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**Acoustics—Field measurements of
airborne sound insulation of facade
elements and facades**

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Land, Infrastructure, Transport and Tourism, through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law.

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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.

Acoustics—Field measurements of airborne sound insulation of facade elements and facades

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **ISO 140-5** published in 1998 with some modifications of the technical contents.

The portions with continuous sidelines or dotted underlines are the matters in which the corresponding International Standard have been modified. A list of modifications with explanations is given in Annex JD. In order to make the contents of measuring methods simple and understandable, the loudspeaker method is summarized in the text and the real noise methods are summarized in Annexes. The measuring method with the road traffic noise is given in Annex JA without modifying the corresponding International Standard. The measuring method of the sound insulation of facade where the test sound is incident on the surface of facade under measurement from indoor side is given in Annex JB. This method is not specified in the corresponding International Standard but shown as reference based on the fruits of research in Japan. The method to obtain the equivalent sound absorption area level by measuring the indoor average sound pressure level is given in Annex JC. This method is not specified in the corresponding International Standard but shown as reference based on the recent fruits of research in Japan.

1 Scope

This Standard specifies the element method and the global method for measurement of airborne sound insulation of the facade elements and the whole facades of the building. The element method aims to obtain the apparent sound reduction index of a facade element, for example a window. The global method aims to obtain the general level difference which responds to the incident condition of each noise source integrated into the whole room. The measuring method having high reproducibility in the element method is that using a loudspeaker as the sound source, and the measuring method having high realistic sound insulation in the global method is that using the actual traffic as the sound source. The overview of measuring methods is shown in table 1.

In the element loudspeaker method, the apparent sound reduction index comparable with the result measured in accordance with **JIS A 1416** can be obtained. The element road traffic noise method is useful when the element loudspeaker method cannot be used for some practical reasons, but it tends to result in lower values of the apparent sound reduction index than the loudspeaker method. When the loudspeaker cannot be set outside, the method in which the loudspeaker is set in a room (inside sound source method) to obtain the level difference is available for the same purpose as the element loudspeaker method as shown in Annex JB; however, the correspondence of both methods has yet to be verified.

The global road traffic noise method yields the sound pressure level difference between a certain indoor place and a position 2 m or 1 m in front of the facade, and is used to obtain the real sound insulation between inside and outside of the room. This

method is used when the sound insulation including the effect of other sound source to the room of interest or the effect of all flanking paths relative to nearby roads is measured.

The element road traffic noise method and the global road traffic noise method are given in Annex JA. The measuring methods using the aircraft traffic noise and the railway traffic noise are given in Annex D. The global loudspeaker method yields the sound pressure level difference between the position 2 m or 1 m in front of the facade and the indoor position, and this method is useful when the real noise source is not available. The results of these global methods cannot be compared with those obtained in accordance with **JIS A 1416**.

NOTE 1 The method for laboratory measurement of airborne sound insulation of building elements is specified in **JIS A 1416**.

NOTE 2 The method for field measurement of airborne sound insulation of wall between two rooms, floor, door, etc. in building is specified in **JIS A 1417**.

NOTE 3 The International Standard corresponding to this Standard is as follows.
ISO 140-5:1998 *Acoustics—Measurement of sound insulation in buildings and of building elements—Part 5: Field measurements of airborne sound insulation of façade elements and façades* (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**.

Table 1 Overview and type of measuring method

No.	Measuring method	Clause to be referred	Quantifier of result	Field of application
Element method (facade elements of interest)				
1	Element loudspeaker method	Clause 5	R'_{45°	Preferred method to estimate the apparent sound reduction index of facade elements
2	Element road traffic noise method	Annex JA (normative)	$R'_{tr,s}$	Alternative to No. 1 when road traffic noise of sufficient level is available
3	Element railway traffic noise method	Annex D (informative)	$R'_{rt,s}$	Alternative to No. 1 when railway traffic noise of sufficient level is available
4	Element aircraft traffic noise method	Annex D (informative)	$R'_{at,s}$	Alternative to No. 1 when aircraft traffic noise of sufficient level is available
Global method (whole facades of interest)				
5	Global loudspeaker method	Clause 5	$\underline{D}_{ls,2m}$ $\underline{D}_{ls,1m}$ $\underline{D}_{ls,2m,nT}$ $\underline{D}_{ls,1m,nT}$ $\underline{D}_{ls,2m,n}$ $\underline{D}_{ls,1,n}$	Alternative to No. 6, No. 7 and No. 8

Table 1 (concluded)

No.	Measuring method	Clause to be referred	Quantifier of result	Field of application
6	Global road traffic noise method	Annex JA (normative)	$D_{tr,2m}$ $D_{tr,1m}$ $D_{tr,2m,nT}$ $D_{tr,1m,nT}$ $D_{tr,2m,n}$ $D_{tr,1,n}$	Preferred method to estimate the global sound insulation of a facade exposed to road traffic noise
7	Global railway traffic noise method	Annex D (informative)	$D_{rt,E2m}$ $D_{rt,E1m}$ $D_{rt,E2m,nT}$ $D_{rt,E1m,nT}$ $D_{rt,E2m,n}$ $D_{rt,E1m,n}$	Preferred method to estimate the global sound insulation of a facade exposed to railway traffic noise
8	Global aircraft traffic noise method	Annex D (informative)	$D_{at,E2m}$ $D_{at,E1m}$ $D_{at,E2m,nT}$ $D_{at,E1m,nT}$ $D_{at,E2m,n}$ $D_{at,E1,n}$	Preferred method to estimate the global sound insulation of a facade exposed to aircraft traffic noise
9	Indoor sound source method	Annex JB (informative)	D_{ps}	Alternative to method No. 5 when outdoor loudspeaker cannot be used

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For the standards with the indication of year, only the edition of the indicated year shall be applied but not any revisions made thereafter (including amendments). For those with no indication of year, the most recent edition (including amendments) shall be applied.

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

NOTE : Corresponding International Standard: ISO 140-3:1995 *Acoustics—Measurement of sound insulation in buildings and of building elements—Part 3: Laboratory measurements of airborne sound insulation of building elements* (MOD)

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

NOTE : Corresponding International Standard: ISO 717-1:1996 *Acoustics—Rating of sound insulation in buildings and of building elements—Part 1: Airborne sound insulation* (MOD)

JIS C 1509-1 *Electroacoustics—Sound level meters—Part 1: Specifications*

NOTE : Corresponding International Standard: IEC 61672-1 *Electroacoustics—Sound level meters—Part 1: Specifications* (IDT)

JIS C 1514 *Electroacoustics—Octave-band and fractional-octave-band filters*

NOTE : Corresponding International Standard: IEC 61260:1995 *Electroacoustics—Octave-band and fractional-octave-band filters* (IDT)

JIS C 1515 *Electroacoustics—Sound calibrators*

NOTE : Corresponding International Standard: IEC 60942 *Electroacoustics—Sound calibrators* (IDT)

JIS Z 8401 *Guide to the rounding of numbers*

ISO 140-2:1991 *Acoustics—Measurement of sound insulation in buildings and of building elements—Part 2: Determination, verification and application of precision data*

ISO 3382:1997 *Acoustics—Measurement of the reverberation time of rooms with reference to other acoustical parameters*

ISO 5725-1:1994 *Accuracy (trueness and precision) of measuring methods and results—Part 1: General principles and definitions*

3 Terms and definitions

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

3.1 average sound pressure level on a test surface $L_{1,s}$

ten times the common logarithm of the ratio of the surface and time average of the sound pressure squared on the surface of facade element of interest to the square of the reference sound pressure [unit: decibel (dB)]

The averaging on the surface of facade element is taken over the entire test surface including reflecting effects from the facade element.

3.2 average sound pressure level in a room L_2

ten times the common logarithm of the ratio of the space and time average of the sound pressure squared in the room of interest to the square of the reference sound pressure [unit: decibel (dB)]

The averaging in the space is taken over the entire room with the exception of the direct radiation part near a sound source and the near field of the room boundary such as wall and window.

3.3 equivalent continuous sound pressure level L_{eq}

value of the sound pressure level of a continuous steady sound that, within the measurement time interval, has the same average sound pressure squared as the sound pressure level that varies with time [unit: decibel (dB)]

3.4 sound reduction index R

ten times the common logarithm of the ratio of the sound power (W_1) incident on the specimen to the sound power (W_2) transmitted through the specimen, and given by the equation (1) [unit: decibel (dB)]

$$R = 10 \log_{10} \frac{W_1}{W_2} \dots\dots\dots (1)$$

NOTE : For the definition of amount herein, “sound reduction index” is used in the corresponding International Standard, on the other hand, “sound transmission loss” is also widely used in general. “ONKYÔ TÔKA SONSITU” widely used in Japan corresponds to “sound transmission loss” and “ONKYÔ GENSUI SIHYÔ” corresponds to “sound reduction index”.

3.5 apparent sound reduction index R'

ten times the common logarithm of the ratio of the sound power (W_1) incident on the facade element of interest to the total transmitted sound power ($W_2 + W_3$) if the effect of transmitted sound power (W_3) by flanking propagation or others in addition to the transmitted sound power (W_2) through the facade element under measurement is significant, and given by equation (2) [unit: decibel (dB)]

$$R' = 10 \log_{10} \left(\frac{W_1}{W_2 + W_3} \right) \dots\dots\dots (2)$$

3.6 apparent sound reduction index, 45° incidence R'_{45°

measured amount of the airborne sound insulation of a facade element when the sound source is a loudspeaker and when the angle of sound incidence, which is the angle between the centre axis of loudspeaker directed towards the centre of the facade element and the direction vertical to the surface of facade element, is 45° , and given by equation (3) [unit: decibel (dB)]

$$R'_{45^\circ} = L_{1,s} - L_2 + 10 \log_{10} \left(\frac{S}{A} \right) - 1.5 \dots\dots\dots (3)$$

where, $L_{1,s}$: average sound pressure level on the test surface of the facade element outside (dB)

L_2 : average sound pressure level in a room in the receiving room (dB)

S : sound incident area of the facade element given in Annex A (m^2)

A : equivalent sound absorption area in the receiving room (m^2)

NOTE : Equation (3) is based on the assumption that the sound is incident from one angle only (45°), the outside surface of facade element is perfectly reflection and the sound field in the receiving room is perfectly diffuse.

3.7 level difference $D_{ls,2m}$

difference between the outdoor average sound pressure level at the position 2 m vertically outside the facade element surface $L_{1,2m}$ and the average sound pressure level in the receiving room L_2 , and given by equation (4) [unit: decibel (dB)]

$$D_{ls,2m} = L_{1,2m} - L_2 \dots\dots\dots (4)$$

NOTE : When the outdoor sound pressure level at the position 1 m vertically outside the surface of facade element $L_{1,1m}$ is used, the level difference is denoted as $D_{ls,1m}$.

3.8 standardized level difference $D_{ls,2m,nT}$

value obtained by adding the level difference to ten times the common logarithm of the ratio of the reverberation time (T) in the receiving room to the reference reverberation time (T_0), and given by equation (5) [unit: decibel (dB)]

$$D_{ls,2m,nT} = D_{ls,2m} + 10 \log_{10} \left(\frac{T}{T_0} \right) \dots\dots\dots (5)$$

where, $T_0 : 0.5 \text{ s}$

NOTE : When the outdoor sound pressure level at the position 1 m vertically outside the surface of facade element $L_{1,1m}$ is used, the standardized level difference is denoted as $D_{ls,1m,nT}$.

3.9 normalized level difference $D_{ls,2m,n}$

value obtained by subtracting ten times the common logarithm of the ratio of the equivalent sound absorption area in the receiving room (A) to the reference equivalent sound absorption area (A_0) from the level difference, and given by equation (6) [unit: decibel (dB)]

$$D_{ls,2m,n} = D_{2m} - 10 \log_{10} \left(\frac{A}{A_0} \right) \dots\dots\dots (6)$$

where, $A_0 : 10 \text{ m}^2$

NOTE : When the outdoor sound pressure level at the position 1 m vertically outside the surface of facade element $L_{1,1m}$ is used, the normalized level difference is denoted as $D_{ls,1m,n}$.

4 Measurement equipment

4.1 General

For the measurement of the sound pressure level, the sound level metre (noise metre) of Class 1 or Class 2 specified in **JIS C 1509-1** shall be used. Whole equipment including microphones shall be calibrated by using an acoustical calibrator of Class 1 or better specified in **JIS C 1515**.

For the frequency analysis, the octave or one-third-octave band filters specified in **JIS C 1514** shall be used. The equipment used for the reverberation time measurement shall be in accordance with the requirements of **ISO 3382**.

NOTE : For the equipment above, the real time type frequency analyzer conforming to **JIS C 1509-1** and **JIS C 1514** may be used.

4.2 Loudspeaker

The directivity of the loudspeaker in a free field shall be so that the differences in the sound pressure level in each frequency band are 5 dB or under on the whole imaginary surface whose orientation to the speaker and size are the same as those of the facade elements or the whole facades under measurement.

NOTE : When one dimension of the surface of facade element or whole facades under measurement exceeds 5 m, the difference of the sound pressure level on the whole imaginary surface may be permissible up to 10 dB. In this case, the purport should be stated in the test report.

5 Measuring method

5.1 General

Two methods of the element method and the global method which use the loudspeaker shall be specified.

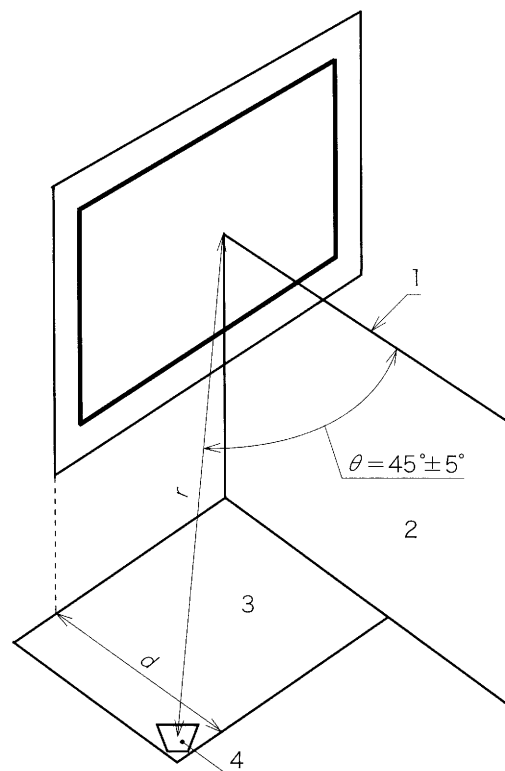
The measurement result by the element method is comparable with the sound reduction index of the facade element obtained in the laboratory conforming to **JIS A 1416** under the definite conditions.

In the global method, the airborne sound insulation of the whole facades or the whole building shall be measured.

Unless otherwise specified, the second decimal place of the calculated value obtained by the measurement according to this Standard shall be rounded to the first decimal place in accordance with **JIS Z 8401**.

5.2 Principle for measurement

The loudspeaker is set at the position where the sound incidence angle to the centre of test surface becomes $(45 \pm 5)^\circ$ as shown in figure 1. In the element method, the average sound pressure level on a test surface is evaluated. In the global method, the apparent sound reduction index 45° incidence R'_{45° or the level difference $D_{ls,2m}$ and $D_{ls,1m}$ is evaluated by using the average sound pressure level at the position 2 m or 1 m vertically outside the test surface and the average sound pressure level in the receiving room.



- 1 : Vertical to centre of facade element
- 2 : Vertical surface
- 3 : Horizontal surface
- 4 : Position of loudspeaker
- r : Distance from loudspeaker to centre of facade element
- d : Vertical distance from imaginary surface containing facade element to centre of loudspeaker sound source

Figure 1 Position of loudspeaker (sound source)

5.3 Frequency range for measurement

The measurement of sound pressure level shall be carried out on the frequency band of which the centre frequency is as follows.

Octave band measurement: 125 Hz, 250 Hz, 500 Hz, 1 000 Hz and 2 000 Hz

One-third-octave band measurement: 100 Hz, 125 Hz, 160 Hz, 200 Hz, 250 Hz, 315 Hz, 400 Hz, 500 Hz, 630 Hz, 800 Hz, 1 000 Hz, 1 250 Hz, 1 600 Hz, 2 000 Hz, 2 500 Hz and 3 150 Hz

NOTE 1 For the octave band measurement, the frequency band with centre frequency of 4 000 Hz should also be measured. For the one-third-octave band measurement, the frequency band with centre frequency of 4 000 Hz and 5 000 Hz should also be measured.

NOTE 2 If the measurement on the low frequency bands is necessary, the measurement on the frequency band with centre frequency of 63 Hz shall be added in the case of octave band measurement, and the measurement on the frequency bands with centre frequencies of 50 Hz, 63 Hz and 80 Hz shall be added in the case of one-third-octave band.

5.4 Position of loudspeaker

The position of the loudspeaker shall be selected so that the variation of the sound pressure level in each octave band on the facade element under measurement is minimized and the flanking propagation sound becomes small. Also, the sound source is preferably set on the ground, or alternatively set as high above the ground as possible to minimize the reflection from the ground surface. The distance r from the sound source to the centre of the facade element under measurement in figure 1 shall be 5 m or more ($d > 3.5$ m) in the element method and 7 m or more ($d > 5$ m) for the global method.

5.5 Generation of sound

The sound generated from the loudspeaker shall be steady and have a continuous spectrum throughout the frequency range under measurement. The difference between the sound power levels in one-third-octave bands belonging to one octave band shall be within 6 dB in 125 Hz octave band, within 5 dB in 250 Hz band and within 4 dB in 500 Hz band or over. In all frequency bands under measurement, the sound power of the sound source shall be set so that the sound pressure level in the receiving room exceeds the background noise level by 10 dB or more.

5.6 Measurement of average sound pressure level on test surface for element method

5.6.1 Test requirements

The following steps shall be carried out for the purpose of the measurement to obtain results as comparable as possible to those of laboratory measurements.

- a) Verification that the facade element under test is in accordance with the specified construction and is properly mounted according to the manufacturer's instructions
- b) Estimation on the sound reduction index of the facade to ensure that the sound transmission through the wall surrounding the facade element does not contribute significantly to the sound pressure level in the receiving room.

In addition, verification that the area of opening is representative of that of the laboratory and that the niche opening and window position in the niche do not deviate from the requirements specified in **JIS A 1416** shall be carried out.

Annex C shows some examples for these verification. In case of doubt about unacceptably high sound transmission through the wall surrounding the facade element, the procedure in Annex B shall be carried out.

NOTE : "Niche" means a recess generated on both sides of a building element when it is mounted in facade opening.

5.6.2 Measurement of sound pressure level on surface of facade element

The average sound pressure level $L_{1,s}$ on the surface of facade element of interest shall be measured. The microphone shall be fastened directly on the surface of facade element with a strong adhesive tape. When the microphone membrane is set parallel to the plane of facade element, the distance from surface of facade element to the microphone membrane shall be 10 mm or under. When the microphone is set vertical to the plane of facade element, the distance from surface of facade element to the

microphone membrane shall be 3 mm or under. The microphone shall be equipped with a hemispherical windscreen (see figure 2). The diameter of microphone shall be 13 mm or under to satisfy the conditions above.

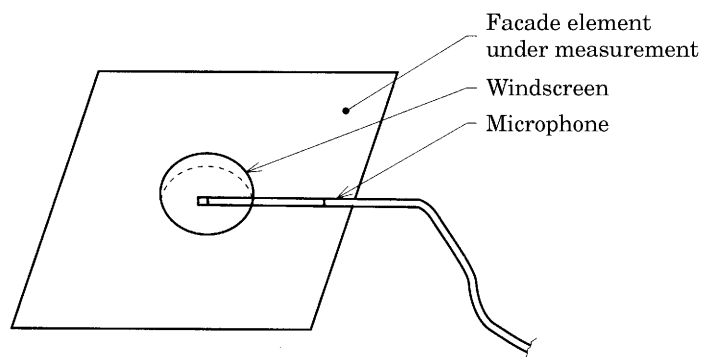


Figure 2 Example of microphone setting on surface of facade element

When simultaneous measurements are carried out outdoors and indoors, the microphone (including cables) confirmed that it does not affect the sound insulation of facade element should be used in the case where the microphone is fastened to the surface of the facade element.

Three to ten measurement positions shall be selected according to the difference in the sound pressure levels between the positions on the surface of facade element. The measurement positions shall be distributed evenly but asymmetrically on the whole of measurement surface. The number of measurement positions shall be set to n . When the maximum value of difference in the sound pressure levels between two measurement positions in one frequency band is n dB or over, the number of measurement positions shall be increased up to ten. It is preferable to begin with three measurement positions ($n = 3$).

If the facade element of interest is mounted on a niche of the facade, ten measurement positions shall always be selected.

If the difference in the sound pressure levels between measurement positions is 10 dB or over, this shall be stated in the test report.

As an alternative to several fixed measurement positions, a moving microphone may be used provided that the distance to the facade element is kept constant and the S/N ratio is kept at 10 dB or over.

5.6.3 Evaluation of average sound pressure level on a test surface

According to the measured values of the sound pressure level on n points measured in accordance with 5.6.2, the average sound pressure level on a test surface shall be evaluated according to equation (7).

$$L_{1,s} = 10 \log_{10}(10^{L_1/10} + 10^{L_2/10} + \dots + 10^{L_n/10}) - 10 \log_{10}(n) \dots\dots\dots (7)$$

where, $L_1, L_2, \dots, L_n$ are sound pressure levels on measurement point 1, 2, $\dots, n$.

NOTE : The difference in the sound pressure levels may be affected by the height above ground, recess, balcony, position of facade element of interest, etc.

5.7 Measurement of average sound pressure level in a room

The average sound pressure level in a receiving room shall be measured by either of the following methods.

- a) **Fastened microphone method** Five or more measurement positions 0.7 m or over away one another shall be uniformly distributed in the space 0.5 m or over apart from room boundaries, furnitures, etc. and 1.0 m or over apart from the facade element of interest in the receiving room.
- b) **Moving microphone method** The measurement shall be carried out by using the moving microphone equipment whose sweep radius is 0.7 m or over in the receiving room. The microphone shall be continuously traversed in the space 0.5 m or over apart from room boundaries, furnitures, etc. and 1.0 m or over apart from the facade element of interest. The traverse plane shall be inclined to the floor surface and the angle shall be 10° or over for each surface of the wall. The traverse period shall be 15 s or over.

c) Averaging time

- 1) **When using fastened microphone method** The averaging time of sound pressure level at each microphone set position in the frequency band under measurement shown in 5.3 shall be 3 s or longer for frequency bands with centre frequency of 250 Hz or under and 2 s or longer for frequency bands of 500 Hz or over in the octave band measurement, and 6 s or longer for frequency bands with centre frequency of 400 Hz or under and 4 s or longer for frequency bands of 500 Hz or over in the one-third-octave band. The equivalent continuous sound pressure level meanwhile shall be measured.

NOTE : The equivalent continuous sound pressure level may be automatically measured by using the integrated average function of noise metre. When using a noise metre without the integrate average function, the average of indicated value for each frequency band shall be read.

- 2) **When using moving microphone method** The averaging time shall be the cycle of moving microphone equipment or over and also 30 s or longer, and shall be integral multiple of the traverse cycle.

NOTE : In this method, the equivalent continuous sound pressure level shall surely be measured by using a noise metre with the integrated average function.

- d) **Correction for effect of background noise** The background noise level shall surely be measured to ensure that the measurement results in the receiving room are not affected by the noise from outdoor, the electrical noise in the sound receiving system, the electrical cross-talk between the sound source room and the receiving room, etc.

The background noise level shall be at least 6 dB (preferably 10 dB or over) below the level of the signal measured and the background noise combined. If this difference is 6 dB or more, the sound pressure level from which the effect of the background noise is eliminated shall be evaluated according to equation (8). When the difference is smaller than 6 dB, this correction shall not be carried out and the measurement results of sound pressure level shall be recorded as the reference value.