



Airborne sound insulation between two cinemas

Ilya Tsukernikov Research Institute of Building Physics (NIISF RAABS), Moscow, Russia. Alexander Fadeev

Research Institute of Building Physics (NIISF RAABS), Moscow, Russia.

Summary

The number of cinemas has increased over the past 10 - 15 years in Russia. The main part of new cinemas is multiplex cinemas in the shopping and entertainment malls. It is mean that in multiplex two cinemas may show the movies at the same time. The problem of airborne sound isolating by a partition/slab between two multiplex cinemas halls is considered. The analysis of the regulatory and technical documents (the International Standard, and the national documents of the Russian Federation, as well as the corporative standards of international cameramen) is done. The levels of penetrating noise through a partition between two cinemas halls are measured for two cinemas. The discrepancy between the estimated sound insulation parameters and the requirements of the current regulatory documents are shown.

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1. Introduction

There are more than 4000 operating cinema halls on the territory of the Russian Federation in 2017. Most of them are part of multiplexes. This means that several rooms can be located in close proximity to each other. In the majority of multiplexes, the cinema halls are divided among themselves by a partition, less often – by a slab.

The acoustic system of the modern cinema hall is characterized by the ability to reproduce high levels in the low frequency range (octave bands with centre frequencies (f_c) 31.5, 63 and 125 Hz). At the same time, as is known from the theory and practice of building acoustics, the sound insulation of airborne noise by a barrier in the low frequency is less than in the middle and high frequencies. That's why operation of two cinemas halls can lead to penetration of the sound of one cinema hall into another, to cause complaints of cinema visitors to penetrating noise.

These facts allow us to consider the task of airborne sound insulation of a barrier (partition or slab) between two cinemas in the low frequency as one of the actual problems of building acoustics. This article reviews the current national, international regulatory framework, as well as the standards of enterprises of leading cinema industry operators. The results of field acoustic measurements of the airborne sound insulation by a partition between two cinemas in Moscow are given. Deficit of airborne sound insulation by the partition with respect to the current normative and technical documents is shown, especially in the low-frequency range (octave bands with $f_{c.} = 31.5 - 250$ Hz).

2. Regulation by normative and technical documents

2.1. National standards of the Russian Federation

On the territory of the Russian Federation, there is the Code of Rules SP 51.13330.2011 [1], the main requirements of which are mandatory for implementation in accordance with the Decree of the Government of the Russian Federation No. 1521 of December 26, 2014 [2]. This document regulates airborne sound insulation between rooms of different purposes. But there is no cinema hall category in [1]. At the same time SP 51.13330.2011 regulates the permissible values of sound pressure levels of penetrating noise for cinemas with Dolby equipment.

There are no cinema industry standards in the field of building acoustic today in Russia. We can note the Building Regulations and Rules SNiP II-L.15-68 [3] which was in force from 1968 to 1977. This document limits the levels of penetrating noise below 40 dB in octave bands with $f_{c.} = 31.5 - 8000$ Hz. However, the revolutionary changes in the cinema industry do not allow it to be used. The positions of [1] and [3] are given in Table I.

Normative document	Limit sound pressure level, dB, in octave band with centre frequencies, Hz								
	31,5	63	125	250	500	1000	2000	4000	8000
SP 51.13330-2011 [1] SNiP II-L.15-68 [3]	72 40	55 40	44 40	35 40	29 40	25 40	22 40	20 40	18 40
IMAX [4] (ISO 9568: 1993 [5], SMPTE RP141-1995 [6])	65	54	44	37	31	27	24	22	21
THX Standard [7]	69	57	48	42	35	31	29	28	27

Table I. Maximum permissible sound pressure levels of background noise in the cinema hall.

Table II. Minimum NR levels between two cinema halls.

Normative document	NR level, dB, in octave band with centre frequencies, Hz								
	31,5	63	125	250	500	1000	2000	4000	8000
IMAX [4]	40	55	65	70	70	70	70	70	70
THX Standard [7]	38	48	52	54	66	66	66	66	66

2.2 International and cinema industry documents

One of the leading operators of cinema hall industry is IMAX Corporation (Canada). IMAX has an internal document [4], which requires the levels of background noise (from all sources inside or outside the cinema hall), based on the requirements of the International Standard ISO 9568: 1993 [5] and the standard of the Society of Motion Picture and Television Engineers SMPTE RP141-1995 [6]. Document [4] also limits the requirements for minimum noise reduction levels (NR) penetrating to the IMAX cinema hall from another cinema hall.

Lucasfilm LTD (USA) is another of leader of cinema hall industry. Lucasfilm LTD has an internal standard THX Standard [7], which regulates the maximum levels of background noise (NC - noise criteria) from all sources inside or outside the cinema hall as NC30 and limits the levels of NR too.

The positions of documents [4-7] are given in Table I and minimum NR values are given in Table II.

SP 51.13330-2011 [1] has the most stringent requirements for noise penetrating into the cinema hall in the middle and high frequency bands. IMAX document [4] and International Standard [5] and Standard [6] have the most stringent requirements for noise penetrating into the cinema hall in the low frequency bands. These documents have more stringer requirements for noise reduction between cinema halls than Standard [7]. SP 51.13330-2011 has no requirements for external noise reduction.

3. Field measurements of airborne sound insulation in the multiplex (Moscow)

Acoustic measurements of airborne sound insulation between two cinema halls were made in August 2017. Considered a couple of cinema halls, separated by a partition.

3.1. Field measurement scheme

On the multi-channel acoustic system of the source cinema hall was given a test signal ("pink" noise). Sound pressure levels in both cinema halls were measured by sound level meter "EKOFIZIKA-110A" (Russia). The sound level meter was installed at a height of 1,2 meter from the floor. Source cinema hall was cinema hall 3 for 207 visitors (volume is 5000 m³). Microphone cinema hall was cinema hall 4 for 197 visitors (volume is 5000 m³). Acoustic measurement scheme is shown in Figure 1.

3.2. Measurement results

The measured values of sound pressure levels and normative curves according to Table I are shown in Figure 2.

Noise penetrating in the cinema hall 4 exceeds the permissible values of normative technical documents. In the low frequencies range (octave bands with $f_c = 63 - 250$ Hz) the penetrating noise exceeds the permissible values of all normative documents. In the middle and high frequencies ranges (octave bands with $f_c = 500 - 4000$ Hz) the penetrating noise exceeds the permissible values of normative documents [1, 4-6].



Figure 1. Cinema halls 3 and 4 (situation plan).

Figure 2. Sound pressure levels in cinema halls 3 and 4.



3.3 NR evaluation

The noise reduction by the partition between the cinema halls is determined by the formula:

$$NR = L_{m1} - L_{m2} , (1)$$

where L_{m1} , L_{m2} are the average values of sound pressure levels in source and microphone cinema halls, dB.

The results of calculations in octave bands are shown in Figure 3 and compared with the requirements of Table II.



Figure 3. Measured noise reduction by the partition between cinema halls 3 and 4.

Noise reduction by the partition between two cinema halls does not meet the requirements of IMAX Standard [4] in octave bands with $f_c = 31.5$ – 8000 Hz. Noise reduction by the partition between two cinema halls meets the requirements of the THX Standard in only one octave band with $f_c = 8000$ Hz. The worst sound insulation is observed in the low-frequency range (octave band with $f_c = 31.5 - 250$ Hz), were the NR deficit exceeds 26 dB in relation to the requirements of IMAX Standard [4] and 20 dB in comparison with the requirements of the THX standard [7].

4. Cinema hall field measurement (Saint Petersburg)

The measurements were made in August 2017. The sound pressure levels were measured during

the trailer was played (3-5 minutes) in the central part of the cinema hall with volume 1600 m^3 . The sound level meter was installed at a height of 1,2 m from the floor. The measurement results are shown in Figure 4.



Figure 4. Measured sound pressure levels in cinema halls.

Trailer sound has a pronounced low-frequency character. The sound pressure levels emitted by trailer in octave bands with $f_c = 31.5$ and 63 Hz are more than pink noise signal used in section 3. This fact clearly demonstrates that there is airborne sound insulation deficit in the low-frequency range for this cinema hall too and there is the need to increase the soundproofing properties of the partitions, especially in the low-frequency range.

5. Conclusions

The experimental studies have established deficit of airborne sound insulation by a partition between two cinema halls in relation to the current normative and technical documents. It is shown that the most problematic frequency range is the low-frequency range (octave bands with $f_c = 63-250$ Hz).

Field measurements of sound pressure levels in the cinema hall during the trailer sound reproduction confirmed the pronounced low-frequency nature of the emitted noise. This fact shows that increase airborne sound insulation in the low-frequency range by a partition between two cinema halls is actual task of building acoustics.

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