

---

---

**Metallic and other inorganic  
coatings — Measurement of the linear  
thermal expansion coefficient of  
thermal barrier coatings**

*Revêtements métalliques et autres revêtements inorganiques —  
Mesure du coefficient de dilatation thermique linéaire des  
revêtements barrières thermiques*

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

ISO 22680:2020

<https://standards.iteh.ai/catalog/standards/sist/c9b6aa7f-ca69-4140-90de-5b4e53447929/iso-22680-2020>



**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

ISO 22680:2020

<https://standards.iteh.ai/catalog/standards/sist/c9b6aa7f-ca69-4140-90de-5b4e53447929/iso-22680-2020>



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2020

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

# Contents

	Page
Foreword.....	iv
Introduction.....	v
<b>1 Scope.....</b>	<b>1</b>
<b>2 Normative references.....</b>	<b>1</b>
<b>3 Terms and definitions.....</b>	<b>1</b>
<b>4 Principle.....</b>	<b>2</b>
<b>5 Apparatus for measuring the linear thermal expansion coefficient.....</b>	<b>3</b>
5.1 Apparatus.....	3
5.2 Supporting jig.....	4
<b>6 Specimen.....</b>	<b>4</b>
6.1 Test specimen.....	4
6.2 Reference specimen.....	5
<b>7 Measuring procedure.....</b>	<b>5</b>
<b>8 Test report.....</b>	<b>5</b>
<b>Annex A (informative) An example of the measurement of the linear thermal expansion coefficient of a TC.....</b>	<b>7</b>
<b>Bibliography.....</b>	<b>9</b>

**iTeh STANDARD PREVIEW**  
(standards.iteh.ai)

ISO 22680:2020

<https://standards.iteh.ai/catalog/standards/sist/c9b6aa7f-ca69-4140-90de-5b4e53447929/iso-22680-2020>

## 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](http://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](http://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](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*.

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](http://www.iso.org/members.html).

## Introduction

Thermal barrier coatings are highly advanced material systems, generally applied to surfaces of hot-section components made of nickel or cobalt-based superalloys, such as combustors, blades and vanes of power-generation gas turbines in thermal power plants and aero-engines operated at elevated temperatures.

The function of these coatings is to protect metallic components for extended periods at elevated temperatures by employing thermally insulating materials that can sustain an appreciable temperature difference between load bearing alloys and coating surfaces. These coatings permit the high-temperature operation by shielding these components, thereby extending their lives.

Although the linear thermal expansion coefficient is an important property of thermal barrier coatings, the existing International Standard (e.g. ISO 17562) describes only a method for measuring this parameter for monolithic ceramics.

This document specifies a method for measuring the linear thermal expansion coefficient of the ceramic top coat for thermal barrier coating.

## iTeh STANDARD PREVIEW (standards.iteh.ai)

ISO 22680:2020

<https://standards.iteh.ai/catalog/standards/sist/c9b6aa7f-ca69-4140-90de-5b4e53447929/iso-22680-2020>

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

ISO 22680:2020

<https://standards.iteh.ai/catalog/standards/sist/c9b6aa7f-ca69-4140-90de-5b4e53447929/iso-22680-2020>

# Metallic and other inorganic coatings — Measurement of the linear thermal expansion coefficient of thermal barrier coatings

## 1 Scope

This document specifies a method for measuring the reproducible linear thermal expansion coefficient of ceramic top coats (TCs) for thermal barrier coatings (TBCs) up to 1 300 °C.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3611, *Geometrical product specifications (GPS) — Dimensional measuring equipment: Micrometers for external measurements — Design and metrological characteristics*

ISO 17139, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Thermophysical properties of ceramic composites — Determination of thermal expansion*

ISO 17562, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for linear thermal expansion of monolithic ceramics by push-rod technique*

ISO 22680:2020

## 3 Terms and definitions

<https://standards.iteh.ai/catalog/standards/sist/c9b6aa7f-ca69-4140-90de-5b4e53447929/iso-22680-2020>

For the purposes of this document, the terms and definitions given in ISO 17139 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

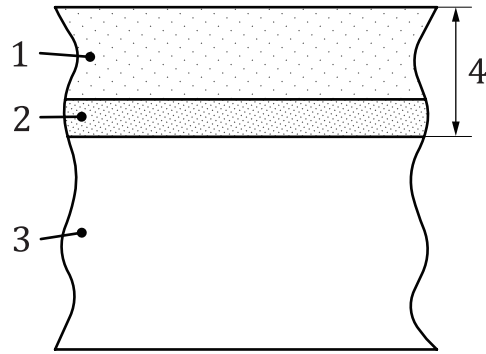
### 3.1

#### thermal barrier coating

#### TBC

two-layer coating consisting of a metallic bond coat (BC) and a ceramic top coat (TC), in order to reduce heat transfer from outside the top coat through the coating to the substrate

Note 1 to entry: See [Figure 1](#).



**Key**

- |   |                |   |                               |
|---|----------------|---|-------------------------------|
| 1 | top coat (TC)  | 3 | substrate                     |
| 2 | bond coat (BC) | 4 | thermal barrier coating (TBC) |

**Figure 1 — Diagrammatic view of a section of a TBC**

[SOURCE: ISO 14188:2012, 3.1, modified — “ceramic top coat” has replaced “oxide top coat”, “substrate” has replaced “base material”, and a different note to entry and figure has been used.]

**3.2 mean linear thermal expansion coefficient**

$\alpha(T)$   
linear thermal expansion between temperatures  $T_1$  and  $T_2$  divided by the temperature increment from  $T_1$  to  $T_2$  and the length at room temperature  $T_0$ , as shown by the formula:

$$\alpha(T) = \frac{L(T_2) - L(T_1)}{L(T_0)} \times \frac{1}{(T_2 - T_1)}$$

ISO 22680:2020  
https://standards.iteh.ai/catalog/standards/sist/c9b6aa7f-ca69-4140-90de-5b4e53447929/iso-22680-2020

where

$$T = \frac{T_2 + T_1}{2};$$

$L(T_0)$  is the initial length of the specimen at room temperature;

$L(T_1)$  is the length of the specimen at temperature  $T_1$ ;

$L(T_2)$  is the length of the specimen at temperature  $T_2$ .

**4 Principle**

Ceramic TCs exhibit an unstable linear thermal expansion coefficient during the initial few heating cycles, as shown in [Annex A](#). Therefore, the measurement shall be repeated until the reproducible linear thermal expansion coefficient is obtained. The fundamental procedures are shown in [Figure 2](#). A specimen of a TC, prepared as described in [Clause 6](#), that constitutes a TBC is heated to a specified temperature at a controlled heating rate. During the heating, the linear thermal expansion coefficients of the specimen are measured based on the change of the length and the temperature of the specimen. The measurement shall be repeated until the criterion to finish the measurement mentioned in [Clause 7](#) is satisfied.



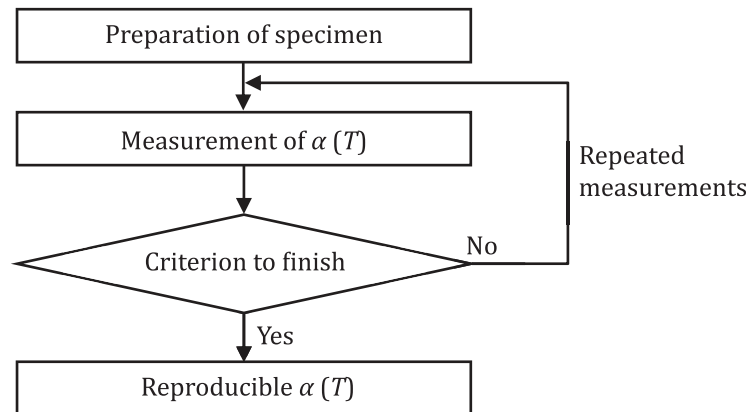
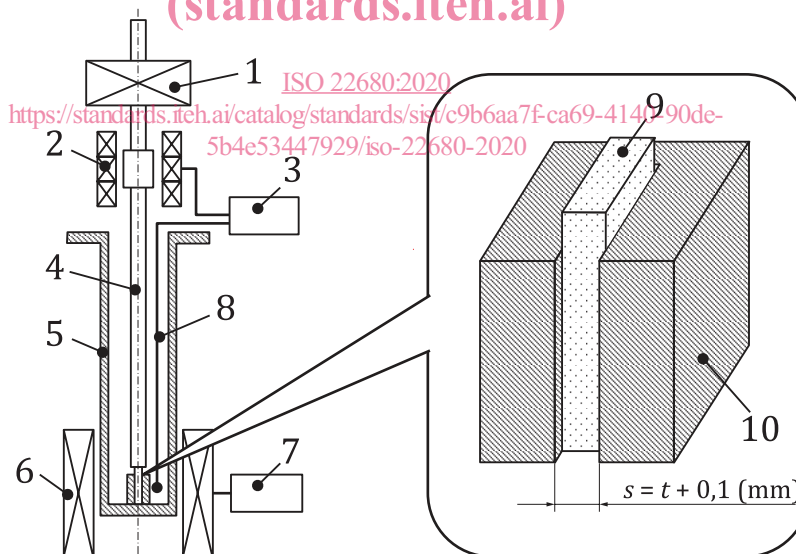


Figure 2 — Fundamental procedures for determining the linear thermal expansion coefficient

## 5 Apparatus for measuring the linear thermal expansion coefficient

### 5.1 Apparatus

An example of the apparatus for measuring the linear thermal expansion coefficient is schematically shown in Figure 3. The apparatus shall be specified in accordance with ISO 17139 and shall be calibrated using the reference specimen (see 6.2). Care shall be taken to ensure that the thermocouple tip is in close proximity to the specimen in accordance with ISO 17562.



#### Key

- |   |                          |          |                        |
|---|--------------------------|----------|------------------------|
| 1 | load controlling device  | 7        | temperature controller |
| 2 | differential transformer | 8        | thermocouple           |
| 3 | recorder                 | 9        | specimen               |
| 4 | push rod                 | 10       | supporting jig         |
| 5 | specimen holder          | <i>s</i> | width of slit          |
| 6 | furnace                  | <i>t</i> | thickness of specimen  |

Figure 3 — Typical apparatus for measuring the linear thermal expansion coefficient