SWIMMING POOL DESIGN CRITERIA

by

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INTRODUCTION

A hospital therapy pool was designed with a return air system that ducted from 0 - 100% of return air back through the air handler. Over time the corrosive, chlorinated air has caused the fins on the air handling unit (AHU) coils to rust away, leaving bare tubes. The facility has hot and chilled water available, and these are the means by which a stable and healthy pool environment had to be crafted.

The pool enclosure (see Figure 1) is 45' X 65', 10' high and the only glass is three skylights. The existing system supplies 5000 cfm of air through ducts above the 30' X 60' pool surface. The air flow is minimal across the pool surface, and the return duct is high (water vapor tends to rise); two important design criteria: the system provides almost 6 air changes per hour, which is adequate for most codes. No changes to the ductwork or air quantity is needed.

The pool water is maintained at about 98°F. This causes a high humidity problem year-round. At present the occupants complain in the summer of high humidity and high temperature and of high humidity and low temperature in the winter. The client needs an economical system that provides comfortable conditions in all seasons.

The ASHRAE Handbook specifies 80 to 85°F at 50 to 60% humidity for a therapy pool environment. This was the design target.

RATE OF EVAPORATION

ASHRAE gives a function to find the rate of evaporation from the pool surface, normalized for 1000 Btu/lb for water to vapor at the surface water temperature and for air velocities of 10 to 30 fpm over the water surface:

$$Wp = 0.1 A (Pw - Pa) \qquad (1)$$

where Wp = evaporation of water, lb/hour

A = area of pool surface, sq. ft.

Pw = saturation vapor pressure at the surface water temperature, in. Hg.

Pa = saturation vapor pressure at room air dew point, in. Hg.

Ambient temp.	Rh	Lbs. Moisture	Grains Needed	Grains Available
80	50	180	58	14
80	70	150	49	43
85	50	161	52	25
85	60	146	47	47
80	75	146	47	47
90	50	146	47	47

TABLE ONE - Moisture Conditions

The analysis requires the evaluation of evaporation rate at several conditions, as illustrated in Table One. The third column shows the rate of evaporation at the given conditions of temperature and relative humidity. The fourth column shows the grain depression in the supply air needed to offset the given amount of evaporation, for air leaving the cooling coil at 55 dB/54.5wB.

GRAIN DEPRESSION

The first task is to find the weight of air introduced into the space by the HVAC system:

$$5000 \text{ cu.ft./min.} * \text{lb. air}/13.8 \text{ cu.ft.} = 362 \text{ lb air/min.} \quad (2)$$

where the volume of air in cubic feet, per pound of dry air is taken off the psychometric chart. Next, the rate of evaporation from the pool surface is converted into grains/minute:

$$180 \text{ lb./hr.} * \text{hr.}/60 \text{ min.} * 7000 \text{ gr./lb.} = 21{,}000 \text{ gr./min.} \quad (3)$$

This is multiplied by the amount of air entering the conditioned space each minute:

$$21{,}000 \text{ gr./min.} * \text{min.}/362 \text{ lb. air} = 58 \text{ grains/lb. dry air} \quad (4)$$

to give the amount of grains that are added to each pound of air ducted to the space. Conversely, this is the number of grains/lb. that the dehumidified air must be lower, than the space setpoint conditions, in order to maintain a stable environment.

The last column in Table 1 gives the amount of dehumidification that is available with leaving coil conditions of 55 dB/54.5 wB and 65 grains/lb. The Table shows that more moisture is introduced to the space than is "extracted" in the first three conditions - so the 80°F air will drift upward in humidity to 75% (line #5) before the system stabilizes. Also, 85°F will stabilize at 60% humidity and 90°F air will reach an equilibrium at 50% humidity.

The condition that is closest to the ASHRAE target is 85°F/60% - this will be used to size the air handler capacity.

COIL SECTION

The cooling coil must be sized to bring the air down to 55/54.9 during the hottest day of the year outside (assuming a 100% outside air system). This gives a capacity of 28 tons cooling.

outside air h = 38.5 Btu/lb

h = 23.1 Btu/lb off coil

$$Q = \frac{4.45 * 5000 \text{ cfm } (38.5 - 23.1)}{12{,}000 \text{ Btu/ton}} = 28.5 \text{ Tons} \quad (5)$$

This process is shown in Figure 1. The diamond points show the average ambient conditions through the cooling season. The above enthalpy is the maximum at any temperature - the ASHRAE peak is slightly lower, as shown.

The next step is to evaluate the actual cooling load of the space. This has two components: (1) the space load as calculated by an energy analysis program, to include envelope, people and equipment, (this was calculated to be 6.6 tons), and (2) the heat emitted by the 98°F pool surface into the conditioned space. This was estimated by assuming a nominal U-value of 1/0.6 for the pool surface (e.g. for still air, heat flow upward). Substituting

$$Q = UA (T_1 - T_2) \quad (6)$$

$$= 1/.6 \text{ (1800 sq.ft.) } (102 - 85)$$

$$= 51{,}000 \text{ Btu H}$$

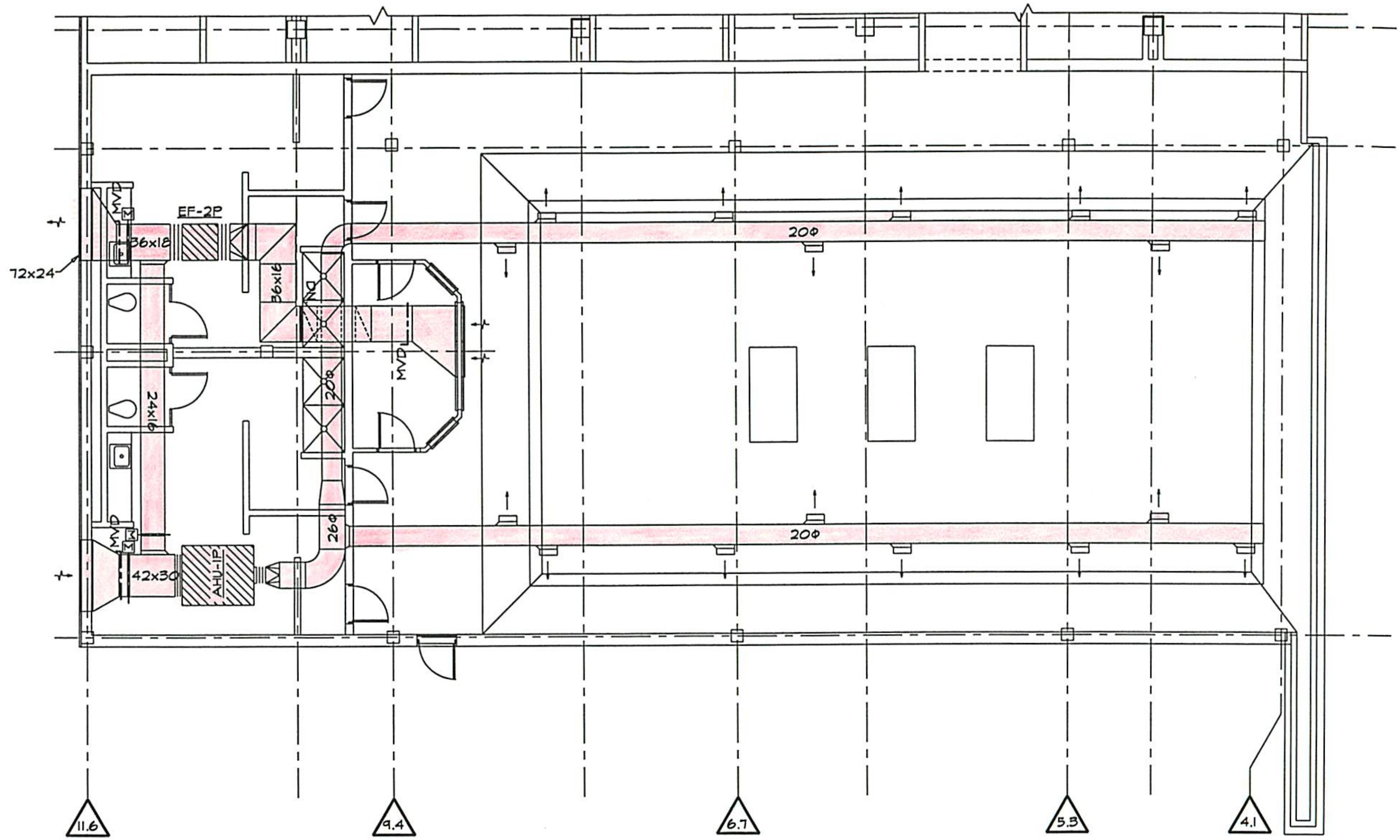
$$= 4.25 \text{ tons}$$

Thus, the total cooling load at peak conditions is about 11 tons. The supply air must therefore be re-heated, as shown in Figure one, so that it only does 11 tons of cooling to the space.

CONTROLS

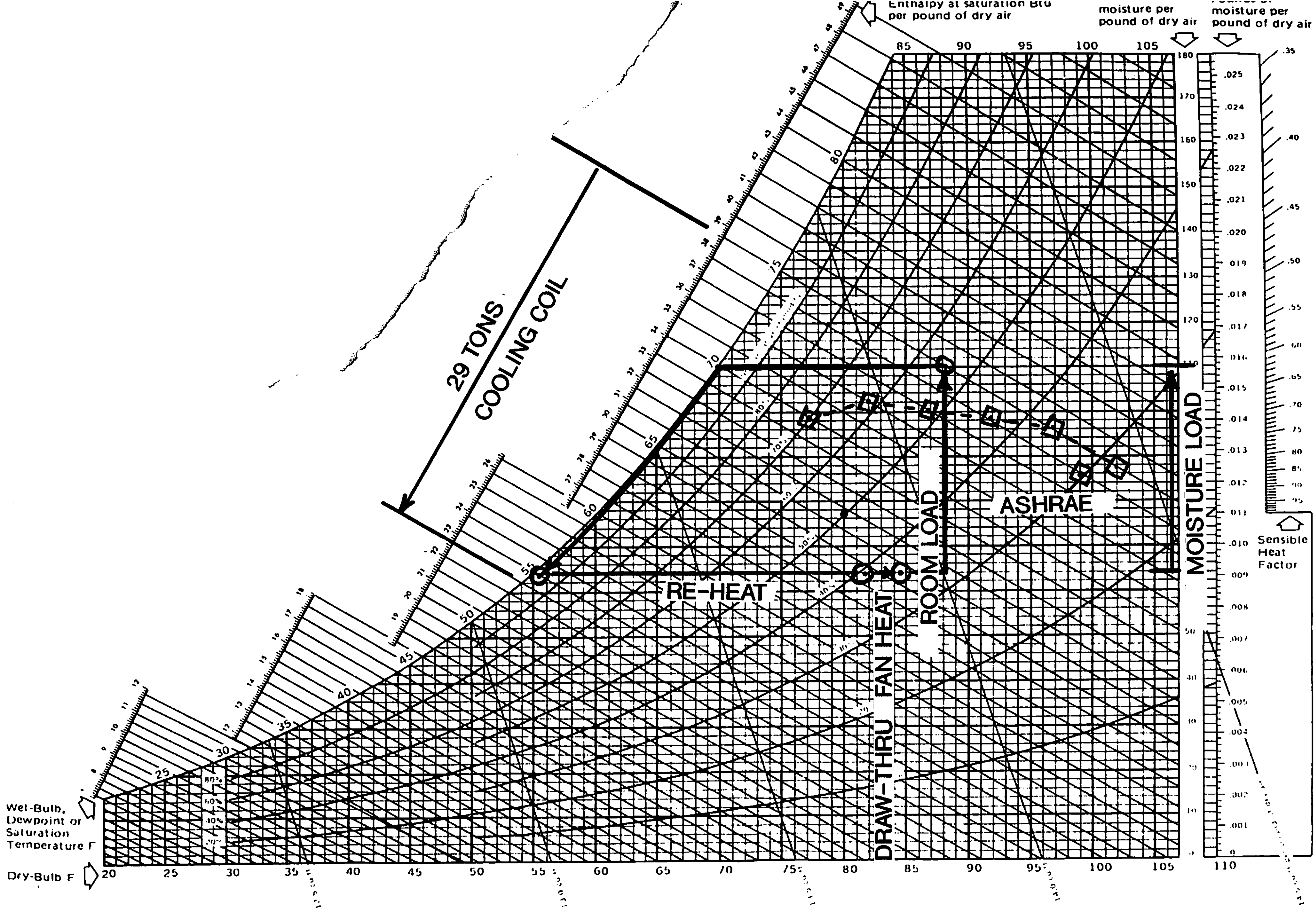
The system requires two thermostats to maintain 85/60% conditions in the space. Since the rate of evaporation from the pool surface is constant, the humidity of the supply air (e.g. the grains/lb.) must be constant. Thus, the leaving air temperature off the cooling coil must always be 55°F. This is maintained by a duct averaging thermostat off the cooling coil, controlling a three way valve modulating flow to the cooling coil.

The space temperature is controlled by the hot water coil during both the cooling and heating seasons. In the cooling season the system tends to over-cool the space, which must be avoided because evaporation from the pool increases, as does space humidity. Using an averaging, duct-mounted flow through the coil is the most accurate monitoring means since the fan will operate continuously. (The air handler fan and exhaust fan operate constantly to control the constant evaporation from the pool surface).



EXISTING
THERAPY POOL AREA OVERALL

1 SCALE: 1/8" = 1'-0"



THERAPY POOL CYCLE

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