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Increase of sound proofing of air duct

Igor Shubin, Vladimir Gusev and Marina Pestereva

Research Institute of Building Physics (NIISF RAABS), 21, Lokomotivny pr., 127238 Moscow, Russian Federation
marina_niisf@mail.ru

One of ways of noise protection from transit air duct is increase of sound insulation of air duct by different acoustical materials. The main interest of this work is in comparative analysis of acoustic efficiency different thermal insulation materials for use as sound insulation coverings. The report contains analysis of the distribution of noise through round and rectangular air ducts. There was discovered different types of thermal insulation materials such as easy made foam materials and fibrous materials. Tests are executed in the reverberation chamber. The received results have shown advantage of a fibrous material.

A high noise level of transit air ducts, as is known, presents a serious problem.

One of the ways of reducing noise emitted by transit air-ducts in rooms through which they pass is to increase the soundproofing property of their walls by means of various coats.

The paper discusses a comparative analysis of the acoustic efficiency of various soundproofing materials when they are used as soundproofing coats of surfaces of circular and rectangular air ducts.

Sound propagation through walls of circular and rectangular air ducts is characterized by peculiar acoustic properties.

In the engineering analysis of sound isolation a rectangular air duct is considered as a thin-walled plate. The sound in such structures propagates presumably in the form of flexural waves which are easily induced by airborne sound waves and in their turn they emit easily sound energy into the surrounding space (Fig. 1).

Sound transmission through cylindrical shells (for circular air ducts) is of a more complex pattern as there not only flexural but longitudinal waves also play an important role (Fig. 2).

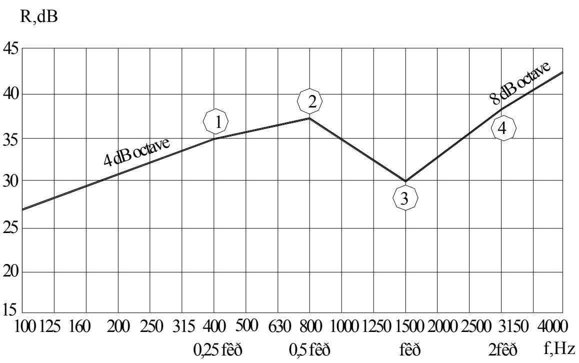

Fig. 1. The frequency property of isolation of airborne sound of a steel thin-wall plate.

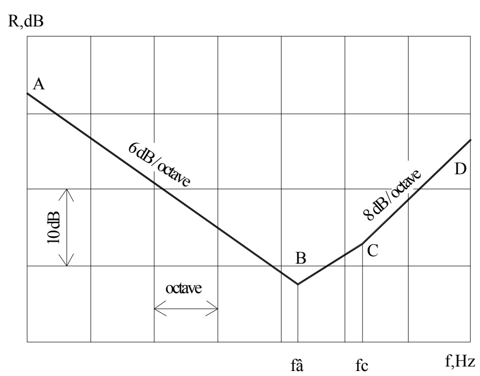

Fig. 2. The frequency property of isolation of airborne sound of a steel cylindrical shell.

The soundproofing of a two-layer structure (the wall of the air-duct with a heat-insulation coating) is defined by the following formula:

$\mathbf{R=R_1+\Delta R_1}$,

$\mathbf{\Delta R_1=8.7lgs\beta}$ at $s\beta>1$

$\mathbf{\Delta R_1=0}$ at $s\beta\leq1$, where

R_1 is soundproofing of a single-layer structure of the air-duct,

ΔR_1 is the additional soundproofing of the heat-insulation coating layer,

S is the thickness of the heat-insulation material, mm,

β is the damping factor for this material, 1/cm.

For the comparative analysis of the acoustic efficiency of heat-insulation coating for lining of air ducts the following materials were tested

1. A synthetic lightweight foamed material – shells on circular air ducts, 40 mm and 50 mm thick (δ=35 kg/m^3).

2. A lightweight foamed self-adhesive sheet heat-insulation material out of foamed polyethylene coated with aluminum foil, 10 mm and 20 mm thick(ρ=25 kg/m^3).

3. A fibrous ISOVER heat-insulation material out of rolled glass-wool laminated with aluminum foil, 30 mm (ρ=30 kg/m^3) and 100 мм thick (ρ=22 kg/m^3).

The tests were carried out by the reverberation technique based on acoustic measurements in the reverberation chamber of 120 m^3 in volume.

In determining the soundproofing properties circular and rectangular air ducts were used, the length of the air ducts was 3 m, the thickness of the walls was 0.55 mm.

During the tests the air duct ends (open ends) were closed tightly with plug fittings of high soundproofing properties. The tested material was spread along the total length of the air ducts and adhered tightly to the air duct walls to achieve the maximum acoustic effect.

The scheme of the experimental installation for determining the acoustic characteristics of materials is shown in Fig. 3.

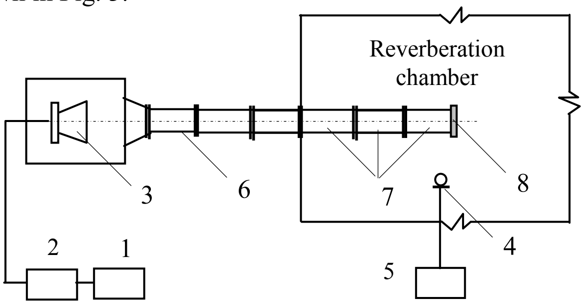

Fig. 3 The scheme of the experimental installation for testing air ducts coating.

1 – white noise generator;

2 – power amplifier;
3 – sound source;
4 – measuring mike;
5 – Larson&Devis sound-level meter- spectrum analyzer of type 2800 (USA made)
6 – connecting air duct;
7 – air duct being tested (coated);
8 – soundproofing plug fitting.

The test results are given in Table 1.

Figures 4 and 5 show the influence that the ISOVER heat-insulation coating exerts on the soundproofing properties of a circular air duct. Figures 6 and 7 also illustrate the influence of the heat- insulation material on soundproofing properties of rectangular air ducts.

It is seen that at low frequencies the soundproofing property of air ducts increases but not more than by 3 to 5 dB. As the frequency goes up, the soundproofing property increases significantly up to 20 dB and higher. It is important when it is necessary to reduce noise of transit air ducts emitting high-frequency aerodynamic noise.

Mean values of soundproofing of walls of circular air ducts due to coating with ISOVER type material, 30 mm thick, increase from 5 to 17 dB in the mean and high-frequency ranges of frequencies (1000-8000 Hz), and for the coating thickness of 100 mm they increase by 11 to 20 dB.

The mean values of increase of soundproofing of rectangular air duct walls due to ISOVER coating are somewhat lower than for circular ducts. But for the thickness of 30 mm they are equal to 7 – 10 dB and for the layer thickness of 100 mm they reach 10 to 13 dB.

As is seen from Table 1, the coating of air ducts with lightweight foamed materials manifests itself in the soundproofing of air ducts only at very high frequencies. The enhancement of soundproofing by just 6 to 10 dB is achieved only within the octave band with the mean geometric frequency of 8000 Hz, which means that such materials cannot be recommended for tackling most practical problems of reducing noise emitted by transit air ducts.

The presented results of the acoustic tests carried out show the preference of the ISOVER fibrous material coating of air ducts in increasing their soundproofing properties.

Hence fibrous material of the ISOVER type can be recommended to design companies to be used for increasing soundproofing of air ducts.

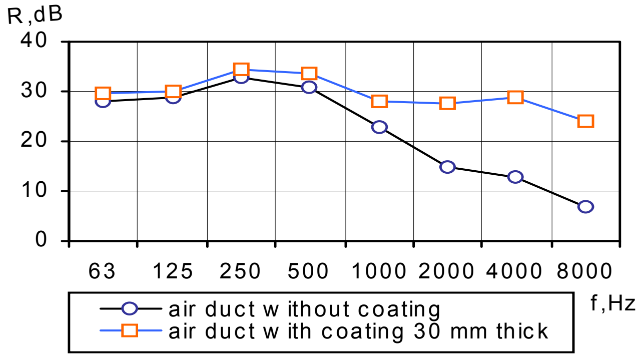

Fig. 4. The enhancement of soundproofing property of circular air ducts due to ISOVER material, 30 mm thick (a - air duct without coating, b - air duct with coating, 30 mm thick)

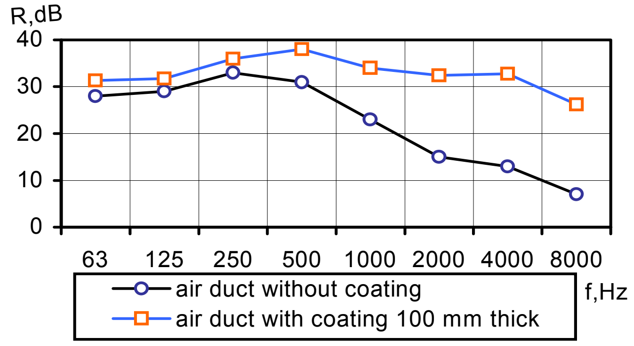

Fig. 5 The enhancement of soundproofing property of circular air ducts due to ISOVER material, 100 mm thick (a - air duct without coating, b - air duct with coating, 100 mm thick)

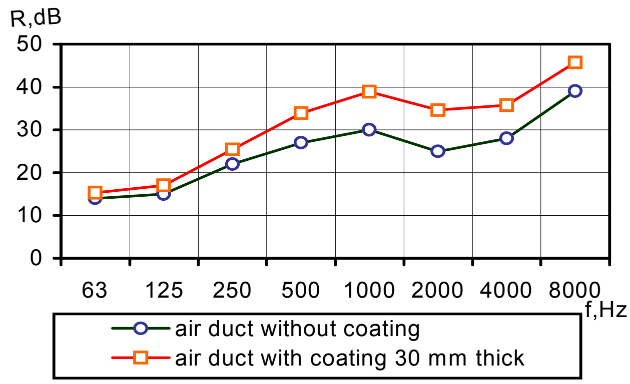

Fig. 6. Enhancemen soundproofing property of rectangular air ducts due to ISOVER coating, 30 mm thick. (a - air duct without coating, b - air duct with coating, 30 mm thick)

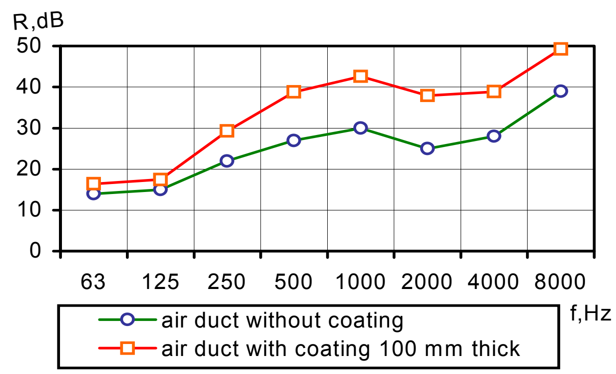

Fig. 7. Enhancement of soundproofing property of rectangular air ducts due to ISOVER coating material, 100 mm thick. (a - air duct without coating, b - air duct with coating, 100 mm thick)

Table 1 Increase of soundproofing property of air ducts due to heat-insulation materials

Cross-section of duct	Material thickness, mm	Geometric mean frequency of octave bands , Hz							
		63	125	250	500	1000	2000	4000	8000
1	2	5	6	7	8	9	10	11	12
Synthetic foamed material, δ=35 kg/m^3 (shells on circular air ducts)									
Circular									
	40 mm	1	3	3	1	-2	0	5	9
	50 mm	1	0	0	4	-4	2	5	10
Foamed self-adhesive sheet material, δ=25 kg/m^3 (foamed polyethylene)									
Rectangular									
	10 mm	1	2	1	1	1	2	2	4
	20 mm	2	2	1	2	1	0	3	6
Circular									
	10 mm	1	-4	4	0	-1	0	4	4
	20 mm	0	1	0	-1	-2	-1	4	4
Fibrous material of ISOVER type δ=30 kg/m^3(t=30mm), δ=22 kg/m^{3}3(t=100mm)									
Rectangular									
	30 mm	1.3	2.0	3.4	6.9	8.9	9.6	7.8	6.7
	100 mm	2.4	2.5	7.3	11.8	12.6	12.9	10.9	10.3
Circular									
	30 mm	1.5	1.0	1.5	2.5	5.1	12.5	15.8	17.2
	100 mm	3.3	2.8	3.0	7.0	11.0	17.4	19.8	19.2