Existing System Evaluation

Hoboken Residential, NJ

Tech 3 – AE 481 Senior Project

October 21, 2005

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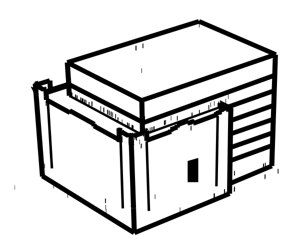


Introduction

The seven story building has 6 floors of condominiums, one floor of retail space, and an unoccupied basement. Two roof top air handling units provide the breathing zone fresh air. A 15000 CFM unit supplies outdoor air to individual fan coil units in the apartments. A 1755 CFM unit supplies 100% OA to egress corridors. For the retail space, only a capped duct between the first floor and roof is provided for 3000 CFM. The duct for the apartment supply is capped at the basement to allow for basement ventilation fit-out as well. The basement receives tempered outdoor air from the larger RTU. Two fans on the roof supply unconditioned ventilation to the boiler room and to pressurize the stairwell, and many exhaust fans reject air from the apartments. A central boiler & hot water loop provides heat via fin tube radiators in the apartments, and a central chiller / cooling tower system provides chilled water for cooling coils in the Fan Coil Units. .

A: Design Objectives, Requirements:

Provide thermal comfort and control to occupants
Meet design codes
Reasonable costs to building owner
LEED rating

B: Energy Sources and Rates

Gas and electricity costs are modeled for PSE&G energy rates. There is no municipal steam or chilled water in Hoboken NJ

PUBLIC SERVICE ELECTRIC AND GAS COMPANY — **First Revised Sheet No. 67A Superseding Original Sheet No. 67A**

B.P.U.N.J. No. 14 ELECTRIC

BASIC GENERATION SERVICE – FIXED PRICING (BGS-FP)
ELECTRIC SUPPLY CHARGES
(Continued)

BGS ENERGY CHARGES:

Applicable to Rate Schedules GLP and LPL-Sec.
Charges per kilowatthour:

Rate Schedule	For usage in each of the months of October through May: Charges	Charges Including SUT	For usage in each of the months of June through September: Charges	Charges Including SUT
GLP	5.4921 ¢	5.8216 ¢	6.7786 ¢	7.1853 ¢
GLP Night Use	4.1632 ¢	4.4130 ¢	4.0329 ¢	4.2749 ¢
LPL-Sec. under 750 kW				
On-Peak	6.5705 ¢	6.9647 ¢	8.7655 ¢	9.2914 ¢
Off-Peak	4.1632 ¢	4.4130 ¢	4.0329 ¢	4.2749 ¢
LPL-Sec. equal to or greater than 750 kW but less than 1,250 kW				
On-Peak	7.0705 ¢	7.4947 ¢	9.2655 ¢	9.8214 ¢
Off-Peak	4.6632 ¢	4.9430 ¢	4.5329 ¢	4.8049 ¢

Gas Commodity Price

2000

Billing Period	Cents/Therm
January-00	23.380
February-00	25.830
March-00	25.607
April-00	29.257
May-00	31.120
June-00	42.383
July-00	45.383
August-00	37.477
September-00	46.437
October-00	53.040
November-00	46.213
December-00	63.203

2001

Billing Period	Cents/Therm
January-01	97.880
February-01	69.397
March-01	50.903
April-01	54.423
May-01	49.833
June-01	39.217
July-01	33.417
August-01	31.903
September-01	24.180
October-01	18.883
November-01	30.603
December-01	25.393

2002

Billing Period	Cents/Therm
January-02	27.870
February-02	19.837
March-02	23.813
April-02	34.183
May-02	33.443
June-02	33.490
July-02	33.857
August-02	29.380
September-02	34.627
October-02	36.407
November-02	41.100
December-02	42.203

2003

Billing Period	Cents/Therm
January-03	50.320
February-03	55.000
March-03	92.823
April-03	51.067
May-03	53.580
June-03	59.880
July-03	55.817
August-03	46.997
September-03	50.160
October-03	45.200
November-03	44.857
December-03	47.200

2004

Billing Period	Cents/Therm
January-04	62.240
February-04	57.393
March-04	51.180
April-04	53.653
May-04	58.577
June-04	66.897
July-04	63.263
August-04	59.980
September-04	51.897
October-04	54.590
November-04	79.727
December-04	71.770

2005

Billing Period	Cents/Therm
January-05	63.470
February-05	63.597
March-05	62.393
April-05	71.280
May-05	70.070
June-05	62.623
July-05	71.580
August-05	74.520
September-05	101.363
October-05	130.010
November-05	
December-05	

Water Utility Prices:

Quarterly Conservation Residential Rate effedctive January 1, 2005:

Consumption (1,000 gallons)	**Rate** per 1,000 Gallons
0 - 5,000	$2.480
5,001 - 20,000	$2.642
Over 20,000	$3.077

C: Cost Factors

There is the opportunity to save money on electricity if it is used off-peak instead of on-peak.

D: Site Factors

The building owners had to gain special exceptions to zoning laws, since it did not fulfill the parking quota, and the elevator well exceeds height restrictions. The LEED rating played a large part of the zoning board allowing these exceptions. The building is a partial renovation, but this does not have a huge effect on the constraints of the mechanical system, since the renovated enclosure must still meet code.

E: Outdoor & Indoor Design Conditions

Outdoor Design Conditions:
ASHRAE 90.1 (Modeled for NYC LaGuardia)
Heating Design Temperature – 13 F Dry Bulb
Cooling DesignTemperature – 89 F Dry Bulb
- 73 F Wet Bulb

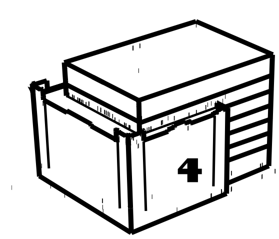
Indoor Design Conditions:
Per residence controls

F: Design Ventilation

Residential Apartments	Actual Total Exhaust	Actual OA Supply
Exhaust & Supply (Continuous)		
Floors 2-5		
Unit A	445	445
Unit B	445	445
Unit C	370	370
Unit D	370	370
Unit E	445	445
Unit F	445	445
Floor 6		
Duplex A	175	245
Duplex B	250	245
Unit C	445	445
Unit D	445	445
Floor 7		
Duplex A	270	200
Duplex B	195	200
Unit C	445	445
Unit D	445	445
Corridors	-	160

G: Design Heating and Cooling Loads

(Please find all 32 zones of apartment loads on Y Drive / Bananas / TRACE Results. A building summary is included below)



System Checksums

By ae

BUILDING — **VAV w/Baseboard Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 5 / 16; Outside Air: OADB/WB/HR: 79 / 65 / 71

Clg Space Peak — Mo/Hr: 5 / 16; OADB: 79

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	24,509	0	24,509	3.29	24,509	4.48
Glass Solar	199,644	0	199,644	26.76	199,644	36.46
Glass Cond	8,643	0	8,643	1.16	8,643	1.58
Wall Cond	23,562	0	23,562	3.16	23,562	4.30
Partition	-102,942		-102,942	-13.80	-102,942	-18.80
Exposed Floor	0		0	0.00	0	0.00
Infiltration	11,934		11,934	1.60	4,771	0.87
Sub Total ==>	165,350	0	165,350	22.17	158,187	28.89
Internal Loads						
Lights	211,732	0	211,732	28.38	211,732	38.67
People	128,765		128,765	17.26	64,383	11.76
Misc	30,717	0	30,717	4.12	30,717	5.61
Sub Total ==>	371,214	0	371,214	49.76	306,832	56.04
Ceiling Load	21,472	-21,472	0	0.00	21,472	3.92
Ventilation Load	0	0	140,679	18.86	0	0.00
Ov/Undr Sizing	61,071		61,071	8.19	61,071	11.15
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			7,660	1.03		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	619,108	-21,473	745,974	100.00	547,562	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1; OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	-25,722	-25,722	2.02
Glass Solar	0	0	0.00
Glass Cond	-154,093	-154,093	12.13
Wall Cond	-68,301	-68,301	5.38
Partition	-98,040	-98,040	7.72
Exposed Floor	0	0	0.00
Infiltration	-82,873	-82,873	6.52
Sub Total ==>	-429,029	-429,029	33.77
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-22,535	0	0.00
Ventilation Load	0	0	0.00
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		10,268	-0.81
OA Preheat Diff.		-851,785	67.04
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-451,564	-1,270,546	100.00

TEMPERATURES

	Cooling	Heating
SADB	56.0	70.0
Plenum	83.3	61.3
Return	75.0	61.3
Ret/OA	77.1	0.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.2	0.0

AIRFLOWS

	Cooling	Heating
Vent	13,710	0
Infil	1,062	1,062
Supply	25,853	0
MinStop/Rh	0	0
Return	26,915	0
Exhaust	14,772	1,062
Rm Exh	0	0
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	53.0	0.0
cfm/ft²	0.59	0.00
cfm/ton	415.88	
ft²/ton	702.10	
Btu/hr-ft²	17.09	-29.86
No. People	258	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	62.2	746.0	595.3	25,853	77.1	63.7	66.9	55.7	54.1	59.8
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	62.2	746.0								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	43,646		
Part	4,300		
ExFlr	0		
Roof	7,205	0	0
Wall	25,193	6,918	27

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-451.6	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-851.8	13,710	0.0	55.7
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-1,303.4			

H: Annual Energy Use

Costs are evaluated for the entire building, not for individual apartments. This will be evaluated in the future to determine the cost effects of HVAC changes to apartment owners. The cost of water consumed and corresponding treatment is not included, miscellaneous equipment and domestic water pumping costs are not included.

ENERGY CONSUMPTION SUMMARY

By ae

	Elect Cons. (kWh)	Gas Cons. (therms)	Water Cons. (1000 gals)	Percent of Total Energy	Total Source Energy* (kBtu/yr)
Primary heating					
Primary heating	19,710.0	11,660.9		29.9 %	14,292.9
Primary cooling					
Cooling Compressor	153,728.6			12.7 %	15,741.9
Tower/Cond Fans	14,837.1		631.3	1.2 %	1,519.3
Condenser Pump				0.0 %	0.0
Other CLG Accessories	4,645.0			0.4 %	475.7
Cooling Subtotal....	173,210.7		631.3	14.3 %	17,736.8
Auxiliary					
Supply Fans	129,999.4			10.8 %	13,312.0
Circ Pumps				0.0 %	0.0
Base Utilities				0.0 %	0.0
Aux Subtotal....	129,999.4			10.8 %	13,312.0
Lighting					
Lighting	543,444.1			45.0 %	55,648.8
Receptacle					
Receptacles				0.0 %	0.0
Heating plant load					
Base Utilities				0.0 %	0.0
Cogeneration					
Cogeneration				0.0 %	0.0
Totals					
Totals**	866,364.1	11,660.9	631.3	100.0 %	100,990.5

MONTHLY UTILITY COSTS

By ae

Alternative: 1

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Electric													
On-Pk Cons. ($)	3,027	2,791	3,072	3,592	4,513	6,823	7,664	7,949	6,201	3,883	3,330	3,036	55,879
Off-Pk Cons. ($)	1	1	1	1	1	0	0	0	0	0	0	0	5
Total ($):	3,028	2,792	3,073	3,593	4,514	6,823	7,664	7,949	6,201	3,883	3,330	3,036	55,884
Gas													
On-Pk Cons. ($)	2,858	2,401	3,007	1,262	783	729	744	748	743	913	1,375	3,094	18,657
Water													
On-Pk Cons. ($)	0	1	0	40	142	319	399	435	255	60	17	0	1,668
Monthly Total ($):	5,885	5,193	6,080	4,895	5,439	7,871	8,807	9,132	7,199	4,856	4,722	6,130	76,209

Residential Apartments

Annual Hot Water Consumption	People	Gallons per year	Grams Water	Delta T deg C	Calorie Load	Joule Load	Joules in Nat.Gas with boiler eff	Cost $	Gallons Natural Gas
Floors 2-5									
Unit A	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Unit B	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Unit C	3	32850	124350390	55.6	6.914E+09	28948422611	41354889444	627.183	285473
Unit D	3	32850	124350390	55.6	6.914E+09	28948422611	41354889444	627.183	285473
Unit E	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Unit F	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Floor 6									
Duplex A	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Duplex B	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Unit C	4	36500	138167100	55.6	7.682E+09	32164914012	45949877160	696.87	317192
Unit D	4	36500	138167100	55.6	7.682E+09	32164914012	45949877160	696.87	317192
Floor 7									
Duplex A	-	-	-	-	-	-	-	-	-
Duplex B	-	-	-	-	-	-	-	-	-
Unit C	4	36500	138167100	55.6	7.682E+09	32164914012	45949877160	696.87	317192
Unit D	4	36500	138167100	55.6	7.682E+09	32164914012	45949877160	696.87	317192
						Totals:	5.97348E+11		10403889

G: Controls and Schematics

Controls and Schematics

The Heating-Water Supply Controls

The Heating-Water Supply Temperature Control is regulated by a thermistor temperature sensor. (A) The temperature sensor controls how much to modulate control valves (B) to maintain the supply temperature. The temperature reset control is regulated by an outdoor air sensor which communicates to a unitary controller or DDS system software what the set temperature should be. If the outdoor air temperature is less than -30 F, the supply temperature is 195 F; if the outdoor is 75 F, the supply temperature is 130F, with a straight-line relationship for intermediate outdoor temperatures.

Primary circulating pumps (C) are started when outdoor air temperature is less than 65 F.

(I assume boilers are started when the software indicates a heating load. I could not find this description in sequence of controls)

Central Refrigeration Equipment Controls

(Since the drawings show water-side free cooling, but the controls have not yet been revised to specify it, I assume that the controls would be similar to the existing sequence, summarized below, except there would be another stage of condenser loop pumps (D) turned on after the tower-side condenser pumps (E) and before the chillers would be allowed to run, and that these second-stage condenser pump valves would close when the temperature of the tower condenser loop is low enough to meet the cooling load)

To start the central chilled water plant, the condenser-water pumps will start first. They must receive confirmation from the water pressure transducer (F) in the cooling tower that there is water in the cooling tower sump, confirmation from the outdoor air temperature sensor that the air is less than 50 F, and confirmation from the software that there is a cooling demand in the building.

Once the condenser-water pumps have started, a water pressure transducer (G) in the condenser water loop will energize the chilled water pumps (H) and the cooling tower fans.

Once the chilled water pumps have started, the chiller will receive confirmation from the condenser loop transducer and the chilled water loop pressure transducer (I) to energize the chiller internal control circuit.

Chilled Water Supply Temperature Controls

Internal temperature controls, reset according to highest cooling demand specified by system software.

Condenser Water Temperature

A temperature sensor in the cooling tower sump controls how much to modulate control valve open to cooling tower and closed to bypass and cycle tower fans on to maintain 65 F sump temperature.

Roof Top Units Control Sequences

Supply Volume Control

Volume controlled by static pressure transmitter sensing supply-duct static pressure (J) referenced to conditioned-space static pressure *(assume fan coil unit supply inlet before fan)* (K) to maintain constant supply-duct static pressure, which regulates the damper opening and motor speed.

Heating Coil

Coil circulating pump is energized by the DDC system schedule (L). The system schedule and supply duct-mounted thermostat (J) control the modulating control valve to maintain air temperature set point.

Cooling Coil

Coil circulating pump is energized by the DDC system schedule (L). The system schedule and supply duct-mounted thermostat (J) control the modulating control valve to maintain air temperature set point.

Fan Coil Units Control Sequences

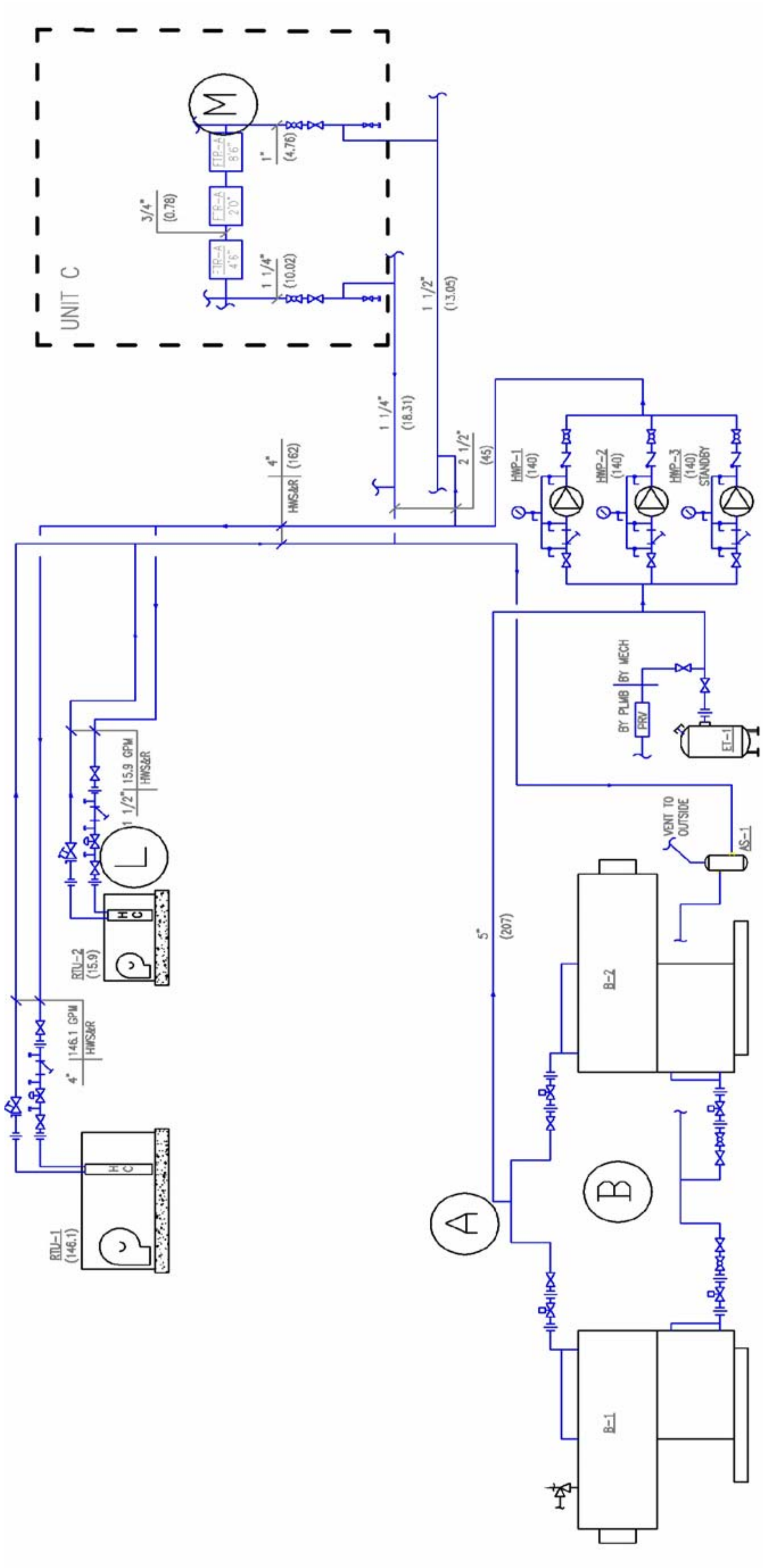
The room thermostats are manually operated and control the fan cycles and electronic control-valve for the cooling coils.

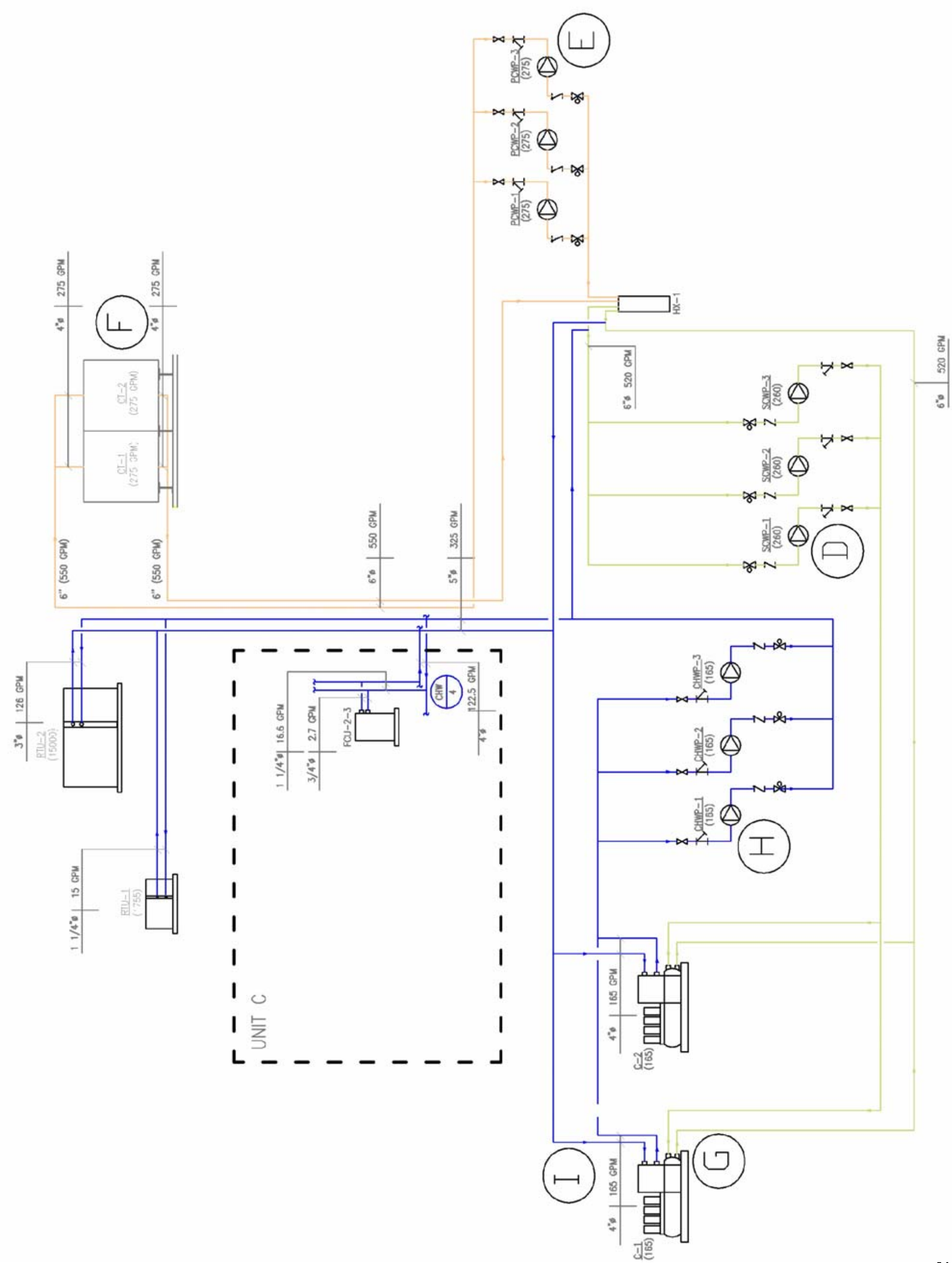
Hydronic Fin Tube Radiator Control Sequences

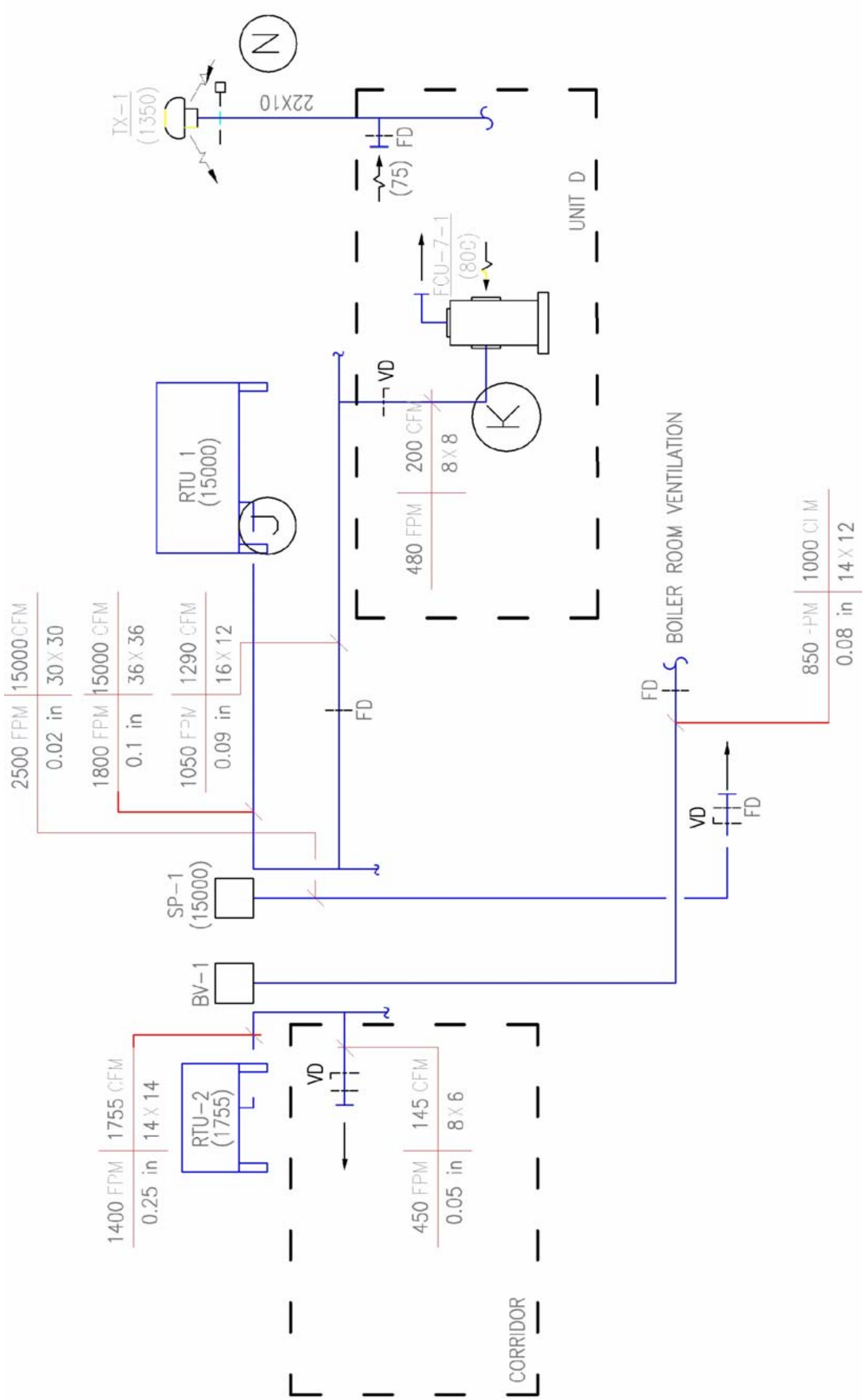
The room thermostats are manually operated and modulate the electronic control-valve operators in the local hot water loop. (M)

Exhaust Fans Control Sequences

The room thermostats indicate occupancy and cycle the exhaust fans. (N)


UNIT C
M
L
A
B
B-1
B-2
RTU-1 (146.1)
RTU-2 (15.9)
HMP-1 (140)
HMP-2 (140)
HMP-3 (140) STANDBY
ET-1
AS-1
VENT TO OUTSIDE
BY PLMB
BY MECH
PRV
4" 146.1 GPM HWS&R
1 1/2" 15.9 GPM HWS&R
4" HWS&R (162)
5" (207)
2 1/2" (45)
1 1/4" (18.31)
1 1/2" (13.05)
1 1/4" (10.02)
3/4" (0.78)
1" (4.76)


E
PCWP-3 (275)
PCWP-2 (275)
PCWP-1 (275)
F
4"Ø 275 GPM
4"Ø 275 GPM
CT-2 (275 GPM)
CT-1 (275 GPM)
HX-1
6"Ø 520 GPM
6"Ø 520 GPM
SCWP-3 (260)
SCWP-2 (260)
SCWP-1 (260)
D
6" (550 GPM)
6" (550 GPM)
6"Ø 550 GPM
5"Ø 325 GPM
3"Ø 126 GPM
RTU-2 (15000)
1 1/4"Ø 16.6 GPM
3/4"Ø 2.7 GPM
FCU-2-3
CHW 4
4"Ø 122.5 GPM
CHWP-3 (165)
CHWP-2 (165)
CHWP-1 (165)
H
1 1/4"Ø 15 GPM
RTU-1 (755)
UNIT C
4"Ø 165 GPM
C-2 (165)
I
G
4"Ø 165 GPM
C-1 (165)


TX-1
(1350)
22X10
FD
(75)
UNIT D
FCU-7-1
(800)
VD
200 CFM
8 X 8
480 FPM
RTU 1
(15000)
2500 FPM
15000 CFM
0.02 in
30 X 30
1800 FPM
15000 CFM
0.1 in
36 X 36
1050 FPM
1290 CFM
0.09 in
16 X 12
FD
BOILER ROOM VENTILATION
850 FPM
1000 CFM
0.08 in
14 X 12
VD
FD
SP-1
(15000)
BV-1
RTU-2
(1755)
1400 FPM
1755 CFM
0.25 in
14 X 14
VD
450 FPM
145 CFM
0.05 in
8 X 6
CORRIDOR

H: List of Equipment

List of Equipment

Chilled Water System Pumps

	Type	GPM	Pump Efficiency	Brake HP	Minimum Motor HP	RPM
CHWP 1,2,3	In-Line Centrifuge	165	63	7.29	15	1800
PCWP 1,2,3	In-Line Centrifuge	275	16	8.5	10	1800
SCWP 1,2,3	In-Line Centrifuge	210	14	2.06	3	1750

Hot Water System Pumps

HWP 1,2,3	Base Mounted Centrifuge	140	70.4	4.36	15	1800

	Total Flow Rate GPM	Entering Water Temperature	Leaving Water Temperature	Ambient Air Temperature (WB)
Cooling Towers 1 & 2	275	100 F	85 F	78 F

GPM per Cell	Number of Cells	Number of Fan Motors	HP Per Fan Motor
275	1	1	15

Supply, Return, and Exhaust Air Fans (20 Fans Total)

CFM	Max Fan Speed (RPM)	Wheel Diameter (in)	Motor HP	Motor RPM
500-15000	1014-1725	22-29	1/15 - 7.25	1140- 1725

Factor Assembled HVAC Systems

	Serves	Total Air Quantity (OA)	Filter Efficiency
RTU-1	Apartments	15000	MERV -13
RTU-2	Egress Corridors	1755	MERV -13

Cooling Coil										
Air Side				Water Side						
Entering DB	Entering WB	Leaving DB	Leaving WB	Flow Rate (GPM)	Entering Temp	Leaving Temp	Total Cooling Capacity (MBH)	Sensible Cooling (MBH)	Number of Sections	Face Area (SF)
91 F	77 F	58 F	58 F	115	45 F	61 F	918	599	42	31.2
91 F	77 F	60 F	60 F	12.3	45 F	61 F	99	66.6	6	3.4

Cooling Coil							
Air Side		Water Side					
Entering DB	Leaving DB	Flow Rate (GPM)	Entering Temp	Leaving Temp	Total Heating Capacity (MBH)	Number of Circuts	Face Area (SF)
0 F	70 F	146	180 F	160 F	1430	28	31.2
0 F	70 F	15.9	180 F	160 F	155	2	3.4

Supply Fan	
Motor HP	Motor RPM
20	920
3	1750

Hot Water Boilers

				Hot Water Data			Natural Gas Burner Data
	Boiler HP	Gross Output (MBH)	Net Output	Flow Rate (GPM)	Entering Temperature	Leaving Temperature	Gas Heat Contern (BTU/CF)
B-1,2	52	1750	1400	140	180 F	160 F	1017

Electric Scroll Chillers		Evaporator				
	Nominal Tons	Flow Rate (GPM)	Entering Water Temp	Leaving Water Temp	No of Passes	Fouling Factor
C-1,2	104	165	61 F	45 F	2	0.0001

Condenser					Electric Compressor #1			
Flow Rate (GPM)	Entering Water Temp	Leaving Water Temp	No of Passes	Fouling Factor	Input KW	KW/ Ton	RLA	LRA
260	185 F	100 F	2	0.00025	82.3	0.79	100	500

Electric Compressor #2			
Input KW	KW/ Ton	RLA	LRA
82.3	0.79	100	640

Fan Coil Units (42 Total)	Cooling Coil			
Air Quantity (CFM)	Entering Water Temp	Leaving Water Temp	Total Cooling Capacity (MBH)	Total Sensible
1200-1900	45 F	61 F	7-40	7-40

Fin Tube Radiators

	Heating Capacity (BTU/L.F.)	Number of Rows	Material
FTR-A	520	2	Steel
FTR-B	670	3	Steel

Conclusion & Critique:

The building meets code ventilation & exhaust requirements, and envelope requirements.

Some positive things about the present design:

Central Cooling system is more efficient than individual ac units
Central Boilers are more efficient than individual resistive heating
Water-Side free cooling saves energy

Some negative things about the present design:

Hard to meter energy consumed by individual apartments
Higher First Costs; it is hard to justify extra expense to building owner when he will not see the energy savings, since they are condos and not rented apartments
Much larger cooling bills for apartments with south-facing windows
Much larger heating bills for apartments with roof exposures

Currently, the ideal HVAC system for the building owner is one that attains a LEED rating (in this case necessary for zoning violations), is the least expensive, and is easily managed and metered. The HVAC system was designed towards these goals. However, these objectives may change over the duration of this study. For example, condo owner's interest in energy costs may change due to rising prices. And it might not, depending on the income level and education of the expected homeowner. Even if the energy expense becomes a priority, the way the costs are divided up may change the total effect. Also, the high demand for housing in this area could override any other factors and maintain the present design objectives. It other words, it is difficult to evaluate the success of the system when who is true owner, and what their priorities are, is more subjective. I look forward to evaluating the system based on the true present goals, and prioritizing possible systems with these criteria.