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Research Article

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Gas Flow Effect in the Response Time of Dew-Point Meter

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Abstract In the relative humidity measurements, many factors are effect in the response time of dew-point meter. In calibration system, it was used dew-point meter. So, this paper illustrate the effect of gas flow rate in the response time of dew-point meter measurements. Gas flow rate has effect in the dew-point meter response time. Response time is important in calibration process to determine the waiting time to stable the calibration system and start to record the measurement. All parameter are fixe but the flow of dew-point meter pump changed from 20 L/H to 60 L/H. The dew-point meter has flow controller to change the flow. In case that all parameters of two-pressure generator are fix, the measurements shows that when the flow is slow, the response time of the sensor of dew-point meter was slow. When the flow is fast, the response time of the sensor of dew-point meter was fast. Also from this paper we find the relationship between flow rate and response time of dew-point meter. In addition, the flow rate is one of important uncertainty sources. It was effected by two items, first is stability and second is reproducibility.

Keywords gas flow; relative humidity; response time; dew-point meter

1. Introduction

The main activities of the thermal metrology laboratory in NIS in Egypt in the field of humidity are focused on the maintenance and improvement of standards and calibration method. In addition, NIS provides humidity calibration services. For getting accurate and uniform humidity measurements inside and outside Egypt. Several hygrometers calibration facilities have been developed at the thermal metrology laboratory at NIS [1]. Relative humidity measurement is very important in many fields like industries, health, agriculture and trade. We are needed to measure it more accurate than later. Also we need to do more investigation about the parameters which effect on relative humidity measurements and some kind of equipment used in this field. Response time is the time which is need to stable the measurements of sensor in case put the sensor from room temperature to the medium temperature.

Dew-point meter is classified as transfer standard in humidity measurement, so it is important to research about some factors effect in the response of it. The flow is important factor effect in the response time of dew-point meter. When flow rate change, the response time was changed. The importance of this paper is show the behavior of dew-point meter with change of flow to development the manufacture of this equipment. The choice of dew-point meter is depend on high accuracy of its sensor [2].

In addition, the flow rate is one of uncertainty sources. So, this study is benefit to reduce the uncertainty value if we got good stability using dew-point meter and accurate flow meter.

2. Apparatus and method

The system which used in this paper is consists of two-pressure generator as primary standard in the field of humidity and dew-point meter.

2.1. Two-pressure generator

Two-pressure humidity generator from Thunder Scientific 2500 ST- USA is used in this paper as an accurate primary standard with accuracy ±0.5 %. The adjustment of temperature and relative humidity was fix in the all measurement at 20% and 25°C. For accurate measurements, we have to assure stable conditions of known temperature and relative humidity, which are both measured with dew-point meter [3].

Equation (1) shows how to calculate relative humidity using a two-pressure generator [4].

$\%RH = [ew(T_s)/ew(T_c)] \times [P_c/P_s] \times 100$ (Equation 1)

Where $ew(T_s)$ – the saturation vapor pressure at the saturation temperature, T_s, $ew(T_c)$ – the saturation vapor pressure at the chamber temperature, T_c, P_c – the absolute pressure in the chamber, and P_s – the absolute pressure in the saturator.

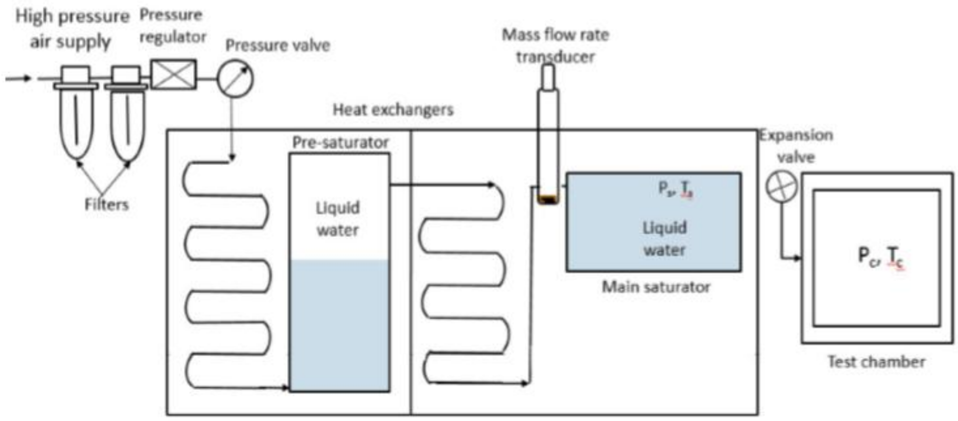

Figure 1: Humidity generator Thunder Scientific 2500 ST

Figure 1 shows a schematic diagram of two-pressure humidity generator involves saturating air, with water vapor at a given pressure and temperature. The saturated gas then flows through an expansion valve where it is isothermally reduced to chamber pressure. If the temperature of the gas is held constant during pressure reduction, the humidity, at chamber pressure, may then be approximated as the ratio of two absolute pressures [5].

2.2. Dew-Point Meter

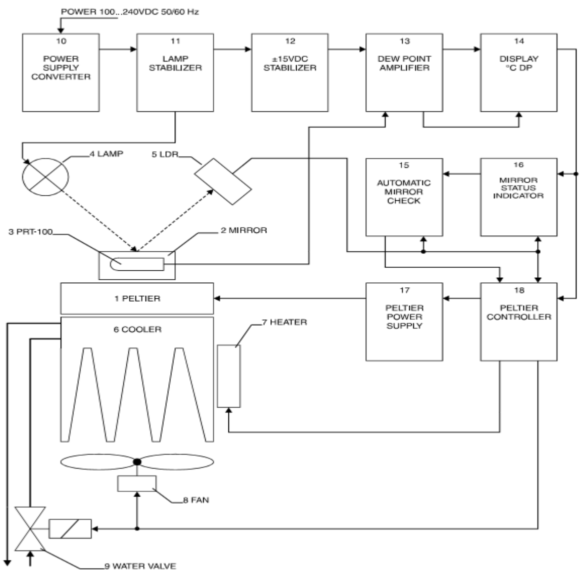

Figure 2: Schematic diagram of chilled mirror (dew-point meter)

As the reference instrument, we used the dew-point meter MBW DP 30 range from +60 °C to -60 °C for temperature and from 0 L/H to 60 L/H for flow. Chilled mirror is the principle of working operating of dew-point meter. The standard uncertainty of reference dew-point meter is ±0.2 °C in the entire range of dew-point temperatures. Dew-point meter was calibrated by comparison with standard Pt-100 at dew point generator outside Egypt (Switzerland)[4].The calibration certificate of dew-point meter issued by five points, -50 °C, -25 °C, 0 °C, +25 °C, +50 °C.

With appropriate gas connections on the back panel of the instrument the measuring gas flow rate can be read on the flowmeter in liters per hour. The FLOW-CAL-switch must be set according to the kind of gas measured.

For correct indication of the measured flow rate the FLOW CAL-switch must be set to the measured gas type. For standard instruments the switch is fixed for AIR. Measurements were performed in the humidity generator Thunder Scientific 2500 ST. It is accurate for calibrations of relative humidity and dew-point meter sensors [5]. This is open circuit because we are not connect the out of dew-point meter to generator again.

2.3. Method

After power on dew-point meter for twenty minutes at least as warming up, we can read the measurement from it. At the same time, power on the two-pressure generator and adjust the set point at 20% and 25^{o}C.

Connect the tube of dew-point meter with the hole of generator which out the humid air to chamber of generator.

Dew-point meter is important to measure the dew point which is standard of measurements. In addition of measure the air temperature, the standard relative humidity calculated. Also, dew-point meter the instrument which was recorded the response time regarding to the flow of two-pressure generator.

After stability of dew-point meter reading, record the readings. Change the rate of dew-point meter flow to start another point.

3. Results

In this paper the study was done at five flow rates 60 L/H, 50 L/H, 40 L/H, 30 L/H, 20L/H at the fixed RH 20% and 25 ^{o}C because these point more stable in two-humidity generator. We are controlled the flow rate from Dew-point meter. We performed six experiments per each point.

Figure (3) shows the response time from 8.5°C up to the stable of dew-point of generator which is 1.3°Cwith uncertainty ±0.6 °C at flow rate 60 L/H. The response time at this case is 40 minutes.

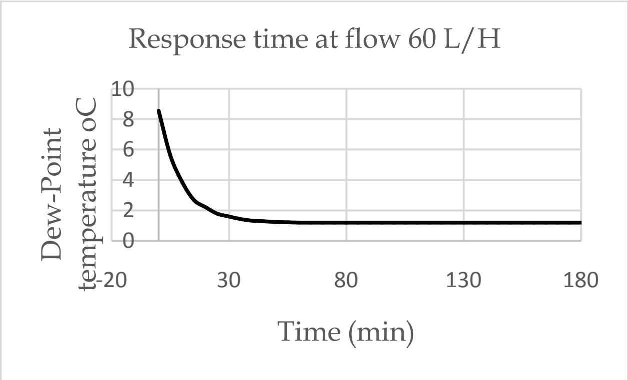

Figure 3: The relation between flow at 60 L/H and response time of dew-point meter

Figure (4) shows the response time from 8.5°C up to the stable of dew-point of generator which is 1.17with uncertainty ±0.6 °C at flow rate 50 L/H. The response time at this case is 60 minutes.

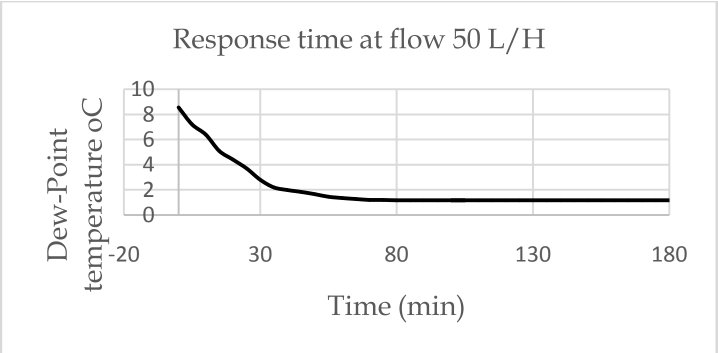

Figure 4: The relation between flow at 50 L/H and response time of dew-point meter

Figure (5) shows the response time from 8.5°C up to the stable of dew-point of generator which is 1.19with uncertainty ±0.6 °C at flow rate 40 L/H. The response time at this case is 80 minutes.

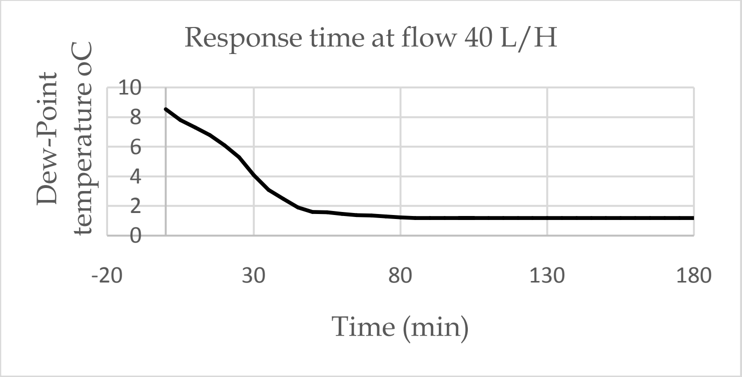

Figure 5: The relation between flow at 40 L/H and response time of dew-point meter

Figure (6) shows the response time from 8.5°C up to the stable of dew-point of generator which is 1.18with uncertainty ±0.6 °C at flow rate 30 L/H. The response time at this case is 105 minutes.

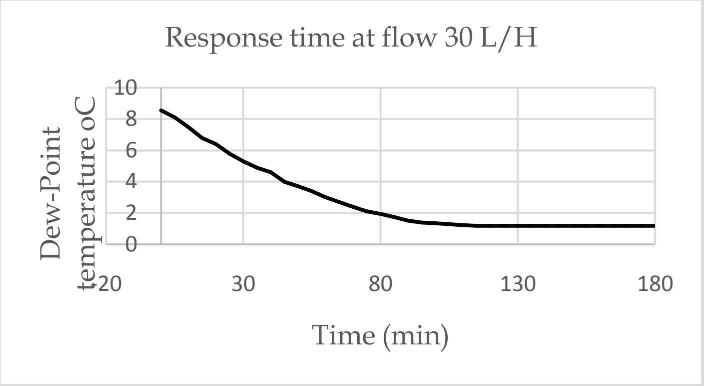

Figure 6: The relation between flow at 30 L/H and response time of dew-point meter

Figure (7) shows the response time from 8.5°C up to the stable of dew-point of generator which is 1.19with uncertainty ±0.6 °C at flow rate 20 L/H. The response time at this case is 115 minutes.

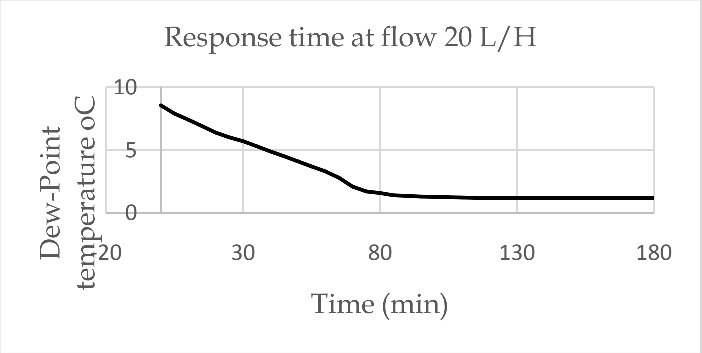

Figure 7: The relation between flow at 20 L/H and response time of dew-point meter

Table (1) shows the relationship between flow rate and response time of dew-point meter.

Table 1: The relation between flow rate and response time of dew-point meter

Flow Rate L/H	Time min
20	115
30	105
40	80
50	60
60	40

Figure (8) was shows that the relation between response times is inversely with flow rate.

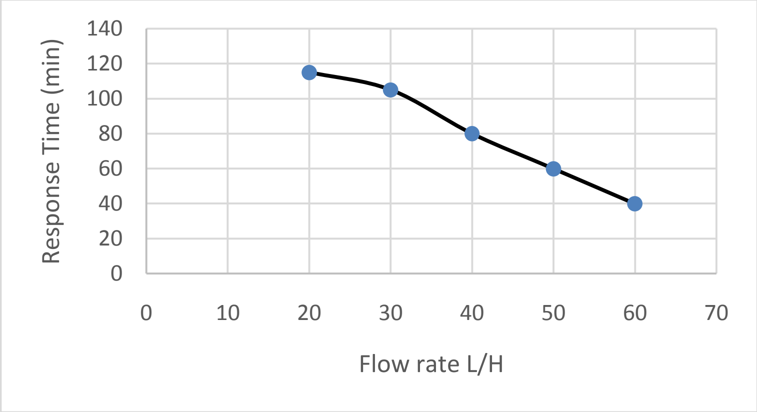

Figure 8: the relation between response time and flow rate

From the figures, it is clear that when the flow rate increases, the response time decrease so this is inversely relationship between them. Also high flow rate was more stable than low flow rate. This means that we need more time for calibration when we use low flow rate. The stability was started after 40 min at 60 L/H and after 115 min at 20 L/H. All results are within the uncertainty.

Table 2: The uncertainty budget

Symbol	Uncertainty source	Value	Divisor	Sensitive Coefficient	Uncertainty Contribution
Ustd	Unc of Ref. Standard	0.200	2	1	0.100000
Udrf	Drift of Ref. Standard	0.150	1.7321	1	0.086603
Urepro	Accuracy	0.050	1.7321	1	0.028868
Ures	Resolution	0.010	3.4641	1	0.002887
Umed	Stability of medium	0.400	1.7321	1	0.230940
Urep	Repeatability (type A)	0.240	1.73205	1	0.138564
	Combined Un.				0.301455
	Expanded Un.				0.602910

4. Conclusion

The study of relationship between flow rate of gas and response time of dew-point meter was inversely relationship. It was done at different relative humidity and fixed temperature.

The study shows that in low relative humidity, the response time of dew-point meter is too longer than that is in high relative humidity. Also, this paper gives the time which after that we can start the calibration of hygrometer.

The high and low flow rate are not effect on the stability of measurements.

So, we are recommended use high flow rate of gas during the calibration process especially if we have large amount of hygrometers for calibration to save time.

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