



JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS H 8453 : 2018

(OSTEC/JSA)

**Measurement method for thermal
conductivity of thermal barrier
coatings**

ICS 25.220.20;25.220.40;27.040

Reference number : **JIS H 8453 : 2018 (E)**

PROTECTED BY COPYRIGHT

Date of Establishment: 2010-11-22

Date of Revision: 2018-02-20

Date of Public Notice in Official Gazette: 2018-02-20

Investigated by: Japanese Industrial Standards Committee
Standards Board for ISO area
Technical Committee on Metal and Inorganic
Materials

JIS H 8453:2018, First English edition published in 2018-06

Translated and published by: Japanese Standards Association
Mita MT Building, 3-13-12, Mita, Minato-ku, Tokyo, 108-0073 JAPAN

In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

© JSA 2018

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

PROTECTED BY COPYRIGHT

Contents

	Page
Introduction	1
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Principle	4
5 Apparatus for measuring thermal diffusivity	4
6 Specimen	5
6.1 Shape and dimensions	5
6.2 Surface treatment	6
7 Measuring procedure	6
7.1 Specimen thickness	6
7.2 Thermal diffusivity	7
7.3 Specific heat capacity	10
7.4 Bulk density	10
8 Calculation of thermal conductivities of BC and TC, and apparent thermal conductivity of TBC	11
8.1 Calculation of thermal conductivities of BC and TC	11
8.2 Calculation of apparent thermal conductivity of TBC	11
9 Report	11
9.1 Items to be reported	11
9.2 Additional items to be selected for the report	12
Annex A (normative) Areal heat diffusion time method	13
Annex B (informative) Examples of theoretical temperature-rise curves	15
Bibliography	18
Annex JA (informative) Comparison table between JIS and corresponding International Standard	19

Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Foundation of Osaka Science & Technology Center (OSTEC)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14. Consequently **JIS H 8453:2010** is replaced with this Standard.

This **JIS** document is protected by the Copyright Law.

Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, applications for a patent after opening to the public or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, applications for a patent after opening to the public or utility model rights.

Measurement method for thermal conductivity of thermal barrier coatings

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 18555:2016**, Edition 1, with some modifications of the technical contents.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JA.

1 Scope

This Standard specifies the method for determining the thermal conductivities of thermal barrier coatings that consist of metallic bond coats and ceramic top coats, in a direction normal to the coating surface, at room temperature. This Standard is applicable to thermal barrier coatings that are mainly used for high-temperature components of a gas turbine.

NOTE The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 18555:2016 *Metallic and other inorganic coatings—Determination of thermal conductivity of thermal barrier coatings* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are **IDT** (identical), **MOD** (modified), and **NEQ** (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 7502 *Micrometers*

JIS B 7507 *Vernier, dial and digital callipers*

JIS H 7801 *Method for measuring thermal diffusivity of metals by the laser flash method*

JIS H 8401 *Methods of thickness measurement for sprayed coatings*

JIS R 1611 *Measurement methods of thermal diffusivity, specific heat capacity, and thermal conductivity for fine ceramics by flash method*

JIS R 1672 *Determination of specific heat of fiber-reinforced ceramics composite by differential scanning calorimetry methods*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS R 1611**, and the following apply.

3.1

thermal barrier coating (TBC)

two-layer coating consisting of a metallic bond coat (BC) and a ceramic top coat (TC) of high melting point and low thermal conductivity, in order to reduce transfer of heat of combustion gas to the substrate which constitutes a high-temperature component (see Figure 1)

A specimen prepared by applying BC to a substrate is hereafter referred to as BC specimen, and a specimen prepared by applying TBC to a substrate as TBC specimen.

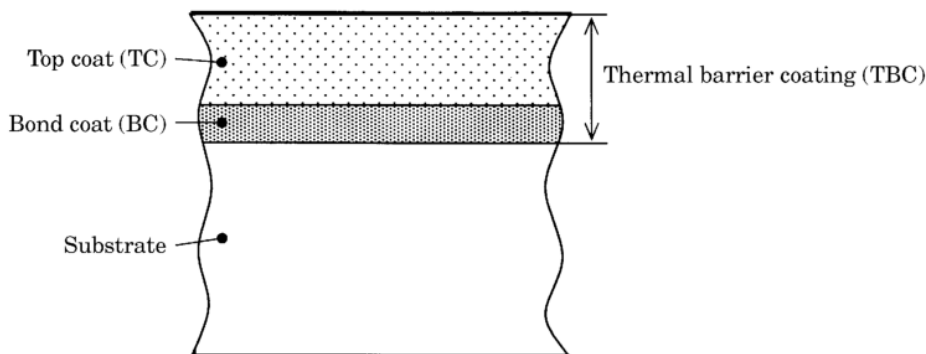


Figure 1 Diagrammatic view of a section of TBC

3.2

apparent thermal diffusivity, α_{app}

thermal diffusivity (m^2/s) of the specimens and substrate with thermal barrier coating in a direction normal to the coating surface, when BC or TBC specimen is regarded as a single-layer specimen

3.3

normalized temperature rise, $T(t)/\Delta T$

value which is determined by dividing the difference between the temperature of the specimen rear surface after the pulse heating by flash method [1] and the temperature of the specimen rear surface before the pulse heating by the difference between the maximum temperature of the specimen rear surface and the temperature of the specimen rear surface before the pulse heating, expressed by the following (see Figure 2):

$$\frac{T(t)}{\Delta T} = \frac{T_1(t) - T_0}{T_{max} - T_0}$$

where, $T_1(t)$: temperature of specimen rear surface after pulse heating

t : time

T_0 : temperature of specimen rear surface before pulse heating

T_{max} : maximum temperature of specimen rear surface

3.4

temperature-rise curve

curve which shows the variation in the normalized temperature rise of the specimen rear surface with time [see the thick solid line in Figure 2 b)]

3.5

half rise-time, $t_{1/2}$

time (s) required for the normalized temperature rise to reach 0.5 in the temperature-rise curve shown in Figure 2 b)

3.6

areal heat diffusion time, A

area (=A) with time-dimension (s) which is bordered by the vertical axis at time 0 s, horizontal axis at maximum temperature rise 1.0, and the temperature-rise curve (thick solid curve), as shown in Figure 2 b)

3.7

heat diffusion time, τ_0

time period (s) beginning with pulse heating of the specimen front surface until time at which the specimen temperature becomes uniform, expressed by the following (for square plate specimens):

$$\tau_0 = \frac{d^2}{\alpha}$$

where, τ_0 : heat diffusion time (s)
 d : thickness of specimen (m)
 α : thermal diffusivity (m²/s)

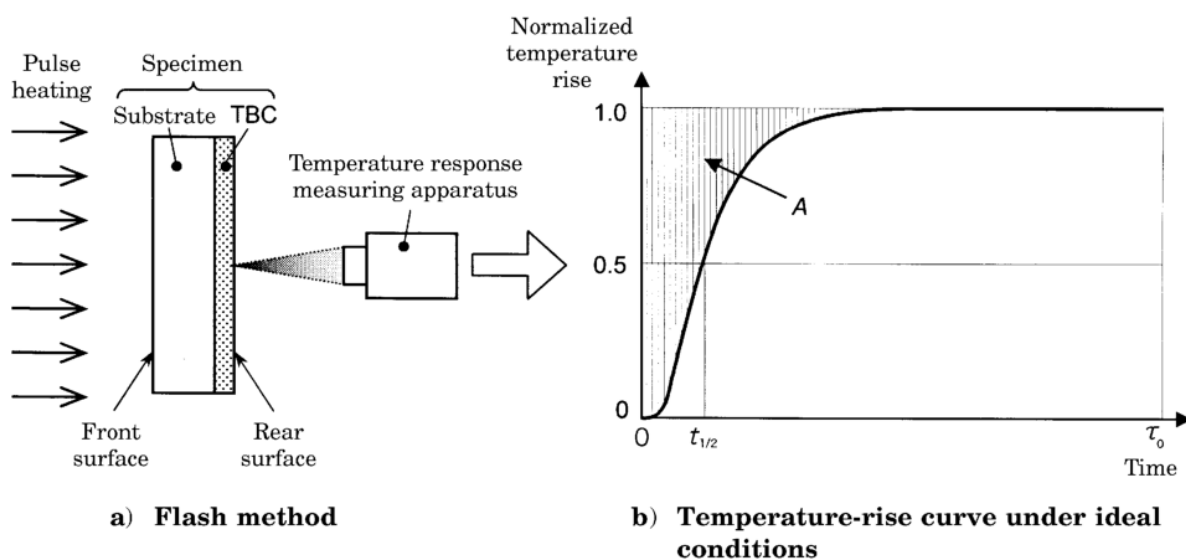


Figure 2 Flash method and temperature-rise curve

3.8

apparent thermal conductivity of TBC, λ_{TBC}

thermal conductivity of TBC specimen in a direction normal to the coating surface of TBC [W/(m·K)]

4 Principle

Thermal conductivities of the substrate, BC, and TC are determined according to calculations using the thermal diffusivities, specific heat capacities and bulk densities. The fundamental procedures are shown in Figure 3.

The fundamental procedures for determining the thermal diffusivities of the substrate, BC, and TC consist of the measurement of temperature-rise curves of three types of specimens (substrate, BC specimen, and TBC specimen) by a flash method, and of calculations. The thermal diffusivities of the BC and TC are obtained by applying a multi-layer analytical model to the temperature-rise curves.

The specific heat capacities of the substrate, BC, and TC are determined according to the differential scanning calorimetry method specified in **JIS R 1672**. The bulk densities of the substrate, BC, and TC are determined from the mass and volume of the specimen.

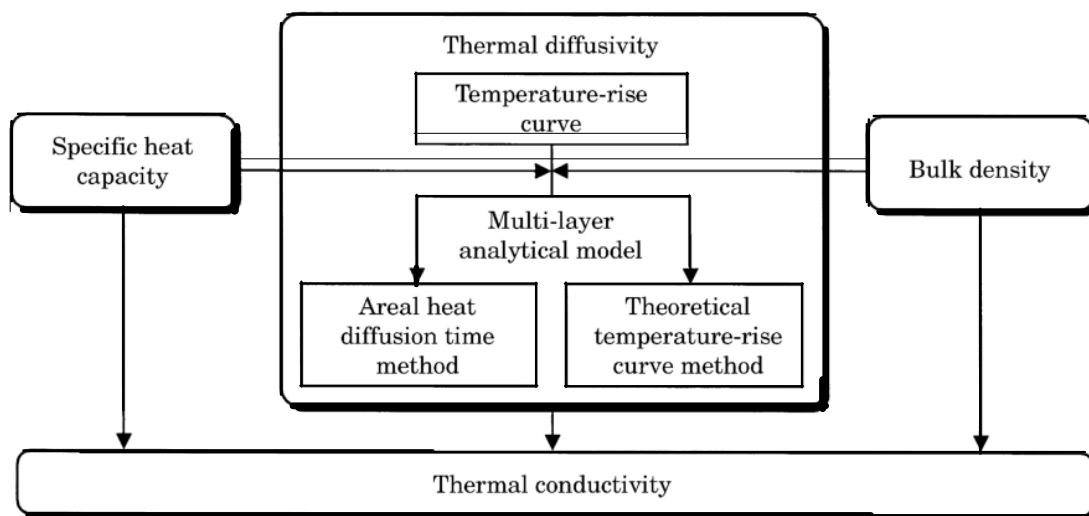


Figure 3 Fundamental procedures for determining thermal conductivity

5 Apparatus for measuring thermal diffusivity

An example of the apparatus for measuring the thermal diffusivity by the flash method is schematically shown in Figure 4.

The apparatus consists of the following: pulse heating light source, data recorder, measuring circuit, temperature response measuring apparatus, specimen holder, chamber, contact thermometer, and temperature indicator. The apparatus shall be specified according to **JIS R 1611** and should be calibrated using reference data and reference materials in reference to Annex E of **JIS R 1611**.