



VENMAR CES^{INC}

COST-EFFECTIVE COMMERCIAL VENTILATION™

CALCULATION OF VENTILATION REQUIREMENTS FOR INDOOR POOLS BASED ON MOISTURE EVAPORATION

The prime reason for ventilation of enclosed pool areas is to prevent build up of uncomfortable and possibly damaging humidity. Therefore, ventilation rates for pool areas can best be determined by examining the moisture removing capabilities of an air-to-air heat exchanger at various flow rates and then comparing this capability with the amount of moisture introduced into the air from the pool.

In general , it may be said that a mechanical ventilation rate of 1 ACH (one air change per hour) of the pool enclosure will be sufficient to maintain reasonable relative humidity levels when a pool cover is used regularly. However, the ventilation system should be capable of supplying 2 (two) ACH for maintenance of good air quality in all operating conditions.

MOISTURE PRODUCTION OF INDOOR POOLS:

The amount of water evaporated from a pool depends on:

- a) the surface area of the pool;
- b) the water temperature;
- c) the indoor air temperature and relative humidity;
- d) the amount of air movement over the pool surface.

In short, the following principles apply:

- 1) The larger the water surface area, the greater the amount of water evaporated. Therefore, using a pool cover to reduce the surface area of water exposed reduces the amount of water evaporated;
- 2) The higher the water temperature, the higher the evaporation rate;
- 3) The lower the indoor air temperature, the higher the evaporation rate;
- 4) The lower the indoor relative humidity the higher the evaporation rate;
- 5) The greater the air movement over the pool area, the higher the evaporation rate. Thus, activity in the pool area will increase the evaporation rate.

CHART 1 (Evaporation Rates) gives specific rates for various conditions.

CALCULATION OF VENTILATION REQUIREMENTS FOR INDOOR POOLS BASED ON MOISTURE EVAPORATION Continued

MOISTURE REMOVAL CAPABILITIES:

In addition to the volume of air being exchanged, moisture removal depends largely on the moisture content of both the inside and outside air. The actual content can be calculated knowing the air temperature and its relative humidity.

While CHART II (Flowrate Factor) shows specific flowrates required for a pound of water removal, the trends below outline the principles:

- 1) The higher the indoor relative humidity, the larger the moisture removing capabilities;
- 2) The higher the indoor temperature, the larger the moisture removing capabilities;
- 3) The lower the outdoor temperature, the larger the moisture removing capabilities.

Detailed Calculation of Total Ventilation Requirements:

Using the CHARTS and equations provided on the worksheet, and making decisions on water temperature, indoor temperature and relative humidity levels based on comfort levels, energy use and window construction (triple glazed windows will allow higher humidity levels before condensation occurs than will single or double glazed), calculate the required total ventilation rate.

The application of the theoretical total ventilation rate, to the pool in design, should be adjusted for natural ventilation rates, pool, and pool cover use, to give the required mechanical ventilation rate.

The calculation for the minimum air required to remove water which evaporates from the surface of a pool is obtained from the ASHRAE APPLICATIONS HANDBOOK.

The first table contains the "evaporation rate" of water based on the water temperature, room temperature and room relative humidity.

The second table contains the "flowrate factor" based on the indoor temperature, outdoor temperature, and room relative humidity.

The total ventilation rate per square foot of water surface area is the product of these two values.

The total ventilation rate is this product multiplied by the water surface area.

(See calculation next page)

CALCULATION OF VENTILATION REQUIREMENTS FOR INDOOR POOLS BASED ON MOISTURE EVAPORATION Continued

Calculation:

1. From Table 1, select the appropriate “evaporation rate” based on the room air temperature, water temperature and relative humidity.

Example: From Table I

Air Temp. = 30°C

Water Temp. = 28°C

Relative Humidity = 50%

Evaporation Rate = 0.050 lb/(sq.ft-hr.)

2. From Table II, select the corresponding “flowrate factor” depending on the indoor air temperature, outdoor air temperature and room relative humidity.

Example: From Table II

Indoor Temp. = 30°C

Outdoor Temp. = -10°C

Relative Humidity = 50%

Flowrate Factor = 19.20 cfm-hr/lb.

3. Multiply the values obtained from Step 1 and Step 2 to obtain the minimum required flowrate.

Min. flowrate = 0.050 x 19.20 cfm/sq.ft.

Min. flowrate = .96 cfm/sq.ft.

4. Multiply the value in Step 3 by the area of the pool.

Example: If the pool area is 500 sq. ft. (a standard 16' x 32' pool)

The total required flowrate = 480 cfm.

This total ventilation rate can now be used to calculate the mechanical ventilation rate required.

Assume that the pool enclosure has a natural ventilation rate of .25 ACH (or if the actual value is known, use the known value). Calculate the pool enclosure volume and corresponding air volume leakage in cfm.

(See example next page)

CALCULATION OF VENTILATION REQUIREMENTS FOR INDOOR POOLS BASED ON MOISTURE EVAPORATION Continued

Example: If pool enclosure is 30' x 50' x 12'
Total volume is 18,000 cubic feet
With a natural ventilation rate of .25 ACH

$$\begin{aligned}\text{Air volume per hour} &= 18,000 \times .25 \\ &= 4500 \text{ cu.ft./hr}\end{aligned}$$

OR 75 cu.ft./min (cfm)

Subtract the natural ventilation rate from the total ventilation rate required.

In our Example: Mechanical ventilation rate required = 480 - 75 = 405 cfm

If a pool cover is to be used regularly, the mechanical ventilation rate can be reduced by 1/3rd.

In our Example: Mechanical ventilation rate required with pool cover = 405 x .66 = 267 cfm

This would represent the minimum mechanical ventilation rate to be supplied.

* * *

SYSTEM INSTALLATION

After calculating the mechanical ventilation rate required for the pool enclosure, it is necessary to consider the distribution network for both the supply and exhaust air streams.

Proper duct design will:

1. minimize air flow requirements;
2. ensure a comfortable recreation environment;
3. optimize humidity control , including elimination of condensation on windows.

Please refer to Sketch I and 2, enclosed, for typical layouts.

In general, please note that:

1. The airflows and duct lengths Indicated on the sketches are meant as examples only - actual performance may differ;

CALCULATION OF VENTILATION REQUIREMENTS FOR INDOOR POOLS BASED ON MOISTURE EVAPORATION Continued

2. Supply air should be discharged near exterior windows. If the supply air is being heated, the supply grills may be close to the ground - otherwise, discharge height should be at least eight feet.
3. Return grills and lines should be located near the ceiling;
4. Maintain a reasonable distance (at least eight feet) between supply and return grills, to prevent short circuiting.

Reheating of Supply Air:

Although the air-to-air heat exchanger will recover up to 80% of indoor air temperature, the incoming fresh air supply may be uncomfortably cool. Therefore it may be desirable to add an electric duct heater to heat the incoming air.

The accompanying chart gives examples of the power required in a duct heater to heat the incoming air at various conditions.

REHEAT REQUIRED TO BRING THE INCOMING AIRSTREAM UP TO VARIOUS TEMPERATURES BASED ON TWO AIRFLOWS

Airflow (cfm)	Indoor Air Temp. (°C)	Reheat Required at Outdoor Air Temp. (KW)			
		0°C	-10°C	-20°C	-30°C
350	20	1.5	2.5	3.0	4.0
350	25	2.5	3.5	4.0	5.0
350	30	3.5	4.5	5.0	6.0
700	20	3.5	5.5	7.0	8.5
700	25	5.5	7.5	9.0	10.5
700	30	7.5	9.5	11.0	12.5

CHART I (°C) Evaporation Rate

Air Temp °C	Relative Humidity																										
	40%			50%			60%			40%			50%			60%			40%			50%			60%		
	Evaporation Rate lb/(sq.ft-hr)																										
20	0.061	0.054	0.047	0.072	0.065	0.058	0.084	0.078	0.071	0.098	0.091	0.085	0.113	0.107	0.100	0.130	0.123	0.117									
21	0.059	0.052	0.045	0.070	0.063	0.056	0.083	0.075	0.068	0.096	0.089	0.082	0.112	0.104	0.097	0.128	0.121	0.114									
22	0.057	0.050	0.042	0.068	0.061	0.053	0.081	0.073	0.065	0.095	0.087	0.079	0.110	0.102	0.094	0.127	0.119	0.111									
23	0.055	0.047	0.039	0.067	0.058	0.050	0.079	0.071	0.063	0.093	0.085	0.076	0.108	0.100	0.091	0.125	0.116	0.108									
24	0.053	0.045	0.036	0.065	0.056	0.047	0.077	0.068	0.060	0.091	0.082	0.073	0.106	0.097	0.088	0.123	0.114	0.105									
25	0.051	0.042	0.033	0.062	0.053	0.044	0.075	0.066	0.056	0.089	0.079	0.070	0.104	0.094	0.085	0.120	0.111	0.102									
26	0.049	0.039	0.029	0.060	0.050	0.040	0.073	0.063	0.053	0.086	0.076	0.067	0.101	0.092	0.082	0.118	0.108	0.098									
27	0.047	0.036	0.026	0.058	0.047	0.037	0.070	0.060	0.049	0.084	0.073	0.063	0.099	0.089	0.078	0.116	0.105	0.095									
28	0.044	0.033	0.022	0.055	0.044	0.033	0.068	0.057	0.045	0.081	0.070	0.059	0.097	0.085	0.074	0.113	0.102	0.091									
29	0.041	0.030	0.018	0.053	0.041	0.029	0.065	0.053	0.041	0.079	0.067	0.055	0.094	0.082	0.070	0.111	0.099	0.087									
30	0.039	0.026	0.014	0.050	0.037	0.025	0.062	0.050	0.037	0.076	0.063	0.051	0.091	0.079	0.066	0.108	0.095	0.083									
Water Temp °C	24			26			28			30			32			34											

CHART I (°F) Evaporation Rate

Air Temp °F	Relative Humidity																										
	40%			50%			60%			40%			50%			60%			40%			50%			60%		
	40%	50%	60%	40%	50%	60%	40%	50%	60%	40%	50%	60%	40%	50%	60%	40%	50%	60%	40%	50%	60%	40%	50%	60%			
Evaporation Rate lb/(sq.ft-hr)																											
68	0.069	0.063	0.056	0.079	0.073	0.066	0.090	0.084	0.077	0.102	0.095	0.089	0.115	0.108	0.102	0.129	0.122	0.116									
70	0.068	0.060	0.053	0.078	0.070	0.063	0.088	0.081	0.074	0.100	0.093	0.086	0.113	0.106	0.099	0.127	0.120	0.113									
72	0.065	0.058	0.050	0.075	0.068	0.060	0.086	0.079	0.071	0.098	0.090	0.083	0.111	0.103	0.096	0.125	0.117	0.110									
74	0.063	0.055	0.047	0.073	0.065	0.057	0.084	0.076	0.068	0.096	0.088	0.079	0.109	0.101	0.092	0.123	0.115	0.106									
76	0.061	0.052	0.043	0.071	0.062	0.053	0.082	0.073	0.064	0.094	0.085	0.076	0.107	0.098	0.089	0.121	0.112	0.103									
78	0.059	0.049	0.039	0.069	0.059	0.049	0.080	0.070	0.060	0.091	0.082	0.072	0.104	0.095	0.085	0.118	0.109	0.099									
80	0.056	0.046	0.035	0.066	0.056	0.045	0.077	0.067	0.056	0.089	0.079	0.068	0.102	0.091	0.081	0.116	0.105	0.095									
82	0.053	0.042	0.031	0.063	0.052	0.041	0.074	0.063	0.052	0.086	0.075	0.064	0.099	0.088	0.077	0.113	0.102	0.091									
84	0.050	0.039	0.027	0.060	0.049	0.037	0.071	0.060	0.048	0.083	0.071	0.060	0.096	0.084	0.073	0.110	0.098	0.087									
86	0.047	0.035	0.022	0.057	0.045	0.032	0.068	0.056	0.043	0.080	0.068	0.055	0.093	0.080	0.068	0.107	0.094	0.082									
88	0.044	0.031	0.017	0.054	0.041	0.027	0.065	0.052	0.038	0.077	0.063	0.050	0.090	0.076	0.063	0.104	0.090	0.077									
Water Temp °F	78			81			84			87			90			93											

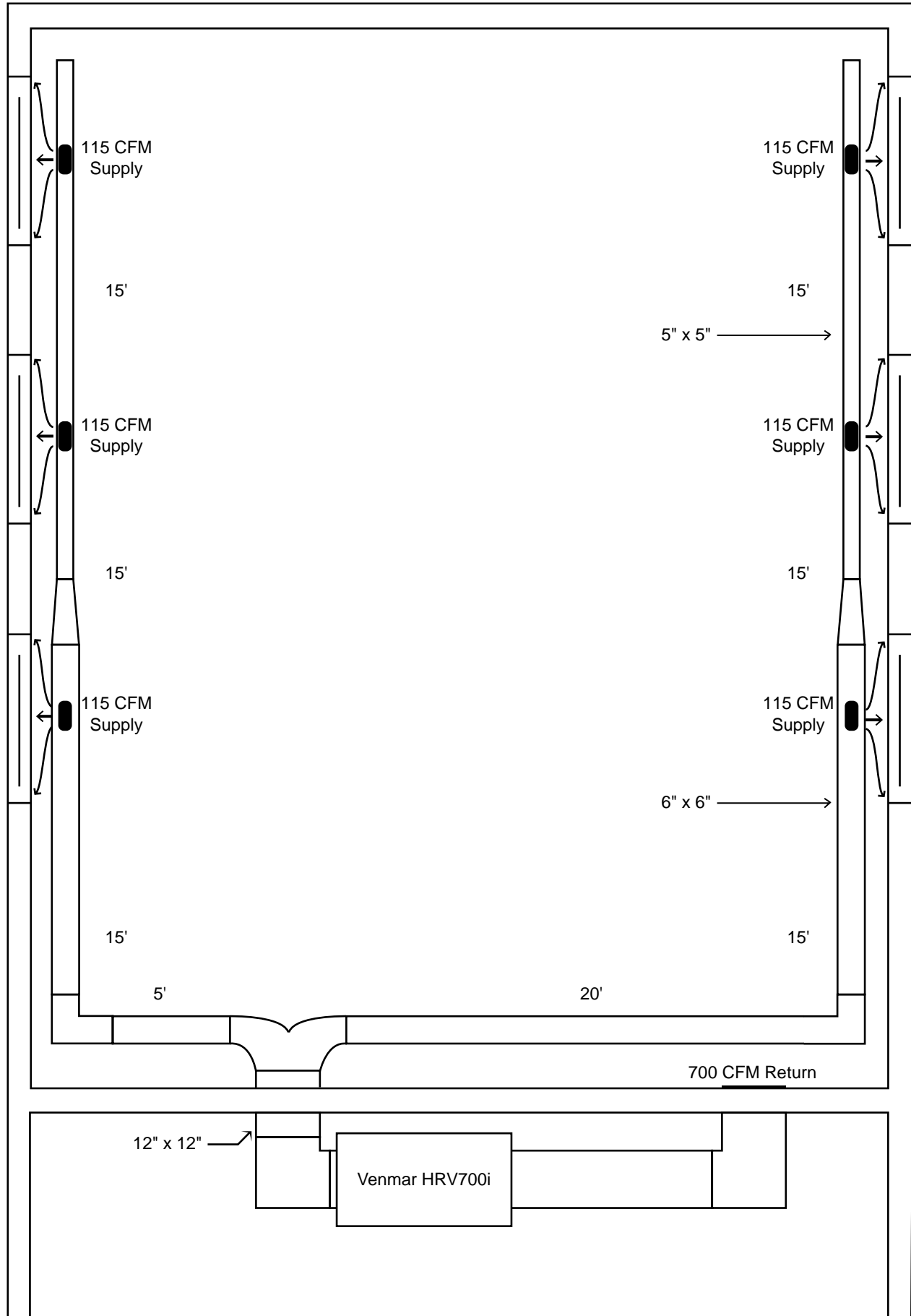
CHART II (°C) Flowrate Factor

Outside Temp °C	Relative Humidity																										
	40%			50%			60%			40%			50%			60%			40%			50%			60%		
	Flowrate Factor (cfm-hr/lb)																										
-35.0	39.70	31.40	26.00	34.90	27.70	22.90	30.80	24.40	20.20	27.20	21.60	17.90	24.10	19.10	15.80	21.30	16.90	14.00									
-32.5	40.00	31.70	26.20	35.20	27.90	23.00	31.00	24.50	20.30	27.40	21.70	17.90	24.20	19.20	15.90	21.50	17.00	14.10									
-30.0	40.50	32.00	26.40	35.60	28.10	23.20	31.30	24.70	20.40	27.60	21.80	18.00	24.40	19.30	15.90	21.60	17.10	14.10									
-27.5	41.10	32.40	26.60	36.00	28.40	23.40	31.70	25.00	20.60	27.90	22.00	18.20	24.60	19.40	16.00	21.80	17.20	14.20									
-25.0	41.90	32.80	27.00	36.60	28.80	23.80	32.10	25.20	20.80	28.20	22.20	18.30	24.90	19.60	16.20	22.00	17.30	14.30									
-22.5	42.90	33.50	27.40	37.40	29.20	24.00	32.70	25.60	21.00	28.70	22.50	18.50	25.20	19.80	16.30	22.30	17.50	14.40									
-20.0	44.20	34.20	27.90	38.40	29.80	24.40	33.40	26.10	21.30	29.30	22.90	18.70	25.70	20.10	16.50	22.60	17.70	14.60									
-17.5	45.90	35.20	28.60	39.60	30.60	24.90	34.40	26.60	21.70	30.00	23.30	19.00	26.20	20.40	16.70	23.00	18.00	14.70									
-15.0	48.10	36.50	29.40	41.30	31.50	25.50	35.60	27.40	22.20	30.90	23.80	19.40	26.90	20.90	17.00	23.60	18.30	14.90									
-12.5	51.10	38.20	30.50	43.40	32.80	26.30	37.20	28.50	22.80	32.10	24.50	19.90	27.80	21.40	17.40	24.10	18.70	15.20									
-10.0	55.10	40.40	31.90	46.30	34.40	27.30	39.30	29.50	23.60	33.60	25.40	20.40	29.50	22.10	17.80	25.10	19.20	15.60									
-7.5	60.90	43.40	33.70	50.30	36.60	28.70	42.20	31.10	24.60	35.70	26.60	21.20	30.50	22.90	18.40	26.30	19.90	16.00									
-5.0	69.50	47.70	36.20	56.10	39.50	30.50	46.10	33.20	25.90	38.30	28.10	22.10	32.50	24.10	19.10	27.80	20.70	16.50									
-2.5	83.60	53.90	39.70	64.90	43.70	32.90	51.90	36.10	27.60	42.50	30.20	23.40	35.30	25.60	20.00	29.80	21.30	17.20									
0.0	56.80	41.30	32.40	47.50	35.00	27.70	40.10	30.00	23.90	34.30	25.80	20.70	29.40	22.30	18.00	25.50	19.40	15.70									
2.5	62.70	44.40	34.30	51.60	37.20	29.10	43.00	31.50	24.90	36.30	27.00	21.40	31.00	23.20	18.50	26.60	20.10	16.10									
5.0	71.50	48.60	36.80	57.40	40.10	30.80	47.00	33.60	26.10	39.10	28.50	22.30	33.00	24.30	19.20	28.10	20.90	16.60									
7.5	85.60	54.70	40.10	66.10	44.20	33.20	52.70	36.40	27.80	43.00	30.50	23.50	35.70	25.70	20.10	30.00	22.00	17.30									
10.0	110.9	64.00	45.00	80.20	50.10	36.40	61.30	40.40	30.00	48.60	33.10	25.10	39.40	27.60	21.30	32.60	23.30	18.10									
12.5	169.0	79.90	52.20	106.8	59.40	41.00	75.70	46.10	33.10	57.20	36.90	27.20	44.90	30.20	22.70	36.30	25.20	19.20									
15.0	429.6	112.0	64.30	173.1	75.40	48.10	103.9	55.3	37.6	71.90	42.60	30.20	53.60	33.90	24.80	41.70	27.70	20.60									
Indoor Temp °C	20			22			24			26			28			30											

CHART II (°F) Flowrate Factor

Outside Temp °F	Relative Humidity																	
	40%	50%	60%	40%	50%	60%	40%	50%	60%	40%	50%	60%	40%	50%	60%	40%	50%	60%
Flowrate Factor (cfm-hr/lb)																		
-30.0	39.70	31.50	26.10	35.70	28.30	23.40	32.10	25.50	21.10	29.00	23.00	19.00	26.10	20.70	17.20	23.60	18.70	15.50
-25.0	40.20	31.80	26.20	36.10	28.50	23.60	32.40	25.70	21.20	29.20	23.10	19.10	26.30	20.90	17.20	23.80	18.80	15.60
-20.0	40.80	32.10	26.50	36.50	28.80	23.80	32.80	25.90	21.40	29.50	23.30	19.20	26.60	21.00	17.40	24.00	19.00	15.70
-15.0	41.60	32.60	26.80	37.20	29.20	24.00	33.30	26.20	21.60	29.90	23.60	19.40	26.90	21.20	17.50	24.20	19.10	15.80
-10.0	42.60	33.20	27.20	38.00	29.70	24.40	34.00	26.60	21.90	30.40	23.90	19.60	27.30	21.50	17.70	24.60	19.30	15.90
-5.0	43.90	34.10	27.80	39.00	30.40	24.80	34.80	27.10	22.20	31.10	24.30	19.90	27.90	21.80	17.90	25.00	19.60	16.10
0.0	45.70	35.10	28.50	40.40	31.20	25.40	35.90	27.80	22.70	32.00	24.80	20.30	28.60	22.20	18.20	25.60	20.00	16.30
5.0	48.10	36.50	29.40	42.30	32.30	26.10	37.40	28.70	23.20	33.20	25.50	20.70	29.50	22.80	18.60	26.30	20.40	16.60
10.0	51.50	38.40	30.60	44.90	33.80	27.00	39.40	29.80	24.00	34.70	26.40	21.30	30.70	23.50	19.00	27.30	21.00	17.00
15.0	56.20	41.00	32.20	48.50	35.80	28.30	42.10	31.40	25.00	36.80	27.60	22.10	32.40	24.50	19.60	28.60	21.70	17.50
20.0	63.40	44.70	34.50	53.70	38.50	30.00	46.00	33.50	26.30	39.70	29.30	23.10	34.60	25.70	20.40	30.30	22.70	18.10
25.0	74.90	50.10	37.60	61.70	42.50	32.40	51.80	36.40	28.10	44.00	31.50	24.50	37.80	27.40	21.50	32.70	24.10	19.00
30.0	95.90	58.70	42.30	75.30	48.50	38.80	61.00	40.80	30.60	50.50	34.70	26.40	42.50	29.80	23.00	36.20	25.90	20.10
35.0	60.50	43.20	33.60	51.60	37.40	29.40	44.50	32.70	25.80	38.60	28.60	22.70	33.70	25.20	20.10	29.70	22.40	17.90
40.0	69.20	47.50	36.10	57.80	40.60	31.30	49.00	35.00	27.20	42.00	30.50	23.90	36.30	26.70	21.00	31.60	23.40	18.60
45.0	83.60	53.90	39.70	67.50	45.20	33.90	55.80	38.40	29.20	46.90	33.00	25.40	39.90	28.50	22.20	34.30	24.90	19.50
50.0	110.9	64.00	45.00	84.30	52.10	37.70	66.70	43.30	32.00	54.40	36.50	27.40	45.20	31.20	23.70	38.20	26.90	20.70
55.0	180.3	82.40	53.30	119.2	63.30	43.30	86.90	50.90	36.00	67.00	41.80	30.30	53.60	34.90	25.90	44.00	29.60	22.30
60.0	686.3	124.0	68.10	232.3	86.00	52.60	134.7	64.30	42.20	92.30	50.40	34.60	68.60	40.80	28.90	53.60	33.70	24.50
Indoor Temp °F	68			71			74			77			80			83		

SKETCH #1



SKETCH #2

