National Institute of Advanced Industrial Science and Technology

National Metrology Institute of Japan

Reference Material Certificate

NMIJ CRM 5805-a
No. +++

High-Purity Copper for Thermal Expansivity Measurements

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

Certified Values

The certified values of thermal expansivity α and their expanded uncertainties U in this CRM are given from the following equations. The value of α is the linear thermal expansivity based on a specimen length at 20 °C (L_0). The value of U given by the equation is the half-width of the expanded uncertainty interval calculated using a coverage factor (k) of 2, which gives a level of confidence of approximately 95 %.

at 20 K $\leq T <$ 31 K,

$$\alpha/(10^{-6}\,\mathrm{K}^{-1}) = -1.559444\times10^{-4}\cdot(T/\mathrm{K})^2 + 4.133681\times10^{-5}\cdot(T/\mathrm{K})^3 + 1.663047\times10^{-7}\cdot(T/\mathrm{K})^4 - 4.939234\times10^{-9}\cdot(T/\mathrm{K})^5$$

at 31 K $\leq T <$ 100 K,

$$\alpha/(10^{-6}\,\mathrm{K}^{-1}) = 3.716863 - 3.917249\times10^{-1}\cdot(T/\mathrm{K}) + 1.446383\times10^{-2}\cdot(T/\mathrm{K})^2 - 1.753929\times10^{-4}\cdot(T/\mathrm{K})^3 + 9.827042\times10^{-7}\cdot(T/\mathrm{K})^4 - 2.157414\times10^{-9}\cdot(T/\mathrm{K})^5$$

at 100 K $\leq T <$ 170 K,

$$\alpha/(10^{-6}\,\mathrm{K}^{-1}) = -1.631489\times10^{1} + 6.048822\times10^{-1}\cdot(T/\mathrm{K}) - 5.705181\times10^{-3}\cdot(T/\mathrm{K})^2 + 3.203064\times10^{-5}\cdot(T/\mathrm{K})^3 - 9.990485\times10^{-8}\cdot(T/\mathrm{K})^4 + 1.324350\times10^{-10}\cdot(T/\mathrm{K})^5$$

at 170 K $\leq T \leq$ 300 K,

$$\alpha/(10^{-6}\,\mathrm{K}^{-1}) = -1.281768 + 1.845905\times10^{-1}\cdot(T/\mathrm{K}) - 7.519537\times10^{-4}\cdot(T/\mathrm{K})^2 + 1.279893\times10^{-6}\cdot(T/\mathrm{K})^3 - 1.157627\times10^{-10}\cdot(T/\mathrm{K})^4 - 1.368713\times10^{-12}\cdot(T/\mathrm{K})^5$$

at 20 K $\leq T \leq$ 300 K,

$$U/(10^{-6}\,\mathrm{K}^{-1}) = 5.80\times10^{-2} - 3.80\times10^{-4}\cdot(T/\mathrm{K}) + 1.55\times10^{-6}\cdot(T/\mathrm{K})^2 - 1.86\times10^{-9}\cdot(T/\mathrm{K})^3$$

The calculated results from above equations at typical temperature points are shown in the table below. The value of U is rounded up to the third decimal place.

T/K	$\alpha/(10^{-6}\,\mathrm{K}^{-1})$	$U/(10^{-6}\,\mathrm{K}^{-1})$	T/K	$\alpha/(10^{-6}\,\mathrm{K}^{-1})$	$U/(10^{-6}\,\mathrm{K}^{-1})$
20	0.279	0.052	180	14.665	0.029
40	2.260	0.046	200	15.174	0.030
60	5.457	0.041	220	15.585	0.030
80	8.328	0.037	240	15.927	0.031
100	10.486	0.034	260	16.220	0.032
120	12.044	0.032	280	16.479	0.033
140	13.182	0.031	300	16.713	0.034
160	14.024	0.030			

Analysis

Each certified value was determined by the following measurement methods:

(1) The thermal expansion measurement from 10 K to 315 K was conducted by a laser interferometric dilatometer, and the determination of specimen length at 20 °C was carried out by a digital linear scale.

(2) The certified values were determined as a function of temperature by a least square method under restrictive conditions with the weight of the measurement uncertainty.

Metrological Traceability

Each certified value was determined from the measurement results in a change of specimen temperature (ΔT), a change of specimen length (ΔL) and a specimen length at 20 °C (L_0). The value of ΔT, ΔL, and L_0 were measured by instruments calibrated by reference standards which were an Iodine stabilized He-Ne leaser, a Platinum resistance thermometer, a standard resistance and a block gauge, respectively. In the results, the certified value is traceable to the International System of Units (SI).

Expiration of Certification

This certificate is valid from the date of shipment to March 31, 2029, provided that the material remains unopened and is stored in accordance with the instructions given in this certificate.

Description of the material

This CRM is in the form of a rectangular block with a base of 10 mm × 10 mm and a length of 30 mm, kept in a plastic case.

Homogeneity

The homogeneity of the CRM was determined by analyzing the measurement results on 4 specimens (20 mm × 20 mm× 8 mm) which were cut from different positions of an ingot of copper. The homogeneity of thermal expansivity is reflected in the uncertainty of the certified value.

Instructions for Storage

This CRM should be stored at a temperature of 25 ºC or below, and under a nitrogen gas atmosphere.

Instructions for Use

- Do not use this CRM for any purpose other than the calibration of a dilatometer.
- The certificated value denotes the value of the thermal expansivity along the 30 mm length direction of the distributed shape of the CRM.
- Cautions with respect to thermal cycles.
  - Avoid a thermal shock which causes cracks in the CRM.
  - Avoid heating above 315 K.
- Processing of specimen
  - Customers can cut and polish the CRM to adjust to their dilatometer.
  - When processing, note that the certificated value denotes the value of the thermal expansivity along the 30 mm length direction of the distributed shape of the CRM.
  - Avoid generating cracks and plastic deformation in the specimen in consideration of thermal and mechanical stress in processing.
- When cracks are generated in the specimen, do not use the specimen.

Precautions for Handling

Handling of the CRM is similar to that of the solid of copper. Refer to the safety data sheet (SDS) on this CRM before use.

Preparation

This CRM was made from a high-purity copper ingot with the purity of about 99.999 at%. The CRM was cut in a rectangular block with a base of 10 mm × 10 mm and a length of 30 mm by electrical discharge machining.

NMIJ Analysts

The technical and production managers for this CRM are YAMADA N. and the analyst is YAMADA N.

Information

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

Reproduction of Certificate

In reproducing this certificate, 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 CRM, please contact:
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National Metrology Institute of Japan,
Center for Quality Management of Metrology, Reference Materials Office,
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Phone: +81-29-861-4059; Fax: +81-29-861-4009, https://unit.aist.go.jp/nmij/english/refmate/

Revision history
April 1, 2015: "Metrology Management Center" was renamed to "Center for Quality Management of Metrology."
January 12, 2018: The limit of validity of the certificate was extended from "March 31, 2019" to "March 31, 2024."
May 26, 2022: The limit of validity of the certificate was extended from "March 31, 2024" to "March 31, 2029."