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NOISE CONTROL FOR A BETTER ENVIRONMENT

Evaluation of the noise that penetrating through the partition between two cinema halls

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ABSTRACT

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 noise penetration through a partition between two cinema halls that make up the multiplex is considered. The analysis of the regulatory and technical documents (the International Standard, the national documents of the Russian Federation, as well as the corporative standards of international cameramen) is done. The results of a series of field measurements of acoustic parameters are presented. The actual airborne sound insulation by partition wall and the single-number quantities are evaluated. It is shown for sound generated by cinema hall acoustic system playing a promo trailer, that as the spectral adaptation term of the expediency to use the arithmetic average of the both spectral adaptation terms for enlarged frequency range. The discrepancy between actual attenuation of noise levels and the requirements of the current regulatory documents in the field of low frequencies (octave bands with average geometric frequencies of 31.5 - 125 Hz) is demonstrated.

Keywords: Noise, Airborne sound insulation by a barrier, Cinema
I-INCE Classification of Subject Number: 33

1. INTRODUCTION

There are more than 4000 operating cinema halls on the territory of the Russian Federation in 2018. 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

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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 is 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 – 125 Hz).

2. REGULATION BY NORMATIVE AND TECHNICAL DOCUMENTS

2.1 National standard 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 1.

2.2 International and cinema industry documents

One of the leading operators of cinema hall industry is IMAX (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 2.

Table 1. Maximum permissible sound pressure levels of background noise in the cinema hall

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]	72	55	44	35	29	25	22	20	18
SNiP II-L.15-68 [3]	40	40	40	40	40	40	40	40	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 2. 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

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 CINEPLEX

Field measurements of airborne sound insulation between two cinema halls were done in April 2018. A couple of cinema halls separated by a partition were considered.

3.1 Field measurement scheme

There are cinema hall 5 for 109 seats and cinema hall 6 for 44 seats on the 3rd floor of the shopping and entertainment complex in Moscow.

The source hall is cinema hall 5 and the receiving hall is cinema hall 6. The volume of cinema hall 5 is 1150 m^3. The volume of cinema hall 6 is 720 m^3. Situation plan of the cinema halls is shown in Figure 1.

There are microphone posisions of sound level meter in the source and reciving halls in Figure 1. The posisions of microphons were chosen accordance with GOST 27296-2012 [8] at a height of 1.2-1.5 m no closer than 2 m from the walls and not in the central area of the rooms.

The area of the partition between two cinema halls is 115 m^2. Schematic diagram of the device partitions between cinema halls is shown in Figure 2.

Sound pressure levels (SPL) were recorded simultaneously by microphones of two sound level meters «ECOPHYSICA 110» with the measurement time of 30 seconds.

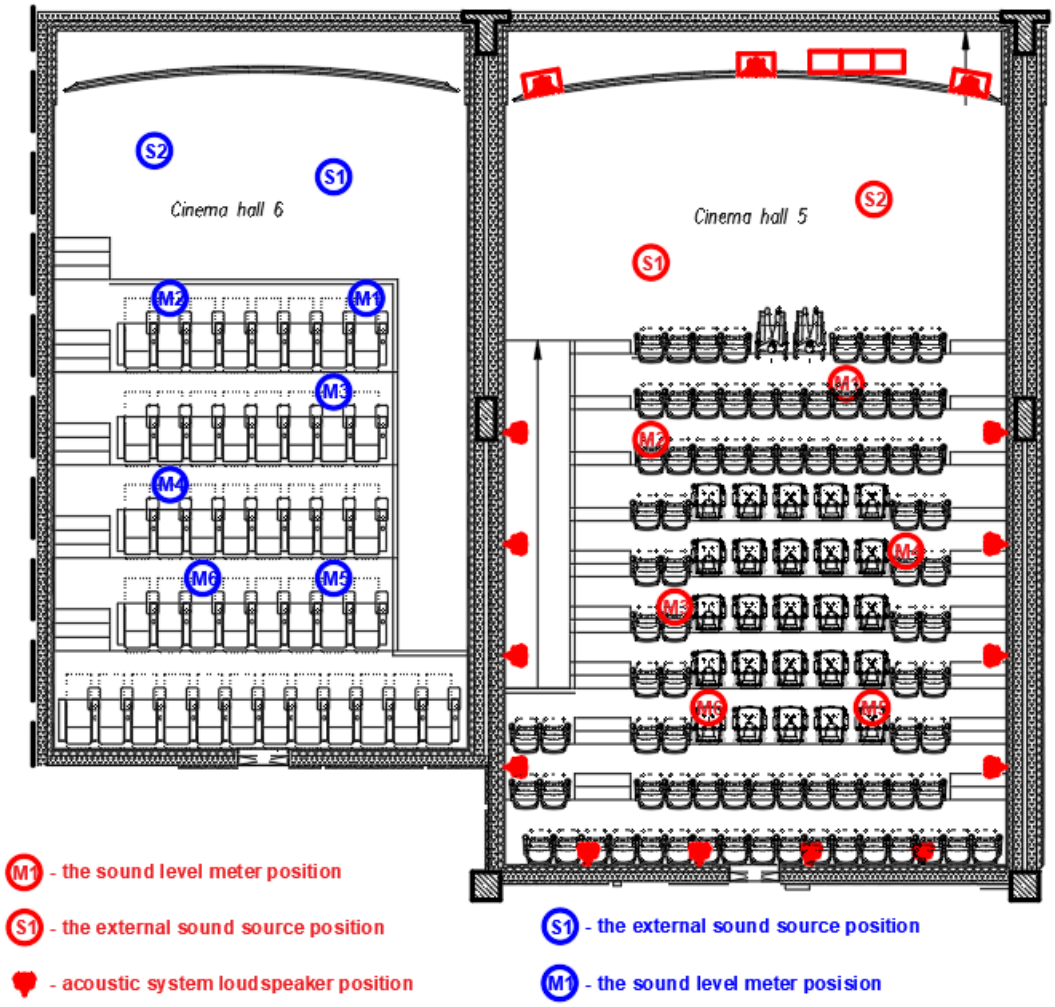

Figure 1. Cinema halls 5 and 6 (situation plan)

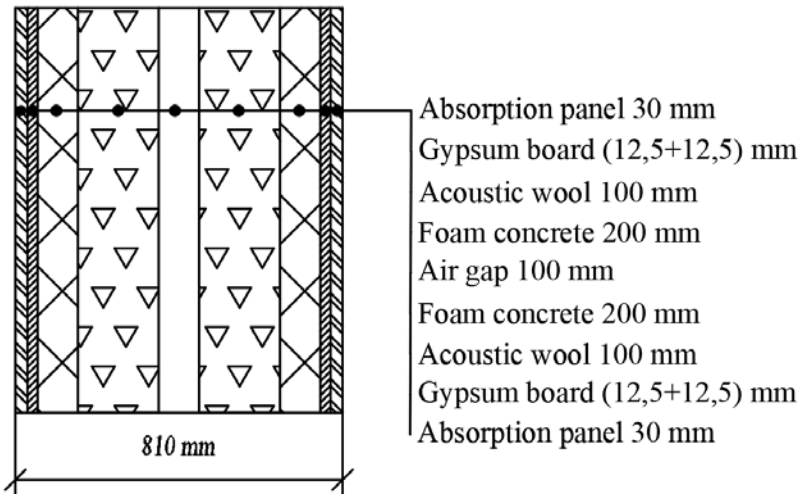

Figure 2. Partition scheme

The sound sources are a special source (acoustic system «BEHRINGER EUROLIFE B615», Germany, China) and the cinema hall 5 multichannel acoustic system. A modulated signal with a spectrum of pink noise generated in the EASERA

software package based on the HP laptop was fed to the acoustic system «BEHRINGER EUROLIFE B615». The cinema hall multichannel acoustic system played promo trailer.

3.2 Measurement result of airborne sound insulation between cinema hall 5 and 6

Field airborne sound insulation measurement between halls 5 and 6 was done according to GOST 27296-2012 [8]. Reverberation time was measured according with GOST R ISO 3382-2-2013 [9] and is shown in Table 3.

Table 3. Receiving cinema hall reverberation time

f_c, Hz	50	63	80	100	125	160	200
T, s	0.41	0.54	0.58	0.52	0.66	0.62	0.56
f_c, Hz	250	315	400	500	630	800	1000
T, s	0.55	0.53	0.48	0.37	0.31	0.27	0.29
f_c, Hz	1250	1600	2000	2500	3150	4000	5000
T, s	0.27	0.28	0.27	0.25	0.30	0.31	0.28

The measured values of SPL in the source and receiving cinema halls are shown on Figure 3.

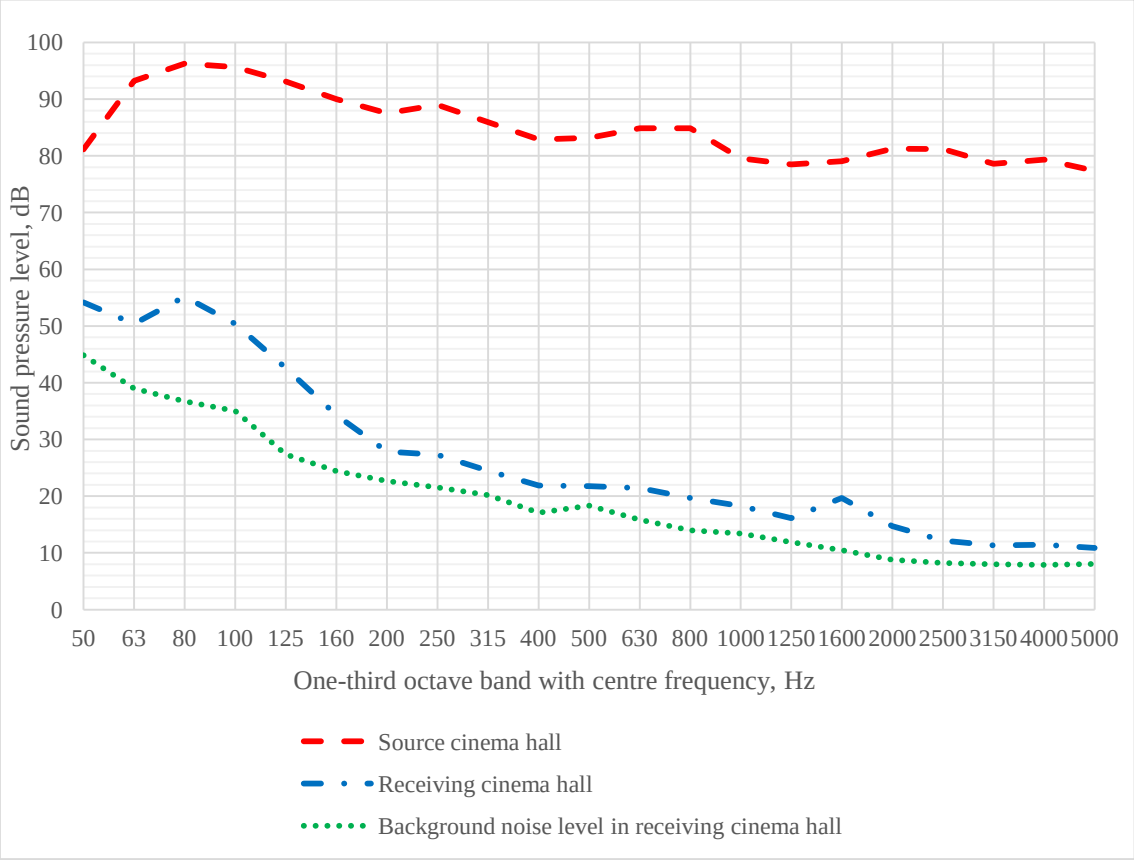

Figure 3. Source and receiving cinema hall SPL

The apparent sound reduction index between two cinema halls is calculated by Equation 1[8]:

$$R' = L_{m1} - L_{m2} + 10\lg\frac{S}{A_2}, \quad (1)$$

where L_{m1} is the average SPL in the source cinema hall, dB; L_{m2} is the average SPL in the receiving cinema hall, dB; S is the partition area, m^2; A is the equivalent sound absorption area of receiving cinema hall, m^2.
Equivalent sound absorption area was determined from Equation 2:

$$A_2 = \frac{0.16V}{T}, \quad (2)$$

where V is the receiving cinema hall volume, m^3; T is the receiving cinema reverberation time, s, taken from Table 3.

Airborne sound insulation is calculated into account the influence of background noise according to the [8]. The results are shown in Table 4.

Table 4. Apparent sound reduction index between halls 5 and 6

f_c, Hz	50	63	80	100	125	160	200
R', dB	24.0	40.1	38.6	42.3	48.6	53.5	59.0
f_c, Hz	250	315	400	500	630	800	1000
R', dB	59.9	60.6	59.7	59.0	59.2	60.4	57.8
f_c, Hz	1250	1600	2000	2500	3150	4000	5000
R', dB	58.6	54.8	61.8	64.9	65.0	65.7	63.8

Weighted apparent sound reduction index R'_w and spectrum adaptation terms C and C_{tr} was calculated accordance with GOST R 56769-2015 [10], which is the harmonized introduction of International Standard ISO 717-1:2013 in Russia. Trailer sound is similar to a disco sound that is why accordance with [10] it is necessary to calculate and use C_{tr}. The results are:

R'_w= 60 dB, C= -1, C_{tr} = -3; $C_{50\text{-}3150}$ = -3, $C_{tr,50\text{-}3150}$ = -12; $C_{50\text{-}5000}$ = -2, $C_{tr,50\text{-}5000}$ = -12.

Spectrum adaptation term C_{tr} for octave frequency bands with f_c = 50-3150 Hz and f_c = 50-5000 Hz differs significantly from spectrum adaptation term C_{tr} for tradition octave frequency bands with f_c = 100-3150 Hz. This fact shows that low-frequency range significantly affects airborne sound insulation.

For choosing spectrum adaptation term it is recommended in [10] to compare the A-weighted spectrum of a certain type of noise with Spectrum 1 and Spectrum 2 from [10]. The A-weighted SPL measured in the source cinema hall during promo trailer is played, Spectrum 1 and Spectrum 2, , are given in Figure 4. All curves are shifted to 80 dB in octave frequency band with f_c = 500 Hz.

The A-weighted SPL in the source cinema hall is between Spectrum 1 and Spectrum 2 in the frequency range with f_c = 63 - 500 Hz and for spectral adaptation term determination it should be used the arithmetic average of the values of both spectra for enlarged frequency range: C_{p} = ($C_{50\text{-}5000}$.+ $C_{tr,50\text{-}5000}$)/2 = -7 dB..

At the same time according to [10] the sum of weighted sound reduction index $R'_w$and spectral adaptation term shall be equal to the reduction of A-weighted sound pressure level by partition. The difference of the measured A-weighted sound pressure levels between two cinema halls is 53.3 dB and with an accuracy of 0.3 dB is equal to$R'_w + C_{\text{p}}$.

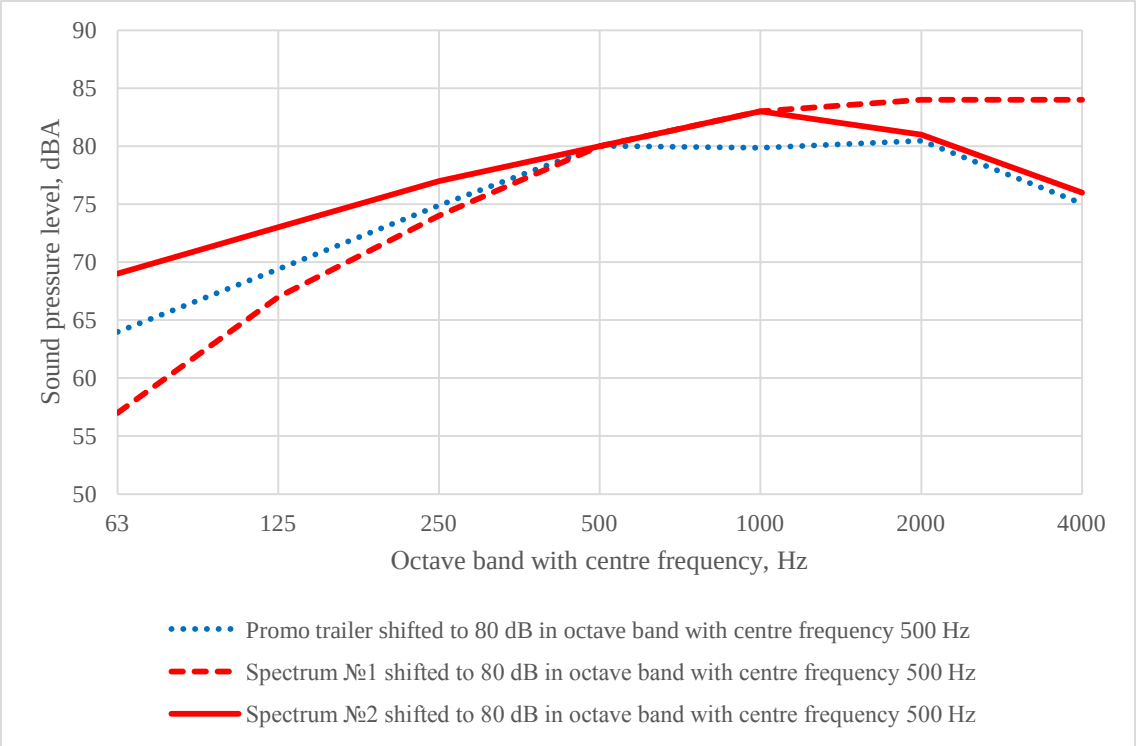

Figure 4. A-weighted source cinema hall SPL when promo trailer is played

3.3 Comparison of measurement results with the requirements of regulatory and technical documents

Besides of measurements of airborne sound insulation between two cinema halls the sound pressure levels were measured in source and receiving cinema halls during playback of the trailer. The trailer was played by the source hall speakers at normal volume. The measured sound pressure levels in the receiving cinema hall when trailer is playing and when the standard external loudspeaker (which used in airborne sound insulation measurements in subsection 3.2) emits the pink noise are shown in Figure 5. Figure 5 also shows the requirements of the regulatory and technical documents specified in Table 1.

The penetrating noise in the receiving cinema hall from the both sources exceeds the permissible values of all regulatory and technical documents in the low-frequency range: in octave bands with f_c = 31.5-63 Hz for the cinema acoustic system and in octave bands with f_c = 63-125 Hz for standard external loudspeaker.

The noise reduction (NR) by the partition between the cinema halls is determined by Equation 3:

$$NR = L_{m1} - L_{m2} \tag{3}$$

where L_{m1} is the average SPL in the source cinema hall, dB; L_{m2} is the average SPL in the receiving cinema hall, dB.

The NR values in octave frequency bands for pink noise (emitted by the standard external loudspeaker) and for promo trailer noise are shown in Figure 6 and compared with the requirements from Table 2.

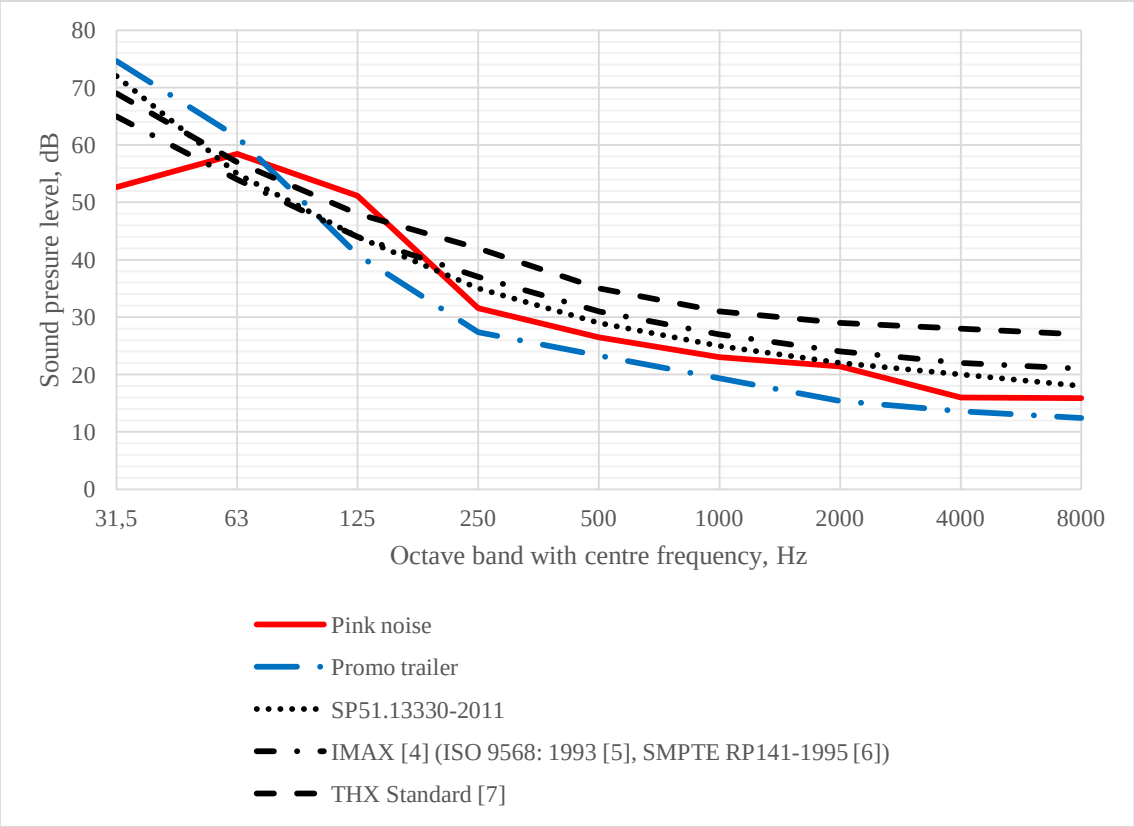

Figure 5. SPL in the cinema hall 6

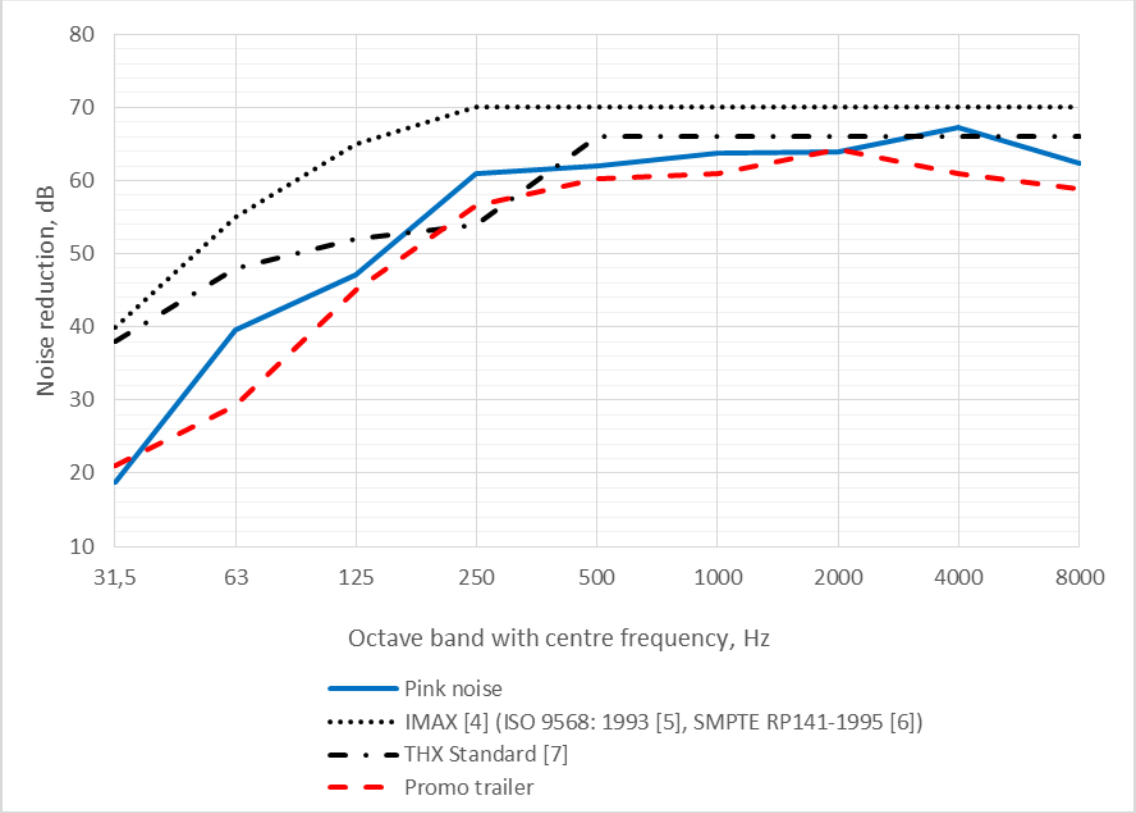

Figure 6. Noise reduction by a partition between cinema halls 5 and 6

Noise reduction between cinema halls does not meet the requirements of the International Standard [5] and documents [4, 6] for both type of sound signal. THX standard requirements are met only for two octave bands with f_c = 250 Hz and 4000 Hz for noise from standard external loudspeaker. The worst sound reduction is observed in the low-frequency range (octave bands with f_c = 31.5-125 Hz), where the noise reduction deficit exceeds 19 dB relative to the requirements of the International standard [5] and documents [4, 6] and 6 dB compared to the requirements of the standard THX [7].

5. CONCLUSIONS

The trailer sound does not attribute neither to the reference Spectrum №1 nor Spectrum №2 and for the spectral adaptation term of a partition between two cinema halls it should be used the arithmetic average of the both spectral adaptation terms $C_{50\text{-}5000}$ and $C_{tr,50\text{-}5000}$ for enlarged frequency range..

The deficit of airborne reduction by the partition relative to the existing normative technical documents is established. It is shown that the most problematic frequency range is the low-frequency range (octave bands with f_c = 31.5-125 Hz).

6. REFERENCES

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