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A review of the measurement procedure of the ISO 1996 standard. Relationship with the European Noise Directive

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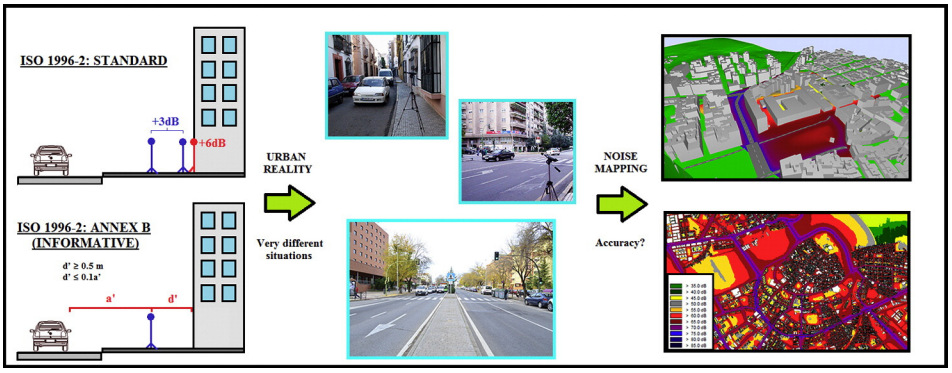
HIGHLIGHTS

- ISO 1996-2 standard and the accuracy of estimations of noise doses were reviewed.
- A wide variation among standard corrections and experimental results was published.
- Unexpected increases of sound level with height have been reported in literature.
- Detailed studies regarding the standard and its Annex B (informative) are necessary.
- Results of the application of the European Noise Directive could be being affected.

GRAPHICAL ABSTRACT



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ABSTRACT

Accuracy in the knowledge of the sound field incident on a façade is essential for proper planning of control actions. Independently of the chosen method for noise mapping, if we wish to know the exposed population, it is essential to measure the incident noise level on the façade. Regarding the geometry of the measuring point in relation to the façade and other elements of the environment, the normative part of the ISO 1996-2 standard only makes reference to the distance between the microphone and the façade. The rest of the geometric aspects that could influence the result of a measurement are not considered in the standard. Although some of these aspects are considered in Annex B, the annex is only informative. The ISO 1996 standard is considered in the European Noise Directive as a reference in the elaboration of strategic noise maps, the main tool for assessing the exposure of the population to noise pollution.

This work presents a detailed review of the literature and proposes research strategies in order to study the relationships between the ISO 1996-2 standard measurements procedure and the accuracy of the estimations of noise doses received by people obtained by the application of the European Noise Directive. The published results show significant relative differences with respect to the values proposed by the standard for the corrections and indicate the possibility of the influence of these results on the accurate development of strategic maps.

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Contents

1. Introduction

Worldwide economic and social development occurred over the last decades. Among other consequences, this has led to a significant increase in the number of people living in cities (Buhaug and Urdal, 2013; Henderson and Gun, 2007; Mulligan and Crampton, 2005) and in the use of transport infrastructure. As a result, a progressive increase in noise levels in economically developing countries (Zannin and Sant'Ana, 2011), and, possibly in other related environmental problems (Can et al., 2011; Fernández-Camacho et al., 2015) has taken place. In developed countries, the situation can be considered stabilized, as in case of Europe, where estimations indicate that more than 125 million people could actually be exposed to road traffic noise above 55 dB L_{den} (day-evening-night–level indicator), including more than 37 million exposed to noise levels above 65 dB L_{den} (EEA, 2014).

In the 1990s, some studies detailed the harmful effect of acoustic pollution on the health of human beings (Passchier-Vermeer and Passchier, 2000). This includes annoyance (Arana and García, 1998; Fidell et al., 1991; Fields, 1998; Guski, 1999) and sleep disturbance (Carter, 1996; Öhrström, 1990, 1991, 1995; Thiessen, 1988). Such feelings of displeasure show a relation with adverse effects on human emotions, leading to anger, disappointment (Fields, 1998) and even stress (Evans et al., 1995, 2001). Stress hormones have the potential to increase the incidence risk of cardiovascular diseases (Babisch et al., 1990, 1994; Ising et al., 1999). Also, in the same years, the first studies were published that disclosed the approximate percentages of the European population who are exposed to day and night levels higher than 55 dBA (Berglund et al., 1999; Lambert and Vallet, 1994). In the margins of uncertainty of these studies, they indicate that about 40% of the population in the European Union is exposed to road traffic noise with an equivalent sound pressure level exceeding 55 dBA daytime; and 20% is exposed to levels exceeding 65 dBA. More than 30% are exposed at night to L_{eq} exceeding 55 dBA which are disturbing to sleep. The emergence of this large number of studies in different countries allowed carrying out a meta-analysis and some synthesis curves emerged, which can be used for the prediction of the percentage of annoyed subjects (Miedema and Oudshoorn, 2001; Miedema and Vos, 1998). According to these curves, the estimations indicated approximately 23%, 18% and 10% of highly annoyed receivers for L_{den} of 65 dB in the cases of aircraft, road traffic and railway respectively.

Taking into account the evident adverse effects of environmental noise, the European Commission recognized community noise as an environmental problem, and an international focus on the problem was initiated. Therefore, environmental noise emerged as a major issue in environmental legislation and policy (EC, 1996).

The establishment of the European Noise Directive (EC, 2002) represented a significant improvement in awareness among the general public and policymakers about the knowledge of the acoustic situation in the cities of the member states (Murphy and King, 2010). Nevertheless, the European Noise Directive has not only had an impact in European countries (D'Alessandro and Schiavoni, 2015; Licitra and Ascari, 2014; Kephalopoulos et al., 2014; Vogiatzis and Remy, 2014) but has also been used as a reference by various studies made in cities around the world (Chang et al., 2012; Suárez and Barros, 2014; Zuo et al., 2014).

Accuracy in the knowledge of the acoustic situation is essential for the identification of the sites concerned. And, as a consequence, it is also very relevant for proper planning of control actions for each situation. Moreover, this knowledge of the acoustic situation can help us to fight other serious environmental problems because of the relationship of sound levels with other atmospheric pollutants (Allen et al., 2009; Morelli et al., 2015; Vlachokostas et al., 2012). In order to conduct studies of the acoustic situation and its effects on the inhabitants of cities and for the planning of possible solutions, an important option to consider is noise mapping. In this direction, according to the European Noise Directive, noise mapping is the main tool for the assessment of human exposure to environmental noise pollution. Consequently, searching for the obtention of better noise maps means better assessments of exposed population and, therefore, an improving in the design of action plans.

To obtain a noise map, different methods or strategies can be considered. Generally, we can differentiate between computerized methods based on models of sound field propagation and studies carried out with “in situ” measurements. These methods differ largely from each other in methodological aspects associated with the selection of sampling points. However, even when a computerized method is used, “in situ” measurements are necessary for calibration or validation (WG-AEN, 2007). In connection with this topic, the ISO 1996 international standard (ISO 1996-1, 2003; ISO 1996-2, 2007) describes aspects related to the calculation and measurement procedure of the sound pressure level outdoors, and it is used as a reference for noise mapping by the European Noise Directive. Although this paper focuses on the study of the application of the corrections proposed in ISO 1996 standard, similar considerations for traffic noise measurements are included in NT ACOU 039 (NT ACOU 039, 2002). In addition, some standards (ISO 140-5, 1998; ISO 16283-3, 2016; EN 12354-3, 2000) and papers (Berardi, 2013; Berardi et al., 2011) take into consideration the reflections on the building surface for façade sound insulation measurements.

Independently of the chosen method for noise mapping, if we wish to know the population exposed to noise, the fundamental question is to evaluate the incident noise level on the façade to the desired height. It is known that the incident sound level depends on many factors, both temporal and spatial. Therefore, to get a suitable assessment, it is important to consider not only the characteristics of the sound source but also the situation of the evaluation point regarding the source and the specific urban environment of each street or façade that we intend to evaluate. In this way, for each configuration, the sound energy incident on the façade of the building under consideration is evaluated as accurately as possible.

ISO 1996-2 guidelines are often followed to obtain measurement noise mapping or for the calibration and validation of calculated noise maps. But what is the level of accuracy that we can obtain with the