PSYCH-2

PSYCHROMETRICS

by

Jeffrey G. Boldt, P.E.

EVERY 2" STATIC = 1° INCREASE IN AIR

PSYCHROMETRIC CHARTS

To understand cooling, humidification and dehumidification it is first necessary to understand psychrometric charts. A "psych chart" shows the properties of air at various temperatures and containing various amounts of moisture.

The most common psych chart is ASHRAE Psychrometric Chart # 1 which is based on the air pressure at sea level and covers temperatures between 32°F and 120° F. See figure 1. Charts are also available for high and low temperature applications and higher altitudes.

At the bottom of the chart the **dry bulb temperature** is listed. This is the temperature that a thermometer measures. When the term "temperature" is used, it normally means dry bulb temperature. Dry bulb temperature does not indicate the amount of moisture in air.

Along the right edge of the chart are **humidity ratio** values. These indicate the amount of moisture in each pound of dry air. The figures vary between zero and 0.030 pounds of moisture per pound of dry air. Penciled into the right edge are **Grains** of moisture per pound of dry air. 7,000 grains equals one pound and grains can be calculated as 7,000 times the humidity ratio. Grains are often used because humidity ratio figures are small and difficult to remember. Air containing no moisture is called **dry air**.

Around the entire perimeter of the chart are **enthalpy** figures. These represent the amount of energy in each pound of dry air. Enthalpy (energy) increases when either dry bulb temperature or humidity increase. Enthalpy figures can be negative. They are based on zero Btu per pound for dry air at 0°F.

Nearly parallel to the enthalpy lines are a lighter set of lines of **wet-bulb temperature**. These lines represent the dry bulb temperature which the air would be cooled to if it were cooled by evaporating water into it until **saturated** (able to accept no more moisture). An evaporative cooler or a sling psychrometer will cool air along the wet-bulb lines. The maximum wet-bulb temperatures experienced in the midwest are usually around 85°F. When your friends say that the temperature was 100 degrees and the relative humidity was 100%, they are mistaken. This would represent a wet-bulb temperature of 100 degrees. Humans can not survive at wetbulb temperatures much above 90°F.

Dew point temperature or **dew point** is the temperature at which condensation will begin to form when air is cooled **sensibly** (without adding or removing moisture).

Relative humidity (RH) is indicated by a set of curved lines. Relative humidity is 100% when air is saturated and is zero percent for dry air. Warm air can hold more moisture than cool air. 80°F air at 50% RH contains more moisture than 50°F air at 100% RH.

Standard air is defined as dry air at 59 degrees F and 29.921 inches barometric pressure (average sea level pressure). This is the air that is assumed in the formula $Q=1.085*cfm*\Delta T$. In this equation Q is energy, and ΔT is the change in temperature. Because of humidity in the supply air the actual figure is closer to 1.1 than 1.085 for most cooling systems. If designing at high altitudes this figure is not correct and compensation must be made for less dense air with less heating or cooling capacity per cubic foot.

Volume is shown by lines sloping more steeply than enthalpy lines. The figures range from 12.5 to 15.0 cubic feet per pound of dry air.

PSYCHROMETRIC CHART FOR BASIC COOLING

Figure 2 shows a typical air handling system. The circled numbers correspond to the psychrometric conditions on the psych charts that follow. Figure 3 is a psych chart showing the operation of a common comfort cooling application. Point 1 is the space condition of 75°F and 52% RH. Point 2 is the outside air condition on a peak day of 95°F and 78°F wet-bulb. Point 3 is the mixed-air condition assuming that the system uses 25% outside air. This air is cooled from point 3 to point 4 by a cooling coil. Initially the cooling coil has no effect on humidity ratio (this is sensible cooling), but as the air approaches saturation, moisture is removed. The air does not ever quite touch the saturation line. A typical cooling coil will have a discharge of 55°F dry-bulb and 54.8°F wet-bulb. The psych charts distributed by Trane include curves showing the action of cooling coils, but these do not closely represent the performance of modern coils.

The energy used by the cooling coil can be determined from the formula $Q=4.5*cfm*\Delta h$, where h is enthalpy. If we assume a 1000 cfm system our energy use is $4.5*1000*(31.6-22.3) = 41,850$ Btuh. One ton is 12,000 Btuh, so this is 3.5 tons.

This is an efficient system for comfort cooling because the resulting humidity of 52% is acceptable and no additional energy is needed to adjust the humidity. This is not necessarily true for process cooling.

The location of point 1 is determined by two things - the condition of the air leaving the cooling coil (point 4), and the **sensible heat ratio** of the load in the space being cooled. The sensible heat ratio is the ratio of sensible heat (heat due to temperature change) to the total heat. Total heat also includes **latent heat**, which is heat due to the addition or removal of moisture.* In most buildings the main source of latent heat is people breathing and perspiring. Average values are about 250 Btuh per person for both sensible and latent heat. A whirlpool or a room humidifier would add latent heat in a room.

PSYCHROMETRIC CHART FOR WINTER HEATING

Figure 4 shows our typical air handling system during winter. The outside air is assumed to be 15°F and 100% RH. Note that the humidity ratio of this air is equal to the humidity ratio of 75°F air at 9% RH. Using the same 25% outside air gives a mixed air condition of 60°F at 25% RH. This air is heated to 95°F (point 4) to heat the space. It then enters the space and is cooled (by the building envelope) and humidified (by the occupants). The result is a space RH of only 15%. This is OK for some buildings, but not for hospitals, museums, computer rooms, etc.

The dashed lines on Figure 4 show the conditions of the air if a humidifier is added. The humidifier is most effective if added after the heating coil as the hot air has the most ability to absorb the steam and the vapor trail is much shorter. The humidifier used in this example is a steam unit.

Steam humidifiers do not provide much sensible heating or cooling. Evaporative humidifiers (also called air washers, evaporative coolers, "April Air" humidifiers, etc.) provide a great deal of sensible cooling. This is because they move the condition of the air up and left along the wet bulb lines. Although these humidifiers use no energy, the heating coil must heat the air more to compensate for the sensible cooling they provide. These units are popular in dry climates where cooling and humidification are desirable. They are then referred to as "swamp coolers" or evaporative coolers.

PSYCHROMETRIC CHART FOR EVAPORATIVE COOLING

Figure 5 shows a typical evaporative cooling application. Hot dry air is cooled and humidified by an evaporative cooler to provide cool humid supply air to the building. These types of systems are often used for greenhouses and other areas where it is necessary only to reduce the temperature slightly and humidity is not a concern. Evaporative coolers require careful maintenance to avoid algae, slime and bacteria growth.

TYPICAL USES OF PSYCHROMETRIC CHARTS

1. Determine whether equipment is providing the amount of heat, cooling or humidification that it was intended to provide.

2. Determining whether areas with different temperature and humidity needs can be handled by the same air handling unit.

3. Deciding what supply air temperature is needed to satisfy the needs of an area.

4. Understanding the weather report!

5. Need OA in AHU schedule, not wb as it is not adiabatic.

ASHRAE PSYCHROMETRIC CHART NO. 1

NORMAL TEMPERATURE

BAROMETRIC PRESSURE 29.921 INCHES OF MERCURY

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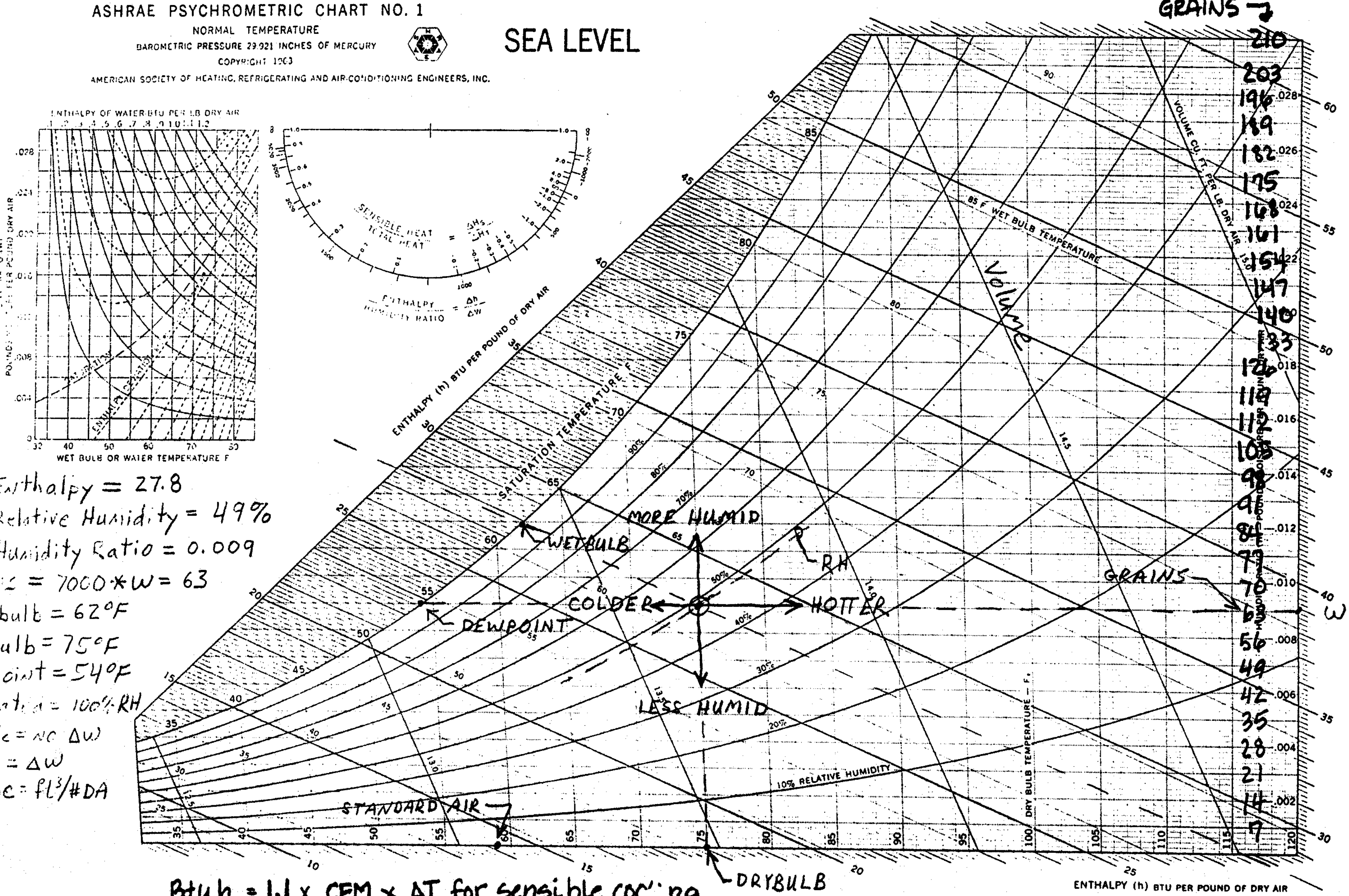
SEA LEVEL

(7000 GRAINS = 1 POUND)



h = Enthalpy = 27.8

RH = Relative Humidity = 49%

ω = Humidity Ratio = 0.009

Grains = 7000 * ω = 63

Wetbulb = 62°F

Drybulb = 75°F

Dewpoint = 54°F

Saturated = 100% RH

Sensible = no Δω

Latent = Δω

Volume = ft³/#DA

Btuh = 1.1 x CFM x ΔT for sensible cooling

Btuh = 4.5 x CFM x ΔT for all situations

FIGURE

KJWW ENGINEERING CONSULTANTS

PROJECT	DATE	BY	PROJECT NO.
PSYCHROMETRICS	10-5-95	JGB	ED

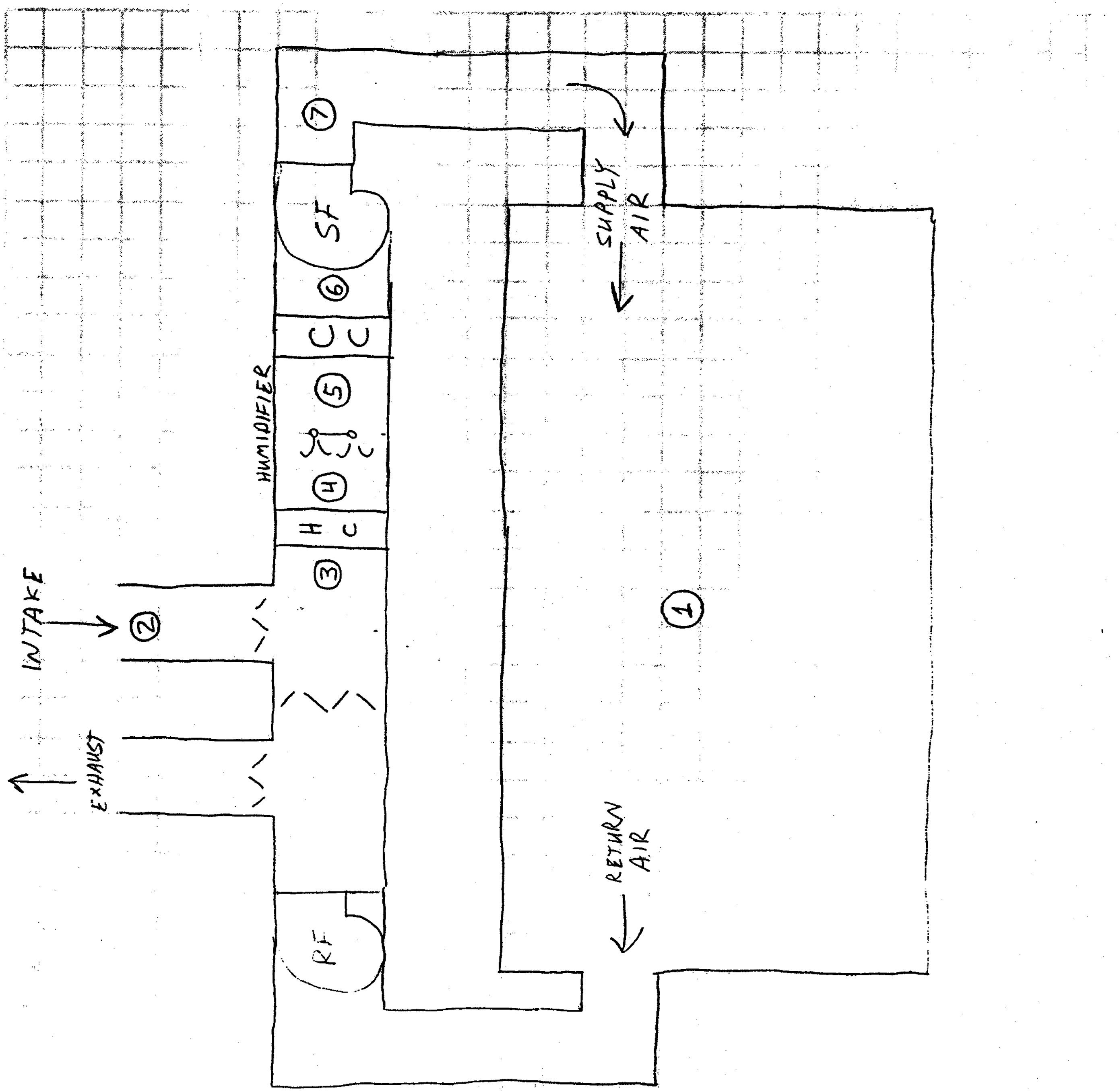
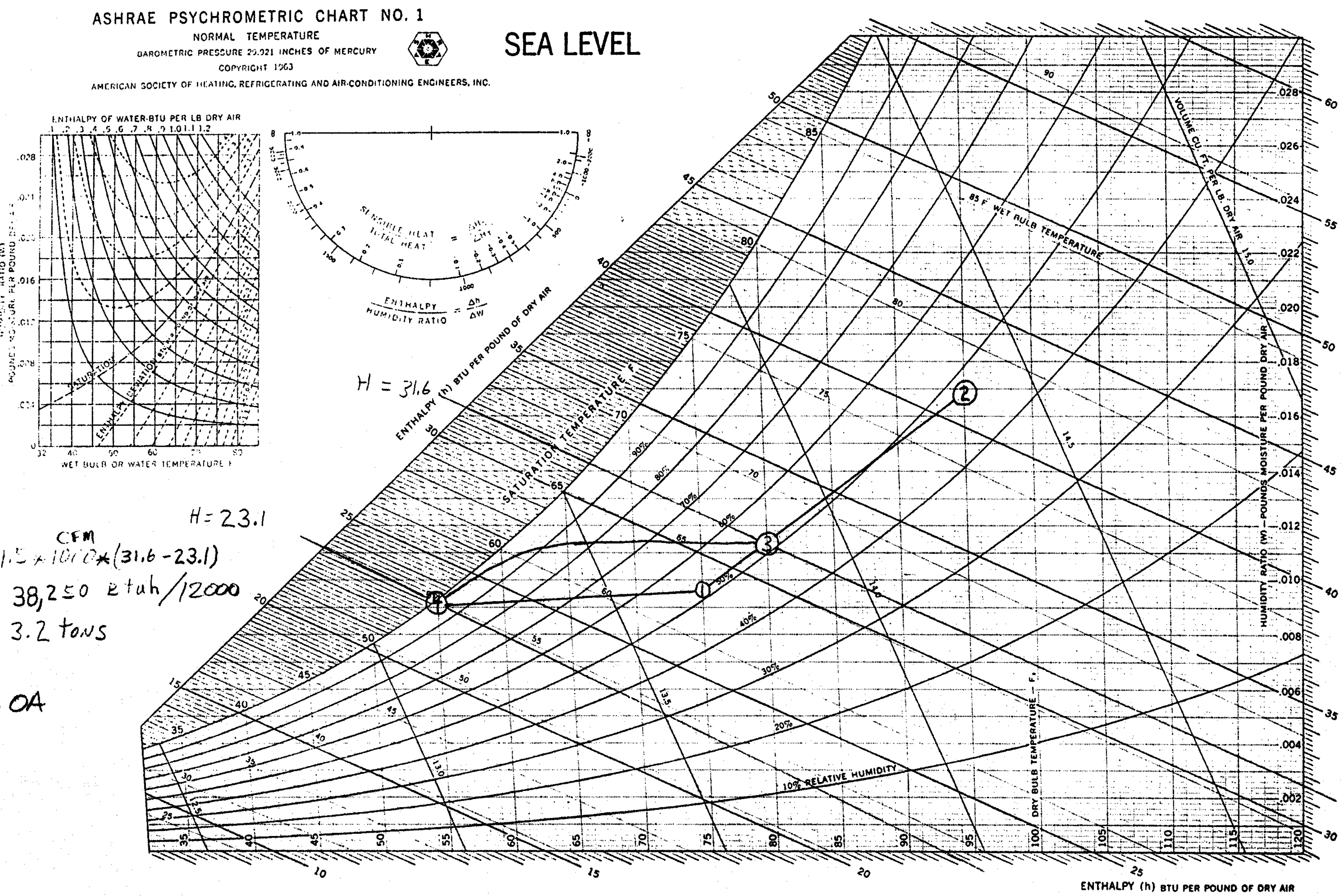


FIGURE 2



CFM

Q = 4.5 × 1000 * (31.6 − 23.1)

= 38,250 Btuh / 12000

= 3.2 tons

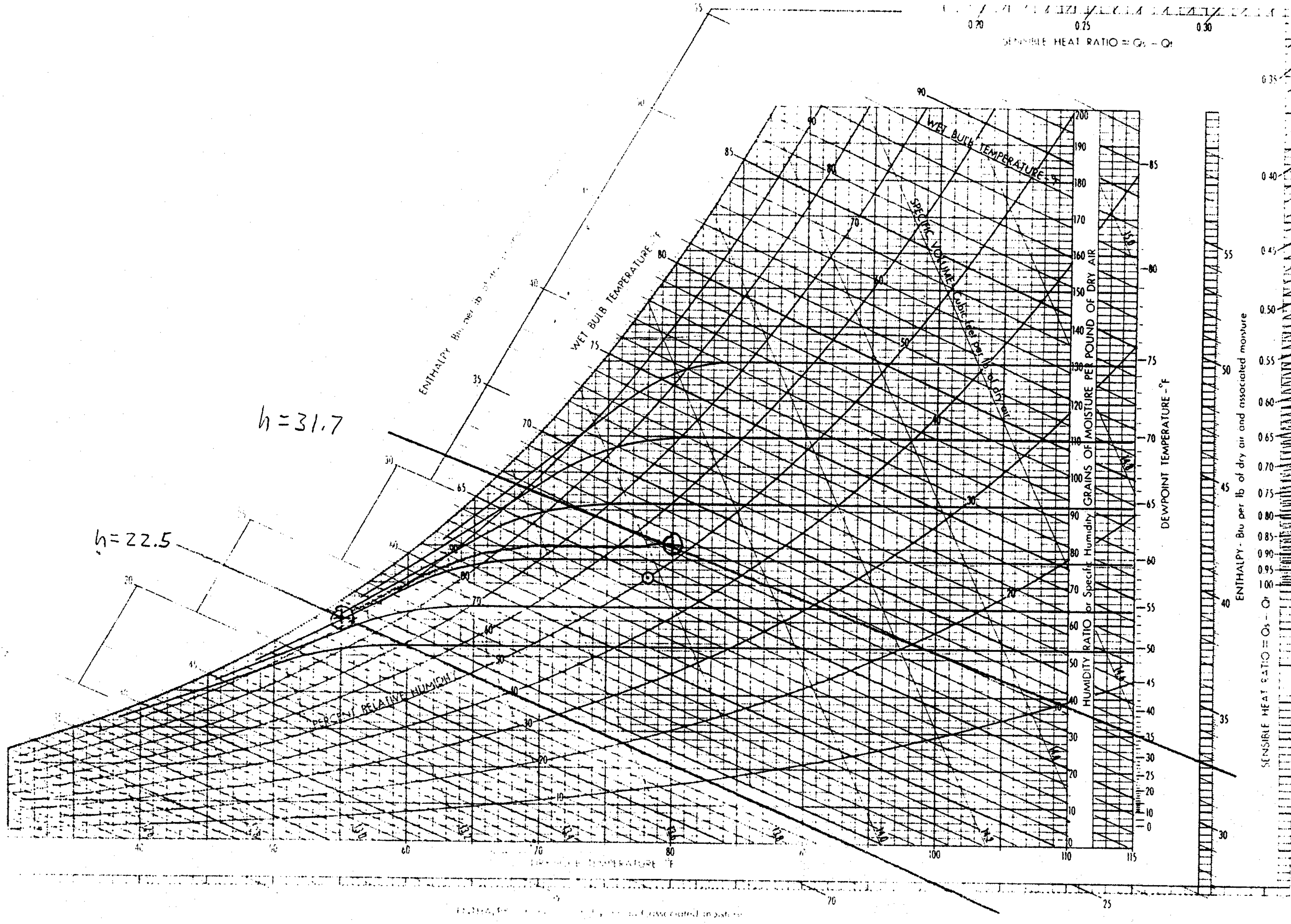
25% OA

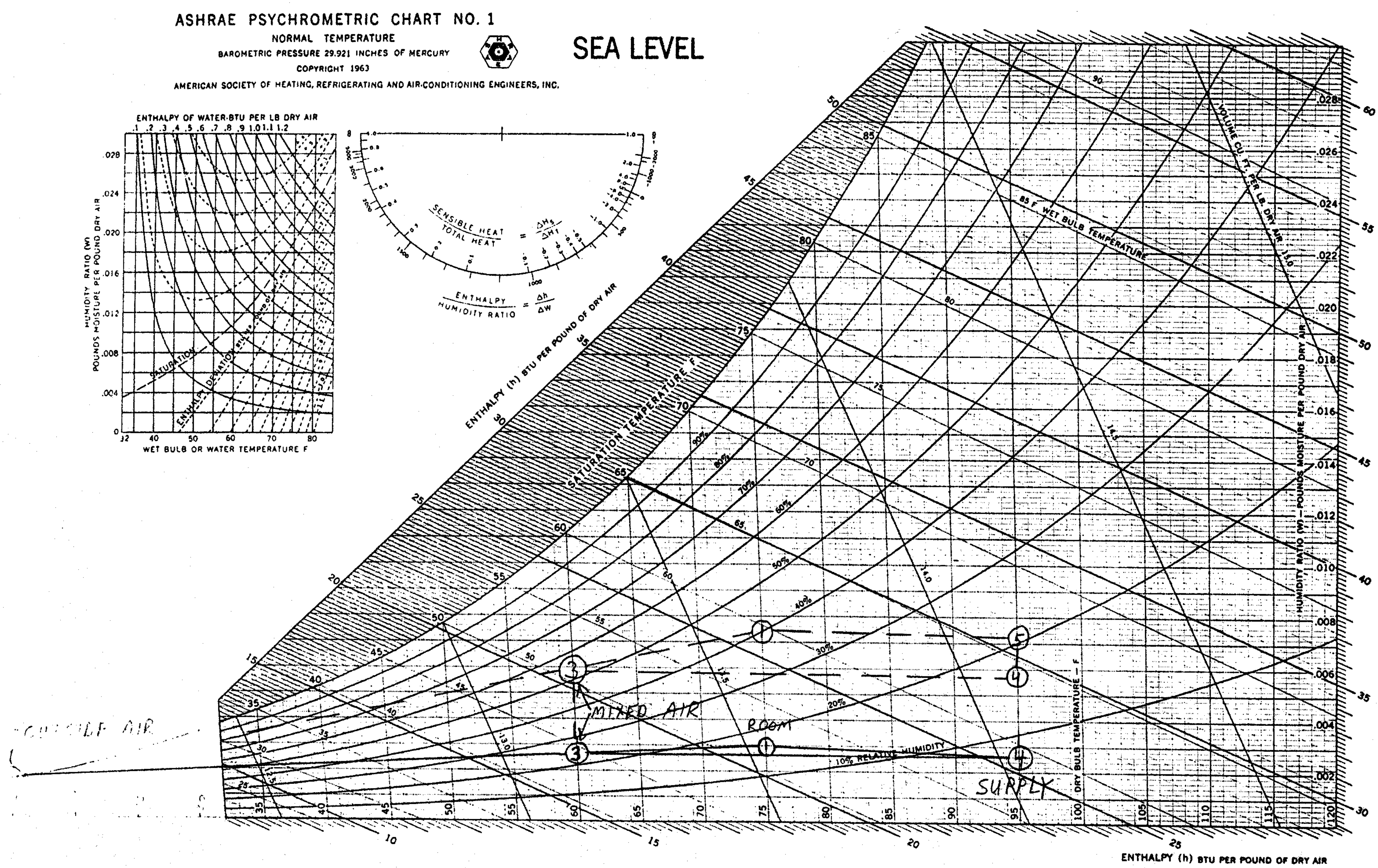
COMFORT COOLING

Figure 3

TRANE™

PSYCHROMETRIC CHART





HEATING SYSTEM

100% RH at 15°F = 9% RH at 75°F
SOLID LINES = NO HUMIDIFIER
DASHED LINES = STEAM HUMIDIFIER

FIGURE 4

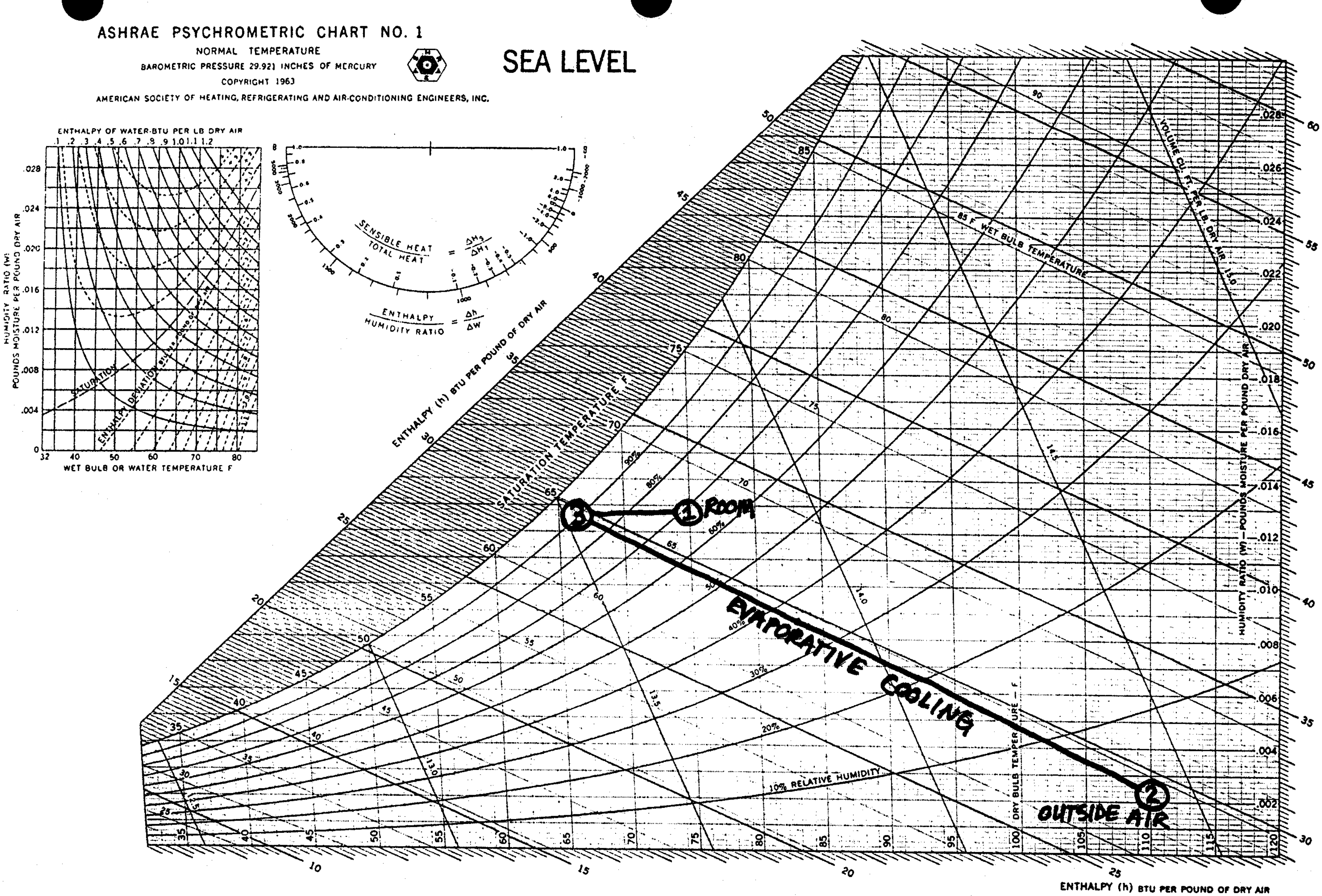


FIGURE 5 EVAPORATIVE COOLING