# Study on Calibration of Artificial Climate Chamber for Biological Application

Wei Gong[1], Wen Zhang[1], Tingting Ren[1*], Lingjian Zeng[1], and Li Feng[1]

[1] Chongqing Academy of Metrology and Quality Inspection, Chongqing, 401123, China

**Abstract.** Artificial climate chamber for biological application is widely used in biological laboratories. Parameters such as temperature, humidity and light intensity of artificial climate chamber can directly decide the accuracy of the experimental results. At present, there is no relevant calibration specification, or method for artificial climate chamber in China. This article presents a novel calibration method for artificial climate chambers for biological application to evaluate temperature, humidity, and light intensity control performance of the equipment, by determine corresponding environmental conditions, calibration standards, location of standards and calculation equations. The calibration results show that the calibration method is scientific and practical for metrological performance evaluation of artificial climate chambers for biological application.

## 1. Introduction

Artificial climate chamber for biological application is a precision instrument used to create artificial climate through purposeful combination of three key elements - temperature, humidity and light, and to simulate various climate types that may occur in the natural world to study the relationship between climate factors and the characteristics of the biological samples. The working principle of the climate chamber is to install the temperature, humidity and light intensity sensors in the chamber to detect the temperature, humidity and light intensity inside the chamber, and then send the measured data to the controller for data processing and control the working state of the refrigerator, heater, humidifier and lighting unit, so as to accurately adjust the temperature, humidity, light intensity inside of the chamber, and simulate the natural climate.[1][2][3]

Various types of artificial climate chambers have played an important role in biological studies. The artificial climate chambers can be used to simulate the growth environment suitable for animals and plants to get rid of the dependence on the natural environment. If the artificial climate box is used in the process of plant breeding, seedling raising, tissue cell and microorganism cultivation, the efficiency and quality of scientific experiment and research will be greatly improved. [4][5][6]

Temperature, humidity and light intensity are 3 key parameters to evaluate the performance of artificial climate chamber, which are essential to the accuracy of the experimental results. However, there is no calibration specification for artificial climate chamber in China at present. Therefore, it is urgent to develop an effective calibration method that can evaluate the temperature, humidity, light intensity inside the chamber, which can ensure the reliability of the artificial climate chamber in daily use.

## 2. Calibration conditions

### 2.1 Environmental conditions

During the whole process of the measurement, temperature should be (5~ 35) ℃, and humidity should be no more than 80%RH.

### 2.2 Metrological standards

Temperature and humidity itinerant detecting instrument with the temperature measurement range of no narrow than (-10~100)℃, temperature definition better than 0.1℃, temperature maximum permissive error no more than ±0.5℃, humidity measurement range of no narrow than (0~100)%RH, humidity definition better than 0.1%RH, and humidity maximum permissive error no more than ±5%RH, is needed to calibrate the temperature and humidity of artificial climate chamber. Illuminometer with measurement range of no narrow than (0~19999) lx, definition better than 1 lx, and maximum permissive error no more than ±5% is needed to calibrate the light intensity of artificial climate chamber.

* Corresponding author's e-mail: cd@cqjz.com.cn

## 3. Calibration method

### 3.1 Temperature and humidity calibration

Temperature humidity measuring sensors of temperature and humidity itinerant detecting instrument are located in each corner and in the center of the working space (see figure 1) for artificial climate chambers up to 2000 l. Additional temperature sensors should be located in in front of the center of each wall for chambers over 2000 l (see figure 2).[7][8]

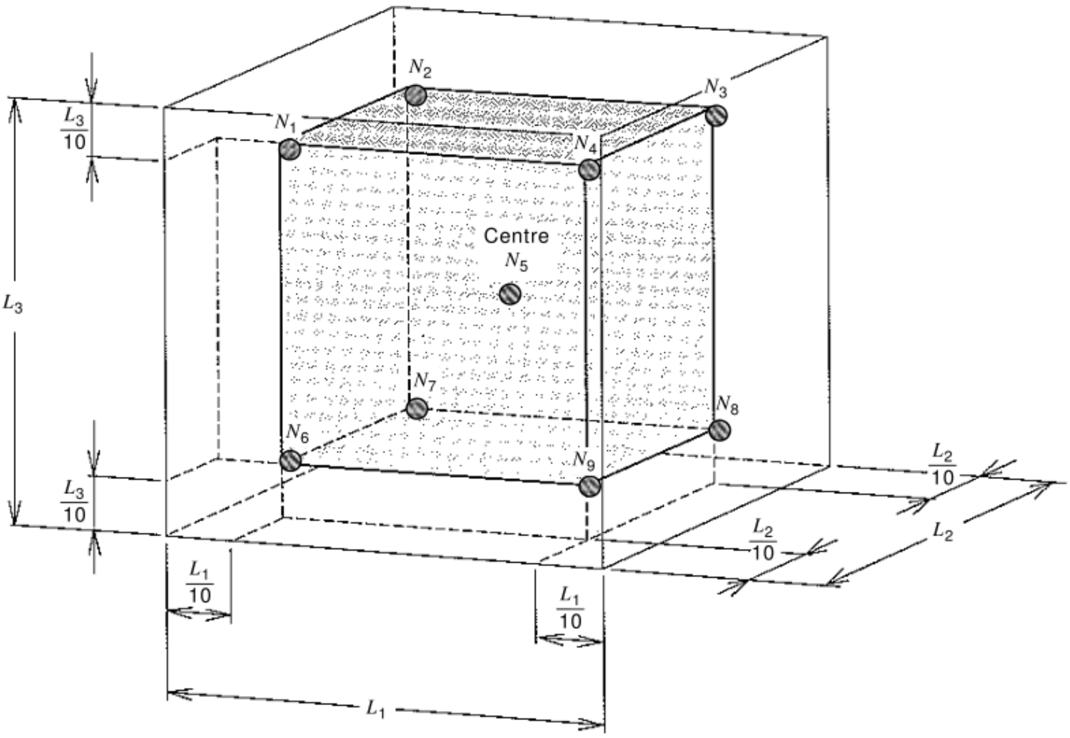


**Figure 1.** Location of sensors for artificial climate chambers up to 2000 l.

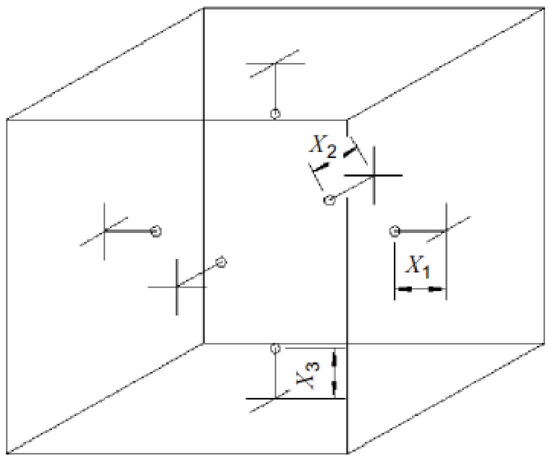


**Figure 2.** Location of additional sensors for artificial climate chambers over 2000 l.

Set the calibration temperature and humidity, start the artificial climate chamber, take 16 readings of each sensor at regular intervals of 2 min in 30 min during steady temperature and humidity condition of the chamber at set temperature and humidity. The indication error, fluctuation, and variation in space of temperature and humidity shall be calibrated in order to evaluate temperature and humidity controlling performance of the artificial climate chamber.

*3.1.1Temperature or humidity indication error. Temperature or humidity indication error is calculated according to equation (1).*

$$\text{Indication error} = N_{\text{IndicationAve}} - N_{\text{centerAve}} \quad (1)$$

Where $N_{\text{IndicationAve}}$ is mean of temperature or humidity indications of the calibrated artificial climate chamber, and $N_{\text{centerAve}}$ is mean temperature or humidity at chamber center.

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*3.1.2 Temperature or humidity fluctuation.*

$$\text{Fluctuation} = \pm\left(\frac{N_{\text{CenterMax}} - N_{\text{CenterMin}}}{2}\right) \quad (2)$$

Where $N_{\text{CenterMax}}$ is highest temperature of humidity of center point, and $N_{\text{CenterMin}}$ is the lowest temperature or humidity of center point.

3.1.3 *Temperature or humidity variation in space.* For artificial climate chambers up to 2000 l, temperature or humidity variation in space is calculate according to equation (3).

$$\text{Variation in space} = \left|\text{Max}(N_{\text{CornerAve}[j]} - N_{\text{CenterAve}})\right| \quad (3)$$

Where $N_{\text{CenterAve}}$ is mean temperature or humidity at chamber center, and $N_{\text{CornerAve}[j]}$ is mean or humidity at corner of working space. (j=1 to 8) .

For artificial climate chambers over 2000 l, temperature or humidity variation in space can also be calculated referring to equation (3).

## 3.2 Light intensity calibration

Illuminometers are located according to figure 3 and figure 4 to calibrate the light intensity of the artificial climate chambers up to 2000 l.[9]

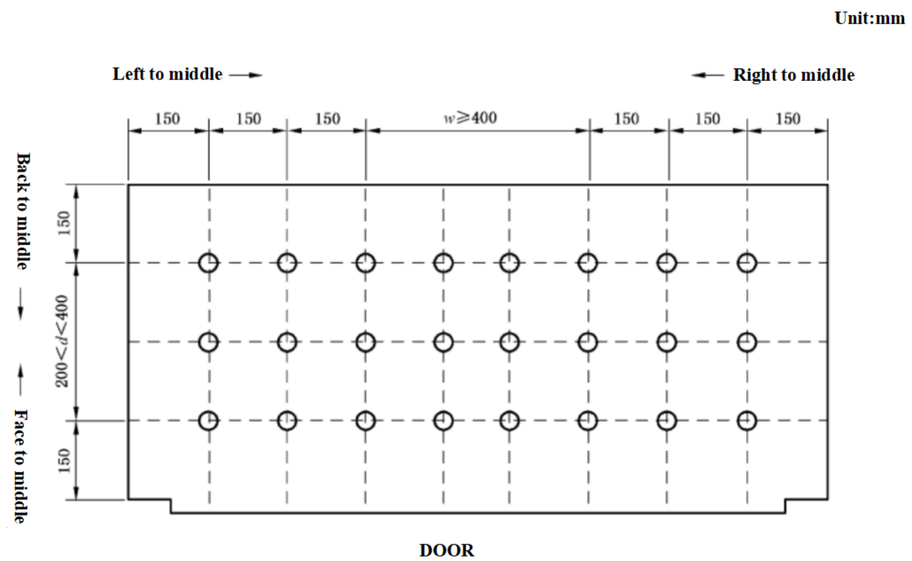


**Figure 3.** Horizontal layout of illuminometers for artificial climate chambers up to 2000 l.

As we can see in figure 3, within the horizontal test plane, take the left and right sides of the chamber as the boundary, and divide the grid line from the left and right sides to the middle with a spacing of 150 mm. If the spacing ($w$) of the middle grid meets the condition of 200 mm < $w$ < 400 mm, draw the last grid line in the middle longitudinal position; If $w \leqslant$ 200 mm, no more grid line needs to be drawn. In the same way, take the front and back of the chamber as the boundary, and divide the horizontal grid lines. Locate the illuminometers on the intersections of the grids. The horizontal layout of illuminometers for artificial climate chambers over 2000 l is the same except that the spacing is to be changed to 300 mm.[9]

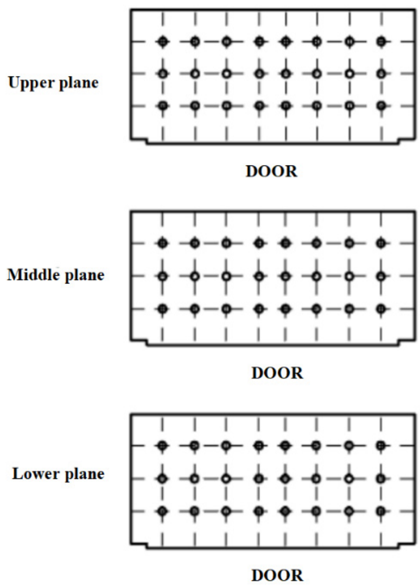


**Figure 4.** Vertical layout of illuminometers for artificial climate chambers

As we can see in figure 4, the upper calibration plane is 150 mm from the top of the chamber, the lower calibration plane is 150 mm from the bottom of the chamber, and the middle calibration plane is at half the distance between the upper and lower planes. Each plane is placed with illuminometers according to figure 3.

3.2.1 *Light intensity relative indication error.* Put the built in illuminometer of the artificial climate chamber closely next to standard illuminometer located at the chamber center. The light intensity relative indication error is calculated according to equation (4).

$$\text{Relative indication error} = \frac{E_{\text{Chamber}} - E_{\text{Standard}}}{E_{\text{Standard}}} \times 100\% \quad (4)$$

Where $E_{\text{Chamber}}$ is mean of light intensity indication of the calibrated artificial climate chamber, and $E_{\text{Standard}}$ is light intensity measured by standard illuminometer located at chamber center.

3.2.2 *Light intensity distribution.* The Light intensity distribution is calculated according to equation (5).[10]

$$\text{Distribution} = \frac{E_{\text{StandardMin}}}{E_{\text{StandardMax}}} \times 100\% \quad (5)$$

Where $E_{\text{StandardMax}}$ is highest light intensity measured by all standard illuminometers, while $E_{\text{StandardMin}}$ is the lowest.

## 4. Experimental verification of calibration method

The calibration results of 4 typical types of artificial climate chambers for biological application are demonstrated in table 1.

**Table 1.** Calibration results of 4 typical types of artificial climate chambers for biological application.

| Type | Parameters | | Result |
|---|---|---|---|
| MGC-250HP-2L | Temperature(℃) | Indication error | 1.2 |
| | | Fluctuation | 0.3 |
| | | Variation in space | 1.6 |
| | Humidity(%RH) | Indication error | 2.7 |
| | | Fluctuation | 2.5 |
| | | Variation in space | 3.9 |
| | Light intensity | Relative indication error (%) | 16.9 |
| | | Distribution ( % ) | 30.4 |
| RGX250E | Temperature(℃) | Indication error | 1.5 |
| | | Fluctuation | 0.2 |
| | | Variation in space | 1.9 |
| | Humidity(%RH) | Indication error | 2.7 |
| | | Fluctuation | 2.3 |
| | | Variation in space | 4.2 |
| | Light intensity | Relative indication error(%) | 15.7 |
| | | Distribution ( % ) | 29.8 |
| BIC-250 | Temperature(℃) | Indication error | 1.7 |
| | | Fluctuation | 0.4 |
| | | Variation in space | 1.3 |
| | Humidity(%RH) | Indication error | 2.5 |
| | | Fluctuation | 2.2 |
| | | Variation in space | 4.6 |
| | Light intensity | Relative indication error (%) | 17.7 |
| | | Distribution ( % ) | 33.7 |
| PQX-250A | Temperature(℃) | Indication error | 1.2 |
| | | Fluctuation | 0.3 |
| | | Variation in space | 1.9 |
| | Humidity(%RH) | Indication error | 2.7 |
| | | Fluctuation | 2.2 |
| | | Variation in space | 3.9 |
| | Light intensity | Relative indication error(%) | 12.9 |
| | | Distribution( % ) | 31.3 |

As we can see from table 1: the temperature indication error and variation in space calibration results can meet the requirement of JJF 1101-2019 *Calibration Specification for Environmental Testing Equipment for Temperature and Humidity Parameters*[11] of no more than ±2℃, the temperature fluctuation calibration results can meet the requirement of JJF 1101-2019 of no more than ±0.5℃, the humidity indication error and fluctuation calibration results can meet the requirement of JJF 1101-2019 of no more than ±3%, the humidity variation in space can meet the requirement of JJF 1101-2019 of no more than ±5%, and light intensity relative indication error and distribution calibration results can meet the enterprise standards of manufacturers. The feasibility and applicability of the calibration method have been proven.

## 5. Conclusion

This article presents a novel calibration method for artificial climate chambers for biological application to evaluate temperature, humidity, and light intensity control performance of the equipment, by determine corresponding environmental conditions, calibration standards, location of standards and calculation equations. The calibration results show that the calibration method is scientific and practical for metrological performance evaluation of artificial climate chambers for biological application. The follow-up study will develop the specific calibration device for artificial climate chamber, and the device will integrate temperature, humidity and light intensity measurement function, in order to reduce the size of the measurement apparatus, improve the portability of the calibration device, and upgrade the calibration scheme and accuracy.

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