THE

MAC

HUMIDITY/MOISTURE

HANDBOOK

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Introduction

Through the years we at Machine Applications Corporation have had the opportunity to discuss many different humidity/moisture measurement and control applications with a large number of users and potential users of measurement equipment. We find that very few have a firm understanding of this somewhat specialized field of engineering.

The confusion that exists is probably due to the following:

<u>One</u>, words like *humidity, moisture, vapor, dew point, steam, fog, condensation*, etc. are used in everyday speech even though their meanings are understood in the most general way. These same words when use by a scientist or an engineer have very specific meanings which are misinterpreted by someone who does not use them in their scientific sense regularly. An example would be the following sentences. *"The water is boiling. I can see steam coming out of the pot."* Those who work with steam know that it is invisible and that the cloud that is seen above the pot of boiling water is actually water droplets that form as the steam cools and condenses as it mixes with the air above the pot.

<u>Two</u>, there are many different ways to represent the amount of moisture that is dissolved in the air or other atmosphere. *Relative humidity, specific humidity, humidity ratio, dew point, percent by volume, and grams per cubic meter* are all used to express a measure of the amount of water vapor that is mixed with other gases.

Relative Humidity

Relative humidity is familiar to most of us because of its everyday usage with regard to the weather. Relative humidity is usually abbreviated "RH" and is expressed as a percentage between zero and 100%. RH indicates the amount of moisture in the air as a percentage of the maximum amount the air can hold (below 212°F). Unfortunately the amount of moisture the air can hold depends on the temperature of the air. The following graph shows the maximum percentage of water vapor that the air can hold at a given temperature.

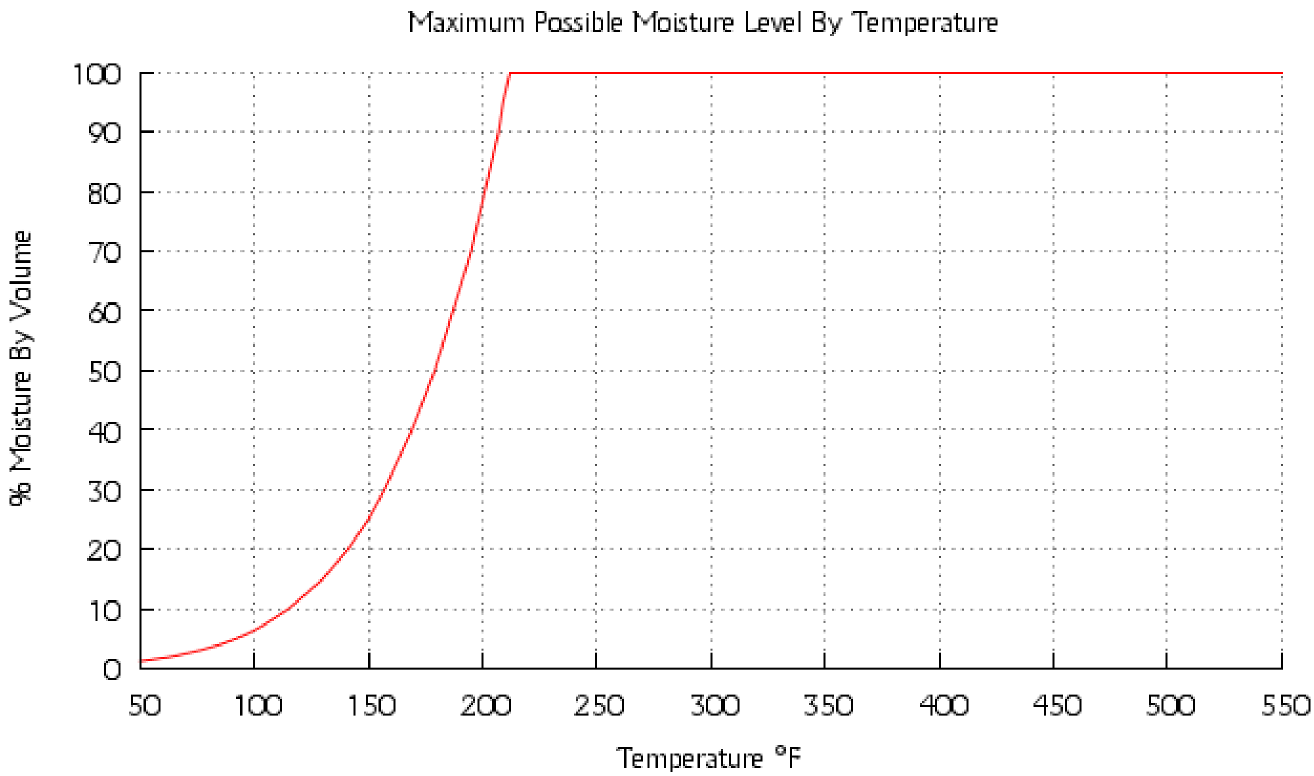

Figure 1

The graph shows that the higher the temperature (up to 212°F) the higher the amount of water vapor the air can hold. At 212°F and above it is possible for the air to be totally water vapor (steam) and the % moisture by volume can reach 100%.

Before we give the technical definition of RH we must explain the terms that will be used in the definition.

Partial Pressure

Let's take an empty jar and screw the lid on tight. The air in the jar is the same air that is in the room outside of the jar. To make things simple assume that the air is 20% oxygen and 80% nitrogen.

The pressure inside the jar is the same as the atmospheric pressure outside the jar which is about 14.7 PSI. The pressure inside the jar is caused by the oxygen O_2 molecules and the nitrogen N_2 molecules bouncing around hitting the sides of the jar. If we could remove the oxygen from the jar there would be fewer molecules to collide with the jar. The pressure would be less and would be due totally to the nitrogen molecules. The pressure exerted by the nitrogen molecules alone would be 80% of 14.7 PSI which is 11.76 PSI. If we left the oxygen in the jar and removed the nitrogen, the pressure would be 20% of 14.7 PSI which is 2.94 PSI.

The partial pressure of a gas is the part of the total pressure that is exerted by that gas alone.

P_O = Partial pressure of oxygen = 2.94 PSI
P_N = Partial pressure of nitrogen = 11.76 PSI
P_T = Total Pressure = $P_O + P_N$ = 14.7 PSI

If we took our jar up a mountain to 10,000 ft. above sea level and then sealed it, the total pressure would only be 10.1 PSI.

P_O = 2.02 PSI, P_N = 8.08 PSI, P_T = 10.1 PSI

Saturation Pressure (Ps)

The saturation pressure of water vapor is the partial pressure of water vapor at 100% relative humidity. 100% relative humidity is the point where liquid water and water vapor are in equilibrium, which means the water is evaporating into vapor and the vapor is condensing into liquid. Since water boils at 212°F at atmospheric pressure, the pressure Ps must go above atmospheric pressure when the temperature goes above 212°F. To maintain 100% relative humidity at 250°F would require a pressure near 30 PSI or two times atmospheric pressure.

Figure 2 shows the saturation pressure for water vs. temperature from 50°F to 550°F.

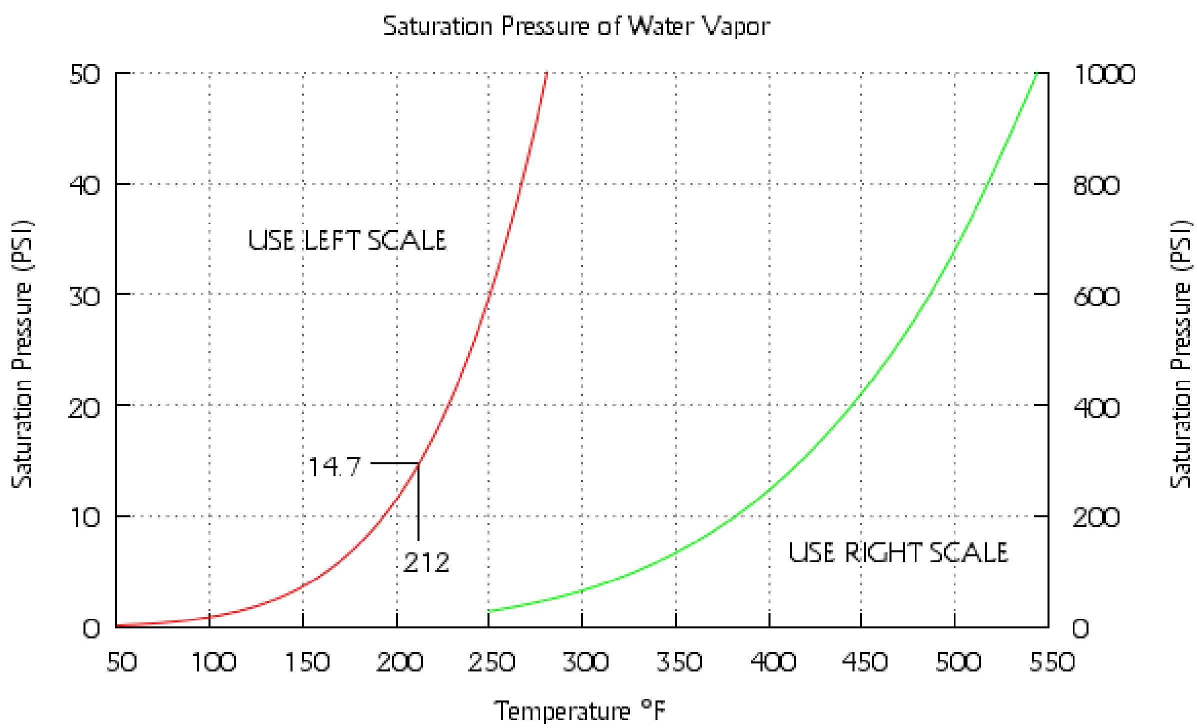

Figure 2

As we shall see this rapid increase in saturation pressure above 212°F is why it is impossible to reach 100% RH at atmospheric pressure above 212°F. The physics definition of RH is expressed by the following equation:

$$\%RH = Pw/Ps \times 100$$

Pw is the partial pressure of water vapor in the air and Ps is the saturation pressure. Above 212°F Pw is equal to the atmospheric pressure when the moisture level is 100%, but Ps, the saturation pressure, increases rapidly with temperature. The graph in Figure 3 shows the maximum RH vs. temperature at atmospheric pressure. Note that below 212°F it is possible to achieve 100% RH even though the % moisture in the air by volume is less than 100% (as shown on the graph in Figure 1). Above 212°F the maximum RH is less than 100% even when the atmosphere is 100% water vapor (100% moisture by volume).

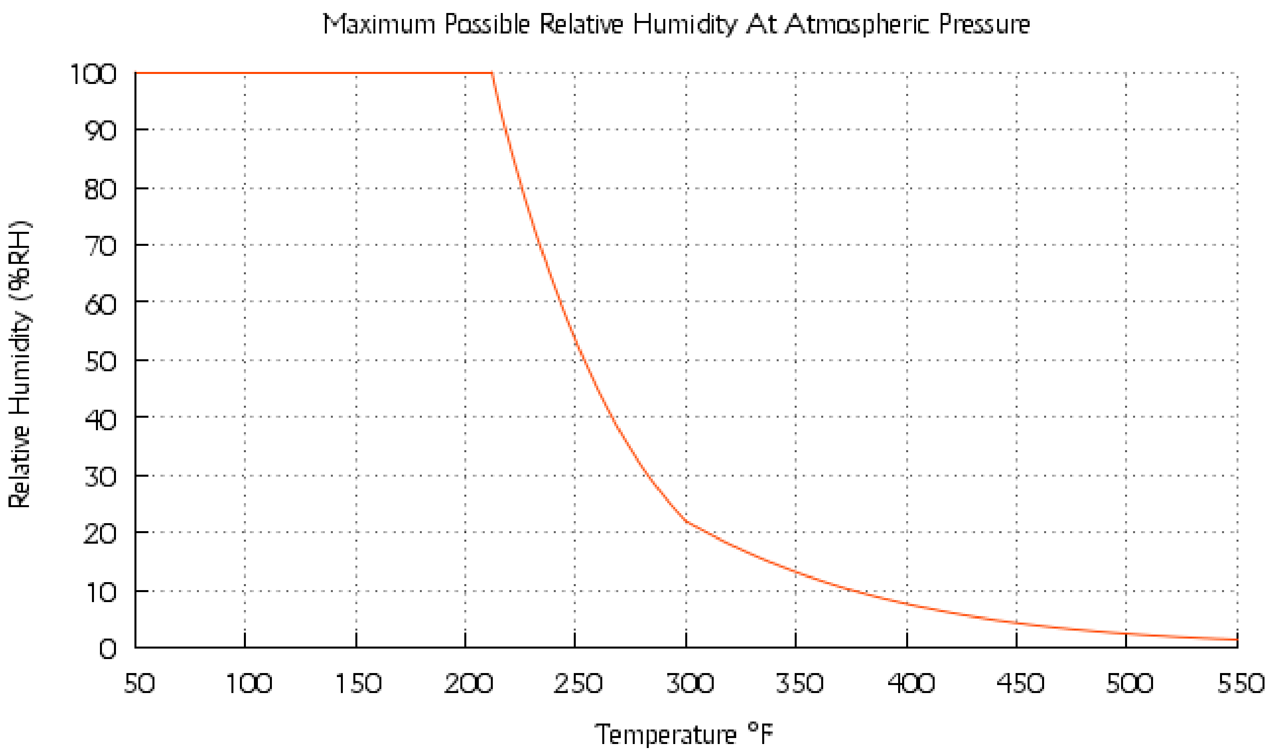

Figure 3

At 400°F the maximum possible RH is 5.9%. At 700°F the maximum possible RH is .48%.

Although there are instruments available to measure RH up to 400°F, it can be seen from the graphs of Figure 1 and Figure 3 that the relative humidity is a useless and even misleading scale for indicating moisture level above 212°F. An instrument that could measure relative humidity with an

±1% accuracy at 400°F would give us a measure of the % moisture by volume to an accuracy of ±1 part in 5.9 or ±17%.

The relative humidity scale gives us some surprising results at ordinary room temperature as well. Let us assume that the room we are in is at a temperature of 60° and the relative humidity is 50%. The % water vapor in the room at these conditions is .87%. If we turn on our electric heater and increase the room temperature to 75°F the RH will drop to 33% even though the % moisture by volume remains at .87%.

With this example we begin to get an idea of the difference between a relative moisture scale and an absolute moisture scale. The relative humidity changes when the temperature changes, but the % water vapor by volume does not change with temperature. It changes only when water vapor is added or removed from the atmosphere.

The atmosphere around us is composed of a mixture of gases in the following proportions when the air is totally dry:

Nitrogen	78.084%
Oxygen	20.948%
Argon	.934%
Carbon Dioxide	.0314%
Neon	.00182%
Methane	.00015%
Hydrogen	.00005%
Other trace gases	.000056%

Since air is seldom totally without water vapor, the above percentages change depending on the amount of water vapor that is mixed with other gases.

As we have already stated, 50% RH @ 60°F corresponds to .87% water vapor. 50% RH @ 95°F corresponds to 2.8% moisture by volume, and 100% RH @ 95°F is a moisture level of 5.6% by volume.

The atmosphere inside a gas fired boiler will be very different than the atmosphere around us. Most of the oxygen will be used up to burn the fuel. The carbon in the fuel burns and becomes carbon dioxide and the hydrogen in the fuel burns and becomes water vapor. If the fuel was methane and the combustion air was totally dry (0% water vapor) the atmosphere in the boiler would be:

73% Nitrogen
18% Water vapor
9% Carbon Dioxide

At the high temperatures inside a boiler the relative humidity would be close to zero even though the % moisture by volume would be 18%.

When it is raining or snowing outside the relative humidity is nearly 100%. This is because the water vapor from the snow or water droplets will evaporate into the air as long as the RH is less than 100%. When the outside temperature is 10°F and it is snowing, the %

moisture in the air is about .2%, even though the relative humidity is near 100%. If we bring the air into our home and heat it to 72°F, the relative humidity drops to 7.59%. The % water vapor is still .2% if all we do is heat the air.

Other Absolute Moisture Scales

The previous examples have shown that % moisture by volume is an absolute scale and does not change with temperature. There are other absolute scales as well:

% Moisture by Volume, $\%M_V$
Grams per Cubic Meter, g/m^3
Humidity Ratio (LB Water/LB Dry Air or g Water/g Dry Air), W
Specific Humidity (LB Water/LB Mixture or g Water/g Mixture), q
Dew Point Temperature, td

% Moisture by Volume ($\%M_V$)

The % Moisture by Volume can be defined in a least two ways:

$$\%M_V = \frac{\text{Number of } H_20 \text{ molecules per unit volume}}{\text{Total number of molecules per unit volume}} * 100$$

$$\%M_V = P_W/P_T*100$$

P_W = Partial pressure due to water vapor
P_T = Total pressure (usually atmospheric pressure)

Grams Per Cubic Meter

In some countries a popular moisture measurement scale is grams of water vapor per cubic meter. This scale is based on the density of water vapor at standard conditions of temperature and pressure (STP). There are several different STP values that are given by various standards organizations. In this publication we will use the STP of the International Union of Pure and Applied Chemistry (IUPAC). The STP of the IUPAC is 0°C and 100kPa.

Pure water vapor (100% H2O by volume) can not exist at STP because 0.6% water vapor by volume has a dew point of 0°C at this pressure. Except for water vapor, all the constituents of air can exist as a gas at STP. We will use this fact in order to calculate a theoretical value for g/M^3 of water vapor.

The density of air at STP is given as 1275.4 g/m^3. The density of water vapor is 62.19% the density of air. If 100% water vapor could exist at STP it would have a density of 1275.4 times .6219 which equals 793.17 g/M^3.

The last column on TABLE 1 is calculated using a value 7.9317 g/M^3 for each 1.0% of water vapor by volume.

Humidity Ratio

The humidity ratio is sometimes referred to as moisture content or the mixing ratio. It is the mass of water vapor per unit mass of dry air. The humidity ratio (W) can be calculated if the % moisture by volume ($\%M_V$) is known.

$$\text{Humidity Ratio} = W = .622 \times \%M_V/(100-\%M_V)$$

This equation is valid only for the normal mixture of gases in the atmosphere. When a different mixture of gases is present as is found inside a boiler flue, the factor .622 must change. This factor is the ratio of the molecular weight of water vapor (18.015) to the average molecular weight of the other gases (28.965 in the case of air).

$$18.015/28.965 = .622$$

Note that the % moisture by volume scale is totally independent of the molecular weights of the other gases in the mixture, as in a boiler or direct fired oven.

Specific Humidity

Specific humidity is the ratio of the mass of water vapor to the total mass of the mixture of water vapor and dry air. The specific humidity (q) can be calculated if the % moisture by volume ($\%M_V$) is known.

Specific Humidity = q = $.622 \times \%M_V/[(100-\%M_V) + .622 \times \%M_V]$

The factor .622 is for normal air only. It must be corrected if the average molecular weight of the gases is different than air.

Dew Point

As we have shown in previous examples, when air below 212°F is cooled the relative humidity increases. The dew point is the temperature at which the relative humidity reaches 100%. The RH can not exceed 100%, so if we continue to cool air it will give up moisture in the form of condensation.

This is how dew forms, why a glass of ice water gets wet on the outside, and why condensation trails form behind aircraft at high altitudes (it is cold up there). If the dew point temperature is below 32°F, snow will form instead of rain or frost will form instead of dew. Below 32°F the dew point is sometimes called the frost point.

There is a direct correlation between the concentration of water vapor in the air and the dew point temperature. This is also true for other gases in the air. If we could cool the air to extremely low temperatures, carbon dioxide would condense into CO_2 snow. By measuring the temperature at which this happens we could determine the concentration of CO_2 in the air. The same is true of the nitrogen and oxygen in the air. Depending on the concentration of a gas we must reach its condensation point (dew point) to get it to condense into a liquid, or its frost point to get it to condense into a solid form.

The boiling points of the major components of air at atmospheric pressure are:

Water Vapor	H_2O	212°F
Carbon Dioxide	CO_2	-108°F
Oxygen	O_2	-297°F
Nitrogen	N2	-321°F

These temperatures are also the temperature at which a 100% concentration would liquify (dew point temperature). When the concentration of a gas in mixture is less than 100% the liquidization temperature becomes lower.

The point of this discussion is that there is nothing special about the way water vapor behaves compared to other gases in the atmosphere except that the dew point and frost point of water vapor occur at ordinary ambient temperatures.

Figure 4 gives the dew/frost point temperatures for low concentrations of moisture in the air.

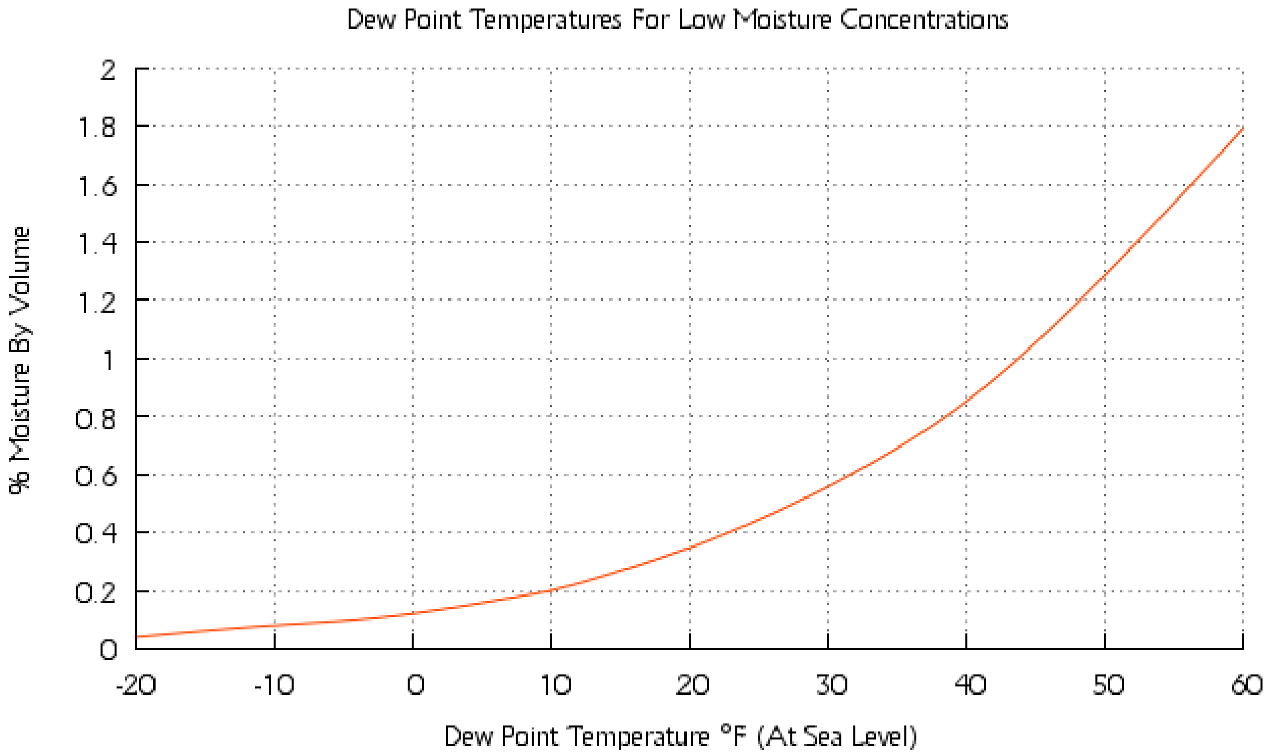

Figure 4

Figure 5 gives the dew point temperature for medium and high concentrations of moisture in the air.

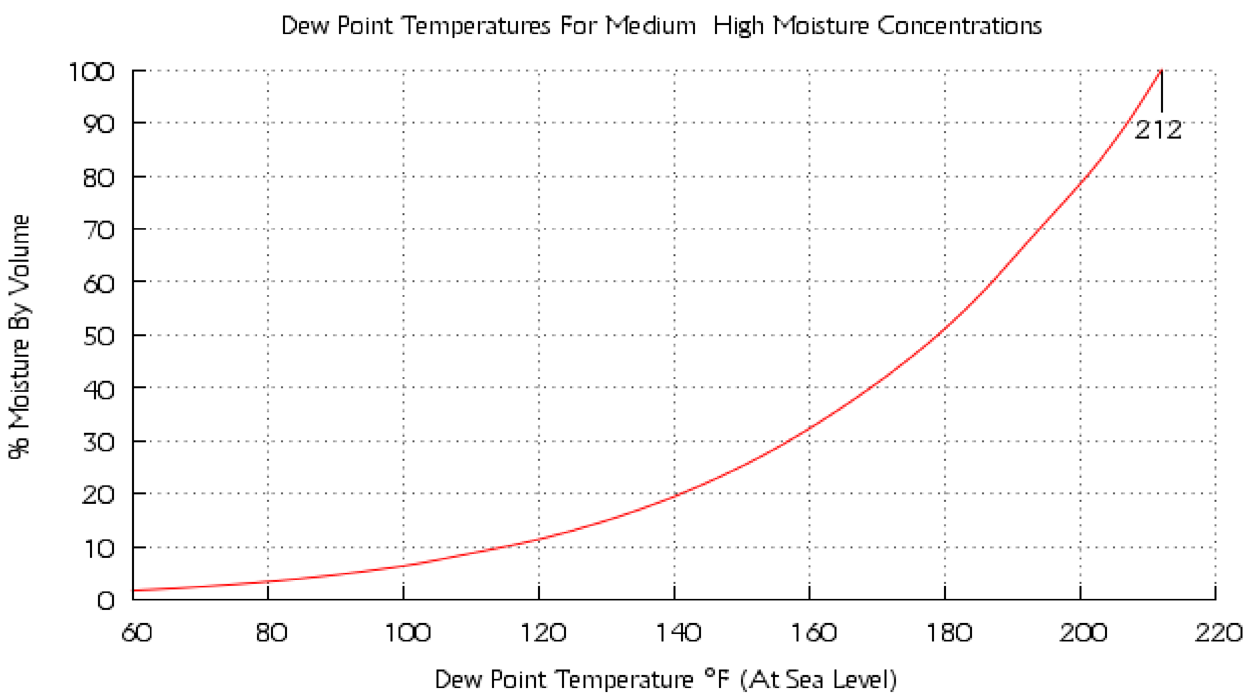

Figure 5

The dew point can be determined from the % moisture by volume by using a graph of the saturation pressure (Ps) of water vapor (as in Figure 2) or a table of Ps vs. temperature.

Example:
If the % moisture by volume is 25%, what is the dew point temperature?

First find the partial pressure of water vapor (Pw).

At atmospheric pressure and 25% M_V, Pw= 25% of 14.7 PSI or 3.68 PSI.
At the dew point RH = 100% so Pw must equal Ps.
Go to Figure 2 and find Ps at 3.68 PSI and read the corresponding temperature from the graph (150°F).

Dew point is not quite an absolute scale. Dew point does change with pressure, and atmospheric pressure changes with altitude. The atmospheric pressure in Denver, Colorado is only 12.2 PSI (5200 ft. above sea level). At sea level water boils @ 211.9°F. In Denver water boils a 203°F. These two temperatures are dew point temperatures corresponding to 100% moisture by volume, but they are different due to change in total pressure.

Comparison of Absolute Moisture Scales

Values for five different moisture scales are tabulated in **Table 1 – Moisture/Humidity Scales** (found on pages 14 thru 19). This table can be used to convert from one moisture scale to another.

Table 1 can be used to convert to or from relative humidity (RH) at temperatures below 212°F.

Example 1:
If the relative humidity (RH) is 50% and the temperature is 76°F, what is the % moisture by volume (%M_V)?

First find the temperature of 76°F in the dew point column. Then look across to the %M_V column and find 3%. This tells us that 100% RH at 76°F (dew point temperature) is 3% moisture by volume (M_V%). 50% RH corresponds to 50% of 3% or 1.5% M_V.

Example 2:
If the % moisture by volume is 4% and the temperature is 107°F, what is the RH?
First find the temperature of 107°F in the dew point column. Then look across to the %M_V column and find 8% moisture by volume. Since 8% is the moisture level @ 100%RH @ 107°F, 4% M_V corresponds to 50% RH.

Each moisture scale that we have discussed is preferred by people that work in specific disciplines.

Relative Humidity (RH)

When dealing with human comfort at normal ambient temperatures relative humidity is the preferred scale. Weather forecasters (meteorologists) and heating, ventilating and air conditioning engineers (HVAC) use relative humidity regularly.

% Moisture by Volume (M_V)

This scale is the most intuitive of the absolute scales. People who work in the areas of combustion and pollution control engineering routinely measure flue gas constituents in % moisture by volume. Because of the linear nature of this scale it is easy to display and easy to regulate using normal set point P.I.D. controllers. For these reasons %M_V is also used in the areas of food processing, product drying and product humidifying.

Humidity Ratio (W)

This scale is preferred by people who work in the product drying process since it can be directly used in energy calculations. This scale is also commonly used as the vertical axis on most psychometric charts. Because this scale is very non linear and goes thru many orders of magnitude, it is a difficult scale to display or use in a control mode. Since it is simple to convert between scales, %M_V is used for display and control of the moisture level, and then converted to humidity ratio for calculations.

Dew Point Temperature (td)

This scale is widely used by people who are concerned with the possibility of water condensing in pipes carrying compressed air or other gases. Dew point is also used by those working with sampling systems for the same reason. Condensation in lines can be avoided by maintaining the working fluid at a temperature well above its dew point or by drying a fluid to a dew point well below the lowest temperature to which it will be exposed.

Table 1 – Moisture/Humidity Scales

% Moisture By Volume	Humidity Ratio	Speific Humidity	Dew Point Temperature	Grams Per Cubic Meter *
%Mv	W $\frac{LB\ H_2O}{LB\ Dry\ Air}$	q $\frac{LB\ H_2O}{LB\ Mixture}$	td	g/m^3
0.0	0	0	-460°F(-273.3°C)	0.00
0.1	0.000623	0.000622	-4°F(-20.0°C)	0.79
0.2	0.00125	0.00124	10°F(-12.2°C)	1.59
0.3	0.00187	0.00187	18°F(-7.8°C)	2.38
0.4	0.00250	0.00249	24°F(-4.4°C)	3.17
0.5	0.00313	0.00312	28°F(-2.2°C)	3.97
0.6	0.00375	0.00374	32°F(0°C)	4.76
0.7	0.00438	0.00437	36°F(2.2°C)	5.55
0.8	0.00502	0.00499	39°F(3.9°C)	6.35
0.9	0.00565	0.00562	42°F(5.6°C)	7.14
1.0	0.00628	0.00624	45°F(7.2°C)	7.93
2.0	0.0127	0.0125	64°F(17.8°C)	15.86
3.0	0.0192	0.0189	76°F(24.4°C)	23.80
4.0	0.0259	0.0253	85°F(29.4°C)	31.73
5.0	0.0327	0.0317	92°F(33.3°C)	39.66
6.0	0.0397	0.0382	98°F(36.7°C)	47.59
7.0	0.0468	0.0447	103°F(39.4°C)	55.52
8.0	0.0541	0.0513	107°F(41.7°C)	63.45
9.0	0.0615	0.0579	111°F(43.9°C)	71.39
10.0	0.0691	0.0646	115°F(46.1°C)	79.32

*At standard temperature and pressure as defined by The International Union of Pure and Applied Chemistry (IUPAC)

Table 1 – Moisture/Humidity Scales (continued)

% Moisture By Volume	Humidity Ratio	Speific Humidity	Dew Point Temperature	Grams Per Cubic Meter *
%Mv	W LB H_2O / LB Dry Air	q LB H_2O / LB Mixture	td	g/m^3
11.0	0.0769	0.0714	118°F(47.8°C)	87.25
12.0	0.0848	0.0782	121°F(49.4°C)	95.18
13.0	0.0929	0.085	124°F(51.1°C)	103.11
14.0	0.101	0.0919	127°F(52.8°C)	111.04
15.0	0.110	0.0989	130°F(54.4°C)	118.98
16.0	0.118	0.106	132°F(55.6°C)	126.91
17.0	0.127	0.113	134°F(56.7°C)	134.84
18.0	0.137	0.120	136°F(57.8°C)	142.77
19.0	0.146	0.127	139°F(59.4°C)	150.70
20.0	0.155	0.135	141°F(60.6°C)	158.63
21.0	0.165	0.142	143°F(61.7°C)	166.57
22.0	0.175	0.149	144°F(62.2°C)	174.50
23.0	0.186	0.157	146°F(63.3°C)	182.43
24.0	0.196	0.164	148°F(64.4°C)	190.36
25.0	0.207	0.172	150°F(65.6°C)	198.29
26.0	0.219	0.179	151°F(66.1°C)	206.22
27.0	0.207	0.187	153°F(67.2°C)	214.16
28.0	0.242	0.195	154°F(67°C)	222.09
29.0	0.254	0.203	156°F(68.9°C)	230.02
30.0	0.267	0.210	157°F(69.4°C)	237.95

*At standard temperature and pressure as defined by The International Union of Pure and Applied Chemistry (IUPAC)

Table 1 – Moisture/Humidity Scales (continued)

% Moisture By Volume	Humidity Ratio	Speific Humidity	Dew Point Temperature	Grams Per Cubic Meter *
%Mv	W $\frac{\text{LB } H_2O}{\text{LB Dry Air}}$	q $\frac{\text{LB } H_2O}{\text{LB Mixture}}$	td	g/m^3
31.0	0.279	0.218	158°F(70.0°C)	245.88
32.0	0.293	0.226	160°F(71.1°C)	253.81
33.0	0.306	0.235	161°F(71.7°C)	261.75
34.0	0.320	0.243	162°F(72.2°C)	269.68
35.0	0.335	0.251	163°F(72.8°C)	277.61
36.0	0.350	0.259	165°F(73.9°C)	285.54
37.0	0.365	0.268	166°F(74.4°C)	293.47
38.0	0.381	0.276	167°F(75.0°C)	301.40
39.0	0.398	0.285	168°F(75.6°C)	309.34
40.0	0.415	0.293	169°F(76.1°C)	317.27
41.0	0.432	0.302	170°F(76.7°C)	325.20
42.0	0.450	0.311	171°F(77.2°C)	333.13
43.0	0.469	0.319	172°F(77.8°C)	341.06
44.0	0.489	0.328	173°F(78.3°C)	348.99
45.0	0.509	0.337	174°F(78.9°C)	356.93
46.0	0.530	0.346	175°F(79.4°C)	364.86
47.0	0.552	0.355	176°F(80.0°C)	372.79
48.0	0.574	0.365	177°F(80.6°C)	351.22
49.0	0.598	0.374	178°F(81.1°C)	388.65
50.0	0.622	0.383	179°F(81.7°C)	396.59

*At standard temperature and pressure as defined by The International Union of Pure and Applied Chemistry (IUPAC)

Table 1 – Moisture/Humidity Scales (continued)

% Moisture By Volume	Humidity Ratio	Speific Humidity	Dew Point Temperature	Grams Per Cubic Meter *
%Mv	W $\frac{LB\ H_2O}{LB\ Dry\ Air}$	q $\frac{LB\ H_2O}{LB\ Mixture}$	td	g/m^3
51.0	0.647	0.393	180°F(82.2°C)	404.52
52.0	0.674	0.403	181°F(82.8°C)	412.45
53.0	0.701	0.412	182°F(83.3°C)	420.38
54.0	0.730	0.422	182°F(83.3°C)	428.31
55.0	0.760	0.432	183°F(83.9°C)	436.24
56.0	0.792	0.442	184°F(84.4°C)	444.18
57.0	0.824	0.452	185°F(85.0°C)	452.11
58.0	0.859	0.462	186°F(85.6°C)	460.04
59.0	0.895	0.472	187°F(86.1°C)	467.97
60.0	0.933	0.483	187°F(86.1°C)	475.90
61.0	0.973	0.493	188°F(86.7°C)	483.83
62.0	1.01	0.504	189°F(87.7°C)	491.77
63.0	1.06	0.514	190°F(87.8°C)	499.70
64.0	1.11	0.525	190°F(87.8°C)	507.63
65.0	1.16	0.536	191°F(88.3°C)	515.56
66.0	1.21	0.547	192°F(88.9°C)	523.49
67.0	1.26	0.558	192°F(88.9°C)	531.42
68.0	1.32	0.569	193°F(89.4°C)	539.36
69.0	1.38	0.581	194°F(90.0°C)	547.29
70.0	1.45	0.592	194°F(90.0°C)	555.22

*At standard temperature and pressure as defined by The International Union of Pure and Applied Chemistry (IUPAC)

Table 1 – Moisture/Humidity Scales (continued)

% Moisture By Volume	Humidity Ratio	Speific Humidity	Dew Point Temperature	Grams Per Cubic Meter *
%Mv	W $\frac{LB\ H_2O}{LB\ Dry\ Air}$	q $\frac{LB\ H_2O}{LB\ Mixture}$	td	g/m^3
71.0	1.52	0.604	195°F(90.6°C)	563.15
72.0	1.60	0.615	196°F(91.1°C)	571.08
73.0	1.68	0.627	197°F(91.7°C)	579.01
74.0	1.77	0.639	197°F(91.7°C)	586.95
75.0	1.87	0.651	198°F(92.2°C)	594.88
76.0	1.97	0.663	198°F(92.2°C)	602.81
77.0	2.08	0.676	199°F(92.8°C)	610.74
78.0	2.21	0.688	200°F(93.3°C)	618.67
79.0	2.34	0.701	200°F(93.3°C)	626.60
80.0	2.49	0.713	201°F(93.9°C)	634.54
81.0	2.65	0.726	201°F(93.9°C)	642.47
82.0	2.83	0.739	202°F(94.4°C)	650.40
83.0	3.04	0.752	203°F(95.0°C)	658.33
84.0	3.27	0.766	203°F(95.0°C)	666.26
85.0	3.52	0.779	204°F(95.6°C)	674.19
86.0	3.82	0.793	204°F(95.6°C)	682.13
87.0	4.16	0.806	205°F(96.1°C)	690.06
88.0	4.56	0.820	206°F(96.7°C)	697.99
89.0	5.03	0.830	206°F(96.7°C)	705.92
90.0	5.60	0.848	207°F(97.2°C)	713.85

*At standard temperature and pressure as defined by The International Union of Pure and Applied Chemistry (IUPAC)

Table 1 – Moisture/Humidity Scales (continued)

% Moisture By Volume	Humidity Ratio	Speific Humidity	Dew Point Temperature	Grams Per Cubic Meter *
%Mv	W $\frac{\text{LB } H_2O}{\text{LB Dry Air}}$	q $\frac{\text{LB } H_2O}{\text{LB Mixture}}$	td	g/m^3
91.0	6.29	0.863	207°F(97.2°C)	721.78
92.0	7.15	0.877	208°F(97.8°C)	729.72
93.0	8.26	0.892	208°F(97.8°C)	737.65
94.0	9.74	0.907	209°F(98.3°C)	745.58
95.0	11.80	0.922	209°F(98.3°C)	753.51
96.0	14.90	0.937	210°F(98.9°C)	761.44
97.0	20.10	0.953	210°F(98.9°C)	769.37
98.0	30.50	0.968	211°F(99.4°C)	777.31
99.0	61.60	0.984	211°F(99.4°C)	785.24
100.0	∞	1	212°F(100.0°C)	793.17

*At standard temperature and pressure as defined by The International Union of Pure and Applied Chemistry (IUPAC)

Conclusion

At this point you should be able to convert from any of the moisture scales to any other, but it is important to keep the following in mind:

- For a constant % moisture level dew point changes with pressure or altitude.
- For a constant % moisture level humidity ratio and specific humidity change with gas mixtures other than air (affected by products of combustion).

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