Andrew Rhodes

The Pennsylvania State University
Architectural Engineering – Mechanical

The Hilton Baltimore Convention Center Hotel

Thesis Proposal

Faculty Advisor: Dr. William Bahnfleth

December 15, 2006

Thesis Building Sponsor:
Southland Industries
22960 Shaw Road, Suite 800
Sterling, VA 20166
www.southlandind.com

Table of Contents

1.0 Executive Summary:

The purpose of this report is to summarize the information obtained throughout the completion of the Mechanical Technical Assignments, in an effort to propose a mechanical system redesign for the Hilton Baltimore Convention Center Hotel (HBCCH). If approved, this proposal will serve as a guideline for research to be followed throughout the spring semester.

Once alternatives for redesign are summarized, the proposal describes the final proposed redesign. Ultimately, the main thrust of the redesign is the elimination of the district chilled water system in favor of on site cooling. This redesign is justified based on the objectives of reduced life-cycle cost and energy consumption. Coordination and integration are then discussed, leading to the elaboration of related breadth work to be completed. Lastly, a tentative work schedule for the spring semester is created.

2.0 Project Background

The HBCCH, set to open in August of 2008, is a multi-use hotel located in the heart of downtown Baltimore. Immediately adjacent to both Oriole Park at Camden Yards and the Baltimore Convention Center (see Figure-1 below), the hotel has over 750,000 square feet of usable space. At a cost of over $250 million, the HBCCH is comprised of two separate buildings, East and West, connected by a walking bridge which spans Eutaw Street. A second walking bridge, spanning Howard St., connects the HBCCH to the existing Baltimore Convention Center.

Figure-1: Site Location

The lower three levels of the East and West Buildings make up the East Podium and West Podium. The podiums are the public spaces of the HBCCH, housing ballrooms, meeting rooms, a restaurant, a pool, prefunction spaces, and offices. Two guest room towers, one 19 stories tall and one 21 stories tall, sit atop the West Podium and contain more than 750 guest rooms.

3.0 Existing Mechanical Systems

The vast majority of redesign work will involve the HBCCH's mechanical systems. The following gives a summary of the building mechanical systems as originally designed.

Cooling

The HBCCH receives chilled water from the ComfortLink district chilled water system. Chilled water is supplied by two plate and frame heat exchangers. 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).

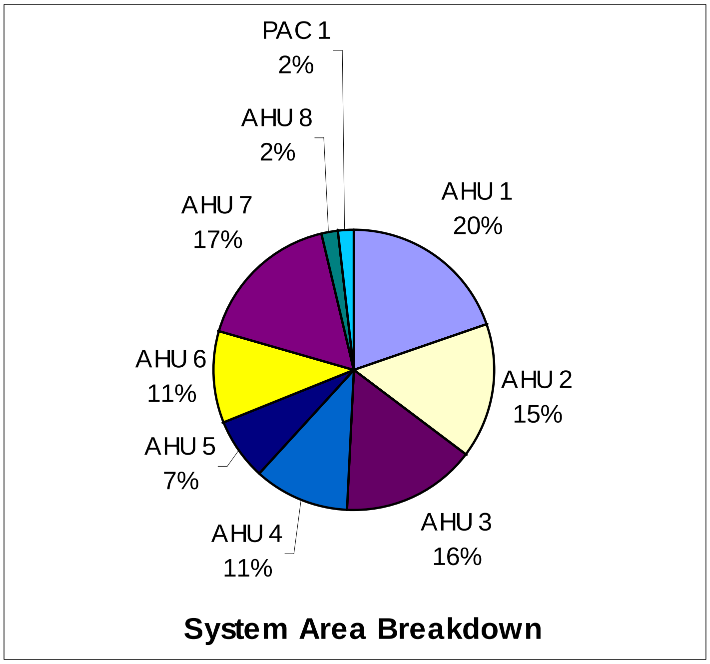
Chilled water piping for the building systems of the HBCCH originates on the secondary or warm side of ComfortLink's heat exchangers. Chilled water is distributed in two main pumping zones; one zone is the guest room towers, and the second zone is for the east and west podium public areas. Two variable speed pumps are provided for each zone, each sized for 60% of the design flow rate. 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-2: 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 a pressure reducing station. 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 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 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.

4.0 Alternative Designs Considered

Initially, several design alternatives were considered. These alternatives are described below.

Achieving LEED Gold Certification

As seen in the LEED points study carried out in Mechanical Technical Report #2, the HBCCH would receive many LEED points as designed. Improvements to the mechanical system could be made in order for the HBCCH to achieve a gold certification. While this would be a worthwhile exercise, it would not provide the same level of rigor and educational value as the proposed mechanical redesign.

Replacing the Guest Room Fan Coil Units

Another option for redesign would be to replace the makeup air units and fan coil units serving the guest room towers. This alternative was quickly dismissed once it was learned that both Southland Industries and Hilton Hotels employ this method of cooling and heating for nearly all of their hotel projects.

On Site Heating

The current design, utilizing district steam, could be redone to have on site heating instead. This option would include the selection of boilers and all related equipment. This alternative was dismissed because the district steam is most likely going to be used in order to include absorption cooling as the main emphasis of the mechanical redesign.

5.0 Proposed Redesign

After considering the alternatives listed in Section 4.0 of this report, a final plan for the mechanical redesign was chosen. This redesign, along with the associated breadth work listed in Section 6.0 of this report, will be presented in April 2007.

Scope of Mechanical Redesign

The primary focus of the mechanical redesign will involve replacing the existing district chilled water service with complete on site cooling. The district service will be replaced by either steam driven absorption cooling or electric chillers. Absorption cooling is the primary area of interest, but the first portion of the spring semester will be spent comparing these two options and deciding which to choose.

Since the HBCCH already utilizes district steam for domestic and heating hot water, steam service is already located within the building and could be utilized for the absorption cooling. The steam enters the building at high pressure and is stepped down to a much lower pressure before it is distributed throughout the building. This means that both single-effect and double-effect absorption cooling is possible.

Once a specific method of cooling is chosen, a life-cycle cost analysis will be completed. This analysis will compare the district chilled water system to the proposed on site system considering issues such as first cost of equipment and materials, maintenance and personnel, steam and electricity usage, and lost rentable space.

Another portion of the redesign involves generating electricity at the current steam pressure reducing station. Currently all of the energy released when the steam is stepped down from high to low pressure is lost. This energy could be used by a small turbine to provide some electricity to the building.

Justification of Mechanical Redesign

Reduced life-cycle cost and energy consumption are the two main objectives of this redesign. While it is still unknown whether these objectives will be met, the educational value of this redesign makes it worthwhile regardless of the life-cycle cost analysis results.

Coordination and Integration

Coordination and integration will be very important as the proposed redesign unfolds. Equipment will be removed and added, and the need for mechanical spaces will certainly change. The largest need for coordination will arise from the impact the redesign has on other building systems. The electrical system will need to be changed, and the structural system could possibly be affected. These topics are discussed further in Section 6.0 of this report.

6.0 Breadth Work

Redesigning the building mechanical systems of the HBCCH will directly affect many of the building's other systems. As a result, these systems must be reevaluated to ensure their overall operation. At the same time, intentionally changing another building system could be a method of increasing the performance of the building mechanical systems. After considering both of these scenarios, a summary of the assumed breadth work required was formed.

Lighting/Electrical

The electrical service of the HBCCH will need to be changed once the new mechanical system has been designed. The loads from the new equipment will have to incorporated into the current electrical design. As a result, feeders, panel boards, and over current protection will be resized. The electrical service will also have to be altered if any changes are made to the building's lighting systems.

The lighting system of the HBCCH will be analyzed only in areas with extremely high lighting power densities. These areas will be located with the help of the ASHRAE 90.1 analysis carried out in Mechanical Technical Report #2. Alternative lighting layouts and design concepts will be evaluated for these areas. Lowering the lighting power densities would also lower the lighting load seen by the HBCCH's cooling systems.

Construction Management

The scope of this breadth study is limited to the guest room towers of the HBCCH. A short interval production schedule (SIPS) will be created for the construction of the guest room towers. This portion of the HBCCH is well-suited for a SIPS since the layout of each floor is extremely repetitive. If created well, the SIPS should minimize both construction time and cost for the guest room towers. While this breadth study has no immediate impact on the performance of mechanical system, cost savings could be used to purchase required mechanical equipment.

Structural

The structural system of the HBCCH will be studied only at locations where new building mechanical equipment would need to be placed. This new equipment would increase the structural load on the building's framing members and slabs, possibly requiring the resizing of these structural elements.

7.0 Project Methods

The initial focus of the spring semester will be the selection of the chillers for redesign. Load calculations from Trane TRACE will be used to aide in equipment selection. Once selected, the equipment chosen will be put back into TRACE in order to calculate energy consumption and operating costs.

Once all new equipment is selected, it will need to be put into the floor plans of the HBCCH. This process could involve the expansion of existing mechanical rooms. Once all equipment is properly located the subsequent electrical and structural analyses can take place. It's important to remember that other coordination and integration issue could arise throughout the course of the semester. These issues will be dealt with as needed. References for all data needed include the ASHRAE Handbooks of Fundamentals, HVAC Systems and Equipment, and HVAC Applications. Many manufacturer catalogs and websites will also be utilized in order to obtain necessary information. Design professionals will provide valuable insight and knowledge as well.

8.0 Preliminary Research

Listed below are reference materials that have been consulted and will be used throughout the redesign process. More references will certainly be added to this list as redesign work progresses throughout the spring.

ASHRAE Handbook, Fundamentals. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA 2005.

ASHRAE Handbook, HVAC Applications. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA 2003.

ASHRAE Handbook, HVAC Systems and Equipment. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA 2004.

CoolTools Chilled Water Plant Design and Specification Guide. Pacific Gas and Electric Company, San Francisco, CA 2000.

Electrical Systems in Buildings. S. David Hughes. Delmar Publishers, Inc., Albany, NY 1988.

9.0 Tentative Work Schedule

The primary goal for the spring is to stay on or ahead of schedule. This will allow me ample time to complete all of the required work. The main mechanical redesign will be the primary focus throughout the beginning of the semester, and breadth work will follow since it is largely impacted by what takes place in the mechanical redesign. A tentative work schedule is listed in Table-1 below. Please note that this schedule is tentative and can change at any time.

Table-1: Tentative Work Schedule

Tentative Work Schedule		
Week	**Dates**	**Tasks to be Accomplished**
Week 1	1/16-1/19	Research / Gathering Info
Week 2	1/22-1/26	Research / Gathering Info
Week 3	1/29-2/2	Research / Gathering Info
Week 4	2/5-2/9	Mechanical Redesign
Week 5	2/12-2/16	Mechanical Redesign
Week 6	2/19-2/23	Mechanical Redesign
Week 7	2/26-3/2	Mechanical Redesign
Week 8	3/5-3/9	Mechanical Redesign
Week 9	3/12-3/16	Spring Break - Flex time (catch up, get ahead, unexpected tasks, etc...)
Week 10	3/19-3/23	Breadth Work / Tie up loose ends of mechanical redesign
Week 11	3/26-3/30	Breadth Work / Tie up loose ends of mechanical redesign
Week 12	4/2-4/6	Finish up breadth work
Week 13	4/9-4/13	Tie up all loose ends / Prepare presentation
Week 14	4/16-4/20	Presentations

10.0 References

1. Mechanical Technical Report #1 – Andrew Rhodes
2. Mechanical Technical Report #2 – Andrew Rhodes
3. Mechanical Technical Report #3 – Andrew Rhodes
4. MC Dean, Electrical Drawings and Specifications.
5. Southland Industries, Mechanical Drawings and Specifications.
6. Mike McLaughlin and Andrew Tech, Thesis Consultants, Southland Industries.
7. The Pennsylvania State University Architectural Engineering Department, Thesis Advisor: Dr. William Bahnfleth.
8. Dennis Manning, General Manager, ComfortLink district chilled water plant
9. Past Thesis Technical Reports, e-Studio Archives, 2004-2005.