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

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

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

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*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.

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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.

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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

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, standards.iteh.ai/catalog/standards/sist/efc7550f-b3d1-4f9d-9006-efd45fd60f0c/iso-140-18-2006
 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

$$L = 10 \lg \frac{p_1^2 + p_2^2 + \dots + p_n^2}{np_0^2} \text{ dB} \tag{2}$$

where p_1, p_2, \dots, 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 $1 \times 10^{-12} \text{ W/m}^2$

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

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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 m³. 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 m² and 20 m², 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 m² 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 $\pm 0,5$ 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 m² to 20 m², 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 \times 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 m², 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.