Chamber Temperature Uniformity Analysis
Of the
Thunder Scientific Model 2500 Two-Pressure Humidity Generator

1 Introduction

Described here is the Chamber Temperature Uniformity for a Model 2500 Humidity Generator. Chamber temperature uniformity has a direct influence on relative humidity gradients within the test chamber. In order to determine the chamber temperature uniformity, 10 thermometers of equivalent type and nominal resistance where calibrated together over the temperature range 15 to 35°C. The thermometers were then strategically placed at various locations within the test chamber, approximately 1 to 2 inches from each corner (8 probes total), and 2 inches left and right of center (2 probes total).

2 Defining Equations

The maximum measurement deviation from the mean will be determined by noting the maximum and minimum readings from the set of probes at the same point in time, then taking half the difference of these values.

$$\text{MaxDev} = \pm 0.5(\text{MaxReading}-\text{MinReading}) \quad [1]$$

The uniformity will then be computed by RSS combination (root of the sum of the squares) of the maximum deviation, MaxDev, and the estimated thermometer uncertainty, u(T).

$$\text{uniformity}^2 = \text{MaxDev}^2 + u^2(T) \quad [2]$$

3 Calibration of Thermometers

The 10 thermometers were calibrated at the same time, in the same bath, against the same reference thermometer. Although they were calibrated in a well stirred fluid bath, yet used in air, self heating is not considered a significant contributor since all probes are used in the same type of environment. All should be subjected to similar self heating effects which tend to cancel one another when viewing differences between probes. The accuracy of the reference standard is also considered insignificant, since the desired value here is relative probe difference, not individual probe accuracy. The only concern in calibration of the thermometers is the relative accuracy of each with respect to the group. With this in mind, the uncertainty of the probes, u(T), with respect to each other after calibration is estimated to be

$$u(T) = \pm 0.025°C$$

3.1 Measurement of Chamber Temperatures

The following data was gathered during the uniformity analysis conducted on 4 Dec 1997, using a Model 2500, serial number 9711116. The generator was run at a fixed humidity of 50% RH, and was allowed to stabilize for a minimum of one hour at each temperature listed. Note that the maximum and minimum readings are indicated in bold type.

Probe	**Location**	**15°C nominal**	**25°C ambient**	**35°C nominal**
1	Lower Left Front	15.169	24.937	34.856
2	Lower Right Front	15.215	24.906	34.812
3	Lower Left Rear	**15.333**	**24.938**	**34.710**
4	Lower Right Rear	15.225	24.916	34.787
5	Upper Left Front	**15.150**	24.935	**34.868**
6	Upper Right Front	15.164	24.897	34.853
7	Upper Left Rear	15.163	24.935	34.850
8	Upper Right Rear	15.156	24.914	34.852
9	Left Center	15.171	24.917	34.847
10	Right Center	15.169	**24.894**	34.829
Maximum Deviation (MaxDev)		±0.0915	±0.022	±0.079

4. Chamber Temperature Uniformity

As per equation 2, the uniformity at each of the 3 temperatures is computed as

$$\text{uniformity} = \text{sqr}(0.0915^2 + 0.025^2)$$

$$= \pm 0.095°C \text{ (at } 15°C)$$
$$= \pm 0.033°C \text{ (at } 25°C)$$
$$= \pm 0.083°C \text{ (at } 35°C)$$

This is within the stated accuracy specification of ±0.10°C when the chamber is operated within ±10°C of ambient temperature.

5. Calculation of Percent Relative Humidity Gradients

The Relative Humidity Gradients (uniformity) within the test chamber caused by the temperature uniformity is calculated based on the 50%RH@Pc given the temperatures observed within the chamber in section 3.1. This is mathematically calculated assuming a uniform Dew Point within a chamber void of any heat-generating devices.

Note: When the 2500 generator is operated in %RH@PcTc mode the system will maintain the desired %RH value at the chamber temperature probe. Any %RH uniformity would then originate from the point of the chamber temperature probe.

Probe	***Location***	***15°C nominal***	***25°C ambient***	***35°C nominal***
1	Lower Left Front	49.459 %RH	50.188 %RH	50.400 %RH
2	Lower Right Front	49.313 %RH	50.281 %RH	50.523 %RH
3	Lower Left Rear	**48.940 %RH**	**50.185 %RH**	**50.810 %RH**
4	Lower Right Rear	49.281 %RH	50.251 %RH	50.594 %RH
5	Upper Left Front	**49.520 %RH**	50.194 %RH	**50.367 %RH**
6	Upper Right Front	49.475 %RH	50.308 %RH	50.409 %RH
7	Upper Left Rear	49.478 %RH	50.194 %RH	50.417 %RH
8	Upper Right Rear	49.500 %RH	50.257 %RH	50.412 %RH
9	Left Center	49.453 %RH	50.248 %RH	50.426 %RH
10	Right Center	49.459 %RH	**50.317 %RH**	50.476 %RH
Maximum Deviation (MaxDev)		±0.290 %RH	±0.066 %RH	±0.222 %RH

5.1. Percent Relative Humidity Uncertainties Based on the Temperature Uncertainty

Calculating the percent relative humidity uncertainty at each temperature range based on the uncertainty of the temperature probes in section 3 we obtain the following:

uRH(T) = ±0.079 (at 15°C)
uRH(T) = ±0.075 (at 25°C)
uRH(T) = ±0.069 (at 35°C)

6. Chamber Percent Relative Humidity Uniformity

As per equation 2, the uniformity at each of the 3 temperature ranges is computed as

$$\text{uniformity} = \text{sqr}(0.290^2 + 0.079^2)$$

= ±0.300%RH (at 15°C)
= ±0.100%RH (at 25°C)
= ±0.232%RH (at 35°C)