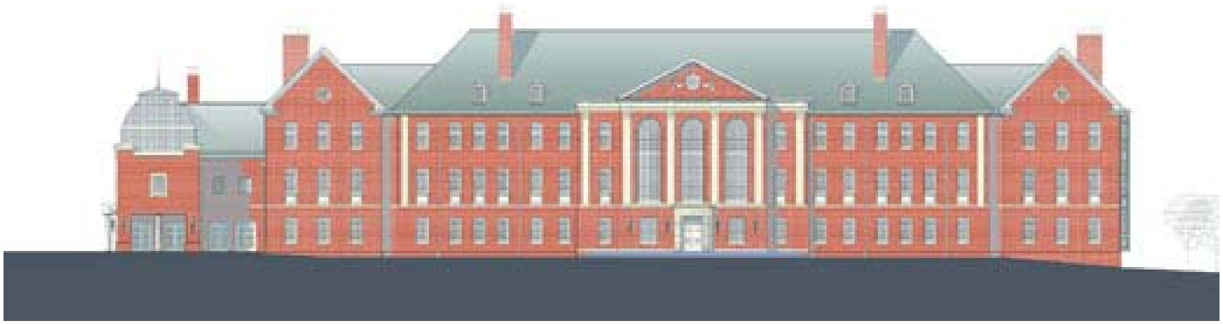
TECHNICAL REPORT 3

Mechanical Systems – Existing Conditions & Evaluation



Ann & Richard Barshinger Life Science & Philosophy Building

Franklin & Marshall College

Lancaster, PA

Brian Ault

The Pennsylvania State University

Architectural Engineering

Mechanical Option

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Executive Summary

The Barshinger Life Science & Philosophy Building (LS&P) at Franklin & Marshall College (F&M) in Lancaster, PA is F&M's new laboratory, office, and classroom facility for the Biology, Psychology, and Philosophy departments and their associated education spaces. It is a 3-story building plus basement. This steel braced-frame structure encompasses 104,000 square feet.

This report summarizes the existing equipment, its intended operation, and provides a critique of the system, providing coverage of good design areas, and areas that could not/were not explored.

Modified flow diagrams are provided at the end of the report to show simple flows within the mechanical systems for the entire building, as well as the central chilled water distribution system for campus. Modified equipment lists are also provided.

The mechanical system that was chosen for the Life Science & Philosophy Building is designed to provide sufficient ventilation throughout the building's single air distribution system for the great amounts of exhaust taken from all the labs. This is based on old tried-and-true methods of design, and is fairly simple, and will likely last for many years.

Design Objectives & Requirements

This new Life Science & Philosophy Building at Franklin and Marshall College is partially funded by a gift from Ann & Richard Barshinger. This is the second building with their namesake at the F&M campus. The building provides a common space for the Biology, Psychology, and Philosophy Departments, as well as the Biological Foundations of Behavior and Scientific and Philosophical Studies of the Mind Programs. These labs, support offices/student spaces, faculty offices, and common study areas partly replace older facilities spread throughout the campus, and provide 40% more area for these departments and programs to spread and continue their growth, as well as provide the most cutting-edge resources to the students and faculty studying at F&M.

F&M has not been building many new facilities in recent years, mostly due to a dislike of the look and feel of most "new, sleek" buildings. Much care was taken to have this new facility blend with the rest of campus. The planned location was in place of 11 turf tennis courts to the west of the faculty/staff parking lot, and to the north of the Central Utilities Plant. This put the new building right at the heart of old campus. The college told EYP that a Colonial-Revival building was the look they wanted, clad in brick to match the older buildings on campus, one in particular – Fackenthal Science Building. This, and the addition of a $1.1Million Vermont Slate Roof, allows the building to blend in, at least partly, with the other core campus buildings.

This is to be the first of a few buildings slated for construction in the northwest quadrant of campus. Most of the infrastructure of "old campus" has been pushed to its limits, including the central chilled water plant. Originally, 4,000 square feet of floor space in the basement was planned for a new chiller plant, with all cooling towers placed on the flat hidden section of the new building's roof. However, after the soils reports came back, this plan was scrapped, and the building's chiller was relocated. The soil under the tennis courts was extremely rocky, so excavation was expensive. Because of this, the excavation for the chiller plant was eliminated, and kept to only the minimum needed for the vivarium, and vital mechanical systems. The building's chiller was moved to the central plant, and crammed into a very tight spot next to an existing chiller, but the tower was kept on the new roof. The new growth/master plan is to place the chiller plant (if possible) in one of the new buildings, or to place one chiller in each of those buildings, and locate the towers on the new building. Also planned is a reduction of the Central Utilities Plant, back to the original 1932 building. That requires shifting the existing chillers in the building to towers located on the roof of the new building. There is a great deal of space available up there, and it will be packed full of cooling towers within 15 years.

One other new feature of the building is not quite so obvious to us. Most students are accustomed to having areas to lounge, study, and relax, usually located in close proximity to their work areas. Because most of the space these labs and centers were in before was extremely cramped, no space was given to the students for use at their discretion. The new LS&P Building allows room for the students to relax and study, with close access to the best resources they have during their class times. Also to be included for the students was a café, now located in the central atrium. Many students (and faculty/staff too) do not have time for a walk to less-than-healthy options downtown a few blocks away, so a source of healthy, to-go food was needed in the central area of campus.

The great number of labs contained in the building caused a great deal of airflow to be needed. This also requires a great deal of equipment that is not known for its aesthetic quality. To hide this, the building gives a large area of the roof to mechanical equipment, hidden behind the sloped slate sections of roof. This allowed the two main air handlers, all three exhaust air handlers, the summer boiler, cooling tower, and all condensing units (for environmental chambers) to be placed on the roof without ever being seen. There is one working gas fireplace in the building located in the Humanities Common Room on the first floor, but there are four main chimneys. All four are false chimneys, and only exist from the roof slab up, but two of them are used to disguise the discharges from the exhaust air handlers.

Design Conditions

The outdoor design conditions for Lancaster Pennsylvania used by Einhorn-Yaffee-Prescott for the Barshinger Life Science & Philosophy Building are called out in the Air Handler schedule as the outdoor conditions. The summer design is based on a 92°F dry-bulb temperature with coincident wet bulb of 78°F, with winter sizing at 0°F. The ASHRAE Fundamentals calls out design temperatures at 99.6% as 8°F dry-bulb for heating, 93°F dry-bulb/74°F wet bulb for cooling. The building is sized to meet 100% of the heating load (minimum extreme was 0.8°F), but could fall short on the maximum extreme day of 97°F dry-bulb/81°F wet bulb.

The interior of the building is rather simple for thermal comfort design. All heating/cooling setpoints for both occupied and unoccupied modes of operation are adjustable for each thermostat by the building's DDC control system. The initial setpoints for occupied times are cooling to 72°F, heating to 70°F, and during unoccupied times heating to 65°F and cooling to 85°F. These are the initial setpoints for all spaces, regardless of occupancy, size, type or location. Schedules of occupancy are listed on the controls legend; two are defined. "Lab & Support" spaces are to be scheduled as occupied 24 hours a day, 7 days a week. These spaces include the entire vivarium, most laboratory rooms on the upper floors, and the greenhouse. "Normal" occupied spaces are pretty much everything else – classrooms, the atrium, corridors, offices, etc. These are only scheduled for occupancy from 6am-6pm, Monday-Friday, excluding holidays. These occupancy schedules are to be adjustable by the Building Automation System (BAS) by F&M personnel. Terminal devices in continuously occupied spaces are to always maintain their space's thermal comfort, as measured by the T-Stats, and Humidistats. The remaining spaces that are only intermittently occupied move to their minimum unoccupied ventilation flow rate, and then modulate the reheat coil valve as necessary for heating, and slowly modulate to allow more airflow once the unoccupied cooling setpoint is reached (85°F).

Ventilation Requirements

The Life Science and Philosophy Building was evaluated for its systems' compliance with ASHRAE Standard 62.1-2007 that establishes minimum ventilation requirements for buildings in Technical Report 1. This report found that only AHU-3 which serves the vivarium is in compliance with the standard. The other two units (AHU-1, AHU-2) do not meet the standard outright. They do, however, have CO2 sensors in the return air streams, and if the building's average CO2 levels climb above a setpoint (adjustable), ventilation is increased. The following chart shows the airflow rates for these main air handlers, and their associated exhaust air handlers.

	Type	Supply Max	Supply Min	Outdoor Air Max	Outdoor Air Min	62.1-2007 Calculated OA	Return Max	Return Min	Relief Max	Relief Min
AHU-1	VAV	50,000	20,000	50,000	15,000	11,000	23,000	8,000	23,000	0
AHU-2	VAV	50,000	20,000	50,000	15,000	12,600	23,000	8,000	23,000	0
AHU-3	100% OA	15,000	7,500	15,000	7,500	2,500	-	-	-	-

	Type	Exhaust Max	Exhaust Min
EAHU-1	VAV	30,000	0
EAHU-2	VAV	30,000	0
EAHU-3	VAV	15,000	7,000

Energy Sources / Rates

Electricity is provided to the building from a feeder off the campus' main electrical service to the north of the building along Harrisburg Pike. Service is provided by PPL, rate schedule LP-4 for 12.5kV commercial distribution. The building is not metered separately from the rest of campus, so the rate is applied to the entire campus' 12.5kV distribution network.

Charge	$/kW	$/kWh		
	all billing kW	0-200	201-400	401-up
Distribution	2.312	0.000	0.000	0.000
Competitive Transition	0.139	0.00172	0.00133	0.00116
Intangible Transition	0.744	0.00925	0.00714	0.00623
Capacity & Energy	4.107	0.04987	0.03758	0.03229
Totals	**7.302**	**0.06084**	**0.04605**	**0.03968**

While PPL does provide off-peak meters for shifted heating and cooling application, it does cost an additional $25 each month. Since no form of energy storage exists on campus, and it was not sought during the design of the new LS&P Building, this energy metering was not pursued. PPL currently does not offer any great incentives to include green power in a commercial design, a plan is in the works that will be implemented after the full deregulation of the electricity industry in Pennsylvania after 2009.

Heating for all purposes (space, humidification, sterilization, and service hot water) is provided by the central steam plant during the cooler months of the year, and from a building-located summer boiler to handle the reduced loads. The central plant has two 90psi steam boilers, fired by either natural gas or No. 2 Fuel Oil. These boilers are for steam generation only, and do not provide steam for any cogeneration or other mechanical/drive devices (save one steam-driven backup condensate pump). This "main" steam is used throughout campus, including the LS&P Building, as the steam injected for humidification. Because of this, no advanced water treatment (chemical additives) can be used – introducing that chemical mixture into the airstream for a laboratory could cause experiment-ruining side effects. This causes a bit of scale buildup on the inside of the boilers, so they are shut down each summer for cleaning, when steam demand is at a minimum.

Annual Energy Use

The building is not metered separately from the rest of the Franklin & Marshall campus, so no current building energy use data is available. The Carrier Hourly Analysis Program 4.34 was used to size and estimate the energy users and usage for the building. These results were presented in Technical Report 2, but are summarized in the table below, and in Appendix 1.

	Annual Gross Cost ($/year)	Annual Unitized Gross Cost ($/sf)
Electricity	$178,339	$1.71
Natural Gas	$15,583	$0.15
Total	$193,922	$1.86

Design Heating & Cooling Loads

One of the models created in HAP was used to provide a rough estimate for equipment sizing. The actual rooms were input to the program, and it outputs a description of the size of each air handler's component sizes, and can be used to estimate energy use by the building's overall systems. The design loads did not match those found in the actual building.

A possible reason for this discrepancy is that HAP is primarily used for supply-side design of spaces for comfort. It is not used for laboratory spaces, whose ventilation is primarily driven by the use of exhaust systems within the space. Because of the extremely high exhaust rates, more outdoor air is required for the entire building. This drastically increases the heating and cooling requirements placed on the air handling units. HAP is only able to calculate energy use based on actual lighting (which is quite high), and 62.1-2007 ventilation requirements. One very good thing about this method is that each space is properly ventilated in the model, unlike the actual building, so outdoor air requirements are slightly higher in the model than in the designer's minimum ventilation case.

The tables below summarize the heating and cooling requirements at each of the three air handlers in both the model, and in the real building. AHU-3 is very far off because there is no 100% OA unit type that can be created in HAP. A VAV system is the closest that can be selected. The actual data is provided on the schedules, part of the design documentation provided by Einhorn Yaffee Prescott. A detailed callout of the HAP model is provided in Appendix 3.

Cooling Coil Sizing				
	Calc. C/C tons	Calc. sf/ton	actual C/C tons	actual sf/ton
AHU-1	142.5	267.7	215	177.5
AHU-2	165	249.5	215	191.5
AHU-3	30.1	221	115	57.8

Heating Section Sizing				
	Calc. Sensible (MBH)	Calc. Latent (lbs/hr)	actual Sensible (MBH)	actual Latent (lbs/hr)
AHU-1	28.2	337	2158	851
AHU-2	41	389	2158	851
AHU-3	20.5	71.5	971	511

Intended System Operation

The vast majority of this building's HVAC system is driven by air. All cooling and almost all heating is provided through the building's main air distribution system. There is some hydronic radiation to help offset some heat lost through large exterior glass areas, but all other heating is provided through airstreams within the building. Everything is controlled by a Direct Digital Control system.

All zones (except electrical/telecom rooms, and the main electrical room) have hydronic reheat coils, fed from a central heat exchanger using the campus' steam distribution system. This loop also provides heat to the fin-tube radiators, but they are controlled by two-position valves set on an outdoor temperature reset. Each zone has its own thermostat, which throttles the airflow through each VAV box down to the minimum cooling required, and once the cooling effect is minimized, the reheat valve is opened. If that does not provide enough heat (such as during morning warmup), the box is allowed to open proportionally to increase heat delivery. These spaces (zones) mostly have both general and contaminant source exhaust, since most spaces are labs. Some offices, corridors, and common gathering areas have return air that will be directed back to the main air handling units, since it is free of contaminants. This air is drawn back to the main AHUs (1 and 2 only have return fans) and can then be sent back into the building, or out through a relief damper.

The building's heating and cooling power is provided through campus steam and by a chiller located in the central utilities plant, just to the south of the new building. This centralized system provides a more cost-effective and slightly more efficient energy delivery for all of campus. There is a pressure reduction station to keep building steam pressures down to 10 psi, and the building has two chilled water pumps to pull water from the north loop, supplied by the central chiller plant. Steam heats all the main heating coils, domestic water heaters, the main heat exchanger for the hydronic loop, and provides drive steam for all the building's humidifiers. Chilled water is provided through a Primary/Secondary central chilled water plant. The building is located on the plant's North Loop, the only building built so far. More expansion is planned in the future. The 550 ton chiller is slightly oversized to account for growth and load sharing, and for use during low total loading of the central plant. This can save the campus from operating any of the other three older, less efficient chillers to satisfy the background load on a swing-season day.

The building is driven primarily by exhaust systems. The inputs to the whole building are provided by the operation of hoods, and sashes. As the pressure in the exhaust ductwork increases (closer to zero), the exhaust air handlers ramp up because of the differential pressure sensors (shown on the controls diagrams, not found on any floorplans or ductwork plans) signal provided to the VFD controllers. This causes the building overall to become less positively pressurized, and the amount of supply (and/or outdoor air) is increased to maintain the building at a positive pressure differential to the outside. Pressure sensors are indicated on the controls diagrams, but never located on the mechanical floor plans. If there is a great call for supply air while no air is being exhausted, a great deal of return air is drawn from the building (uncontrolled pressure differential ductwork – no dampers) and directed through the air handler, conditioned, then delivered back to the spaces. Return air is drawn back to the air handler, but can either be re-sent to the building, or sent outside through the relief dampers. The air handlers can function in an economizer mode, but only one set of outdoor air dampers is provided, so controlling ventilation can be an issue. During economizer operation, all air returned from the building is directed out as relief air, and lots of outdoor air is brought into the building. If more outdoor air is needed for conditioning than is needed for building pressurization, the exhaust systems draw more air from the general exhaust grilles to keep positive pressurization limited. This control feedback override isn't provided for ventilation reasons; the designers assume that there will always be some exhausting going on while the building is occupied, enough to meet minimum ventilation requirements.

Most pumps in the building are controlled by Variable Frequency Drives, a great way to save energy. They all have differential pressure sensors placed in many places throughout the building, and are set to maintain varying and adjustable pressure differences between the supply and return lines. This eliminates the need for balancing valves, but they are provided at *every* load coil none the less. All load coils (hydronic) are controlled by 2-way valves; no 3-way bypass valves are provided. To keep the hot water in the hydronic loop hot all the time, the fin-tube radiation in the north-end study alcoves is left on year-round. This provides some flow at the ends of branches at all times. This limits system reaction time when a reheat coil calls for hot water.

The chilled water system on the F&M campus is a bit odd. It was originally conceived as one chiller located at the Central Utilities Plant to serve a lab next to the CUP. This was later expanded through the 70's and 80's, and second and third chillers were added as the secondary supply lines were extended to other offices and dorms near the CUP. Outlying buildings still maintain their own cooling power independent of the central system. This project was originally supposed to house the new central chilled water plant in the basement, but that idea was scrapped because of extensive excavation expenses. The roof of the LS&P Building still has cooling towers planned for installation for all the chillers, but the chillers themselves will need to be located somewhere else.

When the designers combined the separated chilled water systems (each had been a P/S system before, each serving dedicated loads) into one, they kept all the secondary CHWS lines connected, and shared a common line with the primary return, secondary return (as usual), but also connected that line to the primary supply, but not through a decoupler line. This reduces central plant flexibility, especially in areas far from the CUP where pressure differentials are not high enough without full secondary pumping power engaged. Also, because primary chilled water can't be sent to both sets of secondary pumps without being warmed by return water from the North Loop (the LS&P building), if there isn't enough pressure to induce flow at the far chilled water coils, not only must the other set of secondary pumps be turned on, but also one of the older chillers in the other section of the main plant. While all 4 chillers are located in the same building, not 70 feet apart, they are plumbed into opposite ends of the hydraulic system, so they act like two separated plants.

Critique

This building requires enormous amounts of exhaust and makeup air. Period. Laboratories have a tendency to require this, and as such, this building's systems provide that, fairly well actually. The exhaust and makeup are each centralized for major areas of the building, making an energy recovery system much simpler and more cost-effective. It also makes maintenance much easier. The energy recovery is the first place that the designers fell a bit short however. Simple runaround loops (glycol) and coils are provided between the exhaust and outdoor (makeup) air streams. This provides some heat transfer, but its only intent is to help during the winter heating months, not during the summer. Also, it is sensible-only recovery. Since the building is maintained at a fairly high humidity (dew point is 50F), and it is rather dry in the winter, coupled with moist summer days, and the same low (relatively) dew point during the summer, latent heat recovery would be a good thing. Plus, simple runaround coils and loops are not all that effective, especially when the exhaust units and makeup streams are in close proximity (all but AHU-3 are on the main roof).

Since a great deal of airflow is required, this also takes up a lot of shaft space for ductwork. This cannot be avoided, since the airflow capacity needs to be there for exhaust, and the central location allows energy recovery. This, I'm sure, was a very difficult battle to have with the lead architects, but the mechanical system designers were able to hold their ground.

To keep first costs to a minimum, perimeter heating was eliminated except where absolutely necessary. Since the airflow will be in each room, most likely during occupied times when we care about thermal comfort, sufficient heat can be provided through reheat coils to keep the rooms warm. This is aided by the relative non-existence of glass in the facade. The facades are only about 25% glass, relatively low for new buildings. That means that the mean radiant temperature is higher, and the perimeter heating needed to offset those losses can be eliminated. This takes away a huge initial cost from the construction, plus continued pumping energy and controls, with associated pipe losses, mostly through minimal insulation.

Airflow within the building is adequate – air is kept moving through the entire building by many diffusers and grilles.

The drawback of using such a limited number of Air Handlers to serve all labs and general-use spaces is that the general spaces, without heat sources, can remain mostly comfortable with a minimum of cool air supplied. The labs need lots of air, and taking that air from a cool supply system into a room with relatively low heat gains for the airflow causes a great need for final polish heating to keep the room warm enough for comfort. The room controllers allow slightly for this – during periods of high exhaust (greater than 40% of maximum), the room's temperature is allowed to drift down, slightly limiting the need for reheat. This differential is initially set at 2 degrees, but is adjustable. Hopefully the building staff and occupants do not change that through the life of the building. A separate makeup only air supply system for the labs would be ideal, but would crowd the ceiling space with more ductwork, and increase costs. This may or may not have a large energy savings, probably why one supply network was deemed sufficient.

The exterior of the building is built very strong, and looks very pleasing from the outside. Much care was taken to prevent air infiltration/exfiltration. The heavy walls also help to keep sound intrusion to a minimum. Good windows were chosen, mostly inoperable, and were installed very well. Since many outlets and plumbing fixtures are placed along the exterior walls, drilling into the concrete block was not a great prospect. 2x4 steel studs were placed along the interior side of the block to allow a standard cavity and mounting surface for all the junction boxes, pipes, and fixtures. This is a great idea, but could also go further. The building has 2” foam insulation on the exterior surface of this block wall, which provides R-10 over the entire skin of the building. This interior cavity was left hollow to allow for building systems’ installation. That is one great opportunity for insulation. After all the infrastructure is installed in these exterior walls, but before drywall goes up, simple R-15 batt insulation could be placed in the cavity, effectively doubling the insulation value in the walls. This would not have a great effect in the summer, but the savings in winter heating seasons would be great, especially when the room reheat coils are already making up a great deal of heating for ventilation and comfort, those heating systems should not also have to make up for a building that is losing more heat than it would if every opportunity to insulate was taken. If, instead of batt insulation, spray-applied polyurethane insulation were used, that would eliminate the need for a vapor barrier, reducing the time required to glue that to the exterior surface of the concrete block. This would likely be offset by the installation time and cost for the additional insulation, but that has another savings as well – energy savings.

Overall, the building is well-designed, and built to last many years. However, there was no pursuit of new or emerging HVAC technologies in the design of the building. In a world where many things can change very quickly, especially regarding energy costs, energy use/taxation, and building infrastructure, sticking with the old “tried-and-true” methods may or may not be the best move, especially when these systems are the ones being attacked by many energy-conscious designers and system specialists.

Appendix 1 – Energy Use Summary from Technical Report

Annual Cost Summary

Table 1. Annual Costs

Component	LSand P ($)
Air System Fans	26,233
Cooling	28,014
Heating	15,630
Pumps	3,087
Cooling Tower Fans	5,383
HVAC Sub-Total	**78,348**
Lights	104,465
Electric Equipment	11,110
Misc. Electric	0
Misc. Fuel Use	0
Non-HVAC Sub-Total	**115,574**
Grand Total	**193,922**

Table 2. Annual Cost per Unit Floor Area

Component	LSand P ($/ft²)
Air System Fans	0.305
Cooling	0.326
Heating	0.182
Pumps	0.036
Cooling Tower Fans	0.063
HVAC Sub-Total	**0.912**
Lights	1.216
Electric Equipment	0.129
Misc. Electric	0.000
Misc. Fuel Use	0.000
Non-HVAC Sub-Total	**1.345**
Grand Total	**2.258**
Gross Floor Area (ft²)	85902.0
Conditioned Floor Area (ft²)	85902.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 3. Component Cost as a Percentage of Total Cost

Component	LSand P (%)
Air System Fans	13.5
Cooling	14.4
Heating	8.1
Pumps	1.6
Cooling Tower Fans	2.8
HVAC Sub-Total	**40.4**
Lights	53.9
Electric Equipment	5.7
Misc. Electric	0.0
Misc. Fuel Use	0.0
Non-HVAC Sub-Total	**59.6**
Grand Total	**100.0**

Table 1. Annual Costs

Component	LSand P ($)
HVAC Components	
Electric	62,765
Natural Gas	15,583
Fuel Oil	0
Propane	0
Remote HW	0
Remote Steam	0
Remote CW	0
HVAC Sub-Total	**78,348**
Non-HVAC Components	
Electric	115,574
Natural Gas	0
Fuel Oil	0
Propane	0
Remote HW	0
Remote Steam	0
Non-HVAC Sub-Total	**115,574**
Grand Total	**193,923**

Table 2. Annual Energy Consumption

Component	LSand P
HVAC Components	
Electric (kWh)	886,096
Natural Gas (Therm)	14,969
Fuel Oil (na)	0
Propane (na)	0
Remote HW ()	647,951
Remote Steam (na)	0
Remote CW (na)	0
Non-HVAC Components	
Electric (kWh)	1,631,240
Natural Gas (Therm)	0
Fuel Oil (na)	0
Propane (na)	0
Remote HW ()	0
Remote Steam (na)	0
Totals	
Electric (kWh)	2,517,336
Natural Gas (Therm)	14,969
Fuel Oil (na)	0
Propane (na)	0
Remote HW ()	647,951
Remote Steam (na)	0
Remote CW (na)	0

Table 3. Annual Emissions

Component	LSand P
CO_2 (lb)	3,373,185
SO_2 (kg)	0
NO_x (kg)	0

Table 4. Annual Cost per Unit Floor Area

Component	LSand P ($/ft²)
HVAC Components	
Electric	0.731
Natural Gas	0.181
Fuel Oil	0.000
Propane	0.000
Remote HW	0.000
Remote Steam	0.000
Remote CW	0.000
HVAC Sub-Total	**0.912**
Non-HVAC Components	
Electric	1.345
Natural Gas	0.000
Fuel Oil	0.000
Propane	0.000
Remote HW	0.000
Remote Steam	0.000
Non-HVAC Sub-Total	**1.345**
Grand Total	**2.258**
Gross Floor Area (ft²)	85902.0
Conditioned Floor Area (ft²)	85902.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 5. Component Cost as a Percentage of Total Cost

Component	LSand P (%)
HVAC Components	
Electric	32.4
Natural Gas	8.0
Fuel Oil	0.0
Propane	0.0
Remote HW	0.0
Remote Steam	0.0
Remote CW	0.0
HVAC Sub-Total	**40.4**
Non-HVAC Components	
Electric	59.6
Natural Gas	0.0
Fuel Oil	0.0
Propane	0.0
Remote HW	0.0
Remote Steam	0.0
Non-HVAC Sub-Total	**59.6**
Grand Total	**100.0**

Appendix 2 – Lists of Major Equipment

Finned Tube Radiators								
	Btu/LF	gpm/LF	Water Temp (°F)	Pipe Size	Fin Size (in.)	Fins/ft.	vert. Rows	Mounting Type
Greenhouse	1680	0.17	170	1.25	4.25 square	40	2	Wall
Atrium	1060	0.11	170	1	4.25 square	50	1	Wall
Study Alcoves	1060	0.11	170	1	4.25 square	50	1	Pedestal

Condensate Pumps				
	gpm	Discharge Pressure (psi)	Receiver Capacity (gal)	Motor H.P.
CP-1	60	75	75	7.5
CP-2	15	25	23	0.75
CP-3	15	30	75	0.75

Cooling Towers								
	Nominal Tons	Design WB (°F)	Ent. Water Temp.	Leaving Water Temp.	Fan Type	# Fans	H.P. (each)	Basin Heaters
CT-1	400	-	-	-	-	1	20	-
CT-2	800	-	-	-	-	-	-	-
CT-3	550	-	-	-	-	2	25	-
CT-4	550	78	95	85	Gear Driven VFD	1	30	2 @ 10kW

Air Separators				
	Serves	gpm	Max DP (ft.)	Pipe Size (in.)
AS-1	Heating Water	80	1	3
AS-2	Chilled Water	200	1.5	4
AS-3	AHU-1/2 Heat Recovery	200	1.5	4
AS-4	AHU-3 Heat Recovery	90	1	3

Water-Cooled Centrifugal Chillers													
		Capacity	EER	Evaporator				Compressor	Condenser				Operating
	Refrigerant	(tons)	(kW/ton)	gpm	EWT	LWT	PD (ft.)	kW	gpm	EWT	LWT	PD (ft.)	Weight (lbs)
CH-1	R-11	770	-	1836		45	22.7	-	-	-	-	-	-
CH-2	R-123	250	-	600		45	10.66	-	750	-	-	8.3	-
CH-3	R-11	550	-	1070		50	-	-	-	-	-	-	-
CH-4	R-123	550	0.558	950	56	42	10.0	307.1	1650	85	95	16.0	27,400

Gas-Fired Steam Boiler				
Capacity		Gas Firing Rate	Max Pressure	Operating Press.
Boiler HP	Net MBH	(MBH)	(psig)	(psig)
81.6	2120	3392	15	12

Shell/Tube Heat Exchanger										
Capacity	Shell-Side		Tube Side				Minimum	Max. Overall	Shell
(MBH)	Pressure (psig)	lbs/hr	gpm	EWT (F)	LWT (F)	Max PD (ft)	Surface Area (sf)	Length (in)	Diameter (in)
4880	5	5080	500	160	180	1.9	316	105	18

Pumps									
	Serves	Type	gpm	Head (ft)	BHP	RPM	Min Pump Eff.	Capacity Controls	Motor HP
P-1	Prim CHW - CH-1	Split-Case	1660	85	-	1750	-	None	50
P-2	Prim CHW - CH-1	Split-Case	1660	85	-	1750	-	None	50
P-3	Prim CHW - CH-2	End Suction	600	40	-	1200	-	None	10
P-4	Prim CHW - CH-3	End Suction	1070	40	-	1200	-	None	20
P-5	Prim CHW - CH-3	End Suction	1070	40	-	1200	-	None	20
P-6	Prim CHW - CH-4	End Suction	1070	40	13.0	1160	0.84	None	15
P-7	CHW Solids Separator	End Suction	1150	50	-	1750	-	None	20
P-8	Secondary CHW	Split-Case	2000	75	-	1800	-	VFD	50
P-9	Secondary CHW	End Suction	1800	75	-	1800	-	VFD	50
P-10	Secondary CHW	Split-Case	2000	75	-	1800	-	VFD	50
P-11	Secondary CHW	End Suction	1800	75	41.6	1760	0.82	VFD	50
P-12	CW - CH-1/CT-1	End Suction	1165	60	-	1750	-	None	30
P-13	CW - CH-1/CT-1	End Suction	1165	60	-	1750	-	None	30
P-14	CW - CH-1/CT-1	End Suction	1165	60	-	1750	-	None	30
P-15	CW - CH-2/CT-2	End Suction	750	40	-	1800	-	None	10
P-16	CW - CH-3/CT-3	End Suction	1500	55	-	1750	-	None	30
P-17	CW - CH-3/CT-3	End Suction	1500	55	-	1750	-	None	30
P-18	CW - CH-4/CT-4	End Suction	1650	100	51.4	1760	0.81	VFD	60
P-19	CW - CH-4/CT-4	End Suction	1650	100	51.4	1760	0.81	VFD	60
P-22	Building CHW	End Suction	750	50	11.7	1760	0.81	VFD	15
P-23	Building CHW	End Suction	750	50	11.7	1760	0.81	VFD	15
P-24	Building Heating Water	End Suction	400	65	8.9	1760	0.74	VFD	15
P-25	Building Heating Water	End Suction	400	65	8.9	1760	0.74	VFD	15
P-26	Heat Recovery - AHU-1	In-Line	200	45	4.0	1760	0.6	None	5
P-27	Heat Recovery - AHU-1	In-Line	200	45	4.0	1760	0.6	None	5
P-28	Heat Recovery - AHU-2	In-Line	200	45	4.0	1760	0.6	None	5
P-29	Heat Recovery - AHU-2	In-Line	200	45	4.0	1760	0.6	None	5
P-30	Heat Recovery - AHU-3	In-Line	90	55	2.6	1760	0.5	None	5
P-31	Heat Recovery - AHU-3	In-Line	90	55	2.6	1760	0.5	None	5
P-32	CW Sidestream Filtration	End Suction	142	included with filtration system package					3

Steam Humidifiers			
	Serves	Capacity (lbs/hr)	Steam Pressure (psig)
H-1	Main Building - AHU-1	851	5
H-2	Main Building - AHU-2	851	5
H-3	Main Vivarium - AHU-3	511	5
H-4	Primate Rooms	30	5

Heat Recovery Coils													
		Air-Side							Fluid-Side				
	Location	CFM (max.)	Min. Face Area (sf)	Flow Velocity (fpm)	Rows / FPI	Max PD (in. w.g.)	EAT	LAT	Heating Capacity (MBH)	gpm	EFT	LFT	Max. PD (ft)
HRC-1A	AHU-1	30,000	90	333	8/10	0.25	0	28.5	928	204	45	35.1	5.8
HRC-2A	AHU-2	30,000	90	333	8/10	0.25	0	28.5	928	204	45	35.1	5.8
HRC-3A	AHU-3	15,000	30	500	8/10	0.50	0	23.8	388	90	45	35.1	3.7
HRC-1B	EAHU-1	30,000	53	566	8/10	0.76	78	49.2	936	203	35	45	17.6
HRC-2B	EAHU-2	30,000	53	566	6/8	0.76	78	49.2	936	203	35	45	17.6
HRC-3B	EAHU-3	15,000	30	500	6/8	0.38	78	52.9	408	89	35	45	13.8

Air Handlers - 1											
		Outdoor Air			Suppy Fan						
	Serves	CFM	Summer DB/WB	Winter DB	Type	CFM	Total Pressure (in. w.g.)	RPM	BHP	Motor HP	V / PH
AHU-1	Main Building	50,000-15,000	92 / 78	0	SWSI Plenum	50,000-20,000	8.0	1033	85	100	480 / 3
AHU-2	Main Building	50,000-15,000	92 / 78	0	SWSI Plenum	50,000-20,000	8.0	1033	85	100	480 / 3
AHU-3	Vivarium (Basement)	15,000	92 / 78	0	SWSI Plenum	15,000-7,500	6.5	1150	22	25	480 / 3

Air Handlers - 2															
Return Fan							Steam Heating Coil								
Type	CFM	Total Pressure (in. w.g.)	RPM	BHP	Motor HP	V / PH	Type	Max. Pressure Drop (in. w.g.)	Total Capacity (MBH)	EAT	LAT	Rows / FPI	Steam Press (psig)	lbs / hr
SWSI Plenum	23,000-8,000	2.0	508	10.2	15	480 / 3	VIFB	0.18	2,158	20	60	1 / 9	5	2,247
SWSI Plenum	23,000-8,000	2.0	508	10.2	15	480 / 3	VIFB	0.18	2,158	20	60	1 / 9	5	2,247
N / A	-	-	-	-	-	-	VIFB	0.34	971	0	60	2 / 14	5	1,010

Air Handlers - 3													
Cooling Coil													
Max. Pressure Drop (in. w.g.)	Total Capacity (MBH)	Total Capacity (tons)	Sensible Capacity (MBH)	Sensible Capacity (tons)	Max. Face Velocity (fpm)	EA DB	EA WB	LA DB	LA WB	GPM	EWT	LWT	Max. Water Pressure Drop (ft)
0.6	2,572	214	1,878	156.5	420	86.4	68	51.8	51.2	367	44	58	12.1
0.6	2,572	214	1,878	156.5	420	86.4	68	51.8	51.2	367	44	58	12.1
1.25	1,382	115	657	54.75	500	92	78	52	51.5	197	44	58	11

Exhaust Air Handling Units			
		Exhaust Fan	
	Outdoor Air (cfm)	CFM	Total Pressure (in/ w.g.)
EAHU-1	0-10,000	10,000-30,000	6.0
EAHU-2	0-10,000	10,000-30,000	6.0
EAHU-3	-	7,500-15,000	4.4

Appendix 3 – HAP Sizing Summary

Air System Sizing Summary for AHU-1

Project Name: Franklin and Marshall LSandP-Comp 01/04/2008
Prepared by: PSUAE 11:34AM

Air System Information

Air System Name	**AHU-1**		Number of zones	**43**	
Equipment Class	**CW AHU**		Floor Area	**38140.0**	ft²
Air System Type	**VAV**		Location	**Harrisburg, Pennsylvania**	

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	**142.5**	Tons	Load occurs at	**Jul 1700**	
Total coil load	**1709.6**	MBH	OA DB / WB	**90.1 / 77.5**	°F
Sensible coil load	**788.1**	MBH	Entering DB / WB	**77.8 / 71.2**	°F
Coil CFM at Jul 1700	**26124**	CFM	Leaving DB / WB	**49.5 / 49.5**	°F
Max block CFM at Jul 1700	**30345**	CFM	Coil ADP	**45.7**	°F
Sum of peak zone CFM	**30841**	CFM	Bypass Factor	**0.120**	
Sensible heat ratio	**0.461**		Resulting RH	**52**	%
ft²/Ton	**267.7**		Design supply temp.	**55.0**	°F
BTU/(hr-ft²)	**44.8**		Zone T-stat Check	**43 of 43**	OK
Water flow @ 14.0 °F rise	**244.36**	gpm	Max zone temperature deviation	**0.0**	°F

Preheat Coil Sizing Data

Max coil load	**28.2**	MBH	Load occurs at	**Des Htg**	
Coil CFM at Des Htg	**21301**	CFM	Ent. DB / Lvg DB	**48.8 / 50.0**	°F
Max coil CFM	**30345**	CFM			
Water flow @ 18.0 °F drop	**N/A**				

Humidifier Sizing Data

Max steam flow at Des Htg	**336.68**	lb/hr	Air mass flow	**94794.04**	lb/hr
Airflow Rate	**21301**	CFM	Moisture gain	**.00355**	lb/lb

Supply Fan Sizing Data

Actual max CFM at Jul 1700	**30345**	CFM	Fan motor BHP	**85.00**	BHP
Standard CFM	**30009**	CFM	Fan motor kW	**63.38**	kW
Actual max CFM/ft²	**0.80**	CFM/ft²			

Return Fan Sizing Data

Actual max CFM at Jul 1700	**30345**	CFM	Fan motor BHP	**10.20**	BHP
Standard CFM	**30009**	CFM	Fan motor kW	**7.61**	kW
Actual max CFM/ft²	**0.80**	CFM/ft²			

Outdoor Ventilation Air Data

Design airflow CFM	**21301**	CFM	CFM/person	**33.35**	CFM/person
CFM/ft²	**0.56**	CFM/ft²			

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jul 1700 COOLING OA DB / WB 90.1 °F / 77.5 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 0.0 °F / 0.0 °F		
ZONE LOADS	**Details**	**Sensible (BTU/hr)**	**Latent (BTU/hr)**	**Details**	**Sensible (BTU/hr)**	**Latent (BTU/hr)**
Window & Skylight Solar Loads	3008 ft²	121397	-	3008 ft²	-	-
Wall Transmission	15853 ft²	14616	-	15853 ft²	69789	-
Roof Transmission	12675 ft²	23303	-	12675 ft²	56975	-
Window Transmission	3008 ft²	18973	-	3008 ft²	84228	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	147 ft²	1188	-	147 ft²	2417	-
Floor Transmission	3995 ft²	0	-	3995 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	57962 W	169443	-	0	0	-
Task Lighting	160 W	546	-	0	0	-
Electric Equipment	6245 W	21293	-	0	0	-
People	637	130420	148261	0	0	0
Infiltration	-	8310	17353	-	32103	9868
Miscellaneous	-	80	520	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	**-**	**509569**	**166134**	**-**	**245511**	**9868**
Zone Conditioning	-	452876	166134	-	235656	9868
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Return Fan Load	26124 CFM	18259	-	21301 CFM	-11501	-
Ventilation Load	18338 CFM	134293	755075	14953 CFM	433088	345215
Supply Fan Load	26124 CFM	152159	-	21301 CFM	-95844	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	**-**	**757587**	**921209**	**-**	**561398**	**355083**
Central Cooling Coil	-	788078	921540	-	0	0
Preheat Coil	-	0	-	-	28194	-
Humidification Load	-	-	0	-	-	355128
Terminal Reheat Coils	-	-30491	-	-	533204	-
>> Total Conditioning	**-**	**757587**	**921540**	**-**	**561399**	**355128**
Key:	**Positive values are clg loads Negative values are htg loads**			**Positive values are htg loads Negative values are clg loads**		

Air System Sizing Summary for AHU-2

Project Name: Franklin and Marshall LSandP-Comp — 01/04/2008
Prepared by: PSUAE — 11:37AM

Air System Information

Air System Name	AHU-2		Number of zones	45	
Equipment Class	CW AHU		Floor Area	41112.0	ft²
Air System Type	VAV		Location	Harrisburg, Pennsylvania	

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	164.9	Tons	Load occurs at	Jul 1600	
Total coil load	1978.5	MBH	OA DB / WB	91.4 / 77.9	°F
Sensible coil load	911.2	MBH	Entering DB / WB	78.1 / 71.4	°F
Coil CFM at Jul 1600	30649	CFM	Leaving DB / WB	50.3 / 50.2	°F
Max block CFM at Jul 1700	35409	CFM	Coil ADP	46.5	°F
Sum of peak zone CFM	36616	CFM	Bypass Factor	0.120	
Sensible heat ratio	0.461		Resulting RH	53	%
ft²/Ton	249.4		Design supply temp.	55.0	°F
BTU/(hr-ft²)	48.1		Zone T-stat Check	45 of 45	OK
Water flow @ 14.0 °F rise	282.80	gpm	Max zone temperature deviation	0.0	°F

Preheat Coil Sizing Data

Max coil load	41.0	MBH	Load occurs at	Des Htg	
Coil CFM at Des Htg	25111	CFM	Ent. DB / Lvg DB	48.5 / 50.0	°F
Max coil CFM	35409	CFM			
Water flow @ 18.0 °F drop	N/A				

Humidifier Sizing Data

Max steam flow at Des Htg	388.75	lb/hr	Air mass flow	111748.50	lb/hr
Airflow Rate	25111	CFM	Moisture gain	.00348	lb/lb

Supply Fan Sizing Data

Actual max CFM at Jul 1700	35409	CFM	Fan motor BHP	85.00	BHP
Standard CFM	35017	CFM	Fan motor kW	63.38	kW
Actual max CFM/ft²	0.86	CFM/ft²			

Return Fan Sizing Data

Actual max CFM at Jul 1700	35409	CFM	Fan motor BHP	10.20	BHP
Standard CFM	35017	CFM	Fan motor kW	7.61	kW
Actual max CFM/ft²	0.86	CFM/ft²			

Outdoor Ventilation Air Data

Design airflow CFM	25111	CFM	CFM/person	31.20	CFM/person
CFM/ft²	0.61	CFM/ft²			

Air System Design Load Summary for AHU-2

Project Name: Franklin and Marshall LSandP-Comp 01/04/2008
Prepared by: PSUAE 11:37AM

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jul 1600 COOLING OA DB / WB 91.4 °F / 77.9 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 0.0 °F / 0.0 °F		
ZONE LOADS	**Details**	**Sensible (BTU/hr)**	**Latent (BTU/hr)**	**Details**	**Sensible (BTU/hr)**	**Latent (BTU/hr)**
Window & Skylight Solar Loads	2732 ft²	124020	-	2732 ft²	-	-
Wall Transmission	21876 ft²	30230	-	21876 ft²	125404	-
Roof Transmission	14829 ft²	41376	-	14829 ft²	107768	-
Window Transmission	2704 ft²	17814	-	2704 ft²	75714	-
Skylight Transmission	28 ft²	138	-	28 ft²	588	-
Door Loads	420 ft²	16345	-	420 ft²	12703	-
Floor Transmission	3880 ft²	0	-	3880 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	67362 W	194642	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	8020 W	27272	-	0	0	-
People	805	160752	182784	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	80	640	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	**-**	**612669**	**183424**	**-**	**322177**	**0**
Zone Conditioning	-	547194	183424	-	309161	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	30649 CFM	18465	-	25111 CFM	-11800	-
Ventilation Load	21736 CFM	172399	883854	17808 CFM	514800	410056
Supply Fan Load	30649 CFM	153874	-	25111 CFM	-98336	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	**-**	**891932**	**1067278**	**-**	**713825**	**410056**
Central Cooling Coil	-	911237	1067283	-	0	0
Preheat Coil	-	0	-	-	40996	-
Humidification Load	-	-	0	-	-	410056
Terminal Reheat Coils	-	-19305	-	-	672829	-
>> Total Conditioning	**-**	**891932**	**1067283**	**-**	**713825**	**410056**
Key:	**Positive values are clg loads Negative values are htg loads**			**Positive values are htg loads Negative values are clg loads**		

Air System Sizing Summary for AHU-3

Project Name: Franklin and Marshall LSandP-Comp — 01/04/2008
Prepared by: PSUAE — 11:39AM

Air System Information

Air System Name	**AHU-3**		Number of zones	**25**	
Equipment Class	**CW AHU**		Floor Area	**6650.0**	ft²
Air System Type	**VAV**		Location	**Harrisburg, Pennsylvania**	

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	**30.1**	Tons	Load occurs at	**Jul 1600**	
Total coil load	**361.2**	MBH	OA DB / WB	**91.4 / 77.9**	°F
Sensible coil load	**157.4**	MBH	Entering DB / WB	**77.6 / 72.2**	°F
Coil CFM at Jul 1600	**4609**	CFM	Leaving DB / WB	**45.7 / 45.7**	°F
Max block CFM at Jul 1700	**4998**	CFM	Coil ADP	**41.3**	°F
Sum of peak zone CFM	**5015**	CFM	Bypass Factor	**0.120**	
Sensible heat ratio	**0.436**		Resulting RH	**53**	%
ft²/Ton	**220.9**		Design supply temp.	**55.0**	°F
BTU/(hr-ft²)	**54.3**		Zone T-stat Check	**25 of 25**	OK
Water flow @ 14.0 °F rise	**51.63**	gpm	Max zone temperature deviation	**0.0**	°F

Preheat Coil Sizing Data

Max coil load	**20.5**	MBH	Load occurs at	**Jan 1700**	
Coil CFM at Jan 1700	**4566**	CFM	Ent. DB / Lvg DB	**45.8 / 50.0**	°F
Max coil CFM	**4998**	CFM			
Water flow @ 18.0 °F drop	**N/A**				

Humidifier Sizing Data

Max steam flow at Des Htg	**71.49**	lb/hr	Air mass flow	**17913.48**	lb/hr
Airflow Rate	**4025**	CFM	Moisture gain	**.00399**	lb/lb

Supply Fan Sizing Data

Actual max CFM at Jul 1700	**4998**	CFM	Fan motor BHP	**22.00**	BHP
Standard CFM	**4942**	CFM	Fan motor kW	**16.41**	kW
Actual max CFM/ft²	**0.75**	CFM/ft²			

Outdoor Ventilation Air Data

Design airflow CFM	**4025**	CFM	CFM/person	**33.78**	CFM/person
CFM/ft²	**0.61**	CFM/ft²			

Air System Design Load Summary for AHU-3

Project Name: Franklin and Marshall LSandP-Comp
Prepared by: PSUAE

01/04/2008
11:39AM

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jul 1600 COOLING OA DB / WB 91.4 °F / 77.9 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 0.0 °F / 0.0 °F		
ZONE LOADS	**Details**	**Sensible (BTU/hr)**	**Latent (BTU/hr)**	**Details**	**Sensible (BTU/hr)**	**Latent (BTU/hr)**
Window & Skylight Solar Loads	0 ft²	0	-	0 ft²	-	-
Wall Transmission	2212 ft²	2689	-	2212 ft²	7401	-
Roof Transmission	0 ft²	0	-	0 ft²	0	-
Window Transmission	0 ft²	0	-	0 ft²	0	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	6640 ft²	0	-	6640 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	14810 W	43185	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	80 W	273	-	0	0	-
People	119	27211	42485	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	4775	5175	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	**-**	**78133**	**47660**	**-**	**7401**	**0**
Zone Conditioning	-	70953	47660	-	7054	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	4609 CFM	0	-	4025 CFM	0	-
Ventilation Load	3712 CFM	32272	156128	3242 CFM	93462	75408
Supply Fan Load	4609 CFM	45958	-	4025 CFM	-34107	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	**-**	**149182**	**203788**	**-**	**66408**	**75408**
Central Cooling Coil	-	157409	203788	-	-12611	0
Preheat Coil	-	0	-	-	18341	-
Humidification Load	-	-	0	-	-	75408
Terminal Reheat Coils	-	-8227	-	-	60679	-
>> Total Conditioning	**-**	**149182**	**203788**	**-**	**66408**	**75408**
Key:	**Positive values are clg loads Negative values are htg loads**			**Positive values are htg loads Negative values are clg loads**		

1. Plant Information:

Plant Name .... **LSandP**
Plant Type .... **Chiller Plant**
Design Weather .... **Harrisburg, Pennsylvania**

2. Cooling Plant Sizing Data:

Maximum Plant Load .... **337.2** Tons
Load occurs at .... **Jul 1700**
ft²/Ton .... **254.8** ft²/Ton
Floor area served by plant .... **85902.0** ft²

3. Coincident Air System Cooling Loads for Jul 1700

Air System Name	Mult.	System Cooling Coil Load (Tons)
AHU-2	1	164.7
AHU-3	1	30.1
AHU-1	1	142.5

System loads are for coils whose cooling source is ' Chilled Water ' .

1. Plant Information:

Plant Name .... **Sample Plant**
Plant Type .... **Remote Hot Water**
Design Weather .... **Harrisburg, Pennsylvania**

2. Heating Plant Sizing Data:

Maximum Plant Load .... **1266.7** MBH
Load occurs at .... **Winter Design**
BTU/(hr-ft²) .... **14.7** BTU/(hr-ft²)
Floor area served by plant .... **85902.0** ft²

3. Coincident Air System Heating Loads for Winter Design

Air System Name	Mult.	System Heating Coil Load (MBH)
AHU-1	1	533.2
AHU-2	1	672.8
AHU-3	1	60.7

System loads are for coils whose heating source is ' Hot Water ' .

1. Plant Information:

Plant Name .... **LSandP heat**
Plant Type .... **Steam Boiler Plant**
Design Weather .... **Harrisburg, Pennsylvania**

2. Heating Plant Sizing Data:

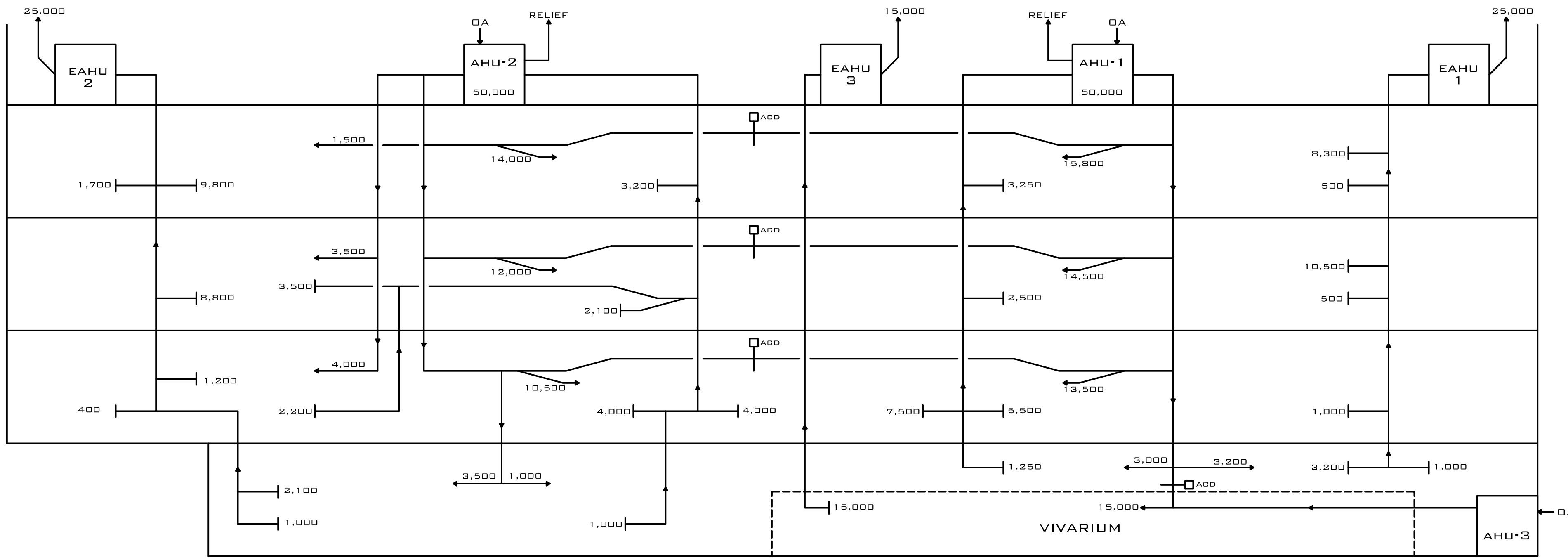
Maximum Plant Load .... **928.1** MBH
Load occurs at .... **Winter Design**
BTU/(hr-ft²) .... **10.8** BTU/(hr-ft²)
Floor area served by plant .... **85902.0** ft²

3. Coincident Air System Heating Loads for Winter Design

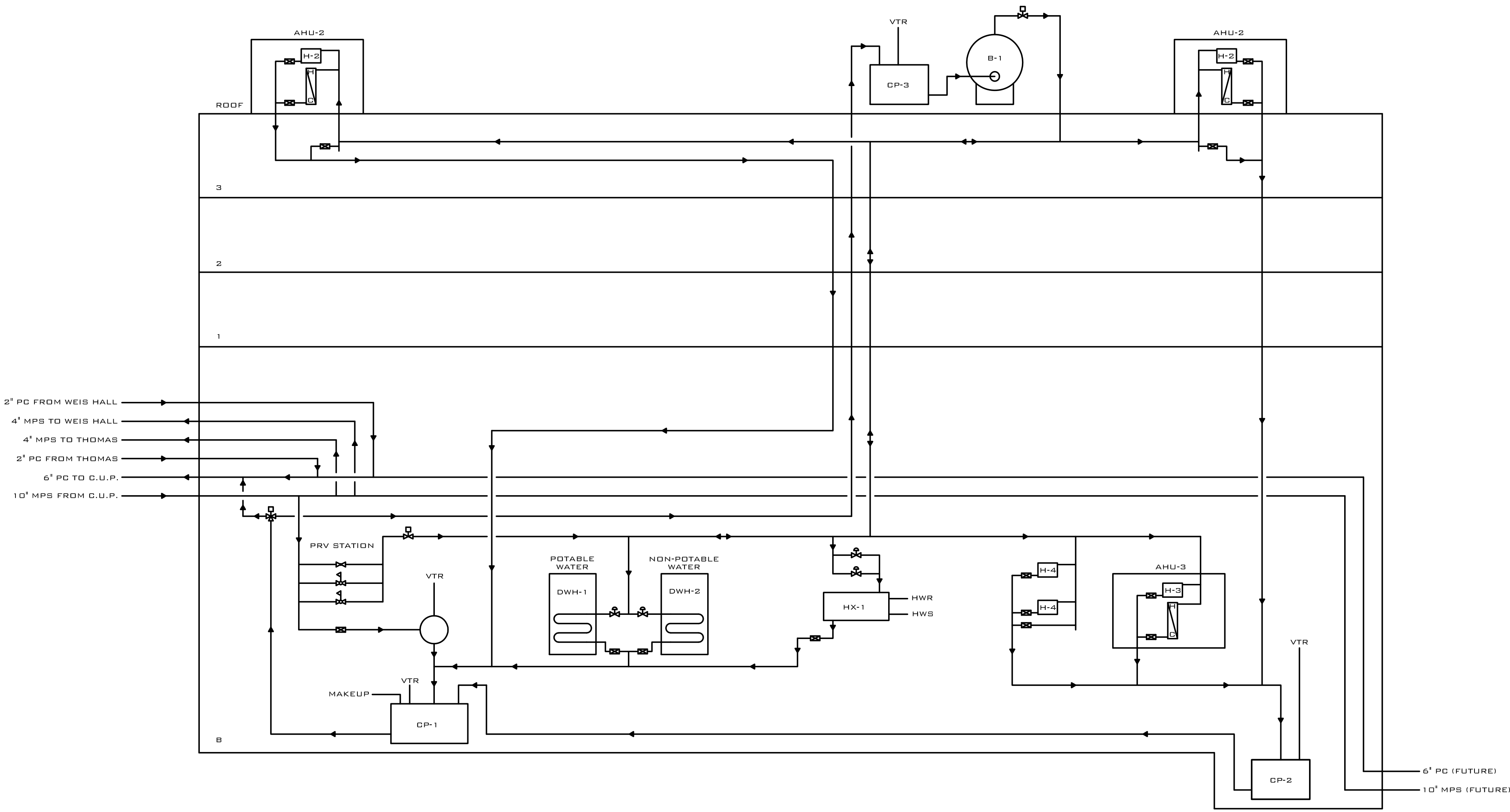
Air System Name	Mult.	System Heating Coil Load (MBH)
AHU-3	1	93.7
AHU-2	1	451.1
AHU-1	1	383.3

System loads are for coils whose heating source is ' Steam ' .

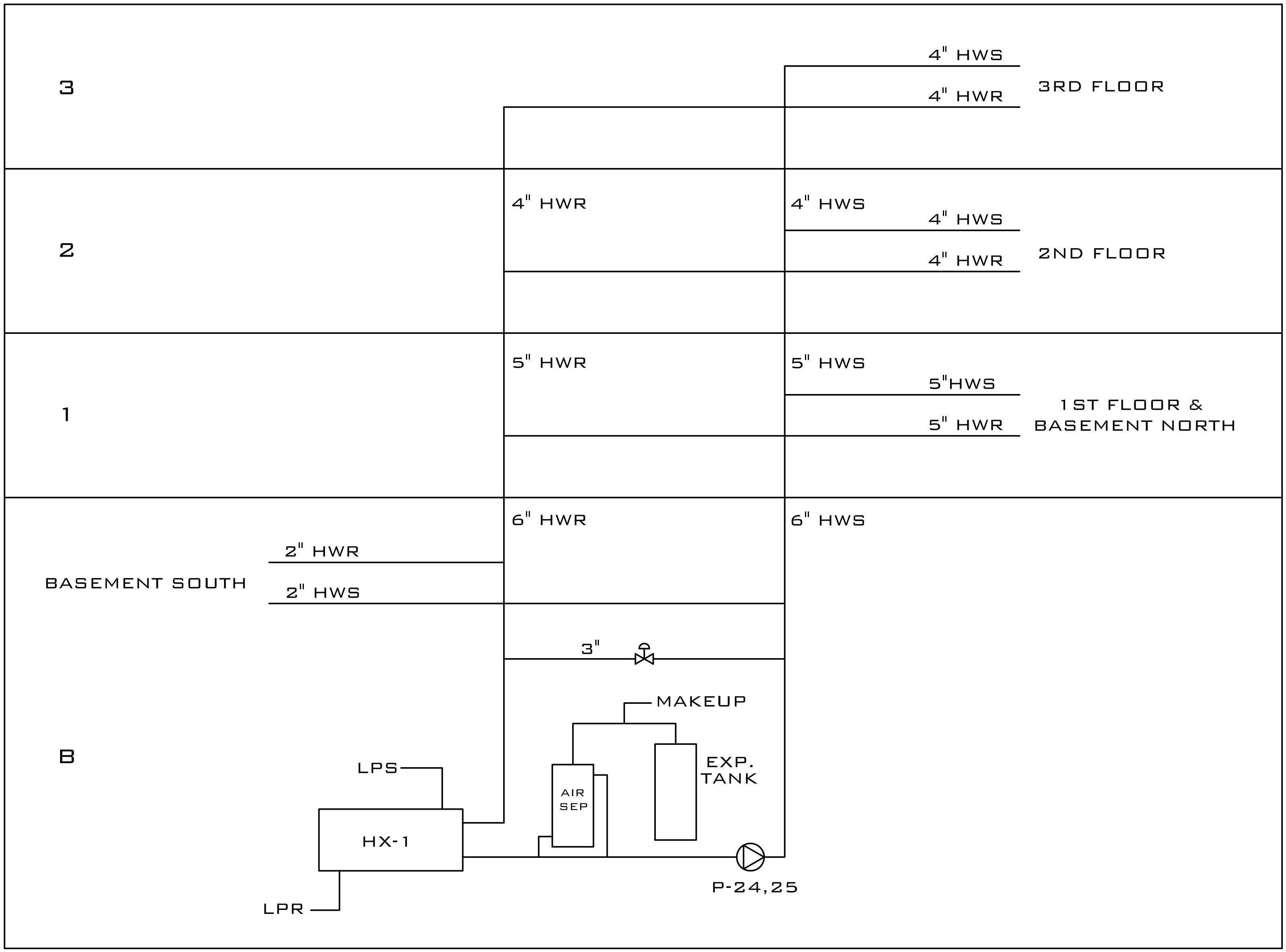
Appendix 4 – System Flow Diagrams



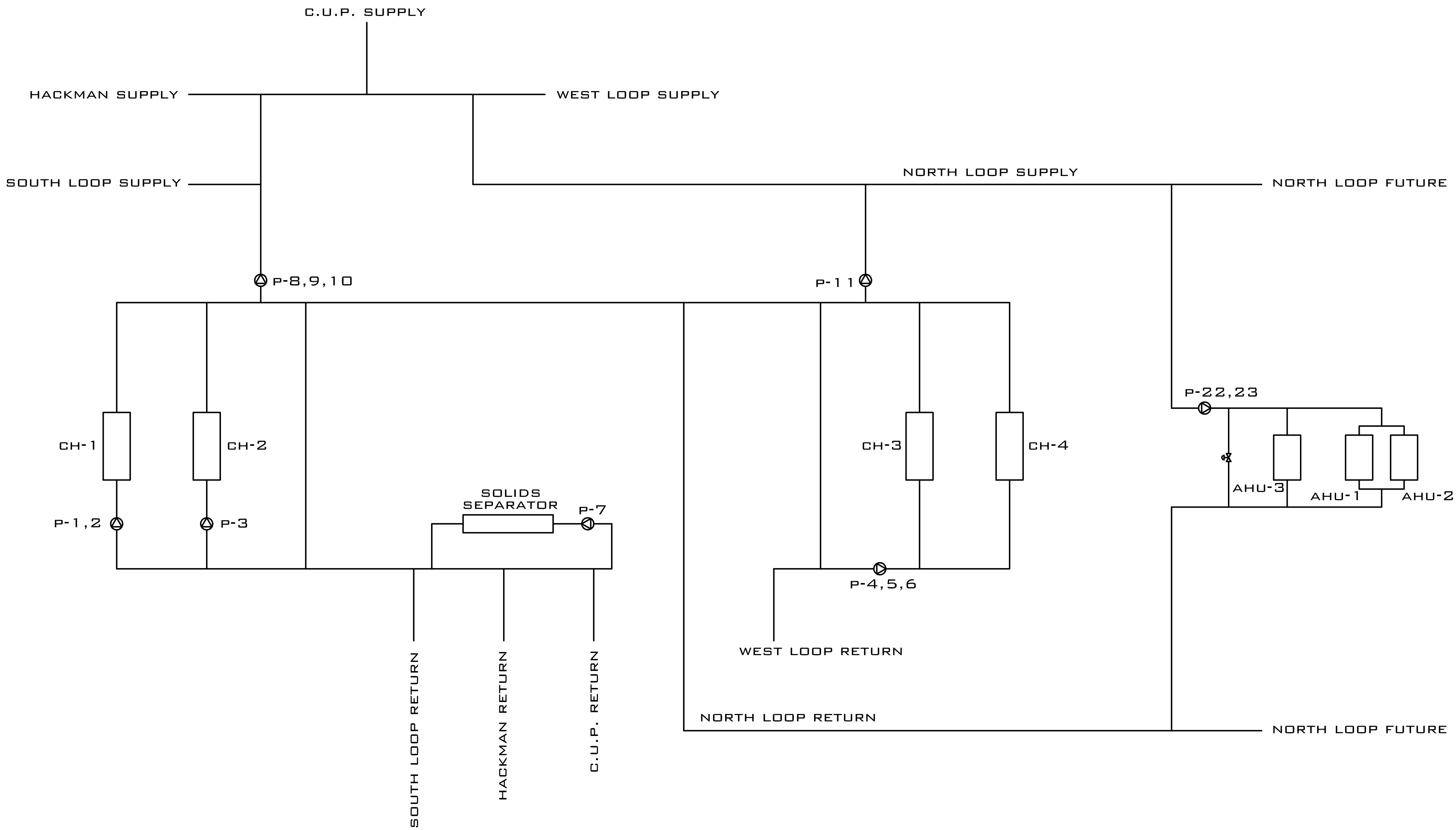
AIR SYSTEMS FLOW DIAGRAM



STEAM & CONDENSATE



HYDRONIC WATER HEATING



CHILLED WATER FLOW DIAGRAM