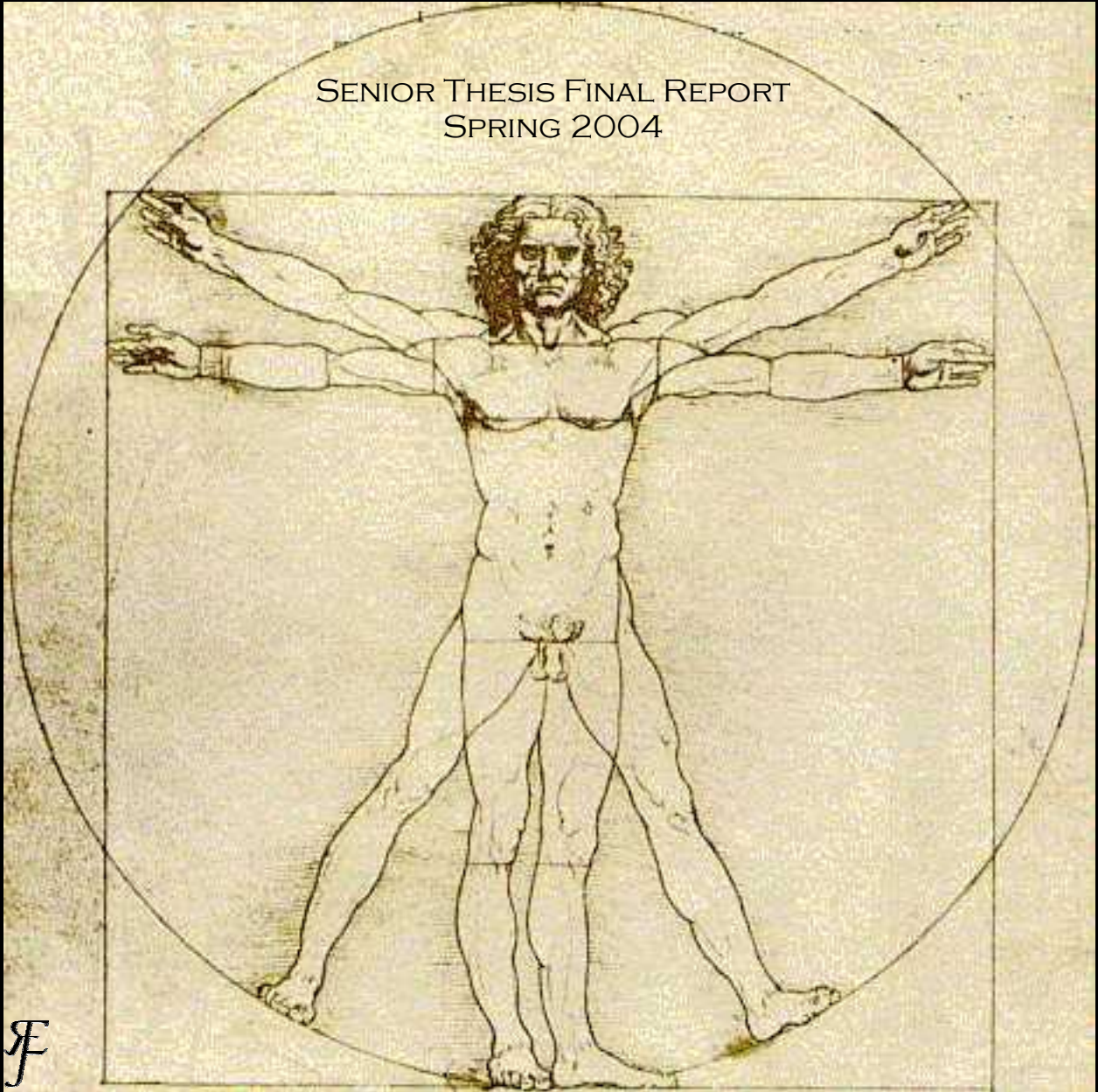


COMMUNITY HOSPITAL OF LANCASTER

WARWICK TOWNSHIP, PENNSYLVANIA

SENIOR THESIS FINAL REPORT
SPRING 2004



*Robert J. Egan
The Pennsylvania State University
Architectural Engineering
Mechanical*



COMMUNITY HOSPITAL OF LANCASTER

New Replacement Facility

Warwick Township, PA

Robert J. Egan

Mechanical Design Option

Faculty Consultant - James Freihaut

CPEP web address: <http://www.arche.psu.edu/thesis/2004/rjel29>



Design and Construction Team

Owner - Health Management Associates, Naples FL
 Architect - Helman Hurley Charvat Peacock, Maitland FL
 MEPFP - GRG Consulting Engineers, Maitland FL
 Structural - Stanley D. Lindsey & Assoc., Nashville TN
 Primary Contractor - Turner Construction, New York NY

Architecture



Multi-tier three story structure
 Glass and red brick façade
 114,000 sq. healthcare facility

Mechanical Systems

Central Energy plant system set for future expansion
 Six air handling units ranging from 5,065 - 13,980 CFM
 VAV with hot water terminal reheat
 Electric Radiant Heat Panels
 Two 450 ton centrifugal chillers
 Two 450 ton open cell cooling towers
 Two 300 HP gas/ oil fired boilers

Electrical / Lighting Systems

Hospital Service - 4000A 480Y/ 277V, 3Ø
 Energy Plant Service - 3000A 480Y/ 277V, 3Ø
 Emergency Generator - 1250kW/ 1562 kVA
 providing 480Y/ 277V

Lighting - Mainly 2 x 4 fluorescent lay-in ceiling fixtures
 Specialty lighting for O.R. and I.C.U. suites
 Some wall sconce and canister ceiling down lighting

Structural Systems

Slab on grade foundation
 Continuous perimeter footing
 Spot footings at framing base
 Steel framing with Curtain and load bearing walls

Special Design Features

Lancaster is home to a high concentration of Amish residents. The hospital design includes some features that comply with the simple life of the Amish including:
 areas designated for horse and buggies
 hitching posts
 shed specifically for the Amish

Building height limited due to close proximity of
 → Lancaster Airport

Very large entry canopy

Memorial garden outside administration area

Waterside economizer on chilled water plant

Construction Data

Construction dates

⌚ Start - October 2001

End - → June 2004

Approx. total cost (not including furniture or medical equip.)

\$41 million

Building Cost

\$37 million

Design Fees

\$3.5 million

Additional Medical Equipment and Furniture Cost

\$14.4 million





Executive Summary

To receive a Bachelor's of Architectural Engineering degree from The Pennsylvania State University, the candidate must write a Thesis and defend it in a presentation before a jury of his / her faculty, members of industry and peers. In the fall semester, the prospective candidate chooses a recently built or renovated building to research throughout that semester. The student learns all aspects of the building including architecture, electrical services, mechanical building systems, structure, delivery method, zoning issues and costs. Throughout the semester the student also submits technical assignments concerning his or her option. These assignments help the student learn the intricacies of the building with respect to their chosen field. At the end of the semester, a proposal is submitted by the student for review by the faculty. This is a proposal for a redesign of the student's building. The redesign consists of a depth in the student's option and at least two breadths in other option areas. The redesign takes the entire spring semester at the end of which all the research, information and results are gathered together and submitted in a Thesis. This is my 5th year senior design thesis.

Community Hospital of Lancaster is in the final stages of construction and will open in the next few months. Over the last eight months I have been studying all aspects of the facilities design, paying particular attention to the mechanical building systems, which is my option. I proposed to incorporate a ground coupled heat pump system to study the feasibility and performance of such a system.

The mechanical redesign of Community Hospital of Lancaster is restricted to the patient rooms on the second and third floors of the south west wing of the building. These rooms are served by a 100% O.A. unit with no energy recovery. 4 pipe fan coils serve each room and are controlled individually by room thermostats. The chilled water cooled 100% O.A. unit conditions the ventilation air down to 54 °F which is then supplied to the Fan coil units in each room. The air is terminally conditioned at the room and mixed with room air.

My redesign utilizes a total energy recovery wheel to precondition the ventilation air using energy harvested from the exhaust air. Just adding the wheel alone reduced energy consumption significantly. Water Source Heat Pumps replaced the 4 pipe Fan Coil Units and a ground water loop circulated through the building. The 200 bore well field is under the adjacent parking lot and provides the necessary heat sink for the WSHPs.



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First costs were determined and then compared to annual energy savings to calculate a pay back period for the new system. The period was less than 5 years which is usually a cut off point for many owners. The building was simulated in HAP both before and after the redesign to ensure an unbiased and accurate comparison of the systems. The results were very promising and showed energy costs dropping over 50%. RS Means was used to compare the new and old systems as well to provide accuracy. The new system cost over 20% more than the original design. Some free demo software was used as well to simulate the bore field and estimate the cost of installing the ground loop.

The new WSHPs were selected and their performance data was used to determine the electrical load required by each. Conductors were sized to provide power from the designated panel and the panel was analyzed before and after the redesign. It was determined that WSHPs have a higher electrical demand than fan coils, most like due to the compressor that pumps the heat from one medium to the other.

Since it was determined that the new WSHP would not weigh much different than the fan coils they were replacing, a typical composite floor structure was analyzed instead. A simple redesign of the bay by adding an additional composite beam allowed for the selection of a shallower beam. This structural analysis and the previous electrical analysis are the breadth work of the thesis.

This thesis signifies the culmination of a year long educational project and a six year learning experience.



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Introduction

The Community Hospital of Lancaster is a brand new replacement healthcare facility located in Warwick Township, Lancaster County, Pennsylvania. This new, state of the art hospital is located on a 43 acre parcel of land and is to be constructed on some 18 acres of that land. The main hospital structure is approximately 114,000 square feet, with a 3 story, multi-tiered structural design.

The hospital will facilitate a multitude of healthcare functions including MRI, Radiology, Pharmacy, Cardiology, and Neonatal care. The main building also is equipped with Emergency, Intensive care; Operation and Isolation areas. As with most hospitals, administration and in-patient rooms are also part of the facility's function. An attached single story structure is home specifically to Women's Healthcare.

The Mechanical system redesign of the Community Hospital of Lancaster includes utilization of high efficiency geothermal (ground coupled) heat pump systems. A central loop to circulate heat within the hospital building from which unitary room heat pumps will extract and reject heat will also be analyzed. The main electrical panel serving the mechanical systems will be resized (including feeders) to compliment the lower demand due to the higher efficiency of the equipment. An independent structural analysis will determine if beam depth can be reduced significantly by addition of a single member.





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Project Team

Owner	Health Management Associates
Architect	Helman Hurley Charvat Peacock / Architects, P.A.
Mechanical, Electrical, Plumbing & Fire Protection	GRG Consulting Engineers, Inc.
Structural	Stanley D. Lindsey & Associates, LTD.
Primary Contractor	Turner Construction Company
Landscape Architect	ECOS Environmental Design, Inc.
Civil Engineer	Rettew Associates, Inc.





Site and Architecture



Community Hospital of Lancaster is located on a 43 acre plot of land in Warwick Township, Pennsylvania. The building site is located off of Millport Road, less than a mile NW of Lancaster Airport on PA Route 501 (Lilitz Pike). The airport proximity placed some constraints on the building height and architecture. The new 114,000 ft² facility is virtually inline with the small landing strip at the airport. The rest of the site is surrounded with vast open fields of farming land, including that of the local Amish farmers, as well as some residential homes. Some businesses are within eyesight of the hospital as well as a small industrial park less than a mile to the south.

The Architecture of Community Hospital of Lancaster is a simple, yet attractive red brick façade with highly reflective glazing. The structure is multi-tiered and is three (3) stories tall at the highest tier. The second and third floor of the south and west wings house semi-private patient rooms including three (3) isolation rooms per wing per floor. The first floor of these wings contains administrative facilities including offices, classrooms; file storage and conference rooms.

The hospital is a full service medical facility and is equipped with an Intensive Care Unit, Emergency Room, Operating Rooms, Radiology, CATH Labs, MRI, CAT scan and an entire centre for Women's Healthcare including Neonatal care. Plans for future phases of expansion include more floor space added to existing construction as well as two separate 20,000 ft² Medical Office Buildings.



One of the most striking architectural features of the building is the large entry canopy, which is noticeable immediately. Emergency ambulance vehicles have a separate entry canopy and the Woman's Centre also has its own entrance canopy as well. The highly reflective blue glass façade helps lower solar gain in the large south facing windows as well as provide a striking contrast to the red brick exterior walls. A memorial garden enhances the grounds to the west of the main building (north side of the west wing) just outside the dining and lounge areas.



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Additional noteworthy features of the design are specifically intended to cater to the simple lifestyle of the local Amish population. They include areas designated solely for horse and buggy parking, hitching posts and a shed specifically for the Amish.





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Site History and Zoning

The 43 acre site on which CHOL is being built is formerly used for farming. Agricultural use of the land is apparent due to the large number of farms within eyesight of the construction. The site is currently Zoned I-2 Campus Industrial because of the hospital construction and has to meet the local Warwick Township Zoning Ordinance.

Community Hospital of Lancaster is designed to be a replacement facility for the aging CHOL located in downtown Lancaster City.

Major Model Codes

AIA Hospital + Healthcare Facilities - 2001

BOCA - 1996

International Mechanical Code - 1996

International Plumbing Code - 1995

National Fire Protection Agency - 2002

National Electric Code - 2002





Existing Building Systems

Mechanical

The existing (designed) mechanical system for the Community Hospital of Lancaster consists of a centralized cooling and heating system. During the cooling season, heat is rejected from the



hospital campus via secondary chilled water loop which is pumped from the central energy plant (CEP) building. Two (2) 450 nominal ton centrifugal chillers extract the heat from the chilled water loop and reject it through two (2) 450 ton open cell cooling

towers via the condenser loop. The system is also set up to take advantage of low temperatures by use of a 300 ton (3600 MBH) plate frame heat exchanger. The heat exchanger is designed to bypass the chillers when outdoor air temperatures fall below 55°F, thereby saving energy. Heating is provided by the CEP as well, which utilizes two (2) 300 HP gas / oil fired boilers. A separate hot water loop on which the boilers are set in parallel to provides the necessary heating, reheat and terminal heating.



Six (6) chilled water air handling units (AHUs) and twelve (12) chilled water rooftop units (RTUs) supply a total of 175,000 CFM re-circulated and conditioned fresh air to all the spaces of Community Hospital of Lancaster. All of the AHUs and RTUs (with the exception of AHU 5) precondition ventilation air with return air before entering the cooling and heating coils. A "Mee Fog" system is incorporated into some of the air systems to increase the humidity of the conditioned supply air in dry winter months. AHU 1 serves a VAV system which supplies air to the Administration, business and educational areas of the hospital. AHU 2

serves the Pharmacy and nearby open areas. AHU 3 serves the 2nd floor nurse station as well as open areas including second floor hallways. AHU 4 provides air for the Intensive Care unit on the 2nd floor. AHU 6 supplies the 3rd floor nurse station and open areas including hallways. AHU 5 is a 100% O.A. unit that serves Patient and Isolation rooms on the 2nd and 3rd floors of the south west





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wing. Each room served by AHU 5 has a 4-pipe fan coil unit (FCU) which mixes the supply air with room air and is controlled by an individual thermostat in each room.



The RTUs serve the rest of the hospital spaces. RTU 1 serves Outpatient Holding while nearby RTU 2 supplies air to the Emergency Room. RTUs 3 and 4 are paired together to serve the Radiology Department. RTUs 5 and 6 are similarly paired together to serve the Operating Room. The Clinical Labs & Offices, General Storage, Kitchen and Restaurant are individually served by RTUs 7 thru 10 respectively. RTUs 11 and 12 are paired and serve the Women's Centre.





Electrical



Two main panels draw from the local utility, one at 4000A 480Y/277V 3Ø the other at 3000A 480Y/277 3Ø. The first panel is dedicated to the main hospital building, which includes the Woman's Pavilion. The second serves the central energy plant building and off its equipment including the cooling towers. The main hospital panel serves 10 separate panels without stepping down in voltage. From those 10 distribution

panels, the power is then distributed and stepped down as needed via dry type transformers. The central energy plant panel serves a multitude of mechanical and life safety systems. The plants main panel serves a multitude of secondary panels and is stepped down as needed for specific apparatus. Both the hospital panel and the energy plant panels are tied together and are set to receive emergency power from a 1250kW/1562kVA Diesel Generator to keep life support systems functioning at all times. Multiple surge suppression devices are located on each major panel to ensure safety of the system from overload.



Lighting

Lighting mainly consists of 2x4 ceiling inlay fluorescent light fixtures with 32W lamps. This lighting is present in virtually all spaces of the hospital however wall sconces and directional ceiling canister lighting is used to highlight certain wall areas or desk areas. The lighting becomes very specialized in the surgery, intensive care and neonatal care zones of the hospital. This type of lighting was not within the specs of the MEPFP engineer and is under the design of a healthcare facility specialist.

Structural

Main hospital building has rigid frame construction with 8 inch slab on grade concrete. Steel structural columns are supported by rectangular concrete footings. Wide flange structural steel, beams, girders and columns with some load bearing concrete and masonry walls. Floor framing consists of 5 ¼ inch lightweight concrete slab resting on composite metal deck supported by wide flange steel beams. Fenestration is curtain wall construction tied into steel framing.



Project Delivery Method

The Community Hospital of Lancaster used the traditional Design - Bid - Build method.

Fire Protection

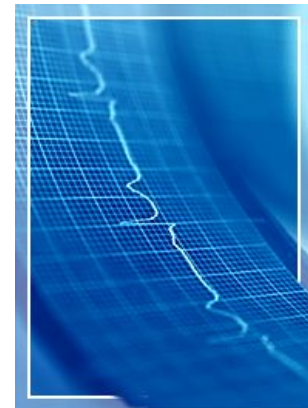
Passive fire protection systems include spray on fire proofing of all steel structure, fire retardant paint and fire rated doors and finishes. Active fire protection consists of a wet and dry pipe sprinkler system. Water is supplied from local utility and is boosted by a 1000 GPM electric fire pump. Fire pull alarms are located throughout facility and smoke and heat sensors monitor conditions as part of a pre-action suppression system.

Transportation

The building is multi-tiered, with the largest tier standing at 3 stories. 4 independent piston driven elevators allow ADA passage between all floors. Stair wells provide access and egress from each floor.

Telecommunications

Community Hospital of Lancaster utilizes intercom and P.A. systems as well as inside/outside line phone systems. Data, T.V. and voice ports are present in every patient room and at all nurse and office stations. Monitoring systems for patient rooms as well as security are present throughout the facility. Medical gas pressure monitors, water pressure monitors and I.A.Q. (CO₂, CO etc...) monitors are located in all zones where applicable. Fire safety monitors and alarms (including pull stations and strobes for the visually impaired) are installed to work with the pre-action fire suppression system and alert local fire departments.



Special Systems

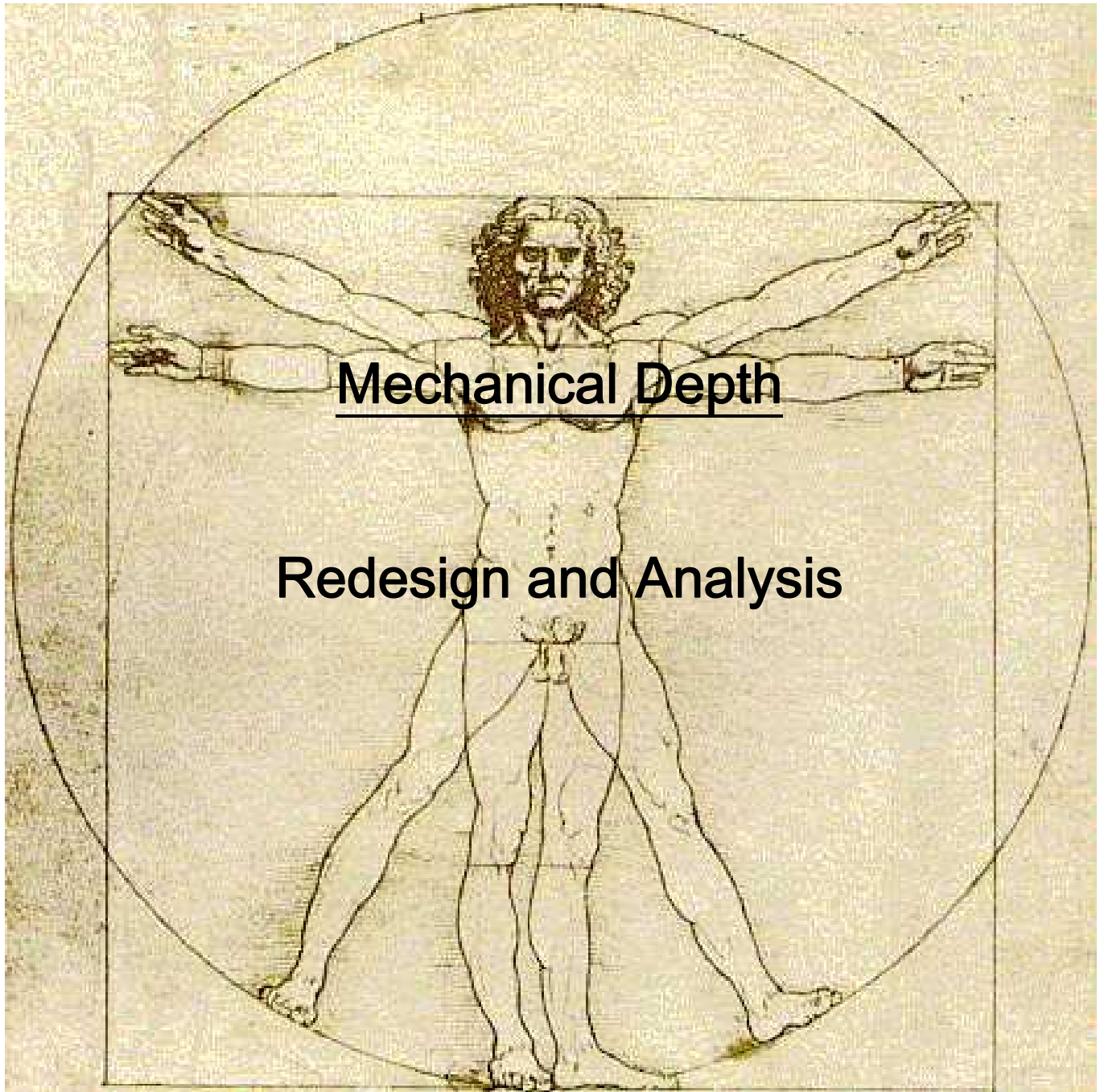
Specialized patient monitoring systems including biological (heart, kidney ...etc) as well as security monitoring systems (electronic and magnetic door locking, key card readers, etc...) are installed in CHOL. Medical Gas and air flow sensors and monitors are also included. There are also specialized monitors for Radiology, neonatal care, Magnetic Resonance Imaging and similar equipment.



Thesis Goals

The goals of my 5th year Architectural Engineering Senior Thesis are as follows:

- √ Apply the knowledge, experience and skills I have learned and acquired during my studies at The Pennsylvania State University as well as summer internships.
- √ Illustrate my understanding of building mechanical systems, their design, function and use.
- √ Illustrate my understanding of other building systems including structural, electrical and construction management.
- √ Learn useful knowledge from my research about ground coupled heat-pumps, including how they function, proper application and efficient design.
- √ Apply the knowledge gained from my thesis research and combine it with previous knowledge to design an efficient mechanical system for the Community Hospital of Lancaster which utilizes the beneficial features of ground coupled heat pump loop systems.





Mechanical Analysis

Scope

The scope of my mechanical redesign will include the 2nd and 3rd floors of the SW hospital wing which includes Semi-Private, Private and Isolations rooms. This area was chosen because it will provide a realistic venue for Water Source Heat Pump application. In addition, it is in close proximity to large parking areas beneath which the Ground Loop heat exchangers will be located. Also, the area is served by a 100% O.A. unit which will be analyzed for possible heat recovery. Each Patient Room has an exterior wall that is largely fenestration, and will affect room loads depending on room location and orientation.





Introduction

The scope of my mechanical redesign and analysis includes only the 2nd and 3rd floors of the SW wing of Community Hospital of Lancaster. Specifically, it will include 60 semi-private and private patient rooms. The isolation rooms are left out of the analysis because they require direct exhaust and therefore cannot participate in the energy recovery analysis. The 60 spaces total 19,380 ft² or approximately 17% of the total hospital floor area.



The current design includes a chilled water cooled 100% O.A. unit which supplies conditioned ventilation air only, at 54°F which is ducted to each room's 4-pipe fan coil unit (FCU). The FCU combines room air with the supply air and terminally conditions it via cooling and heating coils to the room set point. Each FCU is governed by a thermostat located in its respective room. Room air is removed via the room's negatively charged toilet exhaust which is ducted to a roof mounted exhaust fan. The air is not re-circulated to prevent the possibility of cross contamination. The existing design will deliver fresh conditioned air to each space effectively and properly. The goal of the redesign is to utilize the efficiency of Water Source Heat Pumps (WSHP), in addition to an Energy Recovery wheel, and to reject / harvest the heat energy to / from the constant ground temperatures of the earth. It is anticipated that proper use of these systems will result in considerable energy savings and reduce operating costs.

Design Requirements

Patient rooms must be kept at an acceptable temperature and humidity 24 hours a day, 7 days a week, 52 weeks a year. It is imperative that adequate fresh air is brought into each room and additionally that room air not be returned to the supply ducts to prevent any possibilities of cross contamination of spaces. Each room must have the ability to control the room air temperature. Ventilation air must be properly filtered to prevent against outside contaminants being introduced into the patient rooms.





Design Conditions



Temperature Setpoints	db (°F)	wb (°F)
Cooling Supply Air	55	54
Heating Supply Air	55	54
Room Set Point Cooling	75	
Room Set Point Heating	70	
Design Summer Outdoor Air	92	74
Design Winter Outdoor Air	29	

Design Conditions from ASHRAE Handbook 2001 Table 1A





Design Concept

My design concept follows a simple procedure. First use a total energy recovery wheel (also called enthalpy wheel) to transfer heat and moisture between the exhausted room air and the incoming ventilation air, thus preconditioning it and lowering the load on the cooling and heating coils. This simple change can have a large effect on the energy consumption of the 100% O.A. unit. Secondly, replace each room 4-pipe FCU with a water source heat pump (WSHP). The WSHP will reject and harvest heat energy from a water loop which is to be installed in place of the 4-pipe chilled water / hot water loop. Lastly, install a field of vertical ground heat exchangers under the nearby parking area to reject / harvest heat energy from the earth. The WSHP and water loop system will have a much higher efficiency than the traditional terminal FCUs.

The new mechanical equipment consists of a 30 Ton 100% O.A. AHU equip with an enthalpy wheel, sixty (60) one ton WSHP and a 200 bore closed ground loop heat exchanger (including all the piping associated with it). Mechanical equipment removed from the previous design will include the simulated original 50 ton 100% O.A. unit, sixty (60) one ton 4-pipe FCUs (including the chilled and hot water piping).



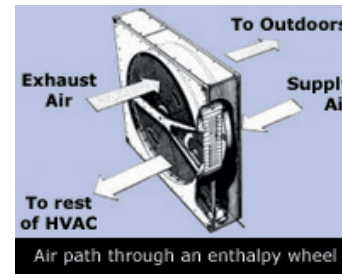
Three scenarios will be simulated by Carriers Hourly Analysis Program (HAP 4.2). The first simulation will be run of the existing system only including the 60 private and semi-private rooms. The second simulation will consist of the simulated original system, with the inclusion of an enthalpy wheel. The third and final simulation will be of the new design which will include the use of an enthalpy wheel and sixty (60) WSHP units.

The results of the three energy analysis will be compared for energy savings. A first cost analysis of each of the three scenarios will follow.

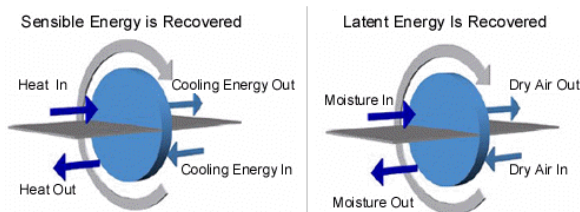


Energy Recovery Wheels (Enthalpy Wheels)

Energy recovery wheels are usually associated with 100% O.A. units because of the wasted heat energy from exhausting air instead of re-circulating it to precondition the ventilation air. When exhaust is passed through the energy wheel, heat and moisture can be extracted a liquid desiccant that covers fins inside the wheel (or deposited depending on the season) and then deposited (or extracted) into the incoming stream of outdoor ventilation air. It's a simple concept that can save considerable energy. Community of Hospital of Lancaster does not use this energy saving device despite having ducted exhaust air from the patient rooms. Oddly enough, the vertical exhaust ducting to the roof is very close to the 100% O.A. AHU. Upon further investigation, I was informed by the MEP that the system was originally designed to support an energy wheel; however the Owner chose not to use the device fearing cross contamination.



This is not a new concern when dealing with energy recovery wheels. To combat any possibility of cross contamination, a purge cycle has been introduced. The purge cycle is a small wedge of



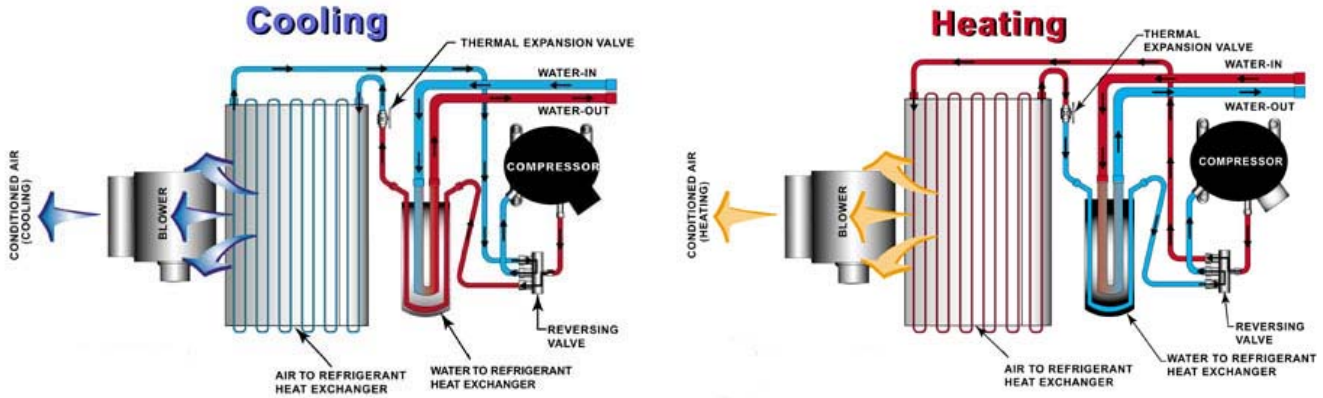
the wheel that takes fresh incoming outdoor air and “purges” the section of the wheel that is about rotate into the supply air stream. This ensures that the supply side of the wheel is always uncontaminated.

Water Source Heat Pumps (WSHP)

Water source heat pumps are not new in the HVAC industry. They have been around for nearly 40 years and continue to be made more efficient and effective. WSHP consist simply of a fan, a coil, a refrigerant loop, a compressor and are connected to building water loop. The fan coil units that are currently installed in CHOL have a 4-pipe system. This means that there are two (2) coils, one for heating and one for cooling. Those coils are fed by hot water (heating coil) and chilled water (cooling coil) and condition the air using one or the other (sometimes both). A WSHP has only one coil and uses only one water loop to perform the necessary conditioning. If heating is called for, the WSHP will extract heat from the building water loop using an evaporation cycle and then condense the refrigerant in the coil to reject the heat into the air stream. If cooling

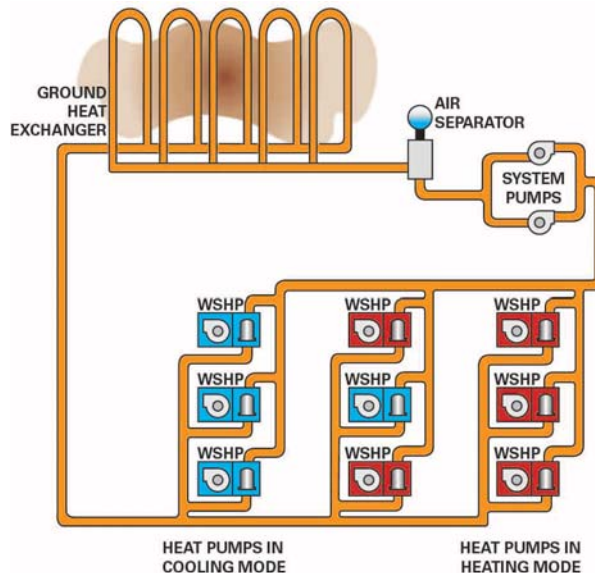


is called for, the process is exactly opposite and heat is rejected into the water loop. It's a simple process and is very efficient.



Ground Coupled Water Loop

In many WSHP building water loops, heat is rejected / extracted from the outside air using a cooling tower. In a growing number of other cases, the water loop exchanges heat with the earth. There are essentially two (2) ways the water loop can do this. One is the water loop can exchange with a surface body of water, like a spring fed lake or a river / stream. Even the ocean can be used. The other is with ground water. The ground water can either be an underground aquifer or the water inside the pores of the surrounding soils. An open loop can be used when dealing with bodies of water and underground aquifers. This loop draws water from one area, passes it through the building directly or uses a heat exchanger of some type (plate frame, water to water heat pump, etc...) and then deposits the rejected water at a different location. A closed loop can also be used with these bodies of water, but it is the only system that can be used with a horizontal or vertical system. A closed system uses the same water in a continuous loop. Heat is exchanged to the earth via horizontal or vertical bore fields of heat exchangers.





The benefits of these systems include relatively constant ground temperatures, unlike outdoor air which can vary greatly throughout the year. Also the systems can be far more efficient than traditional rejection systems if designed properly. They require just enough energy to pump the water through the loop. In the past, first costs have been prohibitive; however in recent years the cost has dropped substantially and systems have been designed to be even more efficient. In some cases there is virtually no first cost difference between ground loop systems and traditional HVAC systems. Energy cost savings can be substantial.

Design Procedure

In order to compare the existing system with the proposed system, I chose to model them utilizing Carriers Hourly Analysis Program (HAP). I was able to obtain much of the design data used by the MEP engineer and entered it into HAP so that I could simulate the existing design accurately. Because my redesign does not include the isolation rooms, I had to simulate the loads of the 100% O.A. unit and FCUs in only those 60 spaces. I chose not to include the isolation rooms for the simple reason that the exhaust from these rooms is directly ejected outside because of the potentially harmful contaminated and disease that might be present in the room air. Therefore, I only sized and simulated the system for what it would be if it only served the 60 spaces included in the analysis. Therefore, I simulated 60 individual zones on the system and my original design 100% O.A. unit sized at 50 tons and my ventilation air is 5981 CFM. This system had a max heating load of 280 MBH.

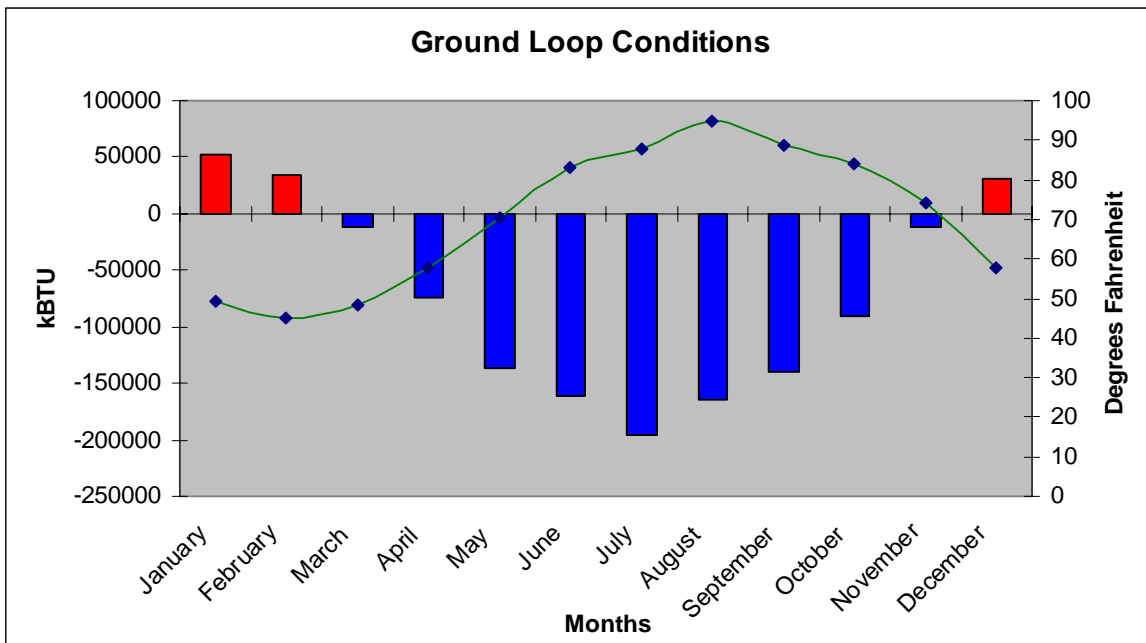


The first redesign step was quite simply to add an energy recovery wheel to the existing system. I was curious how much load would be taken off of the system with this simple addition. I choose a wheel, using SEMCO's Wheel selection procedure, with an effectiveness of 84% and .41 in. wg. pressure loss. With the energy wheel, the cooling coil load dropped to 41.4 tons and the heating load dropped to 86.6 MBH. This means with a simple energy wheel addition, cooling and heating loads on the 100% O.A. unit dropped 17% and 70% respectively. In the energy cost analysis we will see that this wheel alone pays for itself in less than one year.



For my ultimate redesign, I inputted a WSHP in each zone and was sure to set the supply air temperature to the same 55°F that was supplied by the original FCUs. The energy recovery wheel was used as well to maximize the efficiency of the design. Since HAP does not have a specific analysis for a Ground Coupled heat loop, I chose to use the open loop surface water option for analysis. In doing so, I was able to input a water loop temperature for each month of the year. This temperature affects the efficiency of the heat pumps and is very important to get an accurate simulation.

To choose the temperatures I assumed that the water temperature would fluctuate between 40 and 95°F between the heating and cooling seasons respectively. The bottom of the sine curve occurs just after the peak of the heating season (40°F) and the top of the curve occurs just after the peak of the cooling season (95°F).



To determine the loop temperature I used HAP load outputs to determine the heat energy range between the largest cooling month and the largest heating month. Every month in between those two peaks is a percentage of that range. The temperature would be proportional to that month's percentage of the range.



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	Loop Temp (°F)
January	49.2
February	45.0
March	48.6
April	57.9
May	70.5
June	83.3
July	88.0
August	95.0
September	88.7
October	83.9
November	74.0
December	57.9



Using these temperatures, HAP can account for the change in efficiency due to the swing in loop water temperature. The simulation showed a considerable drop in the cooling coil load to 27.5 tons, which is 45% smaller than that of the original design. This will allow for a smaller 100% O.A. unit to be chosen as well as increase the overall efficiency of the entire system. Each WSHP was sized at just over ½ ton. Due to the CFM requirements, I chose a 1 ton Trane unit for each of the spaces.

To size the vertical ground loop exchanger, I utilized free software found on the Geothermal Heat Pump Consortium website. The program called GS Heat Pump Design KISS (keep it simple & solid). It is found as a demo version on www.geokiss.com. The program allowed me to use block loads from my design cooling and heating days in combination with Annual Equivalent Full Load Hours to determine the necessary performance of the field. I was also able to determine the shape of my field (L x W) as well as the configuration for my ground loops. Soil conductivity and ground water temperature were also parameters that could be set by the user.

For my exchanger field I chose 5 inch diameter wells in a 20 by 10 pattern. My exchanger pipes will be 2 ¼" in diameter. The 200 well exchanger field will be located in close proximity to CHOL's south west wing, where the Patient rooms are located. The bores will be spaced 20 ft apart and have a duel exchanger per loop configuration. This means that loop water will travel into the ground twice before entering the return (building supply) header pipe. The ground temperature was set at the researched value of 52°F.



According to the GSHPD my well will have to be 752 ft deep per bore. This is a total of 150360 ft of bore. This is based on the worst case scenario for cooling. The necessary length of exchanger is determined by the following two equations.

Length required for cooling

$$L_c = \frac{q_a R_{ga} + (q_{lc} - 3.41 * W_c)(R_b + PLF_m R_{gm} + R_{gd} F_{sc})}{T_g - ((t_{wi} + t_{wo})/2) - t_p}$$

Length required for heating

$$L_h = \frac{q_a R_{ga} + (q_{lh} - 3.41 * W_h)(R_b + PLF_m R_{gm} + R_{gd} F_{sc})}{T_g - ((t_{wi} + t_{wo})/2) - t_p}$$

These formulas were found in the 2000 ASHRAE System and Equipment Handbook

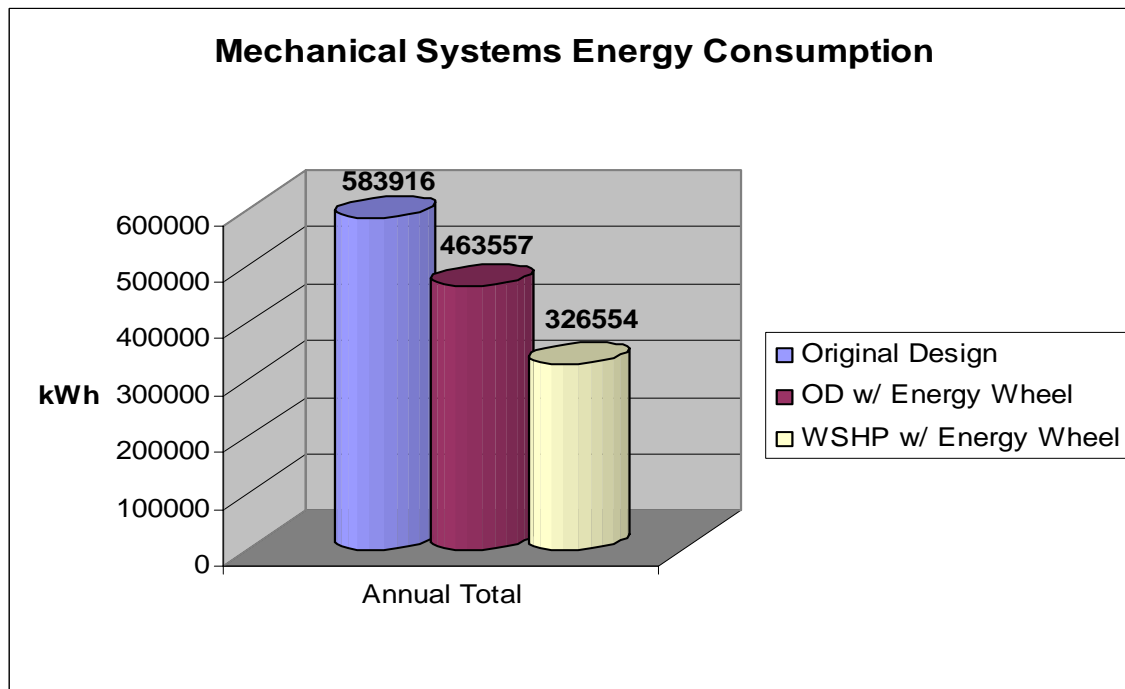
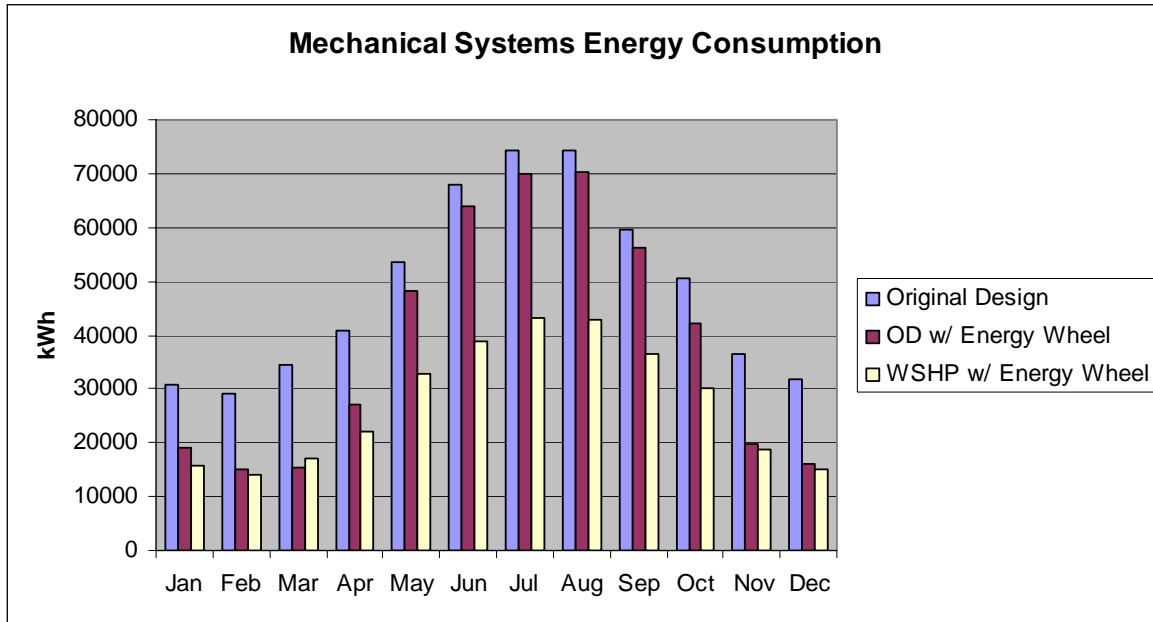
The larger of the two values governs the bore length. Divide the total bore length by the number of bores to determine how deep each bore must be. This value is given by the program as a worst case scenario, meaning little ground water movement. A second value is given if the ground water movement is considerable to high. In this particular case, the bore length dropped to 76410 ft of bore or 383 ft per bore. This is a 50% drop in bore length. A third value given is the hybrid bore value.

A hybrid system would make use of both ground coupled heat exchangers as well as water to air cooling towers. Essentially, this system would reject and harvest the same amount of heat energy per year. This would prevent soil temperatures from rising over time. All of the excess heat from the loop would be rejected via the cooling tower. The bore length for a hybrid system is 21870 ft. or 109 ft. per bore. Of course in a system like this you would vastly decrease the size of the vertical loop field. The field could be realistically downsized to 40 bores.



Energy Consumption

A comparative analysis was performed in HAP. The results of this analysis show that a WSHP consumes far less energy than the other two systems, especially the original design. The combination of WSHPs and an energy recovery wheel prove to be the most efficient design from an energy standpoint consuming over 60% less energy.





First Cost and Operating Costs Analysis

The two major costs associated with mechanical systems are first cost and operating costs. Using the 2003 Mechanical Cost Data edition of RSMeans, I estimated what the current system components would cost and then estimated the installed components for the new WSHP and ground loop. Since RSMeans does not specifically address ground loop systems, I utilized a program written by the University of Alabama call the Geothermal System cost estimator. This includes all HDPE piping, headers as well as drilling and back filling costs. The pump, which was sized by the GS Heat Pump Design (geokiss.com) was priced using RSMeans and will circulate the loop water.

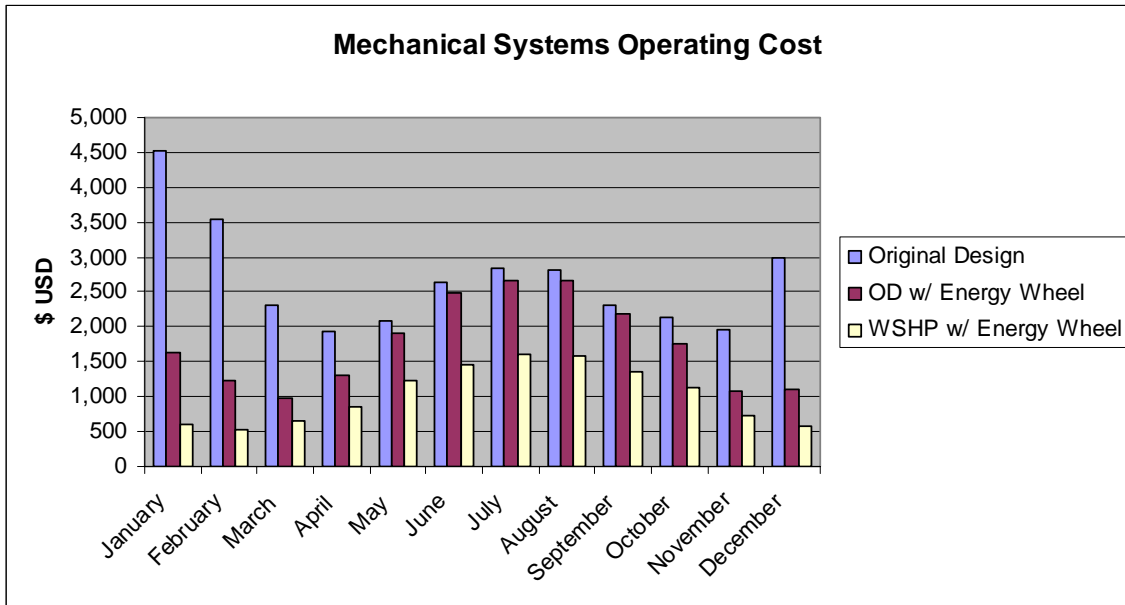
Original Design		WSHP with Energy Wheel	
50 Ton 100% O.A.unit	\$ 140,600	30 Ton 100% O.A. unit	\$ 126,600
60 Fan Coil Units	91,578	Enthalpy	10,200
Stainless Steel Piping	113,380	60 WSHP	138,000
		30 HP ground loop pump	18,600
		Estimated ground loop field	125,000
		Used Geothermal Systems Cost estimator	
Total	\$ 345,558		\$ 418,400

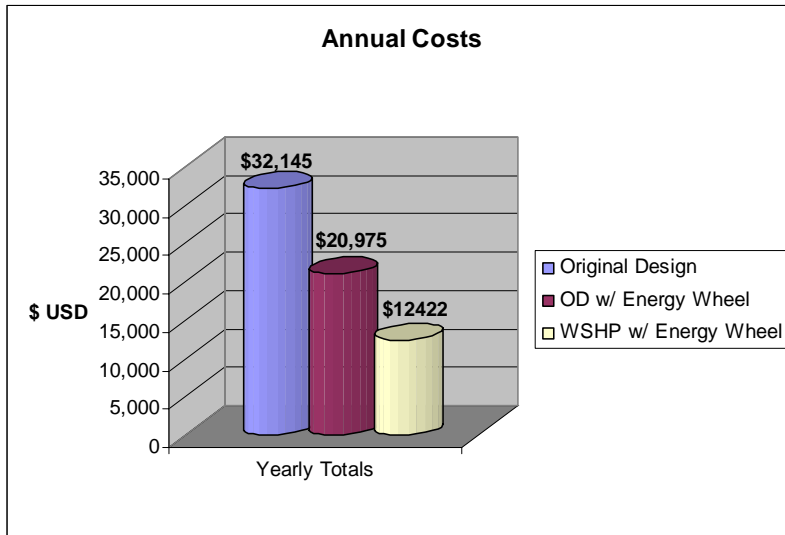
It's obvious from the above table that a WSHP system utilizing a ground loop is still quite expensive. The difference between the two first costs is approximately \$73000 which is a hefty 21% increase over the original design. While this is a considerable amount of money, it would be wise first to check the cost break down of the energy analysis simulation. The WSHP system and accompanying ground loop should be very efficient and cut the operating costs considerably.



Operating Costs

Utilizing Carriers Hourly Analysis Program (HAP) I was able to obtain a cost breakdown for the three different designs. The original design had Mechanical Operating costs of around \$32,000 dollars. With the addition of the Energy wheel, the costs dropped dramatically to around \$21,000 dollars. Because of the efficiency of reclaiming the heat and moisture from the exhaust, there was incredible savings in the cooling months of the year. When compared with the cost of the enthalpy wheel (\$10,200) we see that the payback is one year, after which the savings can accrue. In all cases the WSHP and Energy wheel fell well below the operating costs of the other two systems.





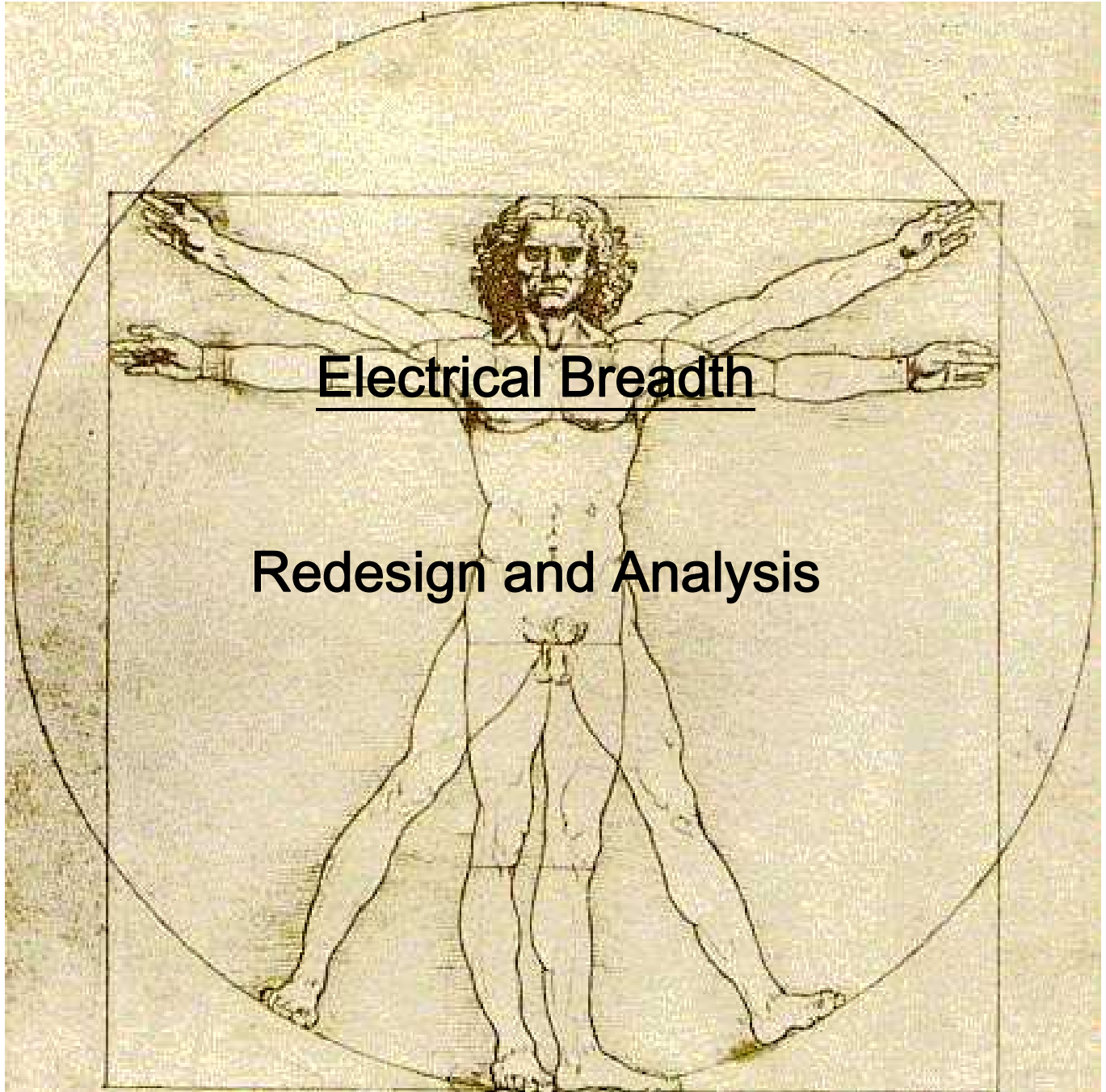
The WSHP, energy wheel and ground loop design save about \$20,000 a year in operating costs. This represents an operating cost reduction of nearly 62% from the original design. With some simple division we can roughly calculate the payback period of the new design.

$$\$73000 / \$19723 \text{ per year} = 3.7 \text{ years payback}$$

Mechanical Analysis Conclusion

Ground Source Heat systems are incredibly efficient. Despite a 20% jump in initial first costs, the new design was still able to have a relatively quick payback because of the huge increase in energy savings. One aspect of the analysis, which is particularly noteworthy, is how the enthalpy wheel paid for itself in less than one year's time. Energy recovery wheels are a very simple and proven tool when it comes to heat recovery. It is easy to understand the worry about cross contamination from the energy wheel, however, with the purge cycle and designing the intake to be blow thru and the exhaust draw thru a pressure differential is created which prevents any exhaust air from entering the supply side.

This analysis provided a great deal of knowledge involving Water Source Heat Pumps, building water loops and of course Ground coupled heat exchangers. It is a simple technology that needs to be made further use of. Whenever possible this type of system should at minimum be explored and considered. In a time where fuel prices are rising rapidly and air quality is an issue, ground loop exchangers will be explored and perfected further.





Electrical Analysis

Scope

The scope of electrical analysis is the electrical service to the water source heat pumps. Two sub panels (2Q/A and 3Q/A) currently serve the existing Fan coil units. Panel 2Q/A serves the 30 FCUs on the second floor and panel 3Q/A serves the 30 FCUs on the third floor. The analysis will examine how the new WSHPs affect the loads on each panel.

The use of Water Source Heat Pumps in place of the 4-pipe fan coils will vary the power requirement for each space. Fan coils draw load for the delivery fan inside the unit. A Water source heat pump has a fan as well as a compressor to run the evaporation and compression cycle which “pumps” heat from either the air, or the building water loop. Since WSHP were not part of the original design, we will need to incorporate them into the power supply.

I have selected a Trane heat pump model number GEH 012. According to the manufacturer’s Electrical performance data, this model has a Total Full Load Ampacity of 12.2, when drawing from a 115 V power supply at 60 Hz and single phase. The National Electric Code, the governing electrical code for the Community Hospital of Lancaster, specifies that a “branch circuit conductor that supplies a single motor in a continuous duty application must have a rating of 125% of the full load current. This percentage rating will be used as the design ampacity.

NEC 310-16 was used to size the conductors. Copper thermoplastic wire (THW) was chosen for the conductor and size kcmil 14 was selected. Conduit sizing was obtained from NEC Table C1. Metallic tubing was chosen as the material for the conduit and size 16 (1/2” dia) was selected. Circuit breaker maximum sizes were specified as 25 amps in the manufacturer’s data. However a simple calculation yielded 20 amps as an appropriate size.

$$12.2 * 1.25 = 15.25 \text{ A}$$

$$12.2 * 1.75 = 21.35 \text{ A}$$

The breaker has to be larger than 125% but less than 175% of the rated capacity.
= 20 A



The following table provides all of the values for the Typical WSHP included in this design.

Voltage	HP	Full Load Current	VA	125% Amperage
115/60/1	1/6	12.2	1753.75	15

175 % Amperage	Circuit Breaker	Conductor	Conduit Size	
21.35	20	#14 THW	16 (1/2")	

Panel Boards

The two panel boards directly affected by the new mechanical systems are panels 2Q/A and 3Q/A. They are each fed by panel 2PQ/A and 3PQ/A respectively. Prior to the redesign, each panel had relatively low loads on them. Panel 2Q/A read 79 adjusted amps and panel 3Q/A showed 64 adjusted amps. The panel schematics follow, first with each original design and then with the redesign.

The existing design combined two Fan Coil units on to many of the breakers. The breakers were sized at 15 Amps single phase. Each FCU had a 696 VA load. Many of the breakers served a circuit in which two fan coils were present. From the table above, it is apparent that the WSHPs are drawing much more load. Each WSHP has a 1753 VA design load. This is well over twice the previous design. Due to this, there is no opportunity to pair up circuits as was possible with the FCUs. In addition, the fault protection had to be upgraded to a 20 Amp breaker. Panel 2Q/A now shows a load of 159 adjusted amps and like wise Panel 3Q/A now show a load of 151 adjusted amps. This is a substantial increase from the previous design, however each panel has a BUS Rating of 225 A. I was unable to determine what the design conductors were for the panel however I would assume that they are sized for 225 A. Using THW as the conductor wire, the necessary size would be 4/0 kcmil.

Electrical Analysis Conclusion

As expected, the Water Source heat pumps put a greater load on the local panel. Due to the larger draw of the new equipment, I would suggest that another panel be added if possible to support specifically the function of the heat pumps. The panels appeared to be quite maxed out and would realistically need to be made larger if this system were to be put in place.



COMMUNITY HOSPITAL OF LANCASTER

WARWICK TOWNSHIP, PA



PANEL 2Q/A																	
VOLTAGE: 208Y/120V, 3PH, 4W BUS RATING: 225 A MAIN: 150 A MCB										10% AIC RATING 4/5/2004 1:45 AM							
LOAD (VOLT AMPS)				C N K O T	LOAD SERVED	CB	PHASE			CB	LOAD SERVED	C N K O T	LOAD (VOLT AMPS)				
LTG	REC	MOTOR	HEAT				AMP/P	A	B				C	AMP/P	LTG	REC	MOTOR
		1392		1	FCU	15/1	*	-	-	15/1	FCU	2			1392		
		1392		3	FCU	15/1	-	*	-	15/1	FCU	4			1392		
		1392		5	FCU	15/1	-	-	*	15/1	FCU	6			1392		
		1392		7	FCU	15/1	*	-	-	15/1	FCU	8			1392		
		696		9	FCU	15/1	-	*	-	15/1	FCU	10			1392		
		1392		11	FCU	15/1	-	-	*	15/1	FCU	12			1392		
		1392		13	FCU	15/1	*	-	-	15/1	FCU	14			1392		
		1392		15	FCU	15/1	-	*	-	20/1	SPARE	16					
				17	SPARE	15/1	-	-	*	20/1	SPARE	18					
		696		19	EF-15	15/1	*	-	-	15/1	FCU-8	20			696		
		696		21	EF-16	15/1	-	*	-	15/1	EF-9	22			528		
				23	SPARE	15/1	-	-	*	-	SPACE	24					
		696		25	EF-40	15/1	*	-	-	15/1	EF-50	25			664		
		864		27	EF-48	15/1	-	*	-	15/1	EF-51	28			864		
		864		29	EF-49	15/1	-	-	*	15/1	EF-52	30			696		
		696		31	EF-54	15/1	*	-	-	20/1	SPARE	32					
				33	SPARE	20/1	-	*	-	20/1	SPARE	34					
				35	SPARE	20/1	-	-	*	20/1	SPARE	36					
				37	SPARE	20/1	*	-	-	-	SPACE	38					
				39	SPARE	20/1	-	*	-	-	SPACE	40					
				41	SPARE	20/1	-	-	*	-	SPACE	42					
0	0	14952	0	FEEDER SIZE: SEE ONE LINE DIAGRAM										0	0	13392	0
SUB TOTALS				FED FROM: PANEL 2PQ/A MOUNTING: SURFACE LOCATION: ELEC. EQUIP. 258 FOOTNOTES: (1) = SHUNT TRIP CB (2) = GROUND FAULT CB (3) = DEMAND FACTOR FROM NEC 70, ARTICLE 220										SUB TOTALS			
PHASE LOADING				mark with an X as appropriate: _____ ISOLATION GROUND BUS _____ 200% NEUTRAL _____ FEED-THRU LUGS _____ SHUNT TRIP MAIN CB _____ OUTDOOR ENCLOSURE _____ STAINLESS STEEL COVER										PANEL TOTALS			
0	0	12000	0											0	0	28344	0
0	0	9216	0	CONNECTED KVA TOTALS										0.00	0.00	28.34	0.00
0	0	7128	0	DEMAND FACTOR										1.25	(3)	1.00	1.00
TOTALS				ADJUSTED KVA TOTALS										0.00	0.00	28.34	0.00
				TOTAL CONNECTED KVA										28.34			
				TOTAL ADJUSTED KVA										28.34			
				THREE PHASE VOLTAGE										208			
				TOTAL PANEL										79			
				ADJUSTED AMPERAGE										79			

Original Design



COMMUNITY HOSPITAL OF LANCASTER

WARWICK TOWNSHIP, PA



PANEL 3Q/A															
VOLTAGE: 208Y/120V, 3PH, 4W BUS RATING: 225 A. MAIN: 150 A, MCB										10k AIC RATING 415G2004 1-48 AM					
LOAD (VOLT AMPS)				C N K O	LOAD SERVED	CB	PHASE	CB	LOAD SERVED	C N K O	LOAD (VOLT AMPS)				
LTG	REC	MOTOR	HEAT	T		AMP/VP	A	B	C	AMP/VP		LTG	REC	MOTOR	HEAT
		696		1	FCU-8	15/1	*	-	-	15/1	EF-28			528	
				3	SPARE	20/1	-	-	-	15/1	EF-29			864	
				5	SPARE		-	-	*	15/1	EF-30			696	
		664		7	EF-32	15/1	*	-	-	15/1	SPARE				
				9	SPARE		-	-	*	15/1	FCU			1392	
				11	SPARE	15/1	-	-	*	15/1	FCU			1392	
		1392		13	FCU	15/1	*	-	-	15/1	FCU			1392	
		1392		15	FCU	15/1	-	-	*	15/1	FCU			1392	
		1392		17	FCU	15/1	-	-	*	15/1	FCU			1392	
		1392		19	FCU	15/1	*	-	-	15/1	FCU			1392	
		1392		21	FCU	15/1	-	-	*	15/1	FCU			1392	
		696		23	FCU	15/1	-	-	*	15/1	FCU			1392	
				25	SPARE	20/1	*	-	-	15/1	FCU			696	
				27	SPARE	20/1	-	-	*	20/1	SPARE				
				29	SPARE	20/1	-	-	*	20/1	SPARE				
				31	SPACE		*	-	-		SPACE				
				33	SPACE		-	-	*		SPACE				
				35	SPACE		-	-	*		SPACE				
				37	SPACE		*	-	-		SPACE				
				39	SPACE		-	-	*		SPACE				
				41	SPACE		-	-	*		SPACE				
0	0	9216	0	FEEDER SIZE: SEE ONE LINE DIAGRAM								0	0	13920	0
SUB TOTALS				FED FROM: PANEL 3PQ/A MOUNTING: SURFACE LOCATION: ELEC. EQUIP. 360 FOOTNOTES: (1) = SHUNT TRIP CB (2) = GROUND FAULT CB (3) = DEMAND FACTOR FROM NEC 70, ARTICLE 220								SUB TOTALS			
PHASE LOADING				mark with an X as appropriate: _____ ISOLATION GROUND BUS _____ 200 % NEUTRAL _____ FEED-THRU LUGS _____ SHUNT TRIP MAIN CB _____ OUTDOOR (ENCLOSURE) _____ STAINLESS STEEL COVER								PANEL TOTALS			
0	0	8352	0	PHASE A								0.00	0.00	23.14	0.00
0	0	7824	0	PHASE B								1.25	(3)	1.00	1.00
0	0	6960	0	PHASE C								0.00	0.00	23.14	0.00
A	B	C	TOTALS	TOTALS								23.14			
8352	7824	6960		Project Name: LANCASTER C.H Project Number: 20254.00								23.14			
										CONNECTED KVA TOTALS	0.00	0.00	23.14	0.00	
										DEMAND FACTOR	1.25	(3)	1.00	1.00	
										ADJUSTED KVA TOTALS	0.00	0.00	23.14	0.00	
										TOTAL CONNECTED KVA	23.14				
										TOTAL ADJUSTED KVA	23.14				
										THREE PHASE VOLTAGE	208				
										TOTAL PANEL					
										ADJUSTED AMPERAGE	64				

Original Design



COMMUNITY HOSPITAL OF LANCASTER

WARWICK TOWNSHIP, PA



PANEL 2Q/A																		
VOLTAGE: 208Y/120V, 3PH, 4W BLB RATING: 225 A MAIN: 150 A, MCB										10% AIC RATING 46/2004 1:43 AM								
LOAD (VOLT AMPS)				C N K O T	LOAD SERVED	CB	PHASE			CB	LOAD SERVED	C N K O T	LOAD (VOLT AMPS)					
LTG	REC	MOTOR	HEAT				AMP/P	A	B				C	AMP/P	LTG	REC	MOTOR	HEAT
		1753		1	WSHP	20/1	*	-	-	20/1	WSHP	2			1753			
		1753		3	WSHP	20/1	-	*	-	20/1	WSHP	4			1753			
		1753		5	WSHP	20/1	-	-	*	20/1	WSHP	6			1753			
		1753		7	WSHP	20/1	*	-	-	20/1	WSHP	8			1753			
		1753		9	WSHP	20/1	-	*	-	20/1	WSHP	10			1753			
		1753		11	WSHP	20/1	-	-	*	20/1	WSHP	12			1753			
		1753		13	WSHP	20/1	*	-	-	20/1	WSHP	14			1753			
		1753		15	WSHP	20/1	-	*	-	20/1	WSHP	16			1753			
		1753		17	WSHP	20/1	-	-	*	20/1	WSHP	18			1753			
		696		19	EF-15	15/1	*	-	-	15/1	FCU-8	20			696			
		696		21	EF-16	15/1	-	*	-	15/1	EF-9	22			696			
		0		23	SPARE	15/1	-	-	*	---	SPACE	24						
		696		25	EF-40	15/1	*	-	-	15/1	EF-50	26			696			
		864		27	EF-48	15/1	-	*	-	15/1	EF-51	28			864			
		864		29	EF-49	15/1	-	-	*	15/1	EF-52	30			864			
		696		31	EF-54	15/1	*	-	-	20/1	WSHP	32			1753			
		1753		33	WSHP	20/1	-	*	-	20/1	WSHP	34			1753			
		1753		35	WSHP	20/1	-	-	*	20/1	WSHP	36			1753			
		1753		37	WSHP	20/1	*	-	-	20/1	WSHP	38			1753			
		1753		39	WSHP	20/1	-	*	-	20/1	WSHP	40			1753			
		1753		41	SPARE	20/1	-	-	*	20/1	WSHP	42			1753			
SUB TOTALS				FEEDER SIZE: SEE ONE LINE DIAGRAM										SUB TOTALS				
				FED FROM: PANEL 2PQ/A MOUNTING: SURFACE LOCATION: ELEC. EQUIP. 258 FOOTNOTES: (1) = SHUNT TRIP CB (2) = GROUND FAULT CB (3) = DEMAND FACTOR FROM NEC 70, ARTICLE 220														
PHASE LOADING				mark with an X as appropriate: _____ ISOLATION GROUND BUS _____ 200% NEUTRAL _____ FEED-THRU LUGS _____ SHUNT TRIP MAIN CB _____ OUTDOOR ENCLOSURE _____ STAINLESS STEEL COVER										PANEL TOTALS				
LTG	REC	MOTOR	HEAT											LTG	REC	MOTOR	HEAT	
0	0	19425	0	PHASE A										0.00	0.00	57.24	0.00	
0	0	20482	0	PHASE B										1.25	(3)	1.00	1.00	
0	0	17337	0	PHASE C										0.00	0.00	57.24	0.00	
A	B	C	TOTALS											TOTAL CONNECTED KVA				
19425	20482	17337												TOTAL ADJUSTED KVA	57.24			
				Project Name: LANCASTER C.H.										THREE PHASE VOLTAGE	208			
				Project Number: 20254.00										TOTAL PANEL				
														ADJUSTED AMPERAGE	57.8			

Redesigned to include WSHP



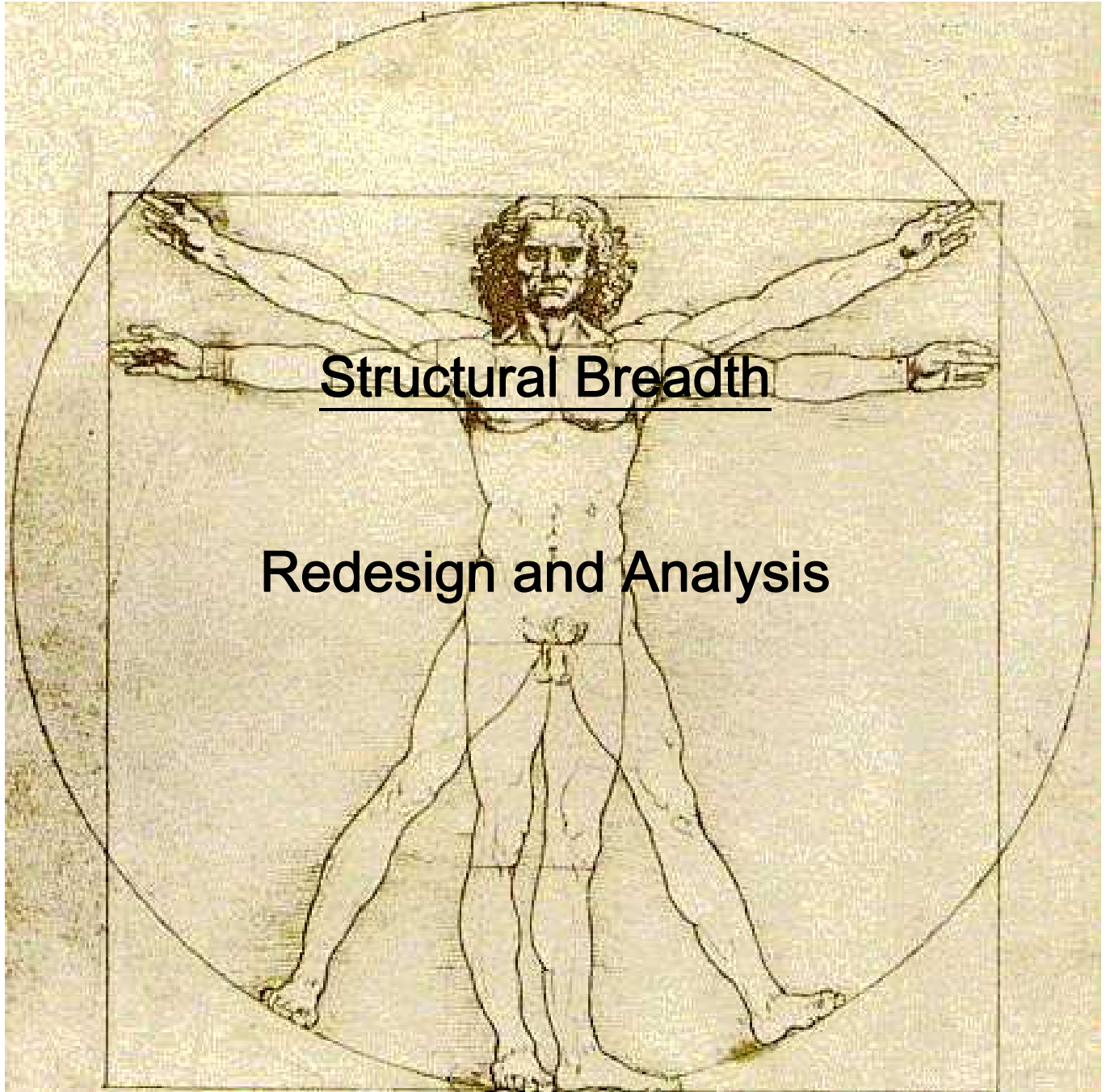
COMMUNITY HOSPITAL OF LANCASTER

WARWICK TOWNSHIP, PA



PANEL 3Q/A																	
VOLTAGE: 208Y/120V, 3PH, 4W BUS RATING: 225 A. MAIN: 150 A. MCB										10k AIC RATING 4/5/2004 1:43 AM							
LOAD (VOLT AMPS)				C N K O	LOAD SERVED	CB	PHASE	CB	LOAD SERVED	C N K O	LOAD (VOLT AMPS)						
LTG	REC	MOTOR	HEAT	F		AMP/FP	A	B	C	AMP/FP	F	LTG	REC	MOTOR	HEAT		
				1	FCU-8	15/1	*	-	-	10/1	2						
				3	SPARE	20/1	-	*	-	15/1	4				864		
				5	SPACE		-	-	+	15/1	6				606		
				7	EF-32	15/1	*	-	-	15/1	8						
				9	SPACE		-	*	-	20/1	10				1753		
				11	SPACE	15/1	-	-	+	20/1	12				1753		
				13	WSHP	20/1	*	-	-	20/1	14				1753		
				15	WSHP	20/1	-	*	-	20/1	16				1753		
				17	WSHP	20/1	-	-	+	20/1	18				1753		
				19	WSHP	20/1	*	-	-	20/1	20				1753		
				21	WSHP	20/1	-	*	-	20/1	22				1753		
				23	WSHP	20/1	-	-	+	20/1	24				1753		
				25	WSHP	20/1	*	-	-	20/1	26				1753		
				27	WSHP	20/1	-	*	-	20/1	28				1753		
				29	WSHP	20/1	-	-	+	20/1	30				1753		
				31	WSHP	20/1	*	-	-	20/1	32				1753		
				33	WSHP	20/1	-	*	-	20/1	34				1753		
				35	WSHP	20/1	-	-	+	20/1	36				1753		
				37	WSHP	20/1	*	-	-	20/1	38				1753		
				39	WSHP	20/1	-	*	-		40						
				41	SPACE		-	-	+		42						
0	0	0	26102	0	FEEDER SIZE: SEE ONE LINE DIAGRAM						0	0	0	29383	0		
SUB TOTALS				FED FROM: PANEL 3PQ/A MOUNTING: SURFACE LOCATION: ELEC. EQUIP. 360 FOOTNOTES: (1) = SHUNT TRIP CB (2) = GROUND FAULT CB (3) = DEMAND FACTOR FROM NEC 70, ARTICLE 220										SUB TOTALS			
PHASE LOADING				mark with an 'X' as appropriate: _____ ISOLATION GROUND BUS _____ 200 % NEUTRAL _____ FEED-THRU LUGS _____ SHUNT TRIP MAIN CB _____ OUTDOOR ENCLOSURE _____ STAINLESS STEEL COVER										PANEL TOTALS			
0	0	0	59618	0	PHASE A				0.00	0.00	54.49	0.00					
0	0	0	16394	0	PHASE B				1.25	(3)	1.00	1.00					
0	0	0	16473	0	PHASE C				0.00	0.00	54.49	0.00					
A	B	C	TOTALS	TOTALS				CONNECTED KVA TOTALS	0.00	0.00	54.49	0.00					
19618	16394	16473		TOTALS				DEMAND FACTOR	1.25	(3)	1.00	1.00					
				Project Name: LANCASTER C.H.				ADJUSTED KVA TOTALS	0.00	0.00	54.49	0.00					
				Project Number: 20254.00				TOTAL CONNECTED KVA	54.49								
								TOTAL ADJUSTED KVA	54.49								
								THREE PHASE VOLTAGE	208								
								TOTAL PANEL									
								ADJUSTED AMPERAGE	151								

Redesigned to include WSHP

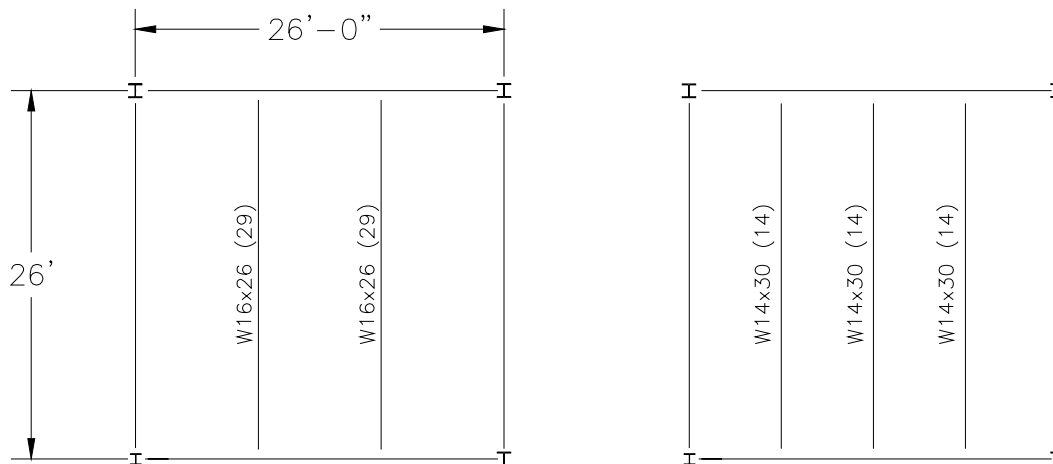




Structural Analysis

Scope

The scope of the structural analysis is independent from both the Mechanical and Electrical analysis. It includes a typical bay of composite beam construction located on the second floor of Community Hospital of Lancaster. The hospital is built utilizing the strength of the composite beam structure which is essentially a beam and poured concrete bonded together using shear studs.



This structural redesign is quite simple yet effective. The typical bay on the left is the original design with two equally spaced beams in conjunction with the floor slab above. The number in parenthesis after the beam shape and strength is the number of shear studs on each beam of the system. In the original design the beams were spaced at 8'-8" O.C. and were sized at W16x26 composite beam with 29 shear studs per beam.

The goal is to determine how much a composite beam depth would be shortened if an additional beam were placed into the bay. A shorter beam sometimes means more room for mechanical designers to place their systems, and would prevent having to change floor to ceiling height or adjust plenum depth. Therefore one beam was added to the bay. The three beams were equally spaced at 6.5' O.C.



COMMUNITY HOSPITAL OF LANCASTER

WARWICK TOWNSHIP, PA



The live loads and dead loads were found on the cover page to the structural drawings. Concrete slab information was also located here.

Loads:

Live Loads 60 psf
 Dead Loads 90 psf



Uniform factored load

$$W_u = 1.2 (90) (6.5') + 1.6 (80) (6.5') = 1534 \text{ lb/ft} = 1.534 \text{ kip/ft}$$

$$M_u = W_u l^2 / 8 = 1.534 \text{ kip/ft} (26')^2 / 8 = 129.62 \text{ kip/ft}$$

Assume $a = 1''$ $Y_2 = 5 \frac{1}{4}'' - \frac{1}{2}'' = 4.75''$

$\Delta_{\text{allow}} = L/360$ $26 * 12 / 360 = 0.87 \text{ inches}$

$$\Delta = \frac{5(W_u) (L)^4}{(384 EI) * 1728} \quad I = 211$$

W10x15 $\Phi M_p = 60, \Phi M_n = 127, Q_n = 140$

$$a_{\text{req}} = \frac{\Sigma Q_n 140}{.85 * 4 * ((26/4) * 12)} = .53 < 1.0$$

$$\Delta = \frac{5 * 1.75685 * 26^4}{384 (29000) I} = .87$$

$I = 695$

W14x30

$I = 704$

Use W14x30



Using the LRFD Manual of Steel Construction Table 5 -14 Composite W Shapes Design strength in flexure $\Phi_b M_n$, kip-ft and Table 5 -14 Lower Bound Elastic Moments of Inertia I_{lb} for plastic composite sections, I was able to determine that 3, 26 foot W14x30 shape beams spaced 6.5' O.C. apart can withstand the loads of the 5 1/4" LW structural concrete slab. The beams are two inches shallower than those of the existing design. Deflection was too large on the W10x15 beam and thus the W14x30 was chosen.

Structural Analysis Conclusion

The structural design, while seemingly simple, actually required some research to complete. It is a useful knowledge to have, especially when you need to explore other means of gaining those precious inches in your mechanical plenums. The span for this analysis was rather short, only 26', however over a larger span or different loading conditions the results could vary. It is also useful to know when moving large mechanical equipment around such as RTUs or AHUs. Utilizing composite beam construction, the mechanical designer can double check to be sure the structure will hold the heavy mechanical equipment.



Summary & Conclusions

The implementation of Water Source Heat Pumps on a geothermal water loop greatly increases heating and cooling efficiency. With the addition of a total energy recovery wheel, the savings grow. These systems can cost more than a conventional system, however it is possible to recover the investment in an acceptable amount of time. Geothermal technology is making advances and is incorporated in more designs as time goes by. It might be beneficial to instruct future engineers about the realistic uses of this energy saving method, especially in times where energy is expensive.

The research involved in this thesis was extensive and very useful. Many agencies and organizations are more than happy to assist engineers who are in pursuit of more environmentally friendly design. The programs that are available are functional, however are rudimentary. Nevertheless, they were incredibly useful within the scope of my analysis. The results of my research have shown that use of ground loop exchangers is very efficient. Once a ground loop is installed, it is virtually maintenance free for up to 50 years or more. The major costs involved with ground coupled heat pumps are initial costs and pumping costs. Energy consumption is dropped considerably across the board.

The simulations prove that something as simple as an energy recovery wheel can have drastic implications on heating and cooling loads. It is important that energy saving technology is implemented as much as possible. This hospital analysis is a text book example of unnecessarily wasted energy. I believe that technology like this can be pushed further and made even more efficient so that excluding it from a design will not be an option.





Acknowledgements

I would first like to thank God for the incredible life He has been so generous to give me. Out of His love, I have the greatest family in the world and have been blessed with many great friends.

I would also like to thank:

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Sam Snyder and **Joe Firrantello** - for always answering my dumb questions

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Lastly, I would like to thank all of the many great people who made my times here at PSU so great, that I put off graduation as long as I could, just so I could stay.

A special acknowledgment to the Mick, Olly & Gavin at the Brickies in Leeds, UK. Olly, thanks for letting me sleep in the pub all those times, I owe you.

Disclaimer:

I do not claim ownership of all the pictures included in this thesis. All logos, renderings and photos are property of their respective owners and are only borrowed for enrichment of this Thesis.



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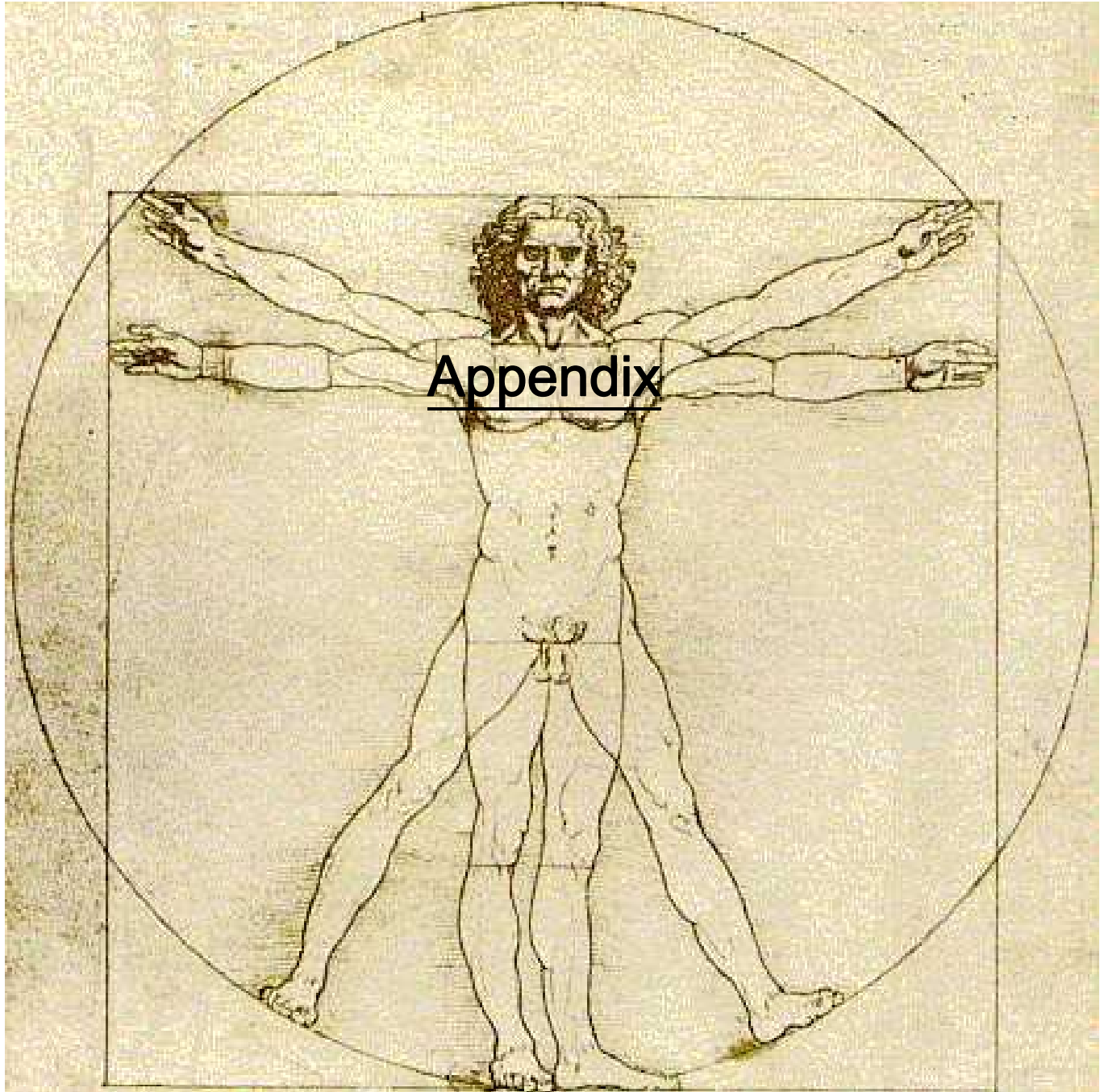
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Annual Cost Summary

20254.02 Community of Lancaster WSHP
psuae

04/02/2004
11:15PM

Table 1. Annual Costs

Component	CHOL Existing Conditions (\$)
Air System Fans	601
Cooling	12,940
Heating	8,973
Pumps	9,632
Cooling Tower Fans	0
HVAC Sub-Total	32,145
Lights	13,468
Electric Equipment	3,117
Misc. Electric	0
Misc. Fuel Use	0
Non-HVAC Sub-Total	16,585
Grand Total	48,730

Table 2. Annual Cost per Unit Floor Area

Component	CHOL Existing Conditions (\$/ft²)
Air System Fans	0.031
Cooling	0.668
Heating	0.463
Pumps	0.497
Cooling Tower Fans	0.000
HVAC Sub-Total	1.659
Lights	0.695
Electric Equipment	0.161
Misc. Electric	0.000
Misc. Fuel Use	0.000
Non-HVAC Sub-Total	0.856
Grand Total	2.515
Gross Floor Area (ft²)	19380.0
Conditioned Floor Area (ft²)	19380.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 3. Component Cost as a Percentage of Total Cost

Component	CHOL Existing Conditions (%)
Air System Fans	1.2
Cooling	26.6
Heating	18.4
Pumps	19.8
Cooling Tower Fans	0.0
HVAC Sub-Total	66.0
Lights	27.6
Electric Equipment	6.4
Misc. Electric	0.0
Misc. Fuel Use	0.0
Non-HVAC Sub-Total	34.0
Grand Total	100.0

Annual Cost Summary

20254.02 Community of Lancaster WSHP Final
psuae

04/05/2004
08:53AM

Table 1. Annual Costs

Component	CHOL WSHP TER (\$)
Air System Fans	1,534
Cooling	6,457
Heating	349
Pumps	4,082
Cooling Tower Fans	0
HVAC Sub-Total	12,422
Lights	13,854
Electric Equipment	3,207
Misc. Electric	0
Misc. Fuel Use	0
Non-HVAC Sub-Total	17,061
Grand Total	29,483

Table 2. Annual Cost per Unit Floor Area

Component	CHOL WSHP TER (\$/ft ²)
Air System Fans	0.079
Cooling	0.333
Heating	0.018
Pumps	0.211
Cooling Tower Fans	0.000
HVAC Sub-Total	0.641
Lights	0.715
Electric Equipment	0.166
Misc. Electric	0.000
Misc. Fuel Use	0.000
Non-HVAC Sub-Total	0.880
Grand Total	1.521
Gross Floor Area (ft ²)	19380.0
Conditioned Floor Area (ft ²)	19380.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 3. Component Cost as a Percentage of Total Cost

Component	CHOL WSHP TER (%)
Air System Fans	5.2
Cooling	21.9
Heating	1.2
Pumps	13.8
Cooling Tower Fans	0.0
HVAC Sub-Total	42.1
Lights	47.0
Electric Equipment	10.9
Misc. Electric	0.0
Misc. Fuel Use	0.0
Non-HVAC Sub-Total	57.9
Grand Total	100.0

Annual Cost Summary

20254.02 Community of Lancaster WSHP
psuae

04/02/2004
11:17PM

Table 1. Annual Costs

Component	CHOL WSHP TER (\$)
Air System Fans	1,542
Cooling	6,483
Heating	351
Pumps	0
Cooling Tower Fans	0
HVAC Sub-Total	8,375
Lights	13,931
Electric Equipment	3,225
Misc. Electric	0
Misc. Fuel Use	0
Non-HVAC Sub-Total	17,156
Grand Total	25,532

Table 2. Annual Cost per Unit Floor Area

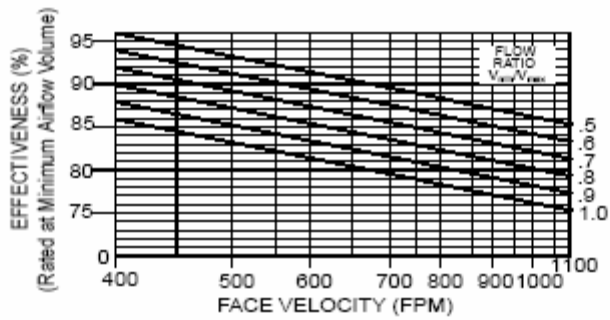
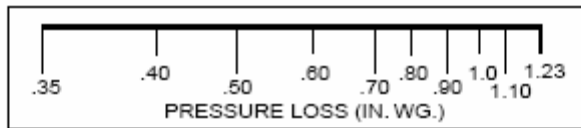
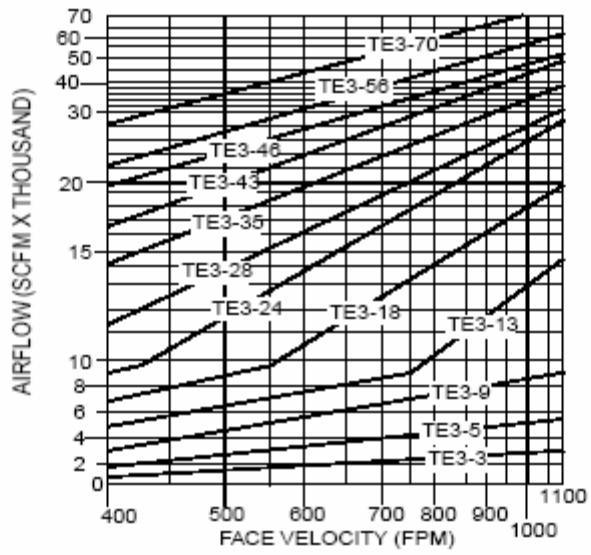
Component	CHOL WSHP TER (\$/ft ²)
Air System Fans	0.080
Cooling	0.335
Heating	0.018
Pumps	0.000
Cooling Tower Fans	0.000
HVAC Sub-Total	0.432
Lights	0.719
Electric Equipment	0.166
Misc. Electric	0.000
Misc. Fuel Use	0.000
Non-HVAC Sub-Total	0.885
Grand Total	1.318
Gross Floor Area (ft ²)	19380.0
Conditioned Floor Area (ft ²)	19380.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 3. Component Cost as a Percentage of Total Cost

Component	CHOL WSHP TER (%)
Air System Fans	6.0
Cooling	25.4
Heating	1.4
Pumps	0.0
Cooling Tower Fans	0.0
HVAC Sub-Total	32.8
Lights	54.6
Electric Equipment	12.6
Misc. Electric	0.0
Misc. Fuel Use	0.0
Non-HVAC Sub-Total	67.2
Grand Total	100.0

TOTAL ENERGY RECOVERY WHEEL SIZE



Design Lengths * Heat Pump Series: Trane (Standard Efficiency) *****

Required BORE length with minimal groundwater movement = 150360 ft (752 ft/bore)
(Design based on COOLING mode - net annual heat rejection to ground)

Required BORE lengths with high rates of groundwater movement (or year 1)
Cooling: L= 76410 ft (382 ft/bore), Heating: L= 21850 ft (109 ft/bore)

Unit Inlet (cooling) = 85.0 degrees F
Unit Outlet (cooling) = 95.4 degrees F
Unit Inlet (heating) = 50.0 degrees F
Unit Outlet (heating) = 44.1 degrees F
Normal ground temp = 52.0 degrees F

Cooling Load/Demand = 5631 MBtuh / 491 kW
Heating Load/Demand = 1014 MBtuh / 78 kW
Cooling EER (Ht Pump/Sys) = 11.5 / 10.9
Heating COP (Ht Pump/Sys) = 3.8 / 2.8
Loop Pump Head/Flow Rate = 60 ft / 1408 gpm
Loop Pump Power/Demand = 30.5 hp / 26.7 kW

Total Heat Pump Capacity = 5647.4 Mbtuh (cooling)
Total Heat Pump Capacity = 5741.6 Mbtuh (heating)

U-tube Diameter = 1.25 inch
Separation dist. = 20.0 ft
Grid = 20 wide by 10 deep
Grout Conductivity = 1.50 Btu/hr-ft- degrees F
Bore Diameter = 5.00 inches

Bore Resistance = 0.102 hr-ft-F/Btu
Ground Resistance (Cooling) = 0.343 hr-ft-F/Btu
Ground Resistance (Heating) = 0.334 hr-ft-F/Btu

Long Term Ground Temperature Rise = 3.7 degrees F
(Center of Loop Field)

Thermal Conductivity = 1.40 Btu/hr-ft-degrees F
Thermal Diffusivity = 0.93 ft²/day

Ground Temperature = 52.0 degrees F

Hybrid Design Lengths * Heat Pump Series: Trane (High Efficiency) *****

Required BORE length for heating, L = 21870 ft (109 ft/bore)

Tower Size for Downsized Ground Loop

Flow = 1455 gpm, Condenser Capacity = 7539 MBtuh, Range = 10.4 degrees F

Tower Size for Balanced Ground Heat Load

Flow = 1474 gpm, Condenser Capacity = 7641 MBtuh, Range = 10.4 degrees F

Required operating hours @ 10 degrees F Range = 7920 hrs/yr

 @ 20 degrees F Range = 3960 hrs/yr

 @ 30 degrees F Range = 2640 hrs/yr

Unit Inlet (cooling) = 85.0 degrees F

Unit Outlet (cooling) = 95.4 degrees F

Unit Inlet (heating) = 50.0 degrees F

Unit Outlet (heating) = 44.1 degrees F

Normal ground temp = 52.0 degrees F

Cooling Load/Demand = 5631 MBtuh / 488 kW

Heating Load/Demand = 1014 MBtuh / 78 kW

Cooling EER (Ht Pump/Sys) = 11.5/10.3

Heating COP (Ht Pump/Sys) = 3.8 / 2.8

Pump/Cooling Tower Demand = 26.7/31.9 kW

System Liquid Flow Rate = 1408 gpm

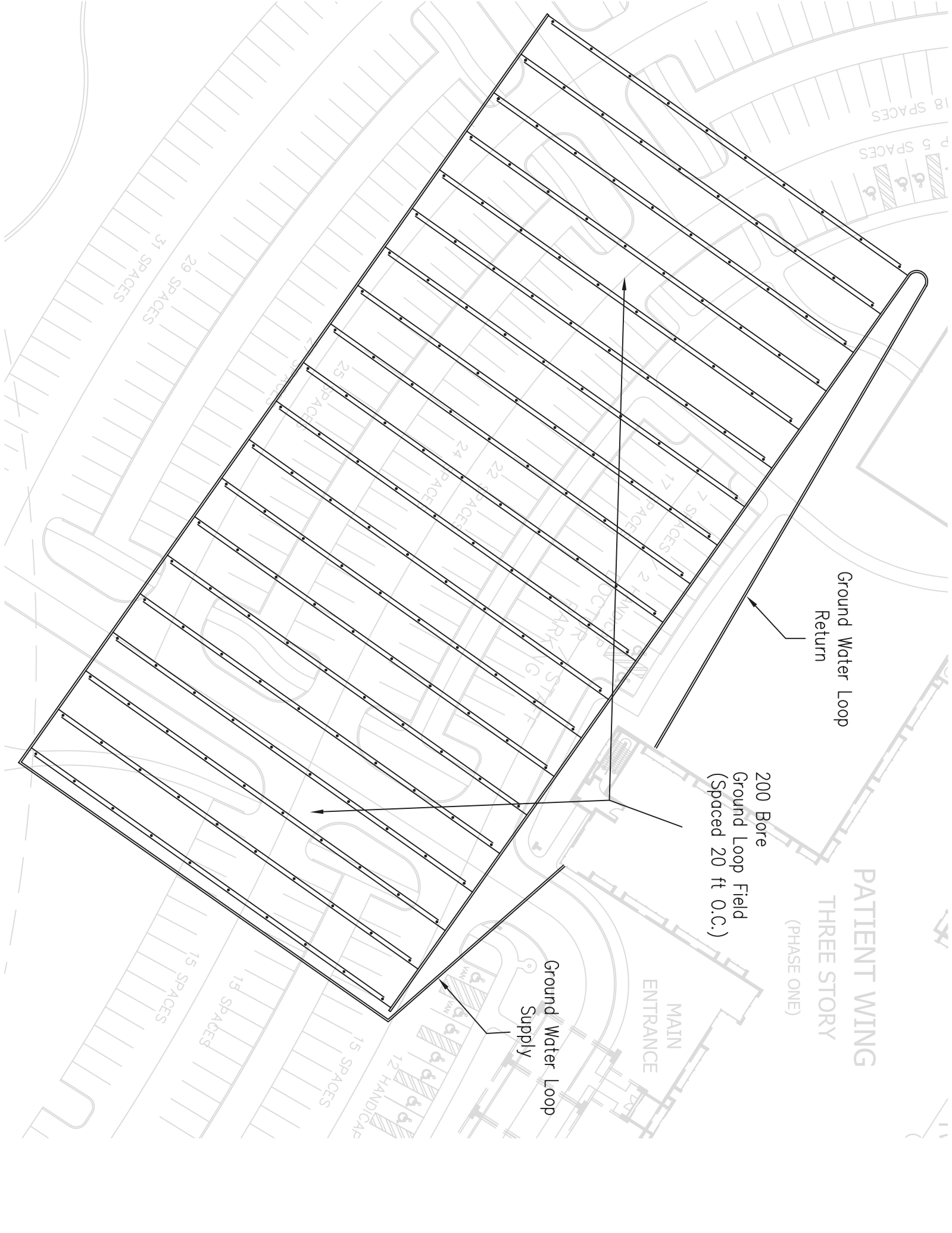
Ground Water Loop
Return

200 Bore
Ground Loop Field
(Spaced 20 ft O.C.)

Ground Water Loop
Supply

PATIENT WING
THREE STORY
(PHASE ONE)

MAIN
ENTRANCE





General Data

Table G1: General data about the units

Model GEH		006	009	012	015
Unit Size	Length (in)	40	40	40	40
	Height (in)	15	15	15	15
	Width (in)	20	20	20	20
Compressor Type		Rotary	Rotary	Rotary	Rotary
Approximate Weight	with Pallet (lb)	188	188	188	188
Approximate Weight	without Pallet (lb)	158	158	158	158
Filter Size	Actual (in)	14 5/8 x 20 1/4	14 5/8 x 20 1/4	14 5/8 x 20 1/4	14 5/8 x 20 1/4
Water in/out size (FPT)	inches	1/2	1/2	1/2	1/2
Condensate size (NPTI)	inches	3/4	3/4	3/4	3/4
Blower Wheel Size	Direct Drive (in)	9 x 4	9 x 4	9 x 4	9 x 4

Table G2: General data about the units (continued)

Model GEH		018	024	030	036
Unit Size	Length (in)	46	46	46	50
	Height (in)	17	17	17	19
	Width (in)	23	23	23	25
Compressor Type		Rotary	Reciprocating	Reciprocating	Reciprocating
Approximate Weight	with Pallet (lb)	278	278	278	318
Approximate Weight	without Pallet (lb)	248	248	248	288
Filter Size	Actual (in)	16 3/8 x 23 5/8	16 3/8 x 23 5/8	16 3/8 x 23 5/8	18 5/8 x 25 3/8
Water in/out size (FPT)	inches	3/4	3/4	3/4	3/4
Condensate size (NPTI)	inches	3/4	3/4	3/4	3/4
Blower Wheel Size	Direct Drive (in)	9 x 6	10 x 6	10 x 6	12 x 8

Table G3: General data about the units (continued)

Model GEH		042	048	060
Unit Size	Length (in)	50	58	58
	Height (in)	19	21	21
	Width (in)	25	33	33
Compressor Type		Reciprocating	Reciprocating	Scroll
Approximate Weight	with Pallet (lb)	318	428	428
Approximate Weight	without Pallet (lb)	288	398	398
Filter Size	Actual (in)	18 5/8 x 25 3/8	20 5/8 x 29 3/4	20 5/8 x 29 3/4
Water in/out size (FPT)	inches	1	1	1
Condensate size (NPTI)	inches	3/4	3/4	3/4
Blower Wheel Size	Direct Drive (in)	12 x 8	12 x 11	12 x 11



General Data

Table G4: General data about the units

Model GEV		006	009	012	015	018
Unit Size	Length (in)	21 1/2	21 1/2	21 1/2	21 1/2	21 1/2
	Height (in)	31 1/4	31 1/4	31 1/4	31 1/4	39 1/4
	Width (in)	19 1/2	19 1/2	19 1/2	19 1/2	21 1/2
Compressor Type		Rotary	Rotary	Rotary	Rotary	Reciprocating
Approximate Weight	with Pallet (lb)	178	178	178	178	268
Approximate Weight	without Pallet (lb)	158	158	158	158	248
Filter Size	Actual (in)	15 7/8 x 19 7/8	15 7/8 x 19 7/8	15 7/8 x 19 7/8	15 7/8 x 19 7/8	17 7/8 x 24 7/8
Water in/out size (FPT)	inches	1/2	1/2	1/2	1/2	3/4
Condensate size (NPTI)	inches	3/4	3/4	3/4	3/4	3/4
Blower Wheel Size	Direct Drive (in)	9 x 4	9 x 4	9 x 4	9 x 4	10 x 6

Table G5: General data about the units (continued)

Model GEV		024	030	036	040	042
Unit Size	Length (in)	21 1/2	21 1/2	26 1/2	21 1/2	26 1/2
	Height (in)	39 1/4	39 1/4	41 7/8	39 1/4	41 7/8
	Width (in)	21 1/2	21 1/2	24 1/2	21 1/2	24 1/2
Compressor Type		Reciprocating	Reciprocating	Reciprocating	Reciprocating	Reciprocating
Approximate Weight	with Pallet (lb)	268	268	308	268	308
Approximate Weight	without Pallet (lb)	248	248	288	248	288
Filter Size	Actual (in)	17 7/8 x 24 7/8	17 7/8 x 24 7/8	19 7/8 x 24 7/8	17 7/8 x 24 7/8	19 7/8 x 24 7/8
Water in/out size (FPT)	inches	3/4	3/4	3/4	3/4	3/4
Condensate size (NPTI)	inches	3/4	3/4	3/4	3/4	3/4
Blower Wheel Size	Direct Drive (in)	10 x 6	10 x 6	10 x 6	10 x 6	12 x 8

Table G6: General data about the units (continued)

Model GEV		048	060	072	090	120
Unit Size	Length (in)	30 1/2	30 1/2	42	42	42
	Height (in)	46 7/8	46 7/8	62 5/8	62 5/8	62 5/8
	Width (in)	26 1/2	26 1/2	36 1/4	36 1/4	36 1/4
Compressor Type		Reciprocating	Scroll	Recip (2)	Recip (2)	Scroll (2)
Approximate Weight	with Pallet (lb)	396	396	617	648	861
Approximate Weight	without Pallet (lb)	348	348	577	608	821
Filter Size	Actual (in)	27 7/8 x 29 7/8	27 7/8 x 29 7/8	20 x 20 (4)	20 x 20 (4)	20 x 20 (4)
Water in/out size	inches	1 FPT	1 FPT	1 1/4 FPT	1 1/4 FPT	1 1/2 FPT
Condensate size (NPTI)	inches	3/4	3/4	3/4	3/4	3/4
Blower Wheel Size and quantity		12 x 11 (DD)	12 x 11 (DD)	12.62 x 12.62	12.62 x 12.62	12.62 x 12.62

Table G7: General data about the units (continued)

Model GEV		150	180	240	300
Unit Size	Length (in)	81 5/8	81 5/8	81 5/8	81 5/8
	Height (in)	68	68	68	68
	Width (in)	36 1/4	36 1/4	36 1/4	36 1/4
Compressor Type		Scroll (2)	Scroll (2)	Scroll (2)	Scroll (2)
Approximate Weight	with Pallet (lb)	1215	1225	1615	1665
Approximate Weight	without Pallet (lb)	1170	1180	1580	1640
Filter Size	Actual (in)	19 5/8 x 24 5/8 (6)	19 5/8 x 24 5/8 (6)	19 5/8 x 24 5/8 (6)	19 5/8 x 24 5/8 (6)
Water in/out size (sweat)	inches	1 1/2 FPT	1 1/2 FPT	2 FPT	2 FPT
Condensate size (NPTI)	inches	3/4	3/4	3/4	3/4
Blower Wheel Size and quantity (regular-low static/high static)		15 x 15	15 x 15	(2) 12 x 12	(2) 15 x 11 / (2) 12 x 12



General Data

Air-to-Refrigerant Coils

Table G8: GEH/GEV 006, 009

Working Pressure	425
Tubes High	14
Tubes Deep	2
No. of Circuits	1
Finned vol. (h,w,d)	14 x 16 x 1.734
Coil Surface Area (Ft ²)	1.56
Fins Per Inch	12
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G9: GEH/GEV 012

Working Pressure	425
Tubes High	14
Tubes Deep	3
No. of Circuits	2
Finned vol. (h,w,d)	14 x 16 x 2.598
Coil Surface Area (Ft ²)	1.56
Fins Per Inch	12
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G10: GEH/GEV 015

Working Pressure	425
Tubes High	14
Tubes Deep	3
No. of Circuits	1
Finned vol. (h,w,d)	14 x 16 x 2.598
Coil Surface Area (Ft ²)	1.56
Fins Per Inch	12
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G11: GEH 018, 024, 030

Working Pressure	425
Tubes High	16
Tubes Deep	4
No. of Circuits	4
Finned vol. (h,w,d)	16 x 19 x 3.464
Coil Surface Area (Ft ²)	2.11
Fins Per Inch	12
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G12: GEV 018, 024, 030, 040

Working Pressure	425
Tubes High	21
Tubes Deep	4
No. of Circuits	4
Finned vol. (h,w,d)	21 x 16 x 3.464
Coil Surface Area (Ft ²)	2.33
Fins Per Inch	12
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G13: GEH/GEV 036, 042

Working Pressure	425
Tubes High	18
Tubes Deep	4
No. of Circuits	6
Finned vol. (h,w,d)	18 x 21 x 3.464
Coil Surface Area (Ft ²)	2.63
Fins Per Inch	12
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G14: GEH 048, 060

Working Pressure	425
Tubes High	20
Tubes Deep	4
No. of Circuits	8
Finned vol. (h,w,d)	20 x 29 x 3.464
Coil Surface Area (Ft ²)	4.03
Fins Per Inch	12
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G15: GEV 048, 060

Working Pressure	425
Tubes High	24
Tubes Deep	4
No. of Circuits	8
Finned vol. (h,w,d)	24 x 25 x 3.464
Coil Surface Area (Ft ²)	4.17
Fins Per Inch	12
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G16: GEV 072 (dual compr. circuit)

Working Pressure	425
Tubes High	24
Tubes Deep	4
No. of Circuits	6 refrig flow paths (2X)
Finned vol. (h,w,d)	24 x 34 x 3.464
Coil Surface Area (Ft ²)	5.67
Fins Per Inch	14
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G17: GEV 090 (dual compr. circuit)

Working Pressure	425
Tubes High	28
Tubes Deep	4
No. of Circuits	7 refrig flow paths (2X)
Finned vol. (h,w,d)	28 x 34 x 3.464
Coil Surface Area (Ft ²)	6.61
Fins Per Inch	14
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G18: GEV 120 (dual compr. circuit)

Working Pressure	425
Tubes High	36
Tubes Deep	4
No. of Circuits	9 refrig flow paths (2X)
Finned vol. (h,w,d)	36 x 34 x 3.464
Coil Surface Area (Ft ²)	8.50
Fins Per Inch	14
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper



Performance Data ARI-ISO (WLHP/GLHP)

Table G19: GEV 150 (dual compr. circuit)

Working Pressure	425
Tubes High	28
Tubes Deep	2
No. of Circuits	7 refrig flow paths (2X)
Finned vol. (h,w,d)	28 x 73 x 1.734
Coil Surface Area (Ft ²)	14.19
Fins Per Inch	14
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G20: GEV 180 (dual compr. circuit)

Working Pressure	425
Tubes High	32
Tubes Deep	3
No. of Circuits	9 refrig flow paths (2X)
Finned vol. (h,w,d)	32 x 73 x 2.598
Coil Surface Area (Ft ²)	16.22
Fins Per Inch	14
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table G21: GEV 240, 300
(dual compr. circuit)

Working Pressure	425
Tubes High	36
Tubes Deep	4
No. of Circuits	18 refrig flow paths (2X)
Finned vol. (h,w,d)	36x 73 x 3.464
Coil Surface Area (Ft ²)	18.25
Fins Per Inch	14
Tube Material	Copper
Tube OD (in)	3/8
Wall Thickness	0.014
Return Bends	Copper

Table P1: ARI-ISO WLHP and GLHP Performance

Unit Size	Rated Water Flow (GPM)	Rated Air Flow (SCFM)	Cooling Capacity WLHP (BTUH)	EER WLHP	Heating Capacity WLHP (BTUH)	COP WLHP	Cooling Capacity GLHP (BTUH)	EER GLHP	Heating Capacity GLHP (BTUH)	COP GLHP
006	1.5	190	7060	13.0	8160	4.3	6980	14.4	4690	3.1
009	2.1	285	8760	12.85	10900	4.6	8710	14.5	6100	3.1
012	2.8	380	12500	13.15	13200	4.35	12400	14.2	8700	3.2
015	3.5	460	14100	14.0	17200	4.8	14200	16.0	10200	3.45
018	4.2	570	19100	13.5	21600	4.45	18900	14.9	13000	3.15
024	5.5	760	25800	12.6	30400	4.35	26000	13.8	17800	3.25
030	6.9	900	28500	12.5	33100	4.25	28700	13.5	19800	3.1
036	8.3	1140	36000	13.7	41800	4.7	35200	14.5	22200	3.25
GEV 040	9.2	1200	38500	12.75	44200	4.2	38500	13.6	26100	3.1
042	9.7	1330	40200	12.05	47500	4.2	41700	13.4	27400	3.1
048	11.0	1520	49000	12.75	55300	4.25	49000	13.65	32000	3.1
060	14.5	1900	59300	12.8	72300	4.4	58500	13.75	43300	3.1
GEV 072	18.0	2400	72900	13.7	85100	4.8	72600	14.8	51600	3.5
GEV 090	22.5	3000	90300	13.0	104300	4.5	89800	14.0	63200	3.2
GEV 120	30.0	4000	120200	12.7	142800	4.4	118000	13.5	86400	3.2
GEV 150	37.5	5000	144000	15.5	171400	5.5	148100	17.3	105400	3.9
GEV 180	45.0	6000	173600	13.0	209800	4.8	178900	14.5	128700	3.5
GEV 240	60.0	8000	250300	13.1	276800	4.3	257200	14.5	186600	3.4
GEV 300	75.0	10000	282900	12.1	339400	4.2	291700	13.2	220900	3.3



Rated in accordance with ISO Standard 13256-1: 1998 (Water Loop Heat Pumps and Ground Loop Heat Pumps).

Models with capacities greater than 135,000 BTUH are not included in the ARI water-to-air and brine-to-air heat pump certification program.



Performance Data 012-Cooling

Table P8: GEH/GEV 012 Cooling Performance

Performance data is tabulated for cooling at 80.6 F DB/66.2 F WB entering air at ARI/ISO 13256-1 rated CFM.

For conditions other than what is tabulated, multipliers must be used to correct performance. See the *fan correction factors Table* for CFM other than rated and the *cooling correction factors* for variations in entering air temperature. WLHP data shown in **bold** type is performance data at ARI/ISO 13256-1. The **bold** type for GLHP is a rating point only. For ARI 13256-1 GLHP conditions, apply 15% methanol by volume per the antifreeze correction factors found on page 107.

RATED GPM: 2.8
RATED CFM: 380

MINIMUM CFM: 304
MAXIMUM CFM: 456

EWT	GPM	Total Mbtuh	Sen Mbtuh	SHR	Power kW	Reject Mbtuh	LWT	Ft. Hd.	CFM	ISO Cap Mbtuh	ISO Pwr kW	ISO EER
45	1.8	14.3	10.4	0.73	0.88	17.3	64.2	4.7	380	14.6	0.79	18.5
	2.2	14.4	10.4	0.72	0.85	17.3	60.7	6.5		14.7	0.76	19.3
	2.5	14.4	10.5	0.73	0.84	17.3	58.8	8.0		14.7	0.76	19.3
	2.8	14.5	10.5	0.72	0.83	17.3	57.4	9.6		14.8	0.75	19.7
	2.9	14.5	10.5	0.72	0.82	17.3	56.9	10.1		14.8	0.74	20.0
	3.1	14.5	10.5	0.72	0.82	17.3	56.2	11.2		14.8	0.75	19.7
	3.4	14.5	10.5	0.72	0.80	17.2	55.1	13.0		14.8	0.73	20.3
55	1.8	13.9	10.0	0.72	0.80	16.6	73.4	4.4	380	14.2	0.71	20.0
	2.2	13.9	10.0	0.72	0.77	16.5	70.0	6.1		14.2	0.68	20.9
	2.5	14.0	10.0	0.71	0.77	16.6	68.3	7.4		14.3	0.69	20.7
	2.8	14.1	10.1	0.72	0.75	16.7	66.9	8.9		14.4	0.67	21.5
	2.9	14.1	10.1	0.72	0.75	16.7	66.5	9.4		14.4	0.67	21.5
	3.1	14.1	10.1	0.72	0.75	16.7	65.8	10.5		14.4	0.68	21.2
	3.4	14.1	10.0	0.71	0.72	16.6	64.8	12.2		14.4	0.65	22.2
68	1.8	13.1	9.6	0.73	0.91	16.2	86.0	4.1	380	13.4	0.82	16.3
	2.2	13.2	9.6	0.73	0.88	16.2	82.7	5.6		13.5	0.79	17.1
	2.5	13.2	9.6	0.73	0.88	16.2	81.0	6.9		13.5	0.80	16.9
	2.8	13.3	9.7	0.73	0.86	16.2	79.6	8.3		13.6	0.78	17.4
	2.9	13.3	9.7	0.73	0.86	16.2	79.2	8.8		13.6	0.78	17.4
	3.1	13.3	9.6	0.72	0.86	16.2	78.5	9.8		13.6	0.78	17.4
	3.4	13.3	9.6	0.72	0.83	16.1	77.5	11.3		13.6	0.76	17.9
GLHP 77	1.8	12.5	9.3	0.74	1.00	15.9	94.7	3.9	380	12.8	0.91	14.1
	2.2	12.6	9.3	0.74	0.97	15.9	91.5	5.3		12.9	0.88	14.7
	2.5	12.7	9.4	0.74	0.96	16.0	89.8	6.6		13.0	0.88	14.8
	2.8	12.7	9.4	0.74	0.95	15.9	88.4	7.9		13.0	0.87	15.0
	2.9	12.8	9.4	0.73	0.95	16.0	88.1	8.4		13.1	0.87	15.1
	3.1	12.8	9.4	0.73	0.94	16.0	87.4	9.4		13.1	0.86	15.3
	3.4	12.8	9.4	0.73	0.92	15.9	86.4	10.9		13.1	0.85	15.4
WLHP 86	1.8	12.0	9.1	0.76	1.08	15.7	103.5	3.7	380	12.3	0.99	12.4
	2.2	12.1	9.1	0.75	1.05	15.7	100.3	5.1		12.4	0.96	12.9
	2.5	12.1	9.1	0.75	1.05	15.7	98.6	6.3		12.4	0.97	12.8
	2.8	12.2	9.2	0.75	1.03	15.7	97.3	7.6		12.5	0.95	13.2
	2.9	12.2	9.2	0.75	1.03	15.7	96.9	8.1		12.5	0.95	13.2
	3.1	12.2	9.2	0.75	1.03	15.7	96.2	9.0		12.5	0.95	13.2
	3.4	12.2	9.1	0.75	1.00	15.6	95.2	10.5		12.5	0.93	13.4
95	1.8	11.3	8.8	0.78	1.19	15.4	112.2	3.5	380	11.6	1.10	10.5
	2.2	11.4	8.8	0.77	1.16	15.4	109.1	4.9		11.7	1.07	10.9
	2.5	11.5	8.9	0.77	1.15	15.4	107.4	6.1		11.8	1.06	11.1
	2.8	11.5	8.9	0.77	1.14	15.4	106.1	7.4		11.8	1.06	11.1
	2.9	11.5	8.9	0.77	1.13	15.4	105.7	7.8		11.8	1.05	11.2
	3.1	11.6	8.9	0.77	1.13	15.5	105.1	8.8		11.9	1.05	11.3
	3.4	11.6	8.9	0.77	1.11	15.4	104.1	10.2		11.9	1.04	11.4
105	1.8	10.5	8.5	0.81	1.35	15.1	121.9	3.4	380	10.8	1.26	8.6
	2.2	10.6	8.5	0.80	1.31	15.1	118.8	4.8		10.9	1.22	8.9
	2.5	10.6	8.6	0.81	1.31	15.1	117.2	5.9		10.9	1.22	8.9
	2.8	10.7	8.6	0.80	1.30	15.1	115.9	7.1		11.0	1.22	9.0
	2.9	10.7	8.6	0.80	1.29	15.1	115.5	7.6		11.0	1.21	9.1
	3.1	10.7	8.6	0.80	1.29	15.1	114.8	8.5		11.0	1.21	9.1
	3.4	10.8	8.6	0.80	1.27	15.1	114.0	9.9		11.1	1.20	9.3
115	1.8	9.6	8.1	0.84	1.49	14.7	131.5	3.3	380	9.9	1.40	7.1
	2.2	9.7	8.1	0.84	1.46	14.7	128.5	4.6		10.0	1.37	7.3
	2.5	9.8	8.2	0.84	1.45	14.7	126.9	5.7		10.1	1.36	7.4
	2.8	9.9	8.2	0.83	1.44	14.8	125.7	6.9		10.2	1.36	7.5
	2.9	9.9	8.2	0.83	1.44	14.8	125.3	7.4		10.2	1.36	7.5
	3.1	9.9	8.2	0.83	1.44	14.8	124.6	8.3		10.2	1.36	7.5
	3.4	9.9	8.2	0.83	1.41	14.7	123.7	9.7		10.2	1.34	7.6
120	1.8	9.3	7.9	0.85	1.50	14.4	136.2	3.2	380	9.6	1.41	6.8
	2.2	9.4	7.9	0.84	1.47	14.4	133.2	4.5		9.7	1.38	7.0
	2.5	9.5	7.9	0.83	1.46	14.5	131.7	5.6		9.8	1.37	7.2
	2.8	9.5	8.0	0.84	1.45	14.4	130.4	6.8		9.8	1.37	7.2
	2.9	9.5	8.0	0.84	1.45	14.4	130.0	7.3		9.8	1.37	7.2
	3.1	9.6	7.9	0.82	1.44	14.5	129.5	8.2		9.9	1.36	7.3
	3.4	9.6	7.9	0.82	1.42	14.4	128.6	9.6		9.9	1.35	7.3



Performance Data 012-Heating

Table P9: GEH/GEV 012 Heating Performance

Performance data is tabulated for heating at 68 F DB entering air at ARI/ISO 13256-1 rated CFM.

For conditions other than what is tabulated, multipliers must be used to correct performance. See the *fan correction factors Table* for CFM other than rated and the *heating correction factors* for variations in entering air temperature. WLHP data shown in **bold** type is performance data at ARI/ISO 13256-1. The **bold** type for GLHP is a rating point only. For ARI 13256-1 GLHP conditions, apply 15% methanol by volume per the antifreeze correction factors found on page 107.

RATED GPM: 2.8 MINIMUM CFM: 304
RATED CFM: 380 MAXIMUM CFM: 456

EWT	GPM	Htg Cap Mbtuh	Absorb Mbtuh	Power kW	LWT	Ft. Hd.	CFM	ISO Cap Mbtuh	ISO Pwr kW	ISO COP
25	1.8	8.0	5.2	0.83	19.2	5.6	380	7.7	0.74	3.0
	2.2	8.2	5.4	0.83	20.1	7.7		7.9	0.74	3.1
	2.5	8.3	5.4	0.84	20.7	9.4		8.0	0.76	3.1
	2.8	8.4	5.5	0.84	21.1	11.2		8.1	0.76	3.1
	2.9	8.4	5.5	0.84	21.2	11.8		8.1	0.77	3.1
	3.1	8.5	5.6	0.84	21.4	13.1		8.2	0.77	3.1
GLHP 32	3.4	8.5	5.6	0.84	21.7	15.0	380	8.2	0.77	3.1
	1.8	9.2	6.3	0.85	25.0	5.3		8.9	0.76	3.4
	2.2	9.3	6.4	0.86	26.2	7.3		9.0	0.78	3.4
	2.5	9.4	6.5	0.86	26.8	8.9		9.1	0.78	3.4
	2.8	9.5	6.6	0.86	27.3	10.6		9.2	0.78	3.4
	2.9	9.6	6.7	0.86	27.4	11.2		9.3	0.79	3.4
45	3.1	9.6	6.7	0.86	27.7	12.4	380	9.3	0.79	3.4
	3.4	9.7	6.7	0.87	28.0	14.3		9.3	0.79	3.4
	1.8	11.0	7.9	0.90	36.2	4.7		9.4	0.81	3.4
	2.2	11.2	8.1	0.91	37.6	6.5		10.7	0.81	3.9
	2.5	11.3	8.2	0.92	38.4	8.0		10.9	0.82	3.9
	2.8	11.4	8.3	0.92	39.1	9.6		11.0	0.84	3.8
55	2.9	11.4	8.3	0.92	39.3	10.1	380	11.1	0.84	3.9
	3.1	11.4	8.3	0.92	39.6	11.2		11.1	0.85	3.8
	3.4	11.5	8.4	0.92	40.1	13.0		11.1	0.85	3.8
	1.8	12.1	8.9	0.93	45.1	4.4		11.2	0.85	3.9
	2.2	12.3	9.1	0.93	46.7	6.1		11.8	0.84	4.1
	2.5	12.4	9.2	0.94	47.6	7.4		12.0	0.84	4.2
WLHP 68	2.8	12.4	9.2	0.94	48.4	8.9	380	12.1	0.85	4.2
	2.9	12.5	9.3	0.94	48.6	9.4		12.1	0.86	4.1
	3.1	12.5	9.3	0.94	49.0	10.5		12.2	0.86	4.2
	3.4	12.6	9.4	0.94	49.5	12.2		12.2	0.86	4.2
	1.8	13.2	10.0	0.95	56.9	4.1		12.3	0.87	4.1
	2.2	13.4	10.1	0.96	58.8	5.6		12.3	0.87	4.1
75	2.5	13.5	10.2	0.96	59.8	6.9	380	13.100	0.87	4.4
	2.8	13.5	10.2	0.96	60.7	8.3		13.200	0.87	4.5
	2.9	13.6	10.3	0.96	60.9	8.8		13.200	0.88	4.4
	3.1	13.6	10.3	0.96	61.3	9.8		13.300	0.88	4.4
	3.4	13.7	10.4	0.97	61.9	11.3		13.300	0.88	4.4
	1.8	13.7	10.4	0.97	63.4	3.9		13.400	0.90	4.4
86	2.2	13.9	10.6	0.97	65.3	5.4	380	13.4	0.88	4.5
	2.5	14.0	10.7	0.98	66.4	6.6		13.6	0.88	4.5
	2.8	14.1	10.8	0.98	67.3	8.0		13.7	0.89	4.5
	2.9	14.1	10.8	0.98	67.5	8.5		13.8	0.90	4.5
	3.1	14.2	10.9	0.98	68.0	9.5		13.8	0.90	4.5
	3.4	14.3	10.9	0.99	68.6	11.0		13.9	0.90	4.5
86	1.8	14.6	11.2	0.99	73.5	3.7	380	14.0	0.92	4.5
	2.2	14.8	11.4	1.00	75.6	5.1		14.3	0.90	4.7
	2.5	14.9	11.5	1.01	76.8	6.3		14.5	0.91	4.7
	2.8	14.9	11.5	1.01	77.8	7.6		14.6	0.92	4.6
	2.9	15.0	11.6	1.01	78.0	8.1		14.6	0.93	4.6
	3.1	15.0	11.6	1.00	78.5	9.0		14.7	0.93	4.6
3.4	15.1	11.7	1.01	79.1	10.5	14.7	0.92	4.7		
								14.8	0.94	4.6

Table P10: 012 Fan Correction Factors

Entering CFM	Cooling Capacity	Sensible Capacity	Cooling Input Watts	Heating Capacity	Heating Input Watts
304	0.974	0.892	0.965	0.972	1.032
323	0.980	0.919	0.973	0.979	1.024
342	0.987	0.945	0.981	0.986	1.016
361	0.993	0.972	0.990	0.993	1.008
380	1.000	1.000	1.000	1.000	1.000
418	1.012	1.051	1.020	1.013	0.984
437	1.019	1.078	1.030	1.020	0.976
456	1.025	1.105	1.042	1.027	0.968



Performance Data Electrical

E1-Electrical performance

Model No.	Volts	Total FLA	Comp RLA (ea)	Comp LRA (ea)	No. of Com-pres.	Cmp MCC	Blower Motor FLA	Blower Motor HP	Fan Motor Num	Minimum Circuit Ampacity	Maximum Overcurrent Protective Device	Electric Heat kW	Electric Heat Amps	
006	115/60/1	6.8	5.70	36.2	1	9.1	1.20	1/12	1	8.3	15	0	0	
	208/60/1	3.4	2.80	17.7	1	4.6	0.60	1/12	1	4.1	15	0	0	
	208/60/1	4.48	2.8	17.7	1	4.6	0.60	1/12	1	5.6	15	0.82	3.9	
	230/60/1	3.4	2.80	17.7	1	4.6	0.60	1/12	1	4.1	15	0	0	
	230/60/1	4.88	2.8	17.7	1	4.6	0.60	1/12	1	6.1	15	1.00	4.3	
	220-240/50/1	3.6	3.10	18.8	1	5.2	0.52	1/12	1	4.4	15	0	0	
	220-240/50/1	7.3	3.1	18.8	1	5.2	0.52	1/12	1	9.2	15	1.64	6.8	
	265/60/1	3.0	2.45	15.0	1	3.9	0.52	1/12	1	3.6	15	0	0	
	265/60/1	5.5	2.5	15.0	1	3.9	0.52	1/12	1	6.9	15	1.33	5.0	
	009	115/60/1	8.3	7.20	45.6	1	10.9	1.20	1/12	1	10.2	15	0	0
208/60/1		4.0	3.40	22.2	1	6.4	0.60	1/12	1	4.9	15	0	0	
208/60/1		6.48	3.4	22.2	1	6.4	0.60	1/12	1	8.1	15	1.23	5.9	
230/60/1		4.0	3.40	22.2	1	6.4	0.60	1/12	1	4.9	15	0	0	
230/60/1		7.08	3.4	22.2	1	6.4	0.60	1/12	1	8.9	15	1.50	6.5	
220-240/50/1		5.0	4.30	22.2	1	6.6	0.72	1/8	1	6.1	15	0	0	
220-240/50/1		9.72	4.3	22.2	1	6.6	0.72	1/8	1	12.2	15	2.17	9.0	
265/60/1		3.6	3.10	18.8	1	5.2	0.52	1/12	1	4.4	15	0	0	
265/60/1		8.0	3.1	18.8	1	5.2	0.52	1/12	1	10.0	15	2.00	7.5	
012		115/60/1	12.2	10.60	56.7	1	16.0	1.57	1/8	1	14.8	25	0	0
	208/60/1	5.7	5.00	27.9	1	8.3	0.70	1/8	1	7.0	15	0	0	
	208/60/1	8.5	5.0	27.9	1	8.3	0.70	1/8	1	10.6	15	1.63	7.8	
	230/60/1	5.7	5.00	27.9	1	8.3	0.70	1/8	1	7.0	15	0	0	
	230/60/1	9.4	5.0	27.9	1	8.3	0.70	1/8	1	11.8	15	2.00	8.7	
	220-240/50/1	5.5	4.80	27.0	1	8.5	0.72	1/8	1	6.7	15	0	0	
	220-240/50/1	12.02	4.8	27.0	1	8.5	0.72	1/8	1	15.0	15	2.70	11.3	
	265/60/1	5.0	4.30	22.2	1	6.6	0.72	1/8	1	6.1	15	0	0	
	265/60/1	10.72	4.3	22.2	1	6.6	0.72	1/8	1	13.4	15	2.65	10.0	
	015	208/60/1	6.1	5.40	29.0	1	9.2	0.70	1/8	1	7.5	15	0	0
208/60/1		10.3	5.4	29.0	1	9.2	0.70	1/8	1	12.9	15	2.00	9.6	
230/60/1		6.1	5.40	29.0	1	9.2	0.70	1/8	1	7.5	15	0	0	
230/60/1		11.6	5.4	29.0	1	9.2	0.70	1/8	1	14.5	15	2.50	10.9	
220-240/50/1		7.8	6.30	32.0	1	10.0	1.53	1/3	1	9.4	15	0	0	
220-240/50/1		15.23	6.3	32.0	1	10.0	1.53	1/3	1	19.0	20	3.28	13.7	
265/60/1		5.5	4.80	27.0	1	8.5	0.72	1/8	1	6.7	15	0	0	
265/60/1		13.22	4.8	27.0	1	8.5	0.72	1/8	1	16.5	20	3.30	12.5	
018		208/60/1	9.4	7.60	45.0	1	13.0	2.10	1/3	1	11.6	15	0	0
		208/60/1	13.6	7.6	45.0	1	13.0	2.10	1/3	1	17.4	20	2.46	11.8
	230/60/1	9.4	7.60	45.0	1	13.0	2.10	1/3	1	11.6	15	0	0	
	230/60/1	14.8	7.6	45.0	1	13.0	2.10	1/3	1	18.9	20	3.00	13.0	
	220-240/50/1	11.4	9.90	55.0	1	13.8	1.53	1/3	1	13.9	20	0	0	
	220-240/50/1	19.63	9.9	55.0	1	13.8	1.53	1/3	1	24.5	25	4.35	18.1	
	265/60/1	7.8	6.30	32.0	1	10.0	1.53	1/3	1	9.4	15	0	0	
	265/60/1	16.63	6.3	32.0	1	10.0	1.53	1/3	1	20.8	25	4.00	15.1	
	380-415/50/3	4.9	3.90	25.0	1	5.4	0.95	1/3	1	5.8	15	0	0	
	380-415/50/3	11.45	3.9	25.0	1	5.4	0.95	1/3	1	14.3	15	4.35	10.5	
024	208/60/1	12.7	10.90	56.0	1	15.3	2.10	1/3	1	15.7	25	0	0	
	208/60/1	17.5	10.9	56.0	1	15.3	2.10	1/3	1	22.3	25	3.26	15.7	
	230/60/1	12.7	10.90	56.0	1	15.3	2.10	1/3	1	15.7	25	0	0	
	230/60/1	19.2	10.9	56.0	1	15.3	2.10	1/3	1	24.0	25	4.00	17.4	
	220-240/50/1	12.4	10.90	58.0	1	15.3	1.53	1/3	1	15.2	25	0	0	
	220-240/50/1	24.03	10.9	58.0	1	15.3	1.53	1/3	1	30.0	35	5.40	22.5	
	265/60/1	11.4	9.90	55.0	1	13.8	1.53	1/3	1	13.9	20	0	0	
	265/60/1	21.53	9.9	55.0	1	13.8	1.53	1/3	1	26.9	30	5.30	20.0	
	208/60/3	9.3	7.50	51.0	1	10.5	2.10	1/3	1	11.5	15	0	0	
	208/60/3	10.8	7.5	51.0	1	10.5	2.10	1/3	1	13.9	15	3.26	9.0	
	230/60/3	9.3	7.50	51.0	1	10.5	2.10	1/3	1	11.5	15	0	0	
	230/60/3	11.8	7.5	51.0	1	10.5	2.10	1/3	1	15.1	15	4.00	10.0	
	380-415/50/3	5.0	4.00	28.0	1	5.6	0.95	1/3	1	6.0	15	0	0	
	380-415/50/3	8.45	4.0	28.0	1	5.6	0.95	1/3	1	10.6	15	5.40	7.5	
	460/60/3	4.9	3.90	25.0	1	5.4	0.95	1/3	1	5.8	15	0	0	
	460/60/3	7.65	3.9	25.0	1	5.4	0.95	1/3	1	9.6	15	5.30	6.7	

														PANEL 2Q/A									
														VOLTAGE: 208Y/120V,3PH,4W BUS RATING: 225 A. MAIN: 150 A. MCB						10k AIC RATING 4/5/2004 1:48 AM			
LOAD (VOLT AMPS)				C N K O T	LOAD SERVED	CB			PHASE			CB			LOAD SERVED	C N K O T	LOAD (VOLT AMPS)						
LTG	REC	MOTOR	HEAT			AMP/P	A	B	C	AMP/P	A	B	C	AMP/P			A	B	C	LTG	REC	MOTOR	HEAT
		1392		1	FCU	15/1	*	-	-	15/1			15/1	FCU	2				1392				
		1392		3	FCU	15/1	-	*	-	15/1			15/1	FCU	4				1392				
		1392		5	FCU	15/1	-	-	*	15/1			15/1	FCU	6				1392				
		1392		7	FCU	15/1	*	-	-	15/1			15/1	FCU	8				1392				
		696		9	FCU	15/1	-	*	-	15/1			15/1	FCU	10				1392				
		1392		11	FCU	15/1	-	-	*	15/1			15/1	FCU	12				1392				
		1392		13	FCU	15/1	*	-	-	15/1			15/1	FCU	14				1392				
		1392		15	FCU	15/1	-	*	-	20/1			20/1	SPARE	16								
				17	SPARE	15/1	-	-	*	20/1			20/1	SPARE	18								
		696		19	EF-15	15/1	*	-	-	15/1			15/1	FCU-8	20				696				
		696		21	EF-16	15/1	-	*	-	15/1			15/1	EF-9	22				528				
				23	SPARE	15/1	-	-	*	---			---	SPACE	24								
		696		25	EF-40	15/1	*	-	-	15/1			15/1	EF-50	26				864				
		864		27	EF-48	15/1	-	*	-	15/1			15/1	EF-51	28				864				
		864		29	EF-49	15/1	-	-	*	15/1			15/1	EF-52	30				696				
		696		31	EF-54	15/1	*	-	-	20/1			20/1	SPARE	32								
				33	SPARE	20/1	-	*	-	20/1			20/1	SPARE	34								
				35	SPARE	20/1	-	-	*	20/1			20/1	SPARE	36								
				37	SPARE	20/1	*	-	-					SPACE	38								
				39	SPARE	20/1	-	*	-					SPACE	40								
				41	SPARE	20/1	-	-	*					SPACE	42								
0	0	14952	0	FEEDER SIZE: SEE ONE LINE DIAGRAM												0	0	13392	0				
SUB TOTALS				FED FROM: _____ ISOLATION GROUND BUS PANEL 2PQ/A _____ 200 % NEUTRAL MOUNTING: _____ FEED-THRU LUGS SURFACE _____ SHUNT TRIP MAIN CB LOCATION: _____ OUTDOOR ENCLOSURE ELEC. EQUIP. 258 _____ STAINLESS STEEL COVER FOOTNOTES: (1) = SHUNT TRIP CB (2) = GROUND FAULT CB (3) = DEMAND FACTOR FROM NEC 70, ARTICLE 220												SUB TOTALS							
PHASE LOADING																PANEL TOTALS							
0	0	12000	0													0	0	28344	0				
0	0	9216	0													0	0	2834	0				
0	0	7128	0													0	0	2834	0				
A	B	C														0	0	2834	0				
12000	9216	7128		TOTALS												0	0	2834	0				
Project Name: LANCASTER C.H. Project Number: 20254.00																							
														CONNECTED KVA TOTALS				0.00	0.00	28.34	0.00		
														DEMAND FACTOR				1.25	(3)	1.00	1.00		
														ADJUSTED KVA TOTALS				0.00	0.00	28.34	0.00		
														TOTAL CONNECTED KVA				28.34					
														TOTAL ADJUSTED KVA				28.34					
														THREE PHASE VOLTAGE				208					
														TOTAL PANEL									
														ADJUSTED AMPERAGE				79					

														PANEL 3Q/A									
														VOLTAGE: 208Y/120V,3PH,4W BUS RATING: 225 A. MAIN: 150 A. MCB						10k AIC RATING 4/5/2004 1:48 AM			
LOAD (VOLT AMPS)				C N K O T	LOAD SERVED	CB			PHASE			CB			LOAD SERVED	C N K O T	LOAD (VOLT AMPS)						
LTG	REC	MOTOR	HEAT			AMP/P	A	B	C	AMP/P	A	B	C	AMP/P			A	B	C	LTG	REC	MOTOR	HEAT
		696		1	FCU-9	15/1	*	-	-	15/1			EF-28	2					528				
				3	SPARE	20/1	-	*	-	15/1			EF-29	4					864				
				5	SPACE		-	-	*	15/1			EF-30	6					696				
		864		7	EF-32	15/1	*	-	-	15/1			SPARE	8									
				9	SPACE		-	*	-	15/1			FCU	10					1392				
				11	SPACE		-	-	*	15/1			FCU	12					1392				
		1392		13	FCU	15/1	*	-	-	15/1			FCU	14					1392				
		1392		15	FCU	15/1	-	*	-	15/1			FCU	16					1392				
		1392		17	FCU	15/1	-	-	*	15/1			FCU	18					1392				
		1392		19	FCU	15/1	*	-	-	15/1			FCU	20					1392				
		1392		21	FCU	15/1	-	*	-	15/1			FCU	22					1392				
		696		23	FCU	15/1	-	-	*	15/1			FCU	24					1392				
				25	SPARE	20/1	*	-	-	15/1			FCU	26					696				
				27	SPARE	20/1	-	*	-	20/1			SPARE	28									
				29	SPARE	20/1	-	-	*	20/1			SPARE	30									
				31	SPACE		*	-	-				SPACE	32									
				33	SPACE		-	*	-				SPACE	34									
				35	SPACE		-	-	*				SPACE	36									
				37	SPACE		*	-	-				SPACE	38									
				39	SPACE		-	*	-				SPACE	40									
				41	SPACE		-	-	*				SPACE	42									
0	0	9216	0	FEEDER SIZE: SEE ONE LINE DIAGRAM												0	0	13920	0				
SUB TOTALS				FED FROM: _____ ISOLATION GROUND BUS PANEL 3PQ/A _____ 200 % NEUTRAL MOUNTING: _____ FEED-THRU LUGS SURFACE _____ SHUNT TRIP MAIN CB LOCATION: _____ OUTDOOR ENCLOSURE ELEC. EQUIP. 360 _____ STAINLESS STEEL COVER FOOTNOTES: (1) = SHUNT TRIP CB (2) = GROUND FAULT CB (3) = DEMAND FACTOR FROM NEC 70, ARTICLE 220												SUB TOTALS							
PHASE LOADING																PANEL TOTALS							
0	0	8352	0													0	0	23136	0				
0	0	7824	0													0	0	2314	0				
0	0	6960	0													0	0	2314	0				
A	B	C														0	0	2314	0				
8352	7824	6960		TOTALS												0	0	2314	0				
Project Name: LANCASTER C.H.																							
Project Number: 20254.00																							
														CONNECTED KVA TOTALS		0.00	0.00	23.14	0.00				
														DEMAND FACTOR		1.25	(3)	1.00	1.00				
														ADJUSTED KVA TOTALS		0.00	0.00	23.14	0.00				
														TOTAL CONNECTED KVA		23.14							
														TOTAL ADJUSTED KVA		23.14							
														THREE PHASE VOLTAGE		208							
														TOTAL PANEL									
														ADJUSTED AMPERAGE		64							

														PANEL 2Q/A									
														VOLTAGE: 208Y/120V,3PH,4W BUS RATING: 225 A. MAIN: 150 A. MCB						10k AIC RATING 4/5/2004 1:43 AM			
LOAD (VOLT AMPS)				C N K O T	LOAD SERVED	CB			PHASE			CB			C N K O T	LOAD (VOLT AMPS)							
LTG	REC	MOTOR	HEAT			AMP/P	A	B	C	AMP/P	LOAD SERVED			LTG		REC	MOTOR	HEAT					
		1753		1	WSHP	20/1	*	-	-	20/1	WSHP	2			1753								
		1753		3	WSHP	20/1	-	*	-	20/1	WSHP	4			1753								
		1753		5	WSHP	20/1	-	-	*	20/1	WSHP	6			1753								
		1753		7	WSHP	20/1	*	-	-	20/1	WSHP	8			1753								
		1753		9	WSHP	20/1	-	*	-	20/1	WSHP	10			1753								
		1753		11	WSHP	20/1	-	-	*	20/1	WSHP	12			1753								
		1753		13	WSHP	20/1	*	-	-	20/1	WSHP	14			1753								
		1753		15	WSHP	20/1	-	*	-	20/1	WSHP	16			1753								
		1753		17	WSHP	20/1	-	-	*	20/1	WSHP	18			1753								
		696		19	EF-15	15/1	*	-	-	15/1	FCU-8	20			696								
		696		21	EF-16	15/1	-	*	-	15/1	EF-9	22			528								
		0		23	SPARE	15/1	-	-	*	---	SPACE	24											
		696		25	EF-40	15/1	*	-	-	15/1	EF-50	26			864								
		864		27	EF-48	15/1	-	*	-	15/1	EF-51	28			864								
		864		29	EF-49	15/1	-	-	*	15/1	EF-52	30			696								
		696		31	EF-54	15/1	*	-	-	20/1	WSHP	32			1753								
		1753		33	WSHP	20/1	-	*	-	20/1	WSHP	34			1753								
		1753		35	WSHP	20/1	-	-	*	20/1	WSHP	36			1753								
		1753		37	WSHP	20/1	*	-	-	20/1	WSHP	38			1753								
		1753		39	WSHP	20/1	-	*	-	20/1	WSHP	40			1753								
		1753		41	SPARE	20/1	-	-	*	20/1	WSHP	42			1753								
0	0	27301	0	FEEDER SIZE: SEE ONE LINE DIAGRAM										0	0	29943	0						
SUB TOTALS				FED FROM: _____ ISOLATION GROUND BUS PANEL 2PQ/A _____ 200 % NEUTRAL MOUNTING: _____ FEED-THRU LUGS SURFACE _____ SHUNT TRIP MAIN CB LOCATION: _____ OUTDOOR ENCLOSURE ELEC. EQUIP. 258 _____ STAINLESS STEEL COVER FOOTNOTES: (1) = SHUNT TRIP CB (2) = GROUND FAULT CB (3) = DEMAND FACTOR FROM NEC 70, ARTICLE 220										SUB TOTALS									
PHASE LOADING														PANEL TOTALS									
0	0	19425	0											0	0	57244	0						
0	0	20482	0											0	0	5724	0						
0	0	17337	0											0	0	5724	0						
A	B	C												0	0	5724	0						
19425	20482	17337												0	0	5724	0						
Project Name: LANCASTER C.H.														CONNECTED KVA TOTALS									
Project Number: 20254.00														DEMAND FACTOR									
														ADJUSTED KVA TOTALS									
														TOTAL CONNECTED KVA									
														TOTAL ADJUSTED KVA									
														THREE PHASE VOLTAGE									
														TOTAL PANEL									
														ADJUSTED AMPERAGE									

LOAD (VOLT AMPS)				C N K O T	LOAD SERVED	CB AMP/P	PHASE			CB AMP/P	LOAD SERVED	C N K O T	LOAD (VOLT AMPS)				
LTG	REC	MOTOR	HEAT				A	B	C				LTG	REC	MOTOR	HEAT	
		696		1	FCU-9	15/1	*	-	-	15/1	EF-28	2			528		
				3	SPARE	20/1	-	*	-	15/1	EF-29	4			864		
				5	SPACE		-	-	*	15/1	EF-30	6			696		
		864		7	EF-32	15/1	*	-	-	15/1	SPARE	8					
				9	SPACE		-	*	-	20/1	WSHP	10			1753		
				11	SPACE	15/1	-	-	*	20/1	WSHP	12			1753		
		1753		13	WSHP	20/1	*	-	-	20/1	WSHP	14			1753		
		1753		15	WSHP	20/1	-	*	-	20/1	WSHP	16			1753		
		1753		17	WSHP	20/1	-	-	*	20/1	WSHP	18			1753		
		1753		19	WSHP	20/1	*	-	-	20/1	WSHP	20			1753		
		1753		21	WSHP	20/1	-	*	-	20/1	WSHP	22			1753		
		1753		23	WSHP	20/1	-	-	*	20/1	WSHP	24			1753		
		1753		25	WSHP	20/1	*	-	-	20/1	WSHP	26			1753		
		1753		27	WSHP	20/1	-	*	-	20/1	WSHP	28			1753		
		1753		29	WSHP	20/1	-	-	*	20/1	WSHP	30			1753		
		1753		31	WSHP	20/1	*	-	-	20/1	WSHP	32			1753		
		1753		33	WSHP	20/1	-	*	-	20/1	WSHP	34			1753		
		1753		35	WSHP	20/1	-	-	*	20/1	WSHP	36			1753		
		1753		37	WSHP	20/1	*	-	-	20/1	WSHP	38			1753		
		1753		39	WSHP	20/1	-	*	-		SPACE	40					
				41	SPACE		-	-	*		SPACE	42					
0	0	26102	0	FEEDER SIZE: SEE ONE LINE DIAGRAM								0	0	28383	0		
SUB TOTALS				FED FROM: _____ ISOLATION GROUND BUS PANEL 3PQ/A _____ 200 % NEUTRAL MOUNTING: _____ FEED-THRU LUGS SURFACE _____ SHUNT TRIP MAIN CB LOCATION: _____ OUTDOOR ENCLOSURE ELEC. EQUIP. 360 _____ STAINLESS STEEL COVER FOOTNOTES: (1) = SHUNT TRIP CB (2) = GROUND FAULT CB (3) = DEMAND FACTOR FROM NEC 70, ARTICLE 220								SUB TOTALS					
PHASE LOADING												PANEL TOTALS					
0	0	19618	0									0	0	54485	0		
0	0	18394	0									0	0	54.49	0.00		
0	0	16473	0									0	0	54.49	0.00		
A	B	C										0	0	54.49	0.00		
19618	18394	16473		TOTALS								0	0	54.49	0.00		
Project Name: LANCASTER C.H.																	
Project Number: 20254.00																	
												CONNECTED KVA TOTALS	0.00	0.00	54.49	0.00	
												DEMAND FACTOR	1.25	(3)	1.00	1.00	
												ADJUSTED KVA TOTALS	0.00	0.00	54.49	0.00	
												TOTAL CONNECTED KVA	54.49				
												TOTAL ADJUSTED KVA	54.49				
												THREE PHASE VOLTAGE	208				
												TOTAL PANEL					
												ADJUSTED AMPERAGE	151				