Technical Report 3

Mechanical

Mechanical Systems Existing Conditions Evaluation

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Mechanical Systems Summary

The Medical Office Building is located in North-East United States and is to house many medical offices as well as some examination rooms and a physical therapy area. The building is two stories with a total square footage of 72,706.

The main heating and cooling for the Medical Office Building will be provided by two roof top units supplying VAV boxes with reheat coils. The roof top units are self-contained, meaning that there are no hot or cold water lines running to the units. The units utilize a closed loop refrigerant system for cooling and a gas furnace system fueled by propane for heating. The VAV system utilizes electric resistance for the reheat system.

A few additional electric baseboard heating systems are utilized at the entrances to the building. There are also five ductless split system units that supply control rooms for important medical equipment.

Executive Summary

The objective of this report is to summarize the entire mechanical system for the Medical Office Building as they have been designed. The design for the Medical Office Building is a typical design for medical office buildings of this size. It is a low cost design that is energy efficient and complies with the necessary ASHRAE standards. There is some improvement that could be done in the area of energy sources for the heating and cooling of the building.

Mechanical System Design Requirements

Design Objectives

The Medical Office Building was designed to provide a building that will satisfy the needs for medical examination as well as physical therapy and imaging. The building is designed to be energy efficient and meet the design standards of ASHRAE.

Design Conditions

The Medical Office Building is located in the North-East United States. This area is in zone 5A according to ASHRAE 90.1 table B-1. This area is very humid in the summers and can be quite cold in the winters. Indoor and outdoor air conditions for the building were obtained from the ASHRAE Handbook of Fundamentals 2009.

The indoor design temperatures were designed to be 72°F for the winter and 75°F for the summer with a maintained relative humidity of 50%.

	Summer Design Cooling (0.4%)	Winter Design Heating (99.6%)
Outdoor Air Dry Bulb (°F)	92.4	9.4
Outdoor Air Wet Bulb (°F)	74.1	-
Indoor Air Design Temp (°F)	75	72

Table 1: Design temperatures

Ventilation

The Medical Office Building has two roof top units. These units provide the appropriate amount of ventilation necessary to be compliant with the ventilation rate procedure found in ASHRAE Standard 62.1. All areas requiring a direct exhaust to the outside have been equipped with their own separate exhaust ducts and fans. These areas only include the bathrooms and due to the low amount of air being exhausted from them, heat recovery systems were not included for these. A heat recovery system has been built into the roof top units for energy savings. The roof top units have been equipped with MERV 8 filters placed before the heating and cooling coils.

Minimum ventilation rates for people-based calculations and area-based calculations were all taken from ASHRAE Standard 62.1 and can be seen below in table 2.

Room Type	People-Based (CFM/Person)	Area-Based (CFM/S.F)
Conference	5	0.06
Corridor	0	0.06
Lobby	5	0.06
Office	5	0.06
Physical Therapy	20	0.06
Procedure Room	15	0.06
Reception	5	0.06
Storage	0	0.12

Table 2: Room ventilation requirements

Both of the roof top units were compliant with providing the appropriate amount of outside air. The units that were selected also provide more outdoor air than what was required as can be seen in table 3.

System	Calculated Outdoor Air (CFM)	Design Outdoor Air (CFM)
RTU-1	3767	4260
RTU-2	4272	4600

Table 3: Comparison of calculated and design outdoor air

Heating and Cooling Loads

A load simulation for the Medical Office Building was performed using the TRANE Trace program. The calculations for this program were performed using a block load procedure. Similar rooms in the building were grouped together in a "block" which simplified the calculation process. The blocks were then given a template which was specific to the type of space. The blocks were as follows:

- Conference
- Corridor
- Lobby
- Office
- Physical Therapy
- Procedure
- Reception
- Storage

The simulation was run for all times of the year. The results were used to create a graph that depicts the amount of heating and cooling for each month shown below.

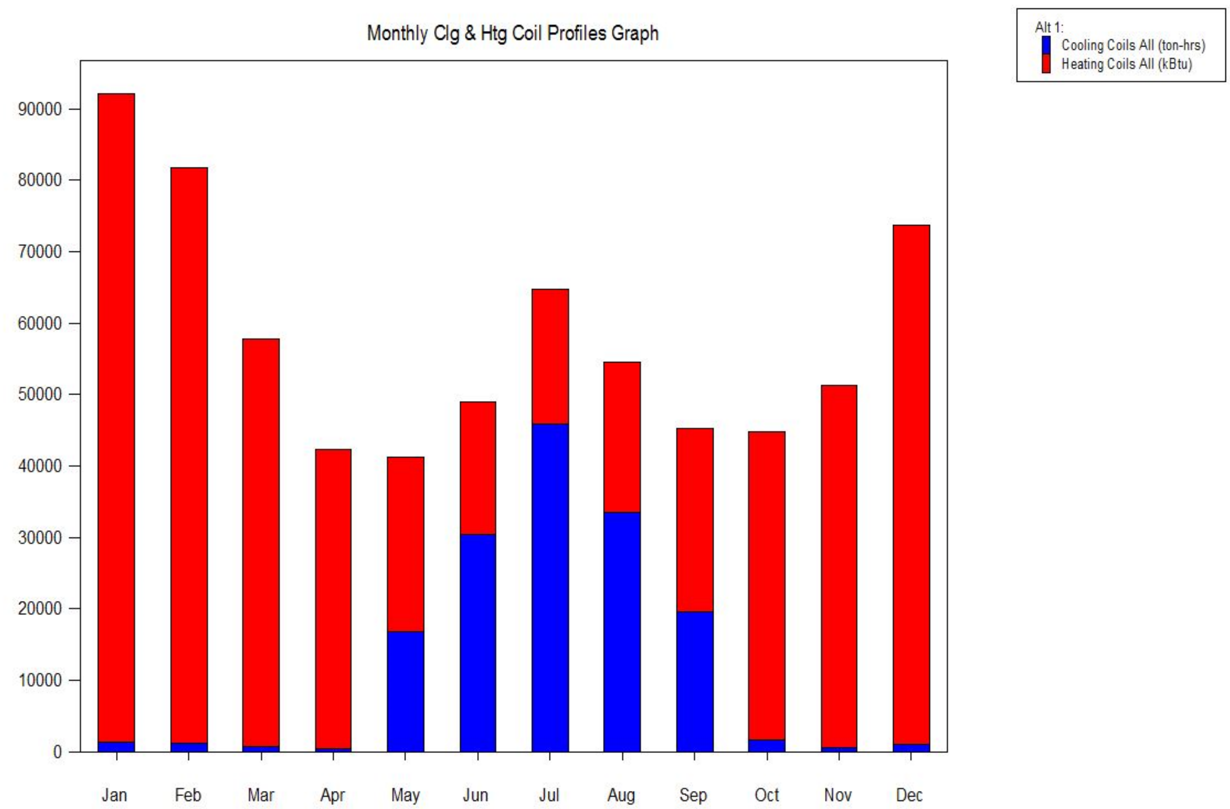

Figure 1: Monthly heating and cooling profiles

As the figure shows, there is a majority of heating in the colder months and cooling in the warmer months. Since the system is equipped with VAV reheat boxes, there will be some heating in the summer to bring the supply air temperature up to the desired level.

Annual Energy Use

The Trane TRACE program was used to do an energy analysis on the Medical Office Building. From this analysis, it was determined that the Medical Office Building would use an estimated 3.6 million kBtu per year.

Detailed information was not able to be obtained from the design documents regarding fuel costs, water and air flow rates and equipment performance characteristics so the default information provided by TRACE was utilized and gave a quite reasonable estimation for energy and cost analysis.

The following table provides an annual energy summary for the Medical Office Building.

	Electric (kWh)	Gas (kBtu)	Total Building Energy
Heating	-	709,240	709,240
Cooling	204,744	-	698,791
Lighting	529,746	-	1,808,024
Receptacles	115,781	-	395,161

Table 4: Annual energy summary

The total cost per year to run the Medical Office Building is $46,060 with $3,564 going to gas and $42,514 going to electricity. This brings the average cost per square foot of the building to $1.02.

Energy Sources

The main energy source for the systems in the Medical Office Building is propane gas. The propane is used in the boilers to provide domestic hot water for the entire building as well as primary heating for the roof top units. Coal can also be assumed to be an energy source for the electricity provided to the building from the provider.

System Cost

Exact cost for the Medical Office Building could not be obtained but using R.S. Means, it was determined that the cost of the system and installation would be $10.70/SF which comes out to be $750,00 for the entire building.

System Operation and Schematics

Water Operation and Schematics

The domestic hot water for the building is provided by two propane gas fired boilers. The cold water enters the building where it splits to go to the two boilers and a mixing valve. The water is heated in the boilers and then leaves at a temperature of 140°F. The water then goes to a mixing valve where it is mixed with cold water until it is brought down to a temperature of 110°F. The water then leaves the valve and is distributed to the whole building.

Any unused hot water is returned to the mechanical room by a circulating pump. The pump has a sensor so that it only runs when there is water in the pipe. After passing the pump the return water is mixed with the incoming cold water to the boilers, thus reducing the amount of energy needed to heat the water due to the increase in temperature of the incoming cold water.

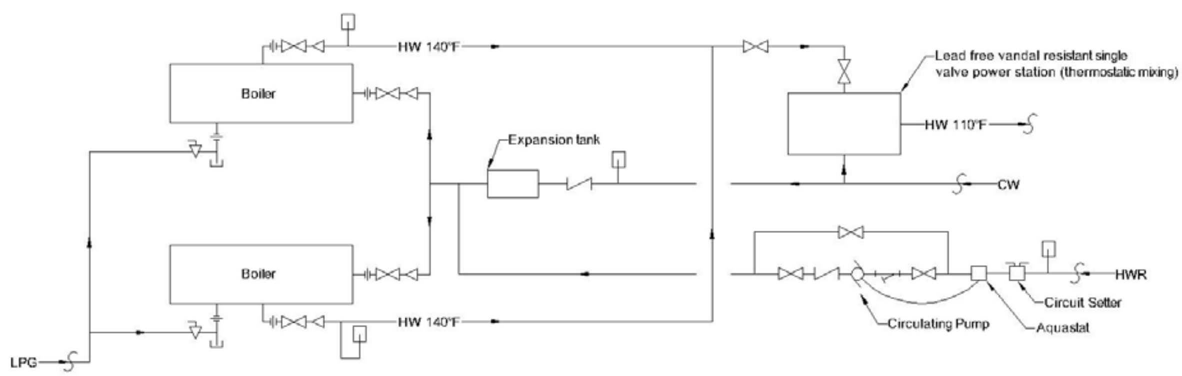

Figure 2: Domestic hot water schematic

Air Operation and Schematics

The roof top units will be provide with their own integral manufacturer's control panel. The system is equipped with an economizer cycle that will operate at 100% outdoor air when the conditions are appropriate. The refrigeration system will operate when the ambient air temperature is above 52.5°F and will be disabled when the ambient air temperature is below 40°F. The system will modulate the outdoor air dampers to avoid the need to reheat the supply air. When the building is unoccupied the entire unit will shut down and the dampers will be shut except in the heating season, when the unit will cycle on to maintain the night setback temperature. When the system is warming up or cooling down, the outdoor air dampers will remain closed and the return air dampers will be fully open. When smoke is detected, the system will shut down the fans and close the dampers and sound an alarm.

The system will supply air at 55°F to the VAV boxes where the air will then be heated and humidified if necessary to meet the criteria of the zone.

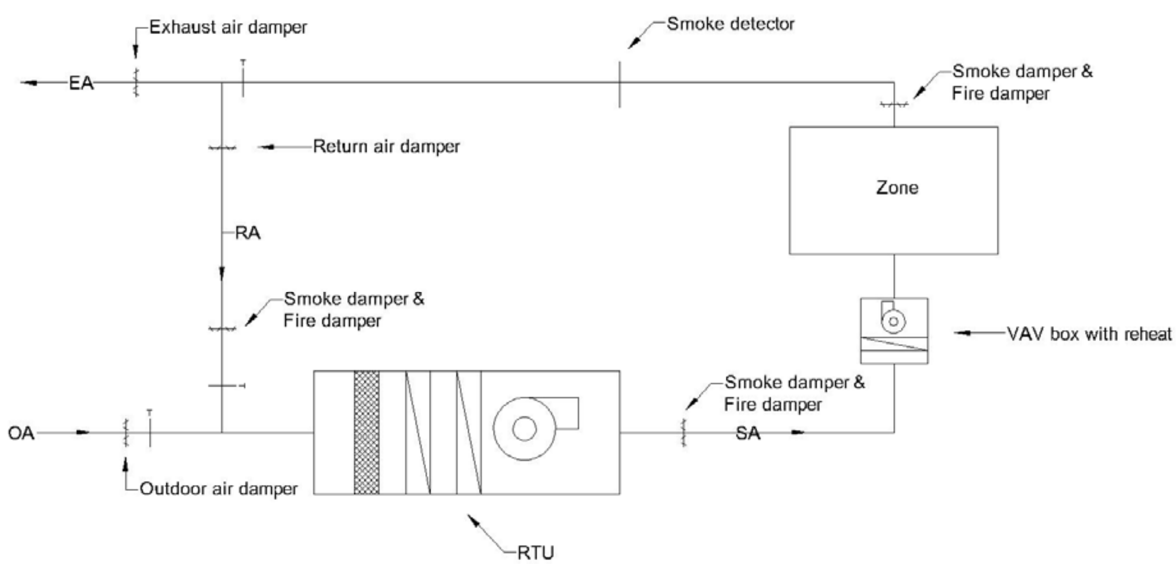

Figure 3: Air operations schematic

Major Equipment Schedules

Roof Top Unit Schedule									
	Supply Fan			Return Fan		Cooling Coil	Propane Heating	
	Total CFM	OA CFM	HP	Total CFM	HP	Sensible Capacity (MBH)	Output Capacity (MBH)	Efficiency
RTU-1	21300	4260	30	17040	15	571.1	697	80
RTU-2	23000	4600	40	18400	15	583.9	697	80

Table 5: Roof top unit schedule

Ductless Split-System Schedule (Outdoor Unit)		
	Location	Nominal Tons
ACCU-1	Roof	2
ACCU-2		1.5
ACCU-3		1.5
ACCU-4		1.5
ACCU-5		3

Table 6: Ductless split-system schedule (outdoor unit)

Ductless Split-System Schecule (Indoor Unit)				
	Location	Service	CFM	Total Cool
AC-1	Main Elec. Room	Main Elec. Room	775	24000
AC-2	MRI Elec.	MRI Elec.	750	5250
AC-3	General IT Room	Main Elec. Room	425	18000
AC-4	Radiology IT Room	Main Elec. Room	425	18000
AC-5	Elevator Equip Room	Main Elec. Room	920	36000

Table 7: Ductless split-system schedule (indoor unit)

Domestic Hot Water Heater Schedule				
	Location	Storage Capacity	Natural Gas Input (CFH)	Temp. Outlet (°F)
PH-1.1	Mech. Room	60 Gal.	120	140
PH-1.2				

Table 8: Domestic hot water heater schedule

Domestic Water Pump Schedule			
	Location	HP	GPM
PHC-4.1	Mech. Room	0.3	14
PW-1.1		5	160
PW-1.2			

Table 9: Domestic water pump schedule

Mechanical Lost Usable Space

The lost usable space taken up by the mechanical room is 1244 square feet. This space was taken from a small corner of the building on the first floor. The vertical duct risers take up 36 square feet from the second floor. These risers are hidden in a wall next to a hallway as to not create any awkward space. The total lost usable space taken by the mechanical system is 1280 square feet.

LEED Analysis

The Medical Office Building was not designed to obtain a LEED certification. The building was on the other hand designed to be energy efficient by using an economizer cycle for the roof top units, using energy efficient glazing, and by designing the exterior to have a low transfer rate of air and moisture. It is believed that this building would be able to obtain a LEED certification with very few modifications.

Overall Evaluation

The design for the Medical Office Building is an effective design for a building of this size. This design is very common for medical office buildings for obvious reasons. It is a relatively low cost design at $750,000 for the whole building, the operating cost is of a reasonable number at $46,060 per year, and the building is energy efficient and complies with ASHRAE standards for design. An area for improvement could be the source of energy for the heating and cooling, although this would add a significant amount to the cost of the building.