AN ATTEMPT TO DECREASE THE NOISE POLLUTION OF URBAN BUSSES USING A NEW EXHAUST SILENCER*

Gabriel ANGHELACHE[1], Dănuț STĂNCIOIU[2]

The paper presents an attempt to reduce the noise pollution of urban buses through the investigation of the efficiency of a new exhaust silencer, comparing to the original one. First, the sound pressure levels (SPL) and sound spectra were measured outside and inside the stationary bus, at two engine revolution speeds, with and without original exhaust silencer. The data show a higher efficiency of the screens around the engine comparing to the original silencer. An experimental prototype was designed and built. The noise measurements made with the prototype silencer fitted on the bus show a tendency of decreasing the sound pressure levels.

1. INTRODUCTION

The noise produced by urban busses is a significant contributor to the overall pollution affecting the urban environment. The main sources of the mentioned noise are gas intake/exhaust, engine itself, tyre-road contact, cooling fan and powertrain. The two major possibilities to reduce the bus noise consist of decreasing the noise of any principal source, and control of sound transmission path. The paper presents the attempt to reduce the bus noise through the investigation of the efficiency of a new exhaust silencer, in comparison to the standard silencer.

2. THE TEST PROGRAM

A sample of eight buses sorted out from two closely-related versions, labeled A and B in the present paper, made by the same manufacturer, with an odometer readings of 200,000 km, and belonging to a transport company was tested [1]. To decrease the noise levels, the urban buses included in the newer "B" version are equipped with acoustic shields around the engine. The driver's compartment is also completely separate by the bus's saloon to break out the air-borne transmission path.

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*Presented at SISOM2007 and Homagial Session of the Commission of Acoustics, Bucharest, 29–31 May 2007.

[1] "Politehnica" University of Bucharest, Automotive Engineering Department, Bucharest, Romania.
[2] University of Liverpool, Department of Engineering, United Kingdom.

Rev. Roum. Sci. Techn. – Méc. Appl., TOME 53, N° 1, P. 105–114, Bucarest, 2008

The noise measurements were performed in accordance with the national and European standards, but the sound pressure levels were measured in eight locations outside and inside the bus. At this stage, the tests were done only for the stopped bus, at idle and 1 800 rpm. In some circumstances, the sound spectra were calculated.

The efficiency of the manufactured silencer was tested on one of the eight buses, by carrying out noise measurements with and without silencer. Later on, a prototype silencer was installed instead of the manufactured one.

3. THE EVALUATION OF OVERALL SPL FOR TWO TYPES OF BUSES

The sound pressure levels, measured inside and outside the stopped buses, at two engine speeds, are shown in Figs. 1, 2, and 3.

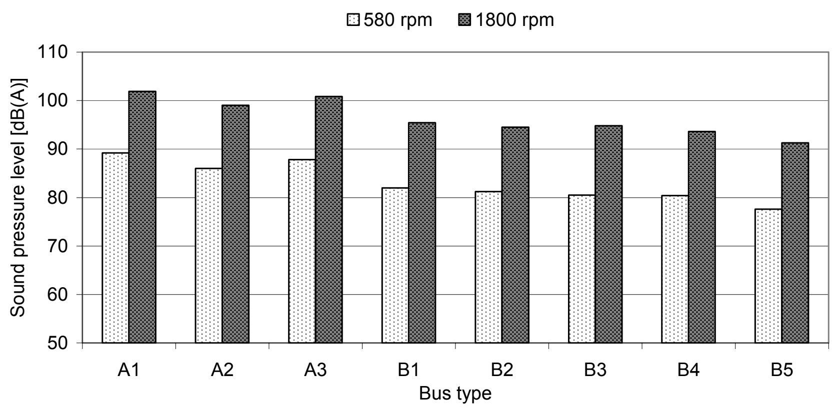

Fig. 1 – Exterior sound pressure level measured near the exhaust pipe extremity.

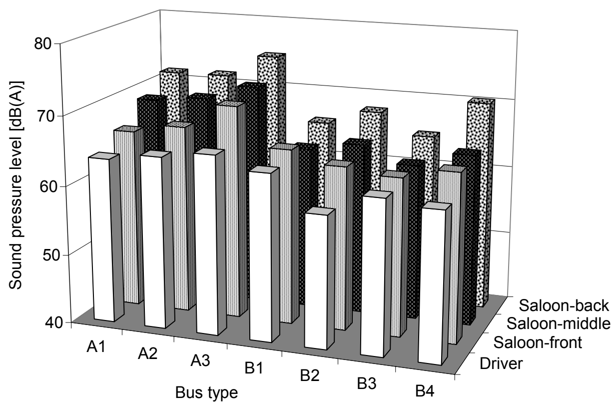

Fig. 2 – Interior sound pressure levels measured at 580 rpm.

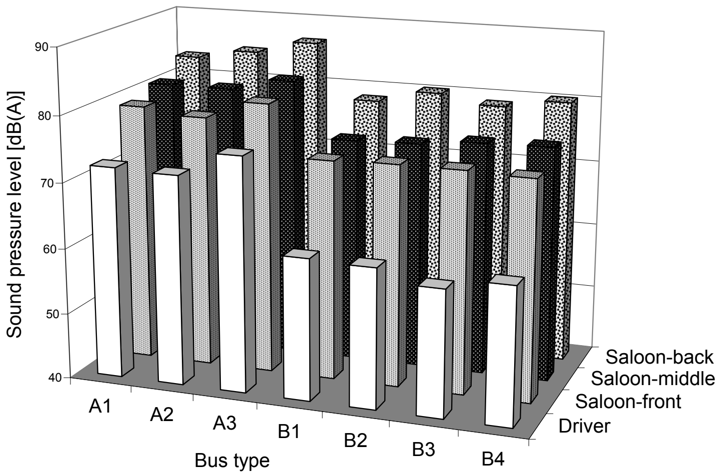

Fig. 3 – Interior sound pressure levels measured at 1 800 rpm.

The exterior sound pressure levels of the older "A" bus version exceed drastically the limit imposed by the recent standards, therefore specific actions have to be implemented to reduce the noise pollution. The data presented in Figs. 1–3 prove the importance of the screens around the engine of a "B" version bus, thanks to which the sound pressure levels decrease both inside and outside the bus.

4. NOISE REDUCTION EFFICIENCY OF THE ORIGINAL SILENCER

Noise measurements were performed for a "B" version bus with and without original silencer. Some results regarding the sound pressure levels and noise spectra are shown in Figs. 4–9. The decreasing of the sound pressure levels due to the original silencer is insufficient, smaller than that obtained by using the screens around the engine. The main possible reasons are:

- the noise produced by the engine itself has a great weight in the overall noise level;
- the original silencer was not tuned to the bus engine.

The paper presents the work involved in silencer – engine tuning process.

According to Figs. 6–9, the original silencer works efficiently for frequencies below 250 Hz, with a maximum of attenuation around 63 Hz for the exterior noise, and around 31.5 Hz for the interior noise at idle. The silencer's efficiency is reduced when the engine speed increases.

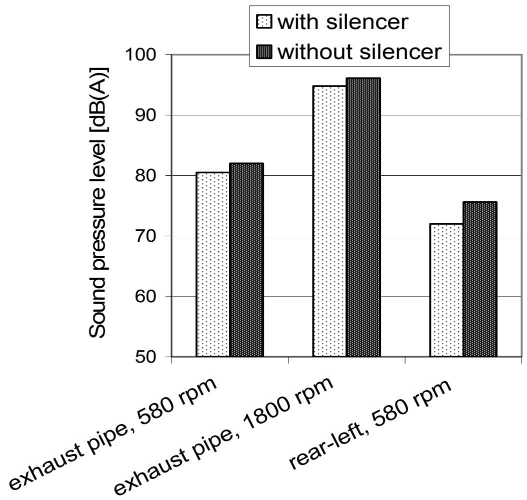

Fig. 4 – Exterior sound pressure levels with / without exhaust silencer

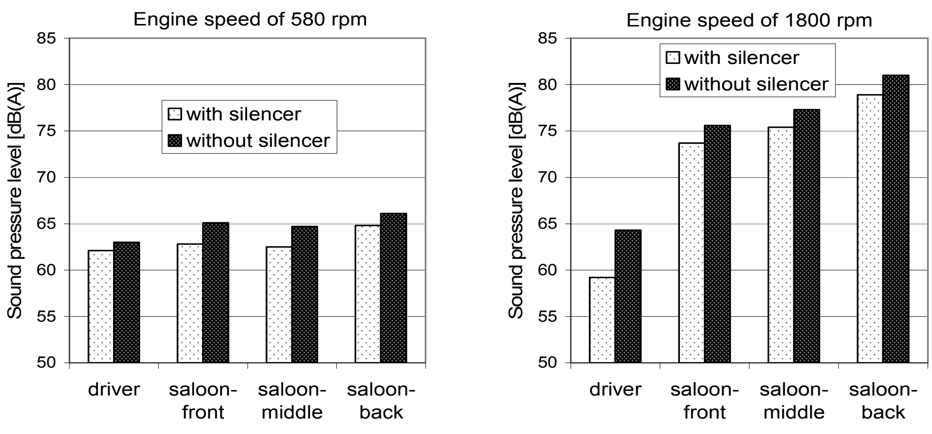

Fig. 5 – Interior sound pressure levels with / without exhaust silencer.

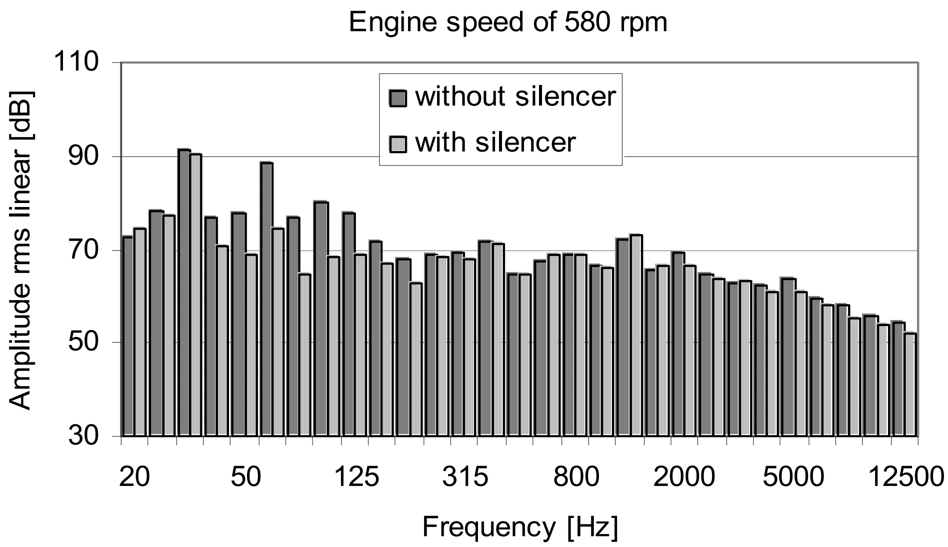

Fig. 6 – 1/3 Octave frequency spectrum of the exterior noise measured near the exhaust pipe extremity.

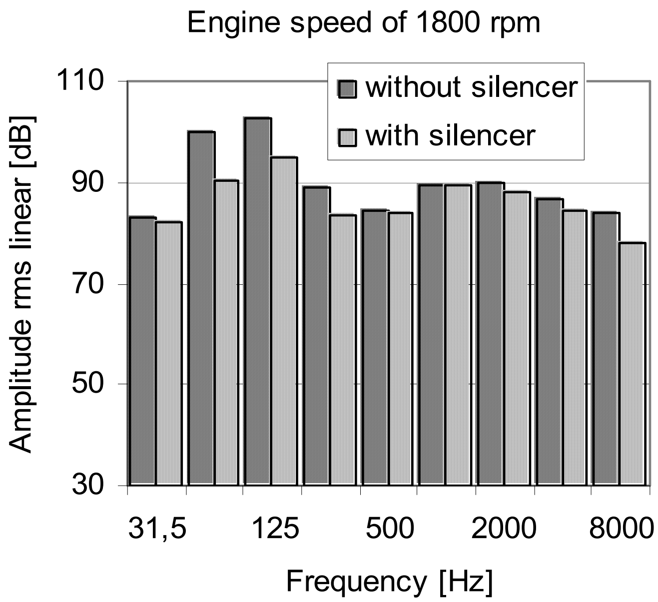

Fig. 7 – 1/1 Octave frequency spectrum of the exterior noise measured near the exhaust pipe extremity.

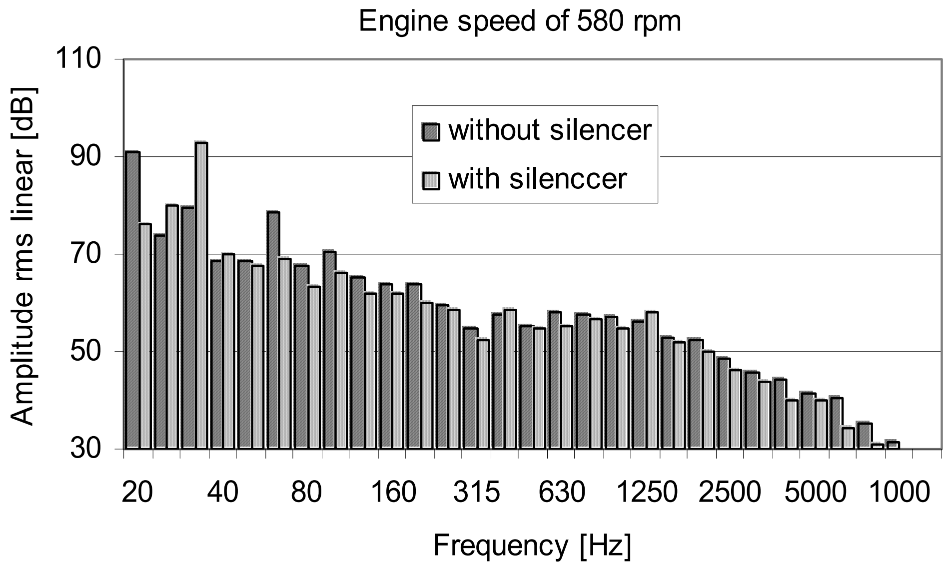

Fig. 8 – 1/3 Octave frequency spectrum of the interior noise measured in the back side of the saloon.

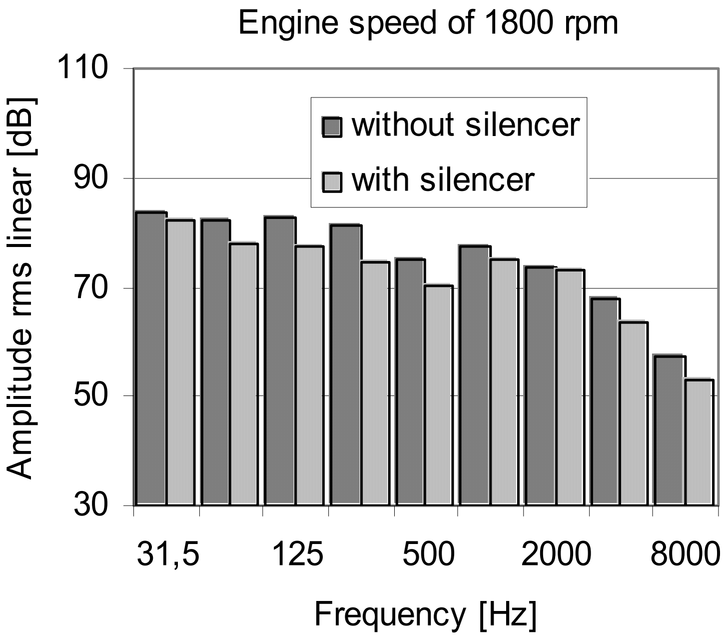

Fig. 9 – 1/1 Octave frequency spectrum of the interior noise measured in the back side of the saloon.

5. DESIGNING THE PROTOTYPE EXHAUST SILENCER

The most important input data required in designing the exhaust silencer are the engine technical specifications, and noise frequency spectra of the bus without silencer, presented in Figs. 6–9. The overall dimensions of the silencer were chosen in accordance with the available room between bus body and engine. The exterior silencer shape was selected to be a prism, modular-designed to easy access for changing the interior architecture.

The calculus methodology of the silencer model was based on works [2] and [3]. Two interior designs of the prototype silencer, shown in Figs. 10 and 11, have been taken into consideration.

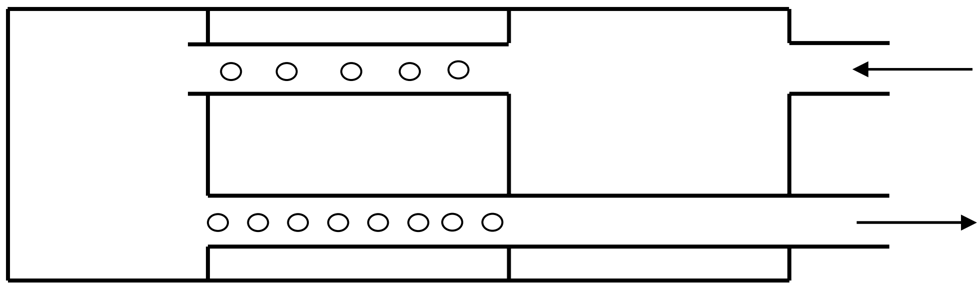

Fig. 10 – First sketch of the silencer interior design.

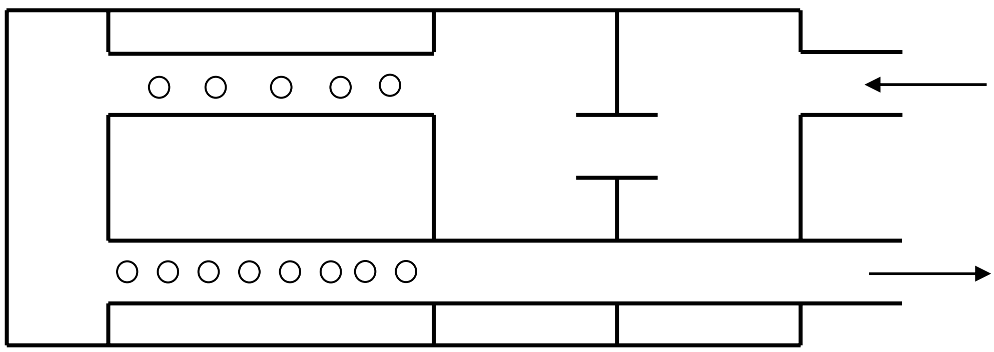

Fig. 11 – Second sketch of the silencer interior design.

By analytical investigation the authors have obtained the theoretical attenuation magnitude *vs.* frequency for either of the interior architectures. The optimum design, exposed in Fig. 11, was chosen following the analysis of the noise attenuation curves. Figs. 12 and 13 present the uncover prototype silencer and its assembly position on the bus.

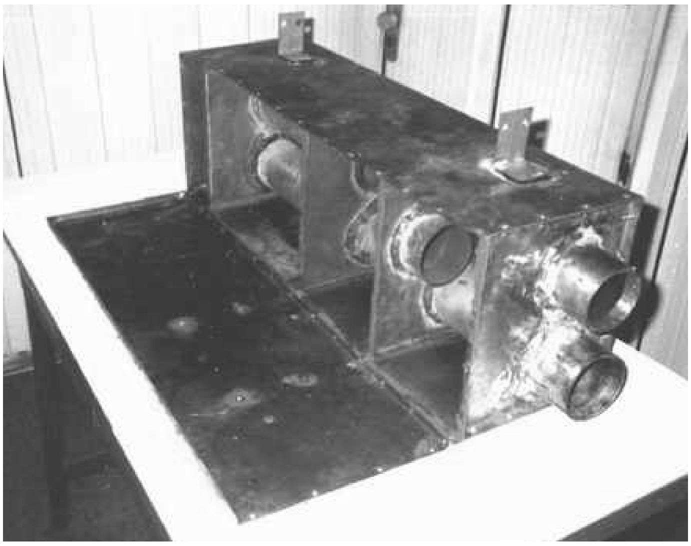

Fig. 12 – The uncover silencer prototype.

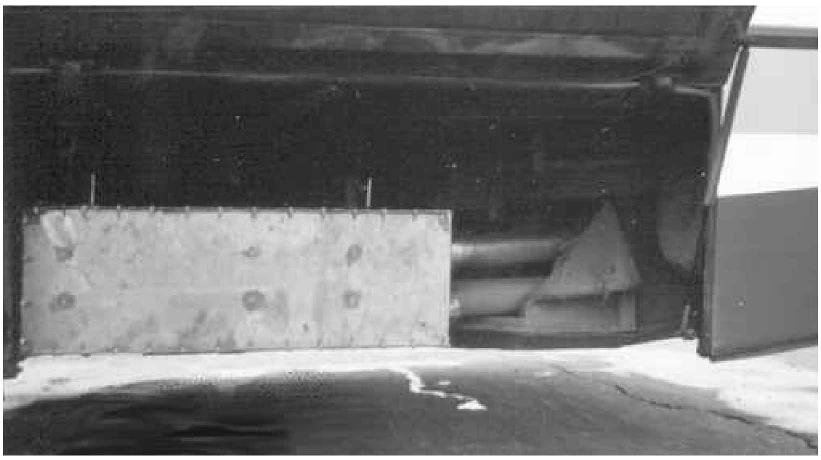

Fig. 13 – The silencer prototype assembled on the bus.

6. THE EFFICIENCY OF THE SILENCER PROTOTYPE ON DECREASING THE NOISE LEVEL

Using the prototype instead of the original silencer, a new set of noise measurements was performed. Graphical comparisons between the sound pressure levels and noise spectra for the original and prototype silencers are shown in Figs. 14 and 15.

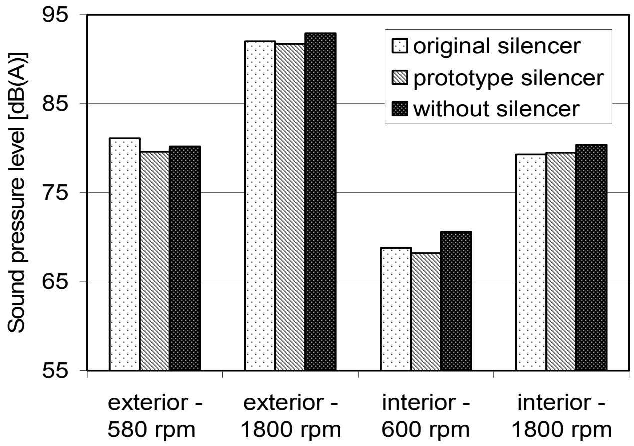

Fig.14 – The efficiency of the original and prototype silencers.

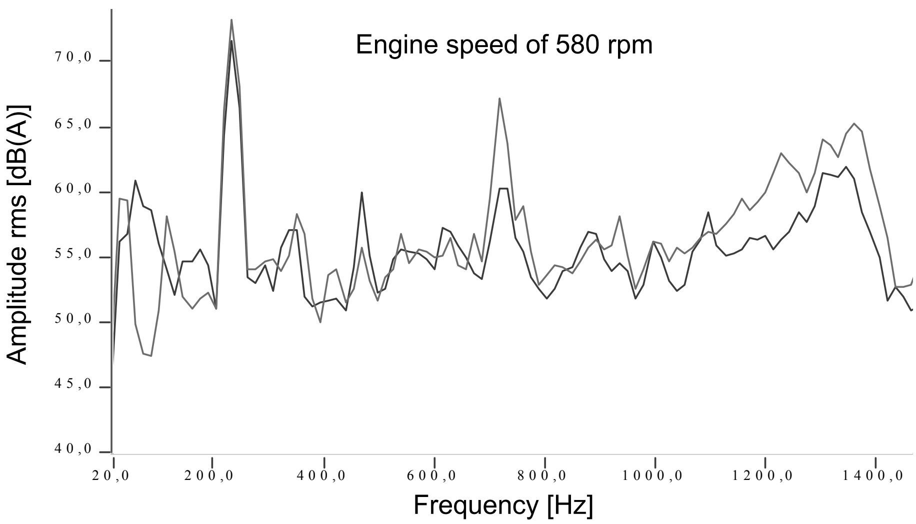

Fig. 15 – Frequency-weighted spectrum of the exterior noise measured near the exhaust pipe extremity;
black – prototype silencer; grey – original silencer.

In most of the mentioned test conditions, the prototype is more effective with the exception of case when engine runs at 1 800 rpm, when a slight increase in the sound pressure level was observed.

7. CONCLUSIONS

Even in this early stage of design, the prototype silencer leads to small decrease in the sound pressure level when compared to the original silencer. In addition, there is a considerable potential to improve the efficiency of the prototype silencer, through refining its analytical model and optimizing the interior architecture.

The analysis of the main sources of exhaust noise produced by stationary bus reveals that the engine itself is the loudest one. The most efficient way to reduce the engine radiated noise consists of baffling it with acoustic shields.

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