Technical Assignment 3
Mechanical Systems Existing Conditions Evaluation

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November 21, 2005
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Johns Hopkins Hospital Medical Office Building
Baltimore Maryland

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Executive Summary of
Existing Equipment Summary
As Applied to
Johns Hopkins Hospital Medical Office Building

In this technical report, the existing equipment in the MOB will be evaluated from a functional standpoint. The design influences and goals for the MOB will be discussed as well as possible other mechanical selections and their advantages or disadvantages.

A table of major mechanical systems is provided along with a number of simplified schematics of the major mechanical systems in the building. These schematics along with the equipment table will provide an easily interpreted system operation guide.

Design Objectives and Requirements

The JHH MOBs mechanical system was designed with first cost in mind primarily. For this reason the MOB is conditioned with all electric systems. The cooling is accomplished by six package dx units manufactured by York that are located on the roof. The heating is accomplished via terminal VAV reheat units.

The MOBs four floors have uneven thermal loading and ventilation requirements due to their varied use. The Basement Level as well as the First Floor is mostly patient examination areas. This means many of the spaces are unoccupied for much of the day, and very few of the spaces have significant thermal load from electronics or the sun. The upper two floors have different ventilation and load requirements than the lower two because their primary use is as office and conference space. To accommodate this difference in needs, the upper floor is served exclusively by two of the rooftop units, while the other four units are ducted into two pairs, one serving the southern side of floors Basement through Second and one serving the Northern side. They access the lower floors through two mechanical shafts in the building.

As well as the standard MEP equipment, the MOB also utilizes Oxygen supply. The Oxygen is piped in from the central Oxygen plant at Johns Hopkins Hospital. There is a 9000 lb main supply tank, as well as a 3000 lb reserve tank. The Oxygen is reduced to 55 psig at the main station, regulated by a central automated hub and supplied to the MOB via a 1” supply line.

Outdoor and Indoor Design Conditions

The MOB is located in Baltimore Maryland. The design summer dry bulb and wet bulb temperatures are 93 and 75 degrees Fahrenheit respectively. The average summer entering dry bulb and wet bulb temperatures for the dx units are 74 and 62 degrees Fahrenheit.

The indoor design set points are 72 degrees Fahrenheit and 50% relative humidity. This is standard design practice for Leach Wallace in areas where patients are present.

The rooftop units distribute cooled air at 53 degrees Fahrenheit with a wet bulb temperature of 50 degrees Fahrenheit.

Under heating conditions the air is heated to between 80 and 89 degrees by the terminal reheat units.

Site Factors Influencing Design

There are few site conditions influencing design at the MOB. The site itself is relatively tight, and for this reason rooftop placement of the AHUs was chosen. The most interesting site factor is actually one that doesn’t influence the design.

The central chilled water and steam plant for Johns Hopkins Hospital campus is located on the same block as the MOB and is not utilized. The central plant is under capacity, and about one hundred yards away from the MOB. It might seem like a foregone conclusion that since the MOB is going to be owned and occupied by JHH, they would opt to take an efficient chilled water and steam system over the all electric option. However because of its lower first cost they went with the all electric system.

Energy Sources, Rates, and Incentives for the MOB

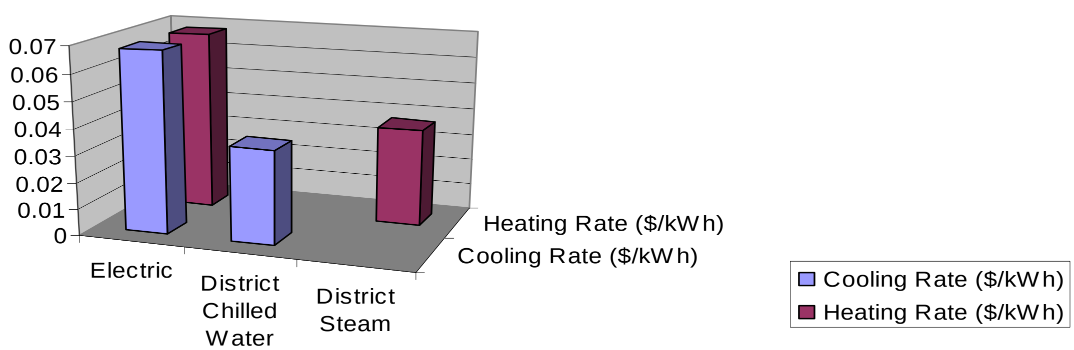
The MOB uses all electric systems. The electricity demand rate is quoted at $.068 per kWh as per Johns Hopkins Hospital. The cooling and dehumidifying as well as the main fans are all located in the packaged dx units on the roof.

Heating accomplished through electric reheat terminal VAV boxes. The demand rate for these is of course $.068 per kWh as well.

The peculiar thing about Johns Hopkins Hospitals choice to go with all electric system is peculiar because the central plant for JHH is located on the exact same block as the MOB.

This plant could supply cheap chilled water and steam and is currently under capacity. Chilled water could be supplied at the rate of $10.33 per million BTU or $.0353 per kWh from the JHH central plant. Steam could be supplied at a rate of $1.0784 per Therm or $.03679 per kWh from the same plant.

Figure 1



	Electric	District Chilled Water	District Steam
Cooling Rate ($/kWh)	0.068	0.0353	
Heating Rate ($/kWh)	0.068		0.0368

Figure 1 shows the relative cost of Electric vs District Chilled water in a cooling application, and Electric vs District Steam in a heating application.

Design Ventilation and Tech Report One Ventilation

At design conditions the six rooftop AHUs are set to intake ten percent outdoor air. The total amount of outdoor air supplied to the building is 12200 cfm.

In technical report one, it was found that the MOB required only 8516 cfm of outdoor air to satisfy the requirements set forth by ASHRAE std 62.1-2004. The building was therefore found to comply with std 62.1-2004.

Design Thermal Load and Tech Report Two Thermal Load

Of the six rooftop units that handle cooling, two are rated at 61.7 Tons and four are rated at 61.1 Tons. There is also a split system dx fancoil unit with a rooftop air cooled condensing unit. This is located on a lower roof above the first floor and is used to take excess load from two large dialysis rooms located in the rear of the building. This secondary cooling system is rated at 7.5 Tons. Total cooling capacity for the MOB is therefore 375.4 Tons.

The total cooling load found by HAP in the second technical report was well below the system capacity. HAP returned an expected cooling need of 250.9 Tons.

The heating component of the MOB shows an even larger discrepancy in size between design and technical report twos findings.

The design heating load of the MOB is 380 KW. This is all accomplished by terminal electric reheat fan powered VAV boxes. This is quite higher than the heating estimate from HAP of just over 58 KW of heating needed. One possible reason for the apparent over sizing of the heating equipment could be possible uneven heating needs of the spaces. This would require over sizing of the individual VAV box reheat coils so that boxes can individually meet demands placed on them.

Annual Design Energy Use
and
Tech Report Three Annual Energy Use

Leach Wallace and Associates estimate the annual energy use at 3,139,077 kWh. This number is slightly higher than the HAP estimate, but the HAP load is conservative on its estimate of office computer load.

The HAP annual energy use found in the third tech report 2,634,237 kWh. The HAP load also uses a low setting of 10% for the times when the building is empty which may be slightly low.

Summary of Major Equipment

The major equipment in the MOB consists of the rooftop air handling units, with accompanying exhaust fans. There is also a small supplementary split system with the air handler located in the elevator machine room and the heat rejected from an air cooled condensing unit on the lower level roof. In terms of plumbing, the MOB is fairly sparse. There only major plumbing system is the domestic hot water system located entirely in the basement plumbing room. There are two storm water sump pumps, one in the lower level courtyard and one in the elevator shaft. There is a second pump in the lower level courtyard that serves as a sewage ejector.

Major Equipment Spreadsheet

Category	Name	Description	Location	SA (cfm)	OA (cfm)	Gross Cooling Cap (Tons)	LAT (degrees F)	SA Fan Power (number and HP)	RA Fan Power (HP)
AIR HANDLING UNITS	AHU-1	Package DX unit	Rooftop	21000	2100	61.13	53	(2) 17.35	8.1
	AHU-2	Package DX unit	Rooftop	21000	2100	61.13	53	(2) 17.35	8.1
	AHU-3	Package DX unit	Rooftop	21000	2100	61.13	53	(2) 14.78	7.1
	AHU-4	Package DX unit	Rooftop	21000	2100	61.13	53	(2) 14.78	7.1
	AHU-5	Package DX unit	Rooftop	21000	2100	61.7	53	(2) 6.95	5.9
	AHU-6	Package DX unit	Rooftop	21000	2100	61.7	53	(2) 6.95	5.9

Category	Name	Description	Location	SA (cfm)	OA (cfm)	Gross Cooling Cap (Tons)	Comp Power (HP)	Fan Power (HP)
RECIRC UNIT	ACCU-1	Split System Condensing Unit	Lower Rooftop			7.5	7.5	0.5
	FCU-1	Split System DX unit	Elevator Mech Room	3000	0	7.5		2

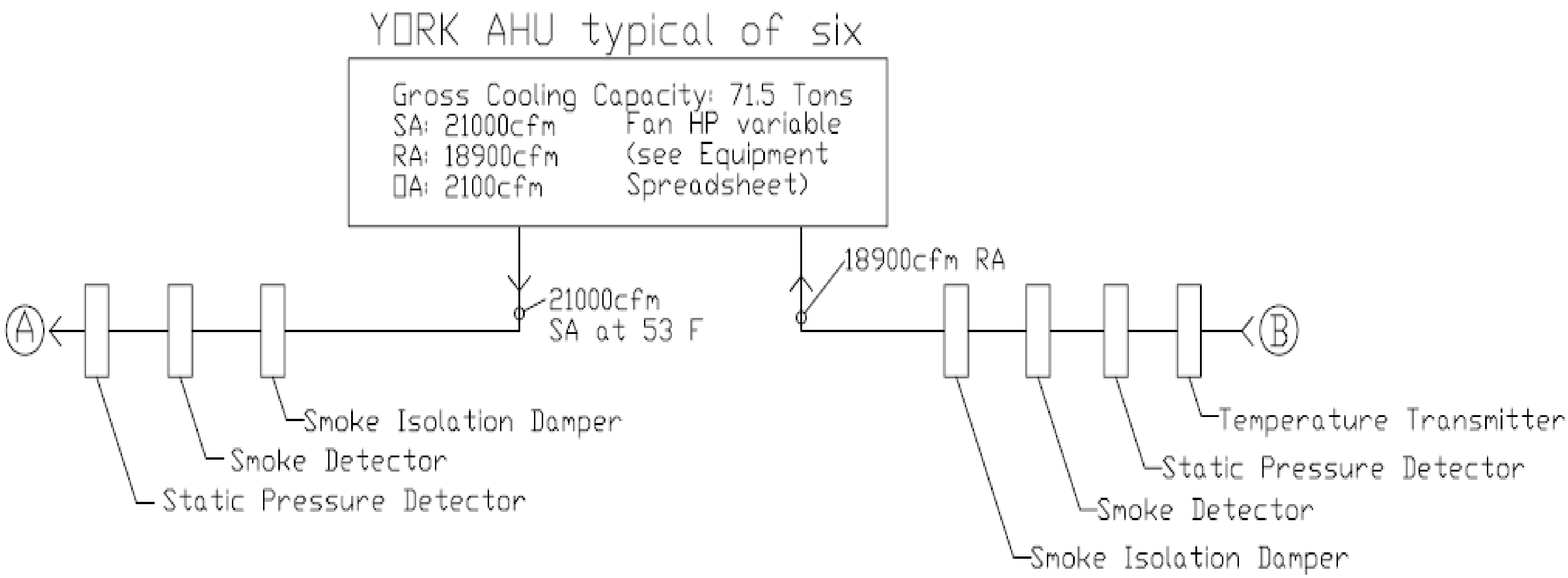
Category	Name	Description	Location	Capacity (gallons)	Rate (GPM)	EWT (degrees F)	LWT (degrees F)	Power (kW)
DOMESTIC HOT WATER	EWH-1	Domestic Water Heater	Plumbing 102	225	180	40	120	36
	ET-1	Expansion Tank	Plumbing 102	2				

Category	Name	Description	Location	Flow Rate (GPM)	Head (feet wg)	Motor Speed (RPM)	Power (HP)
	P-1	Domestic Hot Water Pump	Plumbing 102	7	40	1750	0.75
SUMP PUMPS	SP-2	Storm Water Sump Pump	Lower Level Courtyard	380	41	1735	15
	SP-3	Sewage Ejector	Lower Level Courtyard	100	41	1690	5
	SP-4	Elevator Shaft Sump Pump	Elevator Shaft Sump	25	25	3600	0.5

Category	Name	Description	Location	Max Flow (cfm)	Static Pressure (inches wg)	Fan Power (HP)
EXHAUST FANS	EF-1	Lavatory Exhaust Fan	Rooftop	3235	1	1
	EF-2	Lavatory Exhaust Fan	Rooftop	3250	1	1.5
	EF-3	Lavatory Exhaust Fan	Rooftop	3025	1	1
	EF-4	Lavatory Exhaust Fan	Rooftop	600	0.4	0.125

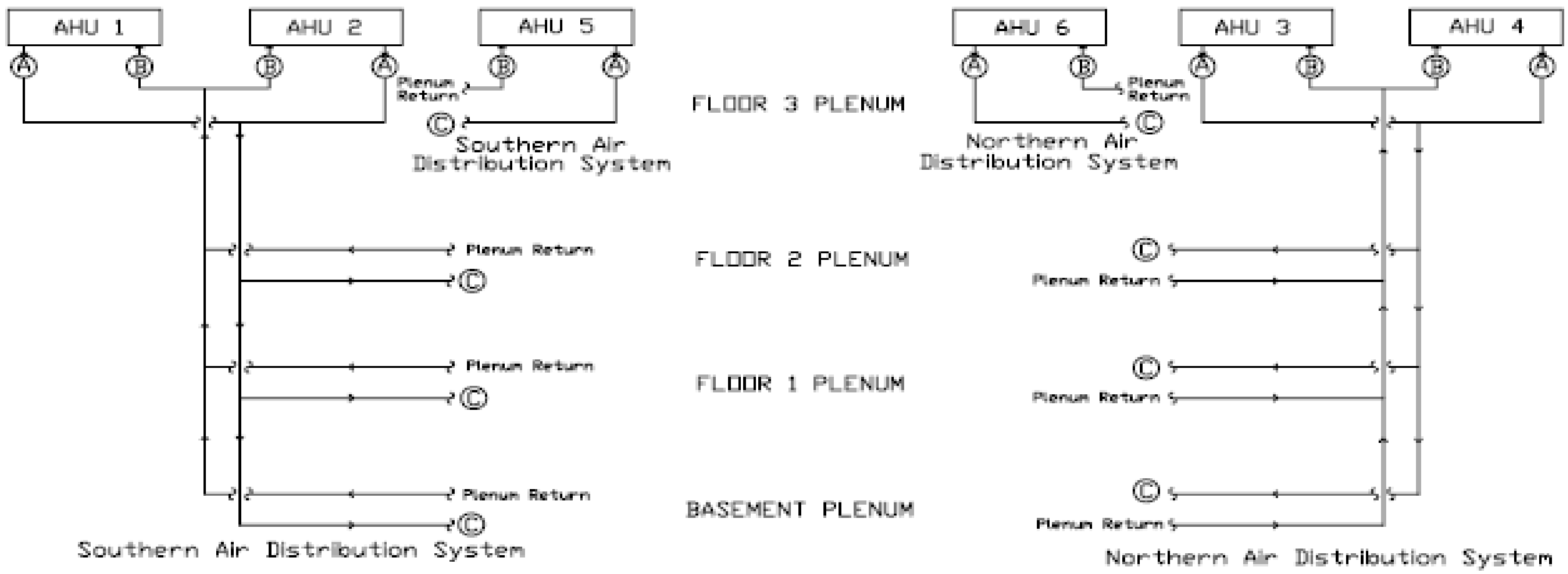
Air Handling Unit Schematic

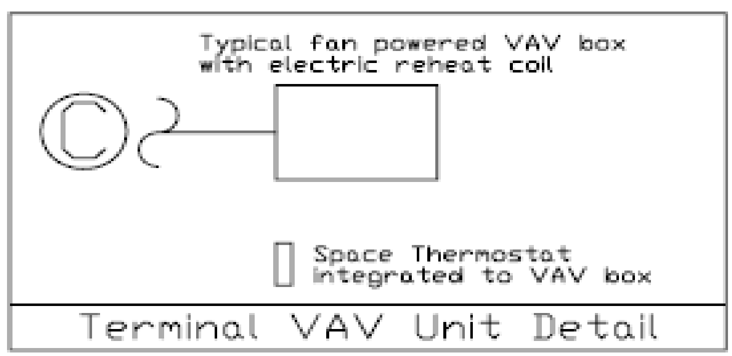
This schematic shows the typical rooftop AHU with it's immediate connections, namely the smoke isolation dampers and static pressure sensors.



Duct Riser Diagram

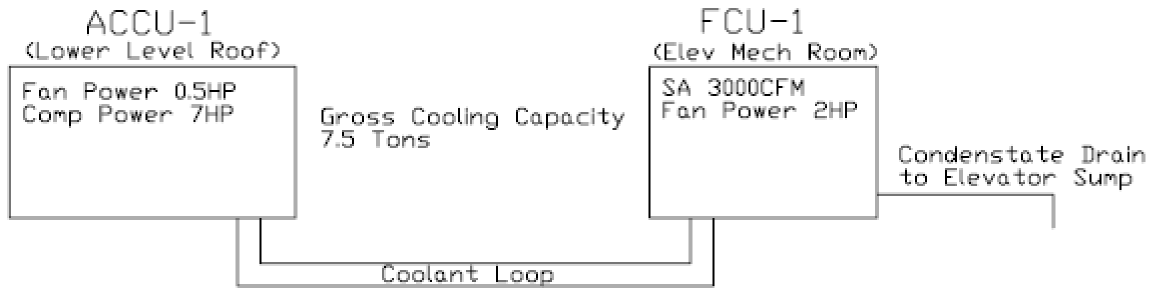
This diagram shows the way in which the AHUs are ducted together in the case of AHUs 1-4 as well as the floors the particular air handlers serve. Both duct risers are located in one of two main mechanical shafts in the building.





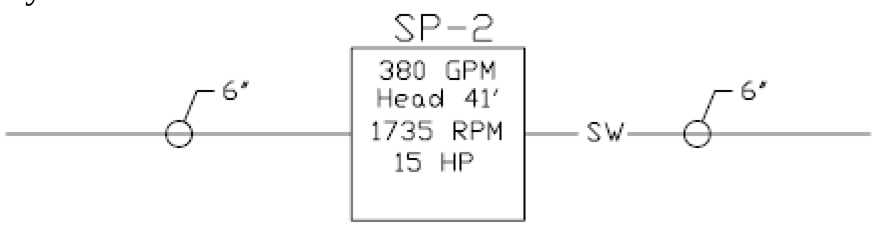
Split System DX Unit with Air Cooled Condensing Unit

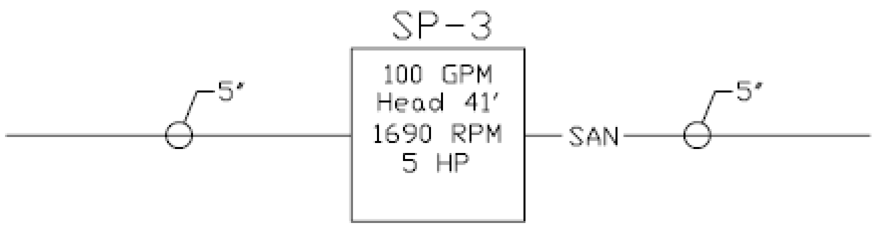
This diagram shows the very basic split system. The air handler is located in the basement elevator mechanical room and the heat rejecting air cooled condensing unit is located on the lower level roof.

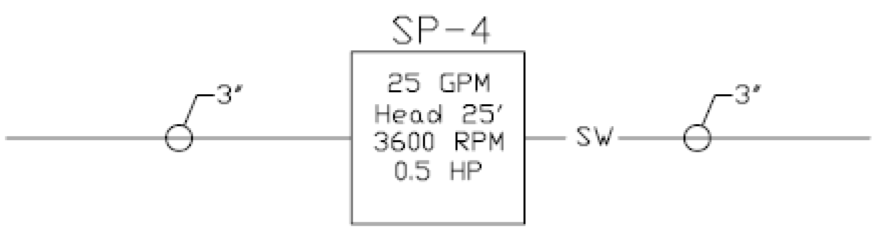


Sump Pumps

Both SP-2 and SP-4 are storm water sump pumps, SP-2 is located in the lower level courtyard, and SP-4 is located in the elevator shaft. SP-3 basically a booster pump for the sewage system, and is located in the lower level courtyard.

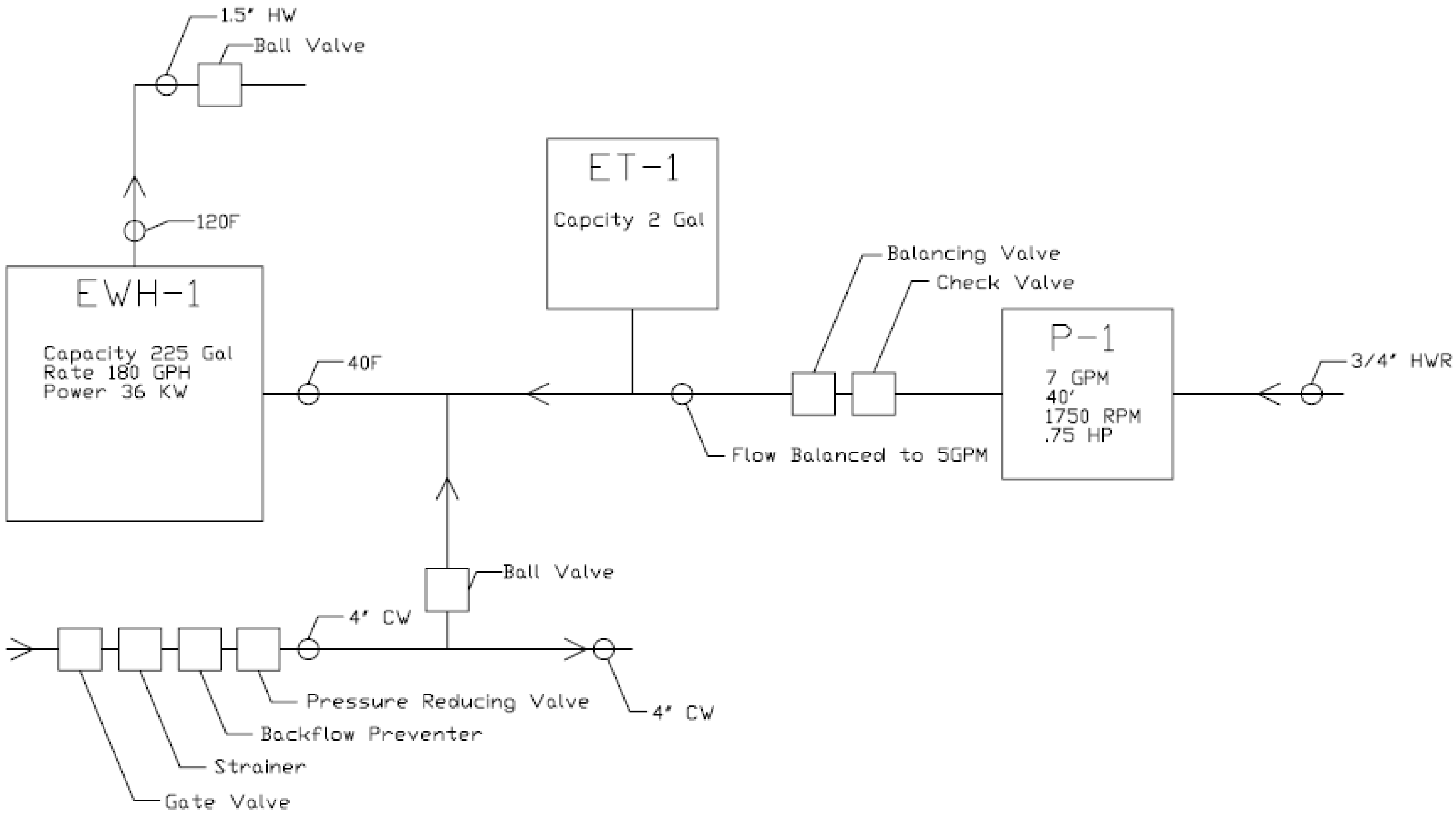






Domestic Hot Water Schematic

This Diagram shows the plumbing layout in the room called Plumbing 102. This room is the main plumbing room for the building and is located in Southern end of the Basement.



System Description

The system description will begin with the Air Handling Units and work its way down the building. The Air Handling Units are all electric packaged DX units. This means that within a single unit, return air and outdoor air are mixed at one end of the unit. From there the mixed air is filtered, and passed through a cooling coil. In more efficient systems, the coolant from this cooling coil would be sent to a chiller where its heat is rejected to a water loop that in turn rejects heat to the air via a large but inexpensive cooling tower. The DX in the air handlers designation means that instead of this hydronic loop found in most systems, the coolant simply runs through a condenser coil at the other end of the unit and the heat is rejected directly to air that is drawn over the coil by fans.

The end result is that in cooling situations, warm air and electricity go into the unit, and cold air comes out. This is one of the most inefficient ways to cool air and has its only bonus in its low first cost.

There are six air handling units on the roof, but not all of them serve distinct areas in the MOB. Air handlers One and Two are ducted together in the Third Floor Plenum and serve the Southern side of floors B-2. Air handlers Three and Four are similarly ducted together and serve the Northern side of floors B-2. The only floor now left unserved is the Third Floor. The Third Floor is served exclusively by AHU5 on the South side and AHU6 on the North side. All access to the basement, first floor, and second floor is through either the southern main mechanical shaft, or the northern main mechanical shaft.

There is also a much smaller air handler that is located in the Elevator Mechanical Room in the basement. This unit operates in the same manor as the larger main AHUs except that the heat rejecting condenser coils are separate from the supply fans and evaporator coil. The air cooled condensing unit is located on a lower level rooftop on the back (Western) side of the building and connected to the AHU via a refrigerant loop in the lower level plenum.

Plumbing typically takes a larger role in a building. However, without a hydronic cooling system, the MOB only has significant plumbing for domestic hot water.

This system consists of a hot water service loop with a water pump balanced to 5GPM. This hot water is passed by an expansion tank then is mixed with cold water supply. This new mixed water line feeds the 225 gallon capacity electric water heater. The water heater EWH-1 serves the domestic hot water needs of the MOB.

The three other plumbing details of note are the sump pumps. There is a sump pump, SP-3, at the base of the elevator shaft to collect and expel any water that makes its way into the elevator shaft as well as the condensate from the split system DX unit in the elevator mechanical room.

The other two sump pumps are located in the small lower level courtyard on the Northern side of the building. SP-2 expels storm water from the courtyard. SP-3 has the unfortunate job of being the sanitary booster pump. It elevates the sanitary discharge into a main sanitary line.

Operating History

The MOB is still under construction and therefore has no operating history.

Critique of System

The choice to use all electric systems in the MOB is a decision based on first cost. Johns Hopkins Hospital will be the owner and sole tenant of this building upon its completion. This seems like a position where the owner would be eager to use more efficient systems that will eventually save them money. This option is even facilitated by the fact that Johns Hopkins Hospital owns and operates a central chilled water and steam plant. This plant is under capacity and resides on the exact same block as the MOB.

Some of the only possible advantages to an all electric system lie in the fact that it’s much less complicated. Without chillers, rooftop plumbing systems and cooling towers, an electric DX setup should lend itself to a shortened construction time as well as less maintenance. The use of all electric systems also eases coordination issues with the rest of campus as well the surrounding city of Baltimore. The only inputs the building requires are electric, water and oxygen. This list could be lengthened to electric water, oxygen, oil and/or gas, steam and chilled water with a more efficient system.

It seems that a system utilizing the nearby district chilled water and steam capacity of the JHH campus would have been a more cost effective solution in the long run.