Comparison of the Performance of the Two Dry Block Furnaces for RTC158B and Const660

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Abstract. The dry block temperature calibrator uses air as the calibration medium with small volume and light weight, and therefore is widely applied in field calibration work. With the improvement and vigorous development of the technology of domestic instruments, the technology of domestic dry body furnace is also developing rapidly. Whether the performance of domestic dry block temperature calibrator is better than the foreign instruments, this question is not very clear yet. Therefore, this study focuses on the comparative analysis of the performance parameters of the two dry-type temperature calibrators of Foreign dry furnace-RTC158 and domestic dry furnace-Const660, such as temperature deviation, temperature volatility, axial deviation, and radial deviation. The results reveal that the comprehensive performance of domestic instrument-Const660 is better than foreign instrument-RTC158.

Keywords. Dry block temperature calibrator, comprehensive performance, the performance parameters.

1. Introduction

The dry block temperature calibrator uses air as the calibration medium with small volume and light weight, and therefore is increasingly used in field calibration work [1-3]. Since 1984, the dry block temperature calibrator is used as an evaluation instrument because the instrument has always been mastered by foreign companies, such as AMETEK and FLUKE. In 2008, China began developing calibration specifications for dry-block temperature calibrators, and began implementation in September 2010. The promulgation and implementation of JJF1257-2010, in which Dry Temperature Calibrator Method provides standard calibration methods and uncertainty evaluation suggestions for the instrument, and promotes the technical improvement and product quality of domestic dry temperature calibrator manufacturers.

Dry block temperature calibrator is the main equipment to detect precision platinum resistance and industrial platinum resistance thermometer, which has a very broad market prospect, and demand continues to grow [4-6]. Based on the premise of the rapid development of the dry block temperature calibrator, it is very important to evaluate the performance of domestic dry-type temperature calibrator [7-10]. According to JJF1257-2010 (Dry-block-type temperature calibrator calibration method), the overall performance of a dry-type calibrator can be evaluated by analyzing parameters of temperature deviation, temperature fluctuation, axial uniformity, radial uniformity, lifting temperature time, and load characteristics.
In this study, selecting the two dry block furnaces of RTC158B and CST660, which are made by AMETEK in the United states and Const in China. By evaluating the performance parameters of two dry temperature calibrators, promote the technical development and improvement of domestic dry temperature calibrator, and improve the production technical level, output, sales and market share of domestic dry temperature calibrator.

2. Method
Shown in figure 1, the two dry block furnaces of RTC158B and CST660S are selected as the test target. The standard platinum resistance was used as a reference thermometer involved in the experimental calculation. And table 1 is the temperature calibration point of the dry block temperature calibrator.

| Dry furnace model | Measurement range/°C | Measured temperature/°C | Stability time / min |
|-------------------|----------------------|-------------------------|---------------------|
| RTC-158(AMETEK)   | -22 ~ 155            | -22, 0, 50, 100         | 0                   |
|                   |                      | 155                     | 10                  |
| 660(Const)        | -22 ~ 155            | -22, 0, 50, 100         | 0                   |
|                   |                      | 155                     | 10                  |

Figure 1. Two dry-type temperature calibrators of AMETEK RTC158 and Const660.

In this experiment, four performance parameters of two dry temperature calibrators were measured: temperature deviation, temperature fluctuation, axial uniformity, radial uniformity.

The temperature deviation is calculated as equation (1):

$$\Delta T = \frac{\sum_{i=1}^{n}(t_{ci} - t_{si})}{n}$$

In equation (1), $\Delta T$ is the temperature deviation, $t_{ci}$ indicates the temperature values shown by the dry block temperature calibrator when the number of measurement is i. $n$ is the number of measurement.

(1) Measurement of temperature volatility is calculated as equation (2):

Insert the reference thermometer into the dry furnace measuring hole and ensure contact with the measuring hole bottom. When the temperature reaches thermal equilibrium, the temperature values are
recorded at every two-minute intervals within 30 minutes. Half of the maximum and minimum value is the temperature volatility.

$$T_{vol} = \frac{T_{\text{max}} - T_{\text{min}}}{2}$$  \hspace{1cm} (2)

(2) Measurement of axial uniformity

Put the reference thermometer to the bottom, after the value is stable (the dry block temperature calibrator screen prompts the identification), record the indicated value \(t_0\);

Lift the reference thermometer up to the bottom 20 mm, 40 mm, 60 mm, and record the schematic value \(t_{20}, t_{40}, t_{60}\) respectively.

$$\Delta T_{ax} = t_m - t_i$$  \hspace{1cm} (3)

(3) Radial uniformity

Measure the maximum temperature difference between the hole \# a and the temperature measuring hole \# b.

Two reference thermometers A and B were inserted into two measurement holes \#a, \#b and ensure contact at the bottom of the measurement hole. After the temperature is stable, the schematic values of the two reference thermometers can be read at the first time. The reference thermometer exchange measurement hole, that is the reference thermometer A was inserted into hole \# b and the reference thermometer B was inserted into hole \# a., the measured values of the two reference thermometers are read at the second time. Repeat the above operation.

A total of 4 measurements were performed: \(t_{Aa1}, t_{Aa2}, t_{Aa3}, t_{Aa4}, t_{Bb1}, t_{Bb2}, t_{Bb3}, t_{Bb4}\).

Radial uniformity is calculated by equation (4):

$$\Delta T_{ab} = \frac{1}{4}(t_{Aa1} + t_{Bb2} + t_{Aa3} + t_{Bb4}) - \frac{1}{4}(t_{Bb1} + t_{Ab2} + t_{Bb3} + t_{Ab4})$$  \hspace{1cm} (4)

3. Results

3.1. Temperature Deviation

Figure 2 shows the temperature deviation of two furnace for RTC158B and Const660, figure 2(a) shows the five times measurement results of RTC158 at different temperatures from -22℃~155℃, figure 2(b) shows the five times measurement results of Const660 at different temperatures from -22℃~155℃. From figure 2(a) and (b), compared to RTC158, Const660 has smaller temperature fluctuations at each temperature measured. To further perform a clearer comparative analysis of them. Comparing the average temperature value at each measured point is required, which is shown as in figure 2(c). From figure 2(c), as the measured temperature increases, the temperature deviation is bigger. The maximum temperature deviation for the RTC158 is 0.06℃, and the maximum temperature deviation for the Const660 is -0.12℃. Comparing with the RTC158, the temperature deviation of Const660 is relatively large.

![Figure 2](image-url)

(a) Temperature deviation of RTC158B  (b) Temperature deviation of Const660  (c) Comparison of average deviation between RTC158B and Const660

Figure 2. The temperature deviation of two furnaces RTC158B and CST660.
3.2. Volatility of Temperature
Figure 3 shows the temperature volatility of two furnaces RTC158B and CST660 with at the temperature measurement point of 22°C, 100°C, and 155°C. Figure 3 (a) and (b) show the RTC dry furnace with a maximum temperature fluctuation of 0.028°C, while the maximum temperature fluctuation of Const660 reached 0.01°C. This means that the dry furnace of RTC158B has large temperature fluctuations, comparing with dry furnace of Const660.

![Figure 3. The temperature volatility of two furnaces RTC158B and CST660.](image)

Further analysis of figure 3 (c), revealing that the temperature fluctuation of RTC158 is greater than Const660 at each temperature measurement point.

3.3. Axial Uniformity
Figure 4 shows the axial uniformity of two furnaces RTC158B and CST660 at the temperature points of -22°C, 100°C and 155°C. Figure 4 shows that the axial uniformity of Const660 is better than that of the dry furnace of RTC158B at the different temperature measurement points. This means the axial uniformity of dry furnace for Const660 is better than that of RTC158.

![Figure 4. The axial uniformity of two furnaces RTC158B and CST660.](image)

3.4. Radial Uniformity
Figure 5 shows the radial uniformity of two furnaces RTC158B and Const660 at different temperature measurement point. At the measured temperature of -22 °C, the maximum axial uniformity of the dry block furnace RTC158 is 0.008°C, and the maximum axial uniformity of the dry block furnace Const660 is 0.013 °C. However, it can be obtained from figure 5 (c) that the average radial uniformity of the dry block furnace RTC158 is higher than the Const660 at different temperature measurement points, meaning the radial uniformity of dry-block furnace Const660 is better than that of RTC158.
4. Conclusion

Through a comprehensive performance analysis of the two dry-type temperature calibrators for two furnace RTC158B and Const660, and measuring the temperature deviation, temperature fluctuation, axial uniformity, and radial uniformity of the two dry-type temperature calibrators. The performance superiority of the two dry-type temperature calibrators can be evaluated. According to result, although the temperature deviation of domestic dry block calibrator-const660 is bigger than that of RTC158, but the performance of the temperature fluctuation, axial uniformity and radial uniformity are better than those of RTC158.

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