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**Test method for long term change in
apparent thermal conductivity of vacuum
insulation panels for buildings**

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Foreword

This Japanese Industrial Standard has been established by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Act.

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Test method for long term change in apparent thermal conductivity of vacuum insulation panels for buildings

1 Scope

This Japanese Industrial Standard specifies the method for testing in a laboratory the long term change in apparent thermal conductivity of the vacuum insulation panels (VIPs) for buildings comprising silica particles and glass wool cores.

The method covered by this Standard considers only the permeation of water vapour and dry air from surroundings as parameters affecting the long term change in apparent thermal conductivity, and no other parameters.

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 A 0202 *Thermal insulation — Vocabulary*

JIS A 1487 *Test method of thermal transmission properties for vacuum insulated building components*

JIS A 9529 *Vacuum insulation panels for buildings*

JIS Z 8126-1 *Vacuum technology — Vocabulary — Part 1 : General terms*

JIS Z 8126-2 *Vacuum technology — Vocabulary — Part 2 : Vacuum pumps and related terms*

JIS Z 8126-3 *Vacuum technology — Vocabulary — Part 3 : Vacuum gauges and related terms*

3 Terms and definitions, and symbols and units

For the purpose of this Standard, the terms and definitions given in JIS A 0202, JIS A 1487, JIS A 9529 and JIS Z 8126-1 to JIS Z 8126-3 and the following apply.

3.1 Terms and definitions

3.1.1

long term performance

predicted thermal performance values of VIP when it is integrated into a building component and continuously used under given external and internal conditions

NOTE In this Standard, external and internal conditions are set to be 25 years of continuous use in an environment at a temperature of 23 °C and a relative humidity of 50 % (standard condition), and the average of the apparent thermal conductivity during this period is calculated as the long

term performance of the VIP.

3.1.2

deactivation

state in which the amount of adsorption of an adsorbent is saturated

3.2 Symbols and units

Symbols and units shall be as given in Table 1. Subscripts of symbols shall be as given in Table 2.

Table 1 Symbols

Symbol	Definition	Unit
A	area	m^2
d	thickness	m
f	acceleration factor	—
K	permeability per unit surface area of envelope	$\text{g}/(\text{m}^2 \cdot \text{day} \cdot \text{Pa})$
m	mass	g
m'	mass change rate ^{a)}	g/day
P	permeability of envelope	$\text{g}/(\text{day} \cdot \text{Pa})$
p	pressure	Pa
p'	internal pressure change rate ^{a)}	Pa/day
R	thermal resistance	$\text{m}^2 \cdot \text{K}/\text{W}$
T	absolute temperature	K
t	time	day
V	volume	m^3
X	water content in mass	%
λ	apparent thermal conductivity	$\text{W}/(\text{m} \cdot \text{K})$
λ'	change rate of apparent thermal conductivity ^{a)}	$\text{W}/(\text{m} \cdot \text{K} \cdot \text{day})$
Φ	relative humidity	%
Ψ	permeability per unit length of envelope edge seal layer	$\text{g}/(\text{m} \cdot \text{day} \cdot \text{Pa})$
Δp	change of internal pressure	Pa
ΔX	change of water content in mass	%
$\Delta \lambda$	change of apparent thermal conductivity	$\text{W}/(\text{m} \cdot \text{K})$
$\Delta \phi$	change of relative humidity	%
Note ^{a)} For symbols used in this Standard, an apostrophe (') means rate of change (amount of change per unit time), and delta (Δ) means difference (amount of change).		

Table 2 Subscripts

Subscript	Definition
A	surface area
acc	accelerated condition
aged	average during the service life time
air	dry air
AL	aluminium foil laminated film

Table 2 Subscripts (concluded)

Subscript	Definition
COP	centre of panel
D	product
des	desiccant
env	envelope
es	edge seal
gett	getter
ini	initial
l	length
p	change of internal pressure caused by dry air
s	service life time
sat	saturation
sp	specimen
std	standard condition (temperature 23 °C, relative humidity 50 %)
sur	surface
t	change over time
VM	metalized film
v	water vapour
0	internal pressure 0Pa

4 Calculation of long term performance

4.1 General

This subclause specifies the method for estimating the long term change of apparent thermal conductivity at the centre of panel (COP) of a VIP and that of a whole VIP based on an assumed service life time of the VIP.

4.2 COP

The average of change of apparent thermal conductivity at the COP during the service life time shall be calculated as specified in Clause 5 or Clause 6, and using the result, the average of the apparent thermal conductivity and the thermal resistance at the COP during the service life time shall be obtained according to Formula (1) and Formula (2) :

$$\lambda_{\text{COP,aged}} = \lambda_{\text{COP}} + \Delta\lambda_{\text{COP,aged}} \quad \dots\dots\dots(1)$$

where, $\lambda_{\text{COP,aged}}$: average of apparent thermal conductivity at COP during service life time [W/(m·K)]

λ_{COP} : initial apparent thermal conductivity at COP [W/(m·K)] (see **JIS A 9529**)

$\Delta\lambda_{\text{COP,aged}}$: average of change of apparent thermal conductivity at COP during service life time [W/(m·K)]

$$R_{\text{COP,aged}} = \frac{d_N}{\lambda_{\text{COP,aged}}} \quad \dots\dots\dots(2)$$

where, $R_{\text{COP,aged}}$: average of thermal resistance at COP during service life time [(m²·K)/W]
 d_N : nominal thickness of product (m)

4.3 Product

The average of the apparent thermal conductivity and the thermal resistance of a product during the service life time shall be calculated according to Formula (3) and Formula (4) using $\Delta\lambda_{\text{COP,aged}}$ obtained according to Formula (1) :

$$\lambda_{\text{aged}} = \lambda + \Delta\lambda_{\text{COP,aged}} \dots\dots\dots(3)$$

where, λ_{aged} : average of apparent thermal conductivity of product during service life time [W/(m·K)]
 λ : initial apparent thermal conductivity of product [W/(m·K)]

$$R_{\text{aged}} = \frac{d_N}{\lambda_{\text{aged}}} \dots\dots\dots(4)$$

where, R_{aged} : average of apparent thermal resistance of product during service life time [(m²·K)/W]
 λ_{aged} : average of apparent thermal conductivity of product during service life time [W/(m·K)]

4.4 Rounding of numbers

The average of the apparent thermal conductivity at the COP during the service life time under the standard condition shall be expressed by rounding to three decimal places. The average of the thermal resistance at the COP during the service life time under the standard condition shall be expressed by rounding to one decimal place.

5 Long term performance of glass wool core VIPs

5.1 General

The change of apparent thermal conductivity at the COP of a specimen shall be measured under the standard condition or under the accelerated condition, and the average of the apparent thermal conductivity at the COP during the service life time (for example, 25 years) under the standard condition shall be obtained by calculation.

The flow chart for estimating the long term performance is shown in Annex A. The adsorption properties of an adsorbent shall be verified as specified in Annex E.

5.2 Specimen

The specimen shall be (300 ± 5) mm × (300 ± 5) mm in size and have a thickness equal to the product thickness. Three such specimens shall be used for each condition. In consideration of possible breakage of the envelope during the test, a maximum of one spare specimen may be measured at the same time so that, should the envelope of the specimen break, the test can be continued with the spare specimen.

5.3 Test procedure

5.3.1 General

The long term performance test of a glass wool core VIP shall be carried out according to Procedure A or Procedure B, the former being intended for products not containing a getter and the latter, for those containing a getter.

5.3.2 Procedure A (for products not containing a getter)

5.3.2.1 Test of change of apparent thermal conductivity at COP under the standard condition or accelerated condition

The test procedure for the apparent thermal conductivity at the COP under the standard condition or the accelerated condition shall be as follows.

- a) The initial apparent thermal conductivity λ_{ini} at the COP of each specimen shall be measured as specified in 8.2 of JIS A 9529.

The apparent thermal conductivity at the COP may be rounded to five decimal places, in which case, however, the value of the fifth decimal place shall be taken as being informative.

- b) The specimen shall be conditioned under any of the conditions given in Table 3 for a period of 180 days $\pm$ 5 days. The absolute humidity for the accelerated condition shall be about 8.7 g/kg.

Table 3 Conditions for specimen conditioning

Condition ^{a)}	Temperature
Standard	23 °C
Accelerated 1	40 °C, 45 °C and 50 °C
Accelerated 2	40 °C, 60 °C and 80 °C
In the case of products using an aluminium foil laminated film or a metalized film composed of polyethylene terephthalate (PET), Accelerated condition 2 should be selected.	
Notes ^{a)} For products using a metalized film composed of ethylene vinyl alcohol copolymer (EVOH) resin, one of the following conditions shall be selected :	
a) Standard;	
b) Standard and Accelerated 1;	
c) Standard and Accelerated 2.	

- c) At the start of storage after 30 days, 60 days, 90 days, 120 days, 150 days and 180 days during the conditioning period, the apparent thermal conductivity at the COP shall be measured as specified in 8.2.2 of JIS A 9529. Up to 5 days of deviation from the above measurement days, plus or minus, is permissible. When the change of internal pressure for 180 days is 30 Pa or less, measurement shall be continued until it exceeds 30 Pa. It is permissible to perform six measurements or more at such intervals as generating internal pressure change of 5 Pa or more. The change of internal pressure between two measurement points shall not exceed 100 Pa. Example of measurement result (average of three specimens) is shown in Figure 1.

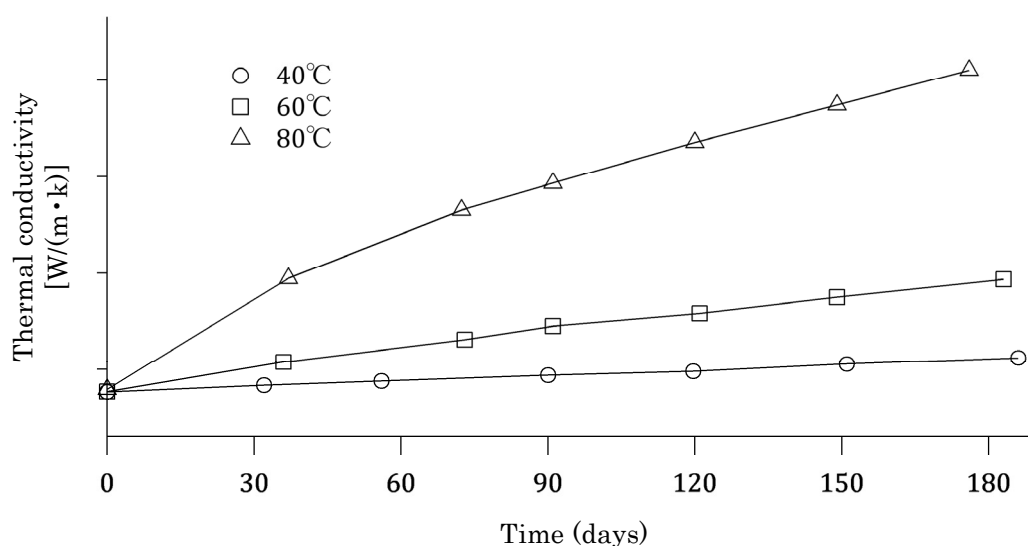


Figure 1 Thermal conductivity measurement result of specimen under accelerated condition (example)

5.3.2.2 Calculation of internal pressure change rate and dry air permeability of specimen under the standard condition

The calculation procedure of the internal pressure change rate and dry air permeability of a specimen under the standard condition shall be as follows.

- a) The internal pressure shall be obtained according to Formula (5) using the measurement result of the apparent thermal conductivity at the COP (average of three specimens) under the standard condition or accelerated condition, and linear approximation shall be performed by the least-squares method and a regression equation shall be obtained.

$$p_{\text{air}} = \frac{\lambda(p) - \lambda_0}{\lambda_{\text{air}} - [\lambda(p) - \lambda_0]} \cdot p_h \quad \dots\dots\dots (5)$$

where, p_{air} : internal pressure of VIP (Pa)
 $\lambda(p)$: apparent thermal conductivity at COP [W/(m·K)]
 λ_0 : apparent thermal conductivity at COP at an internal pressure of 0 Pa [W/(m·K)] (see Annex C)
 λ_{air} : thermal conductivity of dry air [= 0.026 W/(m·K)¹⁾]
 p_h : coefficient showing the relation between the internal pressure and apparent thermal conductivity at COP (Pa) (see Annex C)

Note ¹⁾ Value at which dry air stands still at room temperature.

- b) The gradient of the regression equation obtained in a) shall be taken as the internal pressure change rate ($\Delta p_{\text{air}}/\Delta t = p'_{\text{t,air}}$). An example of the calculation result is shown in Figure 2.

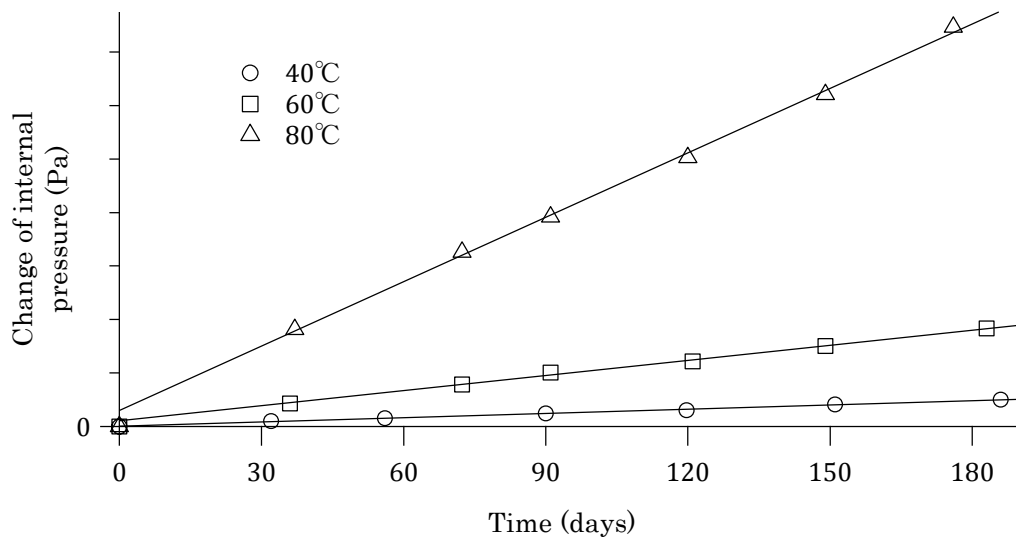


Figure 2 Calculation result of internal pressure of specimen under accelerated condition (example)

- c) When the measurement is performed under Accelerated condition 1 or Accelerated condition 2, the internal pressure change rate under the accelerated condition shall be plotted on a single logarithmic chart as shown in Figure 3, and a regression equation shall be obtained by linear approximation by the least-squares method. Based on the regression equation, the internal pressure change rate under the standard condition shall be obtained by extrapolation. For products using films composed of EVOH base material, however, it shall be confirmed that the difference between the internal pressure change rate under the standard condition obtained from the regression equation and the internal pressure change rate obtained from the change of apparent thermal conductivity at the COP under the standard condition is within 10 %.

If this confirmation reveals a difference larger than 10 %, the result of the specimen conditioned under Accelerated condition 1 or under Accelerated condition 2 (see Table 3) shall not be used for calculation.