

National Institute of Advanced Industrial Science and Technology

National Metrology Institute of Japan



Reference Material Report

NMIJ RM 1102-a

No. +++



Thermal Expansion Reference Material (Glass-Like Carbon): Form 1

This reference material (RM) is produced in accordance with the NMIJ's management system and is in compliance with ISO 17034 and ISO/IEC 17025. This RM is intended for use in calibrating push-rod dilatometers and thermomechanical analyzers or as a reference specimen in thermal expansion measurements.

### Indicative Values

The indicative values of thermal expansivity  $\alpha$  are given from the following equation:

$$\alpha(T)/(10^{-6}\text{K}^{-1}) = 3.5276 - 1.8257 \times 10^{-2} \cdot (T/\text{K}) + 7.8848 \times 10^{-5} \cdot (T/\text{K})^2 - 1.4048 \times 10^{-7} \cdot (T/\text{K})^3 \\ + 1.3357 \times 10^{-10} \cdot (T/\text{K})^4 - 6.6706 \times 10^{-14} \cdot (T/\text{K})^5 + 1.3763 \times 10^{-17} \cdot (T/\text{K})^6$$

This equation is available in the temperature range of 293.15 K to 1100 K.

The calculated results from above equation and the expanded uncertainties  $U$  at typical temperature points in this RM are given in the table below. The uncertainty of each indicative value is the expanded uncertainty obtained by multiplying the combined standard uncertainty by a coverage factor ( $k$ ) of 2, and it is the half-width of an interval estimated to have a level of confidence of approximately 95 %.

Temperature $T$ (K)	Thermal expansivity $\alpha$ ( $10^{-6}\text{K}^{-1}$ )	Expanded uncertainty $U$ ( $10^{-6}\text{K}^{-1}$ )
293.15	2.263	0.074
300	2.284	0.073
350	2.453	0.073
400	2.642	0.073
450	2.838	0.073
500	3.030	0.073
550	3.212	0.073
600	3.381	0.073
650	3.536	0.073
700	3.677	0.073
750	3.804	0.073
800	3.919	0.074
850	4.022	0.074
900	4.114	0.074
950	4.195	0.074
1000	4.266	0.074
1050	4.328	0.076
1100	4.383	0.076

### Analysis

Each indicative value was determined based on absolute measurements of thermal expansivity for five glass-like carbon samples. The five test samples (dimensions: 25 mm × 25 mm × 6 mm) were cut from a glass-like carbon plate which was thermally treated at 2273 K. All distributed pieces of this RM (dimensions: 6 mm × 6 mm × 10 mm) were also cut from this glass-like carbon plate. The thermal expansivity of the five test samples was measured by a laser interferometric dilatometer in the following way: Each test sample was heated and cooled in a stepwise manner over the temperature range of 293 K to 1240 K. The thermal expansivity of the test sample was calculated as

$$\alpha(T) = \frac{L_{n+1} - L_n}{L_0 (T_{n+1} - T_n)},$$

where  $L_0$  is length of a sample at room temperature 293.15 K (20 °C), ( $T_n$  and  $T_{n+1}$ ) are the adjacent temperatures of the sample in the stepwise heating and cooling cycle, and ( $L_n$  and  $L_{n+1}$ ) are the lengths of the sample at  $T_n$  and  $T_{n+1}$ . The value of  $L_0$  was measured by a digital linear scale. The temperature difference ( $T_{n+1} - T_n$ ) was set to be approximately 50 K or 25 K. For each sample, 80 values of thermal expansivity were obtained. All thermal expansivity values of the five test samples were pooled, and the sixth-order polynomial function of temperature was obtained by the method of least squares. The samples were heated in a furnace in which helium gas at an amount equivalent to a pressure of 95 Pa and a temperature of 293 K, was sealed during the measurements.

### Expiration of Report

The report of this RM is valid until March 31, 2030, provided that the material remains unopened and is stored in accordance with the instructions given in this report.

### Description of the Material

This RM is a black block composed of glass-like carbon, taking the form of 6 mm square and 10 mm long.

### Homogeneity

The homogeneity of the RM was determined by analyzing the measurement results of the five test samples taken from different positions of the glass-like carbon plate. The homogeneity of thermal expansivity has been incorporated into the uncertainties of the indicative values.

### Instructions for Storage

This RM should be stored at a temperature of 23 °C ± 5 °C and at a relative humidity of 50 % or less.

### Instructions for Use

It is recommended that the thermal expansion along the 10 mm longitudinal direction the distributed piece of the RM is used as a reference for dilatometer calibration or verification, though thermal expansion characteristic of glass-like carbon is considered isotropic. This is because the indicative values given above correspond to the thermal expansivity measured along the longitudinal direction. A distributed piece of the RM should be heated in vacuum or in an atmosphere of inert gas such as argon or nitrogen.

### Precautions for Handling

This RM is considered as a chemically safe material under normal conditions for use. When handling, wear appropriate protective gloves. Refer to the safety data sheet (SDS) on this RM before use.

### Preparation

This RM was made from a glass-like carbon plate which was thermally treated at 2273 K. Each distributed piece of the RM, produced from the glass-like carbon plate, is in the form of a block 6 mm square and 10 mm long.

### NMIJ Analysts

The technical manager for this RM is YAMADA N. The production manager and the analyst are WATANABE H.

### Information

If substantive technical changes occur that affect the value assignment before the expiration of this report, NMIJ will notify the registered customer. Customer registration on the NMIJ Website (given below) will facilitate notification. Technical reports regarding this RM can be obtained from the contact details given below.

### Reproduction of Report

In reproducing this report, it should be clearly indicated that the document is a copy.

April 1, 2020

ISHIMURA Kazuhiko  
President

National Institute of Advanced Industrial Science and Technology

If you have any questions about this RM, please contact  
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#### Revision history

- April 1, 2015: “Metrology Management Center” was renamed to “Center for Quality Management of Metrology.”  
October 17, 2019: The expiration of report was extended from March 31, 2020 to March 31, 2025.  
January 25, 2024: The expiration of report was extended from March 31, 2025 to March 31, 2030.