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AMENDMENT 2
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Acoustics — Laboratory measurement of sound insulation of building elements —

Part 1: **Application rules for specific products**

AMENDMENT 2: Rainfall sound

Acoustique — Mesurage en laboratoire de l'isolation acoustique des éléments de construction —

Partie 1: Règles d'application pour produits particuliers

AMENDEMENT 2: Bruit produit par la pluie

Reference number
ISO 10140-1:2010/Amd.2:2014(E)

Foreword

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The committee responsible for this document is ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*.

Acoustics — Laboratory measurement of sound insulation of building elements —

Part 1: Application rules for specific products

AMENDMENT 2: Rainfall sound

Page v, Introduction

Add the following third paragraph.

Annex K has been developed for the measurement of rainfall sound.

Pages 31 to 32

At the end of Annex I and before the Bibliography, insert Annex K (see new Annex K below).

Page 32, Bibliography

Delete the following reference (i.e. Reference[6]); then, renumber Reference [7] onwards.

[6] ISO 140-18, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 18: Laboratory measurement of sound generated by rainfall on building elements*

Add the following entries.

19] ISO 15186-1:2000, *Acoustics — Measurement of sound insulation in buildings and of building elements using sound intensity — Part 1: Laboratory measurements*

[20] IEC 60721-2-2, *Classification of environmental conditions — Part 2-2: Environmental conditions appearing in nature — Precipitation and wind*

[21] McLoughlin, J., Saunders, D.J. and Ford, R.D. Noise generated by simulated rainfall on profiled steel roof structures. *Appl. Acoust*. **42**, 1994, pp. 239–255

[22] Suga, H., Tachibana, H. Sound radiation characteristics of lightweight roof constructions excited by rain. *Building Acoustics*. **1** (4), 1994, pp. 249–255

Annex K
(normative)

Roofs, roof/ceiling systems, roof windows and skylights — Rainfall sound

K.1 Application

This annex applies to the impact sound insulation of roofs, roof/ceiling systems and skylights excited by artificial rainfall. The results obtained can be used for assessing the noise to be produced by rainfall on a given building element in the room or space below. The results can also be used to compare rainfall sound insulation capabilities of building elements and to design building elements with appropriate rainfall sound insulation properties.

Real rain can be classified in terms of rainfall rate, typical drop diameters and fall velocities in accordance with IEC 60721-2-2. These values are given in Table K.1.

Table K.1 — Classification of rain type according to IEC 60721–2–2

Rainfall type	Rainfall rate mm/h	Typical drop diameter mm	Fall velocity m/s
Moderate	up to 4	0,5 to 1,0	1 to 2
Intense	up to 15	1 to 2	2 to 4
Heavy	up to 40	2 to 5	5 to 7
Cloudburst	greater than 100	>3	> 6

However, this part of ISO 10140 is based on measurements with artificial raindrops under controlled conditions using a water tank in a laboratory test facility in which flanking sound transmission is suppressed. Water tanks for two types of rain are specified in ISO 10140-5.

NOTE Measurements using real rain, although a useful means for validation purposes, are not included because of the variable, unpredictable and intermittent nature of real rain. Other mechanical simulation methods under investigation by researchers are not sufficiently well developed at the time of publication to adequately simulate real rain both in terms of sound levels and spectra generated.

The quantity to be determined is the radiated sound intensity level in the test room in third octave bands, L_i, the sound power level per unit area referenced to a value of 1×10^{-12} W/m^2. Also, the corresponding A-weighted intensity level, L_{IA}, is to be determined and for comparison purposes these levels as normalized with the results for a reference object, $L_{I,\mathrm{norm}}$ and $L_{IA,\mathrm{norm}}$.

The general guidelines in the relevant clauses of the basic ISO 10140-3 shall always be followed.

K.2 Test element

K.2.1 Standard element and laboratory configuration

The size of the opening in the roof of the test room shall be between 10 m^2 and 20 m^2, with the length of the shorter edge being not less than 2,3 m. The test element shall be well sealed at the perimeter so no transmission of sound from the outside to the receiving room takes place through the joint between the test element and the test facility. The joints within the test element, if any, shall be sealed in a manner as similar as possible to the actual construction.

For skylights, the preferred dimensions are 1 500 mm × 1 250 mm with limit deviations of ± 50 mm. Skylights shall be installed in a filler slab construction of sufficiently high airborne sound insulation and well sealed at the perimeter so that the sound field measured in the test room is only that generated by the impact excitation of the test element and radiated from the test element.

The minimum slope of the test element is 5° for roofs and 30° for skylights. The slope used shall be the lowest that is feasible to ensure water drainage. Unrepresentative niches should be limited as far as is possible in practice for small test elements like skylights, for example by installing the test element in a test opening in a construction having the same slope as the slope of the test element.

The position of a small test opening in the surrounding roof construction shall fulfil the same specifications as for a small test opening in a test wall in accordance with ISO 10140-5.

K.2.2 Other configurations

Elements of surface area less than 1 m^2 are not recommended. The slope of the test element may be the actual slope for specific situations/systems, if known.

K.3 Boundary and mounting conditions

See ISO 10140-3.

K.4 Test and operating conditions

K.4.1 General

The standard rainfall type used for comparison between products shall be the heavy type as specified in ISO 10140-5:2010, Table H.1.

Other types of rainfall are permitted as long as their characteristics as rainfall rate, volume median drop diameter and drop velocity are indicated; however, if a rainfall rate lower than the heavy rain is needed, the intense type described in ISO 10140-5:2010, Table H.1, is recommended.

After impacting on the test specimen, the water shall be drained to eliminate extraneous noise generation. The water supply pump shall either be located well away from the test room, or shall be housed in an acoustic enclosure so that its contribution to the background noise does not make rainfall measurements invalid. For smaller test specimens such as skylights, a single position for the artificial raindrop generation system is sufficient. For larger test specimens (10 m^2 to 20 m^2, see K.2.1), three positions for the artificial raindrop generation system shall be chosen. The location of the impact of artificial raindrops on the test specimen should be slightly off-centre to avoid symmetry. For non-uniform smaller test specimens (size close to 1,25 m × 1,5 m, see K.2.1) the whole surface shall be excited.

Prior to the commencement of acoustic measurements, a steady artificial rainfall rate shall be maintained over the test specimen for at least 5 min.

K.4.2 Determination of the sound intensity level (indirect method)

While maintaining the steady artificial rainfall rate, the average sound-pressure level in the test room shall be determined and corrected for background noise following ISO 10140-3. When using three positions of the rain generation system (i.e. for large test specimen) the three corresponding sound pressure levels shall be added energetically. Also, the reverberation time of the test room follows from ISO 10140-3.

The sound intensity level, L_I, is determined from the average sound pressure level for each one-third-octave band by Formula (K.1):

$$L_I = L_{pr} - 10\lg(T/T_0) + 10\lg(V/V_0) - 14 - 10\lg(S_e/S_0) \text{ dB} \quad (K.1)$$

where

L_{pr} is the averaged sound-pressure level in the test room, in decibels;

T is the reverberation time of the test room, in seconds;

T_0 is the reference time (= 1 s);

V is the volume of the test room, in cubic metres (m^3);

V_0 is the reference volume (= 1 m^3);

S_e is the area of the test specimen directly excited by the rainfall, in square metres; it corresponds to the specimen size for smaller test specimens and to three times the perforated area of the tank (see ISO 10140-5:2010, Figure H.1) for larger test specimens;

S_0 is the reference area (= 1 m^2).

The one-third-octave band levels, L_I, can be combined and converted to yield the A-weighted sound intensity level, L_{IA}, by applying the standardized A-weighting factors as given in Formula (K.2):

$$L_{IA} = 10\lg \sum_{j=1}^{j_{max}} 10^{0,1(L_{Ij}+C_j)} \text{ dB} \quad (K.2)$$

where

L_{Ij} is the level in the jth one-third-octave band;

j_{max} = 18

C_j are the values for one-third-octave band centre frequencies between 100 Hz and 5 000 Hz, which are given in Table K.2.

NOTE The sound power level radiated by the whole test specimen (of area S) could then be calculated as:

$$L_W = L_I + 10\lg(S/S_0) \text{ dB} \quad (K.3)$$

If octave band levels L_{Ioct} are to be determined, these values must be calculated for each octave band based on the three values of the corresponding third octave bands, as follows:

$$L_{Ioct} = 10\lg\left[\sum_{j=1}^{3} 10^{0,1\times(L_{I1/3oct\,j})}\right] \text{ dB} \quad (K.4)$$

Table K.2 — Values of j and C_j for one-third-octave bands

j	One-third-octave band centre frequency Hz	C_j dB
1	100	−19,1
2	125	−16,1
3	160	−13,4
4	200	−10,9
5	250	−8,6
6	315	−6,6
7	400	−4,8
8	500	−3,2
9	630	−1,9
10	800	−0,8
11	1 000	0
12	1 250	0,6
13	1 600	1
14	2 000	1,2
15	2 500	1,3
16	3 150	1,2
17	4 000	1
18	5 000	0,5

K.4.3 Direct measurement of sound intensity

As an alternative to using the sound pressure level measurement method, the sound intensity method may be employed to directly determine the sound intensity levels (see ISO 15186-1). The test room, referred to as the receiving room throughout the whole ISO 15186-1, shall then be any room meeting the requirements of the field indicator, F_{pI}, with the background noise as specified in ISO 15186-1:2000, 6.4.2 and 6.5.

If $L_{I\mathrm{m}}$ is the sound intensity level directly measured over a measuring surface, S_{m}, for each one-third-octave band centre frequency, then the sound intensity level L_I radiated by the test specimen shall be given by Formula (K.5):

$$L_I = L_{I\mathrm{m}} + 10\lg\left(S_{\mathrm{m}} / S_{\mathrm{e}}\right)\ \mathrm{dB} \tag{K.5}$$

From this, the A-weighted value and octave band values can be deduced in the same way as given in K.4.1.

K.5 Test report

See ISO 10140-3. The following additional information shall also be reported:

a) equipment and methodology used for measurements of sound pressure levels and rainfall rates;

b) description of the artificial rainfall generation system, including its characteristics and, if the system differs from the water tank described in ISO 10140-5, Annex H, the methodology used for the measurements of the rainfall rate, fall velocity and drop diameter (and spread angle if applicable), as well as the results and date of these measurements;