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Measurements of sound propagation inside air conditioning ducts

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Sound generated by the fan of the air conditioning system propagates along air ducts up to the conditioned rooms. The impossibility of lining the ducts from the inside with sound absorbing materials facilitates sound propagation up to great distances from the generation point.
Moreover, particular conformations of the system, as small bending radius, fire barriers, ventilation grilles, may generate new noise also near the expulsion points.
Measurements have been carried out in a number of hospitals HVAC systems, where inspection openings have been realised at various distances from the fan.
Results show sound spectra typical of the systems analysed and point out the necessity of particular insulating devices where there is noise generation inside the ducts.
The comparison with limiting values defined in Italian regulation for hospitals points out some critical situations.

INSTRUMENTATION AND MEASUREMENT PROCEDURE

Measurements have been carried out by means of a Sound Level Meter Brüel & Kjær 2230 equipped wit a microphone B&K 4155, a foam ball (diameter 90 mm), a preamplifier and a cable extension. The signal has then been recorded with a Digital Audio Tape and post processed with frequency analysis in laboratory.

According to ISO 5136 [1], the air velocity inside the ducts was lower than 15 m/s, as it is necessary for measurements with foam ball of 90 mm diameter. The microphone was inserted inside the duct through an inspection opening. The position of the microphone inside the duct was parallel to the air flow (with the air pressure perpendicular to the microphone membrane) and at a radial distance, r, from the duct axis so that $2r/\phi \approx 0,5$ (ϕ is the diameter of the duct).

All sound analysis was performed from 80 Hz to 10 kHz and with global values of Equivalent SPL in dBA.

Inspection openings were realised near the fan and at various distances from it, up to the receiving rooms.

MEASUREMENTS RESULTS

Figure 1 shows three sound spectra measured near the fan and at various distances from it. The upper line refers to the measurement point placed 2 meters after the fan. A silencer realized with sound absorbing material was present between the fan and the measurement point.

From the graph, the decay of the sound level of 5 dB/oct, typical of centrifugal fans [2], is evident.

A peak in the SPL, probably a resonance frequency, is also evident at 250 Hz.

The intermediate line refers to the measurement point located between the fan and the receiving room.

The sound attenuation due to distance and to bends is approximately 20 dB at all frequencies. At high frequency, a sound resonance due to fire barrier reduces the attenuation.

According to Allen [2], in circular unlined metal ducts, the attenuation due to distance is of about 0,1 dB/meter for frequencies below 1000 Hz and of about 0,3 dB/meter for higher frequencies. The attenuation provided by round or square bends with turning vanes may be estimated in the range from 0 to 3 dB, being greater for higher frequencies and for larger ducts diameters.

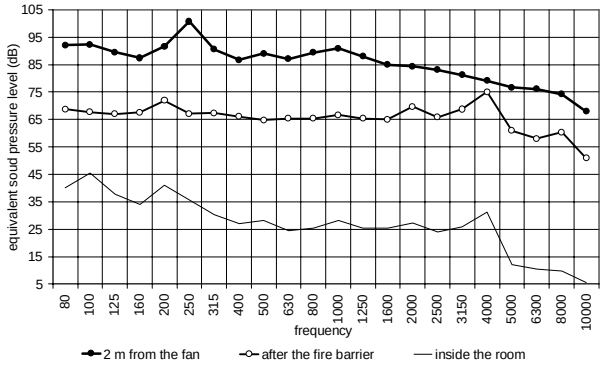

FIGURE 1: Sound spectra measured at various distances from the fan, inside the duct: first case study. (L_{eq} = 39 dBA in the receiving room).

In the lower line of figure 1, referred to the measurement point located inside one receiving room, at 1 meter distance from the grille, the two sound resonance at low and high frequency are also evident.

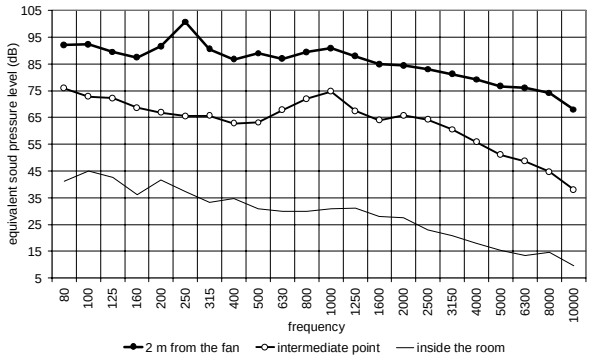

FIGURE 2: Sound spectra measured at various distances from the fan, inside the duct: second case study. (L_{eq} = 40 dBA in the receiving room).

Figure 2 shows measurements results for a second case study in the same hospital and for the same centrifugal fan. The first line refers to the same measurement point as in figure 1.

COMPARISON WITH LIMITING VALUES

Table 1 shows the limiting values for noise produced by ventilation systems, according to the Italian norm [3] and legislation [4].

Limiting values are given as global values of equivalent SPL in dBA, measured in the receiving room.

In the two case observed, equivalent SPL (40 and 39 dBA), measured inside the receiving rooms at 1 meter of distance from the diffuser, exceeds the limiting value of Italian legislation of about 15 dB.

Table 1. Limiting values of equivalent SPL produced by air-conditioning systems for hospitals, according to Italian Norm UNI 8199 and to the Italian law.

Kind of interior	Limiting value (dBA)
Hospital rooms	30
Wards	40
Surgical rooms	35
Corridors	40
Public spaces	40
Services	40
All interiors (Italian law)	25

It is necessary to underline that the limiting values defined by Italian legislation refer to mean values measured inside the receiving room. For this reason, values measured in front of the diffuser have to be corrected to keep in count the absorption of the receiving room.

CONCLUSIONS

The global values of sound pressure level have been measured in eight different conditioned rooms, in the same conditions as described above. Results are quite always in the range from 40 to 50 dBA.

These values are from 10 to 20 dB higher than the limiting values of the Italian norm and from 20 to 30 dB higher than the value of the Italian law.

It is therefore necessary to use devices to reduce these levels below the limiting values.

With reference to figure 1, the sound resonance at 4000 Hz, probably due to the fire barrier, produce an increase of about 1 dB in the global sound pressure level in dBA measured in the room.

In all cases, sound spectra are particularly high at low frequencies. A reduction of 10 dB in sound pressure levels from 100 to 500 Hz can result in a reduction of the global level in dBA of more than 5 dB.

ACKNOWLEDGEMENTS

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