Building and Plant
Energy Analysis Report:
Technical Assignment #2

Calvert Memorial Hospital
Prince Frederick, MD

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Executive Summary:

In this report a building and plant energy analysis was done for Calvert Memorial Hospital located in Prince Frederick Maryland. There were many different criteria that were considered in this analysis. Calvert did not directly apply to some of these analyses because most of them apply to office buildings only. For instance, the LEED Green Rating system was not applicable to the hospital, but there were some attributes that could be considered in the rating system. The indoor air quality of the hospital is compliant with ASHRAE Std. 90.01-2001 except for some of the patient tower patient rooms, which are going to be corrected in the future.

Envelope and lighting compliance was another issue examined in this report. The building envelope U-values for the wall and roof were 0.100 Btu/hr/ft^2/F and 0.691 Btu/hr/ft^2/F respectively with a SHGC of 0.792 for the windows. A 7.2% ratio of building window area to wall area was determined. For Calvert Memorial's envelope structure, ASHRAE recommends U-values of 0.124 Btu/hr/ft^2/F for the walls and 0.67 Btu/hr/ft^2/F with a SHCG of 0.39 for the windows. For lighting compliance, Calvert was evaluated by comparing the ASHRAE Space-by-Space method to the design document information. For the 13,011 ft^2 area of building being examined, it was found that all spaces complied with the standard except for some critical care and med rooms.

The lost rentable space for the hospital is approximately 16,971 ft^2 (9.2% of the hospital area). The first cost of the mechanical equipment totaled roughly $9,404,102, which came to be about $51 per square foot of building area.

Energy Cost and Utilization data were determined for the 184,360 ft^2 hospital using a power density of 6.2 watts/ft^2. The resulting peak load was 1143 KW, which occurred in February of 2002. The total yearly electrical usage of that year was 8,279,169 KWH. Additional pollutants were present due to two 150 hp boilers with 5021 MBtu output each. For one boiler the total emissions for one year were 363.69 lbm of particulates, 4,364.28 lbm of NOx, 5,455.34 lbm of CO, 36.37 lbm of SOx, and 581.90 lbm of Hydrocarbons.

The rest of the report contains Hourly Analysis information on the hospital's load and ventilation calculations.

LEED Green Building Rating:

The LEED (Leadership in Energy and Environmental Design) Green Building Rating System is a national standard that determines a "green building." The LEED standard supplies a guideline for improving the environmental qualities, occupant features, and economic returns of a particular building. Office buildings provide the main area of analysis for these ratings which are defined in the following categories: water efficiency, energy and atmosphere, materials and resources, indoor environmental air quality, and sustainable sites. If the building structure is in compliance with any one of the items in these categories, it will be awarded with a certain amount of points. A building receives a LEEDS certification if it maintains 26-32 points, Silver if it contains 33-38 points, Gold if it contains 39-51 points, and Platinum if it maintains over 52 points.

Because the rating system pertains to office buildings, it does not directly apply to Calvert Memorial Hospital. However there are a few attributes which can exemplify some of the LEED rating principles.

In the Indoor Environmental Quality section of the rating, it is assured that the hospital meets the required indoor air quality (IAQ) performance. There are heat pumps located in the patient rooms on the 2^{nd}-5^{th} floors which create a violation in ASHRAE standard of proper IAQ to the space. Due to the mold growth in the condensate pans located inside the heat pumps, bacteria and mold spores are exposed to the breathable air in the patient rooms. Although these room areas are a very large portion of the hospital, the rest of the indoor spaces all meet the ASHRAE requirements and are controlled by either variable-air-volume or constant volume air systems.

IAQ is probably the most important aspect of Calvert Memorial Hospital. As stated above, the LEED rating system is usually implemented in office buildings, but the IAQ section is highly applicable to Calvert Memorial Hospital. Any items that will chemically affect the air in the hospital are extruded through a ducted exhaust system. Obviously there is no smoking permitted inside the confines of the hospital which helps reduce carbon dioxide levels. Areas where painting or material renovations are in progress are also isolated from the rest of the hospital. Clean air is the main priority.

ASHRAE Std. 90.1-2001:

ASHRAE Std. 90.1-2001 is a standard that provides minimum requirements for energy-efficient building design with the exception of low-rise residential buildings. The relevant requirements used in this report fall under the following two sections: 5-Builidng Envelope and 9-Lighting.

Envelope Compliance:

Calvert Memorial Hospital's envelope compliance with the ASHRAE Standard 90.1-2001 will be evaluated in this section. The envelope of the hospital includes all walls, windows, and roof materials touching the outside air. Each of these exterior surfaces contains heat transfer values that determine how much heat is lost or gained by the building. In order to determine the hospital's heat transfer coefficients, information was obtained from the design documents. Design document information determined a wall U-value of 0.100 Btu/hr/ft^2/F, a roof U-value of 0.100 Btu/hr/ft^2/F, and a window U-value of 0.691 Btu/hr/ft^2/F with a shading coefficient of 0.792. The building fenestration percentage is found by determining the building's window-to-wall area ratio. The total building window area is 5,830 ft^2 and the total building wall area is 79,512 ft^2, therefore the window-to-wall ratio or building fenestration percentage is 7.2%. These U-values and fenestration requirements comply with Table B-13, ASHRAE Std. 90.1-2001 Building Envelope Requirements, except for the U-value for the hospital walls and the U-value and SHGC factor for the windows. ASHRAE recommends a wall U-value of 0.124 Btu/hr/ft^2/F and a window U-value of 0.67 Btu/hr/ft^2/F with a SHGC of 0.39. See Appendix 1 -Wall, Roof, and Window Properties for components of calculations.

Lighting Compliance:

For this report, the interior lighting allowance for Calvert Memorial Hospital was determined. The area of analysis involves only the 2nd and 3rd floor areas which encompass approximately 13,011 ft^2 of the 185,000 ft^2 building. The ASHRAE Std.90.1-2001 "Space-by-Space" method was used and then compared to the existing HAP load calculations for the building.

The Space-by-Space method introduced allowable lighting power densities for certain types of rooms. Table 9.3.1.2 lists a plethora of values for different types of interior spaces. Lighting power density values were used for Hospital/Healthcare Buildings with the following space types: Open-Plan Offices, Lobbies, Restrooms, Corridors/Transitions, Electrical/Mechanical, Nurse Station, Exam/Treatment, Patient Rooms, Medical Supplies, and Laundry-Washing. With the square footages of each area and the corresponding lighting power density multiplier, the appropriate wattage was determined for each space. For an example, here is the calculation for the wattage present in Patient Room 2003:

$$\mathbf{260\ ft^2 \times 1.2\ watts/ft^2 = 312\ watts}$$

After the Space-by-Space calculations were computed, the design document lighting power density factors were employed. For the same space, Patient Room 2003, the following calculation was made:

$$\mathbf{260\ ft^2 \times 2.0\ watts/ft^2 = 520\ watts}$$

These two values illustrate that Patient Room 2003 has more than the required watts to the room; therefore it is in compliance with the ASHRAE standard. The focus of my thesis falls on the 2nd and 3rd floors, so this calculation was done for every room on those two floors. See Appendix 2 – Interior Lighting Power Allowance for all computed values. Highlighted in yellow are the spaces that do not comply with the ASHRAE 90.1-2001 Standard. The non-compliant spaces consist of critical care and med rooms. In the future these rooms may require more lighting due to the critical tasks that are being performed in the spaces.

Lost Rentable Space:

This section depicts the lost rentable space for Calvert Memorial Hospital. The lost rentable space includes all mechanical rooms and areas where mechanical equipment are present. Vertical shafts are also included in the lost rentable space analysis. Any mechanical equipment that is located on the roof is not considered in the lost rentable space calculation.

It is determined that the two interior mechanical rooms in the hospital utilize roughly 14,589 ft^2 of the hospital space. The vertical chases for ductwork and plumbing consisted of an approximate area of 2,382 ft^2. Therefore, the total lost rentable space due to the building mechanical system is 16,971 ft^2 which is approximately 9.2 % of the building area.

Mechanical First Cost:

The Mechanical First Costs are determined from all of the mechanical and plumbing equipment located in Calvert Memorial Hospital. Due to the renovation of many of the interior spaces of the hospital, removal costs are included in the first cost analysis of the mechanical equipment. Also included in these costs are items such as ductwork, piping, variable frequency controllers, rigging, structural reinforcement, electrical configuration, low pressure steam and condensate, insulation, testing and balancing commissioning, pumps, heat exchangers, and of course all the air handling units, boilers, chillers, generators, and cooling towers. A table of the total costs for the mechanical equipment is illustrated in Appendix 3 – Mechanical Equipment First Cost. Information for the total cost of the 184,360 ft^2 hospital building is not readily available, but judging on the size of the hospital the percentage of mechanical costs with respect to the total construction costs should fall between the RS Mean Mechanical Cost Data standards of 4% and 12%. By knowing the mechanical cost ($9,404,102) and the square footage of the building (184,360 ft^2), we can determine a $51/$ft^2$ mechanical cost of the hospital.

Energy Estimates and Utilization Data:

In this section the energy utilization of the entire building will be evaluated due to more accurate measurements received by the utility company. Calvert Memorial Hospital purchases secondary service electrical power from Southern Maryland Electric Cooperative (SMECO) at 480Y/277 volts. The approximate area of the hospital is 184,360 ft^2. With a power density of 6.2 Watts/ft^2 (the power density on a peak day), it was determined that the hospital's total electric usage for the year 2002 was 8,279,169

KWH. The peak demand load was 1143 KW, and occurred in the month of February. The hours of peak load operation were approximately 7243.37 hours. An example of how this data calculation is illustrated as follows:

184,360 ft^2 x 6.2 watts/ft^2 x 1 KW / 1000 watts = 1143 KW

1143 KW x 7243.37 hours = 8,279,169 KWH

It was interesting to find that this peak demand load occurred in the winter instead of the summer months as expected. This is most likely due to the water-source heat pumps used to heat the patient rooms, as well as the electric domestic hot water heaters, and some of the electric steam boilers.

In addition to Calvert Memorial Hospital's electrical usage, there are additional emission rates of pollutants into the environment due to the electrical power plants that operate the building. The hospital uses two gas-fired Cleaver Brooks Hot Water Boilers. Each boiler is 150 horsepower with 5021 MBtu/hr output. Cleaver Brooks Emission data tables were used to determine the approximate amounts of Particulates, NOx, CO, SOx, and Hydrocarbons emitted to the atmosphere. Emitted pollutants from each different pollutant type were calculated to be 0.05021 lbm/KWH of particulates, 0.60252 lbm/KWH of NOx, 0.75315 lbm/KWH of CO, 0.005021 lbm/KWH of SOx, and 0.080336 of Hydrocarbons. Based on the 8,279,169 KWH electrical usage of Calvert Memorial Hospital in 2002, the total emissions for that year were 363.69 lbm of particulates, 4,364.28 lbm of NOx, 5,455.34 lbm of CO, 36.37 lbm of SOx, and 581.90 lbm of Hydrocarbons. An example calculation for NOx is given below. For the rest of the calculations and more calculation data, see Appendix 4 – Emissions Data for the Cleaver Brooks Boiler Emissions Data charts and the Emissions Calculation Table.

(0.12 Lbm NOx / 1000MBtu) x (5021 MBtu/hr) = 0.60252 Lbm NOx/hr

(0.60252 Lbm NOx/hr) x (7243.37 hr/year) = 4,364.28 Lbm NOx /year

Design Load Estimation:

The load and energy analysis datum were obtained from the ASHRAE standards and the computer program Hourly Analysis Program (HAP). The calculations were based on Calvert Memorial Hospital which is located in Prince Frederick, MD. Weather

data for Baltimore, MD was used for this analysis due to it being the closest weather data available by the HAP program. Important values resulting from the HAP calculation include items such as the estimated design heating and cooling loads and outdoor air ventilation rates.

HAP computes these values by implementing individual data for each room. In each space there are many things to consider such as: lighting and equipment loads (watts/sqft), design occupancy for each room, building envelope data, and space height and square footage. These calculations will be impertinent when comparing the building's computed load and ventilation rates. See Appendix 5 – Load Calculations for HAP Calculations and a description of the space load assumptions.

Appendix 1 -Wall, Roof, and Window Properties:

Wall Properties - [Template Wall (U = 0.1)]

Wall Assembly Name: **Template Wall (U = 0.1)**

Outside Surface Color: Medium Absorptivity: **0.675**

Layers: Inside to Outside	Thickness in	Density lb/ft³	Specific Ht. BTU/lb/F	R-Value hr-ft²-F/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
Gypsum board	0.625	50.0	0.26	0.56000	2.6
Air space	0.000	0.0	0.00	0.91000	0.0
R-11 batt insulation	1.000	0.5	0.20	5.60000	0.0
LW concrete block	4.000	38.0	0.20	1.51500	12.7
Face brick	4.000	125.0	0.22	0.43300	41.7
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	9.625			10.04	57.0

Overall U-Value: 0.100 BTU/hr/ft²/F

Wall Properties

Roof Properties - [Template Roof (U=0.1)]

Roof Assembly Name: **Template Roof (U=0.1)**

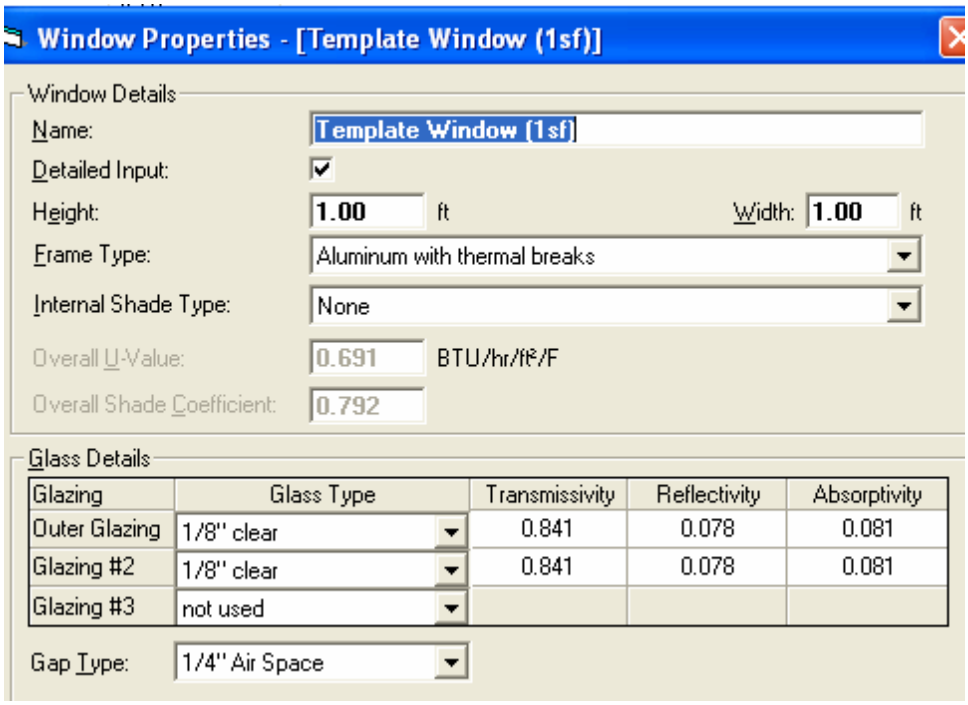
Outside Surface Color: Dark Absorptivity: **0.900**

Layers: Inside to Outside	Thickness in	Density lb/ft³	Specific Ht. BTU/lb/F	R-Value hr-ft²-F/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
Steel deck	0.034	489.0	0.12	0.00011	1.4
Board insulation	1.000	2.0	0.22	8.70000	0.2
Built-up roofing	0.376	70.0	0.35	0.33200	2.2
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	1.410			10.05	3.7

Overall U-Value: 0.100 BTU/hr/ft²/F

Roof Properties

Appendix 1 -Wall, Roof, and Window Properties (Cont'd):



Window Properties

Appendix 2 – Interior Lighting Power Allowance:

SPACE-BY-SPACE METHOD OF CALCULATING							HAP CALCULATION				
INTERIOR LIGHTING POWER ALLOWANCE							INTERIOR LIGHTING POWER ALLOWANCE				
NO.	SPACE NAME	ROOM NUM	NO. OF SPACES	SPACE (SQFT)	LPD (W/SQFT)	POWER (W)	SPACE NAME	SPACE (SQFT)	LPD (W/SQFT)	POWER (W)	COMPLIANCE
1	Passage	2002	1	85	1.6	136	Passage	85	2	170	YES
2	Patient room	2003	1	260	1.2	312	Patient room	260	2	520	YES
3	Toilet	2004	1	45	1	45	Toilet	45	2	90	YES
4	Work Station	2005	1	12	1.3	15.6	Work Station	12	2	24	YES
5	Toilet	2006	1	45	1	45	Toilet	45	2	90	YES
6	Patient room	2007	1	260	1.2	312	Patient room	260	2	520	YES
7	Patient room	2008	1	260	1.2	312	Patient room	260	2	520	YES
8	Toilet	2009	1	45	1	45	Toilet	45	2	90	YES
9	Work Station	2010	1	12	1.3	15.6	Work Station	12	2	24	YES
10	Toilet	2011	1	45	1	45	Toilet	45	2	90	YES
11	Patient room	2012	1	260	1.2	312	Patient room	260	2	520	YES
12	Equipment Storage	2013	1	144	0.3	43.2	Equipment Storage	144	2	288	YES
13	Corridor	2014	1	315	1.6	504	Corridor	315	2	630	YES
14	Nurse's Station	2015-16	1	200	1.8	360	Nurse's Station	200	2	400	YES
15	Service Lobby	2017	1	240	1.8	432	Service Lobby	240	2	480	YES
16	Passage	2018	1	130	1.6	208	Passage	130	2	260	YES
17	Med	2019	1	140	3	420	Med	140	2	280	NO
18	Staff Work Room	2020	1	320	1.8	576	Staff Work Room	320	2	640	YES
19	Nurse's Station	2021	1	185	1.8	333	Nurse's Station	185	2	370	YES
20	Staff Lounge/Locker	2022	1	345	1.4	483	Staff Lounge/Locker	345	2	690	YES
21	Staff Toilet	2023	1	70	1	70	Staff Toilet	70	2	140	YES
22	Toilet	2025	1	45	1	45	Toilet	45	2	90	YES
23	Patient Room	2026	1	355	1.2	426	Patient Room	355	2	710	YES
24	Patient Room	2027	1	355	1.2	426	Patient Room	355	2	710	YES
25	Toilet	2028	1	45	1	45	Toilet	45	2	90	YES
26	Corridor	2029	1	740	1.6	1184	Corridor	740	2	1,480	YES
27	Toilet	2030	1	45	1	45	Toilet	45	2	90	YES
28	Patient Room	2031	1	355	1.2	426	Patient Room	355	2	710	YES
29	Patient Room	2032	1	375	1.2	450	Patient Room	375	2	750	YES
30	Toilet	2033	1	45	1	45	Toilet	45	2	90	YES
31	Passage	3002	1	85	1.6	136	Passage	85	2	170	YES
32	CCU Rm	3003	1	265	2.8	742	CCU Rm	265	2	530	NO
33	CCU Rm	3004	1	265	2.8	742	CCU Rm	265	2	530	NO
34	CCU Rm	3005	1	265	2.8	742	CCU Rm	265	2	530	NO
35	CCU Rm	3006	1	265	2.8	742	CCU Rm	265	2	530	NO
36	Family Waiting	3007	1	345	1.4	483	Family Waiting	345	2	690	YES
37	Office	3008	1	108	1.5	162	Office	108	2	216	YES
38	Equip Storage	3015	1	305	0.3	91.5	Equip Storage	305	2	610	YES
39	Staff Lounge/Lockers	3016	1	360	1.4	504	Staff Lounge/Lockers	360	2	720	YES
40	Staff Lounge/Lockers	3017	1	340	1.4	476	Staff Lounge/Lockers	340	2	680	YES
41	Staff Toilet	3018	1	65	1	65	Staff Toilet	65	2	130	YES
42	Staff Toilet	3019	1	65	1	65	Staff Toilet	65	2	130	YES
43	Soiled Utility	3020	1	140	0.7	98	Soiled Utility	140	2	280	YES
44	Clean Supply	3021	1	200	0.7	140	Clean Supply	200	2	400	YES
45	Family Consult	3022	1	100	1.5	150	Family Consult	100	2	200	YES
46	Nourishment	3023	1	75	1.6	120	Nourishment	75	2	150	YES
47	Corridor	3024	1	665	1.6	1064	Corridor	665	2	1,330	YES
48	Corridor	3025	1	135	1.6	216	Corridor	135	2	270	YES
49	Meds	3026	1	90	3	270	Meds	90	2	180	NO
50	Jan Closet	3027	1	35	0.3	10.5	Jan Closet	35	2	70	YES
51	Office	3028	1	255	1.5	382.5	Office	255	2	510	YES
52	CCU Rm	3029	1	255	2.8	714	CCU Rm	255	2	510	NO
53	CCU Rm	3030	1	255	2.8	714	CCU Rm	255	2	510	NO
54	CCU Rm	3033	1	255	2.8	714	CCU Rm	255	2	510	NO
55	CCU Rm	3034	1	255	2.8	714	CCU Rm	255	2	510	NO
56	Elec Closet	3035	1	140	1.3	182	Elec Closet	140	2	280	YES
57	Iso CCU Rm	3036	1	260	2.8	728	Iso CCU Rm	260	2	520	NO
58	Iso CCU Rm	3037	1	260	2.8	728	Iso CCU Rm	260	2	520	NO
59	Corridor	3038	1	260	1.6	416	Corridor	260	2	520	YES
60	Nurse's Station	3039	1	865	1.8	1557	Nurse's Station	865	2	1,730	YES
	TOTALS			13011		21984.9	TOTALS	13011		26,022	

Appendix 3 – Mechanical Equipment First Cost:

Mechanical Equipment	Cost
AHU-ED/LAB-1	$1,116,376
AHU-RAD-1	$543,913
AHU-OP-1	$560,018
AHU-ICU-1	$560,018
AHU-ICU-2	$1,196,902
AHU-PT-1	$999,248
AHU-PT-2	$633,223
AHU-5	$95,167
AHU-6	$95,167
AHU-7	$398,967
AHU-11	$27,068
CHILLED WATER PLANT	$1,890,153
BOILER PLANT	$326,700
CLEAN STEAM GENERATOR	$234,256
DOMESTIC WATER SYSTEM PRESSURE	$133,233
DOMESTIC HOT WATER SYSTEM	$242,309
HEAT PUMP COOLING TOWER	$351,384
Total Cost:	**$9,404,102**

Appendix 4 – Emissions Data:

Model CB Boilers — Firetube Boilers

Table A2-13. Model CB Boiler Emission Data

[illegible]		ESTIMATED LEVELS UNCONT		
		[illegible]URAL GAS	[illegible].OIL [B]	[illegible].OIL [C]
CO	ppm[A]	200	90	95
	Lb/MMBtu	0.15	0.07	0.075
NOx	ppm[A]	100	185	502
	Lb/MMBtu	0.12	0.25	0.67
SOx	ppm[A]	1	278	278
	Lb/MMbtu	0.001	0.52	0.52
HC/VOCs	ppm[A]	40	50	70
	Lb/MMBtu	0.016	0.025	0.035
PM	ppm[A]	-	-	-
	Lb/MMBtu	0.01	0.025	0.160

NOTES:
Refer to Section E for detailed emission information.
A. ppm levels corrected to 3% O_2, dry basis.
B. Based on fuel constituent levels of:
Fuel-bound nitrogen content = 0.05% by weight
Sulfur content = 0.5% by weight
Ash content = 0.01% by weight
C. Based on fuel constituent levels of:
Fuel-bound nitrogen content = 0.7% by weight
Sulfur content = 0.5% by weight
Ash content = 0.1% by weight
Conradson carbon residue = 16% by weight

ENGINEERING DATA

The following engineering information is provided for Model CB Firetube Boilers. Additional detail is available from your local Cleaver-Brooks authorized representative. Refer to Tables A2-14 through A2-18.

Blowdown Water Requirements

Some local codes require blowdown tanks to be constructed in accordance with recommendations of the National Board of Boiler and Pressure Vessel Inspectors.

The National Board's recommendations base the size of the blowdown tank on the removal of at least 4 inches of water from the boiler.

Table A2-19 lists the approximate quantity of water represented by 4 inches of water at normal operating level for Cleaver-Brooks Model CB Boilers.

Table A2-14. Heating Surface, Model CB Boilers

BOILER HP	HEATING SURFACE (SQ-FT)	
	FIRESIDE	WATERSIDE
15	75	85
20	100	109
25	125	144
30	150	162
40	200	219
50	250	266
60	300	323
70	350	388
80	400	441
100	500	544
125	625	679
150	750	820
200	1000	1092
250	1250	1346
300	1500	1623
350	1750	1932
400	2000	2151
500	2500	2691
600	3000	3262
700	3500	3810
750	3500	3810
800	3500	3810

A2-24 Cleaver-Brooks

(Emissions data taken from the online Cleaver Brooks® Catalog)

Appendix 4 – Emissions Data (Cont'd):

Estimated Emissions (Volumetric Flow Rate Per Million Btu/hr Input) Boiler Type: Gas fired					
Emitted Pollutants	**Lbm/MMBtu**	**Lbm/MBtu**	**PPM**	**Lbm/MBtu x 5021 MBtu/hr**	**Total Emissions (Lbm/Year)**
Particulates	0.01	0.00001	0	0.05021	363.69
NOx	0.12	0.00012	100	0.60252	4364.28
CO	0.15	0.00015	200	0.75315	5455.34
SOx	0.001	0.000001	1	0.005021	36.37
Hydrocarbons (HC)	0.016	0.000016	40	0.080336	581.90

(The table above shows calculation of Pollutants Emitted by the hospital boilers.)

Appendix 5 – Load Calculations:

Air System Information

Air System Name	CMH 2&3 Flr AHU	Number of zones	35
Equipment Class	UNDEF	Floor Area	13011.0 ft²
Air System Type	VAV	Location	Baltimore, Maryland

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM	Peak zone sensible load	Calculation Months	Jan to Dec
Space CFM	Individual peak space loads	Sizing Data	Calculated

Central Cooling Coil Sizing Data

Total coil load	40.9	Tons	Load occurs at	Jul 1500	
Total coil load	491.1	MBH	OA DB / WB	95.0 / 79.0	°F
Sensible coil load	378.0	MBH	Entering DB / WB	77.3 / 64.5	°F
Coil CFM at Jul 1500	15809	CFM	Leaving DB / WB	55.0 / 53.9	°F
Max block CFM at Jul 1500	18626	CFM	Coil ADP	52.5	°F
Sum of peak zone CFM	19225	CFM	Bypass Factor	0.100	
Sensible heat ratio	0.770		Resulting RH	49	%
ft²/Ton	317.9		Design supply temp.	55.0	°F
BTU/(hr-ft²)	37.7		Zone T-stat Check	35 of 35	OK
Water flow @ 10.0 °F rise	98.28	gpm	Max zone temperature deviation	0.0	°F

Supply Fan Sizing Data

Actual max CFM at Jul 1500	18626	CFM	Fan motor BHP	0.00	BHP
Standard CFM	18523	CFM	Fan motor kW	0.00	kW
Actual max CFM/ft²	1.43	CFM/ft²	Fan static	0.00	in wg

Outdoor Ventilation Air Data

Design airflow CFM	2598	CFM	CFM/person	22.01	CFM/person
CFM/ft²	0.20	CFM/ft²			

Zone Sizing Data

Zone Name	Maximum Cooling Sensible (MBH)	Design Air Flow (CFM)	Minimum Air Flow (CFM)	Time of Peak Load	Maximum Heating Load (MBH)	Zone Floor Area (ft²)	Zone CFM/ft²
VAV 01	11.1	606	6	Jul 1300	6.7	350.0	1.73
VAV 02	10.3	562	6	Jul 1300	5.5	265.0	2.12
VAV 03	7.1	390	4	Jul 1400	5.3	260.0	1.50
VAV 04	10.3	562	6	Jul 1300	5.5	265.0	2.12
VAV 05	31.1	1703	17	Jul 1300	9.8	1125.0	1.51
VAV 06	10.3	562	6	Jul 1300	5.5	265.0	2.12
VAV 07	12.5	687	7	Jul 1300	5.0	665.0	1.03
VAV 08	12.9	705	7	Jul 1300	6.8	345.0	2.04
VAV 09	6.0	329	3	Jul 1000	2.8	108.0	3.05
VAV 10	12.8	703	7	Jul 1300	4.9	680.0	1.03
VAV 11	7.3	402	4	Jul 1400	6.1	260.0	1.55
VAV 12	3.6	195	2	Jul 1400	4.8	140.0	1.39
VAV 13	9.7	534	5	Jul 1600	7.0	255.0	2.09
VAV 14	9.7	534	5	Jul 1600	7.0	255.0	2.09
VAV 15	9.7	534	5	Jul 1600	7.0	255.0	2.09
VAV 16	9.7	534	5	Jul 1600	7.0	255.0	2.09
VAV 17	9.7	530	5	Jul 1300	4.9	495.0	1.07
VAV 18	14.3	784	8	Aug 1300	5.7	360.0	2.18
VAV 19	12.9	706	7	Jul 1600	6.5	290.0	2.44
VAV 20	18.5	1012	10	Jul 1600	11.0	340.0	2.98
VAV 21	6.5	357	4	Jul 1900	3.3	390.0	0.91
VAV 22	10.2	557	6	Jul 1700	5.5	420.0	1.33
VAV 23	5.0	272	3	Jul 1500	1.4	305.0	0.89
VAV 24	9.3	509	5	Jul 1700	3.2	400.0	1.27
VAV 25	7.7	423	4	Jul 0900	3.2	305.0	1.39
VAV 26	6.0	327	3	Jul 2100	1.4	400.0	0.82
VAV 27	7.7	423	4	Jul 0900	3.2	305.0	1.39
VAV 28	9.3	509	5	Jul 1700	3.2	400.0	1.27
VAV 29	4.5	247	2	Jan 2300	0.0	255.0	0.97
VAV 30	14.3	782	8	Jul 1700	4.2	345.0	2.27
VAV 31	12.6	692	7	Jul 1700	2.8	460.0	1.50
VAV 32	7.0	384	4	Jul 1700	2.6	370.0	1.04
VAV 33	4.7	257	3	Jan 2300	0.0	200.0	1.28
VAV 34	8.2	451	5	Jul 0900	2.8	459.0	0.98
VAV 35	8.5	463	5	Jul 2100	0.7	764.0	0.61

Appendix 5 – Load Calculations (Cont'd):

Zone Terminal Sizing Data

Zone Name	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 20.0 °F	Zone Htg Coil Load (MBH)	Zone Htg Water gpm @ 20.0 °F	Mixing Box Fan Airflow (CFM)
VAV 01	6.7	0.67	0.0	0.00	0
VAV 02	5.5	0.55	0.0	0.00	0
VAV 03	5.3	0.53	0.0	0.00	0
VAV 04	5.5	0.55	0.0	0.00	0
VAV 05	9.8	0.98	0.0	0.00	0
VAV 06	5.5	0.55	0.0	0.00	0
VAV 07	5.0	0.50	0.0	0.00	0
VAV 08	6.8	0.68	0.0	0.00	0
VAV 09	2.8	0.28	0.0	0.00	0
VAV 10	4.9	0.49	0.0	0.00	0
VAV 11	6.1	0.61	0.0	0.00	0
VAV 12	4.8	0.48	0.0	0.00	0
VAV 13	7.0	0.70	0.0	0.00	0
VAV 14	7.0	0.70	0.0	0.00	0
VAV 15	7.0	0.70	0.0	0.00	0
VAV 16	7.0	0.70	0.0	0.00	0
VAV 17	4.9	0.49	0.0	0.00	0
VAV 18	5.7	0.57	0.0	0.00	0
VAV 19	6.5	0.65	0.0	0.00	0
VAV 20	11.0	1.10	0.0	0.00	0
VAV 21	3.3	0.33	0.0	0.00	0
VAV 22	5.5	0.55	0.0	0.00	0
VAV 23	1.4	0.14	0.0	0.00	0
VAV 24	3.2	0.32	0.0	0.00	0
VAV 25	3.2	0.32	0.0	0.00	0
VAV 26	1.4	0.14	0.0	0.00	0
VAV 27	3.2	0.32	0.0	0.00	0
VAV 28	3.2	0.32	0.0	0.00	0
VAV 29	0.0	0.00	0.0	0.00	0
VAV 30	4.2	0.42	0.0	0.00	0
VAV 31	2.8	0.28	0.0	0.00	0
VAV 32	2.6	0.26	0.0	0.00	0
VAV 33	0.0	0.00	0.0	0.00	0
VAV 34	2.8	0.28	0.0	0.00	0
VAV 35	0.7	0.07	0.0	0.00	0

Appendix 5 – Load Calculations (Cont'd):

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
VAV 01							
3002 Passage	1	2.1	Jul 1400	114	2.7	85.0	1.34
3003 CCU Rm	1	8.5	Jul 1300	465	3.9	265.0	1.75
VAV 02							
3004 CCU Rm	1	9.9	Jul 1300	541	5.5	265.0	2.04
VAV 03							
3037 Iso CCU Rm	1	6.7	Jul 1400	369	5.3	260.0	1.42
VAV 04							
3005 CCU Rm	1	9.9	Jul 1300	541	5.5	265.0	2.04
VAV 05							
3038 Corridor	1	4.6	Jul 1300	253	2.3	260.0	0.97
3039 Nurse's Station	1	24.8	Jul 1300	1359	7.6	865.0	1.57
VAV 06							
3006 CCU Rm	1	9.9	Jul 1300	541	5.5	265.0	2.04
VAV 07							
3024 Corridor	1	11.6	Jul 1300	633	5.0	665.0	0.95

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
VAV 08							
3007 Family Waiting	1	12.4	Jul 1300	677	6.8	345.0	1.96
VAV 09							
3008 Office	1	5.8	Jul 1000	320	2.8	108.0	2.97
VAV 10							
3015 Equip Storage	1	5.3	Jul 1300	291	2.2	305.0	0.95
3021 Clean Supply	1	3.5	Jul 1300	191	1.4	200.0	0.95
3022 Family Consult	1	1.7	Jul 1300	95	0.7	100.0	0.95
3023 Nourishment	1	1.3	Jul 1300	71	0.5	75.0	0.95
VAV 11							
3036 Iso CCU Rm	1	7.0	Jul 1400	381	6.1	260.0	1.46
VAV 12							
3035 Elec Closet	1	3.4	Jul 1400	184	4.8	140.0	1.31
VAV 13							
3034 CCU Rm	1	9.4	Jul 1600	513	7.0	255.0	2.01
VAV 14							
3033 CCU Rm	1	9.4	Jul 1600	513	7.0	255.0	2.01
VAV 15							
3030 CCU Rm	1	9.4	Jul 1600	513	7.0	255.0	2.01
VAV 16							
3029 CCU Rm	1	9.4	Jul 1600	513	7.0	255.0	2.01
VAV 17							
3018 Staff Toilet	1	1.2	Jul 1300	68	0.9	65.0	1.05
3019 Staff Toilet	1	1.1	Jul 1300	62	0.5	65.0	0.95
3020 Soiled Utility	1	2.6	Jul 1300	140	1.5	140.0	1.00
3025 Corridor	1	2.3	Jul 1300	129	1.0	135.0	0.95
3026 Meds	1	1.7	Jul 1300	91	1.0	90.0	1.01
VAV 18							
3016 Staff Lounge/Locker	1	13.8	Aug 1300	755	5.7	360.0	2.10
VAV 19							
3027 Jan Closet	1	0.7	Jul 1300	37	0.5	35.0	1.05
3028 Office	1	11.8	Jul 1600	649	6.0	255.0	2.54

Appendix 5 – Load Calculations (Cont'd):

VAV 20							
3017 Staff Lounge/Locker	1	18.0	Jul 1600	984	11.0	340.0	2.89
VAV 21							
2002 Passage	1	1.4	Jul 2000	79	1.9	85.0	0.93
2003 Patient Room	1	4.1	Jul 1500	224	1.4	260.0	0.86
2004 Toilet	1	0.4	Jan 2300	23	0.0	45.0	0.51
VAV 22							
2032 Patient Room	1	9.1	Jul 1700	500	5.5	375.0	1.33
2033 Toilet	1	0.4	Jan 2300	23	0.0	45.0	0.51
VAV 23							
2006 Toilet	1	0.4	Jan 2300	23	0.0	45.0	0.51
2007 Patient Room	1	4.1	Jul 1500	224	1.4	260.0	0.86
VAV 24							
2030 Toilet	1	0.4	Jan 2300	23	0.0	45.0	0.51
2031 Patient Room	1	8.3	Jul 1700	454	3.2	355.0	1.28
VAV 25							
2008 Patient Room	1	6.9	Jul 0900	376	3.2	260.0	1.44
2009 Toilet	1	0.4	Jan 2300	23	0.0	45.0	0.51
VAV 26							
2027 Patient Room	1	5.0	Jul 2100	272	1.4	355.0	0.77
2028 Toilet	1	0.4	Jan 2300	23	0.0	45.0	0.51
VAV 27							
2011 Toilet	1	0.4	Jan 2300	23	0.0	45.0	0.51
2012 Patient Room	1	6.9	Jul 0900	376	3.2	260.0	1.44
VAV 28							

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft^2)	Space CFM/ft^2
2025 Toilet	1	0.4	Jan 2300	23	0.0	45.0	0.51
2026 Patient Room	1	8.3	Jul 1700	454	3.2	355.0	1.28
VAV 29							
2021 Nurse's Station	1	3.5	Jan 2300	190	0.0	185.0	1.03
2023 Staff Toilet	1	0.7	Jan 2300	36	0.0	70.0	0.51
VAV 30							
2022 Staff Lounge/Locker	1	13.8	Jul 1700	754	4.2	345.0	2.19
VAV 31							
2019 Med	1	1.9	Jan 2300	102	0.0	140.0	0.73
2020 Staff Work Room	1	10.1	Jul 1700	553	2.8	320.0	1.73
VAV 32							
2017 Service Lobby	1	5.3	Jul 1700	288	2.6	240.0	1.20
2018 Passage	1	1.2	Jan 2300	66	0.0	130.0	0.51
VAV 33							
2015-16 Nurse's Station	1	4.4	Jan 2300	241	0.0	200.0	1.20
VAV 34							
2013 Equipment Storage	1	4.6	Jul 0900	253	2.8	144.0	1.76
2014 Corridor	1	2.9	Jan 2300	161	0.0	315.0	0.51
VAV 35							
2005 Work Station	1	0.1	Jan 2300	6	0.0	12.0	0.51
2010 Work Station	1	0.1	Jan 2300	6	0.0	12.0	0.51
2029 Corridor	1	7.1	Jul 2100	389	0.7	740.0	0.53

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