INTERNATIONAL STANDARD

ISO 18099

Second edition
2022-08

Thermal insulating products for building equipment and industrial installations — Determination of the coefficient of thermal expansion

Produits isolants thermiques pour l'équipement du bâtiment et les installations industrielles — Détermination du coefficient de dilatation thermique

Reference number
ISO 18099:2022(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 88, *Thermal insulating materials and products*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 18099:2013), which has been technically revised.

The main changes are as follows:

— EN 13471:2001 and ISO 18099:2013 have been merged into one document;

— Clause 2, Normative references, has been added and the numbering of the following clauses has been changed accordingly;

— editorial revisions.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Thermal insulating products for building equipment and industrial installations — Determination of the coefficient of thermal expansion

1 Scope

This document specifies the equipment and procedures for determining the coefficient of linear thermal expansion. It is applicable to thermal insulating products within the temperature range –196 °C to 850 °C, subject to the possible temperature limitation of the test specimens. It is not applicable to products which experience dimensional changes during the test due to the loss of hydration water or which undergo other phase changes.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
linear thermal expansion
reversible changes in the length of a product resulting from a change in temperature

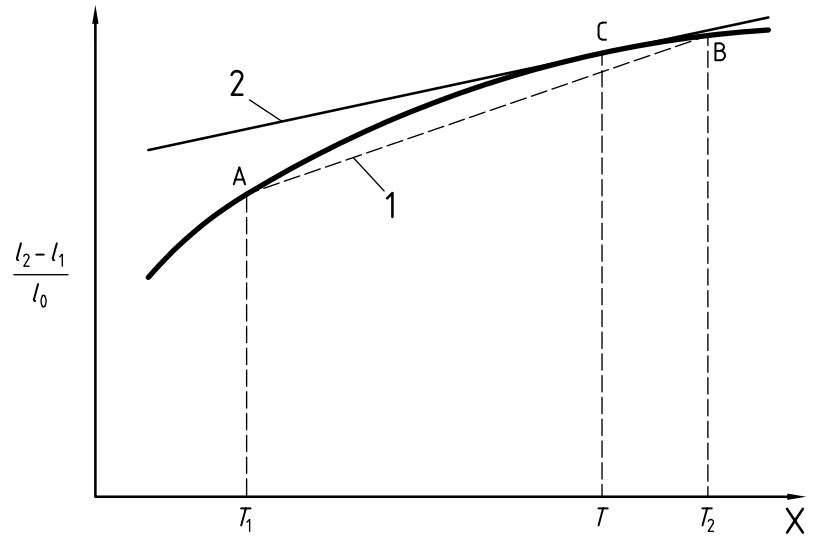
3.2
mean coefficient of linear thermal expansion, α_m, between different temperatures
reversible change in length divided by the length at the reference temperature and the temperature difference between the test temperatures

Note 1 to entry: See Figure 1.

3.3
coefficient of thermal expansion, α_t, at the temperature T
limit value of α_m as the higher temperature approaches the lower temperature

Note 1 to entry: See Figure 1.

Note 2 to entry: The definition of α_m and α_t assumes that the function giving the length variation in relation to the temperature variation is continuous. This excludes the use of the mean coefficient of linear thermal expansion, α_m, when the test specimen experiences physical change due to change of phase, e.g. recrystallisation or loss of water of hydration. The curve giving the length variation as a function of the temperature variation can be reported, but the mean coefficient of thermal expansion should not be calculated for parts of the curve, which are not continuous.



Key

X temperature

1 mean coefficient of thermal expansion between T_1 and T_2 (illustrated by the gradient of the dotted line between the points A and B)

2 coefficient of thermal expansion at T (illustrated by the gradient of the tangent at point C)

Figure 1 — Relative length variation as a function of temperature

4 Principle

The changes in a product's linear dimensions, as its temperature is changed, are measured and characterised. It shall be done in a continuous way when the full curve over a temperature range is needed or only at two specified temperatures if only a mean coefficient of linear thermal expansion between these temperatures is needed.

5 Apparatus

5.1 Dilatometer, with appropriate dimensions and suitable for the temperature range (see Figure 2).

NOTE The usual dilatometers are of the tube or rod type, fabricated of high-purity vitreous silica. Modern dilatometers incorporate the essential features described below.

5.2 Micrometer calliper, a calliper with micrometer indication permitting direct reading of the test specimen lengths at different temperatures. The accuracy of these measurements shall be such that consecutive measurements at the same temperature are determined to $2 \times 10^{-4} \times l_0$ for the length and to $2 \times 10^{-5} \times l_0$ for the length variations.

5.3 Electrical furnace, for high temperatures, an electrical furnace, capable of maintaining the mean temperature of the test specimen to within ±2 K of the desired test temperature and the maximum and minimum temperature of the test specimen to within ±2 K.

The electrical furnace shall be capable of limiting the rate of temperature change to 1 °C/min during the change from one test temperature to another.

5.4 Test chamber, for low and cryogenic temperatures, a test chamber, capable of maintaining the mean temperature of the test specimen to within ±1 K of the desired test temperature and the maximum and minimum temperature of the test specimen to within ±1 K.

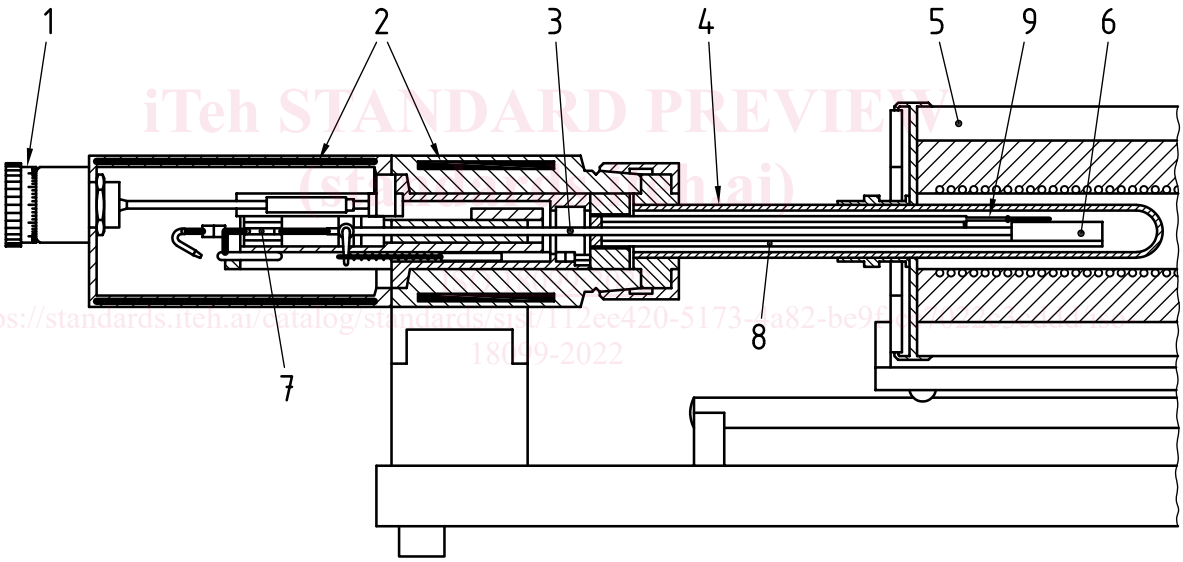
The test chamber shall be capable of limiting the rate of temperature change to 1 °C/min during the change from one test temperature to another.

5.5 Temperature-measuring instruments, calibrated thermocouples suitable for the temperature needed for the test with an accuracy of ±0,5 K from -196 °C to 200 °C, ±1 K from 200 °C to 500 °C, and ±2 K from 500 °C to 850 °C.

The thermocouples shall be connected to a continuous recording device. If only the mean coefficient of linear thermal expansion, $\alpha_{m,}$ between two temperatures is needed, the measurements shall only be carried out at these temperatures.

NOTE Devices, which are normally used for the simultaneous recording of the length variation and the temperature provide a curve of $\frac{\Delta l}{l_0}$ as a function of T_2 - T_1.

5.6 Equipment to prepare the test specimen, suitable saw or thin-walled steel tube to prepare the test specimen.



Key

1 micrometer screw
2 thermostat
3 push-rod
4 protective tube
5 furnace
6 test specimen
7 linear variable differential transducer
8 test specimen carrier
9 thermocouple

Figure 2 — Example of a dilatometer

6 Test specimens

6.1 Dimensions of test specimens

Because of its small dimensions, the test specimen should be carefully selected to be representative of the product being tested.

The dimensions of the test specimens shall be appropriate for the dimensions of the dilatometer and suitable for the test material.

Dimensions of the test specimens shall be as specified in the relevant product standard.

NOTE In the absence of a product standard, the dimensions of test specimens can be agreed between parties.

Typical test specimens have a length of (50 ± 1) mm with square cross section of (10 ± 1) mm or a diameter of (10 ± 1) mm. Smaller or larger dimensions are acceptable, but the user of this document should be aware that too-short test specimens give a loss of sensitivity, while too-long test specimens can be subjected to axial temperature differences or physical deformation such as creep or elastic strain rates.

The tolerance on parallelism and flatness between the two faces of the test specimen used for the length determination shall not be more than 1 % of their linear dimension.

6.2 Preparation of test specimens

Any skins, facings, and/or coatings shall be removed.

Test specimens shall be sawn or cut from the product with a thin-walled steel tube in the direction in which the measurement of the coefficient of linear thermal expansion shall be made and in which the linear dimensions are to be recorded.

Special requirements for preparation such as annealing or drying under specified conditions shall be indicated where relevant in the product standard.

For anisotropic products, the measurements shall be carried out both in the direction of the length and of the width.

6.3 Number of test specimens

The number of test specimens shall be as specified in the relevant product standard. If the number is not specified, then at least two test specimens shall be used.

NOTE In the absence of a product standard or any other international technical specification, the number of test specimens can be agreed between parties.

6.4 Conditioning of test specimens

The test specimens shall be stored for at least 6 h at (23 ± 5) °C. In case of dispute, they shall be stored at (23 ± 2) °C and (50 ± 5) % relative humidity (RH) for the time specified in the relevant product standard.

In tropical climates, different conditioning and testing conditions can be relevant. In this case, the conditions shall be (27 ± 5) °C and (65 ± 5) % RH.

7 Procedure

7.1 Test conditions

The test shall be started at (23 ± 2) °C, due to the importance of accurate temperatures for this test method.

In tropical climates, different conditioning and testing conditions can be relevant. In this case, the conditions shall be (27 ± 5) °C and (65 ± 5) % RH.

7.2 Test procedure

Clean the test specimen and install it in the dilatometer, making sure that the end surfaces as well as the contact surfaces of the dilatometer are free of foreign particles.

Measure its length at (23 ± 2) °C which shall be considered as the reference temperature. In tropical climates, measure its length at (27 ± 5) °C.

Place the thermocouples in representative manner, ensuring good contact with the test specimen.

Insert the dilatometer assembly in the furnace or in the test chamber.

Heat or cool the system, making sure that the temperature gradient given in the relevant product standard is respected. If no information is available, do not exceed 3 K/min and 1 K/min for the last 50 °C interval.

Stabilize the temperature at temperature intervals not greater than 50 °C over a time sufficient to obtain homogeneous temperature within the test specimen. Usually, 30 min is sufficient.

Measure the temperature and the test specimen length when constant temperature is recorded (±2 K for high temperatures and ±1 K for low temperatures). Record the length variation/temperature curves continuously, following the instructions specific to the instrument used.

Bring the temperature back to the reference value and remeasure the length. If irreversible changes have occurred, repeat the cycles until only reversible changes occur.

The result shall be calculated from the readings of the reversible changes.

8 Calculation and expression of results

Apply the corrections specific to the instrument used to the measured lengths, e.g. the correction for the expansion of the quartz support over the length of the test specimen.

Calculate the mean coefficient of linear thermal expansion, α_m, in $°C^{-1}$ between the temperatures T_1 and T_2 using Formula (1):

$$\alpha_m = \frac{1}{l_0} \times \frac{l_2 - l_1}{T_2 - T_1} \tag{1}$$

where

l_0 is the length of the test specimen, in millimetres, at the reference temperature T_0, in degree Celcius;

l_1 is the length of the test specimen, in millimetres, at the temperature T_1, in degree Celcius;

l_2 is the length of the test specimen, in millimetres, at the temperature T_2, in degree Celcius.

If required, determine the coefficient of thermal expansion, α_t, at the temperature T, as the tangent to the above curve.

9 Accuracy of measurement

NOTE It has not been possible to include a statement on the accuracy of the method in this version of this document, but it is intended to include such a statement when this document is next revised.

10 Test report

The test report shall include the following information:

a) a reference to this document, i.e. ISO 18099:2022;

b) product identification:

   1) product name, factory, manufacturer, or supplier;

   2) production code number;

   3) type of product;

   4) packaging;

   5) the form in which the product arrived at the laboratory;

   6) other information as appropriate, e.g. nominal dimensions;

c) test procedure:

   1) pre-test history and sampling, e.g. who sampled and where;

   2) time between sampling and conditioning;

   3) conditioning;

   4) conditioning and testing conditions in tropical climates, if applicable;

   5) annealing, drying conditions;

   6) presence of facings, the mass of the facing, and the method of removal, if necessary;

   7) presence of surface skins and the method of removal, if necessary;

   8) if any deviation from Clauses 6 and 7;

   9) date of testing;

   10) general information relating to the test;

   11) events which can have affected the results;

Information about the apparatus and identity of the technician should be available in the laboratory but it need not be recorded in the report.

d) results:

   1) all individual values of the coefficient of thermal expansion in each temperature interval or at each temperature, mean value in the same temperature intervals or at the same temperatures.