University of Miami Interdisciplinary Laboratory

AE 482 Mechanical Project Proposal

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AE 482 Mechanical Project Proposal-Executive Summary
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Executive Summary:

The University of Miami Interdisciplinary Laboratory has two mechanical systems serving its office spaces and its laboratory and vivarium spaces. The office system is variable volume, return air, and the laboratory and vivarium system is constant volume, 100% outdoor air. Both systems employ chilled water for dehumidification, with hot water reheat at the terminal units.

I propose to change the dehumidification method of the laboratory and vivarium system to a spray desiccant system. By thus reducing the cooling coil load, I hope to save energy consumption of the system. The new equipment will be heavy and may require new electrical connections. The redesign of the supporting structure and electrical supply means will constitute breadth projects.

Additionally, I propose to change the laboratory and vivarium system to a variable volume system. This will be accomplished by using variable volume terminal units, similar to those already part of the office system design. The Phoenix Controls for the fume hood exhaust system will also be changed to be variable volume. These steps will also decrease the system energy consumption.

Changes in these aspects may require a reordering of the overall air handling process, and chilled/hot water piping resizing and reconfiguring, as well as control sequencing, will be performed as necessary.

An economic analysis will show a higher first cost for this new equipment, but payback will occur over a certain period of time with the energy saved. This time period will be determined by the analysis as well.

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System Background

The University of Miami Interdisciplinary Laboratory (hereafter referred to as the UMIL) is a 180,000 square foot university animal research laboratory, located in Miami, Florida, that includes office, laboratory, and animal vivarium space. The building's heating, ventilation, and air conditioning (HVAC) is separated into two systems. One is a recirculated air, variable volume system that serves all the office spaces. Space air is either ventilated by exhaust fans out of the building as needed, or it is collected through a return air plenum, mixed with incoming outdoor air, and taken through the system air handling unit. The volumetric flow of this supply air is adjusted both by a variable speed fan in the air handling unit as well as variable speed terminal units. These devices regulate the amount of air supplied to each space based on ventilation and load requirements.

The other system serves the laboratory and vivarium spaces, and it is this system that will be analyzed for redesign. It is a constant volume, 100% outdoor air system. Due to the sensitive nature of the use of the spaces, it is not recommended to recirculate the air that is already in the spaces, because it may have picked up any number of contaminants along the way. Experiments being run, the presence of several kinds of animals, and the storing of hazardous materials affect the air within these parts of the UMIL. Exhausting all this air away from the building, and re-supplying the spaces with air exclusively from the outside, provides a healthy and safe environment for the animals and human workers as well ensures untainted experimental results.

Despite the indoor air quality benefits of a 100% outdoor air system, there is a drawback in terms of energy required, and hence of cost of operation. A main purpose of an HVAC system is to provide comfortable indoor air conditions despite uncomfortable outdoor air conditions. In order to take outside air and change its conditions to meet indoor comfort requirements, a great amount of energy is required. A method to reduce that energy cost, which is used by the office system of the UMIL, is to mix air that was already in the space with the incoming outdoor air. This process automatically brings the supply air closer to the desired conditions, so it takes less energy to complete the change. This method is used in many buildings, but as was stated earlier, air recirculation is not an option for the laboratory and vivarium system in the UMIL.

Unlike the office system of the UMIL, the laboratory system is constant volume, meaning that it does not vary the flow rate of supply air to its spaces. With the laboratory system, varied flows of hot water are introduced, via heating coils within terminal units, to a constant air stream entering each space. While the ventilation requirements are kept by the constant supply air volume, the varying space cooling or heating loads are met by the varying hot water stream. These requirements are met, but the drawback to this system, again, is the energy (financial) cost. During normal operation of the system, the level of supplied air volume can far exceed the required amount due to the present conditions. At those times, less air supplied would mean less energy to condition the air. In the case of the UMIL, a constant air volume system for the laboratory and vivarium spaces is nevertheless used, because of owner request. Due to previous unsatisfactory experiences with variable volume systems, the simpler constant volume system was desired.

A method undertaken to relieve the energy burden of the constant volume outdoor air laboratory system is the use of energy recovery units. Laboratory and vivarium space air, exhausted through the general exhaust system, is first passed through the energy recovery units. The cool return air heats water, in coils, that is then pumped to the air handling units. The now cool water serves to help lower the temperature of the hot, incoming, outdoor air, saving the system from doing that cooling itself. This “runaround” coil system helps to ease the sensible cooling load, but it does not ease much of the latent load, which can be quite significant in the hot, humid Miami climate.

The present method incorporated by the UMIL office and laboratory systems to dehumidify the outside air to meet the design humidity level is by cooling. Chilled water in the cooling coil cools the incoming air to the point that it loses moisture in the form of condensation. Once the dehumidification process is complete, the air needs to be reheated to the correct temperature, because it is now too cold. Again, with the hot, humid Miami climate, dehumidification through cooling may create an excessive energy cost. In this case, alternative dehumidification, such as desiccant options, can be considered.

Proposed Design Modifications

I hope to prove that a liquid spray-tower dehumidification system would be more cost effective than the present cooling dehumidification system. The steps necessary to accomplish this are, first, to investigate in detail the latent energy change that the outside air needs to undergo in order to meet design space criteria. Then an alternative dehumidification system, such as a spray desiccant system, can be designed, and the energy results be compared with the present chilled water dehumidification. An enthalpy wheel is not considered as the dehumidification option because of the inconvenient location of the air handling units in relation to the general exhaust system, also because of the potential for contaminants in the exhaust stream to be transmitted to the incoming air. Finally, changes may need to be made to the air handling units themselves in order to adjust to the new dehumidification system. Information resources for these tasks include:

-ASHRAE Humidity Control Design Guide for Commercial and Institutional Buildings (Harriman, Brundrett, and Kittler; MIT Press, 2001)

-The Dehumidification Handbook Second Addition (Munters CargoCaire© Incentive Group, 1990)

Considerations for the feasibility of a new dehumidification system also need to be evaluated. New equipment would be large, heavy, and power-consuming, meaning there needs to be sufficient space, structural support, and electrical wiring. Space will be the most significant, because redesign of the structure and wiring can be undertaken as breadth projects. Economics also need to be considered. An analysis of the first cost of the new system will be compared with the energy saved by it, and the payback period will be determined.

Additionally, I hope to prove that a variable volume air supply system for the laboratory and vivarium spaces would be more cost effective than the present constant air volume design. The will be shown by a new design which includes variable volume terminal units instead of the present constant volume terminal units. Variable volume terminal units are already part of the design for the office system, so it will be simple to use the same units for the new laboratory design. However, because there will be changes to the central air handling units due to a new dehumidification system, the present hot water piping to the terminal units may need to be resized or changed to chilled water piping. As another consideration for the change to a variable air system, the fume hood exhaust valve controls may be changed to variable volume, instead of the present constant volume. The Phoenix© controls currently operating the fume hood exhaust fans either turn them on at constant speed or turn them off. This is determined by the fume hoods being manually opened or closed. New controls can regulate the speed of the fans by how open the fume hoods are; for example, a hood 50% open will cause the exhaust to operate at 50% capacity. The control sequences will be changed accordingly to meet the new variable volume system requirements. Information resources for these tasks include:

-Phoenix Controls Corporation© Product Information and Design Guides.

-Heating, Ventilation, and Air Conditioning Analysis and Design, 6^{th} Edition (McQuiston, Parker, Spitler; John Wiley & Sons, Inc.; 2005)

-ASHRAE Handbook 2004

The attached calendar depicts the work schedule for which I hope to accomplish this proposal. The proposal is divided into tasks that should take about two weeks each to accomplish. By adhering to this schedule, I will be able to even out the work load appropriately, as well as to ensure adequate attention to all the redesign considerations.

Conclusion

The University of Miami Interdisciplinary Laboratory is a 180,000 square foot university facility that contains two air handling systems serving office space, and laboratory and vivarium space respectively. Proposed modifications to the laboratory and vivarium space are the addition of a spray-desiccant dehumidification system and the change of the present constant air supply system to variable via variable volume terminal units and variable volume Phoenix Control fume hoods. The changes will affect the overall sequence of the air handling system, meaning possible piping resizing or change in piping sequence. The analysis of the feasibility of this redesign will include space constraints, equipment first cost and installation, new control sequences, new air handling unit layout, and ultimately energy and operation cost savings.