Technical Report Two

Building and Plant Energy Analysis

Father O'Connell Hall Renovation

The Catholic University of America

Washington, D.C

Kevin Andreone | Mechanical | Laura Miller | 10/4/2013

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Executive Summary

The purpose of this report is to estimate and analyze Father O'Connell's load and energy consumption. This was done using Trane Trace 700 software, which is acceptable software with professionals across the industry. Due to time restraints a block load calculation was done for simplification. The building was split up into 54 zones and five AHU's to analyze. Trace was used to calculate airflows and coil loads for each system.

Father O'Connell estimated the total peak cooling load to be 105 tons and a total peak heating load to be 93.5 tons. It makes sense that the cooling load would be higher than the heating load because the building is located in Washington, DC. When these are compared to the design capacities of the chiller and boilers it seems to be fairly accurate.

Energy consumptions were estimated using standard utility rates already in Trace. It was found that Father O'Connell consumes a total of 289,522 kWh/year, 3,095 therms/year of natural gas 277(1000gal) of water each year. These values are broken down further later in the report. Also, utilities cost about $17,000 each year.

Building Overview

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

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

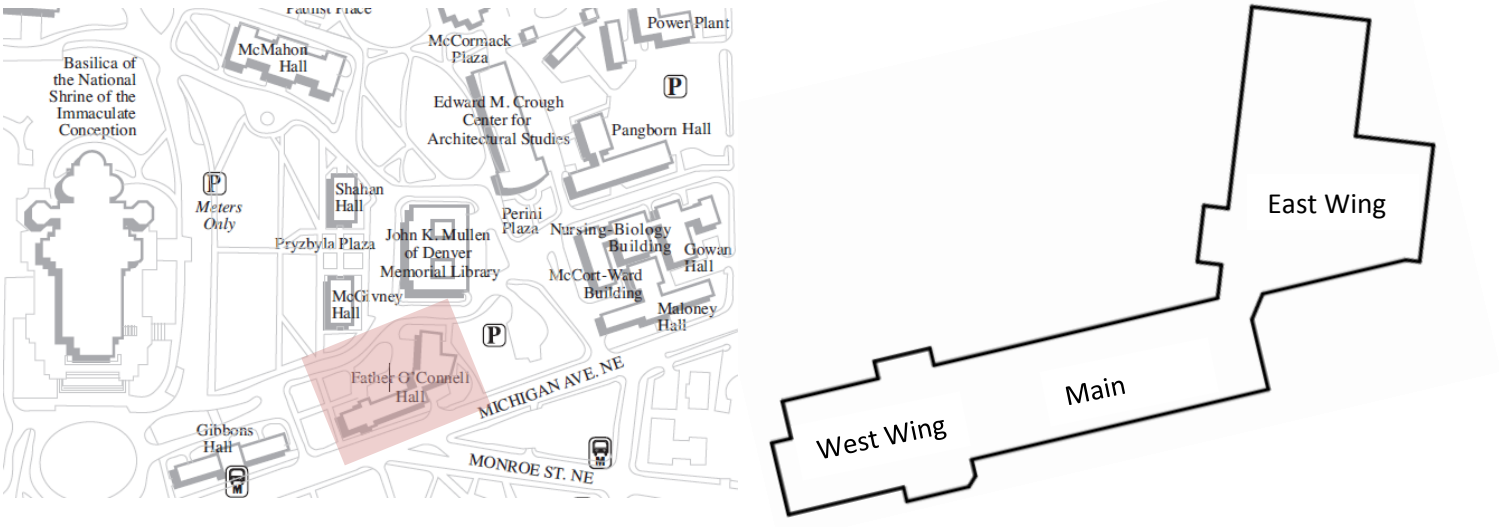


Figure 1: Father O'Connell Hall located on The Catholic University Campus.

Mechanical System Overview

Father O'Connell Hall is ventilated using seven air handling units, with one being 100% outdoor air (OAHU-1). *Figure 1* below shows the zoning for each air handling units throughout the building. All New AHU's will be equipped with economizer cycle to maximize ventilation and reduce energy. The 100% outdoor air unit will also have an air-to-air plate exchanger as well as

a wraparound heat pipe heat recovery exchanger to pre-condition supply air temperatures and further reduce energy consumption. Recirculation of this air is provided by fan powered boxes, VAV's, and air transfer ducts located in the plenum above the ceiling on the basement and first floors.

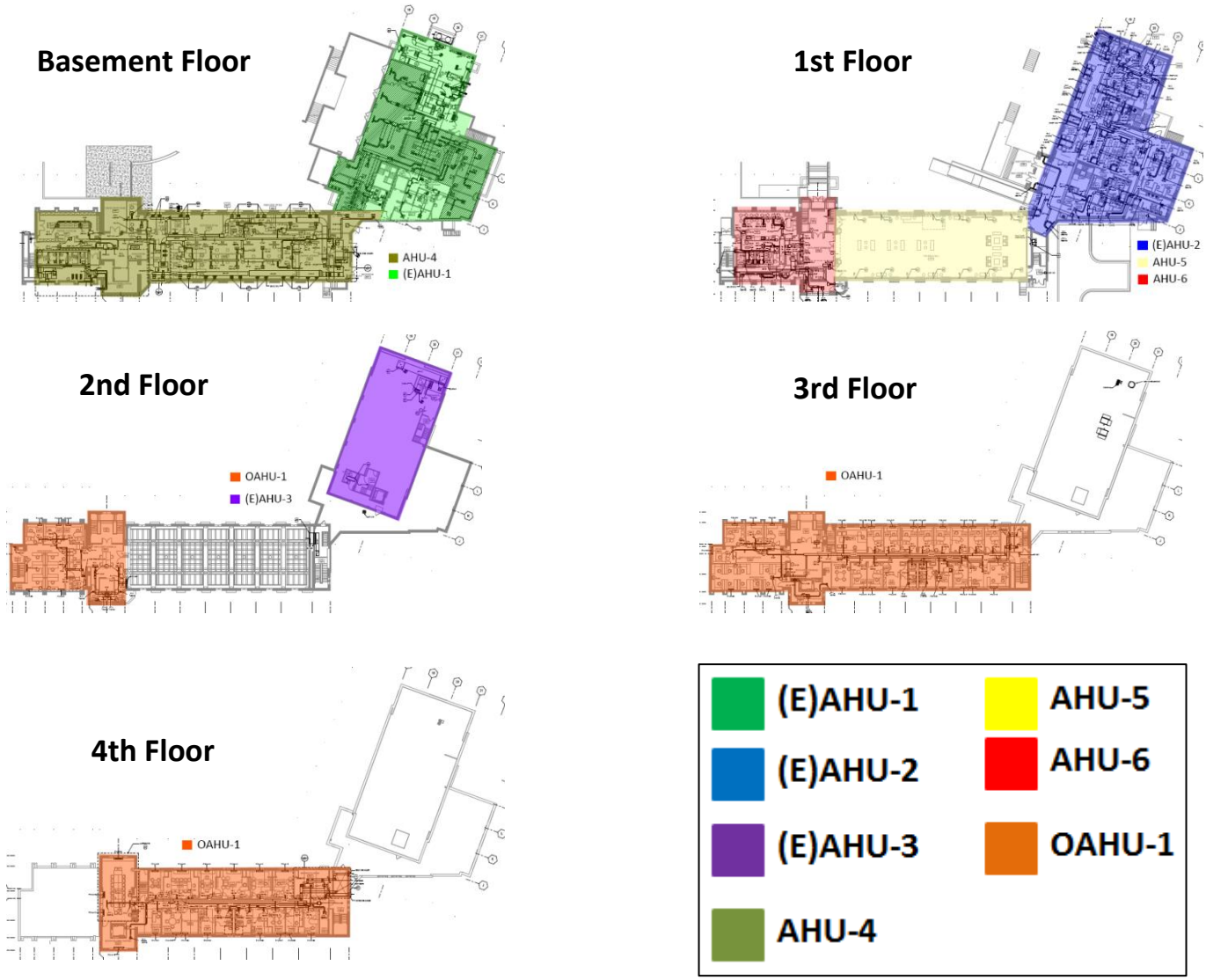


Figure 2: Air Handling Unit Zoning

Chilled Water System

Chilled water is provided from one 97.7 ton electric air-cooled chiller located on grade on the south side of east wing. Chilled water is provided directly to all air handling units (AHU's) and all fan coil units (FCU's) located on floors 2 to 4. Chilled water flow delivered to all AHU's and FCU's is controlled by a proportional integral controller (PIC) control valve regulated by two

chilled water pumps with VFD's. Additional cooling for two telecom rooms is provided by two ductless split system units.

Heating Hot Water System

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

Load Calculation

Father O'Connell Hall Renovation building load and energy modal was done using Trane Trace 700. This is an accepted program by many building industry professionals for load and energy consumption calculations. Trane was utilized to calculate ventilation loads, heating and cooling loads, and annual energy and operating costs at Father O'Connell Hall. Block loading was done since time was a sensitive issue. Restrooms and stairwells were neglected since these would not contribute to any cooling loads. Also existing zones that were not changed were also neglected for these calculations. These block zones can be seen in the figures 3-7 below.

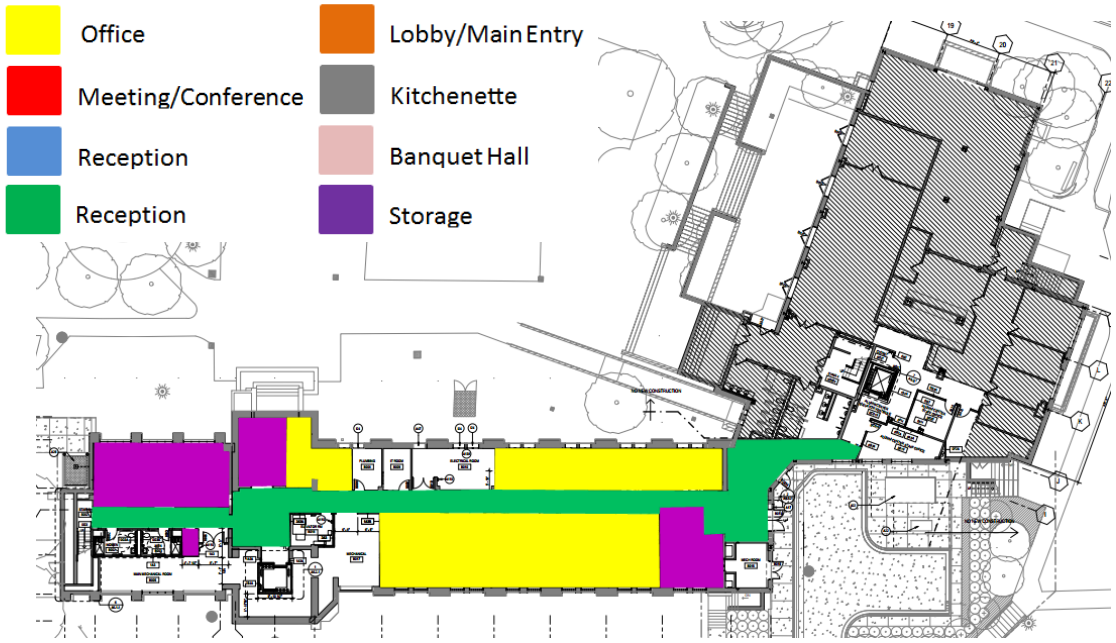


Figure 3: Basement Level Block Loads

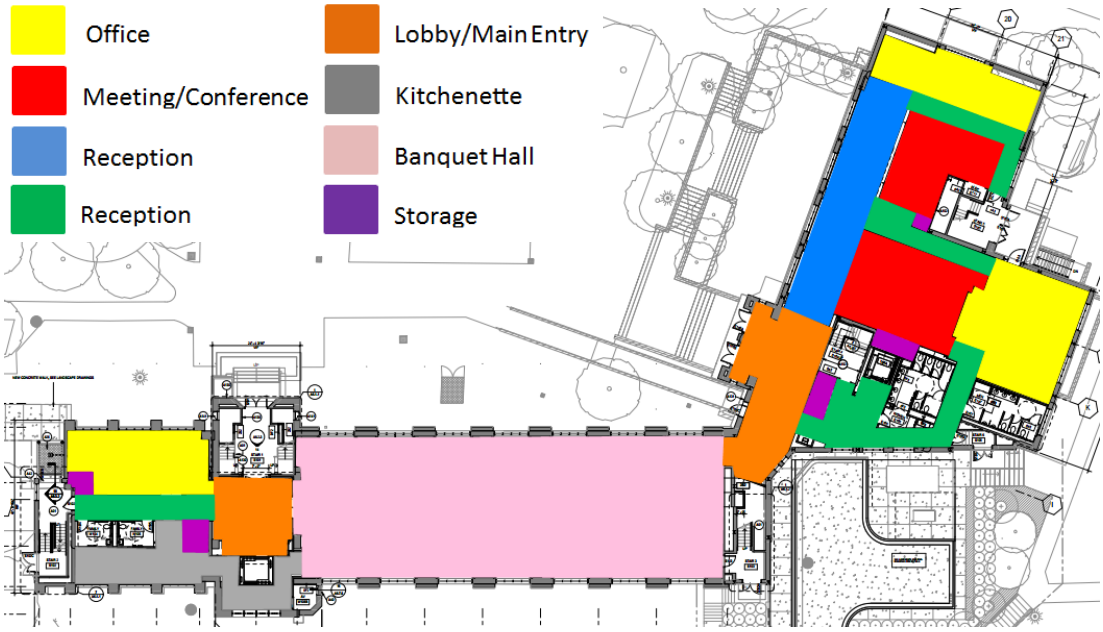


Figure 4: First Floor Block Loads

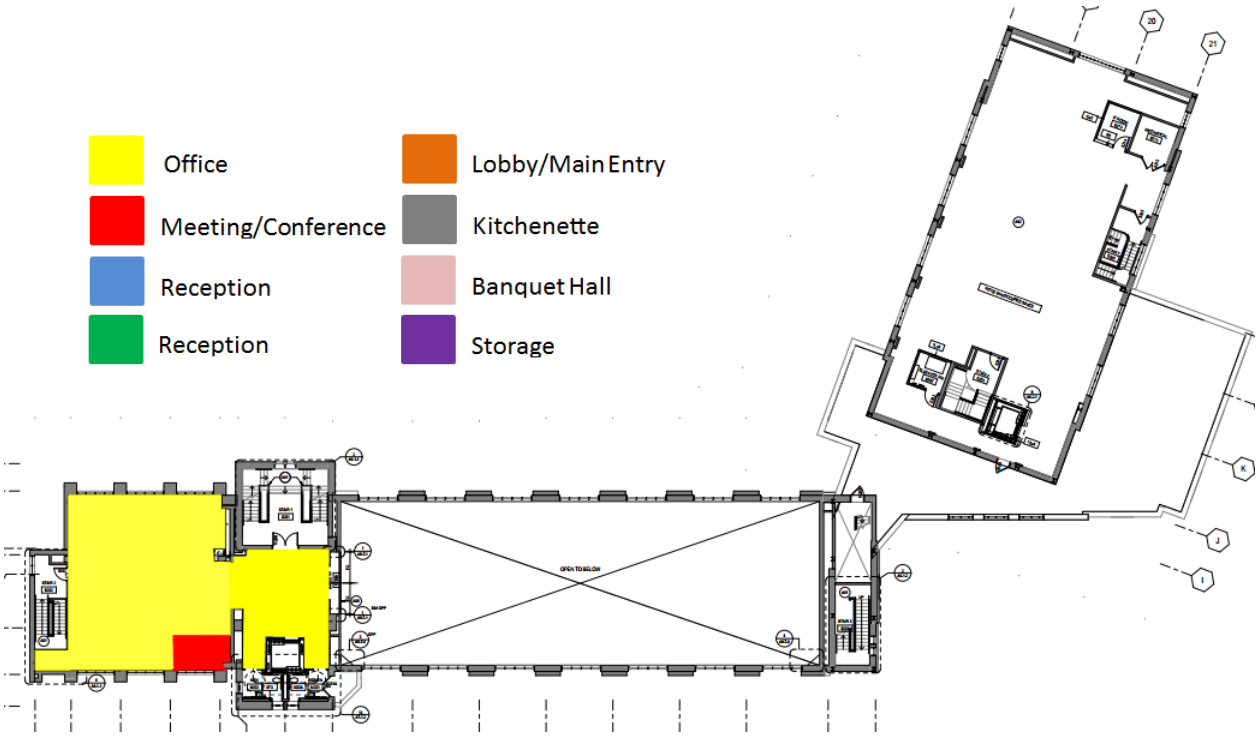


Figure 5: Second Floor Block Loads

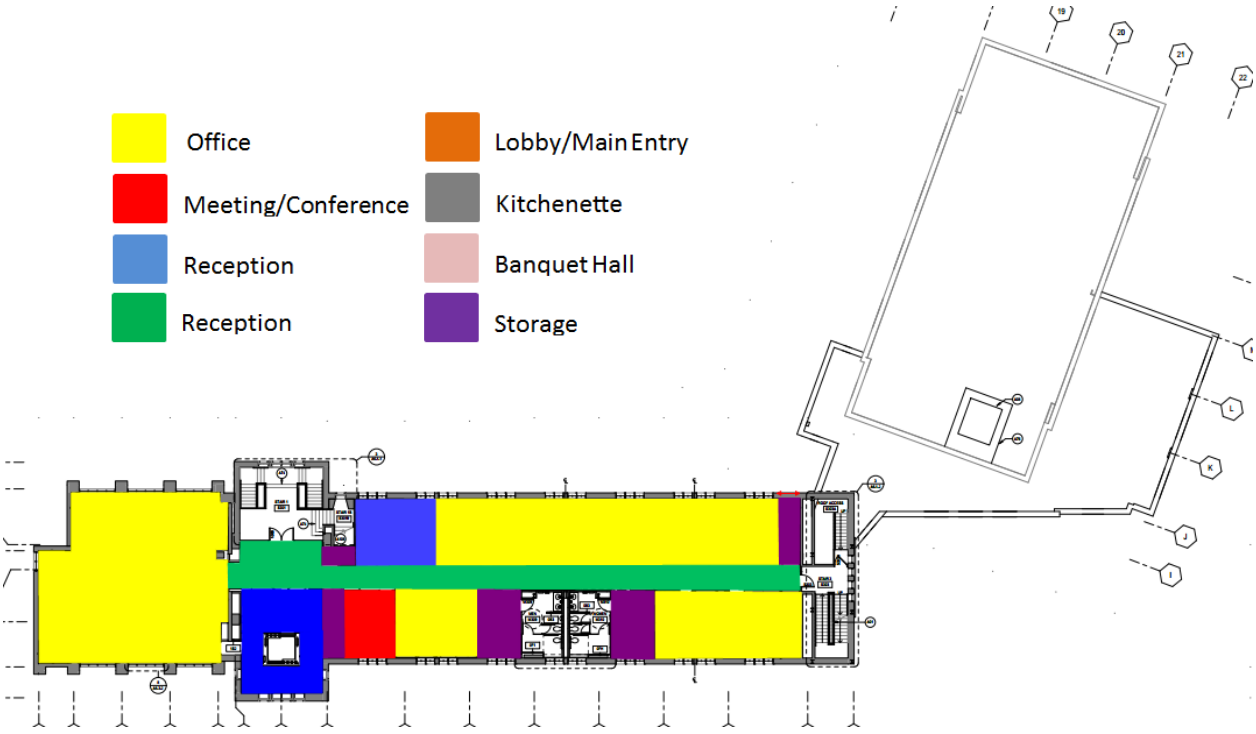


Figure 6: Third Floor Block Loads

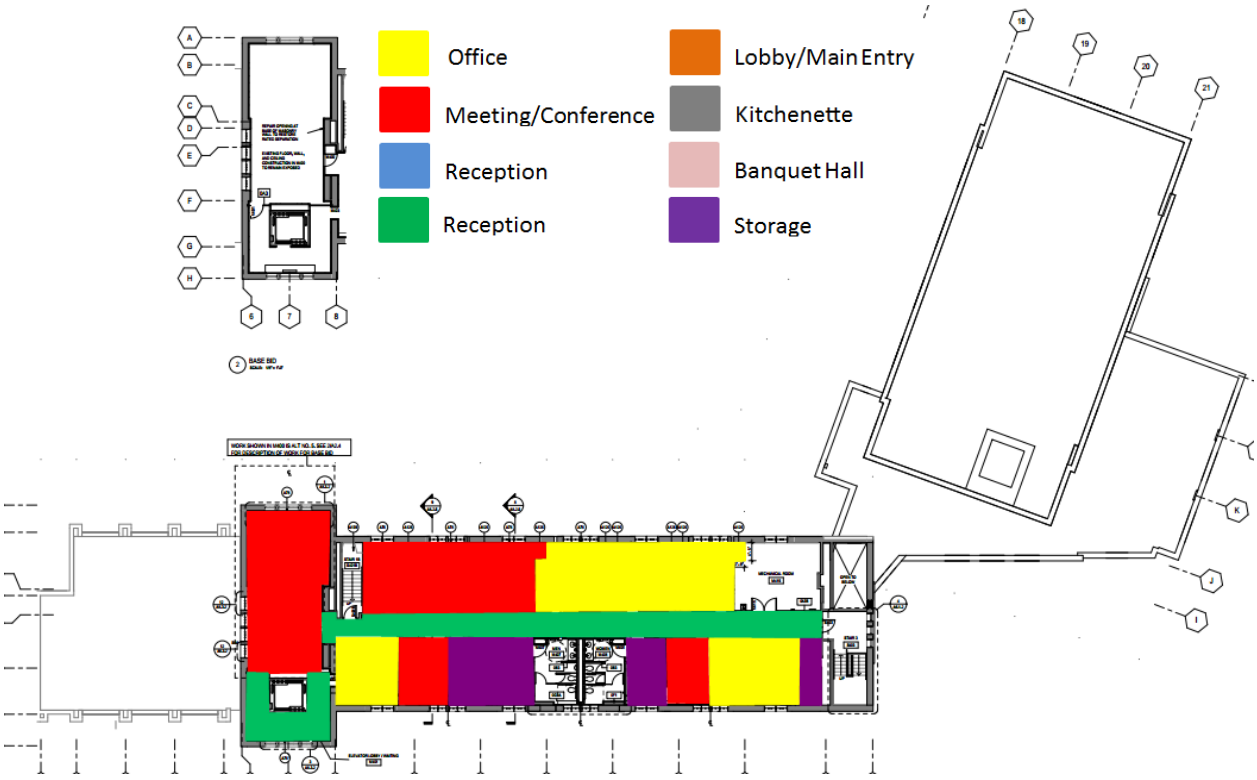


Figure 7: Fourth Floor Block Loads

Design Conditions

Father O'Connell Hall is located on the campus of The Catholic University of America in Washington, D.C. Figure 8 to the right shows the design conditions for Washington, D.C. specified from ASHRAE that Trane Trace 700 uses as default settings.

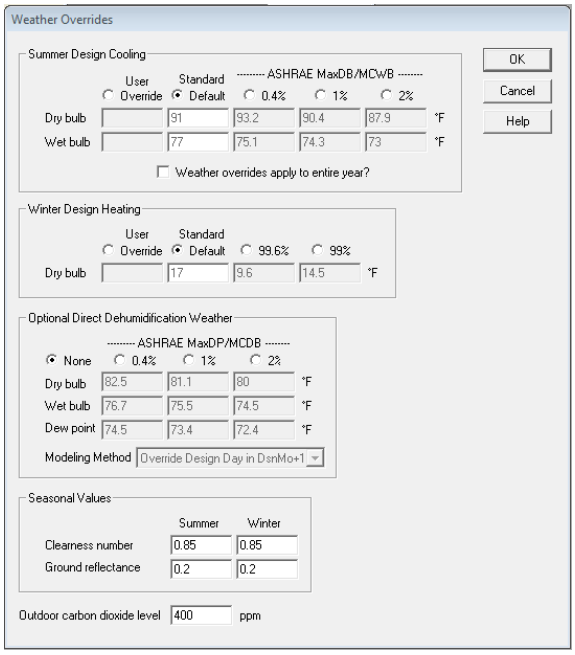


Figure 8: Washington, D.C. Design Conditions

Internal Loads

The internal loads for the seven different space types are shown in table below. These values are found from a combination of ASHRAE Standard 90.1-2010 and design documents provided

from the owner. Note that for an office space 125 watts was used per person since each person will be provided a desk with computer, monitor, phone, etc. The occupancy was determined by counting chairs from the furniture plans provided from the design documents so each space is different. A summary of the internal loads for each space can be seen in Figure 9 below.

Internal Loads		
Space Type	Lighting Power Density	Miscellaneous Loads
Office	1.1	125 W/Person
Corridor	0.4	0.0 W/SF
Conference	1.3	0.8 W/SF
Lobby/Reception	1.5	0.6 W/SF
Storage	0.6	0.0 W/SF
kitchennete	1.3	1.5 W/SF
Banquet Hall	1.3	0.6 W/SF

Figure 9: Internal Loads

Schedules

Occupancy schedules for people, lights, and miscellaneous loads were utilized during normal work hours because Father O'Connell is mostly an office/administrative building. Loads during the day are much higher than at night with off peak hours of 11:00pm to 7:00am used during the weekday.

Construction

Father O'Connell Hall is constructed of three conjoined buildings: the east wing, the west wing, and the main building. Figures 10 and 11 below show the wall and roof construction for each conjoined structure. R-values were found from ASHRAE 2010 Fundamentals Handbook. There is not much insulation in the walls or roofs and may show a potential for improvement in my design.

East and West Wing, and Main Building Wall Construction			
Thickness	Type	R-Value	U-Value
	Exterior, Outside 15 mph wind	0.17	
4"	Limestone	1	
8"	Masonry Block	1	
7/8"	Air Gap	1.18	
5/8"	Gypsum Wall Board	0.57	
	Interior, Still Air	0.68	
	Overall Value	**4.6**	**0.2173913**

Figure 10: Wall Construction Values

East and West Wing Roof			
Thickness	Type	R-Value	U-Value
	Exterior, Outside 15 mph wind	0.17	
3/8"	Built Up Roof	0.33	
3"	Insulation(R-3)	9	
3"	Light Weight Concrete	0.38	
	Interior, Inside Still Air	0.61	
	Overall Value	**10.49**	**0.0953289**

East and West Wing Roof			
Thickness	Type	R-Value	U-Value
	Exterior, Outside 15 mph wind	0.17	
1/2"	Terrecotta Tile	0.18	
3/8"	Felt Membrane	0.33	
4"	Light Weight Concrete	1.6	
	Interior, Inside Still Air	0.61	
	Overall Value	**2.89**	**0.3460208**

Figure 11: Roof Construction Values

Calculated Load vs. Design Load

Using the system checksums, which can be found in Appendix B, the calculated airflow is compared with the design airflow found on the design documents. The load calculations were fairly accurate which can be seen in figure 12 below. A possible reason for additional error is that it is a common practice to oversize equipment to ensure peak cooling loads can be met. It should also be noted that there were complications modeling the 100% outside air handling unit. This was modeled in Trace so that the sensible cooling loads were also met by the air handling unit, rather than additional fan coil units as seen in the design documents. Although, the ventilation load was fairly accurate. Figure 13 below shows the buildings peak cooling and heating loads compared to the capacities of the single chiller and combined two boilers. As you can see loads are fairly similar giving an indication the load calculations are somewhat accurate.

Unit	Design (CFM)	Calculated (CFM)	Error (%)
AHU-2	7790	7446	4.4
AHU-4	4100	3537	13.7
AHU-5	8000	9090	-13.6
AHU-6	3500	3302	5.7
OAHU-1	1800	1697	5.7

Figure 12: Design vs. Calculated Airflow

Design vs Calculated Energy Capacities			
Cooling		Heating	
Design (Tons)	97.7	Design (Tons)	83.333
Calculated (Tons)	105.1	Calculated (Tons)	93.5
Error (%)	7.6	Error (%)	12.2

Figure 13: Design vs. Calculated Energy Capacity

Energy Consumption and Cost

Trace was also used to calculate the Father O'Connell's energy usage and cost. This energy usage is a rough estimate. One major assumption was that fan coil units were not taken into account so fan energy would be much higher. In addition, unit heaters located in stairwells were also not taken into account. An energy model from the mechanical engineers could not be obtained for comparisons.

Figure 14 below shows that Father O'Connell consumes a total of 289,522 kWh/year, 3,095 therms/year of natural gas 277(1000gal) of water each year. Graph 1 clearlybreaks down the building energy consumption usage into heating, cooling, fans/pumps, lighting, and receptacles. It makes sense that heating requires the most energy followed by cooling.

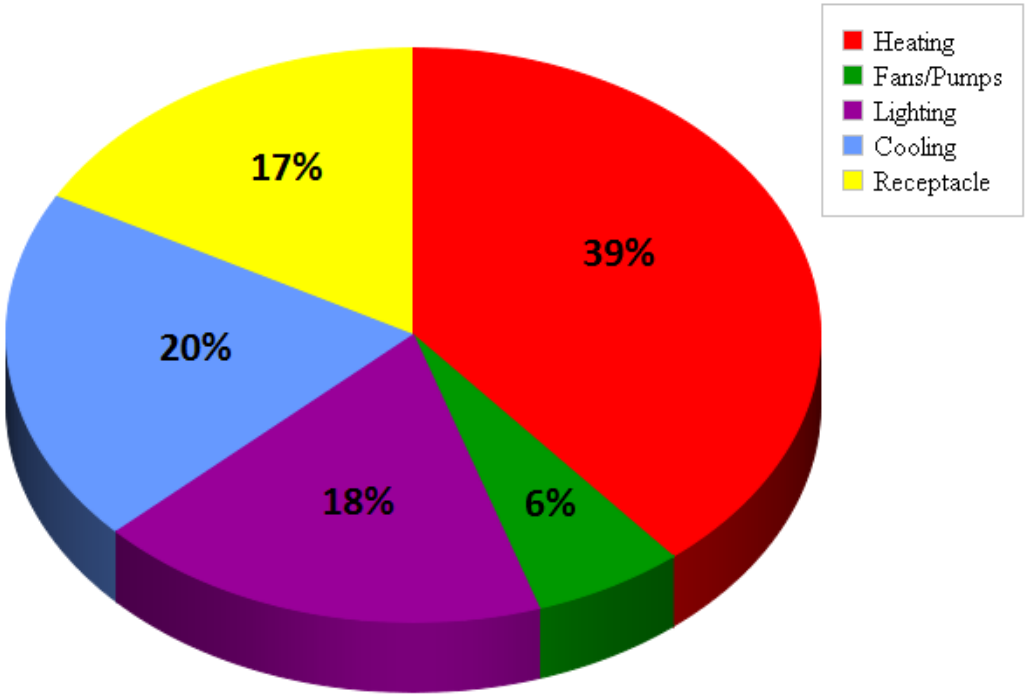
MONTHLY ENERGY CONSUMPTION

By ACADEMIC

------ Monthly Energy Consumption ------

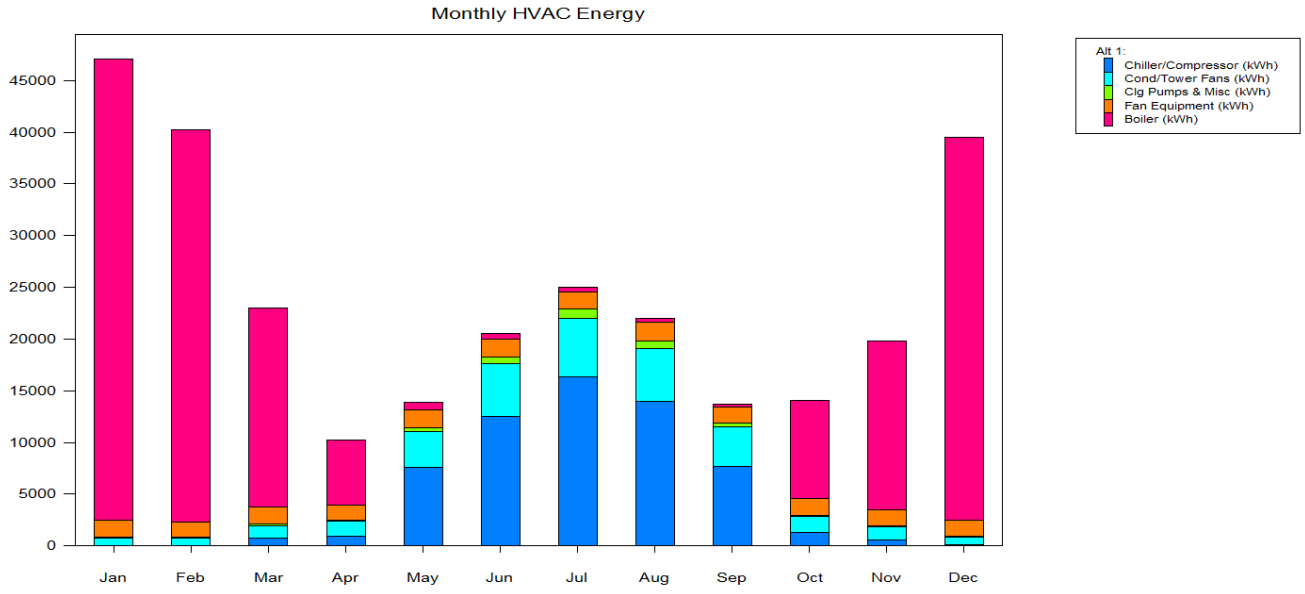
Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1													
Electric													
On-Pk Cons. (kWh)	17,190	15,587	19,649	17,706	27,840	34,968	38,270	37,169	26,762	19,715	18,087	16,579	289,522
On-Pk Demand (kW)	72	73	76	95	142	177	191	172	147	98	90	72	191
Off-Pk Demand (kW)	7	7	6	9	16	30	32	28	23	9	7	6	32
Mid-Pk Demand (kW)	67	67	68	78	123	143	165	153	134	80	69	68	165
Gas													
On-Pk Cons. (therms)	219	198	123	54	8	3	1	1	3	68	92	154	924
Off-Pk Cons. (therms)	872	727	266	52	2	7	10	5	1	114	253	788	3,096
Mid-Pk Cons. (therms)	430	368	265	107	16	11	7	6	7	140	213	322	1,892
On-Pk Demand (therms/hr)	2	2	1	1	0	0	0	0	0	1	1	2	2
Off-Pk Demand (therms/hr)	3	3	2	1	0	0	0	0	0	1	2	3	3
Mid-Pk Demand (therms/hr)	7	7	6	4	0	0	0	0	0	5	6	6	7
Water													
Cons. (1000gal)	2	2	6	7	34	53	67	59	33	8	5	2	277

Figure 14: Monthly Energy Consumption



Graph 1: Energy Consumption

Graph 2 below shows the monthly energy usage due to the chiller/compressor, condenser/tower fans, pumps, fan equipment, and the boiler. The graph makes sense with cooling equipment operating more in the summer months between May and September and the boiler operating in the winter months of November to March.



Graph 2: Monthly HVAC Energy Usage

Cost

Exact utility rates were able to be obtained so standard utility rates were used from Trane Trace 700. It was found that the annual utility cost is $16,965. The utility cost per area is 0.31 $/ft^2. Figure 10 below shows the Trace output for monthly utility costs.

MONTHLY UTILITY COSTS

By ACADEMIC

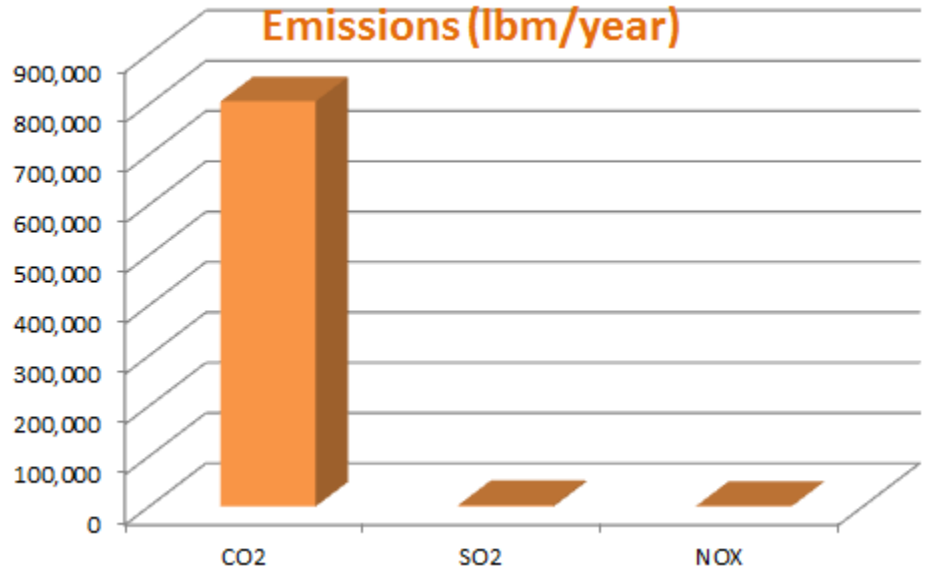
Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	------- Monthly Utility Costs -------												
Alternative 1													
Electric													
On-Pk Demand ($)	719	726	764	950	1,424	1,771	1,912	1,720	1,473	980	896	720	14,055
Off-Pk Demand ($)	34	33	32	44	81	148	162	142	115	44	34	32	900
Total ($):	752	760	796	994	1,505	1,919	2,074	1,862	1,587	1,024	930	752	14,955
Gas													
On-Pk Cons. ($)	110	99	61	27	4	2	1	1	1	34	46	77	462
Off-Pk Cons. ($)	436	364	133	26	1	3	5	2	0	57	127	394	1,548
Total ($):	546	463	194	53	5	5	6	3	2	91	172	471	2,010
Monthly Total ($):	1,298	1,222	991	1,047	1,510	1,924	2,080	1,865	1,589	1,114	1,102	1,223	16,965

Building Area = 54,000 ft²
Utility Cost Per Area = 0.31 $/ft²

Figure 15: Monthly Utility Costs

Emissions

The emissions for Father O'Connell Hall for CO2, SO2, and NOX can be seen in graph 3 below. As you can see CO2 by far has the highest emissions. This will be a goal of mine to reduce the CO2 emission in future assignments.



Graph 3 : Monthly Utility Costs

Appendix A

System Checksums

By ACADEMIC

AHU-2 — **Bypass VAV with Reheat (30% Min Flow Default)**

COOLING COIL PEAK

Peaked at Time: Mo/Hr: 7 / 17
Outside Air: OADB/WB/HR: 89 / 76 / 114

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent OfTotal (%)
Envelope Loads				
Skylite Solar	0	0	0	0
Skylite Cond	0	0	0	0
Roof Cond	0	9,733	9,733	4
Glass Solar	37,048	0	37,048	16
Glass/Door Cond	5,082	0	5,082	2
Wall Cond	18,938	3,738	22,676	10
Partition/Door	0		0	0
Floor	0		0	0
Adjacent Floor	0	0	0	0
Infiltration	0		0	0
Sub Total ==>	61,068	13,471	74,538	33
Internal Loads				
Lights	16,611	4,153	20,764	9
People	64,700	0	64,700	29
Misc	12,218	0	12,218	5
Sub Total ==>	93,529	4,153	97,682	43
Ceiling Load	2,994	-2,994	0	0
Ventilation Load	0	0	56,740	25
Adj Air Trans Heat	0		0	0
Dehumid. Ov Sizing			0	0
Ov/Undr Sizing	0		0	0
Exhaust Heat		-2,224	-2,224	-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 ==>	157,591	12,406	226,737	100.00

CLG SPACE PEAK

Mo/Hr: 7 / 17
OADB: 89

	Space Sensible Btu/h	Percent OfTotal (%)
Envelope Loads		
Skylite Solar	0	0
Skylite Cond	0	0
Roof Cond	0	0
Glass Solar	69,052	44
Glass/Door Cond	3,463	2
Wall Cond	15,624	10
Partition/Door	0	0
Floor	0	0
Adjacent Floor	0	0
Infiltration	0	0
Sub Total ==>	88,138	56
Internal Loads		
Lights	16,274	10
People	38,730	25
Misc	12,132	8
Sub Total ==>	67,136	43
Ceiling Load	2,381	2
Ventilation Load	0	0
Adj Air Trans Heat	0	0
Ov/Undr Sizing	48	0
Grand Total ==>	157,704	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design
OADB: 17

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent OfTotal (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-7,360	7.65
Glass Solar	0	0	0.00
Glass/Door Cond	-18,922	-18,922	19.67
Wall Cond	-32,222	-37,754	39.26
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-51,143	-64,036	66.59
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	-15,982	0	0.00
Ventilation Load	0	-66,729	69.39
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	29,774	29,774	-30.96
Exhaust Heat		13,055	-13.59
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		-8,246	8.57
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-37,351	-96,171	100.00

TEMPERATURES

	Cooling	Heating
SADB	56.0	85.0
Ra Plenum	76.8	60.6
Return	76.8	60.6
Ret /OA	78.7	54.0
Fn Mtr TD	0.0	0.0
Fn Bld TD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	7,446	2,234
Terminal	7,446	2,234
Main Fan	7,446	2,234
Sec Fan	0	0
Nom Vent	1,129	1,129
AHU Vent	1,129	1,129
Infil	0	0
Min Stop/Rh	2,234	2,234
Return	7,446	7,560
Exhaust	1,129	1,243
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	15.2	15.2
cfm/ft²	1.39	1.39
cfm/ton	394.07	
ft²/ton	283.15	
Btu/hr·ft²	42.38	-16.66
No. People	160	

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	18.9	226.7	162.6	7,446	78.7	65.4	72.6	56.0	55.6	65.3
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
OptVent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	18.9	226.7								

AREAS

	Gross Total ft²	Glass ft²	Glass (%)
Floor	5,350		
Part	0		
IntDoor	0		
ExFlr	0		
Roof	1,772	0	0
Wall	4,258	878	21
ExtDoor	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-72.2	2,234	56.0	85.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-16.9	7,446	54.0	56.0
Reheat	-34.9	2,234	56.0	70.0
Humidif	0.0	0	0.0	0.0
OptVent	0.0	0	0.0	0.0
Total	-89.1			

Project Name:
Dataset Name: Load Calcs-blockload.trc

TRACE® 700 v6.2.10 calculated at 05:40 PM on 10/03/2013
Alternative -1 System Checksums Report Page 1 of 5

System Checksums

By ACADEMIC

AHU-4 — Parallel Fan Powered VAV, Htg Coil on Mixing Box Outlet

COOLING COIL PEAK

Peaked at Time: Mo/Hr: 7 / 17
Outside Air: OADB/WB/HR: 89 / 76 / 114

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)
Envelope Loads				
Skylite Solar	0	0	0	0
Skylite Cond	0	0	0	0
Roof Cond	0	0	0	0
Glass Solar	18,702	0	18,702	7
Glass/Door Cond	4,236	0	4,236	2
Wall Cond	13,420	2,697	16,117	6
Partition/Door	0		0	0
Floor	0		0	0
Adjacent Floor	0	0	0	0
Infiltration	0		0	0
Sub Total ==>	36,359	2,697	39,056	15
Internal Loads				
Lights	10,398	2,599	12,997	5
People	18,450	0	18,450	7
Misc	16,330	0	16,330	6
Sub Total ==>	45,178	2,599	47,778	18
Ceiling Load	1,558	-1,558	0	0
Ventilation Load	0	0	177,827	67
Adj Air Trans Heat	0		0	0
Dehumid. Ov Sizing			0	0
Ov/Undr Sizing	23		23	0
Exhaust Heat		-3,748	-3,748	-1
Sup. Fan Heat			3,354	1
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 ==>	83,118	-10	264,289	100.00

CLG SPACE PEAK

Mo/Hr: 5 / 17
OADB: 88

	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads		
Skylite Solar	0	0
Skylite Cond	0	0
Roof Cond	0	0
Glass Solar	20,605	27
Glass/Door Cond	3,841	5
Wall Cond	12,168	16
Partition/Door	0	0
Floor	0	0
Adjacent Floor	0	0
Infiltration	0	0
Sub Total ==>	36,614	49
Internal Loads		
Lights	10,398	14
People	10,250	14
Misc	16,330	22
Sub Total ==>	36,978	49
Ceiling Load	1,482	2
Ventilation Load	0	0
Adj Air Trans Heat	0	0
Ov/Undr Sizing	23	0
Exhaust Heat		
OA Preheat Diff.		
RA Preheat Diff.		
Additional Reheat		
Underflr Sup Ht Pkup		
Supply Air Leakage		
Grand Total ==>	75,098	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design
OADB: 17

	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	-16,009	-16,009	7.26
Wall Cond	-25,387	-30,553	13.85
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-41,396	-46,562	21.11
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	-1,817	0	0.00
Ventilation Load	0	-80,419	36.46
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-2,307	-2,307	1.05
Exhaust Heat		1,675	-0.76
OA Preheat Diff.		-92,940	42.14
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 ==>	-45,520	-220,555	100.00

TEMPERATURES

	Cooling	Heating
SADB	56.0	85.0
Ra Plenum	76.0	68.9
Return	76.0	68.9
Ret/OA	89.3	17.0
Fn Mtr TD	0.1	0.0
Fn Bld TD	0.2	0.0
Fn Frict	0.6	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	3,546	2,722
Terminal	3,546	2,722
Main Fan	3,546	1,361
Sec Fan	0	1,361
Nom Vent	3,546	1,361
AHU Vent	3,546	1,361
Infil	0	0
Min Stop/Rh	1,361	1,361
Return	3,546	1,361
Exhaust	3,546	1,361
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	100.0	50.0
cfm/ft²	0.68	0.26
cfm/ton	160.99	
ft²/ton	235.97	
Btu/hr-ft²	50.85	-67.64
No. People	41	

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	22.0	264.3	134.8	3,537	89.3	75.9	114.1	55.2	54.6	62.9
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	22.0	264.3								

AREAS

	Gross Total ft²	Glass ft²	Glass (%)
Floor	5,197		
Part	0		
Int Door	0		
Ex Flr	0		
Roof	0	0	0
Wall	3,319	658	20
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-69.7	2,722	62.0	85.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-150.8	3,546	17.0	55.2
Reheat	-22.5	1,361	55.2	70.0
Humidif	-131.0	3,546	2.6	55.3
Opt Vent	0.0	0	0.0	0.0
Total	-351.5			

Project Name:
Dataset Name: Load Calcs-blockload.trc

TRACE® 700 v6.2.10 calculated at 05:40 PM on 10/03/2013
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System Checksums

By ACADEMIC

AHU-5 — **Dispacement Ventilation CV**

COOLING COIL PEAK

Peaked at Time: Mo/Hr: 7 / 12
Outside Air: OADB/WB/HR: 87 / 77 / 121

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)
Envelope Loads				
Skylite Solar	0	0	0	0
Skylite Cond	0	0	0	0
Roof Cond	0	0	0	0
Glass Solar	61,646	0	61,646	25
Glass/Door Cond	4,939	4,939	9,877	4
Wall Cond	5,940	5,940	11,879	5
Partition/Door	0		0	0
Floor	0		0	0
Adjacent Floor	0	0	0	0
Infiltration	0		0	0
Sub Total ==>	72,524	10,878	83,402	34
Internal Loads				
Lights	8,114	12,171	20,286	8
People	43,500	22,500	66,000	27
Misc	2,934	2,934	5,867	2
Sub Total ==>	54,548	37,605	92,153	38
Ceiling Load	0	0	0	0
Ventilation Load	0	0	58,742	24
Adj Air Trans Heat	0		0	0
Dehumid. Ov Sizing			0	0
Ov/Undr Sizing	0		0	0
Exhaust Heat		-569	-569	0
Sup. Fan Heat			8,619	4
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 ==>	127,072	47,914	242,346	100.00

CLG SPACE PEAK

Mo/Hr: 9 / 12
OADB: 79

	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads		
Skylite Solar	0	0
Skylite Cond	0	0
Roof Cond	0	0
Glass Solar	84,591	70
Glass/Door Cond	933	1
Wall Cond	2,524	2
Partition/Door	0	0
Floor	0	0
Adjacent Floor	0	0
Infiltration	0	0
Sub Total ==>	88,048	72
Internal Loads		
Lights	8,114	7
People	22,500	19
Misc	2,934	2
Sub Total ==>	33,548	28
Ceiling Load	0	0
Ventilation Load	0	0
Adj Air Trans Heat	0	0
Exhaust Heat	0	0
Grand Total ==>	121,595	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design
OADB: 17

	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	-51,952	-51,952	13.94
Wall Cond	-42,828	-42,828	11.49
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-94,780	-94,780	25.43
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	0	0	0.00
Ventilation Load	0	-75,288	20.20
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-202,659	-202,659	54.37
Exhaust Heat		0	0.00
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 ==>	-297,439	-372,727	100.00

TEMPERATURES

	Cooling	Heating
SADB	63.0	90.0
Ra Plenum	79.4	70.0
Return	75.4	70.0
Ret/OA	77.1	62.6
Fn Mtr TD	0.1	0.0
Fn Bld TD	0.2	0.0
Fn Frict	0.6	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	9,090	9,090
Terminal	9,090	9,090
Main Fan	9,090	9,090
Sec Fan	0	0
Nom Vent	1,274	1,274
AHU Vent	1,274	1,274
Infil	0	0
Min Stop/Rh	0	0
Return	9,090	9,090
Exhaust	1,274	1,274
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	14.0	14.0
cfm/ft²	1.99	1.99
cfm/ton	450.10	
ft²/ton	226.39	
Btu/hr·ft²	53.01	-60.79
No. People	200	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB/HR °F	Enter WB/HR gr/lb	Leave DB °F	Leave WB/HR °F	Leave WB/HR gr/lb
Main Clg	20.2	242.4	179.9	9,090	77.1	66.6	81.2	62.2	58.4	67.1
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	20.2	242.4								

AREAS

	Gross Total ft²	Glass ft²	Glass (%)
Floor	4,572		
Part	0		
IntDoor	0		
ExFlr	0		
Roof	0	0	0
Wall	5,310	1,593	30
ExtDoor	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-278.0	9,090	62.6	90.0
Aux Htg	-94.8	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-372.7			

Project Name:
Dataset Name: Load Calcs-blockload.trc

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System Checksums

By ACADEMIC

AHU-6 — **Bypass VAV with Reheat (30% Min Flow Default)**

COOLING COIL PEAK

Peaked at Time: Mo/Hr: 7 / 12
Outside Air: OADB/WB/HR: 87 / 77 / 121

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)
Envelope Loads				
Skylite Solar	0	0	0	0
Skylite Cond	0	0	0	0
Roof Cond	0	0	0	0
Glass Solar	22,619	0	22,619	28
Glass/Door Cond	2,216	0	2,216	3
Wall Cond	1,856	560	2,416	3
Partition/Door	0		0	0
Floor	0		0	0
Adjacent Floor	0	0	0	0
Infiltration	0		0	0
Sub Total ==>	26,692	560	27,252	33
Internal Loads				
Lights	6,653	1,663	8,316	10
People	13,750	0	13,750	17
Misc	11,953	0	11,953	15
Sub Total ==>	32,357	1,663	34,020	42
Ceiling Load	349	-349	0	0
Ventilation Load	0	0	20,792	25
Adj Air Trans Heat	0		0	0
Dehumid. Ov Sizing			0	0
Ov/Undr Sizing	0		0	0
Exhaust Heat		-211	-211	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 ==>	59,397	1,663	81,853	100.00

CLG SPACE PEAK

Mo/Hr: 9 / 12
OADB: 79

	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads		
Skylite Solar	0	0
Skylite Cond	0	0
Roof Cond	0	0
Glass Solar	43,120	62
Glass/Door Cond	-1,013	-1
Wall Cond	960	1
Partition/Door	0	0
Floor	0	0
Adjacent Floor	0	0
Infiltration	0	0
Sub Total ==>	43,067	62
Internal Loads		
Lights	6,653	10
People	7,935	11
Misc	11,860	17
Sub Total ==>	26,448	38
Ceiling Load	360	1
Ventilation Load	0	0
Adj Air Trans Heat	0	0
Dehumid. Ov Sizing		
Ov/Undr Sizing	68	0
Exhaust Heat		
Sup. Fan Heat		
Ret. Fan Heat		
Duct Heat Pkup		
Underflr Sup Ht Pkup		
Supply Air Leakage		
Grand Total ==>	69,943	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design
OADB: 17

	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	-11,464	-11,464	32.01
Wall Cond	-7,380	-9,296	25.95
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-18,843	-20,760	57.96
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	-5,931	0	0.00
Ventilation Load	0	-21,793	60.84
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	8,209	8,209	-22.92
Exhaust Heat		3,850	-10.75
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		-5,325	14.87
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-16,565	-35,819	100.00

TEMPERATURES

	Cooling	Heating
SADB	56.0	85.0
Ra Plenum	75.5	61.3
Return	75.5	61.3
Ret /OA	76.8	56.3
Fn Mtr TD	0.0	0.0
Fn Bld TD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	3,302	991
Terminal	3,302	991
Main Fan	3,302	991
Sec Fan	0	0
Nom Vent	369	369
AHU Vent	369	369
Infil	0	0
Min Stop/Rh	991	991
Return	3,302	3,330
Exhaust	369	397
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	11.2	11.2
cfm/ft²	1.54	1.54
cfm/ton	484.14	
ft²/ton	315.05	
Btu/hr·ft²	38.09	-14.90
No. People	36	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Entering DB °F	Entering WB °F	Entering HR gr/lb	Leaving DB °F	Leaving WB °F	Leaving HR gr/lb
Main Clg	6.8	81.9	60.3	3,302	76.8	63.6	66.9	56.0	55.4	64.6
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	6.8	81.9								

AREAS

	Gross Total ft²	Glass ft²	Glass (%)
Floor	2,149		
Part	0		
Int Door	0		
Ex Flr	0		
Roof	0	0	0
Wall	1,371	532	39
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Entering °F	Leaving °F
Main Htg	-32.0	991	56.0	85.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-15.5	991	56.0	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-32.0			

Project Name:
Dataset Name: Load Calcs-blockload.trc

TRACE® 700 v6.2.10 calculated at 05:40 PM on 10/03/2013
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System Checksums

By ACADEMIC

OAHU-1 — **Fan Coil**

COOLING COIL PEAK

Peaked at Time: Mo/Hr: 7 / 17
Outside Air: OADB/WB/HR: 89 / 76 / 114

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent OfTotal (%)
Envelope Loads				
Skylite Solar	0	0	0	0
Skylite Cond	0	0	0	0
Roof Cond	0	78,989	78,989	24
Glass Solar	68,439	0	68,439	21
Glass/Door Cond	16,916	0	16,916	5
Wall Cond	34,279	7,128	41,408	13
Partition/Door	0		0	0
Floor	0		0	0
Adjacent Floor	0	0	0	0
Infiltration	0		0	0
Sub Total ==>	119,634	86,118	205,751	63
Internal Loads				
Lights	37,545	9,386	46,931	14
People	68,250	0	68,250	21
Misc	30,811	0	30,811	9
Sub Total ==>	136,606	9,386	145,993	44
Ceiling Load	21,854	-21,854	0	0
Ventilation Load	-29,648	0	-29,648	-9
Adj Air Trans Heat	0		0	0
Dehumid. Ov Sizing			253	0
Ov/Undr Sizing	2		2	0
Exhaust Heat		-9,627	-9,627	-3
Sup. Fan Heat			12,569	4
Ret. Fan Heat		2,923	2,923	1
Duct Heat Pkup		0	0	0
Underflr Sup Ht Pkup			0	0
Supply Air Leakage		0	0	0
Grand Total ==>	248,457	66,936	328,215	100.00

CLG SPACE PEAK

Mo/Hr: Sum of
OADB: Peaks

	Space Sensible Btu/h	Percent OfTotal (%)
Envelope Loads		
Skylite Solar	0	0
Skylite Cond	0	0
Roof Cond	0	0
Glass Solar	138,434	55
Glass/Door Cond	8,536	3
Wall Cond	23,417	9
Partition/Door	0	0
Floor	0	0
Adjacent Floor	0	0
Infiltration	0	0
Sub Total ==>	170,388	68
Internal Loads		
Lights	35,243	14
People	39,244	16
Misc	29,996	12
Sub Total ==>	104,483	42
Ceiling Load	14,414	6
Ventilation Load	-37,757	-15
Adj Air Trans Heat	0	0
Ov/Undr Sizing	2	0
Grand Total ==>	251,529	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design
OADB: 17

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent OfTotal (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-71,391	25.81
Glass Solar	0	0	0.00
Glass/Door Cond	-62,908	-62,908	22.74
Wall Cond	-57,440	-70,438	25.46
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-120,349	-204,737	74.02
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	-19,318	0	0.00
Ventilation Load	-28,371	-28,371	10.26
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		8,507	-3.08
OA Preheat Diff.		-52,008	18.80
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 ==>	-168,038	-276,609	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	75.0
Ra Plenum	80.1	65.5
Return	80.1	65.5
Ret/OA	80.1	65.5
Fn Mtr TD	0.1	0.0
Fn Bld TD	0.2	0.0
Fn Frict	0.7	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	11,282	11,282
Terminal	11,282	11,282
Main Fan	11,282	11,282
Sec Fan	0	0
Nom Vent	1,697	1,697
AHU Vent	1,697	1,697
Infil	0	0
Min Stop/Rh	0	0
Return	12,979	12,979
Exhaust	1,697	1,697
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	15.0	15.0
cfm/ft²	0.83	0.83
cfm/ton	303.85	
ft²/ton	365.09	
Btu/hr·ft²	32.87	-20.40
No. People	163	

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	27.4	328.2	291.9	11,282	80.4	64.4	65.0	54.3	54.3	62.9
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
OptVent	9.8	117.4	48.7	1,697	80.7	74.8	121.1	55.0	54.9	64.4
Total	37.1	445.6								

AREAS

	Gross Total ft²	Glass ft²	Glass (%)
Floor	13,556		
Part	0		
IntDoor	0		
ExFlr	0		
Roof	5,576	0	0
Wall	8,491	2,273	27
ExtDoor	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-224.6	11,282	65.5	83.4
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
OptVent	-52.0	1,697	42.5	70.0
Total	-276.6			

Project Name:
Dataset Name: Load Calcs-blockload.trc

TRACE® 700 v6.2.10 calculated at 05:40 PM on 10/03/2013
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Appendix B

SYSTEM SUMMARY
DESIGN COOLING CAPACITIES
By ACADEMIC

Alternative 1

Building Airside Systems and Plant Capacities

Plant	System	Peak Plant Loads: Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Peak Total ton	Block Plant Loads: Time Of Peak mo/hr	Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Block Total ton
Cooling plant - 001		95.3	0.0	9.8	0.0	0.0	0.0	0.0	105.1	7/17	85.1	0.0	9.3	0.0	0.0	0.0	0.0	94.4
	AHU-4	22.0	0.0	0.0	0.0	0.0	0.0	0.0	22.0	7/17	21.6	0.0	0.0	0.0	0.0	0.0	0.0	21.6
	AHU-2	18.9	0.0	0.0	0.0	0.0	0.0	0.0	18.9	7/17	15.5	0.0	0.0	0.0	0.0	0.0	0.0	15.5
	AHU-5	20.2	0.0	0.0	0.0	0.0	0.0	0.0	20.2	7/17	19.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0
	AHU-6	6.8	0.0	0.0	0.0	0.0	0.0	0.0	6.8	7/17	4.2	0.0	0.0	0.0	0.0	0.0	0.0	4.2
	OAHU-1	27.4	0.0	9.8	0.0	0.0	0.0	0.0	37.1	7/17	24.8	0.0	9.3	0.0	0.0	0.0	0.0	34.2
Building totals		95.3	0.0	9.8	0.0	0.0	0.0	0.0	105.1		85.1	0.0	9.3	0.0	0.0	0.0	0.0	94.4

Building peakload is 105.1 tons.

Building maximum block load of 94.4 tons occurs in July at hour 17 based on system simulation.

SYSTEM SUMMARY
DESIGN HEATING CAPACITIES
By ACADEMIC

Alternative 1

System Coil Capacities

System Description	System Type	Main System Btu/h	Aux System Btu/h	Preheat Btu/h	Reheat Btu/h	Humid. Btu/h	Optional Vent Btu/h	Stg 1 Desic Regen Btu/h	Stg 2 Desic Regen Btu/h	Stg 1 Frost Prevention Btu/h	Stg 2 Frost Prevention Btu/h	Heating Totals Btu/h
AHU-4	Parallel Fan Powered VAV, Htg Coil on Mix	-69,728	0	-150,786	-22,533	-130,988	0	0	0	0	0	-351,502
AHU-2	Bypass VAV with Reheat (30% Min Flow De	-72,212	0	-16,909	-34,861	0	0	0	0	0	0	-89,121
AHU-5	Dispacement Ventilation CV	-277,947	-94,780	0	0	0	0	0	0	0	0	-372,727
AHU-6	Bypass VAV with Reheat (30% Min Flow De	-32,027	0	0	-15,461	0	0	0	0	0	0	-32,027
OAHU-1	Fan Coil	-224,601	0	0	0	0	-52,008	0	0	0	0	-276,609
Totals		-676,515	-94,780	-167,695	-72,855	-130,988	-52,008	0	0	0	0	-1,121,986

Building Plant Capacities

Plant	System	Peak Loads: Main Coil MBh	Preheat Coil MBh	Reheat Coil MBh	Humid. Coil MBh	Aux Coil MBh	Opt Vent Coil MBh	Misc Load MBh	Stg 1 Desic. Regen. MBh	Stg 2 Desic. Regen. MBh	Stg 1 Frost Prev. MBh	Stg 2 Frost Prev. MBh	Base Utility MBh	Absorption Load MBh
Heating plant - 002		677	168	0	131	95	52	0	0	0	0	0	0	0
	AHU-4	70	151	0	131	0	0	0	0	0	0	0	0	0
	AHU-2	72	17	0	0	0	0	0	0	0	0	0	0	0
	AHU-5	278	0	0	0	95	0	0	0	0	0	0	0	0
	AHU-6	32	0	0	0	0	0	0	0	0	0	0	0	0
	OAHU-1	225	0	0	0	0	52	0	0	0	0	0	0	0

Building peak load is 1,122.0 MBh.