2$$

t_a = design temperature, °F

Using the indoor design temperatures from Table 4, the maximum acceptable air velocity can be determined for winter and summer.

iii. *Mean Radiant Temperature (MRT)*

The mean radiant temperature (t_r) is a key variable in thermal calculations for the human body. It is the uniform temperature of an imaginary enclosure in which radiant heat transfer from the human body equals the radiant heat transfer in the actual nonuniform enclosure. The following equation from the ASHRAE fundamental handbook can be used if the temperature difference between the planes of the enclosure is assumed to be relatively small and the individual is assumed to be in a seated position. The plane radiant temperature is assumed to be at 68 °F.

$$t_r = \frac{0.18[t_{pr}(\text{up}) + t_{pr}(\text{down})] + 0.22[t_{pr}(\text{right}) + t_{pr}(\text{left})] + 0.30[t_{pr}(\text{front}) + t_{pr}(\text{back})]}{[2 * (0.18 + 0.22 + 0.30)]}$$

t_{pr} = plane radiant temperature, °F
t_r = mean radiant temperature, °F

iv. *Operative Temperature (OT)*

$$t_o = At_a + (1 - A)t_r$$

t_o = operative temperature, °F
t_a = design temperature, °F
A = coefficient representing the ratio of heat transfer (Convection/Radiation)

The coefficient, A, can be determined from the Normative Appendix A by using the maximum acceptable air velocity.

v. *Results*

Winter	Summer
OT Range 69 °F - 76°F	
V = 93.162 fpm	V = 36.453 fpm
A = 0.6	A = 0.5
t_r = 68 °F	
t_o = 69.3 °F	t_o = 70.825 °F

Table 5 - Calculated Thermal Environmental Conditions

Looking at the results it can be determined that the operative temperatures for both summer and winter lie within operative temperature range.

5.2. ASHRAE STANDARD 62.1

ASHRAE Standard 62.1 determines the ventilation for acceptable Indoor Air Quality (IAQ), in which "there are no known contaminants at harmful concentrations …. and substantial majority (80% or more) of people exposed do not express dissatisfaction". Two procedures are highlighted to determine mechanical ventilation for buildings: Ventilation Rate Procedure (VRP), and IAQ procedure (IAQP).

VRP produces minimum ventilation rates based on the contaminant source as well as its concentration in the breathing zone of the building occupancy types as tabulated in Table 6.2.2.1 of ASHRAE Standard 62.1.

IAQP is performance-based design, in which outdoor ventilation air rates are calculated based on specific kind of contaminant source, concentrations and perceived air quality target. Since IAQP is limited by insufficient specifications and unavailable data, IAQP method is not used for the ventilation.

VRP Procedure

5.2.1. Particulate Matter, Ozone and Other Outdoor Air Contaminants

Air quality in Turkey is a big concern since measurements show that the number of particulate matter with a diameter of 2.5 and 10 micrometers (PM2.5 and PM10) in Turkey's atmosphere are significantly higher than the European Union and World Health Organization.

	PM 2.5 (µg/m^3)	PM 10 (µg/m^3)
Turkey	39	50
EU Annual limits	25	40

Table 6 - Turkey Air Quality

According to ASHRAE Standard 62.1, particulate filters or air cleaning devices shall be provided to clean the outdoor air with minimum efficiency reporting values (MERV) of 11 or higher when the National guidelines for PM2.5 and PM10 are exceeded. Also, no ozone cleaning devices are needed as the most recent three years average annual fourth-highest daily maximum eight-hour average ozone concentration is below 0.107 ppm (209 µg/m^3).

5.2.2. Outdoor Airflow Calculations

i. *Breathing Zone Outdoor Airflow*

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

V_{bz} = Breathing Zone Outdoor Airflow, cfm
A_z = Zone Floor Area, ft^2
P_z = Zone Population, # of people
R_p = Outdoor airflow rate per person, cfm/person (Table 6.2.2.1)
Ra = Outdoor airflow rate per unit area, cfm/ft^2 (Table 6.2.2.1)

ii. *Zone Outdoor Airflow*

$$V_{oz} = \frac{V_{bz}}{E_z}$$

V_{oz} = Zone Outdoor Airflow, cfm
E_z = Zone Distribution Effectiveness (Table 6.2.2.2)

iii. *Primary Outdoor Air Fraction*

$$Z_p = \frac{V_{oz}}{V_{pz}}$$

V_{pz} = Zone Primary Airflow from air handler including outdoor and recirculated air, cfm

Z_p = Outdoor Air Fraction

iv. *Uncorrected Outdoor Air Intake*

$$V_{ou} = D \sum\nolimits_{all\ zones} (R_p * P_z) + \sum\nolimits_{all\ zones} (R_a * A_Z)$$

V_{ou} = Uncorrected Outdoor Air Intake, cfm
D = Occupant Diversity (use equation below)

$$D = \frac{P_s}{\sum_{all\ zones} P_z}$$

P_s = total population in the area served by the system
P_z = Zone Population, # of people

v. *Outdoor Air Intake*

$$V_{ot} = \frac{V_{ou}}{E_v}$$

V_{ot} = Outdoor Air Intake
V_{ou} = Uncorrected Outdoor Air Intake, cfm
E_v = System Ventilation Efficiency, (find using Z_p in Table 6.2.5.2)

5.2.3. Exhaust System

The two methods to design exhaust systems are Perceptive and Performance Compliance Path. In Perceptive compliance path, the exhaust rate is determined by ASHRAE Standard 62.1 Table-6.5. Whereas, in Performance compliance path, the exhaust rate is determined according to contamination source and concentration using Informative Appendix B. Since the building has no contamination zones or areas, it is safe to use the perceptive compliance path method. The following spaces listed in Table 7 below, require an exhaust system.

Occupancy Category	Exhaust Rate
Storage Rooms	1.5 (cfm/ft^2)
Toilets	50 (cfm/unit)
Kitchen – Commercial	See Section 7.7.2

Table 7 - Exhaust Rate

5.3. ASHRAE STANDARD 90.1

ASHRAE Standard 90.1 is used to determine the minimum energy efficiency requirements for a building. For compliance, section 6 (HVAC System), and section 9 (Lighting) of standard 90.1 are most applicable. Section 5 (Building Envelope) is not considered because it is superseded by standard 189.1 (*section 4.4*). All other sections are not applicable.

5.3.1. HVAC System

The cooling capacity of the building is greater than 16kW (54,000 BTU/h), and the Climate Zone is 3A. Therefore, an economizer is needed according to the standard 90.1 - Table 6.5.1. The high limit shutoff control settings for an air economizer based on Table 6.5.1.1.3 is $T_{oa} > 65°F$

5.3.2. Lighting
The two methods for lighting system compliance are Building area compliance method and Space by Space method. For this project Space by Space method was used and all the lighting power densities allowances were taken from ASHRAE Standard 90.1 - Table 9.6.1 to calculate lighting load.

6. LOAD CALCULATIONS

6.1. INTRODUCTION
Heating and Cooling Load calculations were performed by Trace 700. Templates for internal load, airflow, thermostat, construction were made for different types of spaces such as offices, retail, lodging etc. The templates incorporated values from the ASHRAE standards and the fundamental handbook. The model was inputted as rooms in Trace 700. The rooms were based on the zoning conducted in *Section 4.5*. Systems were also created for each type of space (retail, lodging, offices). Each space was assigned only one type of system due to varying design requirements (*Table 1*) and efficiency. Finally, the weather data file from the ASHRAE website was imported into Trace for calculations.

The team used CLTD/CLF method for cooling load and UATD for heating load calculations.

6.2. VERIFICATION
Excel was used to verify the accuracy of the load calculations completed via Trace 700. For the verification purposes, one zone from the building was chosen as a reference. Heating and cooling load calculations were conducted for the reference zone using excel spreadsheets and compared to the results obtained from Trace 700. The VAV-206 (*Figure 6*) was chosen as the reference zone.

Load Calculations	Trace 700 (Btu/h)	Excel (Btu/h)	% Difference
Heating	3603	3788	4.85%
Cooling	5744	5672	1.3%

Table 8 - Verifying Results

6.3. RESULTS
The summary of the results from Trace 700 are displayed in Table 9 below. The full calculations are shown in the Appendix.

Space Type	Heating (cfm)	Cooling (cfm)	Total Heating Load (Btu/h)	Total Cooling Load (Btu/h)
level 1	3,992	8,485	118,165	201,817
level 2	3,780	9684	105,743	220,925
level 3	2,777	7,229	87,193	95,203
level 4	2,651	7,211	105,823	94,981
Dining Area	587	587	9,269	16,305
Kitchen 1 (VAV-120)	429	1,429	13,013	26,505
Kitchen 2 (VAV-121)	601	2004	14,217	33,477

Table 9 - Load Calculation & Airflow Results

7. System Selection

7.1. Overview & Variable Air Volume (VAV)

The next step in the process after load calculations is system selection. The objective of the system selection is to control and maintain the building space load since it continuously changes due to varying outdoor air temperature, solar radiation, and internal loads. Therefore, a zone control strategy is implemented. As stated in the OPR, the use of Variable Air Volume (VAV) boxes throughout the building is required to be a part of the control strategy. Due to the various types of VAV boxes, VAV boxes with reheat were selected since they provide a better temperature and humidity control. The VAV boxes model SDV8, as shown in the Appendix, were selected from ehprice. The boxes were sized based on the maximum cfm of each zone determined in Trace. The general layout of the AHU and VAV box connection is shown in Figure 9 below.

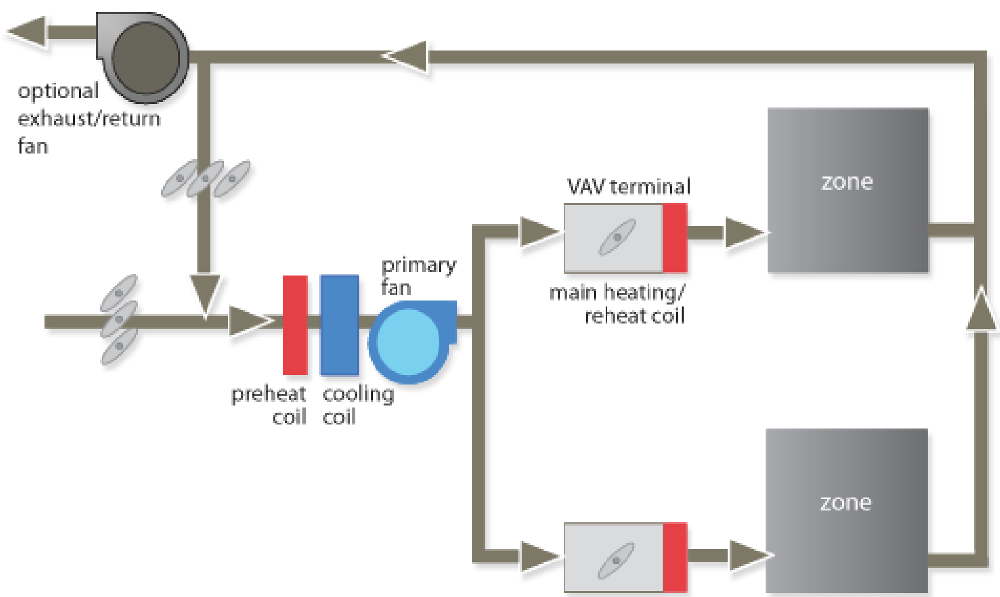


Figure 9 - Layout of AHU & VAV box connection

7.2. Air Handling Units (AHU)

Air Handling Unit condition air and direct it to VAV boxes, where it is distributed to its dedicated zone or space. For this building except the restaurant, four Trane Performance Climate Changer AHU shown in Appendix will be used. Each AHU is sized according to the load and ventilation calculations in TRACE 700, and one AHU will serve one floor. This is decided based upon the occupancy variance (*section- 4.1*), which effects the schedules and the load. Thus, having one AHU per floor makes the process more efficient and decreases the amount of duct work needed (low first cost). Table 10 below contains the information needed from the TRACE 700 calculations to size each AHU.

The restaurant area needs special attention due to different design considerations, such as exhaust, makeup air and fire safety (see *section 7.7*).

Floor	Air Flow	Cooling Load					Heating Load		
		Sensible [Btu/h]	Total [Btu/h]	Total Capacity [Btu/h]	Entering Temp [^{0}F]	Leaving Temp [^{0}F]	Total [BTU/h]	Entering Temp [^{0}F]	Leaving Temp [^{0}F]
1st Floor	8845	173,808	201,817	29.3	75.4	53.2	345,323	53.2	97.6
2ndFloor	9684	189,967	220,925	29	75.1	54.2	295,486	54.2	97
3rd Floor	7229	92,234	95,203	10.3	78	67.5	225,653	67.5	101.3
4th Floor	7211	92,013	94,981	10.5	78.4	67.5	243,043	67.5	108.9

Table 10 - AHU Sizing

7.3. Dedicated Outdoor Air System (DOAS)

One Trane Performance Climate Changer AHU shown in the Appendix is used as a DOAS. The DOAS will be placed on the roof and it is sized based on the total outdoor air ventilation load of the building except the restaurant. The DOAS will take care of the total outdoor air space ventilation requirements not space load. The DOAS will connect all the AHU's through a single duct passing thorough the mechanical room. The addition of the DOAS will help in annual energy savings from the fan and chiller.

7.4. Energy Recovery

There are two ways to exhaust room air, a duct return or plenum return. Except the restaurant and bathrooms, the team decided to use plenum return for the remainder of the building. The exhausted air from the plenum will return to the AHU to be conditioned and recirculated, because the return air and supply air are both considered to be Class 1 air. The return air requires less energy and conditioning to return to desired temperature. Therefore, the recirculated air will help recover energy and save money.

7.5. Filters, and Noise Control

The DOAS and four AHU's will require MERV 11 or higher filters in accordance to the particulate matter analysis presented in *section 5.2.1*.
The OPR provided the design requirements of NC 35 for office and NC 30 for retail and lodging spaces. The noise control requirements will be met by lining the main ducts with acoustical boards and adding flexible ducts to the diffusers. Also, the VAV boxes were sized using the noise attenuation. Since the bathrooms are not regarded as living spaces, the noise from the bathroom exhaust fan was not considered.

7.6. Refrigeration & Heat Production Equipment

The primary system selected for the building is a water chiller and a boiler connected to a cooling tower. The cooling tower was sized according to the overall flow rate (GPM) based on the cooling capacity of the building. The cooling tower chosen is from TRANE COOL-PRC002-EN– Galvanized model shown in Appendix. Since Istanbul is located near an ocean, the galvanized model was selected to protect against rust and corrosion. The cooling tower was selected from series of quiet cooling towers since it will be placed on the roof of the building and noise control is needed.

The boiler system will serve SDV8 VAV reheat terminal units. It was sized according to the total heating load of the building from Trace 700. A safety factor of 1.1 was applied to oversize the boiler to compensate for any error in the load calculations. The boiler chosen for the building is Viessmann VITOCROSSAL 300 – CA3 Series 2.5, which has an output of 2,352 MBTH. Its specifications are available in the Appendix.

Similarly, the chiller of the building was sized based on the total cooling load of the building from Trace 700. A safety factor of 1.1 was once again applied to compensate for any error in the load calculations. The chiller chosen for the building is TRANE ProChill B4k – SS20AC, which has a cooling capacity of 132 TR and 1584 MBTH. The detailed specifications of the chiller are available in the Appendix.

7.7. SPECIAL INSTRUCTION AREA (RESTAURANT)

7.7.1. Dining Area

Based on the provided layout, the restaurant consists of dining area and 2 kitchen areas which are located at VAV 119, VAV 120, and VAV 121 respectively (see *Figure 6*). A separate HVAC system was designed for the restaurant due to different class of air, need for kitchen exhaust and duct work. Therefore, the dining area is only served by a single VAV zone rooftop unit sized based on the load calculation in Trace. Yorkz H037 Predator Series with cooling capacity of 3 Ton and supply air capacity of 1200 CFM was selected for serve the dining area.

7.7.2. Kitchen

Seeing that the restaurant has a commercial kitchen, exhaust and fire safety requirements need to be considered. Therefore, ventilation calculations were done by hand for the commercial kitchen to comply with NFPA 96 standard. Standard NFPA 96 provides minimum exhaust and fire safety requirements related to the design, installation, operation, inspection, and maintenance of all public and private cooking operations. It applies to cooking equipment used for commercial cooking operations but does not apply to cooking equipment located in a single-family dwelling unit. Based on NFPA 96, the following configurations need to be considered.

i. **Kitchen Exhaust System**

Based on the OPR and the kitchen equipment list, it was determined that the kitchen needs a type 1 hood. This type 1 hood needs to be implemented with grease filters, and fire suppression system underneath the hood. Moreover, the hood must be constructed and supported by steel of not less than 18 gauge or stainless steel of 20 gauge. The hood also requires tight continuous welded seams and joints for the entire hood enclosure in an event of a fire. Furthermore, wall mounted canopy hoods were chosen for their functionality and versatility compared to other types of hoods.

ii. **Filters**

Grease extraction removal devices are used to remove built up grease downstream of the kitchen exhaust hood. These extraction devices are to be mounted with baffle filters not less than 18" from the cooking equipment based on NFPA 96.

iii. **Kitchen Airflow Rate (CFM)**

Kitchen airflow rate is critical in designing an exhaust system to remove heat during cooking. To correctly size the kitchen airflow rate, it requires two parameters. The parameters being the effective length of the hood and maximum net exhaust flow rate. Figure 10 below illustrates the wall-mounted canopy hood (right side) and the top view of the hood placement (left side). The typical distance of rear gap and front overhang of the hood are 3 inches and 6 inches respectively based on common practice in the industry.

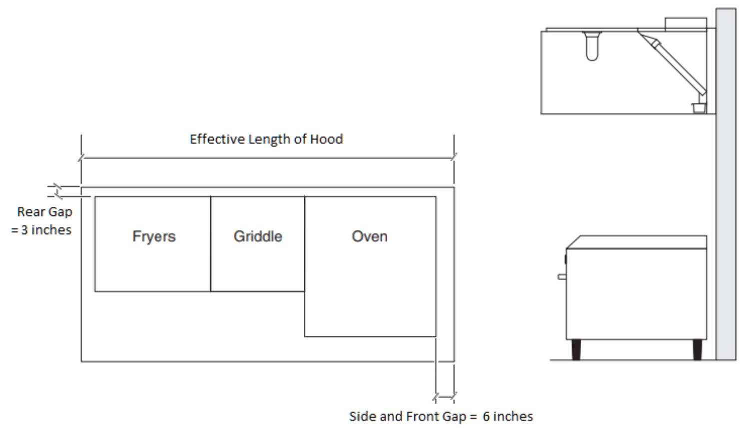


Figure 10 - Kitchen Exhaust Hood

Furthermore, Table 6.5.7.2.2 in ASHRAE standard 90.1 provides the maximum net exhaust flow rate based on the type of hood and equipment. The required CFM can be determined by multiplying the effective length of hood by maximum exhaust flow rate per foot. Below is the summary of required CFM for VAV – 120 (Kitchen #1) and VAV – 121 (Kitchen #2).

	VAV 120	VAV 121
Type of Hood	Wall-mounted canopy	Wall-mounted canopy
Equipment	Medium Duty	Heavy Duty
Max Exhaust Flow Rate	210 CFM/Ft	280 CFM/Ft
Linear Foot of Hood	7 Ft	7.67 Ft
Required CFM	1470 CFM	2147 CFM

Table 11 - Kitchen Hood & Exhaust

iv. **Kitchen Duct Construction**

Kitchen ducts exhaust air with heat and grease laden vapour through the system termination either at the roof top or an exterior wall. The duct system must have openings to provide sufficient access to permit periodic maintenance and inspection. It must be constructed with materials and connections that will not compromise its integrity should a fire occur in the duct. The termination point for the exhaust air must be located to prevent recirculation of the exhaust air back into the building or any adjacent building. The following must be considered to meet standard NFPA 96:

1. Access to Ducts: a minimum 20”x20” opening shall be provided for personnel entry to duct system.
2. Duct Clearance: minimum clearance must be provided for limited combustible materials (3 inches) and combustible materials (18 inches).

3. Duct materials: ducts must be constructed of and supported by not less than 16-gauge galvanized steel or 18-gauge stainless steel. Moreover, all kitchen ducts must be welded with liquid tight continuous seams, joints, penetrations, and duct hood collar connections.
4. Termination of Exhaust System through the roof must provide
   - A minimum of 3 m (10 ft) of horizontal clearance from the outlet to adjacent buildings, property lines and air intakes.
   - A minimum of 1.5 m (5 ft) of horizontal clearance from the outlet (fan housing) to any combustible structure.
   - A vertical separation of 0.92 m (3 ft) below any exhaust outlets for air intakes within 3 m (10 ft) of the exhaust outlet.
   - A drain to collect grease out of any traps or low points formed in the fan or ducts near terminations of the system.
   - An upblast fan installed on 18" high fan curb with flexible weatherproof electric cable and service hold open retainer to permit inspection and cleaning.

v. **Kitchen Exhaust Fan**

Based on commercial kitchen design, airflow velocity is limited from 1500 FPM to 1800 FPM. For this project 1500 FPM airflow velocity is sufficient as shown in the duct sizing calculations in the Appendix. Furthermore, to select a proper kitchen exhaust fan, the static pressure loss also must be calculated. Following are the parameters to consider for static pressure loss.

- Static pressure loss that comes from removable grease extractor
- Entrance Loss based on exhaust duct velocity
- Static pressure loss that comes from ducts and associated fittings
- Fan system effect, typically ranges from 0.05" w.g to 0.2" w.g

The detailed calculations for static pressure are shown in Appendix. Once the static pressure of exhaust fan is found, the next step is to choose a typical fan used in commercial kitchen. Upblast fan is chosen by considering termination of exhaust fan requirements in kitchen duct construction. The table below provides the summary of static pressure loss for kitchen exhaust and the selected fan properties from Greenheck.

	VAV 120	VAV 121
Static Pressure	1.0638" wg	1.112" w.g
Greenheck Model	Size-161XP-CUBE	Size-180HP-CUBE
Motor HP	1	0.75
Fan RPM	2138	1215
Fan CFM	1743	2286

Table 12 - Kitchen Exhaust Fan Properties

vi. **Makeup Air System**

The makeup air unit for the kitchen was based on the required cfm (*Table 11*). It was decided to be placed on the roof of the kitchen. Also, the selected makeup air unit is an indirect gas fired with evaporative cooling from Greenheck. The table below shows the selected make up air unit for both kitchens.

	VAV 120	VAV 121
Model	IG-110	IG-112
MBH (Input)	150-175	175-300
Static Pressure	0.75" w.g	0.75" w.g
Airflow	2000 CFM	2600 CFM
RPM	912	761

Table 13 - Kitchen Makeup Air Unit

vii. **Fire Suppression System**

Fire suppression system is critical in commercial kitchen design. NFPA 96 requires all fire extinguishing systems to comply with ANSI/UL 300 to provide minimum fire testing standard in the kitchen. In an event of emergency, the fire extinguishing equipment discharges cold water mist to spray water within the exhaust plenum and turns on the fan circuit. Therefore, it was decided to use Greenheck Wall Canopy Hood equipped with Ansul R-102 fire suppression system. This Ansul R-102 fire suppression system works efficiently due to nozzles and their placement.

Figure 11 - Greenheck Wall Canopy Hood

8. Duct Design

Duct Design layout for the building is shown in the Appendix, it was done by using equal friction method. Following were the steps used to size ducts.

- Determine the supply air velocity requirement. The supply air velocity for residential and commercial are limited to 1000 FPM and 1200 FPM respectively.
- Using ductulator, a duct sizing calculator online, initial static pressure loss can be obtained by comparing supply air velocity and total CFM.

Building Level	Type	Airflow (CFM)	Velocity (FPM)	Initial Static Pressure (inch w.g)
1	Commercial	8845	1200	0.055
2	Commercial	9684	1200	0.05
3	Residential	7229	1000	0.04
4	Residential	7211	1000	0.04
Dining (VAV 119)	Commercial	587	1200	0.28

Table 14 - Duct Static Pressure loss

- Once initial static pressure loss is determined, this static pressure will be used to size the ductworks in the building.
- Determine the location of each supply air diffuser, return air grille, and VAV box in the building.
- The final step is to determine the static pressure required for the fan in AHU to overcome resistance or pressure drop in ductworks. The following steps are required to get total static pressure in the building:
  - Fan system effect
  - Duct equivalent length from straight duct and duct fittings.
  - Pressure drop from terminal unit and diffuser

  Below is the summary of the required static pressure for different spaces in the building.

	Level 1 (Retail)	Level 2 (Office)	Level 3 (Lodging)	Level 4 (Lodging)	VAV 119 (Dining)
Fan system effect (in w.g)	0.15	0.15	0.15	0.15	0.15
Duct Equivalent (in w.g)	0.15	0.12	0.09	0.09	0.21
Terminal Unit (in w.g)	0.10	0.10	0.10	0.10	0.10
Diffuser (in w.g)	0.10	0.10	0.10	0.10	0.10
Total Static Pressure (in w.g)	0.50	0.47	0.44	0.44	0.56

Table 15 - Building Static Pressure Loss

As mentioned in *section 7.7.2*, commercial kitchen is treated as a special instruction area which needs to comply with standard NFPA 96. However, the process of sizing the ducts is the same. For commercial kitchen duct design calculations look in the Appendix.

9. Energy Analysis

9.1. Energy Consumption Summary

For energy analysis, energy modeling software eQuest was used to determine annual energy consumption of the HVAC system in the building. Due to the requirement of using VAV boxes, the energy consumption of the designed VAV system was performed.

The overall annual energy consumption of the building is 1,034,194.3 kWh and it is shown graphically in Figure 12 and numerically in Table 16 below.

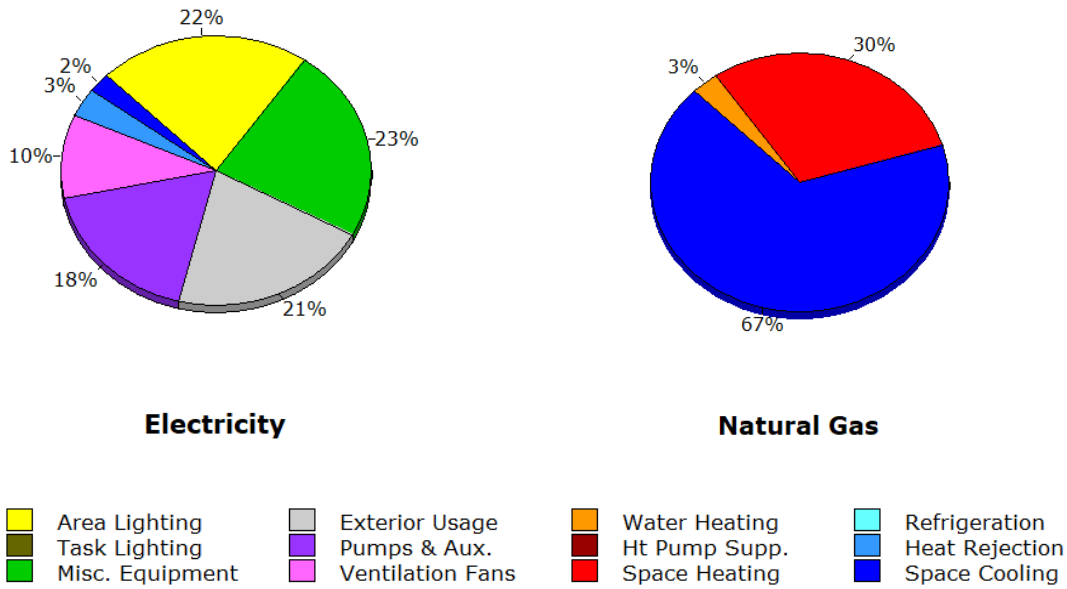


Figure 12 -Breakdown of Energy Consumption

	Electricity (kWh x000)	Natural Gas (kWh)
Space Cool	24.2	2007.8
Heat Reject.	35.6	0
Refrigeration	0	0
Space Heat	0	896.8
HP Supp.	0	0
Hot Water	0	89.7
Vent. Fans	104	0
Pumps & Aux.	183.5	0
Ext. Usage	215.6	0
Misc. Equip.	238.5	0
Task Lights	0	0
Area Lights	229.8	0
Total	1,031.20	2,994.30

Table 16 - Energy Consumption

ASHRAE Standard 189.1 states that on-site renewable energy system is a mandatory provision for future installations. Since this is not a single-story building, the annual energy production of renewable energy systems should not be less than 10kBtu/ft^2 (32 kWh/m^2) multiplied by the gross roof area, which equals to 177,784 kBtu (52103kWh). The renewable energy can cover 5% of annual electricity use.

Due to its geographical location, Turkey has huge economic potential in solar energy. Photo Voltaic modules can be installed on the roof of the main building, where they will have least interference. The shading-series of SunPower solar panel was chosen for its highest efficiency of 21.5% with

345W/panel output. This module has high initial cost compared to others, but it will produce higher returns in the long run. Sizing of PV panel with cost analysis is shown below.

Number of Panels:

$$Annual\ Renewable\ Energy = 52103\ kWh$$

$$Annual\ Mean\ Solar\ energy = 120.4 \frac{kWh}{ft^2}$$

$$Efficiency\ of\ X - series = 21.5\ \%$$

$$PV\ array\ are\ requirement = \frac{52103\ kWh}{0.215 * 120.4 \frac{kWh}{ft^2}} = 2012.79\ ft^2$$

$$Pannel\ Size = \ 17.54\ ft^2$$

$$Number\ of\ Pannel = \frac{2012.79\ ft^2}{17.54\ ft^2} = 114.75\ \rightarrow\ 115\ pannels$$

Cost of Panels:

$$Pannel\ Cost = 360\ USD\ /pannel$$

$$Total\ Cost = \$41,400$$

9.2. Life Cycle Cost Analysis

Life cycle cost analysis was done to ensure it falls within the requirement \$200/ft^2 budget. Since the building covers 70,000 ft^2, the total budget is \$14 million. Figure 13 below, shows the total monthly bills for both electricity and gas determined via eQuest.

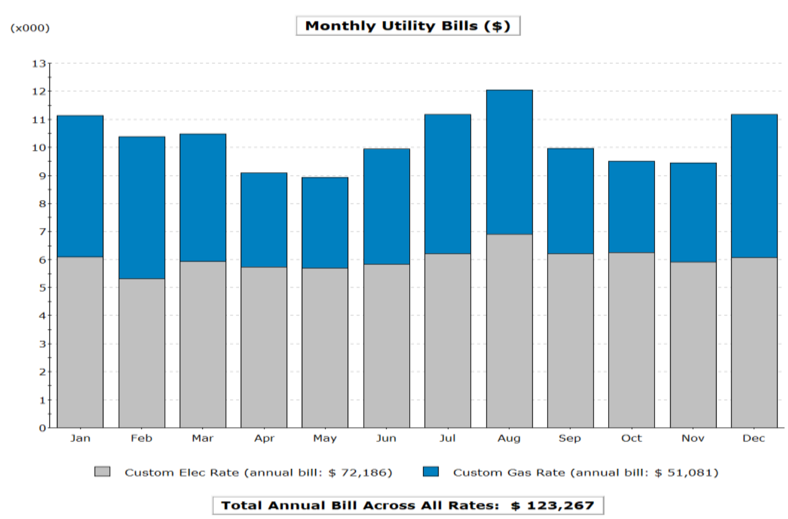


Figure 13 - Annual Cost

Equipment Type	Cost
4 - Air Handling Units	$70,000
1 - DOAS	$25,000
1 - Rooftop Unit	$1,200
2 - Makeup Air Units	$ 2,000
1 - Water Chiller	$60,000
1 - Boiler	$10,000
1 - Cooling Tower	$18,000
1 - Kitchen Hood	$60,000
1 - Fire Suppression System	$1,500
76 - VAV boxes	$85,000
500 - Diffusers & Grills	$140,000
Duct Work	$300,000
Total	**$772,700**

Table 17 - Equipment & Labor Cost

Using the value for total annual bill across all rates in Figure 13, the operating cost for 50 years is calculated to be $6.2 million. Table 17 shows that the capital investment needed for the building is $772,700. It considers both, equipment and labor cost for installation in the building. An additional 3% of the initial investment for maintenance, 3% inflation and 4% return on investment resulted in $6.5 million for operation and maintenance costs. Combining the operation and maintenance with the initial cost results in a total life cycle cost of $7.3 million ($104 USD/ft^2). The total life cycle cost is approximately 50% below the budget.

10. CONCLUSION

The load calculations of proposed four story building north of Istanbul, Tukey near Arnavutkoy were performed in compliance with latest edition of ASHRAE Standard 55, 62.1, and 90.1. Additionally, ASHRAE standard 189.1 for high performance energy efficiency and standard NFPA 96 for Ventilation Control and Fire Protection of Commercial Cooking Operations were also considered.

The load calculations were performed by using TRACE 700 and the results were verified by the calculations done in Excel. The zoning was done based on the amount of VAV boxes (thermostats) used, thus the area of the zoning was controlled to be less than 1000ft^2 to achieve maximum thermal comfort. Spaces with similar occupancy, lighting, plug loads and temperature requirements were grouped into a single zone.

The result, of the overall cooling load for the building is 656 MBH and heating load is 439 MBH. As required, each zone is assigned a VAV box for temperature control. The primary system in the building consists of water chiller, a boiler and a cooling tower to supply and extract the heat. The building is assigned 4 air handling units (AHU), one for each level. The restaurant is assigned 1 rooftop unit (RTU) for the dining area and 2 makeup air units (MAU) for the two commercial kitchens.

A 50-year life cycle cost analysis of the building system is $104 USD/ft, which is less than the budget of $200 USD/ft.

11. ACKNOWLEDGEMENTS

The team would like to thank Joseph Cheung (Professor - BCIT) for his time, guidance, and technical reviews throughout the project. The team would also like to extend their thanks to Bo Li (Professor - BCIT) for his help in energy analysis.

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APPENDIX

Static Pressure Calculation – Commercial Kitchen

VAV 120

$$Hood\ with\ Removable\ Grease\ Extractor = 0.75''\ w.g.$$

$$Enterance\ Loss = 0.09''\ w.g.$$

$$Fan\ System\ Effect = 0.2''\ w.g.$$

Straight Duct used for compliance with standard NFPA 96.

$$Duct\ Length = 110\ in\ =\ 9.1671\ ft$$

Static pressure over 100 ft based on 1500 FPM with 1470 CFM is 0.26" w.g.

$$Static\ Pressure = \frac{0.26''\ \text{w.g.}}{100\ ft} * 9.1671\ ft = 0.0238''\ w.g.$$

Overall static pressure of duct for VAV 120 will be sum of each static pressure as shown below.

$$Total\ Static\ Pressure =\ 0.75\ \text{w.g.} + 0.09''\text{w.g.} + 0.2''\ \text{w.g.} + 0.0238''\ w.g. =\ 1.0638''\ w.g.$$

VAV 121

For VAV 121, two different size of ducts are used.

$$Hood\ with\ Removable\ Grease\ Extractor = 0.75''\ w.g.$$

$$Enterance\ Loss = 0.09''\ w.g.$$

$$Fan\ System\ Effect = 0.2''\ w.g.$$

Straight and fitting duct used for compliance with standard NFPA 96.

$$Main\ Duct\ Length = 76\ in\ =\ 6.33\ ft$$

Static pressure over 100 ft based on 1500 FPM with 2147 CFM is 0.2" w.g.

$$Static\ Pressure = \frac{0.2\text{" w.g.}}{100\ ft} * 6.33\ ft = 0.0127"\ w.g.$$

$$\#2\ and\ \#3\ Duct\ Length = 38\ in\ =\ 3.167\ ft$$

Static pressure over 100 ft based on 1500 FPM with 1074 CFM is 0.28" w.g.

$$Static\ Pressure = \frac{0.28\text{" w.g.}}{100\ ft} * 3.167\ ft = 0.00887"\ w.g.$$

Since two size of ducts are used in this system, pressure loss from the expansion joints is considered.

$$Area\ Ratio = \frac{\text{Main Duct Area}}{\text{\#2 Duct Area}} = \frac{200\ in^2}{100\ in^2} = 2, Gradual\ Change\ Angle = 60^{\circ}$$

$$\rightarrow Expansion\ Loss = 0.0435"\ w.g.$$

$$Pressure\ Loss = \left(\frac{\text{New Velocity}}{1500\ fpm}\right)^2 * Expansion\ Loss\ from\ Table$$

$$= \left(\frac{1613\ fpm}{1500\ fpm}\right)^2 * 0.0435\text{ w.g.} = 0.05030"\ w.g.$$

Overall static pressure of duct for VAV 121 will be sum of each static pressure as shown below.

$$Total\ Static\ Pressure$$

$$= 0.75\text{ w.g.} + 0.09\text{"w.g.} + 0.2\text{" w.g.} + 0.0127"\ w.g. + 0.00887"\ w.g. + 0.0530"\ w.g.$$

$$= 1.112"\ w.g.$$

Duct Size Calculation – Commercial Kitchen

VAV 120

$$Kitchen\ Type = Medium\ duty = 210\frac{CFM}{ft}$$

$$Total\ CFM = 7\ ft\ *\ 210\frac{CFM}{ft} = 1470\ CFM$$

$$Assumed\ Duct\ Velocity = 1500\ FPM$$

$$Duct\ Size = \frac{Total\ CFM}{Duct\ Velcity} = \frac{1470\ CFM}{1500\ FPM} = 0.98\ ft^2 = 141.12\ in^2 \rightarrow 12" \times 12"\ \ Duct\ Size$$

Confirm assumption,

$$Velocity = \frac{1470\ CFM}{144\ in^2} * \frac{1\ ft^2}{144\ in^2} = 1470\ FPM$$

It is very close to the standard velocity design range, 1500 FPM to 1800 FPM.

VAV 121

For the main duct (#1) size,

$$Kitchen\,Type = Heavy\ duty = 250\frac{CFM}{ft}$$

$$Total\ CFM = 7.67\ ft\ *\ 280\frac{CFM}{ft} = 2147\ CFM$$

$$Assumed\ Duct\ Velocity = 1500\ FPM$$

$$Main\ Duct\ Size = \frac{Total\ CFM}{Duct\ Velcity}\ = \frac{2147\ CFM}{1500\ FPM} = 1.4313\ ft^2\ = 203.112\ in^2 \rightarrow 20"\times 10"\ \ Duct\ Size$$

Confirm assumption,

$$Velocity = \frac{2147\ CFM}{200\ in^2} * \frac{1\ ft^2}{144\ in^2} = 1545.84\ FPM$$

It is in the velocity design range, 1500 FPM to 1800 FPM

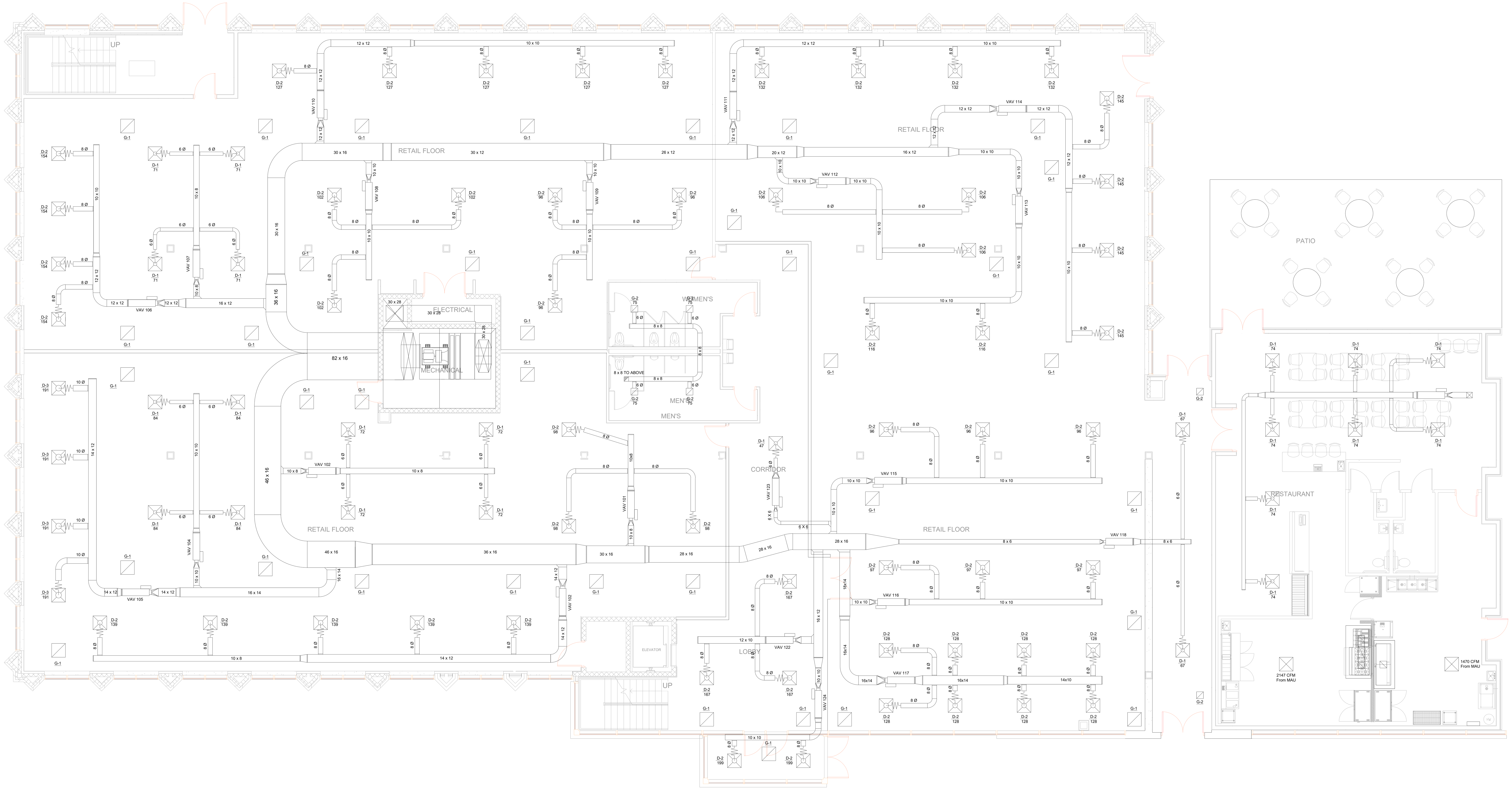
As additional duct size(#2 and #3),

$$CFM\ = 0.5 *\ 2147\ CFM = 1074\ CFM$$

$$Duct\ Size = \frac{CFM}{Duct\ Velcity}\ = \frac{1074\ CFM}{1500\ FPM} = 0.7166\ ft^2\ = 103.102\ in^2 \rightarrow 10"\times 10"\ \ Duct\ Size$$

Confirm assumption,

$$Velocity = \frac{1074\ CFM}{100\ in^2} * \frac{1\ ft^2}{144\ in^2} = 1546.56\ FPM$$



NO	Revision	Date

Project Title

ASHRAE DESGIN COMPETITION

Drawing Title

MECHANICAL FLOOR
PLAN LEVEL - 1

Job Number

BCIT-ME-1718-06

Drawn

F.H/A.A/M.C

Check.

J.C.

Scale

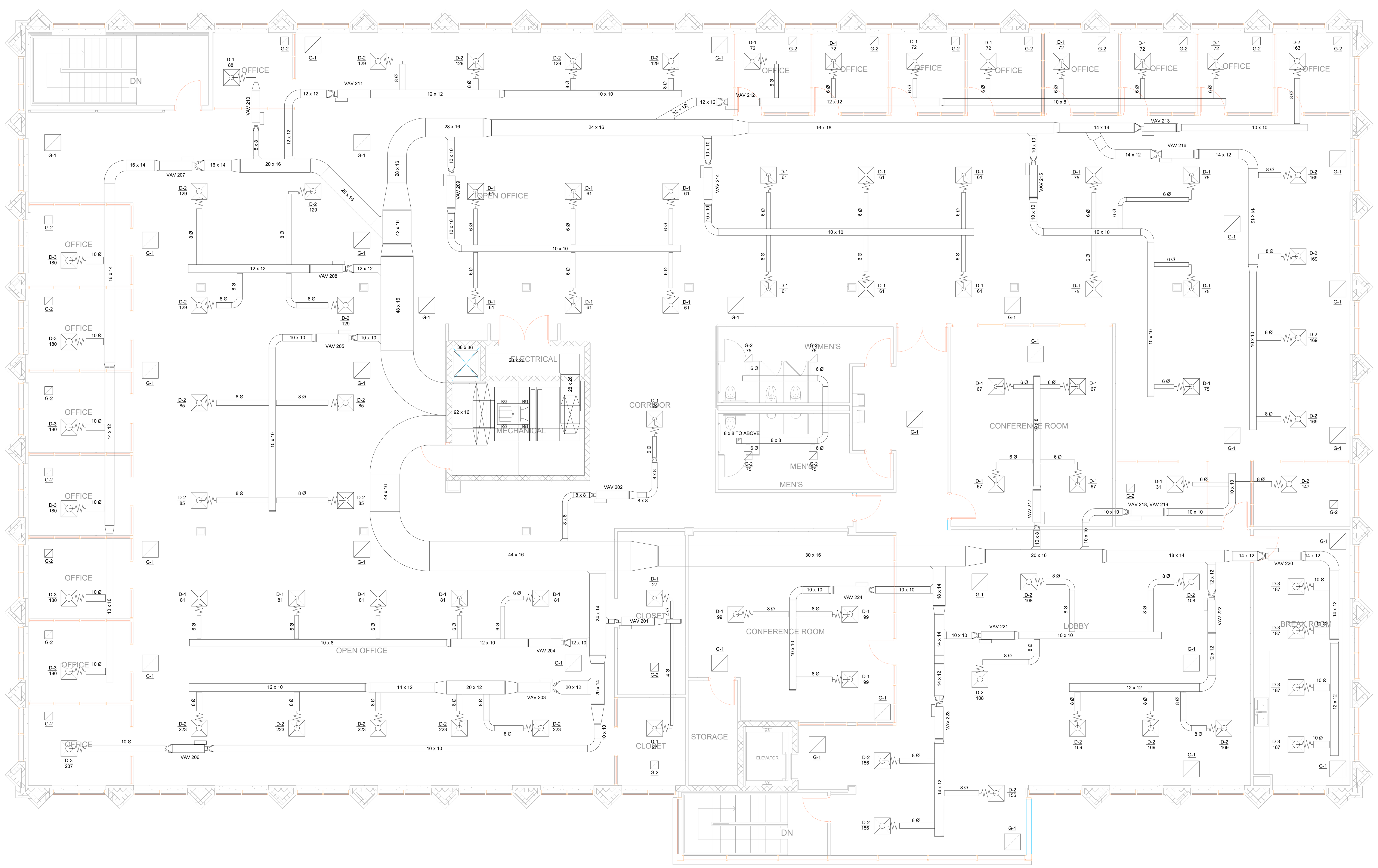
SCALE 1/8" = 1' - 0"

Date

2018/05/02

Drawing No.

M 1 of 4



NO	Revision	Date

Project Title

ASHRAE DESGIN COMPETITION

Drawing Title

MECHANICAL FLOOR
PLAN LEVEL - 2

Job Number

BCIT-ME-1718-06

Drawn

F.H/A.A/M.C

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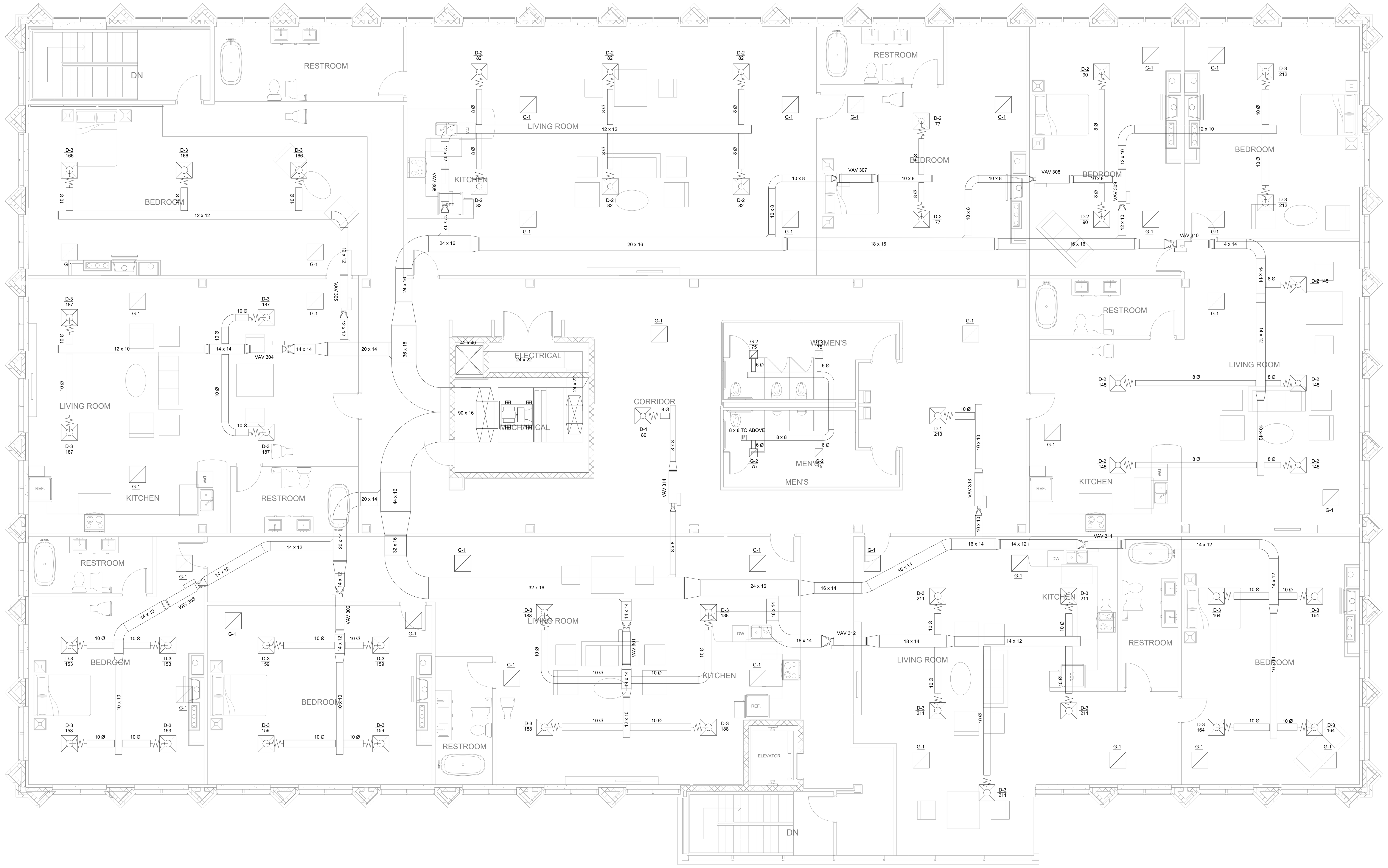
2018/05/02

Drawing No.

M 2 of 4



NO	Revision	Date

Project Title

ASHRAE DESGIN COMPETITION

Drawing Title

MECHANICAL FLOOR PLAN LEVEL - 3

Job Number

BCIT-ME-1718-06

Drawn

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J.C.

Scale

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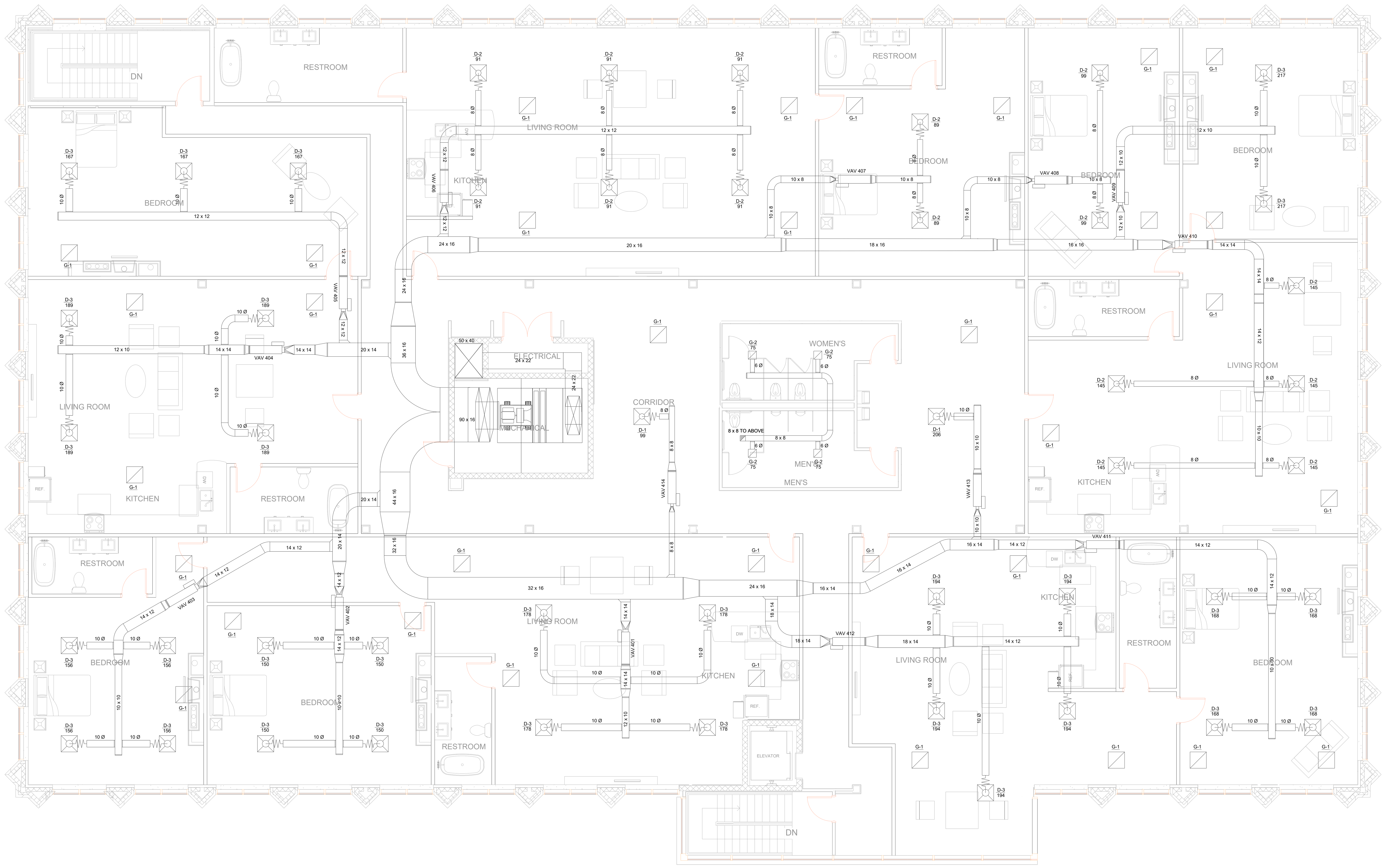
Date

2018/05/02

Drawing No.

M 3 of 4



NO	Revision	Date

Project Title

ASHRAE DESGIN COMPETITION

Drawing Title

MECHANICAL FLOOR PLAN LEVEL - 4

Job Number

BCIT-ME-1718-06

Drawn

F.H/A.A/M.C

Check.

J.C.

Scale

SCALE 1/8" = 1' - 0"

Date

2018/05/02

Drawing No.

M 4 of 4

System Checksums
By BCIT

Level 1 AHU — Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK — Peaked at Time: Mo/Hr: 8 / 15; Outside Air: OADB/WB/HR: 83 / 70 / 88
CLG SPACE PEAK — Mo/Hr: 8 / 16; OADB: 83
HEATING COIL PEAK — Mo/Hr: Heating Design; OADB: 30

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	0	0	0	0	0
Glass Solar	47,719	0	47,719	16	49,034	28
Glass/Door Cond	7,430	0	7,430	2	7,348	4
Wall Cond	14,871	4,354	19,225	6	14,850	9
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	19,620		19,620	7	7,988	5
Sub Total ==>	89,639	4,354	93,994	31	79,219	46
Internal Loads						
Lights	27,191	6,798	33,988	11	28,204	16
People	41,830	0	41,830	14	22,376	13
Misc	39,276	0	39,276	13	39,735	23
Sub Total ==>	108,296	6,798	115,094	38	90,315	52
Ceiling Load	3,849	-3,849	0	0	3,779	2
Ventilation Load	0	0	95,969	32	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	33		33	0	0	0
Exhaust Heat		-5,567	-5,567	-2		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	201,817	1,737	299,522	100.00	173,313	100.00

HEATING COIL PEAK	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	-37,010	-37,010	10.54
Wall Cond	-30,959	-41,967	11.96
Partition/Door	0	0	0.00
Floor	-11,567	-11,567	3.30
Adjacent Floor	0	0	0
Infiltration	-33,450	-33,450	**9.53**
Sub Total ==>	-112,986	-123,995	35.33
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-5,178	0	0.00
Ventilation Load	0	-53,951	15.37
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		5,830	-1.66
OA Preheat Diff.		-174,281	49.65
RA Preheat Diff.		0	0.00
Additional Reheat		-4,592	1.31
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-118,165	-350,988	100.00

TEMPERATURES	Cooling	Heating
SADB	56.0	96.3
Ra Plenum	74.2	68.9
Return	74.2	68.9
Ret/OA	75.3	58.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS	Cooling	Heating
Diffuser	8,845	3,992
Terminal	8,845	3,992
Main Fan	8,845	3,992
Sec Fan	0	0
Nom Vent	5,341	3,992
AHU Vent	5,341	3,992
Infil	748	748
MinStop/Rh	3,992	3,992
Return	9,594	4,741
Exhaust	6,090	4,741
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS	Cooling	Heating
% OA	60.4	100.0
cfm/ft²	0.59	0.27
cfm/ton	306.22	
ft²/ton	518.06	
Btu/hr·ft²	23.16	-23.24
No. People	133	

COOLING COIL SELECTION	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	25.0	299.5	188.0	8,707	75.3	65.9	79.5	56.0	54.9	61.9
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	3.9	47.1	46.9	5,341	83.8	69.6	84.9	76.0	67.2	84.9
Total	28.9	346.6								

AREAS	Gross Total	Glass ft²	Glass (%)
Floor	14,965		
Part	0		
Int Door	0		
ExFlr	410		
Roof	0	0	0
Wall	5,083	2,984	59
Ext Door	162	162	100

HEATING COIL SELECTION	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-181.1	3,992	56.0	96.3
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-62.9	3,992	56.0	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	-166.6	5,341	30.3	58.0
Total	-347.7			

System Checksums
By BCIT

Level 2 AHU — Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK — Peaked at Time: Mo/Hr: 8 / 14; Outside Air: OADB/WB/HR: 83 / 70 / 87
CLG SPACE PEAK — Mo/Hr: 8 / 14; OADB: 83
HEATING COIL PEAK — Mo/Hr: Heating Design; OADB: 30

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	0	0	0	0	0
Glass Solar	52,452	0	52,452	17	52,452	28
Glass/Door Cond	5,971	0	5,971	2	5,971	3
Wall Cond	19,239	5,050	24,289	8	19,239	10
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	16,937		16,937	6	7,053	4
Sub Total ==>	94,599	5,050	99,649	33	84,716	45
Internal Loads						
Lights	26,224	6,556	32,780	11	26,224	14
People	52,374	0	52,374	17	31,072	16
Misc	44,294	0	44,294	15	44,294	23
Sub Total ==>	122,892	6,556	129,448	43	101,590	54
Ceiling Load	3,434	-3,434	0	0	3,434	2
Ventilation Load	0	0	79,504	26	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-4,456	-4,456	-1		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	220,925	3,716	304,145	100.00	189,740	100.00

HEATING COIL PEAK	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	-31,817	-31,817	10.49
Wall Cond	-38,952	-50,518	16.65
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-29,537	-29,537	**9.74**
Sub Total ==>	-100,306	-111,872	36.88
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-5,437	0	0.00
Ventilation Load	0	-51,075	16.84
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		6,129	-2.02
OA Preheat Diff.		-145,136	47.85
RA Preheat Diff.		0	0.00
Additional Reheat		-1,386	0.46
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-105,743	-303,340	100.00

TEMPERATURES	Cooling	Heating
SADB	56.0	94.8
Ra Plenum	74.2	68.8
Return	74.2	68.8
Ret/OA	75.0	58.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS	Cooling	Heating
Diffuser	9,684	3,780
Terminal	9,684	3,780
Main Fan	9,684	3,780
Sec Fan	0	0
Nom Vent	4,450	3,780
AHU Vent	4,450	3,780
Infil	661	661
MinStop/Rh	3,780	3,780
Return	10,344	4,440
Exhaust	5,111	4,440
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS	Cooling	Heating
% OA	46.0	100.0
cfm/ft²	0.69	0.27
cfm/ton	338.40	
ft²/ton	489.16	
Btu/hr·ft²	24.53	-21.73
No. People	157	

COOLING COIL SELECTION	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	25.4	304.2	206.5	9,684	75.0	64.9	75.1	56.0	54.7	61.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	3.3	39.2	39.1	4,450	83.8	69.6	84.9	76.0	67.2	84.9
Total	28.6	343.4								

AREAS	Gross Total	Glass ft²	Glass (%)
Floor	13,998		
Part	0		
Int Door	0		
ExFlr	0		
Roof	0	0	0
Wall	5,069	2,777	55
Ext Door	0	0	0

HEATING COIL SELECTION	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-165.3	3,780	56.0	94.8
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-59.6	3,780	56.0	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	-138.8	4,450	30.3	58.0
Total	-304.1			

System Checksums
By BCIT

Level 3 AHU — Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK — Peaked at Time: Mo/Hr: 8 / 15; Outside Air: OADB/WB/HR: 83 / 70 / 88
CLG SPACE PEAK — Mo/Hr: 8 / 15; OADB: 83
HEATING COIL PEAK — Mo/Hr: Heating Design; OADB: 30

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	0	0	0	0	0
Glass Solar	52,328	0	52,328	53	52,328	57
Glass/Door Cond	1,979	0	1,979	2	1,979	2
Wall Cond	9,080	3,051	12,132	12	9,080	10
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	4,904		4,904	5	2,802	3
Sub Total ==>	68,291	3,051	71,343	72	66,190	72
Internal Loads						
Lights	7,459	1,865	9,323	9	7,459	8
People	2,504	0	2,504	3	1,636	2
Misc	15,107	0	15,107	15	15,107	16
Sub Total ==>	25,069	1,865	26,934	27	24,202	26
Ceiling Load	1,715	-1,715	0	0	1,715	2
Ventilation Load	0	0	1,722	2	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	128		128	0	128	0
Exhaust Heat		-1,578	-1,578	-2		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	95,203	1,623	98,549	100.00	92,234	100.00

HEATING COIL PEAK	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	-30,413	-30,413	13.48
Wall Cond	-24,977	-34,463	15.27
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-26,841	-26,841	11.89
Sub Total ==>	-82,231	-91,717	40.65
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-4,962	0	0.00
Ventilation Load	0	-48,160	21.34
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		4,524	-2.00
OA Preheat Diff.		-90,300	40.02
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-87,193	-225,653	100.00

TEMPERATURES	Cooling	Heating
SADB	67.5	101.3
Ra Plenum	79.2	72.2
Return	79.2	72.2
Ret/OA	78.0	58.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS	Cooling	Heating
Diffuser	7,229	2,777
Terminal	7,229	2,777
Main Fan	7,229	2,777
Sec Fan	0	0
Nom Vent	2,809	2,777
AHU Vent	2,809	2,777
Infil	553	553
MinStop/Rh	2,777	2,777
Return	7,782	3,330
Exhaust	3,362	3,330
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS	Cooling	Heating
% OA	38.9	100.0
cfm/ft²	0.56	0.21
cfm/ton	703.44	
ft²/ton	1,263.21	
Btu/hr·ft²	9.50	-17.20
No. People	28	

COOLING COIL SELECTION	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	8.2	98.6	85.0	7,229	78.0	67.7	84.5	67.5	63.8	82.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	2.1	24.8	24.7	2,809	83.8	69.6	84.9	76.0	67.2	84.9
Total	10.3	123.3								

AREAS	Gross Total	Glass ft²	Glass (%)
Floor	12,982		
Part	0		
Int Door	0		
ExFlr	0		
Roof	0	0	0
Wall	4,166	2,445	59
Ext Door	0	0	0

HEATING COIL SELECTION	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-105.7	2,777	67.5	101.3
Aux Htg	0.0	0	0.0	0.0
Preheat	-30.0	2,809	58.0	67.5
Reheat	-18.6	2,777	67.5	73.4
Humidif	0.0	0	0.0	0.0
Opt Vent	-87.6	2,809	30.3	58.0
Total	-223.3			

System Checksums
By BCIT

Level 4 AHU — Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK — Peaked at Time: Mo/Hr: 8 / 15; Outside Air: OADB/WB/HR: 83 / 70 / 88
CLG SPACE PEAK — Mo/Hr: 8 / 15; OADB: 83
HEATING COIL PEAK — Mo/Hr: Heating Design; OADB: 30

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	7,652	7,652	8	0	0
Glass Solar	45,766	0	45,766	45	45,766	50
Glass/Door Cond	1,875	0	1,875	2	1,875	2
Wall Cond	10,916	3,300	14,215	14	10,916	12
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	4,903		4,903	5	2,802	3
Sub Total ==>	63,459	10,952	74,411	73	61,359	67
Internal Loads						
Lights	9,374	2,343	11,717	12	9,374	10
People	2,727	0	2,727	3	1,859	2
Misc	15,032	0	15,032	15	15,032	16
Sub Total ==>	27,132	2,343	29,476	29	26,265	29
Ceiling Load	4,389	-4,389	0	0	4,389	5
Ventilation Load	0	0	1,713	2	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-4,036	-4,036	-4		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	94,981	4,870	101,564	100.00	92,013	100.00

HEATING COIL PEAK	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-22,891	9.42
Glass Solar	0	0	0.00
Glass/Door Cond	-30,413	-30,413	12.51
Wall Cond	-30,974	-41,111	16.92
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-26,841	-26,841	11.04
Sub Total ==>	-88,228	-121,256	49.89
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-17,595	0	0.00
Ventilation Load	0	-45,972	18.92
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		15,433	-6.35
OA Preheat Diff.		-91,248	37.54
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-105,823	-243,043	100.00

TEMPERATURES	Cooling	Heating
SADB	67.5	108.9
Ra Plenum	79.9	69.1
Return	79.9	69.1
Ret/OA	78.4	58.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS	Cooling	Heating
Diffuser	7,211	2,651
Terminal	7,211	2,651
Main Fan	7,211	2,651
Sec Fan	0	0
Nom Vent	2,806	2,651
AHU Vent	2,806	2,651
Infil	553	553
MinStop/Rh	2,651	2,651
Return	7,764	3,204
Exhaust	3,359	3,204
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS	Cooling	Heating
% OA	38.9	100.0
cfm/ft²	0.56	0.20
cfm/ton	685.08	
ft²/ton	1,233.29	
Btu/hr·ft²	9.73	-18.56
No. People	28	

COOLING COIL SELECTION	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	8.5	101.6	88.0	7,211	78.4	67.8	84.5	67.5	63.8	82.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	2.1	24.8	24.7	2,806	83.8	69.6	84.9	76.0	67.2	84.9
Total	10.5	126.3								

AREAS	Gross Total	Glass ft²	Glass (%)
Floor	12,982		
Part	0		
Int Door	0		
ExFlr	0		
Roof	12,982	0	0
Wall	4,308	2,445	57
Ext Door	0	0	0

HEATING COIL SELECTION	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-123.5	2,651	67.5	108.9
Aux Htg	0.0	0	0.0	0.0
Preheat	-29.9	2,806	58.0	67.5
Reheat	-17.7	2,651	67.5	73.4
Humidif	0.0	0	0.0	0.0
Opt Vent	-87.5	2,806	30.3	58.0
Total	-241.0			

System Checksums
By BCIT

Dining Area — Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK — Peaked at Time: Mo/Hr: 8 / 14; Outside Air: OADB/WB/HR: 83 / 70 / 87
CLG SPACE PEAK — Mo/Hr: 7 / 19; OADB: 79
HEATING COIL PEAK — Mo/Hr: Heating Design; OADB: 30

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	869	869	3	0	0
Glass Solar	428	0	428	1	504	4
Glass/Door Cond	173	0	173	1	123	1
Wall Cond	263	16	279	1	487	4
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	1,873		1,873	6	512	4
Sub Total ==>	2,737	885	3,623	12	1,626	14
Internal Loads						
Lights	1,509	377	1,886	6	1,692	15
People	8,707	0	8,707	30	5,704	49
Misc	1,704	0	1,704	6	1,936	17
Sub Total ==>	11,920	377	12,297	42	9,331	80
Ceiling Load	420	-420	0	0	691	6
Ventilation Load	0	0	12,956	44	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	1,227		1,227	4	0	0
Exhaust Heat		-842	-842	-3		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	16,305	0	29,261	100.00	11,648	100.00

HEATING COIL PEAK	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-2,043	5.76
Glass Solar	0	0	0.00
Glass/Door Cond	-941	-941	2.65
Wall Cond	-1,768	-1,894	5.34
Partition/Door	0	0	0.00
Floor	-2,047	-2,047	5.77
Adjacent Floor	0	0	0
Infiltration	-3,791	-3,791	**10.68**
Sub Total ==>	-8,547	-10,716	30.19
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-722	0	0.00
Ventilation Load	0	-26,223	73.88
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		1,447	-4.08
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-9,269	-35,492	100.00

TEMPERATURES	Cooling	Heating
SADB	55.8	84.0
Ra Plenum	74.5	68.1
Return	74.5	68.1
Ret/OA	82.9	30.3
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS	Cooling	Heating
Diffuser	587	587
Terminal	587	587
Main Fan	587	587
Sec Fan	0	0
Nom Vent	587	587
AHU Vent	587	587
Infil	85	85
MinStop/Rh	587	587
Return	671	671
Exhaust	671	671
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS	Cooling	Heating
% OA	100.0	100.0
cfm/ft²	0.49	0.49
cfm/ton	240.55	
ft²/ton	488.12	
Btu/hr·ft²	24.58	-29.82
No. People	34	

COOLING COIL SELECTION	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	2.4	29.3	17.9	587	82.9	69.6	86.5	55.8	54.2	59.6
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.4	29.3								

AREAS	Gross Total	Glass ft²	Glass (%)
Floor	1,190		
Part	0		
Int Door	0		
ExFlr	73		
Roof	1,190	0	0
Wall	879	0	0
Ext Door	54	54	100

HEATING COIL SELECTION	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-18.7	587	55.8	84.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-16.8	587	30.3	55.8
Reheat	-9.4	587	55.8	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-35.5			

System Checksums
By BCIT

Kithcen 120 — VAV w/Baseboard Heating

COOLING COIL PEAK — Peaked at Time: Mo/Hr: 7 / 13; Outside Air: OADB/WB/HR: 82 / 68 / 80
CLG SPACE PEAK — Mo/Hr: 7 / 13; OADB: 82
HEATING COIL PEAK — Mo/Hr: Heating Design; OADB: 30

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	392	392	1	0	0
Glass Solar	2,221	0	2,221	8	2,221	9
Glass/Door Cond	185	0	185	1	185	1
Wall Cond	319	22	341	1	319	1
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	2,725	414	3,139	12	2,725	11
Internal Loads						
Lights	732	183	916	3	732	3
People	3,795	0	3,795	14	1,737	7
Misc	0	0	0	0	0	0
Sub Total ==>	4,528	183	4,711	17	2,469	10
Ceiling Load	50	-50	0	0	50	0
Ventilation Load	0	0	0	0	0	0
Adj Air Trans Heat	19,202		19,202	71	19,202	79
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		0	0	0		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	26,505	547	27,052	100.00	24,447	100.00

HEATING COIL PEAK	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-812	4.34
Glass Solar	0	0	0.00
Glass/Door Cond	-1,127	-1,127	6.03
Wall Cond	-1,701	-1,820	9.73
Partition/Door	0	0	0.00
Floor	-1,689	-1,689	9.03
Adjacent Floor	0	0	0
Infiltration	0	0	**0.00**
Sub Total ==>	-4,517	-5,449	29.13
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-219	0	0.00
Ventilation Load	0	0	0.00
Adj Air Trans Heat	-8,277	-8,277	44
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-4,980	26.62
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-13,013	-18,706	100.00

TEMPERATURES	Cooling	Heating
SADB	58.2	70.0
Ra Plenum	73.7	68.5
Return	73.7	68.5
Ret/OA	73.7	68.5
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS	Cooling	Heating
Diffuser	1,429	429
Terminal	1,429	429
Main Fan	1,429	429
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	0	0
MinStop/Rh	429	429
Return	1,429	429
Exhaust	0	0
Rm Exh	1,470	1,470
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS	Cooling	Heating
% OA	0.0	0.0
cfm/ft²	3.05	0.92
cfm/ton	633.77	
ft²/ton	207.49	
Btu/hr·ft²	57.83	-39.99
No. People	9	

COOLING COIL SELECTION	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	2.3	27.1	25.0	1,429	73.7	61.4	60.7	58.2	54.9	58.6
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.3	27.1								

AREAS	Gross Total	Glass ft²	Glass (%)
Floor	468		
Part	0		
Int Door	0		
ExFlr	60		
Roof	468	0	0
Wall	781	0	0
Ext Door	30	30	100

HEATING COIL SELECTION	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-18.7	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-5.7	429	58.2	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-18.7			

System Checksums
By BCIT

Kitchen 121 — VAV w/Baseboard Heating

COOLING COIL PEAK — Peaked at Time: Mo/Hr: 7 / 21; Outside Air: OADB/WB/HR: 75 / 63 / 64
CLG SPACE PEAK — Mo/Hr: 8 / 21; OADB: 75
HEATING COIL PEAK — Mo/Hr: Heating Design; OADB: 30

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	592	592	2	0	0
Glass Solar	0	0	0	0	0	0
Glass/Door Cond	0	0	0	0	0	0
Wall Cond	309	21	331	1	364	1
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	309	613	922	3	364	1
Internal Loads						
Lights	654	163	817	2	654	2
People	3,213	0	3,213	9	1,492	5
Misc	0	0	0	0	0	0
Sub Total ==>	3,867	163	4,030	12	2,145	7
Ceiling Load	40	-40	0	0	37	0
Ventilation Load	0	0	0	0	0	0
Adj Air Trans Heat	29,261		29,261	86	29,261	92
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		0	0	0		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	33,477	736	34,213	100.00	31,806	100.00

HEATING COIL PEAK	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-689	3.21
Glass Solar	0	0	0.00
Glass/Door Cond	0	0	0.00
Wall Cond	-876	-936	4.36
Partition/Door	0	0	0.00
Floor	-613	-613	2.86
Adjacent Floor	0	0	0
Infiltration	0	0	**0.00**
Sub Total ==>	-1,489	-2,238	10.43
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-116	0	0.00
Ventilation Load	0	0	0.00
Adj Air Trans Heat	-12,612	-12,612	59
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-6,607	30.79
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-14,217	-21,457	100.00

TEMPERATURES	Cooling	Heating
SADB	59.3	70.0
Ra Plenum	73.7	69.1
Return	73.7	69.1
Ret/OA	73.7	69.1
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS	Cooling	Heating
Diffuser	2,004	601
Terminal	2,004	601
Main Fan	2,004	601
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	0	0
MinStop/Rh	601	601
Return	2,004	601
Exhaust	0	0
Rm Exh	2,240	2,240
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS	Cooling	Heating
% OA	0.0	0.0
cfm/ft²	5.12	1.54
cfm/ton	702.88	
ft²/ton	137.24	
Btu/hr·ft²	87.44	-54.84
No. People	8	

COOLING COIL SELECTION	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	2.9	34.2	32.5	2,001	73.7	61.4	60.8	59.3	55.6	59.5
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.9	34.2								

AREAS	Gross Total	Glass ft²	Glass (%)
Floor	391		
Part	0		
Int Door	0		
ExFlr	22		
Roof	391	0	0
Wall	356	0	0
Ext Door	0	0	0

HEATING COIL SELECTION	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-21.5	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-7.2	601	59.3	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-21.5			

NO	Revision	Date

Project Title
ASHRAE DESGIN COMPETITION

Drawing Title
SYSTEM CHECKSUMS
FROM TRANE TRACE 700

Job Number
BCIT-ME-1718-06

Drawn
F.H/A.A/M.C

Check
J.C.

Scale
SCALE N.T.S

Date
2018/05/02

Drawing No.
A3 of 4

Trane Performance Climate Changer Air Handler

Unit Overview - AHU-1

Application	Unit Size	External Dimensions Height	External Dimensions Width	External Dimensions Length	Weight Installed	Weight Rigging
Indoor unit	21	52.8 in	80.0 in	138.5 in	2784 lb	2671 lb

Quantity of Shipping Sections	Largest Ship Split Height	Largest Ship Split Width	Largest Ship Split Length	Heaviest Ship Split	Elevation
2 pieces	52.8 in	80.0 in	86.9 in	1589 lb	0.00 ft

Supply Fan		
Airflow	8845 cfm	Total Static Pressure 3.757 in H2O

Heating Coil Section

Coil Performance	
Capacity	
Total	425.90 MBh

Cooling Coil Section

Coil Performance	
Capacity	
Total	351.00 MBh
Sensible	246.23 MBh

Construction Features

Panel	2in. foam injected R-13 with thermal break
Panel Material	All unit inner panels - galvanized
Integral Base Frame	2.5in. integral base frame
Paint	Unpainted/field painted
Agency Approval	YES

Unit Electrical

Circuit	Voltage/Phase/Frequency	FLA	MCA	Fuse Size
Circuit number 1 Supply fan motor(s)	575/3/60	10.00 A	12.50 A	20.00 A

Warranty

Warranty section	Std. warranty only

Air mixing section - Position: 1

Face	Path	Type	Airflow	Face Velocity	Area	Pressure Drop	Hood
Back	Return	High velocity parallel damper	8845 cfm	1691 ft/min	5.23 sq ft	0.516 in H2O	
Top	Outside	High velocity parallel damper	8845 cfm	1691 ft/min	5.23 sq ft	0.516 in H2O	N/A

Section Options	
Door Location	Right

Trane Performance Climate Changer Air Handler

Unit Overview - AHU-2

Application	Unit Size	External Dimensions Height	External Dimensions Width	External Dimensions Length	Weight Installed	Weight Rigging
Indoor unit	21	52.8 in	80.0 in	138.5 in	2771 lb	2659 lb

Quantity of Shipping Sections	Largest Ship Split Height	Largest Ship Split Width	Largest Ship Split Length	Heaviest Ship Split	Elevation
2 pieces	52.8 in	80.0 in	86.9 in	1577 lb	0.00 ft

Supply Fan		
Airflow	9684 cfm	Total Static Pressure 3.955 in H2O

Heating Coil Section

Coil Performance	
Capacity	
Total	451.60 MBh

Cooling Coil Section

Coil Performance	
Capacity	
Total	348.00 MBh
Sensible	250.52 MBh

Construction Features

Panel	2in. foam injected R-13 with thermal break
Panel Material	All unit inner panels - galvanized
Integral Base Frame	2.5in. integral base frame
Paint	Unpainted/field painted
Agency Approval	YES

Unit Electrical

Circuit	Voltage/Phase/Frequency	FLA	MCA	Fuse Size
Circuit number 1 Supply fan motor(s)	575/3/60	10.00 A	12.50 A	20.00 A

Warranty

Warranty section	Std. warranty only

Air mixing section - Position: 1

Face	Path	Type	Airflow	Face Velocity	Area	Pressure Drop	Hood
Back	Return	High velocity parallel damper	9684 cfm	1852 ft/min	5.23 sq ft	0.619 in H2O	
Top	Outside	High velocity parallel damper	9684 cfm	1852 ft/min	5.23 sq ft	0.619 in H2O	N/A

Section Options	
Door Location	Right

Trane Performance Climate Changer Air Handler

Unit Overview - AHU-3

Application	Unit Size	External Dimensions Height	External Dimensions Width	External Dimensions Length	Weight Installed	Weight Rigging
Indoor unit	21	52.8 in	80.0 in	138.5 in	2990 lb	2878 lb

Quantity of Shipping Sections	Largest Ship Split Height	Largest Ship Split Width	Largest Ship Split Length	Heaviest Ship Split	Elevation
2 pieces	52.8 in	80.0 in	86.9 in	1546 lb	0.00 ft

Supply Fan		
Airflow	7229 cfm	Total Static Pressure 3.114 in H2O

Heating Coil Section

Coil Performance	
Capacity	
Total	264.99 MBh

Cooling Coil Section

Coil Performance	
Capacity	
Total	234.80 MBh

Construction Features

Panel	2in. foam injected R-13 with thermal break
Panel Material	All unit inner panels - galvanized
Integral Base Frame	2.5in. integral base frame
Paint	Unpainted/field painted
Agency Approval	YES

Unit Electrical

Circuit	Voltage/Phase/Frequency	FLA	MCA	Fuse Size
Circuit number 1 Supply fan motor(s)	575/3/60	8.60 A	10.75 A	15.00 A

Warranty

Warranty section	Std. warranty only

Air mixing section - Position: 1

Face	Path	Type	Airflow	Face Velocity	Area	Pressure Drop	Hood
Back	Return	High velocity parallel damper	7229 cfm	1382 ft/min	5.23 sq ft	0.345 in H2O	
Top	Outside	High velocity parallel damper	7229 cfm	1382 ft/min	5.23 sq ft	0.345 in H2O	N/A

Section Options	
Door Location	Right

Trane Performance Climate Changer Air Handler

Unit Overview - AHU-4

Application	Unit Size	External Dimensions Height	External Dimensions Width	External Dimensions Length	Weight Installed	Weight Rigging
Indoor unit	21	52.8 in	80.0 in	138.5 in	2994 lb	2882 lb

Quantity of Shipping Sections	Largest Ship Split Height	Largest Ship Split Width	Largest Ship Split Length	Heaviest Ship Split	Elevation
2 pieces	52.8 in	80.0 in	86.9 in	1550 lb	0.00 ft

Supply Fan		
Airflow	7211 cfm	Total Static Pressure 3.118 in H2O

Heating Coil Section

Coil Performance	
Capacity	
Total	285.44 MBh

Cooling Coil Section

Coil Performance	
Capacity	
Total	234.44 MBh
Sensible	168.41 MBh

Construction Features

Panel	2in. foam injected R-13 with thermal break
Panel Material	All unit inner panels - galvanized
Integral Base Frame	2.5in. integral base frame
Paint	Unpainted/field painted
Agency Approval	YES

Unit Electrical

Circuit	Voltage/Phase/Frequency	FLA	MCA	Fuse Size
Circuit number 1 Supply fan motor(s)	575/3/60	8.60 A	10.75 A	15.00 A

Warranty

Warranty section	Std. warranty only

Air mixing section - Position: 1

Face	Path	Type	Airflow	Face Velocity	Area	Pressure Drop	Hood
Back	Return	High velocity parallel damper	7211 cfm	1379 ft/min	5.23 sq ft	0.343 in H2O	
Top	Outside	High velocity parallel damper	7211 cfm	1379 ft/min	5.23 sq ft	0.343 in H2O	N/A

Section Options	
Door Location	Right

Trane Performance Climate Changer Air Handler

Unit Overview - DOAS

Application	Unit Size	External Dimensions Height	External Dimensions Width	External Dimensions Length	Weight Installed	Weight Rigging
Outdoor unit	66	96.1 in	140.5 in	225.5 in	10340 lb	9626 lb

Quantity of Shipping Sections	Largest Ship Split Height	Largest Ship Split Width	Largest Ship Split Length	Heaviest Ship Split	Elevation
3 pieces	96.1 in	140.5 in	95.3 in	4779 lb	0.00 ft

Supply Fan		
Airflow	33000 cfm	Total Static Pressure 3.943 in H2O

Heating Coil Section

Coil Performance	
Capacity	
Total	1342.07 MBh

Cooling Coil Section

Coil Performance	
Capacity	
Total	469.92 MBh
Sensible	452.94 MBh

Construction Features

Panel	2in. foam injected R-13 with thermal break
Panel Material	All unit inner panels - galvanized
Integral Base Frame	6in. integral base frame
Paint	Slate gray
Agency Approval	YES

Unit Electrical

Circuit	Voltage/Phase/Frequency	FLA	MCA	Fuse Size
Circuit number 1 Supply fan motor (each x 4)	575/3/60	10.00 A	12.50 A	20.00 A

Warranty

Warranty section	Std. warranty only

Air mixing section - Position: 1

Face	Path	Type	Airflow	Face Velocity	Area	Pressure Drop	Hood
Back	Outside	High velocity parallel damper	33000 cfm	2005 ft/min	16.46 sq ft	0.753 in H2O	Yes

Section Options	
Door Location	Right

Trane Single Effect Steam Fired Water Chiller - ProChill B4k, SS20AC

Specification

Cooling Capacity	132 TR
Chilled Water	
Flow Rate	318.8 GPM
Colling Water	
Flow Rate	467 GPM

Viessmann Gas Fired Condesing Boiler - VITOCROSSAL 300, CA3 2.5

Specification

Output	2352 MBTH

NO	Revision	Date

Project Title
ASHRAE DESGIN COMPETITION

Drawing Title
AHU SPECIFICATIONS

Job Number
BCIT-ME-1718-06

Drawn
F.H/A.A/M.C

Check
J.C.

Scale
SCALE N.T.S

Date
2018/05/02

Drawing No.
A2 of 4

Status	Model	Tag	Unit Size	Inlet Dia	Max Primary (CFM)	Min Primary (CFM)	* Max Discharge NC 2008	Max Discharge NC	EAT (°F)	Supply Air Temp (°F)	Return Air Temp (°F)	LAT (°F)	Fluid Flow (GPM)	Fluid Type	EWT (°F)	LWT (°F)	Weight (lbs)
Performance Calculated	SDV8	VAV 101	6	6	295	88	--	--	56	56	79.8	110.8	4.76	WTR	180	177.7	36
Performance Calculated	SDV8	VAV 102	8	8	695	208	--	--	56	56	134.9	142.3	9.47	WTR	180	175.7	46
Performance Calculated	SDV8	VAV 103	6	6	288	86	--	--	56	56	79.8	111.2	4.76	WTR	180	177.7	36
Performance Calculated	SDV8	VAV 104	6	6	337	101	--	--	56	56	79.8	110.2	1.34	WTR	180	170.6	36
Performance Calculated	SDV8	VAV 105	8	8	763	229	--	--	56	56	103.9	108.9	0.67	WTR	180	138.9	46
Performance Calculated	SDV8	VAV 106	8	8	616	185	--	--	56	56	103.7	108.9	0.47	WTR	180	133.1	46
Performance Calculated	SDV8	VAV 107	6	6	283	85	--	--	56	56	79.8	110.9	3.58	WTR	180	177	36
Performance Calculated	SDV8	VAV 108	4	4	306	92	23 (3)	28 (2)	56	56	79.8	162.6	5.6	WTR	180	176	42
Performance Calculated	SDV8	VAV 109	6	6	287	86	--	--	56	56	79.8	110.3	2.94	WTR	180	176.4	36
Performance Calculated	SDV8	VAV 110	8	8	637	209	--	--	56	56	129.3	135	9.52	WTR	180	176	46
Performance Calculated	SDV8	VAV 111	8	8	529	159	--	--	56	56	133.9	145.2	4.07	WTR	180	172	46
Performance Calculated	SDV8	VAV 112	6	6	318	95	--	--	56	56	79.8	110.8	1.17	WTR	180	169.8	36
Performance Calculated	SDV8	VAV 113	4	4	233	70	20 (3)	29 (2)	56	56	79.8	109.9	0.88	WTR	180	170.1	37
Performance Calculated	SDV8	VAV 114	8	8	581	174	--	--	56	56	111.8	117.9	0.7	WTR	180	145.1	46
Performance Calculated	SDV8	VAV 115	6	6	288	86	--	--	56	56	79.8	110.3	2.94	WTR	180	176.4	36
Performance Calculated	SDV8	VAV 116	6	6	291	87	--	--	56	56	79.8	110.7	4	WTR	180	177.3	36
Performance Calculated	SDV8	VAV 117	8	8	1021	306	--	--	56	56	92.1	96.2	2.75	WTR	180	169.8	44
Performance Calculated	SDV8	VAV 118	4	4	150	45	--	22 (2)	56	56	146.1	145.8	0.48	WTR	180	160.9	39
Performance Calculated	SDV8	VAV 119	8	8	587	176	--	--	56	56	83.7	152.9	3.27	WTR	180	168.1	50
Performance Calculated	SDV8	VAV 122	6	6	501	150	--	--	56	56	111.3	117.6	0.76	WTR	180	152.4	38
Performance Calculated	SDV8	VAV 123	4	4	150	45	--	22 (2)	56	56	106	106.9	0.2	WTR	180	154	37
Performance Calculated	SDV8	VAV 124	6	6	398	119	--	--	56	56	96.5	101.3	1.29	WTR	180	170.4	36
Performance Calculated	SDV8	VAV 201	4	4	150	45	--	22 (2)	56	56	95.4	106.9	0.2	WTR	180	154	37
Performance Calculated	SDV8	VAV 202	4	4	150	45	--	22 (2)	56	56	99.6	111.9	0.32	WTR	180	161.9	37
Performance Calculated	SDV8	VAV 203	10	10	1117	335	--	--	56	56	95.2	103.4	0.64	WTR	180	123.6	54
Performance Calculated	SDV8	VAV 204	6	6	403	121	--	--	56	56	86.1	139.5	4.9	WTR	180	175.3	38
Performance Calculated	SDV8	VAV 205	6	6	340	102	--	--	56	56	86.1	93	0.29	WTR	180	150.3	36
Performance Calculated	SDV8	VAV 206	4	4	237	71	21 (3)	29 (2)	56	56	107.6	119.2	1.84	WTR	180	174.4	37
Performance Calculated	SDV8	VAV 207	10	10	1082	325	--	--	56	56	96.1	104.6	0.65	WTR	180	124.7	54
Performance Calculated	SDV8	VAV 208	6	6	517	155	--	20 (2)	56	56	89.6	96.5	1.37	WTR	180	169.5	36
Performance Calculated	SDV8	VAV 209	6	6	367	110	--	--	56	56	86.1	92.7	0.33	WTR	180	151.8	36
Performance Calculated	SDV8	VAV 210	4	4	150	45	--	22 (2)	56	56	120.5	106.9	0.2	WTR	180	154	37
Performance Calculated	SDV8	VAV 211	6	6	515	154	--	--	56	56	120.1	134.1	5.65	WTR	180	175.1	38
Performance Calculated	SDV8	VAV 212	8	8	503	151	--	--	56	56	128.1	143.4	2.58	WTR	180	168.3	46
Performance Calculated	SDV8	VAV 213	4	4	163	49	--	23 (2)	56	56	120.9	134.8	0.28	WTR	180	149	39
Performance Calculated	SDV8	VAV 214	6	6	361	108	--	--	56	56	86.1	92.6	0.31	WTR	180	151.1	36
Performance Calculated	SDV8	VAV 215	6	6	374	112	--	--	56	56	86.1	92.9	0.34	WTR	180	152.6	36
Performance Calculated	SDV8	VAV 216	8	8	675	202	--	--	56	56	98.7	108	0.52	WTR	180	134	46
Performance Calculated	SDV8	VAV 217	4	4	268	80	20 (3)	27 (2)	56	56	75.7	104.3	0.57	WTR	180	164.4	50
Performance Calculated	SDV8	VAV 219	4	4	214	45	--	28 (2)	56	56	98.4	106.9	0.2	WTR	180	154	37
Performance Calculated	SDV8	VAV 220	8	8	750	225	--	--	56	56	94	101.9	2.5	WTR	180	170.6	44
Performance Calculated	SDV8	VAV 221	4	4	215	64	--	28 (2)	56	56	86.1	114.9	1.96	WTR	180	175.6	37
Performance Calculated	SDV8	VAV 222	6	6	508	152	--	--	56	56	96.8	105.6	3.46	WTR	180	175	36
Performance Calculated	SDV8	VAV 223	8	8	625	188	--	--	56	56	92.2	99.9	2.34	WTR	180	171.9	44
Performance Calculated	SDV8	VAV 224	6	6	298	89	--	--	56	56	75.7	104.4	0.8	WTR	180	167.6	36
Performance Calculated	SDV8	VAV 301	8	8	752	226	--	--	67.5	67.5	97.1	105.7	3.34	WTR	180	174.2	44
Performance Calculated	SDV8	VAV 302	8	8	637	191	--	--	67.5	67.5	93.6	101.6	0.71	WTR	180	159.6	44
Performance Calculated	SDV8	VAV 303	8	8	613	184	--	--	67.5	67.5	100.5	109.8	4.72	WTR	180	176.3	44
Performance Calculated	SDV8	VAV 304	8	8	749	225	--	--	67.5	67.5	95.1	103.4	1.63	WTR	180	168.9	44
Performance Calculated	SDV8	VAV 305	6	6	498	149	--	20 (2)	67.5	67.5	95.5	103.8	1	WTR	180	167.9	36
Performance Calculated	SDV8	VAV 306	6	6	492	148	--	--	67.5	67.5	124.2	140.7	7.68	WTR	180	176.8	38
Performance Calculated	SDV8	VAV 307	4	4	154	46	--	22 (2)	67.5	67.5	115.7	135.1	4.57	WTR	180	178.5	37
Performance Calculated	SDV8	VAV 308	4	4	181	54	--	25 (2)	67.5	67.5	122.2	138.9	0.32	WTR	180	153	39
Performance Calculated	SDV8	VAV 309	6	6	424	127	--	--	67.5	67.5	112.2	125.3	0.61	WTR	180	153	38
Performance Calculated	SDV8	VAV 310	8	8	727	218	--	--	67.5	67.5	98.7	107.9	1.55	WTR	180	167.3	44
Performance Calculated	SDV8	VAV 311	8	8	657	197	--	--	67.5	67.5	104.5	115.5	0.5	WTR	180	138.2	46
Performance Calculated	SDV8	VAV 312	8	8	1056	317	--	--	67.5	67.5	93	100.5	3.64	WTR	180	173.6	44
Performance Calculated	SDV8	VAV 313	4	4	213	64	--	27 (2)	67.5	67.5	110	132	0.28	WTR	180	147.5	39
Performance Calculated	SDV8	VAV 314	4	4	150	45	--	22 (2)	67.5	67.5	102.4	126.6	1.41	WTR	180	175.8	37
Performance Calculated	SDV8	VAV 401	8	8	711	213	--	--	67.5	67.5	105.8	115.3	0.57	WTR	180	139.9	46
Performance Calculated	SDV8	VAV 402	8	8	598	179	--	--	67.5	67.5	100.1	108	1.97	WTR	180	171.8	44
Performance Calculated	SDV8	VAV 403	8	8	625	188	--	--	67.5	67.5	105.5	114.4	4.01	WTR	180	175.1	44
Performance Calculated	SDV8	VAV 404	8	8	754	226	--	--	55	55	75	95.4	2.1	WTR	180	170	44
Performance Calculated	SDV8	VAV 405	6	6	501	150	--	20 (2)	67.5	67.5	101.4	109.7	1.4	WTR	180	169.9	36
Performance Calculated	SDV8	VAV 406	8	8	542	163	--	--	67.5	67.5	131.6	146.9	3.15	WTR	180	170.8	46
Performance Calculated	SDV8	VAV 407	4	4	177	53	--	24 (2)	67.5	67.5	125.4	140.2	0.33	WTR	180	154.3	39
Performance Calculated	SDV8	VAV 408	4	4	199	60	--	26 (2)	67.5	67.5	75	144	0.55	WTR	180	161.3	39
Performance Calculated	SDV8	VAV 409	6	6	435	130	--	--	67.5	67.5	119.4	131.7	1.05	WTR	180	162.2	38
Performance Calculated	SDV8	VAV 410	8	8	722	217	--	--	67.5	67.5	105.8	114.9	0.57	WTR	180	139.6	46
Performance Calculated	SDV8	VAV 411	8	8	672	202	--	--	67.5	67.5	110.1	120.2	0.7	WTR	180	146.1	46
Performance Calculated	SDV8	VAV 412	10	10	967	290	--	--	67.5	67.5	100.5	108.6	8.92	WTR	180	177	52
Performance Calculated	SDV8	VAV 413	4	4	206	62	--	27 (2)	67.5	67.5	122.3	151.9	1.4	WTR	180	171.6	39
Performance Calculated	SDV8	VAV 414	4	4	150	45	--	22 (2)	67.5	67.5	113.9	147.1	0.4	WTR	180	159.9	39

NO	Revision	Date

Project Title
ASHRAE DESGIN COMPETITION

Drawing Title
VAV SCHEDULES

Job Number
BCIT-ME-1718-06

Drawn
F.H/A.A/M.C

Check
J.C.

Scale
SCALE = N.T.S

Date
2018/05/02

Drawing No.
A1 of 4