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Laboratory measurement of walking noise on floors

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National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Laboratory measurement of walking noise on floors

Mesurage en laboratoire du bruit des pas sur les planchers

Messung von Gehschall auf Fußböden im Prüfstand

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Foreword

This document (EN 16205:2013) has been prepared by Technical Committee CEN/TC 126 "Acoustic properties of building elements and of buildings", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2013, and conflicting national standards shall be withdrawn at the latest by December 2013.

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Introduction

This document sets up a laboratory measurement method to determine noise radiated from a floor covering on a standard concrete floor when excited by a standard tapping machine. The noise is measured in the room where the floor covering and the excitation are located. There is no restriction concerning the type of floor covering unless that the required small pads of the flooring could not be assembled. Using the standard tapping machine according to EN ISO 10140 means that a more general excitation compared to walking alone is regarded – in the same way as it is accepted for impact sound improvement measurements of floor coverings. The results are expressed in terms of the normalised A-weighted average sound pressure level in the walking room. The results provide information about the noise radiated. A more sophisticated psychoacoustic evaluation did not seem to be appropriate in view of the fact that this measurement stands for a large range of sources with different acoustical behaviour (even if only different types of walking were regarded). A subjective classification of the quality of the floor coverings is not intended.

1 Scope

This European Standard specifies a laboratory measurement method to determine noise radiated from a floor covering on a standard concrete floor when excited by a standard tapping machine.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 10140-1, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 1: Application rules for specific products (ISO 10140-1)*

EN ISO 10140-2, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 2: Measurement of airborne sound insulation (ISO 10140-2)*

EN ISO 10140-3, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 3: Measurement of impact sound insulation (ISO 10140-3)*

EN ISO 10140-4:2010, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 4: Measurement procedures and requirements (ISO 10140-4:2010)*

EN ISO 10140-5, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 5: Requirements for test facilities and equipment (ISO 10140-5)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 10140 and the following apply.

3.1
sufficiently large specimen
specimen whose radiated sound power does not increase any longer with size, or which covers the total area of the floor

Note 1 to entry: In case of uncertainty the testing laboratory will decide, which size is sufficient.

3.2
pads
pieces of the flooring under test, which are as large as the hitting areas of the tapping machine hammers

Note 1 to entry: Quadratic pads should be the smallest possible including the whole hitting area.

3.3
walking sound pressure level (in third-octave band *i*)
$L_{n,\text{walk},i}$
normalised impact sound pressure level in the upper (walking) room with a standardised contribution of the concrete bare floor underneath the floor covering under test

Note 1 to entry: It is calculated according to Formula (1):

$$L_{n,\text{walk},i} = \begin{cases} L_{i,\text{ref},b} + L_{i,\text{Fl},c} - L_{i,\text{Fl},b} & \text{if } L_{i,\text{with}} < \left(L_{i,\text{pads}} + 10 \cdot \log\left(\frac{T_{i,upper,with}}{T_{i,upper,pads}} \right) \right) \\ 10 \log_{10} \left(\frac{0{,}16 \cdot V_{\text{upper}}}{A_0} \left(\frac{10^{\frac{L_{i,\text{with}}}{10}}}{T_{i,\text{upper,with}}} - \frac{10^{\frac{L_{i,\text{pads}}}{10}}}{T_{i,\text{upper,pads}}} \right) + 10^{\frac{L_{i,\text{ref,b}} + L_{i,\text{Fl,c}} - L_{\text{i,Fl,b}}}{10}} \right) & \text{else} \end{cases} \tag{1}$$

where

$L_{i\ \text{,with}}$	is the impact sound pressure level measured in the upper room, when a sufficiently large specimen is lying on the test floor;
$L_{i\ \text{,pads}}$	is the impact sound pressure level measured in the upper room, when only pads of the flooring material are lying on the test floor below the tapping machine hammers;
$L_{i,\text{Fl,b}}$	is the impact sound pressure level measured in the lower room, when the tapping machine acts on the bare floor in the upper room;
$L_{i,\text{Fl,c}}$	is the impact sound pressure level measured in the lower room, when the tapping machine acts on the sufficiently large specimen in the upper room;
$L_{i,\text{ref,b}}$	is the reference values for the bare floor as given in Annex B;
V_{upper}	is the volume of the upper room, in cubic metres;
$T_{i,\text{upper,with}}$	is the reverberation time in the upper room with sufficiently large floor covering installed, in seconds;
$T_{i,\text{upper,pads}}$	is the reverberation time in the upper room with pads installed, in seconds;
A_0	10 m².

This definition presumes, that the reverberation time in the lower room does not change between the measurements of $L_{i,\text{Fl,c}}$ and $L_{i,\text{Fl,b}}$.

Note 2 to entry: This can be achieved by leaving the lower room unchanged.

3.4
A-weighted walking sound pressure level
$L_{n,\text{walk,A}}$
A-weighted sound pressure level, calculated from $L_{n,\text{walk},i}$ according to Formula (2) with C_i according to EN 61672-1:

$$L_{n,walk,A} = 10 \cdot \lg \sum_{i=1}^{21} 10^{\left(L_{n,walk,i} + C_i\right)/10} . \tag{2}$$

4 Principle

A floor test facility according to EN ISO 10140 for impact and airborne sound measurements is used. It consists of two medium sized and medium damped rooms above each other, separated by a standard homogeneous concrete floor. As a walking noise source, a standard tapping machine according to EN ISO 10140 is applied. Several average sound pressure level measurements in third-octave bands are made in the upper and lower rooms with the bare floor either uncovered or covered with pads or sufficiently large "full-size" specimens of the tested flooring. In the upper room the reverberation times with large specimens and with merely pads present shall be determined.

The walking sound pressure level is then calculated according to Formula (1) from the sound power directly radiated from the floor covering into the upper room plus the sound power from the bare floor under the floor covering, which radiates back into the upper room. Finally the A-weighted walking sound pressure level is calculated from the measured average sound pressure levels.

In Formula (1) the radiation from the bare floor through the floor covering is corrected for deviations of the actual laboratory floor from the reference spectrum in Annex B. Furthermore, the tapping machine self noise theoretically cancels out and therefore is not needed explicitly. However, because of the uncertainty of the measured quantities, the resulting walking sound pressure level in the second line in Formula (1) may become very uncertain and even complex, in particular when a loud tapping machine is used and the flooring doesn't radiate much itself. Complex values are avoided by setting the inner bracket to zero as a minimum (first line in Formula (1)). To detect unreliable results, the uncertainty of $L_{n,\text{walk}}$ shall be calculated for each third octave band and stated in the test report.

All details like test facility requirements, tapping machine characteristics, positioning of tapping machine and microphones, averaging etc. are kept as close as possible to the requirements of laboratory measurements of impact noise as given in EN ISO 10140.

5 Test arrangement

5.1 Test facilities

A room arrangement for impact and airborne sound pressure level measurements according to EN ISO 10140 shall be used.

5.2 Equipment

See EN ISO 10140.

5.3 Mounting of the specimens

The floor coverings or the corresponding pads shall be mounted according the instructions of EN ISO 10140 and Annex C.

6 Test procedure

All specifications of EN ISO 10140, concerning:

- generation of the sound field;
- measurement of impact sound pressure levels;
- measurement of reverberation time;
- correction for background noise; and
- additional measures to be regarded at low frequencies (EN ISO 10140-4:2010, Annex A)

shall be followed. The measurement shall run in third-octave bands from 50 Hz to 5 000 Hz.

Proceed as follows:

1	Apply the tapping machine on the bare floor in the upper room.	Measure $L_{i,\mathrm{Fl,b}}$ in the lower room.	Ensure negligible air-borne sound transmission through the lab floor. Reverberation time in the lower room shall remain unchanged until the end of all measurements.
2	Let the tapping machine hammer on pads of the investigated flooring. (Support the feet with pieces of the flooring, too, to keep the falling height of the hammers.)	Measure reverberation time $T_{\mathrm{i,upper,pads}}$ and $L_{\mathrm{i,pads}}$ in the upper room.	
3	Install a sufficiently large piece of the floor covering on the floor.	Measure reverberation time $T_{\mathrm{i,upper,with}}$ and $L_{\mathrm{i,with}}$ in the upper room.	
4		Determine $L_{\mathrm{i,Fl,c}}$ in the lower room.	Ensure negligible air-borne sound transmission through the lab floor. Check that reverberation time in the lower room (or state of the room) is unchanged.

7 Evaluation of results

From the measured sound pressure levels, the following final results shall be evaluated:

a) walking sound pressure level $L_{n,\mathrm{walk},i}$ (in third-octave bands) according to Formula (1);

b) the uncertainty of the walking sound pressure level, $u_{\mathrm{walk},i}$, according to Formula (3);

c) the A-weighted walking sound pressure level $L_{n,\mathrm{walk,A}}$ according to Formula (2);

d) the uncertainty of the A-weighted walking sound pressure level, $u_{\mathrm{walk,A}}$, according to Formula (4).

8 Precision

It is assumed, that in Formula (1) essentially only the four measured levels and the reverberation times are uncertain. The uncertainty of the walking noise level of a third-octave band i, $u_{\mathrm{walk},i}$, then results from Formula (3).

$$u_{\mathrm{walk},i} = 10^{-L_{n,\mathrm{walk},i}/10} \cdot \sqrt{2 \cdot 10^{\left(L_{i,Fl,c} + L_{i,\mathrm{ref,b}} - L_{i,\mathrm{Fl,b}}\right)/5} \cdot u_L^2 + \left(\frac{0{,}16\, V_{\mathrm{upper}}}{A_0}\right)^2 \left[\left(\frac{10^{L_{i,\mathrm{pads}}/10}}{T_{i,\mathrm{upper,pads}}}\right)^2 + \left(\frac{10^{L_{i,\mathrm{with}}/10}}{T_{i,\mathrm{upper,with}}}\right)^2\right] \cdot \left(u_L^2 + u_{LT}^2\right)} \quad (3)$$

where

u_{L} is the uncertainty of the measured levels, in decibels;

u_{LT} is the uncertainty of the reverberation time levels, in decibels.

If particular values are not known, the following ones according to [4] and [5] should be used for all third-octave bands:

— u_L = 0,4 dB;

— u_{LT} = 0,5 dB.

Shielding effects by the tapping machines ([6] and [7]) are ignored here.

The uncertainty of the A-weighted walking sound pressure level results from Formula (4).

$$u_{\text{walk,A}} = \frac{1}{\sum_{j=1}^{21} 10^{\left(L_{n,\text{walk},j}+C_j\right)/10}} \cdot \sqrt{\sum_{i=1}^{21} \left[10^{\left(L_{n,\text{walk},i}+C_i\right)/10} \cdot u_{\text{walk},i}\right]^2} \quad (4)$$

where

C_i, C_j are the A-weighting coefficients in the third-octave bands i resp. j.

9 Expression of results

$L_{i,\text{ref,b}}$, $L_{i,\text{Fl,b}}$, $L_{i,\text{Fl,c}}$, $L_{i\ ,\text{with}}$, $L_{i,\text{pads}}$, $L_{n,\text{walk},i}$ and $u_{\text{walk},i}$ shall be given in a table as third octave band levels in dB to one decimal place.

$L_{n,\text{walk},i}$ shall be given together with uncertainty bars of ± $u_{\text{walk},i}$ in a graph, scaled as follows:

— 5 mm for one third octave band;

— 20 mm for 10 dB.

NOTE An example is shown in Annex A.

The A-weighted walking sound pressure level $L_{n,\text{walk,A}}$ shall be given in dB(A) both rounded to an integer and to one decimal place together with the uncertainty $u_{\text{walk,A}}$ as shown by the following example:

EXAMPLE $L_{n,\text{walk,A}}$ = 80 dB(A) (79,7 dB(A) ± 1,2 dB(A)).

10 Test report

The test report shall include at least the following information:

a) reference to this standard;

b) name and address of the testing laboratory;

c) manufacturer's name and product identification;

d) name and address of the person or the organisation who ordered the test;

e) name and address of the person or the organisation in charge of sampling, details of sampling, and name and the address of the person or the organisation in charge of installing the test object;

f) date of taking of the test object or test material, date of installing the specimen;

g) date of the test;

h) date of the issue of the test report;

i) detailed description of the bare floor: dimensions, mass per unit area, material;

j) detailed description of the floor covering including size of the specimens, details of the fitting into the test facility and of the fixing to the bare floor;

k) description of the test facility: type of suppression of the flanking transmission, volumes of the test rooms;

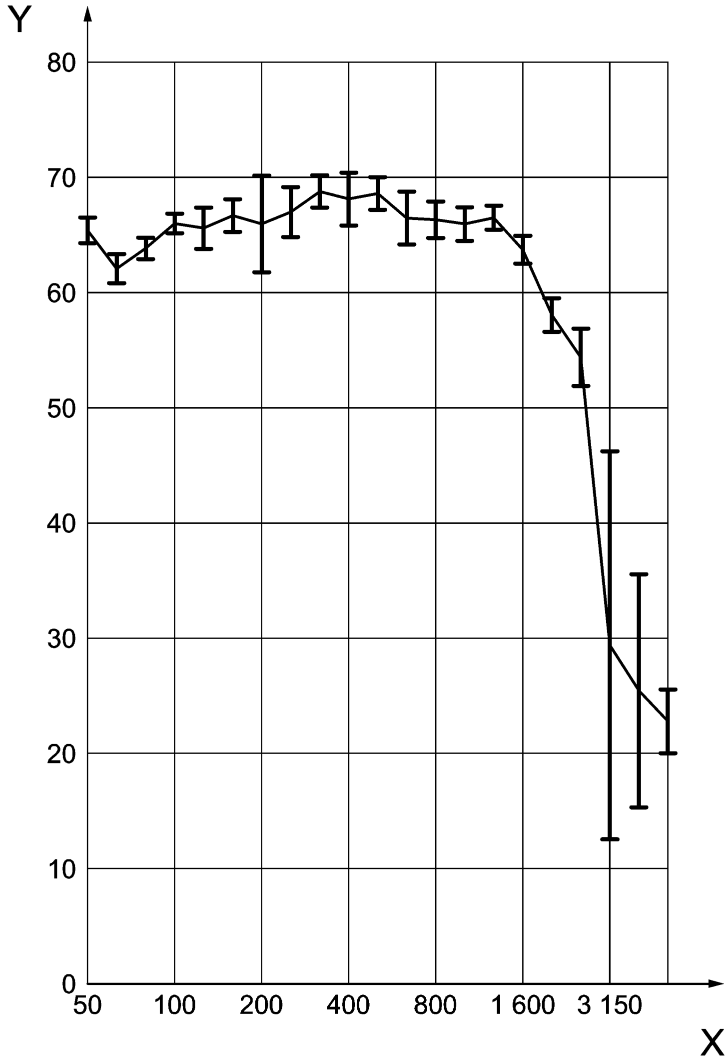
l) air temperature, static air pressure and humidity in both rooms during the measurement;

m) short description of the measuring method and a list of measuring equipment;

n) all results as specified in Clause 9.

Annex A
(informative)

Presentation of the walking noise spectrum with uncertainty bars (example)



Key

X frequency, in hertz

Y walking sound pressure level, $L_{n,walk}$, in decibels

Figure A.1 — Presentation of the walking noise spectrum with uncertainty bars (example)

Annex B
(normative)

Reference spectrum for laboratory bare floors

Table B.1 — Reference spectrum for laboratory bare floors

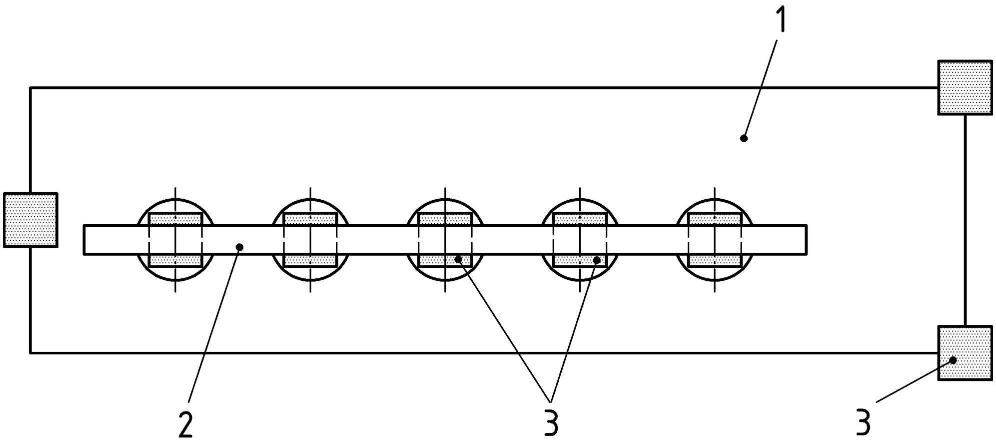
Frequency Hz	$L_{i,\mathrm{ref,b}}$ dB
50	65,5
63	66,0
80	66,5
100	67,0
125	67,5
160	68,0
200	68,5
250	69,0
315	69,5
400	70,0
500	70,5
630	71,0
800	71,5
1 000	72,0
1 250	72,0
1 600	72,0
2 000	72,0
2 500	72,0
3 150	72,0
4 000	72,0
5 000	72,0

NOTE These values agree above 80 Hz with the normalised impact sound pressure levels of the reference floor in EN ISO 717-2.

Annex C
(informative)

Fixing the pads below the tapping machine

Figure C.1 and Figure C.2 show an arrangement which allows to keep the pads of the tested material in place while the tapping machine is acting. The weight of the mat together with the adhesive tape (sticky side towards the mat and the pads) prevents the pads from jumping.



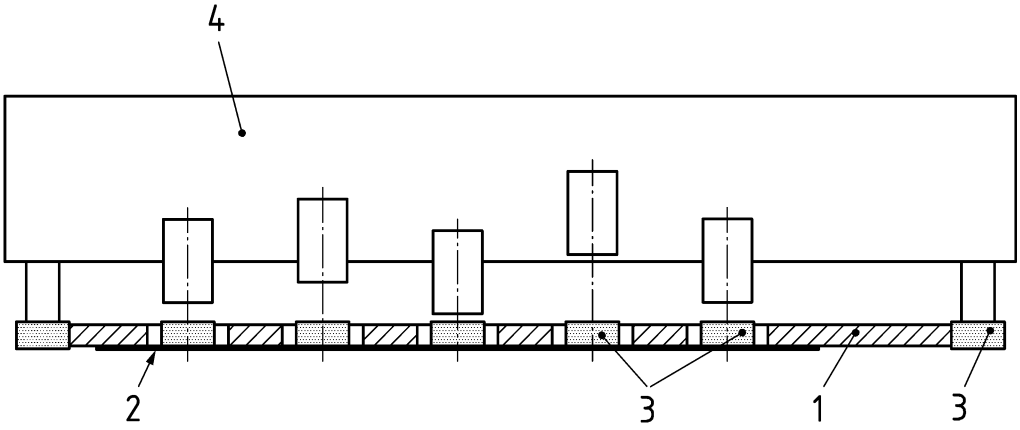
Key

1 rubber mat

2 adhesive tape, sticky side towards the pads

3 pads of the tested material

Figure C.1 — Arrangement to fix the pads of the tested material below the tapping machine's feet and hammers, view from below



Key

1 rubber mat

2 adhesive tape, sticky side towards the pads

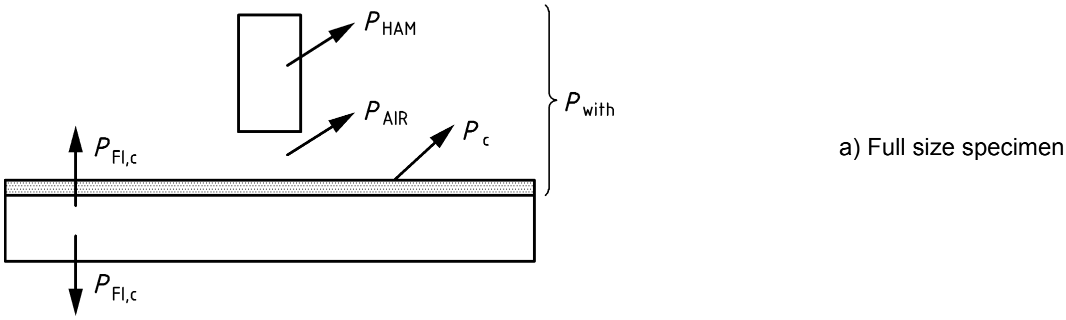
3 pads of the tested material

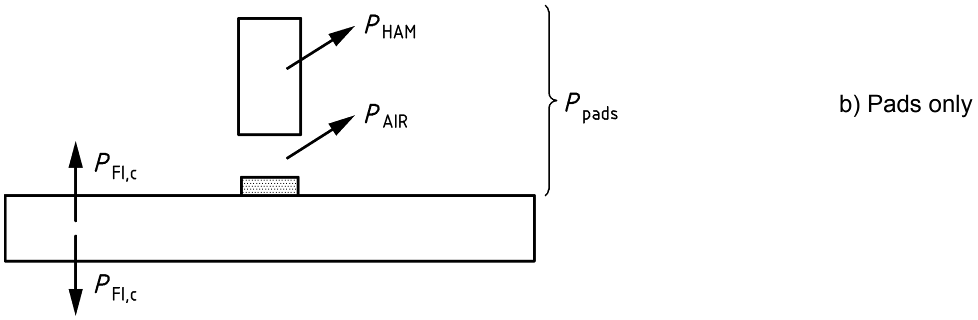
4 tapping machine

Figure C.2 — Sectional view of the arrangement

Annex D
(informative)

Background of the measuring method





Key

P_{HAM} sound power radiated by the tapping machine

P_{AIR} sound of squeezed out air between hammer and flooring

$P_{Fl,c}$ sound radiated from the supporting floor into the lower and upper rooms, when covered with the floor covering under test

P_c sound power radiated directly from floor covering

P_{with} total sound power in the upper room with (full size) flooring in place

P_{pads} total sound power in the upper room with pads in place

Figure D.1 — Sound power contributions of the different effects in the upper and lower rooms when exciting walking noise in the upper room with a tapping machine

Walking noise of a floor covering is defined as the sound power radiated directly from the floor covering, P_c, plus the sound power radiated from the supporting floor through the floor covering into the upper room, $P_{Fl,c}$. As this part depends also on the respective laboratory floor, it is adjusted by the ratio of the impact sound powers of the uncovered (bare) laboratory floor, $P_{Fl,b}$, and the reference bare floor given in EN ISO 10140, $P_{ref,b}$. Thus the walking noise power $P_{walk,i}$ in third octave band i becomes:

$$P_{walk,i} = P_{i,c} + \frac{P_{i,ref,b}}{P_{i,Fl,b}} \cdot P_{i,Fl,c} \, . \qquad \text{(D.1)}$$

Supposed, that the replacement of the full-size floor covering by the small pads will keep all power contributions unchanged apart from the omission of the power P_c of the flooring under test, then P_c can be determined by subtracting P_{pads} from.P_{with}

Expressing the power terms by the corresponding measurable sound pressure level and reverberation time values then yields Formula (1) in this standard:

$$L_{n,walk,i} = 10 \log_{10} \left(\frac{0{,}16 \cdot V_{upper}}{A_0} \left(\frac{10^{\frac{L_{i,with}}{10}}}{T_{i,upper,with}} - \frac{10^{\frac{L_{i,pads}}{10}}}{T_{i,upper,pads}} \right) + 10^{\frac{L_{i,ref,b} + L_{i,Fl,c} - L_{i,Fl,b}}{10}} \right) . \qquad \text{(D.2)}$$

With plate-like floor coverings on resilient layers, the assumption of equivalence of pads and full-size floorings may be violated, thus leading to an incorrect regard of the supporting floor and possibly of the tapping machine self noise (tapping machines are differently sensitive to changes of the underlay). But those floorings normally are sufficiently decoupled from the supporting floor and loud enough compared with the tapping machine to make the corrections then negligible. If, however, the tapping machine was louder than the floor covering, it was inappropriate for this measurement anyway, and the mandatory uncertainty evaluation should reveal this clearly.

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