Ft. Detrick Defense Medical Logistics Center

Frederick, MD

Mechanical Systems Existing Conditions Report

Technical Assignment 3
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Executive summary

Ft. Detrick Defense Medical Logistics Center (DMLC) is a three-story office building located on the Ft. Detrick military base in Frederick, MD. The building is 129,960 square feet and it houses the top medical planning organizations within the Department of Defense representing the Army, Navy, Air Force, and Marines. The building was designed to comply with common standards, ASHRAE 62.1-2004 and ASHRAE 90.1-2004, but because it is a military structure, it is also designed to meet Unified Facilities Criteria (UFC). These guidelines keep in mind occupant safety in the event of a terrorist attack.

Ventilation requirements for the building are met for all air handling units except for AHU-1. However, the critical zone for AHU-1 occurs in a storage room. Since a storage facility likely will not be occupied 100% of the time, the designer may have assumed that supplying that space with 58% outdoor air was not critical. The result of the cooling load comparison is that four of the six cooling systems exceeded Trace's recommendations, and the result of the heating load comparison shows that all air handling units' heating coils are greatly oversized. Boilers on the project are powered by natural gas, and all other HVAC equipment is electric. Utilities are predicted to cost $156,209 per year, which is $1.28/ft^2 per year.

A complete heating, ventilating, and air conditioning system is provided for Ft. Detrick. This report describes each system's components and sequence of control in detail. Control sequence logic resides in direct digital control (DDC) hardware that implements LonWorks technology. A DDC panel controls each individual system, with the exception of the glycol system.

The layout of the mechanical systems is efficient in that it conserves ductwork and piping. From an energy standpoint, however, there is room for improvement. VAV boxes provide good temperature control, but waste energy in the reheat process. The minimum outdoor air required for AHU-1 per ASHRAE 62.1-2007 exceeds the actual outdoor air. However, the critical zone for AHU-1, and four other AHUs, occurs in a storage room. Since a storage facility likely will not be occupied 100% of the time, reducing the amount of outdoor airflow to the building's many storage spaces may result in an energy savings. The design heating analysis shows that all air handling unit heating coils are very oversized. Sizing the units for smaller heating coils will result in smaller sized boilers, which can lead to an energy savings. In addition, there is no energy recovery system in the building. Implementing this kind of system would also decrease energy consumption.

Building Overview

Ft. Detrick Defense Medical Logistics Center (DMLC) is a three-story office building located on the Ft. Detrick military base in Frederick, MD. The building is 129,960 square feet and it houses the top medical planning organizations within the Department of Defense representing the Army, Navy, Air Force, and Marines. The figure in Appendix A shows an area breakdown of the building and displays space relationships. As seen in this figure, the majority of the building consists of open office space. This minimizes the area needed strictly for circulation space. Mechanical rooms housing the building's seven air handling units (AHUs) are located at the north and south ends of the buildings. The central plant is located in the southwest corner of the first floor.

Design Objectives & Requirements

The mechanical engineer for Ft. Detrick, Baker and Associates, designed the building in accordance with the following specifications:

- ASHRAE 62-2004: Ventilation for Acceptable Indoor Air Quality
- ASHRAE 90.1-2004: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings
- Unified Facilities Criteria (UFC) 4-010-01: Anti-Terrorism/Force Protection (AT/FP) Standards
- UFC 3-410-01FA-Design: Heating, Ventilation, and Air Conditioning
- UFC 3-410-02A-Design: HVAC Control Systems
- Unified Facilities Guide Specifications (UFGS)

ASHRAE 62.1 and ASHRAE 90.1 are widely used in commercial building design. AT/FP, UFC, and UFGS are military-specific design standards. AT/FP guidelines were established for occupant safety in the incidence of a terrorist attack. Structural measures include blast-proof windows and requirements for preventing progressive collapse. Mechanical measures require that HVAC equipment is not roof-mounted. Exceptions include condensing units for DX systems and exhaust fans and hoods. Also included is a minimum "stand-off" distance between the building and parking lots or roads. The design also limits airborne contamination to reduce the potential for chemical, biological, and radiological agents being distributed throughout buildings. To ensure this, outdoor air intake louvers are placed on the second and third floor only. An emergency shutoff switch in the HVAC control system that can immediately shut down the air distribution system throughout the building in the event of contamination is also provided.

UFC and UFGS documents provide planning, design, and construction criteria and are applied to all Department of Defense structures. The basic principles of these documents are to design each system as simply as possible and to base system selections on life cycle cost effectiveness. They also state to provide the necessary amount of space for maintenance and commissioning of equipment. All designs must be sustainable according to the SPiRiT rating system. This sustainability ranking system is used in lieu of LEED for all military buildings. Ft. Detrick will receive a Silver Rating when construction is complete.

Design Outdoor & Indoor Conditions

The design outdoor conditions are taken from the mechanical scope of work for Ft. Detrick provided by Baker and Associates.

Table 1
Outdoor Design Conditions for Frederick, MD

Latitude	39°, 26 minutes
Longitude	77°, 26 minutes
Elevation	355 ft
Degree Days Heating (65°F Base)	5059
Degree Days Cooling (65°F Base)	948
Daily Range	26°F
Summer Winds	WNW 7.5 mph
Winter Winds	N 15 mph
Heating Design Dry Bulb Temperature	12°F
Cooling Design Dry Bulb Temperature	91°F
Cooling Design Wet Bulb Temperature	75°F

The design indoor conditions are also taken from the mechanical scope of work and are summarized in Table 2. Indoor design relative humidity is 50% in the summer with no humidity control in the winter unless noted otherwise. Night setback temperatures are 90°F in the summer and 55°F in the winter except in the IT/Comm Rooms.

Table 2
Indoor Design Criteria for Ft. Detrick

Space	Summer Indoor Temperature (°F)	Winter Indoor Temperature (°F)	Minimum Room Circulation (ACH/hr)	Outside Air (ACH/hr)	Maximum Noise Level (NC)	Notes
Offices	76	68	4	1	35	-
Conference Rooms	76	68	6	4	30	-
IT/Comm Rooms	72	72	6	2	40	-
Lobby	76	70	4	1	40	-
Classrooms	76	70	6	4	30	-
Corridors	76	68	6	2	30	-
Locker Rooms	78	68	10	2	35	-
Vestibule	-	50	-	-	40	-
Copy Rooms	76	70	10	2	40	-
Elevator Machine Room	90	50	-	-	45	-
File Storage Rooms	76	68	4	2	40	-
Storage	76	68	4	1	40	-
Cafeteria	76	68	5	1	40	-
Toilets/ Janitor Rooms	-	68	10	Exhaust	45	1
Arms Room	-	68	6	1	45	2
Mechanical/ Electrical Rooms	-	55	10	Exhaust	50	-
Receiving	76	55	4	1	40	-

1- Exhaust from adjacent areas
2- Dehumidifier to maintain 30% relative humidity

Design Ventilation Requirements

Ventilation rates for Ft. Detrick were designed to be in accordance with ASHRAE 62.1-2004. Outside air quantities were to meet the required ventilation rates and maintain a positive pressure relative to the outdoors. Exceptions to this include toilet rooms, locker rooms, janitors' closets, mechanical/electrical rooms, storage rooms, and break and snack rooms, which are under negative pressure relative to adjacent areas.

In Technical Assignment 1, the Ventilation Rate Procedure found in Section 6 of ASHRAE 62.1-2007 was used to determine compliance with the standard. To comply with ASHRAE 62.1-2007, the total design outdoor air intake (V_{ot}) must be less than or equal to the actual outdoor air intake. The actual outdoor air intake was taken from the air handling unit schedule in the design documents. The following table summarizes Ft. Detrick's compliance with ASHRAE 62.1-2007.

Table 3
Ventilation Compliance Summary

AHU	Maximum Z_p	Nominal OA ($\sum V_{oz}$)	Total Design OA Intake (V_{ot})	OA Supplied	Comply
1	0.58	2843	4566	4460	NO
2	0.53	1733	2951	4210	YES
3	0.52	2235	3589	4975	YES
4	0.36	2092	2704	4550	YES
5	0.33	2120	2686	4670	YES
6	0.56	2584	4438	4985	YES
7	0.18	376	394	450	YES

The minimum outdoor air required for AHU-1 per ASHRAE 62.1-2007 exceeds the actual outdoor air supplied by 106 cfm, so it is not in compliance with the standard. However, the critical zone for AHU-1 occurs in a storage room. The critical zone is where maximum Z_p occurs. Since a storage facility likely will not be occupied 100% of the time, the designer may have assumed that supplying that space with 58% outdoor air was not critical. Also note that out of the seven AHUs, four of the critical zones are storage spaces. Reducing the amount of outdoor airflow to the building's many storage spaces may result in an energy savings.

Design Heating & Cooling Loads

The actual heating and cooling loads are found on the mechanical schedules in the construction documents provided by Baker and Associates. In Technical Assignment 2, the design loads were estimated using Trane's Trace 700. The outdoor air ventilation rates, electrical loads, weather data and design occupancies were taken from the design documents provided by Baker and Associates. The lighting W/ft^2 was determined by ASHRAE 90.1. The occupancy, lighting, and equipment schedules are not stated in the design documents, so Trace's default office schedules were used. Infiltration is neglected in this calculation since it is also neglected in the design documents. Table 4 compares Trace's computed loads and ventilation indices with those found in the design documents.

Table 4
Cooling Load Comparison

System	Trace Load (ft^2/ton)	Actual Load (ft^2/ton)	Percent Difference
AHU-1	517.2	492.9	5%
AHU-2	539.6	496.4	8%
AHU-3	511.6	585.9	13%
AHU-4	613.6	536.5	13%
AHU-5	371.1	555.2	33%
AHU-6	392.5	551.7	29%
Unit Heaters	-	-	-
Air Conditioning Units	695.7	102.5	85%

The actual load is determined by dividing the square footage the unit serves by the unit's capacity in tons, which for all air handling units is 35 tons. The result is that four of the six cooling systems exceeded Trace's recommendations. AHU-3 may require more load because it covers the largest square footage of the six air handling units. It is also important to note that AHU-5 and AHU-6 may require more cooling load because they are on the top floor. Because of this, the roof load factors into the total cooling load.

The design heating loads for Ft. Detrick are summarized in Table 5.

Table 5
Heating Load Comparison

System	Trace BTUh	Design BTUh	Percent Difference
AHU-1	242,297	616,000	61%
AHU-2	245,566	623,400	61%
AHU-3	309,329	697,900	56%
AHU-4	192,725	677,200	72%
AHU-5	422,620	761,800	45%
AHU-6	361,922	772,800	53%
Unit Heaters	75,014	52,900	29%

Annual Energy Consumption and Operating Cost

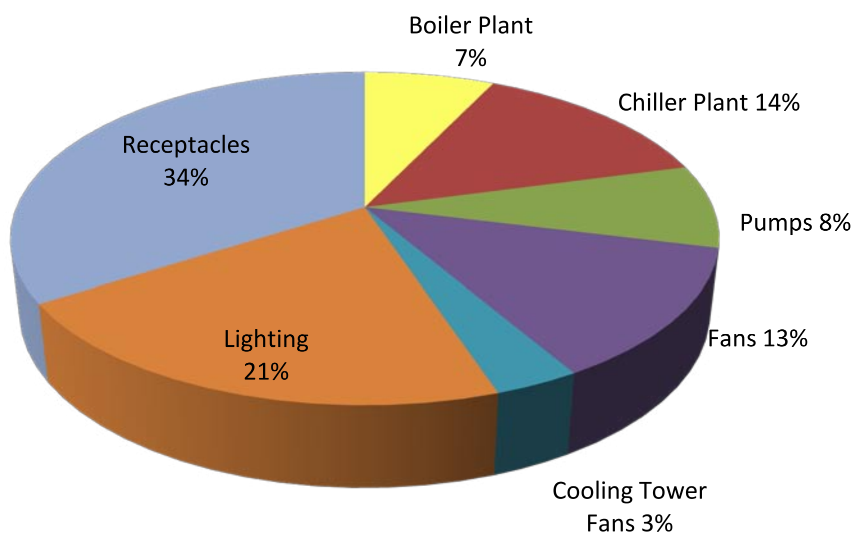
Boilers on the project are powered by natural gas, and all other HVAC equipment is electric. A steam system was once located in underground brick trenches throughout the site. This system, consisting of manholes, piping, equipment, and trench, was removed and capped at the main. Underground natural gas service was connected by Frederick Gas Company, a division of Washington Gas. Natural gas enters the building underground through the boiler room. The underground electric line enters the building through the electrical room on the first floor. The utility company for Ft. Detrick is Baltimore Gas and Electric, and their rates are outlined in Table 6.

Table 6
Utility Rates - Baltimore Gas and Electric

Utility Type	Rate Type	Summer Charge	Winter Charge
Electric Consumption	On Peak	\$0.07/kWh	\$0.055/kWh
Electric Consumption	Off Peak	\$0.044/kWh	\$0.04/kWh
Electric Demand	On Peak	\$10.22/kW	\$4.94/kW
Electric Demand	Off Peak	\$4.94/kW	\$4.94/kW
Gas Consumption	-	\$0.4165/therm	

An annual energy consumption analysis was performed in Trane's Trace 700 using the same ventilation rates, internal generations, and envelope characteristics as in the design load estimation. Fuel costs and equipment performance characteristics are taken from the design documents provided by Baker and Associates. Figure 1 summarizes the results of the energy consumption analysis.

Figure 1 - Annual Energy Consumption Summary



The HVAC system requires 45% of total energy, lighting requires 21%, and receptacle loads, which include computers and other office equipment, require 34%. Table 7 breaks down the estimated cost of energy for each of these components.

Table 7
Utility Costs

Component	Annual Electric Cost	Annual Gas Cost	Total Cost	Cost /ft^2
HVAC	$ 70,052	$ 539	$ 70,591	$ 0.58
Lighting	$ 32,691	$ -	$ 32,691	$ 0.27
Receptacles	$ 52,928	$ -	$ 52,928	$ 0.43
Total	$ 155,670	$ 539	$ 156,209	$ 1.28

Another important factor to consider in an energy analysis is the emissions generated by the building. Table 8 summarizes the estimated emissions profile for Ft. Detrick.

Table 8
Annual Emissions Summary

Emission	lb/ft^2 Electric Produced	Total lb Produced by Electric Power	lb/kWh Gas Produced	Total lb Produced by Gas Power	Total Amount Produced (lb)
Particulates	1.02E-02	1,245.10	0.00E+00	-	1,245
NO_x	7.02E-02	8,569.24	1.35E-05	1.54	8,571
SO_x	1.19E-01	14,526.21	2.54E-03	290.39	14,817
CO_2	2.18E+01	2,661,104.20	1.34E+00	153,200.32	2,814,305

Baker and Associates, the HVAC design engineer for the project, performed an energy analysis in Trane's System Analyzer for the design of Ft. Detrick. Table 9 compares the results of the HVAC engineer's analysis with the results from Trace.

Table 9
Energy Consumption Comparison

Component	Annual Electric Consumption (kWh)	Annual Gas Consumption (Therms)
Trace Result	1,557,197	3,902
System Analyzer Result	1,823,591	12,092
Percent Difference	15%	68%

There is a significant difference in energy consumption between this analysis and the analysis done by the HVAC design engineer. System Analyzer differs from Trace in that it provides a quick evaluation of a building rather than a room-by-room assessment. System Analyzer is used in early stages of design when individual room data is still unknown. Instead of room data, the user simply inputs the area of the entire building and picks a building occupancy. In this case, "office" occupancy was selected. Equipment and fuel costs are inputted in the same fashion as Trace. The amount of energy generated and the cost of energy is then computed.

System Analyzer is less accurate than Trace because it evaluates the building as a whole without taking the individual rooms into consideration. Because office occupancy is selected for the entire building in System Analyzer, the program interprets the entire building as office space. This results in a higher energy consumption value for two reasons. Office occupancy in System Analyzer receives a lighting load of 1.5 W/ft^2. In Trace, offices receive 1.1 W/ft^2 and most other occupancy types receive even lower values. Also, the miscellaneous equipment demand in System Analyzer is set at 2 W/ ft^2, and Trace sets it at 2 W/ ft^2 for Utility rooms only. All other spaces receive 1.5 W/ft^2 or less.

Mechanical Systems Summary and Control Logic

A complete heating, ventilating, and air conditioning system is provided for Ft. Detrick. In this section, each system is described in detail. Equipment characteristics can be found in Appendix B, and Schematics for each system are in Appendix C. The building's automatic temperature control (ATC) system is manufactured by Trane. Control sequence logic resides in direct digital control (DDC) hardware that implements LonWorks technology. A DDC panel controls each individual system, with the exception of the glycol system.

Hot Water System

The hot water distribution system for Ft. Detrick consists of 2 gas-fired boilers (B-1 and B-2 on Schematic C-1), 2 inline boiler circulation pumps (P-1 and P-2), and two variable speed pumps that provide hot water to the building (P-3 and P-4). The boilers are each sized at 2160 MBH. Each boiler has an inline circulation pump to protect the boiler from thermal shock. The building loop pumps are provided with variable frequency drives to adjust to the building flow requirements. The hot water piping is laid out in a reverse return loop. Supply water temperature is 180°F with a 20° design drop for the heating coils. The hot water serves HVAC heating loads only, which includes the AHU heating coils, VAV reheat coils, and unit heaters. Domestic water is heated by electric water heaters.

The hot water system enables when the outside air temperature falls below 70°F or when any area is in occupied mode according to the set time of day schedule. The maximum hot water supply temperature is 180°F, and the minimum hot water supply temperature is 100°F. The maximum water temperature is reached when the outdoor air temperature falls below 0°F and the minimum water temperature is reached when the outdoor air temperature rises above 60°F. The hot water supply temperature setpoint is reset proportionally between the maximum and minimum supply temperatures.

The DDC system monitors the status of P-3 and P-4 and can enable or disable their VFDs. The pumps operate in a lead/lag fashion, with the lead pump running continuously whenever the hot water system is enabled. If the lead pump fails, the lag pump is enabled by the DDC system. The boiler circulation pumps, P-1 and P-2, are also enabled or disabled by the DDC system. If the boilers are disabled, P-1 and P-2 continue to run for 15 minutes to extract all available residual heat. The pumps' speed is also controlled by the DDC system. The DDC system monitors the hot water piping system differential pressure (DP on Schematic C-1). If differential pressure falls below the setpoint, pump speed increases, and if it rises above the setpoint, pump speed decreases.

Boilers also operate in a lead/lag fashion. When the flow meter (FM on Schematic C-1) senses that the primary and secondary pumps have energized, the combustion air fan will energize and its damper will open. After this, the boiler enables.

Chilled Water System

The chilled water distribution system for Ft. Detrick is a decoupled loop system consisting of 2 rotary screw water-cooled indoor chillers (CH-1 and CH-2 on Schematic C-2), 2 constant volume evaporator pumps serving the primary loop (P-5 and P-6), and 2 variable volume pumps that provide chilled water to the building (P-7 and P-8). The chillers are each sized at 220 tons. Chilled water leaving the evaporator is supplied at 42°F with a 12°F maximum rise designed for terminal unit air coils. Chilled water serves the cooling coils of AHU-1 through AHU-6. AHU-7 is self contained.

The chilled water system enables when the outdoor air temperature rises above 52°F and any area is in occupied mode according to the set time of day schedule. The chillers also operate in a lead/lag manner. The system is disabled when the outdoor air temperature falls below 50°F or when no areas are in occupied mode. When the chilled water system is enabled, the building pumps, P-7 and P-8, energize. P-7 and P-8 operate together, sharing the pump load equally. They operate continuously, providing variable volume flow to the building.

After the pumps have been energized, the lead chiller's solenoid isolation valve (S on Schematic C-2) opens and is proven open by an end switch before the lead evaporator and condenser pumps are energized (condenser water system is outlined in the next section). Once flow through the evaporator and condenser is proven via the flow switch (F on Schematic C-2) and condenser water requirements are met (see next section), the lead chiller enables. The lag chiller is added to the system when the lead chiller water discharge temperature remains 2.5°F above the setpoint temperature for over 10 minutes, and the calculated tonnage remains greater than the nominal capacity for more than 10 minutes. The lag chiller is subtracted when the chilled water system ΔT is less than the design ΔT (12°F).

Differential pressure (DP on Schematic C-2) is monitored after the cooling coils of the last air handling unit (AHU-6). It is controlled in the same fashion as in the hot water system.

Condenser Water System

The condenser water system consists of 2 induced-draft cooling towers (CT-1 and CT-2 on Schematic C-3) and 2 constant volume condenser pumps (P-9 and P-10) that also operate in a lead/lag fashion. The cooling towers are each sized for 630 gpm. The entering water temperature is 95°F and the leaving water temperature is 85°F. The entering air wet bulb temperature is 77°F.

As mentioned in the previous section, condenser water requirements must be met for the chillers to be enabled. First, the chiller must maintain a 23 psi system differential oil pressure at all times. Second, the entering condenser water temperature to the chiller must be greater than 45°F. Third, the leaving condenser water temperature from the chiller must be 17°F higher than the evaporator leaving water temp within 2 minutes of start-up, and a 25°F differential must be maintained thereafter.

The DDC system controls the condenser water loop temperature by monitoring the cooling towers' variable speed fans. When the lead chiller is enabled, the lead cooling tower is also enabled. Also, the cooling towers are linked to the chillers in a way that permits either tower to serve either chiller when both lead and lag chillers are enabled. When this occurs, the common condenser entering water temperature becomes the control variable. On a rise in common condenser entering water temperature above 85°F, the lead tower's fan energizes and modulates to maintain the setpoint. If the temperature continues to rise, the lag tower's fan energizes and modulates. While the lag tower's fan is enabled, the lead tower's fan remains at 100%. As common condenser entering water temperature drops below setpoint, the lag tower's fan modulates toward minimum speed and eventually shuts down. Once the lag tower's fan shuts down, the lead tower's fan modulates toward minimum speed and shuts down when entering condenser water temperature falls below 83°F.

Air Handling Systems

A variable air volume system consists of variable air volume (VAV) boxes and an air handling unit (AHU) that supplies air to the boxes. Ft. Detrick contains six air handling units (AHU-1 through AHU-6) that are on during regular operation and one emergency air handling unit (AHU-7) that runs by generator power. AHU-1 through AHU-6 supply a mixture of outdoor and recirculated air to multiple zones. AHU-7 supplies only recirculated air. Each floor has 2 mechanical rooms, one on the north end and one on the south end, where an air handling unit is housed. The emergency unit is on the south end of the second floor and serves the Joint Operations Command office area if the power to AHU-4 goes out.

All AHUs are controlled by variable frequency drives and distribute air through VAV hot-water reheat boxes. In this design, each zone is controlled individually by adjusting the airflow. Schematic C-4 shows the operation sequence for AHU-1 through 6, and Schematic C-5 shows the operation sequence for AHU-7.

AHU-1 through AHU-6

AHU-1 through AHU-6 and their corresponding VAV boxes are managed by the area control and time of day schedule in the DDC system. The equipment is controlled as a system to ensure desired operation. The units are programmed in the time of day schedule for optimal start and stop. Optimal start occurs two hours before the air handler is scheduled to serve occupied spaces. At this time, if the average space temperature for its VAV boxes is more than 3°F below the average occupied heating setpoint temperature, the unit shall enter warm-up mode. In warm-up mode, the supply and return fans run continuously and circulate 100% return air. The heating coil valve modulates to 100% coil flow to raise the average space temperature to the occupied heating setpoint. The VAV box dampers modulate to satisfy their individual space heating setpoints. When the average occupied heating space temperature setpoint is met, the unit enters normal occupied mode.

During optimal start, if the average space temperature is more than 3°F above the average occupied cooling setpoint, the unit enters cool-down mode. The supply and return fans run continuously, and the outside air damper modulates up to 100% when economization is enabled. If economization is disabled, the outdoor air damper closes and the cooling coil valve modulates to full flow. The VAV box dampers modulate to satisfy their individual space heating setpoints. When the average occupied cooling space temperature setpoint is met, the unit enters normal occupied mode.

In occupied mode, the outdoor air damper is opened and the supply and return fans continue to run. When the supply and return fans are enabled, the variable speed drive starts at minimum frequency. It modulates to maintain a duct static pressure of 1.75 in wg. The economizer, heating valve, and cooling valve modulate in sequence to maintain a discharge air temperature of 55°F. When heating is required, the outdoor air damper maintains the minimum cfm, the cooling coil valve is closed, and the hot water coil valve modulates to maintain the discharge air temperature setpoint. When economization is enabled and cooling is required, the outdoor air damper modulates above the minimum to provide cooling. Low limit control prevents the mixed air temperature from falling below 40°F. When economization is disabled, the outdoor air damper maintains the scheduled minimum cfm and the cooling coil valve modulates to maintain the discharge air temperature setpoint.

When the time of day schedule is in unoccupied mode, the outside air damper closes, the heating coil valves open, the cooling coil valves close, the supply and return fans shut down, and the associated VAV boxes open their dampers. When space temperature rises 4°F above the setpoint, the air handler goes into occupied cooling mode, and when space temperature falls 4°F below the setpoint, the air handler goes into occupied heating mode. The unit is disabled once the setpoint temperature is reached.

AHU-7

Upon a failure of AHU-4, its supply and return duct dampers close, and AHU-7 serves as a backup. When AHU-7 is commanded to run, its supply and return air duct dampers spring open, and the associated VAV box dampers open 100%. The unit's supply fan runs continuously. The DX cooling coil enables when the average space temperature rises above 74°F. When there is a call for heating, the served VAV boxes modulate their hot water reheat valves to raise the space temperature to 72°F.

Glycol System

The building's glycol system serves air conditioning units in the communication rooms along with AHU-7. The units are served by a drycooler (DC-1 on Schematic C-6) outside of the building. Control for the drycooler and its pumps is wired internally, so it is not connected to the DDC system. The glycol piping is run below grade and enters the building through the mechanical room on the first floor. Risers within the mechanical rooms distribute the glycol to the second and third floors.

Mechanical Systems Critique

Airside Systems

The mechanical engineer for Ft. Detrick, Baker and Associates, was able to minimize the necessary amount of ductwork through careful placing of equipment. Two air handling units serve each floor, one on the north side and one on the south side. This layout conserves material because it eliminates long runs of ductwork. One way that the mechanical system uses excess material is in the fully-ducted return. This cannot be changed, however, because it is a requirement in the AT/FP guidelines.

The air handling units serve VAV reheat boxes in each zone. This is a good option for Ft. Detrick because it has many different types of spaces. Each zone contains a thermostat so occupants can adjust to the desired temperature. This is important because zones next to exterior walls, for example, may need more heat in the winter than interior zones. A drawback of VAV reheat systems is that the entering air to the VAV boxes is approximately 53°F. The box then reheats the already cooled air to the desired temperature of the occupants, which is inefficient and expensive. Also, because of the reheat coils, boilers and boiler pumps have to run all year round, which can also get expensive.

The minimum outdoor air required for AHU-1 per ASHRAE 62.1-2007 exceeds the actual outdoor air supplied by 106 cfm, so it is not in compliance with the standard. However, the critical zone for AHU-1 occurs in a storage room. Since a storage facility likely will not be occupied 100% of the time, the designer may have assumed that supplying that space with 58% outdoor air was not critical. Also note that out of the seven AHUs, four of the critical zones are storage spaces. Reducing the amount of outdoor airflow to the building's many storage spaces may result in an energy savings.

Water Side Systems

Because the mechanical rooms are stacked vertically, the hot water and chilled water piping to the air handling units can run vertically through the rooms, which minimizes the amount of piping. The reverse return loop also minimizes the extra piping needed. In Technical Assignment 2, it was determined that the rentable space lost through the mechanical rooms was merely 5.2%.

The design heating analysis shows that all air handling unit heating coils are very oversized. The unit that consumes the least energy is 45% oversized, and the unit that consumes the most energy is 72% oversized. Sizing the units for smaller heating coils will result in smaller sized boilers, which can lead to an energy savings. In addition, there is no energy recovery system in the building. Implementing this kind of system would also decrease energy consumption.

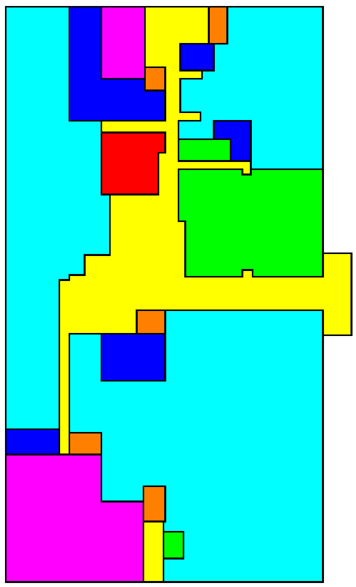
References

Mechanical Construction Documents. Baker and Associates, Moon Township, PA. 2007.

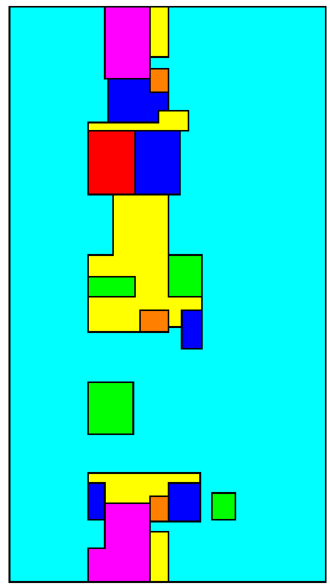
Air Balancing Company, Inc. www.airbalancingco.com. December 2, 2007.

Unified Facilities Criteria. U.S. Army Corps of Engineers, Baltimore, MD. 2003.

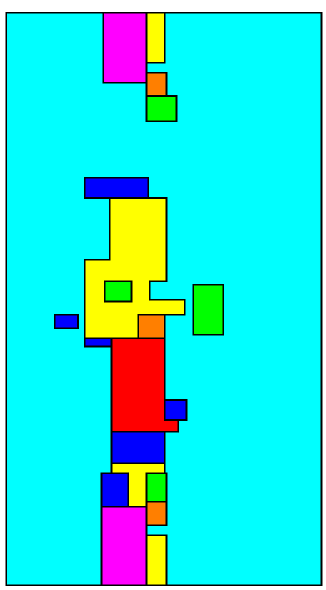
Appendix A – Space Relationship & Area Breakdown Diagram



First Floor



Second Floor



Third Floor

- Offices - 75.7%
- Circulation/Restroom Space - 7.8%
- Mechanical Rooms - 5.2%
- Conference Rooms - 4.2%
- Storage - 4.1%
- Classrooms - 2.0%
- Electrical Rooms - 1.1%

Appendix B – Equipment Characteristics

Boilers

Tag	Type	Output Capacity (MBH)	Maximum Working Pressure (psig)	Water Data			Burner Data	
				EWT (°F)	LWT (°F)	GPM	Gas Input (MBH)	Min. Gas Pressure (in wg)
B-1,2	Flexible Watertube	2160	160	160	180	216	2700	7

Unit Heaters

Tag	Quantity	Area Served	Type/Position	cfm	Air Temperature Rise (°F)	GPM	EWT/LWT (°F)	MBH	ΔP (ft water)
CUH-A	1	Entrance Vestibule	Recessed Ceiling Cabinet	210	76	1.7	180/160	17.1	12.48
UH-A	2	Boiler Room	Horizontal	545	30	2.5	180/165	17.9	0.12
UH-B	6	Mechanical Rooms	Horizontal	545	30	2.5	180/165	17.9	0.12

Rotary Screw Water Cooled Chillers

Tag	Nominal Tons	Full Load KW/ton	NPLV KW/ton	Evaporator				Condenser			
				GPM	EWT (°F)	LWT (°F)	ΔP (ft water)	GPM	EWT (°F)	LWT (°F)	ΔP (ft water)
CH-1,2	220	0.653	0.567	438	54	42	6.3	630	85	95	6.7

Induced-Draft Cooling Towers

Tag	GPM	ΔP (psig)	EWT (°F)	LWT (°F)	EAT wb (°F)
CT-1,2	630	5.95	95	85	77

Air Handling Units

Tag	Area Served	Min OA cfm	Supply Fan				
			Fan Type	Fan RPM	cfm	Total/External Static Pressure (in wg)	Motor HP
AHU-1	1st Floor-North	4460	Draw-Thru Plenum	1227	14,260	6.06/3.25	25
AHU-2	1st Floor-South	4210	Draw-Thru Plenum	1229	14,430	3.06/3.25	25
AHU-3	2nd Floor-North	4975	Draw-Thru Plenum	1301	16,155	6.47/3.25	30
AHU-4	2nd Floor-South	4550	Draw-Thru Plenum	1280	15,675	6.33/3.25	30
AHU-5	3rd Floor-North	4670	Draw-Thru Plenum	1341	17,365	6.51/3.00	30
AHU-6	3rd Floor-South	4985	Draw-Thru Plenum	1353	17,890	6.57/3.00	30
AHU-7	JOC-2nd Floor	450	Forward Curved	1476	2775	-	2

Tag	Area Served	Min OA cfm	Return Fan				
			Fan Type	Fan RPM	cfm	Total Static Pressure (in wg)	Motor HP
AHU-1	1st Floor-North	4460	Inline	1725	14,260	0.5	5
AHU-2	1st Floor-South	4210	Inline	1725	14,430	0.5	5
AHU-3	2nd Floor-North	4975	Inline	1725	16,155	0.5	5
AHU-4	2nd Floor-South	4550	Inline	1725	15,675	0.5	5
AHU-5	3rd Floor-North	4670	Inline	1725	17,365	0.5	5
AHU-6	3rd Floor-South	4985	Inline	1725	17,890	0.5	5
AHU-7	JOC-2nd Floor	450	-	-	-	-	-

Tag	Area Served	Min OA cfm	Chilled Water/DX Cooling Coil					
			EAT db/wb (°F)	LAT db/wb (°F)	Capacity Total/Sensible (MBH)	Air Pressure Drop (in wg)	Water Pressure Drop (ft water)	GPM
AHU-1	1st Floor-North	4460	80.7/67.3	51.9/51.6	676.2/451.9	0.54	13.7	112
AHU-2	1st Floor-South	4210	80.4/67.1	53.4/52.8	629.8/429.8	0.51	12.1	105
AHU-3	2nd Floor-North	4975	80.6/67.3	52.4/52.0	748.8/502.5	0.67	16.5	124
AHU-4	2nd Floor-South	4550	80.4/67.0	52.8/52.3	696.0/476.4	0.61	14.5	116
AHU-5	3rd Floor-North	4670	80.0/66.7	53.7/53.1	727.8/510.1	0.71	15.7	121
AHU-6	3rd Floor-South	4985	80.2/66.9	53.9/53.3	743.2/517.8	0.72	16.3	123
AHU-7	JOC-2nd Floor	450	80.0/65.9	58.7/56.0	84.9/64.0	-	-	-

Tag	Area Served	Min OA cfm	Hot Water Heating Coil			
			Capacity (MBH)	Air Pressure Drop (in wg)	Water Pressure Drop (ft water)	GPM
AHU-1	1st Floor-North	4460	616.0	0.08	7.5	61.5
AHU-2	1st Floor-South	4210	623.4	0.08	7.6	62.5
AHU-3	2nd Floor-North	4975	697.9	0.11	9.5	70.0
AHU-4	2nd Floor-South	4550	677.2	0.10	9.0	67.6
AHU-5	3rd Floor-North	4670	761.8	0.13	11.3	76.1
AHU-6	3rd Floor-South	4985	772.8	0.13	11.6	77.2
AHU-7	JOC-2nd Floor	450	-	-	-	-

Drycooler

Tag	Service	Location	Capacity	Airside Data			Fluidside Data				Fan Data	
				Standard cfm	EAT (°F)	LAT (°F)	GPM	EFT (°F)	LFT (°F)	ΔP (ft water)	Qty	HP
DC-1	IT/Comm room units	on grade	291	18,965	95	109	62.5	120	109	9.8	3	3/4

Air Conditioning Units

Tag	Space Served	cfm Hi/Low	Cooling Data				Condenser Data		
			Nominal Cooling (tons)	EAT db (°F)/RH (%)	Total Capacity (BTUH)	Sensible Capacity (BTUH)	Gallons	GPM	ΔP (ft water)
ACU-1 thru 6	IT/Comm	750/600	1.5	72/50	16,900	14,300	0.5	5.0	16.4
ACU-7	Elevator Equipment	750/600	1.5	72/50	16,900	14,300	0.5	5.0	16.4
ACU-8	Server	1800	3.0	72/50	34,300	31,400	1.2	10.0	14.2
ACU-9	Workroom	2800	5.0	72/50	56,000	50,200	2.0	17.5	18.9

Pumps

Tag	Pump Type	Service	Fluid Temperature (°F)	GPM	ΔP (ft water)	Impeller Diameter	NPSH (ft water)	Motor HP	Motor RPM
P-1	Closed-Coupled Inline	HW Primary	180	216	30	6.5	-	3	1750
P-2	Closed-Coupled Inline	HW Primary	180	216	30	6.5	-	3	1750
P-3	Centrifugal End Suction	HW Secondary	180	216	90	10	-	10	1750
P-4	Centrifugal End Suction	HW Secondary	180	216	90	10	-	10	1750
P-5	Centrifugal End Suction	CHW Primary	44	438	45	7	-	10	1750
P-6	Centrifugal End Suction	CHW Primary	44	438	45	7	-	10	1750
P-7	Centrifugal End Suction	CHW Secondary	44	350	90	10	-	15	1750
P-8	Centrifugal End Suction	CHW Secondary	44	350	90	10	-	15	1750
P-9	Centrifugal End Suction	CDW Primary	44	630	45	8	7.9	10	1750
P-10	Centrifugal End Suction	CDW Primary	44	630	45	8	7.9	10	1750

Air Separators

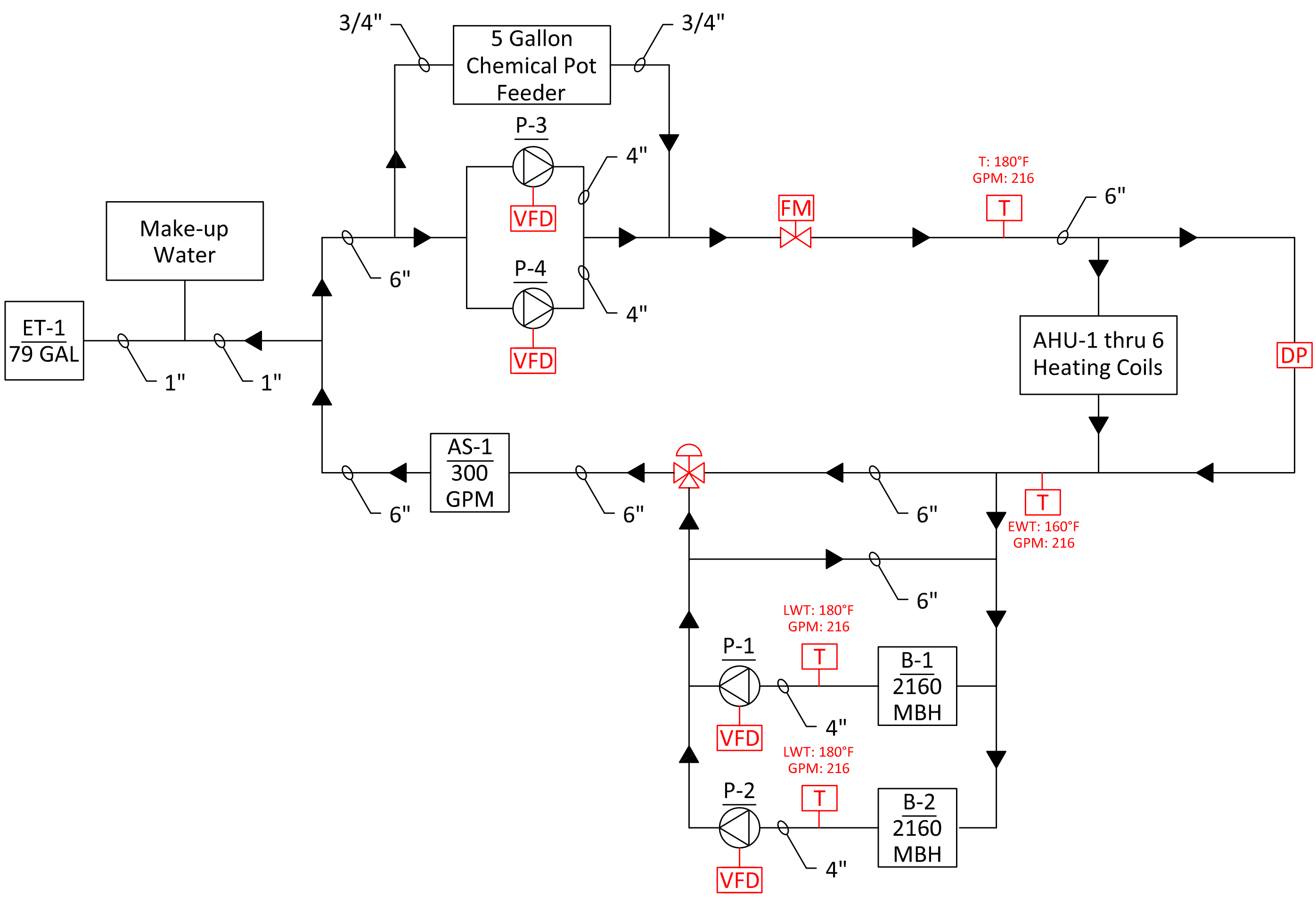
Tag	Location	Service	Type	GPM	Maximum ΔP (ft water)	connection size
AS-1	Boiler Room	HW	Centrifugal	300	10	4" Flanged
AS-2	Boiler Room	CHW	Centrifugal	580	8	6" Flanged

Expansion Tanks

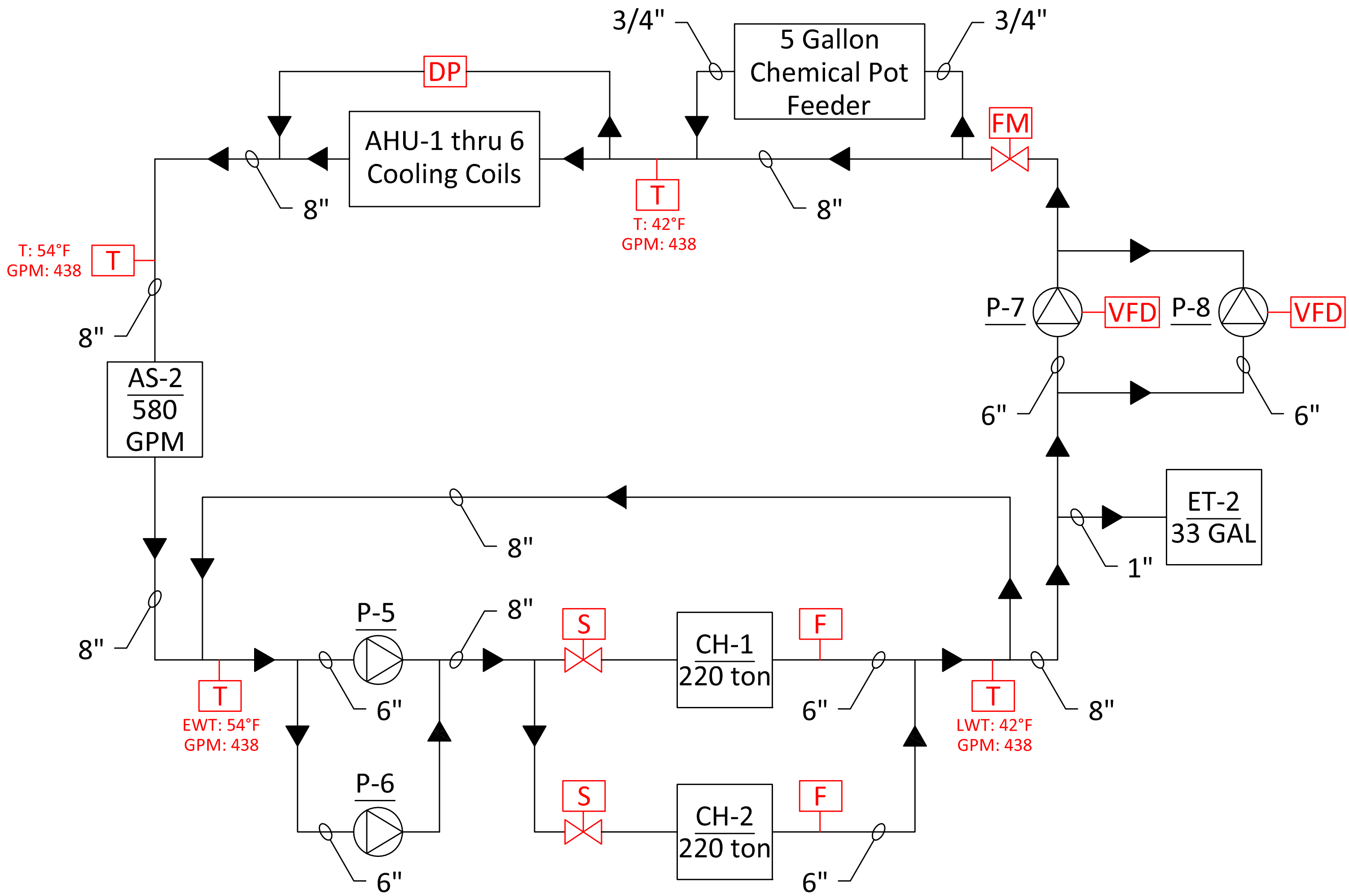
Tag	Type	Service	Location	Size	Connection Size	Volume Tank (Gal)	Volume Acceptance (Gal)
ET-1	Vertical	HW	Boiler Room	24"Ø x 53" H	1" NPT	79	79
ET-2	Vertical	CHW	Boiler Room	16"Ø x 45" H	1/2" NPT	33.6	11.3

Appendix C – System Schematics

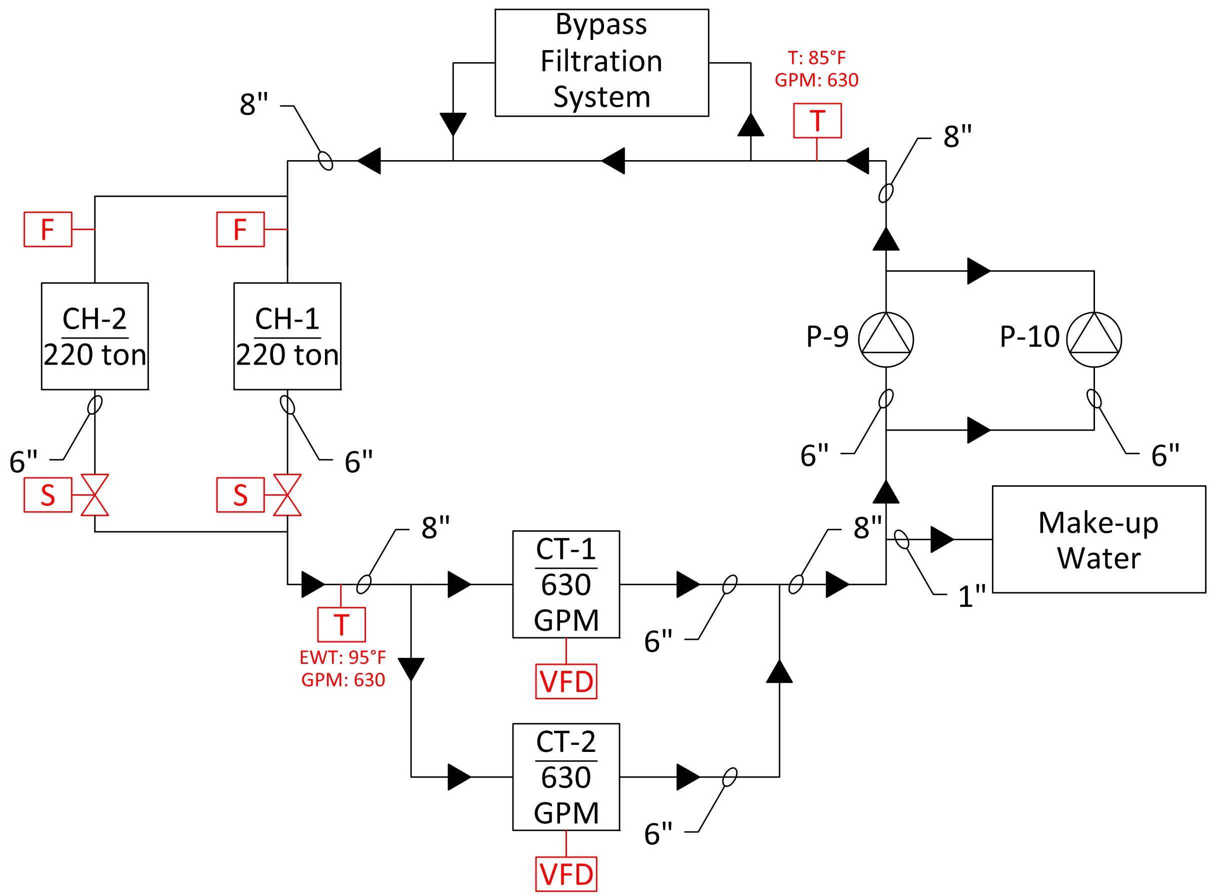
Schematic C-1: Hot Water System Schematic



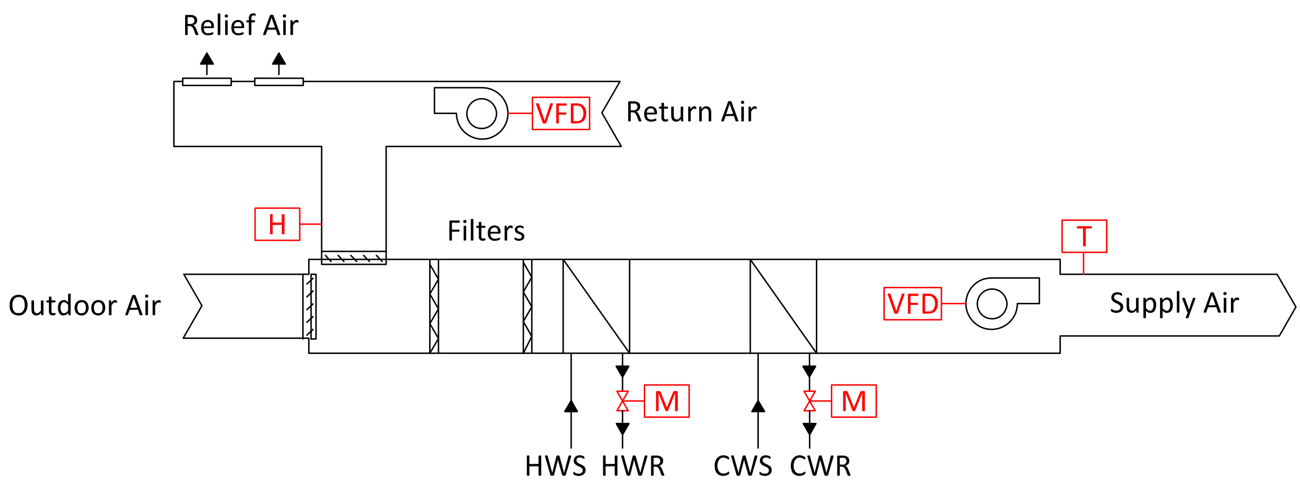
Schematic C-2: Chilled Water System Schematic



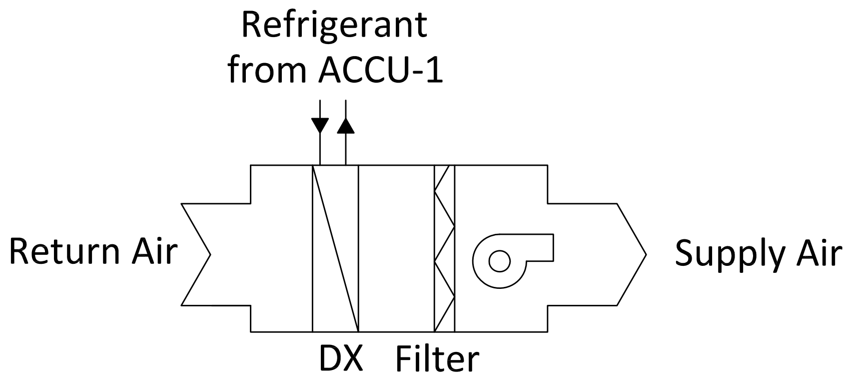
Schematic C-3: Condenser Water System Schematic



Schematic C-4: AHU-1 through 6 Schematic



Schematic C-5: AHU-7 Schematic



Schematic C-6: Glycol System Schematic