TECHNICAL ASSIGNMENT #3

Existing Conditions Evaluation

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Margaret M. Alkek Building for Biomedical Research
Baylor College of Medicine
Houston, TX
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Executive Summary

This report examines the existing conditions for the Margaret M. Alkek Building for Biomedical Research in Houston, TX. Groundbreaking for this building took place on September 15, 2005 and is well short of being completed. Due to this complete utility rates were not available nor was an operating history for the building.

Baylor College of Medicine as an experienced owner had an extensive design narrative put together for engineers on the project to follow. These narratives listed requirements for all different systems involved in the building. The building was to be located on campus and utilized the existing campus chilled water and steam loops. The building also was to be built with a low first cost and a system that was easy to maintain, meaning the building had to have a simple system or a system similar to other buildings on campus. This report discusses what criteria put forth by the owner.

The final part of this report looks at the four major systems in the building; steam, heating hot water, chilled water and air side. Each system is described in brief, including how it operates. A simplified schematic is included for each system as well as schedules for key equipment in the building. This report concludes with a critique of the existing systems.

System Description

Overview

The Margaret M. Alkek Building for Biomedical Research is an 8 story and approximately 200,000 square foot research tower being built on the existing campus at Baylor College of Medicine (BCM). The building is to be located between the Jewish Institute for Medical Research and the Texas Medical Center Garage #6. The research tower will be constructed on top of an existing subterranean Transgenic Mouse Facility. The building's 8 stories will include 2 levels of animal research facilities, flexible laboratory space and office space. Cardiovascular sciences, diabetes and metabolic disease, cancer, pharmacogenomics, imaging and informatics & proteomics are the research areas that will be covered within the new research tower.

Construction of the new research tower required BCM to replace one of the existing 800 ton chillers in the North Campus chiller plant with a 1300 ton centrifugal chiller to accommodate the extra load from the new research tower. The tower has access to the campus chilled water loop, as well as a high pressure steam loop. The campus chilled water is pumped into a plate and frame heat exchanger which is responsible for the process chilled water in the tower. The steam loop runs into 3 shell & tube clean steam generators which produce the steam needed in the building for process and humidification. The steam runs through the building in low pressure (15 psig) and medium pressure (80 psig) loops. A portion of the low pressure steam is sent to two shell & tube heat exchangers which generate the hot water for the building which feeds heating coils in the air handling units as well as all reheat coils.

There are 12 air handlers in total that supply the tower. Of the 12 air handlers 10 are located in the level 3 mechanical space and the other 2 are located on the roof. On the roof there is a 15,000 cfm and 10,000 cfm air handler which serves to pressurize the north and south stairwells, respectively. 4 25,000 cfm air handlers service the vivarium spaces, office and lab spaces on levels 1 and 2. There are 2 10,000 cfm air handlers that serve the level 3 mechanical space. The final 4 air handlers are 50,000 cfm and serve the main lab and office spaces on floors 4-8. Fan coil units are used in the emergency electrical rooms, elevator equipment room and in the eastern corridors on levels 4-8.

Levels 1 & 2 contain all of the animal research facilities and vivarium space. Level 2 is constant volume 100% outdoor air, as it contains no office space and all vivarium and research spaces are constant volume and exhausted through fume hoods and exhaust fans located on the roof (via exhaust risers). Level 1 contains the lobby of the research tower. This lobby space and the attached corridor are variable volume spaces and are the only spaces on level 1 in which the air is returned instead of exhausted. All the vivarium spaces and animal research spaces on level 1 are constant volume and exhausted similar to level 2. The animal facility cagewash on level 1 is variable volume and is exhausted through exhaust diffusers as well as exhaust hoods. There is office space on level 1 which is variable volume however the air in this space is also exhausted and not returned. There are many vestibules which separate the "dirty" and "sterile" sides of level 1 which is divided by the cagewash. The "dirty" side is the office side and also where dirty cages are brought into the cagewash to be cleaned and the sterile side is the opposite side of the building where the sterile cages are removed from the cage wash.

Level 3 has only a few spaces to consider. In the northeastern corner of the building there is some storage space, corridor, glass wash and equipment service area that needs to be considers for heating and cooling. These spaces are all constant volume and exhausted. The rest of the space on level 3 is the mechanical area containing a majority of the air handlers. There are louvers along the north side of the building that allow for outdoor air to come in and feed the air handlers.

On levels 4-8 the research laboratories are variable volume, as are the office spaces on the opposite side of the floors. However not all spaces on levels 4-8 are variable volume there are a some laboratory support spaces that are constant volume, typically the presence of a fume hood will indicate constant volume. The air within the laboratory and laboratory support spaces is exhausted through exhaust fans located on the roof via exhaust risers or through fume hoods that also exhaust through the roof. The laboratory and office spaces on levels 4-8 are separated by a pressurized corridor/interaction space. Air in the office side and separating corridor/interaction space is returned.

Design Requirements & Intent

As the owner, Baylor College of Medicine dictated the criteria for designing the mechanical systems of the Margaret M. Alkek Building for Biomedical Research. Within the design narrative put forth by BCM it states that the mechanical designer;

"…will implement the most appropriate and cost effective schemes for various materials, methods of distribution, etc. and make recommendations to the Design Team for the most advantageous system components on the basis of first cost vs. operating cost, reliability, safety and easy of maintenance."

BCM also put forth a list of characteristics that they deemed desirable in their HVAC system components. The list includes; a modular approach, energy responsiveness, flexibility for future changes, durability; ease of maintenance, reliability, and redundancy of critical components. BCM's design narrative goes on to stress that the layout of mechanical equipment should encourage routine preventative maintenance by providing easy access. Due to the location of the tower being on campus, BCM would like the building to utilize the campus chilled water loop as well as the TECO steam loop that also exists on the Texas Medical Center (which BCM is a part of). The overriding theme of the design narrative is that the system has a low first cost and is easy to maintain.

BCM's design narrative is extensive and sets many of the design conditions required for design of the mechanical systems in the research tower. In their design narrative BCM also puts forth requirements for winter and summer design set points as well as ventilation, pressurization and filtration requirements broken down by room. BCM also specifies their Outside design conditions which can be seen below in Figure 1 as well as internal heating loads for the various rooms in the building which can be reviewed in Figure 3.

Outside Conditions

1. Summer: 97°F db/80°F wb
2. Winter: 20°F
3. Air Cooled Condensers: 115°F db

Figure 1

Space Type	Minimum O.A. Ventilation Rate	Summer Design		Winter Design		Pressurization	Minimum Supply Air Filtration	Remarks
		Max. Temperature (F)	Max. Relative Humidity (%rh)	Min. Temperature (F)	Min. Relative Humidity (%rh)			
Public Spaces and Office Areas								
Offices	20 cfm / person	74	55%	72	30%	Note 1	90%	-
Office Support	20 cfm / person	74	155%	72	30%	-	90%	-
Common Areas / Lobbies	20 cfm / person	74	55%	72	30%	Note 1	90%	-
Conference Rooms	20 cfm / person	74	55%	72	30%	-	90%	-
Conference Center	20 cfm / person	74	55%	72	30%	-	90%	-
Coffee / Break	20 cfm / person	74	55%	72	30%	-	90%	-
Laboratory Spaces								
Lab Workstation	100% / 6 ach	74	55%	72	30%	(-)	90%	-
Open Lab	100% / 6 ach	74	55%	72	30%	(--)	90%	-
Lab Support	100% / 6 ach	74	55%	72	30%	(---)	90%	-
Tissue Culture	100% / 6 ach	74	55%	72	30%	(+)	90%	-
Microscopy	100% / 6 ach	74	55%	72	30%	(+)	90%	-
Equipment Room	100% / 6 ach	74	55%	72	30%	(---)	90%	-
Glasswash	100% / 6 ach	74	65%	72	30%	(---)	90%	-
Glasswash Equipment	100% / 6 ach	85	65%	72	30%	(---)	90%	-
Darkroom	100% / 6 ach	74	55%	72	30%	(---)	90%	-
Cold Room	0.5 cfm / sq.ft.	-	-	-	-	None	90%	Note 2
Equipment Corridor	100% / 6 ach	78	55%	72	30%	(-)	90%	Note 5
Animal Facility Spaces								
Animal Holding Rooms	100% / 15 ach	Note 4	55%	Note 3	30%	Note 4	HEPA	Note 6

Space Type	Minimum O.A. Ventilation Rate	Summer Design		Winter Design		Pressurization	Minimum Supply Air Filtration	Remarks
		Max. Temperature (F)	Max. Relative Humidity (%rh)	Min. Temperature (F)	Min. Relative Humidity (%rh)			
Animal Procedure	100% / 15 ach	Note 4	55%	Note 3	30%	Note 4	HEPA	Note 6
Animal Hold Corridor	100% / 10 ach	74	55%	72	30%	Note 4	HEPA	Note 6
Animal Bedding / Feed	100% / 10 ach	74	55%	72	30%	(-)	HEPA	-
Dirty Cagewash	100% / 15 ach	78	65%	72	30%	(--)	HEPA	-
Clean Cagewash	100% / 15 ach	78	65%	72	30%	(+)	HEPA	-
Sterile Cagewash	100% / 15 ach	78	65%	72	30%	(++)	HEPA	-
Animal Corridor	100% / 10 ach	78	55%	72	30%	(+)	HEPA	-
Animal Gown	100% / 10 ach	78	55%	72	30%	(++)	HEPA	-
Specialty Spaces								
Specialty Lab	100% / 6 ach	74	55%	72	30%	TBD	90%	-
Miscellaneous Spaces								
Mech. / Elec. Rooms	Recirculation	85	60%	65	-	None	20%	-
Tel/Data Rooms	-	75	55%	60	30%	None	20%	-
Elevator Machine Rooms	-	78	60%	65	20%	None	20%	-
Receiving/Storage	100% Exhaust	78	-	65	-	None	20%	-
General Storage	-	78	-	72	-	None	20%	-
Hazardous Storage	100% Exhaust	78	-	72	-	(-)	20%	-
Waste Storage	100% Exhaust	78	-	72	-	(-)	20%	-
Toilet / Locker Rooms	100% Exhaust	78	-	72	-	(-)	80%	-
Housekeeping Closets	100% Exhaust	78	-	72	-	(-)	-	-

Note 1: Space pressurization is positive relative to adjacent labs and otherwise neutral.
Note 2: Environmental room temperature control is by Division 11.
Note 3: Animal holding and procedure spaces will have temperatures adjustable between 68°F and 80°F.
Note 4: Animal holding and procedure space pressurization will be adjustable from positive to negative.
Note 5: Equipment space will be provided with minimum air and house fed chilled water fan coil units to offset the equipment sensible heat load.
Note 6: Animal Room exhaust will include dander filter.

Figure 2

Space Type	People Load	Lighting Load	Equipment Load	Remarks
Public Spaces and Office Areas				
Offices	100 gsf/person	1.5 W/gsf	4.0 W/gsf	-
Office Support	250 gsf/person	1.5 W/gsf	4.0 W/gsf	-
Common Areas / Lobbies	250 gsf/person	1.5 W/gsf	0.5 W/gsf	-
Conference Rooms	25 gsf/person	1.5 W/gsf	2.0 W/gsf	-
Conference Center	25 gsf/person	1.5 W/gsf	0.5 W/gsf	-
Coffee / Break	25 gsf/person	1.5 W/gsf	0.5 W/gsf	-
Laboratory Spaces				
Lab Workstation	100 gsf/person	1.5 W/gsf	8 W/gsf	-
Open Lab	100 gsf/person	1.5 W/gsf	8 W/gsf	-
Lab Support	100 gsf/person	1.5 W/gsf	16 W/gsf	-
Tissue Culture	100 gsf/person	1.5 W/gsf	16 W/gsf	-
Microscopy	100 gsf/person	1.5 W/gsf	16 W/gsf	-
Equipment Room	100 gsf/person	1.5 W/gsf	16 W/gsf	-
Glasswash	200 gsf/person	1.5 W/gsf	Note 2	-
Glasswash Equipment	-	1.5 W/gsf	Note 2	-
Darkroom	100 gsf/person	1.5 W/gsf	8 W/gsf	-
Cold Room	-	-	-	-
Equipment Space	100 gsf/person	1.5 W/gsf	40W/gsf	-
Animal Facility Spaces				
Animal Holding Rooms	Note 1	1.5 W/gsf	Note 2	-
Animal Procedure	Note 1	1.5 W/gsf	Note 2	-
Animal Hold Corridor	200 gsf/person	1.5 W/gsf	-	-
Animal Bedding / Feed	200 gsf/person	1.5 W/gsf	Note 2	-
Dirty Cagewash	200 gsf/person	1.5 W/gsf	Note 2	-
Clean Cagewash	200 gsf/person	1.5 W/gsf	Note 2	-
Sterile Cagewash	200 gsf/person	1.5 W/gsf	Note 2	-
Animal Corridor	200 gsf/person	1.5 W/gsf	0.5 W/gsf	-
Animal Gown	100 gsf/person	1.5 W/gsf	0.5 W/gsf	-
Specialty Spaces				
Specialty Lab	100 gsf/person	1.5 W/gsf	8 W/gsf	
Miscellaneous Spaces				
Mech. / Elec. Rooms	-	-	-	Note 3
Tel/Data Rooms	-	1.5 W/gsf	Note 5	-
Elevator Machine Rooms	-	1.5 W/gsf	Note 2	-
Receiving/Storage	200 gsf/person	1.5 W/gsf	1.5 W/gsf	-
General Storage	200 gsf/person	1.5 W/gsf	1.5 W/gsf	-

Space Type	People Load	Lighting Load	Equipment Load	Remarks
Hazardous Storage	-	-	-	Note 4
Waste Storage	-	-	-	Note 4
Toilet / Locker Rooms	-	-	-	Note 4
Housekeeping Closets	-	-	-	Note 4

Figure 3

The building utilizes the campus chilled water loop for all chilled water production through a plate and frame heat exchanger. For domestic hot water and heating hot water the campus steam loop is utilized. Cost analyses were done for chilled water production as well as steam production for the Baylor College of Medicine campus. The electricity rate for BCM is $0.0515/kWh and the natural gas rate is $7.15/MMBTU. After the analysis was carried out it was found that steam production cost $0.0831/1000lbs of steam and chilled water production cost $0.0028/ton-hour. However, these prices did not factor into the decision to use the campus loops. BCM wants all their buildings on these loops for simplicity and that was the overriding factor.

Previous Simulation & Building Studies

The Margaret M. Alkek Building for Biomedical Research has yet to be constructed as such energy utilization data is not available for the research tower. The mechanical designers for this building also did not carry out simulations that would estimate the heating/cooling loads, ventilation requirements or energy utilization. However, simulations were carried out for the sake of this series of reports.

In the first technical report the building was analyzed with regards to ASHRAE's standard 62, which considers building ventilation. BCM put forth criteria for air handling units in their design narrative. The design narrative states what percentage of supply air the units should have based on which areas they serve. The results of the first technical report compared the ventilation rates required for Standard 62 to what the actual design outdoor air rate is, which was taken off of design documents. Figure 4 below shows the criteria for the air handling units used in the building, which also shows the % of outdoor air that BCM desires. Figure 5 after this shows the tabular results of the first technical report and compares the minimum required outdoor air per standard 62 versus the designed ventilation rate.

Supply Air (AHU) System	COMPONENTS										CRITERIA					
	Prefilters (30%)	After Filters	Hot Water Preheat Coil	Humidifier	Cooling Coils (Draw-Thru)	UV Emitter	Sound Attenuator (Fan Inlet)	Supply Fans	Sound Attenuator (Fan Discharge)	Final Filters	% Outside Air (Minimum)	Volume Control	Fan Heat Gain Allowance (F)	Unit Discharge Temp (F db)	Emergency Power	Remarks
Laboratory/Office	•	•	•	•	•	•	•	•	•	•	75	VV	4	56	Yes	Note 1
Animal	•	•	•	•	•	•	•	•	•	•	100	VV	4	54	Yes	Note 2
Recirculation	•				•	•		•			0	CV	2	60	No	
Stairwell	•		•		•	•		•			100	CV	2	60	Yes	Note 3

Note 1: Lab/Office units will be sized such that each of four (4) units is sized for 25% of peak load, and cross connected. Two (2) of four (4) units operate when on emergency power and will provide nominal 65% redundancy.
Note 2: Animal system will have 75% air handling unit redundancy (each unit sized for 75% of peak load).
Note 3: Stairwell AC units shall be sized for normal mode cooling at 10% outside air and smoke mode heating at 100% outside air.

Figure 4

AHU Tag	Service	Level(s)	62.1 O.A.	Actual O.A.
AHU-A.1a	Animal Facilities	1,2	8,651	100,000
AHU-A.1b	Animal Facilities	1,2		
AHU-A.1c	Animal Facilities	1,2		
AHU-A.1d	Animal Facilities	1,2		
AHU-L.1a	Lab/Office/Lobby	1,4-8	13,106	50,150
AHU-L.1b	Lab/Office/Lobby	1,4-8		
AHU-L.2a	Laboratory	4-8	9,970	100,000
AHU-L.2b	Laboratory	4-8		

Figure 5

The second technical report on the Margaret M. Alkek Building for Biomedical Research dealt with ASHRAE's standard 90, energy utilization and heating/cooling loads. Simulations for energy utilization and heating/cooling were carried out in Carrier's Hourly Analysis Program (version 4.20). The results of this report can be seen in Appendix A. These results will give the design cooling/heating loads as well as the annual energy consumption for the building.

An important note as to the limitations of these reports is that 4 air handlers were not considered. These air handlers only do recirculation of air in the 3rd floor mechanical area and pressurization of stairwells and were deemed unimportant for the sake of these reports.

System Operation

This section of the report will describe the operation of the four main systems throughout the building. These systems are the steam, chilled water, heating hot water and air systems within the building. Each section will describe the system and reference and accompanying schematic of the system. Schedules for the accompanying equipment used in the systems can be found in the back of this report in Appendix B. Larger views of the schematics can be found in Appendix C.

Building Steam System

The Margaret M. Alkek Building for Biomedical Research has an extensive steam system. Baylor College of Medicine's campus is located at the Texas Medical Center which produces its own steam via the Texas Medical Center Central Heating and Cooling Services Cooperative Association (TECO). The research tower utilizes this campus steam loop for many different uses.

The campus steam loop conditions are 398°F and 225 psig. The building draws in 26,000 lb/hr of steam at peak load. The amount of demand depends on the following; humidification in the air handlers, the amount of process of steam required, domestic hot water and heating hot water needs. The high pressure steam is brought into the building and then goes through a series of pressure reducing valves which creates medium pressure steam (80 psig) and low pressure steam (15 psig) loops.

The low pressure steam loop feeds two shell & tube heat exchangers (HE-1 & HE-2 on Figure 6 below) which create the heating hot water for the building. HE-2 unit is used as standby. The low pressure steam is then returned to a condensate pump (CP-1 on Figure 6 below) and then is fed back into the TECO condensate system. The high pressure return and low pressure return from the pressure reducing valves feed into a flash tank which vents off any existing steam and then connects to the same condensate pump as the low pressure steam system which again connects into the TECO condensate system.

The medium pressure steam loop goes to feed 3 clean steam generators and the domestic hot water heaters. As shown on figure 6, CSG-1 creates clean low pressure steam (CLPS) which feeds the air handling units for humidification needs. This CLPS then returns to a condensate cooler which connects to the existing water recovery system on campus. CSG-2 & CSG-3 create clean medium pressure steam which feeds all the process steam requirements throughout the building for sterilization of lab equipment and other needs. The process steam is then returned to a flash tank which then feeds clean low pressure return steam into the same condensate cooler as mentioned above which then connects to the existing water recovery system. The domestic hot water heaters connect right off of the medium pressure steam loop. All of the medium pressure return from the CSG's and domestic water heaters connects to a flash tank which connects back to CP-1 (same condensate pump as the other HPR and MPR connect into) and then into the TECO condensate system.

The amount of steam drawn off the high pressure steam loop depends entirely on the heating and steam generation needs of the building at any point in time. See the below schematic (Figure 6) for a complete view of steam usage in the building.

BUILDING STEAM SYSTEM

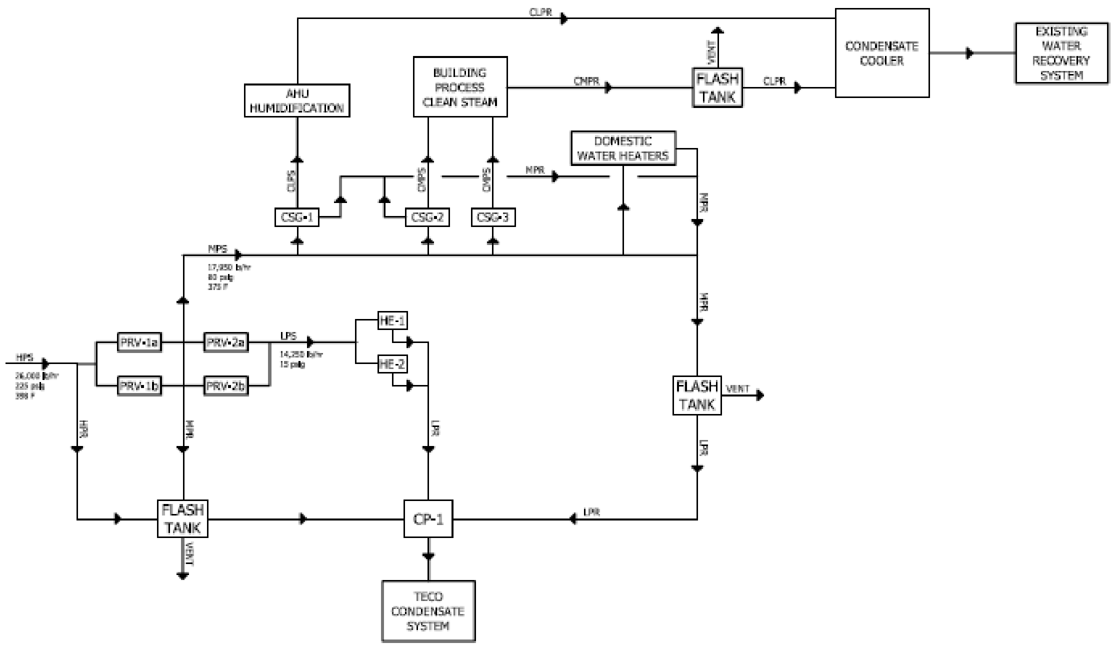


Figure 6

Building Chilled Water System

The Margaret M. Alkek Building for Biomedical Research utilizes the existing campus chilled water loop for all its chilled water needs. The chilled water is produced in the north campus chiller plant. With the addition of the new research tower, a chiller had to be replaced. An existing 800 ton centrifugal chiller was replaced with a new 1300 ton centrifugal chiller to assist in the handling of the new load on campus and for future expansion. The campus loop circulates chilled water at 45°F.

Chilled water is drawn into the building and separated into two loops. The first loop takes 45°F water through two pumps in parallel (CHP-1 & CHP-2). This chilled water is pumped to the cooling coils on the air handling units that serve levels 4-8’s office and lab space (AHU-L.1a, AHU-L.1b, AHU-L.2a and AHU-L.2b) as well as the cooling coils on the stairwell pressurization air handlers. The sensors on the coils in the air handling units connect back to the two pumps (CHP-1 & CHP-2) which are connected to variable frequency drives for control of how much chilled water is brought into the building via this loop. At peak load this loop will draw in 2750 GPM. The chilled water used by these air handlers is then returned at 60°F to the campus chilled water return loop.

The second chilled water loop created within the building feeds the air handlers for the animal research facility floors (AHU-A.1a, AHU-A.1b, AHU-A.1c and AHU-A.1d), fan coil units and process cooling throughout the building. Two parallel pumps (CHP-3 & CHP-4) draw in 1720 GPM (peak design load) of chilled water, of which, 1360 goes directly to the air handlers for the animal research facility floors. A sensor on the cooling coils connects back to the variable frequency drives attached to CHP-3 and CHP-4. The chilled water is returned from these air handlers at 60°F to the campus chilled water return loop. A 360 GPM branch breaks off to feed a plate and frame heat exchanger (PFX-1). Chilled water enters the PFX-1 at 45°F and leaves at 60°F, this water then is returned to the campus chilled water return loop. The plate and frame heat exchanger creates 50°F chilled water which then feeds fan coil units and any process cooling needs throughout the rest of the building. The water is then returned to the PFX-1 at 65°F. The schematic of this system can be seen below.

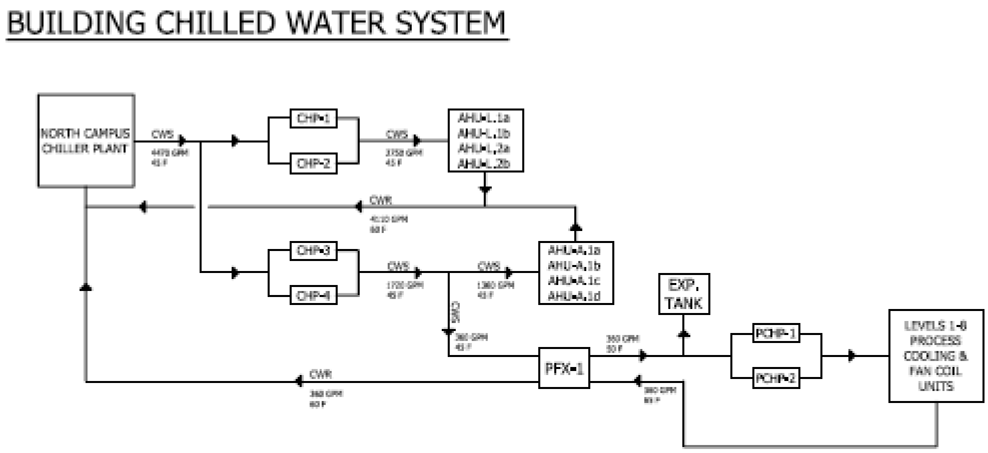


Figure 7

Building Heating Hot Water System

The research tower's heating hot water system is fairly simple. As stated above in the steam section two shell & tube heat exchangers (HE-1 & HE-2) are used for heating hot water creation for the building. HE-2 is a standby unit. At peak design HE-1 creates 950 GPM (peak design load) of heating hot water for distribution throughout the building. The two heat exchangers are connected to two parallel pumps (HWP-1 & HWP-2) which distribute the heating hot water. There are 3 loads that the heating hot water feeds; the reheat coils in the VAV/CV boxes on levels 1 and 2, the reheat coils in the VAV/CV boxes on levels 4-8 and level 3 which houses the air handling units for laboratory, office and animal research facilities. The heating hot water is distributed at 190°F and returned at 160°F.

The controls on the heating hot water are slightly more complex than the other systems. Each space (or zone) within the building has its own CV or VAV box. Each box (with the exception of cold rooms, electrical and mechanical rooms) has a reheat coil in the box. The thermostats in each room then connect to the diffusers and reheat coils. If the thermostat is set to where reheat is needed at the box, the reheat coil is turned on. The reheat coils in the boxes and heating coils in the boxes connect to the variable frequency drives connected to the pumps for control of how much heating hot water is distributed. The complete diagram can be seen below.

BUILDING HEATING HOT WATER SYSTEM

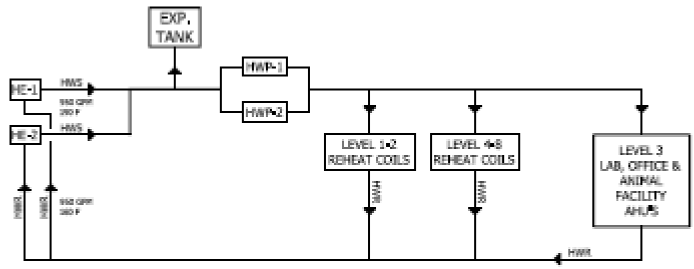


Figure 8

Building Air Side Systems

The research tower's air system is relatively simple as well. The building has three separate air systems with multiple air handling units serving each of these three systems. System 1 serves animal research facility on levels 1 and 2. System 2 serves the laboratory spaces on levels 4-8, while System 3 serves the office spaces on levels 4-8 as well as the remaining laboratory spaces not covered by System 2.

System 1: AHU-A.1a, AHU-A.1b, AHU-A.1c & AHU-A.1d

System 1 serves the animal facilities on levels 1 & 2. This system consists of air handlers; AHU-A.1a, AHU-A.1b, AHU-A.1c and AHU-A1.d. The animal facilities on the first floor are made up of animal housing rooms in which animals to conduct experiments on are held. Connected to the animal housing rooms are procedure rooms where the experiments or preparation for experiments can be carried out. A majority of the space on level 1 is taken up by a cage wash facility for cleansing of all the cages in which animals are stored. Level 2 consists almost exclusively of the aforementioned animal housing rooms and adjacent procedure rooms.

System 1's four air handlers are stacked in a 2x2 configuration and "dump" all their supply air into a supply plenum where air from all 4 air handlers is mixed. Air is then supplied from there to the appropriate spaces on levels 1 & 2. The system is 100% outdoor air, this is due to needing the air as clean as possible so as to not influence experiments or spread contaminants/sickness. The air is exhausted from these spaces through four separate means; biological safety cabinets (similar to fume hoods), an exhaust riser dedicated to animal spaces, toilet exhaust and an exhaust for the cagewash exhaust which is a "wet" exhaust because of the steam used to sterilize during cleaning.

The thermostats determine how much air is required for these spaces which connect back to the variable frequency drives connected to the fans of the air handling unit as well as the VAV/CV boxes. The exhaust tracks the supply so that pressurization required in certain rooms are maintained. Many of the spaces within this system are constant volume to maintain pressurization due to the fume hoods and biological safety cabinets which draw a constant amount of air from the room. The diagram of this system can be seen below in Figure 9.

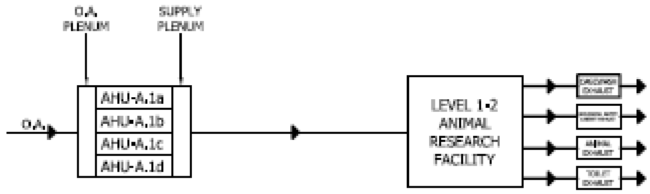


Figure 9

System 2: AHU-L.2a & AHU-L.2b

System 2 serves the laboratory spaces on levels 4-8. This system consists of air handlers; AHU-L.2a and AHU-L.2b. The laboratory spaces on these levels are for research purposes at the college. The adjacent spaces are laboratory support and are made up of spaces such as fume hood rooms, equipment rooms, microscopy and general lab support rooms. The air handlers are stacked on top of each other and supply into a supply plenum similar to system 1. This system is also 100% outdoor air for the same reasons as system 1.

System 2 is controlled the same as System 1. The difference being that much fewer spaces are constant volume due to only a few fume hoods being present (and in specific rooms). The spaces are exhausted via exhaust risers that connect to four exhaust fans connected in parallel. The diagram of this system can be seen below.

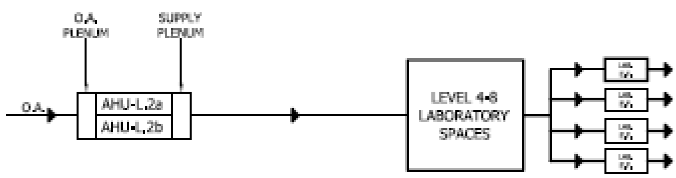


Figure 10

System 3: AHU-L.1a & AHU-L.1b

System 3 is the only system in the research tower that uses recirculated air. This system serves the rest of the laboratory spaces on levels 4-8 not covered by system 2, the office spaces on levels 4-8 and the main lobby and attached corridor on level 1. This system is made up of air handling units AHU-L.1a and AHU-L.1b. These units are also stacked one on top of the other and use the supply plenum like the other 2 systems. Air in the laboratory spaces on these floors is exhausted through the roof of the building. The office side of levels 4-8 and few level 1 spaces are the spaces that are returned. The system is approximately 50% outdoor air.

The controls on System 3 are similar to the other 2 systems. In this case return tracks the supply in the office spaces that return air. There are no constant volume spaces (outside of the restrooms) in this system because the few laboratory spaces that are covered by this system do not require it. The laboratory spaces are exhausted by exhaust fans located on the roof via duct risers. The diagram of this system can be seen below in Figure 11.

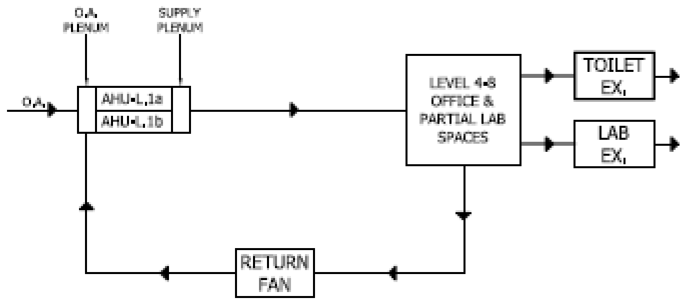

O.A. PLENUM
SUPPLY PLENUM
O.A.
AHU-L.1a
AHU-L.1b
LEVEL 4-8 OFFICE & PARTIAL LAB SPACES
TOILET EX.
LAB EX.
RETURN FAN

Figure 11

Existing System Critique

The Margaret M. Alkek Building for Biomedical Research is a research tower in which air quality control is critical. Experiments regarding disease that is studied on animals and other general laboratory research could potentially be hazardous to the occupants of the building. Therefore, ensuring that clean, fresh air was supplied to all spaces was critical. The solution presented by the designers in the case of this new research tower was to use 100% outdoor air systems. This solution ensures that all spaces will not have problems with contamination from other spaces. There is an air handling unit that uses return but the return air comes from office spaces and is not considered to be contaminated. While this solution ensures air quality control, it consumes more energy than other possible solutions. 100% outdoor air systems will use more energy because all air that is brought in must be conditioned to the desired supply conditions. Return air systems for these spaces could be used however it is assumed that heavy filtration and conditioning of the return air would need to take place to ensure that any contaminants were removed. The optimization point between the cost and energy usage of filtration and conditioning of return air of these spaces compared to the cost and energy usage of conditioning 100% outdoor air is a point of interest.

C. Every effort shall be made to design, layout and install equipment in locations which will tend to encourage routine preventative maintenance by providing easy access for maintenance personnel.

Figure 12

A point that was stressed in the previously mentioned BCM design narrative for the research tower was ease of maintenance (the direct quote can be seen above in Figure 10). Ease of maintenance is important for several reasons. The first reason is that most owners want to reduce first cost as much as possible, included in first cost of a building is training maintenance staff on operation and upkeep of equipment. If an owner, such as BCM, has several buildings in close proximity of each other, these buildings tend to share a maintenance staff. For this reason, BCM wanted similar equipment to other buildings that exist on their campus so little to not training in maintenance would be required. This restricts the design engineer in what equipment they can use. For this reason the building uses simple equipment that is similar to other equipment that exists on campus. The inherent problem with simple equipment is that despite the first cost benefits, these pieces of equipments tend to consume more energy.

The initial cost of the building's mechanical systems for the building is $21,114,878 according to an estimate done by Stephen N. Skabla Jr. on April 11, 2005. This accounts for approximately 30% of the buildings overall first cost. Laboratory buildings tend to have complex systems and be energy intensive. The term complex systems does not necessarily apply to the individual pieces of equipment used but more in terms of how much equipment is used and how it is all interrelated. The simplicity of the equipment used within the building keeps the first cost of the building down however, as stated above; the building consumes more energy because of this fact. Also the equipment occupies an entire floor of the new research tower's space. This eliminates some of the payback the building would receive through research grants, attraction of top research and breakthroughs in new research.

The art of designing a building lies in the balance of first cost, operation cost, energy consumption and maintenance. The Margaret M. Alkek Building for Biomedical Research emphasizes ease of maintenance and low first cost. The result of this is a building that consumes a considerable amount of energy (in Appendix A from the results of Technical Report #2, 377 kBTU/ft^2) and has mechanical systems that take up approximately 15-20% of the building. A point of contention worth analyzing for this building would be the benefit of more complex systems with lower operating costs versus the simple system with higher operating cost and energy consumption.

Appendix A – Energy Analysis Results

Zone Sizing Summary for AHU-L.2a & L.2b

Project Name: Baylor College Of Medicine | 10/31/2005
Prepared by: psuae | 03:37AM

Air System Information

Air System Name .... **AHU-L.2a & L.2b**
Equipment Class .... **CW AHU**
Air System Type .... **VAV**

Number of zones **3**
Floor Area .... **43625.0** ft²
Location .... **Houston, Texas**

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM .... **Peak zone sensible load**
Space CFM .... **Individual peak space loads**

Calculation Months .... **Jan to Dec**
Sizing Data .... **Calculated**

Zone Sizing Data

Zone Name	Maximum Cooling Sensible (MBH)	Design Air Flow (CFM)	Minimum Air Flow (CFM)	Time of Peak Load	Maximum Heating Load (MBH)	Zone Floor Area (ft²)	Zone CFM/ft²
Zone 1	1499.2	73347	733	Oct 1400	72.9	42400.0	1.73
Zone 2	115.4	5362	54	Jan 2000	0.0	525.0	10.21
Zone 3	107.6	3334	33	Jan 2000	0.0	700.0	4.76

Zone Terminal Sizing Data

Zone Name	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 30.0 °F	Zone Htg Coil Load (MBH)	Zone Htg Water gpm @ 30.0 °F	Mixing Box Fan Airflow (CFM)
Zone 1	0.0	0.00	72.9	4.86	0
Zone 2	0.0	0.00	0.0	0.00	0
Zone 3	0.0	0.00	0.0	0.00	0

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
Zone 1							
Lev 4-8: Chem Storage	5	1.5	Jan 2000	71	0.0	130.0	0.55
Lev 4-8: Corr R4C2	5	2.9	Jan 2000	141	0.0	375.0	0.38
Lev 4-8: Corr R4C3	5	4.9	Jan 2000	238	0.0	635.0	0.38
Lev 4-8: Corr R4C5	5	4.4	Jan 2000	216	0.0	575.0	0.38
Lev 4-8: Dark Room	5	9.9	Jan 2000	486	0.0	165.0	2.94
Lev 4-8: Equip (S34)	5	17.2	Jan 2000	839	0.0	285.0	2.94
Lev 4-8: Fume Hood (S37)	5	8.1	Jan 2000	398	0.0	135.0	2.94
Lev 4-8: Fume Hood (S38)	5	8.1	Jan 2000	398	0.0	135.0	2.94
Lev 4-8: Lab	5	11.3	Jan 2000	554	0.0	335.0	1.65
Lev 4-8: Lab W R430.M	5	14.7	Nov 1400	717	2.5	290.0	2.47
Lev 4-8: Lab W R430.R	5	29.6	Nov 1400	1449	4.8	585.0	2.48
Lev 4-8: Lab W R431.M	5	17.4	Jan 2000	851	0.0	515.0	1.65
Lev 4-8: Lab W R431.R	5	33.9	Jan 2000	1661	0.0	1005.0	1.65
Lev 4-8: Lab W R450.M	5	12.0	Jun 1700	588	2.5	290.0	2.03
Lev 4-8: Lab W R450.R	5	24.2	Jun 1700	1182	4.8	585.0	2.02
Lev 4-8: Lab W R451.M	5	17.4	Jan 2000	851	0.0	515.0	1.65
Lev 4-8: Lab W R451.R	5	33.9	Jan 2000	1661	0.0	1005.0	1.65
Lev 4-8: Microscopy S21	5	3.0	Jan 2000	147	0.0	50.0	2.94
Lev 4-8: Microscopy S28	5	3.0	Jan 2000	147	0.0	50.0	2.94
Lev 4-8: Microscopy S40	5	3.0	Jan 2000	147	0.0	50.0	2.94
Lev 4-8: Microscopy S41	5	3.0	Jan 2000	147	0.0	50.0	2.94
Lev 4-8: Tis Cul R454	5	8.1	Jan 2000	398	0.0	135.0	2.94
Lev 4-8: Tis Cul R439	5	8.1	Jan 2000	398	0.0	135.0	2.94
Lev 4-8: Lab S (S20)	5	13.5	Jan 2000	663	0.0	225.0	2.94

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft^2)	Space CFM/ft^2
Lev 4-8: Lab S (S31)	5	13.5	Jan 2000	663	0.0	225.0	2.94
Zone 2							
Lev 4-8: IDF	5	23.1	Jan 2000	1072	0.0	105.0	10.21
Zone 3							
Lev 4-8: Electrical	5	21.5	Jan 2000	667	0.0	140.0	4.76

Air System Sizing Summary for AHU-L.2a & L.2b

Project Name: Baylor College Of Medicine — 10/31/2005
Prepared by: psuae — 03:37AM

Air System Information

Air System Name	**AHU-L.2a & L.2b**		Number of zones	**3**	
Equipment Class	**CW AHU**		Floor Area	**43625.0**	ft²
Air System Type	**VAV**		Location	**Houston, Texas**	

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM	**Peak zone sensible load**	Calculation Months	**Jan to Dec**
Space CFM	**Individual peak space loads**	Sizing Data	**Calculated**

Central Cooling Coil Sizing Data

Total coil load	**239.2**	Tons	Load occurs at	**Aug 1500**	
Total coil load	**2870.8**	MBH	OA DB / WB	**96.0 / 77.0**	°F
Sensible coil load	**2160.2**	MBH	Entering DB / WB	**82.0 / 66.2**	°F
Coil CFM at Aug 1500	**70477**	CFM	Leaving DB / WB	**53.5 / 52.2**	°F
Max block CFM at Oct 1500	**81964**	CFM	Coil ADP	**50.4**	°F
Sum of peak zone CFM	**82043**	CFM	Bypass Factor	**0.100**	
Sensible heat ratio	**0.752**		Resulting RH	**41**	%
ft²/Ton	**182.4**		Design supply temp.	**55.0**	°F
BTU/(hr-ft²)	**65.8**		Zone T-stat Check	**3 of 3**	OK
Water flow @ 15.0 °F rise	**382.98**	gpm	Max zone temperature deviation	**0.0**	°F

Preheat Coil Sizing Data

Max coil load	**20.3**	MBH	Load occurs at	**Des Htg**	
Coil CFM at Des Htg	**820**	CFM	Ent. DB / Lvg DB	**27.0 / 50.0**	°F
Max coil CFM	**81964**	CFM			
Water flow @ 30.0 °F drop	**1.35**	gpm			

Humidifier Sizing Data

Max steam flow at Des Htg	**9.21**	lb/hr	Air mass flow	**3677.56**	lb/hr
Airflow Rate	**820**	CFM	Moisture gain	**.00251**	lb/lb

Supply Fan Sizing Data

Actual max CFM at Oct 1500	**81964**	CFM	Fan motor BHP	**49.90**	BHP
Standard CFM	**81644**	CFM	Fan motor kW	**37.21**	kW
Actual max CFM/ft²	**1.88**	CFM/ft²			

Outdoor Ventilation Air Data

Design airflow CFM	**18000**	CFM	CFM/person	**48.23**	CFM/person
CFM/ft²	**0.41**	CFM/ft²			

Air System Design Load Summary for AHU-L.2a & L.2b

Project Name: Baylor College Of Medicine 10/31/2005
Prepared by: psuae 03:37AM

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1500 COOLING OA DB / WB 96.0 °F / 77.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 27.0 °F / 22.7 °F		
ZONE LOADS	**Details**	**Sensible (BTU/hr)**	**Latent (BTU/hr)**	**Details**	**Sensible (BTU/hr)**	**Latent (BTU/hr)**
Window & Skylight Solar Loads	3920 ft²	37869	-	3920 ft²	-	-
Wall Transmission	910 ft²	1713	-	910 ft²	4094	-
Roof Transmission	0 ft²	0	-	0 ft²	0	-
Window Transmission	3920 ft²	28502	-	3920 ft²	68796	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	0 ft²	0	-	0 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	70673 W	220052	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	406763 W	1333179	-	0	0	-
People	373	81345	76506	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	**-**	**1702659**	**76506**	**-**	**72890**	**0**
Zone Conditioning	-	1672238	76506	-	50871	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Return Fan Load	52477 CFM	0	-	87 CFM	0	-
Ventilation Load	18000 CFM	377512	634001	820 CFM	37064	9720
Supply Fan Load	70477 CFM	110442	-	820 CFM	-27426	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	**-**	**2160192**	**710507**	**-**	**60510**	**9720**
Central Cooling Coil	-	2160192	710594	-	-23012	0
Preheat Coil	-	0	-	-	20300	-
Humidification Load	-	-	0	-	-	9720
Terminal Reheat Coils	-	0	-	-	0	-
Zone Heating Unit Coils	-	0	-	-	63222	-
>> Total Conditioning	**-**	**2160192**	**710594**	**-**	**60510**	**9720**
Key:	**Positive values are clg loads Negative values are htg loads**			**Positive values are htg loads Negative values are clg loads**		

Zone Sizing Summary for AHU-L.1a & L.1b

Project Name: Baylor College Of Medicine — 10/31/2005
Prepared by: psuae — 04:14AM

Air System Information

Air System Name .... **AHU-L.1a & L.1b**
Equipment Class .... **CW AHU**
Air System Type .... **VAV**

Number of zones **2**
Floor Area .... **56220.0** ft²
Location .... **Houston, Texas**

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM .... **Peak zone sensible load**
Space CFM .... **Individual peak space loads**

Calculation Months .... **Jan to Dec**
Sizing Data .... **Calculated**

Zone Sizing Data

Zone Name	Maximum Cooling Sensible (MBH)	Design Air Flow (CFM)	Minimum Air Flow (CFM)	Time of Peak Load	Maximum Heating Load (MBH)	Zone Floor Area (ft²)	Zone CFM/ft²
Zone 1	704.1	34445	17223	Jul 1700	144.8	34795.0	0.99
Zone 2	919.0	56250	28125	Oct 1400	47.7	21425.0	2.63

Zone Terminal Sizing Data

Zone Name	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 30.0 °F	Zone Htg Coil Load (MBH)	Zone Htg Water gpm @ 30.0 °F	Mixing Box Fan Airflow (CFM)
Zone 1	315.0	21.01	144.8	9.66	0
Zone 2	514.4	34.31	47.7	3.18	0

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
Zone 1							
Lev 4-8: Off R402-404	5	11.3	Jun 1700	554	3.9	385.0	1.44
Lev 4-8: Off R411-413	5	14.5	Jul 1700	708	3.9	350.0	2.02
Lev 4-8: Off R415-417	5	14.7	Nov 1400	722	3.8	345.0	2.09
Lev 4-8: Office (S4)	5	19.6	Jul 1700	959	5.3	460.0	2.08
Lev 4-8: Meeting (S1)	5	10.8	Jun 1700	526	3.9	230.0	2.29
Lev 4-8: Meeting R414	5	11.1	Sep 1600	542	3.9	230.0	2.36
Lev 4-8: Elev Lobby	5	12.4	Jan 2000	606	0.0	1615.0	0.38
Lev 4-8: Break Area	5	16.2	Jan 2000	793	0.0	785.0	1.01
Lev 4-8: Bathroom	5	6.6	Jan 2000	323	0.0	320.0	1.01
Lev 4-8: Conference	5	12.9	Jan 2000	631	0.0	625.0	1.01
Lev 4-8: Corridor R4C7	5	5.8	Jan 2000	282	0.0	750.0	0.38
Lev 4-8: Corridor R4C6	5	4.9	Jan 2000	240	0.0	640.0	0.38
Level 1: Lobby/Elevetor	1	12.7	Jun 1700	622	7.0	575.0	1.08
Level 1: Corridor R1C1	1	17.6	Jun 1700	860	14.2	545.0	1.58
Zone 2							
Lev 4-8: Lab W R430.L	5	29.6	Nov 1400	1449	4.8	585.0	2.48
Lev 4-8: Lab W R431.L	5	33.9	Jan 2000	1661	0.0	1005.0	1.65
Lev 4-8: Lab W R450.L	5	24.2	Jun 1700	1182	4.8	585.0	2.02
Lev 4-8: Lab W R451.L	5	33.9	Jan 2000	1661	0.0	1005.0	1.65
Lev 4-8: Fume Hood (S14)	5	8.1	Jan 2000	398	0.0	135.0	2.94
Lev 4-8: Fume Hood (S15)	5	8.1	Jan 2000	398	0.0	135.0	2.94
Lev 4-8: Lab S (S13)	5	8.4	Jan 2000	412	0.0	140.0	2.94
Lev 4-8: Lab S (S16)	5	8.4	Jan 2000	412	0.0	140.0	2.94
Lev 4-8: Equip (S17)	5	17.2	Jan 2000	839	0.0	285.0	2.94
Lev 4-8: Tis Cul R439	5	8.1	Jan 2000	398	0.0	135.0	2.94
Lev 4-8: Tis Cul R457	5	8.1	Jan 2000	398	0.0	135.0	2.94

Air System Sizing Summary for AHU-L.1a & L.1b

Project Name: Baylor College Of Medicine — 10/31/2005
Prepared by: psuae — 04:14AM

Air System Information

Air System Name	AHU-L.1a & L.1b		Number of zones	2	
Equipment Class	CW AHU		Floor Area	56220.0	ft²
Air System Type	VAV		Location	Houston, Texas	

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM	Peak zone sensible load		Calculation Months	Jan to Dec
Space CFM	Individual peak space loads		Sizing Data	Calculated

Central Cooling Coil Sizing Data

Total coil load	360.1	Tons	Load occurs at	Aug 1500	
Total coil load	4321.2	MBH	OA DB / WB	96.0 / 77.0	°F
Sensible coil load	2664.8	MBH	Entering DB / WB	88.7 / 72.0	°F
Coil CFM at Aug 1500	70776	CFM	Leaving DB / WB	53.7 / 52.5	°F
Max block CFM at Sep 1600	89983	CFM	Coil ADP	49.8	°F
Sum of peak zone CFM	90695	CFM	Bypass Factor	0.100	
Sensible heat ratio	0.617		Resulting RH	45	%
ft²/Ton	156.1		Design supply temp.	55.0	°F
BTU/(hr-ft²)	76.9		Zone T-stat Check	2 of 2	OK
Water flow @ 15.0 °F rise	576.47	gpm	Max zone temperature deviation	0.0	°F

Preheat Coil Sizing Data

Max coil load	1003.0	MBH	Load occurs at	Des Htg	
Coil CFM at Des Htg	45348	CFM	Ent. DB / Lvg DB	29.4 / 50.0	°F
Max coil CFM	89983	CFM			
Water flow @ 30.0 °F drop	66.90	gpm			

Humidifier Sizing Data

Max steam flow at Des Htg	576.59	lb/hr	Air mass flow	203269.20	lb/hr
Airflow Rate	45348	CFM	Moisture gain	.00284	lb/lb

Supply Fan Sizing Data

Actual max CFM at Sep 1600	89983	CFM	Fan motor BHP	49.90	BHP
Standard CFM	89632	CFM	Fan motor kW	37.21	kW
Actual max CFM/ft²	1.60	CFM/ft²			

Outdoor Ventilation Air Data

Design airflow CFM	56950	CFM	CFM/person	71.74	CFM/person
CFM/ft²	1.01	CFM/ft²			

Air System Design Load Summary for AHU-L.1a & L.1b

Project Name: Baylor College Of Medicine 10/31/2005
Prepared by: psuae 04:14AM

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1500 COOLING OA DB / WB 96.0 °F / 77.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 27.0 °F / 22.7 °F		
ZONE LOADS	**Details**	**Sensible (BTU/hr)**	**Latent (BTU/hr)**	**Details**	**Sensible (BTU/hr)**	**Latent (BTU/hr)**
Window & Skylight Solar Loads	10168 ft²	156084	-	10168 ft²	-	-
Wall Transmission	3120 ft²	6419	-	3120 ft²	14036	-
Roof Transmission	0 ft²	0	-	0 ft²	0	-
Window Transmission	10168 ft²	73930	-	10168 ft²	178448	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	0 ft²	0	-	0 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	91076 W	283583	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	276373 W	905821	-	0	0	-
People	794	173028	162735	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	**-**	**1598865**	**162735**	**-**	**192484**	**0**
Zone Conditioning	-	1568863	162735	-	172282	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Return Fan Load	28705 CFM	0	-	16523 CFM	0	-
Ventilation Load	44794 CFM	994653	1493649	42713 CFM	1919798	608184
Supply Fan Load	70776 CFM	101306	-	45348 CFM	-68914	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	**-**	**2664822**	**1656384**	**-**	**2023166**	**608184**
Central Cooling Coil	-	2664823	1656387	-	0	0
Preheat Coil	-	0	-	-	1002952	-
Humidification Load	-	-	0	-	-	608184
Terminal Reheat Coils	-	0	-	-	829338	-
Zone Heating Unit Coils	-	0	-	-	190875	-
>> Total Conditioning	**-**	**2664823**	**1656387**	**-**	**2023166**	**608184**
Key:	**Positive values are clg loads Negative values are htg loads**			**Positive values are htg loads Negative values are clg loads**		

Zone Sizing Summary for AHU-A.1a, A.1b, A.1c & A.1d

Project Name: Baylor College Of Medicine 10/31/2005
Prepared by: psuae 03:37AM

Air System Information

Air System Name .... **AHU-A.1a, A.1b, A.1c & A.1d**
Equipment Class .... **CW AHU**
Air System Type .... **VAV**

Number of zones **8**
Floor Area .... **31696.0** ft²
Location .... **Houston, Texas**

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM .... **Sum of space airflow rates**
Space CFM .... **Individual peak space loads**

Calculation Months .... **Jan to Dec**
Sizing Data .... **Calculated**

Zone Sizing Data

Zone Name	Maximum Cooling Sensible (MBH)	Design Air Flow (CFM)	Minimum Air Flow (CFM)	Time of Peak Load	Maximum Heating Load (MBH)	Zone Floor Area (ft²)	Zone CFM/ft²
Zone 1	135.6	15265	3335	Jun 1700	15.6	8315.0	1.84
Zone 2	398.6	16110	8055	Jan 2000	0.0	6030.0	2.67
Zone 3	19.8	919	459	Jan 2000	0.0	80.0	11.48
Zone 4	22.5	696	348	Jan 2000	0.0	275.0	2.53
Zone 5	374.4	37825	9573	Oct 1500	45.2	16231.0	2.33
Zone 6	5.8	236	118	Jan 2000	0.0	550.0	0.43
Zone 7	21.0	976	488	Jan 2000	0.0	85.0	11.48
Zone 8	20.0	619	310	Jan 2000	0.0	130.0	4.76

Zone Terminal Sizing Data

Zone Name	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 30.0 °F	Zone Htg Coil Load (MBH)	Zone Htg Water gpm @ 30.0 °F	Mixing Box Fan Airflow (CFM)
Zone 1	61.0	4.07	15.6	1.04	0
Zone 2	147.3	9.83	0.0	0.00	0
Zone 3	8.4	0.56	0.0	0.00	0
Zone 4	3.7	0.25	0.0	0.00	0
Zone 5	175.1	11.68	45.2	3.02	0
Zone 6	2.2	0.14	0.0	0.00	0
Zone 7	8.9	0.60	0.0	0.00	0
Zone 8	3.3	0.22	0.0	0.00	0

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
Zone 1							
Level 1: AHR 126A,D	2	3.4	Jan 2000	370	0.0	115.0	3.22
Level 1: AHR 126B,C	2	3.6	Jan 2000	394	0.0	125.0	3.15
Level 1: AHR 126F,H,J	2	18.9	Jan 2000	2069	0.0	750.0	2.76
Level 1: AHR 126G	1	3.8	Jan 2000	417	0.0	135.0	3.09
Level 1: AHR 126K	1	3.1	Jan 2000	334	0.0	100.0	3.34
Level 1: Proc 126JA,HA	1	4.3	Jan 2000	474	0.0	130.0	3.65
Level 1: Proc. 126FA	1	5.2	Jan 2000	572	0.0	160.0	3.58
Level 1: Corridor	1	0.7	Jan 2000	76	0.0	90.0	0.84
Level 1: Corridor R102	1	5.9	Jun 1700	643	5.2	125.0	5.15
Level 1: Corridor R1C2	1	8.9	Jun 1700	972	5.2	520.0	1.87
Level 1: Corridor/Janito	1	6.1	Jan 2000	672	0.0	800.0	0.84
Level 1: Break/Training	1	15.9	Jun 1700	1737	5.2	535.0	3.25
Level 1: Fire Command	1	4.0	Jan 2000	439	0.0	195.0	2.25
Level 1: Meeting	1	1.8	Jan 2000	192	0.0	85.0	2.26

Zone Sizing Summary for AHU-A.1a, A.1b, A.1c & A.1d

Project Name: Baylor College Of Medicine — 10/31/2005
Prepared by: psuae — 03:37AM

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
Level 1: Men's R102(1)	1	0.0	Jan 0000	170	0.0	340.0	0.50
Level 1: Office R104B	1	1.7	Jan 2000	191	0.0	85.0	2.25
Level 1: Office R106	1	1.5	Jan 2000	169	0.0	75.0	2.25
Level 1: Office R108	1	1.5	Jan 2000	169	0.0	75.0	2.25
Level 1: Pass Through	1	1.1	Jan 2000	122	0.0	145.0	0.84
Level 1: R1C3 + R114	1	11.6	Jan 2000	1268	0.0	1510.0	0.84
Level 1: Staging	1	1.1	Jan 2000	122	0.0	145.0	0.84
Level 1: Ster. Pass Thro	1	1.2	Jan 2000	134	0.0	160.0	0.84
Level 1: Sterile R1C5	1	1.3	Jan 2000	139	0.0	165.0	0.84
Level 1: Vest + Corridor	1	1.2	Jan 2000	126	0.0	150.0	0.84
Level 1: Vestibule R126	1	0.8	Jan 2000	92	0.0	110.0	0.84
Level 1: Women's R102B	1	0.0	Jan 0000	170	0.0	340.0	0.50
Level 1: Feed Stor R134	1	1.8	Jan 2000	196	0.0	160.0	1.23
Zone 2							
Level 1: Clean Cage	1	124.3	Jan 2000	5024	0.0	1400.0	3.59
Level 1: Dirty Cage	1	124.3	Jan 2000	5024	0.0	1400.0	3.59
Level 1: Gown R128	1	1.5	Jan 2000	60	0.0	165.0	0.36
Level 1: Robotic Transit	1	30.6	Jan 2000	1238	0.0	345.0	3.59
Level 1: Sterile Cage	1	99.9	Jan 2000	4037	0.0	1125.0	3.59
Level 1: Sterile R1C5	1	1.3	Jan 2000	51	0.0	165.0	0.31
Level 1: Ster. Pass Thro	1	1.2	Jan 2000	50	0.0	160.0	0.31
Level 1: Decon Storage	1	5.6	Jan 2000	226	0.0	500.0	0.45
Level 1: Domestic Pump	1	1.6	Jan 2000	66	0.0	145.0	0.45
Level 1: Elev Mach Rm	1	2.6	Jan 2000	105	0.0	120.0	0.87
Level 1: Fire Pump	1	1.3	Jan 2000	52	0.0	115.0	0.45
Level 1: Storage R116	1	2.0	Jan 2000	79	0.0	175.0	0.45
Level 1: Storage R124	1	1.3	Jan 2000	52	0.0	115.0	0.45
Level 1: Storage R130	1	1.1	Jan 2000	45	0.0	100.0	0.45
Zone 3							
Level 1: IDF	1	19.8	Jan 2000	919	0.0	80.0	11.48
Zone 4							
Level 1: Electrical	1	19.2	Jan 2000	595	0.0	125.0	4.76
Level 1: Mechanical	1	3.2	Jan 2000	101	0.0	150.0	0.67
Zone 5							
Level 2: AHR R203	1	14.8	Jan 2000	1431	0.0	540.0	2.65
Level 2: AHR R204,8,10	3	22.4	Jul 1700	2160	2.6	655.0	3.30
Level 2: AHR R207	1	10.3	Jan 2000	992	0.0	330.0	3.01
Level 2: AHR R209	1	15.5	Jan 2000	1494	0.0	570.0	2.62
Level 2: AHR R223	1	17.2	Jan 2000	1661	0.0	650.0	2.56
Level 2: AHR R224	1	17.2	Jan 2000	1661	0.0	650.0	2.56
Level 2: AHR R227	1	17.3	Jan 2000	1672	0.0	655.0	2.55
Level 2: AHR R228	1	19.4	Jan 2000	1870	0.0	750.0	2.49
Level 2: AHR R229	1	17.3	Jan 2000	1672	0.0	655.0	2.55
Level 2: AHR R230	1	17.3	Jan 2000	1672	0.0	655.0	2.55
Level 2: AHR R234	1	15.1	Jan 2000	1462	0.0	555.0	2.64
Level 2: AHR R238	1	14.9	Jan 2000	1444	0.0	546.0	2.64
Level 2: AHR R240	1	19.1	Jan 2000	1849	0.0	740.0	2.50
Level 2: Corridor R2C2	1	6.9	Jan 2000	668	0.0	900.0	0.74
Level 2: Corridor R2C4	1	4.8	Jan 2000	467	0.0	630.0	0.74
Level 2: Corridor R2C5	1	12.3	Nov 1400	1188	4.4	475.0	2.50
Level 2: Corridor R2C6	1	4.8	Jan 2000	464	0.0	625.0	0.74
Level 2: Dirty Staging	1	2.1	Jan 2000	204	0.0	275.0	0.74
Level 2: Elevator Lobby	1	2.4	Jan 2000	234	0.0	315.0	0.74
Level 2: Proc R204A	1	5.3	Jul 1700	513	0.9	135.0	3.80
Level 2: Proc R204B	1	3.8	Jan 2000	369	0.0	135.0	2.73
Level 2: Proc R208A	1	4.9	Jul 1700	472	0.9	115.0	4.10
Level 2: Feed Storage	1	1.1	Jan 2000	108	0.0	100.0	1.08

Zone Sizing Summary for AHU-A.1a, A.1b, A.1c & A.1d

Project Name: Baylor College Of Medicine 10/31/2005
Prepared by: psuae 03:37AM

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft^2)	Space CFM/ft^2
Level 2: R203A,3B,9A,9B	4	3.2	Jan 2000	306	0.0	105.0	2.91
Level 2: R2C1+R200,etc	1	21.8	Jun 1700	2108	13.9	1150.0	1.83
Level 2: R2C5+R211+etc	1	38.0	Nov 1400	3672	17.3	650.0	5.65
Level 2: Vest + Ster	1	5.0	Jan 2000	482	0.0	650.0	0.74
Level 2: Vestibule	1	3.0	Jan 2000	293	0.0	395.0	0.74
Zone 6							
Level 2: Gown R237	1	1.3	Jan 2000	53	0.0	145.0	0.36
Level 2: Storage	1	1.2	Jan 2000	48	0.0	105.0	0.45
Level 2: Storage + Irrad	1	3.4	Jan 2000	136	0.0	300.0	0.45
Zone 7							
Level 2: IDF	1	21.0	Jan 2000	976	0.0	85.0	11.48
Zone 8							
Level 2: Electrical	1	20.0	Jan 2000	619	0.0	130.0	4.76

Air System Sizing Summary for AHU-A.1a, A.1b, A.1c & A.1d

Project Name: Baylor College Of Medicine — 10/31/2005
Prepared by: psuae — 03:37AM

Air System Information

Air System Name	AHU-A.1a, A.1b, A.1c & A.1d		Number of zones	8	
Equipment Class	CW AHU		Floor Area	31696.0	ft²
Air System Type	VAV		Location	Houston, Texas	

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM	Sum of space airflow rates		Calculation Months	Jan to Dec	
Space CFM	Individual peak space loads		Sizing Data	Calculated	

Central Cooling Coil Sizing Data

Total coil load	272.9	Tons	Load occurs at	Aug 1500	
Total coil load	3275.1	MBH	OA DB / WB	96.0 / 77.0	°F
Sensible coil load	1847.2	MBH	Entering DB / WB	96.0 / 77.0	°F
Coil CFM at Aug 1500	40949	CFM	Leaving DB / WB	54.1 / 53.0	°F
Max block CFM at Sep 1500	71404	CFM	Coil ADP	49.4	°F
Sum of peak zone CFM	72646	CFM	Bypass Factor	0.100	
Sensible heat ratio	0.564		Resulting RH	39	%
ft²/Ton	116.1		Design supply temp.	55.0	°F
BTU/(hr-ft²)	103.3		Zone T-stat Check	8 of 8	OK
Water flow @ 15.0 °F rise	436.92	gpm	Max zone temperature deviation	0.0	°F

Preheat Coil Sizing Data

Max coil load	561.3	MBH	Load occurs at	Des Htg	
Coil CFM at Des Htg	22687	CFM	Ent. DB / Lvg DB	27.0 / 50.0	°F
Max coil CFM	71404	CFM			
Water flow @ 30.0 °F drop	37.44	gpm			

Humidifier Sizing Data

Max steam flow at Des Htg	249.49	lb/hr	Air mass flow	101692.30	lb/hr
Airflow Rate	22687	CFM	Moisture gain	.00245	lb/lb

Supply Fan Sizing Data

Actual max CFM at Sep 1500	71404	CFM	Fan motor BHP	49.90	BHP
Standard CFM	71125	CFM	Fan motor kW	37.21	kW
Actual max CFM/ft²	2.25	CFM/ft²			

Outdoor Ventilation Air Data

Design airflow CFM	65850	CFM	CFM/person	167.19	CFM/person
CFM/ft²	2.08	CFM/ft²			

Air System Design Load Summary for AHU-A.1a, A.1b, A.1c & A.1d

Project Name: Baylor College Of Medicine — 10/31/2005
Prepared by: psuae — 03:37AM

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1500 COOLING OA DB / WB 96.0 °F / 77.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 27.0 °F / 22.7 °F		
ZONE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	3160 ft²	38224	-	3160 ft²	-	-
Wall Transmission	1200 ft²	2421	-	1200 ft²	5398	-
Roof Transmission	0 ft²	0	-	0 ft²	0	-
Window Transmission	3160 ft²	22976	-	3160 ft²	55458	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	0 ft²	0	-	0 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	50246 W	156450	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	206236 W	675945	-	0	0	-
People	394	85849	80742	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	**-**	**981865**	**80742**	**-**	**60856**	**0**
Zone Conditioning	-	977252	80742	-	46870	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Return Fan Load	4409 CFM	0	-	1723 CFM	0	-
Ventilation Load	40949 CFM	828898	1347173	22687 CFM	1003135	263163
Supply Fan Load	40949 CFM	41072	-	22687 CFM	-17856	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	**-**	**1847222**	**1427915**	**-**	**1032150**	**263163**
Central Cooling Coil	-	1847222	1427915	-	0	0
Preheat Coil	-	0	-	-	561341	-
Humidification Load	-	-	0	-	-	263163
Terminal Reheat Coils	-	0	-	-	409953	-
Zone Heating Unit Coils	-	0	-	-	60856	-
>> Total Conditioning	**-**	**1847222**	**1427915**	**-**	**1032150**	**263163**
Key:	**Positive values are clg loads Negative values are htg loads**			**Positive values are htg loads Negative values are clg loads**		

1. Annual Coil Loads

Component	Load (kBTU)	(kBTU/ft²)
Cooling Coil Loads	51,281,000	389.848
Heating Coil Loads	1,697,024	12.901
Grand Total	**52,978,024**	**402.749**

2. Energy Consumption by System Component

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)	Source Energy (kBTU)	Source Energy (kBTU/ft²)
Air System Fans	2,210,349	16.804	7,894,103	60.013
Cooling	8,788,251	66.810	31,386,612	238.607
Heating	1,697,024	12.901	1,697,024	12.901
Pumps	536,344	4.077	1,915,515	14.562
Cooling Towers	3,387,235	25.750	12,097,270	91.966
HVAC Sub-Total	**16,619,203**	**126.342**	**54,990,523**	**418.049**
Lights	6,336,376	48.170	22,629,912	172.037
Electric Equipment	26,582,176	202.083	94,936,352	721.724
Misc. Electric	0	0.000	0	0.000
Misc. Fuel Use	0	0.000	0	0.000
Non-HVAC Sub-Total	**32,918,552**	**250.253**	**117,566,264**	**893.761**
Grand Total	**49,537,755**	**376.596**	**172,556,787**	**1311.810**

Notes:
1. 'Cooling Coil Loads' is the sum of all air system cooling coil loads.
2. 'Heating Coil Loads' is the sum of all air system heating coil loads.
3. Site Energy is the actual energy consumed.
4. Source Energy is the site energy divided by the electric generating efficiency (28.0%).
5. Source Energy for fuels equals the site energy value.
6. Energy per unit floor area is based on the gross building floor area.
   Gross Floor Area .... **131541.0** ft²
   Conditioned Floor Area .... **131541.0** ft²

1. Annual Coil Loads

Component	Load (kBTU)	(kBTU/ft²)
Cooling Coil Loads	51,281,000	389.848
Heating Coil Loads	1,697,024	12.901
Grand Total	**52,978,024**	**402.749**

2. Energy Consumption by Energy Source

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)	Source Energy (kBTU)	Source Energy (kBTU/ft²)
HVAC Components				
Electric	14,921,924	113.439	53,292,584	405.141
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Hot Water	373,890	2.842	373,890	2.842
Remote Steam	1,323,135	10.059	1,323,135	10.059
Remote Chilled Water	0	0.000	0	0.000
HVAC Sub-Total	**16,618,948**	**126.340**	**54,989,608**	**418.042**
Non-HVAC Components				
Electric	32,919,014	250.257	117,567,888	893.774
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Hot Water	0	0.000	0	0.000
Remote Steam	0	0.000	0	0.000
Non-HVAC Sub-Total	**32,919,014**	**250.257**	**117,567,888**	**893.774**
Grand Total	**49,537,962**	**376.597**	**172,557,496**	**1311.815**

Notes:
1. 'Cooling Coil Loads' is the sum of all air system cooling coil loads.
2. 'Heating Coil Loads' is the sum of all air system heating coil loads.
3. Site Energy is the actual energy consumed.
4. Source Energy is the site energy divided by the electric generating efficiency (28.0%).
5. Source Energy for fuels equals the site energy value.
6. Energy per unit floor area is based on the gross building floor area.
   Gross Floor Area .... **131541.0** ft²
   Conditioned Floor Area .... **131541.0** ft²

Appendix B – Schedules

AIR HANDLING UNIT SCHEDULE

Tag #	Location	Service	CFM	Quantity	Supply Fan						Hot Water Preheat Coil								
											Air Side				Water Side				
					Fan Type	Min S.P.	Max BHP	Min MHP	RPM	VFD	Max Face Velocity (FPM)	EDB (°F)	LDB (°F)	Max ΔP Inch H_2O	Flow GPM	EWT (°F)	LWT (°F)	Max ΔP feet H_2O	Max Face Velocity (FPM)
AHU-L.1a	Level 3 M.E.R.	Lab/Office	50,000	2	PLUG	9.0	49.9	60	1190	Yes	500	20	50	0.1	114	190	160	3.0	450
AHU-L.1b	Level 3 M.E.R.	Lab/Office	50,000	2	PLUG	9.0	49.9	60	1190	Yes	500	20	50	0.1	114	190	160	3.0	450
AHU-L.2a	Level 3 M.E.R.	Lab	50,000	2	PLUG	9.0	49.9	60	1190	Yes	500	20	50	0.1	114	190	160	3.0	450
AHU-L.2b	Level 3 M.E.R.	Lab	50,000	2	PLUG	9.0	49.9	60	1190	Yes	500	20	50	0.1	114	190	160	3.0	450
AHU-A.1a	Level 3 M.E.R.	Animal Facility	25,000	1	PLUG	9.0	49.9	60	1190	Yes	500	20	50	0.1	57	190	160	3.0	450
AHU-A.1b	Level 3 M.E.R.	Animal Facility	25,000	1	PLUG	9.0	49.9	60	1190	Yes	500	20	50	0.1	57	190	160	3.0	450
AHU-A.1c	Level 3 M.E.R.	Animal Facility	25,000	1	PLUG	9.0	49.9	60	1190	Yes	500	20	50	0.1	57	190	160	3.0	450
AHU-A.1d	Level 3 M.E.R.	Animal Facility	25,000	1	PLUG	9.0	49.9	60	1190	Yes	500	20	50	0.1	57	190	160	3.0	450
AHU-R.1	Level 3 M.E.R.	Level 3. M.E.R.	10,000	1	PLUG	3.0	-	10	-	No	-	-	-	-	-	-	-	-	450
AHU-R.2	Level 3 M.E.R.	Level 3 Elec	10,000	1	PLUG	3.0	-	10	-	No	-	-	-	-	-	-	-	-	450
AHU-S.1	Roof	Stair Press. (N)	15,000	1	PLUG	3.5	-	15	-	Yes	-	-	-	-	-	-	-	-	450
AHU-S.2	Roof	Stair Press. (S)	10,000	1	PLUG	3.5	-	10	-	Yes	-	-	-	-	-	-	-	-	450

Chilled Water Coiling Cool										Leaving Air Temperature	Power
Air Side					Water Side						
EDB (°F)	EWB (°F)	LDB (°F)	LWB (°F)	Max ΔP Inch H_2O	Flow GPM	EWT (°F)	LWT (°F)	Max ΔP feet H_2O			
97	80	51.4	51.1	1.25	680.6	45	60	16		56	480V/3PH/60HZ
97	80	51.4	51.1	1.25	680.6	45	60	16		56	480V/3PH/60HZ
97	80	51.4	51.1	1.25	680.6	45	60	16		56	480V/3PH/60HZ
97	80	51.4	51.1	1.25	680.6	45	60	16		56	480V/3PH/60HZ
97	80	51.4	51.1	1.25	340.3	45	60	16		56	480V/3PH/60HZ
97	80	51.4	51.1	1.25	340.3	45	60	16		56	480V/3PH/60HZ
97	80	51.4	51.1	1.25	340.3	45	60	16		56	480V/3PH/60HZ
97	80	51.4	51.1	1.25	340.3	45	60	16		56	480V/3PH/60HZ
80	66	60	59	-	-	45	60	-		62	480V/3PH/60HZ
80	66	60	59	-	-	45	60	-		62	480V/3PH/60HZ
78	65	54	53.5	-	-	45	60	-		56	480V/3PH/60HZ
78	65	54	53.5	-	-	45	60	-		56	480V/3PH/60HZ

CENTRIFUGAL CHILLER SCHEDULE

Tag #	Nom Tons	Electric Data			Evaporator				Condenser			Compressor Data		
		Volts	Phase	Full Load Amps	EWT (°F)	LWT (°F)	GPM	FLUID	EWT (°F)	LWT (°F)	GPM	RLA	KW RATING	kW/TON MAX
CH-3	1300	4160	3	130	44	56	2600	WATER	88	97.5	3900	121.3	817	0.63

FAN COIL UNIT SCHEDULE																
			Fan		Motor Data @ 60HZ				Chilled Water Coil @ 75Fdb/63Fwb EAT						
Tag #	Location	Service	CFM	RPM	WATTS	RPM	VOLTS	PHASE	SENS MBH	TOTAL MBH	EWT (°F)	LWT (°F)	GPM	Max ΔP Inch H_2O	Unit Type
FCU-1	See Plans	Lab Eqpt Rm	600	-	250	-	120	1	12	-	50	60	-	-	Horizontal
FCU-2	Level 3 M.E.R.	Emer Elec Rm	600	-	250	-	120	1	12	-	50	60	-	-	Vertical
FCU-3	See Plans	Elev Mach Rm	1800	-	250	-	120	1	36	-	50	60	-	-	Horizontal

FAN SCHEDULE

Tag #	Location	Service	CFM	SP (In. H_2O)	RPM	Fan Type	VFD	Motor Data @ 60 HZ				
								MBHP	MHP	RPM	VOLTS	PHASE
EX-L.1a	ROOF	Lab Exhaust	40,000	4.0	970	SWSI	Yes	43.9	50	1800	480	3
EX-L.1b	ROOF	Lab Exhaust	40,000	4.0	970	SWSI	Yes	43.9	50	1800	480	3
EX-L.2a	ROOF	Lab Exhaust	40,000	4.0	970	SWSI	Yes	43.9	50	1800	480	3
EX-L.2b	ROOF	Lab Exhaust	40,000	4.0	970	SWSI	Yes	43.9	50	1800	480	3
EX-A.1	ROOF	Animal Exhaust	50,000	4.0	1130	SWSI	Yes	67.6	75	1800	480	3
EX-A.2	ROOF	Animal Exhaust	50,000	4.0	1130	SWSI	Yes	67.6	75	1800	480	3
EX-1	ROOF	General Exh (W)	4000	1.5	1380	Roof MTD	No	1.7	3	1800	480	3
EX-2	ROOF	General Exh (E)	1600	1.5	1580	Roof MTD	No	0.8	1.5	1800	480	3
EX-3	ROOF	Chemical Storage	1750	1.5	-	In-Line UP	No	-	1.5	1800	480	3
EX-4a	ROOF	Animal BSC Exh	15,075	5.5	1418	SWSI	Yes	19.3	25	1800	480	3
EX-4b	ROOF	Animal BSC Exh	15,075	5.5	1418	SWSI	Yes	19.3	25	1800	480	3
EX-5	ROOF	L1 Cagewash Exh	6800	3.0	1482	SWSI	No	5.1	7.5	1800	480	3
EX-6	ROOF	L1 Gas Decon Exh	250	1.0	1580	SWSI	No	0.1	0.5	1800	480	3
EX-7	ROOF	L3 Cylinder Exh	300	1.0	1580	SWSI	No	0.1	0.5	1800	480	3
EX-8	ROOF	Snorkel Exh (N)	10,000	4.0	-	SWSI	Yes	-	15	1800	480	3
EX-9	ROOF	Snorkel Exh (S)	10,000	4.0	-	SWSI	Yes	-	15	1800	480	3
EX-10	ROOF	L4 Special Lab Exh	1200	4.0	2690	SWSI	No	1.3	2	1800	480	3
EX-11	ROOF	L5 Special Lab Exh	1200	4.0	2690	SWSI	No	1.3	2	1800	480	3
EX-12	ROOF	L6 Special Lab Exh	1200	4.0	2690	SWSI	No	1.3	2	1800	480	3
EX-13	ROOF	L7 Special Lab Exh	1200	4.0	2690	SWSI	No	1.3	2	1800	480	3
EX-14	ROOF	L8 Special Lab Exh	1200	4.0	2690	SWSI	No	1.3	2	1800	480	3
RF-L.1	LEVEL 3 M.E.R.	Office Return	47,000	3.0	1238	Mixed Flow	Yes	42.33	50	1800	480	3
SF-1	ROOF	Stair Press (E)	15,000	1.0	-	Mixed Flow	Yes	-	5	1800	480	3

WATER PUMP SCHEDULE

Tag #	Location	Service	GPM	Total Head (Ft. H_2O)	Type	VFD	Motor Data @ 60 HZ				
							BHP	MHP	RPM	VOLTS	PHASE
HWP-1	LEVEL 3 M.E.R.	Heating HW	950	65.0	End Suction	Yes	-	25	1750	480	3
HWP-2	LEVEL 3 M.E.R.	Heating HW	950	65.0	End Suction	Yes	-	25	1750	480	3
HWP-L.*	LEVEL 3 M.E.R.	AHU-L.* PHC	114	10.0	In-Line	No	-	1	1750	480	3
HWP-A.*	LEVEL 3 M.E.R.	AHU-A.* PHC	57	10.0	In-Line	No	-	0.5	1750	480	3
CHP-1	LEVEL 3 M.E.R.	Building CHW	2720	60.0	Double Suction	Yes	-	60	1780	480	3
CHP-2	LEVEL 3 M.E.R.	Building CHW	2720	60.0	Double Suction	Yes	-	60	1780	480	3
CHP-3	LEVEL 3 M.E.R.	Animal/Process CHW	1720	60.0	Double Suction	Yes	-	40	1765	480	3
CHP-4	LEVEL 3 M.E.R.	Animal/Process CHW	1,720	60.0	Double Suction	Yes	-	40	1765	480	3
PCHP-1	LEVEL 3 M.E.R.	Process CHW	360	100.0	End Suction	Yes	12.1	20	1750	480	3
PCHP-1	LEVEL 3 M.E.R.	Process CHW	360	100.0	End Suction	Yes	12.1	20	1750	480	3

PLATE & FRAME HEAT EXCHANGER SCHEDULE

Tag #	Location	Service	SIDE A (Process Chilled Water)						Side B (Campus Chilled Water)					
			EWT (°F)	LWT (°F)	GPM	Fluid	P.D. (PSI)	Fouling Factor	EWT (°F)	LWT (°F)	GPM	Fluid	P.D. (PSI)	Fouling Factor
PFX-1	Level-3 M.E.R.	Process Chilled Water	50	9	360	Water	10	0.0005	45	60	360	Water	10	0.0005

HEAT EXCHANGER (STEAM-WATER) SCHEDULE

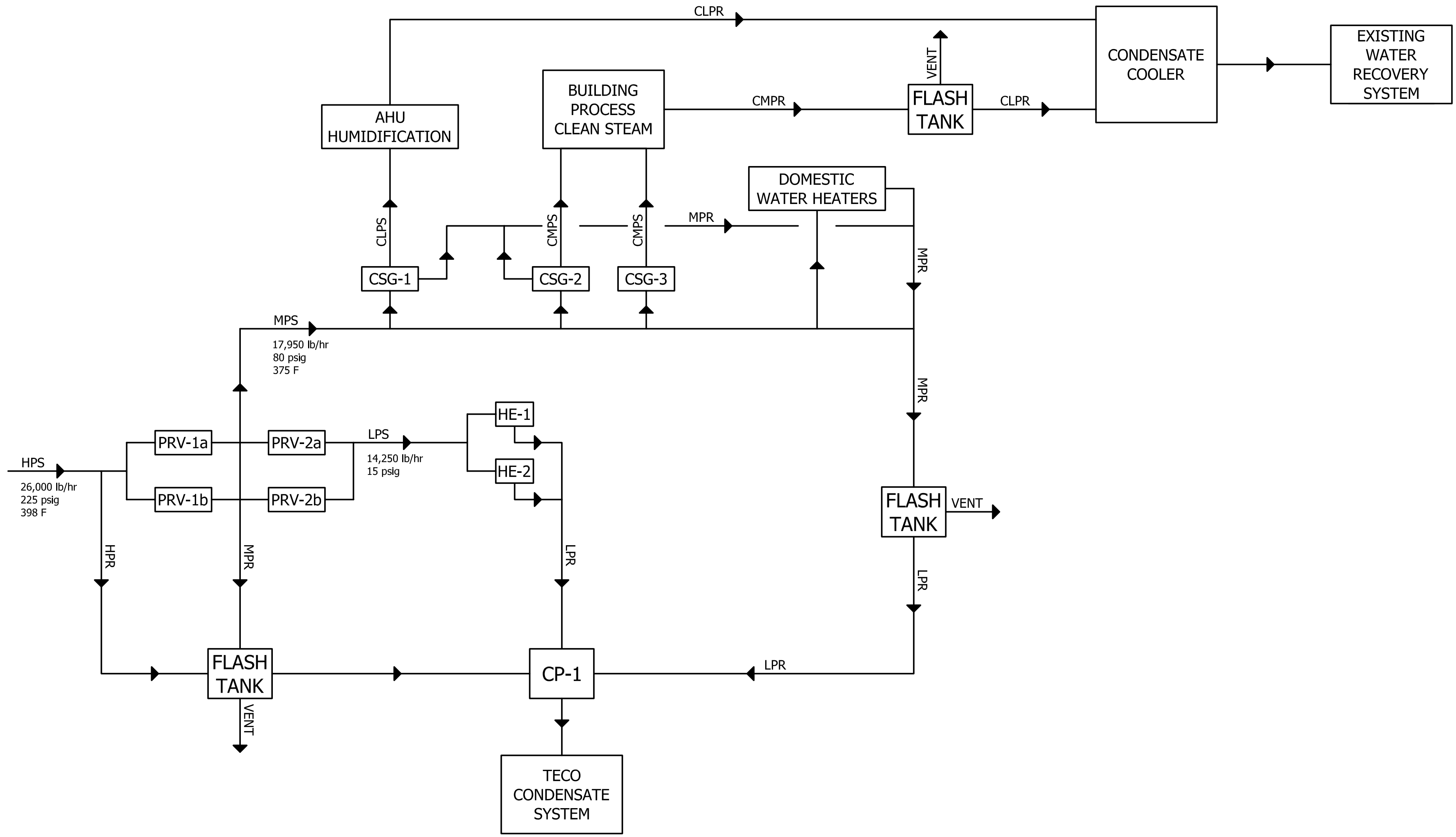
Tag #	Location	Service	No. of Passes	Water Side (Tube)					Steam Side (Shell)		
				EWT (°F)	LWT (°F)	GPM	Min MBH	Pressure Rating	Oper. Pressure	#'s Per HR	Pressure Rating
HE-1	Level-3 M.E.R.	Heating Hot Water	2	160	190	950	14,250	150	2	14,850	150
HE-2	Level-3 M.E.R.	Heating Hot Water	2	160	190	950	14,250	150	2	14,850	150

CLEAN STEAM GENERATOR (STEAM-STEAM) SCHEDULE

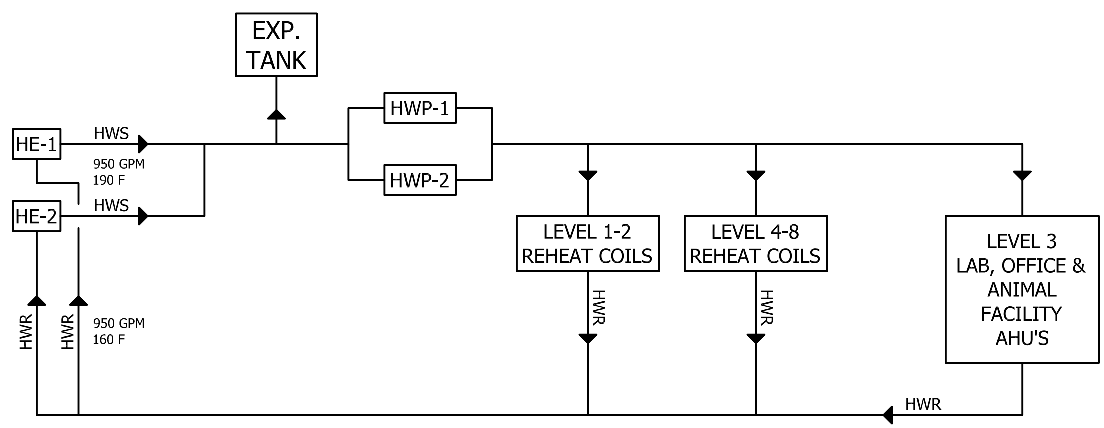
Tag #	Location	Service	ASME Pressure Rating	No. of Passes	Shell Side (Water)					Tube Side (Campus Steam)		
					Feed Water		Operating Pressure	Steam Load (Lbs/Hr)	Fouling Factor	Oper. Pressure	Steam Load (Lbs/Hr)	Fouling Factor
					EWT (°F)	GPM						
CSG-1	Level-3 M.E.R.	Humidification (LP)	150	2	50	9	10	4,100	0.001	80	5,350	0.001
CSG-2	Level-3 M.E.R.	Process (MP)	150	2	50	10	55	4,800	0.001	80	6,300	0.001
CSG-3	Level-3 M.E.R.	Process (MP)	150	2	50	10	55	4800	0.001	80	6,300	0.001

Appendix C – Enlarged Schematics

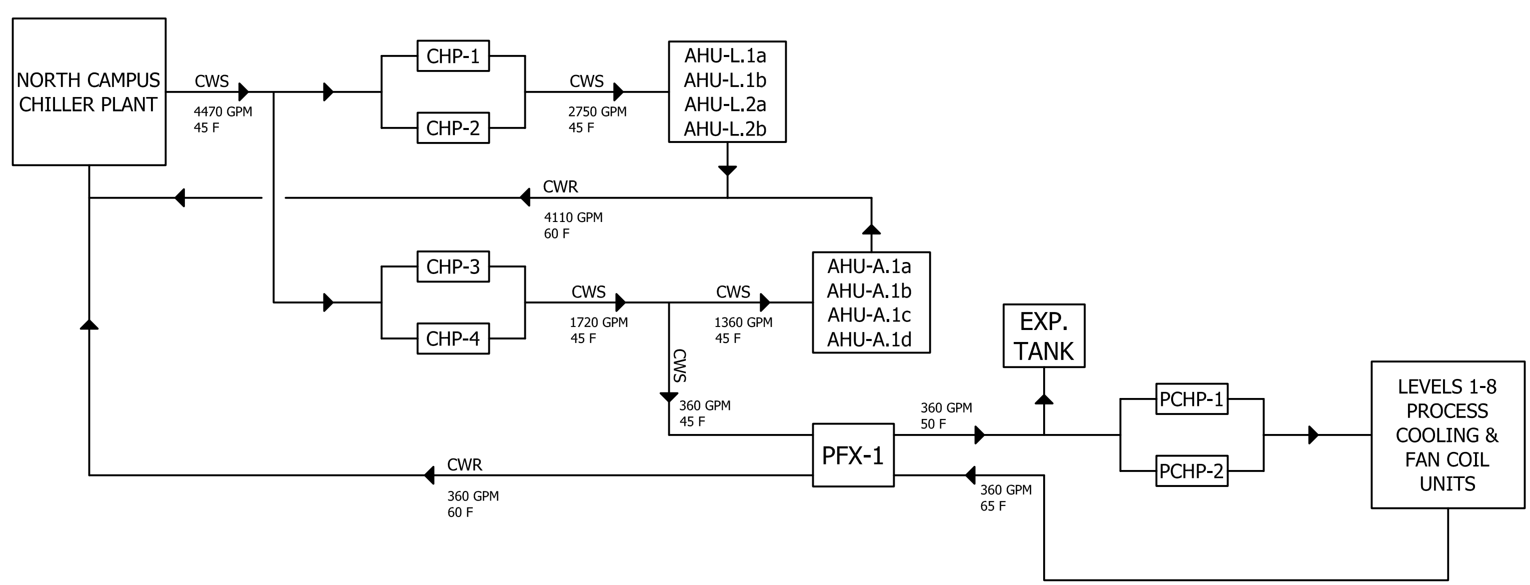
BUILDING STEAM SYSTEM



BUILDING HEATING HOT WATER SYSTEM



BUILDING CHILLED WATER SYSTEM



BUILDING AIR SYSTEMS