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The Hilton Baltimore Convention Center Hotel

Mechanical Technical Report #3

Mechanical Systems Existing Conditions Evaluation

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1.0 Executive Summary:

The purpose of this report is to summarize the existing mechanical systems in the Hilton Baltimore Convention Center Hotel (HBCCH). Design objectives and requirements, as well as energy sources and their corresponding rates, are studied in order to better understand the design criteria for the HBCCH. Influential cost and site factors are also considered, eventually conveying the fact that district chilled water and steam systems were good system choices.

Outdoor and indoor design conditions and design heating and cooling loads are presented, and schedules of major mechanical equipment and schematics of their use in the HBCCH are included. A description of system operation is discussed in order to provide further understanding of the building's mechanical systems. Lastly, a critical evaluation of the system is carried out. The purpose of this critique is to bring together the results of all the Mechanical Technical Reports in order to identify possible opportunities for redesign and study.

2.0 Design Objectives and Requirements

Project Information

The HBCCH is a full-service hotel located in the heart of downtown Baltimore. Immediately adjacent to both Oriole Park at Camden Yards and the Baltimore Convention Center, guests at the HBCCH will range from businessmen attending conferences to tourists looking to visit Inner Harbor and catch a Baltimore Orioles' game. With more than 750 guest rooms, the two towers which rise above the east and west podiums are the hotel portion of the HBCCH. Ballrooms, a restaurant, a swimming pool and exercise area, numerous meeting rooms, and large prefunction spaces are found throughout the lower podiums. At a cost of over $250 million, Hilton Hotels wants the HBCCH to be the centerpiece of Baltimore's downtown attractions.

Basis of Design

The main design objective is to provide Hilton Hotels with a quality, on-budget, hotel which allows for the designed use of all spaces. With hotels around the world, Hilton Hotels is a very experienced owner and is extremely familiar with the building construction process. Hilton Hotels lists all of their requirements in their manual, "Hilton Design and Construction Standards". The building mechanical system design must meet or exceed the expectations of this document.

Guest Room Towers

The HBCCH has two guest room towers. One tower reaches from level 4 to level 19, while the lower tower ranges from level 4 to level 14. Both towers are atop the west podium, and together they house the more than 750 guest rooms. These spaces, primarily occupied in the evening and overnight hours, require individual control of space temperature. Each guest room hotel therefore requires its own air conditioning and heating unit. Vertical fan coil units are located in each guest room in order to meet this requirement, and outside air is brought into the guest rooms from makeup air units located on the roofs of the towers.

Individual temperature control is not the only requirement in the guest room towers. Noise is also a concern. Guests require a comfortable, reasonably quiet space to occupy and sleep in. Maintenance requirements must also be taken into consideration. Due to the high volume of guests expected in the HBCCH, it is important that the systems in the guest rooms be reliable enough to not require constant maintenance.

Public Spaces

The lower levels of the HBCCH, or podiums, contain many different types of public spaces. These spaces, including restaurants, ballrooms, prefunction spaces, meeting rooms, and lobbies, have highly variable occupancies. Meeting rooms could be completely full or entirely empty on a normal business day. At the same time, ballrooms and restaurants tend to be highly occupied in the afternoon and evening hours, while the hotel lobby is typically most crowded in the morning. This variable pattern of occupancy lends itself to a variable air volume (VAV) system.

The hotel swimming pool and exercise area are also public spaces, but they have special temperature and humidity requirements. Because of these special requirements, the swimming pool and exercise room are on their own separate systems.

Service Spaces

The many service spaces in the HBCCH contain equipment that generate heat. Mechanical rooms, electrical rooms, laundry rooms, etc… all require enough supply air to keep this generated heat from becoming a concern.

3.0 Energy Sources and Rates for the Site

Electricity

Electricity is supplied to the HBCCH from Baltimore Gas and Electric. Rates are listed in Table-1 below.

Table-1: Electricity Rates

Charge	Rate	
	Summer	Non-Summer
Minimum Customer Charge	$110	$110
Delivery Service Charge (cents/kWh)	1.239	1.239
Demand Charges (per kW)		
Generation Charge	-	-
Transmission Charge	$1.05	$1.05
Delivery Service	$2.67	$2.67
Energy Charges (cents/kWh)		
Peak	9.319	5.534
Intermediate	8.802	5.406
Off-Peak	8.464	5.118
Hours		
Peak	10am-8pm	7am-11am 5pm-9pm
Intermediate	7am-10am 8pm-11pm	11am-5pm
Off-Peak	11pm-7am	9pm-7am

Chilled Water

District chilled water comes to the HBCCH from ComfortLink in Baltimore, Maryland. ComfortLink supplies chilled water to over twenty sites in the downtown Baltimore area.

The rates for district chilled water are listed in Table-2 below. HBCCH currently reserves 1,800 tons of capacity with ComfortLink.

Table-2: District Chilled Water Rates

Charge	Monthly Rate
Capacity Charge	$210/ton of capacity
Usage Charge	$0.15/tonhr

Steam

District steam arrives at the HBCCH from Trigen. As of this time, Trigen and Hilton Hotels have not released information regarding the rates being charged for the district steam. A charge of $1.30/therm was assumed for the energy analysis conducted in Mechanical Technical Report #2.

4.0 Cost Factors Influencing Design Conditions

Hilton Hotels played a key role in determining the building mechanical system installed in the HBCCH. Systems were chosen mainly because Hilton Hotels uses similar systems at their various other sites. As a result, first cost and energy efficiency were not massive concerns during the design process.

The only unique cost factor considered was a rebate from ComfortLink concerning the purchase of district steam. ComfortLink serves over twenty sites in the downtown Baltimore area from three chiller plants located throughout the city. The HBCCH will be the largest site on ComfortLink's district system. Because of this fact, ComfortLink was willing to lower their typical capacity charge. The end result is a capacity charge of $210/ ton. It is impossible to compare this cost to the standard cost because ComfortLink and Hilton Hotels have not disclosed the standard cost.

5.0 Site Factors Influencing Design Conditions

The site for the HBCCH is two square blocks in a densely populated neighborhood of downtown Baltimore, Maryland. This site sits directly between Oriole Park at Camden Yards and the Baltimore Convention Center. Because of its high-profile nature, the designers of the HBCCH wanted to minimize the aesthetic effects the mechanical system components would have on the surrounding environment. A green roof was designed to cover the lower podiums roofs, and strategies were considered to place as little equipment on rooftops as possible.

Space was the other main site factor influencing design conditions. The site layout for the HBCCH leaves little or no room on the ground for mechanical equipment, and the owners of the building wanted to have very little lost rentable space caused by the building systems. Lost rentable space would result in smaller profits made by the hotel.

The result was that a creative approach had to be taken in order to accommodate both of these site factors. Due to its availability in the area, the building mechanical system design team deciding to utilize district steam and chilled water systems. Trigen district steam and ComfortLink district chilled water systems were already serving the adjacent Baltimore Convention Center, so getting the systems on site was not overly difficult. As a result, very little space is needed inside the HBCCH for mechanical rooms, and the outdoor aesthetic of the structure is maintained.

It's also important to realize building orientation is a crucial site factor that can seriously influence design conditions. Heating and cooling loads from the building envelope change drastically depending on the direction of the exposure. No massive expanses of glass face north in the HBCCH, helping to control the design heating load. On the other hand, designers were forced to place large glass curtain walls on the south facing side of the structure, certainly increasing the design cooling load.

6.0 Outdoor and Indoor Design Conditions

The outdoor and indoor design conditions listed in Table-3 and Table-4 below were specified in Southland Industries' *Basis of Design for the Hilton Baltimore Convention Center Hotel*. These values were used by the building mechanical system designer for all load calculations. Values were determined using ASHRAE Fundamentals and through consultations with Hilton Hotels.

Outdoor Design Conditions

Table-3: Outdoor Design Conditions

Outdoor Design Conditions	
Summer DB and coincident WB	93˚F DB/ 75˚F WB
Summer WB for 100% OA Systems	78˚F
Winter DB	4˚F

Indoor Design Conditions

Table-4: Indoor Design Conditions

Indoor Design Conditions				
ROOM TYPE	INDOOR CONDITIONS			HVAC NOISE CRITERIA
	SUMMER TEMP	RELATIVE HUMIDITY	WINTER TEMP	
Ballrooms	73.0 +/- 2.0°F	60% max	70.0 +/- 2.0°F	NC-35
Conference Rooms	73.0 +/- 2.0°F	60% max	70.0 +/- 2.0°F	NC-35
Electrical Rooms	75.0 +/- 5.0°F	60% max	70.0 +/- 5.0°F	-
Elevator Machine Rooms	75.0 +/- 5.0°F	60% max	70.0 +/- 5.0°F	-
Exercise Room	73.0 +/- 2.0°F	60% max	70.0 +/- 2.0°F	NC-40
Guest Rooms	73.0 +/- 2.0°F	60% max	70.0 +/- 2.0°F	NC-30
Guest Toilet Room	74.0 +/- 2.0°F	60% max	67.0 +/- 2.0°F	-
Kitchen/Pantry	78.0 °F max	-	70.0 °F min	NC-40
Lobby	73.0 +/- 2.0°F	60% max	70.0 +/- 2.0°F	NC-35
Meeting Rooms	73.0 +/- 2.0°F	60% max	70.0 +/- 2.0°F	NC-35
Offices and Open Office Area	74.0 +/- 2.0°F	60% max	67.0 +/- 2.0°F	NC-35
Prefunction	73.0 +/- 2.0°F	60% max	70.0 +/- 2.0°F	NC-35
Pool	82.0 °F max	60% max	82.0 °F min	NC-40
Public Corridors	73.0 +/- 2.0°F	60% max	70.0 +/- 2.0°F	NC-35
Restaurants	73.0 +/- 2.0°F	60% max	70.0 +/- 2.0°F	NC-35
Restrooms	74.0 +/- 2.0°F	60% max	67.0 +/- 2.0°F	-

Indoor Design Conditions				
ROOM TYPE	INDOOR CONDITIONS			HVAC NOISE CRITERIA
	SUMMER TEMP	RELATIVE HUMIDITY	WINTER TEMP	
Service Corridors	74.0 +/- 2.0^{o}F	60% max	67.0 +/- 2.0^{o}F	NC-50
Storage Rooms	74.0 +/- 2.0^{o}F	60% max	67.0 +/- 2.0^{o}F	-
Training Rooms	73.0 +/- 2.0^{o}F	60% max	70.0 +/- 2.0^{o}F	NC-35
Telecom Rooms	70.0 +/- 2.0^{o}F	60% max	70.0 +/- 2.0^{o}F	-
Work Areas & Housekeeping	76.0 +/- 2.0^{o}F	60% max	65.0 +/- 2.0^{o}F	NC-50

7.0 Design Ventilation Requirements

Table-5 below compares the design ventilation requirements with the ventilation requirements estimated in Mechanical Technical Report #1. Note that no values were estimated for the Makeup Air Units in Mechanical Technical Report #1, so there are no values to compare the design values to. The estimated values are lower than the design values for every system except AHU 8. This discrepancy is most likely due to the assumption made for space occupancy. The design engineer and the estimate made in Mechanical Technical Report #1 used two different space types.

Table-5: Ventilation Requirements

System	Design OA (CFM)	Estimated OA (CFM) From Tech 1
MAU 1	34,000	-
MAU 2	23,000	-
MAU 3	21,000	-
MAU 4	8,000	-
AHU 1	14,000	13,589
AHU 2	24,000	23,435
AHU 3	16,000	15,160
AHU 4	11,000	10,657
AHU 5	25,000	14,223
AHU 6	28,000	26,193
AHU 7	28,000	27,039
AHU 8	3,000	3,366
PAC 1	4,300	2,661

8.0 Design Loads

Cooling loads were calculated in Mechanical Technical Report #2 using TraneTRACE. The results of that analysis are compared to the cooling loads taken from the contract documents in Table-6 below.

Table-6: Design and Calculated Cooling Loads

System	Output	Cooling (ft^2/ton)
AHU 1	TRACE	332.85
	Design	250.16
AHU 2	TRACE	185.37
	Design	136.80
AHU 3	TRACE	272.85
	Design	161.23
AHU 4	TRACE	258.14
	Design	163.75
AHU 5	TRACE	70.16
	Design	56.50
AHU 6	TRACE	83.22
	Design	65.46
AHU 7	TRACE	142.07
	Design	114.69
AHU 8	TRACE	238.38
	Design	123.96
MAU 1	TRACE	194.96
	Design	287.64
MAU 2	TRACE	240.51
	Design	306.45
MAU 3	TRACE	146.92
	Design	60.99
MAU 4	TRACE	157.24
	Design	55.03

Design heating loads can be below in Table-7. There is still concern about the values of the heating loads calculated in Mechanical Technical Report #2, so those values were not included. Future analysis must be made before any redesigns are calculated in the spring semester.

Table-7: Design Heating Loads

System	Sensible Heating Load (MBH)
AHU 1	922.3
AHU 2	1,581.1
AHU 3	1,054.1
AHU 4	790.6
AHU 5	1,712.9
AHU 6	1,844.6
AHU 7	1,844.6
AHU 8	197.6
MAU 1	2,056.3
MAU 2	1,391.0
MAU 3	1,723.7
MAU 4	656.6

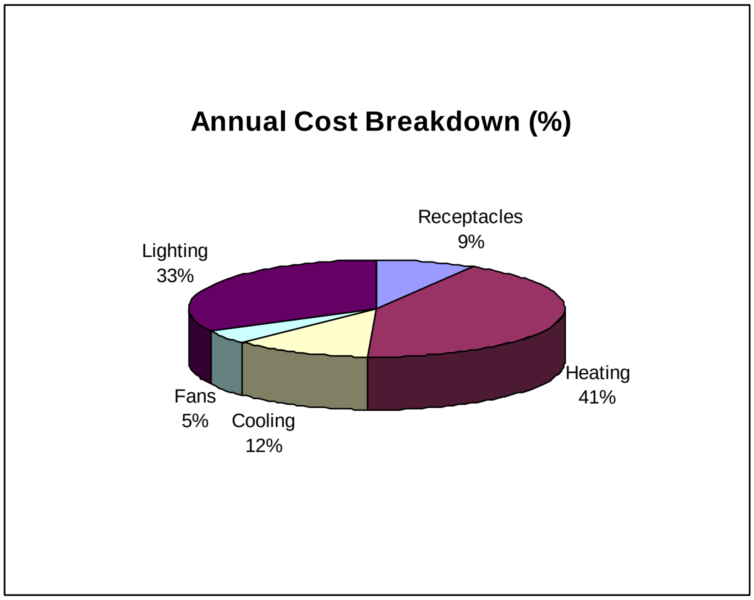
9.0 Annual Energy Use

As stated in Mechanical Technical Report #2, the overall cooling cost to operate the HBCCH is $7.07 per square foot. This value, seemingly rather high at first glance, is expensive due to the fact that the building purchases chilled water from a district system. This high cost is offset by the fact that the building mechanical system had a very low first cost and will have very low maintenance costs.

The results of the energy and cost analysis completed in Mechanical Technical Report #2 can be seen below in Figure-1. The building design engineer has not yet completed an energy analysis, and it is unlikely that one will ever be completed. This fact means there are no designer values available for comparison.

After completing the energy and cost analysis and reviewing the results, it is increasingly clear that something is not correct in the overall annual cost breakdown. Heating costs should not be the highest energy cost for a multi-use facility in downtown Baltimore, Maryland. Numerous attempts were made to find an error in the heating portion of the building load estimation program used in Section 8.0 of this report, but none could be found. It is obvious that further work and hopefully future comparison with the building design engineer's energy analysis need to be carried out to eliminate this issue before any alternatives or redesigns are carried out in the spring.

Figure-1: Energy Use Cost Breakdown



10.0 Schedules of Major Equipment

All data provided below was obtained in the contract documents for the HBCCH.

Table-8: Air Handling Units

Air Handling Units (AHUs)									
Designation		AHU 1	AHU 2	AHU 3	AHU 4	AHU 5	AHU 6	AHU 7	AHU 8
Serves		W-Mezz	E-Ground	W-2	E-2/3	E-Ball	W-Ball	W-Ball	W-4
Location		W-Mezz	E-Mezz	W-3	E-Roof	E-Roof	W-3	W-3	W-Roof
Supply Fan	Supply (CFM)	31,000	31,000	38,000	26,000	47,000	48,500	48,500	4,000
	Outdoor (CFM)	14,000	24,000	16,000	11,000	25,000	28,000	28,000	3,000
	TSP (IN WG)	4.50	4.50	4.50	4.00	4.00	4.50	4.50	4.76
	ESP (IN WG)	-	-	2.50	2.00	2.00	-	-	2.00
	Fan RPM	1,357	1,357	810	1,080	887	887	887	3360
	BHP	35.3	35.3	33.3	28.5	42.2	45.1	45.1	6.1
	Nameplate HP	40	40	40	40	50	50	50	7.5
Relief Fan	Relief (CFM)	29,000	32,000	37,000	27,000	21,000	12,000	12,000	-
	TSP (IN WG)	1.00	1.00	1.00	1.25	1.25	1.00	1.00	-
	ESP (IN WG)	-	-	-	0.75	0.75	-	-	-
	Fan RPM	2,300	1,169	1,169	632	579	582	582	-
	BHP	8.4	14.9	13.2	8.7	16.3	3.5	3.5	-
	Nameplate HP	10	20	15	10	20	5	5	-
Preheat Coil	Face Area (SQ FT)	25	47	52	23	88	92	92	8
	Face Velocity (FPM)	500	500	735	500	536	530	530	523
	Capacity (MBH)	922	1,581	1,054	791	1,713	1,845	1,845	198
	EDB (F)	4	4	4	4	4	4	4	4
	LDB (F)	65	65	65	65	65	65	65	65
	Press. Drop (IN WC)	0.10	0.10	0.12	0.10	-	-	-	0.21
	Flow (GPM)	46.1	79.1	52.7	39.5	85.6	92.2	92.2	9.9
	EWT (F)	180	180	180	180	180	180	180	180
	LWT (F)	140	140	140	140	140	140	140	140
	Press. Drop (FT WC)	1.30	1.30	2.40	8.70	0.26	0.24	0.24	2.80
Cooling Coil	Face Area (SQ FT)	62	62	85	52	92	97	97	8
	Face Velocity (FPM)	500	500	445	500	513	502	502	523
	Capacity (Ton)	162	229	198	134	268	329	302	26
	Sens. Cap. (MBH)	991	1,113	1,200	834	1,535	1,705	1,705	143
	EDB (F)	82.1	85.7	81.8	82.2	83.4	86.8	86.8	85.5
	EWB (F)	71.6	77.7	71.6	71.4	73.4	77.1	75.5	75.2
	LDB (F)	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5
	LWB (F)	50	50	50	50	50	50	50	50
	Press. Drop (IN WC)	1.06	0.87	0.75	0.97	1.08	1.02	1.02	1.68
	Flow (GPM)	193.9	379.5	243.4	178.1	458.9	563.3	516.9	51.5
	EWT (F)	42	42	42	42	42	42	42	42
	LWT (F)	62.0	62.0	61.5	60.0	56.0	56.0	56.0	54.0
	Press. Drop (FT WC)	11.80	15.80	11.50	10.50	6.90	7.00	7.00	10.50

Table-9: Makeup Air Units

Makeup Air Units (MAUs)					
Designation		MAU 1	MAU 2	MAU 3	MAU 4
Serves		High Tower	Low Tower	W-Kitchen	E-Kitchen
Location		W-19	W-14	W-3	E-Mezz
Supply Fan	Supply (CFM)	34,000	23,000	21,000	8,000
	Outdoor (CFM)	34,000	23,000	21,000	8,000
	TSP (IN WG)	4.10	4.80	3.80	3.70
	ESP (IN WG)	1.50	1.50	1.50	1.50
	Fan RPM	946	1,077	1152	1,711
	BHP	32.4	28	18	8.9
	Nameplate HP	40	30	20	10
Preheat Coil	Face Area (SQ FT)	65	51	40	17
	Face Velocity (FPM)	472	455	525	473
	Capacity (MBH)	2,056	1,391	1,724	657
	EDB (F)	4	4	4	4
	LDB (F)	60	60	80	80
	Press. Drop (IN WC)	0.15	0.20	0.23	0.22
	Flow (GPM)	102.8	69.6	86.2	32.8
	EWT (F)	180	180	180	180
	LWT (F)	140	140	140	140
	Press. Drop (FT WC)	1.90	3.20	2.90	36.20
Cooling Coil	Face Area (SQ FT)	72	51	40	17
	Face Velocity (FPM)	472	455	525	473
	Capacity (Ton)	184	124	159	61
	Sens. Cap. (MBH)	734	497	773	309
	EDB (F)	72.5	72.5	88.3	88.3
	EWB (F)	72.1	72.1	78.1	78.1
	LDB (F)	52.5	52.5	52.5	52.5
	LWB (F)	52	52	52	52
	Press. Drop (IN WC)	1.04	1.08	1.34	1.23
	Flow (GPM)	315.0	213.1	259.7	103.9
	EWT (F)	42	42	42	42
	LWT (F)	56	56	56	56
	Press. Drop (FT WC)	5.5	19.8	18.3	8.5
Reheat Coil	Face Area (SQ FT)	2	3	-	-
	Face Velocity (FPM)	525	525	-	-
	Capacity (MBH)	922	624	-	-
	EDB (F)	55	55	-	-
	LDB (F)	80	80	-	-
	Press. Drop (IN WC)	0.15	0.20	-	-
	Flow (GPM)	46.1	31.2	-	-
	EWT (F)	180	180	-	-
	LWT (F)	140	140	-	-
	Press. Drop (FT WC)	1.90	3.20	-	-

Table-10: Pumps

Pumps							
Designation	HHWP 1	HHWP 2	HHWP 3	CHWP 1	CHWP 2	CHWP 3	CHWP 4
Location	W-B1	W-B1	W-B1	E-Mezz	E-Mezz	E-Mezz	E-Mezz
Flow (GPM)	750	750	750	1,920	1,920	720	720
TDH (FT WG)	140	140	140	120	120	120	120
Impeller Diameter (IN)	12.625	12.625	12.625	12.000	12.000	11.875	11.875
Efficiency	79.9	79.9	79.9	84.4	84.4	79.3	79.3
RPM	1,800	1,800	1,800	1,800	1,800	1,800	1,800
Brake Horsepower	33.6	33.6	33.6	69.4	69.4	27.7	27.7
Nameplate Horsepower	40	40	40	75	75	40	40

Table-11: Steam to Water Heat Exchangers

Steam to Water Heat Exchangers			
Designation		HHWX 1	HHWX 2
Location		W-B1	W-B1
Shell Side	Fluid	Steam	Steam
	Flow (LBS/HR)	16,500	16,500
	Pressure (PSIG)	150	150
	Temp (F)	250	250
Tube Side	Fluid	Water	Water
	Flow (GPM)	810	810
	EWT (F)	140	140
	LWT (F)	180	180
	Press. Drop (FT WC)	5	5

Table-12: Water to Water Heat Exchangers

Water to Water Heat Exchangers			
Designation		CHWX 1	CHWX 2
Location		E-Mezz	E-Mezz
Primary Side	Fluid	Water	Water
	Flow (GPM)	1,500	1,500
	EWT (F)	37	37
	LWT (F)	54	54
	Press. Drop (FT WC)	23	23
Secondary Side	Fluid	Water	Water
	Flow (GPM)	1,715	1,715
	EWT (F)	56	56
	LWT (F)	42	42
	Press. Drop (FT WC)	23.2	23.2

Table-13: Typical Vertical Fan Coil Units

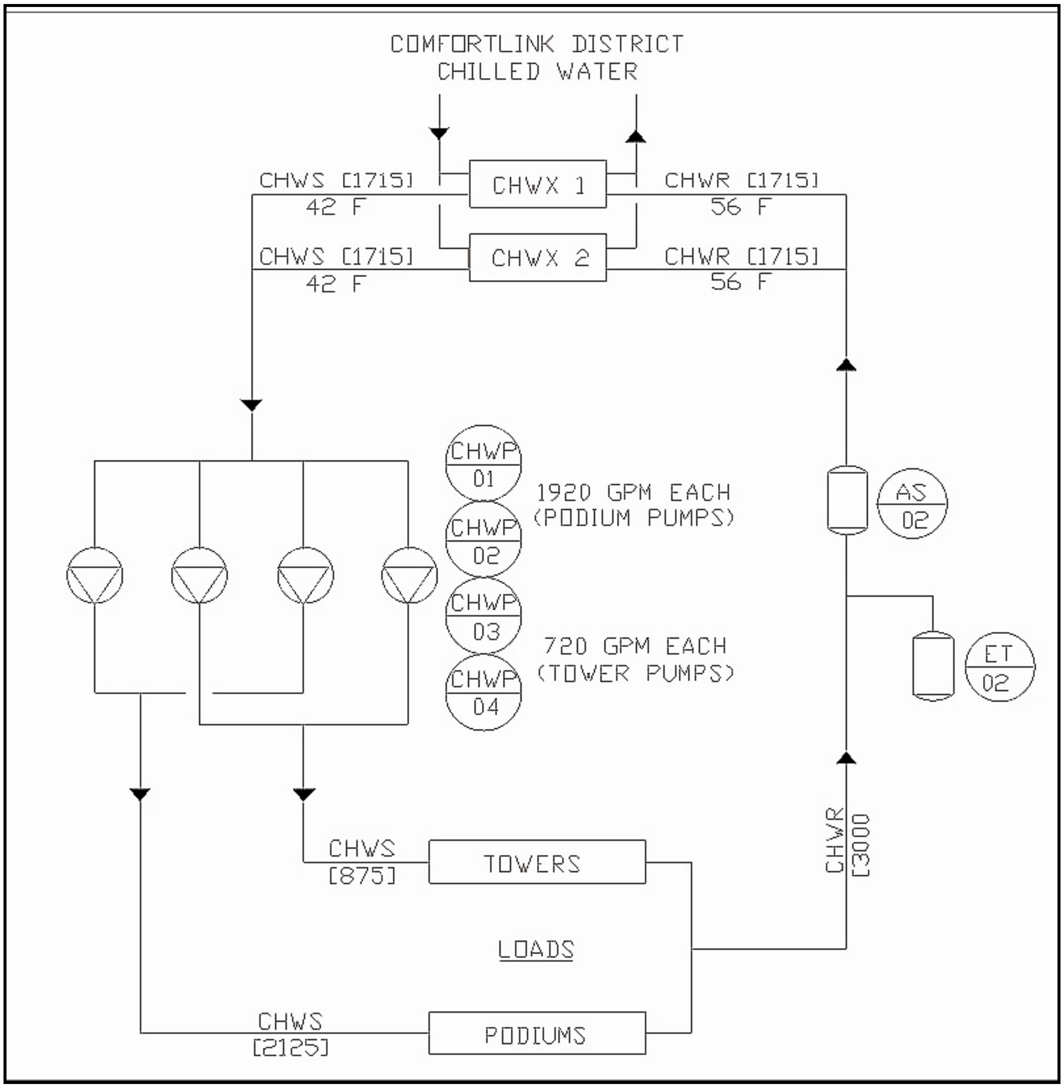
Typical Vertical Fan Coil Units							
Designation		VFCU A	VFCU B	VFCU C	VFCU D	VFCU E	VFCU F
Supply Fan	Supply (CFM)	350	350	350	350	450	450
	Outdoor (CFM)	-	-	-	-	-	-
	TSP (IN WG)	0.60	0.60	0.60	0.60	0.60	0.60
	ESP (IN WG)	-	-	-	-	-	-
	BHP	0.02	0.02	0.02	0.02	0.04	0.04
	Nameplate HP	1/35	1/35	1/35	1/35	1/25	1/25
Electric Heating Coil	Capacity (MBH)	2.0	3.0	2.0	3.0	4.0	4.0
	Capacity (KW)	6.8	10.2	6.8	10.2	13.7	13.7
	EAT (F)	68.0	68.0	68.0	68.0	68.0	68.0
	LAT (F)	86.0	95.0	86.0	95.0	96.0	96.0
Cooling Coil	Capacity (MBH)	13.4	13.4	13.4	13.4	16.8	16.8
	Sens. Cap. (MBH)	8.5	8.5	8.5	8.5	10.8	10.8
	EDB (F)	80.0	80.0	80.0	80.0	80.0	80.0
	EWB (F)	67.0	67.0	67.0	67.0	67.0	67.0
	LDB (F)	58.0	58.0	58.0	58.0	58.0	58.0
	LWB (F)	54.4	54.4	54.4	54.4	54.4	54.4
	Flow (GPM)	3.0	3.0	3.0	3.0	3.8	3.8
	EWT (F)	45.0	45.0	45.0	45.0	45.0	45.0
	LWT (F)	55.0	55.0	55.0	55.0	55.0	55.0
	Press. Drop (FT WC)	12.70	18.80	-	-	-	-

11.0 Schematic Drawings of Mechanical Systems

All of the following schematics were created using information found in the HBCCH's contract documents. Section 12.0 of this report corresponds with the schematics and should be referenced in order to better understand them.

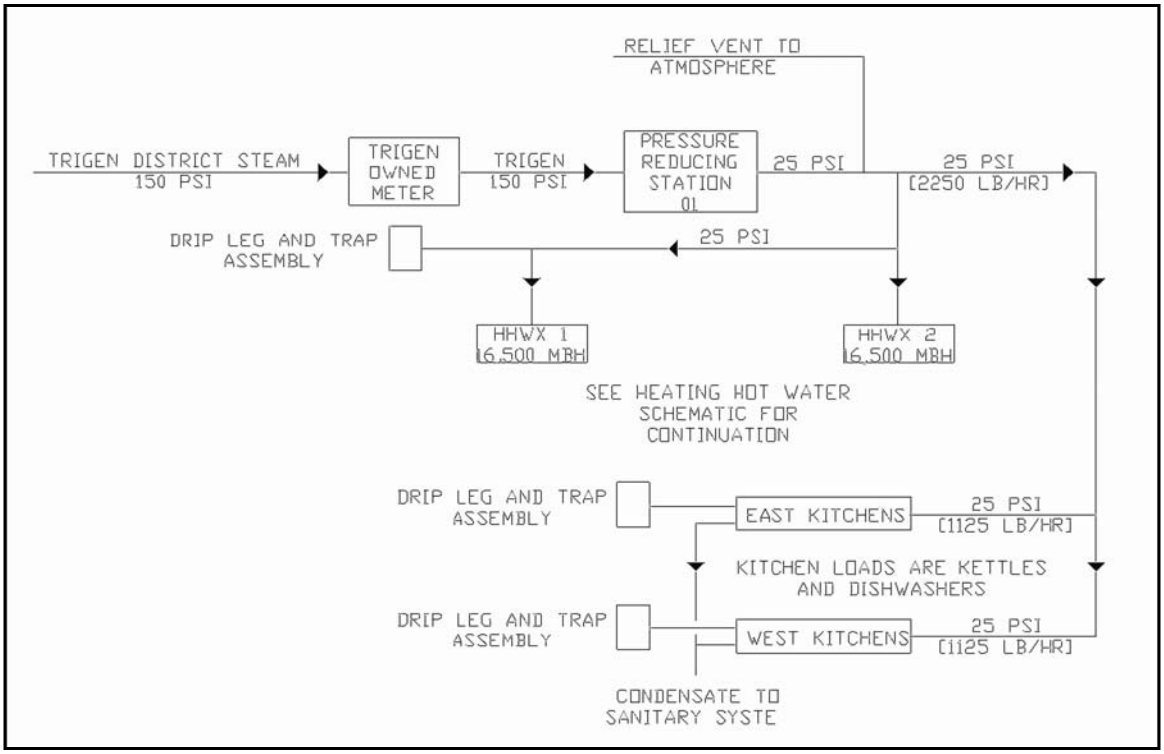
Chilled Water

Figure-2: Chilled Water Schematic



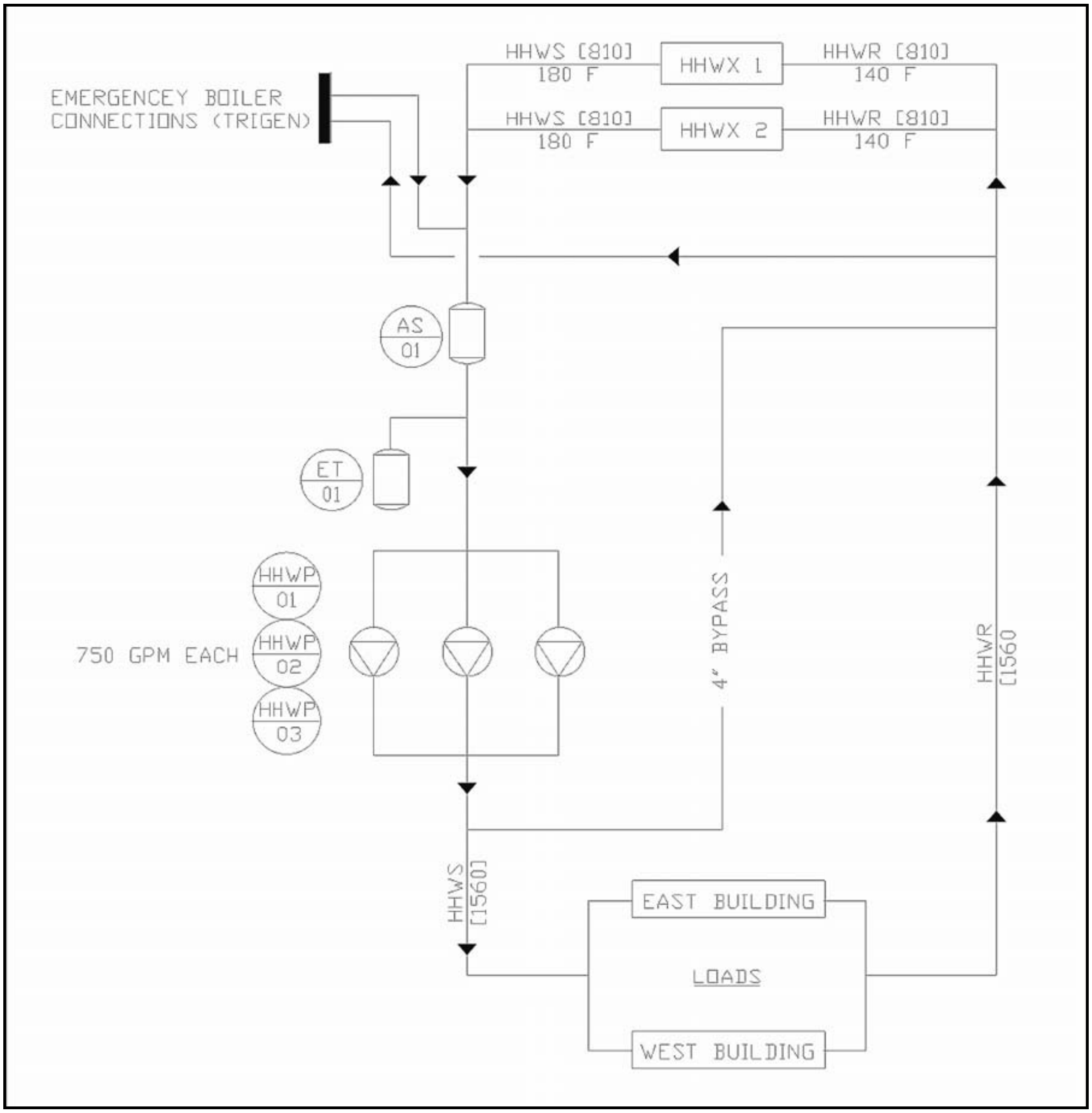
Steam

Figure-3: Steam Schematic



Heating Hot Water

Figure-4: Heating Hot Water Schematic



12.0 Description of System Operation

Cooling

The HBCCH receives chilled water from the ComfortLink district chilled water system. Chilled water is supplied by two ComfortLink-owned plate and frame heat exchangers designated CHWX 1 and CHWX 2, seen in Figure-2 of this report. These heat exchangers are located in the mechanical room on the east podium mezzanine level. The capacity of each heat exchanger is roughly 1,000 tons. The district or primary side of both heat exchangers receive district chilled water from ComfortLink chilled water piping originating in the Baltimore Convention Center and running across the bridge spanning Howard Street to the mezzanine mechanical room in the east podium. This water is designed to have a seventeen degree change in temperature (37 F to 54 F).

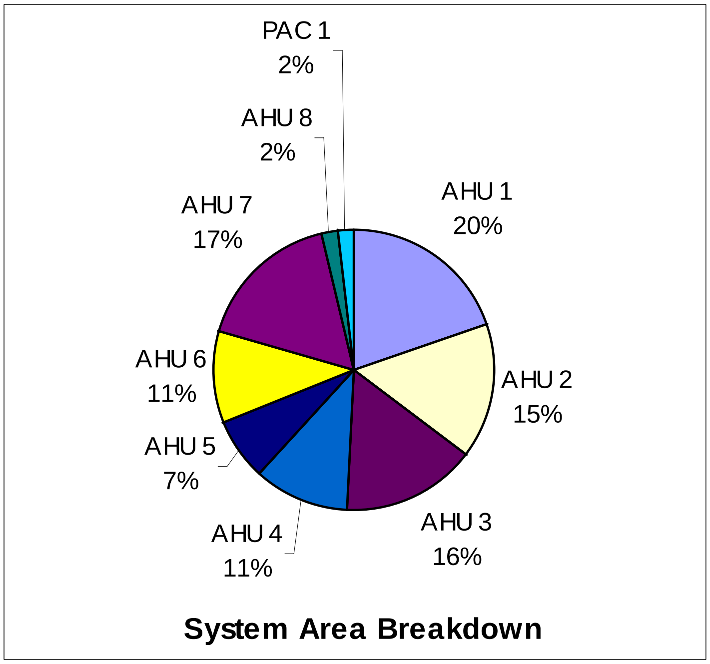
Chilled water piping for the building systems of the HBCCH originates on the secondary or warm side of ComfortLink's heat exchangers. Chilled water is distributed in two main pumping zones; one zone is the guest room towers, and the second zone is for the east and west podium public areas. Two variable speed pumps are provided for each zone, each sized for 60% of the design flow rate. These pumps are designated CHWP 1, CHWP 2, CHWP 3, and CHWP 4 in Figure-2 of this report. CHWP 1 and CHWP 2 serve the podium zone while CHWP 3 and CHWP 4 serve the guest room towers. It's important to note that the pumps were selected such that should one pump fail, the other will be able to provide 100% of the total flow for the zone. Differential pressure sensors in the systems control the variable speed drives of the pumps to maintain the required flow and pressure. The chilled water system is designed for a fourteen degree temperature difference between the supply and return (42 F to 56 F).

Air Handling

AHU 1: Located in the West Podium mezzanine level mechanical room, this AHU serves the ground and mezzanine levels of the West Podium. The unit is balanced to supply 31,000 cfm of air, with a minimum of 14,000 cfm of outdoor air. AHU 1 will be an indoor built-up variable volume unit with; an economizer section, filters, HW preheat coil, chilled water cooling coil, dual plenum supply fans, discharge plenum, and sound attenuators. Supply and relief fans will have variable frequency drives.

AHU 2: Located in the East Podium mezzanine level mechanical room, this AHU serves the ground level of the East Podium. The unit is balanced to supply 31,000 cfm of air, with a minimum of 24,000 cfm of outdoor air. AHU 2 will be an indoor variable volume unit with an economizer section, filters, HW preheat coil, chilled water cooling coil, plenum supply fan, discharge plenum, and sound attenuators. Supply and relief fans will have variable frequency drives.

Figure-5: System Area Breakdown



AHU 3: Located in the West Podium third level mechanical room, this AHU serves the second level of the West Podium. The unit is balanced to supply 38,000 cfm of air, with a minimum of 16,000 cfm of outdoor air. AHU 3 will be an indoor variable volume unit, with an economizer section, filters, HW preheat coil, chilled water cooling coil, plenum supply fan, discharge plenum, and sound attenuators. Supply and relief fans will have variable frequency drives.

AHU 4: Located on the roof of the East Podium second level, this AHU serves the second and third levels of the East Podium. The unit is balanced to supply 26,000 cfm of air, with a minimum of 11,000 cfm of outdoor air. AHU 4 will be an outdoor variable volume unit with; intake and relief louvers, economizer section with relief fan, filters, HW preheat coil, chilled water cooling coil, plenum supply fan, and discharge and return plenums. Supply and relief fans will have variable frequency drives.

AHU 5: Located on the roof of the East Podium second level, this AHU serves the second level and junior ballroom areas of the East Podium. The unit is balanced to supply 47,000 cfm of air, with a minimum of 25,000 cfm of outdoor air. AHU 5 will be an outdoor variable volume unit with; intake and relief louvers, economizer section with relief fan, filters, HW preheat coil, chilled water cooling coil, plenum supply fan, and discharge and return plenums. Supply and relief fans will have variable frequency drives.

AHU 6 and AHU 7: Located in the West Podium third level mechanical room, these units serve the grand ballroom and third level prefunction areas of the West Podium. The units are both balanced to supply 48,500 cfm of air, with a minimum of 28,000 cfm of outdoor air each. AHU 6 and 7 will be outdoor variable volume units with; intake and relief louvers, economizer section with relief fan, filters, HW preheat coil, chilled water cooling coil, plenum supply fan, and discharge and return plenums. Supply and relief fans will have variable frequency drives.

AHU 8: Located on the roof of the West Podium fourth level, this AHU serves the exercise areas on the fourth level of the West Podium. The unit is balanced to supply 4,000 cfm of air, with a minimum of 3,000 cfm of outdoor air. AHU 8 will be a constant volume unit, with an economizer section, filters, HW preheat coil, run-around hot water reheat coil, chilled water cooling coil, plenum supply fan, and discharge and return plenums.

PAC 1: Located in the pool equipment room on the fourth level of the West Podium, this unit serves the swimming pool and pool equipment room. The unit is balanced to supply 5,300 cfm of air, with a minimum of 4,300 cfm of outdoor air. PAC 1 will be an indoor packaged unit with ducted outdoor air, filter, refrigerant DX cooling coil, hot gas reheat coil, auxiliary heating coil and DX hot gas pool heater for heat reclaim.

The remainder of the spaces in the HBCCH receive outdoor air from four makeup air units.

MAU 1 and MAU 2: These units, located on the roof of the guest towers, provide conditioned outdoor air to the guest room bathrooms, corridors and elevator lobbies in the guest room towers. These units are 100% outdoor air units which keep the guest rooms properly ventilated. The remainder of the space load in the guest rooms is treated by fan coil units located in each room.

*MAU 3 and MAU 4***:** These units serve the large kitchen areas in the podiums. MAU 3 is located in the East Podium, and it serves the Multi-Purpose Restaurant Kitchen. MAU 4, located in the West Podium, serves the main kitchen area serving the grand ballroom. These units are 100% outdoor air units.

Guest Room FCUs: The fan coil units in the guest rooms are 2-pipe vertical stacked, (high-rise) fan coil units. Chilled water will be distributed using vertical risers located in chases. The units will be equipped with electric resistance heat. The FCUs will be non-ducted concealed type to be located in drywall enclosures at the outside walls of the guest rooms. Return air will be through a louvered access door on the fan coil unit enclosure

Heating

Steam from the Trigen district steam system enters the HBCCH in the mechanical room located in the southeast corner of the west podium. This steam, initially at 150 psi, passes through a Trigen owned metering station before entering Pressure Reducing Station 1 (Figure-3). The steam, now at 25 psi, splits in order to serve two separate purposes. 2,250 lbs/hr of steam serve the kettles and dishwashers located in the east and west podium kitchens. The remainder of the steam is used in order to create heating hot water for the building systems located throughout the HBCCH.

Two shell and tube heat exchangers, HHWX 1 and HHWX 2 in Figure-3 and Figure-4 of this report, are used to convert the steam into heating hot water. These heat exchangers, designed for an inlet temperate of 140 F and outlet temperature of 180 F, are each sized for 810 gpm and 6,500 MBH.

Heating hot water is distributed throughout the HBCCH using three dedicated variable speed pumps. Each pump is designed for 50% of the total design flow. These pumps, designated HHWP 1, HHWP 2, and HHWP 3 in Figure-4 of this report, can each handle 750 gpm of flow. A differential pressure sensor in the system controls the variable speed drives of the pumps in order to maintain the required flow and pressure. Heating hot water serves preheat and reheat coils in AHU's and MAU's, VAV reheat coils, and domestic hot water generation.

13.0 Critique of the System

The mechanical system design of the Hilton Baltimore Convention Center Hotel has quite a few good aspects. After reviewing the systems chosen, the district chilled water and steam systems appear to be quality design choices. The district systems, while causing expensive utility rates, provide guaranteed reliability and maintainability, low construction cost, and handle the site factors provided in this report. The district systems also cut down on lost rentable space, a critical factor in any building designed to turn a profit. It would, however, be interesting to compare the district systems to the life-cycle costs and requirements for self-cooling and heating.

Separating the building into two types of air-side systems also appears to be a wise design decision. The guest room towers require individual temperature control, and a VAV system would create massive amounts of ductwork and piping running throughout the towers. The VFCU's are relatively small, effective systems, and using the MAU's to provide the necessary ventilation air certainly minimizes the number of shafts and chases required for ductwork. At the same time, the podiums of the HBCCH lend themselves to a standard VAV system. The spaces have highly variable uses and occupancies, and the building owner is familiar with using VAV systems in its other hotels. It would, however, be worthwhile to consider design changes for the east and west podiums. It's possible that changes could result in increased performance of the building mechanical systems.

It would also be worthwhile to consider green building design for the HBCCH. As discussed in Mechanical Technical Report #2, the HBCCH nearly meets LEED certification as designed. Design changes could allow for more LEED points to be obtained, resulting in increased environmental awareness and energy efficiency.

14.0 References

1. Mechanical Technical Report #1 – Andrew Rhodes
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6. The Pennsylvania State University Architectural Engineering Department, Thesis Advisor: Dr. William Bahnfleth.
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9. Past Thesis Technical Reports, e-Studio Archives, 2004-2005.