A new in-situ method for the acoustic performance of road traffic noise reducing devices

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Abstract: This paper presents the results of a European Commission funded research called "Adrienne". It had to design a new measurement method for the sound absorption and airborne sound insulation of Noise Reducing Devices (N.R.D.) to be used either in a laboratory or in-situ. It uses M.L.S. signal fed through a specific loudspeaker/microphone unit, and applies a subtraction technique. This work has been done with 8 European laboratories, and a first round test showed very encouraging results.

BACKGROUND AND OBJECTIVES

When drafting the related EN 1793, the CEN/TC 226/Working Group 6 (road equipments, anti-noise devices), met problems with the existing ISO 354 and ISO 140 methods. These methods had been drafted for acoustic products to be used inside buildings, when WG6 deals with anti-noise devices along roads, i.e. outside buildings. In fact, EN 20354 (ISO 354) cannot be used with non flat products used under specific incidences, and another existing method (AFNOR S31-089) has limitations in the low frequency limit and still cannot be used with non flat products.

The new method has to measure flat and non flat Noise Reducing Devices (N.R.D.), giving values for absorption and insulation which can be realistic with the intended used (road traffic noise).

MLS METHOD AND SUBTRACTION TECHNIQUE FOR SOUND ABSORPTION

Facing its major advantages (Garai, 1993), M.L.S. method has been chosen from 4 existing methods: it has a flat frequency spectrum, the sequences are repeatable and provide high S/N ratio, finally, M.L.S. has an excellent background noise immunity. We also verify the stability of the method when facing external perturbations as wind or temperature variations. We defined the Reflection Loss (see also fig.1a) as (1):

$$RL(o) = \frac{1}{n} \sum_{m=1}^{n} \left[ \frac{[\sum_{j=1}^{n} p_{r}(t_j)W_{o}(t_j)]^{2}}{[\sum_{j=1}^{n} p_{o}(t_j)W_{o}(t_j)]^{2}} \right]$$

where $p_{o}(t)$ is the reference sound pressure, $p_{o}(t)$ is the reflected one at angle $\theta$, $W_{o}(t)$ and $W_{o}(t)$ are the "Adrienne" windows for the reference and reflected signals, $d_{o}(t)$ and $d_{o}(t)$ are the gain functions to correct for spherical divergence the reference and reflected signals, respectively. Both $W_{o}(t)$ and $W_{o}(t)$ windows are: 0.5 msec half Blackman-Harris, 5.18 msec rectangular, and then 2.24 msec half Blackman-Harris shapes.

In order to extract the direct pulse from this window, we used the subtraction technique (Mommerz, 1995), for which we designed a new loudspeaker/microphone unit, keeping the distance loudspeaker/microphone constant at 1.25 m, and then allowing to extract the direct pulse from the global signal.

Different averages are done on different angles of incidence (50-90°, 90-130°, and 50-130°).

First extensive tests, carried out on 6 samples by 8 laboratories, have shown that measurements are very similar, and that single number rating results following EN1793-1 have remarkable repeatability (±1 dB).

MLS METHOD FOR AIRBORNE SOUND INSULATION

The basic method is similar to that one used for sound absorption, we keep the same loudspeaker, signal, and signal analysis, and the same "Adrienne" windows. The flow chart diagram corresponding to the airborne sound insulation measurements is presented at figure 1b. We defined the Transmission Loss as (2).
where \( p_f(t) \) is the free-field sound pressure, \( p_{se}(t) \) is the transmitted one at location \( k \) of the 9 points scan, \( d_0 \) is the distance microphone-loudspeaker in free-field, and \( d_k \) the same distance at location \( k \). Comparative tests carried out on 3 samples in 3 different configurations give similar results and repeatability on single number ratings following EN1793-2 of ±2 dB.

\[
TL(\omega) = -10 \log \left( \frac{1}{n} \sum_{i=1}^{n} \left[ \frac{1}{3} \left( p_f(t) W_r(t) \right)^2 \right] d\omega \left( \frac{d_k}{d_0} \right)^2 \right)
\]

\( (2) \)

FIGURE 1a. measuring sound absorption

FIGURE 1b. measuring airborne sound insulation

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