# Mechanical Systems Technical Assignment 3

Existing Conditions Evaluation

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The Waverly on Lake Eola
Orlando, FL
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## Executive Summary

The purpose of this report is to study and summarize the existing mechanical systems of The Waverly on Lake Eola in Orlando, Florida. The Waverly on Lake Eola is a 23 story, 371,000 square foot luxury condominium high-rise. The design objectives and requirements for The Waverly were first studied. The main objectives were to provide superior air quality by supplying all spaces with 100% outdoor air, while keeping the first cost of the system relatively low.

Energy sources and rates must be taken into account during mechanical systems design. The electricity to The Waverly is provided by the Orlando Utilities Commission. Cost of electricity was not an overbearing issue to the contractor considering tenants would eventually be paying the bills. The primary factor of the site that creates difficulties is the hot and humid climate of Orlando. The experience the mechanical design firm, GRG consulting engineers, has with the area made them a good candidate for design.

Outdoor and Indoor design conditions were found in the AESHRAE Fundamentals handbook. Calculations for design ventilation requirements were done in order to see if the air quality is up to code. Since The Waverly utilizes 100% outdoor air in all spaces, these requirements were easily met. Design heating and cooling load calculations are not yet complete, but will be added to the report upon completion.

Basic schematic drawings of the system were created in order to better describe, and understand the existing system. Equipment schedules are also found in the report. A conceptual description of the mechanical system utilizes the schematic drawings to describe the system in a manner that could be understood easily. Lastly, the building is critiqued according to all information gathered in the report.

## Design Objectives and Requirements

The Waverly on Lake Eola is a high-rise luxury condominium facility located on beautiful Lake Eola in downtown Orlando, Florida. This 23 story building is designed to provide luxury lifestyle amenities to its tenants and has a total floor area of approximately 371,000 square feet. Views of the lake and downtown Orlando were important in design, and Graham Gund Architects came up with a curved design that maximizes panoramic views of the city.

Floor to ceiling windows throughout the building, while providing gorgeous views of the surrounding area, created a load issue for the mechanical designer of the project, GRG. The developer also requested 100% outdoor air supply to maintain a maximum air quality supply for the tenants of the building.

Since the condominiums are sold off to tenants by the developer, first cost of the mechanical system was a primary concern. While first cost is important, a good mechanical designer would prefer the opportunity to design based on life cycle cost, energy efficiency, and environmental impact. This, however, is not the case with The Waverly and had to be taken into account.

GRG utilized a system consisting of different water source heat pumps for each condominium to condition the spaces. Spaces are to be maintained at approximately 72 ºF and 50% RH. With the hot and humid climate of Orlando, this creates a large cooling load for the building. All these factors must be taken into account when designing the mechanical systems for the Waverly.

## Energy Sources and Rates

The Waverly on Lake Eola is located in downtown Orlando, with rates based on the Orlando Utilities Commission (OUC). Electricity from the OUC will provide power to all tenant units, as well as all common areas and the entire HVAC system with the exception of the boiler.

As this is a residential building, utility rate cost factors were not widely considered. This meant that a somewhat standard system was implemented to ensure a low first cost. Each tenant is responsible for his or her own electric bill, and generally speaking pays standard demand rates.

The Waverly utilizes electrically efficient lighting techniques throughout the building. Evapco's efficient closed circuit fluid cooler helps save on water cooling for the buildings HVAC systems. Since The Waverly is a luxury condominium building, energy costs were not assumed a critical issue by the owner.

## Electric Rates

All electricity cost data was found on the OUC website, www.ouc.com.

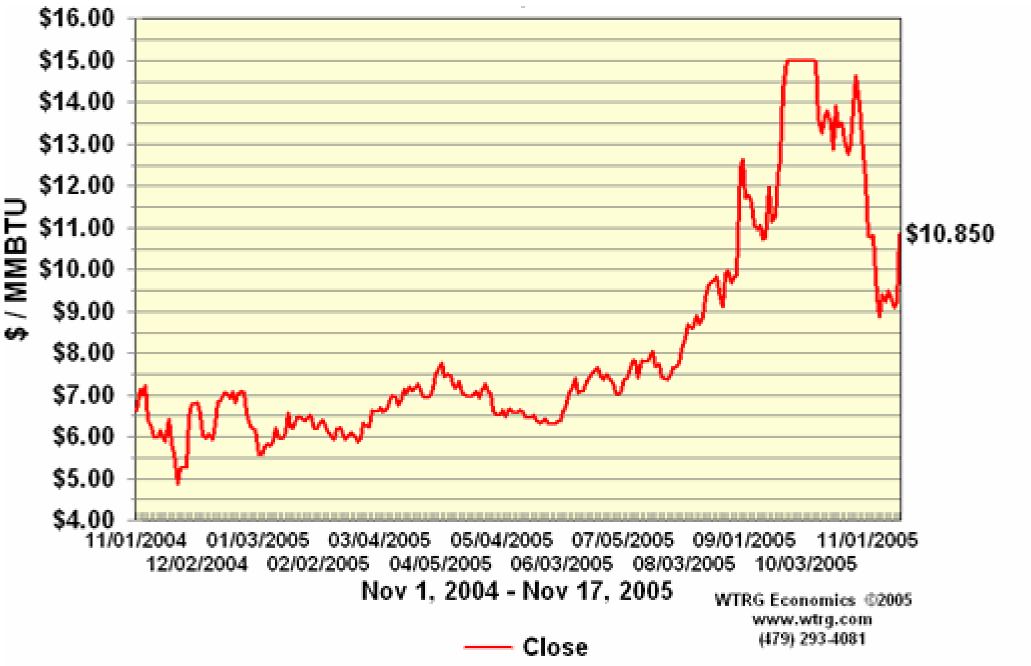
| STANDARD DEMAND RATES | | |
|---|---|---|
| | SECONDARY | PRIMARY |
| Customer Charge | $15.00 per month | $25.00 per month |
| Demand Charge | $6.50 per kW | $6.00 per kW |
| Base Charge | 2.205 cents per kWh | 2.171 cents per kWh |
| Fuel Charge | 3.272 cents per kWh | 3.223 cents per kWh |
| Total Energy Charge | 5.477 cents per kWh | 5.394 cents per kWh |

| OPTIONAL TIME OF USE RATES | | |
|---|---|---|
| | SECONDARY | PRIMARY |
| Customer Charge | $15.00 per month | $25.00 per month |
| Demand Charge | $6.50 per kW | $6.00 per kW |
| **Winter On-Peak Charges** | | |
| Base Charge | 2.039 cents per kWh | 2.034 cents per kWh |
| Fuel Charge | 3.026 cents per kWh | 3,019 cents per kWh |
| Total Energy Charge | 5.065 cents per kWh | 5.053 cents per kWh |
| **Winter Shoulder Charges** | | |

| | | |
|---|---|---|
| Base Charge | 1.505 cents per kWh | 1.500 cents per kWh |
| Fuel Charge | 2.234 cents per kWh | 2.226 cents per kWh |
| Total Energy Charge | 3.739 cents per kWh | 3.726 cents per kWh |
| **Winter Off-Peak Charges** | | |
| Base Charge | 1.351 cents per kWh | 1.348 cents per kWh |
| Fuel Charge | 2.005 cents per kWh | 2.002 cents per kWh |
| Total Energy Charge | 3.356 cents per kWh | 3.350 cents per kWh |
| **Summer On-Peak Charges** | | |
| Base Charge | 4.270 cents per kWh | 4.268 cents per kWh |
| Fuel Charge | 6.338 cents per kWh | 6.337 cents per kWh |
| Total Energy Charge | 10.608 cents per kWh | 10.605 cents per kWh |
| **Summer Shoulder Charges** | | |
| Base Charge | 3.048 cents per kWh | 3.046 cents per kWh |
| Fuel Charge | 4.526 cents per kWh | 4.521 cents per kWh |
| Total Energy Charge | 7.574 cents per kWh | 7.567 cents per kWh |
| **Summer Off-Peak Charges** | | |
| Base Charge | 2.023 cents per kWh | 2.021 cents per kWh |
| Fuel Charge | 3.003 cents per kWh | 3.001 cents per kWh |
| Total Energy Charge | 5.026 cents per kWh | 5.022 cents per kWh |

## Natural Gas Rates

The specific supplier of natural gas for The Waverly was not found, so price estimates are based on the website: www.orlandogasprices.com and are accurate up to November 17, 2005. The chart below shows the fluctuations in gas prices throughout the year.



## Outdoor and Indoor Design Conditions

Outdoor design conditions for Orlando, Florida were taken from the ASHRAE Fundamentals Handbook, 2001 edition. Summer figures represent conditions that are exceeded 0.4% of the year. Winter figures represent figures that are exceeded except for 0.4% of the year. The system is not designed for any extreme conditions outside of this range, and may not meet indoor air requirements in those situations.

Latitude: 28.43

Longitude: 81.42

Elevation: 105 feet

**Summer conditions**:

Design dry bulb: 94 ºF
Mean coincident wet bulb: 76 ºF

**Winter conditions**:

Design dry bulb: 66 ºF

**Indoor Air requirements**:

Dry bulb temperature: 72 degrees F
Relative Humidity: 50%

## Site Factors

The Waverly on Lake Eola is located on the bank of Lake Eola in Orlando, Florida. The original plan for 230 apartments on this site meant that the Waverly would have to be a high rise building. Parking considerations for over 300 residents had to also be considered in design. The eventual concept was born as a 23 story luxury apartment complex consisting of a parking deck on the bottom four floors. The building footprint uses over 75% of the site area.

Luxury was the main concern when ZOM development hired Graham Gund Architects for the design. The beautiful views of the area are accentuated by floor to ceiling windows throughout the building. The buildings distinct "wave" or "wiggle" allows for more window space for residents of the building creating unique, panoramic views of downtown Orlando and Lake Eola.

Since the Waverly is one of the tallest buildings in the area, placing much of the mechanical equipment on the roof 19th floor did not create a problem aesthetically. The fact that the tower of the building is 3 stories taller than this main roof helps to make the mechanical systems easily accessible. The hot and humid climate of Orlando helped in choosing the system, since the main use is cooling. GRG is based out of Maitland, FL, a suburb of Orlando, and has much experience with the area. The location directly next to a lake helps with natural cooling of The Waverly's envelope.

## Design Ventilation Requirements

All building HVAC systems in the United States must comply with ASHRAE standards. This report examines the compliance of The Waverly on Lake Eola with ASHRAE standard 62.1 by a comparison with ASHRAE's ventilation rate calculation procedure. ASHRAE standard 62.1 is used to assure that systems are designed with proper ventilation levels to avoid health problems, and maximize zone comfort. The Waverly on Lake Eola is a 23 story luxury condominium facility. There are five stories of parking and other amenities for residents of the building. The 3$^{rd}$ through 5$^{th}$ floor include some apartments in addition to parking. The 22$^{nd}$ floor is a 3,000 square foot luxury penthouse. The 23$^{rd}$ floor is reserved for building systems.

The Waverly on Lake Eola's mechanical system uses a unique system to supply air. All 230 apartments are supplied by a separate heat pump that acts as an air handling unit for that zone. The 22$^{nd}$ floor penthouse utilizes two heat pumps. Three rooftop heat pumps supply shared spaces throughout the building. Four supply fans located on the roof are used for stairwell pressurization. All supply air utilizes 100% outdoor air to maximize comfort to building residents. Buildings utilizing 100% outdoor air typically have no problem complying with ASHRAE standard 62.1, so long as the proper amount of air is supplied to each space.

The Waverly is split into a 23 story tower section, and a "wave" section of 19 floors. Since all apartments are designed to similar specifications based on their occupancy, calculations were focused to a specific part of the building. All zones with heat pumps attached to a specific relief hood were studied. The Southwestern most section of the tower was chosen for evaluation. This relief hood is connected to heat pumps supplying apartments from the 3$^{rd}$ to the 22$^{nd}$ floors. This required studying the supply air, occupancy, space use, and floor area of each space supplied by this air handling unit.

After running calculations based on ASHRAE standard 62.1, it is apparent that these spaces not only meet outdoor air requirements, but far exceed the necessary specifications. This provides for a healthy and comfortable environment for residents of the building. The use of 100% outdoor air provides consistently high levels of outdoor air entering each space. The reason all buildings are not designed to 100% outdoor air specifications is to decrease energy use. The design of The Waverly on Lake Eola focuses more on clean air than energy savings, providing a comfortable environment for residents.

The next pages contain a spreadsheet displaying examples of The Waverly's outdoor air requirements for different spaces.

| Design Use | CFM | Az | Pz | Req. CFM | Rp | Ra | Vbz | Excess OA |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Floor 3 | | | | | | | | |
| HP 3 | 760 | | | | | | | |
| Bedroom | 180 | 238 | 2 | | 15 | 0.06 | 44.28 | 135.72 |
| Bath | 60 | 73 | 1 | 50 | | | 50 | 10 |
| Main Room | 225 | 244 | 2 | | 15 | 0.06 | 44.64 | 180.36 |
| Kitchen | 125 | 60 | 2 | 100 | | | 100 | 25 |
| Laundry | 60 | 30 | 1 | | 15 | 0.06 | 16.8 | 43.2 |
| Total on HP | 650 | | | | | | 255.72 | 394.28 |
| | | | | | | | | |
| Floors 4-18 | | | | | | | | |
| HP 18 | 760 | | | | | | | |
| Master Bedroom | 120 | 194 | 2 | | 15 | 0.06 | 41.64 | 78.36 |
| Master Bath | 50 | 68 | 1 | 50 | | | 50 | 0 |
| Bedroom 2 | 90 | 140 | 1 | | 15 | 0.06 | 23.4 | 66.6 |
| Family Room | 140 | 255 | 3 | | 15 | 0.06 | 60.3 | 79.7 |
| Window Room | 150 | 216 | 3 | | 15 | 0.06 | 57.96 | 92.04 |
| Kitchen | 90 | 130 | 3 | 100 | | | 100 | -10 |
| Bathroom 2 | 50 | 64 | 1 | 50 | | | 50 | 0 |
| Electrical | 50 | 51 | 1 | | 15 | 0.06 | 18.06 | 31.94 |
| Entrance | 50 | 54 | 3 | | 15 | 0.06 | 48.24 | 1.76 |
| Hall | 40 | 58 | 2 | | 15 | 0.06 | 33.48 | 6.52 |
| Total on HP | 830 | | | | | | 483.08 | 346.92 |
| | | | | | | | | |
| Floor 19 | | | | | | | | |
| HP 18 | 760 | | | | | | | |
| Master Bedroom | 115 | 187 | 2 | | 15 | 0.06 | 41.22 | 73.78 |
| Master Bath | 65 | 85 | 1 | 50 | | | 50 | 15 |
| Family Room | 290 | 325 | 2 | | 15 | 0.06 | 49.5 | 240.5 |
| Kitchen | 100 | 121 | 2 | 100 | | | 100 | 0 |
| Bath/Laundry | 50 | 62 | 1 | 50 | | | 50 | 0 |
| Hall | 50 | 80 | 2 | | 15 | 0.06 | 34.8 | 15.2 |
| Total on HP | 670 | | | | | | 325.52 | 344.48 |
| | | | | | | | | |
| Floors 20-21 | | | | | | | | |
| HP 25 | 1070 | | | | | | | |
| Master Bedroom | 140 | 157 | 2 | | 15 | 0.06 | 39.42 | 100.58 |
| Master Bath | 100 | 121 | 1 | 50 | | | 50 | 50 |
| Bedroom 2 | 125 | 109 | 1 | | 15 | 0.06 | 21.54 | 103.46 |
| Large Room | 420 | 365 | 3 | | 15 | 0.06 | 66.9 | 353.1 |
| Kitchen | 110 | 110 | 3 | 100 | | | 100 | 10 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Bathroom 2 | 75 | 60 | 1 | | 15 | 0.06 | 18.6 | 56.4 |
| Half Bath | 50 | 24 | 1 | 50 | | | 50 | 0 |
| Hall | 50 | 61 | 3 | | 15 | 0.06 | 48.66 | 1.34 |
| Total on HP | 1070 | | | | | | 395.12 | 674.88 |
| | | | | | | | | |
| Penthouse (22) | | | | | | | | |
| HP 26 | 1070 | | | | | | | |
| Bedroom 2 | 140 | 152 | 1 | | 15 | 0.06 | 24.12 | 115.88 |
| Bathroom 2 | 40 | 45 | 1 | 50 | | | 50 | -10 |
| Bedroom 3 | 110 | 124 | 1 | | 15 | 0.06 | 22.44 | 87.56 |
| Bedroom 4 | 140 | 120 | 1 | | 15 | 0.06 | 22.2 | 117.8 |
| Study | 140 | 150 | 3 | | 15 | 0.06 | 54 | 86 |
| Family Room | 125 | 94 | 7 | | 15 | 0.06 | 110.64 | 14.36 |
| Kitchen | 125 | 108 | 4 | 100 | | | 100 | 25 |
| Bathroom 3 | 50 | 55 | 1 | | 15 | 0.06 | 18.3 | 31.7 |
| Laundry | 50 | 30 | 1 | | 15 | 0.06 | 16.8 | 33.2 |
| Hall | 50 | 100 | 2 | | 15 | 0.06 | 36 | 14 |
| Entrance | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 50 |
| Total on HP | 1020 | | | | | | 454.5 | 565.5 |
| | | | | | | | | |
| Penthouse (cont.) | | | | | | | | |
| HP 27 | 650 | | | | | | | |
| Master Bedroom | 130 | 158 | 2 | | 15 | 0.06 | 39.48 | 90.52 |
| Master Bath | 75 | 114 | 2 | 50 | | | 50 | 25 |
| Master Closet | 40 | 78 | 0 | 0 | | | 0 | 40 |
| Bedroom 5 | 105 | 90 | 1 | | 15 | 0.06 | 20.4 | 84.6 |
| Window Room | 300 | 430 | 7 | | 15 | 0.06 | 130.8 | 169.2 |
| Total on HP | 650 | | | | | | 240.68 | 409.32 |
| | | | | | | | | |
| Total from HP | 16020 | | | | | | | |
| Total CFM OA | 16750 | | | | | Vot | 8829.8 | 7920.22 |

## Design Heating and Cooling Loads and Energy Use

Calculations for design heating and cooling loads are still in progress.

## Major Equipment Characteristics

| Heat Pumps | | | | Heating Coil | | Cooling Coil | |
|---|---|---|---|---|---|---|---|
| Local | Service | CFM | Min. Amp. | Cap. MBH | Heat of Abs. | Cap. MBH(tot.) | Cap. MBH(sens.) |
| 1 | 1st Floor | 1960 | 36.3 | 79.8 | 61686 | 58.2 | 40.8 |
| 2 | 1st Floor | 1960 | 36.6 | 79.8 | 61686 | 58.2 | 40.8 |
| 3 | 1st Floor | 760 | 13.6 | 29.5 | 23297 | 22.8 | 15.5 |
| 5 | 1st Floor | 1290 | 22.3 | 42.5 | 33165 | 34.5 | 25 |
| 7 | 1st Floor | 760 | 13.6 | 29.5 | 23297 | 22.8 | 15.5 |
| 8 | 2nd Floor | 1290 | 22.3 | 42.5 | 33165 | 34.5 | 25 |
| 9 | 2nd Floor | 1290 | 22.3 | 42.5 | 33164 | 34.5 | 25 |
| 11 | 5th Floor | 1290 | 22.3 | 42.5 | 33164 | 34.5 | 25 |
| 12a | 5th Floor | 760 | 29.3 | 29.5 | 23297 | 48.1 | 34.2 |
| 12b | 5th Floor | 760 | 13.6 | 29.5 | 23297 | 22.8 | 15.5 |
| 13 | 1st Floor | 370 | 7.2 | 14.4 | 10741 | 11 | 7.6 |
| 14 | 5th Floor | 1840 | 29.3 | 58.2 | 45113 | 48.1 | 34.2 |
| 15 | 5th Floor | 1340 | 25.3 | 50.2 | 38243 | 40.1 | 27.2 |
| 16 | 5th Floor | 1840 | 29.3 | 58.2 | 45113 | 48.1 | 34.2 |
| 17 | Tenant | 650 | 9.5 | 19.8 | 14832 | 14.1 | 9.7 |
| 18 | Tenant | 760 | 13.6 | 29.5 | 23297 | 22.8 | 15.5 |
| 19 | Tenant | 1070 | 20.2 | 42.4 | 33138 | 31.5 | 22.8 |
| 20 | Tenant | 460 | 9.5 | 19.8 | 14832 | 14.1 | 9.7 |
| 21 | Tenant | 760 | 13.6 | 29.5 | 23297 | 22.8 | 15.5 |
| 22 | Tenant | 760 | 13.6 | 29.5 | 23297 | 22.8 | 15.5 |
| 23 | Tenant | 760 | 13.6 | 29.5 | 23297 | 22.8 | 15.5 |
| 24 | Tenant | 760 | 13.6 | 29.5 | 23297 | 22.8 | 15.5 |
| 25 | Tenant | 1070 | 20.2 | 42.4 | 33138 | 31.5 | 22.8 |
| 26 | 22nd Floor | 1070 | 20.2 | 42.4 | 33138 | 31.5 | 22.8 |
| 27 | 22nd Floor | 650 | 13.1 | 25 | 19844 | 18 | 12.7 |
| 28a | Penthouse | 1290 | 22.3 | 42.5 | 33165 | 34.5 | 25 |
| 28b | Penthouse | 1960 | 36.3 | 79.8 | 61686 | 58.2 | 40.8 |
| 29 | Penthouse | 3340 | 58.4 | 112 | 89055 | 93.7 | 70.9 |

| | | | Heating Coil | | Cooling Coil | | |
|---|---|---|---|---|---|---|---|
| Rooftop | Service | CFM | Cap. MBH | GPM | GPM | Cap. MBH(tot.) | Cap. MBH(sens.) |
| 1 | Tube | 5610 | 303 | 135 | 135 | 491 | 239 |
| 2 | Wave | 4830 | 263 | 120 | 130 | 423 | 203 |
| 3 | Wave | 9250 | 514 | 250 | 250 | 836 | 406 |

| Closed Circuit Fluid Cooler | | | Liquid | | Fan Data | | Pump Data | |
|---|---|---|---|---|---|---|---|---|
| | Nom. Tons | EAT WB(ºF) | GPM | Max. PD(psi) | CFM | HP | GPM | HP |
| 1 | 500 | 79 | 1500 | 14.1 | 159900 | 2*25 | 1600 | 2*25 |

| Boiler | Capacity | | | Electical | |
|---|---|---|---|---|---|
| | Input(MBH) | Output(MBH) | Min. Eff. | Req. Ampacity | Voltage |
| 1 | 3000 | 2400 | 80% | 20 | 120 |

| Chilled Water Pumps | Capacity(GPM) | Psig | Head(ft.) | Eff. | Impeller Sz.(inch.) | BHP | HP |
|---|---|---|---|---|---|---|---|
| 1 | 750 | 125 | 100 | 82 | 10.375 | 22.96 | 30 |
| 2 | 750 | 125 | 100 | 82 | 10.375 | 22.96 | 30 |
| 3 | 750 | 125 | 100 | 82 | 10.375 | 22.96 | 30 |

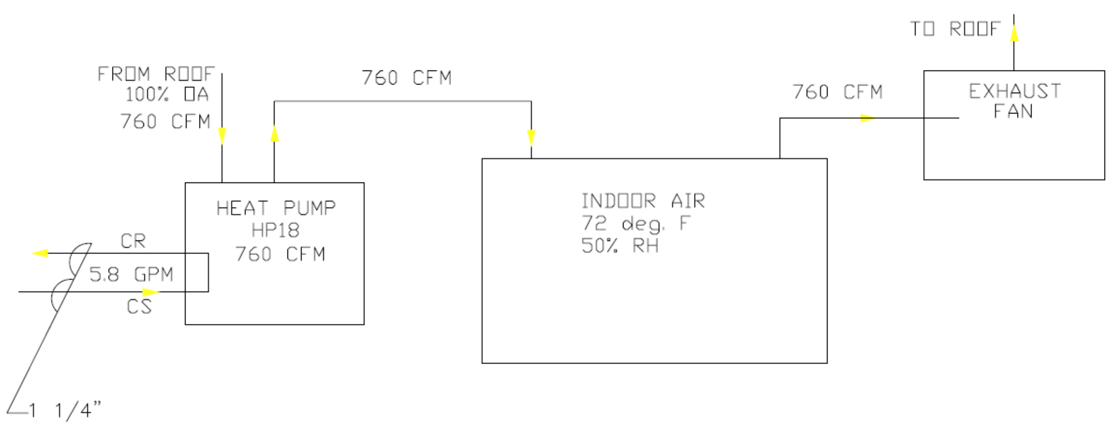
| Supply Fans | Fan Type | CFM | in.wg. | FPM | Motor Data | |
|---|---|---|---|---|---|---|
| | | | | | BHP | HP |
| 1 | Utility Set | 14400 | 1.35 | 2380 | 5.7 | 7.5 |
| 2 | Filtered Supply | 5000 | 0.5 | | 1.6 | 2 |
| 3 | Filtered Supply | 9000 | 0.5 | | 4.01 | 5 |
| 4 | Vaneanal | 12600 | 1.25 | | 3.77 | 7.5 |

| Air Separator | Size(inch.) | GPM |
|---|---|---|
| 1 | 10 | 1500 |

## Basic System Operation

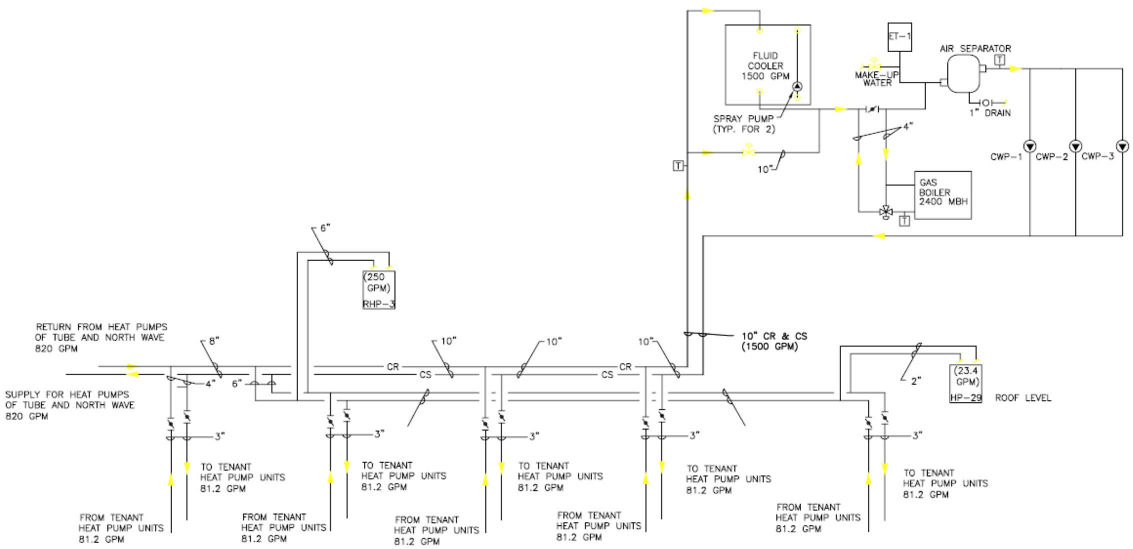
Water source heat pumps provide the primary heating and cooling of conditioned spaces throughout The Waverly on Lake Eola. Each condominium is serviced by at least one private heat pump servicing only that unit. Three rooftop heat pumps service the public and shared spaces of the building. This includes the gym facilities, lobbies, conference rooms, public restrooms, and other lifestyle amenities areas available for use by the tenants.

Tenant spaces account for the majority of the building layout, and basic operation of tenant heat pumps will be discussed first. Each water source heat pump is located in a mechanical room next to the unit. 100% outdoor air is supplied to the heat pump from a duct extending vertically to the roof. Cold water supplied from the rooftop closed circuit fluid cooler works with the heat pump to cool and dehumidify the outdoor air. The air is then heated by the heat pump and supplied to the space at conditioned temperatures. Cold return water is pumped back to the rooftop fluid cooler. A negative pressurization in the main part of the condominium creates an airflow taking the air towards exhaust ducts located in the hallway, kitchens, and bathrooms. Air exhausted from the space is brought to a vertical exhaust shaft and exhausted out the roof. The volumetric flow rates of air through these systems range from 460 to 3340 CFM. A flow chart for the heat pump for a 19th floor two bedroom, two bath unit is show below.




Rooftop heat pumps are used to condition the common areas throughout the building. The basic operation is the same as heat pumps located throughout the building with some minor differences. The rooftop location allows these heat pumps to be supplied directly from the outside without vertical supply ducts. Conditioned air is then supplied to the spaces below through vertical supply ductwork. All other parts of the operation are the same as listed above; accept this is on a much larger scale ranging from 4830 to 9250 CFM. The cold water supply to RHP-3 is displayed on the cdw flow chart shown below.

The cold water supply for the water source heat pumps both on the roof and throughout the building is crucial to the design.  All pumps are supplied with water from one closed circuit fluid cooler located on the roof.  This EVAPCO fluid cooler is capable of cooling 1500 GPM of return water.  The water is supplied to the cooler from the return line coming from heat pump units.  After cooling and condensing the water is temperature tested and can be mixed with water from the atmospheric boiler to heat if necessary.  An AMTROL expansion tank is located at this point to maintain safe pressures so that equipment is not damaged.  Next, a Bell & Gossett air separator is utilized to remove air bubbles from the supply water to ensure maximum efficiency.  Cold water pumps then pump the water to heat pump units throughout the building.  Cold water returns after it is used by the heat pumps to cool and dehumidify the outdoor air.  A portion of the cdws system is shown in the flow chart below.



## System Critique

The Waverly on Lake Eola uses a system comprised of separate water source heat pumps for each apartment. This system is effective at providing a comfortable environment for residents of the building. GRG Inc. is an established design firm and provided a system that uses 100% outdoor air to maximize comfort throughout the building.

Condominium units are often designed for a low first cost, since the eventual heating and cooling costs are handled by future owners of the building. This provides a less than optimal situation for the HVAC designers in charge of the project. All good HVAC engineers try to optimize efficiency during the design process, especially given recent rises in energy prices. In the case where a developer is interested almost solely in up front cost this makes design difficult. The completion date of the project also comes into play providing less time for the engineer to design an innovative system.

ZOM development requested the use of 100% outdoor air from the mechanical systems. This means that, while air quality is improved, more load is put on the system, especially during the summer months in Florida, than would be applicable if a typical mixed air system were used. Another issue increasing the load on the HVAC system is the floor to ceiling windows located on the majority of the building envelope. This creates a faster heat loss during the winter and more heat gain during the summer. All of these luxurious amenities create difficult situations for the mechanical engineer.

GRG came up with a well-designed system for The Waverly given the circumstances of 100% OA, many floor to ceiling windows, and emphasis on low first cost. This system, however, will use a large amount of energy, especially electricity to properly condition the spaces. This is apparent even without completion of load calculations. While GRG met all requirements in design, it would have been possible to make a more energy efficient system given different circumstances. A focus on efficiency and environmental impact, as opposed to time and up front cost would have provided a more preferable situation for design. During the proposal stage of thesis I plan to focus on these issues and hopefully improve upon an already well-designed system without sacrificing air quality.