Jessica R. Baker
Mechanical Option
"Mechanical Technical Report #3"

The Montgomery County Conference Center and Hotel (MCCCH), Rockville, MD

Architectural renderings compliments of RTKL Associates

Mechanical Technical Report #3

Mechanical Systems Existing Conditions Report

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Thesis Building Sponsors:

Southland Industries
22960 Shaw Road, Suite 800
Sterling, VA 20166
www.southlandind.com
and
HITT Contracting
www.hitt-gc.com
and
Quadrangle Development Corporation
www.quadrangledevcorp.com

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1.0 Executive Summary:

The purpose of this report is to summarize the existing building mechanical systems found in the Montgomery County Conference Center and Hotel in Rockville, MD. The mechanical design objectives and requirements will be studied, ultimately conveying the fact that the building owners had much influence over MCCCH's final mechanical design. Energy sources and rates for the building's site will be obtained and reported along with other factors that influenced the design, like cost and building site constraints. Outdoor and indoor design conditions and design heating/cooling loads will be calculated. Schedules of major mechanical equipment and schematics of their use will be presented for further comprehension of the building's mechanical systems. Finally, a description of the mechanical system's operation will be discussed and followed by an overall critique of MCCCH's mechanical system.

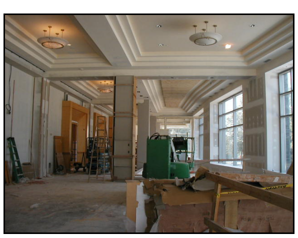
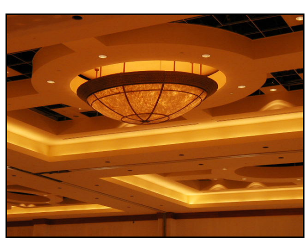
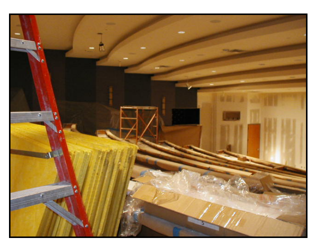
The building is currently under construction and it set to open on any day. However, because of this factor, actual building utility bills and energy consumption data could not be acquired for use throughout this report. All information that could be obtained was included. Missing information will become available soon and will be implemented throughout all future work.

Architectural renderings compliments of RTKL Associates

2.0 Design Objective and Requirements:

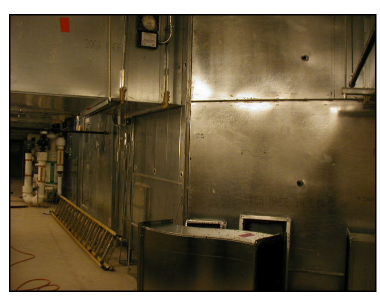
The overall size of the Montgomery County Conference Center and Hotel (MCCCH) in Rockville, MD is approximately 240,000 square feet. The conference center portion, with its two stories extending into the hotel main and lower level, comprises about 100,000 square feet of this total. The hotel makes up the remaining square footage with its nine stories of guestrooms. The hotel is owned by Quadrangle Development and run by Marriot International. The conference center is owned by Montgomery County of Maryland. The overall project cost was approximately forty-five million dollars. Ultimately, MCCCH's location, size, two major owners, cost, and possible future clients determined the building's many special mechanical design requirements.

One of the mechanical design/construction issues throughout the conference center and hotel's public areas was running ductwork above and around the very elaborate, custom ceiling designs. In most of the main spaces, very large ductwork had to be maneuvered to avoid interference with the many different ceiling types. This also made the placement of air diffusers very tricky. The diffusers had to be strategically located for correct and even air distribution while not "taking away" from the beauty of the different ceiling designs. As a result, a lot of circular ductwork was used for the main air distribution lines throughout these areas of the building. This way, the ductwork took up slightly less cross-sectional area above the ceilings. Extremely large size and long runs of ductwork were avoided by creating multiple runs of main lines in opposite directions. This made it easier to move the ductwork around the ceiling designs. Major diffuser location discrepancies were dealt with during the building's construction. (See construction photos below for examples of the many elaborate ceiling designs.)

Another mechanical design concern was that of space in the building's several mechanical rooms. Two very large (50,000 cfm) air handling units serve the conference center and are located in a mezzanine level mechanical room, adjacent to the conference center. The units, themselves, are extremely large with their supply and return ductwork being just as big. The design area allotted for the two units on the mezzanine level was not large enough to house both the units and their ductwork. The bends and turns made by the very large ductwork inside the mechanical room made it impossible to fit everything into certain corners of the designated area. However, provisions were made and drywall sections cut/ductwork adjusted throughout the room's construction in order to compensate for these issues. All coil pulls and access doors were made sure to be accessible. (Changes were not made during the design phase as these problems were not apparent at the time.) Another mechanical room in the building with spacial problems was that of the hotel's main floor mechanical room. The actual volumes of the two AHU's placed in this room were also not fully considered during design. Now, after construction of the room, a person can barely move freely between/around the two AHU's. Pieces of equipment are squeezed into corners where any servicing of coils, etc. will be extremely difficult. Nothing has yet to be done to correct this very tight mechanical room in the building. Things may be changed with the need for future servicing of equipment. (See photos below of the two very crowded mechanical rooms within MCCCH.)







For the MCCCH's chiller plant, located in the pumping room on the conference center's lowest level, a standard chiller(s)/boiler(s) design was originally intended. However, the building owners and design engineers came into contact with an absorption chiller manufacturer from China (BROAD USA) during the building's design phase. At that time, the chiller manufacturer had just begun to implement its products throughout the United States. Through some negotiation, BROAD USA ended up making a very good offer to provide two direct-fired absorption chillers for the building project. Hence, the building chiller plant design was changed in order to incorporate the new type of chiller(s)/heater(s) as opposed to the traditional chiller(s)/boiler(s) combination. (Absorption chiller photo below.)

A design problem involving the guestroom portion of the hotel dealt with figuring out what type of individual guestroom ventilation/climate control should be utilized throughout the hotel's nine stories. Most hotel mechanical designs incorporate the use of horizontal fan coil units or unit ventilators (containing both cooling and heating coils) in each individual guestroom. However, in MCCCH, all hotel guestrooms floors (floors 2-10) are identical with respect to room layout. Therefore, the locations of guestroom fan coil units from one floor to the next would not change as the units must be placed against exterior walls for ventilation purposes. Because of this, 4-pipe vertical fan coil units were chosen for the design instead of the typical horizontal units. The particular vertical units chosen came pre-assembled and could simply be lifted into place in each room, on each floor. The units were also exactly as tall as the guestroom ceilings, making it possible to connect with any fan coil units above and/or below, ultimately, constructing the chilled and hot water riser piping needed for the units. (See VFC photo below.)

Lastly, one of the most important design requirements for MCCCH involved designing the main conference center and hotel areas for noise criteria. Acoustics played a very special role in areas like the conference center's auditorium, ballroom, and lecture classrooms. The hotel and conference center's main lobbies were also a concern for acoustics given that most of the floors and walls in those areas were made of very hard surfaces. Typical acoustic design is acceptable anywhere below NC 30. However, this project's design was geared lower around NC 20-25 for mechanical system components in or near the critical spaces mentioned above. Duct sizes were increased in areas where acoustic problems occurred. This lowered the air velocity through the ducts, ultimately lowering the sound pressure levels. Equipment vibration for the very large units serving the conference center was also considered. All pumps and fans were mounted on vibration isolation pads while the piping near any pumps utilized spring hangers for additional isolation purposes.

3.0 Energy Sources and Rates for the Site:

The Montgomery County Conference Center and Hotel's electricity is supplied by Pepco of Maryland. The building's natural gas supply comes from Washington Gas. Both of the energy sources are delivered to the building by underground supply lines that enter through the main electrical and mechanical rooms. Up-to-date customer rates from each of the energy suppliers can be found online at www.pepco.com and www.washgas.com.

Monthly Electrical Service Charges

According to Pepco, MCCCH falls under the Type 1, Commercial Customers, General Service (GS) rate structure. The General Service (GS) rate structure is as follows (taken from www.pepco.com):

	Billing Months of June – October (Summer)	**Billing Months of November – May (Winter)**
Standard Offer Service (Generation, Transmission including GRT, and PCA)		
Generation		
All kwh	\$0.06378 per kwh	\$0.05390 per kwh
Procurement Cost Adj. **1/**	www.pepco.com for monthly rate.	
Transmission		
All kwh	\$0.00374 per kwh	\$0.00374 per kwh
Gross Receipts Tax	2.0408% applied to transmission bill.	
Distribution Service		
Customer Charge	\$8.87 per month	\$8.87 per month
All kwh	\$0.03357 per kwh	\$0.01779 per kwh
Delivery Tax	\$0.00062 per kwh	\$0.00062 per kwh
Md. Environmental	\$0.00015 per kwh	\$0.00015 per kwh
Md. GPC	-\$0.0016695 per kwh	-\$0.0016695 per kwh
Montgomery County	\$0.0128658 per kwh	\$0.0128658 per kwh
or		
Prince Georges County	\$0.004946 per kwh	\$0.004946 per kwh
Universal Service Charge	See page 28 of Pepco's Md. Electric Rate Schedules.	
Gross Receipts Tax	2.0408% applied to distribution bill excluding the GPC, and the Montgomery or Prince Georges County Surcharge.	
Administrative Credit 1/	www.pepco.com for monthly rate.	

1/ Rates effective July 1, 2004. This rate changes periodically. Please visit www.pepco.com for the most current information.

All totaled, this electric rate structure gives an approximate cost of $1,920.72 / 14,560 kWh.

Monthly Natural Gas Service Charges

According to Washington Gas, MCCCH falls under the Firm Commercial and Industrial Service System Charges rate structure. This rate structure is as follows (taken from www.washgas.com):

RATE SCHEDULE NOS. 2 AND 2 A
Firm Commercial and Industrial Service

System Charges (All Billing Months)
Heating and/or Cooling
(a) Normal Weather Annual Usage
Less Than 3,000 therms . . . . $ 15.50
(b) Normal Weather Annual Usage
3,000 therms or more . . . . $ 36.25
Non-heating and Non-cooling . . . . $ 14.00

Distribution Charges (per Therm)
First 300 therms or less per month . . . $ 0.3183
Next 6,700 therms per month . . . . $ 0.2177
Over 7,000 therms per month . . . . $ 0.1599

Additional cost information obtained from the contractor includes the gas supply service charge of $0.888/TH and Montgomery County's charge of $0.116/TH.

4.0 Cost Factors:

MCCCH's total mechanical system cost most definitely played a role in the system's selection and design. The owners were looking for a very standard system that would "do the job" while not costing an extreme amount of money. They were also very experienced with building development and operation, so, they had a very strong influence throughout the building's entire design process. (They had built buildings like MCCCH before and were looking to simply "copy" the mechanical designs from those past buildings. Their building operators/maintenance crew already knew how to handle the standard system design that the owners were leaning toward.) Thus, the mechanical engineers really didn't have a lot of liberty in the system's selection or optimization. (ex. Utility rates and related rebates were not considered in the design of MCCCH's mechanical system.)

The mechanical system for MCCCH had to be quick and easy to construct and start-up. Therefore, the mechanical engineers went for the standard VAV system with multiple air handling units located throughout the building. The hotel guestrooms got the general, "one fan coil unit per guestroom" design. The owners were very familiar with this type of system and were happy with it and its cost. Nothing that could have added any additional costs was implemented into the mechanical system's design.

The first cost of MCCCH's mechanical system did not really play a significant role in design as the system was pretty standard and the owners were experienced with the system and its approximate first cost. However, there was some evidence that the first cost did matter at least a little bit. The original mechanical system was to contain two chillers and boilers but, the owner worked out a deal with BROAD USA to get two direct-fired absorption chillers at a much lower first cost (mentioned in the Design Objective and Requirements section of this paper). The exact difference between the two systems' first costs could not be obtained for this report but, it was stated that purchasing the absorption chiller machines in place of the two chillers and boilers was significantly less money. It obviously was as the building now contains the two absorption chillers.

Energy efficiency was not really considered in the design of MCCCH's mechanical system as it could have created additional costs for the system. When creating energy efficient designs, 'green' or LEED system design usually comes into play. With these types of systems, first costs and payback periods automatically tend to get larger no matter what the engineer tries to do. In order for these system designs to actually happen, building owners must possess the excess money and sincere interest in conserving energy. For this project, energy efficiency was not a top priority for the owners.

The final contract value for the Montgomery County Conference Center and Hotel's mechanical system (M&P) was approximately $7,000,000. This value was out of a total building cost of about $45,000,000. The large fraction indicates a high possibility that the mechanical system type was, in fact, driven by first cost.

5.0 Site Factors Influencing Design Decisions:

MCCCH's mechanical system design was most definitely impacted by the overall building's site constraints. The Montgomery County Conference Center and Hotel's site was located in the very dense, commercial area of Rockville, MD. (This geographic location sees all the on-goings of the Washington Metropolitan region.) Because of this, the building's plot of land was rather small and the building itself had to be oriented perfectly in order to fit on the site without interfering with building access, parking, etc. However, throughout all of the adjusting to the site, the building's mechanical rooms became mezzanine levels and rooftops. Multiple air handling units along with other random pieces of building equipment were squeezed into what was left of the very small mechanical rooms. And, as a result, MCCCH's lack of allotted space for mechanical equipment made it extremely hard on the building's mechanical design engineers and contractors (mentioned earlier). Regardless, the system design was completed based on what space was available and special maintenance plans were created for the very tight mechanical spaces.

Another factor that played a large role in the design of MCCCH's mechanical system was the overall size of the building. Major pieces of mechanical equipment were based on the total size of the building, which was ultimately tied to the site constraints. The building's orientation on the site also played into the mechanical system's design. There was a great possibility for different building loads at different site orientations.

Additionally, due to where the building was located and how low the "low" conference center roof was, all roof-top mechanical equipment had to be placed on either the conference center's "high" roof or the hotel tower's roof. This way, eye-sores and noise problems could be avoided on the outside of the building in all directions. The building's two cooling towers and a couple AHU's were placed in these recommended areas. This placement plan also allowed the building to fit in well with its high class surroundings.

6.0 Outdoor and Indoor Design Conditions:

Outdoor Design Conditions

Climatic Design Conditions for 1,459 locations throughout the United States, Canada, and around the world are listed in Chapter 27 of the ASHRAE Fundamentals. This chapter gives a table containing design information pertaining to heating and cooling in buildings. For the MCCCH project, the design condition data from the Washington, District of Columbia location was used and is as follows:

Summer Conditions (ASHRAE 1%) at Atmospheric Pressure

Dry Bulb Temperature: 95 ^{o}F

Coincident Wet Bulb Temperature: 76 ^{o}F

Summer Daily Range: 16.6 ^{o}F

Winter Conditions (ASHRAE 99%) at Atmospheric Pressure

Dry Bulb Temperature: 15 ^{o}F

Coincident Wet Bulb Temperature: 12.2 ^{o}F

Indoor Design Conditions

The indoor design conditions were specified in MCCCH's project documents/specifications and are the following:

Dry Bulb Temperature: 72 ^{o}F

Relative Humidity: 50%

(MCCCH's spaces were to be kept within an approximate 1.5 ^{o}F range of this set point.)

7.0 Design Heating and Cooling Loads:

All heating and cooling design loads were taken from the MCCCH contract documents. They are for both the conference center and hotel (added together) and are contained in Table 1 below:

Design Loads				
Unit	Quantity, #	Heating Capacity, MBH	Sensible Cooling Capacity, MBH	Total Cooling Capacity, MBH
AHU-1	1	1123	1660	2660
AHU-2	1	1123	1660	2660
AHU-3	1	807	406	609
AHU-4	1	357	244	360
AHU-5	1	357	244	360
AHU-6	1	69	40	60
AHU-7	1	76.3	101	157
AHU-8	1	98.2	-	270
AHU-9	1	130	-	338
MAU-1	1	308	-	-
MAU-2	1	333	-	-
AC-1	4	-	127.2	191.2
AC-2	4	-	149.6	228
AC-3	4	-	91.6	102
4-pipe FCU-1	133	864.5	917.7	1117.2
4-pipe FCU-2	132	976.8	1056	1254
4-pipe FCU-3	3	24	75.9	105.9
CUH-1	4	68	-	-
CUH-4	10	68	-	-
UH-1	4	68	-	-
EBB	440 LF	374000	-	-
Totals	**=**	**380850.8**	**6773**	**10472.3**

Table 1: MCCCH's Design Heating and Cooling Loads

8.0 Schedules of Major Equipment:

Air Handling Units												
Designation		AHU-1	AHU-2	AHU-3	AHU-4	AHU-5	AHU-6	AHU-7	AHU-CS1	AHU-CS2	MAU-1	MAU-2
Serves		CC	CC	Restaurant	Kitchen	Hotel F.F.	Exercise	Pool	Guest Corr.	Guest Corr.	Kit. Hood	Kit. Hood
Location		Mezz.	Mezz.	Mezz.	Mezz.	Hotel F.F.	Hotel F.F.	Stairway (CM)	Hotel Roof	Hotel Roof	Mezz.	Mezz.
Configuration		Draw-Thru	Draw-Thru	Draw-Thru	Draw-Thru	Draw-Thru	Draw-Thru	Draw-Thru	Draw-Thru	Draw-Thru	Draw-Thru	Draw-Thru
Fan Section Data	CFM Supply	50000	50000	12500	9000	9000	1400	3200	4000	5000	5600	6025
	OA CFM Max	50000	50000	12500	9000	9000	1400	3200	4000	5000	5600	6025
	OA CFM Min	30000	30000	5000	2250	2250	350	1000	4000	5000	5600	6025
	TSP. Inch of WG	4.04	4.04	4.78	5	5	2.5	3.5	4.7	4.7	4	3.5
	ESP. Inch of WG	-	-	2.9	3.8	3.8	1.2	1.2	2.5	2.5	1.5	1.5
	Fan Type	Plug	Plug	Plug	AF	AF	FC	FC	AF	AF	BI	BI
	Fan RPM	656	656	1219	2054	2054	1888	1829	2713	2468	2462	2055
	H.P.	60	60	15	15	15	2	5	7.5	7.5	7.5	7.5
Preheat Coil Section Data	Cap. MBH	1469	1469	-	-	-	-	76.3	195	244	-	-
	GPM	100	100	-	-	-	-	5	13	16.3	-	-
	Circ. Pump	P-9	P-10	-	-	-	-	-	P-11	P-12	-	-
	EAT (F)	34	34	-	-	-	-	58	10	10	-	-
	LAT (F)	61.1	61.1	-	-	-	-	80	55	55	-	-
	EWT (F)	180	180	-	-	-	-	180	180	180	-	-
	LWT (F)	150	150	-	-	-	-	150	150	150	-	-
	No. of Rows	1	1	-	-	-	-	1	1	1	-	-
	Max P.D. (ft)	3.8	3.8	-	-	-	-	2	2	2	-	-
	Air PD Ins. WG.	0.06	0.06	-	-	-	-	0.18	0.08	0.07	-	-
	Max FV FPM	550	550	-	-	-	-	730	-	-	-	-
Cooling Coil Section Data	Total MBH	2660	2660	609	360	360	60	157	270	338	-	-
	Sens. MBH	1660	1660	406	244	244	40	101	-	-	-	-
	EAT FDB	86	86	81.3	80	80	80	80	90	90	-	-
	EAT FWB	71	71	67	67	67	67	67	74	74	-	-
	LAT FDB	55.4	55.4	51.3	55	55	53.5	51	54	54	-	-
	LAT FWB	54.8	54.8	50.9	54.2	54.2	53	50.8	54.5	54.5	-	-
	GPM	423	423	96	60	60	11	25	45	56	-	-
	EWT (F)	44	44	42	42	42	44	44	44	44	-	-
	LWT (F)	56	56	54	54	54	55	56.5	56	56	-	-
	No. of Rows	6	6	5	4	4	6	8	8	8	-	-
	Max P.D. (ft)	14	14	11.5	6.3	6.3	4.35	4.4	10	10	-	-
	Max FV FPM	550	550	450	450	450	420	550	-	-	-	-
	Air PD Ins. WG.	0.87	0.87	0.8	0.56	0.56	0.65	1.67	0.7	0.65	-	-
Heating Coil Section Data	Cap. MBH	1123	1123	807	357	357	69	76.3	98.2	130	308	333
	Circ. Pump	-	-	P-15	P-16	P-17	P-18	-	-	-	P-22	P-23
	GPM	56	56	42	36.7	36.7	4.6	5	6.5	9	20	22
	EAT (F)	55	55	46.5	56	56	-	58	55	55	14	14
	LAT (F)	75.7	75.7	94.5	92.6	92.6	-	80	77.7	79	65	65
	EWT (F)	180	180	180	180	180	180	180	180	180	180	180
	LWT (F)	150	150	150	150	150	150	150	150	150	150	150
	No. of Rows	1	1	1	1	1	1	1	1	1	1	1
	Max P.D. (ft)	2	2	5	5	2	2	2	2	2	2	2
	Air PD Ins. WG.	0.06	0.06	0.15	0.08	0.08	0.12	0.18	0.06	0.05	0.11	0.11
	Max FV FPM	550	550	550	550	550	510	730	-	-	500	500
Final Filter	Efficiency - ASHRAE (%)	30	30	30	30	30	30	30	30	30	30	30
	Air PD Ins. WG. (Mid-level)	1.62	1.62	1.57	1.51	1.58	1.2	1.8	1.2	1.2	1.75	1.51

Notes: Basis of Design - Ventrol and Venmar
See fan notes for list of abbrev.
Provided:
4" Housekeeping pads and 1/4" Neoprene pads
VFD's and controls
Heating coils with face and bypass dampers
Rooftop units mounted on roof curb
Smoke detectors
Recirc. Pumps on HW coils
Heresite coating

Exhaust Air Fans

Designation	Serves	CFM	E.S.P. Inches W.G.	Fan RPM	Fan Dia. (in)	Motor H.P. (Watts)	Type	Accessories	Controlled by	Interlock with
EF-1	Hotel Smoke Exhaust	18600	0.75	768		7.5	US, BD	D, HD	Smoke Alarm	
EF-2	Not Used									
EF-3	Lower Level Pantry	125	0.5	750		(100)	CLG, DD	VI, D	Wall Switch	
EF-4	Lower Level Elec.	750	0.375	1550		1/6	IL, DD	VI, D	Thermostat	
EF-5	Pool Equip.	200	0.5	830		(166)	CLG, DD	VI, D	Runs Cont.	
EF-6	Men's Pool	300	0.5	735		(146)	CLG, DD	VI, D		AHU-7
EF-7	Women's Pool	300	0.5	735		(146)	CLG, DD	VI, D		AHU-7
EF-8	Soiled Linen	300	0.5	735		(146)	IL, DD	D	EMS	
EF-9	Not Used									
EF-10	Crawl Space Exhaust	1000	0.5	1262		1/4	PRV, UB, DD	D, HD	Humidistat	
EF-11	2 Speed Fan Lower Level Toilet / Smoke	3500 & 7000	0.75 & 2.5	1750	18	5	VA, BD	VI, D	EMS and Smoke Alarm	
EF-12	Ballroom Toilet South	1600	0.5	1529		1/3	PRV, DD	D	EMS	
EF-13	Ballroom Toilet North	600	0.375	1090		(313)	IL, DD	VI, D	EMS	
EF-14	Chiller Room	940	0.25	950		1/6	IL, DD	D	EMS	
EF-15	Toilet Exhaust Riser	315	0.25	1300		1/30	PRV, DD	PRC, D	EMS	
EF-16	Toilet Exhaust Riser	430	0.25	1725		1/4	PRV, DD	PRC, D	EMS	
EF-17	South Kitchen Exhaust	7500	1.75	1660		7.5	PRV, UB, DD	D, HD, GC	Kitchen Hood	
EF-18	North Kitchen Exhaust	7500	1.75	1660		7.5	PRV, UB, DD	D, HD, GC	Kitchen Hood	
EF-19	Dishwasher Exhaust	3900	1	1295		1-1/2	PRV, UB, DD	D, HD, GC	Dishwasher	
EF-20	Servery Exhaust	2625	1	3053		3	PRV, UB, DD	D, HD, GC	Kitchen Hood	
EF-21	Toilet Exhaust Riser	560	0.25	1550		1/15	PRV, DD	PRC, D	EMS	
EF-22	2 Speed Fan Pool Roof	975 & 1300	0.375	1171	18	1/4	VA, DD	VI, D	AHU-7 and Smoke Alarm	AHU-7
EF-23	Lower Level Pump Room	200	1.25	1050	10	1/20	Wall, DD			
EF-24 to EF-34	Toilet Exhaust Riser	630	0.25	1300		1/12	PRV, DD	PRC, D	EMS	
EF-E	EMR or Elec. Closet	80	0.25	750		(100)	Wall, DD	D	EMS	
EF-38, EF-39	Locker Rooms	600	0.375	1080		(785)	CLG, DD	VI, D	EMS	
EF-40	Loading Dock Storage	300	0.5	735		(146)	Wall, DD	D	EMS	
EF-41	Exercise Room	350	0.25	1550		(212)	CLG, DD	VI, D	EMS	
EF-42	Linen	630	0.25	1350		1/12	PRV, DD	PRC, D	EMS	
EF-43	Prefunction Smoke Exhaust	20000	4				VA, BD	OG, D, W.P.	Smoke Alarm	
EF-44		500	0.7	1550		1/6	IL, DD	VI, D	EMS	Projector
EF-45	Lobby Smoke Exhaust	18000	4	1495	39	20	VA, BD	VI, D	Smoke Alarm	
EF-46, EF-47	M&E Shop	200	0.25	1000		(264)	CLG, DD	VI, D	Wall Switch	
EF-48	Dimming Room	600	0.375	1080		(785)	CLG, DD	VI, D	Thermostat	
EF-49	Concierge Lounge	100	0.25	950		(80)	CLG, DD	VI, D	Wall Switch	
EF-51	Elec. Closet Riser	720	0.375	1140		1/6	PRV, DD	PRC, D	EMS	

Return Air Fans

Designation	Serves	CFM	E.S.P. Inches W.G.	Fan RPM	Fan Dia. (in)	Motor H.P. (Watts)	Type	Accessories	Controlled by
RF-1	Part of AHU-1	50000	1.5	687	44.5	30	AF	VFD	AHU-1
RF-2	Part of AHU-2	50000	1.5	687	44.5	30	AF	VFD	AHU-2
RF-3	2 Speed Fan - AHU-3 and Zone 4 Smoke	7500 & 18000	1 and 4	1495	39	20	VA, BD	VI, VFD, D	AHU-3 and Smoke Alarm
RF-4	Kitchen	6500	1	1061	22.5	1	IL, BD	VI, D	AHU-4

Supply Air Fans

Designation	Serves	CFM	E.S.P. Inches W.G.	Fan RPM	Fan Dia. (in)	Motor H.P. (Watts)	Type	Accessories	Controlled by
SF-1	Stair Pressurization	12000	1	1750	28	5	VA, DD, MD	D, VI	FA
SF-2	Stair Pressurization	12000	1	1750	28	5	VA, DD, MD	D, VI	FA
SF-3	Mechanical Room	940	0.5	1140		1/6	IL, DD	D, VI	

All Fans Note:
AF - Air Foil
B.D. - Belt Drive
BDD - Back Draft Damper
CAB. - Cabinet
CC - Conference Center
D - Disconnect
D.D. - Direct Drive
EMS - Energy Management System
F.A. - Fire Alarm
G.C. - Grease Collector
GD - Gravity Damper
H.D. - Housing Drain
I.G. - Inlet Guard
I.L. - In Line
MD - Motorized Damper
O.G. - Outlet Guard
P - Propeller
PRC - Prefab. Roof Curb
PRV - Power Roof Ventilator
UB - Upblast
US - Utility Set
VFD - Variable Freq. Drive
VA - Vane Axial
VI - Vibration Isolator
W.P. - Weather Proof Enclosure

Pumps										
				Motor						
Designation	Serves	GPM	Total Head (FT)	RPM	HP	Pump Inlet (in)	Pump Outlet (in)	Pump Eff.	Max. NPSH	Pump Type
P-1 / P-2	Primary Hot Water	1000	50	1750	20	4	6	78	14	ES. IB.
P-3 / P-4	Secondary Chilled	1440	65	1750	40	6	8	73	20	ES. IB. VFD.
P-5	Primary Chilled (CH-1)	720	50	1750	15	4	5	72	15	ES. IB.
P-6	Primary Chilled (CH-2)	720	50	1750	15	4	5	72	15	ES. IB.
P-7	Condenser (CH-1)	1300	65	1750	40	6	8	70	20	ES. IB.
P-8	Condenser (CH-2)	1300	65	1750	40	6	8	70	20	ES. IB.
P-9	AHU-1 HW Preheat Coil	76	20	1750	1	2	2	66		IL. CIRC.
P-10	AHU-2 HW Preheat Coil	76	20	1750	1	2	2	66		IL. CIRC.
P-11	AHU-CS1 HW Preheat Coil	13	20	1750	0.5	1.25	1.25	40		IL. CIRC.
P-12	AHU-CS2 HW Preheat Coil	16	20	1750	0.5	1.25	1.25	45		IL. CIRC.
P-13										Not Used
P-14										Not Used
P-15	AHU-3 Heating Coil	42	20	1750	0.5	1.25	1.25	59		IL. CIRC.
P-16	AHU-4 Heating Coil	16	20	1750	0.5	1.25	1.25	45		IL. CIRC.
P-17	AHU-5 Heating Coil	56	20	1750	0.75	2	2	62		IL. CIRC.
P-18	AHU-6 Heating Coil	9	20	1750	0.33	1	1	29		IL. CIRC.
P-19										Not Used
P-20										Not Used
P-21										Not Used
P-22	MAU-1 Heating Coil	20	20	1750	0.5	1.25	1.25	50		IL. CIRC.
P-23	MAU-2 Heating Coil	20	20	1750	0.5	1.25	1.25	50		IL. CIRC.

Note: Basis of Design - Weinmanm, Amtrol
ES - End Suction
IB - Inertia Base
VFD - Variable Frequency Drive
IL - In line

Variable Air Volume Boxes							
	Box Data					Electric Heating Coil Data	
Designation	Max CFM	Min CFM	Inlet S.P. Inch W.G.	Max. Box P.D. Inch W.G.	Inlet Diam. in Inches	kW	No. of Stages
A	450	135	1	0.7	6	1	1
B	750	225	1	0.7	8	1.5	1
C	1100	330	1	0.7	10	2	1
D	1500	450	1	0.7	12	2.5	1
E	1800	540	1	0.7	14	3	1
F	2500	750	1	0.7	16	3.5	1
G	4500	1350	1	0.7	24x16	10	3
H	1100	550	1	0.7	10	7.5	3
I	1500	750	1	0.7	12	7.5	3
J	1800	900	1	0.7	14	7.5	3
K	3000	1500	1	0.7	16	15	3

Note: Basis of Design - Titus, "DESV"
Interior/Perimeter box designations
Electric heating coils provided with fusible disconnect

4-Pipe Fan Coil Units																			
				Cooling Data									Heating Data						
						EAT		LAT											
Designation	Serves	Nom. CFM	Fan Motor HP	Total MBH	Sens. MBH	F DB	F WB	F DB	F WB	GPM	ENT Water	Water PD (ft)	MBH	EAT	LAT	GPM	ENT Water	Water PD (ft)	Type
A	Guest Room	300	1/12	8.4	6.9	72	60	48.6	48.3	2.5	45	7	6.5	70	104	0.9	140	5	Hi-Rise
B	Guest Room	400	1/12	9.5	8	72	60	49.4	49	2.9	45	4	7.4	70	96	0.6	140	3	Hi-Rise
C	Hospitality Room	1200	1/4	35.3	25.3	72	60	50	49	7.2	45	6	8	70	96	1	140	3	Hi-Rise

Note: Provided:
Disconnect switches
Control valves
Digital Thermostats
Fire-rated boards at back
Factory pre-piped and wired

Water Cooled Computer Room Units															
		Fan Data		Cooling Section Data								Elec. Heat		Humid.	Misc.
Designation	Serves	CFM Supply	Fan (HP)	Total MBH	Sens. MBH	EAT F DB	EAT F WB	Water A EWT F	Water G LWT F	Flow GPM	PD FT	Cap. (kW)	Stages	Cap. lbs./hr	Config.
AC-4	Tele. R.	1175	0.27	25.5	22.9	72	60	45	55	5.1	5.5	5.5	1	3	Wall M.
AC-5	Sec. R.	1175	0.27	25.5	22.9	72	60	45	55	5.1	5.5	5.5	1	3	Wall M.
AC-6	PMS Eq.	1175	0.27	25.5	22.9	72	60	45	55	5.1	5.5	5.5	1	3	Wall M.
AC-7	AYS R.	1175	0.27	25.5	22.9	72	60	45	55	5.1	5.5	5.5	1	3	Wall M.

Note: Units with condensate pumps, humidity control, water detection, disconnect switch, and electric heater
1/4" cold water supply to all units for humidification
Schedule based on low-speed fan setting

Split System A/C Units					
AHU		Capacity		Fan Data	
Designation	Serves	Total	Sens.	HP	CFM
AC-1	EMR1202	47.8	31.8	(1) 1/6	1160
AC-2	EMR1201	57	37.4	(2) 1/6	1220
Condensing Unit			Cond. Fan		
Designation	Cap. At 95 DB	Comp. #	#	HP	-
CU-1	47.8	1	1	1/4	-
CU-2	57	1	1	1/4	-

Electric Heaters				
		Heating Cap.		
Unit	Serves	MBH	kW	Type
CUH-1	Stairs	17	5	Surface Mtd. Cabinet Htr.
CUH-4	Vestibules	6.8	2	Recessed Cab. Htr.
EBB	-	850/LF	250/LF	Electric Baseboard
UH-1	Utility Rooms	17	5	Unit Heater

Note: Basis of Design - Qmark

Direct-Fired Absorption Chillers/Heaters

							Chilled Water				Condenser Water				Heating Water				Fuel				
Designation	Locations	Serves	Cooling Capacity, Tons	Heating Capacity, MBH	COP @ IPLV	Heating Eff.	GPM	EWT (F)	LWT (F)	Max P.D. (FT)	GPM	EWT (F)	LWT (F)	Max P.D. (FT)	GPM	EWT (F)	LWT (F)	Max P.D. (FT)	Type	Min. Pressure	MBH	Operating Wt.	Dimensions
CH-1	Chiller Room	C.C. and Hotel	300	5000	1.25	85%	719	54	44	27	1268	85	95	27	500	160	180	33	Nat. Gas	20" WC	5900	33510 lbs.	201"Lx90"Wx95"H
CH-2	Chiller Room	C.C. and Hotel	300	5000	1.25	85%	719	54	44	27	1268	85	95	27	500	160	180	33	Nat. Gas	20" WC	5900	33510 lbs.	201"Lx90"Wx95"H

Note: Basis of Design - BROAD USA Model 11-H3
Provided:
Duel fuel burner (Nat. gas and No. 2 Fuel Oil)
Control panel and fused disconnect switch

Cooling Towers

								Electric Heaters		Fan Data			
Designation	Location	Serves	GPM	EWT (F)	LWT (F)	EAT (F, WB)	Fan Type	No. Heaters	kW/ Heater	No. Motors	H.P.	Operating Wt.	Dimensions
CT-1	Roof	Chillers	1300	95	85	78	Axial	2	8	2	20 per cell	16720 lbs.	17'-2"x11'-10"x11'-7"H
CT-2	Roof	Chillers	1300	95	85	78	Axial	2	8	2	20 per cell	16720 lbs.	17'-2"x11'-10"x11'-7"H

Note: Basis of Design - BAC Series 1500, Induced Draft, Crossflow
Provided:
Electric water level standpipe with controls
Easy connect piping arrangement with balance clean chamber
Vibration cutout switch
Extended lubrication lines
2 speed motor
Integral control panel and fused disconnect switch

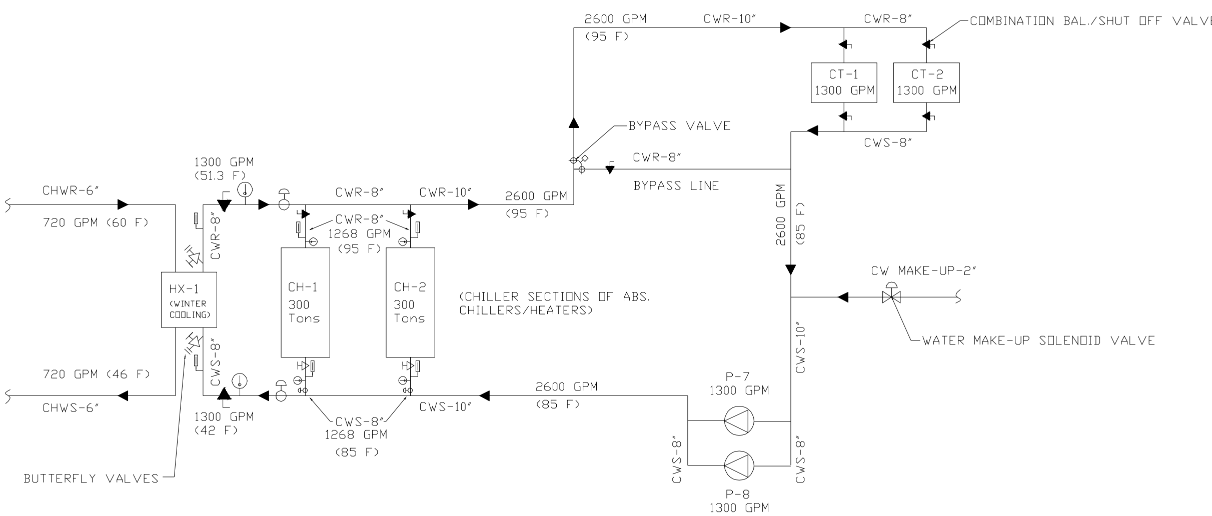
Plate and Frame Heat Exchanger

		Primary Side				Secondary Side			
Designation	Serves	GPM	EWT (F)	LWT (F)	PD (FT)	GPM	EWT (F)	LWT (F)	PD (FT)
HX-1	Hotel Guest Tower	1300	42	51.3	27	720	60	46	27

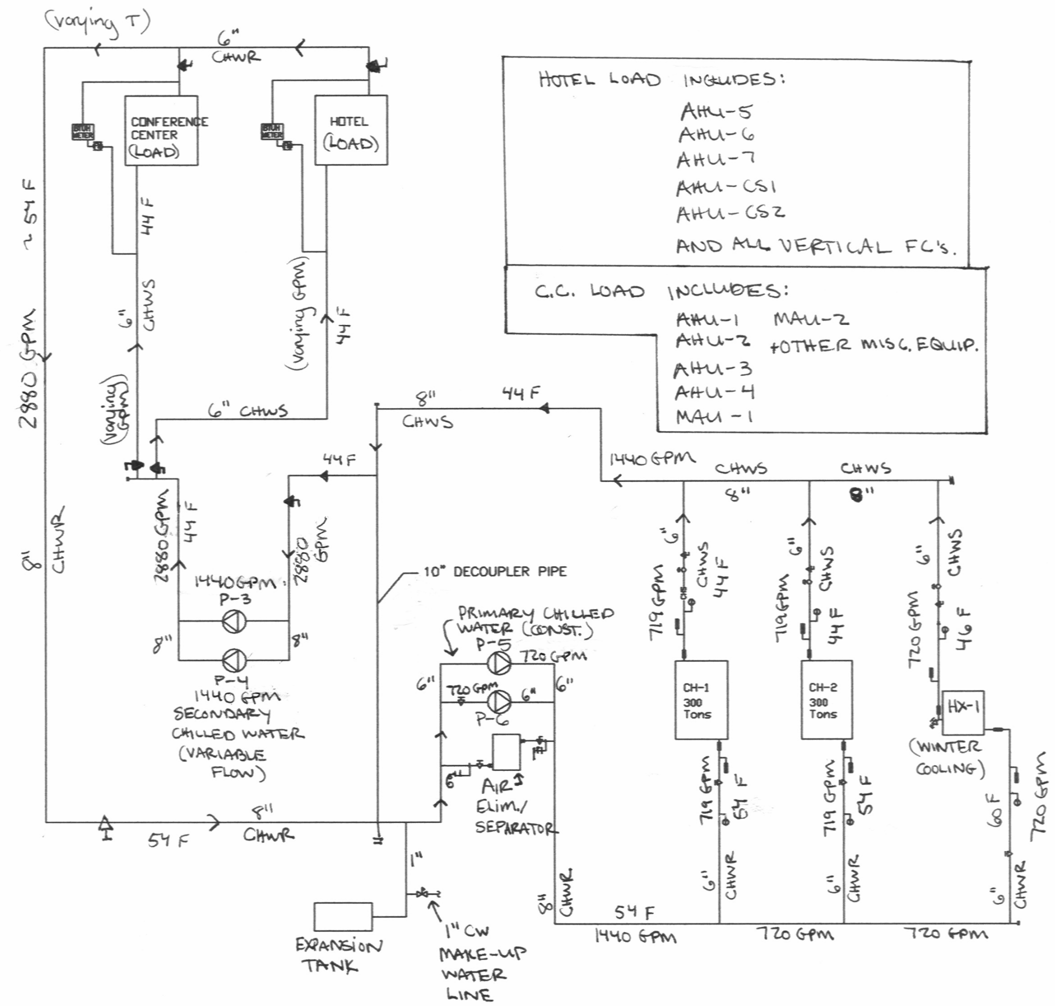
Note: Basis of Design - Tranter

9.0 Schematic Drawings of Existing Mechanical Systems

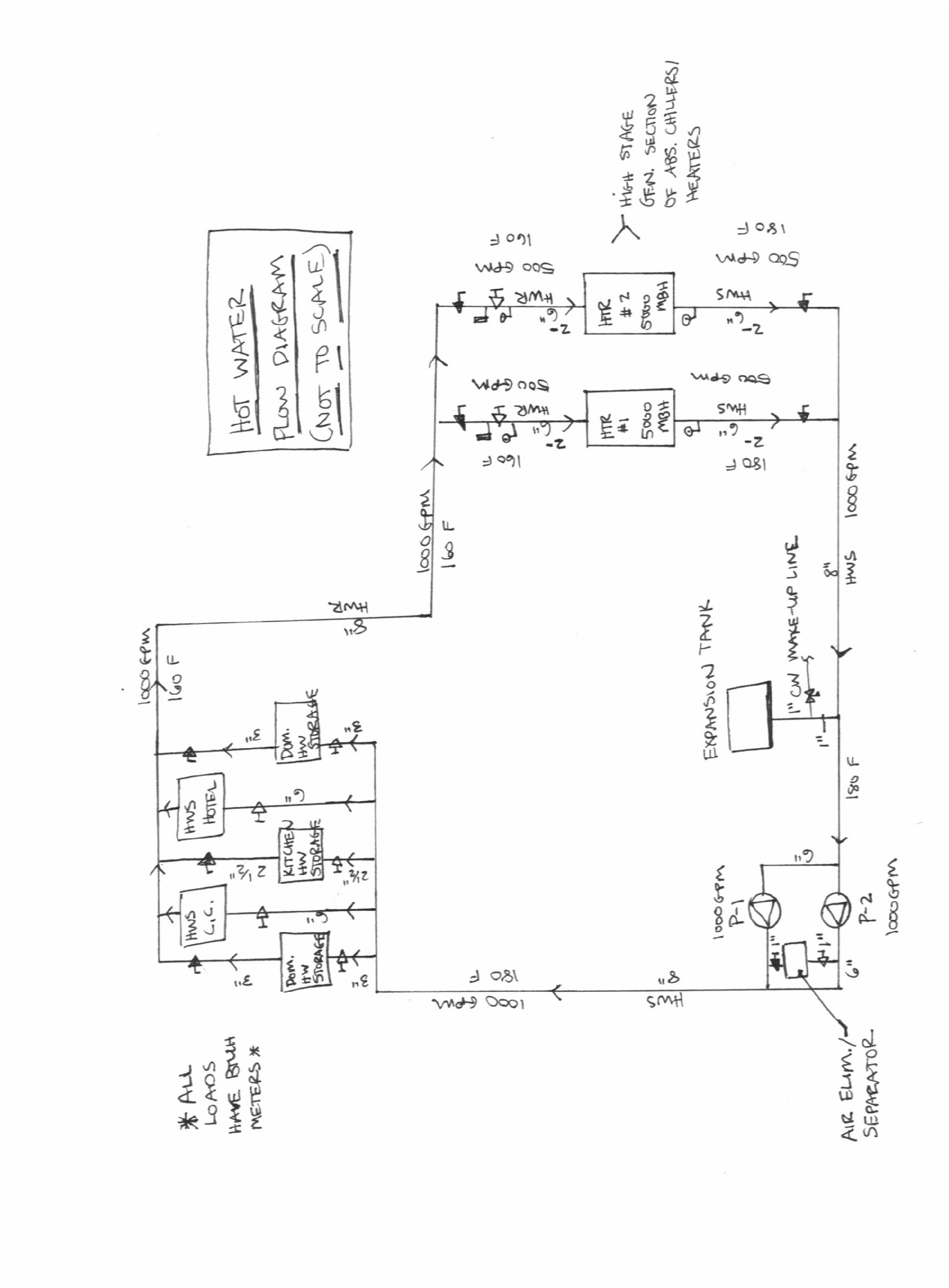
The following are simplified schematic drawings for MCCCH's condenser water, chilled water, hot water, and air systems.

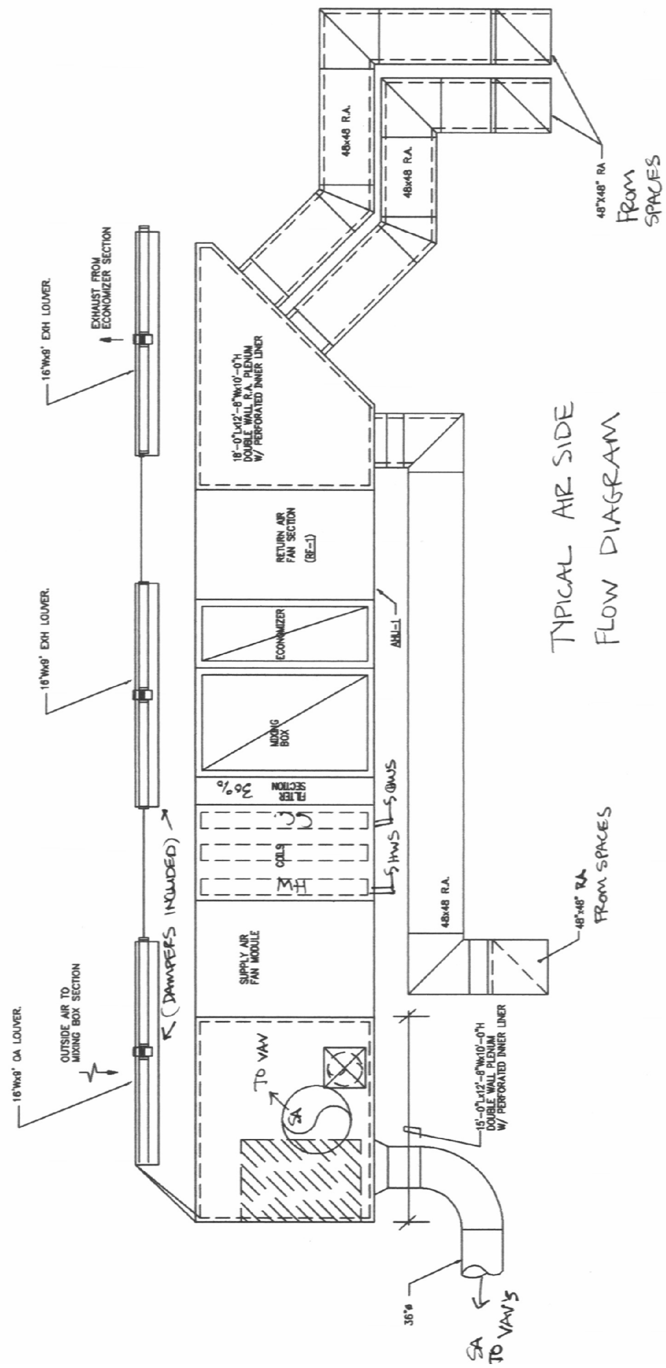


CONDENSER WATER FLOW DIAGRAM
(NOT TO SCALE)



CHILLED WATER FLOW DIAGRAM
(NOT TO SCALE)


HOT WATER FLOW DIAGRAM (NOT TO SCALE)
HIGH STAGE GEN. SECTION OF ABS. CHILLERS/ HEATERS
HTR #1 5000 MBH
HTR #2 5000 MBH
500 GPM
160 F
180 F
HWR
HWS
2-6"
8"
1000 GPM
EXPANSION TANK
1" CW MAKE-UP LINE
1"
6"
P-1
P-2
AIR ELIM./ SEPARATOR
DOM. HW STORAGE
HWS C.C.
KITCHEN HW STORAGE
HWS HOTEL
3"
2 1/2"
* ALL LOADS HAVE BTUH METERS *


TYPICAL AIR SIDE
FLOW DIAGRAM
16'Wx9' OA LOUVER.
OUTSIDE AIR TO MIXING BOX SECTION
16'Wx9' EXH LOUVER.
EXHAUST FROM ECONOMIZER SECTION
(DAMPERS INCLUDED)
SUPPLY AIR FAN MODULE
COILS
FILTER SECTION
30%
MIXING BOX
ECONOMIZER
RETURN AIR FAN SECTION
AHU-1
48x48 R.A.
48"x48" RA FROM SPACES
FROM SPACES
TO VAV
SA TO VAV'S
36"ø

10.0 Description of System Operation:

(Schematic diagrams from Section 9.0 of this report will help with the understanding of Section 10.)

System Overview

The airside mechanical system for the Montgomery County Conference Center and Hotel consists of a combination of variable air volume and constant volume systems served by eleven different air handling units throughout the building. Eight of the air handling units are located in mechanical rooms throughout the building, two rest on the hotel roof, and one is ceiling mounted in a stairway area. (See Sketch 1) Variable air volume boxes with electric reheat distribute air from the air handling units to all spaces in the two-story conference center, as well as, the restaurant and hotel first floor. Constant volume systems are used in the kitchen, exercise room, pool, and guest corridors/elevator areas on each hotel level. (Two of the three air handling units serving the kitchen area provide makeup air to the kitchen hoods, supplying 100% outdoor air.) The following is a list of MCCCH's air handling units/makeup air units and the components of their design. The AHU descriptions below give much more detail than the schedules presented earlier in this report.

Air Handling Units 1 and 2: are located in a mezzanine level mechanical room and serve all spaces in the conference center (Variable Volume), see Sketch 1, Section A. The contents of each AHU include min/max OA dampers, re-circulated air with a variable frequency drive fan, economizer, mixing box, filter (30% ASHRAE efficiency), pre-heat coil, cooling coil, heating coil, and a variable frequency drive supply fan all mounted on a 4" high housekeeping pad with ¼" thick neoprene pads. Both air handling units are balanced at a supply air cfm of 50,000, a max OA cfm of 50,000, and a minimum OA cfm of 30,000.

Air Handling Unit 3: is also located in the mezzanine level mechanical room. It serves the restaurant area on the main level between the conference center and hotel (Variable Volume), see Sketch 1, Section B. The contents of the AHU include min/max OA dampers, re-circulated air with a variable frequency drive fan, economizer, mixing box, filter (30% ASHRAE efficiency), cooling coil, heating coil, and a variable frequency drive supply fan all mounted on a 4" high housekeeping pad with ¼" thick neoprene pads. Air handling unit 3 is balanced at a supply air cfm of 12,500, a max OA cfm of 12,500, and a minimum OA cfm of 5,000.

Air Handling Unit 4: is located in the mezzanine level mechanical room. It serves the kitchen area on the main level between the conference center and hotel (Constant Volume), see Sketch 1, Section C. The contents of the AHU include min/max OA dampers, re-circulated air, economizer, mixing box, filter (30% ASHRAE efficiency), cooling coil, heating coil, and supply fan all mounted on a 4" high housekeeping pad with ¼" thick neoprene pads. Air handling unit 4 is balanced at a supply air cfm of 9,000, a max OA cfm of 9,000, and a minimum OA cfm of 2,250.

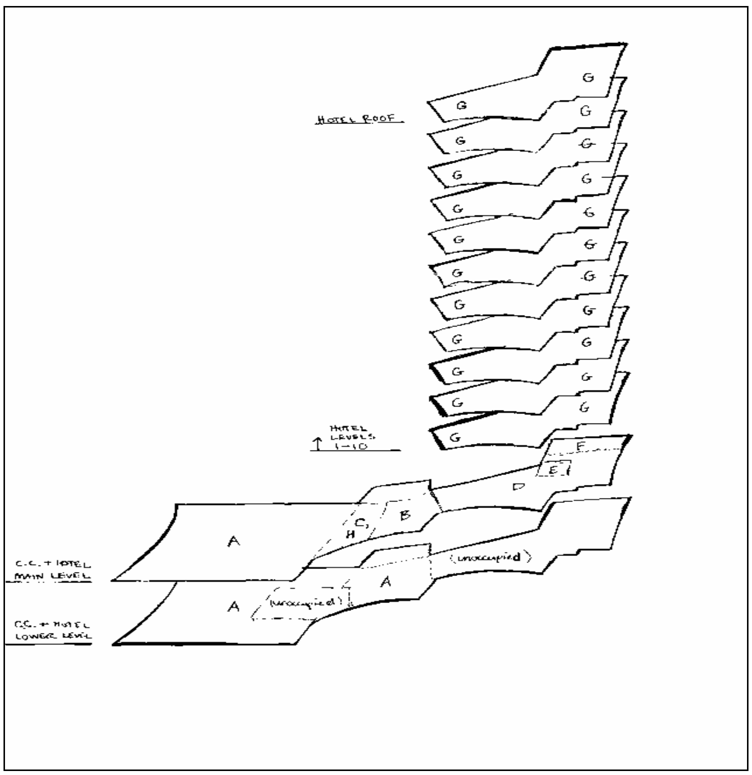
Air Handling Unit 5: is located in a mechanical room on the main hotel level, farthest from the conference center. It serves the hotel's first floor areas (Variable Volume), see Sketch 1, Section D. The contents of the AHU include min/max OA dampers, re-circulated air with a variable frequency drive fan, economizer, mixing box, filter (30% ASHRAE efficiency), cooling coil, heating coil, and a variable frequency drive supply fan all mounted on a 4" high housekeeping pad with ¼" thick neoprene pads. Air handling unit 5 is balanced at a supply air cfm of 9,000, a max OA cfm of 9,000, and a minimum OA cfm of 2,250.

Air Handling Unit 6: is also located in the mechanical room on the main hotel level, farthest from the conference center. It serves the exercise area on the hotel's main level (Constant Volume), see Sketch 1, Section E. The contents of the AHU include min/max OA dampers, re-circulated air, economizer, mixing box, filter (30% ASHRAE efficiency), cooling coil, heating coil, and supply fan all mounted on a 4" high housekeeping pad with ¼" thick neoprene pads. Air handling unit 6 is balanced at a supply air cfm of 1,400, a max OA cfm of 1,400, and a minimum OA cfm of 350.

Air Handling Unit 7: is ceiling mounted above a stairway near the pool area on the hotel's main level. It exists solely to provide air to the pool area (Constant Volume), see Sketch 1, Section F. The contents of the AHU include min/max OA dampers, re-circulated air, economizer, mixing box, filter (30% ASHRAE efficiency), preheat coil, cooling coil, heating coil, and supply fan. Additionally, the coils inside AHU 7 are coated with heresite to prevent corrosion. Air handling unit 7 is balanced at a supply air cfm of 3,200, a max OA cfm of 3,200, and a minimum OA cfm of 1,000.

Air Handling Units 8 and 9: are both located on the roof of the hotel tower. Each provide ventilation (100% OA) to the guest corridors and elevator lobbies on hotel levels 2 through 10 (Constant Volume), see Sketch 1, Section G. The contents of each AHU include an economizer, filter (30% ASHRAE efficiency), preheat coil, cooling coil, heating coil, and supply fan all mounted on a factory finished 18" high roof curb. Air handling unit 8 is balanced at a supply air cfm of 4,000, a max OA cfm of 4,000, and a minimum OA cfm of 4,000. Air handling unit 9 is balanced at a supply air cfm of 5,000, a max OA cfm of 5,000, and a minimum OA cfm of 5,000. (There are no AHUs that serve the individual hotel guestrooms. Each of these areas is provided for by an individual vertical fan coil unit.)

Makeup Air Units 10 and 11: are located in the mezzanine level mechanical room. They provide 100% outdoor air to the kitchen area in order to offset the kitchen exhaust hoods (Constant Volume), see Sketch 1, Section H. The contents of each AHU include an economizer, filter (30% ASHRAE efficiency), cooling coil, heating coil with face and bypass dampers, and supply fan all mounted on a 4” high housekeeping pad with ¼” thick neoprene pads. Makeup air unit 10 is balanced at a supply air cfm of 5,600, a max OA cfm of 5,600, and a minimum OA cfm of 5,600. Makeup air unit 11 is balanced at a supply air cfm of 6,025, a max OA cfm of 6,025, and a minimum OA cfm of 6,025.



Sketch 1: 3-D Sketch of AHU Serving Areas (Not to Scale)

Two 300 ton/5,000 MBH direct fired absorption chillers with duel fuel natural gas burners provide chilled and hot water to the conference center and hotel. The two chillers are located along with the building's end suction pumps in a mechanical room on the lower level of the conference center. Two 1300 gpm cooling towers assist the chillers and are located on the roof of the hotel.

Schedule of Operation

The hours of operation for MCCCH were assumed to be different between the hotel and conference center portions of the building. The hotel was designed to be operating 24-hours/day, 365 days/year. The conference center was assumed to have the following operation schedule:

Monday-Thursday	7:00AM to 7:00PM
Friday-Sunday	6:00AM to 12:00PM

It was also assumed that both the hotel and conference center would be open for events on holidays, etc.

Air Handling Unit Operation

Description

The exact specifications and areas served by the different air handling units throughout MCCCH have already been mentioned above. However, the way in which the AHUs operate has not yet been analyzed.

Most of the air handling units throughout the building supply 50-52 degree F air to the different spaces. All units, except the MAUs in the kitchen area, have outdoor air (OA) dampers running on an economizer cycle between 100% OA and the minimum calculated ventilation air rate. The units also contain centrifugal supply and return fans that slightly pressurize the building spaces. This pressurization was done in such a way that a special smoke containment system could be installed throughout the conference center portion of the building. Smoke zones and fan shut-off and start-up sequences were completely simulated and implemented. Variable speed controls were used on all the different units as well (see AHU descriptions above). Most units do not incorporate the use of ducted returns.

Sequence of Operation

The air handling units in the hotel portion of the building operate almost constantly throughout the year while the conference center units operate on an occupied/unoccupied basis. Normally, on days that the conference center will be occupied, the AHUs that serve the conference center will begin a warm-up approximately one hour prior to the arrival of people. Most of the time, the building's OA dampers will be closed throughout this warm-up and the building will re-circulate its own air (while cooling or heating if the need be) until the return air reaches a "cool enough" or "warm enough" set point, (the exact set point was unknown for this report). At the time that people begin to arrive at the conference center, the exhaust fans will start relieving some of the building's indoor air while the OA dampers open to provide proper ventilation. At this point, the economizer cycle will be in full use and the OA will be used to cool when its temperature is less than the "cool enough" set point. At higher OA temperatures, the OA dampers will again close and the building's AHUs will take care of the building's cooling load. Temperature sensors and air mixing sensors control the economizer cycle and OA dampers. The mechanical cooling will provide 50-52 degree F air at the AHUs. Once this air reaches the VAV boxes or the supply diffusers, it is normally somewhere around 55 degrees F. When a space becomes unoccupied, terminal reheat is used throughout the conference center spaces until certain systems shut off.

Safeties that exist for the building's air-side system include pre-heating and heating coil bypass and recirculation pumps in order to avoid the freezing-up of any AHU coils. Smoke detectors and sensors/fire dampers were installed throughout the ductwork and major air-side equipment in the building. These devices play into the smoke containment system, another safety, which was mentioned earlier in the report.

Direct-Fired Absorption Chiller Operation

Description

The Montgomery County Conference Center and Hotel's two direct-fired absorption chillers run mainly on natural gas but contain duel fuel burners for back-up use with No. 2 fuel oil. Each possesses a COP of 1.25 (at IPLV) and a heating efficiency of 85%. The absorption cycle in these machines, which takes the place of the compressor in traditional chiller equipment, is based on a water and lithium bromide solution.

Sequence of Operation

With a hotel, the demand for hot water is almost always constant. Therefore, normally, at least one absorption chiller in MCCCH is operating at all times. (During the day, people in the hotel need hot water along with the hotel's kitchen and laundry areas. At night, hotel guests demand even more hot water while the laundry also continues.) However, this is ok due to the fact that the hotel also needs cooling around the clock. With at least one absorption chiller running at all times, both heating and cooling will be produced at a constant rate. Most of these energies are used up just by the hotel. As the conference center's occupancy changes, MCCCH's second absorption chiller will turn on and off to provide the necessary treatment in that area of the building.

When the heating and cooling loads/demands do not completely match between the building spaces and absorption machines, thermal storage is implemented. The usual case is that the building demands cooling (chilled water) but not as much hot water. For this situation, MCCCH's design engineers installed hot water holding tanks for the different areas of the building that are likely to demand a lot of hot water all at once (kitchen, hotel, and laundry).

When chilled or hot water is needed in either portion of the building, the respective pumps will turn on and begin pumping water to the particular area. One of the absorption chillers/heaters is likely to already be running and will begin supplying these pumps. (Chiller/Heater supply water temperatures would be based on (OA) controls set throughout the building's AHUs and other mechanical equipment.) Flow sensors/meters will monitor all flows through the chillers/heaters and pumps. If any problems occur, valves will be shut and the pumps turned off prior to any damage. Normally, the chillers/heaters are kept running as they don't like to be quickly shut down and then turned on again. If a severe problem would exist with the chillers/heaters, they would be shut down immediately. In an additional effort to avoid the need for a quick shut down, several stand-by pumps were also installed and wired to start-up at the failure of any lead pumps.

11.0 Critique of the System:

The mechanical system for the Montgomery County Conference Center and Hotel has many very good aspects. However, it is still a very typical/standard design that is almost a carbon copy from other buildings just like MCCCH. Further research of the building could most definitely reveal a more efficient and optimized system. There is also much that could be done with the building's absorption equipment in this analysis for implementing different overall systems. As stated earlier in this report, the absorption equipment was not part of the building's original design and was only implemented due to a very low first cost. The chance that the overall system was optimized with these two new pieces of equipment is very low. The mechanical design engineers for the project were definitely under strong influence from the owner who wanted the standard system coupled with a bargain set of absorption chillers/heaters. Regardless, they did come up with a nice, workable design that dealt with the many constraints and challenges faced by the mechanical system (discussed in previous sections of the report).

With further investigation, the operating costs (energy and maintenance) for MCCCH's mechanical system can be studied. Optimization points can be researched. Small adjustments could be tried in order to create huge differences in MCCCH's mechanical system performance. Time and creativity will hopefully yield some very interesting results.

12.0 References:

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