Thesis Proposal

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Karen Schulte
Mechanical Option
University of Delaware
Center for the Arts
Newark, DE

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Faculty Advisor: Dr. Srebric

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Executive Summary:

The Center for the Arts is a performing arts center located on the University of Delaware campus in Newark, Delaware. The 92000 square foot Center for the Arts consists of a Proscenium Theater, Recital Hall, Orchestra Rehearsal, and Theater Rehearsal as the major performing spaces as well as 32 practices rooms.

For the spring 2006 semester, the proposed mechanical redesign is an underfloor air distribution system for Proscenium Theater in the Center for the Arts performing arts building. The underfloor air distribution system will reduce heating, ventilation and air conditioning background noise transferred to the space and reduce energy costs through the addition of an economizer while maintaining thermal comfort for the occupants of the theater seating area. Energy savings will also result from downsizing or reducing the speed of the fan due to the elimination of most of the branch ductwork associated with an over head distribution system.

The mechanical redesign affects the structure and acoustics of the theater seating space. The addition of the underfloor plenum will be analyzed to ensure structural stability. The balcony will be analyzed to ensure the feasibility of using the underfloor air distribution to supply air to occupants on that level. An acoustical comparison should show that the mechanical redesign brings the theater well within the prescribed limits of room noise criteria as set forth by the University of Delaware.

This report also contains a summary of the air handling units, heating water system, chilled water system and humidification system as designed. Two alternative redesigns were considered, comparing heat recovery system to save on energy costs and the addition of an absorption chiller to attempt to lower energy costs.

Building Summary:

The Center for the Arts is a performing arts center located on the University of Delaware campus in Newark, Delaware. The 92000 square foot Center for the Arts consists of a Proscenium Theater, Recital Hall, Orchestra Rehearsal, and Theater Rehearsal as the major performing spaces as well as 32 practices rooms.

Air Handling Units

AHU-1

Air-Handling Unit 1 is a variable air volume unit that supplies 19,200cfm to 19 zones. This air-handling unit serves the Orchard Street lobby on the south side of the building as well as corridors and interior spaces. According to ASHRAE Standard 62.1-2004, the minimum outdoor air percentage was found to be 35%. In order to comply with ASHRAE Standard 62.1 the scheduled minimum amount of outdoor is 6700cfm.

AHU-2

Air-Handling Unit 2 is a constant air volume unit that serves the Proscenium Theatre seating area and supplies 7,900cfm to that single zone. According to ASHRAE Standard 62.1-2004, the minimum outdoor air percentage was found to be 44%. In order to comply with ASHRAE Standard 62.1 the scheduled minimum amount of outdoor air is 4,000cfm.

AHU-3

Air-Handling Unit 3 is a constant air volume unit that the serves the Proscenium Theatre stage supplies 9,450 cfm to that one zone. According to ASHRAE Standard 62.1-2004, the minimum outdoor air percentage was found to be 8%. In order to comply with ASHRAE Standard 62.1 the scheduled minimum amount of outdoor air is 950 cfm.

AHU-4

Air-Handling Unit 4 is a variable air volume unit that supplies 35,000cfm to 62 zones. This air-handling unit serves the theatre rehearsal and back of the house interior spaceson the lower level, and practice rooms on the second level. According to ASHRAE Standard 62.1-2004, the minimum outdoor air percentage was found to be 33%. In order to comply with ASHRAE Standard 62.1 the scheduled minimum amount of outdoor air is 11,700cfm.

AHU-5

Air-Handling Unit 5 is a constant air volume unit that supplies 10,500cfm to one zone through an under floor distribution system. This air-handling unit serves the Recital Hall seating area and stage. According to ASHRAE Standard 62.1-2004, the minimum outdoor air percentage was found to be 17%. In order to comply with ASHRAE Standard 62.1 the scheduled minimum amount of outdoor air is 1,800cfm.

AHU-6

Air-Handling Unit 6 is a constant air volume unit that supplies 7,000cfm to one zone. This air-handling unit serves the Orchestra Rehearsal room. According to ASHRAE

Standard 62.1-2004, the minimum outdoor air percentage was found to be 42%. In order to comply with ASHRAE Standard 62.1 the scheduled minimum amount of outdoor air is 3,000cfm.

Chilled Water System

The chilled water for the Center for the Arts is supplied from the campus chilled water mains. There are two pumps, located in the lower level mechanical room, that each has a dedicated variable frequency controller to modulate the speed of the pump in order to maintain adequate system differential pressure. The pumps pump the chilled water to the cooling coils in the air handling units and the fan coil units that cool the electrical equipment room.

Heating Water System

The heating system for the Center for the Arts is supplied from the campus steam mains. The steam enters the Center for the Arts as medium pressure steam then reaches a pressure reducing station where the steam is converted to low pressure steam. The low pressure steam is then converted to 200°F water in one of the two steam to water converters. There are two pumps, located in the lower level mechanical room, that each has a dedicated variable frequency controller to modulate the speed of the pump in order to maintain adequate system differential pressure. The heating water is then pumped throughout the building supplying heating water to the air-handling unit preheat and reheat coils, the unit heaters, duct mounted reheat coils and other equipment.

Humidification System

Each of the six air handling units that service the Center for the Arts are equipped with a gas fired steam humidifier. Humidification control is vital to the performance quality within the spaces in the Center for the Arts. Changes in humidity levels affect the tonal quality of tuned instruments. Each of the performance spaces is equipped with humidity sensors so that the humidity levels can be maintained.

Redesign Alternatives:

The Center for the Arts will use an estimated 2.8million kWh each year. In an effort to reduce the energy cost of the Center for the Arts for the University of Delaware heat recovery systems can be implemented on the air handling units. There are a few options for heat recovery to compare the benefits cost and control wise. Heat recovery can be achieved using an enthalpy wheel, desiccant wheel, or a heat exchanger. The overall benefit of this type of study would be to learn the energy savings that results from the addition of these systems.

The use of an absorption chiller can also increase energy savings. There are a number of reasons that would substantiate the consideration of an absorption chiller: water heat is available, low cost source of fuels are available, boiler efficiency is low, or the site has an electrical load limit. Among these the one that is most applicable is the availability of waste heat from the steam central plant located at the university. This alternative would have led to a study of cost and energy consumption associated with the installation of an absorption chiller as well as the finding a location for the chiller within the building.

Proposed Redesign:

The performance spaces in the Center for the Arts are highly sensitive to acoustical noise criteria. The Proscenium Theater's original design consisted of a constant volume overhead distribution system. The proposed redesign will be an underfloor air distribution system for the Proscenium Theater. Underfloor air distribution is extremely effective in controlling HVAC background noise. The current overhead distribution supplies air from forty feet above the audience seating level. The underfloor air distribution system will provide better thermal comfort to the occupants of the seating area of the Proscenium Theater due to the proximity of the supply air to the occupants. The velocity of the supply air needs to be set at a point such that the throw reaches the top of the occupied zone. This creates an environment with an increased temperature near the floor and a decreased temperature gradient thus improving the thermal comfort of the space as compared to the original overhead air distribution.

Underfloor air distribution systems have a positive effect on energy savings. Savings result from increased hours of economizer operation due to higher return air temperatures caused by stratification and reduction in cooling required because of the higher supply air temperatures of UFAD systems. To achieve these savings an economizer will be added to air handling unit 2 that supplies the Proscenium Theater.

One of the main advantages to the underfloor air distribution system is that it eliminates the overhead branch ductwork. The catwalks at the ceiling level of the Proscenium Theater will have better access to the lights and decrease the coordination for the ceiling layout. The elimination of most of the branch ductwork also correlates to a reduction in static pressure and therefore a reduced fan speed and fan energy savings.

Breadth Topics:

Since the acoustics in the Proscenium Theater were a major concern in the original design of the project, there will be a comparison of the acoustical benefits of the underfloor air distribution system with the design constant volume overhead distribution system. The main comparison will be the noise level reduction associated with the underfloor air distribution system.

The underfloor air distribution system will change the structure of the Proscenium Theater. In order to accommodate the underfloor system an air plenum is built under the floor. The Proscenium Theater consists of two floors of seating, the main level which seats the majority of the audience, then the balcony seating area. The raised floor for the plenum needs to support the balcony. The air system by which air is supplied to the balcony will depend on the feasibility of creating a plenum on the balcony level. The new floor structure will be analyzed to ensure loads of the balcony will be met.

Tools and Methods of Research:

The Trane Trace analysis program was used in Technical Assignment #2 and will be used to analyze the proposed redesign of the mechanical system for the Proscenium Theater. The Trane Trace program will provide load data to insure that the underfloor system still comply with ASHRAE Standard 62.1-2004 ventilation rates

In order to analyze the structural system a program such as RAM, Etab, or STAAD will be used based on the recommendation of a faculty advisor. The program that is used should be able to determine if the existing design will be feasible to build and then support the upper level balcony.

Spring Schedule:

The following is a schedule for the spring semester research on the proposed mechanical redesign.

Week			Task
1	9-Jan-05	15-Jan-05	Underfloor Air Distribution Research
2	16-Jan-05	22-Jan-05	Underfloor Air Distribution design
3	23-Jan-05	29-Jan-05	Underfloor Air Distribution design
4	30-Jan-05	5-Feb-05	Structural Analysis
5	6-Feb-05	12-Feb-05	Structural Analysis
6	13-Feb-05	19-Feb-05	Coordinate mechanical and structural aspects of redesign
7	20-Feb-05	26-Feb-05	Energy analysis and comparison
8	27-Feb-05	5-Mar-05	Check compliance of ASHRAE Stds 55 and 62
9	6-Mar-05	12-Mar-05	Spring Break
10	13-Mar-05	19-Mar-05	Acoustical analysis
11	20-Mar-05	26-Mar-05	Wrap up research and analysis of unresolved issues
12	27-Mar-05	2-Apr-05	Write final report
13	3-Apr-05	9-Apr-05	Thesis Report due Apr. 5 / Work on thesis presentation
14	10-Apr-05	16-Apr-05	Thesis Presentations

Bibliography:

ANSI/ASHRAE Standard 55-2004 – Thermal Environmental Conditions for Human Occupancy. ASHRAE Incorporated, Atlanta, GA, 2004.

ANSI/ASHRAE Standard 62.1-2004 – Ventilation for Acceptable Indoor Air Quality. ASHRAE Incorporated, Atlanta, GA, 2004.

Bauman, Fred. "Underfloor Air Technology". http://www.cbe.berkeley.edu/underfloorair/

Kirkegaard Associates. *Acoustic Design Guidelines.* 14 March 2003.

Luskay, Larry. "Design and Construction Consideration for Underfloor Air Distribution Systems". http://www.betterbricks.com/default.aspx?pid=article&articleid=312&typeid=10&topicname=mechanicalsystems&indextype=.

Previous Technical Assignments.