



Practical Psychrometrics Applied to HVAC

An Online Continuing Education Course for Engineers

Course Number: HV-5016

Credit: 5 Hours / 5 PDH / 5 CPD

Practical Psychrometrics Applied to HVAC

Manuel Calzada, P.E.

Introduction

One of the intentions of this course is to provide powerful tools that can facilitate and simplify work in the area of HVAC. This course includes some theory about air and how to estimate its characteristics (relative humidity, enthalpy, dew point, etc.). The theory of psychrometrics can be tedious and in the end, hard to apply to practical cases. The course is designed to address these issues by providing the student the theory needed and finally use the theory in very practical ways to visualize the impact of air conditions in an HVAC system.

The student should know that some of the theory section is similar to the theory covered in the course PSYCHROMETRICS AND ITS USE IN HVAC. This course covers theory and also practical uses of the theory. A graphical representation of the topic is generally accompanied by the use of the psychrometric chart. After the theory is covered and explained in the course, some models are created for the student to use either individually or as modules that can connect to develop solutions to significantly more complex problems.

In this course, there is a discussion of some of the equations that are needed to simulate these processes. Most of the accuracy of the results using these tools is quite good; however, some more refinement may be needed in some areas to slightly improve the final accuracy. In general, the results can provide a good and sound answer to many typical engineering problems.

Much of the course is based on the individual practical applications of HVAC processes. At the end of the course, a small section is designed to address the complete HVAC system with all its individual processes. These tools can be easily used to develop solutions to specific and complex problems.

This course is designed to be a continuation of the previous course, “PSYCHROMETRICS AND ITS USE IN HVAC.” The previous course covered most of the theory that is needed to solve typical HVAC applications. However, some of the topics from the previous course are covered again in this course to make sure that the student can follow the course with minimum problems. The material of this course is more advanced and should be a good refresher course for a Mechanical Engineer. The discussion of the theory is directed more towards the practical application of HVAC.

This course will include a set of topics from the PSYCHROMETRICS AND ITS USE IN HVAC course, as some material is essential for understanding the content of this course.

The purchase of this course will include an Excel file that the student can use to enter initial conditions and to solve for the specific applications. The applications included in this Excel file are the following:

- A) Process of two air streams mixing
- B) Process of a cooling coil
- C) Process of a heating coil
- D) Humidification
- E) Drying
- F) General process of air conditioning space
- G) HVAC system simulation
- H) Psychrometric formulas to provide numerical solutions to the practical problems

These modules developed and provided with the course are designed to be self-contained. This means that if you copy the whole module as illustrated by its own color, you can paste it somewhere else and use it as many times as you'd like.

There are some examples in the course where two mixing modules and two different conditioned spaces are used. As long as the proper inputs are connected to the proper outputs, the student should be able to design almost any type of system and test it for different conditions (What happens if there is more exhaust or the outside relative humidity is lower? How would that affect the cooling coil? What would happen if you open or close a damper to deflect more air in one room or the other room?).

A specific set of screens of the regular Excel sheets is shown at the end of the REFERENCE SECTION of this course.

Even though the accuracy of the simulation programs is within the typical engineering expectations, the student may want to confirm with other sources.

This course includes a more advanced Psychrometric chart calculator that includes the calculation of the dew temperature, which is so widely used in the cooling coil simulation.

It is strongly recommended that the student, prior to using the Excel program included in this course, makes sure that the original program is saved and a copy is used for the test and experimentation. Always keep an original copy in case any problems develop.

The Excel file with the modules shows an example of what the modules can do. From there, the student can copy and paste any of the modules individually to build his/her own system.

This course will help the student to use the individual HVAC processes to develop and understand a complete HVAC system. The student will also be able to see the impact and effects of each of the individual processes. For example, we will be able to predict how increasing the amount of return air would affect the performance of the system (space, coil, etc.).

Also, these modules do not use any macros, and all the calculations are developed in a spreadsheet, so you may be able to use it also on Excel online.

Air Humidity Parameters

Relative Humidity

Relative Humidity (**RH**) is defined as the ratio of the partial water vapor pressure in the air to the saturated partial pressure of the water vapor measured at the same temperature.

Unlike the common belief that the relative humidity is an indicator of how much humidity there is in the air, relative humidity is an indicator of how close the water vapor in the air is to its saturation point.

This concept can be easily represented in a T-S water diagram of fig. 1

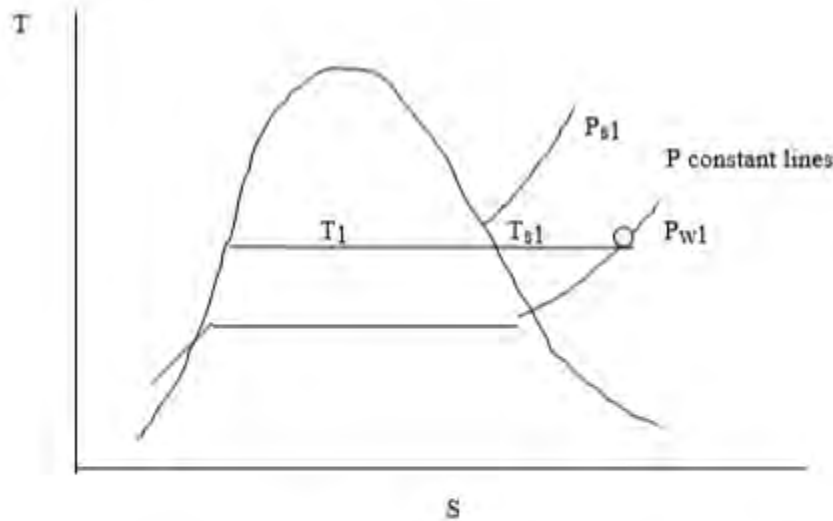


Fig. 1. T-S water diagram showing the constant pressure lines

$$RH = \frac{P_{w1}}{P_{s1}} \Big|_{@T=T_1} \quad (1)$$

Where P_{s1} is the saturated pressure of water vapor @ T_1 . This value is normally obtained from the steam tables evaluated at T_1 . A table in the [Reference Section](#) provides this information.

As the vapor pressure of the air (P_{w1}) approaches the saturation point at T_1 (P_{s1}), the relative humidity RH approaches 100%. Please refer to the equation (1) and fig. 1 to understand this concept.

Since the perfect gas laws are quite accurate at low pressures of air, we can apply them to the relative humidity concept (RH):

$$RH = \frac{R_{w1} * T_{w1} / V_{w1}}{R_{s1} * T_{s1} / V_{s1}} \quad (2)$$

Where R_{w1} = gas constant of water vapor at point 1

T_{w1} = temperature of water vapor at point 1

V_{w1} = volume of water vapor at point 1

R_{s1} = gas constant of the saturated water vapor at point 1

T_{s1} = temperature of the saturated water vapor at point 1

V_{s1} = volume of the saturated water vapor at point 1

Notice that $R_{w1} = R_{s1}$ and $T_{w1} = T_{s1}$. Using this, we can develop a relative humidity equation, which is a function of either the ratio of the specific volume of the water vapor to the saturated water vapor or the ratio of the density of the saturated water vapor to the density of the water vapor;

$$RH = \frac{V_{w1}}{V_{s1}} = \frac{\rho_{s1}}{\rho_{w1}} \quad (3)$$

Humidity Ratio

The humidity ratio is also known as specific humidity, and it is normally represented by (W). It is defined as the ratio of the amount of water vapor in the air to the amount of dry air.

Using the definition and applying the perfect gas laws, and realizing that the volume of water vapor and the air is the same, we can write the following relationship:

$$W = \frac{M_w}{M_a} = \frac{\rho_w}{\rho_a} = \frac{P_w/R_w * T_w}{P_a/R_a * T_a} \quad (4)$$

Since the temperature of the air and the water vapor is also the same, we can use the molecular weight of the air and the water to calculate the air and water constants: $R_w = 1545 / 28.96$ (lbf-ft / lbm-F) and $R_a = 1545 / 18.01$ (lbf-ft / lbm-F). From here, the final equation for the Humidity Ratio becomes:

$$W = 0.622 \frac{P_w}{P_a} \quad (5)$$

The total pressure of the mixture is equal to the sum of the partial pressures: $P_t = P_a + P_w$

$$W = 0.622 \frac{P_w}{P_t - P_w} \quad (6)$$

Dew Point Temperature

The Dew Point Temperature is defined as the temperature of the air at which the water vapor reaches its saturation point when the temperature drops at a constant pressure. This is represented by T_{dp} in fig.2.

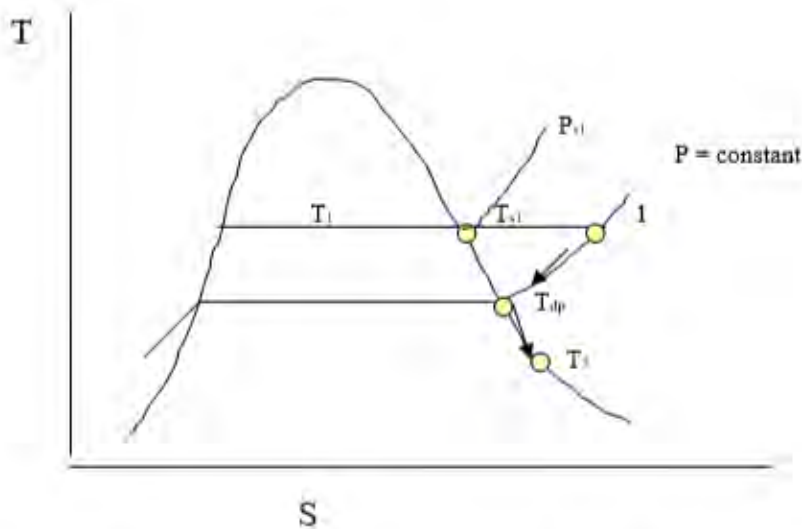


Fig. 2. $T-S$ water diagram showing the dew point temperature

When the temper
line, it will reach
were to continue t
saturated, but now

Example

Calculate the partial
density of moist air

Using equation (1)

To view the remainder of the
course material and to take
the quiz for PDH credit, you
must purchase the course.

Close this window and click
"Add to cart" on the product
page.

constant pressure
dp. If the temperature
continue to remain
temperature T_3 .

humidity ratio, and

$T = 80^\circ\text{F}$