

Calculations of relative humidity errors resulting from dew point and operational temperature errors

The purpose of this note is to provide an answer for the frequent question: If a Dew Point Generator has dew point accuracy, e.g. $\pm 0.2^{\circ}\text{C}$, how does that amount translate to relative humidity (RH) errors? The answer is not that simple as **the amount of RH error is dependent upon the temperature of operation and the % RH desired**. Also, the RH error evaluation resulting from a dew point uncertainty is more suitable for numerical calculations than trying to derive a simple formula from the accepted water vapor pressure equations. However, to provide a more satisfying “numerical” answer to the question, some calculations were carried out and the results were tabulated in the following table.

Exp. Temp. [°C]	Relative Humidity [%]						
	5	20	35	50	65	80	95
20	<u>-18.694</u>	<u>-3.206</u>	<u>4.090</u>	<u>9.273</u>	<u>13.227</u>	<u>16.447</u>	<u>19.175</u>
	5.096	20.341	35.494	50.679	65.853	81.024	96.194
	4.906	19.666	34.511	49.331	64.155	78.989	93.824
	0.096	0.341	0.494	0.679	0.853	1.024	1.194
40	<u>-5.984</u>	<u>12.783</u>	<u>21.620</u>	<u>27.585</u>	<u>32.150</u>	<u>35.877</u>	<u>39.041</u>
	5.087	20.264	35.430	50.589	65.738	80.883	96.025
	4.915	19.740	34.574	49.419	64.270	79.125	93.985
	0.087	0.264	0.430	0.589	0.738	0.883	1.025
60	<u>6.930</u>	<u>28.915</u>	<u>38.950</u>	<u>45.754</u>	<u>50.980</u>	<u>55.257</u>	<u>58.896</u>
	5.069	20.233	35.378	50.514	65.643	80.768	95.890
	4.932	19.770	34.626	49.491	64.362	79.238	94.118
	0.069	0.233	0.378	0.514	0.643	0.768	0.890
80	<u>20.216</u>	<u>44.773</u>	<u>56.080</u>	<u>63.781</u>	<u>69.716</u>	<u>74.586</u>	<u>78.738</u>
	5.062	20.207	35.334	50.453	65.565	80.673	95.779
	4.938	19.795	34.669	49.551	64.438	79.331	94.227
	0.062	0.207	0.334	0.453	0.565	0.673	0.779
100	<u>33.126</u>	<u>60.363</u>	<u>73.012</u>	<u>81.668</u>	<u>88.360</u>	<u>93.865</u>	<u>98.569</u>
	5.056	20.185	35.298	50.402	65.500	80.595	95.686
	4.944	19.816	34.704	49.601	64.503	79.409	94.318
	0.056	0.185	0.298	0.402	0.500	0.595	0.686
	-0.056	-0.184	-0.296	-0.399	-0.497	-0.591	-0.682

Note: All calculations were carried out using “RH Calculator” software, developed by InstruQuest Inc.

To illustrate trends in variations of RH errors, several temperatures of experimental setup (from 20 to 100 °C) were selected. At each of the operational temperature, dew points values were calculated to yield the relative humidity values (from 5 to 95 %). The dew points values are the underlined numbers at the top of each cell. Assuming a dew point uncertainty of $\pm 0.2^\circ\text{C}$, RH values were calculated for the dew points plus 0.2°C and for the dew points minus 0.2°C . The left aligned numbers in each cell are the RH values at the dew points accuracy limits. Subtracting from these numbers the RH values corresponding to the exact dew point values, another pair of numbers (boldface) was generated for each cell to facilitate visual trend analysis. One can easily see that for each operational temperature, the %RH errors increase (nonlinearly) with increase of the desired RH. At a given RH value, increasing the temperature of experiment decreases the %RH error.

Similar table was constructed but this time the error of the operational temperature was allowed to vary by $\pm 0.2^\circ\text{C}$ and the dew point value was assumed to be exact. Similar trends and comparable amount of %RH errors can be observed.

Exp. Temp. [°C]	Relative Humidity [%]						
	5	20	35	50	65	80	95
20	<u>-18.694</u>	<u>-3.206</u>	<u>4.090</u>	<u>9.273</u>	<u>13.227</u>	<u>16.447</u>	<u>19.175</u>
	4.939	19.755	34.569	49.386	64.199	79.016	93.834
	5.062	20.250	35.436	50.624	65.810	80.998	96.188
	-0.061	-0.245	-0.431	-0.614	-0.801	-0.984	-1.166
	0.062	0.250	0.436	0.624	0.810	0.998	1.188
40	<u>-5.984</u>	<u>12.783</u>	<u>21.620</u>	<u>27.585</u>	<u>32.150</u>	<u>35.877</u>	<u>39.041</u>
	4.947	19.789	34.629	49.471	64.310	79.151	93.992
	5.054	20.215	35.375	50.537	65.696	80.857	96.018
	-0.053	-0.211	-0.371	-0.411	-0.680	-0.849	-1.008
	0.054	0.215	0.375	0.471	0.696	0.857	1.018
60	<u>6.930</u>	<u>28.915</u>	<u>38.950</u>	<u>45.754</u>	<u>50.980</u>	<u>55.257</u>	<u>58.896</u>
	4.954	19.816	34.677	49.538	64.401	79.263	94.126
	5.046	20.187	35.325	50.464	65.604	80.744	95.884
	-0.046	-0.184	-0.323	-0.462	-0.599	-0.737	-0.874
	0.046	0.187	0.325	0.464	0.604	0.744	0.884
80	<u>20.216</u>	<u>44.773</u>	<u>56.080</u>	<u>63.781</u>	<u>69.716</u>	<u>74.586</u>	<u>78.738</u>
	4.960	19.839	34.718	49.596	64.476	79.355	94.233
	5.041	20.163	35.285	50.406	65.528	80.651	95.771
	-0.040	-0.161	-0.282	-0.404	-0.524	-0.645	-0.777
	0.041	0.163	0.285	0.406	0.528	0.651	0.771
100	<u>33.126</u>	<u>60.363</u>	<u>73.012</u>	<u>81.668</u>	<u>88.360</u>	<u>93.865</u>	<u>98.569</u>
	4.964	19.858	34.751	49.645	64.539	79.432	94.325
	5.036	20.143	35.250	50.359	65.467	80.574	95.681
	-0.036	-0.142	-0.249	-0.355	-0.461	-0.568	-0.675
	0.036	0.143	0.250	0.359	0.467	0.574	0.681

Note: All calculations were carried out using “RH Calculator” software, developed by InstruQuest Inc.

