Final Report

Mechanical System Redesign

The Salvation Army Ray & Joan Kroc Corps Community Center of Salem Oregon

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The Ray & Joan Kroc Corp Community Center

Salem, Oregon

Project Info

Owner:	Salvation Army
Size:	92,000 SF
Floors:	1
Cost:	$33.3 Million
Delivery Method:	Design-Bid-Build

Project Team

Contractor:	LCG Pence Construction, LLC
Architect:	BRS Architecture
Assistant Architect:	CB2 Architects
M and P Engineer:	GLUMAC International
Electrical Engineer:	Reese Engineering
Structural Engineer:	Miller Consulting Engineers

Architectural Summary

- The Kroc Center contains a competition pool, a leisure pool, a full-size gymnasium, a large chapel / theater, a full-size kitchen, a rock wall, a large fitness area, and supporting rooms.
- A defining characteristic of the Kroc Center is the large wooden canopies that cover the exterior entrances.

Structural System Summary

- The gymnasium, pools, and fitness area all have concrete block walls will a steel roofing structure.
- The remainder of the building has a steel structure withblock sheer walls.
- The large canopies that surround the building employ a wood structure.

Mechanical System Summary

- The two pools are conditioned by large air handling units on the roof, and the hot water for the pools is heated by three boilers in a nearby mechanical room.
- Packaged rooftop units condition the rest of the spaces, and most of them take advantage of VAV boxes to reduce the energy usage.
- Two fan coil units are used to condition the support spaces behind the chapel / theater.
- All the ventilation is provided through the air distribution systems.

Electrical System Summary

- The building has a 480V 3 phase underground electrical feed which enters into a main distribution room.
- The power is then distributed to a mechanical room and three smaller electrical rooms.
- Each smaller room has a panel to supply 480V power and a separate panel that supplies 208V power.

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Executive Summary

This thesis analyzed two major changes to the existing mechanical system and the effects those changes would have on the rest of the building. A dedicated outdoor air system was installed in all areas of the building except for the pools. The ventilation rates were lowered to more closely meet ASHRAE standards. An energy recovery wheel was installed on the DOAS units to precondition the incoming air, and the DOAS units now supply air at room neutral conditions to further decrease the required load. These techniques provided more accurate ventilation while reducing energy use.

The second change was using ground source heat pumps to condition the building, instead of the combination of gas furnaces and DX cooling currently being used. The new system uses water to provide heating and cooling, and uses the steady temperature of the ground as a heat sink. The ground source heat pumps eliminate the need to burn natural gas, and still manage to lower the total building's electrical demand. Extra piping and excavation will be required to install the GSHP system, but the energy savings offset that cost.

As a result of the above changes, the existing air handlers were replaced with heat pumps. The heat pumps use the water from the GSHP system to provide heating and cooling to the building. The existing air handlers were consolidated into eight heat pumps and two large air handlers for the pools.

The cost of the pool water heating was also reduced as a result of the changes in the mechanical system. The new pool air handlers recover energy using a dehumidification coil to collect energy and preheat the water during the cooling seasons. Excess heat in the building water loop during the heating season will completely cover the heating needs of the pools during the winter. The use of these energy saving techniques helped cut the pool utility costs in half.

With the changing of the mechanical equipment, the electrical system had to be adjusted to handle the new loads. Overall, the electrical demand on the building was reduced by over thirty percent. Each panel board was analyzed for load changes, and the differences in wire sizing led to over $86,000 in savings.

The structural system was analyzed to see if it could support the weight of the new mechanical equipment. The structural system had to be changed only slightly to accommodate the new loads. Two joists were increased in size to handle the weight of one of the heat pumps, and the cost of the change was less then $100.

As a result of all of these changes, the energy use in the building was reduced dramatically. The annual utility costs dropped from $141,404 to $69,944. That is an annual savings of $71,460, or about fifty-one percent. Natural gas usage for the boilers and air handlers was reduced from 48,000 therms to just under 6,600 therms, an eighty-six percent reduction. The additional initial costs to change the mechanical, electrical, and structural systems were calculated at $530,828, less then two percent of the total building construction cost. From the additional investment and the annual savings, a simple payback of 7.43 years was calculated.

The Kroc Center was built and is operated by the Salvation Army. This facility was meant to service the community of Salem, Oregon for the next several decades, so making a change that will pay for itself in seven and a half years is a good option. The proposed mechanical system reduces natural gas usage, saves energy, and saves money. It accomplished all three goals of this thesis; it was very successful.

Building Summary

The Salvation Army Ray & Joan Kroc Corps Community Center of Salem Oregon is a new construction project located in Salem, Oregon. The Kroc Center is a one story, ninety-two thousand square foot multi-use facility located on a ten and a half acre campus in the middle of the city. The building was named after Ray and Joan Kroc, the founders of McDonalds. When the Kroc's passed away, they donated over $1 billion to the Salvation Army to build community centers in different cities across the country. The total cost of construction was approximately $33.3 million, and construction was completed in September 2009.

The Kroc Center contains a number of large, energy-intensive spaces including a full-size gymnasium, competition pool, leisure pool, large chapel, commercial size kitchen, and rooms to host community events. The Kroc Center also has several offices, classrooms, small recreation rooms, and support spaces. The different building features enable the Kroc Center to be used year round by children, teens, families and adults from the community.

Existing System Description

Twelve packaged rooftop units supply the majority of air to the Kroc Center. The equipment and the building areas they serve are summarized in Table 1 below. Also including in the chart are the scheduled heating and cooling loads given in the design documents.

Unit	Areas Served	Scheduled (MBH)	
		Cooling	Heating
AHU-1	Competition Pool	802.8	922
AHU-2	Leisure Pool	609.6	737
RTU-1	North Office Wing	763	697
RTU-2	Office Wing	208	284
RTU-3	Chapel	240	410
RTU-4	Climbing Wall	192	284
RTU-5	Gym - North	202	284
RTU-6	Gym - South	202	284
RTU-7	Aerobics Room	60	104
RTU-8	Fitness Center	265	324
RTU-9	Wet Multi-Purpose Room	79	120
RTU-10	Locker Rooms	119	202

TABLE 1 – Major Equipment Summary

AHU1 and AHU2

Two large air handlers condition the competition pool and leisure pools. Though slightly different sizes, the two units operate the same way. First, the return air from the building is pulled by the return fan into the air handling unit and through a sound trap. A fraction of the return air is exhausted and passes through a heat exchanger to help precondition the entering outside air. The outside air and remainder of the return air mix and pass through the cooling and heating coils. The cooling coil is a DX system with the compressor, evaporator, and expansion valve housed in the air handling unit. The heating coil uses hot water supplied from the boilers in the mechanical room to heat the air. After passing through the coils, the supply air flows through a filter and into the supply fan. The supply air then travels through the supply air ducts and is distributed into the space.

Rooftop Units

There are ten packaged rooftop units that supply air to the remainder of the spaces in the Kroc Center. The RTU's are very similar with only small differences between them; so only a typical RTU will be explained. All of the rooftop units have economizers that can use more outside air to condition the space when the outside air is in the desired temperature range. The economizers are capable of producing up to 100 percent outside air. The return air enters the air handler from the bottom of the unit and passes through a sound trap before entering the economizer section of the unit. Once the correct mixture of return and outside air is achieved, the air passes through the cooling coil and the heat exchanger. The cooling coil is a DX unit, the same as what is in AHU-1 and AHU-2. The rooftop units, however, use a heat exchanger instead of a heating coil. A small natural gas burner is located in the unit which heats air that passes through the heat exchanger and conditions the supply air. After passing through the heat exchanger, the air flows through a filter, supply fan, and sound trap before leaving the unit. RTU1, RTU2, and RTU10 have variable frequency drives (VFDs) on the supply fans, because the loads they condition can fluctuate greatly throughout a day. The supply air from these three units passes through VAV boxes with reheat coils before entering the spaces they are conditioning. The other rooftop units have constant speed fans and do not use VAV boxes.

Hot Water Distribution

Three natural gas boilers are located in the mechanical room on the southern side of the Kroc Center. These boilers supply hot water to AHU1, AHU2, and the four heat exchangers that heat the pools. Smaller boilers are located in the building to provide domestic hot water, but they will not be analyzed in the report.

Proposed System Description

The current mechanical system satisfies the building loads and takes steps to conserve energy, but there is opportunity for improvement. The mechanical system will be completely redesigned, focusing on three key changes. First, the natural gas boilers and furnaces will be replaced with ground source heat pumps. Second, a dedicated outdoor air system will be installed to provide better ventilation control and additional energy savings. Lastly, the current air handlers will be consolidated since the ventilation will now be handled separately. The goal of the proposed changes is to eliminate the use of natural gas, save energy, and reduce annual utility costs.

Dedicated Outdoor Air System

In an effort to reduce energy usage, a dedicated outdoor air system (DOAS) will be installed. In a DOAS setup the outdoor air is only conditioned to meet room neutral temperatures which will result in significant energy savings. Also, the outdoor air units will utilize energy recovery units to capture energy from the exhaust air and precondition the incoming outdoor air. A DOAS system is more expensive to install and will require extra ductwork but the energy that is saved will offset the additional costs. The DOAS system will provide more accurate ventilation control by supplying outside air to each room based on its specific needs. A DOAS setup will eliminate some wasted energy and provide a healthier indoor environment.

Ground Source Heat Pumps

Ground source heat pumps will replace two of the three natural gas boilers in the mechanical room and the need for gas furnaces in the air handlers. The heat pumps work by rejecting heat into the earth during the cooling season and collecting heat from the earth during the heating season. The ground wells will supply hot and cold water to the new air heat pumps. Using ground source heat pumps will reduce energy costs, eliminate natural gas usage, lower emissions, and lengthen the life of the entire mechanical system. Part of the Kroc Center campus is undeveloped land that will provide an excellent place for the well field to be drilled.

Air Handler Consolidation

Because all of the outdoor air requirements will now be handled by the DOAS system, the current air handlers need to be resized to more closely satisfy the building loads. As part of the resizing, the current mechanical system will be consolidated to use fewer units. Fewer units will simplify the system and hopefully lower initial costs. This design will reduce the number of major air handlers from fourteen to ten.

Electrical Breath

The changes in the mechanical system will require completely new air handling units, energy recovery units, and water pumps. This equipment has very different electrical requirements than the current equipment so the entire electrical system will be resized. New electrical loads will be tallied and all of the new wires will be sized according to the National Electric Code (NEC). The electrical voltages at different parts in the building will be determined based on equipment needs and wire cost. All of these steps will be used to create an efficient electrical system.

Structural Breadth

All of the new mechanical equipment will be located on the roof of the building where the current mechanical equipment is located. In the new design, new pieces and amounts of equipment will be located above the building. As a result most of the structural system will need to be analyzed to determine if it needs resized. Some parts of the building will require more support, while some parts may allow for some support to be removed. Hopefully the total cost for the structural changes will be insignificant. The current structural system will be retained, but the individual members will be evaluated and resized when necessary.

Mechanical Depths

Dedicated Outdoor Air System

Evaluation of Existing Ventilation System

The ventilation system that was designed and installed in the Kroc Center far exceeded minimum ventilation standards and was not concerned with saving energy. The ventilation airflow was calculated using an older design standard based solely on occupancy. The design occupant density and ventilation rates were both very high compared to the ASHRAE standards. The new system was redesigned using the ventilation and occupant density standards established in ASHRAE Standard 62.1. The changes reduced the ventilation load and lowered the total building load substantially.

Previously, the outdoor air was mixed with the return air before being distributed to the building. This process does not guarantee homogenous mixing of the two airstreams, nor does it account for different amounts of ventilation within each room. Instead each room gets roughly the same percentage of outdoor air regardless of what it needs oftentimes resulting in over ventilating. A dedicated outdoor air system ensures that each room receives the exact amount of outdoor air it needs. Doing so eliminates the waste of over ventilating while enhancing the air quality in each space.

Evaluation of Dedicated Outdoor Air System

The proposed dedicated outdoor air system will eliminate the problems mentioned with the existing system, but the reduction in energy usage is the greatest benefit of the dedicated outdoor air system. An enthalpy wheel will be installed on each of the DOAS units to reclaim energy from the exhaust air and transfer it to the incoming outdoor air. This preconditions the air and can eliminate a large portion of the coil loads. Another energy saving strategy of DOAS units is supplying air at room neutral conditions. During the summer when the outdoor temperature is 92° F, the incoming outdoor air will be cooled to 74° F instead of the typical supply temperature of 55° F. Doing so could reduce the cooling load by nearly half at peak loads. Supplying at room neutral temperature and using the energy recovery wheel will lower the heating and cooling loads on the building, thus saving energy.

Ventilation and Exhaust Calculations

As mentioned above, the ventilation and exhaust rates for each room where determined using ASHRAE Standard 62.1. The ASHRAE standard was closely followed, but a few spaces needed to be changed, usually in regards to occupancy density. The construction documents show that the chapel has 288 seats, so the exact occupancy was used to determine its ventilation. Some spaces like the community rooms are not listed in the default spaces that ASHRAE gives, so some judgment was necessary to determine an appropriate occupancy. The ventilation and exhaust rates were calculated in Excel; the spreadsheet can be found in Appendix A.

The gymnasium, aerobics room, and fitness area were exhausted, even though they are not required to by ASHRAE. These rooms were exhausted to help control odor and humidity in these high activity areas. Exhausting them also helps maintain the proper building pressurization.

Another area that deviated from ASHRAE standards was the locker room. The central locker room is surrounded by fifteen smaller cabanas which each have a toilet and shower and require about 200 CFM of exhaust. Normally this much exhaust would create a very strong draft through the locker room since such a large volume of air is being exhausted. To solve this problem, 2200 CFM of outdoor air is supplied to the central locker room to create a smaller airflow difference of less than 100 CFM between the locker room and each of the cabanas.

For calculating the proper building pressurization, I wanted a net positive pressure equal to 20 to 50 CFM for each window and door. These values were suggested to me by a local mechanical engineer; they ensure the air leaks out of the building at a manageable rate. Using these guidelines, I tweaked the ventilation and exhaust rates to get a total pressurization near the bottom end of that range. With the pools being negatively pressurized, I wanted to make sure that the rest of the building was positively pressurized so the smells and chemicals from the pools would not drift into other parts of the building. By exhausting the gymnasium, aerobics room, and fitness area; the net building pressurization was 4740 CFM, which is between the calculated values of 4090 CFM and 10225 CFM. The full pressurization calculations can be found in Appendix A. the image below shows which areas of the building are positively pressurized (green) and which areas are negatively pressurized (red). Areas that are not colored are not conditioned.

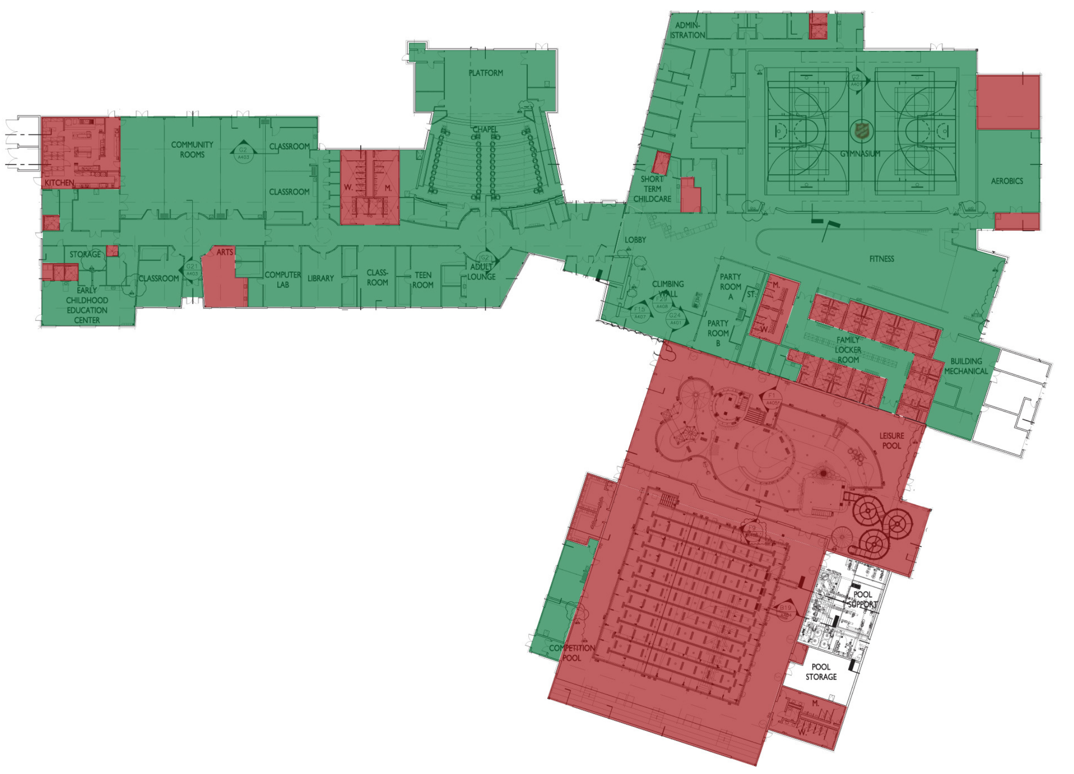

Figure 1 – Building Pressurization

Building Layout

The Kroc Center is a long, narrow building with heavily ventilated spaces at one end, and heavily exhausted spaces at the other end. The most difficult part of laying out the new DOAS units was balancing the ventilation and exhaust on each unit to determine the economic viability of using energy recovery wheels. After several preliminary setups, it was determined that the best layout would require three DOAS units. Figure 2 below shows which sections of the building each unit covers; the units are labeled as energy recovery ventilators (ERVs). The total ventilation and exhaust of each unit is included in Table 2 below:

Figure 2 – ERV Layout

Ventilation & Exhaust Summary		
Equipment	Ventilation	Exhaust
ERV 1	5740	3410
ERV 2	5970	4920
ERV 3	6775	3765

Table 2 – ERV Ventilation & Exhaust

DOAS Unit Selection

The DOAS equipment that was selected for all three units was Carrier 62DC16 w/ ecw. The outdoor air units were selected based on airflow, because each unit far exceeds the required heating and cooling loads. See Table 3 below for a comparison of the design and selected capabilities of the units. The ecw at the end of the product name stands for energy conservation wheel. All of the units will be placed on the roof and will have a single water connection that supplies both hot and cold weather.

Design vs. Selected Capacities						
	Design Load (MBH)		Selected Load (MBH)		Design	Selected
	Cooling	Heating	Cooling	Heating	CFM	CFM
ERV 1	57	112	198	320	5740	6500
ERV 2	95	131	198	320	5970	6500
ERV 3	60	129	201	350	6775	6500

Table 3 – Design vs. Selected Capacities

Pool Ventilation

The original plan was to connect the pools to the dedicated outdoor system, but it was later decided not to proceed with this plan because the exhaust air from the pools contains airborne chemicals that are extremely corrosive. Instead of trying to take this air and run it back through an energy wheel, it is better to exhaust it directly outside. The pool exhaust would eventually corrode an energy wheel and possibly contaminate the incoming outdoor air. The energy savings from using dedicated outdoor air would not outweigh the potential problems. Instead, the pool ventilation is mixed with the supply air and later exhausted directly outdoors.

Ground Source Heat Pumps

Evaluation of Existing Mechanical System

In the existing system, three natural gas boilers supply hot water to the pools as well as the two pool air handlers. All of the other rooftop units have self-contained natural gas furnaces to heat the air. The rooftop units and the pool air handlers all use a DX cooling system to provide the necessary cooling energy. This system is efficient and easily meets the building loads, but it requires a large amount of natural gas. In the city of Salem, electricity prices are very comparable to natural gas prices, so the benefit of burning natural gas is diminished. The current system is more then adequate, but a better system might be available.

Evaluation of GSHP System

Ground source heat pumps (GSHP) use the ground as a heat sink to provide the necessary heating and cooling loads for the building. GSHP systems do not require any natural gas usage, only electricity to pump the water. In Salem, Oregon the low electricity rates make GSHPs an extremely attractive option. The outdoor air is being supplied by the DOAS units now, so the loads on the air handlers are reduced. The existing air handlers need to be removed and replaced with smaller heat pumps. The heat pumps are less expensive then the existing air handlers which could help offset some of the additional cost of the well field. Besides initial cost, there do not appear to be any hindrances to installing a ground source heat pump system.

Site Investigation

Before ground source heat pumps could be seriously considered, it was necessary to determine if there was adequate room on site for the well field. The construction documents state that the building was on a ten and a half acre site, and a quick check on bing maps confirmed that there was enough space for a well field. The image below shows the constructed building and about half of the campus land area. Even from this section of the map, one can see that there is adequate room to install a GSHP system.

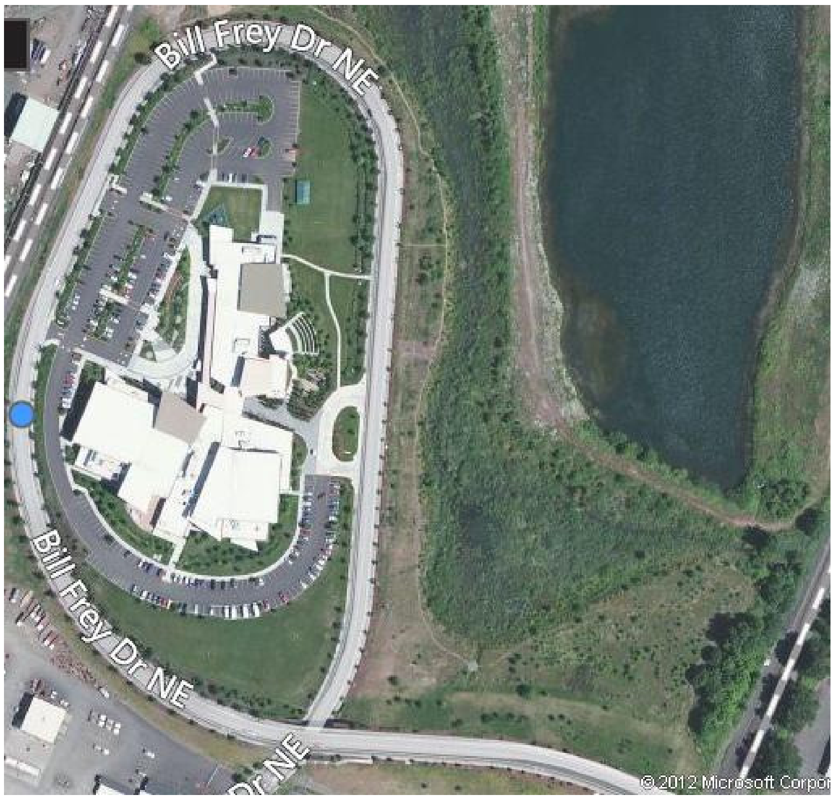

Figure 3 – Site Plan

There are two ponds on the Kroc Center property; only one is visible on this portion of the map. At first, it was believed that the surface water might be usable as a heat sink and could replace some of the wells. Using surface water is cheaper and more efficient then pumping the water into the ground. After further investigation, it was determined that the ponds serve only as retention ponds for the area. The ponds are most likely not deep enough to provide quality year round heat transfer, so the use of surface water heat exchangers was quickly dismissed.

Load Calculations

After determining that a GSHP system was a possibility, the loads on the heat pumps were calculated in TRANE Trace assuming no ventilation. The mechanical system was designed to the strictest ASHRAE standards, meeting the heating and cooling demands 99.6% of the year. Once the loads were determined, each room was assigned to one of eight heat pumps, except for the two pool rooms. The peak heating and cooling loads were determined for each heat pump, and these were added to the peak heating and cooling loads of the DOAS units and pool air handlers to find the total heating and cooling loads on the building. The equipment loads are summarized in Table 4 below. The peak cooling and heating loads for the building were determined to be 2360 MBH and 1175 MBH respectively.

Heating and Cooling Loads		
	Cooling	Heating
HP 1	253	59
HP 2	135	29
HP 3	289	75
HP 4	143	43
HP 5	295	85
HP 6	270	63
HP 7	80	26
HP 8	68	46
ERV 1	57	112
ERV 2	95	131
ERV 3	60	129
AHU 1	423	182
AHU 2	192	195
Totals	2360	1175

Table 4 –Load on Well Field

After the design load was determined, the next step was sizing the well field. I was given access to the program GLHE Pro (the GLHE stands for ground loop heat exchangers), which is used by industry professionals to aid in sizing GSHP systems. The software allows the user to enter several variables including the ground temperature based on the location in the country. I also selected a 6” bore width, 1” piping in the wells, and 20’ spacing between the wells. Using fifteen foot well spacing increased the necessary total length of wells by a few hundred feet, so twenty foot spacing was used instead. After selecting water as the fluid type and entering the building loads, the program calculated that 27,808 feet of total well length was needed to transfer the desired load. A preliminary well field was laid out with ninety-six 300’ deep wells, which is a typical depth for this type of application. This gives a total well length of 28,800 feet, approximately 3.6% larger then designed. The extra length will help account for some efficiency losses in the system.

Site Layout

With the well field sized, it was time to locate it on the property. The wells were laid out in parallel so each well is transferring energy with only a small volume of water. The well field is arranged into eight branches with twelve wells on each branch. The well field and the individual branches use a reverse return system. This ensures an equal pressure change over the whole system, regardless of the actual path of the water. The well field was placed across the road from the building. The image below shows the layout of the well field in relation to the building. Green lines on the drawing represent the supply water coming from the building, and the red lines represent the conditioned water returning to the building. The piping runs into the mechanical room located on the south side of the building.

Figure 4 –Layout of Well Field

Primary / Secondary Piping System

Another key decision is how the piping system will distribute the conditioned water to the mechanical equipment. A primary / secondary loop configuration was chosen for this building. Because the well field is located away from the building, the building is long, and the mechanical room is located at one end of the building, a primary / secondary system works well. Piping water that entire distance would create high friction losses; resulting in high head losses on the pumps. By using the primary / secondary setup, the frictional head loss is cut roughly in half which allows smaller pumps to be used. It also provides a quicker response to load changes, since the conditioned water travels a shorter distance. The drawback of this piping setup is that heat exchangers are required to transfer energy between the primary loop and the secondary loop. Considering the other benefits though, a primary / secondary loop is still the best option.

Determine Water Flow

The next step in the design process was determining the water flow in the primary and secondary loops. Knowing the max load on each piece of mechanical equipment, I worked backwards from that peak load to determine the water flow in GPM necessary to satisfy the load. Assuming a ten degree temperature change, the necessary water flow for each unit was determined using the equation q = 500*GPM*delta T. The results are summarized in Table 5. The total flow for all of the units is 474 GPM. Over time, the ground temperature will rise slowly, decreasing the heat transfer rate as a result of the smaller temperature change. The water flow for the Kroc Center was purposely oversized so that in twenty years the well field will still easily meet the building loads. Over sizing the flow by ten percent yields a flow rate of 521.4 GPM which was rounded up to 525 GPM. A ten degree temperature change was also assumed between the primary and secondary loops so both loops have a flow rate of 525 GPM.

Required Flow Rates			
	Cooling Load	Flow Rate	GPM Used
HP 1	253	50.6	50
HP 2	135	27	27
HP 3	289	57.8	58
HP 4	143	28.6	29
HP 5	295	59	59
HP 6	270	54	54
HP 7	80	16	16
HP 8	68	13.6	14
AHU 1	423	84.6	85
AHU 2	192	38.4	39
ERV 1	57	11.4	12
ERV 2	95	19	19
ERV 3	60	12	12
		Total	474

Table 5 – Water Flow Rates

Sizing Pumps

To size your pumps you must know the flow rate and the head loss of the system. Because there is no net elevation changes, the only sources of head loss are friction, heat exchangers, and the net positive suction head on the pump. On the primary loop, the friction loss was assumed to be the same throughout the whole system. For full flow through a 6” pipe, the head loss is 1.81 ft. / 100 ft. To calculate the total equivalent length of the pipe, take the physical length of the pipe and add equivalent lengths for each of the fittings, these calculations can be found in Appendix A Multiply the total equivalent length by the frictional head loss rate to get a head loss of 54 ft. Add five feet of head loss for the heat exchangers, which comes from the heat exchanger catalog (Appendix A). This gives a total head loss of 59 feet plus net positive suction head with a flow rate of 525 GPM. After looking at Bell & Gossett pump curves, a Series 80 5x5x9 pump with a 15 hp motor is the best fit for this system. The pump curves are also found in Appendix A.

Next, calculate the head loss on the secondary loop pump. Find the frictional head loss by finding the longest total equivalent length in the system and multiply by the same friction loss rate. The frictional head loss in the secondary system is 30 feet. Add in a 5 foot head loss for the heat exchanger and conservatively estimate a 25 foot head loss through the heat pumps. This yields a total head loss of 60 ft. plus net positive suction head. This is essentially the same as the primary loop, so the same pump was chosen.

On both loops, two pumps were installed in parallel. Each pump is sized to handle the entire water flow in the loop. If one pump breaks or needs maintenance, the water flow can be diverted to the other pump; ensuring that the building will remain conditioned even in the event of a breakdown.

Sizing Pipes

With the flow rate known, the piping can now be sized. Assuming an equal amount of water flowing into each branch of the well field and each individual well yields a flow of roughly 5.5 GPM through each well. With that assumption, the flow rates were determined after every connection in the well field. Using these calculated flow rates and a Bell and Gossett System Syzer Calculator, the pipe size was determined for each piece of pipe in the primary loop.

The following diagram shows a single line diagram of the well field layout. The diagram is not to scale, but it shows how the different components of the well field are connected to each other. The sizes shown on the first branch of the well field are typical of all eight branches.

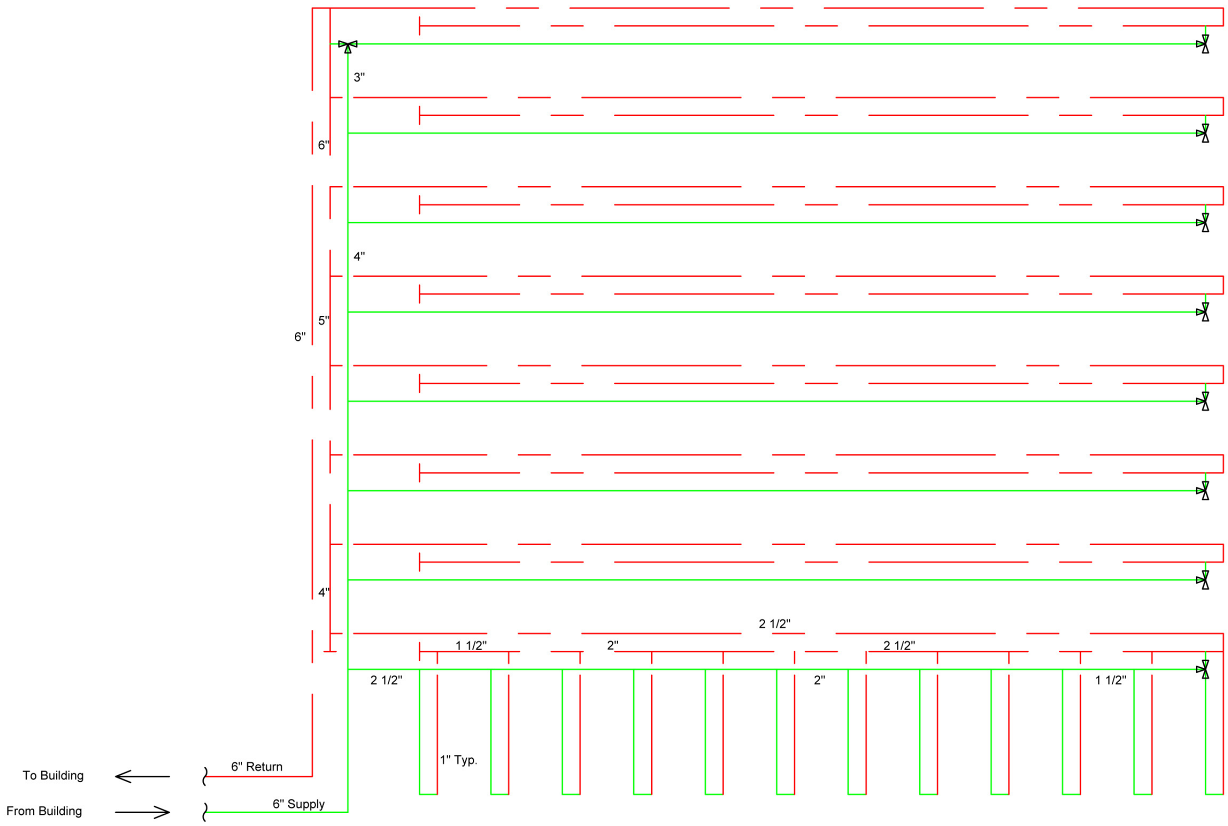

Figure 5 – Well Field Piping Diagram

Heat Exchangers

The only item left to size on the primary loop is the heat exchangers. To conserve space in the crowded mechanical room, Bell & Gossett brazed plate heat exchangers were used. From the selection tables in the B&G catalog (Appendix A), the BP422-80 with a flow rate of 90.9 GPM was chosen. The heat exchanger was chosen based on flow rate since the output of the heat exchangers is well above the required amounts. Divide the total flow of the system by the max flow through each heat exchanger to find that six heat exchangers are necessary. Placing the six heat exchangers in parallel allows the same water flow through each heat exchanger, producing an efficient heat transfer.

At this point the primary loop is completely sized. The following piping diagram shows the portion of the primary loop located inside the building.

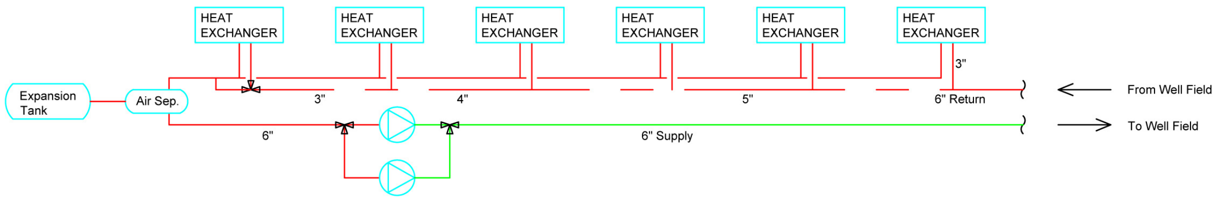

Figure 6 – Primary Loop Piping Diagram

Consolidated Air Handling System

Evaluation of Existing Air Handlers

The existing air handlers were designed to handle the ventilation loads and to heat using natural gas. After installing the DOAS and GSHP systems, the systems are now oversized and incompatible. The ten rooftop units were removed and replaced with water-source heat pumps. The two small outdoor heat pumps were removed and not replaced. The two large pool air handlers are being replaced with slightly smaller but more sophisticated pool units; they will be discussed in the next section.

Evaluation of New Heat Pumps

Hot and cold water is supplied to the heat pumps from the secondary piping loop (building loop). The water enters the heat pump and heat is exchanged with a refrigerant loop within the unit. The refrigerant is then compressed or expanded to reach its desired temperature, before it flows through a coil in the air stream of the heat pump. Using water as the heating and cooling source provides a very efficient transfer of energy to the heat pumps which conditions the building while keeping costs down. Another benefit of heat pumps is they do not use natural gas; they are run completely by electricity. One of the goals of this project was reducing or eliminating natural gas usage within the building; the heat pumps accomplish that goal.

Calculating Building Loads

To calculate the new building loads, the original Trace model had to be adjusted. First, water source heat pumps were chosen to replace the existing gas-fired air handlers. Because the building was already modeled and the heat pumps are only handling the building load, not much had to be done to the energy model. After making the changes mentioned above, the Trace model was rerun and the new results were obtained. The peak cooling load on each unit was determined by taking the space load at full capacity with all of the lights and equipment on. The heating load was determined by taking the load on each space with no occupants and the lights off. Doing so guarantees the highest heating and cooling loads to achieve the most accurate peak loads.

Building Layout

The next step was determining how many heat pumps would be used and what spaces each would condition. The proposed plan was to use seven heat pumps to condition the entire building. It was decided to keep the two pools on their own dedicated air handlers because they would still be providing outside air. This left five heat pumps from the original proposal.

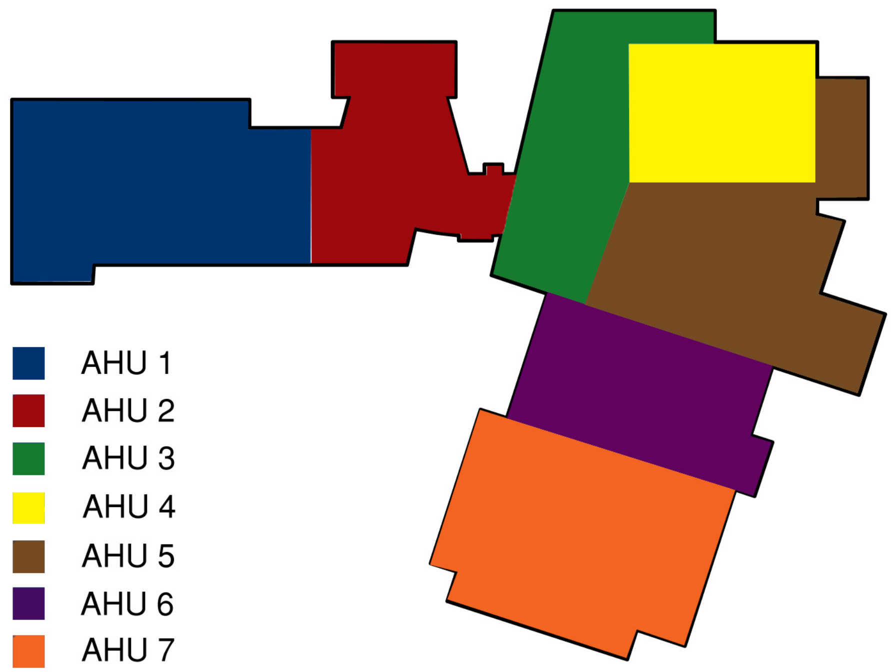

Figure 7 – Original HP Layout

After some investigation, the largest readily available heat pump had a max cooling capacity of only twenty-five tons. Two heat pumps had to be divided to decrease their loads to under twenty-five tons. The heat pump that served the wing of the building with the kitchen, community rooms, and classrooms were located had to be split. The kitchen and a few classrooms were separated from the rest of the spaces, and the two resulting heat pumps were small enough. The other area that needed split was the gymnasium and fitness areas. The gymnasium was given its own heat pump, and the fitness area and aerobics room were put on their own heat pump. The area on the north side of the competition pool, which had a few small multi-purpose rooms and offices, at this point was still unconditioned. A small heat pump was added to condition this space and provide ventilation, since it is isolated from the dedicated outdoor air system.

After adding the last heat pump, the final heat pump distribution was established. The following image shows the final location of each of the heat pumps and the different areas that they condition. It should be noted that the two twenty-five ton units (HP3 and HP5) are located inside the building while the rest are mounted on the roof.

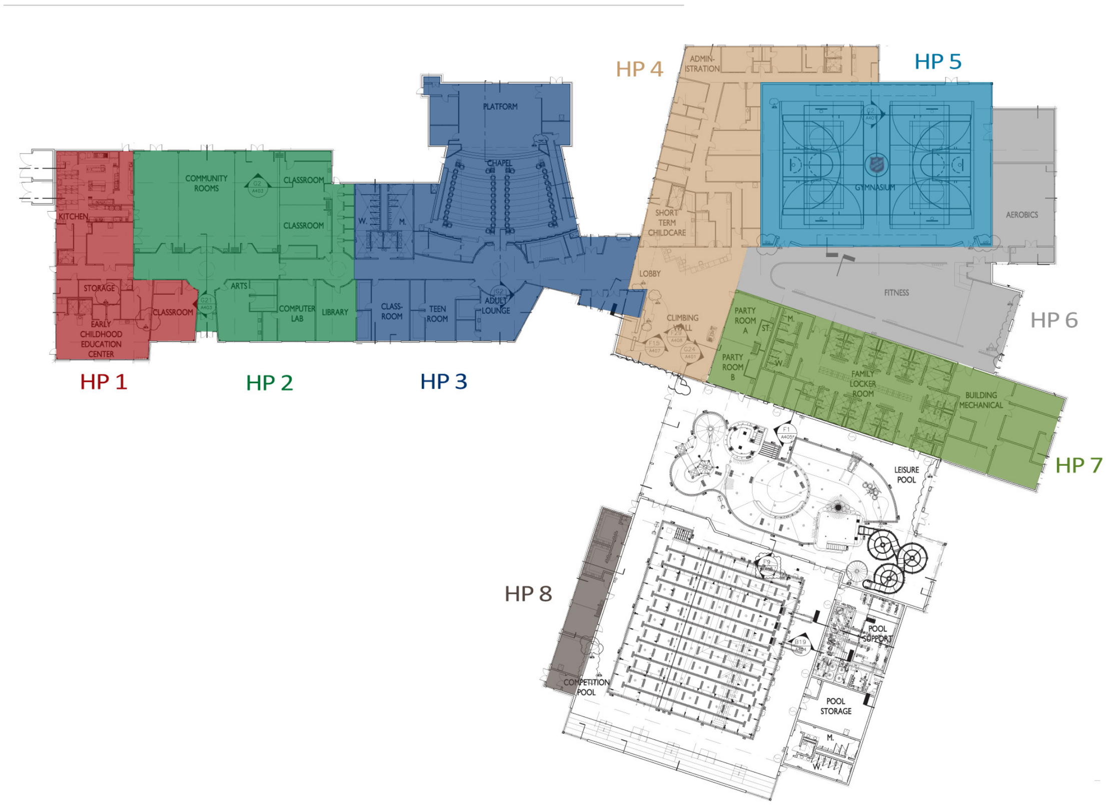

Figure 8 – New Heat Pump Layout

Selecting Heat Pumps

Cooling loads dominate the air handling equipment, and were used as the determining factor for selecting the heat pumps. As a result, the heating capacities of the heat pumps are well above the designed heating load. The existing mechanical system is located on top of the building, so rooftop heat pumps were selected. Unfortunately, the rooftop units are only manufactured up to 20 tons, so two 25 ton units had to be installed inside the building. Luckily there are large storage spaces in the areas of the building that each heat pump conditions, so they can be placed inside without having to make any architectural changes. The design capacities and selected capacities are summarized in Table 6 below. The manufacturer information for each of the heat pumps is listed in Appendix A.

Heat Pump Selection					
	Model	Design Load (MBH)		Selected Load (MBH)	
		Cooling	Heating	Cooling	Heating
HP 1	50RTP20	253	59	264	229
HP 2	50RTP14	135	29	189	168
HP 3	50 VQP300	289	75	345	312
HP 4	50RTP14	143	43	189	168
HP 5	50VQP300	295	85	345	312
HP 6	50RTP20	270	63	264	229
HP 7	50RTP08	80	26	114	98
HP 8	50RTP05	68	46	76	62

Table 6 – Heat Pump Selection

Water Source Heat Pumps

Two water source heat pumps are installed at the end of the supply water line. These pumps are used to preheat the pool water before it enters the boiler. Since the cooling load for the building is much larger then the heating load, there is excess heating available during the winter months. Instead of wasting the heat, it will be used to condition the pool water. The water conditioning is virtually free; the only energy required is the electricity to run the heat pumps.

Piping Diagram

Designing the secondary piping loop, or building loop, was pretty straightforward. We already knew the flow rate of the entire loop and the flow rates required for each heat pump. The building loop also provides the hot and cold water to the dedicated outdoor air units and the two pool air handlers. The secondary piping system uses a reverse return system like the primary loop, so there is a consistent pressure drop across the entire loop. At the end of the supply water line, there is a three-way valve that will allow any excess supply water to flow into the return water line. This is shown in Figure 9 below.

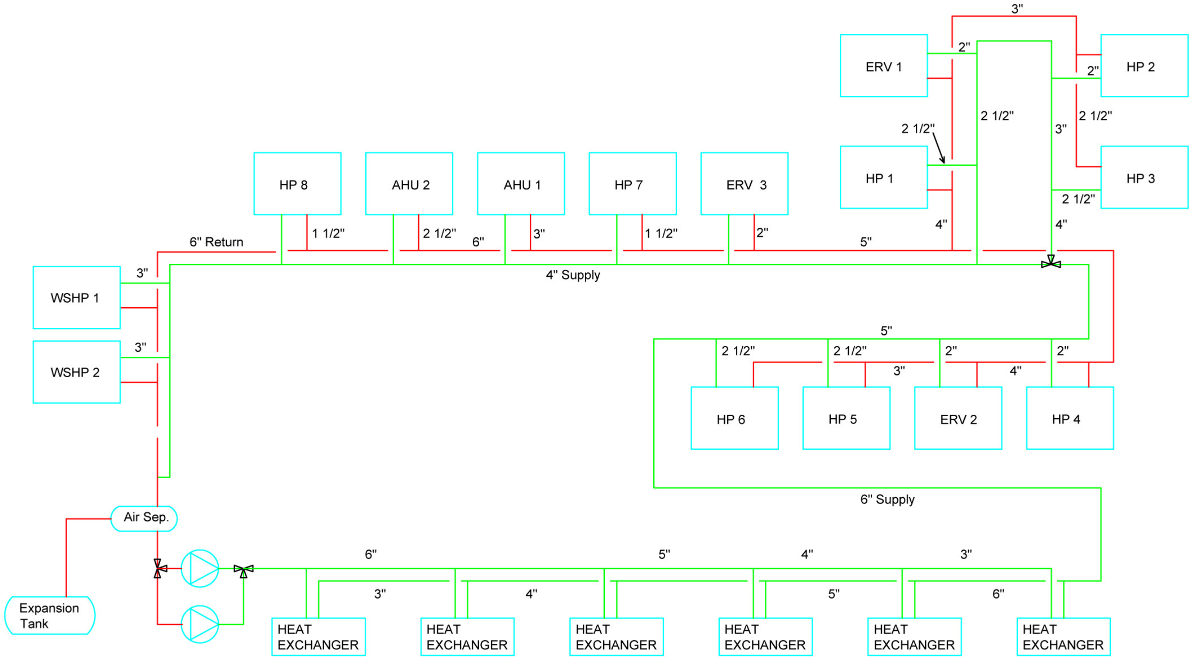

Figure 9 – Building Loop Piping Diagram

The return lines were sized based on the max possible flow through each heat pump, but the supply lines was sized based on the minimum flow. This means that both water lines are designed for the highest possible flow at any load condition. All the piping was sized using design flow rates and the Bell and Gossett System Syzer Calculator.

Energy Calculation

With the new system in place, the Trace model was run to calculate the energy usage and estimated energy costs. Trace gives the electric consumption, electric demand, and natural gas usage on a month by month basis. Using the utility rates given in Table 7 below, the total energy cost for the building was calculated.

Utility Rates							
Electric Demand ($/kw)			Elec. Consumption ($/kwh)			Natural Gas ($/therm)	
First 50 kw	$0.00		First 3000 kwh	$0.0748		Constant	$1.2923
Over 50 kw	$6.11		Next 17,000 kwh	$0.0610			
			Over 20,000 kwh	$0.0464			

Table 7 – Utility Rates

The energy usage is pretty consistent over the entire year, which makes sense since the same amount of water is being pumped when the system is in heating mode and cooling mode. Natural gas usage has been completely eliminated from the primary air handling equipment. Below is the chart showing the new energy calculation, the old energy calculation is included in Appendix A.

Energy Costs by Month and Type						
	EC (kwh)	ED (kw)	Gas (therms)	EC ($)	ED ($)	Gas ($)
January	91045	158	0	$ 4,569	$ 660	$ -
February	83161	159	0	$ 4,203	$ 666	$ -
March	90291	156	0	$ 4,534	$ 648	$ -
April	86814	156	0	$ 4,372	$ 648	$ -
May	87493	163	0	$ 4,404	$ 690	$ -
June	84823	170	0	$ 4,280	$ 733	$ -
July	90464	178	0	$ 4,542	$ 782	$ -
August	89637	179	0	$ 4,503	$ 788	$ -
September	84044	169	0	$ 4,244	$ 727	$ -
October	86880	153	0	$ 4,376	$ 629	$ -
November	88553	159	0	$ 4,453	$ 666	$ -
December	93232	159	0	$ 4,670	$ 666	$ -

Individual Costs:	$ 53,150	$ 8,303	$ -
Total Energy Cost:	$ 61,454		

Table 8 – Monthly Energy Costs

Pool Water Loop

The pool water loop was attached to three natural gas boilers, two 2000 MBH units and one 1000 MBH unit. These boilers also supplied hot water to the two large air handling units during the heating season. In the new mechanical system, the air handlers' hot water is supplied by ground source heat pumps, but the pool water still needs heated. The solution is to reduce the number of boilers and use energy recovery techniques to further reduce the heating load.

Pool Energy Recovery

Dectron is a leader in the design of air handlers constructed specifically for use in natatoriums. The units are built to handle the harsh environments created by the contaminants in the pool areas. The Dectron units have a built in energy recovery system to help with pool heating. When the pool is in cooling mode, warm humid air will pass through a dehumidification coil causing the moisture to condense. The heat captured by this process is combined with heat generated by the compressor and is available for use as heating. Dectron provides a calculator to determine the evaporation load of the pools and the amount of energy that can be recovered. The manufacturer claims that this system can save up to eighty percent of the evaporation load. The calculations were performed and are summarized in Table 9. Because it recovers heat from a dehumidification coil, this energy recovery technique is only available when the air handler is in cooling mode. However, it still produces significant energy savings.

Pool Energy Recovery Calculations						
	Leisure Pool	Comp. Pool	Whirl Pool	Spray Pad Pool		Totals
Step 1	84	80	104	86		
Step 2	85	83	85	85		
Step 3	0.043	0.034	0.144	0.051		
Step 4	0.058	0.047	0.158	0.065		
Step 5	10	10	10	10		
Step 6	14	14	14	14		
Step 7	1	0.8	1	1		
Step 8	0.052	0.033	0.152	0.059		
Step 9	3582	6243	194	1951		
Step 10	185.37	207.68	29.52	115.43		
Step 11	1,786,210,866	2,001,241,097	284,457,932	1,112,323,630		
Gas	$ 28,854.00	$ 32,327.55	$ 4,595.06	$ 17,968.20		$ 83,744.81
Savings	$ 23,083.20	$ 25,862.04	$ 3,676.05	$ 14,374.56		$ 66,995.85
					Total Energy Cost	$ 16,748.96

Table 9 – Dectron Energy Calculation

GSHP Preheating

As previously mentioned, the building piping loop is connected to two water-to-water heat pumps. The heat pumps use the available energy during the heating season to preheat the pool water before it enters the boiler. From the results above we can estimate the pool evaporation load to be 592 MBH, the detailed calculations are shown in Appendix A; the pool heating load is pretty consistent throughout the entire year. It makes sense to design the heat pumps to cover the entire load, since there is plenty of heating energy available. Two thirty ton water-to-water heat pumps were selected, and they will be capable of meeting the entire heating load of the pool while the building is in heating mode.

Piping Diagram

The energy recovery techniques make it necessary to create a third piping loop. The proposed pool loop is shown in the drawing below. The water returning from the pool heat exchangers first passes through the pool dehumidification recovery, because this heating requires no energy to produce. Next the loop will pass through the heat pumps from the building loop. The energy from the heat pumps requires very little energy to produce, but it is extra energy so it is beneficial to use it to heat the pool water. After passing through the two energy recovery systems, the water will enter the boiler to raise the water temperature if necessary. Then the water will be flow from the boiler to the pool heat exchangers.

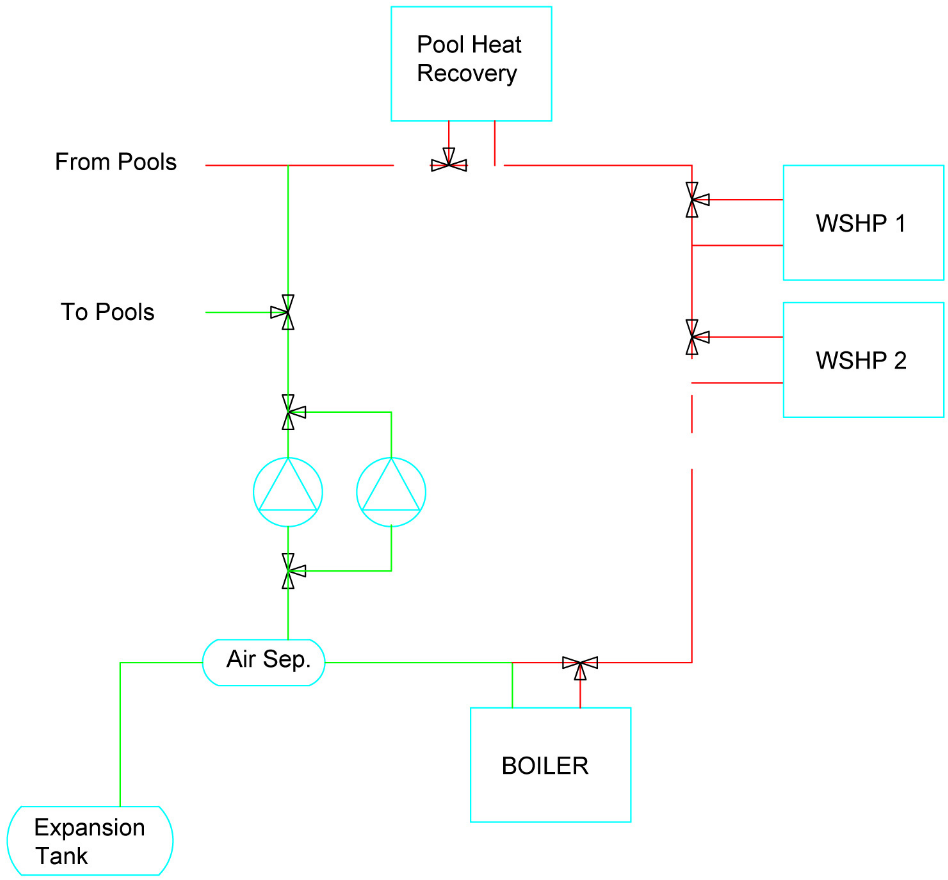

Figure 10 – Pool Loop Piping Diagram

Boiler Reduction

With the new pool heating system in place, there is no need for three boilers. The 1000 MBH boiler and one of the 2000 MBH boilers will be removed, leaving only one 2000 MBH boiler. As seen in Table 10 below, the potential max heating load on the boiler is only 120MBH. So why have such an oversized boiler? For the initial heating of the pool. When the pools are first filled, the water will be below room temperature. The design temperatures for the pools vary slightly, but the water is always above 80° F. If the boiler only supplied 120 MBH of heat, it would take several days or weeks for the water in all the pools to rise to the desired temperatures. Using the large boiler will heat the pools up in a few hours and still be able to handle the full pool load if necessary. This setup will reduce the number of boilers while still achieving the required amount of heating.

Annual Utility Cost

The annual utility cost for the pool heating calculated in Table 9 assumed that the unit is dehumidifying all year long. However, because a two pipe system is being used for all of the mechanical equipment, the dehumidification recovery can only be used while the building is in cooling mode. When the building is in heating mode, the water-to-water heat pumps will provide all of the energy necessary to heat the pool water. Another utility cost calculation was performed under the assumptions that the building is in cooling mode six months of the year, and the boiler is eighty percent efficient. Table 10 below shows the adjusted annual rate.

Energy Costs for Pool					
	Total (MBH)	Recovered	Load on Boiler	Therms	Cost
Heating	592	720	0	0	$ -
Cooling	592	472	120	6570	$ 8,490.41
				Total:	$ 8,490.41

Table 10 – Pool Energy Costs

New Mechanical System Summary

Building Impact

By combining a dedicated outdoor air system with the ground source heat pumps, the annual utility costs were cut in half. The new system can be installed in place of the existing system with little to no changes inside the building, the one exception being the extra ductwork for the DOAS units. The primary air handlers no longer require natural gas, and the rooms are more accurately ventilated. The visible changes to the building are very minimal, but the energy results are quite substantial.

Material Cost of New Piping

One big part of the new mechanical system that has not been mentioned yet is the cost of the extra piping. The mechanical system has to pump 525 GPM of water several hundred feet from the building, down 300 feet into the ground, then back to the building. There is a large amount of piping necessary to make this system work. The piping was sized previously, now the lengths had to be determined. Because the proposed design is not finalized, the piping lengths had to be estimated based on rough location of heat pumps and ground wells. The lengths of each size pipe were tallied and are summarized in Table 11 below. The cost of the pipe is given in dollars per lineal foot of pipe, and discounts were given for ordering large quantities of each size of pipe. The prices and discount rates were obtained from Global Technology and Engineering's website. An extra ten percent was added to the price to account for pipe fittings.

Piping System Costs							
Size	Material	Length	$ / L.F.	Fitting Factor	20' Units	Unit Factor	Cost
1.5"	Steel	1340	$7.70	1.1	67	0.95	$ 10,775.31
2"	Steel	1520	$8.42	1.1	76	0.95	$ 13,378.30
2.5"	Steel	4435	$10.62	1.1	222	0.90	$ 46,628.70
3"	Steel	650	$13.72	1.1	33	1.00	$ 9,808.01
4"	Steel	865	$21.06	1.1	44	0.95	$ 19,036.66
5"	Steel	495	$35.80	1.1	25	1.00	$ 19,491.74
6"	Steel	1615	$43.06	1.1	81	0.95	$ 72,667.07
						Totals	$ 191,785.79

Table 11 – Piping Costs

Mechanical System Cost

Excluding the well field and the extra piping, the cost of the new mechanical system is less then the existing system. A pricing analysis was performed on each piece of mechanical equipment being removed and each piece being added. The summary of those calculations is given in Table 12 below, but the detailed pricing of each category of mechanical equipment is available in Appendix A. The pricing for all of the mechanical units was taken from the RS Means 2012 handbook. The negative numbers represent savings.

Mechanical System Summary	
Equipment	Cost
Rooftop Units	$ (237,000.00)
VAV Boxes	$ (18,585.00)
Boilers	$ (57,700.00)
Heat Pumps	$ 214,000.00
Outdoor Air Units	$ 70,500.00
Pumps	$ 8,000.00
Heat Exchangers	$ 14,100.00
Total	$ (6,685.00)

Table 12 – Mechanical Equipment Costs

Electrical Breadth

Evaluation of Existing Electrical System

Currently a 3000A, 480V feeder enters the building and connects to the Main Distribution Center (MDC) on the south side of the building near the mechanical system. From the MDC, an electrical feed goes out to one of five 3 phase 480V panel boards located in electrical rooms in each of the major sections of the building. The 480V panel boards each feed a smaller 208V panel board in the same rooms. The 480V panel boards power all equipment and some of the lighting in their respective sections of the building. The rest of the lighting and all of the receptacles are powered by the 208V panel boards. The two large air handlers that condition the pools and the packaged rooftop unit above the kitchen are wired directly to the MDC.

Load Changes on Panel Boards

There were six panel boards that changed from the old electrical system. It was necessary to look at each affected one to determine if the panel board is large enough to support the required electrical load and if there are enough open spaces to hook up the new units. For sizing the total demand on each panel board, the demand factors that were included on the bottom of the panel board schedules were used. The complete panel board schedules can be found in Appendix B, but a quick summary of the changes to each panel board will be provided below. The electrical data for the new equipment was taken from the equipment catalogs. All wire sizing was done using the NEC 2008 handbook.

Panel Board HMA

This panel board serves the north end of the building which contains the kitchen, community rooms, and classrooms. Seventeen series fan powered boxes were removed from the panel board. HP 1, HP 2, and ERV 1 were added to the panel board in place of the SFPBs. The electrical load was lowered enough that the panel board could be reduced from a 600A panel board to a 400A panel board. Also, the number of poles was reduced from 126 to 84. Lastly, the total demand on the panel board was reduced from 408A to 300A. Because there was such a large drop in ampacity the feeder size from the MDC to the panel board was also reduced. The original wire feed to this panel board was oversized to compensate for voltage drop, so the new feed wire was sized to be about 100A less then the previous wire. This reduced the feed wire from 2 sets of (4) 500 kcmil wire to 2 sets of (4) 350 kcmil wire. Since this panel board is the furthest from the MDC, this change result in a very large wire cost savings.

Panel Board HMB

This panel serves the middle part of the Kroc Center where the chapel and some multipurpose rooms are located. Two series fan powered boxes, RTU3, RTU4, and two small outdoor heat pumps were all removed from this panel board. HP 3 and ERV 3 were added to the panel board, and the other empty spaces on the panel board were filled with spares. The total demand on the panel board decreased from 324 A to 241 A, so the feeder wire to this panel board could also be reduced. The new wire was sized by multiplying the total demand by 1.25 as a safety factor. As a result, the feeder wire was reduced from 2 sets of (4) 250 kcmil wire to 1 set of (4) 350 kcmil wire.

Panel Board HMC

This panel board services the southeast corner of the building which contains the gymnasium, fitness area, aerobics room, and offices. Nine SFPBs were removed from this panel board as well as RTU2 and RTU5. HP 4 and ERV 2 were added in their place, and the rest of the open poles were designated as spares. The total demand on the panel board decreased from 322A to 231A, so the feeder wire for this panel board was reduced from 2 sets of (4) #3/0 wire to 1 set of (4) 300 kcmil wire.

Panel Board HMD

This panel board is located in the same room as the MDC and serves the locker rooms and the leisure pool room. RTU6, RTU7, RTU8, RTU10 and five SFPBs were removed from this panel board. AHU 1, HP 5, HP 6, HP 7, and four water pumps were added to this panel board. The total demand of this panel board increased from 250A to 365A. The current feeder wire is sized to handle a max ampacity of 400A. Though the load on this panel is pretty close to the max amount, the electrical load includes two backup pumps that will never run at the same time as the main pumps. Because the connected load will never approach the max panel board load, the current design is adequate and the feeder wire does not need resized.

Panel Board HAE

The competition pool and its supporting spaces are serviced by this panel board. RTU 9 was the only piece of equipment that had to be removed from this panel. HP 8 and AHU 2 were added to the panel and raised the total demand from 393A to 402A. The existing panel board and wire sizing are capable of handling the small increase in load, so no adjustments need to be made.

Panel Board LPD

This panel board supplies 208V power to the locker rooms, mechanical room, and leisure pool. Two natural gas boilers are being removed from the panel and nothing is being added. This slight reduction only drops the load from 261A to 252A. The panel board and wire sizes still meet the load and do not need to be changed.

Main Distribution Center

The MDC originally had a demand of 2496A. Because all the panel boards are fed from the MDC, the load changes in the panel boards will be reflected on the MDC. Also, AHU 1, AHU 2, and RTU 1 were directly wired to the MDC. Those three pieces of equipment were removed and placed on the panel boards, so their loads are completely removed from the MDC. After totaling the new electrical loads, the total demand was reduced from 2496A to 1711A. This reduction of over 780A dictates that the feed wire coming into the MDC should be reduced. It was dropped from 8 sets of (4) 500 kcmil wire to 6 sets of (4) 400 kcmil wire. This thirty-one percent load reduction on the MDC exemplifies the large reduction of overall energy consumption in the building.

Electrical Material Cost

To determine the change in cost to wire the new mechanical system, each piece of equipment was analyzed separately. For the existing equipment being removed, wire sizes were given in the construction documents, and the lengths were estimated from the floor plans. For the new equipment being added, the wire sizes were determined using the NEC 2008 handbook and the electrical data from the product catalogs. For the new equipment, it was assumed that each piece of equipment used four wires plus a ground wire. For each panel board, the total length of wire being added and subtracted was totaled for each size wire and multiplied by the price. The prices were taken from a price sheet from Southwire, which can be found in Appendix B. A summary of the wire changes for each panel board can also be found in Appendix B. The total cost changes were totaled for each panel board and summarized in Table 13 below. The table also shows the changes in demand.

Electrical System Change				
Box	**Old Demand (A)**	**New Demand (A)**	**Difference**	**Price Difference**
HMA	408	300	108	$ (30,940.88)
HMB	324	241	83	$ (10,959.59)
HMC	322	231	91	$ (3,140.75)
HMD	250	365	-115	$ 50.32
HAE	393	402	-9	$ 20.28
LPD	261	252	9	$ (55.14)
AHU 1(MDC)	244.5	0	244.5	$ (10,625.73)
AHU 2(MDC)	185.2	0	185.2	$ (4,239.29)
RTU1 (MDC)	188	0	188	$ (17,713.96)
Building Feed	2496	1711.3		$ (8,762.07)
			Total	$ (86,366.80)

Table 13 – New Electrical System Summary

Electrical System Summary

Overall, the electrical system did not change much. By using heat pumps instead of the big air handlers with DX cooling systems, the electrical demand for the air handlers was greatly reduced. Also, by removing all of the SFPBs the load was decreased and became less cluttered. One panel board had to be changed, but it was only reduced one size. A lot of wire was removed or reduced in size which resulted in large savings over the whole building. The negative number in Table 13 above shows how much money would be saved on the electrical system with the new mechanical system. These prices do not include savings in labor, which are significant. The cost savings from labor will be addressed later. Overall, the new electrical system will reduce initial costs and operating costs over the lifetime of the building.

Structural Breadth

Evaluation of Existing Structural System

The Kroc Center uses a steel superstructure with steel joists spanning the beams. All of the air handling units are mounted on the roof and are supported by the joists. The current structure was designed with a number of safety factors to ensure that it could easily support the weight of the existing air handlers. The roof live loads, dead loads, and equipment weights were given in the construction documents.

New Mechanical Equipment Layout

The first step in evaluating the new structural system is determining where the new mechanical equipment will be mounted on the roof. To limit any changes, the new mechanical equipment will be placed in the same locations as the old equipment whenever possible. The first image below shows the rooftop with the locations of the existing equipment. The second image shows the location of the new units. Please note that HP 3 and HP 5 are mounted indoors, not on the roof.

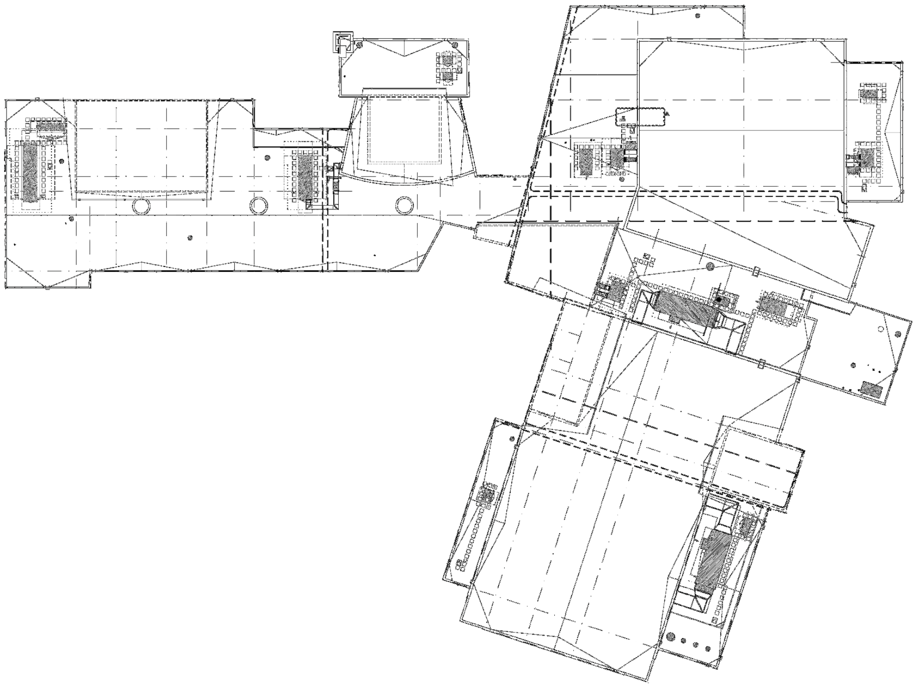

Figure 11 – Original Roof Layout

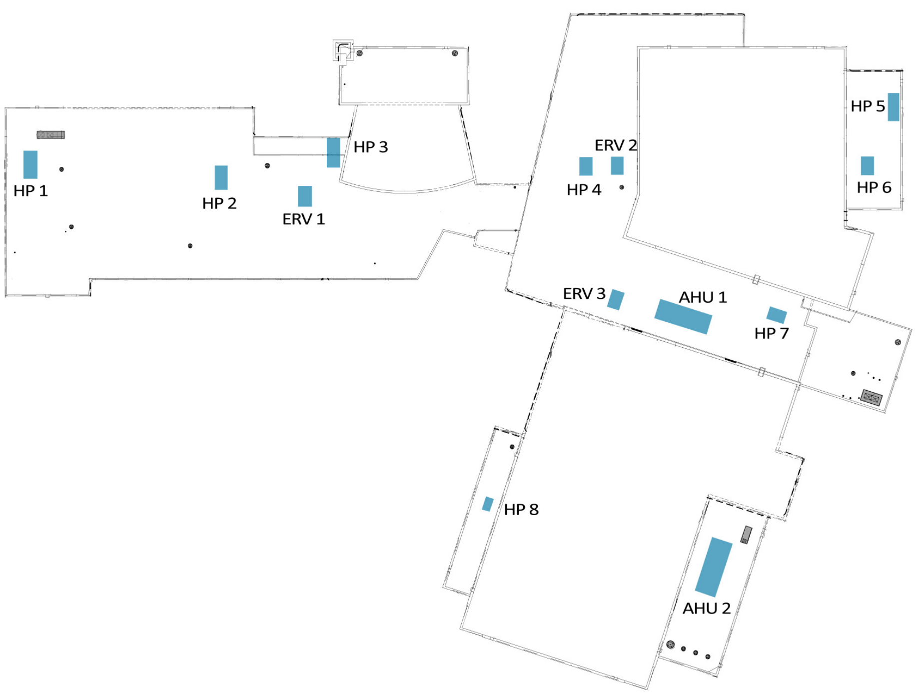

Figure 12 – New Roof Layout

As you can see, most of the new equipment aligns with existing pieces of equipment. The next step is to compare the weights of the old and the new equipment. If the new equipment weighs less then the old equipment, then the existing structural system will support it. If the new equipment weighs more then the old equipment then the structural members will need to be analyzed to see if they can support the added weight. Table 14 below shows the weight of each piece of equipment and the weight of the equipment replacing it. The weights of the new pool units were not available, so it was assumed that they were about the same as the existing pool units. HP 3, HP 5, and the water-to-water heat pumps were not included because they are mounted inside on the floor.

Structural Evaluation Summary				
Old Unit	Weight	Compliance	Weight	New Unit
RTU 1	11500	Yes	1960	HP 1
RTU 2	2750	Yes	1770	HP 4
RTU 3	6400	Yes	3205	ERV 1
RTU 4	2750	No	3205	ERV 3
RTU 5	2750	No	3205	ERV 2
RTU 6	2750	Yes	1960	HP 6
RTU 7	1050	Yes	-	-
RTU 8	3000	Yes	1080	HP 7
RTU 9	1500	Yes	835	HP 8
RTU 10	1700	Yes	-	-
AHU 1	30000	Yes	30000	AHU 1
AHU 2	29000	Yes	29000	AHU 2
OHP 1	400	Yes	-	-
OHP 2	400	Yes	-	-
-	-	No	1770	HP 2

Table 14 – Structural Analysis

Structural Member Analysis

As you can see, ERV 2 and ERV 3 weigh more then the existing equipment so a structural analysis was performed on the steel members in each section of the building. The calculations performed where taken from an example from an AE404 homework problem. The calculations are shown in detail in Appendix C, but both ERVs are supported by the existing structural system.

In Table 14 you can see that RTU 7, RTU 10, OHP 1, and OHP 2 are removed and not replaced by new equipment. They are smaller pieces of equipment, so removing their weight from the structural system does not justify using smaller joists. In those areas, the structural system will remain the same. HP 2 is the only piece of equipment that is being placed in a section of the building without an existing piece of mechanical equipment. A structural analysis was performed and the current joists were not large enough, so a new joist was selected. The two members were increased from 20K5 joists to 26K5 joists. The calculation can be found in Appendix C.

Structural Material Cost

The only change necessary in the entire structural system is changing the two joists under HP 2. Using RS Means, prices were found per lineal foot for steel joists, and the price change was calculated in Table 15 below. It would cost less then $100 to make the structural system compatible with the new mechanical system.

Structural Price Summary					
	Joist Size	Quantity	Length	Price/Lin. Ft.	Price Change
Remove	20K5	2	26	6.15	$ (319.80)
Add	26K5	2	26	7.95	$ 413.40
				Total	$ 93.60

Table 15 – Structural Cost Analysis

Structural System Summary

The existing structural system can support the new mechanical system with virtually no changes. By carefully choosing the locations of the heat pumps and outdoor air units, the existing system was used very efficiently. The results were much better then expected, considering the amount of equipment being replaced. The structural system is adequate and capable of supporting the new mechanical equipment.

Project Summary and Evaluation

Summary of Changes

This report analyzed two major changes to the mechanical system and the effects those changes would have on the rest of the building. A dedicated outdoor air system was installed everywhere in the building except for the pool areas. The DOAS units provide more accurate ventilation while saving energy. Changing the ventilation requirements to match ASHRAE standards reduce the total heating and cooling loads. An energy recovery wheel in the DOAS units preconditions the incoming air and further reduces the load on the equipment. Also, the dedicated outdoor air system supplies air at room neutral conditions instead of conditioning to the design temperatures of the heat pumps. This creates a smaller required temperature difference thus saving additional energy.

The second major change was using ground source heat pumps to condition the building. The existing system used natural gas to provide heating to the air handlers and DX systems to provide the cooling. The new system uses water to provide both heating and cooling, and uses the steady temperature of the ground to condition the water. Water is much better at storing and transferring energy then air is, so using the water reduces the energy usage. The ground source heat pumps eliminate the need to burn natural gas; instead they only require electricity to run the supply pumps and the heat pumps. Extra piping and excavation will be required to install the GSHP system, but the energy savings make it an economical option.

With the above two changes to the mechanical system, all of the air handlers needed replaced. The new heat pumps are more efficient and use the water from the GSHP system to condition the air. The heat pumps were sized based on the new heating and cooling loads calculated in Trace. The load on the heat pumps is smaller then the load on the existing units because the ventilation is now being handled by the DOAS units. The heat pump system reduces the total number of air handlers in the building.

The cost of the pool water heating was dramatically reduced as a result of the changes in the mechanical system. First, the new pool air handlers recover energy from a dehumidification coil to preheat the water during the cooling seasons. And the use of excess heat available in the building water loop during the heating season will completely cover the heating needs of the pools during the winter. The intelligent use of these available energy sources helped to cut the pool energy costs by more then half.

With the changing of the mechanical equipment, the electrical system had to be adjusted to handle the new loads. Overall, the electrical demand on the building was reduced by over thirty percent. Each panel board was analyzed for changes, and the changes in wire sizing led to significant savings in the electrical system.

The structural system was analyzed to see if it would be able to support the weight of the new mechanical equipment. The existing structural system needed to be changed only slightly to be able to accommodate the new loads. Two joists were increased in size to handle the weight of one heat pump; the remainder of the joists were able to handle the weight of the new mechanical equipment.

Energy Savings

Energy usage in the building was greatly reduced by these changes. Natural gas was eliminated for the airside equipment, and cut in half for the pool water heating. Overall, the large reduction in natural gas usage represents a significant savings. By using different energy recovery and savings techniques, the annual utility costs were cut by fifty-one percent. The spreadsheet below shows the energy savings for the mechanical equipment, the pool heating, and the total. The energy savings was better then expected; but considering all the different energy saving strategies used, the results seem accurate.

Annual Utility Cost			
	Building	Pool	Total
Existing System	$ 124,281.00	$ 17,123.00	$ 141,404.00
New System	$ 61,454.00	$ 8,490.00	$ 69,944.00

Total Savings	$ 71,460.00

Table 16 – Annual Utility Cost Savings

Initial Costs and Payback

Despite the large energy savings, the changes in the initial costs still need to be determined so the system payback can be calculated. The payback length for the proposed changes will determine whether or not the new mechanical system is economically feasible. The costs of the mechanical, plumbing, electrical, and structural changes were all calculated earlier in the report and are shown in Table 17.

When each of those values was calculated, labor was not included. Labor rates vary greatly based on location and are hard to estimate accurately. It was assumed the amount of labor that would be saved by installing less electrical wire and fewer pieces of mechanical equipment would offset the increased labor for the piping. Also, the money saved for material and labor on the natural gas piping in the building would offset the increased cost of ductwork.

Determining the cost of the well field was a difficult task as well. The cost of drilling wells varies tremendously from state to state, so a definite number was hard to find. An engineer at a local MEP firm suggested a price range of $12 to $20 per lineal foot. That price includes drilling the well, purchasing the pipe, installing the pipe, and grouting the well. For the cost analysis a price of $15 per lineal foot was used, since a 300 foot well is not excessively deep and would be on the low end of that price range. The price was multiplied by the total length of the wells to obtain the price of installing the well field.

Overall System Summary		
Unit	Cost	
Mechanical	$	(6,685.00)
Plumbing	$	191,786.00
Electrical	$	(86,367.00)
Structural	$	94.00
Well Field	$	432,000.00
Total	$	530,828.00

Table 17 – Initial Cost Summary

The new mechanical system has an additional initial investment of $530,828, but an annual energy savings of $71,460. To determine the simple payback, divide the change in initial investment by the annual savings. This calculation yields a simple payback of 7.43 years. The Kroc Center was built and is operated by the Salvation Army. This facility was meant to service the community of Salem, Oregon for the next several decades, so making a change that will pay for itself in seven and a half years is a good option.

Final Evaluation of Project

The proposed changes to the mechanical system were more successful then anticipated. The annual natural gas demand for the mechanical system and pool boilers was lowered from about 48,000 therms to just under 6,600 therms. That is an 86 percent reduction. The annual utility cost was dropped from $141,404 to $69,944, a reduction of 51 percent. These savings were accomplished with an additional initial investment of $531,000, which is less then two percent of the total construction cost. The proposed mechanical system reduces natural gas usage, saves energy, and saves money. It accomplished all three goals of this thesis; it was very successful.

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Appendix A – Mechanical Information

Ventilation Calculations

Ventilation Requirements									
Room	Description	ASHRAE Class	SF	SF/Occ	Occupants	CFM/Occ	CFM/SF	Total CFM	CFM Used
A101	Community Room	Multi-use Assembly	1100	10	110	7.5	0.06	891	900
A102	Community Room	Multi-use Assembly	1400	10	140	7.5	0.06	1134	1150
A103	Community Room	Multi-use Assembly	1110	10	111	7.5	0.06	900	900
A104	Storage	Corridors	115	0	0	0	0.06	7	0
A105	Classroom	Classrooms (age 9 plus)	550	30	19	10	0.12	256	260
A106	Classroom	Classrooms (age 9 plus)	570	30	19	10	0.12	259	260
A107	Storage	Corridors	110	0	0	0	0.06	7	0
A108	Hall	Corridors	1335	0	0	0	0.06	81	90
A119	Classroom	Classrooms (age 9 plus)	580	30	20	10	0.12	270	270
A120	Storage	Corridors	110	0	0	0	0.06	7	0
A121	Storage	Corridors	110	0	0	0	0.06	7	0
A122	Library	Libraries	575	100	6	5	0.12	99	100
A123	Computer Lab	Computer Lab	575	40	15	10	0.12	219	225
A124	Storage	Corridors	105	0	0	0	0.06	7	0
A125	Storage	Corridors	105	0	0	0	0.06	7	0
A126	Storage	Corridors	105	0	0	0	0.06	7	0
A127	Arts	Art Classroom	570	50	12	10	0.18	223	225
A128	Hall	Corridors	1215	0	0	0	0.06	73	75
A129	Classroom	Classrooms (age 9 plus)	560	30	19	10	0.12	258	260
A130	Storage	Corridors	100	0	0	0	0.06	6	0
A131	Early Childhood	Daycare (through age 4)	965	40	25	10	0.18	424	425
A132	Lobby	Corridors	140	0	0	0	0.06	9	25
A133	Office	Office Space	135	-	2	5	0.06	19	25
A135	Storage	Corridors	50	0	0	0	0.06	3	0
A136	Storage	Corridors	50	0	0	0	0.06	3	0
A137	Storage	Corridors	230	0	0	0	0.06	14	25
A142	Hall	Corridors	270	0	0	0	0.06	17	25
A143	Storage	Corridors	475	0	0	0	0.06	29	30
A145	Office	Office Space	100	-	2	5	0.06	16	25
A146	Kitchen	Kitchen (cooking)	1525	50	31	7.5	0.12	416	420
A147	Vestibule	Main Entry Lobbies	100	100	1	5	0.06	11	25
B101	Chapel	Auditorium Seating Area	2650	-	288	5	0.06	1599	1600
B102	Coat Room	Corridors	200	0	0	0	0.06	12	0
B103	Uniform Storage	Corridors	65	0	0	0	0.06	4	0
B104	Vestibule	Main Entry Lobbies	100	100	1	7.5	0.06	14	25
B105	Lobby	Lobbies/prefunction	3660	35	105	7.5	0.06	1008	1000
B106	Vestibule	Main Entry Lobbies	200	33	7	7.5	0.06	65	70
B107	Adult Lounge	Media Center	605	40	16	10	0.12	233	240
B108	Office	Office Space	115	-	2	5	0.06	17	25
B109	Storage	Corridors	110	0	0	0	0.06	7	0
B110	Teen Room	Media Center	570	40	15	10	0.12	219	220
B111	Office	Office Space	110	-	2	5	0.06	17	25
B112	Storage	Corridors	110	0	0	0	0.06	7	0
B113	Control Booth	Corridors	75	0	0	0	0.06	5	0
B117	Office	Office Space	130	-	2	5	0.06	18	25
B118	Band Storage	Corridors	205	0	0	0	0.06	13	25
B119	Platform	Music/Theater/Dance	1490	30	50	10	0.06	590	600
B120	Storage	Corridors	260	0	0	0	0.06	16	25
B121	Green Room	Corridors	130	0	0	0	0.06	8	0
B122	Hall	Corridors	90	0	0	0	0.06	6	0
B123	Storage	Corridors	20	0	0	0	0.06	2	0
C101	Gymnasium	Gym, stadium (play area)	9180	33	279	0	0.3	2754	2760
C102	Storage	Corridors	810	0	0	0	0.06	49	50
C103	Aerobics	Health Club/Aerobics Room	1270	25	51	20	0.06	1097	1100
C104	Storage	Corridors	180	0	0	0	0.06	11	0
C105	Storage	Corridors	75	0	0	0	0.06	5	0

C106	Supervisor	Office Space	50	-	2	5	0.06	13	25
C107	Fitness	Health Club/Weight Rooms	3220	100	33	20	0.06	854	860
C108	Hall	Corridors	2560	0	0	0	0.06	154	160
C109	Control Desk	Office Space	330	-	2	5	0.06	30	30
C110	Laundry Room	Laundry Rooms, Central	155	0	0	5	0.12	19	0
C111	Work Room	Office Space	245	-	2	5	0.06	25	25
C112	Meeting Room	Conference/Meeting	80	20	4	5	0.06	25	25
C113	Computer Room	Computer Lab	215	40	6	10	0.12	86	90
C114	Count Room	Office Space	55	-	2	5	0.06	14	25
C115	Childcare	Daycare (through age 4)	500	40	13	10	0.18	220	220
C116	Storage	Corridors	50	0	0	0	0.06	3	0
C118	Office	Office Space	105	-	2	5	0.06	17	25
C119	Corridor	Corridors	2080	0	0	0	0.06	125	125
C120	HR	Office Space	165	-	2	5	0.06	20	25
C121	Finance	Office Space	375	-	2	5	0.06	33	35
C122	Storage	Corridors	70	0	0	0	0.06	5	0
C123	Conference Room	Conference/Meeting	330	20	17	5	0.06	105	105
C125	Operations Dir.	Office Space	530	145	4	5	0.06	52	55
C131	County Coor.	Office Space	195	-	2	5	0.06	22	25
C132	Open Offices	Office Space	305	145	3	5	0.06	34	40
C133	Corp Officer	Office Space	195	-	2	5	0.06	22	25
C137	Exec. Director	Office Space	190	-	2	5	0.06	22	25
C138	Bus. Manager	Office Space	135	-	2	5	0.06	19	25
C141	Break Room	Breakrooms	235	20	12	5	0.12	89	90
D101	Climbing Wall	Lobbies/prefunction	405	35	12	7.5	0.06	115	115
D102	Storage	Corridors	135	0	0	5	0.06	9	0
D103	Party Room A	Classrooms (age 9 plus)	455	30	16	10	0.12	215	215
D105	Party Room B	Classrooms (age 9 plus)	455	30	16	10	0.12	215	215
D109	Locker Room	* Assumption 1	1270	50	26	5	0.06	207	2200
D127	Guard Room	Office Space	170	-	2	5	0.06	21	25
D128	Office	Office Space	120	-	2	5	0.06	18	25
D129	Aquatics Dir.	Office Space	120	-	2	5	0.06	18	25
D130	Gen. Storage	Corridors	835	0	0	5	0.06	51	50
D131	Main Elec	Corridors	260	0	0	0	0.06	16	0
D132	Maintenance	Corridors	400	0	0	0	0.06	24	0
D135	Custodial Supply	Corridors	300	0	0	0	0.06	18	0
D136	Office	Office Space	115	-	2	5	0.06	17	25
D137	Leisure Pool	Swimming (pool & deck)	9000	33	273	0	0.48	4320	4400
E101	Competition Pool	Swimming (pool & deck)	11500	33	349	0	0.48	5520	5600
E109	Entry	Main Entry Lobbies	90	100	1	5	0.06	11	25
E110	Meet Manage.	Office Space	290	-	2	5	0.06	28	25
E111	Multi-Purp. B	Multipurpose Assembly	230	10	23	5	0.06	129	130
E112	Multi-Purp. A	Multipurpose Assembly	230	10	23	5	0.06	129	130
E113	Team Lockers	Corridors	210	50	5	0	0.06	13	20
E114	Team Lockers	Corridors	210	50	5	0	0.06	13	20

TOTAL	28835

Exhaust Calculations

Exhaust Requirements								
Room	Description	SF	Height	ACH	CFM/SF	ACH based CFM	ASHRAE based CFM	CFM Used
A115	Women's Room	405	10	10	0	675	490	675
A116	Janitor	50	10	10	0	84	50	85
A117	Toilet	55	10	10	0	92	50	100
A118	Men's Room	400	10	10	0	667	490	675
A127	Arts Classroom	570	10		0.7	0	399	400
A134	Janitor	30	10	10	0	50	30	75
A138	Toilet	45	10	10	0	75	50	75
A139	Toilet	35	10	10	0	59	50	75
A140	Laundry	45	10	10	0	75	0	75
A144	Toilet	55	10	10	0	92	50	100
A146	Kitchen	1525	11.5		0.7	0	1068	1075
C101	Gymnasium	9180	33			0	0	2600
C103	Aerobics	1270	13			0	0	1000
C107	Fitness	3220	28			0	0	800
C110	Laundry Room	155	9	10	0	233	0	240
C117	Toilet	70	10	10	0	117	50	120
C139	Janitor	45	10	10	0	75	45	75
C140	Toilet	50	10	10	0	84	50	85
D107	Men's Room	215	8	10	0	287	280	290
D108	Women's Room	215	8	10	0	287	280	290
D109	Locker Room	1270	11		0.5	0	635	0
D110	Cabana	115	10	10	0.5	192	58	200
D111	Cabana	115	10	10	0.5	192	58	200
D112	Cabana	115	10	10	0.5	192	58	200
D113	Cabana	115	10	10	0.5	192	58	200
D114	Cabana	115	10	10	0.5	192	58	200
D115	Cabana	115	10	10	0.5	192	58	200
D116	Cabana	200	10	10	0.5	334	100	200
D117	Cabana	115	10	10	0.5	192	58	200
D118	Cabana	115	10	10	0.5	192	58	200
D119	Cabana	115	10	10	0.5	192	58	200
D120	Toilet	65	10	10	0	109	70	110
D121	Cabana	115	10	10	0.5	192	58	200
D122	Cabana	115	10	10	0.5	192	58	200
D123	Cabana	115	10	10	0.5	192	58	200
D124	Cabana	115	10	10	0.5	192	58	200
D125	Cabana	115	10	10	0.5	192	58	200
D126	Janitor	40	10	10	0	67	40	75
D137	Leisure Pool	9870	36		0.5	4935	4935	4950
E101	Competition Pool	13220	34		0.5	6610	6610	6650

TOTAL	23695

Pressurization Calculations

Pressurization Requirements					
Room	Description	Doors	Windows	Low Amt	High Amt
A101	Community Room	1	3	80	200
A102	Community Room	1	4	100	250
A103	Community Room	1	3	80	200
A105	Classroom	0	1	20	50
A108	Hall	1	0	20	50
A119	Classroom	0	1	20	50
A122	Library	0	1	20	50
A123	Computer Lab	0	1	20	50
A127	Arts	0	1	20	50
A129	Classroom	0	1	20	50
A131	Early Childhood	1	3	80	200
A142	Hall	1	0	20	50
A145	Office	0	0.5	10	25
A146	Kitchen	2	0	40	100
A147	Vestibule	1	1	40	100
B101	Chapel	2	0	40	100
B104	Vestibule	1	1	40	100
B105	Lobby	0	2	40	100
B106	Vestibule	2	1	60	150
B107	Adult Lounge	0	1.5	30	75
B108	Office	0	0.75	15	37.5
B110	Teen Room	0	0.75	15	37.5
B119	Platform	0	1	20	50
B120	Storage	1	0	20	50
B122	Hall	1	0	20	50
C101	Gymnasium	1	24	500	1250
C103	Aerobics	0	2	40	100
C107	Fitness	0	2	40	100
C108	Hall	2	0	40	100
C115	Childcare	1	0.5	30	75
C119	Corridor	1	0	20	50
C125	Operations Dir.	0	2	40	100
C131	County Coor.	0	0.5	10	25
C132	Open Offices	0	2	40	100
C133	Corp Officer	0	1	20	50
C137	Exec. Director	0	1	20	50
C138	Bus. Manager	0	0.5	10	25
C141	Break Room	0	1.5	30	75
D101	Climbing Wall	1	1	40	100
D131	Main Elec	0	1	20	50
D132	Maintenance	0	1	20	50
D133	Sprinkler Valve	0	1	20	50
D134	Bldg Mechanical	0	1	20	50
D137	Leisure Pool	3	83	1720	4300
E101	Competition Pool	1	5	120	300
E102	Pool Support	1	0	20	50
E108	Spectator Seating	0	15	300	750
E109	Entry	1	0	20	50
E110	Meet Manage.	0	1	20	50
E111	Multi-Purp. B	0	1	20	50
E112	Multi-Purp. A	0	1	20	50

Total	4090	10225

Bell and Gossett Heat Exchanger Catalog

Selection Tables*

RADIANT FLOOR HEATING—SECTION SCHEDULE BASIS							
Boiler Side: Water: 180 F Supply, 160 F Return Radiant Floor Side: 120 F Supply, 100 F Return							
Model	HEAT EXCHANGER BTU/Hr (max output)	BOILER SIDE		RADIANT WATER SIDE		B&G PUMP SELECTION†	PIPE SIZE
		Flow GPM	Pressure Drop PSI	Flow GPM	Pressure Drop PSI		
BP400-10	25,000	2.6	1.7	2.6	1.2	NRF-22	3/4"
BP400-10	30,000	3.1	2.4	3.0	1.6	NRF-22	3/4"
BP400-10	35,000	3.6	3.1	3.5	2.1	NRF-22	3/4"
BP400-10	40,000	4.1	4.0	4.0	2.8	NRF-36	3/4"
BP400-10	45,000	4.6	5.0	4.5	3.4	NRF-36	1"
BP400-10	50,000	5.2	6.1	5.0	4.2	NRF-36	1"
BP400-10	60,000	6.2	8.6	6.1	5.9	NRF-36	1"
BP400-20	75,000	7.7	3.0	7.6	2.6	NRF-36	1"
BP400-20	100,000	10.3	5.2	10.1	4.4	NRF-36	1-1/4"
BP400-20	125,000	12.9	7.9	12.6	6.8	NRF-36	1-1/4"
BP400-30	150,000	15.5	5.3	15.2	4.9	NRF-36	1-1/4"
BP400-30	175,000	18.0	7.1	17.7	6.5	PL-36	1-1/4"
BP400-40	200,000	20.6	5.8	20.2	5.5	PL-36	1-1/2"
BP400-40	225,000	23.2	7.3	22.7	6.9	PL-55	1-1/2"
BP411-20	250,000	25.8	3.3	25.2	3.0	PL-75	2"
BP411-20	275,000	28.3	4.0	27.8	3.6	PL-50	2"
BP411-20	300,000	30.9	4.7	30.3	4.2	PL-55	2"
BP411-20	350,000	36.1	6.3	35.3	5.6	PL-55	2"
BP411-30	400,000	51.2	4.8	40.4	4.6	601	2"
BP411-30	450,000	46.4	6.1	45.4	5.8	607	2"
BP411-30	500,000	51.5	7.4	50.5	7.1	608	2"
BP422-40	600,000	61.8	8.1	60.6	7.6	609	2-1/2"
BP422-50	700,000	72.1	7.1	70.7	6.8	612	2-1/2"
BP422-60	800,000	82.4	6.5	80.8	6.3	612	2-1/2"
BP422-80	900,000	92.7	4.9	90.9	4.8	611	3"
BP422-80	1,000,000	103	6.0	101.0	5.9	612	3"
BP422-80	1,100,000	113.3	7.2	111.1	7.1	625	3"
BP422-100	1,200,000	123.6	5.9	121.2	5.8	625	3"
BP422-100	1,350,000	139.1	7.5	136.3	7.4	619	3"

Larger Models available upon request

† Assumptions: 50 ft. of total equivalent length of pipe at sizes shown, 1/2 PEX, 0.8 gpm, longest radiant loop is 200 ft., 40 BTU/hr per ft^2

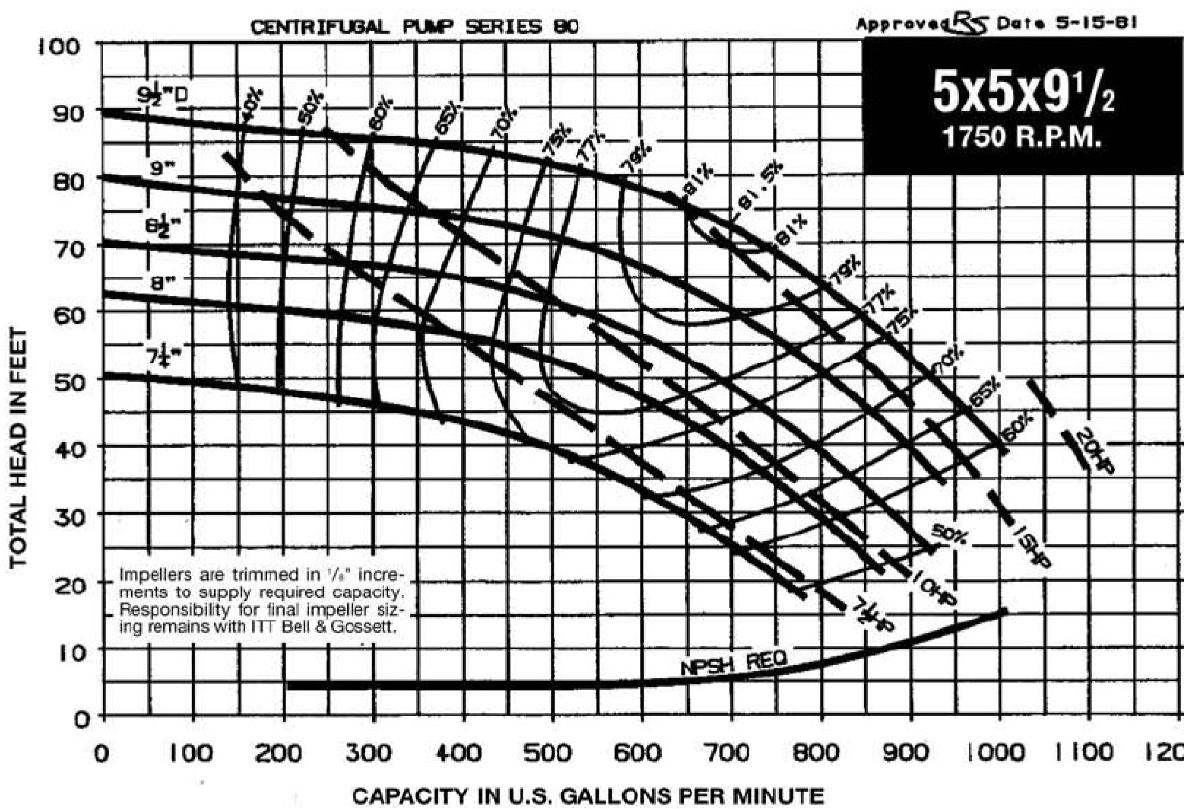
Pump Head Calculation

To find the equivalent length of the fittings, multiply the number of fittings by the equivalent length of each type of fitting. The equivalent length of fittings for 6" steel pipe was taken from an AE454 exam. To calculate total pressure drop (head) multiply the total equivalent length by the pressure drop per 100 feet of pipe, which was discussed in the report. The head loss is used to size the pumps.

	Ground Loop	Building Loop	Equiv. Length of Fitting
Size	6"	6"	
deltaP/ 100'	1.81	1.81	
Length	2500	1200	
45° Fitting	14	0	7
90° Fitting	156	130	13
Pipe Reducers	150	150	15
Throttle Valves	8	8	4
Tees	126	126	11
Equivalent Length	2954	1614	

Pressure Drop	53.5	29.2

Bell and Gossett Series 80 Pump Curves



Carrier Heat Pump Catalog Information

Carrier

50RTP05 UNIT
2000 CFM NOMINAL (Rated) AIRFLOW

WATER/BRINE				COOLING — EAT 80/67 F					HEATING — EAT 70 F				
EWT (F)	GPM	PD psig	PD ft wg	TC	SC	kW	HR	EER	HC	kW	HE	LAT	COP
20	16.0	5.8	13.4	Operation Not Recommended					38.8	3.88	25.5	85.9	2.9
30	8.0	0.9	2.0	75.4	49.2	2.85	85.1	26.5	43.5	3.98	29.9	88.1	3.2
	12.0	2.8	6.6	73.9	47.9	2.72	83.1	27.2	45.4	4.02	31.7	89.0	3.3
	16.0	5.3	12.3	72.7	47.1	2.66	81.8	27.3	46.5	4.04	32.7	89.5	3.4
40	8.0	0.8	1.8	75.7	50.0	3.08	86.2	24.6	50.9	4.13	36.9	91.5	3.6
	12.0	2.5	5.8	75.7	49.5	2.91	85.6	26.0	53.5	4.18	39.2	92.7	3.7
	16.0	4.7	10.9	75.3	49.1	2.84	85.0	26.5	54.9	4.21	40.5	93.4	3.8
50	8.0	0.7	1.6	[illegible]	49.8	3.36	85.8	22.1	[illegible]	4.29	44.2	95.2	4.0
	12.0	2.2	5.0	75.5	50.0	3.16	86.2	23.9	62.0	4.35	47.1	96.6	4.2
	16.0	4.1	9.6	75.7	49.9	3.06	86.2	24.7	63.7	4.39	48.7	97.4	4.3
60	8.0	0.6	1.3	71.8	49.0	3.69	84.4	19.5	66.9	4.45	51.7	98.9	4.4
	12.0	2.0	4.5	73.7	49.7	3.45	85.5	21.4	70.5	4.53	55.1	100.6	4.6
	16.0	3.8	8.8	74.5	49.9	3.34	85.9	22.3	72.5	4.57	56.9	101.5	4.6

Carrier

50RTP08 UNIT
3200 CFM NOMINAL (Rated) AIRFLOW

WATER/BRINE				COOLING — EAT 80/67 F					HEATING — EAT 70 F				
EWT (F)	GPM	PD psig	PD ft wg	TC	SC	kW	HR	EER	HC	kW	HE	LAT	COP
20	24.0	12.3	28.4	Operation Not Recommended					66.8	7.02	42.8	87.3	2.8
30	12.0	2.9	6.7	114.6	76.4	5.03	131.7	22.8	72.6	7.12	48.4	89.0	3.0
	18.0	6.6	15.2	113.6	75.3	4.78	129.9	23.7	75.4	7.16	50.9	89.8	3.1
	24.0	11.0	25.4	112.7	74.6	4.67	128.6	24.1	76.9	7.19	52.4	90.2	3.1
40	12.0	2.3	5.3	114.4	76.9	5.40	132.8	21.2	82.7	7.28	57.8	91.9	3.3
	18.0	5.4	12.4	114.7	76.6	5.12	132.2	22.4	86.3	7.34	61.2	92.9	3.4
	24.0	9.2	21.2	114.5	76.3	4.99	131.5	22.9	88.3	7.38	63.1	93.5	3.5
50	12.0	1.6	3.8	112.6	76.4	5.83	132.6	19.3	[illegible]	7.47	67.9	95.0	3.7
	18.0	4.2	9.7	114.1	76.9	5.50	132.9	20.7	97.8	7.55	72.1	96.2	3.8
	24.0	7.3	16.9	114.5	76.9	5.36	132.8	21.4	[illegible]	7.59	74.3	96.9	3.9
60	12.0	1.1	2.7	109.5	75.2	6.35	131.2	17.2	104.4	7.67	78.3	98.1	4.0
	18.0	3.5	8.1	111.9	76.2	5.96	132.3	18.8	109.5	7.77	83.0	99.6	4.1
	24.0	6.6	15.1	112.9	76.5	5.78	132.6	19.5	112.2	7.82	85.5	100.4	4.2

Performance data (cont)

Carrier

50RTP14 UNIT
5600 CFM NOMINAL (Rated) AIRFLOW

WATER/BRINE				COOLING — EAT 80/67 F					HEATING — EAT 70 F				
EWT (F)	GPM	PD psig	PD ft wg	TC	SC	kW	HR	EER	HC	kW	HE	LAT	COP
20	42.0	11.5	26.5	Operation Not Recommended					112.0	10.20	77.2	86.5	3.2
30	21.0	2.8	6.6	180.4	129.3	7.99	207.6	22.6	121.9	10.41	86.4	88.1	3.4
	31.5	6.2	14.3	171.8	128.1	7.73	198.2	22.2	126.9	10.52	91.0	88.9	3.5
	42.0	10.3	23.9	166.8	127.3	7.63	192.8	21.9	129.7	10.58	93.6	89.4	3.6
40	21.0	2.3	5.3	188.0	130.3	8.56	217.2	22.0	139.9	10.80	103.1	91.1	3.8
	31.5	5.2	12.1	183.6	129.7	8.16	211.4	22.5	146.6	10.94	109.3	92.2	3.9
	42.0	8.9	20.5	180.5	129.3	8.00	207.8	22.6	150.3	11.02	112.7	92.8	4.0
50	21.0	1.8	4.1	190.2	130.9	9.28	221.8	20.5	159.5	11.23	121.2	94.3	4.2
	31.5	4.3	9.9	189.2	130.5	8.76	219.1	21.6	167.7	11.41	128.8	95.7	4.3
	42.0	7.4	17.2	187.9	130.3	8.54	217.0	22.0	172.2	11.51	132.9	96.4	4.4
60	21.0	1.3	3.1	188.1	131.2	10.16	222.8	18.5	179.4	11.68	139.6	97.6	4.5
	31.5	3.7	8.5	189.9	131.0	9.53	222.4	19.9	188.6	11.90	148.0	99.1	4.6
	42.0	6.7	15.4	190.2	130.9	9.24	221.7	20.6	193.4	12.01	152.4	99.9	4.7

Carrier

50RTP20 UNIT
8000 CFM NOMINAL (Rated) AIRFLOW

WATER/BRINE				COOLING — EAT 80/67 F					HEATING — EAT 70 F				
EWT (F)	GPM	PD psig	PD ft wg	TC	SC	kW	HR	EER	HC	kW	HE	LAT	COP
20	60.0	10.2	23.5	Operation Not Recommended					158.1	16.10	103.2	86.3	2.9
30	30.0	2.7	6.3	254.7	182.7	12.65	297.9	20.1	170.9	16.42	114.8	87.7	3.0
	45.0	5.6	13.0	243.6	172.9	11.70	283.5	20.8	176.6	16.56	120.1	88.4	3.1
	60.0	9.2	21.4	236.6	166.9	11.24	274.9	21.1	179.7	16.63	123.0	88.8	3.2
40	30.0	2.3	5.3	263.0	190.6	13.99	310.8	18.8	193.5	16.94	135.7	90.3	3.3
	45.0	4.8	11.2	258.5	186.2	13.11	303.2	19.7	201.3	17.10	143.0	91.3	3.5
	60.0	8.0	18.4	254.8	182.8	12.66	298.0	20.1	205.7	17.20	147.0	91.8	3.5
50	30.0	1.8	4.3	263.2	191.9	15.25	315.2	17.3	219.0	17.48	159.3	93.3	3.7
	45.0	4.0	9.3	263.8	191.6	14.38	312.9	18.3	229.0	17.69	168.6	94.4	3.8
	60.0	6.7	15.5	262.9	190.5	13.95	310.5	18.8	234.5	17.81	173.8	95.1	3.9
60	30.0	1.5	3.5	257.6	188.8	16.50	313.9	15.6	246.1	18.05	184.5	96.4	4.0
	45.0	3.5	8.2	262.0	191.3	15.62	315.3	16.8	258.3	18.31	195.8	97.8	4.1
	60.0	6.2	14.2	263.3	191.9	15.19	315.1	17.3	264.9	18.46	202.0	98.6	4.2

Carrier

50VQP300
10,000 CFM NOMINAL AIRFLOW

EWT (F)	GPM	WPD*		COOLING CAPACITY, EAT 80/67 F					HEATING CAPACITY, EAT 70 F				
		psig	ft wg	TC	SC	kW	HR	EER	HC	kW	HE	LAT	COP
20	76	13.5	31.2	Operation Not Recommended					211.0	20.5	141.0	87.1	3.0
30	38	3.1	7.1	350.0	263.5	16.7	406.9	21.0	230.1	21.1	158.2	88.9	3.2
	56	7.0	16.1	347.6	276.0	15.9	401.7	22.0	238.9	21.3	166.1	89.7	3.3
	76	12.4	28.7	344.6	283.3	15.4	397.1	22.4	244.3	21.5	171.0	90.1	3.3
40	38	2.6	6.1	347.1	247.7	17.8	408.0	19.4	262.9	22.0	188.0	91.8	3.5
	56	6.3	14.5	349.7	258.0	17.0	407.7	20.5	274.3	22.2	198.5	92.9	3.6
	76	11.3	26.2	349.8	264.4	16.6	406.2	21.1	281.3	22.4	204.9	93.5	3.7
50	38	2.4	5.6	338.5	235.2	19.1	403.5	17.7	298.0	22.8	220.3	95.0	3.8
	56	5.9	13.6	344.8	243.3	18.2	406.8	18.9	312.0	23.1	233.2	96.3	4.0
	76	10.7	24.7	347.3	248.4	17.7	407.7	19.5	320.6	23.3	241.2	97.1	4.0
60	38	1.9	4.3	325.9	225.3	20.4	395.4	15.9	335.8	23.7	255.0	98.3	4.2
	56	4.8	11.2	334.7	231.6	19.4	401.0	17.1	352.3	24.0	270.3	99.8	4.3
	76	9.1	20.9	338.9	235.6	18.9	403.5	17.8	362.3	24.3	279.5	100.7	4.4

Physical data

AQUAZONE™ 50RTP03-20 UNITS

UNIT 50RTP	03	04	05	06	08	10	12	14	20
Compressor (qty)	Scroll (1)				Scroll (2)				
Factory Charge R-410A (oz)	64	84	120	132	108	120	130	192	300
Blower Motor									
Motor Quantity	1								
Standard Motor (hp)	1	1	1	1.5	2	3	3	3	5
Large Motor (hp)	N/A	1.5	1.5	2	3	5	5	5	7.5
Blower(s)									
Number of Blowers	1							2	
Blower Wheel Size (dia x w)	10 x 6		2 x 12		15 x 11		15 x 15	15 x 11	
V-belt size, Std drive	A29	A30	A32	AX33	B40	BX42	BX46	B39	BX40
Water Connection Size									
IPT (in.)	3/4		1	1 1/4	1 1/2			2	
Coax Volume									
Volume (US Gallons)	0.61	0.77	1.11	1.30	1.69	2.29	2.68	3.83	4.77
Condensate Connection Size									
FPT (in.)	1								
Air Coil Data									
Air Coil Total Face Area (sq ft)	5		7		9.33	10.5		20	
Filter, Standard, Qty...Size (in.)	4...16 x 20				6...16 x 20			8...16 x 20, [illegible]	
Operating Weight (lb)	735	785	835	880	1080	1125	1175	1770	1960
Shipping Weight (lb)	750	800	[illegible]	900	[illegible]	1150	1200	[illegible]	[illegible]

Physical data

50VQP UNIT PHYSICAL DATA

50VQP UNIT SIZE	084	096	120	150	168	192	240	300
NOMINAL AIRFLOW (cfm)	2,800	3,200	4,000	5,000	5,600	6,400	8,000	10,000
WEIGHT (lb)								
Operating	650		696	700	1300		1346	1404
Packaged	665		711	715	1330		1376	[illegible]

Electrical data

Carrier®

50RTP UNIT SIZE	VOLTAGE CODE	VOLTAGE (V-Ph-Hz)	MIN/MAX VOLTAGE	BLOWER OPTION	COMPRESSOR			MOTOR			TOTAL UNIT FLA	MCA	MAX FUSE/ HACR
					Qty	RLA	LRA	Qty	FLA	Hp			
03	5	208-3-60	197/254	A,B,C	1	10.4	73.0	1	4.0	1.0	14.4	17.0	25
	6	460-3-60	414/506	A,B,C	1	5.8	38.0	1	2.0	1.0	7.8	9.3	15
	1	575-3-60	518/633	A,B,C	1	3.8	36.5	1	1.4	1.0	5.2	6.2	15
04	5	208-3-60	197/254	A,B,C	1	13.7	83.1	1	4.0	1.0	17.7	21.1	35
				D,E	1	13.7	83.1	1	5.0	1.5	18.7	22.1	35
	6	460-3-60	414/506	A,B,C	1	6.2	41.0	1	2.0	1.0	8.2	9.8	15
				D,E	1	6.2	41.0	1	2.4	1.5	8.6	10.1	15
	1	575-3-60	518/633	A,B,C	1	4.8	33.0	1	1.4	1.0	6.2	7.4	15
				D,E	1	4.8	33.0	1	1.9	1.5	6.7	7.9	15
05	5	208-3-60	197/254	A,B,C	1	15.6	110.0	1	4.0	1.0	19.6	23.5	40
				D,E	1	15.6	110.0	1	5.0	1.5	20.6	24.5	40
	6	460-3-60	414/506	A,B,C	1	7.8	52.0	1	2.0	1.0	9.8	11.8	15
				D,E	1	7.8	52.0	1	2.4	1.5	10.2	12.2	15
	1	575-3-60	518/633	A,B,C	1	5.8	38.9	1	1.4	1.0	7.2	8.7	15
				D,E	1	5.8	38.9	1	1.9	1.5	7.7	9.2	15
06	5	208-3-60	197/254	A,B,C	1	20.5	155.0	1	5.0	1.5	25.5	30.6	50
				D,E	1	20.5	155.0	1	6.2	2.0	26.7	31.8	50
	6	460-3-60	414/506	A,B,C	1	9.6	75.0	1	2.4	1.5	12.0	14.4	20
				D,E	1	9.6	75.0	1	3.1	2.0	12.7	15.1	20
	1	575-3-60	518/633	A,B,C	1	7.6	54.0	1	1.9	1.5	9.5	11.4	15
				D,E	1	7.6	54.0	1	2.3	2.0	9.9	11.8	15
08	5	208-3-60	197/254	A,B,C	2	13.7	83.1	1	6.2	2.0	33.6	37.0	50
				D,E	2	13.7	83.1	1	9.2	3.0	36.6	40.0	50
	6	460-3-60	414/506	A,B,C	2	6.2	41.0	1	3.1	2.0	15.5	17.0	20
				D,E	2	6.2	41.0	1	4.3	3.0	16.7	18.3	20
	1	575-3-60	518/633	A,B,C	2	4.8	33.0	1	2.3	2.0	11.9	13.1	15
				D,E	2	4.8	33.0	1	3.4	3.0	13.0	14.2	15
10	5	208-3-60	197/254	A,B,C	2	15.6	110.0	1	9.2	3.0	40.4	44.3	60
				D,E	2	15.6	110.0	1	14.1	5.0	45.3	49.2	60
	6	460-3-60	414/506	A,B,C	2	7.8	52.0	1	4.3	3.0	19.9	21.9	25
				D,E	2	7.8	52.0	1	7.0	5.0	22.6	24.6	30
	1	575-3-60	518/633	A,B,C	2	5.8	38.9	1	3.4	3.0	15.0	16.5	20
				D,E	2	5.8	38.9	1	5.2	5.0	16.8	18.3	20
12	5	208-3-60	197/254	A,B,C	2	20.5	155.0	1	9.2	3.0	50.2	55.3	80
				D,E	2	20.5	155.0	1	14.1	5.0	55.1	60.2	80
	6	460-3-60	414/506	A,B,C	2	9.6	75.0	1	4.3	3.0	23.5	25.9	35
				D,E	2	9.6	75.0	1	7.0	5.0	26.2	28.6	35
	1	575-3-60	518/633	A,B,C	2	7.6	54.0	1	3.4	3.0	18.6	20.5	25
				D,E	2	7.6	54.0	1	5.2	5.0	20.4	22.3	25
14	5	208-3-60	197/254	A,B,C	2	23.2	164.0	1	9.2	3.0	55.6	61.4	80
				D,E	2	23.2	164.0	1	14.1	5.0	60.5	66.3	80
	6	460-3-60	414/506	A,B,C	2	11.2	75.0	1	4.3	3.0	26.7	29.5	40
				D,E	2	11.2	75.0	1	7.0	5.0	29.4	32.2	40
	1	575-3-60	518/633	A,B,C	2	7.9	54.0	1	3.4	3.0	19.2	21.2	30
				D,E	2	7.9	54.0	1	5.2	5.0	21.0	23.0	30
20	5	208-3-60	197/254	A,B,C	2	30.1	225.0	1	14.1	5.0	74.3	81.8	110
				D,E	2	30.1	225.0	1	21.7	7.5	81.9	89.4	110
	6	460-3-60	414/506	A,B,C	2	16.7	114.0	1	7.0	5.0	40.4	44.6	60
				D,E	2	16.7	114.0	1	10.0	7.5	43.4	47.6	60
	1	575-3-60	518/633	A,B,C	2	12.2	80.0	1	5.2	5.0	29.6	32.6	45
				D,E	2	12.2	80.0	1	7.7	7.5	32.1	35.1	45

300	208/230-3-60	197/254	A, B, C	2	48.1	245	14.1	110.3	122.3	150
			D, E	2	48.1	245	21.7	117.9	129.9	175
	460-3-60	414/506	A, B, C	2	18.6	125	7.0	44.2	48.9	60
			D, E	2	18.6	125	10.0	47.2	51.9	70
	575-3-60	518/633	A, B, C	2	14.7	100	5.2	34.6	38.3	50
			D, E	2	14.7	100	7.7	37.1	40.8	50

Water-to-Water Heat Pumps

COOLING CAPACITIES (cont)

50PSW360

SOURCE COIL				LOAD COIL																					
EWT (F)	gpm	Pressure Drop psig	Pressure Drop ft wg	EWT (F)	Flow 35.0 gpm TC (MBtuh)	Power (kW)	THR (MBtuh)	LWT (F)	EER	Pressure Drop psig	Pressure Drop ft wg	Flow 53.0 gpm TC (MBtuh)	Power (kW)	THR (MBtuh)	LWT (F)	EER	Pressure Drop psig	Pressure Drop ft wg	Flow 70.0 gpm TC (MBtuh)	Power (kW)	THR (MBtuh)	LWT (F)	EER	Pressure Drop psig	Pressure Drop ft wg
50	35	1.19	2.75	50	129.3	6.84	152.7	35.2	18.6	0.54	1.20	271.2	13.86	318.5	39.8	19.6	3.60	8.30	277.3	13.94	324.9	42.1	19.9	6.50	15.00
				60	141.0	6.90	164.5	43.9	20.1	0.30	0.70	294.1	13.92	341.6	48.9	21.1	3.44	7.94	299.9	13.97	347.5	51.4	21.5	6.18	14.28
				70	151.3	7.00	175.2	52.7	21.3	0.17	0.40	313.9	14.09	362.0	58.2	22.3	3.29	7.60	319.0	14.14	367.3	60.9	22.6	5.91	13.64
				80	160.2	7.08	184.4	61.7	22.4	0.15	0.30	330.2	14.24	378.8	67.5	23.2	3.15	7.28	334.5	14.28	383.2	70.4	23.4	5.67	13.09
				90	167.5	7.14	191.9	70.9	23.3	0.12	0.30	342.7	14.35	391.6	77.1	23.9	3.02	6.97	345.8	14.38	394.8	80.1	24.0	5.47	12.64
	53	3.59	8.30	50	131.1	6.34	152.8	35.0	20.2	0.54	1.20	275.0	12.76	318.5	39.6	21.5	3.60	8.30	281.1	12.80	324.8	42.0	22.0	6.50	15.00
				60	142.7	6.41	164.6	43.7	21.9	0.30	0.70	297.6	12.90	341.6	48.8	23.1	3.44	7.94	303.3	12.93	347.4	51.3	23.4	6.18	14.28
				70	152.9	6.47	175.0	52.5	23.3	0.17	0.40	316.8	13.01	361.2	58.0	24.3	3.29	7.60	321.9	13.04	366.4	60.8	24.7	5.91	13.64
				80	161.6	6.53	183.8	61.5	24.5	0.15	0.30	332.6	13.11	377.4	67.4	25.4	3.15	7.28	336.8	13.13	381.6	70.4	25.6	5.67	13.09
				90	168.6	6.57	191.0	70.7	25.5	0.12	0.30	344.8	13.18	389.8	77.0	26.2	3.02	6.97	347.9	13.20	392.9	80.1	26.4	5.47	12.64
	70	6.50	15.02	50	131.7	6.12	152.6	35.0	21.1	0.54	1.20	276.2	12.30	318.2	39.6	22.5	3.60	8.30	282.4	12.33	324.5	41.9	22.9	6.50	15.00
				60	143.4	6.18	164.4	43.6	22.8	0.30	0.70	298.9	12.41	341.2	48.7	24.1	3.44	7.94	304.6	12.43	347.0	51.3	24.5	6.18	14.28
				70	153.5	6.22	174.8	52.5	24.3	0.17	0.40	318.1	12.50	360.7	58.0	25.5	3.29	7.60	323.1	12.52	365.8	60.8	25.8	5.91	13.64
				80	162.2	6.26	183.5	61.5	25.6	0.15	0.30	333.7	12.57	376.6	67.4	26.6	3.15	7.28	337.8	12.59	380.8	70.3	26.8	5.67	13.09
				90	169.1	6.29	190.6	70.7	26.7	0.12	0.30	345.6	12.67	388.7	77.0	27.4	3.02	6.97	348.6	12.63	391.7	80.0	27.6	5.47	12.64

50PSW036-360 UNIT PHYSICAL DATA

50PSW UNIT SIZE	036	060	120	180	360
NOMINAL CAPACITY (tons)	3	5	10	14	30
WEIGHT (lb)					
Operating	348	360	726	790	1330
Packaged	373	385	770	800	1340
COMPRESSOR (qty)	Scroll (1)	Scroll (1)	Scroll (2)	Scroll (1)	Scroll (2)
REFRIGERANT TYPE	R-410A				
Factory Charge Per Circuit (lb)	4.5	6.25	6.25	14.9	14.9
CONNECTIONS, IPT (in.)					
Commercial Load/Source	3/4	1	1 1/2	2	
HWG Water In/Out		1/2		N/A	

50PSW UNIT SIZE	VOLTAGE (V-Ph-Hz)	VOLTAGE RANGE MIN/MAX	COMPRESSOR RLA	COMPRESSOR LRA	COMPRESSOR QTY	TOTAL FLA	MCA	MOCP*
036	208/230-1-60	187/254	16.7	79.0	1	16.7	20.9	35
	265-1-60	239/292	13.5	72.0	1	13.5	16.9	30
	208/230-3-60	187/254	10.4	73.0	1	10.4	13.0	20
	460-3-60	414/506	5.8	38.0	1	5.8	7.3	15
	575-3-60	518/633	3.8	36.5	1	3.8	4.8	15
060	208/230-1-60	187/254	30.1	158.0	1	30.1	37.6	60
	208/230-3-60	187/254	20.5	155.0	1	20.5	25.6	45
	460-3-60	414/506	9.6	75.0	1	9.6	12.0	20
	575-3-60	518/633	7.6	54.0	1	7.6	9.5	15
120	208/230-1-60	187/254	30.1	158.0	2	60.2	67.7	90
	208/230-3-60	187/254	20.5	155.0	2	41.0	46.1	60
	460-3-60	414/506	9.6	75.0	2	19.2	21.6	30
	575-3-60	518/633	7.6	54.0	2	15.2	17.1	20
180	208/230-3-60	187/254	53.6	245.0	1	53.6	67.0	110
	460-3-60	414/506	20.7	125.0	1	20.7	25.9	45
	575-3-60	518/633	16.4	100.0	1	16.4	20.5	35
360	208/230-3-60	187/254	53.6	245.0	2	107.2	120.6	150
	460-3-60	414/506	20.7	125.0	2	41.4	46.6	60
	575-3-60	518/633	16.4	100.0	2	32.8	36.9	50

Pool Load Conversion

Convert BTU/yr to MBH				
Leisure Pool	Comp. Pool	Whirl Pool	Spray Pad Pool	Units
1,786,210,866	2,001,241,097	284,457,932	1,112,323,630	BTU/yr
203,905	228,452	32,472	126,978	BTU/hr
204	228	32	127	MBH
41	46	6	25	Required MBH

Dedicated Outdoor Air Equipment

62DC,DD16 WITH ECW

Entering Air Quantity (Cfm)		Temp (F) Air Entering (Edb)									
		75					85				
		Entering Air — Ewb (F)									
		57	62	67	72	75	57	62	67	72	75
4400	TC	161,200	175,000	189,200	203,800	212,200	179,400	179,800	190,400	205,800	215,400
	SHC	155,200	130,000	103,700	76,756	60,000	179,400	180,600	153,400	126,700	110,800
	W	15,616	15,850	16,096	16,372	16,540	15,926	15,384	16,112	16,426	16,606
5100	TC	169,100	179,200	193,500	208,000	216,400	188,000	188,300	194,900	210,100	219,700
	SHC	171,000	140,100	109,500	78,400	59,400	188,000	188,300	167,200	136,100	117,800
	W	16,008	16,196	16,448	16,734	16,900	16,354	16,360	16,456	16,788	16,982
5800	TC	175,100	182,300	196,600	211,100	219,300	195,000	195,400	198,000	213,700	222,800
	SHC	175,100	149,500	115,500	80,000	58,500	195,000	195,400	176,300	146,500	124,700
	W	16,390	16,522	16,776	17,070	17,238	16,756	16,762	16,816	17,108	17,324
6500	TC	180,100	184,500	199,100	213,400	221,300	200,900	201,200	200,900	215,500	225,100
	SHC	180,100	159,600	121,500	82,200	57,300	200,900	201,200	188,800	155,000	131,700
	W	16,750	16,816	17,086	17,386	17,560	17,124	17,130	17,144	17,444	17,646

UNIT AND COMPONENT WEIGHTS (lb)

COMPONENT	62D UNIT SIZE												
	07	08	09	12	14	15	16	20	22	24	30	34	38
Base Unit	1650	1690	1710	1910	1960	2120	2060	2080	3375	3475	3575	3655	4075
Hot Gas Reheat	35	35	35	75	75	75	75	75	120	120	120	120	120
Liquid Subcooling Coil	25	25	25	55	55	55	55	55	100	100	100	100	100
Gas Furnace (Btuh)													
75,000	140	140	140	—	—	—	—	—	—	—	—	—	—
100,000	150	150	150	—	—	—	—	—	—	—	—	—	—
150,000	160	160	160	160	160	160	160	160	—	—	—	—	—
200,000	170	170	170	170	170	170	170	170	—	—	—	—	—
250,000	—	—	—	210	210	210	210	210	—	—	—	—	—
300,000	—	—	—	250	250	250	250	250	250	250	250	250	250
400,000	—	—	—	—	—	—	—	—	275	275	275	275	275
500,000	—	—	—	—	—	—	—	—	420	420	420	420	420
600,000	—	—	—	—	—	—	—	—	500	500	500	500	500
Electric Heater	75	75	75	75	75	75	75	75	100	100	100	100	100
Steam Coil	60	60	60	60	60	60	60	60	120	120	120	120	120
Hot Water Coil	75	75	75	75	75	75	75	75	150	150	150	150	150
Wheel Bypass Dampers	60	60	60	60	60	60	60	60	125	125	125	125	125
Energy Conservation Wheel	350	350	350	420	420	420	420	420	470	470	470	470	470
Power Exhaust	345	345	345	375	375	375	375	375	525	525	525	525	525
Curb 14-in.	275	275	275	275	275	275	275	275	305	305	305	305	305
Curb 24-in.	375	375	375	375	375	375	375	375	425	425	425	425	425

COMPRESSOR ELECTRICAL DATA

VOLTAGE		UNIT SIZE 62D												
		07	08	09	12	14	15	16	20	22	24	30	34	38
Number of Compressors		1	1	1	2	2	2	2	2	2	2	2	2	4
208-230/3/60	RLA (each)	16.0	19.0	23.2	13.7	16.0	22.4	25.0	29.5	29.5	30.1	48.1	55.8	29.5
	LRA	110.0	123.0	164.0	83.1	110.0	149.0	164.0	195.0	195.0	225.0	245.0	340.0	195.0
460/3/60	RLA (each)	7.8	9.7	11.2	6.2	7.8	10.6	12.2	14.8	14.8	16.7	18.6	26.9	14.8
	LRA	52.0	62.0	75.0	41.0	52.0	75.0	100.0	95.0	95.0	114.0	125.0	173.0	95.0
575/3/60	RLA (each)	5.7	7.4	7.9	4.8	5.7	7.7	90.0	12.2	12.2	12.2	14.7	23.7	12.2
	LRA	38.9	50.0	54.0	33.0	38.9	54.0	78.0	80.0	80.0	80.0	100.0	132.0	80.0

CONDENSER FAN MOTOR ELECTRICAL DATA

VOLTAGE		UNIT SIZE 62D												
		07	08	09	12	14	15	16	20	22	24	30	34	38
Number of Fans		1	1	1	2	2	2	2	2	2	2	2	2	2
208/230-3-60	FLA	3.0	4.0	4.0	2.3	2.3	4.0	4.0	4.0	4.0	4.0	5.6	5.6	5.6
460-3-60	FLA	1.5	2.0	2.0	1.2	1.2	2.0	2.0	2.0	2.0	2.0	2.8	2.8	2.8
575-3-60	FLA	0.8	1.8	1.8	0.8	0.8	0.8	1.8	1.8	1.8	1.8	2.3	2.3	2.3

SUPPLY AND EXHAUST FAN MOTOR ELECTRICAL DATA

VOLTAGE		MOTOR HP										
		1/2	3/4	1	1 1/2	2	3	5	7 1/2	10	15	20
208/230-3-60	FLA	2.8	3.4	3.2	4.8	6.3	9.8	15.7	22.3	29.0	43.4	57.0
460-3-60	FLA	1.4	1.7	1.5	2.0	2.9	4.1	6.8	10.0	12.9	18.9	24.5
575-3-60	FLA	0.8	1.3	1.1	1.6	2.3	3.3	5.2	7.6	10.1	15.1	19.6

ENERGY CONSERVATION WHEEL ELECTRICAL DATA

VOLTAGE		WHEEL SIZE (in.)			
		36	42	48	54
208/230-3-60	FLA	2.5	2.5	2.5	3.0
460-3-60	FLA	1.3	1.3	1.3	1.5
575-3-60	FLA	1.0	1.3	1.0	1.5

Original Energy Calculation

Energy Costs by Month and Type

	EC (kwh)	ED (kw)	Gas (therms)	EC ($)	ED ($)	Gas ($)
January	80609	179	5930	$ 4,085	$ 788	$ 7,663
February	72895	183	4662	$ 3,727	$ 813	$ 6,025
March	82440	188	4418	$ 4,170	$ 843	$ 5,709
April	83299	220	2932	$ 4,209	$ 1,039	$ 3,789
May	104332	406	816	$ 5,185	$ 2,175	$ 1,055
June	119639	452	308	$ 5,896	$ 2,456	$ 398
July	152246	510	154	$ 7,409	$ 2,811	$ 199
August	145815	549	216	$ 7,110	$ 3,049	$ 279
September	115558	416	465	$ 5,706	$ 2,236	$ 601
October	94798	286	2064	$ 4,743	$ 1,442	$ 2,667
November	78229	180	5395	$ 3,974	$ 794	$ 6,972
December	78647	176	7352	$ 3,994	$ 770	$ 9,501

Individual Costs:	$ 60,206	$ 19,216	$ 44,858
Total Energy Cost:	$ 124,281		

GLHE Pro Results

Note that though the amount of wells changed from this run to the final report, the total borehole depth was used to size the well field.

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 Active borehole length, ft                         =278.1
 Borehole diameter, in                              = 6
 Borehole spacing, ft                               =20.00
 Borehole Geometry                                  : RECTANGULAR CONFIGURATION
                                                    : 100 : 5 x 20, rectangle
 Soil Type currently used                           :
 Thermal conductivity of the ground, Btu/(hr*ft*°F) =1.000
 Volumetric heat capacity of Ground, Btu/(°F*ft^3)  =32.21
 Volumetric heat capacity of fluid, Btu/(°F*ft^3)   =62.23
 Undisturbed ground temperature, °F                 =55.99
 Borehole thermal resistance, °F/(Btu/(hr*ft))      =0.3949
 Fluid type currently entered                       : Pure Water
 Mass flow rate of the fluid, gal/min               =494.0
 Density of the fluid, lb/ft^3                      =62.31
 Heat Pump Selected                                 : ClimateMaster Classic Model 030


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                           Results

 ************************************************************************

 Borehole Information
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 Each Borehole Depth, ft =   278.08
 Total Borehole Depth, ft =   27807.70
 Distance between borehole centers, ft =   020.00

 Average Temperature
 -------------------

 Maximum Average Temperature, °F =   056.81 at month 116
 Minimum Average Temperature, °F =   055.28 at month 01

 Peak temperature
 ----------------

 Maximum Peak Temperature, °F    =   089.99 at month 115
 Minimum Peak Temperature, °F    =   044.07 at month 01
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Mechanical Equipment Costs

Rooftop Units			
Unit	**Size**	**Pump Size**	**Price**
R1	55	60	$ (63,500.00)
R2	17.5	17.5	$ (24,300.00)
R3	20	20	$ (28,000.00)
R4	15	15	$ (20,800.00)
R5	15	15	$ (20,800.00)
R6	15	15	$ (20,800.00)
R7	5	5	$ (7,650.00)
R8	20	20	$ (28,000.00)
R9	6	6	$ (8,750.00)
R10	10	10	$ (14,400.00)
		Total	$ (237,000.00)

VAV Boxes			
Unit	**Size**	**VAV Size**	**Price**
N1.1	850	500-1000	$ (555.00)
N1.2	850	500-1000	$ (555.00)
N1.3	1600	1100-2000	$ (600.00)
N1.4	1800	1100-2000	$ (600.00)
N1.5	1050	800-1600	$ (570.00)
N1.6	1050	800-1600	$ (570.00)
N1.7	1100	800-1600	$ (570.00)
N1.8	1050	800-1600	$ (570.00)
N1.9	1060	800-1600	$ (570.00)
N1.10	850	500-1000	$ (555.00)
N1.11	850	500-1000	$ (555.00)
N1.12	900	500-1000	$ (555.00)
N1.13	950	500-1000	$ (555.00)
N1.14	940	500-1000	$ (555.00)
N1.15	920	500-1000	$ (555.00)
N1.16	2000	1100-2000	$ (600.00)
N1.17	1020	800-1600	$ (570.00)
N1.18	1740	1100-2000	$ (600.00)
N1.19	1740	1100-2000	$ (600.00)
S1.1	800	500-1000	$ (555.00)
S1.2	860	500-1000	$ (555.00)
S1.3	920	500-1000	$ (555.00)
S1.4	580	300-600	$ (525.00)
S1.5	690	500-1000	$ (555.00)
S1.6	640	500-1000	$ (555.00)
S1.7	420	300-600	$ (525.00)
S1.8	840	500-1000	$ (555.00)
S1.9	1000	800-1600	$ (570.00)
S1.10	660	500-1000	$ (555.00)
S1.11	700	500-1000	$ (555.00)
S1.12	320	300-600	$ (525.00)
S1.13	1360	800-1600	$ (570.00)
S1.14	1490	800-1600	$ (570.00)
		Total	$ (18,585.00)

Boilers				
Unit	Size (MBH)	Boiler Size	Price	
B2	2000	2070	$	(36,000.00)
B3	1000	990	$	(21,700.00)
		Total	$	(57,700.00)

Outdoor Heat Pumps				
Unit	Size	Pump Size	Price	
OHP1	5	5	$	(6,200.00)
OHP2	5	5	$	(6,200.00)
		Total	$	(12,400.00)

New Heat Pumps				
Unit	Size	Pump Size	Price	
HP1	20	20	$	21,400.00
HP2	14	15	$	19,400.00
HP3	25	25	$	28,800.00
HP4	14	15	$	19,400.00
HP5	25	25	$	28,800.00
HP6	20	20	$	21,400.00
HP7	8	10	$	11,700.00
HP8	5	7.5	$	9,300.00
WSHP1	30	30	$	33,100.00
WSHP2	30	30	$	33,100.00
		Total	$	226,400.00

Heat Exchangers			
Unit	Model	Price	
HE 1	BP 422-80	$	2,350.00
HE 2	BP 422-80	$	2,350.00
HE 3	BP 422-80	$	2,350.00
HE 4	BP 422-80	$	2,350.00
HE 5	BP 422-80	$	2,350.00
HE 6	BP 422-80	$	2,350.00
	Total	$	14,100.00

Outdoor Air Units				
Unit	Size	Pump Size	Price	
ERV 1	5	6	$	8,750.00
ERV 2	8	10	$	14,400.00
ERV 3	5	6	$	8,750.00
H Wheel 1	5740	6000 Max	$	12,400.00
H Wheel 2	5970	6000 Max	$	12,400.00
H Wheel 3	6775	8000 Max	$	13,800.00
		Total	$	70,500.00

Pumps			
Unit	Size	Price	
P1	Series 80 - 5x5x9.5	$	4,000.00
P2	Series 80 - 5x5x9.5	$	4,000.00
	Total	$	8,000.00

Appendix B – Electrical Information

Panel HMA Original

Panel Schedule

Panel HMA

Project:	SALEM KROC CENTER	Voltage L-L (V):	480
Job No:	2006129	Voltage L-N (V):	277
Location:	Electrical A141	Type:	3 PHASE, 4 WIRE
Minimum Bus Capacity (A):	600	Short Circuit Rating (A):	See one-line Diagram
Main O.C. Device (A):	None	Mounting:	Surface
Design Capacity (A)"	500	Comments	NEMA 4x - Stainless Steel

Device Amps	Pole	Lighting (VA)	Rect. (VA)	M/LM/E/A/S (VA)	Description	Ckt. No.	Phase	Ckt. No.	Description	M/LM/E/A/S (VA)	Rect. (VA)	Lighting (VA)	Pole	Device Amps
15	3			2953	SFPB-N1.1 Supply Fan Pwr Box	1	A	2	SFPB-N1.8 Supply Fan Pwr Box	3730			3	20
-	-			2953	-	3	B	4	-	3730			-	-
-	-			2953	-	5	C	6	-	3730			-	-
15	3			2953	SFPB-N1.2 Supply Fan Pwr Box	7	A	8	SFPB-N1.9 Supply Fan Pwr Box	3397			3	20
-	-			2953	-	9	B	10	-	3397			-	-
-	-			2953	-	11	C	12	-	3397			-	-
20	3			4397	SFPB-N1.3 Supply Fan Pwr Box	13	A	14	SFPB-N1.10 Supply Fan Pwr Box	2953			3	15
-	-			4397	-	15	B	16	-	2953			-	-
-	-			4397	-	17	C	18	-	2953			-	-
30	3			5730	SFPB-N1.4 Supply Fan Pwr Box	19	A	20	SFPB-N1.11 Supply Fan Pwr Box	2953			3	15
-	-			5730	-	21	B	22	-	2953			-	-
-	-			5730	-	23	C	24	-	2953			-	-
20	3			3730	SFPB-N1.5 Supply Fan Pwr Box	25	A	26	SFPB-N1.12 Supply Fan Pwr Box	2953			3	15
-	-			3730	-	27	B	28	-	2953			-	-
-	-			3730	-	29	C	30	-	2953			-	-
20	3			3397	SFPB-N1.6 Supply Fan Pwr Box	31	A	32	SFPB-N1.13 Supply Fan Pwr Box	3397			3	20
-	-			3397	-	33	B	34	-	3397			-	-
-	-			3397	-	35	C	36	-	3397			-	-
20	3			3730	SFPB-N1.7 Supply Fan Pwr Box	37	A	38	SFPB-N1.14 Supply Fan Pwr Box	3397			3	20
-	-			3730	-	39	B	40	-	3397			-	-
-	-			3730	-	41	C	42	-	3397			-	-
20	3			3397	SFPB-N1.15 Supply Fan Pwr Box	43	A	44	KEF-R.1 Kitchen Exhaust Fan	2827			3	15
-	-			3397	-	45	B	46	-	2827			-	-
-	-			3397	-	47	C	48	-	2827			-	-
30	3			6397	SFPB-N1.16 Supply Fan Pwr Box	49	A	50	MAU-R.1 Makeup Air Unit	1330			3	15
-	-			6397	-	51	B	52	-	1330			-	-
-	-			6397	-	53	C	54	-	1330			-	-
15	3			3064	SFPB-N1.17 Supply Fan Pwr Box	55	A	56	SPARE					15
-	-			3064	-	57	B	58	-					-
-	-			3064	-	59	C	60	-					-
15	3				SPARE	61	A	62	SPARE					20
-	-				-	63	B	64	-					-
-	-				-	65	C	66	-					-
					BUSSED SPACE	67	A	68	BUSSED SPACE					
					BUSSED SPACE	69	B	70	BUSSED SPACE					
					BUSSED SPACE	71	C	72	BUSSED SPACE					
					BUSSED SPACE	73	A	74	BUSSED SPACE					
					BUSSED SPACE	75	B	76	BUSSED SPACE					
					BUSSED SPACE	77	C	78	BUSSED SPACE					
					BUSSED SPACE	79	A	80	BUSSED SPACE					
					BUSSED SPACE	81	B	82	BUSSED SPACE					
					BUSSED SPACE	83	C	84	BUSSED SPACE					
20	1	3072			Kit, Offices/Early Child LTG	85	A	86	SPARE				1	20
20	1	2397			Classrooms	87	B	88	SPARE				1	20
20	1	3750			Community Rooms	89	C	90	SPARE				1	20
20	1	3947			Classrooms, Corridor 128	91	A	92	SPARE				1	20
20	1	2305			Site Lighting	93	B	94	SPARE				1	20
20	1	1383			Site Lighting, Night Lighting	95	C	96	BUSSED SPACE					
20	1	2305			Site Lighting	97	A	98	BUSSED SPACE					
20	1	702			Site Entry Ped Lights	99	B	100	BUSSED SPACE					
20	1				SPARE	101	C	102	BUSSED SPACE					
20	1				SPARE	103	A	104	BUSSED SPACE					
20	1				BUSSED SPACE	105	B	106	BUSSED SPACE					
20	1				BUSSED SPACE	107	C	108	BUSSED SPACE					
					BUSSED SPACE	109	A	110	BUSSED SPACE					
					BUSSED SPACE	111	B	112	BUSSED SPACE					
					BUSSED SPACE	113	C	114	BUSSED SPACE					
					BUSSED SPACE	115	A	116	BUSSED SPACE					
					BUSSED SPACE	117	B	118	BUSSED SPACE					
					BUSSED SPACE	119	C	120	BUSSED SPACE					
					BUSSED SPACE	121	A	122	XFMR To Panel "LPA"	35286			3	175
					BUSSED SPACE	123	B	124	-	36049			-	-
					BUSSED SPACE	125	C	126	-	38390			-	-

Connected VA Phase A:	101971	Demanded VA Phase A:	106237
Connected VA Phase B:	102734	Demanded VA Phase B:	107000
Connected VA Phase C:	105075	Demanded VA Phase C:	109341

	Connected	D.F.	Demand		
Lighting Load:	19861	1.25	24826	Demand Load (A) =	408
Receptacle (First 10 KVA):	0	1.00	0	Spare Capacity (A) =	92
Receptacle (Remainder):	0	0.30	0		
Largest Motor:	19191	1.25	23989		
Remaining Motors:	180864	1.00	180864		
Appliances:	0	0.65	0		
Equipment:	0	1.00	0		
Sub Fed Panl:	109725	1.00	109725		
Total:	329641		339404		
Load (Amps):	396.5		408.2		

Panel HMA New

Panel Schedule

Panel HMA

Project:	SALEM KROC CENTER	Voltage L-L (V):	480
Job No:	2006129	Voltage L-N (V):	277
Location:	Electrical A141	Type:	3 PHASE, 4 WIRE
Minimum Bus Capacity (A):	600	Short Circuit Rating (A):	See one-line Diagram
Main O.C. Device (A):	None	Mounting:	Surface
Design Capacity (A)"	500	Comments	NEMA 4x - Stainless Steel

Device Amps	Pole	Lighting (VA)	Rect. (VA)	M/LM/E/A/S (VA)	Description	Ckt. No.	Phase	Ckt. No.	Description	M/LM/E/A/S (VA)	Rect. (VA)	Lighting (VA)	Pole	Device Amps
60	3			12027	HP 1	1	A	2	KEF-R.1 Kitchen Exhaust Fan	2827			3	15
-	-			12027	-	3	B	4	-	2827			-	-
-	-			12027	-	5	C	6	-	2827			-	-
40	3			8148	HP 2	7	A	8	MAU-R.1 Makeup Air Unit	1330			3	15
-	-			8148	-	9	B	10	-	1330			-	-
-	-			8148	-	11	C	12	-	1330			-	-
60	3			11002	ERV 1	13	A	14	SPARE					15
-	-			11002	-	15	B	16	-					-
-	-			11002	-	17	C	18	-					-
15	3				SPARE	19	A	20	SPARE					20
-	-				-	21	B	22	-					-
-	-				-	23	C	24	-					-
					BUSSED SPACE	25	A	26	BUSSED SPACE					
					BUSSED SPACE	27	B	28	BUSSED SPACE					
					BUSSED SPACE	29	C	30	BUSSED SPACE					
					BUSSED SPACE	31	A	32	BUSSED SPACE					
					BUSSED SPACE	33	B	34	BUSSED SPACE					
					BUSSED SPACE	35	C	36	BUSSED SPACE					
					BUSSED SPACE	37	A	38	BUSSED SPACE					
					BUSSED SPACE	39	B	40	BUSSED SPACE					
					BUSSED SPACE	41	C	42	BUSSED SPACE					
20	1	3072			Kit, Offices/Early Child LTG	43	A	44	SPARE				1	20
20	1	2397			Classrooms	45	B	46	SPARE				1	20
20	1	3750			Community Rooms	47	C	48	SPARE				1	20
20	1	3947			Classrooms, Corridor 128	49	A	50	SPARE				1	20
20	1	2305			Site Lighting	51	B	52	SPARE				1	20
20	1	1383			Site Lighting, Night Lighting	53	C	54	BUSSED SPACE					
20	1	2305			Site Lighting	55	A	56	BUSSED SPACE					
20	1	702			Site Entry Ped Lights	57	B	58	BUSSED SPACE					
20	1				SPARE	59	C	60	BUSSED SPACE					
20	1				SPARE	61	A	62	BUSSED SPACE					
20	1				BUSSED SPACE	63	B	64	BUSSED SPACE					
20	1				BUSSED SPACE	65	C	66	BUSSED SPACE					
					BUSSED SPACE	67	A	68	BUSSED SPACE					
					BUSSED SPACE	69	B	70	BUSSED SPACE					
					BUSSED SPACE	71	C	72	BUSSED SPACE					
					BUSSED SPACE	73	A	74	BUSSED SPACE					
					BUSSED SPACE	75	B	76	BUSSED SPACE					
					BUSSED SPACE	77	C	78	BUSSED SPACE					
					BUSSED SPACE	79	A	80	XFMR To Panel "LPA"	35286			3	175
					BUSSED SPACE	81	B	82	-	36049			-	-
					BUSSED SPACE	83	C	84	-	38390			-	-

Connected VA Phase A:	70620	Demanded VA Phase A:	73627
Connected VA Phase B:	71383	Demanded VA Phase B:	74390
Connected VA Phase C:	73724	Demanded VA Phase C:	76731

	Connected	D.F.	Demand		
Lighting Load:	19861	1.25	24826	Demand Load (A) =	300
Receptacle (First 10 KVA):	0	1.00	0	Spare Capacity (A) =	100
Receptacle (Remainder):	0	0.30	0		
Largest Motor:	36081	1.25	45102		
Remaining Motors:	69921	1.00	69921		
Appliances:	0	0.65	0		
Equipment:	0	1.00	0		
Sub Fed Panl:	109725	1.00	109725		
Total:	235587.9145		249574		
Load (Amps):	283.4		300.2		

Panel HMB Original

Panel Schedule
Panel HMB

Project:	SALEM KROC CENTER	Voltage L-L (V):	480
Job No:	2006129	Voltage L-N (V):	277
Location:	Electrical B115	Type:	3 PHASE, 4 WIRE
Minimum Bus Capacity (A):	600	Short Circuit Rating (A):	See one-line Diagram
Main O.C. Device (A):	None	Mounting:	Surface
Design Capacity (A)"	500	Comments	None

Device Amps	Pole	Lighting (VA)	Rect. (VA)	M/LM/E/A/S (VA)	Description	Ckt. No.	Phase	Ckt. No.	Description	M/LM/E/A/S (VA)	Rect. (VA)	Lighting (VA)	Pole	Device Amps
35	3			6730	SFPB-N1.18 Supply Fan Pwr Box	1	A	2	RTU-R.3 Rooftop Unit	16885			3	70
-	-			6730	-	3	B	4	-	16885			-	-
-	-			6730	-	5	C	6	-	16885			-	-
30	3			5730	SFPB-N1.19 Supply Fan Pwr Box	7	A	8	RTU-R.4 Rooftop Unit	10795			3	50
-	-			5730	-	9	B	10	-	10795			-	-
-	-			5730	-	11	C	12	-	10795			-	-
20	3				SPARE	13	A	14	OHP-R.1 Outdoor Heat Pump	3045			3	15
-	-				-	15	B	16	-	3045			-	-
-	-				-	17	C	18	-	3045			-	-
20	1	3005			Corridor, Teen, Adult LTG	19	A	20	OHP-R.2 Outdoor Heat Pump	3045			3	15
20	1	1789			Chapel, Sto, Offices, Ext LTG	21	B	22	-	3045			-	-
20	1	340			Sto D102, Vest B106, B104	23	C	24	-	3045			-	-
20	1	1675			Site Lighting	25	A	26	SPARE				3	15
20	1				Lobby B105	27	B	28	-				-	-
20	1	1500			Building Sign	29	C	30	-				-	-
20	1				SPARE	31	A	32	BUSSED SPACE					
20	1				SPARE	33	B	34	BUSSED SPACE					
					BUSSED SPACE	35	C	36	BUSSED SPACE					
					BUSSED SPACE	37	A	38	XFMR to Panel "LPB"	39438			3	225
					BUSSED SPACE	39	B	40	-	34248			-	-
-	-				BUSSED SPACE	41	C	42	-	33852			-	-

Connected VA Phase A:	85668	Demanded VA Phase A:	89889
Connected VA Phase B:	80478	Demanded VA Phase B:	84699
Connected VA Phase C:	80082	Demanded VA Phase C:	84303

	Connected	D.F.	Demand		
Lighting Load:	8309	1.25	10386	Demand Load (A) =	324
Receptacle (First 10 KVA):	0	1.00	0	Spare Capacity (A) =	176
Receptacle (Remainder):	0	0.30	0		
Largest Motor:	50655	1.25	63319		
Remaining Motors:	88035	1.00	88035		
Appliances:	0	0.65	0		
Equipment:	0	1.00	0		
Sub Fed Panl:	107538	1.00	107538		
Total:	254537		269278		
Load (Amps):	306.2		323.9		

Panel HMB New

Panel Schedule
Panel HMB

Project:	SALEM KROC CENTER	Voltage L-L (V):	480
Job No:	2006129	Voltage L-N (V):	277
Location:	Electrical B115	Type:	3 PHASE, 4 WIRE
Minimum Bus Capacity (A):	400	Short Circuit Rating (A):	See one-line Diagram
Main O.C. Device (A):	None	Mounting:	Surface
Design Capacity (A)"	400	Comments	None

Device Amps	Pole	Lighting (VA)	Rect. (VA)	M/LM/E/A/S (VA)	Description	Ckt. No.	Phase	Ckt. No.	Description	M/LM/E/A/S (VA)	Rect. (VA)	Lighting (VA)	Pole	Device Amps
70	3			13080	HP 3	1	A	2	ERV 3	11002			3	60
-	-			13080	-	3	B	4	-	11002			-	-
-	-			13080	-	5	C	6	-	11002			-	-
20	3				SPARE	7	A	8	SPARE				3	20
-	-				-	9	B	10	-				-	-
-	-				-	11	C	12	-				-	-
20	3				SPARE	13	A	14	SPARE				3	15
-	-				-	15	B	16	-				-	-
-	-				-	17	C	18	-				-	-
20	1	3005			Corridor, Teen, Adult LTG	19	A	20	SPARE				3	15
20	1	1789			Chapel, Sto, Offices, Ext LTG	21	B	22	-				-	-
20	1	340			Sto D102, Vest B106, B104	23	C	24	-				-	-
20	1	1675			Site Lighting	25	A	26	SPARE				3	15
20	1				Lobby B105	27	B	28	-				-	-
20	1	1500			Building Sign	29	C	30	-				-	-
20	1				SPARE	31	A	32	BUSSED SPACE					
20	1				SPARE	33	B	34	BUSSED SPACE					
					BUSSED SPACE	35	C	36	BUSSED SPACE					
					BUSSED SPACE	37	A	38	XFMR to Panel "LPB"	39438			3	225
					BUSSED SPACE	39	B	40	-	34248			-	-
-	-				BUSSED SPACE	41	C	42	-	33852			-	-

Connected VA Phase A:	63520	Demanded VA Phase A:	66790
Connected VA Phase B:	58330	Demanded VA Phase B:	61600
Connected VA Phase C:	57934	Demanded VA Phase C:	61204

	Connected	D.F.	Demand		
Lighting Load:	8309	1.25	10386	Demand Load (A) =	241
Receptacle (First 10 KVA):	0	1.00	0	Spare Capacity (A) =	159
Receptacle (Remainder):	0	0.30	0		
Largest Motor:	39240	1.25	49051		
Remaining Motors:	33006	1.00	33006		
Appliances:	0	0.65	0		
Equipment:	0	1.00	0		
Sub Fed Panl:	107538	1.00	107538		
Total:	188093		199981		
Load (Amps):	226.2		240.5		

Panel HMC Original

Panel Schedule

Panel HMC

Project:	SALEM KROC CENTER	Voltage L-L (V):	480
Job No:	2006129	Voltage L-N (V):	277
Location:	Electrical C124	Type:	3 PHASE, 4 WIRE
Minimum Bus Capacity (A):	400	Short Circuit Rating (A):	See one-line Diagram
Main O.C. Device (A):	None	Mounting:	Surface
Design Capacity (A)"	400	Comments	NEMA 4x - Stainless Steel

Device Amps	Pole	Lighting (VA)	Rect. (VA)	M/LM/E/A/S (VA)	Description	Ckt. No.	Phase	Ckt. No.	Description	M/LM/E/A/S (VA)	Rect. (VA)	Lighting (VA)	Pole	Device Amps
15	3			2286	SFPB-S1.1 Supply Fan Pwr Box	1	A	2	SFPB-S1.8 Supply Fan Pwr Box	2620			3	15
-	-			2286	-	3	B	4	-	2620			-	-
-	-			2286	-	5	C	6	-	2620			-	-
15	3			2620	SFPB-S1.2 Supply Fan Pwr Box	7	A	8	SFPB-S1.9 Supply Fan Pwr Box	3730			3	20
-	-			2620	-	9	B	10	-	3730			-	-
-	-			2620	-	11	C	12	-	3730			-	-
20	3			3397	SFPB-S1.3 Supply Fan Pwr Box	13	A	14	SPARE				3	20
-	-			3397	-	15	B	16	-				-	-
-	-			3397	-	17	C	18	-				-	-
15	1			859	SFPB-S1.4 Supply Fan Pwr Box	19	A	20	BUSSED SPACE					
					BUSSED SPACE	21	B	22	BUSSED SPACE					
					BUSSED SPACE	23	C	24	BUSSED SPACE					
15	3			2286	SFPB-S1.5 Supply Fan Pwr Box	25	A	26	BUSSED SPACE					
-	-			2286	-	27	B	28	BUSSED SPACE					
-	-			2286	-	29	C	30	BUSSED SPACE					
15	3			2286	SFPB-S1.6 Supply Fan Pwr Box	31	A	32	BUSSED SPACE					
-	-			2286	-	33	B	34	BUSSED SPACE					
-	-			2286	-	35	C	36	BUSSED SPACE					
15	3			1620	SFPB-S1.7 Supply Fan Pwr Box	37	A	38	XFMR to Panel "LPC"	26259			3	175
-	-			1620	-	39	B	40	-	28971			-	-
-	-			1620	-	41	C	42	-	31921			-	-
60	3			12179	RTU-R.2 Rooftop Unit	43	A	44	BUSSED SPACE					
-	-			12179	-	45	B	46	BUSSED SPACE					
-	-			12179	-	47	C	48	BUSSED SPACE					
50	3			10795	RTU-R.5 Rooftop Unit	49	A	50	BUSSED SPACE					
-	-			10795	-	51	B	52	BUSSED SPACE					
-	-			10795	-	53	C	54	BUSSED SPACE					
15	3			2106	REF-R.2 Rooftop Exhaust Fan	55	A	56	BUSSED SPACE					
-	-			2106	-	57	B	58	BUSSED SPACE					
-	-			2106	-	59	C	60	BUSSED SPACE					
15	3			2106	REF-R.3 Rooftop Exhaust Fan	61	A	62	Admin Offices, Childcare			3900	1	20
-	-			2106	-	63	B	64	Gymnasium Lights			3240	1	20
-	-			2106	-	65	C	66	Gymnasium Lights			3240	1	20
15	3				SPARE	67	A	68	Fitness			2160	1	20
-	-				-	69	B	70	Corridor 108			3120	1	20
-	-				-	71	C	72	"C" Canopy Lights, Aerobics			2704	1	20
					BUSSED SPACE	73	A	74	Control Desk Trellis			2200	1	20
					BUSSED SPACE	75	B	76	Building Signage			500	1	20
					BUSSED SPACE	77	C	78	SPARE				1	20
					BUSSED SPACE	79	A	80	SPARE				1	20
					BUSSED SPACE	81	B	82	SPARE				1	20
					BUSSED SPACE	83	C	84	SPARE				1	20

Connected VA Phase A:	75149	Demanded VA Phase A:	87753
Connected VA Phase B:	77002	Demanded VA Phase B:	89606
Connected VA Phase C:	79952	Demanded VA Phase C:	92556

	Connected	D.F.	Demand		
Lighting Load:	21064	1.25	26330	Demand Load (A) =	322
Receptacle (First 10 KVA):	0	1.00	0	Spare Capacity (A) =	78
Receptacle (Remainder):	0	0.30	0		
Largest Motor:	36537	1.25	45671		
Remaining Motors:	108415	1.00	108415		
Appliances:	0	0.65	0		
Equipment:	0	1.00	0		
Sub Fed Panl:	87151	1.00	87151		
Total:	253167		267567		
Load (Amps):	304.5		321.8		

Panel HMC New

Panel Schedule

Panel HMC

Project:	SALEM KROC CENTER	Voltage L-L (V):	480
Job No:	2006129	Voltage L-N (V):	277
Location:	Electrical C124	Type:	3 PHASE, 4 WIRE
Minimum Bus Capacity (A):	400	Short Circuit Rating (A):	See one-line Diagram
Main O.C. Device (A):	None	Mounting:	Surface
Design Capacity (A)"	300	Comments	None

Device Amps	Pole	Lighting (VA)	Rect. (VA)	M/LM/E/A/S (VA)	Description	Ckt. No.	Phase	Ckt. No.	Description	M/LM/E/A/S (VA)	Rect. (VA)	Lighting (VA)	Pole	Device Amps
40	3			8148	HP 4	1	A	2	ERV 2	11002			3	60
-	-			8148	-	3	B	4	-	11002			-	-
-	-			8148	-	5	C	6	-	11002			-	-
20	3				SPARE	7	A	8	SPARE				3	20
-	-				-	9	B	10	-				-	-
-	-				-	11	C	12	-				-	-
20	3				SPARE	13	A	14	SPARE				3	20
-	-				-	15	B	16	-				-	-
-	-				-	17	C	18	-				-	-
15	1				SPARE	19	A	20	BUSSED SPACE					
					BUSSED SPACE	21	B	22	BUSSED SPACE					
					BUSSED SPACE	23	C	24	BUSSED SPACE					
15	3				SPARE	25	A	26	BUSSED SPACE					
-	-				-	27	B	28	BUSSED SPACE					
-	-				-	29	C	30	BUSSED SPACE					
15	3				SPARE	31	A	32	BUSSED SPACE					
-	-				-	33	B	34	BUSSED SPACE					
-	-				-	35	C	36	BUSSED SPACE					
15	3				SPARE	37	A	38	XFMR to Panel "LPC"	26259			3	175
-	-				-	39	B	40	-	28971			-	-
-	-				-	41	C	42	-	31921			-	-
20	3				SPARE	43	A	44	BUSSED SPACE					
-	-				-	45	B	46	BUSSED SPACE					
-	-				-	47	C	48	BUSSED SPACE					
20	3				SPARE	49	A	50	BUSSED SPACE					
-	-				-	51	B	52	BUSSED SPACE					
-	-				-	53	C	54	BUSSED SPACE					
15	3			2106	REF-R.2 Rooftop Exhaust Fan	55	A	56	BUSSED SPACE					
-	-			2106	-	57	B	58	BUSSED SPACE					
-	-			2106	-	59	C	60	BUSSED SPACE					
15	3			2106	REF-R.3 Rooftop Exhaust Fan	61	A	62	Admin Offices, Childcare			3900	1	20
-	-			2106	-	63	B	64	Gymnasium Lights			3240	1	20
-	-			2106	-	65	C	66	Gymnasium Lights			3240	1	20
15	3				SPARE	67	A	68	Fitness			2160	1	20
-	-				-	69	B	70	Corridor 108			3120	1	20
-	-				-	71	C	72	"C" Canopy Lights, Aerobics			2704	1	20
					BUSSED SPACE	73	A	74	Control Desk Trellis			2200	1	20
					BUSSED SPACE	75	B	76	Building Signage			500	1	20
					BUSSED SPACE	77	C	78	SPARE				1	20
					BUSSED SPACE	79	A	80	SPARE				1	20
					BUSSED SPACE	81	B	82	SPARE				1	20
					BUSSED SPACE	83	C	84	SPARE				1	20

Connected VA Phase A:	49621	Demanded VA Phase A:	52371
Connected VA Phase B:	52333	Demanded VA Phase B:	55083
Connected VA Phase C:	55283	Demanded VA Phase C:	58033

	Connected	D.F.	Demand		
Lighting Load:	21064	1.25	26330	Demand Load (A) =	231
Receptacle (First 10 KVA):	0	1.00	0	Spare Capacity (A) =	69
Receptacle (Remainder):	0	0.30	0		
Largest Motor:	33006	1.25	41257		
Remaining Motors:	37080	1.00	37080		
Appliances:	0	0.65	0		
Equipment:	0	1.00	0		
Sub Fed Panl:	87151	1.00	87151		
Total:	178301		191818		
Load (Amps):	214.5		230.7		

Panel HMD Original

Panel Schedule

Panel HMD

Project:	SALEM KROC CENTER	Voltage L-L (V):	480
Job No:	2006129	Voltage L-N (V):	277
Location:	Electrical D131	Type:	3 PHASE, 4 WIRE
Minimum Bus Capacity (A):	400	Short Circuit Rating (A):	See one-line Diagram
Main O.C. Device (A):	None	Mounting:	Surface
Design Capacity (A)"	400	Comments	None

Device Amps	Pole	Lighting (VA)	Rect. (VA)	M/LM/E/A/S (VA)	Description	Ckt. No.	Phase	Ckt. No.	Description	M/LM/E/A/S (VA)	Rect. (VA)	Lighting (VA)	Pole	Device Amps
15	3			583	HWP-1.1 Hot Water Pump	1	A	2	CF-1.4 Ceiling Fan	583			3	15
-	-			583	-	3	B	4	-	583			-	-
-	-			583	-	5	C	6	-	583			-	-
20	3			3048	HWS-1.1 Hot Water Secondary	7	A	8	CF-1.5 Ceiling Fan	583			3	15
-	-			3048	-	9	B	10	-	583			-	-
-	-			3048	-	11	C	12	-	583			-	-
20	3			3048	HWS-1.2 Hot Water Secondary	13	A	14	SPARE				3	15
-	-			3048	-	15	B	16	-				-	-
-	-			3048	-	17	C	18	-				-	-
20	3				SPARE	19	A	20	SPARE				1	20
-	-				-	21	B	22	SPARE				1	20
-	-				-	23	C	24	SPARE				1	20
					BUSSED SPACE	25	A	26	BUSSED SPACE					
					BUSSED SPACE	27	B	28	BUSSED SPACE					
					BUSSED SPACE	29	C	30	BUSSED SPACE					
					BUSSED SPACE	31	A	32	BUSSED SPACE					
					BUSSED SPACE	33	B	34	BUSSED SPACE					
					BUSSED SPACE	35	C	36	BUSSED SPACE					
					BUSSED SPACE	37	A	38	BUSSED SPACE					
					BUSSED SPACE	39	B	40	BUSSED SPACE					
					BUSSED SPACE	41	C	42	BUSSED SPACE					
15	3			2286	SFPB-S1.10 Supply Fan Pwr Box	43	A	44	RTU-R.6 Rooftop Unit	10795			3	50
-	-			2286	-	45	B	46	-	10795			-	-
-	-			2286	-	47	C	48	-	10795			-	-
15	3			2286	SFPB-S1.11 Supply Fan Pwr Box	49	A	50	RTU-R.7 Rooftop Unit	4650			3	25
-	-			2286	-	51	B	52	-	4650			-	-
-	-			2286	-	53	C	54	-	4650			-	-
15	3			953	SFPB-S1.12 Supply Fan Pwr Box	55	A	56	RTU-R.8 Rooftop Unit	13563			3	60
-	-			953	-	57	B	58	-	13563			-	-
-	-			953	-	59	C	60	-	13563			-	-
30	3			5730	SFPB-S1.13 Supply Fan Pwr Box	61	A	62	RTU-R.10 Rooftop Unit	7335			3	35
-	-			5730	-	63	B	64	-	7335			-	-
-	-			5730	-	65	C	66	-	7335			-	-
15	3			4397	SFPB-S1.14 Supply Fan Pwr Box	67	A	68	REF-R.6 Rooftop Exhaust Fan	2106			3	15
-	-			4397	-	69	B	70	-	2106			-	-
-	-			4397	-	71	C	72	-	2106			-	-
15	3			1330	TEF-R.2 Toilet Exhaust Fan	73	A	74	REF-R.7 Rooftop Exhaust Fan	583			3	15
-	-			1330	-	75	B	76	-	583			-	-
-	-			1330	-	77	C	78	-	583			-	-
15	3				SPARE	79	A	80	REF-R.8 Rooftop Exhaust Fan	2106			3	15
-	-				-	81	B	82	-	2106			-	-
-	-				-	83	C	84	-	2106			-	-

Connected VA Phase A:	65965	Demanded VA Phase A:	69356
Connected VA Phase B:	65965	Demanded VA Phase B:	69356
Connected VA Phase C:	65965	Demanded VA Phase C:	69356

	Connected	D.F.	Demand		
Lighting Load:	0	1.25	0	Demand Load (A) =	250
Receptacle (First 10 KVA):	0	1.00	0	Spare Capacity (A) =	150
Receptacle (Remainder):	0	0.30	0		
Largest Motor:	40689	1.25	50861		
Remaining Motors:	157206	1.00	157206		
Appliances:	0	0.65	0		
Equipment:	0	1.00	0		
Sub Fed Panl:	0	1.00	0		
Total:	197895		208067		
Load (Amps):	238.0		250.3		

Panel HMD New

Panel Schedule

Panel HMD

Project:	SALEM KROC CENTER	Voltage L-L (V):	480
Job No:	2006129	Voltage L-N (V):	277
Location:	Electrical D131	Type:	3 PHASE, 4 WIRE
Minimum Bus Capacity (A):	400	Short Circuit Rating (A):	See one-line Diagram
Main O.C. Device (A):	None	Mounting:	Surface
Design Capacity (A)"	400	Comments	None

Device Amps	Pole	Lighting (VA)	Rect. (VA)	M/LM/E/A/S (VA)	Description	Ckt. No.	Phase	Ckt. No.	Description	M/LM/E/A/S (VA)	Rect. (VA)	Lighting (VA)	Pole	Device Amps
15	3			583	HWP-1.1 Hot Water Pump	1	A	2	CF-1.4 Ceiling Fan	583			3	15
-	-			583	-	3	B	4	-	583			-	-
-	-			583	-	5	C	6	-	583			-	-
20	3			3048	HWS-1.1 Hot Water Secondary	7	A	8	CF-1.5 Ceiling Fan	583			3	15
-	-			3048	-	9	B	10	-	583			-	-
-	-			3048	-	11	C	12	-	583			-	-
20	3			3048	HWS-1.2 Hot Water Secondary	13	A	14	SPARE				3	15
-	-			3048	-	15	B	16	-				-	-
-	-			3048	-	17	C	18	-				-	-
20	3				SPARE	19	A	20	SPARE				1	20
-	-				-	21	B	22	SPARE				1	20
-	-				-	23	C	24	SPARE				1	20
					BUSSED SPACE	25	A	26	BUSSED SPACE					
					BUSSED SPACE	27	B	28	BUSSED SPACE					
					BUSSED SPACE	29	C	30	BUSSED SPACE					
					BUSSED SPACE	31	A	32	BUSSED SPACE					
					BUSSED SPACE	33	B	34	BUSSED SPACE					
					BUSSED SPACE	35	C	36	BUSSED SPACE					
					BUSSED SPACE	37	A	38	BUSSED SPACE					
					BUSSED SPACE	39	B	40	BUSSED SPACE					
					BUSSED SPACE	41	C	42	BUSSED SPACE					
70	3			13080	HP 5	43	A	44	AHU 1	12249			3	60
-	-			13080	-	45	B	46	-	12249			-	-
-	-			13080	-	47	C	48	-	12249			-	-
60	3			12027	HP 6	49	A	50	P 1	10614			3	50
-	-			12027	-	51	B	52	-	10614			-	-
-	-			12027	-	53	C	54	-	10614			-	-
20	3			4628	HP 7	55	A	56	P 2	10614			3	50
-	-			4628	-	57	B	58	-	10614			-	-
-	-			4628	-	59	C	60	-	10614			-	-
50	3			10614	P 4	61	A	62	P 3	10614			3	50
-	-			10614	-	63	B	64	-	10614			-	-
-	-			10614	-	65	C	66	-	10614			-	-
15	3				SPARE	67	A	68	REF-R.6 Rooftop Exhaust Fan	2106			3	15
-	-				-	69	B	70	-	2106			-	-
-	-				-	71	C	72	-	2106			-	-
15	3			1330	TEF-R.2 Toilet Exhaust Fan	73	A	74	REF-R.7 Rooftop Exhaust Fan	583			3	15
-	-			1330	-	75	B	76	-	583			-	-
-	-			1330	-	77	C	78	-	583			-	-
15	3				SPARE	79	A	80	REF-R.8 Rooftop Exhaust Fan	2106			3	15
-	-				-	81	B	82	-	2106			-	-
-	-				-	83	C	84	-	2106			-	-

Connected VA Phase A:	98411	Demanded VA Phase A:	101065
Connected VA Phase B:	98410	Demanded VA Phase B:	101064
Connected VA Phase C:	98410	Demanded VA Phase C:	101064

	Connected	D.F.	Demand		
Lighting Load:	0	1.25	0	Demand Load (A) =	365
Receptacle (First 10 KVA):	0	1.00	0	Spare Capacity (A) =	35
Receptacle (Remainder):	0	0.30	0		
Largest Motor:	31842	1.25	39803		
Remaining Motors:	263389	1.00	263389		
Appliances:	0	0.65	0		
Equipment:	0	1.00	0		
Sub Fed Panl:	0	1.00	0		
Total:	295231		303192		
Load (Amps):	355.1		364.7		

Panel HAE Original

Panel Schedule

Panel HAE

Project:	SALEM KROC CENTER	Voltage L-L (V):	480
Job No:	2006129	Voltage L-N (V):	277
Location:	POOL SUPPORT E102	Type:	3 PHASE, 4 WIRE
Minimum Bus Capacity (A):	600	Short Circuit Rating (A):	See one-line Diagram
Main O.C. Device (A):	None	Mounting:	Surface
Design Capacity (A)"	500	Comments	NEMA 4x - Stainless Steel

Device Amps	Pole	Lighting (VA)	Rect. (VA)	M/LM/E/A/S (VA)	Description	Ckt. No.	Phase	Ckt. No.	Description	M/LM/E/A/S (VA)	Rect. (VA)	Lighting (VA)	Pole	Device Amps
70	3			9422	Leis. Pool Filt. Pump - AE 1	1	A	2	Comp Pool Filt Trap - AE21	14411			3	90
-	-			9422	-	3	B	4	-	14411			-	-
-	-			9422	-	5	C	6	-	14411			-	-
20	3			3048	River Activity Pump - AE2	7	A	8	UV System Control - AE27	2000			3	40
-	-			3048	-	9	B	10	-	2000			-	-
-	-			3048	-	11	C	12	-	2000			-	-
60	3			7482	Propulsion Jet Pump - AE 3	13	A	14	Spare				3	15
-	-			7482	-	15	B	16	-				-	-
-	-			7482	-	17	C	18	-				-	-
60	3			7482	Slide Pump - AE5	19	A	20	Whirlpool Filt Pump - AE34	2016			3	15
-	-			7482	-	21	B	22	-	2016			-	-
-	-			7482	-	23	C	24	-	2016			-	-
25	3			3880	Activity Pump - AE6	25	A	26	Whirlpool Jet Pump	3048			3	20
-	-			3880	-	27	B	28	-	3048			-	-
-	-			3880	-	29	C	30	-	3048			-	-
20	3			3048	Blow Hole Pump - AE7A	31	A	32	UV System Control - AE40	833			3	20
-	-			3048	-	33	B	34	-	833			-	-
-	-			3048	-	35	C	36	-	833			-	-
40	3			1667	UV System Control - AE14	37	A	38	Spare				3	15
-	-			1667	-	39	B	40	-				-	-
-	-			1667	-	41	C	42	-				-	-
25	3			5038	RTU-R.9 Rooftop Unit	43	A	44	Spray Pad Filt Trap - AE47	3048			3	20
-	-			5038	-	45	B	46	-	3048			-	-
-	-			5038	-	47	C	48	-	3048			-	-
15	3			2106	MAU-R.2 Makeup Air Unit	49	A	50	Spray Pad Feat Pump - AE48	5820			3	40
-	-			2106	-	51	B	52	-	5820			-	-
-	-			2106	-	53	C	54	-	5820			-	-
35	3			3000	EWH Electric Water Heater	55	A	56	BUSSED SPACE					
-	-			3000	-	57	B	58	BUSSED SPACE					
-	-			3000	-	59	C	60	BUSSED SPACE					
20	1				SPARE	61	A	62	BUSSED SPACE					
20	1				SPARE	63	B	64	BUSSED SPACE					
20	1				SPARE	65	C	66	BUSSED SPACE					
20	1				SPARE	67	A	68	BUSSED SPACE					
					BUSSED SPACE	69	B	70	BUSSED SPACE					
					BUSSED SPACE	71	C	72	BUSSED SPACE					
					BUSSED SPACE	73	A	74	BUSSED SPACE					
					BUSSED SPACE	75	B	76	BUSSED SPACE					
					BUSSED SPACE	77	C	78	BUSSED SPACE					
					BUSSED SPACE	79	A	80	XFMR To Panel "LAE"	25435			3	175
					BUSSED SPACE	81	B	82	-	31517			-	-
					BUSSED SPACE	83	C	84	-	27261			-	-

Connected VA Phase A:	102784	Demanded VA Phase A:	106387
Connected VA Phase B:	108866	Demanded VA Phase B:	112469
Connected VA Phase C:	104610	Demanded VA Phase C:	108213

	Connected	D.F.	Demand		
Lighting Load:	0	1.25	0	Demand Load (A) =	393
Receptacle (First 10 KVA):	0	1.00	0	Spare Capacity (A) =	107
Receptacle (Remainder):	0	0.30	0		
Largest Motor:	43233	1.25	54041		
Remaining Motors:	166314	1.00	166314		
Appliances:	0	0.65	0		
Equipment:	22500	1.00	22500		
Sub Fed Panl:	84213	1.00	84213		
Total:	316260		327068		
Load (Amps):	380.4		393.4		

Panel HAE New

Panel Schedule

Panel HAE

Project:	SALEM KROC CENTER	Voltage L-L (V):	480
Job No:	2006129	Voltage L-N (V):	277
Location:	POOL SUPPORT E102	Type:	3 PHASE, 4 WIRE
Minimum Bus Capacity (A):	600	Short Circuit Rating (A):	See one-line Diagram
Main O.C. Device (A):	None	Mounting:	Surface
Design Capacity (A)"	500	Comments	NEMA 4x - Stainless Steel

Device Amps	Pole	Lighting (VA)	Rect. (VA)	M/LM/E/A/S (VA)	Description	Ckt. No.	Phase	Ckt. No.	Description	M/LM/E/A/S (VA)	Rect. (VA)	Lighting (VA)	Pole	Device Amps
70	3			9422	Leis. Pool Filt. Pump - AE 1	1	A	2	Comp Pool Filt Trap - AE21	14411			3	90
-	-			9422	-	3	B	4	-	14411			-	-
-	-			9422	-	5	C	6	-	14411			-	-
20	3			3048	River Activity Pump - AE2	7	A	8	UV System Control - AE27	2000			3	40
-	-			3048	-	9	B	10	-	2000			-	-
-	-			3048	-	11	C	12	-	2000			-	-
60	3			7482	Propulsion Jet Pump - AE 3	13	A	14	Spare				3	15
-	-			7482	-	15	B	16	-				-	-
-	-			7482	-	17	C	18	-				-	-
60	3			7482	Slide Pump - AE5	19	A	20	Whirlpool Filt Pump - AE34	2016			3	15
-	-			7482	-	21	B	22	-	2016			-	-
-	-			7482	-	23	C	24	-	2016			-	-
25	3			3880	Activity Pump - AE6	25	A	26	Whirlpool Jet Pump	3048			3	20
-	-			3880	-	27	B	28	-	3048			-	-
-	-			3880	-	29	C	30	-	3048			-	-
20	3			3048	Blow Hole Pump - AE7A	31	A	32	UV System Control - AE40	833			3	20
-	-			3048	-	33	B	34	-	833			-	-
-	-			3048	-	35	C	36	-	833			-	-
40	3			1667	UV System Control - AE14	37	A	38	AHU 2	4600			3	20
-	-			1667	-	39	B	40	-	4600			-	-
-	-			1667	-	41	C	42	-	4600			-	-
15	3			2827	HP 8	43	A	44	Spray Pad Filt Trap - AE47	3048			3	20
-	-			2827	-	45	B	46	-	3048			-	-
-	-			2827	-	47	C	48	-	3048			-	-
15	3			2106	MAU-R.2 Makeup Air Unit	49	A	50	Spray Pad Feat Pump - AE48	5820			3	40
-	-			2106	-	51	B	52	-	5820			-	-
-	-			2106	-	53	C	54	-	5820			-	-
35	3			3000	EWH Electric Water Heater	55	A	56	BUSSED SPACE					
-	-			3000	-	57	B	58	BUSSED SPACE					
-	-			3000	-	59	C	60	BUSSED SPACE					
20	1				SPARE	61	A	62	BUSSED SPACE					
20	1				SPARE	63	B	64	BUSSED SPACE					
20	1				SPARE	65	C	66	BUSSED SPACE					
20	1				SPARE	67	A	68	BUSSED SPACE					
					BUSSED SPACE	69	B	70	BUSSED SPACE					
					BUSSED SPACE	71	C	72	BUSSED SPACE					
					BUSSED SPACE	73	A	74	BUSSED SPACE					
					BUSSED SPACE	75	B	76	BUSSED SPACE					
					BUSSED SPACE	77	C	78	BUSSED SPACE					
					BUSSED SPACE	79	A	80	XFMR To Panel "LAE"	25435			3	175
					BUSSED SPACE	81	B	82	-	31517			-	-
					BUSSED SPACE	83	C	84	-	27261			-	-

Connected VA Phase A:	105173.0339	Demanded VA Phase A:	108776
Connected VA Phase B:	111255	Demanded VA Phase B:	114858
Connected VA Phase C:	106999	Demanded VA Phase C:	110602

	Connected	D.F.	Demand		
Lighting Load:	0	1.25	0	Demand Load (A) =	402
Receptacle (First 10 KVA):	0	1.00	0	Spare Capacity (A) =	98
Receptacle (Remainder):	0	0.30	0		
Largest Motor:	43233	1.25	54041		
Remaining Motors:	173481.0339	1.00	173481		
Appliances:	0	0.65	0		
Equipment:	22500	1.00	22500		
Sub Fed Panl:	84213	1.00	84213		
Total:	323427.0339		334235		
Load (Amps):	389.0		402.0		

Electrical Wire Price Sheet

Building Wire Products
Catalog Section 1
Price Page 1 of 2

418C

COMMERCIAL
Distributor List Price Sheet

Copper Building Wire

Date: February 29, 2012

Prices shown are per 1,000 feet. Subject to change without notice. This sheet supersedes Sheet #417C Dated February 13, 2012.

Size	THHN COLORS	THHN BLACK	USE	XHHW	TFFN	TFN
SOLID						
18 AWG	------	------	------	------	------	$133.73
16	------	------	------	------	------	185.58
14	$210.14	$210.14	------	------	------	------
12	317.04	317.04	$577.24	------	------	------
10	501.25	501.25	842.75	------	------	------
STRANDED						
18 AWG	------	------	------	------	$140.71	------
16	------	------	------	------	192.48	------
14	$239.61	$239.61	$566.26	$349.22	------	------
12 AWG	367.57	367.57	675.63	523.57	------	------
10	567.97	567.97	1,012.55	793.05	------	------
8	874.09	874.09	1,385.50	1,218.05	------	------
6	1,344.86	1,344.86	2,095.36	1,812.52	------	------
4 AWG	2,157.51	2,157.51	3,170.01	2,795.04	------	------
3	2,673.98	2,673.98	-----	3,471.18	------	------
2	3,346.96	3,346.96	5,148.52	4,358.15	------	------
1	4,398.48	4,398.48	6,956.49	5,963.61	------	------
1/0 AWG	5,331.09	5,331.09	8,688.20	7,417.60	------	------
2/0	6,682.73	6,682.73	10,921.23	9,270.03	------	------
3/0	8,383.57	8,383.57	13,647.43	11,605.03	------	------
4/0	10,527.79	10,527.79	15,585.32	14,554.90	------	------
250 kcmil	12,486.16	12,486.16	16,401.72	15,198.95	------	------
300	14,898.33	14,898.33	20,146.83	17,120.04	------	------
350	17,444.47	17,444.47	22,817.20	20,002.50	------	------
400	19,854.82	19,854.82	26,033.23	22,809.35	------	------
500 kcmil	24,018.27	24,018.27	30,526.52	27,314.13	------	------
600	30,999.02	30,999.02	36,698.68	32,176.65	------	------
750	52,198.30	52,198.30	65,536.18	53,534.32	------	------
1000	69,269.33	69,269.33	86,784.86	78,544.13	------	------

"Call Southwire for all your wire & cable needs"

THHN with stripes Standard Colors Only	
WHT-BLK, WHT-RED, WHT-BLU, GRN-YEL GRY-BRN, GRY-ORN, GRY-YEL, GRY-PUR	
12 SOLID THHN With Stripes	$376.67
12 STRANDED THHN With Stripes	427.20
10 SOLID THHN With Stripes	560.88
10 STRANDED THHN With Stripes	627.60

Cutting and Paralleling Charges Per Reel	Cutting Only 1 Conductor	Paralleling 2 Conductors
Sizes AWG 18-AWG 2	STD PKG ONLY	$35.00
Sizes 1- 500 kcmil	$22.00	65.00
Sizes 600 kcmil - 1000 kcmil	27.50	100.00

Cutting and Paralleling Charges Per Reel	Paralleling 3 conductors	Paralleling 4 conductors
Sizes AWG 18-AWG 2	$50.00	$70.00
Sizes AWG 1 - 500 kcmil	95.00	125.00
Sizes 600 kcmil - 1000 kcmil	130.00	150.00

(Paralleling charge includes the cost for cutting. An additional charge of $20.00 will apply to any cuts less than 250 feet shipped on reels.)

Notes:

THHN, USE, XHHW, TFFN & TFN Products carry multiple ratings.
(Please see Southwire catalog for detailed information.)

THHN, sizes 14 and 12, are packaged 4-500ft.spools (2000 ft.) /ctn.

THHN, size 10, is packaged 2-500ft. spools (1000 ft.) /ctn.

TFFN & TFN sizes 18 and 16, are packaged 4-500ft. spools (2000 ft.) /ctn.

Orders for items packaged in ctns. must be in ctn. multiples.

AWG - American Wire Gauge.

Kcmil - Thousand Circular-mils.

MADE IN USA

Southwire®

Panel Wire Change Summaries

Panel HMA Wire Cost Changes					
Wire Size	Subtractions	Additions	Difference	Price/Lin. Ft.	Price Change
#14			0	0.24	$ -
#12	7750		-7750	0.37	$ (2,848.67)
#10	975	240	-735	0.57	$ (417.46)
#8		800	800	0.87	$ 699.27
#6		160	160	1.34	$ 215.18
#4			0	2.16	$ -
#3			0	2.67	$ -
#2			0	3.35	$ -
#1		1050	1050	4.40	$ 4,618.40
#1/0	1050		-1050	5.33	$ (5,597.64)
#2/0			0	6.68	$ -
#3/0			0	8.38	$ -
#4/0			0	10.53	$ -
250			0	12.49	$ -
300			0	14.90	$ -
350		4200	4200	17.44	$ 73,266.77
400			0	19.85	$ -
500	4200		-4200	24.02	$ (100,876.73)
				Total	$ (30,940.88)

Panel HMB Wire Cost Changes					
Wire Size	Subtractions	Additions	Difference	Price/Lin. Ft.	Price Change
#14			0	0.24	$ -
#12	820		-820	0.37	$ (301.41)
#10	250	175	-75	0.57	$ (42.60)
#8	320	745	425	0.87	$ 371.49
#6	525	180	-345	1.34	$ (463.98)
#4	135		-135	2.16	$ (291.26)
#3			0	2.67	$ -
#2	720		-720	3.35	$ (2,409.81)
#1			0	4.40	$ -
#1/0			0	5.33	$ -
#2/0			0	6.68	$ -
#3/0		360	360	8.38	$ 3,018.09
#4/0			0	10.53	$ -
250	2880		-2880	12.49	$ (35,960.14)
300			0	14.90	$ -
350		1440	1440	17.44	$ 25,120.04
400			0	19.85	$ -
500			0	24.02	$ -
				Total	$ (10,959.59)

Panel HMC Wire Cost Changes					
Wire Size	Subtractions	Additions	Difference	Price/Lin. Ft.	Price Change
#14			0	0.24	$ -
#12	1950		-1950	0.37	$ (716.76)
#10	305	155	-150	0.57	$ (85.20)
#8		620	620	0.87	$ 541.94
#6	225		-225	1.34	$ (302.59)
#4	240		-240	2.16	$ (517.80)
#3	550		-550	2.67	$ (1,470.69)
#2			0	3.35	$ -
#1			0	4.40	$ -
#1/0		275	275	5.33	$ 1,466.05
#2/0			0	6.68	$ -
#3/0	2200		-2200	8.38	$ (18,443.85)
#4/0			0	10.53	$ -
250			0	12.49	$ -
300		1100	1100	14.90	$ 16,388.16
350			0	17.44	$ -
400			0	19.85	$ -
500			0	24.02	$ -

Total	$ (3,140.75)

Panel HMD Wire Cost Changes					
Wire Size	Subtractions	Additions	Difference	Price/Lin. Ft.	Price Change
#14			0	0.24	$ -
#12	2350	350	-2000	0.37	$ (735.14)
#10	1515	405	-1110	0.57	$ (630.45)
#8	300	815	515	0.87	$ 450.16
#6	285	1340	1055	1.34	$ 1,418.83
#4	210		-210	2.16	$ (453.08)
#3			0	2.67	$ -
#2			0	3.35	$ -
#1			0	4.40	$ -
#1/0			0	5.33	$ -
#2/0			0	6.68	$ -
#3/0			0	8.38	$ -
#4/0			0	10.53	$ -
250			0	12.49	$ -
300			0	14.90	$ -
350			0	17.44	$ -
400			0	19.85	$ -
500			0	24.02	$ -

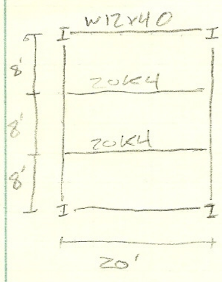
Total	$ 50.32

Panel HAE Wire Cost Changes					
Wire Size	Subtractions	Additions	Difference	Price/Lin. Ft.	Price Change
#14			0	0.24	$ -
#12		1075	1075	0.37	$ 395.14
#10	660		-660	0.57	$ (374.86)
#8			0	0.87	$ -
#6			0	1.34	$ -
#4			0	2.16	$ -
				Total	$ 20.28

Panel LPD Wire Cost Changes					
Wire Size	Subtractions	Additions	Difference	Price/Lin. Ft.	Price Change
#14			0	0.24	$ -
#12	150		-150	0.37	$ (55.14)
#10			0	0.57	$ -
#8			0	0.87	$ -
#6			0	1.34	$ -
#4			0	2.16	$ -
				Total	$ (55.14)

MISC Wire Cost Changes					
AHU 1					
Wire Size	Subtractions	Additions	Difference	Price/Lin. Ft.	Price Change
#4	195		-195	2.16	$ (420.71)
350	585		-585	17.44	$ (10,205.01)
				Total	$ (10,625.73)
AHU 2					
Wire Size	Subtractions	Additions	Difference	Price/Lin. Ft.	Price Change
#6	160		-160	1.34	$ (215.18)
#3/0	480		-480	8.38	$ (4,024.11)
				Total	$ (4,239.29)
RTU 1					
Wire Size	Subtractions	Additions	Difference	Price/Lin. Ft.	Price Change
#4	525		-525	2.16	$ (1,132.69)
#4/0	1575		-1575	10.53	$ (16,581.27)
				Total	$ (17,713.96)
MDC FEED					
Wire Size	Subtractions	Additions	Difference	Price/Lin. Ft.	Price Change
400 KCMIL		720	720	19.85	$ 14,295.47
500 KCMIL	960		-960	24.02	$ (23,057.54)
				Total	$ (8,762.07)

Appendix C – Structural Information



$T_A = 8'(20') = 160'$

Assume Mech. Unit evenly dist.

$DL = 15psf + 10psf = 25psf$

$SL = 25psf$

$w_u = [1.2(25) + 1.6(25)] \times 8' = 560$

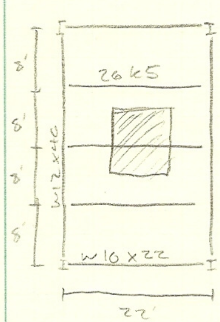
$w_{tl} = (25+25)8 = 400\ plf$

Try 20K4 @ 20' span

$w_u = 560 + 1.2(8)(7.6) = 633 < 825$ ok ✓

$w_{tl} = 400 + (7.6)(8) = 461 < 550$ ok ✓

ERV-3 is ok



$TA = 8'(22) = 176'$

Half of Unit on center joist, evenly distributed

$1600 lbs / 176 = 9.1\ psf_{max}$

$DL = 15psf + 9.1psf = 24.1\ psf$ $SL = 25psf$

$w_u = [1.2(24.1) + 1.6(25)]\ 8' = 551.36\ plf$

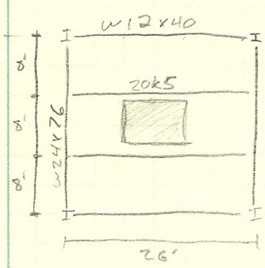
$w_{tL} = (24.1 + 25)8 = 392.8\ plf$

Test 26K5 @ 24' span

$w_u = 551.36 + 1.2(8)(9.8) = 645.44 < 813$ ok ✓

$w_{tl} = 392.8 + 8(9.8) = 471.2 < 535$ ok ✓

ERV 2 is ok ✓



Assume half of mech. unit weight on each of the two trusses

$TA = 8(26) = 208\ ft^2$

$1770/(2 \times 208) = 4.3\ psf$

$DL = 15\ psf + 4.3\ psf = 19.3\ psf$ $\quad SL = 25\ psf$

$w_u = [1.2(19.3) + 1.6(25)] \times 8' = 505.28\ plf$

$w_{LL} = (19.3 + 25)8 = 354.4\ plf$

Try existing 20k5 @ 26' span

$w_u = 505.28 + 8.2(8) = 570.88 < 618$ ok ✓

$w_{LL} = 354.4 + 8.2(8) = 420 > 310$ False ✓

Try 26k5 @ 26' span

$w_u = 505.28 + 9.8(8)(1.2) = 599.36 < 813$ ok ✓

$w_{LL} = 354.4 + 9.8(8) = 432.80 < 535$ ok

This size chosen because it is used elsewhere in the building