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INFLUENCE OF THE MOUNTING CONDITIONS OF AIR DIFFUSION TERMINAL UNITS ON THEIR ACOUSTIC PERFORMANCES

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ABSTRACT
The in situ acoustic performances of air diffusion terminal units sometimes differ greatly from those measured in the laboratory in accordance with the ISO 5135 standard. This stems from the fact that the standard assumes that the grilles (or diffusers) will have a very large air supply plenum, while in practice they are connected to a small plenum, which radically alters their acoustic power level performances. CETIAT has tested a grille equipped with a plenum whose dimensions could be varied: length of the plenum, branch connection diameter and position of the branch connection (rear or side). Each parameter could have two states representative of the true situation found in the field. The purpose was firstly to determine the acoustic performances for each configuration and then to rank the importance of each parameter. These tests show that a grille's sound level can increase by approximately 15 dB(A) when a plenum is added, even though the latter is in its optimal configuration. The increase in sound level reaches 20 dB(A) between the plenum's two extreme configurations. These results confirm that the performances of grilles are radically modified by the type of plenum it is connected to. Regarding the dimensions used in the tests, the analysis also shows that the most influential parameter is the position of the branch connections, followed by the branch connection diameter and finally, the length of the plenum.

1 - INTRODUCTION
The acoustic performance of air diffusion elements is measured in accordance with ISO 5135 [1]. In the case of noise generated by air diffusers, the test assembly is based on ISO 5219 [2] which recommends the use of a large cross-section plenum downstream of the diffuser.
In the field, the cross-section of plenums is often the same as that of the diffuser, resulting in acoustic performances which can be very different from those measured in the laboratory [3].

2 - TEST CONFIGURATIONS
The test series were concentrated on two main points: the influence of the size of a plenum and the influence of the presence of a component such as a perforated plate or a damper.
The plenum, with the same section as the diffuser (600×300 mm), had 3 variable parameters: the length, the diameter of the air supply inlet and the position of the inlet (opposite the diffuser or lateral).
The acoustic tests were carried out at 3 flow rates: 910 m^3/h, 1135 m^3/h and 1340 m^3/h. All of the presented results were adjusted to a flow rate of 1135 m^3/h.
Since each of the 3 parameters could have 2 states, there were 8 possible different configurations (Table 1). Very large differences were immediately observed (20 dB).

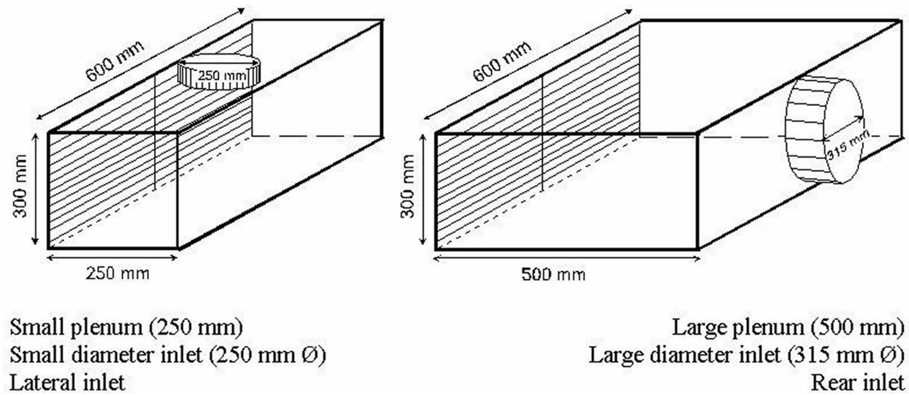

Figure 1: Diagram of the plenum according to the two extreme configurations.

Position of the inlet	Diameter of the inlet (mm)	Length of the damper (mm)	Lw – dB(A) Qv=1135 m^3/h
Lateral	250	250	**60.1**
		500	**55.0**
	315	250	**49.8**
		500	**49.6**
Rear	250	250	**45.1**
		500	**42.8**
	315	250	**41.6**
		500	**40.7**

Table 1: Sound power levels for the 8 configurations.

3 - CLASSIFICATION OF THE PARAMETERS

The average of the differences observed by variation of one of the 3 parameters for each of the 3 flow rates (Table 2) shows that the most influential parameter is the position of the inlet, ahead of the inlet diameter and the length of the plenum.

Position of the inlet (rear / lateral)	Diameter of the inlet (250 / 315 mm Ø)	Length of the plenum (250 / 500 mm)
11 dB	5.6 dB	2.1 dB

Table 2: Classification of the influence of each parameter on the sound level.

4 - DAMPER

A damper was inserted in the supply duct 300 mm from the plenum in 2 of the configurations. Table 3 gives the sound power levels for the damper's 3 positions: 0°, 22° and 45° (0° = open).
The influence of the damper (and therefore the increase in noise level) is greater in the favourable configuration (rear inlet) than the unfavourable configuration (lateral inlet). Readings of the air velocitys at the diffuser outlet provided a partial explanation for the phenomenon. The introduction of the damper on the rear inlet configuration significantly modified the air velocity distribution, which can be locally doubled at the diffuser outlet. On the other hand, in the lateral inlet configuration, the flow distribution changes but remains very heterogeneous. It is probable that the acceleration of the air through the damper and the profile of the air velocity at the plenum inlet are at least as responsible for the growth in noise level as the air velocity distribution alone over the diffuser blades.

Large plenum (500 mm) Large inlet (315 mm Ø)	Damper position	0°	22°	45°
	Lateral inlet	49.6 dB(A)	51.0 dB(A)	51.4 dB(A)
	Rear inlet	40.7 dB(A)	46.8 dB(A)	60.2 dB(A)

Table 3: Sound power level at 1135 m^3/h for different positions of the damper.

5 - PERFORATED PLATE

Still using the same two configurations, a 50% perforated plate was installed in the plenum, parallel to the diffuser and 200 mm upstream of it. The introduction of the perforated plate in configurations with or without a damper resulted in an increase in noise of around 3 dB, irrespective of the configuration (Table 4).

		Without a damper	With a damper at 45°
Large plenum (500 mm) Large inlet (315 mm Ø)	Lateral inlet	+ 3.2 dB	+ 3.7 dB
	Rear inlet	+ 3.1 dB	+ 3.1 dB

Table 4: Increase in sound level due to the insertion of a perforated plate.

Figure 2 gives the distribution of the air velocities at the diffuser outlet; it is clear that the perforated plate makes the air velocities perfectly homogenous. The sound level increases because the surface area for the passage of air is restricted at the position of the perforated plate, which generates, at this location, an increase in the sound levels. In short, the perforated plate takes on the role of a sound source in place of the diffuser. The latter now generates practically no noise because the air velocity at its passage has been significantly reduces.

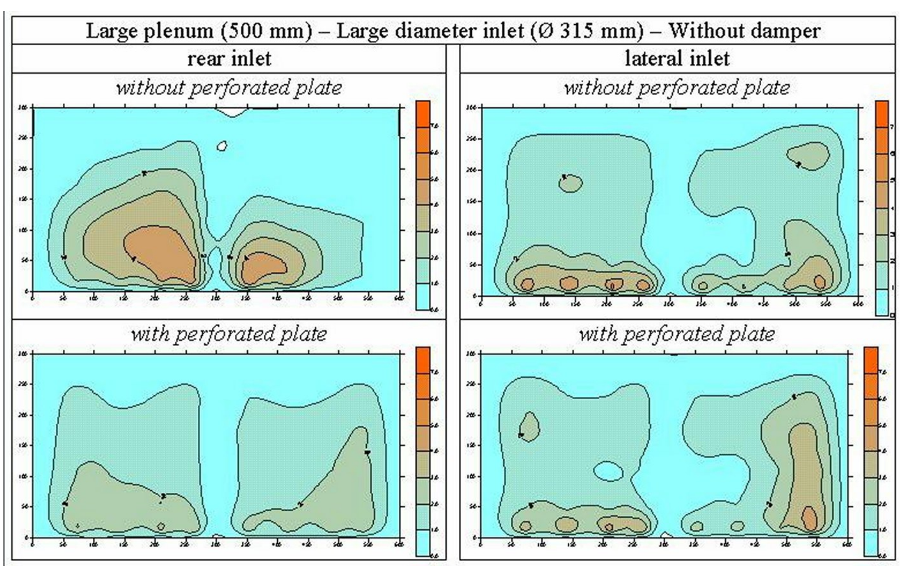

Figure 2: Influence of the perforated plate on the air velocities at diffuser's outlet.

6 - PARTICIPATION OF THE DIFFUSER IN THE GENERATED NOISE

The previous tests show that the diffuser is often not the only origin of noise. Tests were therefore carried out to measure the reduction in sound level when, for a given configuration and at a constant flow rate, the diffuser is removed (Table 5).

Plenum length	Inlet diameter	Inlet position	Damper at 45°	Perforated plate	Difference in sound level
Large (500 mm)	Small (250 mm Ø)	rear	-	-	6.8 dB
	Large (315 mm Ø)	lateral	-	-	5.7 dB
			X	-	0.5 dB
			X	X	0.8 dB
			-	X	1.5 dB

Table 5: Difference in the sound level with and without a diffuser.

These tests show that in configurations with neither a damper or a perforated plate, the diffuser is definitely the main noise source, in the proportions given in the classification above. On the other hand, in the presence of a damper or perforated plate, the diffuser only makes a small contribution to the resulting sound level. The perforated plate acts as a noise generator by reducing the section off the air passage. The damper perturbs the flow and generates locally high air velocities, and therefore a growth in the sound level.

7 - CONCLUSIONS

The acoustic properties of a diffuser alone or equipped with a plenum lead to very different results. The presence of a plenum generates noise due to the section of the air supply feed which is often reduced compared to the section of the diffuser, the non-optimised geometrical designs (generally due to space constrictions) and the presence of additional aerodynamic components.

These experiments give rise to several comments. In all cases, preference must be given to an air flow path which is the straightest possible between the plenum inlet and the diffuser outlet. That assumes a inlet either in the plane parallel to the diffuser, or the largest possible plenum volume, with the maximum possible distance between the supply inlet and the diffuser. Moreover, the quest to reduce the air velocity must be constant, irrespective of the position of the plenum's air supply or even the diffuser: large diameter inlets, large plenum, large straight length in front of the inlet.

Given the disparity between observed sound levels, the use of plenums equipped with diffusers by the manufacturers is recommended. In general, their acoustic characteristics have been verified, providing a good basis for a high quality installation.

REFERENCES

1. **ISO 5135**, *Determination of sound power levels of noise from air terminal devices, high/low velocity/pressure assemblies, dampers and valves by measurement in a reverberation room*, pp. 11, 1992

2. **ISO 5219**, *Air distribution and air diffusion - Laboratory aerodynamic testing and rating of air terminal devices*, pp. 28, 1984

3. **F. Bessac and P.J. Vialle**, Influence des conditions d'installation sur les performances aérauliques et acoustiques d'une grille de diffusion, *Rapport CETIAT*, Vol. NTV 1998/185, pp. 57, 1998