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Acoustics — Measurement of sound insulation in buildings and of building elements —

Part 18: **Laboratory measurement of sound generated by rainfall on building elements**

Acoustique — Mesurage de l'isolement acoustique des immeubles et des éléments de construction —

Partie 18: Mesurage en laboratoire des bruits produit par la pluie sur les éléments de construction

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 140-18 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Buildings acoustics*.

ISO 140 consists of the following parts, under the general title *Acoustics — Measurement of sound insulation in buildings and of building elements*:

— *Part 1: Requirements for laboratory test facilities with suppressed flanking transmission*

— *Part 2: Determination, verification and application of precision data*

— *Part 3: Laboratory measurements of airborne sound insulation of building elements*

— *Part 4: Field measurements of airborne sound insulation between rooms*

— *Part 5: Field measurements of airborne sound insulation of façade elements and façades*

— *Part 6: Laboratory measurements of impact sound insulation of floors*

— *Part 7: Field measurements of impact sound insulation of floors*

— *Part 8: Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a heavyweight standard floor*

— *Part 9: Laboratory measurement of room-to-room airborne sound insulation of a suspended ceiling with a plenum above it*

— *Part 10: Laboratory measurement of airborne sound insulation of small building elements*

— *Part 11: Laboratory measurements of the reduction of transmitted impact sound by floor coverings on lightweight reference floors*

— *Part 13: Guidelines* (Technical Report)

— *Part 14: Guidelines for special situations in the field*

— *Part 16: Laboratory measurement of the sound reduction index improvement by additional lining*

— *Part 18: Laboratory measurement of sound generated by rainfall on building elements*

Introduction

This part of ISO 140 prescribes a laboratory method for the measurement of sound generated by rainfall on building elements using artificial raindrops produced by a water tank.

Ideally, one should expose the test specimen to real rain for such measurements. But real rain is neither steady nor continuous with respect to time. Furthermore, raindrops can vary in diameter due to several factors, including geographic location, which will introduce variability in measured values. One can, however, use real raindrops as a means of validation of measured results obtained with artificial raindrops by building a test room in an unobstructed location. For such research, it is important that the rain sensor or rain gauge is capable of measuring constant short interval rainfall rates. In the absence of drop size information, repeatability and fluctuations of the measured sound levels with real rain can be investigated by undertaking measurements separated by a time interval of at least 24 h.

Artificial raindrop generation systems, other than the water tank used in this part of ISO 140, exist, such as hydraulic spray nozzles; however, so far, nozzles corresponding to the specifications given in this part of ISO 140 are not commercially available: indeed, their flow rate is too high when the drop diameter is correct or the drop diameter is too small when the flow rate is correct. As a result, only the water tank solution is proposed in this part of ISO 140.

An alternative to real rain or artificial raindrops is the dry mechanical excitation of the test specimen. Researchers have used different methods, such as excitation by an impact hammer and other mechanical impacting simulators, with an aim to simulate the noise of real rain. Such methods invariably suffer from the drawback that the noise source does not generate both the sound levels and the sound spectra that compare well with corresponding values generated by the real rain on various types of test specimens. Further research work is encouraged to develop mechanical methods of rain noise generation that can match both the sound levels and spectra of real rain.

Acoustics — Measurement of sound insulation in buildings and of building elements —

Part 18:
Laboratory measurement of sound generated by rainfall on building elements

1 Scope

This part of ISO 140 specifies a laboratory method of measurement of 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.

This part of ISO 140 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. 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 present to adequately simulate real rain both in terms of sound levels and spectra generated.

2 Normative references

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

ISO 140-1:1997, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 1: Requirements for laboratory test facilities with suppressed flanking transmission*

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*

ISO 3382-2, *Acoustics — Measurement of room acoustic parameters — Part 2: Reverberation time in ordinary rooms*

ISO 10848-1:2006, *Acoustics — Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms — Part 1: Frame document*

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

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

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

IEC 61672-1:2002, *Electroacoustics — Sound level meters — Part 1: Specifications*

IEC 61672-2:2003, *Electroacoustics —Sound level meters — Part 2: Pattern evaluation tests*

IEC 60942:2003, *Electroacoustics — Sound calibrators*

3 Terms and definitions

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

3.1
average sound pressure level in a room
L
ten times the common logarithm of the ratio of the space and time average of the squared sound pressure 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 (walls, etc.) is of significant influence

NOTE 1 The sound pressure level is given in decibels (dB).

NOTE 2 If a continuously moving microphone is used, L is determined by the following equation:

$$L = 10 \lg \frac{1/T_m \int_0^{T_m} p^2(t)\,dt}{p_0^2} \text{ dB} \tag{1}$$

where

$p(t)$ is the sound pressure, in pascals;

p_0 is the reference sound pressure and is equal to 20 µPa;

T_m is the integration time, in seconds.

NOTE 3 If fixed microphone positions are used, L is determined by

$$L = 10 \lg \frac{p_1^2 + p_2^2 + \ldots + p_n^2}{n p_0^2} \text{ dB} \tag{2}$$

where $p_1, p_2, \ldots, p_n$ are r.m.s. sound pressures at n different positions in the room. In practice, usually the sound pressure levels L_i are measured. In this case, L is determined by

$$L = 10 \lg \frac{1}{n} \sum_{i=1}^{n} 10^{L_i/10} \text{ dB} \tag{3}$$

where L_i are the sound pressure levels L_1 to L_n at n different positions in the room.

3.2
sound intensity level
sound power level per unit area radiated by the test specimen into the test room below referenced to a value of 1×10^{-12} W/m^2

NOTE The sound intensity level is given in decibels (dB).

3.3
rainfall rate
depth of water layer created by spreading the rainfall on a horizontal surface in a 1 h time interval

NOTE The rainfall rate is given in millimetres per hour (mm/h).

3.4
volume median drop diameter
value when 50 % of the total volume of water sprayed is made up of drops with diameter larger than the median value and 50 % with smaller diameter

NOTE The volume median drop diameter is expressed in millimetres.

4 Equipment

The accuracy of the sound level measurement equipment shall comply with the requirements of accuracy classes 0 or 1 specified in IEC 61672-1:2002 and IEC 61672-2:2003. The complete sound measuring system including the microphone shall be adjusted before each measurement using a sound calibrator which complies with the requirements of accuracy class 1 specified in IEC 60942:2003.

The one-third-octave band filters shall comply with the requirements specified in IEC 61260.

The reverberation time measurement equipment shall comply with the requirements specified in ISO 3382-2.

5 Test arrangement

5.1 Test room

A test room without a permanent roof or with an opening in the roof for installation of the test specimens is required for these measurements; however, if the intensity method is used, then the receiving space shall meet the requirements given in 7.4.

The requirements of the test room are based on ISO 140-1. The volume of the test room shall be at least 50 m^3. The ratios of the room dimensions shall be so chosen that the natural frequencies in the low frequencies are spaced as uniformly as possible. If necessary, diffusing elements should be installed in the test room to obtain a diffuse field.

The airborne sound insulation of the walls, door(s) and floor of the test room shall be sufficiently high so that the sound field measured in the test room is only that generated by the impact excitation of the test specimen and radiated from the test specimen.

The background noise level in the test room shall be sufficiently low to permit the measurement of sound generated by excitation of the test specimen with artificial rainfall. The correction associated with background noise is discussed in 7.3.2.

The reverberation time in the test room should not be excessively long. It is recommended that the reverberation time in the test room be not more than 2 s at low test frequencies. If the reverberation time in the test room is too long, proceed according to ISO 140-1.

5.2 Test specimen

5.2.1 Standard specimen and laboratory configuration

The size of the opening 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 specimen shall be well sealed at the perimeter with the test room to prevent leakage sound transmission. The joints within the test specimen, 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 specimen and radiated from the test specimen.

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

The position of a small test opening in the surrounding roof construction shall fulfil the same specifications as for a window opening in a test wall in accordance with ISO 140-3.

5.2.2 Other configurations

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

6 Classification of rain types

The 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 1.

Table 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

7 Test equipment and procedure

This clause describes the artificial rainfall types for the measurements and generation systems for artificial raindrops.

7.1 Rainfall type

7.1.1 Standard type

The standard rainfall type used for comparison between products shall be the heavy type; it should be noted that the corresponding rainfall rate might be too high when applied to a real case with lighter rain. The characteristic parameters of the artificial raindrops for this type of rainfall shall be chosen in accordance with Table 2, line 2. These values are based on Table 1 and upper limits have been chosen since larger drops produce most of the noise generated.

7.1.2 Other types

Other types of rainfall are permitted as long as their characteristics are indicated; however, if a rainfall rate lower than the heavy rain is needed, then the intense type described in Table 2, line 1 is recommended.

Table 2 — Characteristic parameters for artificial raindrops generation

Rainfall type	Rainfall rate mm/h	Volume median drop diameter mm	Fall velocity m/s
Intense	15	2,0	4,0
Heavy	40	5,0	7,0

Tolerances on the three characteristic parameters for artificial raindrops generation given in Table 2 are as follows:

a) the rainfall rate shall be within ±2 mm/h of the rainfall rate given in Table 2;

b) 50 % of the drops should be within ±0,5 mm of the volume median drop diameter given in Table 2;

c) 50 % of the drops should be within ±1 m/s of the fall velocity given in Table 2.

7.2 Generation of artificial raindrops

7.2.1 General

The artificial raindrop generation system, when connected to a water supply, is capable of generating water drops of uniform diameter in a full water spray pattern. The water supply to generate artificial raindrops may be either a closed loop type or a continuous type that enables continuous generation of constant diameter water drops over a long period of time.

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 5.2.1), 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 5.2.1) the whole surface shall be excited.

7.2.2 Artificial raindrop generation system

The artificial raindrop system shall be a tank with a perforated base capable of generating water drops with the specification given in Table 2 in a full spray pattern. The perforations on the tank base should be distributed over a minimum area of 1,6 m^2, thus totally covering smaller test specimens in the standard configuration with a 30° slope; a random distribution is preferred rather than a uniform distribution (see Figure A.1).

The water supply pressure and the number of perforations shall be chosen so that the water height in the tank is constant and allows the rainfall rate given in Table 2 to be generated by the perforated tank. The perforation characteristics (diameter) of the tank base shall be chosen so that water drops with the volume median drop diameter given in Table 2 are produced by the perforated tank. The fall height of the artificial raindrops shall be adjusted such that either the measured or the theoretically calculated fall velocities based on perforation dimensions, water pressure and fall height are as given in Table 2. For the determination of the fall height for inclined surfaces, see Figure A.2. The specifications, dimensions and other design parameters of tanks with a perforated base that meet the above requirements are given in Annex A, as well as a sketch showing a typical test arrangement (see Figure A.2).

7.2.3 Calibration of the raindrop generation system

The artificial raindrop generation system shall be calibrated.

If a water tank system is used and therefore follows the geometrical characteristics given in Annex A, then only the rainfall rate shall be checked by collecting the water over a given area over a precisely measured time period; the measurement of the rainfall rate allows a quick and simple method for periodic verification of the artificial raindrop generation system.

If another system is selected in order to generate other types of rain fall, the rainfall type characteristics, i.e. the drop size, drop velocity and rainfall rate, shall be given by the manufacturer; if they are not available, they should be measured. Here again, the measurement of the rainfall rate allows a quick and simple method for periodic verification of the artificial raindrop generation system.

NOTE There are several non-intrusive methods to measure drop size and drop velocity as, for example, imaging analysers consisting of a light source (typically a strobe light), a video camera and a computer, or phase Doppler particle analysers consisting of a transmitter, a receiver, a signal processor and a computer.

7.3 Determination of the sound intensity level (indirect method)

7.3.1 Sound pressure level measurements

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

While maintaining the steady artificial rainfall rate, sound-pressure levels in the test room shall be averaged either with a rotating microphone boom or at fixed microphone positions. The sound pressure levels at different positions shall be averaged on an energy basis.

The following separating distances are minimum values and shall be exceeded where possible:

— 0,7 m between microphone positions;

— 0,7 m between any microphone position and room boundaries or diffusers;

— 1,0 m between any microphone and the test specimen.

When using fixed microphones, a minimum of five microphone positions shall be used in the test room; these shall be distributed within the maximum permitted space and spaced uniformly in the test room. The averaging time at each individual microphone position shall be at least 6 s at each frequency band with centre frequencies below 400 Hz. For bands of higher centre frequencies, it is permissible to decrease the averaging time to not less than 4 s.

The frequency range considered is the one specified in ISO 140-3, corresponding to one-third octaves from 100 Hz to 5 000 Hz with a complement, if necessary, of one-third octaves from 50 Hz to 80 Hz.

When using a moving microphone, the sweep radius shall be at least 1 m. The plane of the traverse shall be inclined in order to cover a large proportion of the permitted room space and shall not lie in any plane within 10° of a room surface. The duration of the traverse period shall not be less than 15 s. The averaging time shall cover a whole number of traverses and shall not be less than 30 s.

When using three positions of the rain generation system (i.e. for large tests specimen), the three corresponding sound pressure levels should be added energetically.

7.3.2 Correction for background noise

The background noise levels shall be measured to ensure that the observations in the test room are not affected by extraneous noise. The background level shall be at least 6 dB (and preferably more than 15 dB) below the measured sound pressure levels with artificial rainfall noise signal and background noise combined. When, in any frequency band, the difference between the measured sound pressure level in the test room and the background noise is smaller than 15 dB but greater than 6 dB, calculate corrections to the signal level according to the equation

$$L = 10 \lg \left(10^{L_{sb}/10} - 10^{L_b/10} \right) \text{ dB} \tag{4}$$

where

L is the adjusted signal level, in decibels;

L_{sb} is the level of signal and background combined, in decibels;

L_b is the background noise level, in decibels.

If the difference in levels is less than or equal to 6 dB in any of the frequency bands, use the correction 1,3 dB corresponding to the difference of 6 dB. In that case, the results shall be reported so that it is clear that the reported values are the limit of measurements.

7.3.3 Conversion of sound pressure levels to sound intensity levels

The sound pressure level measured according to 7.3.1 shall be converted to the sound power level per unit area or sound intensity level, L_I, radiated by the test specimen for each one-third-octave band centre frequency by the following equation:

$$L_I = L_{pr} - 10 \lg (T/T_0) + 10 \lg (V/V_0) - 14 - 10 \lg (S_e/S_0) \text{ dB} \tag{5}$$

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 Figure A.1) for larger test specimens.

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

The reverberation time of the test room should preferably be measured by measuring the decay rates using the interrupted noise method as described in the ISO 3382-2.

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 follows:

$$L_{IA} = 10 \lg \sum_{j=1}^{j_{max}} 10^{0,1\left(L_{Ij} + C_j\right)} \text{ dB} \tag{6}$$

where

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

j_{max} = 18, and the C_j values for one-third-octave band centre frequencies between 100 Hz and 5 000 Hz are given in Table 3.

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

$$L_W = L_I + 10 \lg(S / S_0) \text{ dB} \quad (7)$$

Table 3 — 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

If octave band levels $L_{I\text{oct}}$ 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:

$$L_{I\text{oct}} = 10 \lg \left[\sum_{j=1}^{3} 10^{0,1 \times \left(L_{I\,1/3\text{oct}\,j} \right)} \right] \text{ dB} \quad (8)$$

7.4 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 $L_{I\text{m}}$ 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 the following equation:

$$L_I = L_{I\text{m}} + 10 \lg(S_\text{m} / S_\text{e}) \text{ dB} \quad (9)$$

7.5 Normalization using a reference test specimen

7.5.1 Reference test specimen

For comparison purposes, a reference test specimen as described in Annex B, mounted according to the specification given in 5.2.1 and submitted to the heavy rain type as described in 7.1, should be measured (see details in Annex B).

7.5.2 Normalization

The sound intensity levels L_I obtained for the specimen tested according to 7.3.3 or 7.4 should be normalized with respect to the results obtained for the test reference specimen, using the correction term $\Delta L_{I\text{c}}$ defined in Annex B and leading to the normalized sound intensity levels defined by

$$L_{I\,\text{norm}} = L_I - \Delta L_{I\text{c}} \tag{10}$$

The one-third-octave band levels, $L_{I\,\text{norm}}$, can then be combined and converted to yield the A-weighted sound intensity level $L_{I\,\text{A norm}}$ by applying the standardized A-weighting factors as shown in 7.3.3.

8 Expression of results

The sound intensity levels (L_I) and A-weighted sound intensity levels ($L_{I\,\text{A}}$) as a function of frequency should be expressed with a precision to 0,1 dB and presented in a table and a graph. The graphs in the test report should indicate values in decibels as a function of frequency on a logarithmic scale and the following dimensions should be used:

— 5 mm per one-third-octave band;

— 20 mm per 10 dB.

The global A-weighted sound intensity level $L_{I\,\text{A}}$, and the corresponding rainfall rate should also be given.

The normalized sound intensity levels ($L_{I\,\text{norm}}$) as a function of frequency should also be expressed with an accuracy of 0,1 dB and presented in the table and the graph. The global A-weighted normalized sound intensity level $L_{I\,\text{A norm}}$ should also be provided.

9 Measurement uncertainty

The measurement uncertainties associated with rainfall sound pressure levels determined in accordance with this part of ISO 140 are normally evaluated in accordance with the ISO Guide to the Expression of Uncertainties in Measurement (GUM) [3]. However, at the time when this part of ISO 140 was being prepared, insufficient information was available on how to draw up a statement in accordance with the GUM. An indication of the kind of information which would need to be included in such a statement is the uncertainty of the values of sound pressure level, rainfall height, rainfall rate, drop size, the rainfall area, and the determination of the normalization factor $\Delta L_{I\,\text{c}}$.

The uncertainties arise in part from variations between test sites, rain boxes, the geometry of the test room, specimen mountings, niche dimensions, absorption at the specimen mounting and test room structures, and surfaces, background noise, and the type and calibration of instrumentation. They are also due to variations in experimental techniques, including the size and shape of the test specimen, number and location of microphone positions.

Interlaboratory testing should be performed as soon as possible to determine interlaboratory reproducibility, especially for reporting the result of rainfall noise generation from a normalized specimen.

The expanded measurement uncertainty of determinations of sound power level or sound energy level made in accordance with this part of ISO 140, for a coverage probability of 95 % (coverage factor $k = 2$) as defined in the GUM [3], shall be taken to be two times the standard deviation of reproducibility, unless more specific knowledge is available.

10 Test report

The test report shall include the following information:

a) reference to this part of ISO 140;

b) name and the address of the testing laboratory;

c) manufacturer's name and product identification;

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

e) date of test;

f) description of the test specimen, with sectional drawings and mounting conditions including size, thickness, mass per unit area, curing time and condition of components, and a statement indicating who mounted the test object (test institute or manufacturer);

g) details of the test room, its dimensions and volume, materials of construction, and diffusers;

h) method of attachment of the test specimen to the ceiling of the test room, dimensions and slope of the test specimen;

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

j) description of the artificial rainfall generation system, including its characteristics and, if the system differs from the water tank described in Annex A, 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;

k) rainfall type and rainfall rate in millimetres per hour (mm/h);

l) position of the artificial rainfall generation system with respect to the test specimen, as well as the area and location of the test specimen sprayed (for large specimens, this shall be given for all three different positions of the artificial rainfall generation system);

m) temperature and humidity level in the test room, as well as the temperature of the rainwater;

n) sound intensity levels (L_I) and A-weighted sound intensity levels ($L_{I\,\mathrm{A}}$) as a function of frequency in a table and graph form, and global A-weighted sound intensity level $L_{I\,\mathrm{A}}$ as well as the corresponding rainfall rate.

If tests on reference specimen have been performed:

o) normalized sound intensity levels ($L_{I\,\mathrm{norm}}$) as a function of frequency in a table and graph form, and the global A-weighted normalized sound intensity level ($L_{I\,\mathrm{A\,norm}}$).

Annex A
(informative)

Example of a tank with perforated base

Two different tanks with different perforated bases are required for artificial raindrop production; one for heavy type rain (mandatory) and the second for the intense type rain (only recommended if lower rainfall rates are needed). The corresponding specifications are given in Table A.1. The tanks are made from polycarbonate plates of thickness 1 cm; the base is reinforced by metal strips.

Table A.1 — Specifications

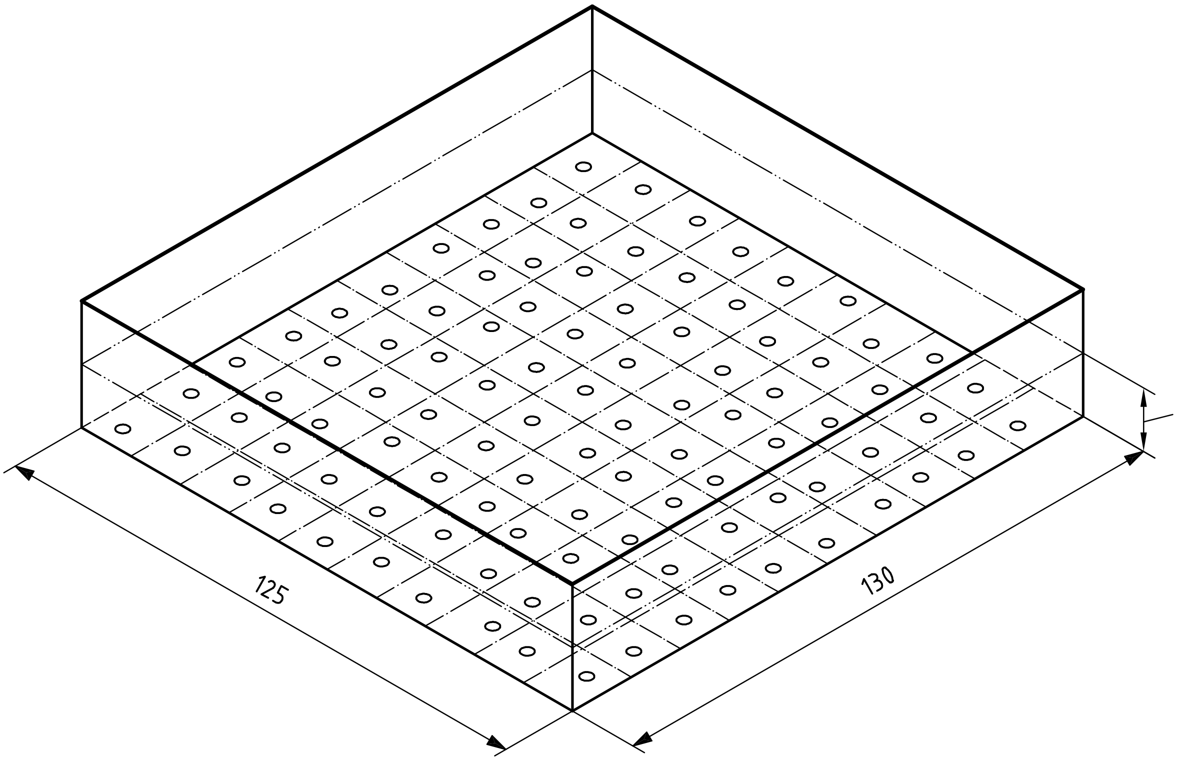
Parameters of tank with perforated base		Intense	Heavy
1	Diameter of holes	0,3 mm to 0,5 mm	1 mm
2	Number of holes per unit area	Approx. 25 m^{-2}	Approx. 60 m^{-2}
3	Fall height	Approx. 1 m	Approx. 3,5 m
4	Volume median drop diameter	2 mm	5,0 mm
5	Distribution of drop size	Max. uniformity	Max. uniformity
6	Fall velocity at fall height	4 m/s	7 m/s
7	Rainfall rate	15 mm/h	40 mm/h
8	Water supply	To allow a constant height of water in the tank (50 mm to overflow limit)	

If the tank with perforated base does not correspond to the geometrical characteristics given above, then the drop size, impact velocity and rainfall rate shall be measured as mentioned in 7.2.3 and correspond to the values given in Table 2.

Tolerances on the rainfall rate, the volume median drop diameter and the fall velocity specified above are given in 7.1.

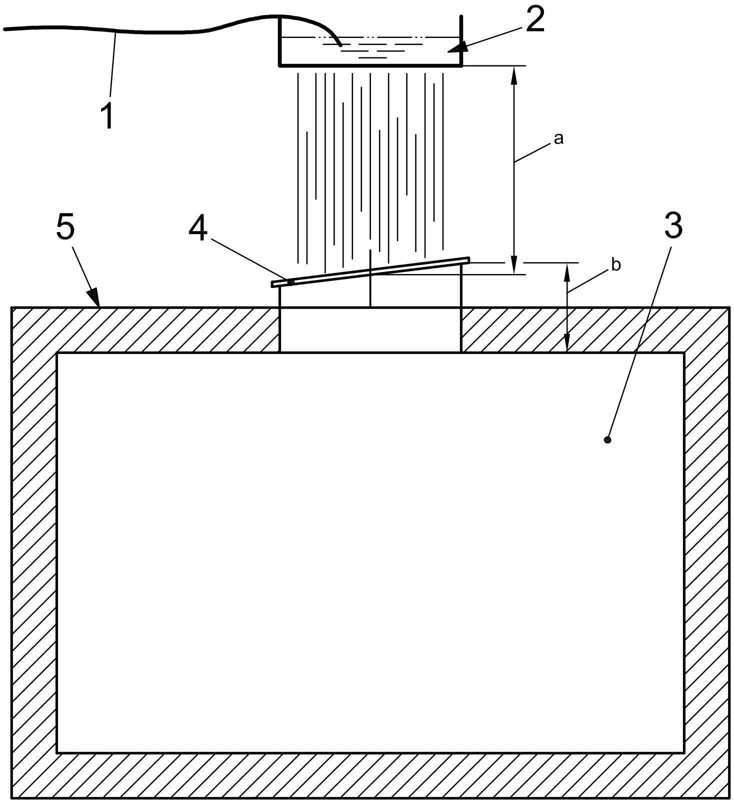
The fall height is evaluated from Figure 6 of Reference [1].

Dimensions in centimetres



a Typical water height.

Figure A.1 — Schematic of tank with perforated base



Key

1 water-supply system
2 tank with perforated base
3 test room
4 test specimen
5 water drainage (arranged by user)

a Fall height.
b Height of the niche.

Figure A.2 — Typical test arrangement

Annex B
(informative)

Reference test specimens

B.1 General

Standard reference test specimens are described in this annex for quality control and to check the reproducibility of laboratory rain noise measurements in different laboratories. Details of the reference test specimens are as follows.

B.2 Small test specimen

The small reference test specimen is made of a single glass pane with a thickness of (6 ± 0,1) mm and an area of (1 250 ± 50) mm × (1 500 ± 50) mm (as specified in ISO 140-1:1997, 3.2.3); the mounting of the glass pane is shown in ISO 140-1:1997, Figure 1, except for the edge used for water drainage. The position of the artificial rainfall generation system is centred with respect to the test specimen.

WARNING — The single glass pane might break during handling at more than 2,5 m above the floor. Therefore, care should be taken during handling.

To calibrate the mounting conditions of the reference test specimen, the structural decay time T_s shall be measured according to ISO 10848-1:2006, 7.3, from which the total loss factor η of the reference specimen is calculated, using:

$$\eta = \frac{2{,}2}{f\ T_s} \tag{B.1}$$

The sound intensity level $L_{I,\text{ref}}$, obtained according to 7.3.3 or 7.4 for the reference specimen, is then corrected for the difference between the measured loss factor η and the reference loss factor η_{ref} given in Table B.1, using:

$$L_{I,\text{m,ref}} = L_{I,\text{ref}} + 10\ \lg \frac{\eta}{\eta_{\text{ref}}}\ \text{dB} \tag{B.2}$$

A correction $\Delta L_{I\text{c}}$ is then calculated from the difference

$$\Delta L_{I\text{c}} = L_{I,\text{m,ref}} - L_{I\text{c, ref}} \tag{B.3}$$

where $L_{I\text{c, ref}}$ is the reference sound intensity level for the small test specimen, given in Table B.1.

B.3 Large test specimen

This will be specified during the next revision of this part of ISO 140.

Table B.1 — Reference loss factor and reference intensity level used for the small reference test specimen

One-third-octave band Hz	**Reference loss factor:** 10 lg(η_{ref}/η_0) ($\eta_0 = 1$) dB	**Intensity level:** $L_{I,c,ref}$ dB
100	−10	45
125	−11	45
160	−11	46
200	−12	46
250	−13	47
315	−13	47
400	−14	47
500	−14	47
630	−15	47
800	−15	46
1 000	−16	44
1 250	−17	42
1 600	−17	43
2 000	−18	46
2 500	−18	51
3 150	−19	50
4 000	−19	46
5 000	−20	44

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