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**Field measurement of sound pressure
level from appliances and equipment
used in water supply and drainage
installations in buildings**

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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 Japan Testing Center for Construction Materials (JTCCM)/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 16032: 2004** *Acoustics—Measurement of sound pressure level from service equipment in buildings—Engineering method* 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.

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Field measurement of sound pressure level from appliances and equipment used in water supply and drainage installations in buildings

Introduction This Japanese Industrial Standard has been prepared based on the first edition of *ISO 16032 Acoustics—Measurement of sound pressure level from service equipment in buildings—Engineering method* published in 2004 with some modifications of the technical contents. Because the original International Standard specifies the measurement on general service equipment in buildings, while this Standard specifies the measurement on only appliances and equipment used in water supply and drainage installations (hereafter referred to as “water equipment”).

The portions given sidelines or dotted underlines in this Standard are the matters different from the original International Standard. A list of modifications with the explanations is given in Annex 3 (informative).

1 Scope This Standard specifies methods for measuring the sound pressure level from water equipment in the room installed to building structures. The water equipment covered by this Standard is the water tap, shower room, bathroom, sink, water closet, pump, boiler, air bubble bath tub, disposer and wastewater treatment tank.

The methods are suitable for rooms with volumes of approximately 300 m³ or less in dwellings, hotels, schools, offices and hospitals, etc. This Standard is not in general intended for measurements in large space such as auditoria and concert halls. Annex B specifies the operating conditions and operating cycles of water equipment.

The water equipment sound pressure level is determined as the maximum A-weighted and optionally C-weighted sound pressure level occurring during a specified operation cycle of the water equipment under test, or as the equivalent continuous sound pressure level determined with a specified integration time.

Information : The indoor sound generated by operation of water equipment refers mainly to solid-borne sound generated by vibration of equipment that affects other rooms where water equipment is not installed. But, the measurement method of this Standard may be applied to measure the quietness inside and outside the room where water equipment is installed.

NOTE : The International Standard corresponding to this Standard 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 16032 : 2004 *Acoustics—Measurement of sound pressure level from service equipment in buildings—Engineering method* (MOD)

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

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

NOTE : IEC 61672-1:2002 *Electroacoustics—Sound level meters—Part 1: Specifications* is identical with the said standard.

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

NOTE : IEC 61260:1995 *Electroacoustics—Octave-band and fractional-octave-band filters* is identical with the said standard.

JIS C 1515 *Electroacoustics—Sound calibrators*

NOTE : IEC 60942:2003 *Electroacoustics—Sound calibrators* is identical with the said standard.

JIS Z 8401 *Guide to the rounding of numbers*

JIS Z 8732 *Acoustics—Determination of sound power levels of noise sources using sound pressure—Precision methods for anechoic and hemi-anechoic rooms*

JIS Z 8734 *Acoustics—Determination of sound power levels of noise sources using sound pressure—Precision methods for reverberation rooms*

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

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

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

3.1 sound pressure level L ten times the logarithm to the base 10 of the ratio of the square of the sound pressure, $p^2(t)$ to the square of the reference sound pressure p_0^2 , measured with a particular time weighting and a particular frequency weighting, selected from those defined in JIS C 1509-1

It is expressed in decibels (dB). The reference sound pressure p_0 is 20 μ Pa.

3.2 average sound pressure level $\bar{L}$ the level expressed in decibels (dB)

$$\bar{L} = 10 \log_{10} \left[\frac{\sum_{i=1}^n 10^{0.1 L_i}}{n} \right] \dots\dots\dots (1)$$

where, L_i : the sound pressure level at the i -th microphone position, in decibels, to be averaged (dB)

3.3 A-weighted sound pressure level calculated from octave-band values in the frequency range 63 Hz to 8 000 Hz L_A the sound pressure expressed in decibels (dB)

$$L_A = 10 \log_{10} \sum_{i=1}^n 10^{0.1(L_i + A_i)} \dots\dots\dots(2)$$

where, L_i : the sound pressure level in octave-band i

A_i : the A-weighting correction for octave-band i (see Annex A).

The value of L_i depends on the measurements, but can be all the parameters of 3.6.

NOTE : In this Standard, the sound pressure level value of all the bands through the frequency weighting A shall also be taken as the A-weighted sound pressure level L_A . In Japan, the value directly measured through the frequency weighting A is also used widely as the A-weighted sound pressure level L_A . To facilitate the comparative study with the past data, this Standard adds this value to the provision when the normalized or the standardized sound pressure level need not be specifically calculated.

3.4 C-weighted sound pressure level calculated from octave-band values in the frequency range 31.5 Hz to 8 000 Hz L_C the sound pressure expressed in decibels (dB)

$$L_C = 10 \log_{10} \sum_{i=1}^n 10^{0.1(L_i + C_i)} \dots\dots\dots(3)$$

where, L_i : the sound pressure level in octave-band i

C_i : the C-weighting correction for octave-band i (see Annex A).

The value of L_i depends on the measurements, but can be all the parameters of 3.6.

NOTE : In this Standard, the sound pressure level value of all the bands through the frequency weighting C shall also be taken as the C-weighted sound pressure level L_C . In Japan, the value through the frequency weighting C is also used widely as the C-weighted sound pressure level L_C . To facilitate the comparative study with the past data, this Standard adds this value to the provision when the normalized or the standardized sound pressure level need not be specifically calculated.

3.5 sound exposure level L_E the sound exposure level of a sound event given by the following formula, as expressed in decibels (dB)

$$L_E = 10 \log_{10} \frac{1}{t_0} \int_{t_1}^{t_2} \frac{p^2(t)}{p_0^2} dt \dots\dots\dots(4)$$

where, $p(t)$: the instantaneous sound pressure (Pa)

t_2 to t_1 : a stated time interval long enough to encompass all significant sound of a stated event (s)

p_0 : the reference sound pressure (2×10^{-5} Pa)

t_0 : the reference duration ($t_0 = 1$ s)

3.6 service equipment sound pressure level in octave-bands in the frequency range 31.5 Hz to 8 000 Hz In the following subclauses 3.6.1 to 3.6.9 are defined the octave-band values which can be measured according to this Standard. See table 1.

3.6.1 $L_{S \max}$ maximum sound pressure level in octave-bands determined with time weighting S

3.6.2 $L_{S \max, nT}$ maximum sound pressure level in octave-bands determined with time weighting S and standardized to a reverberation time of 0.5 s [3.8, equation (5)]

3.6.3 $L_{S \max, n}$ maximum sound pressure level in octave-bands determined with time weighting S and normalized to an equivalent sound absorption area of 10 m² [3.8, equation (6)]

3.6.4 $L_F \max$ maximum sound pressure level in octave-bands determined with time weighting F

3.6.5 $L_F \max, nT$ maximum sound pressure level in octave-bands determined with time weighting F and standardized to a reverberation time of 0.5 s [3.8, equation (5)]

3.6.6 $L_F \max, n$ maximum sound pressure level in octave-bands determined with time weighting F and normalized to an equivalent sound absorption area of 10 m² [3.8, equation (6)]

3.6.7 L_{eq} equivalent continuous sound pressure level

3.6.8 $L_{eq, nT}$ equivalent continuous sound pressure level in octave-bands standardized to a reverberation time of 0.5 s [3.8, equation (5)]

3.6.9 $L_{eq, n}$ equivalent continuous sound pressure level in octave-bands normalized to an equivalent sound absorption area of 10 m² [3.8, equation (6)]

3.7 reverberation time T time that would be required for the sound pressure level to decrease by 60 dB after the sound source has stopped (s)

3.8 standardized/normalized sound pressure level the measured sound pressure levels in octave-bands can be standardized to a reverberation time of 0.5 s or normalized to an equivalent sound absorption area of 10 m², by using the equations (5) and (6), respectively and as expressed in decibels (dB)

$$L_{nT} = L - 10 \log_{10} \frac{T}{T_0} \dots \dots \dots (5)$$

where, L : $L_{S \max}$, $L_F \max$ or L_{eq}

T : the measured reverberation time (s)

T_0 : = 0.5 s

$$L_n = L + 10 \log_{10} \frac{A}{A_0} \dots \dots \dots (6)$$

where, L : $L_{S \max}$, $L_F \max$ or L_{eq}

A : the equivalent sound absorption area (m²)

$$A = \frac{0.16V}{T}$$

0.16 : the value having the unit s/m

V : the room volume (m³)

T : the measured reverberation time (s)

A_0 : the reference equivalent sound absorption area (m²)

$$A_0 = 10 \text{ m}^2$$

NOTE : The standardization to the reference reverberation time of 0.5 s means to use the value of the following equation as the reference equivalent sound absorption area (m²) and to calculate the equation (6).

$$A_0 = 0.32 V$$

The normalization to the reference equivalent sound absorption area of 10 m² means to use the value of the following equation as the reference reverberation time (s) and to calculate the equation (5).

$$T_0 = \frac{0.16V}{A_0}$$

4 Instrumentation Measurement of the maximum sound pressure level according to this Standard implies the use of an octave-band real-time frequency analyser. The analyser shall be able to read values of all octave-band sound pressure levels at the time when the maximum A-weighted or C-weighted sound pressure level occurs during a specified operating cycle of the water equipment under test. It is important to ensure that the equipment used according to this Standard fulfils the requirement stated above. The most common analysers used for building acoustic measurements include this feature.

NOTES 1 The instrumentation system, including the microphone and cable, shall meet the requirements for an instrument specified in **JIS C 1509-1**.

2 For measurements in octave-bands, the filters shall meet the requirements for filters specified in **JIS C 1514**.

3 At the beginning and at the end of the measurements verify, the sensitivity of the instrumentation with a sound calibrator according to **JIS C 1515**.

5 Test method The water equipment sound pressure level is measured in octave-bands in the frequency range 31.5 Hz/63 Hz to 8 000 Hz as the linear (unweighted) spectrum corresponding to the maximum A-weighted or C-weighted sound pressure level occurring during a specified operating cycle of the water equipment under test. Time weighting S or F shall be used.

For evaluation of the equipment sound pressure level, take the octave-band spectrum at that time when the maximum A-weighted or C-weighted sound pressure level occurs. Alternatively or additionally the A-weighted or C-weighted equivalent continuous sound pressure level can be determined with a specified integration time.

The octave-band results are corrected for background noise and, if required, standardized to a reverberation time of 0.5 s or normalized to an equivalent sound absorption area of 10 m². Finally the A-weighted and C-weighted sound pressure levels are calculated from the corrected octave-band results.

The single number quantities which can be determined according to this Standard are calculated from the octave-band values defined in 3.6.1 to 3.6.9. The notation in table 1 shall be used when reporting measurement results.

NOTES 1 The different quantities can be combined according to e.g. requirements in national building code regulations.

2 The A- or C-weighted sound pressure levels are usually calculated from the measurement results of the octave-band sound pressure level. However, when the normalized or standardized sound pressure levels need not be calculated, it is allowed to directly measure the value through the frequency weighting A or the frequency weighting C.

Table 1 Various notations to express the maximum sound pressure level and equivalent continuous sound pressure level (dB)

	A-weighted value (calculated from octave-band values in the frequency range 63 Hz to 8 000 Hz)	C-weighted value (calculated from octave-band values in the frequency range 31.5 Hz to 8 000 Hz)
Maximum sound pressure level, time weighting S	$L_{AS\ max}$ $L_{AS\ max, nT^{(1)}}$ $L_{AS\ max, n^{(1)}}$	$L_{CS\ max}$ $L_{CS\ max, nT^{(1)}}$ $L_{CS\ max, n^{(1)}}$
Maximum sound pressure level, time weighting F	$L_{AF\ max}$ $L_{AF\ max, nT^{(1)}}$ $L_{AF\ max, n^{(1)}}$	$L_{CF\ max}$ $L_{CF\ max, nT^{(1)}}$ $L_{CF\ max, n^{(1)}}$
Equivalent continuous sound pressure level	L_{Aeq} $L_{Aeq, nT^{(1)}}$ $L_{Aeq, n^{(1)}}$	L_{Ceq} $L_{Ceq, nT^{(1)}}$ $L_{Ceq, n^{(1)}}$
Note (1) : See 6.6.		

The different single number quantities given in table 1 are not comparable. Only measurement results obtained with the same method shall be compared.

When measurement results are compared with legal requirements, it shall be ensured that both refer to the same quantity. If the sound contains clearly audible tonal components, this shall be stated in the report.

Windows and doors shall be closed during the measurements. The person performing the test should stay outside the room.

6 Measurement procedure

6.1 General The water equipment sound pressure level is to be determined for a specified operating condition and operating cycle. The conditions shall only be used if they are not opposed to national requirements and regulations.

Measure the sound from the water equipment according to 6.2 to 6.8. Measure the sound pressure level at 3 to 5 microphone positions installed uniformly in the indoor space.

Information : The original International Standard specifies the method that the sound pressure level is measured in 3 microphone positions, 1 position in a corner of the room and 2 positions in the reverberant sound field. In Japan, to evaluate the indoor noise, the method of measurement at 3 to 5 points installed uniformly in the space has been widely used in the past. Accordingly this method is specified. The measurement method based on the microphone positions specified in the original International Standard is described in Annex 1 as informative.

6.2 Installation method of measurement points distributed uniformly in the room

- a) **In the case of the stationary microphone** Choose 3 to 5 indoor positions at least 0.7 m apart each other within the space that is at least 0.7 m away from the wall, floor and ceiling. The positions shall be distributed uniformly in the space.
- b) **In the case of the mobile microphone** When the sound generation property of source is constant in time, use the microphone-moving device whose rotation radius is 0.7 m or more and place the microphone in the space at least 50 cm away from the ceiling, surrounding wall and floor surface, with inclining the rotation plane against the floor surface and keeping it against the wall surface with an angle of at least 10°. Alternatively, the microphone may be moved at the rotational period of 30 s or more, provided that it shall be ensured that the difference between the maximum and the minimum sound pressure level during one period does not exceed 10 dB.

6.3 Measurement method of sound pressure level

- a) **In the case of the stationary microphone** For the maximum sound pressure levels, at each measurement point, measure the maximum A-weighted sound pressure level L_{Amax} , the maximum C-weighted sound pressure level L_{Cmax} , the maximum sound pressure level of the octave-band of the central frequency 63 Hz to 8 000 Hz L_{max} , the noise exposure level L_{AE} , etc., if required. For the equivalent continuous sound pressure levels, at each measurement point, measure the A-weighted equivalent continuous sound pressure level L_{Aeq} , the C-weighted equivalent continuous sound pressure level L_{Ceq} , the equivalent continuous sound pressure level of the octave-band of the central frequency 63 Hz to 8 000 Hz L_{eq} , etc., if required. Make 3 or more measurements at each measurement point.
- b) **In the case of the mobile microphone** If required, measure the A-weighted equivalent continuous sound pressure level L_{Aeq} , the C-weighted equivalent continuous sound pressure level L_{Ceq} , and the equivalent continuous sound pressure level of the octave-band of the central frequency 63 Hz to 8 000 Hz L_{eq} . However, when this method is used, be sure to use a noise meter having the integration average function. The averaging time shall be an integral multiple of the rotational period of the microphone moving device.

This method shall not be used for measurement of the maximum sound pressure level.

6.4 Calculation method of indoor average value of sound pressure level In the case of the stationary microphone, use the calculation method defined in 3.2, and calculate, at each measurement point, the indoor average level of the A-weighted maximum sound pressure level L_{Amax} , the C-weighted maximum sound pressure level L_{Cmax} , the maximum sound pressure level of the octave-band of the central frequency 63 Hz to 8 000 Hz L_{max} , the noise exposure level L_{AE} , the A-weighted equivalent continuous sound pressure level L_{Aeq} , the C-weighted equivalent continuous sound pressure level L_{Ceq} , and the equivalent continuous sound pressure level of the octave-band of the central frequency 63 Hz to 8 000 Hz L_{eq} , etc. The indoor average value shall be rounded to 1 decimal point. However, if the difference between the maximum value and the minimum value at the measurement point exceeds 10 dB, then the average value shall not be calculated, but the maximum value and the minimum value shall be mentioned in the report.

6.5 Correction for background noise Determine the octave-band background noise level and correct the measured water equipment sound pressure level according to clause 8.

6.6 Standardization or normalization of octave-band results If required, the octave-band results corrected for background noise can be standardized or normalized to reference absorption properties of the room. Measure the reverberation time according to clause 7, and make the standardization by use of equation (5) in definition 3.8, and the normalization according to equation (6) in definition 3.8. The A-weighted and C-weighted results shall be rounded to an integer.

If required, to obtain the standardized or normalized values of the A-weighted equivalent continuous sound pressure level L_{Aeq} or C-weighted equivalent continuous sound pressure level L_{Ceq} , calculate them respectively from the octave-band value of the standardized or normalized values in the range 63 Hz to 8 000 Hz. If the 31.5 Hz octave-band contributes to the C-weighted sound pressure level, this shall be mentioned in the report.

Background noise problems may be present when measuring the reverberation time in the 8 000 Hz octave-band. If the 8 000 Hz octave-band sound pressure level of the water equipment noise is at least 15 dB below the octave-band in the spectrum with the highest level, then standardization or normalization shall not be performed in 8 000 Hz octave-band.

NOTES 1 The standardized or normalized sound pressure level may be calculated from the measurement result of the equivalent sound absorption area level using the reference sound source specified in Annex 2.

2 The standardized or normalized sound pressure levels shall be rounded to 2 decimal places according to JIS Z 8401 and expressed with 1 decimal place.

6.7 Calculation of A- and C-weighted values Using either the results achieved in 6.5, or alternatively 6.6, determine the A-weighted level from the octave-band levels in the frequency range 63 Hz to 8 000 Hz according to definition 3.3. Determine the C-weighted level from the octave-band levels in the frequency range 31.5 Hz to 8 000 Hz according