Carl R. Darnall Army Medical Center

Technical Report 2

Mechanical Systems Existing Conditions Evaluation

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Table of Contents

List of Tables

List of Figures

Executive Summary

The purpose of technical report 3 is to evaluate the existing mechanical systems. It lays out the mechanical equipment that make up each system, and the sequence of operation for each system. It summarizes the ventilation evaluation from the first technical report, and the energy consumption analysis from the second technical report. The technical report ends with a LEED certification analysis.

The current mechanical system surpasses the ventilation requirements of ASHRAE 62.1-2013 and 170-2013 due to the 100% outdoor air system. The cooling and heating loads calculated vary slightly from the actual design due to the design engineers using standard UFC-4-510 as the basis of design. The analysis for cooling and heating loads used ASHRAE 62.1 for level 6 offices, and ASHRAE 170 for level 5 medical rooms which explains the discrepancies between the design and calculated cooling and heating loads.

The army medical center uses a steam to water heat exchanger to produce heating water for the building. The steam is first produced by a steam boiler with a stack economizer to recover heat. The heating water is preheated using a heat recovery chiller which recovers heat from the return chilled water and rejects the heat into the return heating water. On the cooling side, the chilled water is sent through centrifugal chillers after the heat recovery chiller. All of the air handlers supply 100% outdoor air, they preheat the air using enthalpy wheels to recover energy from the general exhaust.

A LEED analysis was performed using the version 4 scorecard which differs from the version 2.2 scorecard the design engineers used. The analysis showed an increase in Energy & Atmosphere credits for optimizing energy performance. The newest version of the LEED scorecard offers more points for building automation and energy metering.

Mechanical Overview

The army medical center has an off-site central utility plant which consists of its chilled water plant and heating hot water plant. The medical center receives the services from an underground tunnel. The two heat recovery chillers help provide chilled water during colder weather, and they preheat the heating hot water return. It is base loaded, so during the winter, the centrifugal chillers and cooling towers do not need to run. Each of the four centrifugal chillers has a capacity of 1,250 tons, and the heat recovery chiller provides a capacity of 150 tons. Overall, the system provides enough capacity for future air handlers. The chilled water system provides a supply temperature of 44°F to the air handlers, fan coil units for electrical and telecom rooms. The building uses hot water produced by four gas fired steam boilers. The heated hot water system provides a supply temperature of 140°F.

Floors 5 and 6 of the east bed tower are conditioned by two dedicated outdoor air system (DOAS) air handlers in the penthouse on the roof. Both air handlers have enthalpy recovery wheels which recover energy from the exhaust air. AHU-2 serves constant air volume terminal units on floor 5 which consists of the pediatric department, as well as, a general medical / surgical department. AHU-3 serves constant air volume terminal units on floor 6 which consists of offices for the departments, officers, and the medical library.

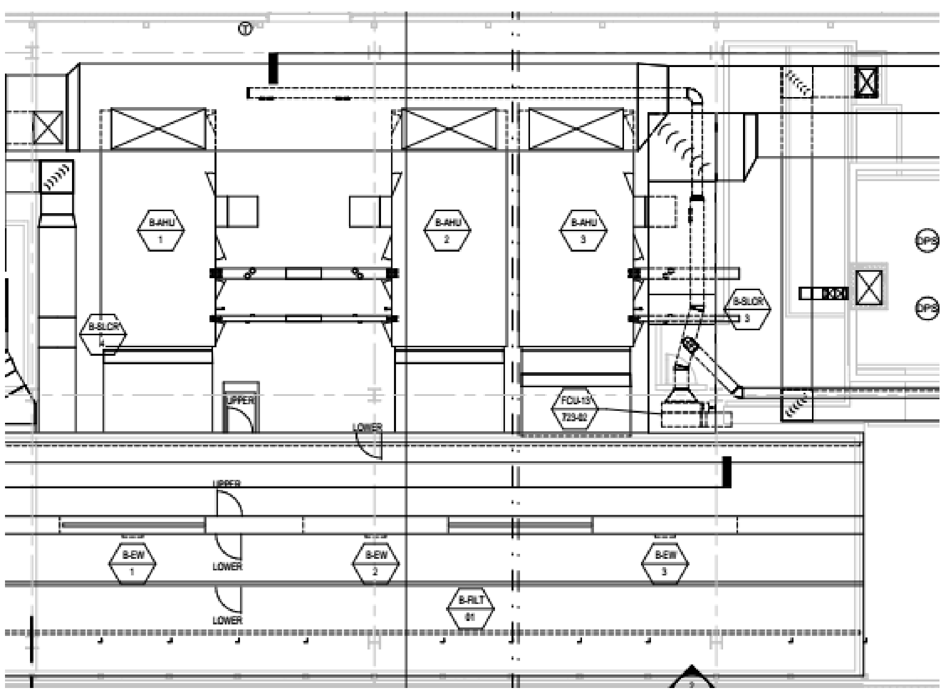

Figure 1 Bedtower Penthouse

Design Considerations

The function of the Medical Center is to replace the current hospital at Fort Hood, located in Killeen, Texas. The medical center consists of pediatric clinics, women's clinic, emergency services, a cafeteria, offices, and other various medical rooms. The medical center's central utility plant is located in a 25,000 sq. ft. building less than 100 feet from the medical center. The building houses the mechanical equipment for the waterside system: the chilled water, heating hot water, and steam systems. The rooftop air handling units are located in the penthouses located on each of the clinic's roofs. The air handlers are designed for 100% outdoor air and contribute to the LEED Gold Certification this building will be awarded upon completion.

Outdoor & Indoor Design Conditions

Carl R. Darnall Army Medical Center is located in a very hot and humid location identified by ASHRAE 90.1 section 5 as Zone 2A in Killeen, Texas. The outdoor air design conditions for both summer and winter are displayed in the table below, Table 1: Climate Data for Coldest & Hottest Months. This table displays the main concern is the cooling loads during the hot months.

Table 1 Climate Data for Coldest & Hottest Months

Coldest Month	Heating DB (99.6%)	Humidification DP/MCDB and HR (99.6%)		
		DP	HR	MCDB
January	23.7	9.8	9.4	33.5

Hottest Month	Cooling DB/MCWB (0.4%)	
	DB	MCWB
August	99.9	73.4

The indoor design conditions for the medical center vary according to occupancy types. The thermostats were placed at nursing stations as well as in the medical rooms, there is a thermostat for each individual medical room in order to meet the patient's needs. The thermostat settings for the three main room types are displayed in the table below, Table 2: Thermostat Settings. In all, most of the supporting rooms are designed for a 78F DB and 81 DP, but the medical rooms are designed at 75 F DB, and 81 driftpoint because of the stringent medical needs. All rooms, no matter the classification, were designed for a relative humidity of 55%.

Table 2 Thermostat Settings

Thermostat Settings			
Space	Cooling Drybulb Temp (F)	Heating Drybulb Temp (F)	Relative Humidity
Conference/Office	78	70	55
Medical Room	75	75	55
Medical Support	78	68	55

Ventilation Requirements

The design engineers proposed a 100% outdoor air system for Carl R. Darnall Army Medical Center. The first technical report was an evaluation of both ASHRAE 62.1 for the offices on level 6 and ASHRAE 170 for the medical rooms and supporting medical rooms for the minimum ventilation rates. The overall calculated outdoor airflows and the actual designed outdoor air flows are listed in table 3: Ventilation Calculations.

Table 3 Ventilation Calculations

Air Handler	Space Type	Actual Design		Calculated
		Supply Airflow	Outdoor Airflow	Outdoor Airflow
AHU-2	Level 5 Medical Rooms	45,000	45,000	7,160
AHU-3	Level 6 Offices	45,000	45,000	13,894

Since the actual design for the medical center is 100% outdoor air, the actual design outdoor airflows are significantly more than the ASHRAE 62.1 calculated airflows. Since, the calculated outdoor airflow is 30% of the supply airflow, it is three times as small as the design dedicated outdoor airflow.

Heating & Cooling Loads

The results from the second technical reports were calculated using Trace 700 model to compare the heating and cooling loads with the actual design. Although, the calculated loads were similar between the design and calculated model, differences can be explained through overcompensation for equipment and lighting loads. The results shown in table 4: Load Comparison, show the similarities between the two floors for the actual designed loads, however, the calculated loads in the model vary by floor. Level 5 calculations are based on ASHRAE 170 and Level 6 calculations are mainly based on ASHRAE 62.1, each air handlers was designed using a different standard which may explain discrepancies between the two. The Trace 700 model was also designed for occupants in the building at all times. The design engineers used UFC-4-510 as the basis for design which is more stringent than ASHRAE 62.1 and ASHRAE 170 for equipment, ventilation and lighting loads.

Table 4 Load Comparison

System	Total Supply / OA (CFM)		Cooling (SF/ton)		Heating (Btuh/ft^2)	
	Design	Calculated	Design	Calculated	Design	Calculated
BAHU-2	25,751	28,583	280.37	220.64	22.7	26.05
BAHU-3	24,188	30,633	280.37	177.18	22.7	28.88

Annual Energy Usage

The annual electrical energy consumption was broken down into monthly energy use and separated into the five top energy consuming loads. As seen in figure 2: Monthly Energy Consumption, the cooling plant consumes the most energy, and the fans consume the least. For most of the systems, the energy usage remains constant, however, as expected, the energy usage for the cooling plant increases during the summer months.

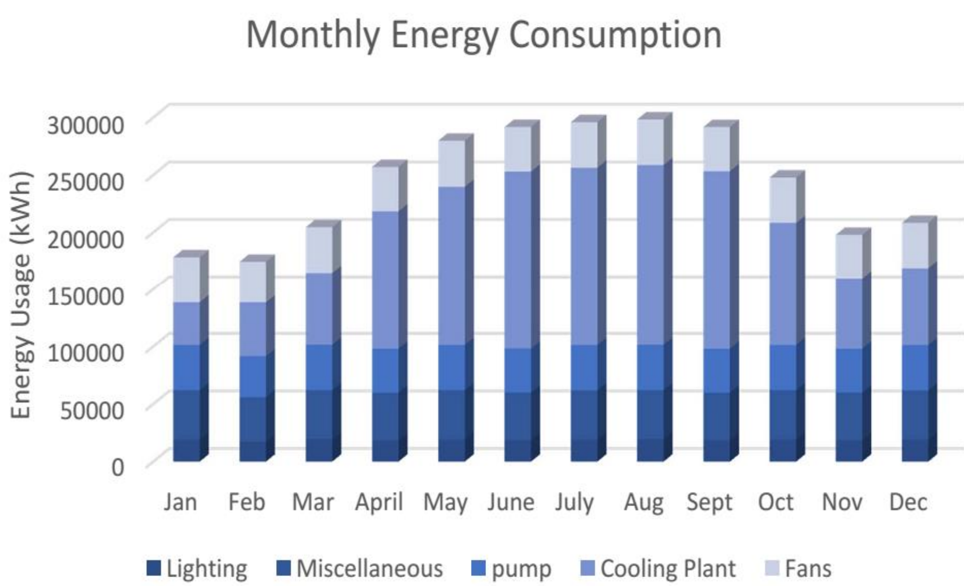

Figure 2 Monthly Energy Consumption

The monthly water consumption spikes during the summer because of the extreme outdoor temperatures, thus requiring a large cooling demand. During the hotter months when the cooling tower must run, the chiller will be require more make up water as seen in figure 3: water consumption.

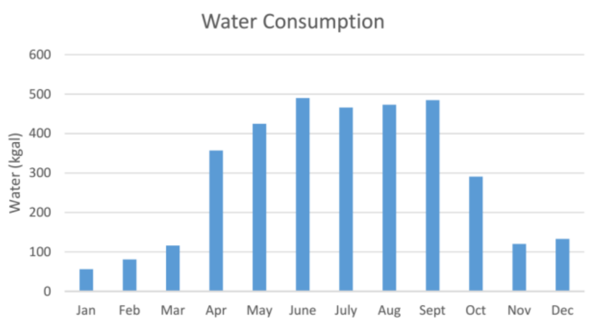

Figure 3 Water Consumption

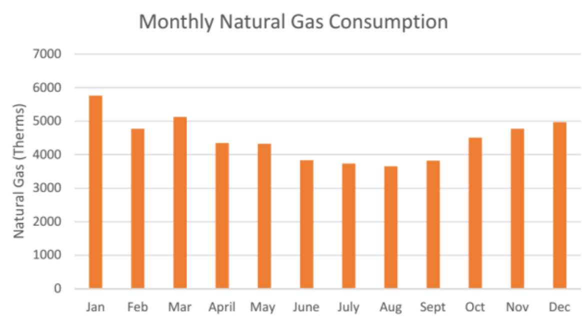

Figure 4 Monthly Natural Gas Consumption

The monthly natural gas consumption is relatively constant since the heating demand is not large during the winter, and only November thru March require more heat than the summer as displayed in figure 4: monthly natural gas consumption.

Energy Sources & Rates

The design engineers provided average utility rates for the three main energy sources: natural gas, electricity, and domestic water. The utility rates were obtained by Energy Star and were used to calculate monthly and annual utility costs. The utility rates provided are displayed in table 5: Utility Rates.

Table 5 Utility Rates

Utility Costs	
Electricity	$0.09418 per KWh
Natural Gas	$6.58362 per mcf
Domestic Water	$2.26693 per kgal

Influencing Factors of the Design

The army medical center is not applicable for rebates or tax relief from energy utility companies. The design engineers focused on saving money through the design of the mechanical systems.

Mechanical First Cost

Overall, the project was awarded to Balfour Beatty and McCarthy with a bid of $534 million for the construction costs. The first mechanical cost of the project was a total of $38,913,000, this cost includes HVAC piping, sheet metal, and equipment which takes installation labor into account, the totals for each trade can be found in table 6: Mechanical First

Cost. This accounts for 7% of the entire construction cost. The mechanical cost does not include insulation, controls, fire stopping, core drilling, and TAB.

Table 6: Mechanical First Cost

Mechanical Cost	
Piping	$13,819,850
Sheet Metal	$13,716,769
Equipment	$11,376,449
Total	$38,913,068

Loss of Usable Space

The majority of the mechanical space is located in the central utility plant and the basement. The only space that is lost due to mechanical systems on floors 5 and 6 are due to mechanical shafts. On level 5, only 371 sq. ft. is lost by mechanical shafts for risers and stair pressurization, the 6th floor loses the same amount of space. The mechanical systems are on separate floors called the IBS floors. The floors have a floor to ceiling height of 8 ft., and exist for the sole purpose of the building systems. Since the IBS levels are designed only for access for maintenance, and the floors are not designed for a heavy live load, it can be assumed that theses floors are not usable. However, the IBS floors cause the medical center to be twice in height. The army medical center's bed tower is currently 120 ft. tall in height, however, if the IBS floors were converted into 5 ft. plenums, the medical center would be 102 ft. in height. With a shorter medical center, pumps can be reduced in pressure because water does not have to overcome as large of a head pressure. Less concrete and façade material would be needed thus reducing costs.

Existing Mechanical Systems

Cooling Equipment

Chilled Water System Equipment

The central utility plant provides chilled water to the medical center for cooling. The chilled water mainly serves the air handlers as well as fan coil units, blower coil units, and a few computer room air conditioning units (CRACs). The chilled water loop provides a 44˚F supply to the building. The chilled water loop's main equipment are the four water cooled centrifugal chillers which use R-134a to provide a cooling capacity of 1,305 tons. The water from the chiller is distributed using variable primary flow pumps. The chilled water pumps are in line designed for 1,900 gpm and provide a head pressure of 185 ft. wc. In table 7: Pump Schedule below, lists more information about the pumps in the heating water, chilled water, and heat recovery systems. A heat recovery chiller also provides chilled water and heating hot water to their respectable systems by absorbing heat from the return chilled water and ejecting it into the return heating hot water.

Table 7 Motor Horsepower Schedule

ID Tag	Service	Flow (GPM)	Head (ft wc)	NPSH (ft wc)	Pump Efficiency (%)	RPM	Number on Emergency Power
HWP-(1-3)	Heating Water	650	180	17.7	76%	3,600	1
CHWP-(1-4)	Chilled Water	1,900	185	10.6	81%	1,800	2
CWP-(1-4)	Condenser Water	2,945	75	22.7	79%	1,770	2
HRP-(1-2)	Heating Water	175	25	9.5	76%	1,800	0
HRP-(3-4)	Chilled Water	220	15	5.8	76%	1,800	0

Condenser Water System

The heat from the centrifugal chiller is rejected into the condenser water which is sprayed through four 13˚F range induced draft counter-flow cooling towers one of them in standby mode. Each cooling tower is designed for a minimum of 690 gpm flow and a maximum of 1,885 gpm. The system uses a continuously drained concrete basin which improves the protection during cold weather and reduces maintenance. The cooling tower blowdown water is re-used for irrigation because the system is chemical free. Condenser water pumps provide a pressure of 75 ft wc each.

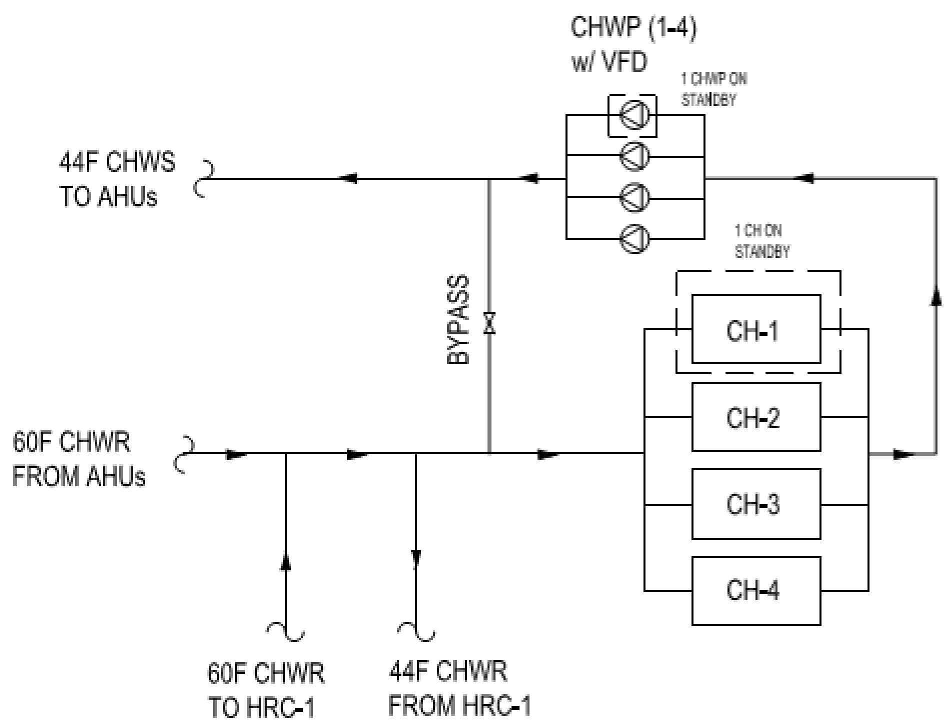

Figure 5 Chilled Water Loop

Chilled Water System Sequence of Operation

The medical center is served chilled water from a central utility plant detached from the building via a utilities tunnel. Upon entering the building, the water branches off the chilled water return main and feeds into the heat recovery chiller loop as seen in figure 5 above. During colder months, HRC-1 can provide chilled water for the base load of the building. If the HRC-1 can cool the chilled water to the required 44˚F, then the chilled water bypasses the centrifugal chillers and distributes back to the medical center. If the temperature of the chilled water leaving the heat recovery chiller rises above 46˚F, then the bypass valve closes, and one of the four centrifugal chillers in parallel turns on. The chillers will turn on sequentially if the leaving temperature of the chiller is at 46F for more than 15 minutes. The chilled water from the HRC-1 returns to the chilled water return main and mixes with the remaining water from the hospital. The chilled water feeds into one of the four in line pumps. One chilled water pump and chiller will be in standby mode, and the lead chiller will alternate weekly, so none of them sit unused for months at a time. Lead pumps alternate weekly in order to ensure equal wear on them. The chilled water loop is a variable primary flow, so the chilled water pumps are accompanied with VFDs to ensure the proper amount of chilled water is distributed within the medical center.

Heating Equipment

The central utility plant provides 140˚F heating hot water to the medical center for the AHUs, and the reheat coils on the CAVs. The returning 110˚F heating hot water is used to preheat domestic hot water, absorb heat from the chilled water return, and it is heated through a heat exchanger by steam.

Steam Boiler

The steam plant produces 150 psig steam by four dual-fuel forced draft steam boilers. The two fuel types used are natural gas, and #2 fuel oil. Each boiler is sized for a gross output of 11,716 MBH. In order to maximize on efficiency, each boiler has a boiler stack economizer which recovers heat from the combustion process. The steam is mainly used for the heating hot water, however, some of it will be distributed within the medical center to serve kitchens and sterilizing equipment.

Humidification Clean Steam Generator

In the penthouse there is a humidification clean steam generator which produces steam for the humidifier in the air handlers. Medium pressure steam comes in at 85 psig from the basement, and is generated into low pressure clean steam at 15 psig. The low pressure steam is supplied to the humidifier in the air handler. The steam entering the humidifier is 40.7F, and after it humidifies the incoming outdoor air, it rises 6˚F, and the outdoor air humidity rises from 37.6% RH to 59.3RH.

Heat Exchangers

The return heating water is used to preheat the domestic hot water using a preheat heat exchanger. This heat exchanger, PHX-1, is double wall shell and tube type. The preheat exchanger has a design capacity of 4,489 MBH and uses the design temp of the return heating hot water of 120˚F to preheat the domestic hot water. Later in the heating water loop, the water passes through the steam and hot water heat exchanger. This heat exchanger is also a shell and tube U-shape type, with the steam in the shell heating the heating water in the tubes. The heat exchangers have a capacity of 9,618lb/hr of steam. The temperature of the incoming steam is 280˚F at 35 psig. The steam heats the incoming 600 gpm water from 110˚F to 140˚F.

Hot Water Pumps

Three in line variable primary pumps distribute heating water to the reheat coils in the CAVs and the heating coils in the air handlers. These pumps operate in parallel which allows one pump in standby mode. Each pump is designed for 650 gpm, and provides 180ft WC head in order to distribute water to the air handlers in the penthouses. Each pump is paired with a variable frequency drive, and two of the pumps are on emergency power. There is enough room and capacity for a future fourth heating water pump.

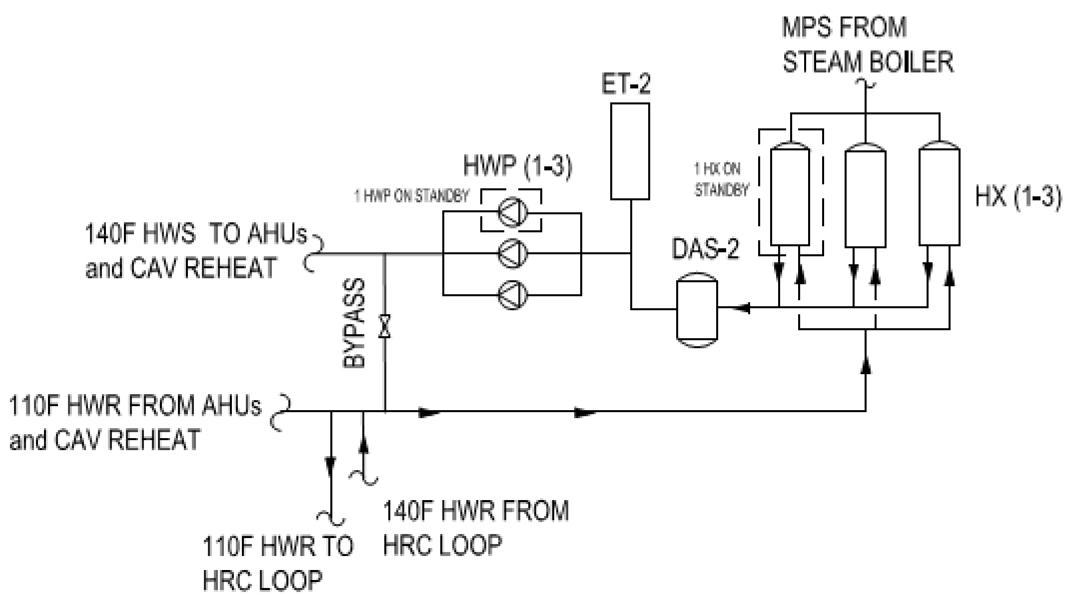

Figure 6 Heating Water Loop

Heating Water System Sequence of Operation

The central utility plant uses steam from the steam boilers to heat the heating hot water. As seen above in figure 6, the hot water returns from the medical center and branches off to feed into the heat recovery chiller loop. The returning heating water from the heat recovery chiller returns to the heating water main and enters the steam and water heat exchangers each sized for 60% of the building heating load capacity. Medium pressure steam enters from the steam boiler and heats the incoming water to 140˚F. If the incoming water rises above 850 gpm, then the second heat exchanger switches on, the third staying in standby mode. The leaving 140˚F heating water enters the heating water pumps. The minimum flow through the pumps is set at 130gpm, if this is met, then the bypass valve opens and the pumps are maintained at a constant speed. Each pump is controlled by a VFD, and one is always in standby mode. The heating pumps distribute 140F to the heating coils in the AHUs and the reheat coils in the CAVs.

Heat Recovery Chiller

The heat recovery chiller provides a base cooling load during the colder months, if chilled water is in demand. The heat recovery chiller is a water cooled scroll chiller. The chiller is rated for a 202 ton capacity, and the condenser side is designed to reject 2,634 MBH of heat. The returned chilled water from the building first enters an in line pump and then enters the evaporator side at 60F. Heat from the 217 gpm of returning chilled water is rejected into the 132 gpm of return heating water. The chiller is designed to produce leaving heating water at 140˚F and leaving chilled water at 44˚F.

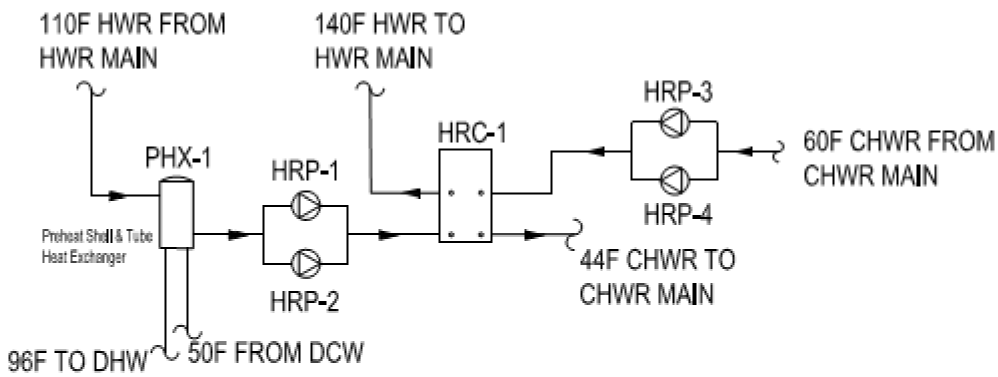

Figure 7 Heat Recovery Chiller Loop

Heat Recovery Chiller System Sequence of Operations

The entering heating water from the medical center first passes through the preheat heat exchanger. Figure 7, above shows how the heat recovery chiller cools the chilled water loop and heats the heating water loop. This heat exchanger preheats the incoming domestic cold water to 96˚F domestic water to serve the medical center's domestic heating needs. The heat exchanger produces 175 gpm of heating hot water which then feeds into one of the two heat recovery pumps rated at 25 ft. wc. The pump efficiency of these pumps is 76%, and they are both parallel in line pumps, one of the two pumps is in standby mode. The heating water proceeds to the heat recovery chiller and heats up to 140˚F and is sent back to the heating water main. On the evaporator side, the chilled water from the chilled water return main enters one of two in line pumps at 217 gpm. The pump provides 15 ft. wc head at 76% efficiency. The water then flows to the heat exchanger where it is cooled down to 44˚F and flows back to the chilled water return main.

Airside System Equipment

Air Handling Units

The two air handlers supplying conditioned outdoor air to the spaces on the fifth and sixth floors are designed for 100% outside air. Both are designed for an outside airflow of 45,000 cfm, and supply the spaces with 55F conditioned air. Before entering the air handlers, outdoor air enters through an enthalpy wheel and is preconditioned with the general exhaust air. The outdoor air is drawn through the AHU by the fan. It is further heated if necessary by the heating coil. After, it is humidified using the 15 psig steam from the clean steam generator. It is then cooled down to the supply temperature of 55F, and passes through the fan and the MERV 14 filter, then it is supplied to the building after passing through the MERV 7 filter in the second bank. Figure 8, below shows the path of outdoor air in the air handler.

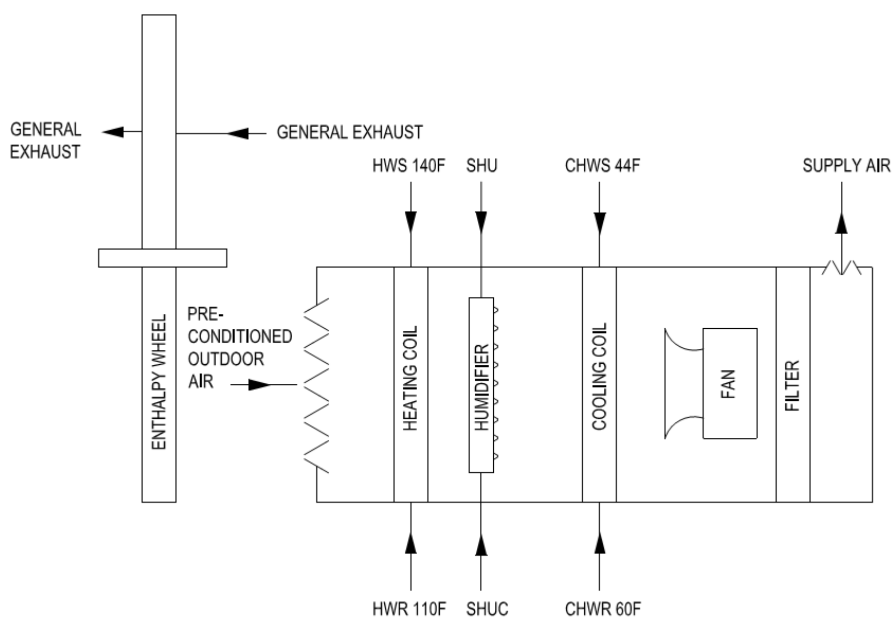

Figure 8 Air Handling Unit

Terminal Units

The supply air from the air handlers supply CAV boxes on the fifth and sixth floors. The CAV boxes have a heating coil to provide the proper conditions for the space. Each patient room is on its own CAV box, and the thermostat is located within the room.

Fan Coil Units

Electrical rooms are provided with fan coil units that supply anywhere from 750 to 1,225 cfm for each space. The chilled water supplies the cooling coils, so the equipment in the room can be properly maintained. The fan coil units have a 1” MERV 7 filter for circulating air within the space.

Operating History

Since the army medical center is new construction, there is no history on the consumption of energy nor metering of energy.

LEED Analysis

At the time of design, the army medical center was aiming for LEED Gold, projected to earn 43 credits by completion. The LEED checklist used was version 2.2 for new construction, however, since the design, version 4 has been released, and the following analysis is made in respect to the newest version.

Energy & Atmosphere Credits

EA Prerequisite: Fundamental Commissioning and Verification Required

In order to guarantee the owner’s project requirements, the commissioning authority will create basis of design documents. Maintenance plans must be created for operating the systems which include sequence of operations, equipment run-time, set points for HVAC equipment, and any other documents that will inform the building operator of the systems.

Prerequisite: Minimum Energy Performance Required

The medical center will follow option 1: whole building energy simulation. The medical center demonstrates an improvement of over 5% for new construction compared to the baseline building performance according to ASHRAE Standard 90.1.

EA Prerequisite: Building Level Energy Metering

Metering devices will be installed in order to monitor the total building energy consumption of electricity, natural gas, chilled water, steam, fuel oil and other fuel sources.

EA Prerequisite: Fundamental Refrigerant Management

The medical center does not use CFC based refrigerants in any of the HVAC or refrigeration systems. The HVAC systems strictly use R-134a refrigerant.

EA Credit: Enhanced Commissioning (3/6)

The commissioning authority will follow the commissioning process for the mechanical, electrical, plumbing and fuel systems. This includes seasonal testing, operator training, reviewing contractor submittals, and other requirements. Since v2.2, monitor based commissioning and thermal envelope commissioning was added to the attainable credits. It is unknown if the commissioning authority will be commissioning for either. At least 3 credits are earned.

EA Credit: Optimize Energy Performance (13/20)

The medical center must outperform the ASHRAE baseline by at least 6% in order to attain any points. The medical center out performs the ASHRAE baseline by 26.2%, so the medical center is awarded 13 credits. Table 8, shown below, displays the distribution of the credits for the percentage improvement in energy performance is shown below.

Table 8 Credits for Improvement in Energy Performance

Points for Percentage Improvement in Energy Performance	
New Construction	Points Healthcare
6%	3
8%	4
10%	5
12%	6
14%	7
16%	8
18%	9
20%	10
22%	11
24%	12
26%	13
29%	14
32%	15
35%	16
38%	17
42%	18
46%	19
50%	20

EA Credit: Advanced Energy Metering (1/1)

All energy sources consumed by the medical center will be recorded using advanced energy metering. The meters are permanently installed, recording at on hour or less of intervals. They are located within the central utility plant. Although, it is unknown if the meters can store the data for more than 36 months.

EA Credit: Demand Response (0/2)

The army medical center is ineligible to be considered for the demand response program of the electric company.

EA Credit: Renewable Energy Production (0/3)

Although a combined heat and power system and a wind power system were first considered during design, the medical center has not adopted any renewable energy production systems.

EA Credit: Enhanced Refrigerant Management (1/1)

The refrigerants selected for the HVAC and refrigeration equipment do not reach the requirement of LCGWP+LCODP*10^5 <= 100, therefore no credit is rewarded. The calculations for worst case scenario are displayed below in table 9: Refrigerant Impact.

Table 9 Refrigerant Impact

Refrigerant	GWP	ODP	LCODP	LCGWP	LCGWP+LCODP*10^5	Credit? (LCGWP+LCODP*10^5<=100)
HFC-134a	93	0.02	0.003	13.95	313.95	No
Lr	2%					
Refrigerant Charge (Rc)	5					
Equipment Life	10					
End of Life Loss (Mr)	10%					

EA Credit: Green Power and Carbon Offsets (0/2)

The design engineers ruled green power out during the design development phase of this project, therefore, are not eligible for this credit.

Indoor Environmental Air Quality Credits

IEQ Prerequisite: Minimum Indoor Air Quality Performance Required

The mechanically ventilated medical center surpasses both ASHRAE 170-2013 and ASHRAE 62.1-2013 requirements for minimum outdoor air flow because of the 100% outdoor air system. In spaces of high occupancy, CO_2 monitors were installed in order to maintain the minimum outdoor airflow.

IEQ Prerequisite: Environmental Tobacco Smoke Control Required

Smoking is prohibited everywhere within the medical center. Proper warnings are along the exterior of the medical center prohibiting smoking within 25 feet of the entries and outdoor air intakes.

IEQ Prerequisite: Minimum Acoustic Performance

The minimum acoustic performance prerequisite is only required for educational buildings, therefore this prerequisite is not applicable to the army medical center.

IEQ Credit: Enhanced Indoor Air Quality Strategies (0/2)

The entryways of the medical center do not have a system that is 10 feet long in the direction of travel to capture dirt and particulates entering the building. Although, it does have a unit heater, the return grilles are not the correct size, nor is there a filter on the unit heater. Entryway vestibules are not pressurized either.

Medical rooms in which activities that emit gases are properly enclosed with self-closing doors, and deck to deck partitions. The rooms are also properly exhausted as required by the prerequisite minimum indoor air quality performance.

All ventilation systems have a MERV reporting value of 14 which surpasses the requirement of 13.

IEQ Credit: Low-Emitting Materials (1/3)

The materials for the interior paints, interior adhesives and sealants, flooring, and composite wood are all low emitting materials. Four of the seven categories of materials will be met in order to attain at least one credit. Since the design engineers are achieving LEED certification from LEED version 2.2, they are not tracking the ceiling, wall, thermal, and acoustic insulation, the furniture or the exterior product materials for emissions.

IEQ Credit: Construction Indoor Air Quality Management Plan (1/1)

Proper actions will be taken during construction to protect absorptive materials, and any materials prone to mold growth from moisture in order to prevent occupants from breathing mold particles in the building. During construction, filters prevent particulates from entering the ventilation system. Tobacco use will be prohibited within the building as well as 25 feet from the building during construction. Construction workers must wear ear protection when using equipment with a decibel level 85 or over as specified by OSHA.

IEQ Credit: Indoor Air Quality Assessment (1/2)

Before occupancy, filters will be changed and a flush-out of the ventilation system will occur of 14,000 cfm of outdoor air per square foot in order to rid the building of particulates. The air will be between 60˚F and 80˚F and have a relative humidity of no higher than 60% as required by the credit.

IEQ Credit: Thermal Comfort (0/1)

In order to meet pressurization requirements for certain procedural rooms, ASHRAE 55 is not met for all of the patient rooms and 50% of the remaining individual occupant spaces. Due to the range of activities occurring and equipment emitting thermal energy and moisture, the thermal comfort controls cannot offset these factors.

IEQ Credit: Interior Lighting (1/1)

Lighting controls are located in the medical supporting areas for the staff. At least 90% of the patient rooms have lighting controls within reach of the bed. There are also lighting controls for both patients within a multi-occupant patient room.

IEQ Credit: Daylight (0/2)

Daylighting studies resulted in a small amount of day lit floor area. Due to exterior shading from awnings, the daylighting credit is not met.

IEQ Credit: Quality Views (0/2)

The patient rooms along the perimeter of the building have direct views to the Texan landscape. Due to the size of the medical center, there are more interior rooms than there are rooms along the exterior, so this credit is not awarded.

IEQ Credit: Acoustic Performance (2/2)

In order to achieve speech privacy for critical rooms, deck-to-deck partition walls enclose the room. The medical center was designed to meet the Design criteria for Minimum Sound Isolation Performance between Enclosed Rooms in the 2010 FGI Guidelines and 2010 SV Guidelines. All mechanical, plumbing and electrical systems were designed with minimum sound pressure levels. Acoustical finishes were chosen in order to meet 2010 FGI guidelines and the 2010 SV guidelines.

LEED Analysis Summary

The LEED scorecard has changed significantly in the Energy & Atmosphere section since version 2.2. The army medical center scored 18 of the 35 possible credits because of the optimal performance. The medical center did not score many of the points because of the design engineer's decision to not pursue green power or renewable energy production.

Many credits were added to the indoor environmental quality section since version 2.2. The overall credits attained during the analysis were 6 of the 16. Three more low emitting materials have been added to the list, however the number of possible credits have decreased. Since the medical center failed the entryway system requirement for the enhanced indoor air quality credit, two credits were not attained. The medical center is a large mass with a lot of its rooms located in the interior zones. These rooms are not able to receive daylighting or views of the landscape which means four possible credits are loss.

There is a potential for an improvement in the energy and atmosphere credits by changing equipment or adding a renewable energy productions system. More indoor environmental quality credits can be achieved by changing the entry way systems, however, the daylight and quality view credits are a little difficult to attain due to the set design of the medical center.

Existing Mechanical Systems Evaluation

It is evident in the design of the Carl R. Darnall Army Medical Center one of the biggest goals was to have a mechanical system that can be easily maintained. The IBS floors allow for facility operators to monitor systems and fix any problems that come up without displacing patients. Although the IBS floors allow for easier maintenance, the extra floor adds construction costs to the project including the extra metal deck, and duct fittings in order to create the accessible walkways.

The 100% outdoor air system surpasses the ventilation requirements presented in ASHRAE 62.1 by a significant amount. Having a 100% outdoor air system requires a large amount of cooling during summer months because the weather is hot and dry. An area worth looking into is this system because it takes up space on the IBS floors due to the size of the ducts. The air handlers require large amounts of chilled water when cooling is in demand. By changing the system to supplying the minimum outdoor airflows, the cooling plant could downsize.

There are opportunities for the army medical center to gain LEED credits. A new LEED analysis after small changes may push it to become LEED platinum by tracking the low-emitting materials and researching into the thermal comfort of the patients in the building.

Appendix A - Schematics