System of national standards for measuring and evaluating sound insulation

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Abstract. The features of international standards being introduced in the Russian Federation in the field of measurement and rating of sound insulation are considered. It has been noted that over the past eight years, on the basis of international standards, a system of fundamental national standards of Russia has been created to measure and evaluate sound insulation in buildings and elements of buildings and structures. The system includes five standards that establish technical methods for laboratory measurements of airborne and impact sound insulation, a standard that establishes approximate methods for field measurements of airborne and impact sound insulation, two standards for a single-number assessment of airborne and impact sound insulation, a standard that sets the rules for determining and application of the uncertainties of sound insulation measurement. In 2018, 2019, on the basis of international standards, drafts of two national standards were prepared on the methods of field measurements of sound insulation of building facades and their elements and sound insulation of airborne sound between two rooms in a building.

1. Introduction

The main regulatory and technical document, according to which since 1987 measurements of sound insulation of building envelopes in Russia, is the Interstate Standard GOST 27296 “Buildings and constructions. Methods for measurement of sound insulation of protecting designs”. The Standard establishes methods for measuring the insulation of air and impact noise by internal and external building envelopes (walls, ceilings and their elements, partitions, floor coverings) of residential and public buildings in laboratory and field conditions. In 2013, five national standards of the GOST R ISO 10140 series “Acoustics. Laboratory measurements of sound insulation of building elements” were introduced as identical standards to the corresponding series of international standards. In 2016, on the basis of the international standard ISO 10052 [1], the national standard GOST R 56689 “Acoustics. Field measurements of airborne and impact sound insulation and of service equipment sound. Survey method”. The standards were prepared by the Research Center for Monitoring and Diagnostics of Technological Systems (NITS KD, Nizhny Novgorod).
In 2016, two national standards GOST R 56769 “Buildings and constructions. Rating of airborne sound insulation” and GOST R 56770 “Buildings and constructions. Rating of impact sound insulation”, in which single-number quantities for airborne and impact sound insulation in buildings and of building elements are defined and rules for their determination are specified. Standards are a partial introduction of similar international standards of the ISO 717 series [2]. In 2018, on the basis of the international standard ISO 12999-1 [3], the national standard GOST R 57900 “Buildings and constructions. Determination and application of measurement uncertainties of sound insulation” was introduced. The standards were developed by the Research Institute of Building Physics of the Russian Academy of Architecture and Building Sciences (NIISF RAABS) as a partial introduction of the international standards.

In 2018, 2019, on the basis of international standards of the ISO 16283 series [4] (parts 1 and 3), draft national standards were developed by NIISF RAABS for technical methods of field measurements of sound insulation of building facades and their elements and airborne sound insulation between two rooms in a building. The national standardization plan for 2020 includes the development of a national standard governing the technical methods of field measurement of impact sound insulation in buildings and of building elements through the partial introduction of part 2 of the international standard ISO 16283 [4].

Together with the national standard GOST R 56235 “Declaration and verification of airborne sound insulation values for sound insulators” introduced in 2014, these standards form a system of fundamental national standards of the Russian Federation, which allows performing certification testing of soundproofing characteristics of building products at the modern world level. This paper describes the features of the national standards included in the system and indicates their differences from the provisions of interstate standard GOST 27296.

2. Laboratory measurements
The requirements for laboratory measurements of airborne and impact sound insulation are set out in parts 2-4 of GOST R ISO 10140. For products without specific application rules, parts 2 and 3 are sufficiently complete and general for the execution of measurements with a technical degree of accuracy. Part 1 (GOST R ISO 10140-1) establishes test requirements for determining the sound insulation of building elements and products with specific application rules, such as light partitions, doors, windows, glazing, shutters, small technical elements, as well as test requirements for improvement of airborne sound insulation by acoustical linings and impact sound insulation by floor coverings. They include requirements for the preparation, installation, test conditions and functioning of the products to be tested, as well as requirements for the determined values and additional information included in the test report. Requirements for laboratory test installations and equipment for measuring sound insulation of building elements are set in GOST R ISO 10140-5. The standard is applicable to laboratory test installations, in which measures are taken to attenuate flanked sound transmission, and the source room is structurally isolated from the reception room. It also provides methods for the certification of new test facilities during their commissioning.

The scope of the standards GOST R ISO 10140 series is fully consistent with the scope of GOST 27296 for measuring sound insulation in laboratory conditions and additionally applies to small technical elements that are construction products (excluding windows and doors) with an area of less than 1 m², made in accordance with a certain size range and transmitting noise between adjacent rooms or from a room to the outside, regardless of the adjacent building structures. Examples of such elements are ventilation panels, air intakes, electric cable ducts, profiles and shutter boxes. In addition, the reference application GOST R 10140-4 provides guidance on measuring sound pressure in the frequency range below 90 Hz (one third octave bands with central frequencies of 50, 63, 80 Hz), and in GOST R ISO 10140-3 an alternative method is given using heavy and soft impact sources to assess
the sound insulation of the floor by impact sound arising from sources with intense low-frequency components, for example, walking without shoes or when a child is jumping on the floor. However, these standards did not find wide application in the Russian measurement practice, that is obviously due to the fact when they were introduced in forth, the use of appropriate laboratory methods from GOST 27296 in the Russian Federation was not canceled.

3. Field Measurements

Survey methods for measuring sound insulation of airborne and impact sound in field conditions are specified in GOST R 56689. They are applicable for measurements in the premises of residential buildings or in other proportionate rooms with a volume of not more than 150 m$^3$ and allow to determine sound insulation parameters in octave frequency bands. They simplified the determination of the average sound pressure levels in the receiving room due to manual scanning by the microphone of the space in the room. As a result, they can be used in preliminary tests to determine the acoustic characteristics of buildings and their elements.

Technical methods for measuring sound insulation of airborne sound are specified in the draft national standards GOST R (ISO 16283-1) “Buildings and constructions. Field measurement of sound insulation of building elements” and GOST R (ISO 16283-3) “Buildings and constructions. Field measurement of sound insulation of facades and their elements”. Measurements are performed in one-third octave frequency bands and, by analogy with laboratory methods, they provide for the use of several measuring circuits: a stationary microphone; a microphone that is manually moved from one position to another; set of stationary microphones; microphone continuously moving along a certain path mechanically or manually (scanned microphone). Unlike the field methods from GOST 27296, they allow to determine apparent sound reduction index and standardized level difference for a building element in the extended frequency range, including one-third octave bands of the low frequency range with central frequencies of 50, 63 and 80 Hz and the high frequency range of 4000 and 5000 Hz. No requirements are imposed on the nature of the sound field in the room: it may may or may not approximate to a diffuse field.

Depending on the frequency range in which the measurements are carried out, two measurement procedures are specified: the main procedure, used when the measurements are carried out in the standard range of one-third octave bands with central frequencies from 100 to 3150 Hz, and the additional low-frequency procedure, used when measurements are performed in the third-octave band with central frequencies from 50 to 80 Hz, if the volume of the source and/or receiver room is less than 25 m$^3$. This procedure is used in addition to the main one and consists of additional measurements of sound pressure levels in the corners of the receiving room. Measurements in one-third octave bands with central frequencies of 4000 and 5000 Hz are also optional.

Depending on the test object, two groups of methods are specified in the draft standard for measuring the sound insulation of facades and their elements: element methods if the object under test is an element of the facade, and facade methods when an entire facade is tested. Depending on the sound source to be used, the methods within the groups are divided into element loudspeaker and facade loudspeaker methods, if a loudspeaker is used as the sound source, and element road traffic, element railway traffic, element aircraft traffic or facade road traffic, facade railway traffic, facade aircraft traffic methods, when the specified types of transport is used as the sound source. The element loudspeaker method is preferred when evaluating the sound insulation of a facade element, and the facade road traffic, facade railway traffic or facade aircraft traffic methods are preferred for evaluating the sound insulation of an entire facade located in a particular place and exposed to noise from a specified mode of transport. The element loudspeaker method can be applied as a technical method in laboratory conditions, when the loudspeaker is located in the adjacent reception room, which does not
require the creation of a diffuse sound field and sound can be transmitted from the loudspeaker to the test specimen at an angle of 45°.

4. Evaluation of single-number quantities

The purpose of introducing the standards GOST R 56769 and GOST R 56770 is the application of methods by which the airborne and impact sound insulation in the frequency bands can be converted into one number, giving an integrated assessment of the soundproofing properties of the structure being evaluated. The single-number quantities in accordance with these standards are intended for rating airborne and impact sound insulation and for simplifying the formulation of acoustical requirements in building codes. The standards define a list of single-number quantities for airborne and impact sound insulation and give rules for their determination based on the results of measurements performed in accordance with the fundamental measuring standards. A single-number quantity is defined as the value in decibels of the estimated curve at a frequency of 500 Hz after shifting it in accordance with established rules.

Before the introduction of these standards in Russia, two single-number quantities were used: the insulation index of airborne sound $R_w$ and the index of the reduced level of impact sound $L_{nw}$. The quantity $R_{mean}$ in dBA was adopted as a single-number assessment of the airborne sound insulation of external building envelopes (including windows and other types of glazing) from external noise produced by the flow of urban transport. In the introduced national standards, the list of single-number quantities is expanded, the concept of a spectral adaptation term is introduced, and their presentation is changed.

Among the quantities characterizing airborne sound insulation by building elements, in addition to the sound insulation index $R_w$, the index of the reduced difference of sound pressure levels of flanked sound transmission $D_{h,c,w}$ and the index of the reduced difference of sound pressure levels of the element $D_{h,e,w}$ are included. The quantities characterizing the airborne sound insulation in buildings along with the apparent airborne sound insulation index $R_{w}′$ include the apparent traffic noise insulation index $R_{w,TR}′$, the reduced sound pressure difference index $D_{n,w}$ and the standardized sound pressure difference index $D_{n,T,w}$. Single-number quantities characterizing the insulation of impact sound between rooms in buildings along with the index of the apparent reduced level of impact sound $L_{n,w}'$ include the index of the standardized reduced level of impact sound $L_{n,T,w}'.

To account the characteristics of particular sound spectra, the concept of spectrum adaptation terms is introduced in the standards and methods for their determination are specified. GOST R 56769 introduces two spectrum adaptation terms $C$ and $C_n$, which are determined using the pink noise spectrum (spectrum No. 1) and the road traffic noise spectrum (spectrum No. 2) appropriately. In accordance with the results of the studies [5], it is recommended to be guided by spectrum No. 1 for railway noise sources, or use A-weighted relative spectra for the noise of passenger trains, electric trains and high-speed trains in accordance with the national standard GOST R 54933 “Noise. Calculation methods for external noise emitted by railway transport”.

Statement of performance of building elements is recommended as stating the two spectrum adaptation terms in parentheses after the single-number quantity, separated by a semicolon, for example $R_w (C, C_n) = 41 (0, -5)$ dB, and the statement of requirements and of performance of buildings shall be based on the sum of this value and the relevant spectrum adaptation term, for example $R_w + C ≥ 45$ dB (e.g. for facades) or $D_{n,T,w} + C ≥ 54$ dB (e.g. between dwellings). As a result, the total amount gives a reduction of the sound level $A$ of a source located inside the building by an internal fencing. For external enclosure construction, the related amount is equal to $R_{mean}$, i.e. meets the reduction of the sound level $A$ from road traffic flow by a facade fencing. Features of introduction of GOST R 56769 in Russia are in detail described in the paper [6].
GOST R 56770 introduces one relevant spectrum adaptation term $C_l$, the determination of which is performed in such a way that adding it to the single-number quantity $L_{n,w}$ gives the linear impact sound level, which is frequency unweighted. It is indicated in the Standard (with references to works [7]-[10]), that the unweighted impact level of a tapping machine is more representative of the $A$-weighted impact levels as caused by walking for all types of floor. In addition, the standard provides a method for calculating the index of reduction of the level of impact sound by floor coverings not only on bare heavy floors (as in GOST 27296), but also on lightweight floors using normalized impact sound pressure levels for three types of the lightweight reference floors specified in GOST R ISO 10140-5.

5. Sound insulation uncertainty assessment

The requirements for the estimation of sound insulation uncertainty are specified in GOST R 57900. The standard includes: a method for estimating uncertainties, rules for determining uncertainties from laboratory tests and procedures for applying uncertainties. In addition, it gives typical uncertainties for quantities determined by measurement standards and their corresponding single-number quantities.

As it pointed in [3], an assessment of uncertainties that is comprehensible and close to reality is indispensable for many questions in building acoustics. Whether a requirement is met, a laboratory delivers correct results or the acoustic properties of a product are better than the same properties of some other product can be decided only by adequately assessing the uncertainties associated with the quantities under consideration.

Uncertainties are expressed in accordance with the principles of GOST R 54500.3 “Uncertainty of measurement. Part 3. Guide to the expression of uncertainty in measurement” with using the numerical method according to GOST R 54500.3.1 “Uncertainty of measurement. Part 3. Guide to the expression of uncertainty in measurement Supplement 1. Propagation of distributions using a Monte Carlo method”. GOST R 54500.3 is identical to ISO/IEC Guide 98-3 [10] and defines a detailed procedure for uncertainty estimating, which is based on a full mathematical model of the measurement procedure. Based on modern knowledge, it is impossible to formulate such models for various quantities in building acoustics. Therefore, this national standard, as the international one, provides only principles for such an uncertainty estimation.

In the standard, the concepts of reproducibility and repeatability are used, which is the traditional way of setting uncertainty in building acoustics. These concepts make it possible to establish the uncertainty of the method and measurements, based on the results of inter-laboratory measurements.

6. Conclusions

At present, in Russia, on the basis of international standards, a system of fundamental national standards for measuring and evaluating the insulation of air and impact noise of buildings and structures and their elements has been practically created, which allows performing certification testing of soundproofing characteristics of building products at the modern world level. It can be improved and supplemented, for example, by the introduction of the i methods using sound intensity. On the other hand the test codes specified certification requirements for certain types of products (e.g. doors and windows) must be brought into line with fundamental standards.

The presence of such a system provides domestic manufacturers of building products with a technical opportunity to enter the world market.

References
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