Chamber Temperature Uniformity Analysis
of the
Thunder Scientific Model 1220 Two-Pressure Humidity Generator

By Michael Hamilton

1 Introduction

Described here is the Chamber Temperature Uniformity for a Model 1220 Humidity Generator equipped with a standard no-window door, a window door, and a 4-port door. Chamber temperature uniformity has a direct influence on relative humidity gradients within the test chamber. To determine the chamber temperature uniformity, ten 100 Ohm RTD probes of equivalent type were calibrated together over the temperature range of 5 °C to 60 °C. The probes were then strategically placed at various locations within two inches of the chamber walls and two inches from the chamber door, as shown in Figure 1.

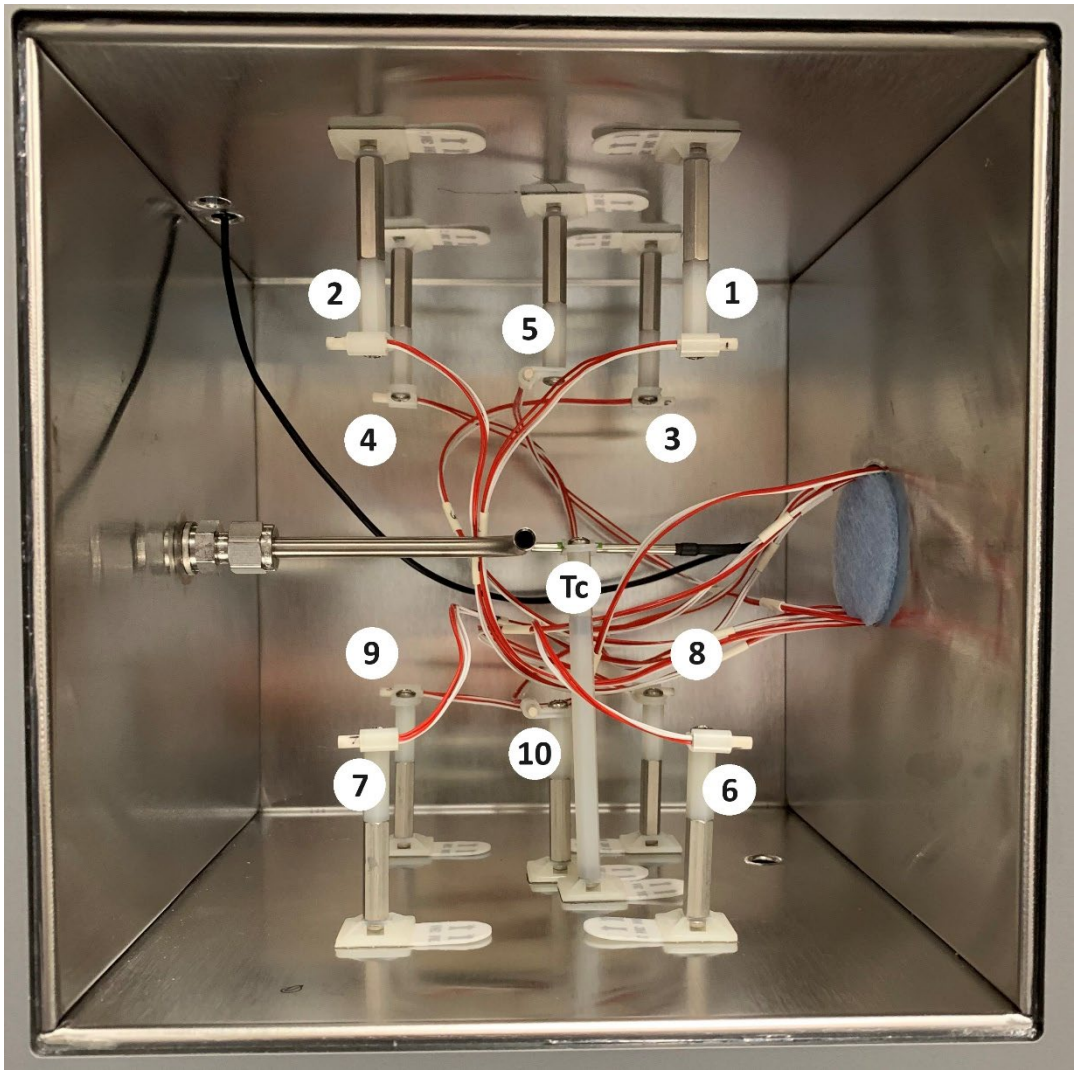

Figure 1

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2 Calibration of Thermometers

The ten RTD probes were calibrated at the same time, in the same bath, and 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 probes were subjected to similar self-heating effects which tend to cancel one another when viewing differences between probes. Each probe's combined uncertainty consists of repeatability, reproducibility, and the reference thermometer uncertainty (Fluke 1595A). The uncertainty for any probe (u(T)) is then determined as the average uncertainty due to probe error using each probe's combined uncertainty.

$$u(T) = \pm 0.01°C$$

3 Defining Equations

The maximum measurement deviation from the mean will be determined by noting the average maximum and minimum readings from the set of probes over a ten-minute sample and then taking half the difference of these values.

$$MaxDev = \pm 0.5 * (MaxReading - MinReading) \quad [1]$$

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

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

3.1 Measurement of Chamber Temperatures

The following data was gathered during the uniformity analysis conducted in 2024 and 2025, using Model 1220 serial numbers 24050001 and 24100002. The generator was operated at a fixed humidity of 50% RH using an automated profile to ensure stability at each point. Ten minutes of data was collected for each probe at each temperature point. The uniformity was then calculated using equations 1 and 2, and the results are given in Tables 1, 2, and 3 and Figures 2, 3, and 4.

3.1.1 No-Window Door

The Model 1220 no-window door is a standard insulated door without a glass window or any additional ports. The chamber door plays a significant role in achieving good chamber uniformity. Throughout testing, the chamber inlet was directed toward the center of the door using a 90° stainless steel tube (Figure 2) to help address the heat loss through the door (especially at temperatures more than ±10 °C ambient) and to avoid blowing directly at the large number of probe wires coming through the side access port. This directed chamber inlet functions similarly to a chamber fan in a larger generator.

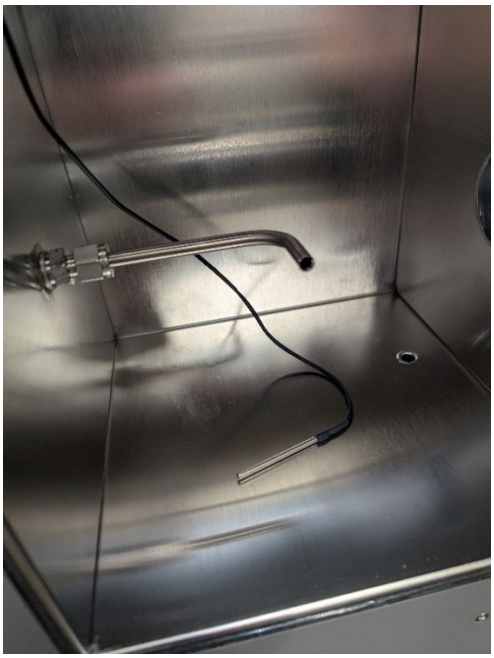

Figure 2

The calculated uniformity using equations 1 and 2 for the no-window door at each temperature is summarized in Table 1 and Figure 3.

No Window Door		
°C	Chamber Uniformity	Uniformity Specification
60	0.047	0.05
50	0.038	0.05
40	0.027	0.05
35	0.024	0.05
30	0.019	0.05
25	0.015	0.05
20	0.014	0.05
15	0.018	0.05
10	0.024	0.05
5	0.030	0.05

Table 1

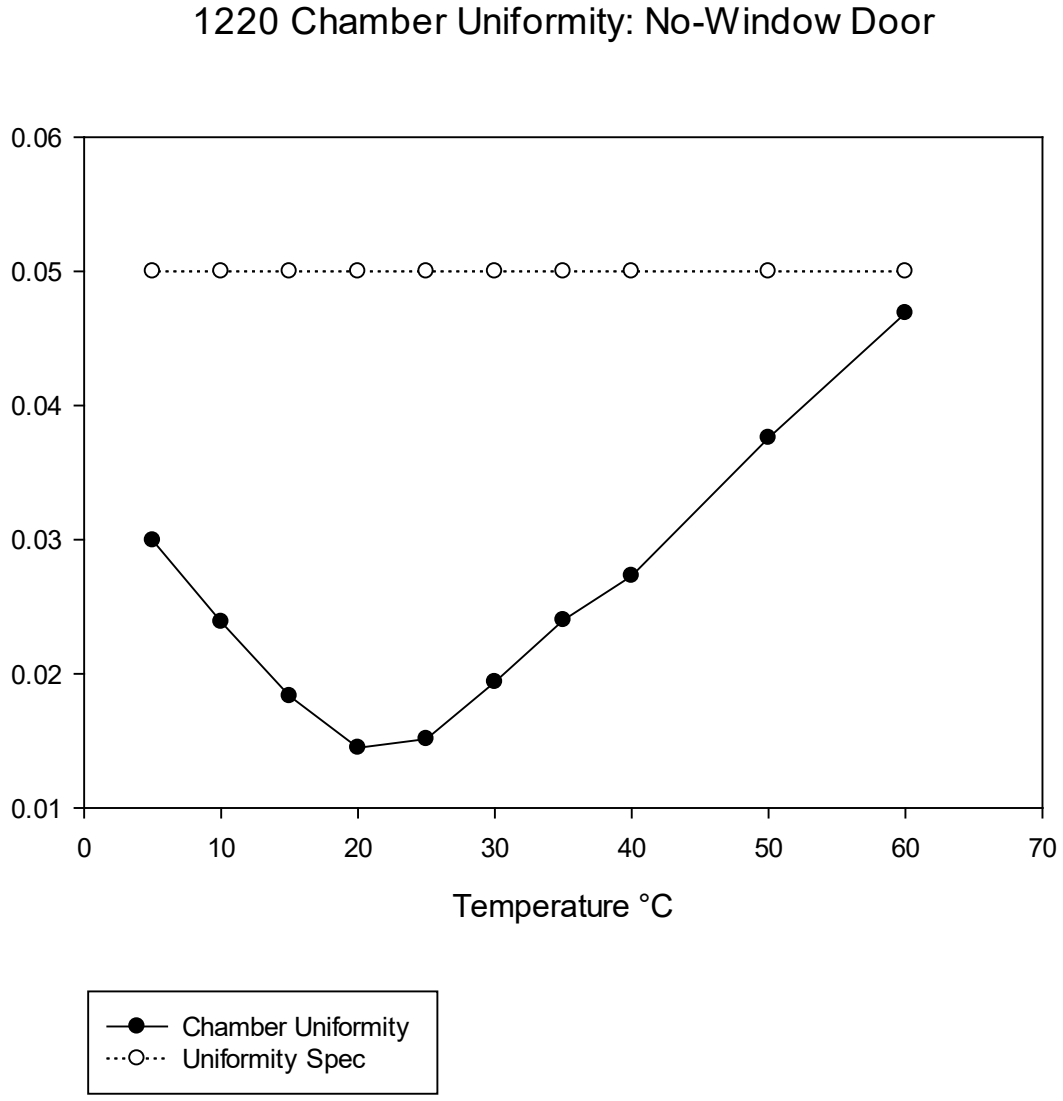

Figure 2

3.1.2 Window Door

The window door option allows the user to visually see the device under test in the chamber during operation. The window door option is only designed for limited chamber temperature ranges (±15 °C of ambient) due to the glass window's poor thermal insulator properties. When using a window door, the chamber uniformity specification is limited to ±15 °C of ambient.

Window Door		
°C	Chamber Uniformity	Uniformity Specification
60	0.085	0.05
50	0.063	0.05
40	0.041	0.05
35	0.033	0.05
30	0.026	0.05
25	0.022	0.05
20	0.023	0.05
15	0.027	0.05
10	0.034	0.05
5	0.044	0.05

Table 2

NOTE: Special consideration is required when using the window door to prevent condensation from forming on the inside of the window glass. It is recommended to limit high humidity at temperatures above 10 °C from ambient to ensure no condensation forms on the window glass.

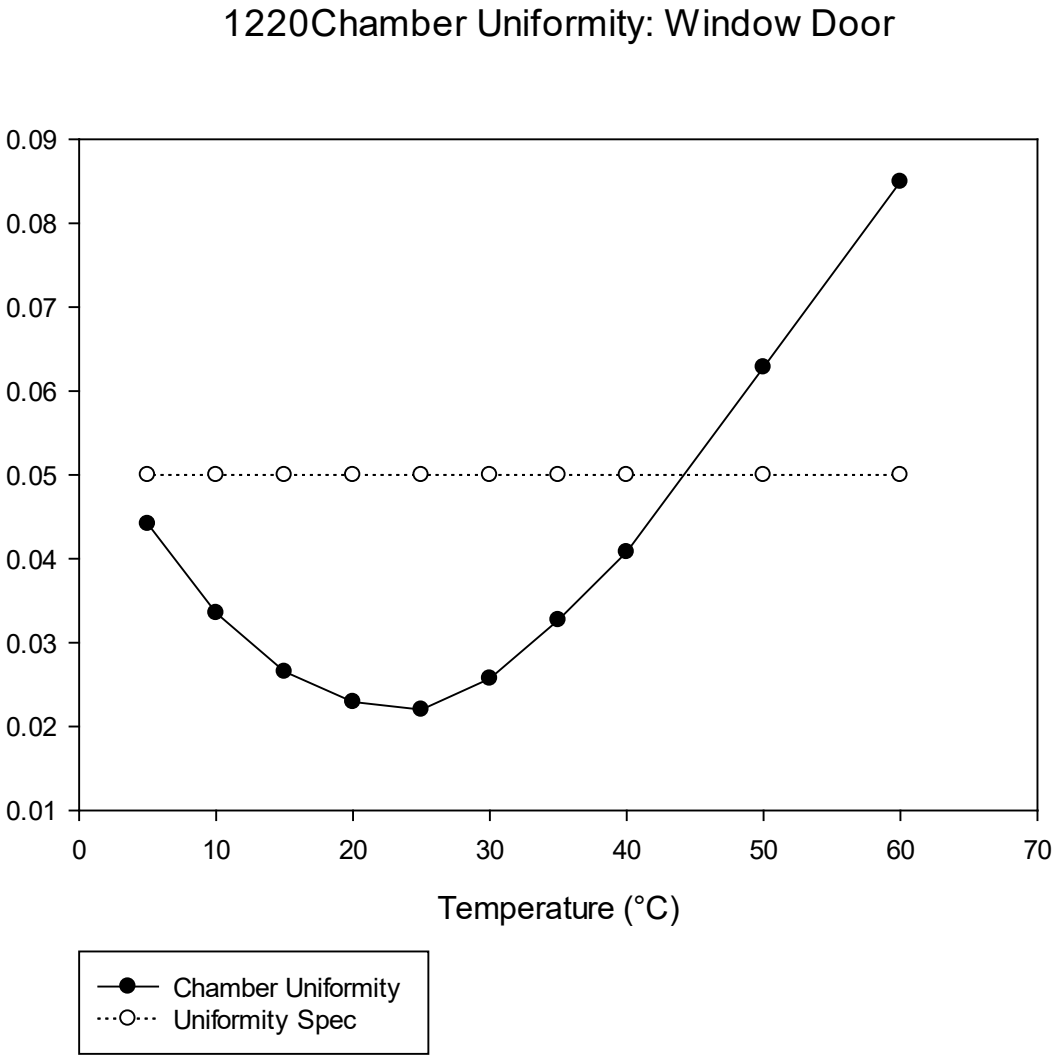

Figure 3

3.1.3 4-Port door

The 4-Port door option allows the user to insert up to four test instruments through the door to calibrate at once. This configuration optimizes the use of the chamber volume but does add points of thermal loss to the chamber. When using a 4-Port door, the chamber uniformity specification is limited to ±15 °C of ambient.

4-Port door		
°C	Chamber Uniformity	Uniformity Specification
60	0.095	0.05
50	0.057	0.05
40	0.037	0.05
35	0.035	0.05
30	0.026	0.05
25	0.026	0.05
20	0.022	0.05
15	0.027	0.05
10	0.036	0.05
5	0.048	0.05

Table 2

NOTE: The generator can still be operated across its full temperature range when using a 4-Port door (or window door); however, the influence of additional temperature uniformity must be accounted for. The 1220 humidity generator is designed to compensate for temperature deviations detected at the chamber's temperature probe. This automatic compensation can be thought of as generating the %RH setpoint at the tip of the chamber probe. Locating the chamber temperature probe with the device under test (DUT) will ensure the %RH setpoint is achieved at the probe's position, thereby mitigating the impact of any temperature non-uniformities within the chamber.

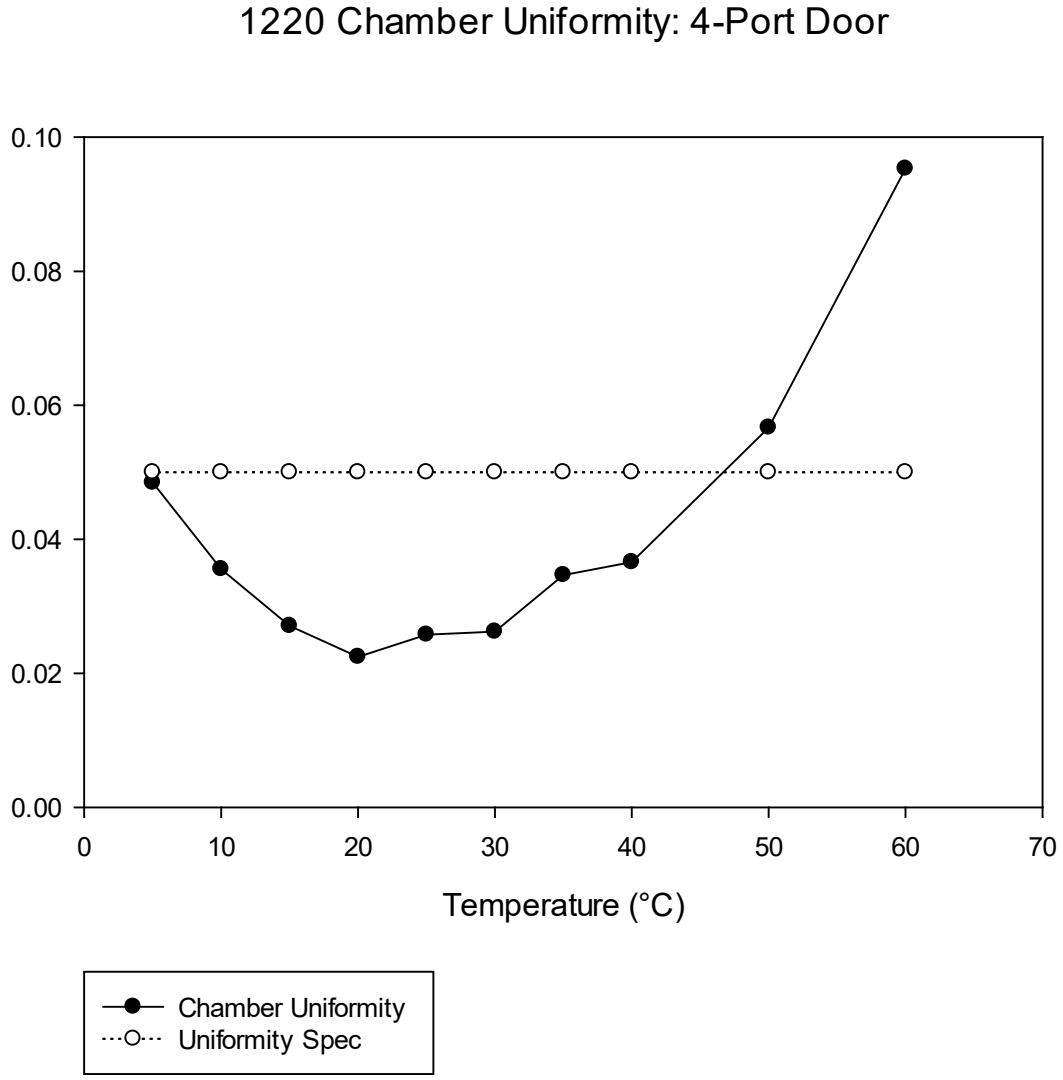

Figure 4

4. Chamber Temperature Uniformity

The maximum chamber uniformity value was selected from Table 1 and rounded up to determine the Uniformity Specification for the Model 1220 Two-Pressure Humidity Generator.

uniformity specification = 0.05 °C [1] [2]

[1] Between the temperature range of 5 °C to 60 °C of ambient temperature when using a "No-Window" door while directing chamber flow towards the center of the door.

[2] Between ±15 °C of ambient temperature when using a "Window" or "4-port" door while directing chamber flow towards the center of the door.

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