Technical Report III

Mechanical Systems Existing Conditions Evaluation

Charles E. Smith Center Renovation

Washington, DC

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Mechanical Option

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Executive Summary

The purpose of this report is to summarize the existing mechanical systems currently in the Charles E. Smith Center and to analyze the effectiveness of these systems.

The Charles E. Smith Center is designed with the main goal of being sustainable. It meets the requirements of Std. 62.1 for ventilation. There was also an energy model simulated in Trane TRACE to better analyze the loads of the building and compare with the actual design. The modeled loads and energy consumption were slightly higher than designed but this is believed to be a result of slightly different systems or zones.

The operational cost of the mechanical system was also calculated using the Trane TRACE modeling programs and Washington, DC general utility rates. A first cost was unable to be acquired but since it is a renovation, first cost should be reduced.

DESIGN OBJECTIVES AND REQUIREMENTS

All HVAC systems are designed to provide proper ventilation and maintain occupant comfort levels for temperature, relative humidity, air quality, etc. However, each system is designed for a specific building with different objectives and requirements depending on building type and location that makes each system unique.

The Charles E. Smith Center had a main objective of being sustainable. To accomplish this in the design process a number of objectives were set. Energy efficient equipment was selected as well as building automation and commissioning in order to reduce operating costs and maintain that all systems continue to work as designed. Other requirements that were set forth were to comply with ASHRAE Std. 62.1 for ventilation and ASHRAE Std. 55 for comfort. Another option that was considered was to purchase "green power" as a way to further increase the sustainability.

DESIGN CONDITIONS

The Charles E. Smith Center was designed for the area of Washington, DC. Table 1 shows the indoor and outdoor conditions that were used as stated in the design documents.

TABLE 1 – DESIGN CONDITIONS

	Indoor Design (°F)		Outdoor Design (°F)
	Cond. Spaces	Uncond. Spaces	
Summer	78	85	95 DB, 78 WB
Winter	70	65	7

Design Loads and Ventilation Requirements

The designed heating, cooling and ventilation loads and requirements are summarized in Table 2 below and compared with the computed loads from the Trane TRACE model. The design cooling load is slightly larger than the computed load and the designed heating load is slightly less than the computed load. A possible explanation for this could be that the gym was modeled as empty which could lower the cooling load required for such a large area as well as raise the heating load when there is no additional load from people. The airflow for supply and ventilation was considerably less for the designed loads which could also be a result of modeling the gym as empty. This does correlate however since almost the entire first floor is 100% OA because of the types of rooms contained there. This would greatly increase the overall airflow without the gymnasium being considered.

Table 2 – Design vs Computed Block Loads

	Cooling (SF/ton)	Heating (BTUh/SF)	Supply Air (CFM/SF)	Ventilation (CFM/SF)
Design Load	378.8	49.0	0.56	0.63
Modeled Load	328.7	57.3	0.84	0.92

Annual Energy Use

The Charles E. Smith Center relies on electric for its main utility. The cooling towers, chillers, pumps, fans, lights, and miscellaneous space heating and receptacles are all powered using supplied electricity. The only aspect of the facility that does not rely entirely on electricity are the four boilers which use natural gas.

Table 3 below shows the breakdown of the total energy each system uses. As the table shows, approximately 80% of the buildings energy consumption is supplied by electricity. The auxiliary equipment including the supply fans and pumps account for 26% of the buildings total energy consumption. This may be a result of the high amounts of OA being supplied to the first floor because of the high latent loads and exhaust requirements. The primary heating system with the combined consumption of the electric and gas accounts for the next largest load on the building. This could result from the gym being modeled as empty which would increase the heating load and energy consumption. The consumed cooling energy is seen as a rather low percentage of the buildings total energy consumption, which is typical for this type of building.

Table 3 – Annual System Energy Consumption

`	Electrical (kWh)	Natural Gas (kBtu)	Total Building Energy (kBtu/yr)	Building Pecent age (%)
Primary Heatin g	58,862	1,793,677	1,994,531	24.3
Primary Coolin g	350,898	-	1,197,369	14.6
Auxiliary	624,453	-	2,130,820	26.0
Lighting	360,920	-	1,231,567	15.0
Receptacle	421,219	-	1,637,325	20.1
			8,191,612	**100**

Energy Sources and Rates

The Charles E. Smith Center has two main sources of energy that it uses, electricity and natural gas. To acquire a rate structure, the annual average of the District of Columbia was taken from the US Energy and Information Administration as of October 2010 and shown in Table 4 below.

Table 4 – Energy Prices

	Price	Units
Electric	0.127	$/kWh
Natural Gas	12.99	$/MBtu

Major Equipment

The facilities heating loads are serviced by four natural gas fired boilers and the cooling loads are serviced by two cooling towers which supply two water-cooled chillers. These units provide the AHU's and the Air Conditioners with the necessary heating and cooling requirements. The Air Conditioners use an energy recovery system and provide the pool as well as all of the blower coils with their load requirements.

Table 5 - Boilers

	Type	Capacity (MBH)	GPM	Supply Temp. (°F)
B-1	Condensing	2000	172	180
B-2	Condensing	2000	172	180
B-3	Condensing	2000	172	180
B-4	Condensing	2000	172	180

Table 6 - Chillers

	Type	Capacity (Tons)	GPM	Condenser Supply Temp. (°F)
CH-1	Screw Compressor	275	375	85
CH-2	Screw Compressor	275	375	85

Table 7 - Air Handling Units

	Capacity (CFM)	Cooling Coil		Heating Coil	
		EAT (°F)	Water Flow (GPM)	EAT (°F)	Water Flow (GPM)
AHU-3	8800	79	40.3	49	6.2
AHU-4	5800	87.6	48	30	20.2
AHU-5	2030	91.8	21.6	16	10.8
AHU-6	2900	88.8	21	25	9.7
AHU-7	1800	89	16.7	24	14.1
AHU-8	27000	86	220	36	62
AHU-9	27000	86	220	36	62
AHU-10	27000	86	220	36	62
AHU-11	14000	86	114	36	10
AHU-12	1200	77	26.5	60	2.6

Table 8 - Air Conditioners

	Type	Capacity (CFM)	Cooling Load (BTU/Hr)	Heating Load (BTU/Hr)
AC-1	DOAS	8900	386260	248250
AC-2	DOAS	19000	671500	563864

Table 9 - Blower Coils

	Capacity (CFM)	Preheat (GPM)	Cooling (GPM)
BC-1	1780	4.3	7.4
BC-2	1300	3.5	5.5
BC-3	1000	2.6	5.7
BC-4	400	1.0	1.2
BC-5	1050	2.3	5.3
BC-6	800	2.1	2.8
BC-7	1240	2.6	5.0
BC-8	900	2.0	2.4
BC-9	415	2.8	4.1

Mechanical System Operation and Schematics

Air Side Operation

The Smith Center facility is comprised of mostly VAV systems. All of the AHU's are single zone VAV and contain both heating and cooling coils which are interconnected with the chilled water and hot water systems. The AC's are 100% OA and provide the natatorium area and the blower coils which have their own chilled water and hot water connections just as the AHU's.

Water Side Operation

The hot water is supplied by four gas fired boilers with two variable frequency drive pumps, one being redundant. The hot water distributes itself to the facility and are on differential pressure controls to maintain the desired set points.

The chilled water is supplied by two water cooled chillers in series with two variable frequency drive pumps. The condensing water system configures the chillers in parallel to equalize the difference between the cooling towers.

Schematics

Figures 1, 2, and 3 below show the condensing water system, chilled water system, and hot water system respectively.

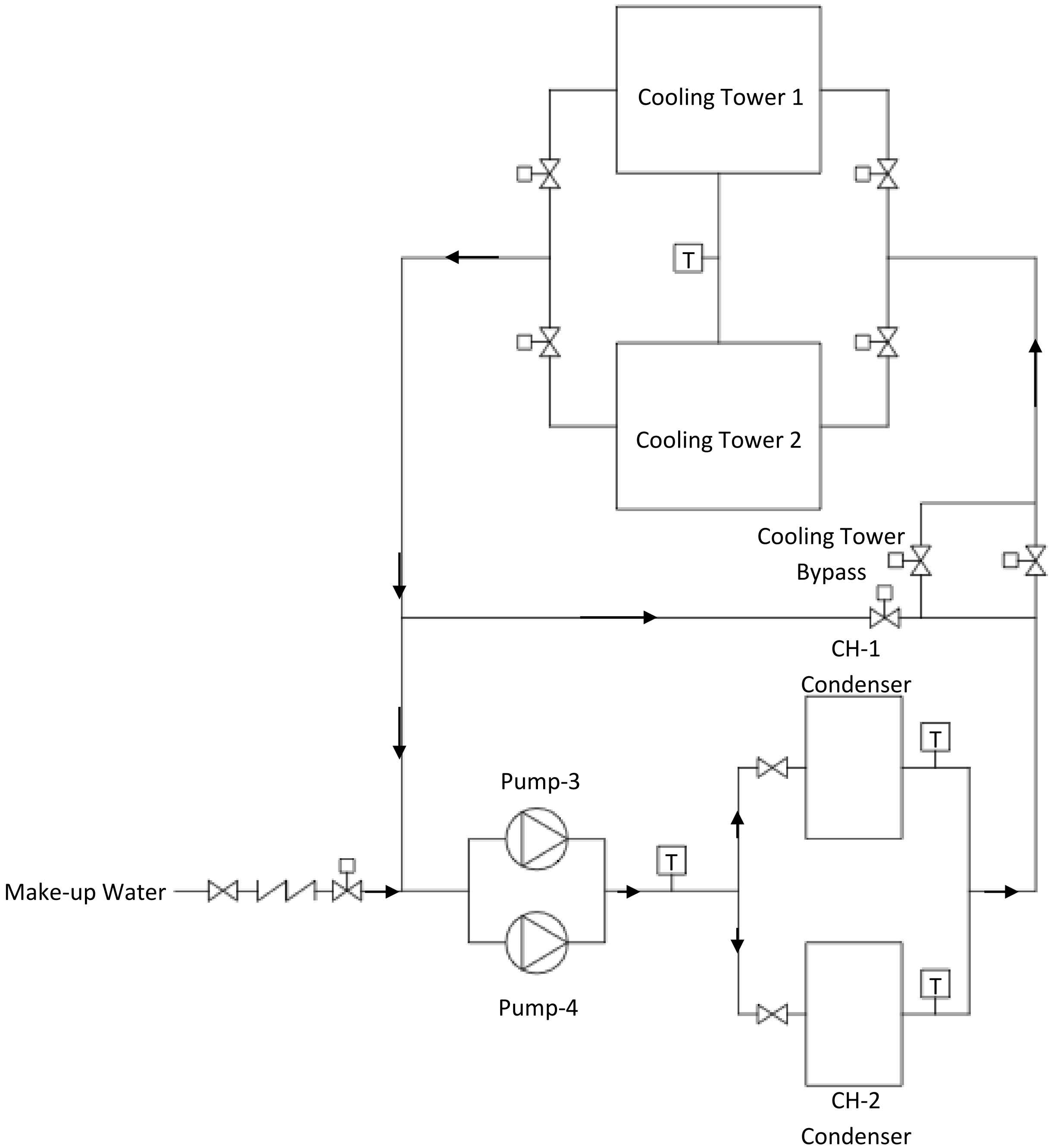

Figure 1 – Condensing Water

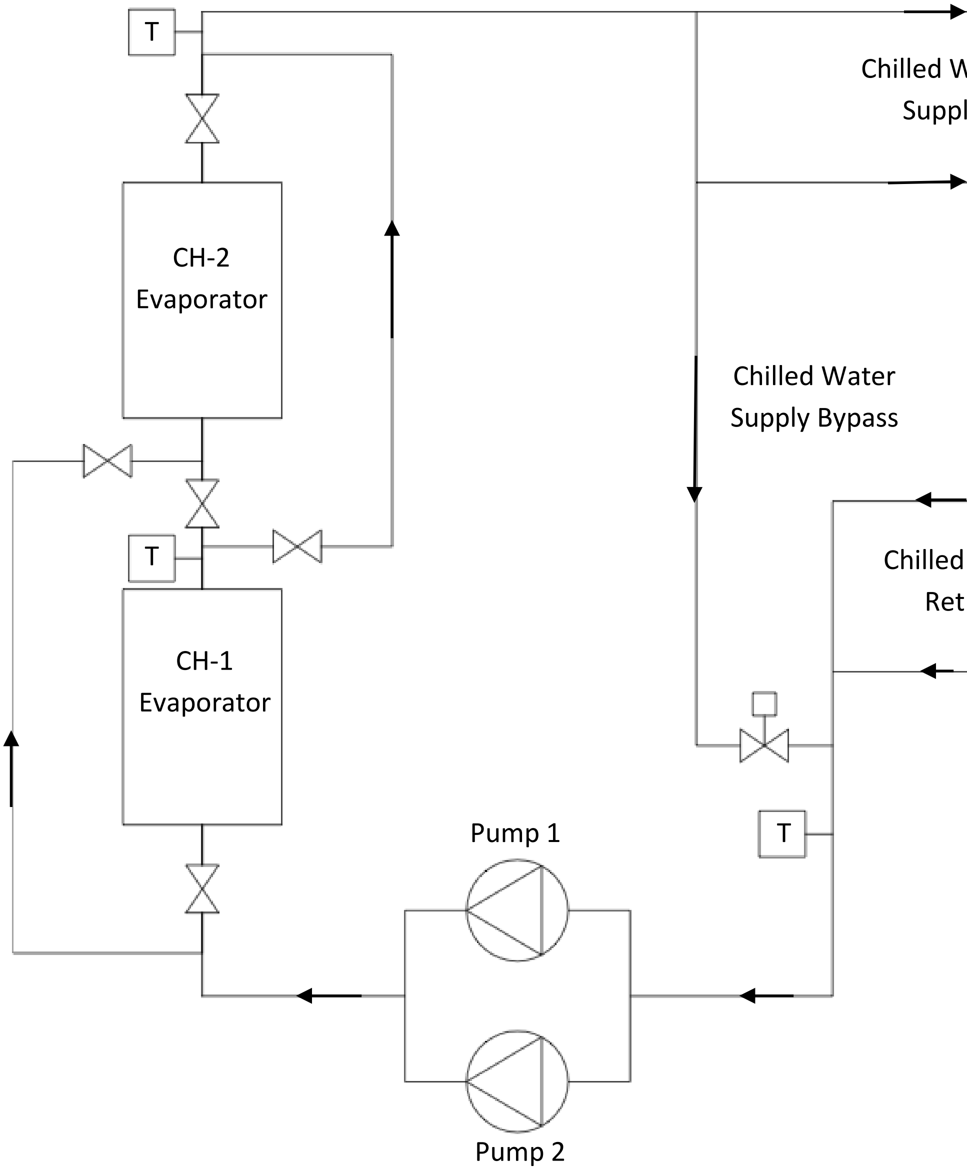

Figure 2 – Chilled Water

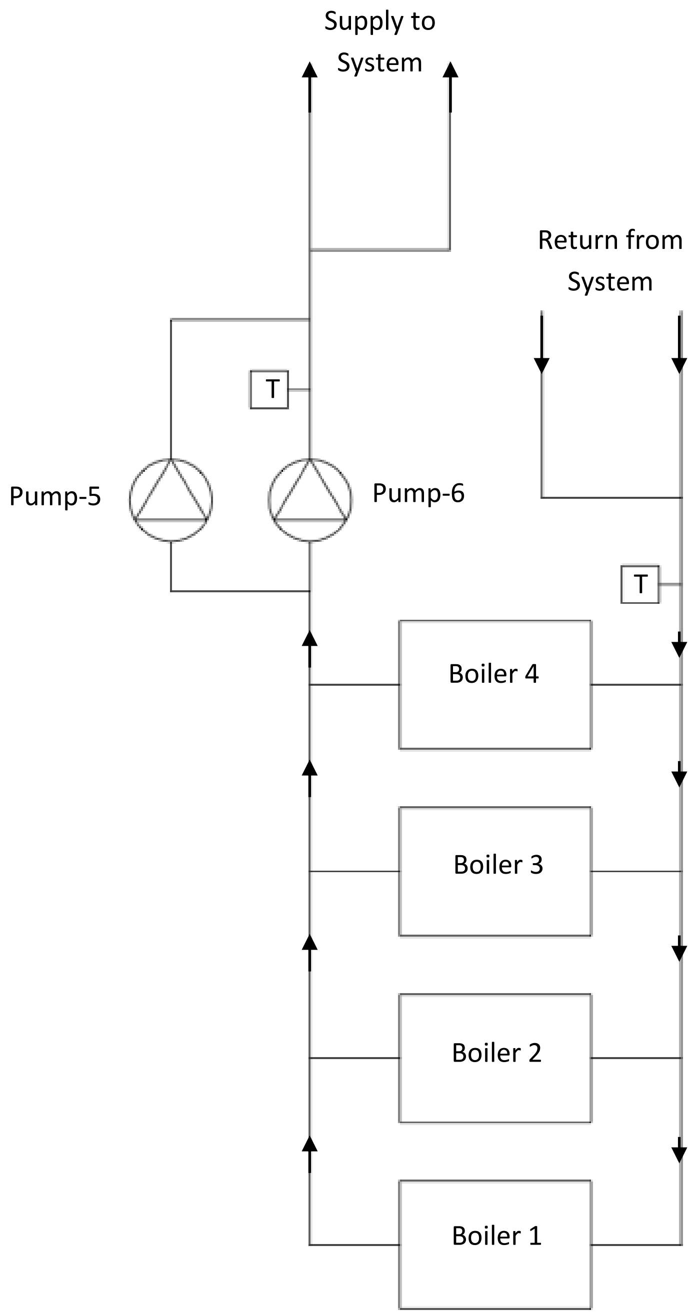

Figure 3 – Hot Water

Mechanical System First Cost

The information on the first cost of the system was unavailable. Since this was a renovation, some of the equipment that was replaced recently(within the past few years) such as the cooling towers and chillers were not replaced under this project and should help keep the first cost down.

Operating History

No operating history is currently available for this building since the new systems have been installed.

LEED Evaluation

The Charles E. Smith Center has been designed to be LEED certified using the LEED NC v2.2 rating system. This report will analyze the Smith Center using the LEED v3 for New Buildings and Major Renovations.

References

- ANSI/ASHRAE Standard 62.1-2007 Ventilation for Acceptable Indoor Air Quality
- ANSI/ASHRAE Standard 90.1-2007 Energy Standard for Buildings Except Low-Rise Residential Buildings
- U.S. Energy Information Administration website, www.eia.gov
- LEED v3 for New Buildings and Major Renovations
- Charles E. Smith Center Renovation Design Documents