

ICS 77.040.99

CCS H 21



**NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

GB/T 4339-2008

**Test methods for thermal expansion characteristic parameters
of metallic materials
(English Translation)**

Issued on: October 10, 2008

Implemented on: May 1, 2009

**Issued by: General Administration of Quality Supervision, Inspection and
Quarantine of the People's Republic of China**

Table of Contents

Foreword...	3
1 Scope...	5
2 Normative References...	5
3 Terms and Definitions...	5
4 Symbols and Descriptions...	6
5 Method Overview...	7
6 Test Devices and Requirements...	7
7 Specimen Preparation...	10
8 Device Calibration...	11
9 Test Procedures...	14
10 Calculation...	16
11 Accuracy and Deviation...	17
12 Test Report...	18

1 Scope

This Standard specifies the definitions and symbols, principles, test devices and requirements, specimen preparation, device calibration, measurement procedures, calculation of measurement results, test report, accuracy and deviation, etc. of the thermal expansion characteristic parameter measurement methods of metallic materials and other related solid materials.

This Standard specifies the use of a push-rod dilatometer to test the linear thermal expansion of rigid solid materials. This is applicable to the testing of the linear thermal expansion of metallic material specimens within the temperature range of $-180\text{ }^{\circ}\text{C} \sim 900\text{ }^{\circ}\text{C}$ with the help of a component composed of the same fused quartz carrier and push rod. It is also applicable to the testing of the linear thermal expansion of specimens with rigid solid characteristics, such as:

ceramics, refractory materials, glass and rocks, etc. If components of high-purity alumina are used instead, the testing temperature range can be expanded to $1,600\text{ }^{\circ}\text{C}$; if isotropic graphite is used, then, it can be expanded to $2,500\text{ }^{\circ}\text{C}$.

2 Normative References

The clauses in the following documents become clauses of this Standard through reference in this Standard. In terms of references with a specified date, all subsequent amendments (excluding corrigenda) or revisions do not apply to this Standard. However, parties to an agreement based on this Standard are encouraged to explore the possibility of adopting the latest versions of these documents. In terms of references without a specified date, the latest version applies to this Standard.

GB/T 8170 Rules of Rounding off for Numerical Values & Expression and Judgement of Limiting Values

JJG 141 Working Noble Metal Thermocouples

JJG 229 Verification Regulation of Industry Platinum Copper Resistance Thermometers

JJG 351 Verification Regulation of Working Base Metal Thermocouple

3 Terms and Definitions

3.1

linear thermal expansion

$\Delta L/L_0$ (ΔL) α ---the specimen length change shown by the displacement sensor, expressed in (μm);

α ---the average linear expansion coefficient, commonly expressed as $10^{-6} \text{ }^\circ\text{C}^{-1}$, in units of ($^\circ\text{C}^{-1}$);

α_t ---the thermal expansion rate at the temperature t , commonly expressed as $10^{-6} \text{ }^\circ\text{C}^{-1}$, in units of ($^\circ\text{C}^{-1}$);

t_0 ---the temperature corresponding to the original length L_0 , expressed in ($^\circ\text{C}$);

t_1, t_2 ---the two temperatures ($t_1 < t_2$) selected during the measurement, expressed in ($^\circ\text{C}$);

Δt ---the temperature difference ($t_2 - t_1$) between t_2 and t_1 , expressed in ($^\circ\text{C}$).

5 Method Overview

5.1

Adopt a stepwise temperature change mode or a slow constant speed temperature change mode for temperature control. Use a push rod fused quartz dilatometer to detect the length change of a solid material specimen relative to its carrier as a function of temperature.

5.2

Distinguished by the basic configuration, there are often various variants, including test devices called "differential dilatometers" that use simulated temperature measurement. The basic requirements for these devices are the same as those specified in this Standard.

5.3

Most thermomechanical analyzers (TMA) have the function of a dilatometer, which has the advantages of high degree of automation and relatively small specimen size. However, if a small-sized specimen is used, considering the measurement accuracy, it can generally only detect high expansion materials, for example, polymers, etc.

6.1 Specimen Carrier and Push Rod or Pipe

6.1.1

The carrier of the specimen and the push rod or pipe are composed of annealed fused quartz, which transmit changes in the length of the specimen to the sensor. The shape and size of the push rod shall ensure that the load is applied to the specimen without causing indentation on the specimen within the required temperature range. Figure 1 shows a typical shape of the pipe and rod.

specimen and its carrier into electrical and optical signals suitable for input to the data processor-recorder. There can be various types, such as: digital encoders, differential or pointer- type conversion devices, etc. The accuracy shall satisfy the performance testing requirements.

For example, within the temperature interval of 20 °C ~ 100 °C, it shall be ensured that the testing accuracy of the specimen with a length of 25 mm and an average linear expansion coefficient of $1.0 \times 10^{-6}/^{\circ}\text{C}$ is better than $\pm 0.1 \times 10^{-6}/^{\circ}\text{C}$. The measurement uncertainty of the displacement sensor used shall be better than $\pm 85 \text{ nm}$ (see 11.3).

The displacement sensor shall be protected, so as to ensure that the maximum temperature change in the sensor caused by the test has no obvious effect on its indication value.

6.3.2 The shape and size of the push rod shall ensure that the load is applied to the specimen without causing indentation on the specimen within the required temperature range. The diameter of the straight circular cross-section push rod used in this method is 2 mm ~ 5 mm.

6.3.3 The expansion displacement measurement system consisting of a displacement sensor, a

data processor-recorder, a specimen carrier and a push rod shall have a stable zero indication.

Within the temperature range used by the system, the absolute value of the apparent average linear expansion coefficient measured for a reference specimen that is homogeneous with the specimen carrier shall not be greater than $0.3 \times 10^{-6}/^{\circ}\text{C}$.

6.4 Temperature Measurement System

This system consists of a calibrated temperature sensing device or device group and a manual, electronic or other equivalent read-out device. The uncertainty of the tested temperature indication is required to be better than $\pm 0.5^{\circ}\text{C}$ or not greater than $\pm 1\%$ of the entire temperature range.

6.4.1

Since this test method involves a wide temperature range, different types of sensing devices can be used depending on the temperature range. Generally, wire-shaped ($\phi 0.5$ mm or finer wire) and foil-shaped thermocouples calibrated by the verification regulation of JJG 141 and JJG 351, as well as wire-shaped resistance thermometers calibrated by the verification regulation of JJG 229 are used.

6.4.2

Within the range of $190^{\circ}\text{C} \sim 350^{\circ}\text{C}$, it is recommended to use E-type or T-type thermocouples. Within the range of $0^{\circ}\text{C} \sim 900^{\circ}\text{C}$, it is recommended to use K-type, S-type and N-type thermocouples. Thermocouples shall be regularly calibrated and inspected, so as to ensure that they are not contaminated during use or eliminate phase changes caused by the migration of alloy components at the joints.

6.4.3

When a thermocouple is used, an ice tank or an equivalent electronic reference device that is not affected by ambient temperature changes shall be used to ensure that its reference end is 0°C .

6.4.4 For additional precautions for temperature detection during precision measurement, see

C.4 in Appendix C.

9.3.1 Fused quartz heated above 500°C will crystallize due to contamination by alkaline compounds. In order to prevent this phenomenon from happening, before each test, it is recommended to clean the fused quartz component with the following process: soak it in 10% hydrofluoric acid aqueous solution for 1 minute, then, use distilled water to thoroughly rinse it.

9.3.2 In order to prevent further contamination by alkaline compounds, the cleaned fused quartz component must not be touched with hands until the measurement is completed.