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KEY UPDATES IN ISO 9613-2:2024 – WHAT'S NEW IN OUTDOOR NOISE PREDICTION STANDARDS

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ABSTRACT

ISO 9613-2:2024 standard, titled "Acoustics — Attenuation of sound during propagation outdoors — Part 2: Engineering method for the prediction of sound pressure levels outdoors", which is a governing standard for outdoor sound propagation calculations, was recently revised with significant enhancements to improve the accuracy, consistency, and applicability of noise prediction models. The revision refines key parameters, such as meteorological corrections, ground effects, and source characterization, along with improved formulas for attenuation due to atmospheric absorption, updated guidance for terrain and obstacle modeling, and expanded methodologies for complex source configurations.

The new features were evaluated in this paper by presenting examples from a commercial noise mapping software that has already adapted the new revision, assessing their impact on noise modeling practice compared to the previous version, ISO 9613-2:1996. The paper also highlights how the updates align with advancements in measurement technologies and software tools. By summarizing these amendments, it offers valuable insights for acousticians, engineers, and regulatory authorities integrating the revised standard.

Keywords: *ISO standards, environmental noise, noise propagation, noise modeling, review study.*

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1. INTRODUCTION

Modeling of outdoor sound propagation poses a critical aspect to urban and rural tranquility, environmental noise assessment, regulatory compliance, and civil planning, as urban acoustics are defined by different noise sources, environmental factors affecting noise propagation and a complex geometry with a high number of surfaces and materials [1].

ISO 9613-2:2024 standard, titled "Acoustics — Attenuation of sound during propagation outdoors — Part 2: Engineering method for the prediction of sound pressure levels outdoors", offers an engineering method for predicting sound attenuation in open environments to estimate noise levels from noise sources ranging from industrial facilities to transportation networks and urban development [2-3]. Since its release in 1996, ISO 9613-2 has been in wide use by acousticians. However, due to the latest advancements in computational noise modeling, environmental acoustics, and noise prediction methods, it went through a revision and was updated in 2024. ISO 9613-2:2024 introduced new correction factors, and refined existing formulas to provide more accuracy in noise modeling of various environmental conditions.

In the 1996 version of ISO 9613-2, sound attenuation was taken into account mainly for ground effect, atmospheric absorption, geometrical divergence, reflections, and diffraction [2]. However, research in outdoor sound propagation revealed some limitations in the use of these calculations, especially with respect to ground effect modeling, multi-edge diffraction, and reflections from curved surfaces [4-5]. One of the newly added features in the 2024 revision addresses these gaps by introducing a ground effect correction factor (K_{geo}), improved screening calculations, and refined directivity correction (D_c) for chimney stacks. Furthermore, the revision includes a comprehensive approach to calculate the foliage attenuation as an alternative to the simplified empirical method of ISO 9613-2:1996.

This study compares ISO 9613-2:1996 and ISO 9613-2:2024 by highlighting the influence of these changes on environmental noise mapping. The methodology section summarizes the main computational changes implemented in the 2024 version and the corresponding scientific literature. Finally, the results section presents the effect of these updates utilizing a commercial noise mapping software which implemented ISO 9613-2:2024, in the form of noise maps. By linking the theory behind the updates in the standard with relevant practical examples, this study describes how ISO 9613-2:2024 improves the accuracy of outdoor noise predictions, and make it a more effective tool for acousticians, urban planners, and policymakers.

2. MATERIALS AND METHODS

As mentioned earlier, the purpose of this study is to compare ISO 9613-2:1996 and ISO 9613-2:2024 standards as they pertain to advancements in outdoor noise propagation modeling.

The comparison is made following an organized approach beginning with a review of ISO 9613-2 revised methodology, which is primarily based on octave band calculations to predict outdoor sound levels taking into account the influence of ground effect, atmospheric absorption geometrical divergence, reflections, and screening by obstacles [2-3]. ISO 9613-2:2024 implements some clarifications adopted from ISO 17534-3 standard, titled "Acoustics — Software for the calculation of sound outdoors — Part 3: Recommendations for quality assured implementation of ISO 9613-2 in software according to ISO 17534-1", which includes improved screening calculations [6]. The mathematical refinements studied in this paper are; K_{geo}, a geometric correction factor that eliminates ground effect attenuation (A_{gr}) under certain height conditions, A_{bar}, barrier attenuation, A_{curv}, which considers additional attenuation from curved surfaces and is part of the attenuation due to miscellaneous other effects (A_{misc}), foliage attenuation, A_{fol}, and chimney stacks directivity factor, D_c.

2.1 Ground Effect Correction Factor

K_{geo} factor in the 2024 revision directly addresses the need for ground interactions with the sound waves, which depends on the ground surface and source-receiver geometry, given by the following formula:

$$K_{geo} = \frac{d_p^2 + (h_S - h_R)^2}{d_p^2 + (h_S + h_R)^2} \quad (1)$$

where,

d_p: the source to receiver distance projected on the horizontal plane, expressed in meters;

h_S: the height of the source above ground, expressed in meters;

h_R: the height of the receiver above ground, expressed in meters.

This new factor led to the need of revising the existing formula to calculate A_{gr} in dB as follows:

$$A_{gr} = 10 \log[1 + (10^{\frac{-A'_{gr}}{10}} + 1) \times K_{geo}] \quad (2)$$

$$A'_{gr} = A_S + A_R + A_m \quad (3)$$

where,

A_S: the source region, stretching over a distance from the source towards the receiver of $30\,h_S$, with a maximum distance of d_p;

A_R: the receiver region, stretching over a distance from the receiver back towards the source of $30\,h_R$, with a maximum distance of d_p;

A_m: a middle region, stretching over the distance between the source and receiver regions. If $d_p < (30\,h_S + 30\,h_R)$, the source and receiver regions will overlap, and there is no middle region.

In summary, K_{geo} eliminates the ground effect if the source and receiver heights are much larger compared to the distance between them, which was confirmed by research that highlighted the need of this factor to increase the modeling accuracy due to the inconsistencies of ground reflection in previous methods [7].

2.2 Improved Screening Calculations

As mentioned earlier, the updated version of the standard expands the screening effect extensively. This effect varies depending on the height of the noise measurement and the distances between the sound source and the screen or barrier [8], this has been done by improving the calculation of the barrier attenuation (A_{bar}) which is determined by (Z_{min}) the minimum difference between the paths of the direct sound as if there were no barrier and diffracted path above the barriers. This is particularly helpful in multi-edge diffraction settings like urban environments.

Furthermore, ISO 9613-2:2024 implements the reflection condition recommended in ISO 17534-3. The barrier attenuation (A_{bar}) in dB, which represents the sound attenuation due to a barrier is considered be equal to the diffraction attenuation of the barrier for each octave band (D_z) if the ground effect (A_{gr}) attenuation is larger than zero.

$$A_{bar} = D_z \text{ if } A_{gr} > 0 \quad (4)$$

2.3 Reflection of Cylindrical Surfaces

ISO 9613-2:2024 now sheds light on two major parts; the first focusing on planar reflections, while the second deals with curved structures as in chimney stacks, storage tanks or silos. A reflection model for cylindrical surfaces was introduced to calculate additional attenuation based on the radius and the angle of incidence.

Curved surfaces in sound wave interactions emphasize the imperfection of the existing models in urban scenarios. For example, curved architectural elements can lead to unplanned sound concentration [9], requiring design interventions to achieve noise free distribution.

New refinements in diffraction and screening calculations have also been introduced. The complex barriers or multi-screen situations [10] lead to underestimation of noise reduction when using a single diffraction edge model as screening attenuation in ISO 9613-2:1996. It further improves this by introducing side screening factors that include diffraction across multiple edges, resulting in more accurate attenuation estimation. Figure 1 illustrates how sound rays are expected to reflect from a cylinder considering all dimensions in projection are parallel to the axis [4].

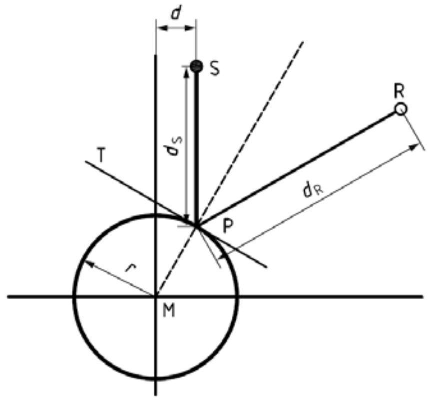


Figure 1. Reflection of sound ray at a cylinder.

The introduction of an additional attenuation term (A_{curv}) also includes reflections from cylindrical surfaces in dB, where A_{curv} can be defined as:

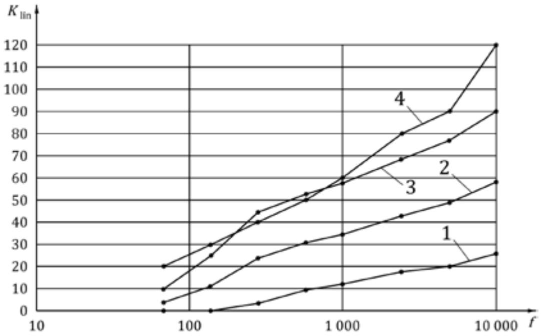
$$A_{curv} = 10\log[1 + \frac{2 d_s d_R}{r(d_s + d_R)}(1 - k^2)^{\frac{-1}{2}}] \quad (5)$$

$$k = \frac{d}{r} \quad (6)$$

where,
M: center-point;
S: point source;
R: receiver;
R: radius, expressed in meters;
P: point of reflection;
T: tangent in point of reflection;
d_s: source-receiver distance, expressed in meters;
d_R point of reflection-receiver distance, expressed in meters;
d: distance of the straight line defined by the incident ray from the center-point, expressed in meterts.

2.4 Attenuation of Foliage

The 2024 revision provides a more comprehensive foliage attenuation (A_{fol}) method, whereas the 1996 edition included only a simple empirical correction for tree belts or vegetation. The new method includes five forestry parameters, namely stem diameter (D), basal area (G), standing stock (V), horizontal structuring (S), and low height foliage (Z). Vegetation density, thickness and structural parameters were found to have a significant impact on sound attenuation in urban and suburban areas [11], which makes this update consistent with these findings. In addition, the frequency dependent attenuation factor (K_{lin}) is introduced in the new method to improve prediction under different environmental conditions. Figure 2 below highlights the typical ranges of K_{lin} as specified in ISO 9613-2:2024 [3].



Key

K_{lin} attenuation factor, expressed in decibels per kilometre

f frequency, expressed in hertz

1 light forest

2 normal forest

3 dense forest

4 attenuation with simplified method A.2.2 for 20 m ≤ d_f ≤ 200 m

Figure 2. Typical K_{lin} factors for different forestall parameters.

2.5 Directivity of Chimney Stack

Finally, the directivity correction of chimney stacks (D_c) is introduced. In ISO 9613-2:1996, chimney stacks were modeled as point sources, with the assumption of an omnidirectional radiation pattern. Nevertheless, the update indicates that industrial stacks have strong directional characteristics and hence a correction factor is required to account for the receiver level calculations. This correction is now embedded in the 2024 update and defined as D_c, which is a function of the opening geometry and radiation characteristics which depends on the frequency. Chimney stack directivity correction (D_c) is now included in the calculation of the receiver level for the equivalent continuous downwind octave band source sound pressure level at a receiver location.

This study evaluates the methodological improvements in outdoor noise prediction using practical simulations of a commercial noise mapping software, i.e. SoundPLAN. The impact of these updates is illustrated with figures and examples through the next section.

3. RESULTS

The present section summarizes the findings of noise modeling utilizing both ISO 9613-2:2024 and ISO 9613-2:2024. The results are presented in the form of noise maps.

3.1 Ground Effect Correction Factor

To evaluate the effect of K_{geo} on environmental noise propagation, two cases were assessed assuming a fully reflective ground (G=0), and noise maps highlighting the difference between 1996 and 2024 versions results were generated. In Figure 3, a point source was placed at a height of 50 m above ground level and a vertical cross-sectional grid noise map was generated to reflect the difference in noise levels between both versions. In a close distance at the same height of the source, a 3 dB difference was observed, which can be related to the fact that K_{geo} removes ground effect if the source and receiver heights are much larger compared to the distance between them. However, in Figure 4, the source was positioned at 2 m above ground level and therefore the difference between both versions is negligible.

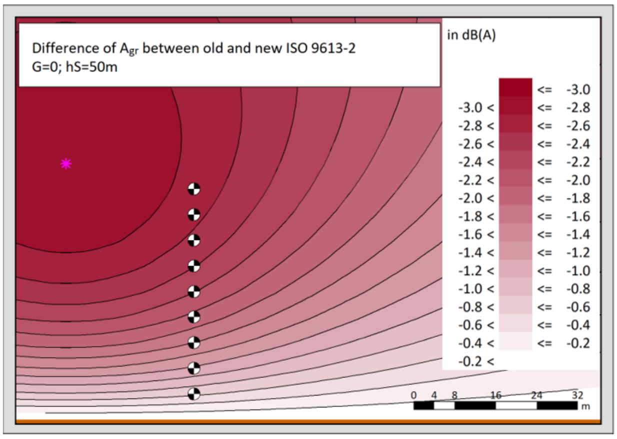


Figure 3. Difference of A_{gr} between 1996 and 2024 ISO 9613-2. Source height 50 m above ground level.

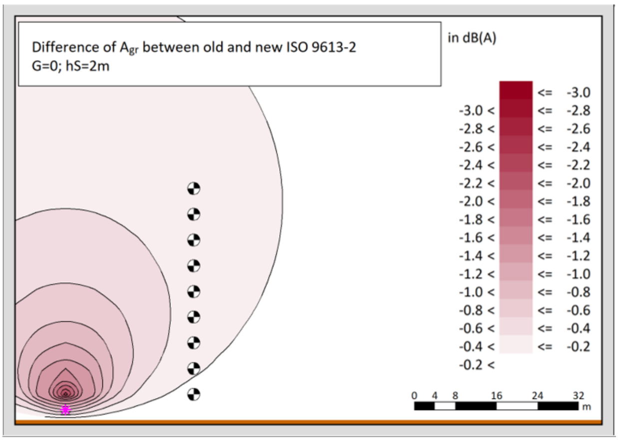


Figure 4. Difference of A_{gr} between 1996 and 2024 ISO 9613-2. Source height 2 m above ground level.

3.2 Reflection of Cylindrical Surfaces

Figure 5 and Figure 6 below show the difference in sound ray reflections at polygons and cylinders for 1/1 octave bands from 63 Hz to 8000 Hz.

In ISO 9613-2:1996, A_{curv} was not defined. Therefore, cylindrical surfaces were modelled as polygons. However, after defining A_{curv} in ISO 9613-2:2024, cylinder objects are now introduced in the mapping software, to account for more reflection points of sound rays. It can be noticed that cylinders have continuous reflections for all frequencies, while polygon objects have minimal reflections on examined frequencies until 500 Hz and straight line reflections due to the multi-edge polygon from 1000 Hz reaching 8000 Hz.

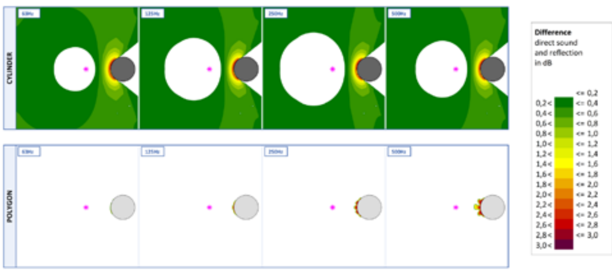


Figure 5. Difference between direct sound and reflection for 1/1 octave bands from 63 Hz to 500 Hz at polygon and cylinder objects.

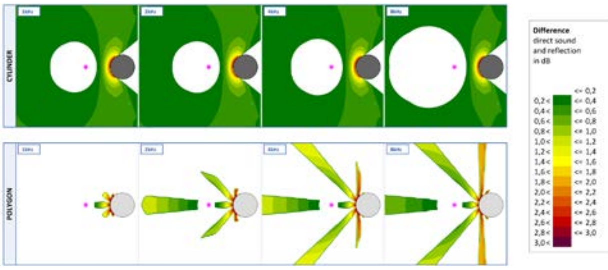


Figure 6. Difference between direct sound and reflection for 1/1 octave bands from 1 kHz to 8 kHz at polygon and cylinder objects.

3.3 Directivity of Chimney Stack

Chimney stacks and other vertical upward-facing open objects' sound is modelled as a point source in the center of the opening assuming omnidirectional radiation. However, ISO 9613-2:2024 indicates that a frequency-dependent directivity correction factor (D_c) shall be considered in noise modeling based on tables resulted from measurements conducted on large industrial chimneys [3].

Figure 7 illustrates how sound waves propagate at 125 Hz and 4000 Hz after implementing the chimney stack directivity correction D_c. This implementation is expected to increase precision and accuracy of noise modeling when compared in-situ sound propagation of chimney stacks.

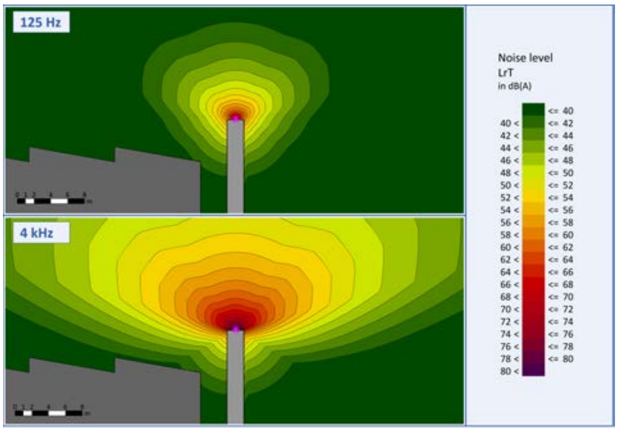


Figure 7. Sound propagation for a chimney stack (radius 1m) implementing directivity correction at 125 Hz and 4 kHz.

In summary, ISO 9613-2:2024 significantly enhances the accuracy of outdoor noise modeling by introducing key refinements that are directly applicable to environmental noise assessments. In practical tools like SoundPLAN, visualizations of parameters such as A_{curv} and K_{geo} illustrate how curved surfaces influence noise propagation and how source and receiver heights affect ground attenuation. These advancements are expected to improve noise mapping overall and enhance the precision of environmental noise evaluations in particular.

4. CONCLUSION

The differences between ISO 9613-2:1996 and ISO 9613-2:2024 are substantial in terms of the modeling of sound propagation. The standard's predictive accuracy is improved through introduction of K_{geo} for ground effects, A_{curv} for cylindrical reflections, refined screening calculations and expanded foliage attenuation model. These changes are shown to be practical for the implementation in noise mapping software, which show that they result in more accurate noise assessments and better mitigation strategies. This revision ensures that ISO 9613-2 continues to be a reliable outdoor noise prediction standard for urban planners, environmental engineers, and regulatory agencies alike.

5. REFERENCES

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