DASCO Medical Office Building

Saint Joseph Medical Center

Towson, Maryland

Mechanical Systems Proposal

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Mechanical Option

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Executive Summary

This report is a proposal for the continued study if the DASCO Medical Office Building into the spring 2008 semester. Architectural Engineering senior thesis projects incorporate a depth study of the building evaluated throughout the fall semester and the associated technical assignments. Depth studies are focused in the option area of each student; in this case the depth study is related to the mechanical system redesign. Redesign is intended to make improvements to the current engineered system based on observations made about its performance, efficiency, cost or quality noted throughout the past assignments. Breadth studies are intended to take each student out of their concentration and explore improvements that can be made to another engineered system in the building. Whether these ideas are of interest to the student or happen to be a result of depth study redesign being integrated with the installed structural or electrical system.

Currently the DASCO building has three direct expansion packaged roof top air handling units that serve the 64,000 square foot facility with 20% outdoor air. Heating is accomplished through variable air volume terminal units equipped with electric reheat. Based on modeling this system in Carrier's Hourly Analysis Program (HAP), it is an inefficient consumer of energy in the form of electricity. However, due to the original design of this building as a shell and core space intended to be fit-out in later phases based on tenant needs, the systems adaptability allows for easy adjustment as rooms are built into the open floor plan. Also, given that this building's design was oriented to ensure low first cost for the owner, there is much room for improvement assuming that budget constraints can be neglected.

In order to redesign the existing mechanical system to create a less energy intensive alternative to what is currently installed; the Saint Joseph Medical Center energy plant will be utilized. There is a central chilled water production plant on the campus of Saint Joseph Medical Center that serves other building on the grounds. Depending on its production capacity, and that needed to create a comfortable, quality environment in the DASCO building, the central plant can be used to satisfy the cooling load in the redesign. Also, to reduce the amount of electricity consumed by the building, a gas fired boiler generating hot water will be installed in the building. This will serve two purposes; one is to provide service hot water, therefore eliminating the domestic water heaters currently installed throughout the building, and another provide perimeter heating through the use of fin tube radiators. Changing the mechanical system to that just described should prove to be less costly to operate than the current system, and also reduce the environmental impact of consuming as much energy as the current system.

Breadth study will be in the area of selecting and sizing an emergency power system. The building shell and core was not engineered with emergency power based on the original proposal from the engineering firm. In addition to emergency power, acoustic concerns will need to be addressed since additional mechanical equipment will need to be installed in the building. Other acoustical considerations are with existing rooms that house nuclear radiation equipment and diagnostic imaging which are adjacent to offices, waiting rooms and patient exam rooms.

Overview of Existing Building and Mechanical System

The DASCO Medical Office Building was constructed by the DASCO Companies on the campus of Saint Joseph Medical Center in Towson, Maryland. Initially the building was designed as a four story, 64,000 square foot shell and core facility. Each open floor plan has approximately 12,700 square feet of leasable space. Mechanical shafts, two private toilets, two elevators, a main corridor and electrical rooms comprise the core which is the remaining 3,300 square feet of each floor. A two story addition to the shell of the building facing the driveway and patient drop-off added 2,200 square feet to the first floor. As tenants such as Midatlantic Cardiovascular Associates, Radamerica Inc., and Saint Joseph Medical Center began to lease the medical office space the open floors were converted into physician offices, exam rooms, conference rooms, and waiting rooms. In addition to these normal office type spaces, specialized rooms were engineered into the building to accommodate the practices of the different physician groups. The building now has two linear accelerators, a nuclear laboratory, infusion suites, and PET/CT scanner. The linear accelerators are located in a separate attachment to the building on the back side. This space is constructed of five foot thick concrete walls which create a two story bunker to house each linear accelerator. The pieces of medical equipment are used to administer radiation treatment to cancer patients. An existing parking garage adjacent to the building has been linked to the building through a compartmentalized breezeway. Construction of this shell building started in October 2005 and the final tenant fit-outs should be complete by November 2007.

The mechanical system for the DASCO Medical Office Building was initially engineered for the shell and core building phase with the knowledge that the building would be fit-out to accommodate tenant needs in the future. Designers understood the building to be a medical office building and not a hospital, so that any future spaces requiring hospital quality fit-outs, such as diagnostic imaging and laboratories, would be evaluated individually. This is evident since additional HVAC equipment has been added to the building since the shell and core construction. The nuclear lab has two computer room air conditioning units providing direct cooling over the two machines located in the space. Fan powered HEPA ceiling modules were added to the clean and ante rooms of the first floor infusion center fit-out. Also due to the cooling demands of the two linear accelerators and the PET/CT scanner, located on the ground floor, each has a separate closed loop chilled glycol system running through individual chillers located outside of the linear accelerator bunker.

Mechanical design for the shell and core building, engineered with the intent of future fit-outs, is an all air variable air volume (VAV) system. There are two 130 ton Trane Intellipak high efficiency direct expansion rooftop air handling units designed for approximately 20% outside air. AHU-1 has a 37,000 cubic feet per minute (cfm) capacity (7,400 cfm outdoor air) intended to serve the ground and first floor; AHU-2 has a 36,000 cfm capacity (7,200 cfm outdoor air) intended to serve the second and third floors. Each is equipped with a 0-100% economizer section with proportional dampers allowing for 0-100% outside air. With the design of the first floor fit-out, which is a multi-disciplinary space, a third air handler was added to the project. This unit is a 30 ton Trane Intellipak high efficiency direct expansion rooftop air handling unit providing approximately 20% outdoor air. The location of the third unit is on the roof of the linear accelerator bunker, and has a capacity of 10,680 cfm (2,000 cfm outdoor air).

Each air handler serves fan powered VAV boxes which provide the outdoor air to the spaces. Any heating requirements are handled at each terminal unit through electric reheat. Return air travels through a ceiling plenum to three separate return air ducts leading back to the air handling units. Service hot water is heated in electric fueled domestic water heaters located in the janitors' closets on each floor.

The first cost of this mechanical system is based on the payment sheet for each phase of work completed by Southern Mechanical Inc., mechanical contractors. Equipment cost totaled $678,784.79, which is equivalent to $9.73 per square foot. In previous technical assignments, the mechanical system was evaluated for compliance with ASHRAE Standard 62.1-2007 for adequate ventilation. Also ASHRAE Standard 90.1-2004 was used to analyze the building energy consumption. In order to compare the DASCO Medical Office Building performance with the criteria from the standard, a model was created using Carrier's Hourly Analysis Program (HAP). The annual energy consumption totals 910,728 kilowatt hours for both HVAC, electrical and lighting components.

The DASCO Medical Office Building was designed as an electricity consuming building. All of the systems, including the lighting and other normal equipment that can be found in a medical office building, with the addition of certain specialized medical equipment, consume energy in the form of generated electricity. Baltimore Gas and Electric is the utility provider for this building, and based on their service rates HAP was able to estimate the annual operating costs summarized in Table 1 below. As is evident from Table 1, the heating load is a very costly part of the operation of this building.

Table - 1, Annual Costs

Component	Cost
Air System Fans	34,357
Cooling	1,139
Heating	28,524
Pumps	0
Cooling Tower Fans	0
HVAC Sub-Total	64,019
Lights	24,980
Electric Equipment	0
Misc. Electric	0
Misc. Fuel Use	0
Non-HVAC Sub-Tot	24,980
Grand Total	89,000

Considered Design Alternatives

Several ideas were considered when deciding on ways that attempt to improve the existing mechanical system. These alternatives are aimed to improve the efficiency of the existing system as well as increase indoor air quality. Eliminating the electric reheat can greatly reduced the energy consumption, in turn reducing the emissions created during the electricity generation process.

After selecting the DASCO Medical Office Building as the project for this thesis project, redesign options were offered by the engineers who initially designed the building. The Saint Joseph Medical Center has a campus chilled water plant that provides cooling to a majority of the other buildings on the property. Depending on the capacity of the plant and the load demands of the DASCO building, this can be an option to eliminate the direct expansion packaged roof-top air handling units. One method to eliminate electric reheat from the project would be to install a boiler with capacity to provide not only for the heating load but also the service hot water. If the service hot water demand can be met, all nine electric domestic water heaters can be eliminated from the building.

Another system type that can handle both heating and cooling loads would be the installation of ground source heat pumps as part of a geothermal system. There is enough ground area in close proximity to the DASCO building that is currently an exposed parking lot for hospital visitors and staff. One constraint of this type of system is the displacement of a large amount of parking spaces during the excavation of the ground for installation of piping loops. A second constraint is exploring the thermal properties of the earth in this area to ensure there is enough capacity to serve the building loads.

Combined heat and power (CHP) systems, also known as cogeneration, are a popular mechanical design for energy intensive buildings, especially hospitals and large office buildings. These systems simultaneously produce electricity and heat from the burning of a single fuel source. Heating and cooling loads can be met at higher efficiencies than conventional HVAC equipment. CHP systems can also provide excess electricity over that which is needed to operate the building it serves and therefore can even contribute to the power grid.

Most likely these options were not explored in much detail during the conceptual design phase because of the nature of designing a building driven by owner desire for low first cost.

Proposed Redesign

Redesign goals are to increase efficiency of the mechanical system by making changes to the equipment installed in the building. Part of making a better built environment is to reduce the amount of natural resources used in the construction process. One way to do this is by designing a system which incorporates existing forms of cooling production, thus eliminating the need to build new equipment. Purchasing new equipment also adds to the project cost, which in this case was an area of design that was to be kept to a minimum. Thus, exploring the capacity of the campus chilled water plant is the design route that will be taken into consideration for this project.

Utilizing an already existing chiller plant to meet the cooling loads modeled using the HAP program is a good method to reduce the amount of electricity the building currently consumes. The chilled water will be integrated with an air handler mounted on the roof that will provide supply air to each space. In order to reduce the amount of fan energy consumed by the current system, it will prove beneficial to select standard VAV boxes instead of parallel fan powered boxes. The supply air fan as part of the air handler can be sized to overcome the static pressure requirements of the longest duct run. This will limit the amount of electricity used to provide the air throughout the building. Instead of using an air plenum to mix and return air at the space temperature, a ducted return system can be implemented. This will allow for the addition of an enthalpy wheel integrated with the air handler to reduce the amount of reheat needed during winter months. Ducting the return air will increase the air quality, which will eventually be filtered through the air handler. However, dust and construction debris normally accumulating in the ceiling space will not interact with the return air.

Eliminating the electric reheat coils from the VAV boxes presents a need to have a different system to provide heating to the spaces. Installing a gas fired boiler to generate hot water can reduce electricity consumption, and also provide the service hot water provided by the domestic water heaters. The hot water can be pumped through the building to perimeter fin tube radiators. Based on the current building model created in HAP, the only areas that have a heating load are those along the perimeter of the building. Supplying heat at the window, along the perimeter, will reduce the amount of energy lost to the outdoor environment, thus increasing the overall efficiency of the building envelope.

The maintainability of a new system design utilizing the central chilled water plant will most likely improve. Since the hospital employs building engineers that regularly check and service the central chilled water plant, the separate service calls to fix problems with the current packaged roof top units can be eliminated. Other than the cleaning of coils and filters, the other maintenance required arises with each VAV box that would need to be addressed on a case by case basis if a problem occurs.

Construction cost may rise due to the integration of piping from the chilled water plant to the DASCO building air handler. However, most of this may be offset by reducing the cost of each VAV box, since fans are eliminated and electric reheat coils are not used. Although the cost of installing fin tube baseboard heating to be integrated with a hot water gas fired boiler can be expensive, heating costs will decrease since the amount of consumed electricity is reduced. Also, each of the nine domestic water heaters are not needed since hot water produced from the boiler can be supplied to sinks and other service hot water applications within the building. The operating cost of the building should be greatly reduced, which may not have been an initial concern by the owner for the original design. Electricity use can be limited to normal receptacle service, lighting and any other medical equipment requiring electricity. In addition to existing electricity consumers, fan power and additional pumps for the supply of chilled water from the plant and hot water from the boiler will also consume electricity.

Breadth Topics

In addition to studying the in-depth redesign of the mechanical system, there are two other areas to be explored. The first is the fact that the building currently has no emergency power system. Initial proposals for the design of the shell and core engineering did not include the fees to design emergency power. Utility company power can at times be unreliable or endure outages. Since this is a medical office building with important medical equipment for the treatment of cancer and for diagnostic imaging, an emergency power generation system is very essential. Sizing an emergency power system for this building incorporates various medical imaging and treatment equipment, as well as normal office receptacle loads and lighting. The second area would be to address the acoustical isolation of the mechanical equipment that will need to be added to the building. On the ground floor there are existing electrical and mechanical rooms that would serve as the place to install the boiler and pumps for the heating system. This area may also serve well as the point where chilled water could be brought in from the central plant. Other areas of concern acoustically are the imaging rooms and nuclear laboratory which are located adjacent to office spaces, waiting rooms and patient exam rooms. The acoustical properties of this equipment can be evaluated to determine how much sound is transmitted to adjacent spaces and the partition construction can be altered to ensure sound is diffused and remains in the rooms where it is generated.

Preliminary Research, Tools and Methods

Information regarding the Saint Joseph Medical Center central chilled water plant will need to be obtained to ensure that there is enough capacity to meet the demand of the DASCO building. Research through ASHRAE Journals about the application of chilled water in mechanical cooling will be the sources of information to aid in the redesign. Also fin tube sizing guidelines from manufacturer catalogs will be consulted when determining how perimeter heating will be accomplished.

In order to properly engineer the breadth studies, electric code regarding the sizing of emergency power systems must be researched. The consultation of acoustics text books will provide the necessary information regarding mechanical noise isolation and transmission reduction.

Selecting new VAV boxes for each zone will require a revised HAP model to include fin tube perimeter heating. Zones can be determined based on similar occupancies and exposures to ensure thermal comfort and adequate ventilation. Construction and operation cost will have to be re-evaluated to compare if improvements can be achieved through the redesign process. This includes new equipment efficiency studies in order to determine how the mechanical system utilizes supplied utility energy. Breadth studies include the gathering of all electrical loads for normal office receptacle approximation and the large medical equipment. This is necessary for the sizing of an emergency power system. It will also be required to research emergency lighting codes to ensure proper lighting for emergency egress and part of the emergency power system. Modeling the rooms under the acoustic breadth will require knowledge of the building material surfaces in these rooms as well as knowing the noise production of the medical equipment over the range of audible frequencies.

Work Schedule for spring 2008 Semester

Month/Day	Activites
1/14-1/20	Classes Begin
	Obtain chiller plant information from engineers
	Adjust HAP model to include chiller plant capacity
1/21-1/27	Research chilled water mechanical cooling
	Research different types of boilers for hot water production
	Research enthaply wheels
	Meet with faculty consultant to check progress
1/28-2/3	Gather spreadsheet information from previous technical assignments
	Determine electrical requirements of building
	Gather acoustic information from equipment specifications
2/4-2/10	Select new equipment (AHU, boiler, VAV boxes)
	Incorporate selected equipment into HAP model
	Size pumps for hot water distribution
2/11-2/17	Research emergemcy power systems
	Select fin tube radiation equipment
2/18-2/24	Meet with faculty consultant to check progress
	Check HAP model to determine energy efficiency
2/25-3/2	Begin to collect new system data
	Size emergency power system
	Make comparisions from old system to new system
	Make adjustments to room acoustics
3/3-3/9	Finish depth studies
	Finish breadth studies
3/10-3/16	Finish any outstanding issues
3/17-3/23	Write final paper
3/24-3/30	Write presentation
3/31-4/6	Spring Break
4/7-4/13	Practice presentation
4/14-4/18	Jury Presentation