Mechanical Technical Assignment 3

Systems and Existing Conditions Evaluation

UNLV Greenspun Hall

Las Vegas, Nevada

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Table of Contents

Executive Summary

The University of Nevada Las Vegas' Greenspun Hall is a 122,000 square foot facility on the east side of the campus which houses mainly offices, classrooms, and media rooms. It was designed to meet ASHRAE Standards 62.1 and 90.1 but did not meet all requirements as analyzed in *Technical Assignment 1 – ASHRAE Standard 62.1 Compliance, ASHRAE Standard 90.1 Compliance* and *Technical Assignment 2 – Building and Plant Analysis*. Once finalized, the USGBC rewarded Greenspun Hall with a LEED silver rating.

The goals for the design of Greenspun Hall were to have an innovative and efficient building. This was achieved by using efficient system components to operate in an innovative primary/secondary system which utilizes chilled beams to meet the load. Through this system, lost usable space was kept to a minimum while increasing energy efficiency, which decreases energy cost. The annual operating cost of the building is $97,185.85.

The cooling system can be described as primary/secondary operated by ddc controls. The primary loop consists of two condensers, two cooling towers, and one plate heat exchanger, which transfer energy to the secondary loop, where the load is located. Fluid is circulated through this system via a number of centrifugal pumps. The heating system can be described as a simple loop consisting of two boilers which supply hot water to the heating coils located in the air handling units.

The system is a very innovative and efficient design, both spatially and operationally. However, the complexity of the system increased construction cost exponentially and elevated the number of construction complications. These headaches would have been reduced with less over-lapping, simpler system.

Design Objectives and Requirements

The University of Nevada Las Vegas' Greenspun Hall is a 122,000 square foot facility on the east side of the campus which houses mainly offices, classrooms, and media rooms. It was designed to meet ASHRAE Standards 62.1 and 90.1 but did not meet all requirements as analyzed in *Technical Assignment 1 – ASHRAE Standard 62.1 Compliance, ASHRAE Standard 90.1 Compliance* and *Technical Assignment 2 – Building and Plant Analysis*. The goal for the building was initially to achieve a LEED Gold status; thus the objectives for the mechanical system are simple and few: energy efficiency and innovation.

Both of these objectives were accomplished in the design of this mechanical system by incorporating new technologies to efficiently achieve a comfortable indoor environment. Greenspun Hall is served by a group of five air-handling units which supply air to a system of chilled beams. Three of the air-handlers are 100% dedicated outdoor air and the other two mix the minimum outdoor air requirement intake with return air. The secondary system for the building consists of several fan coil units which supply cooling assistance for the summer cooling loads. Energy effectiveness is improved through efficient mechanical equipment, such as pumps, chillers, and fans, as well as a flat-plate heat exchanger.

Mechanical components of the Greenspun Hall system are spread throughout, on, and around the building to improve efficiency and minimize loss of usable space. One air handling unit and the heat exchanger are located on the mechanical mezzanine, other air handling units on the roof, chillers and boilers in their respective rooms, fan-coils in the plenum, and cooling towers in the service yard across the parking lot.

Overall, the system does not interfere with the usage of the building in that the mechanical systems only occupy 4,839.75 square feet of the 122,000 square feet of usable space. This is less than 4% of the total square footage of the building's footprint. A break down of the lost usable space due to the mechanical systems is supplied in the chart below.

Lost Usable Space	
Reason	Floor Area (ft^2)
Boiler Room	893.25
Chiller Room	1620
Mechanical Mezzanine	2016
Vertical Shafts	310.5

System Description

Air Distribution

Air is supplied through five air handling units, four of which are roof top units, and three of which are 100% dedicated outdoor air. Air is first filtered through 2" pre-filters and then through pleated MERV-13 rated filters before pre-conditioning through the coils in the air handlers, where air dry bulb temperature is reduced from roughly 100 F to 50 F. It is then distributed to the various zones, where chilled beams can supply further cooling if necessary to meet the load by the same supply of chilled water that the cooling coils in the air handlers used for pre-conditioning.

Due to the region and climate in which Greenspun Hall is located, load anaylsis software (Trace 700) used in *Technical Assignment 2 – Building and Plant Analysis* indicated that heating is not needed and therefore was omitted from the report. However, the designer did include a heating system within the building for the worse case scenario. In heating mode, chilled water would not flow through the chilled beams and hot water would be supplied to the heating coils in the air-handlers from the two boilers. The heating coils were designed to increase dry bulb air temperature from 30 F to 75 F. Additional information regarding the air handling units is located in the condensed schedule below.

Air Handliing Units										
			Motor			Cooling Coil				
Unit	Total CFM	Min. OA CFM	RPM	BHP	Motor HP	EAT (DB/WB)	LAT (DB/WB)	EWT/LWT	GPM	Total MBH
AHU-1	21,000	10,200	1,580	30.1	40	91/64.8	52.5/50.8	45/60.5	100	777.2
AHU-2	17,000	3,600	1,718	23.6	25	101/66	53.7/48.7	45/62.8	85	758
AHU-3	7,000	7,000	1,717	6.6	7.5	108/67	49.5/45.2	45/60.2	50	381
AHU-4	8,200	8,200	1,775	7.8	10	108/67	50.8/45.9	45/59.5	50	370
AHU-5	5,100	5,100	1,775	4.6	7.5	108/67	49.8/45.5	45/59.0	60	274.2

After being distributed to each of the various zones and spaces, air is then collected in the plenum. In the case of a zone needing additional cooling not sufficiently met by the primary system, the secondary system of fan coil units circulate the air over their respective cooling coils and supply it back to that particular zone. Most of the plenum air is delivered back to the air handlers through hallway plenum return and vertical shafts.

Chillers and Heat Exchangers

UNLV Greenspun Hall's mechanical system has two Carrier 19XR centrifugal chillers and one 300 MBH Plate Heat Exchanger which supply chilled water to the air handling units, chilled beams, and fan coil units. This is accomplished by circulating condenser water through the heat rejection loop which supplies cooling to the chilled water loop to circulate back to the loads. The chiller and heat exchanger condensed schedule is found below.

Water Chiller Schedule						
		Chilled Water		Condenser Water		
Unit	Min. Capacity	GPM	EWT/LWT	GPM	EWT/LWT	Refrigerant
CH-1	200	300	60/44	600	85/95	R-134A
CH-2	200	300	60/44	600	85/95	R-134A

Heat Exchanger Schedule					
		Hot Side		Cold Side	
Unit	Capacity	EWT/LWT	GPM	EWT/LWT	GPM
PHX-1	300.6	64/54	600	52/57	1,200

Cooling Towers

The heat rejection loop mainly consists of pumps and cooling towers, not including the chillers. Condenser water is circulated by the pumps, from the chiller to the cooling towers, where heat is rejected through evaporation. The cooler condenser water is then re-circulated back to the chillers. Each tower has its own basin filter and is chemically treated to reduce the chance of contamination. Greenspun Hall has two Marley open-celled cooling towers which are described in the schedule below.

Coolling Tower Schedule								
			Summer			Fan		
Unit	No. of Cells	Tons/Cell	GPM/Cell	EWT/LWT	EAT (WB)	CFM	HP	Weight
CT-1	2	200	600	95/85	78	69,390	10	23,400
CT-2	2	200	600	95/85	78	69,390	10	23,400

Boilers

Greenspun Hall's heating system consists of two RBI Futura gas-fired boilers which simply heat water in the hot water loop to supply the heating coil with hot water. They are summed up in the following schedule.

Boiler Schedule				
			Water	
Unit	Capacity	Pressure	ENT/LVG	GPM
B-1	1,063	100	160/180	106
B-2	1,063	100	160/180	106

Dry-Coolers

UNLV Greenspun Hall has a number of critical spaces that are not cooled by the primary system. These spaces are cooled by six computer room air-conditioning units which operate constantly on their own chilled water loop. The cold fluid is supplied by two dry-coolers, which exchange heat between air and the fluid, to the air-conditioners. The following schedule describes these dry-coolers.

Dry-Cooler Schedule			
		Fluid	
Unit	MBH	GPM	EWT/LWT
DC-1E	186	44	120/111
DC-2E	186	44	120/111

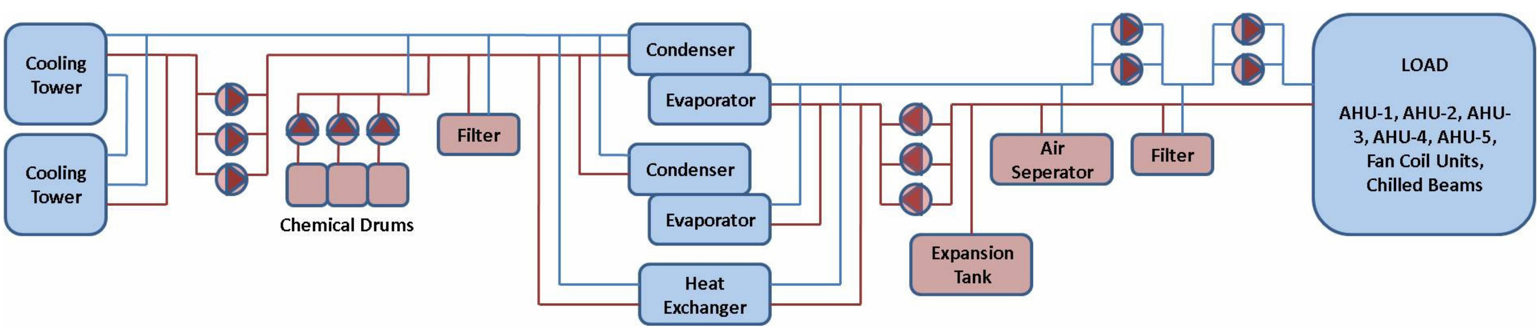
Pumps

None of these loops would be able to operate without the use of pumps. There are 9 inline and 7 end suction pumps controlled by various sensors and valves. All of the pumps are located in the chiller room, boiler room, or service yard and service all the various loops. The following condensed schedule describes these pumps in further detail.

Pump Schedule									
Unit	Service	GPM	NPSHR (ft.)	Head (ft.)	Impeller Size	Working Pressure (psig)	Pump RMP	BHP	Motor HP
CWP-1	Condenser Water	600	9.7	70	9.25	125	1750	13.5	20
CWP-2	Condenser Water	600	9.7	70	9.25	125	1750	13.5	20
CWP-3	Condenser Water	600	9.7	70	9.25	125	1750	13.5	20
DCP-1E	Condenser Water 24/7 Loop	88	7.5	76	8.75	125	1750	2.9	5
DCP-2E	Condenser Water 24/7 Loop	88	7.5	76	8.75	125	1750	2.9	5
CHWP-1	Chilled Water Primary Loop	300	3.7	30	9	125	1150	2.9	5
CHWP-2	Chilled Water Primary Loop	300	3.7	30	9	125	1150	2.9	5
CHWP-3	Chilled Water Primary Loop	300	3.7	30	9	125	1150	2.9	5
CHWP-4	Chilled Water Secondary Loop	505	7.8	85	10	125	1750	13.6	20
CHWP-5	Chilled Water Secondary Loop	505	7.8	85	10	125	1750	13.6	20
CHWP-6	Chilled Water Tertiary Loop	539	8	75	9.625	125	1750	12.8	20
CHWP-7	Chilled Water Tertiary Loop	539	8	75	9.625	125	1750	12.8	20
HWP-1	Heating Hot Water Primary Loop	106	3.3	22	7.5	125	1150	0.9	1.5
HWP-2	Heating Hot Water Primary Loop	106	3.3	22	7.5	125	1150	0.9	1.5
HWP-3	Heating Hot Water Secondary Loop	200	7.9	75	8.875	125	1750	5.4	10
HWP-4	Heating Hot Water Secondary Loop	200	7.9	75	8.875	125	1750	5.4	10

Chilled Water System

The chilled water system for UNLV Greenspun Hall consists of a heat rejection loop (primary) and a load loop (secondary). This system is known as a primary/secondary system with major equipment shown on the diagram below.



The primary chilled water and condenser water pumps operate on a lead/lag basis, rotating weekly to improve operation with the third pump acting as a stand-by pump. The secondary chilled water pumps also operate on a lead/lag basis, rotating weekly, with the lag pump serving as a stand-by pump. These are controlled by variable frequency drives which modulate between 15% and 100% of the maximum speed to maintain the differential pressure required for the system to operate. A modulating differential pressure bypass valve is also located in the secondary loop which is only open when the load is very low and pressure increases.

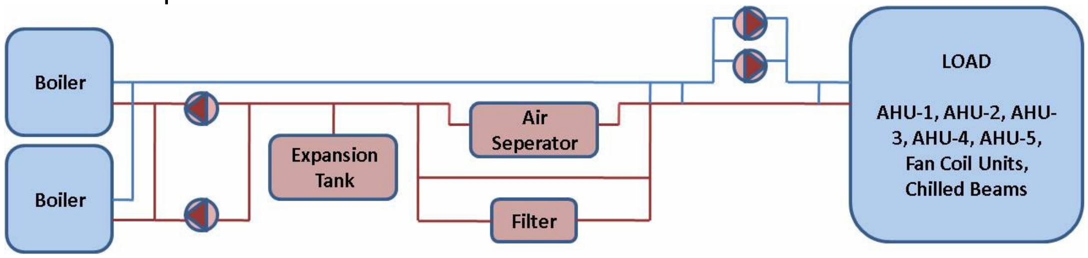
This system operates in one of two modes: chiller or heat exchanger. During chiller mode, both chillers are enabled whenever the outdoor air web bulb temperature exceeds the setpoint. These are equipped with variable speed drives to maintain maximum efficiency. Pumps on the primary side circulate condenser water from the condensers of the chillers through the cooling towers and back to the condensers. The cooling towers reject heat with variable frequency driven fans which modulate to maintain the condenser water supply temperature setpoint. The condenser water is treated by three chemical drums to provide micro-bacterial growth and other biological contamination.

During heat exchanger mode, control valves open to direct flow through the heat exchanger as required to maintain the required chilled water temperature. Chilled water circulates through the load and is pumped back to the chillers and heat exchanger after separation and filtration. The entire system is maintained via the ddc control system.

Heating Water System

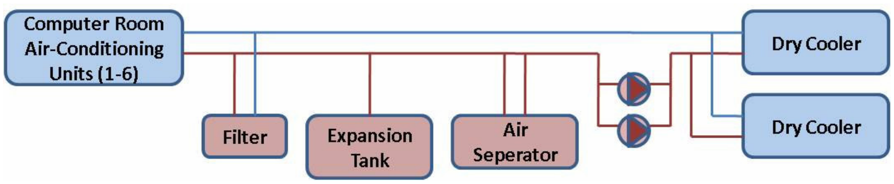
The lead heating water pump will enable whenever the outside air temperature falls below the setpoint. The secondary heating water pumps operate on a lead/lag basis, rotating weekly, with the lag pump operating on stand-by. The variable frequency drive modulates between 15% and 100% to maintain the heating water differential pressure setpoint. The differential pressure bypass valve opens during unusually low load when pressure is high.

Boilers will also operate on lead/lag basis and the lag boiler is enabled whenever the hot water temperature falls below the setpoint while the lead boiler is already in operation. Controls on the boilers are integral based to maintain the setpoint. Hot water travels to the load, controlled by three-way valves, and returns to the boiler after separation and filtration.



Auxiliary Chilled Water System

Dry-coolers perform heat rejection to the outdoor air to reduce the chilled water supply temperature to the computer room air-conditioning load. Circulating pumps operate on a lead/lag, weekly basis with integral control and the lag pump acting as stand-by. Variable frequency drives maintain the differential pressure setpoint. Warmer water is then returned to the dry-coolers after filtration and separation. This loop operates constantly to maintain setpoint temperature in critical rooms.



Design Conditions and Requirements

Indoor and Outdoor Design Conditions

The following information was based off values found in ASHRAE Standard 90.1-2007 and the design documents for Greenspun Hall. These values were entered into Trace 700 for the load analysis by the designer.

Outdoor Design Conditions	
Location	Las Vegas, Nevada
Climate Description	Warm Dry
Latitude	36.08 F
Longitude	115.17 F
Elevation	2,162 ft
Summer Design DB	106 F
Summer Design WB	66 F
Winter Design DB	27 F

Indoor Design Conditions	
Summer DB	75 F
Winter DB	72 F
Relative Humidity	30%

Design Ventilation Requirements

Ventilation requirements for Greenspun Hall follow ASHRAE Standard 62.1-2007 Section 6 to provide minimum amounts of outdoor air. This procedure was followed and requirements were calculated in *Technical Assignment 1 – ASHRAE Standard 62.1 Compliance, ASHRAE Standard 90.1 Compliance.* The results show that the minimum design flow falls short of the calculated amount for AHU-1, but all others easily exceed the minimum ventilation rate which is show in the table below.

	Outdoor Air Ventilation (cfm)	
	Design	Calculated
AHU-1	10,200	12,415
AHU-2	3,600	2,875
AHU-3	7,000	3,305
AHU-4	8,200	2,365
AHU-5	5,100	1,500

Design Cooling Loads

The cooling load for Greenspun Hall was done with the use of Trace 700 load analysis software. These results were presented in detail in *Technical Assignment 2 – Building and Plant Analysis.* The analysis was performed by entering zones with various loads (human, receptacle, lighting, etc.) and schedules, along with equipment and system types. The results showed that the air handlers could sufficiently meet the worst case load as calculated, but the calculated annual energy use was greater than the design annual energy use. These results are summed up in the following tables.

	Cooling Load (MBH)	
	Design	Calculated
AHU-1	777.2	689.2
AHU-2	758	684.9
AHU-3	381	402.3
AHU-4	370	386.4
AHU-5	274.2	281.3

Annual Energy Usage	
Design	Calculated
12,351 MBtu	13,971 MBtu

System Operation

The utility provider for Greenspun hall is the Nevada Power company and local rates are summarized in the table below. The specific contract that the University of Nevada Las Vegas holds with Nevada Power is not available to the public; therefore generic commercial rates were used. As previously noted in previous technical assignments, heating was neglected and therefore gas rates are not needed.

		Consumption	Demand Charge	Flat Rate
		(per KWh)	(per KW)	(per Month)
Summer	On-Peak	0.0906	9.05	268
	Mid-Peak	0.07672	0.41	
	Off-Peak	0.0613	0	
All Other Times		0.0614	0.5	

Due to confidentiality issues with the State of Nevada, some information was withheld and therefore could not be submitted for this report. This includes factors that influenced design, energy contracts, a complete breakdown of the mechanical system first cost, and the short operating history of the system. Although an in depth look at first cost could not be disclosed, the designer was able to reveal an estimate for the bid, which was roughly 9.4 million dollars. This can be broken down to a $77.05/ft^2 initial cost.

By using Nevada Power's commercial rates for southern Nevada, an annual system cost breakdown could be calculated using results from the load analysis done in *Technical Assignment 2 – Building and Plant Analysis.* The annual energy cost was determined to be $97,185.85 to operate the mechanical system of the building. The following is a monthly breakdown of energy usage.

		January	February	March	April	May	June	July	August	September	October	November	December	Annual
KWh	On-Peak	29725	25670	27940	24655	28760	63420	65865	75085	57300	32025	27925	28640	487010
	Mid-Peak	0	0	0	0	0	30175	33680	36670	29215	0	0	0	129740
	Off-Peak	0	0	0	0	0	44810	47020	48905	42065	0	0	0	182800
	Other Times	0	0	0	0	0	0	0	0	0	0	0	0	0
KW	On-Peak	118	114	114	115	118	542	550	552	512	118	118	118	3089
	Mid-Peak	0	0	0	0	0	0	0	0	0	0	0	0	0
	Off-Peak	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other Times	0	0	0	0	0	370	374	374	346	0	0	0	1464

LEED Assessment

The Leadership in Energy and Environmental Design rating system was created by the United States Green Building Council to evaluate a buildings performance and effieciency through design, construction, and operation. The evaluation is based on the following scale:

Certified:	26-32 points
Silver:	33-38 points
Gold:	39-51 points
Platinum:	52-69 points

When UNLV's Greenspun Hall was initially designed, the intent was to achieve a LEED Gold rating. However, due to various reasons including budget and difficulties on the construction site, a LEED Silver rating was rewarded to the building. This information is found on the USGBC website and viewed in Appendix A of this report.

System Critique

The design of mechanical system of Greenspun Hall, although very innovative, could be improved in several ways. It is a very efficient operating system, but not a very cost efficient constructed system. Chilled beams require chilled water to be supplied to each of them along with ductwork throughout the building. Construction cost for such a system, with piping and ductwork, is very high. VAV terminal boxes could be looked at as an alternative for this system of chilled beams.

The auxiliary chilled water system consists of two roof top dry-coolers and a lot of piping to connect to the computer room air-conditioning units, which are spread throughout the building, another high construction cost. This system could tap into the primary/secondary system that the rest of the building utilizes.

The building was required to meet the minimum ventilation rate set forth by ASHRAE Standard 62.1, but it did not receive the LEED credit for increased ventilation. Being that it is such an innovative mechanical design, it should not only meet minimum mechanical requirements, but exceed them.

The finest part about the mechanical system is its cost efficiency. It costs less than $100,000 to operate the building annually. This is related to energy efficiency which was obviously a high design goal set forth at the beginning of the construction process.

Appendix A