BISHOP AQUATIC CENTER HEAT/ENERGY BALANCE

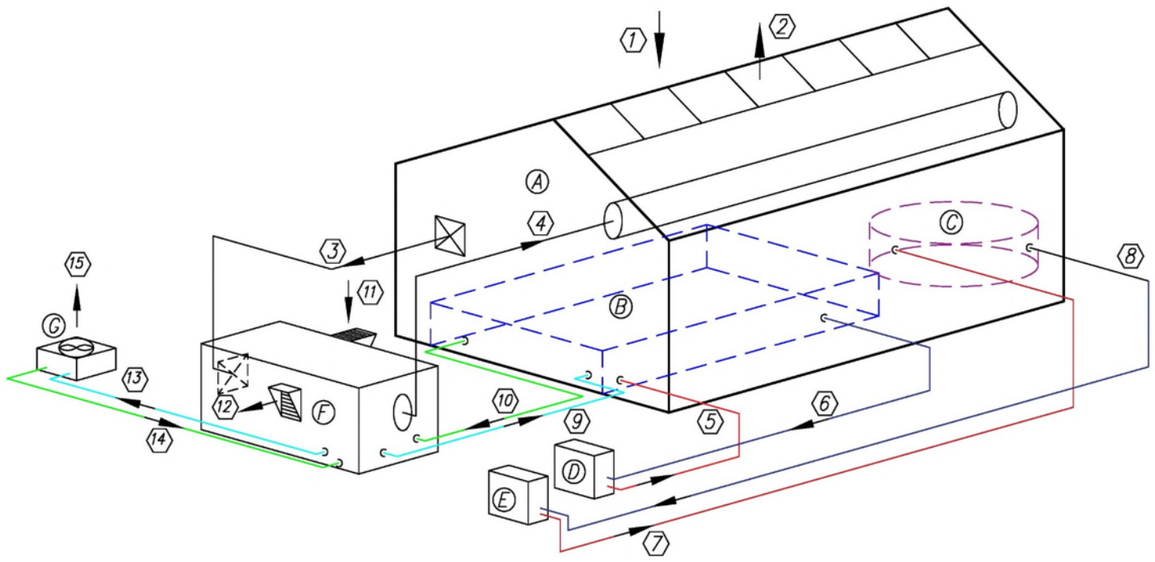
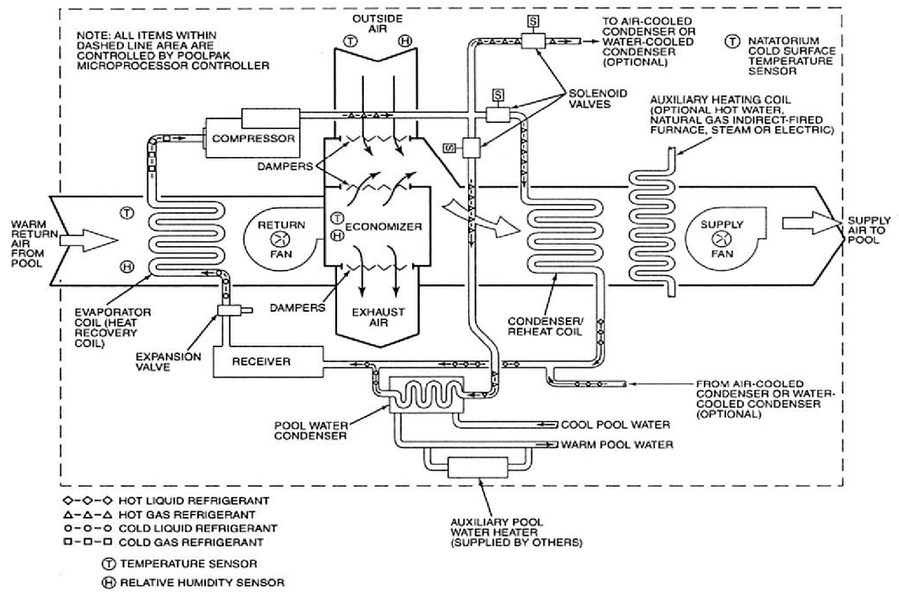


Figure 2-2. SWHP SR System Schematic



Component Parameters/Conditions

Component

	Description	Volume (cu ft)	Volume (gal)	Surface Area (sq ft)	Fluid Dens (lb/cu ft)	Total Mass (lb)	Average T (F)	Relative Hum RH
A	**Aquatic Building (Air Space)**	192000		12750	0.0753	14,458	83	0.6

Relative Humidity Calculation

Date	Time	Dry Bulb Temp (F)	Wet Bulb Temp (F)	DB (Cel) (Celsius)	WB (Cel) (Celsius)	e(d)	e(w)	RH (%)	Dew Point Temp (F)	Sat Ratio (lbw/lba)	Sat Enth (BTU/lba)	Hum Ratio (lbw/lba)	Adj Enth (Btu/lb)	Est. TOTAL Enth (BTU)	Est. Imbalance from Ideal (BTU)	Comment
Ideal Airspace Conditions according to PoolPAK																
		82	**71**	27.8	21.7	37.3	25.9	**58.2**	66.9	0.02401	45.64727	0.01397	**35.00957**	506,154	-	IDEAL (According to PoolPak)
Inside Aquatic Center																
	5/11/2022	7:05 AM	82	76	27.8	24.4	37.3	30.6	76.0	73.3	0.02401	45.64727	0.01824	39.69580	573,906	67,752	Roof Partially Open
	5/11/2022	12:25 PM	95	80	35.0	26.7	56.3	35.0	51.9	77.7	0.03706	63.86000	0.01925	44.03124	636,586	130,432	Roof Open
	5/12/2022	7:20 AM	85	76	29.4	24.4	41.1	30.6	66.2	72.8	0.02654	49.29547	0.01757	39.69961	573,961	67,807	Roof Closed
	5/12/2022	7:30 AM	80	76	26.7	24.4	35.0	30.6	83.3	74.0	0.02246	43.37491	0.01870	39.70460	574,033	67,879	Roof Partially Open
	5/12/2022	1:10 PM	95	82	35.0	27.8	56.3	37.3	57.5	79.7	0.03706	63.86000	0.02130	46.29365	669,295	163,141	Roof Open
	5/13/2022	7:10 AM	82	76	27.8	24.4	37.3	30.6	76.0	73.3	0.02401	45.64727	0.01824	39.69580	573,906	67,752	Roof Partially Open
	5/13/2022	1:00 PM	95	77	35.0	25.0	56.3	31.7	44.1	74.9	0.03706	63.86000	0.01633	40.81684	590,114	83,959	Roof Open
PoolPak Exhaust Air																
	5/13/2022	1:10 PM	80	70	26.7	21.1	35.0	25.0	60.7	65.9	0.02245703	43.37491	0.01363511	34.15117	493,744	(12,410)	**WHY ARE WE REJECTING?**

Relative Humidity Equation

$$e_d = 6.112 \cdot e^{\left(\frac{17.502 \cdot T_d}{240.97 + T_d}\right)}$$

$$\left(\frac{17.502 \cdot T_w}{\quad + T_w}\right)$$

	Description	Volume (cu ft)	Volume (gal)	Surface Ar (sq ft)	Ave Depth (ft)	Fluid Dens (lb/cu ft)	Total Mass (lb)	Desired Temp (F)	Measured Temp (F)	Enthalpy Change (BTU)	Enthalpy Chng (Ton)
B	Lap Pool (72L x 66W)	33,420.23	250,000	4774	7.0	62.4	2,085,422	82	86	**8,341,688**	**695.14**

C	Thera Pool (55'Dia.)	5,881.96	44,000	1185	5.0	62.4	367,034	93	93	-

	Description	Heat Rate (BTU/hr)	Heat Rate (Ton)	Water Flow (GPM)	Heat Chng Pool (F/hr)
D	Lap Pool Heater - Pentair	638,000	53.17		3.27
E	Thera Pool Heater - Pentair	638,000	53.17		0.58

	Description	Evap Coil Cap (BTU/hr)	Evap Coil (Ton)	Pool Cond (BTU/hr)	Evap Coil (Ton)	Supply Fan Flow (cfm)	Air Density (lbs/cu ft)	Air Mass Flow (lbs/n	Air Mass Flow (bs/hr)
F	PoolPak	719,000	59.92	850000	70.8	28000	0.0897	2511.6	150,696

	Description
G	PoolPak - Air Cooled Condenser

$$e_w = 6.112 * e^{(240.97 * T_w)}$$

$$\text{Relative Humidity} = \frac{e_w - N*(1+.00115*T_w)*(T_d - T_w)}{e_d} * 100$$

e = 2.71828182845904
T_d = Dry Bulb Temperature (Celsius)
T_w = Wet Bulb Temperature (Celsius)
N=.6687451584

FLOW - Heat/Mass/Entergy Balance

Line	
1	Solar Radiance into Aquatic Center Air Space

Overall Thermal Transfer

1/4" Glass Single(Horizontal Summer)	0.862068966	BTU/ft^2-F-hr
1/4" Glass Double (Horizontal Summer)	0.5	BTU/ft^2-F-hr

The instantaneous heat gain through transparent areas such as windows and skylights not in direct sunlight:
q = UA(To - Ti)

Assuming half of the roof is not in direct sunlight: 12,750 sq ft/2 =		6375	sq ft		
Air Temperature Difference (inside - Outside)		30	Delta F		
1/4" Glass Single (Farside Roof)	q =	164,871	BTU/hr =	13.74	Tons
1/4" Glass Double (Farside Roof)	q =	95,625	BTU/hr =	7.97	Tons

If the window is in direct sunlight, a portion of the incident solar radiation will be transmitted through the glass
The Instantaneous gain:
q = A(Cs Fshg +U(To - Ti))

Fshg

Table 11.11
Typical Shading Coefficients

glass type	thickness	C_s
single		
regular sheet	$\frac{3}{32}$", $\frac{1}{8}$"	1.00
regular plate	$\frac{1}{4}$"	.95
regular plate	$\frac{3}{8}$"	.91
heat absorbing sheet	$\frac{7}{32}$"	.71
heat absorbing plate*	$\frac{1}{4}$"	.67
	$\frac{3}{8}$"	.57
gray sheet	$\frac{1}{4}$"	.86
gray plate	$\frac{1}{4}$"	.70
double (up to $\frac{1}{2}$" air space)		
both regular sheet	$\frac{3}{32}$", $\frac{1}{8}$"	.90
both regular plate*	$\frac{1}{4}$"	.83

*Plate glass is sheet glass which has been ground and polished.

Table 11.12
Typical Solar Heat Gain Factors
40° North latitude, July 21
BTU/hr-ft²

time a.m.	time p.m.	a.m. orientation N	E	S	W	horizontal
5	7	0	1	0	0	0
6	6	37	137	10	10	31
7	5	30	204	20	19	88
8	4	28	216	29	26	145
9	3	32	194	52	31	194
10	2	35	146	80	35	231
11	1	37	81	102	37	255
12	12	38	41	109	41	262
		N	W	S	E	horizontal
		p.m. orientation				

Cs for Single 1/4" plate glass =	0.95	Fshg (40 deg July 21) =	216	BTU/hr-ft2
Cs for Double 1/4" plate glass =	0.83			

1/4" Glass Single (Direct side Roof)	q =	1,504,896	BTU/hr =	125.41	Tons
1/4" Glass Double (Direct side Roof)	q =	1,337,348	BTU/hr =	111.45	Tons

Expected Heat Gain through Roof (Single plate glass) =	**1,669,766**	BTU/hr =	**139.15**	Tons
Expected Heat Gain through Roof (Double plate glass) =	**1,432,973**	BTU/hr =	**119.41**	Tons

2 Roof Heat Rejection

3 Return Air to PoolPak

Description	Flow (Max Cap) (CFM)	Estimated Temp (F)	Estimated Rel Hum	Calc DB Temp (F)	Fluid Dens (lb/cu ft)	Total Mass (lb)	Desired Temp (F)	Measured Temp (F)	Enthalpy Change (BTU)	Enthalpy Chng (Ton)
Moist Air Back to PoolPak	28000	90	75							

4 Supplied Air from Pool Pak

Description	Flow (Max Cap) (CFM)	Estimated Temp (F)	Estimated Rel Hum	Calc DB Temp (F)	Fluid Dens (lb/cu ft)	Total Mass (lb)	Desired Temp (F)	Measured Temp (F)	Enthalpy Change (BTU)	Enthalpy Chng (Ton)
Dry Air to Aquatic Air Space	28000	84	60							