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An experimental analysis of the correction factors adopted on environmental noise measurements performed with window-mounted microphones

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ABSTRACT

The ISO 1996-2:2008 standard, currently under review and dealing with the description and assessment of environmental noise, suggests applying corrections to the readings in situations where the microphone is mounted directly on a facade or on some of its elements. To obtain the value equivalent to the sound pressure level in free field, the correction corresponds to subtracting 3 dB or 6 dB from the measured value, for the situations where the microphone is located at a distance of 2 m from the facade or directly placed on it, respectively.

In the present study, the influence of the front microphone mounting condition is examined. Also the effect of the velocity and direction of the wind on the correction factor to be applied to measurements is analyzed, for a case where the dominant noise source is road traffic.

The results obtained show that, when the microphone is mounted directly on the window, the difference relative to measurements obtained in free field conditions varies between 4.0 dB and 4.4 dB. This difference is associated with the effect that some wind parameters have on sound propagation, namely the wind velocity and its direction relative to the direction of sound propagation. These parameters show remarkable influence for certain frequency bands, particularly at low and high frequencies.

In the situation where the microphone is directly mounted on a plate of reflective material, with similar characteristics to those required in ISO 1996-2:2008, a difference of 4.9 dB is found. This value is contained in the interval 5.7 ± 0.8 dB, for which the confidence level of 95% is known.

The time evolution of the L_d descriptor is presented, which was obtained based on the sound level values acquired continuously over a period of 47 months. The application of a correction factor to the measured values results in a difference of 2 dB relatively to the value that would be obtained by applying the reference correction factor of 6 dB.

Thus these results advise the need for studies "*in situ*," whenever this measurement solution is used, since the adoption of the agreed value in the test's standard may, in some cases, introduce significant errors in the final results of the long duration descriptors.

1. Introduction

In the measurement of environmental noise sound levels, when the microphone is placed on the facade or in its vicinity, it is required that the measured levels be corrected to compensate for the influence of reflection and diffraction. These phenomena occur due to the interaction of sound waves with the facade wall.

The values of 3 dB or 6 dB are indicated as the corrections to be applied to the measured values in situations where the microphone is positioned respectively at a distance of 2 m or directly on the facades of masonry, concrete, wood, glass or other reflective material of similar characteristics ([1–4]).

The values of these corrections were studied at various sites [5], where distinct configurations of streets were considered, in particular with *L* and *U* shapes and some of its variants such as the width and distance from the opposite wall when the variant configuration is in *L*.

The sound field was the result of the emission and propagation from the passage of vehicles (mobile source) in adjacent traffic lanes. The microphone height placement relative to the ground is always 4 m, which is placed on an aluminum plate with 5 mm thickness and 60 cm × 90 cm dimensions. Considering all studied

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streets' formats, the average distance source – facade was between 6.6 m and 34.0 m. The results of the obtained corrections correspond to the average values recorded from pass-by events (typically between 60 and 300 events), and to which different types of vehicles and traffic conditions, different geometries and different types of flooring (asphalt) contributed.

In the specific work [6] for the long-term environmental noise assessment, and whose measurements occurred throughout a year, two microphones were installed outside. One of the microphones was directly placed on the glass of a window and the other at a distance of 2 m from this facade, both at a height of 4 m relative to the floor and about 250 m from one of the main arterial roads, of Vilnius (Lithuania), an area where noise originates from traffic.

The results obtained from the values $L_{Aeq,1\ h}$, directly calculated by integrating the instantaneous values of the sound pressure levels (125 ms step sampling) during the day, showed good agreement with the reference values of 3 dB.

In this paper the authors experienced an *L* configuration, where the average distance from the source to the facade was approximately 150 m. Two distinct assemblies were considered for the microphone placement. In the first experience the microphone was placed directly on the glass of a window, and in the second on a reflective plate on the facade of the building.

The generating source considered was road traffic and measurements took place over periods of 1 h.

During the several measuring periods that occurred over several days, always during the daytime period, the route presented an average flow of about 2500 vehicles/h.

The mean difference calculation between the values obtained for 1 h in each of the positions and the value corresponding to the position of "free field" was based on the respective sound level values $L_{Aeq,15\ min}$ obtained for successive periods of continuous integration.

2. Experimental installation

2.1. Measurement location

The considered facade is part of the Laboratory of Industrial Aerodynamics, located at Vale das Flores in Coimbra, Portugal.

The surrounding area is transversally crossed by a traffic lane of relative importance, which is indicated in Fig. 1 by the white dashed lines. This road has two lanes in each direction, having traffic quite fluid and an average daily rate (ADR) of approximately 37,000 vehicles per day, with approximately 10% of heavy vehicles. The traffic is mostly fluid and decelerating, in the west–east direction, from 70 km/h, over the bridge, to 50 km/h, after the bridge. In the east–west direction, the traffic is also fluid and accelerates from 50 km/h to 70 km/h.

The Laboratory location is properly characterized in terms of weather regarding the wind speed and direction. These values have been acquired continuously since 2009, as part of a research project that is currently still ongoing.

2.2. Acoustic monitoring system characterization

The measurement system is based upon the use of a laptop and an IT platform, LabView [7]. This system includes a ½″ diameter microphone, model 4189 with its respective pre-amplifier, model 2671, both from Brüel&Kjær and an Analog-to-Digital (AD) data - acquisition board NI 9233, from National Instruments.

All the processing was accomplished by a computational application tool, written by the authors using the programming language G and some tools of the NI Noise & Vibration Toolkits package. The system, with the present software version, has the possibility to process the sound signal in order to obtain the sound pressure level, the noise equivalent level and to analyze it in third octave bands, in real time. Every acquired value can be saved sequentially in an .xls file, where, besides the date and hour, registries of global equivalent constant sound level, as well as all third octave bands values, between 20 Hz and 20 kHz are recorded. The integration time can be configured by the user, allowing measurements from several minutes to several hours, days, months or even longer than a year (see Fig. 2).

This system, in its whole, corresponds to a real time sound level analyzer. It was submitted to a legal metrological control. The IEC61672-1:2002 standard specification compliance, for class I precision, has been verified. In addition to this equipment, a CESVA SC310 1/3 octave band analyzer, also submitted to metrological control for compliance with IEC61672-1:2002, was used to perform the measurements in the "free field" position.

Fig. 1. Aerial view of the studied area, identifying the main traffic route.