2010

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# [TECHNICAL REPORT 3]

Mechanical Systems Existing Conditions for Hotel Felix Located at Chicago, Illinois

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# EXECUTIVE SUMMARY

Throughout the analysis of the mechanical system, it was evident that the mechanical systems were well designed to achieve a LEED Silver rating as the first hotel to do so in Chicago. It was one of the main goal for the owner and the designers and they had to adhere to ASHRAE Standard 62.1 and 90.1 to achieve the silver rating.

With twelve stories of hotel rooms, it was important for the owner to design a mechanical system that would provide comfort for the guest with manual control over the air quality in the rooms. The corridors of the hotels are conditioned using a roof top unit using 100% out door air that is always operating regardless of occupation. The lobby space and basement are conditioned using a self contained unit with VAV terminal boxes with reheat coils. All systems were calculated to meet the minimum ventilation rate of the ASHRAE Standard.

The total mechanical cost for the building was $8,099,507 which is $94.51 per square foot. The total mechanical cost is 28.9% of the overall project cost while the plumbing cost 3.9% of the overall project cost.

# MECHANICAL SYSTEM DESCRIPTION

## INTRODUCTION

Hotel Felix lies is a twelve story high hotel that lies at the heart of downtown Chicago. It is a historical building with great façade design that the owner wanted to preserve for the renovation that took place recently. Through the renovation, the hotel became the first LEED Silver certified hotel in Chicago and is one of the leading energy efficient hotels. It incorporates one roof top units that supplies air to the corridors throughout the building. A Self contained unit is located at the basement that supplies air to the basement, first floor, and mezzanine level. Each hotel room is installed with individual water source heat pumps that the guest can control for their comfort.

## MECHANICAL DESIGN OBJECTIVES

For the renovation, the main focus for the building objective was to design it to be sustainable or "green" building. So, a lot of the mechanical system design was determined by the general requirements and procedures for compliance with certain LEED prerequisites and credits that is needed to obtain LEED Silver Certification.

Knowing that, the building HVAC system was designed in accordance with ASHRAE 90.1-2004 with mandatory provisions 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4 along with prescriptive requirements sections 5.5, 6.5, 7.5, and 9.5 or performance requirements Section 11.

Also, the indoor air quality control system of the building is designed in accordance with the standard ASHRAE 62.1-2004, ventilation for acceptable indoor air quality. The ventilation rates were calculated to meet the ventilation rate procedures of ASHRAE 62.1-2004, sections 4 through 7.

## OUTDOOR AND INDOOR DESIGN CONDITIONS

Outdoor and indoor air conditions for heating and cooling in Chicago, Illinois were used for the energy analysis conducted in Technical Report II. These values were taken from the 2005 ASHRAE Handbook – Fundamentals. The 0.4% and 99.6% values were chosen and is listed below in table 1.

| | Winter Design (99.6%) | Summer Design (0.4%) |
|---|---|---|
| **OA Dry Bulb (°F)** | -5.0 | 91.7 |
| **OA Wet Bulb (°F)** | -- | 74.9 |
| **IA Dry Bulb (°F)** | 80 | 70 |

TABLE 1. WINTER AND SUMMER DESIGN CONDITIONS.

## ENERGY SOURCE

There are two main sources of energy that is consumed by the mechanical system of Felix Hotel. The main source of energy is produced using electricity from the city grid. A company called Exelon Corporation sells the electricity for the hotel. The second necessary source of energy is natural gas. The gas fired heating from the roof top unit is where the gas is consumed. Listed below in table 2 and table 3.

| Electricity | Cost $/kWh |
|---|---|
| **Off Peak Apr – May** | 0.0677 |
| **Off Peak June – Dec** | 0.0795 |
| **Off Peak Jan – may** | 0.0791 |
| **Peak Apr – May** | 0.0731 |
| **Peak June – Dec** | 0.0852 |
| **Peak Jan – May** | 0.0843 |
| **Demand Apr – May** | 8.452 |
| **Demand June – Dec** | 8.915 |
| **Demand Jan – May** | 8.706 |

*TABLE 2. ELECTRICITY PRICE OF FELIX HOTEL*

| Gas | Price (cents/therm) |
|---|---|
| **Off Peak** | 65.38 |
| **Peak** | 72.38 |

*TABLE 3. GAS PRICE OF FELIX HOTEL*

# DESIGN LOADS

## DESIGN VENTILATION REQUIREMENTS.

An analysis was performed using ASHRAE Standard 62.1 to determine the minimum ventilation rates that needs to be supplied to occupied spaces through Technical Assignment 1. Both the roof top unit and self contained unit was analyzed and compared to ventilation rates that were calculated by the design engineer. It was found that both air handling units comply with the minimum ventilation requirement. The roof top unit uses 100% OA so it was able to meet the requirements easily.

## ANNUAL ENERGY USE

The annual energy use analysis was done through Technical Assignment 2. The summary of the findings can be shown in figure 1 and table4.

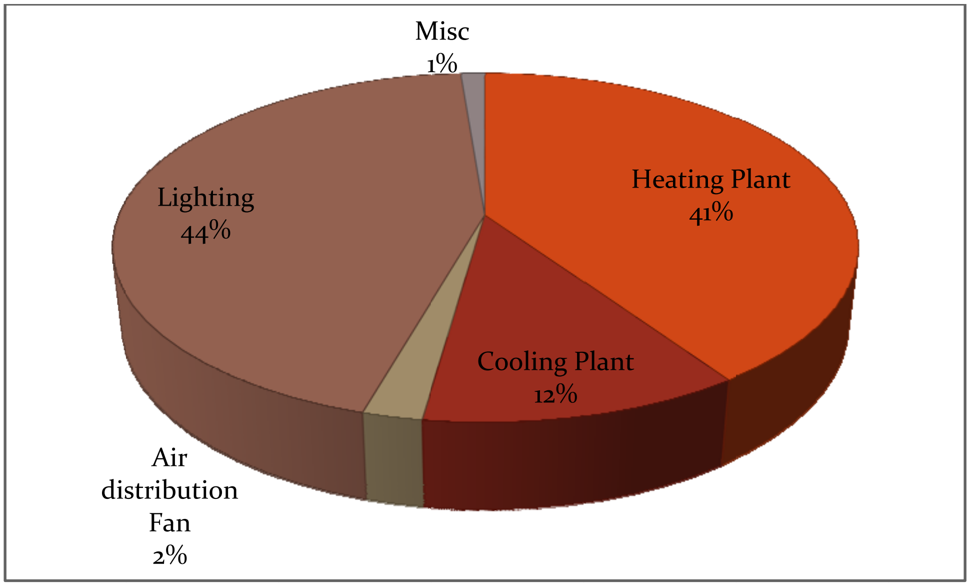


FIGURE 1. ENERGY CONSUMPTION ANNUALLY

| | *Electricity (kWh)* | *Gas (therms)* | *Water (1000 gal)* |
|---|---|---|---|
| **Annual Consumption** | *759,870* | *11,189* | *411* |

*TABLE 4. ANNUAL ENERGY CONSUMPTION BY UTILITY*

# MECHANICAL EQUIPMENT

## SUMMARY

There is a self contained air conditioning unit located at the basement with VAV terminal units to serve the basement, ground, and mezzanine level of the hotel. The self contained air conditioning unit is rated at 8,000 CFM with a 22 ton cooling load. The chilled air is then distributed to the VAV boxes and then heated using a reheat coil. A roof top unit rated at 7,500 CFM and 36 ton serves the corridors of levels 2-12 at a constant volume. Also, in the recent renovation in 2009, water source heat pumps were designed to provide cooling and heating to each individual guest room in the twelve story building. Hot water for the heat pumps are provided by (2) boilers located on the roof and the heat is rejected through an air source cooling tower located on the roof.

| Tag | Area Served | Type | Blower Data | | | Heating | | Cooling | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Total CFM | O.A. Min | Motor HP | MBH Input | MBH Output | MBH Total | Sensible MBH |
| **RTU-13.1** | Hotel Corridors | DX Rooftop | 7500 | 7500 | 7.5 | 813 | 650 | 363 | 290 |

TABLE 5. ROOF TOP UNIT SCHEDULE

| Tag | Area Served | Type | Blower Data | | | Cooling Data | | Electric |
|---|---|---|---|---|---|---|---|---|
| | | | Total | O.A. Min | Motor HP | MBH Total | Sensible MBH | |
| **AHU-B.1** | Basement/1st/mezz | Self contained VAV AHU | 8000 | 2800 | 15 | 363 | 260 | 28 |

TABLE 6. SELF CONTAINED UNIT SCHEDULE

| Tag | Nominal Tons | CFM | Heating | Cooling | | | Condenser |
|---|---|---|---|---|---|---|---|
| | | | Total MBH | Total MBH | Sensible MBH | Rejected MBH | GPM |
| **HP-09** | 0.75 | 300 | 12.1 | 9 | 6.7 | 10.8 | 2.3 |
| **HP-12** | 1 | 400 | 16.4 | 13.2 | 10 | 15.4 | 3 |
| **HP-48** | 3 | 1600 | 58.7 | 46.2 | 37.9 | 56.8 | 11.6 |
| **HP-60** | 5 | 2000 | 76 | 59.4 | 48.1 | 73.4 | 14.8 |

TABLE 7. HEAT PUMPS SCHEDULE

| Tag | Location | Tons | Condenser | Water | | Outside Air | | |
|---|---|---|---|---|---|---|---|---|
| | | | GPM | EWT (°F) | LWT (°F) | Dry Bulb (°F) | Wet Bulb (°F) | HP |
| **CT-13.1** | Roof | 160 | 480 | 85 | 95 | 95 | 78 | 30 |

TABLE 8. COOLING TOWER SCHEDULE

| Tag | Capacity | | Max Pressure Drop (Ft.) | GPM | EWT | LWT |
|---|---|---|---|---|---|---|
| | Input (MBH) | Output (MBH) | | | | |
| **B-13.1** | 1100 | 1045 | 6 | 63 | 97.4 | 120 |
| **B-13.2** | 1100 | 1045 | 6 | 63 | 97.4 | 120 |

TABLE 9. BOILER SCHEDULE

| Tag | Location | Service | GPM | Head (FT.) | Motor Data | | |
|---|---|---|---|---|---|---|---|
| | | | | | HP | BHP | RPM |
| **CTWP-13.1** | $13^{th}$ Floor Mechanical | Condenser Water | 480 | 75 | 15 | 11.4 | 1750 |
| **CTWP-13.2** | $13^{th}$ Floor Mechanical | Condenser Water | 480 | 75 | 15 | 11.4 | 1750 |
| **CWP-13.1** | $13^{th}$ Floor Mechanical | Heat Pump Loop | 370 | 90 | 15 | 11.6 | 1750 |
| **CWP-13.2** | $13^{th}$ Floor Mechanical | Heat Pump Loop | 370 | 90 | 15 | 11.6 | 1750 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **HWP-13.1** | 13th Floor Mechanical | Hot Water | 90 | 50 | 5 | 2.0 | 1750 |

TABLE 10. PUMPS

## MECHANICAL SYSTEM INITIAL COST

The approximate initial cost for the mechanical and plumbing system of the project is listed in the following table 11 according to official estimates.

| | Total Cost | Cost/SF | % of Total Cost |
|---|---|---|---|
| **Mechanical** | $ 8,099,507 | $ 94.51 | 28.9% |
| **Plumbing** | $ 1,081,534 | $ 12.62 | 3.9% |

TABLE 11. MECHANICAL COST

To summarize, the mechanical system cost 28.9% of the overall project cost while the plumbing is 3.9% of the overall project cost. It is a very significant percentage of the project cost.

## LOST USABLE SPACE

The lost space due to mechanical system was calculated and show in table 12 below. A mechanical room is located in the basement for the self contained air conditioning unit. A fire pump room and a gas meter room is also located in the basement that further contributes to lost usable space for the building.

| | Lost space (SF) |
|---|---|
| **Mechanical Room** | 346.4 |

| | |
|---|---|
| **Fire Pump Room** | 364.1 |
| **Gas Meter Room** | 127.9 |

TABLE 12. LOST USABLE SPACE

# LEED ASSESSMENT

Felix Hotel was designed to obtain LEED Silver in mind from design phase, so it strictly adhered to certain requirements and procedures that the U.S. Green Building Council had setup as prerequisites to obtain credits necessary to earn a LEED Silver Certification. By earning LEED certification, the project was to minimize impact on the natural environment in the choice of building materials, during construction and during building use. Also, provide a high level of indoor air quality for building occupants and use water and energy efficiently so that the new hotel can be designed to be a sustainable or "green" building.

For the purpose of LEED analysis for this project, we will only look at the section Energy and Atmosphere and Indoor Environmental Quality. These two sections will affect how the mechanical system is sized and installed.

## ENERGY AND ATMOSPHERE

There are three prerequisites that are required for this section. The three are fundamental commissioning, minimum energy performance, and CFC reduction in HVAC&R equipment. The three were met by properly installing, calibrating, and performing according to the owner's project requirements, establishing the minimum level of energy efficiency for the proposed building and system, and to reduce ozone depletion by eliminating and chlorofluorocarbon-based refrigerants for the HVAC&R equipment.

Another big area where credit was earned was "Optimize Energy Performance" for HVAC and equipment and appliances. This credit shows that the building was able to achieve an "increase level of energy performance above baseline in the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use." This done by comparing an energy calculation using ASHRAE Standard 90.1 with the installed HVAC equipment and achieving better energy performance records.

The building was also able to earn a point in Enhance Commissioning. This meant the commissioning process was introduced early into the design phase and also extended to after the design is complete so it can do a performance verification test. The commissioning process was developed and led by an independent commissioning agent and started as early as pre-functional procedures where a series of field observations were conducted during the installation of commissioned equipment to verify that equipment is installed per the contract documents and is ready for startup.

The point total can be seen in Figure 2.

| 2 | 4 | | | Energy & Atmosphere | 12 Points |
|---|---|---|---|---|---|
| Y | | | Prereq 1 | Fundamental Commissioning | Required |
| Y | | | Prereq 2 | Minimum Energy Performance | Required |
| Y | | | Prereq 3 | CFC Reduction in HVAC&R Equipment | Required |
| | ? | | Credit 1.1 | Optimize Energy Performance - Lighting Power | 3 |
| | ? | | Credit 1.2 | Optimize Energy Performance - Lighting Controls | 1 |
| Y | | | Credit 1.3 | Optimize Energy Performance - HVAC | 2 |
| Y | | | Credit 1.4 | Optimize Energy Performance - Equipment and Appliances | 2 |
| Y | | | Credit 2 | Enhanced Commissioning | 1 |
| | ? | | Credit 3 | Energy Use, Measurement & Payment Accountability | 2 |
| | ? | | Credit 4 | Green Power | 1 |

FIGURE 2. ENERGY AND ATMOSPHERE LEED CREDITS

## INDOOR ENVIRONMENTAL QUALITY

The indoor environmental quality category of the LEED rating system can be shown in the figure 3 below. The prerequisites for minimum IAQ performance and environmental tobacco smoke control were met by making the hotel a smoke free building and establishing a minimum indoor air quality performance.

Low-emitting materials were purchased for adhesives and sealants, paints and coatings, carpet systems, composite wood and laminate adhesives, and systems furniture and seating. This was done by establishing a VOC limit of the South Coast Air Quality Management District (SCAQMD) rule #1168 to make sure low-emitting material is used for adhesives and sealtns. Paints and coats also comply with VOC limits established by Green Seal Standard GS-11 to use low-emitting materials.

| 11 | 2 | 4 | | Indoor Environmental Quality | 17 Points |
|---|---|---|---|---|---|
| Y | | | Prereq 1 | **Minimum IAQ Performance** | Required |
| Y | | | Prereq 2 | **Environmental Tobacco Smoke** (ETS) **Control** | Required |
| | | N | Credit 1 | **Outdoor Delivery Monitoring** | 1 |
| | | N | Credit 2 | **Increased Ventilation** | 1 |
| Y | | | Credit 3 | **Construction IAQ Management Plan**, During Construction | 1 |
| | | N | Credit 3.2 | **Construction IAQ Management Plan**, Before Occupancy | 1 |
| Y | | | Credit 4.1 | **Low-Emitting Materials**, Adhesives & Sealants | 1 |
| Y | | | Credit 4.2 | **Low-Emitting Materials**, Paints & Coatings | 1 |
| Y | | | Credit 4.3 | **Low-Emitting Materials**, Carpet Systems | 1 |
| Y | | | Credit 4.4 | **Low-Emitting Materials**, Composite Wood & Laminate Adhesives | 1 |
| Y | | | Credit 4.5 | **Low-Emitting Materials**, Systems Furniture and Seating | 1 |
| Y | | | Credit 5 | **Indoor Chemical & Pollutant Source Control** | 1 |
| Y | | | Credit 6.1 | **Controllability of Systems**, Lighting | 1 |
| Y | | | Credit 6.2 | **Controllability of Systems**, Temperature and Ventilation | 1 |
| Y | | | Credit 7.1 | **Thermal Comfort**, Compliance | 1 |
| | | N | Credit 7.2 | **Thermal Comfort**, Monitoring | 1 |
| | ? | | Credit 8.1 | **Daylight & Views**, Daylight 75% of Spaces | 1 |
| | ? | | Credit 8.2 | **Daylight & Views**, Views for 90% of Spaces | 1 |
| Y | | | Credit 8.2 | **Daylight & Views**, Views for 90% of Seated Spaces | 1 |

FIGURE 3. INDOOR EIVNROMENTAL QUALITY LEED CREDITS

# EVALUATION OF SYSTEM

Overall, all the mechanical systems in the building are efficient and sized to comply with ASHRAE standards 62.1-2007 and 90.1-2007. Because the building earned a LEED Silver, most of the mechanical system was designed to perform better than a baseline building in performance and energy utilization.

# REFERENCES

ASHRAE Standard 62.1 – 2007

ASHRAE Standard 90.1 – 2007