4. OVERVIEW OF MECHANICAL SYSTEM

The 87,000 SF SLCC is served by six (6) Trane M-Series Climate Changer Air Handing Units (AHUs). Each unit serves a distinct zone within the facility that is unique in use and occupation schedule. VAV terminal units with hot water reheat regulate airflow and supply air temperature to each zone. Thermal energy is delivered via chilled water and high pressure steam from the Central Utilities Building on campus.

4.1. DESIGN OBJECTIVES

The design of the SLCC was based on a balance of energy efficiency, cost, and acoustics while meeting ventilation, energy, refrigeration, and fire protection codes and standards. The mechanical system is tagged with the responsibility to effectively heat and cool the facility while meeting these requirements.

SmithGroup performed the primary architectural and MEP engineering design services for the SLCC. The design only needs to meet DC Codes as of 2006, which refer to ASHRAE Standards 15-1994, 55-1992, 62.1-1989,and 90.1-1989. However, LEED v.2.1 requires compliance with ASHRAE Standards written in 1999 and therefore the SLCC is designed to these criteria instead of DC Codes.

Some of the specific mechanical system design criteria include:

- Efficiently condition the occupied spaces within the SLCC. This includes utilizing air-side economizer, AHU zoning, occupancy sensors, etc.
- Provide adequate acoustics for sensitive spaces such as classrooms, Audiology and Hearing Science Labs, Speech and Language Sciences Labs, the Hearing Aid Fitting Room, and therapy rooms. These spaces are intended to be at or below NC-25.
- Provide adequate indoor air quality by complying with the IMC-2000 and ASHRAE Std. 62.1-1999; exhausting toilet rooms, rooms with large-format copiers and kitchens; effectively filtering outdoor air and mixed air; and maintaining positive pressurization inside the building.
- Utilize central utilities from the campus Central Utilities Building including chilled water (43°F) and steam (100 psig) to eliminate the need for redundant systems.
- Reduce power use by the equipment with the application of variable frequency drives on fan and pump motors.
- Minimize rooftop equipment for aesthetic and service-life purposes. This exposed equipment is limited to several exhaust fans on the third floor roof. All equipment is particularly restricted from installation on the second floor roof because of sightlines from the third floor atrium balcony to this area.
- Distinct zones for scheduling control of the system to isolate high density spaces and reduce overall building ventilation. This avoids a penalty required to properly ventilate the low density spaces due to the primary outdoor air fraction (Z_p).

4.2. SYSTEM ORIENTATION

The six AHUs serve distinct zones within the SLCC (Figure 4.1). The loads, occupancy schedules, and size of spaces dictated the division of zones. For instance, the Student Media Studio (AHU-2, yellow) is not occupied as often as the classrooms. When the studio is in use, though, the cooling loads required to condition a space with a high density of theatrical lighting and video equipment are much greater than those for a classroom or office. The volume of the atrium and fire codes for smoke evacuation makes isolating the atrium to its own zone (AHU-3, light blue) logical. The Hearing Clinic on the second floor operates for extended hours in relation to the offices and labs that surround it on the first and third floors. Therefore the second floor is separated into its own zone (AHU-5, red).

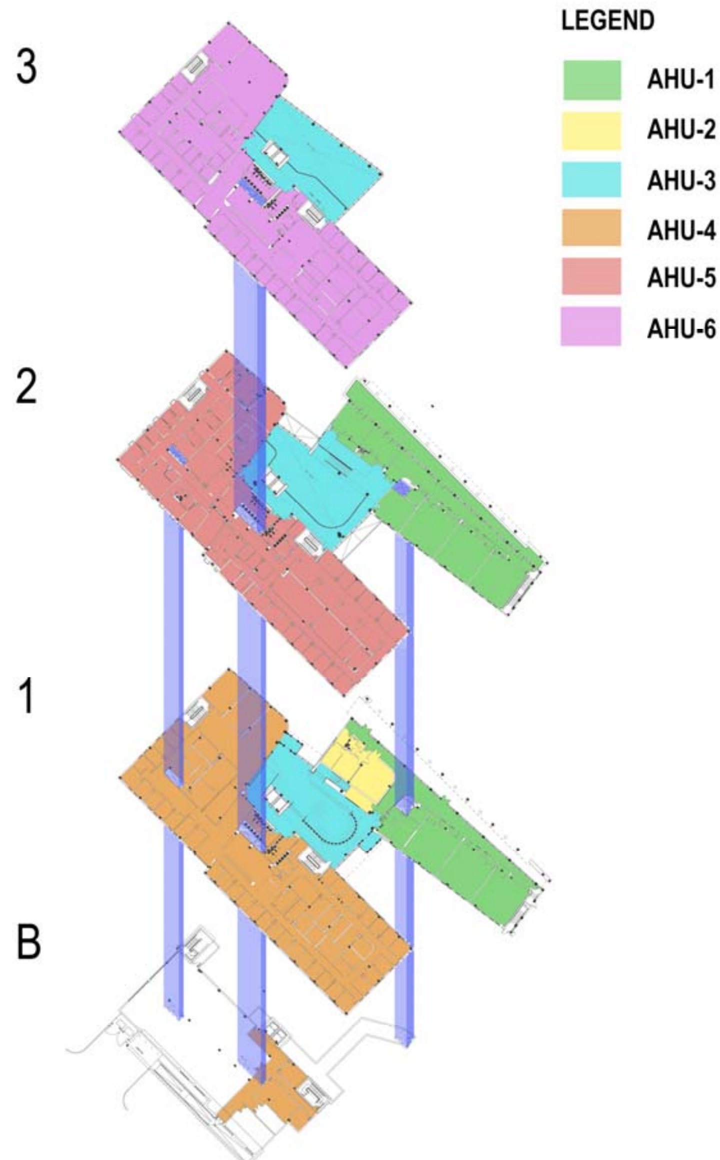

Figure 4.1: Mechanical system zones within the SLCC.

4.3. SYSTEM DESIGN & OPERATION

The mechanical system is designed to meet ASHRAE Standards 62.1-1999 and 90.1-1999 among others, supply air at the conditions described in Table 4.1, and maintain the temperature and humidity conditions described in Table 4.2. A summary of the outdoor and supply airflows for each AHU can be found in Table 4.3.

	Supply Air Conditions					
	AHU-1	AHU-2	AHU-3	AHU-4	AHU-5	AHU-6
$T_{SA, Summer}$ [°F]	55	55	55	55	55	55
$T_{SA, Winter}$ [°F]	60	55	70	55	55	60

Table 4.1: Design Supply Air Temperatures.

	Design Conditions*					
zone →	Outdoor		AHU (all)	CRAC	FCU (all)	UH (all)
	T_{DB} [°F]	T_{MCWB} [°F]	T_{RA} [°F]	T_{DB} [°F]	T_{DB} [°F]	T_{DB} [°F]
Cooling (1%)	91.9	75.3	78	72	85	-
Heating (99%)	20.2	-	72	72	85	55

* Relative humidity maintained at 50%.

Table 4.2: Design Room Air Temperature Setpoints

AHU Summary						
AHU	**# Zones / VAVs**	**Area Served [SF]**	**Design OA [CFM]**	**Design SA [CFM]**	**Capacity [CFM]**	**Unit Size***
1	19	13185	4130	17400	17700	40
2	3	1311	360	2230	2500	6
3	0	7990	2890	13070	13800	35
4	44	15285	4650	14080	13300	30
5	37	15061	4550	11965	11200	30
6	39	15146	5050	14130	13400	30
TOTALS	**142**	**67978**	**21630**	**72875**	**71900**	

* Unit Size for TRANE M-Series Climate Changer AHU

Table 4.3: AHU Summary.

4.3.1. AIRSIDE SYSTEM

The air side mechanical system of the SLCC is a traditional VAV system with reheat. Figure 4.2 includes a full schematic of the airside system. Outside air is introduced to the system through louvers at the basement level of the west façade and delivered to each of the six AHUs where it is mixed with return air. Full side economizer mode is employed in AHUs 1 and 4-6 when the outside air enthalpy is less than the return air enthalpy. Temperature, humidity, and airflow sensor inputs coordinate dampers and fans via direct digital control (DDC) panels. All AHUs use heating hot water and chilled water coils to condition the air stream to design supply conditions (Table 4.1). Each air handler also includes a pre-filter, supply fan, and primary filter.

Supply air is then distributed throughout the building through three shaft spaces (Figure 4.1, dark blue). VAV terminal units – most with hot water reheat or electric reheat – deliver the supply air to each zone via flexibly ducted ceiling diffusers. Room temperature sensors feed data to the DDC panel which modulates the VAV airflow damper. Return air is drawn into the plenum and transferred to the corridors via transfer ducts, and then drawn back to the AHU mixing boxes or exhausted by a return fan. Some spaces including toilet rooms, kitchens, and rooms with large format copiers have direct ducted exhaust to the outside to meet codes. Three 15,000 CFM exhaust fans serve the atrium space in case of a fire emergency.

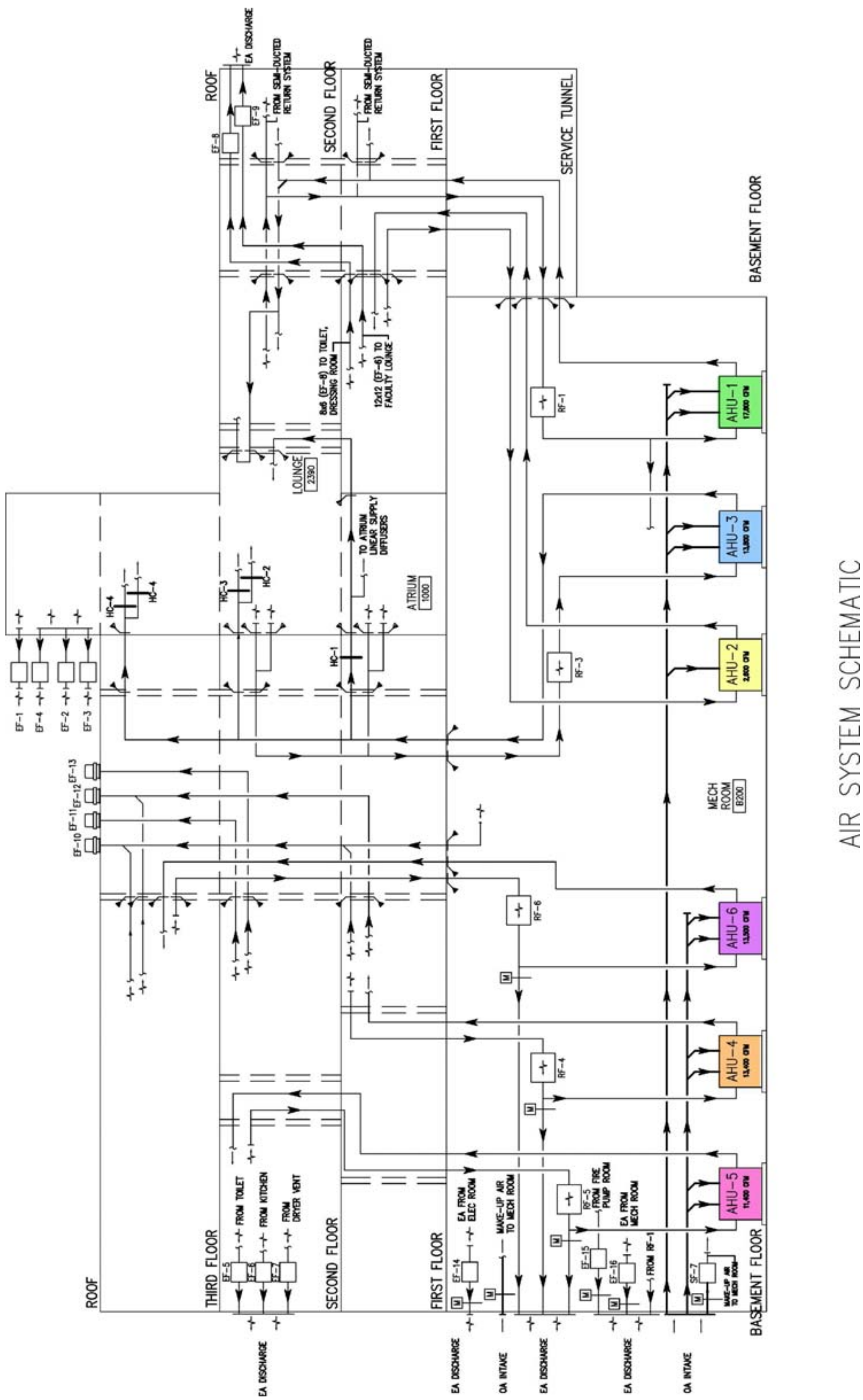

Figure 4.2: Airside System Schematic.

4.3.2. WATERSIDE SYSTEM

The Central Utilities Building at Gallaudet University serves the SLCC with chilled water at 43°F on a 10°F ΔT loop. These service lines enter and leave the facility under the east entrance and are directed to/from the mechanical equipment room (MER). Most of the mechanical piping is confined to the MER, the organization of which can be viewed in the Chilled Water Schematic (Figure 4.3).

The chilled water supply directly serves the loads in the SLCC. After passing through an air separator and expansion tank the chilled water is directed to two parallel 730 gpm pumps (one standby) each capable of producing 93 ft. w.g. of head. These pumps are enabled either manually or automatically by the DDC panel when a cooling coil needs to be used. The pumps are modulated by variable frequency drives controlled by adjustable frequency motor controller (AFMC) with input from a pressure differential sensor between the supply and return flows. The vast majority of chilled water directly serves the cooling coils in the AHUs. Less than four percent of the total flow is directed to the eight fan coil units (FCU) and computer room air conditioning (CRAC) unit. Return chilled water is directly sent back to the Central Utilities Building at 53°F.

The heating hot water (HHW) system of the SLCC is served by 100 psig high pressure steam (HPS) from the Central Utilities Building and enters and leaves the facility under the east entrance. HPS is directed to the PRV Station where the pressure is reduced from to 15 psig. This PRV Station has a capacity of 2800 lbs/hr and two valves controlling 1/3 and 2/3 of the flow each. The low pressure steam (LPS) is then directed to both the steam-to-water heat exchanger and the domestic hot water heater. These devices transfer thermal energy from the steam to the water in the system. The organization of these systems can be viewed in the Heating Hot Water Schematics 1 and 2 (Figure 4.4, Figure 4.5, respectively).

The majority of the LPS is directed to the heating hot water plate and frame heat exchanger. This heat exchanger has a capacity of 2800 MBH and serves the heating hot water coils in all AHUs, VAV HW reheat coils, HW Unit Heaters, and the CRAC unit. One of two 280 gpm pumps (one standby) is activated whenever a heating coil is in use and controlled with AFMCs. Return HHW is directed to an air separator and expansion tank because the pressure on the water is lower here. Return water is then reheated in the heat exchanger and recirculated throughout the system. Condensate from the steam side of the system is collected and pumped back to the Central Utilities Building with a condensate receiver and pump.

The domestic hot water heater uses an indirect steam-to-hot-water heat exchanger and has an auxiliary electric heater for when steam service is down for maintenance. Water stored in the tank is maintained at 140°F.

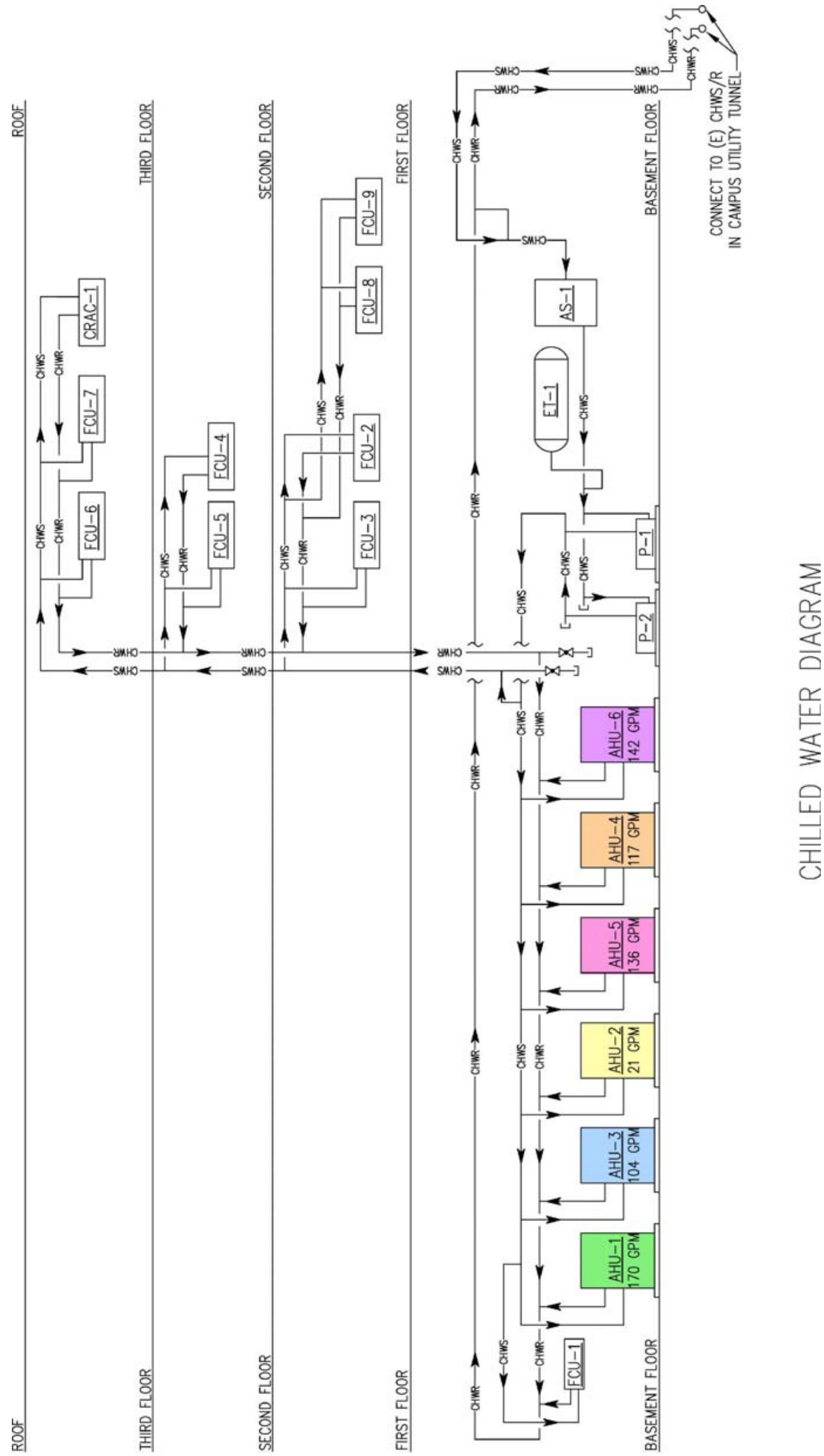

Figure 4.3: Chilled Water System Schematic

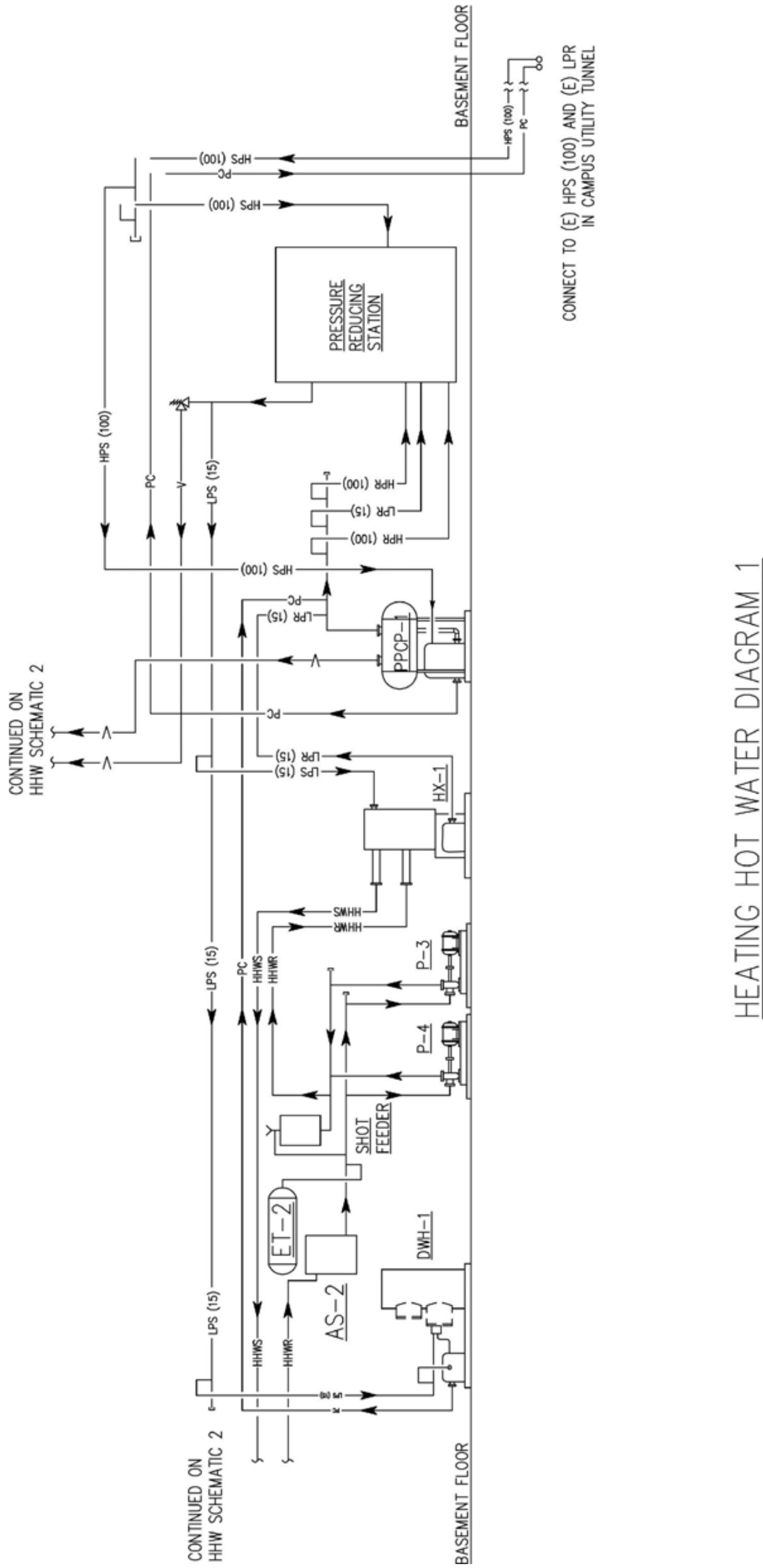

Figure 4.4: Heating Hot Water System Schematic (PRV, HX, Pumps).

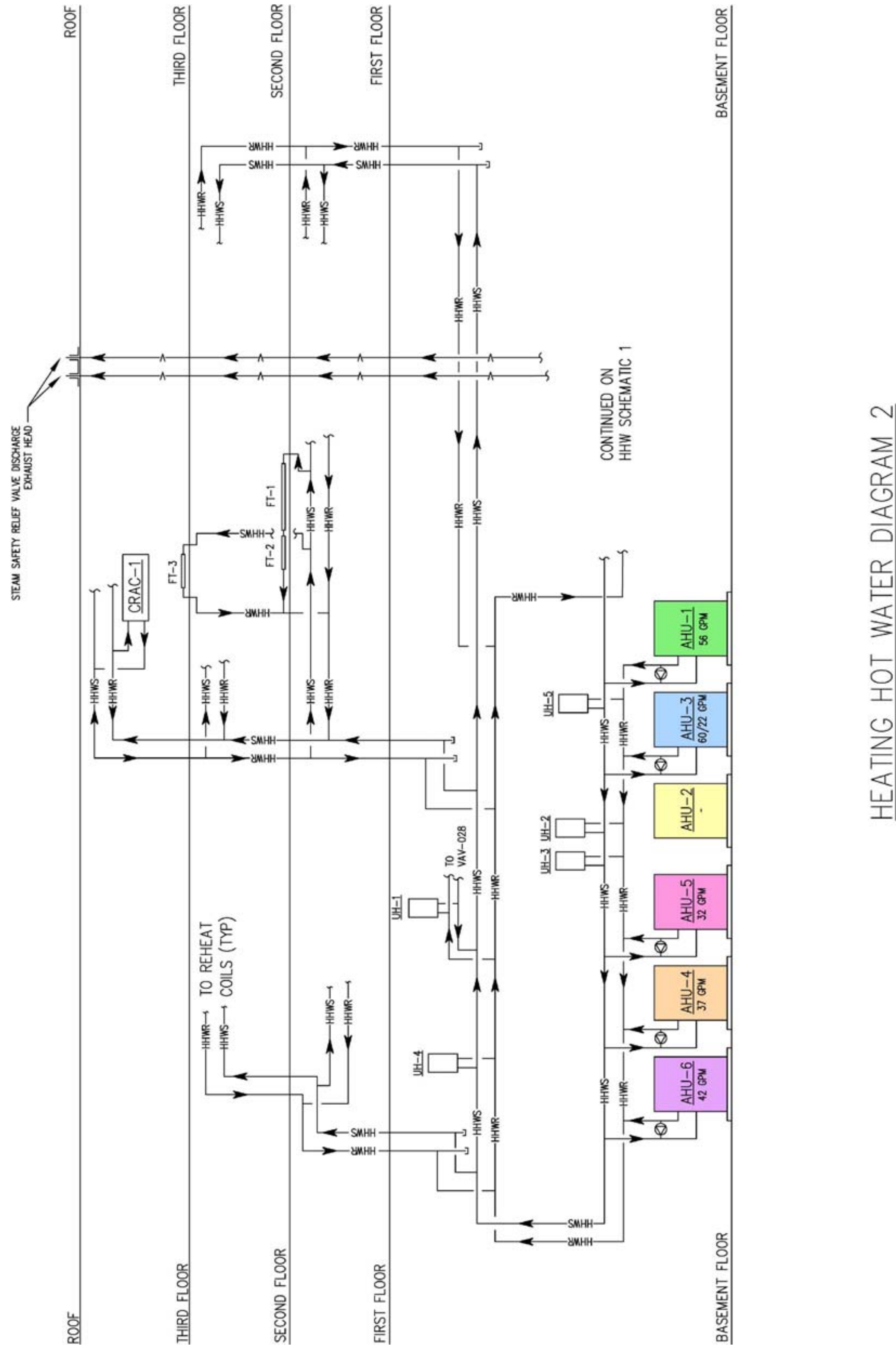

Figure 4.5: Heating Hot Water System Schematic (Distribution).