Design Information

Design Objectives and Requirements	The design objective for this building is "to provide HVAC systems which conform to all applicable codes while maintaining a comfortable environment and minimizing life cycle cost."		
Energy Sources and Rates	Electric	Rate ($)	Cut Off kWh/KW
		0.083	First 150
		0.0505	Next 150
		0.027	All other
	Natural Gas	Summer	$0.334 per therm
		Winter	$0.596 per therm
Site Factors	The air flow to certain spaces is higher based on the orientation of the space (north, south, etc) and the amount of fenestration.		
Design Conditions (from ASHRAE Fundamentals 1997 for Philadelphia, PA)	Outdoor	Summer	92 °F (DB)/79 °F (WB)
		Winter	11 °F (DB)/5 gr/lbm (HR)
	Indoor	Summer	75 °F (DB)/55% RH
		Winter	Information not available at this time
Design Loads	Heating	Information not available at this time	
	Cooling	450 tons (estimated)	

* All information has been obtained from the Statement of Criteria (SOC) authored by Kling, with the exception of the cooling load estimate. The cooling load estimate was obtained from an Excel cooling load estimate performed for the mechanical assignment 2-b.

Sequence of Operation

A. AHU-X (AHUs 1, 2, 3, & 4)-reference dwgs. M-2 and M-3

1. The Building Automation System (BAS) shall Start/Stop AHU-X. This equipment shall operate between 6 am and 7 pm, but will be available to operate at any time.

2. If the temperature entering the heating coil is 45 °F, the heating coil actuator opens until the temperature reaches 52 °F. The temperature is sensed by a thermometer located after the heating coil.

3. The set point (SP) for cooling coil is 55 °F. If the SP, controlled by a thermometer in the supply duct located after the supply fan, varies by 2.5 °F, the chilled water return valve opens to maintain the correct temperature.

4. The SP for supply fan is 1.0" wg. If the SP varies by 0.25" wg, the supply fan maintains the correct pressure by opening the actuator. A pressure transmitter located on the first floor senses the static pressure.

5. A flow transmitter senses the air flow in the supply duct, and another senses the air flow in the return duct. If the SP (see below) varies by 5%, the return fan maintains the correct amount of return air to the mixed air.

AHU-1 and AHU-2 SP= supply cfm-5,850
AHU-3 SP=supply cfm-12,750
AHU-4 SP=supply cfm-6,750

6. Relief air and outdoor air dampers are controlled by a thermometer in the supply duct located before the heating coil. The SP is 52 °F when the air side economizer is in use. The SP otherwise is 1000 ppm carbon dioxide. The dampers modulate when the carbon dioxide concentration rises to 1050 ppm in the return duct and the temperature difference between the outdoor air and return air is less than 20 °F. The carbon dioxide sensor is located after the return fan.

B. Chilled Water System-reference dwg. M-1.1

1. Two thermometers sense the temperature of the chilled water supply (CHWS). One is a redundant sensor. The SP is 45 °F. If the SP rises 2 °F, the chillers are adjusted by the BAS.
2. The SP for the chilled water return (CHWR) is 55 °F. If the temperature, sensed by a thermometer, rises above 60 °F or drops below 48 °F, the chillers are adjusted by the BAS.

C. Condenser Water System-reference dwgs. M-1.1 and M-1.2

1. The redundant condenser water piping (the 10" condenser water supply (CWS) and return (CWR) lines), are to be used in the event of failure of the primary condenser water piping (the 24" CWS and CWR lines). The changeover from primary to redundant piping will be manual using the hand valves.
2. The SP for the CWS is 85 °F. If the temperature, sensed by a thermometer, drops below 55 °F, the CWS is adjusted by the BAS.
3. The cooling tower (CT) fan control SP is 65 °F. If the temperature drops below 60 °F, start the bypass line. If the temperature rises above 80 °F, reverse to spray.

System Critque

The systems in this building are typical for a corporate office building. The chilled water plant, located in the phase one building, is a typical primary-secondary chilled water system (see dwg. M-1). The design has struck a decent balance of first cost and life cycle cost. This balance of first cost and life cycle cost was achieved by studying several alternatives. The one that was chosen was to use three water cooled chillers and one absorption chiller. This greatly reduces the amount of electricity used by the HVAC system. Because, the central plant is located in the phase one building, there is virtually no lost rentable space due to the mechanical system in the phase two building. The system runs pipes through the tunnel, which minimizes ground work and allows the pipes to be easily accessed. The central plant is generously sized, giving room for maintenance, as well as for the future expansion to five chillers. The cooling towers are located in an adjacent service yard, which gives the cooling towers better performance because the air is cleaner, and there is less pumping involved. The central plant has also been sized with some redundancy because the total capacity is 2700 tons. The cooling load of the phase one building is unknown, but a good estimate is 900 tons. This is a little over twice the load of the phase two building, and has been estimated considering that the phase one building is slightly less than twice the size of phase two, but contains a data center. Adding the 900 tons to the estimated phase two load of 450 tons, the central plant has almost complete redundancy.

The air system is not as well designed. The air handling units are typical packaged roof top units (see dwgs. M-2 and M-3). The perimeter areas are supplied with air from linear slot diffusers and the interior spaces are supplied with air by typical 2'x 2' ceiling diffusers. The AHUs deliver an adequate amount of supply air (180,000 scfm), 20% of which is outdoor air (36,300 scfm). According to the ASHRAE Standard 62 Report, this amount of outdoor air in inadequate based on the multiple spaces equation. The system does have a cardon dioxide sensor that senses the concentration of carbom dioxide in the return air. This sensor ensures that there is 20 cfm per person of outdoor air using demand controlled ventilation (refer to sequence of operation). This sensor, however, is located in the return duct. Optimally, the sensor should be placed in a critical space somewhere in the building. In this building, perhaps the best place would be the dining room/servery area. The air system also employs air side economizers, which operate in the spring and fall when outdoor air temperatures are favorable.

The whole HVAC system has been designed with adequate efficiency measures including the gas-fired absorption chiller and the air side economizers. However, the system does not even come close to any level of LEED certification, mainly because the building was not originally designed for LEED certification. It is evident, however, that the mechanical engineers spent the time to study alternatives, and ultimately came up with a solid solution that met the design objective stated earlier in this report.