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Measuring Vapor Pressure Deficit in the Field

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This paper presents a simple method to determine the vapor pressure deficit (VPD) in the field. The VPD is often used to determine baseline curves for plant-based measures of water status (e.g., with infrared thermometers or with stem water potential). Both the air (T) and dew point (T_d) temperature are measured. Then the saturation vapor pressure is calculated using the equation

$$e_s = \exp\left(\frac{17.27T}{T + 237.3}\right)$$

The actual vapor pressure (e) is calculated using the same equation, but with the dew point temperature (T_d) substituted for T in the equation. Rather than making the calculations, the following two tables can be used to determine e_s and e from T and T_d. The two tables are provided so one can print them front to back on a single sheet of paper. The paper can be laminated to prevent damage when working in the field. The first table is for temperatures 32°F through 79°F and the second has temperatures 80°F through 120°F. To use the table, find the dew point temperature

				Vapor Pressure in KPa				

Temp (°F)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
32	0.61	0.61	0.62	0.62	0.62	0.62	0.63	0.63	0.63	0.63
33	0.64	0.64	0.64	0.64	0.65	0.65	0.65	0.65	0.66	0.66
34	0.66	0.66	0.67	0.67	0.67	0.68	0.68	0.68	0.68	0.69
35	0.69	0.69	0.69	0.70	0.70	0.70	0.71	0.71	0.71	0.71
36	0.72	0.72	0.72	0.73	0.73	0.73	0.73	0.74	0.74	0.74
37	0.75	0.75	0.75	0.75	0.76	0.76	0.76	0.77	0.77	0.77
38	0.78	0.78	0.78	0.79	0.79	0.79	0.79	0.80	0.80	0.80
39	0.81	0.81	0.81	0.82	0.82	0.82	0.83	0.83	0.83	0.84
40	0.84	0.84	0.85	0.85	0.85	0.86	0.86	0.86	0.87	0.87
41	0.87	0.88	0.88	0.88	0.89	0.89	0.89	0.90	0.90	0.90
42	0.91	0.91	0.91	0.92	0.92	0.92	0.93	0.93	0.94	0.94
43	0.94	0.95	0.95	0.95	0.96	0.96	0.96	0.97	0.97	0.98
44	0.98	0.98	0.99	0.99	0.99	1.00	1.00	1.01	1.01	1.01
45	1.02	1.02	1.03	1.03	1.03	1.04	1.04	1.04	1.05	1.05
46	1.06	1.06	1.06	1.07	1.07	1.08	1.08	1.09	1.09	1.09
47	1.10	1.10	1.11	1.11	1.11	1.12	1.12	1.13	1.13	1.14
48	1.14	1.14	1.15	1.15	1.16	1.16	1.17	1.17	1.17	1.18
49	1.18	1.19	1.19	1.20	1.20	1.21	1.21	1.21	1.22	1.22
50	1.23	1.23	1.24	1.24	1.25	1.25	1.26	1.26	1.27	1.27
51	1.27	1.28	1.28	1.29	1.29	1.30	1.30	1.31	1.31	1.32
52	1.32	1.33	1.33	1.34	1.34	1.35	1.35	1.36	1.36	1.37
53	1.37	1.38	1.38	1.39	1.39	1.40	1.40	1.41	1.41	1.42
54	1.42	1.43	1.43	1.44	1.44	1.45	1.45	1.46	1.47	1.47
55	1.48	1.48	1.49	1.49	1.50	1.50	1.51	1.51	1.52	1.53

56	1.53	1.54	1.54	1.55	1.55	1.56	1.56	1.57	1.58	1.58
57	1.59	1.59	1.60	1.60	1.61	1.62	1.62	1.63	1.63	1.64
58	1.65	1.65	1.66	1.66	1.67	1.68	1.68	1.69	1.69	1.70
59	1.71	1.71	1.72	1.72	1.73	1.74	1.74	1.75	1.75	1.76
60	1.77	1.77	1.78	1.79	1.79	1.80	1.81	1.81	1.82	1.82
61	1.83	1.84	1.84	1.85	1.86	1.86	1.87	1.88	1.88	1.89
62	1.90	1.90	1.91	1.92	1.92	1.93	1.94	1.94	1.95	1.96
63	1.97	1.97	1.98	1.99	1.99	2.00	2.01	2.01	2.02	2.03
64	2.04	2.04	2.05	2.06	2.06	2.07	2.08	2.09	2.09	2.10
65	2.11	2.12	2.12	2.13	2.14	2.14	2.15	2.16	2.17	2.17
66	2.18	2.19	2.20	2.21	2.21	2.22	2.23	2.24	2.24	2.25
67	2.26	2.27	2.27	2.28	2.29	2.30	2.31	2.31	2.32	2.33
68	2.34	2.35	2.35	2.36	2.37	2.38	2.39	2.40	2.40	2.41
69	2.42	2.43	2.44	2.44	2.45	2.46	2.47	2.48	2.49	2.50
70	2.50	2.51	2.52	2.53	2.54	2.55	2.56	2.56	2.57	2.58
71	2.59	2.60	2.61	2.62	2.63	2.63	2.64	2.65	2.66	2.67
72	2.68	2.69	2.70	2.71	2.72	2.73	2.73	2.74	2.75	2.76
73	2.77	2.78	2.79	2.80	2.81	2.82	2.83	2.84	2.85	2.86
74	2.87	2.88	2.89	2.90	2.91	2.91	2.92	2.93	2.94	2.95
75	2.96	2.97	2.98	2.99	3.00	3.01	3.02	3.03	3.04	3.05
76	3.06	3.07	3.08	3.10	3.11	3.12	3.13	3.14	3.15	3.16
77	3.17	3.18	3.19	3.20	3.21	3.22	3.23	3.24	3.25	3.26
78	3.27	3.28	3.30	3.31	3.32	3.33	3.34	3.35	3.36	3.37
79	3.38	3.39	3.41	3.42	3.43	3.44	3.45	3.46	3.47	3.48

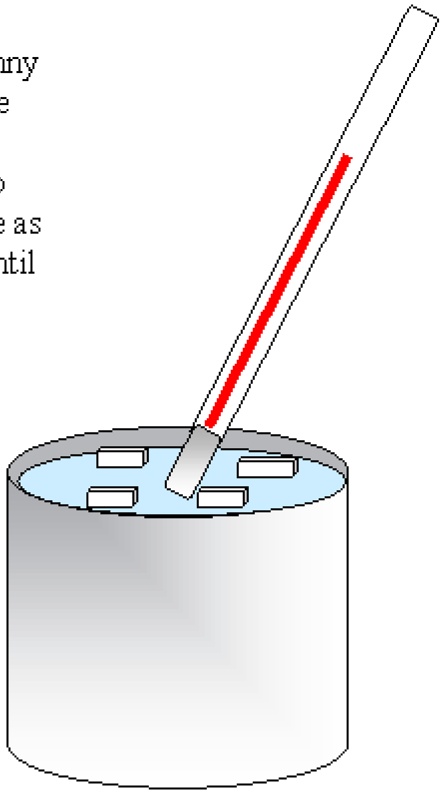
				Vapor Pressure in KPa						
Temp (°F)	**0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
80	3.50	3.51	3.52	3.53	3.54	3.55	3.57	3.58	3.59	3.60
81	3.61	3.62	3.64	3.65	3.66	3.67	3.68	3.70	3.71	3.72
82	3.73	3.74	3.76	3.77	3.78	3.79	3.80	3.82	3.83	3.84
83	3.85	3.87	3.88	3.89	3.90	3.92	3.93	3.94	3.95	3.97
84	3.98	3.99	4.01	4.02	4.03	4.04	4.06	4.07	4.08	4.10
85	4.11	4.12	4.14	4.15	4.16	4.18	4.19	4.20	4.22	4.23
86	4.24	4.26	4.27	4.28	4.30	4.31	4.32	4.34	4.35	4.37
87	4.38	4.39	4.41	4.42	4.44	4.45	4.46	4.48	4.49	4.51
88	4.52	4.54	4.55	4.56	4.58	4.59	4.61	4.62	4.64	4.65
89	4.67	4.68	4.70	4.71	4.73	4.74	4.75	4.77	4.78	4.80
90	4.81	4.83	4.85	4.86	4.88	4.89	4.91	4.92	4.94	4.95
91	4.97	4.98	5.00	5.01	5.03	5.05	5.06	5.08	5.09	5.11
92	5.12	5.14	5.16	5.17	5.19	5.21	5.22	5.24	5.25	5.27
93	5.29	5.30	5.32	5.34	5.35	5.37	5.39	5.40	5.42	5.44
94	5.45	5.47	5.49	5.50	5.52	5.54	5.55	5.57	5.59	5.61
95	5.62	5.64	5.66	5.67	5.69	5.71	5.73	5.74	5.76	5.78
96	5.80	5.82	5.83	5.85	5.87	5.89	5.90	5.92	5.94	5.96
97	5.98	6.00	6.01	6.03	6.05	6.07	6.09	6.11	6.12	6.14
98	6.16	6.18	6.20	6.22	6.24	6.26	6.27	6.29	6.31	6.33

99	6.35	6.37	6.39	6.41	6.43	6.45	6.47	6.49	6.51	6.53
100	6.55	6.57	6.59	6.60	6.62	6.64	6.66	6.68	6.70	6.72
101	6.75	6.77	6.79	6.81	6.83	6.85	6.87	6.89	6.91	6.93
102	6.95	6.97	6.99	7.01	7.03	7.05	7.08	7.10	7.12	7.14
103	7.16	7.18	7.20	7.22	7.25	7.27	7.29	7.31	7.33	7.35
104	7.38	7.40	7.42	7.44	7.46	7.49	7.51	7.53	7.55	7.57
105	7.60	7.62	7.64	7.66	7.69	7.71	7.73	7.76	7.78	7.80
106	7.82	7.85	7.87	7.89	7.92	7.94	7.96	7.99	8.01	8.03
107	8.06	8.08	8.10	8.13	8.15	8.18	8.20	8.22	8.25	8.27
108	8.30	8.32	8.34	8.37	8.39	8.42	8.44	8.47	8.49	8.52
109	8.54	8.56	8.59	8.61	8.64	8.66	8.69	8.71	8.74	8.77
110	8.79	8.82	8.84	8.87	8.89	8.92	8.94	8.97	9.00	9.02
111	9.05	9.07	9.10	9.13	9.15	9.18	9.21	9.23	9.26	9.29
112	9.31	9.34	9.37	9.39	9.42	9.45	9.47	9.50	9.53	9.56
113	9.58	9.61	9.64	9.66	9.69	9.72	9.75	9.78	9.80	9.83
114	9.86	9.89	9.92	9.94	9.97	10.00	10.03	10.06	10.09	10.11
115	10.14	10.17	10.20	10.23	10.26	10.29	10.32	10.35	10.38	10.41
116	10.43	10.46	10.49	10.52	10.55	10.58	10.61	10.64	10.67	10.70
117	10.73	10.76	10.79	10.82	10.85	10.88	10.92	10.95	10.98	11.01
118	11.04	11.07	11.10	11.13	11.16	11.19	11.23	11.26	11.29	11.32
119	11.35	11.38	11.42	11.45	11.48	11.51	11.54	11.58	11.61	11.64
120	11.67	11.70	11.74	11.77	11.80	11.84	11.87	11.90	11.93	11.97

The Ice-Water Can Method to Measure Dew Point

Based on the definition, a simple method to measure the dew point temperature involves cooling a surface until water vapor begins to condense on the surface. This is the principle used in a chilled mirror hygrometer, which is used to measure the dew point. Unfortunately, a chilled mirror uses complicated electronics to measure the dew point and; therefore, it is expensive. A simple, inexpensive method involves using a shinny can, a thermometer, and ice water as shown below.

To measure the **dew point temperature**, slowly add ice cubes to water inside a shinny can to make the water and can temperature drop. Continue to stir the water with a thermometer while adding the ice cubes to insure that the can temperature is the same as the water. Watch the outside of the can until you start to see condensation. When condensation occurs, note the dew point temperature on the thermometer.



During low dew point, freezing conditions, it is sometimes difficult to get the can cold enough for condensation to occur. Adding salt to the liquid ice mixture will help to melt the ice and cool the water. When the temperature is well below freezing, sometimes frost rather than dew will form on the outside of the can. When this occurs, you have measured the “frost point” rather than the dew point temperature. For the same vapor pressure, the frost point will be slightly higher than the dew point temperature. However, for most agricultural operations, there is little difference and they can be used interchangeably.

Conversions

The equations for converting humidity expressions are typically given using the metric system and degrees Celsius. To convert from degrees Fahrenheit (^oF) to degrees Celsius (^oC), use the following:

$$^{\circ}C = \frac{^{\circ}F - 32}{1.8}$$

To convert from the dew point temperature (T_d) in ^oC to other expressions for humidity, first calculate the vapor pressure (e).

$$e = 0.6108 \exp\left(\frac{17.27 T_d}{T_d + 237.3}\right) \quad \text{(kPa)}$$

If you measured the frost point temperature (T_f) in ^{O}C, then use the following:

$$e = 0.6108 \exp\left(\frac{17.27\, T_f}{T_f + 265.5}\right) \quad \text{(kPa)}$$

To calculate the saturation vapor pressure (e_s) at air temperature (T) in ^{O}C, use the following:

$$e = 0.6108 \exp\left(\frac{17.27 T}{T + 265.5}\right) \quad \text{(kPa)}$$

Relative humidity (RH) is calculated as:

$$RH = 100\left(\frac{e}{e_s}\right) \quad (\%)$$

Vapor pressure deficit (VPD) is calculated as:

$$VPD = e_s - e \quad \text{(kPa)}$$