Akton Psychrometric Function Library PFL Reference

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Introduction

The Akton Psychrometric Function Library (PFL) is a collection of numerical functions that are used to determine the properties of air/water mixtures. It is the underlying basis of Akton's Psychrometric chart program. It exists on the user's hard disk as a dynamic link library (DLL) by the name of "akpfl4.dll."

The PFL does not necessarily apply to strictly air and water mixtures. In a more generalized description there are two components, a volatile component, and a non volatile component. In a standard psychrometric chart the volatile component is water, and the non volatile component is air. The PFL makes use of ideal gas laws, and error is introduced when one or both of the components deviate from ideal gas behavior.

All of the calculations performed by the PFL module are documented here. The PFL has the ability to analyze any point that can be represented on a Psychrometric Chart, by being given a pressure, and any two independent specific properties. In some cases it does so by directly performing calculations using the equations described here. In some cases it translates properties to equivalent properties and then directly calculates as just described. In other cases there may not be any way to directly calculate results from the specific properties given, but a unique solution does exist. In such cases, it attempts to find the solution to the entire set of equations through the use of a numerical convergence routine.

There are two parts to the system of equations that comprise the PFL. There are the properties, which can comprise both the input and output of a solution set. There is also a set of constants that are required by some of the equations. The constants pertain strictly to the two components (volatile and non volatile) for which the system of equations is being solved. In previous versions of the PFL these constants where held in a single shared memory space, and were in effect for all instances of all programs using the PFL at the same time. Version 4 of the PFL uses separate memory space for each instance, and so it is now possible to simultaneously run programs that use different PFL constants. In the case of Akton's Psychrometric Chart program the constants are now stored in the chart files.

Constants

Configuration

There is a configuration utility built into the PFL that provides for the manipulation of a set of constants. In previous versions of the PFL these constants where held in a single memory space, and were in effect for all instances of all programs using the PFL at the same time. Version 4 of the PFL uses separate memory space for each instance, so it is now possible to simultaneously run programs that use different PFL constants. In the case of Akton's Psychrometric Chart program the constants are now stored in the chart files. Now when editing the PFL configuration you are only editing the configuration of the psychrometric chart program.

Akton PFL Config		
Air Cp (vapor) A 28.11 B 0.001967 C 4.802e-006 D -1.966e-009 C Use Constant 1.88 T zero 273 Mol. Wt. 28.97	Water Cp (vapor) A 32.24 B 0.001923 C 1.055e-005 D -3.595e-009 I Use Constant 1 1 T zero 273 Mol. Wt. 18.015	Antoine Constants A 16.5362 B 3985.44 C -38.9974 Cp (Liquid) 4184 Freezing Point 273.16 dh(vap) 2500.8
Ideal Gas Constant 8314	K Cancel	Prec 5

There are two principal reasons we have made all the constants available to the user. The first reason is to permit the program to be used in the widest possible range of temperatures and pressures. Under certain conditions it may be that the user can obtain better results by modifying some or all of the constants by the PFL. The second reason is to permit the model to be applied to systems other than air and water. It is up to the users to decide if this is a reasonable approach to their problem.

Antoine Constants

An Antoine equation is used to determine the vapor pressure (Pvap) of a pure component at a given temperature (T) as follows. A B and C are the Antoine constants for Pvap in kilopascals (kPa) and T in degrees Kelvin (K).

ln(Pvap) = A - B/(T+C)

At temperatures below the freezing point the Goff-Gratch formula is used as presented in the ASHRAE brochure on Psychrometry to determine the vapor pressure over pure ice. This formula is hard wired into the library with its constants because of its greater complexity.

Freezing Point

The freezing point is the temperature at which water freezes. It is used to indicate the temperature at which the vapor pressure function switches from pressure over water to pressure over ice.

Heat Capacity (liquid)

The heat capacity of liquid water is assumed to be constant. It is used in the calculation of energy change due to entering or exiting water (Qw by default). This effects total energy change (Qtot by default) also.

Heat Capacity (vapor)

The PFL uses the following equation to calculate the molar heat capacities (Cp) of the two components, using constants A, B, C and D.

 $Cp(T) = A + B(T) + C(T)^{2} + D(T)^{3}$

For any given temperature T, Changes in the molar enthalpy for a component is calculated by solving the definite integral of the equation above as follows.

dh =
$$\int_{\text{Tzero}}^{\text{T}} Cp(T) dt$$

Under extreme conditions or, possibly for other compounds, it may be possible to obtain better results by plugging in a constant value that is applicable to the conditions in question. In that case a constant value can be entered and flagged to be used by the PFL. The units of heat capacity for use by the PFL are kJ / kg K. The heat capacity is used in the calculation of specific enthalpy and wet bulb temperature.

Heat of vaporization

The heat of vaporization for water is used in the calculation of specific enthalpy and wet bulb temperature. The units for use by the PFL are kJ/kg. Normally this value can be obtained from a steam table as delta h(vap) @ Tzero. Tzero refers to the temperature of zero enthalpy.

Ideal gas constant

The ideal gas constant (R) is the constant used in the ideal equation of state.

PV = nRT

The units of R for use by the PFL are $(Pa)(m^3) / (kg mol)(k)$. It is unlikely that there will be any reason to change this value.

Iterations

The iteration parameters for the PFL constitute the convergence criteria for the numerical convergence routine that solves many of the inter-property relationships for air water mixtures. Some care should be exercised in altering these parameters. Overly small values will lead to inaccurate grossly rounded results. Overly large values will lead to a dramatic decrease in program performance. It is recommended that you consider the numerical precision options in the programs that use the PFL when altering these values. If you are using a slower computer great performance enhancement can be achieved by altering these parameters but BE CAREFUL to check your results.

Maximum: This parameter is a cap to the number of iterations that the convergence routine will perform before it quits regardless of whether convergence has been achieved.

Precision: This parameter specifies the number of significant figures to try and match in a convergence attempt. The convergence routine will quit once it has achieved the number of significant places. The number will be truncated beyond the indicated number of places. Significant places refers to actual numerical significance NOT decimal places.

Molecular Weight

The molecular weights are the molar weights of the two components in the system, typically air and water. The molar weight of air is the appropriate weight for a mixture of nitrogen and oxygen corresponding to air. The molecular weights are used to convert components from a mass to molar basis and affect many of the calculations performed by the PFL.

Temperature of zero enthalpy

This constant represents the temperature at which specific enthalpy equals zero. It is generally accepted practice in the English system of units to use 0 degrees F for air and 32 degrees F for water. It is generally accepted practice in the SI system of units to user 0 degrees C for both air and water. The PFL expects these values to be degrees Kelvin (K).

This constant is the most likely constant to be changed, and has been a source of much confusion in the past. If you want your chart to be aligned with commonly published metric charts both Tzero for air and Tzero for water should be set to 273. If you want your chart to be aligned with commonly published english charts, Tzero for water should be set to 273, and Tzero for air should be set to 252.2

Properties

Properties refers to a set of physical and thermodynamic attributes of a mixture of air and water vapor. The psychrometric function library has been designed to solve the entire set of properties given any minimum set of values. In general it takes four properties to solve for the entire set. The first property is absolute pressure. The second and third properties are any two independent specific properties. The fourth property is mass or mass rate, and is only necessary for entry points. For process and mix points the mass property is derived from the selected reference point(s).

Barometric Pressure

Barometric pressure is the absolute or total pressure as can be measured with a barometer. The barometric pressure remains fixed for any given chart. All thermodynamic calculations are carried out assuming constant pressure. In some applications it is important to keep in mind the difference between absolute pressure, and gage pressure. Barometric pressure is interchangeable with the altitude property.

Altitude

Altitude refers to the elevation above sea level. It is translated to and from barometric pressure via equation 1.2.14 on page 6 of the ASHRAE Brochure On Psychrometry.

Humidity Ratio

Humidity ratio refers to the mass to mass ratio of pure water vapor to pure dry air in the mixture. It is generally the vertical axis on a standard psychrometric chart. In the Akton Psychrometric chart it is one of the fundamental properties that other properties are translated to and from. Properties that are solely dependent on humidity ratio, are translated to and from humidity ratio. These include mass and mole fractions, partial pressure and specific latent enthalpy.

By default, humidity ratio is represented by W and a change in humidity ratio is represented by dW.

Specific Humidity

Specific humidity is the humidity ratio on a moist air basis. It can also be used to represent the mass fraction of water in the mixture. It is the mass of pure water per total mass of the mixture. It translates directly to and from humidity ratio.

By default, specific humidity is represented by q and a change in specific humidity is represented by dq.

Partial Pressure of Water

The partial pressure of water refers to the fraction of the total pressure (barometric pressure) that is attributed to water in the mixture. It is calculated as the mole fraction of water multiplied by the total (barometric) pressure.

Ph2o = $(nw/n) \times P$ Where (nw/n) is the molar fraction of water and P is the total or barometric pressure

The partial pressure of water is often confused with the vapor pressure of pure water. The saturation curve (100% relative humidity) can be described as the set of conditions where the partial pressure of water equals the vapor pressure of water.

For the calculations performed by this software, partial pressure translates directly to and from the humidity ratio. If a partial pressure is used to define a point on the chart, it is logically the same as using humidity ratio to define a point on the chart.

By default the partial pressure of water is represented by "Ph2o", and a change in the partial pressure of water is represented by " dPh2o."

Partial Pressure of Air

The partial pressure of air refers to the fraction of the total pressure (barometric pressure) that is attributed to air in the mixture. It is calculated as the mole fraction of air multiplied by the total (barometric) pressure.

Pair = $(na/n) \times P$ Where (na/n) is the molar fraction of air and P is the total or barometric pressure

Because the mole fraction of air can be described as the mole fraction of water subtracted from 1, the partial pressure of air translates to and from the partial pressure of water, which in turn translates to and from humidity ratio. If a partial pressure is used to define a point on the chart, it is logically the same as using humidity ratio to define a point on the chart.

(na/n) = 1 - (nw/n)

By default the partial pressure of air is represented by "Pair", and a change in the partial pressure of air is represented by " dPair."

Molar Fraction of Water

The molar fraction of water refers to the percentage of water in the mixture on a molar basis. By assuming ideal gas behavior this property can also be used to represent the percentage of water in the mixture on a volume basis. Molar fraction and mass fraction of water are related by the following equation. There is no mass fraction property for water because it would be redundant with the specific humidity property.

(nw/n) = (mw/m) * (MoleWt Air / MoleWt Water)

By default the molar fraction of water is represented by "nw/n", and a change in the molar fraction of water is represented by "d_nw/n". The molar fraction of water property translates directly to and from the humidity ratio property.

Molar Fraction of Air

The molar fraction of air refers to the percentage of air in the mixture on a molar basis. By assuming ideal gas behavior this property can also be used to represent the percentage of air in the mixture on a volume basis. Molar fraction and mass fraction of air are related by the following equation. In the case of air the molecular weight of air is the appropriate average molecular weight for a mixture of oxygen and nitrogen (approximately 29).

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(na/n) = (ma/m) * (MoleWt Water / MoleWt Air)
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By default the molar fraction of air is represented by "na/n", and a change in the molar fraction of air is represented by "d_na/n". The molar fraction of air property translates directly to and from the humidity ratio property.

Mass Fraction of Air

The mass fraction of air refers to the percentage of mass which is attributed to the air content of the mixture. It can be described as (mass of dry air) / (total mass). The counter part property for water is denoted as Specific Humidity is keeping with ASHRAE terminology. The relation between the two properties can be described as (mass fraction of air) = 1 - (specific humidity). There is no mass fraction property for water because it would be redundant with the specific humidity property. Because the mass fraction of air is solely dependent upon the specific humidity, it is directly translated to and from humidity ratio.

%air = ma / m or %air = 1 - %water

By default the mass fraction of air is represented by "ma/m", and a change in the mass fraction of air is represented by "d_ma/m".

Dew Point Temperature

The dew point temperature can be described as the point where a given humidity ratio intersects with the saturation curve (100% relative humidity). Physically it represents the temperature at which water will begin to condense out of the mixture if cooled. It is dependent solely on the moisture content of the air water mixture, and thus is translated directly to and from humidity ratio.

td = t(W,rh) where rh = 100%

By default dew point is represented by "td" and a change in dew point is represented by "dtd."

Latent Enthalpy

Latent enthalpy refers to the latent portion of the total specific enthalpy. It is the portion of the enthalpy that is attributed to the vaporization of the water in the mixture. It is the energy per mass necessary to vaporize the water in the mixture, and thus it is dependent solely on moisture content. It is translated to and from humidity ratio. The following equations describe the relationship between latent enthalpy and humidity ratio, and latent enthalpy and total enthalpy.

 $hl = W \times h(vap)$ or hl = h - hsl

where h(vap) = heat of vaporization

There are four latent enthalpy properties that can be selected. Latent enthalpy can be selected on either a dry or moist air basis, and there is a delta property for both. By default they are represented by "hl", "hIMA", "dhl", and "dhIMA" respectively.

Latent Energy

Latent energy is the latent component of the total energy. There are two latent energy properties. The first, represented by default as "El", is a intermediate term used in the calculation of the change in latent energy for a process. It can be calculated as follows.

El = hl x ma

"El" represents the energy required to vaporize the water content of the mixture at the temperature of zero enthalpy. It is calculated by multiplying the specific latent enthalpy by the mass of dry air. Latent energy is dependent on humidity ratio, and mass sample or rate, and thus is translated to and from humidity ratio when used in many calculations. "El" should not be confused with "QI", which is more frequently of interest.

The change in latent energy, is the energy required to vaporize the water that is being added or rejected in the process from one point to another. By default it is represented by "Ql". This property is of interest in a great number of psychrometric processes. It can be calculated as follows.

QI = El@pt2 - El@pt1

Since "QI" is a delta property of "EI", and "EI" is dependent on humidity ratio, and mass sample or rate, "QI" is translated to and from humidity ratio when used in many calculations.

Change In Mass

Change in mass refers to the change in total mass for a process point. It also refers to the change in mass of water in the mixture since it is assumed that the mass of dry air remains constant. It translates directly to and from humidity ratio because of this. It can be used to describe the mass of steam injected, or water absorbed in a humidification process. It can be used to describe coil condensation, or desiccant absorption in a dehumidification process.

By default change mass is represented by "dm." The change in mass can be calculated as follows.

dm = m@pt2 - m@pt1 or dm = dW * ma

Total mass is translated to and from the mass of dry air property. The change in mass property however is translated to and from humidity ratio.

Change In Moles

The change in moles property is the molar counterpart to the change in mass property. It translates to and from humidity ratio because it is assumed that the mass of dry air remains constant during any process. It can be used to describe the moles of steam injected, or water absorbed in a humidification process. It can be used to describe coil condensation, or desiccant absorption in a dehumidification process. The relationship between change in mass and change in moles can be described by the following equation.

(change in moles) = (change in mass) / Mol Wt Water

By default the change in moles property is represented by "dn".

Dry Bulb Temperature

Dry bulb temperature forms the horizontal axis of the chart, it represents the temperature of the mixture as measured with a standard thermometer. Dry bulb temperature is also one of fundamental properties in the Akton Psychrometric Chart. Properties that are solely dependent on dry bulb temperature are translated to and from dry bulb temperature.

By default, dry bulb temperature is represented by "t", and change in dry bulb temperature is represented by "dt."

Vapor Pressure

Vapor pressure refers to the absolute pressure of pure vapor above pure water at a specified temperature. Because vapor pressure is solely dependent upon temperature it translates to and from dry bulb temperature. Vapor pressure is calculated using an Antoine equation. The constants for the Antoine equation are specified in the PFL configuration. If vapor pressure is used to define a point on the chart, the Antoine equation is applied in reverse to determine dry bulb temperature. Otherwise it is calculated from dry bulb temperature.

By default vapor pressure is represented by "Pvap" and a change in vapor pressure is represented by "dPvap."

Relative Humidity

Relative humidity is a measure of saturation for moist air. Ideal gas behavior is assumed, and relative humidity is calculated as the ratio of (partial pressure of water) / (vapor pressure of water at temp). Relative humidity becomes undefined when vapor pressure exceeds barometric pressure, this condition defines the boiling point. Relative humidity is one of the fundamental properties in the Akton Psychrometric chart. There are however no secondary properties solely dependent upon relative humidity. Because the vapor pressure is solely dependent upon dry bulb temperature, relative humidity can be thought of as the degree of saturation when holding constant tempurature.

%rh = (Ph2o / Pvap) x 100

By default relative humidity is represented by "rh", and change in relative humidity is represented by 'drh."

Adiabatic Saturation Ratio

The adiabatic saturation ratio (ASR) is a measure of the saturation of moist air as is relative humidity. However ASR is the degree of saturation when holding enthalpy constant. It is calculated as: The humidity ratio of the current point divided by the humidity ratio at the intersection of the total enthalpy curve with the saturation curve for the current point.

W / (W @ rh=100 & dh=0)

Currently when using the ASR property to define a point, the ASR property may only be combined with the humidity ratio (W), or total enthalpy (h) properties, or properties that are translated to/from (W) and (h). Combining ASR with any other properties will yield the error :"PFL ERROR: unable to solve point."

By default the adiabatic saturation ration is represented by "ASR", and change in the adiabatic saturation ratio is represented by 'dASR."

Specific Volume

The specific volume properties are volume per mass values. The units of specific volume are always; volume/mass. Specific volume is one of the fundamental properties in the Akton Psychrometric chart. Other properties that are solely dependent upon specific volume, are translated to and from specific volume when used in calculations. Specific volumes are calculated using the ideal equation of state.

PV = nRT

The molar volume can be calculated as (V / n) = RT / P where n = 1; thus specific volume is calculated as $v = (V / n) \times moleWt$

There are four specific volume properties that can be selected. Specific volume can be selected on either a dry or moist air basis, and there is a delta property for both. By default they are represented by "v", "vMA", "dv", and "dvMA" respectively.

Density

The density property is the inverse of the (specific volume / moist air property), and is translated to and from specific volume just so. It is often a convenient property when defining points, or analyzing psychrometric processes.

p = 1 / vMA

By default density is represented by "p", and change in density is represented by "dp."

Change in Volume

For many psychrometric processes there is a change in total volume or volume rate associated with the change in specific volume. This property describes that change. It is only occasionally of interest. It is calculated as (volume at point 2) - (volume at point 1) or final total volume minus initial total volume. Beware, it often seems to be misused.

dVtot = Vtot@pt2 - Vtot@pt1

By default change in volume is represented by "dVtot."

Specific Enthalpy

Specific enthalpy (energy per mass) is an arbitrary property. It is always measured relative to arbitrary state which is designated to be zero. For water this is usually liquid water at the freezing point for both the English and metric systems. For air there are different conventions for the English and metric systems. In the metric system 0 degrees C is used to define the zero state. In the English system 0 degrees F is used to define the zero state. Unfortunately 0F does not equal 0C and this has caused much confusion. Specific enthalpy is one of the fundamental properties in the Akton psychrometric chart. Properties that are solely dependent upon specific enthalpy are translated to and from specific enthalpy when used in calculations.

Specific enthalpy is calculated as the sum of the sensible and latent enthalpies .

h = hs + hl

There are four specific enthalpy properties that can be selected. Specific enthalpy can be selected on either a dry or moist air basis, and there is a delta property for both. By default they are represented by "h", "hMA", "dh", and "dhMA" respectively.

Wet Bulb Temperature

Wet bulb temperature refers to the temperature where a given constant specific enthalpy intersects with the saturation curve (100% relative humidity). It is important to note that this is really the temperature of adiabatic saturation and not true wet bulb temperature as can be measured with a sling psychrometer. The difference between the two results from the small amount of sensible energy transfer to the wet bulb thermometer during use of a sling psychrometer. The difference is greatest for points that have a low relative humidity, and smallest for points that have a high relative humidity. It can also be said that the difference is greatest for large differences between wet and dry bulb, smallest for small differences between wet and dry bulb, smallest for small differences between wet and dry bulb. For the purposes associated with the most common uses of the psychrometric chart, this difference is negligible.

Wet bulb temperature is solely dependent upon the specific enthalpy, and is translated directly to and from specific enthalpy when used in calculations. There is not an empirical calculation or equation used to translate between the two. A numerical convergence routine is used to solve for a temperature, given a specific enthalpy and 100% relative humidity.

By default wet bulb temperature is represented by "tw", and change in wet bulb temperature is represented by "dtw."

Total Energy

There are two total energy properties. The first, represented by default as "Etot", is a intermediate term used in the calculation of the change in total energy for a process. It can be calculated as follows.

Etot = ma x h or Etot = EI + Es

"Etot" represents the absolute energy, or the energy necessary to raise the mass sample or rate from the state of zero to the current point. It is calculated as mass multiplied by specific enthalpy. "Etot" is dependent on specific enthalpy and mass, and thus is translated to and from specific enthalpy when used in calculations. The total energy ("Etot") should not be confused with the change in total energy ("Qtot"), which is more frequently of interest.

The change in total energy from one point to another represents the energy added or removed by the process in going from one point to another. By default it is represented by "Qtot". It is NOT the difference in total energy (as defined above) from one point to another. If water is added or removed there is an additional term. It is assumed that water is always added as liquid at the initial temperature, and removed as liquid at the final temperature. This property is of interest in a great number of psychrometric processes. It can be calculated as follows.

Qtot = Qs + Ql - Qw or Qtot = Etot@pt2 - Etot@pt1 - Qw

Since "Qtot" is not and solely dependent on a single property it can not be directly translated to and from one of the fundamental properties. Defining a point in terms of "Qtot" requires the PFL to call the numerical convergence routine recursively. It is possible to try and define two properties which will never converge even if the chart is extrapolated indefinitely. If a point is defined in terms of properties for which there is no solution, an error is returned.

Specific Sensible Enthalpy

Specific sensible enthalpy refers to the sensible energy portion of the total specific enthalpy. It is the energy necessary to raise or lower the air and water vapor (gaseous water) from the temperature of zero enthalpy to the current temperature. It is the portion of the energy term that is not attributed to a change in phase (ice to liquid, or liquid to vapor) for the water component of moist air. It is calculated by integrating the heat capacity over the range of t(zero) to t(current) for both the air and water vapor in the mixture (see heat capacity). Specific sensible enthalpy is one of the fundamental properties on the Akton Psychrometric chart. There is one dependent property: Sensible energy.

There are four specific sensible enthalpy properties that can be selected. Specific sensible enthalpy can be selected on either a dry or moist air basis, and there is a delta property for both. By default they are represented by "hs", "hsMA", "dhs", and "dhsMA" respectively.

Sensible Energy

Sensible energy is the sensible component of the total energy. There are two sensible energy properties. The first, represented by default as "Es", is a intermediate term used in the calculation of the change in sensible energy for a process. It can be calculated as follows.

Es = hs x ma

"Es" represents the energy required to heat or cool the mixture (entirely gaseous) from the temperature of zero enthalpy. It is calculated by multiplying the specific sensible enthalpy by the mass of dry air. Sensible energy is dependent on the specific sensible enthalpy, and mass sample or rate, and thus is translated to and from specific sensible enthalpy used in many calculations. "Es" should not be confused with "Qs", which is more frequently of interest.

The change in sensible energy is the energy required to heat or cool the mixture (entirely gaseous) from one point to another. By default it is represented by "Qs". It can be calculated as follows.

Qs = Es@pt2 - Es@pt1

Since "Qs" is a delta property of "Es", "Qs" is also translated to and from specific sensible enthalpy when used in many calculations.

Mass of Dry Air

Mass of dry air refers to the mass of air in the total mass sample or rate. By default the mass of dry air is represented by "ma". The mass of dry air is assumed to remain constant in any psychrometric process on the chart. The mass of dry air is one of the fundamental properties in the Akton psychrometric chart. All the other properties that can be used to define the mass sample or rate, are translated to and from the mass of dry air property. Mass properties are only relevant for "entry" points, when defining points. For "process" and "mix" points, the mass properties are calculated from the previous point or points, assuming that the mass of dry air remains constant.

Mass of Water

Mass of water refers to the mass of water in the total mass sample or rate. By default the mass of water is represented by "mw". Only the mass of water can change in a psychrometric process, not the mass of air, because the mass of dry air is assumed to remain constant. A change in the mass of water is therefore equivalent to a change in total mass. If the change in mass of water is of interest, use the change in total mass property. The mass of water is translated to the mass of dry air when used to define a point. The following equation describes this relation ship.

mw = ma * W

Total Mass

Total mass refers to the total mass sample or rate for a given point on the chart. By default the mass sample or rate is represented by "m". It is calculates as:

m = ma + mw

There is a delta property to describe a change in total mass. By default it is represented by "dm". Because the mass of air is assumed to remain constant, the change in total mass also represents the change in mass of water for a process. Total mass is translated to and from the mass of dry air property. The change in mass property however is translated to and from humidity ratio (see change in mass).

Moles of Dry Air

The moles of dry air property is the molar counterpart to the mass of dry air property. By default it is represented by "na". It is translated to and from the mass of dry air when used in calculations. It can be calculated as follows.

na = ma / (Mol Wt. Air)

Moles of Water

The moles of water property is the molar counterpart to the mass water property. By default it is represented by "nw". It is translated to and from the mass of dry air when used in calculations. It can be calculated as follows.

nw = mw / (Mol Wt. Water)

Total Moles

The total moles property is the molar counter part to the total mass property. By default it is represented by "n". It is translated to and from the mass of dry air when used in calculations. It can be calculated as the sum of moles of water plus moles of air.

n = nw + na

There is a property to describe a change in total moles. By default it is represented by "dn" (see change in moles).

Volume or Volume Rate

This property represents the volume sample or rate at a point. By default the volume sample or rate is represented by "Vtot". "Vtot" is translated to and from the mass of dry air by the relationship of:

Vtot = ma x v where "v" is the specific volume

There is a property to describe a change in volume. By default it is represented by "dVtot" (see change in volume).

Split Ratio

The split ratio indicates the proportion of mass inherited from a reference point. By default the split ratio is designated by "s", and is assumed to be 100%.

The primary reason that the split ratio property has been added, is to provide a means of splitting a stream, when developing more complex models. The split ratio can NOT be transferred to the edit point dialog box by double clicking on the property inside the properties window. It must be selected for a reference point through the use of the advanced point options, when creating or editing process points or mix points.

Change in Enthalpy/Change in Humidity Ratio

The ratio of change in specific enthalpy to the change in humidity ratio is sometimes referred to as the enthalpy of added or rejected water. By default this ratio is represented by "dh/dW". This property is one of the fundamental properties in the Akton psychrometric chart, and is calculated simply as:

dh/dW = dh / dW

This ratio is useful in the analysis of humidification and dehumidification processes. It can be directly related to the specific enthalpy of the water that is being added or removed from the system. This ratio is not a unitless quantity, the units can be selected from among the units appropriate for specific enthalpy. They can be interpreted as energy per mass of water added or removed. This property is often presented on charts in the form of a protractor in the upper left hand corner when viewing a typical published psychrometric chart.

Defining a point in terms of "dh/dW" requires the PFL to call the numerical convergence routine recursively. It is possible to try and define two properties which will never converge even if the chart is extrapolated indefinitely. If a point is defined in terms of properties for which there is no solution, an error is returned.

Sensible/Total Heat Ratio

This ratio is useful in many heating and cooling processes. By default this ratio is represented by "dhs/dh". This property is usually presented on charts in the form of a protractor in the upper left hand corner when viewing a typical published psychrometric chart. In the Akton psychrometric chart this ratio is approximated by an asymptotic equation of the form:

(x-1)(y) = C:

substitute dhs/dh for x dh/dW for y h(vap) for C

(dhs/dh - 1)(dh/dW) = h(vap)

This allows this ratio to be translated to and from "dh/dW"

dh/dW = h(vap) / (dhs/dh - 1)

Delta Properties

Many of the properties in the Akton psychrometric chart are designated to be "delta" properties. They are all associated with some other non-property for which they are to describe the difference from one point to another on the chart. They are all calculated as (value at current point) - (value at previous point) for their respective non-delta properties. For most of the "delta" properties, when they are used to define a point the result point is calculated as (value of current point) + (delta value). There are a few exceptions.

Exceptions: Change In Mass Change In Moles Change In Volume

Property List

Below is a complete list of all available properties with their default symbols and descriptions. It is possible to change both the symbol and the description of all the properties. Many of the symbols below are used in the property descriptions and definitions in this document and others.

1	Pressure	barometric pressure
2	Altitude	altitude above sea level
3	W	humidity ratio
4	dW	humidity ratio (delta)
5	q	specific humidity
6	dq	specific humidity (delta)
7	Ph2o	partial pressure of water
8	dPh2o	partial pressure of water (delta)
9	Pair	partial pressure of air
10	dPair	partial pressure of air (delta)
11	nw/n	molar fraction of water
12	d_nw/n	molar fraction of water (delta)
13	na/n	molar fraction of air
14	d_na/n	molar fraction of air (delta)
15	ma/m	mass fraction of air
16	d_ma/m	mass fraction of air (delta)
17	td	dew point temperature
18	dtd	dew point temperature (delta)
19	hl	specific latent enthalpy / dry air

20	dbl	anagifia latant anthology / dry gir (dalta)
20		specific latent enthalpy / dry all (delta)
21	nima	specific latent enthalpy / moist air
22	dhima	specific latent enthalpy / moist air (delta)
23	El	latent energy
24	QI	latent energy (delta)
25	dm	mass sample or rate (delta)
26	dn	moles of water in mass sample or rate (delta)
27	t	dry bulb temperature
28	dt	dry bulb temperature (delta)
29	Pvap	vapor pressure
30	dPvap	vapor pressure (delta)
31	rh	relative humidity
32	drh	relative humidity (delta)
33	ASR	Adiabatic saturation ratio
34		Adiabatic saturation ratio (delta)
25		specific volume / dry air
26	v dv	specific volume / dry air
30		specific volume / ury all (deita)
37	VIVIA	specific volume / moist air
38	dvima	specific volume / moist air (deita)
39	p	density of moist air
40	dp	density of moist air (delta)
41	dVtot	volume sample or rate (delta)
42	h	specific enthalpy / dry air
43	dh	specific enthalpy / dry air (delta)
44	tw	wet bulb temperature
45	dtw	wet bulb temperature (delta)
46	hMA	specific enthalpy / moist air
47	dhMA	specific enthalpy / moist air (delta)
48	Etot	total energy
49	Qtot	total energy (delta)
50	hs	specific sensible enthalov / dry air
51	dhs	specific sensible enthalpy / dry air (delta)
52	hsMA	specific sensible enthalpy / moist air
53	dhsMA	specific sensible enthalpy / molet all
54	Fe	sensible energy
55		sensible energy (delta)
55		mana of air in mana comple or rate
50	mu	mass of all in mass sample of rate
57		mass of water in mass sample of rate
58	m	mass sample of rate
59	na	moles of air in mass sample or rate
60	nw	moles of water in mass sample or rate
61	n	total moles in mass sample or rate
62	Vtot	volume sample or rate
63	S	Split ratio
64	dhs/dh	delta Hs to delta H ratio
65	dh/dW	delta H to delta W ratio
66	Qw	energy of liquid water (delta)

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