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**Acoustics—Measurement of sound
insulation in buildings and of building
elements using sound intensity—
Part 2: Field measurements**

ICS 91.120.20

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Land, Infrastructure and Transport through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from the Acoustical Society of Japan (ASJ)/Japanese Standards Association (JSA), with a draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

This Standard has been made based on **ISO 15186-2: 2003** *Acoustics—Measurement of sound insulation in buildings and of building elements using sound intensity—Part 2: Field measurements* for the purposes of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

JIS A 1441 consists of the following 2 parts under the general title “*Acoustics—Measurement of sound insulation in buildings and of building elements using sound intensity*”:

Part 1 : Laboratory measurements

Part 2 : Field measurements

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Acoustics—Measurement of sound insulation in buildings and of building elements using sound intensity—Part 2: Field measurements

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **ISO 15186-2** *Acoustics—Measurement of sound insulation in buildings and of building elements using sound intensity—Part 2: Field measurements* published in 2003 with some modifications of the technical contents.

The portions underlined with dots in this part of **JIS A 1441** are the matters different from the original International Standard. A list of modifications with the explanations is given in Annex 1 (informative).

1 Scope

1.1 General This part of **JIS A 1441** specifies a sound intensity method to determine the *in-situ* sound insulation of walls, floors, doors, windows and small building elements. This measurement method is equivalent to that specified in **JIS A 1417**. It is intended for measurements that have to be made in the presence of flanking transmission. It can be used to provide sound power data for diagnostic analysis of flanking transmission or to measure flanking sound insulation parameters.

This part of **JIS A 1441** can be used by laboratories that could not satisfy the requirements of **JIS A 1441-1**, which deals with laboratory measurements with no or little flanking transmission.

ISO 15186-3 deals with measurements under laboratory conditions, at low frequencies.

This part of **JIS A 1441** also describes the effect of flanking transmission on measurements made using the specified method, and how intensity measurements can be used

- to compare the *in-situ* sound insulation of a building element with laboratory measurements where flanking has been suppressed as specified in **JIS A 1416**,
- to rank the partial contributions for building elements,
- to measure the flanking sound reduction index for one or more transmission paths.

This method gives values for airborne sound insulation, which are frequency dependent. They can be converted into a single number, characterizing the acoustic performance, by application of **JIS A 1419-1**.

1.2 Precision The reproducibility of this intensity method is estimated to be equal to or better than that of the methods of **JIS A 1417** and **JIS A 1428**, when measuring a single small and large building element, respectively.

NOTES 1 If sound reduction measures made using this method are to be compared with those made using the conventional reverberation room method, then it will be necessary to introduce an adaptation term that reflects the bias between the test methods. This term is given in Annex A.

- 2 Some information about the accuracy for this part of **JIS A 1441** and its relationship to the sound reduction index measured according to **JIS A 1416** and **JIS A 1417** is given in Annex B.
- 3 Flanking transmission is discussed in Annex C.
- 4 The International Standard corresponding to this part of **JIS A 1441** is as follows.

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**.

ISO 15186-2:2003 *Acoustics—Measurement of sound insulation in buildings and of building elements using sound intensity—Part 2: Field measurements* (MOD)

2 Normative references The following standards contain provisions which, through reference in this text, constitute provisions of this part of **JIS A 1441**. If the indication of the year of coming into effect is given to these referred standards, only the edition of indicated year constitutes the provision of this part of **JIS A 1441** but the revision and amendment made thereafter do not apply. The normative references without the indication of the year of coming into effect apply only to the most recent editions (including amendments).

JIS A 1416 *Acoustics—Method for laboratory measurement of airborne sound insulation of building elements*

NOTE : **ISO 140-3** *Acoustics—Measurement of sound insulation in buildings and of building elements—Part 3: Laboratory measurements of airborne sound insulation of building elements* is equivalent to the said standard.

JIS A 1417 *Acoustics—Field measurement of airborne sound insulation of buildings*

NOTE : **ISO 140-4** *Acoustics—Measurement of sound insulation in buildings and of building elements—Part 4: Field measurements of airborne sound insulation between rooms* is equivalent to the said standard.

JIS A 1419-1 *Acoustics—Rating of sound insulation in buildings and of building elements—Part 1: Airborne sound insulation*

NOTE : **ISO 717-1** *Acoustics—Rating of sound insulation in buildings and of building elements—Part 1: Airborne sound insulation* is equivalent to the said standard.

JIS A 1428 *Laboratory measurement of airborne sound insulation of small building elements*

NOTE : ISO 140-10 *Acoustics—Measurement of sound insulation in buildings and of building elements—Part 10: Laboratory measurement of airborne sound insulation of small building elements* is equivalent to the said standard.

JIS A 1441-1 *Acoustics—Measurement of sound insulation in buildings and of building elements using sound intensity—Part 1: Laboratory measurements*

JIS C 1507 *Electroacoustics—Instruments for the measurement of sound intensity—Measurement with pairs of pressure sensing microphones*

NOTE : IEC 61043:1993 *Electroacoustics—Instruments for the measurement of sound intensity—Measurements with pairs of pressure sensing microphones* is identical with the said standard.

JIS C 1515 *Electroacoustics—Sound calibrators*

NOTE : IEC 60942 *Electroacoustics—Sound calibrators* is identical with the said standard.

JIS Z 8736-1:1999 *Acoustics—Determination of sound power levels of noise sources using sound intensity—Part 1: Measurement at discrete points*

3 Terms and definitions For the purposes of this part of JIS A 1441, the following terms and definitions apply.

The subscripts are defined in table 1.

NOTE : In this part of JIS A 1441, quantities that represent the average over the measurement surface are explicitly identified using a bar over the measured quantity. For example, $\bar{I}_n$ is the average normal intensity over the measurement surface, whereas the quantity, I_n , without the bar, is the normal intensity obtained at a single point on the measurement surface.

Information : The original International Standard explains the difference of quantity notation between ISO 15186-1 and ISO 15186-2. When we modified both standards, we unified the notation. So, in this part of JIS A 1441, we deleted the explanation of difference.

3.1 average sound pressure level in a source room L_{p1} ten times the logarithm to the base 10 of the ratio of the space and time average of the indoor sound pressure squared to the square of the reference sound pressure, the space average being taken over the entire room with the exception of those parts where the direct radiation of a sound source or the near field of the boundaries such as wall is of significant influence

NOTES 1 This quantity is given in decibels (dB).

2 See JIS A 1417 for more details.

3.2 apparent sound reduction index R' ten times the logarithm to the base 10 of the ratio of the sound power incident on the building element under test to the total sound power radiated into the receiving room by direct transmission and all flanking paths

NOTES 1 Unless special efforts have been made to suppress flanking transmission as specified in **JIS A 1416**, the measured sound power will contain a flanking component. Annex C provides more details.

2 The English expression of ONKYÔ TÔKA SONSITU in Japanese is “sound reduction index” in the corresponding International Standard to this part of **JIS A 1441**. But, the expression “sound transmission loss”, which is equivalent to the above term is also widely in use. ONKYÔ TÔKA SONSITU in Japanese is translation of the latter. The Japanese expression corresponding to the former is ONKYÔ GENSUI SIHYÔ.

3 See **JIS A 1417** for more details.

3.3 sound intensity $\bar{I}$ time-averaged rate of flow of sound energy per unit area oriented normal to the direction of the local particle velocity, which is a vector quantity as given the following equation

$$\bar{I} = \frac{1}{T} \int_{t_1}^{t_2} p(t) \cdot \vec{u}(t) \cdot dt \dots\dots\dots(1)$$

where, $p(t)$: the instantaneous sound pressure at a point (Pa);

$\vec{u}(t)$: the instantaneous particle velocity at the same point (m/s);

T : the integral averaging time starting at the time t_1 and ending at t_2 (s)

NOTE : This quantity is measured in watts per square metre.

3.4 normal sound intensity I_n component of the sound intensity (W/m²) in the direction normal to a measurement surface defined by the unit normal vector $\vec{n}$

$$I_n = \bar{I} \cdot \vec{n} \dots\dots\dots(2)$$

where, $\vec{n}$: the unit normal vector directed out of the volume enclosed by the measurement surface

3.5 normal sound intensity level L_{I_n} ten times the logarithm to the base 10 of the ratio of the unsigned value of the normal sound intensity to the reference intensity I_0 as given by the following equation

$$L_{I_n} = 10 \log_{10} \frac{|I_n|}{I_0} \dots\dots\dots(3)$$

where, I_0 : sound reference intensity (= 10⁻¹² W/m²)

3.6 surface pressure-intensity indicator F_{pI_n} difference between the sound pressure level, $\bar{L}_p$ and the normal sound intensity level, $\bar{L}_{I_n}$, on the measurement surface, both being time-and surface-averaged, given by the following equation

$$F_{pI_n} = \bar{L}_p - \bar{L}_{I_n} \dots\dots\dots(4)$$

where, $\bar{L}_p$: average sound pressure level given by Equation (5) (dB)

$\bar{L}_{I_n}$: average normal sound intensity level given by Equation (6) (dB)

$$\bar{L}_p = 10 \log_{10} \left(\frac{1}{S_M} \sum_{i=1}^N S_{M_i} 10^{0.1 \bar{L}_{pi}} \right) \dots\dots\dots (5)$$

$$\bar{L}_{I_n} = 10 \log_{10} \left| \frac{1}{S_M} \sum_{i=1}^N \frac{S_{M_i} \bar{I}_{ni}}{I_0} \right| \dots\dots\dots (6)$$

where, $\bar{L}_{pi}$: the time- and surface-averaged sound pressure level measured on the i th sub-area (dB)

$\bar{I}_{ni}$: the time- and surface-averaged signed normal intensity measured on the i th sub-area, and there are N sub-areas having a total area of S_M

$$S_M = \sum_{i=1}^N S_{M_i} \dots\dots\dots (7)$$

NOTE : In the limit of equal sub-areas, this indicator corresponds to the negative partial power indicator F_3 defined in **JIS Z 8736-1** and signed pressure-intensity indicator, F_{pI_n} , defined in **JIS Z 8736-3**.

3.7 pressure-residual intensity index δ_{pI0} difference between the indicated sound pressure level, L_p , and the indicated sound intensity level, L_I , when the intensity probe is placed and oriented in a sound field such that the sound intensity is zero, as given by the following equation

$$\delta_{pI0} = L_p - L_{I\delta} \dots\dots\dots (8)$$

where, $L_{I\delta}$: the level of the residual intensity and is given by Equation (9) (dB)

$$L_{I\delta} = 10 \log_{10} \frac{|I_\delta|}{I_0} \dots\dots\dots (9)$$

NOTE : This definition is consistent with that given in the **JIS Z 8736** series. Details for determining δ_{pI0} are given in **JIS C 1507**.

3.8 apparent intensity sound reduction index R'_I index for a building element that separates one source room and one receiving room (which also may be the outside), which is calculated from the normal sound intensity level, as given by the following equation

$$R'_I = \left[L_{p1} - 6 + 10 \log_{10} \left(\frac{S}{S_0} \right) \right] - \left[\bar{L}_{I_n} + 10 \log_{10} \left(\frac{S_M}{S_0} \right) \right] \dots\dots\dots (10)$$

where the first term relates to the incident sound power in the source room and the second term relates to the sound power radiated from the building element(s) contained within the measurement volume in the receiving room. The meaning of notations is as follows.

- L_{p1} : the average sound pressure level in the source room (dB)
- S : the area of the separating building element under test or, in the case of staggered or stepped rooms, that part of the area of walls or floors common to both the source and receiving rooms (m²)
- $\bar{L}_{I_n}$: the average normal sound intensity level over the measurement surface(s) in the receiving room (dB)
- S_M : the total area of the measurement surface(s) (m²)
- S_0 : the reference area (=1m²)

- NOTES 1 Where the intent is to assess the apparent sound reduction index due to all elements radiating sound into the receiving room, the contribution from this index R'_I may be combined with the intensity sound reduction index for each flanking element R_{IFj} (see 3.9), as described in Annex C.
- 2 The weighted apparent intensity sound reduction index, $R'_{I,w}$, is calculated according to **JIS A 1419-1** by replacing R' with R'_I .
- 3 This index R'_I differs fundamentally from the apparent sound reduction index R' of **JIS A 1417** where total sound power from all receiving sources is measured. The definition of apparent intensity sound reduction index allows directionality of the intensity probe to be used, to selectively measure the sound power from each receiving room surface as desired. In principle, by combining the sound power from all surfaces in the receiving room, an estimate of R' can be obtained; Annex C discusses this in more detail.

3.9 intensity sound reduction index for flanking element j R_{IFj} when a building element separates the source room from the receiving room, this index is calculated from the normal sound intensity level for the flanking surface j in the receiving room, as given by the following equation

$$R_{IFj} = \left[L_{p1} - 6 + 10 \log_{10} \left(\frac{S}{S_0} \right) \right] - \left[\bar{L}_{I_n j} + 10 \log_{10} \left(\frac{S_{Mj}}{S_0} \right) \right] \dots\dots\dots (11)$$

where the first term relates to the sound power incident on the separating element under test from the source room and the second term relates to the sound power radiated from the flanking surface j into the receiving room. The meaning of notations is as follows.

- L_{p1} : the average sound pressure level in the source room (dB)
- S : the area of the separating building element under test or, in the case of staggered or stepped rooms, that part of the area of walls or floors common to both the source and receiving rooms (m²)

$\bar{L}_{I_n j}$: the average normal sound intensity level over the measurement surface for the flanking element j in the receiving room (dB)

S_{Mj} : the total area of the measurement surface for the flanking element j in the receiving room (m²)

S_0 : the reference surface (= 1m²)

NOTE : Where the intent is to combine the effect of multiple elements radiating sound into the receiving room, the contribution from this index can be combined with the apparent intensity sound reduction index, R'_I for the separating element (see 3.8), as described in Annex C.

3.10 intensity element normalized level difference $D_{I,n,e}$ difference given by the following equation

$$D_{I,n,e} = [L_{p1} - 6] - \left[\bar{L}_{I_n} + 10 \log_{10} \left(\frac{S_M}{A_0} \right) \right] \dots\dots\dots (12)$$

where, L_{p1} : the average sound pressure level in the source room (dB)

$\bar{L}_{I_n}$: the average normal sound intensity level over the measurement surface in the receiving room (dB)

S_M : the total area of the measurement surface(s) (m²)

A_0 : the reference surface (=10 m²)

NOTES 1 The intensity element normalized level difference is used only for small building elements.

2 The weighted intensity element normalized level difference, $D_{I,n,e,w}$ is calculated according to JIS A 1419-1 by replacing $D_{n,e}$ with $D_{I,n,e}$.

3.11 intensity normalized level difference $D_{I,n}$ difference given by the following equation

$$D_{I,n} = [L_{p1} - 6] - \left[\bar{L}_{I_n} + 10 \log_{10} \left(\frac{S_M}{A_0} \right) \right] \dots\dots\dots (13)$$

where, L_{p1} : the average sound pressure level in the source room (dB)

$\bar{L}_{I_n}$: the average normal sound intensity level over the measurement surface in the receiving room (dB)

S_M : the total area of the measurement surface(s) (m²)

A_0 : the reference surface (=10 m²)

NOTES 1 This index is used when there is not a common building element separating the source room from the receiving room. Such a situation can occur when the rooms are diagonally separated.

- 2 The weighted intensity normalized level difference, $D_{I,n,w}$ is calculated according to **JIS A 1419-1** by replacing D_n with $D_{I,n}$.

3.12 modified apparent intensity sound reduction index $R'_{I,m}$ sound reduction index given by the following equation

$$R'_{I,m} = R'_I + K_C \quad \dots\dots\dots (14)$$

where the values of K_C are given in Annex A

- NOTES
- 1 It is generally recognized that there is a difference between the sound reduction index determined by the sound intensity method as specified in **JIS A 1441-1** and this part of **JIS A 1441** and that measured by traditional methods (specified in **JIS A 1416**, **JIS A 1417** and **JIS A 1428**) at low frequencies. In order to adjust this difference, add the adaptation term K_C to the measurement results of sound intensity method, and obtain the modified apparent intensity sound reduction index.
 - 2 The adaptation values K_C for *in-situ* measurements are consistent with K_C for measurements made in laboratories (as specified in **JIS A 1441-1**). It is recognized that receiving room conditions may introduce a further bias (see Annex B).
 - 3 The weighted modified apparent intensity sound reduction index, $R_{I,m,w}$ is calculated according to **JIS A 1419-1** by replacing R' with $R'_{I,m}$. Correspondingly the notation for $D_{I,n,e,m,w}$ is obtained.

3.13 measurement surface surface totally enclosing the building element under test on the receiving side, scanned or sampled by the probe during the measurements of the sound intensity

3.14 measurement distance d_M distance between the measurement surface and the building element under test in a direction normal to the element

3.15 measurement sub-area part of the measurement surface being measured with the intensity probe using one continuous scan. In the case of discrete position method, the discrete measurement positions are placed on the sub-area.

3.16 measurement volume volume bounded by the measurement surface(s), the building element under test, and any adjacent surfaces that do not radiate significant sound relative to the building element under test

NOTE : See 6.4.2.