Mechanical Project Proposal

Executive Summary:

The Milton S. Hershey Medical Center Academic Support Building is a 5 story, 146,316 square foot office building located on Penn State's College of Medicine land in Hershey, PA. The Penn State University owned building houses various departments of Penn State College of Medicine and The Milton S. Hershey Medical Center. The intent of the mechanical system design was to provide a flexible system that would decrease utility costs, reduce maintenance calls, and reduce renovation costs due to office space churn. While the building's variable air volume (VAV) underfloor air distribution provided the flexibility required, its performance left much to be desired. There were significant thermal, acoustical, pressurization, and performance problems with the system. After a little over two years since building occupation, more than half a million dollars has been spent to correct the mechanical system's problems.

The proposed mechanical system redesign brings back into focus the original design intent of the building owner. Because there is a year round building cooling load and the current design does not meet ASHRAE Standard 62 ventilation requirements, a parallel Dedicated Outdoor Air System (DOAS)/Radiant System will be implemented. It is the intent that the use of the DOAS/Radiant System will reduce first cost, operating costs, and improve IAQ and thermal comfort compared to the VAV underfloor air distribution system. A simple control package that allows for variation in the system equipment (including enthalpy wheel, packaged DX units, and integrated fire suppression system) will be developed to ensure the less common system is not dismissed as unattainable or too complicated to building owners and operators. The raised floor system and the perimeter radiant heating panels will remain in the building, but the depth of the raised floor system will be decreased. The building envelope will be improved by replacing the glazing with windows that have a better U value and solar heat gain factor. The lamps will be changed from T8s to T5s to increase energy savings and be used in integrated prefabricated radiant panel/pendant direct-indirect lighting units. The electrical service to the building will have to be altered due to the changes in mechanical system design.

The Milton S. Hershey Medical Center Academic Support Building
Hershey, PA

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STRUCTURAL

- ASTM A-572 structural steel floor beams
- ASTM A-36 structural steel columns and brackets
- 400psi elevated floor slabs on composite metal deck
- 1900psi foundation block walls

MECHANICAL

- Underfloor air distribution system
- 7,513 sq ft return air plenum mechanical penthouse
- (4) 42,500/3,750 cfm minimum OAT AHUs w/ VFD fan motors and 400lb/hr gas fired humidifiers
- (3) 48.2 boiler hp/1615 MBH gas fired boilers
- (2) 225 ton packaged air-cooled chillers
- 27.1 ton reciprocating winter chiller w/ remote chiller barrel
- 12-16" perimeter hot water radiant heating panels

Floor diffuser and cable tray access.

Access flooring panel.

PROJECT TEAM

- Owner - The Pennsylvania State University
- Architect - Williams Trebilcock and Whitehead
- Construction Manager - Barclay-White, Incorporated
- Site and Civil Engineers - Rettew Associates
- Structural Engineers - Whitney Bailey Cox and Magnani
- Mechanical and Electrical Engineers - Brinjac-Kambic Associates

PROJECT DESCRIPTION

The Milton S. Hershey Medical Center Academic Support Building is a mixed use office building located on Penn State land in Hershey, PA. The 5 story, 145,316 gross sq. ft building houses departments for both Penn State College of Medicine and Hershey Medical Center. The 19 million dollar design-build project was designed to facilitate flexibility of the building program. Its central core houses an elevator bank, restrooms, a stairwell, and shared conference spaces. The angled wings contain suites with distinct entrances for each department.

Access flooring with underfloor ductwork and cable tray installed.

ELECTRICAL/LIGHTING

- 15KVA transformer 13.8KV/480Y/277V
- Main distribution board 2500amp, 480Y/277V main bus, metered
- 208Y/120 112.5KVA transformers on each floor
- 150KW roof mounted generator set
- Moveable underfloor junction boxes housing outlet & data jacks
- General interior lighting from compact fluorescent and T-8 lamps
- Outside lighting is 175W metal halide post-top lighting

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Building Overview:

The Milton S. Hershey Medical Center Academic Support Building is located on The Pennsylvania State University's campus in Hershey, PA. The building is owned by The Pennsylvania State University and was built on university owned land. The five story, 146,316 gross square foot building houses various departments of Penn State College of Medicine and The Milton S. Hershey Medical Center. The intent of the new, mixed office use structure was to relocate departments previously located off-campus or in the existing mega-structure. The result: freeing up space for the remaining critical programs in the mega-structure, reducing travel time from off-campus properties, and allowing Penn State to use prior lease payments to build equity and own the facility. (Penn State College of Medicine Capital Planning) Although the Academic Support Building is located on campus land and near the existing mega-structure, it is also near residential housing and farm fields.

The building was designed for versatility to house the School of Medicine and Hershey Medical Center departments. The building consists of a central core connecting two angled wings. The building wings house the departments' suites with offices on the perimeter and open floor plans in the center. The central core houses a stairwell, lobbies, elevators, rest rooms, and shared conference spaces. The building materials are mostly precast concrete and glass with a mechanical penthouse enclosed in high quality painted steel.

The design process for the building was unique in that not all of the groups involved in the initial design for the Academic Support Building ended up as building occupants. During the design phase, Penn State and Geisinger merged, creating complications when design standards for both institutions needed to be met. Geisinger Health System approached the design being bottom line burdened and throughout the merger exhibited a desire to be in full control of all decision making. It was made clear that they were tenants in this Penn State building and that the interior space would be fit out to suit their needs by the university. As a result, Geisinger Health System was very adamant about the cost per square foot of the building. This required a guaranteed maximum price at an early stage in the project. Once bidding was underway, a de-merger between Penn State and Geisinger occurred, causing the design compromises between them to ultimately be unnecessary.

Reasons for Building Selection:

I pursued a Penn State campus building to utilize the building owner contacts I had through Penn State's Office of Physical Plant (OPP). I decided on The Milton S. Hershey Medical Center Academic Support Building after sifting though a handful of other potential project buildings. The initial appeal was the abundant contacts. I had access to members of the project team through OPP and the building occupants themselves. Only by accident did I find out that McClure Company (where I did my summer internship) was the mechanical contractor on the job. I also wanted a building that was close enough to make site visits during the week if necessary. My primary contact for the Academic Support Building is Terry Achey, Director of Facilities at Penn State's School of Medicine and his staff. He was a member of the core project team during the concept and design phases of the project and is also a current building occupant.

The building also holds a unique interest for me as a mechanical option student. The intent of the building's mechanical system was to decrease utility costs, reduce maintenance calls, and reduce renovation costs due to office space churn. It has an underfloor air distribution system that is still unique in office buildings compared to a more traditional ceiling VAV supply system. The system provides the versatility required by the mixed office use building as well as control over personal air supply through the adjustable diffusers and the flexibility of adding and removing diffusers based on zone occupancy. Underfloor mounted junction boxes with additional 10 ft electrical and data cable slack allowed power and data receptacles to be relocatable as well. The omission of return fans and the placement of gas-powered boilers in the negatively pressured return air plenum were also intriguing.

Building Occupant Feedback:

The building's occupants have registered many complaints about the thermal comfort of the building and after a little over two years of occupancy, more than half a million dollars was spent to attempt to resolve the performance of the mechanical system. Reheat had to be added to the first floor because the floor was concrete slab-on-grade in direct contact with the underfloor supply air plenum and the supply air temperature was much too low. Humidity control in the spaces was also a problem; at one point paychecks couldn't be printed because of the conditions. Other issues that had to be addressed after occupancy were related to noise and building envelope leakage. The building pressurization also became a problem when the doors of the building couldn't be opened. The chillers are not located on the same structural concrete slab that the mechanical equipment inside the penthouse is. They are placed on an isolated concrete island on the membrane roof at the center of each wing. As a result, high frequency compressor noise and vibration noise were a problem for the tenants on the fifth floor.

The gas-fired humidifiers have been changed to electric and the gas-fired boilers were reconfigured to allow them to work properly within the negatively pressurized penthouse. Building owner representatives mentioned watching water gurgling out of the drains and onto the floor in the penthouse because of the negative pressure in the space. A return fan system has been added within the past year, placing return fans in the airshafts and ducting the shafts to the AHU's. The addition of the ductwork removed the penthouse from the air stream. The airshafts have a common wall with conference and meeting rooms on several floors. The noise from the new fans was so great that conversations could not be heard from one end of a 10 ft table to the other. Additional steps had to be taken to dampen the fan noise.

It was determined in Technical Assignment M-1 ASHRAE Standard 62 ventilation compliance report that the building does not meet minimum outdoor air requirements described in Standard 62. The design was not required by the owner to meet ASHRAE Standard 62 at the time. The lost rentable space due to the mechanical system is less than 1.5% of the occupied square footage. The cost per square foot of the mechanical system (HVAC and plumbing) is $17.50/sq ft. The annual electric consumption of the building is 2.7 million kWh at $0.0499/kWh and the annual gas consumption is 7,000 mcf at $5.8853/mcf. These numbers reflect the operation of the mechanical system during and after the above-mentioned renovations. The total annual energy use of the building was compared with office buildings from "A Look at Commercial Buildings in 1995: Characteristics, Energy Consumption, and Energy Expenditures" in Technical Assignment M-2a. The building's energy annual energy consumption is 15% higher than other office buildings polled in the study.

Redesign Goals:

The less than desirable general performance of the mechanical system has already caused the system to be modified as previously mentioned. The basis of the building analysis thus far has been from the as-built drawings supplied by the building owner. These drawings represent the system as it was during building occupancy in May 2000 and will be the basis for the new construction redesign, not a retrofit redesign. The redesign will also be conducted under the assumption that the constraints due to the Penn State and Geisigner merger were lifted prior to design. Specific redesign goals include:

- Improved thermal comfort including space temperature and humidity control
- Improved indoor air quality (IAQ) by system compliance with ASHRAE Standard 62
- Improved acoustical performance
- Reduced energy costs
- Simplified environmental controls system

These areas will be addressed with the intention of better performance without drastically elevated construction, operating, and first costs compared to the system operation depicted on the as-built drawings.

Alternatives Considered:

The raised floor system will be kept due to the increased flexibility of the relocatable junction boxes. The perimeter offices currently have radiant heating ceiling panels near the windows, which will also remain in the building's mechanical system as well as the fan coil units in the first floor lobby. The campus has a central steam and chilled water plant which currently serves other structures on the campus. The option of using distributed utilities from this plant will begin to be explored this semester in a research project conducted in AE 557, *Centralized Cooling Production and Distribution Systems*. The overall feasibility of using distributed utilities from the campus plant will be determined prior to the start of spring semester. Provided acquiring the utilities from the campus plant is a practical solution due to existing utility lines near the building site and sufficient plant capacity, implementing distributed utilities to the redesign will be considered. Scenarios that will be considered are the following:

I

- DX coils in the AHU's for DOAS
- Standalone chillers for chilled water service to radiant cooling panels and existing fan coil units
- Gas-fired equipment for heating

II

- Chilled water coils in the AHU's for DOAS
- Steam and chilled water service from campus plant

III

- Scenario I with integration of fire suppression and thermal transport systems

IV

- Scenario II with integration of fire suppression and thermal transport systems

Proposed Redesign:

The basis of the mechanical system redesign will be the implementation of a Dedicated Outdoor Air System (DOAS)/Radiant system. The benefit of this system over a conventional all air variable air volume (VAV) system is lower first cost, reduced operating cost, improved IAQ and thermal comfort, reduction in required plenum depth, and greater ease in balancing and maintenance. The space loads are decoupled and the DOAS system supplies the air required to meet the space latent load as well as the space ventilation requirements. The parallel radiant cooling ceiling panel system meets the space sensible load not met by the DOAS system. More heating, ventilating, and air conditioning (HVAC) practitioners are coming to the conclusion that using DOAS systems in parallel with sensible cooling systems is a more energy efficient way of conforming to ASHRAE Standard 62's ventilation requirements. (Hedman & Mumma, 2001 www.doas.psu.edu)

The use of the radiant cooling ceiling panels as the parallel sensible cooling system, while widely used in Europe, is not common in American practice. A concern in their use is condensation formation on the panels. This occurs when the chilled water temperature flowing through the panels decreases the panel temperature lower than the space dew point temperature. With proper control of the system, condensation formation can be controlled and dealt with before causing problems in the space.

This provides an opportunity especially of interest for me; controls. The control system does not have to be complicated to manage the system. A simplified and easily understood control package that allows the building owner to select the pieces of equipment in the system like options in a new car will be favored over an intricate and ultimately non-user friendly control package. Some options to the system that will be pursued are the use of an enthalpy wheel, a prepackaged DX coil unit, and/or the integration of the fire suppression and thermal transport systems.

As mentioned above, the radiant heating panels will remain in the perimeter spaces to provide space heating and the raised floor system's depth will be decreased to allow enough room for cable tray access. The building envelope will also be improved by replacing the existing windows with windows that have a better U value and solar heat gain factor. The new window selection will allow the greatest amount of the visible light spectrum in and reflect the other wavelengths of solar radiation. This option will improve the overall building U value as well as reduce the high solar energy intake on the longer south elevation and thus reduce the cooling load. The prefabrication of integrated pendant radiant panels attached to direct-indirect lighting fixtures will also be explored. The energy savings from the use of T5 instead of T8 bulbs will also be looked at as an alternative because of the high ceilings. With the proposed changes to the mechanical system, building envelope, and lighting system, the buildings electrical system will also have to be altered to reflect the changes.

Resources:

The as-built drawings, specifications, environmental control drawings, annual energy usage and utility rates of the building have been obtained through the building owner. The campus underground utility line map, the central steam/chilled water plant flow schematic and sequence of operation as they were prior to the construction of the building have also been obtained for use in the distributed utility feasibility study. The building owner has made construction photos available as well as guided building and plant tours and personnel capable of answering design and operation questions.

Information including existing building envelope characteristics, ventilation rates, and annual energy consumption gained from performing the required mechanical technical assignments will be used as a starting point for further building studies. Compliance with ASHRAE Standards and documentation of its current performance will be improved as a result of the redesign.

A full building model will be constructed in Carrier's Hourly Analysis Program (HAP) version 4.10. (Previous load and energy estimates conducted used a simplified model, combining similar spaces and a simplification of the mechanical system). Other software to be utilized in the redesign includes AutoCAD 2002, Redec Radiant Panel Design CD, and Microsoft Powerpoint, Project, Word, Excel and Visio.

The ASHRAE handbooks and standards, Mechanical and Electrical Equipment for Buildings (MEEB), R.S. Means, and The Fire Protection Handbook will be used as general resources for the redesign in the mechanical, lighting, electrical, and fire protection areas.

Information concerning the DOAS/Radiant system in general will be taken from previous AE course notes as well as the numerous technical papers sited on http://www.doas.psu.edu/. Work regarding the control package design will be done using Automated Logic Controls (ALC) design tools including Microsoft Visio add-ins, Eikon, and WebCTRL software. Information gained in an independent study course scheduled for the spring semester with Dr. Mumma concerning controls will also be implemented.