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Justification of an Amendment for ISO 9613-2:2024

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Abstract

The author served as chairman of ISO TC43 SC1 WG61, the working group responsible for the revision of ISO 9613-2 and presents key findings from the analysis of the sound propagation model defined in this standard.

Although the formalism is simple and clearly structured, particular attention is required for the complex interaction between ground attenuation and barrier attenuation. The impact of proposed revisions on calculated sound levels at distant receiver locations is evaluated using software that implements both the current version of the standard and the planned modifications.

Comparative calculations were performed for large-scale industrial sites covering several square kilometers, including models with up to 6000 individual sound sources. The results demonstrate the expected net effects of the implemented or proposed changes, both for the overall area and for individual sound propagation paths.

Keywords: ISO 9613-2, Analysis of the sound propagation, comparative calculations, large-scale industrial sites

1. Introduction

ISO 9613-2:2024 introduces approximately fifteen significant changes and additions to its 1996 predecessor. Most of these revisions are uncontroversial and reflect the quality-assurance work documented in ISO/TR 17534-3:2015, together with refinements suggested by users. Two changes, however, have given rise to serious concerns: the revised formula for the barrier attenuation D_z (Formula 18) and the revised formula for the meteorological correction K_{met} (Formula 21).

The modification of the barrier attenuation was implemented to avoid an effect of a remaining A_{bar} of 5 dB even with largest distances source-receiver and with low barrier heights if the General method 7.3.1 is applied with ISO 9613-2:1996. The modification of K_{met} was introduced based on the positive experience with this modified version of the formula in the frame of the prediction of road traffic and railway noise. After ISO 9613-2:2024 was published and implemented in software it was possible to recalculate the sound pressure levels for receivers in the vicinity of extended industrial facilities with the previous and the new version of the standard. The comparison showed that the new version led to recalculated receiver levels exceeding these calculated with the previous version systematically.

The analysis revealed that the use of the same formula for the barrier effect A_{bar} for both cases of the two-track method for ground attenuation A_{gr} according to 7.3.1 — the General method — and according to 7.3.2 — the Alternative method — was the main cause of these problems when the new formula of the 2024 version was applied. The largest level increases were detected in cases with large distance source - receiver and with barriers near the source and near the receiver.

An amendment was proposed to continue using these two formulas from the previous version until all issues have been clarified. A software version was created that still incorporates all changes made in Version 2024 but implements only these two formulas as they appeared in the previous version. The comparative calculation shows that this effectively eliminates the observed level increases. This revised version should therefore be introduced with an accepted amendment.

2. Ground effect A_{gr} and barrier effect A_{bar} – single barrier

The reference scenario, shown in Figure 1, comprises a point source and a receiver at 4 m above ground, with no intervening screen. The difference between the level calculated with ground present and that calculated under free-field conditions (4π) gives the "insertion effect" of the ground, equal to the negative ground attenuation – A_{gr}. Under the Alternative Method (7.3.2), the corresponding quantity is – ($A_{gr} – D_\Omega$).

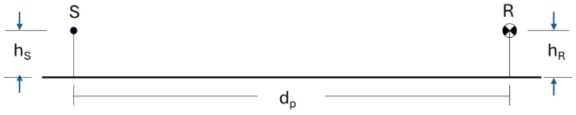


Figure 1: Scenario to determine the insertion loss of the ground

As Figure 2 shows, the deviations from the free-field level for d_p = 1 km, when calculated with method 7.3.1, range from –0.4 dB to +5.3 dB depending on the underlying

geometry. The red curve corresponds to the Alternative Method 7.3.2.

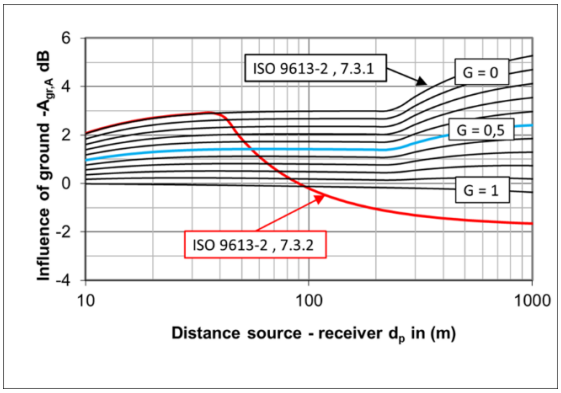


Figure 2: Negative insertion loss of the ground (deviation from free field level). $-A_{gr,A}$ is the arithmetic difference of the A-weighted receiver levels calculated first with ground and then with A_{gr} and D_Ω set to zero applying a flat linear source spectrum.

These results show that at large distance the more detailed ground model with different ground properties represented by the G values produces larger ground effects with higher level increases than the Alternative method 7.3.2.

The effect of barriers can be investigated with scenario Figure 3.

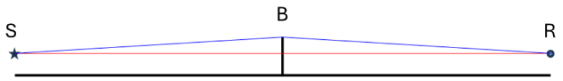


Figure 3: Source S and receiver R at 4 m above ground, with a centrally located screen of variable height.

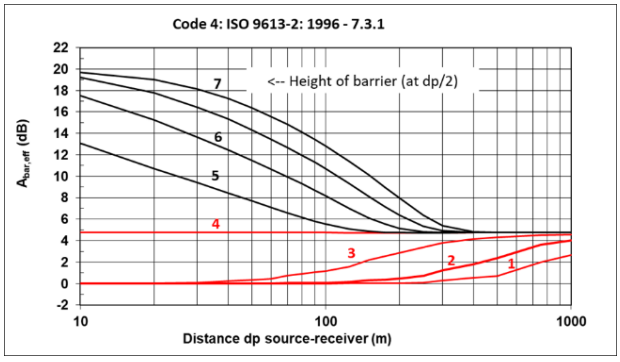


Figure 4: $A_{bar,eff}$ calculated with A_{gr} according to "General Method" (7.3.1) (ISO 9613-2:**1996**).

As it is shown in Figure 4, the effective barrier effect $A_{bar,eff}$ – related to the A-weighted level with a flat linear spectrum – does not vanish with large distances but converges against nearly 5 dB.

The same calculation with scenario Figure 3 but using the "Alternative method" 7.3.2 for the determination of A_{gr} leads to the resulting barrier effect A_{bar} shown in diagram Figure 5. Here the barrier effect $A_{bar,eff}$ vanishes with large distance source – receiver as we expect it.

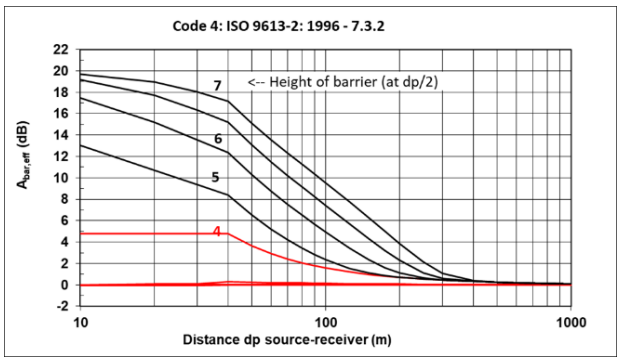


Figure 5: $A_{bar,eff}$ calculated with A_{gr} according to the "Alternative Method" (7.3.2) (ISO 9613-2:**1996**)

3. The modification of D_z in ISO 9613-2:2024

Without presenting all the equations we check the same diagram as shown in Figure 4 but now calculated with the modified equation for D_z according to this new version – see Figure 6.

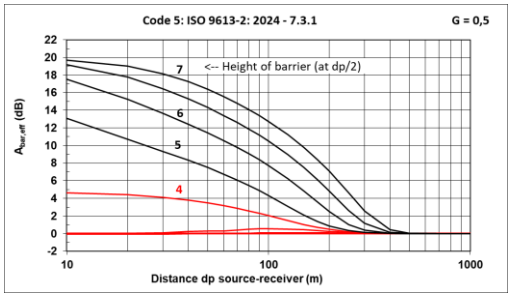


Figure 6: $A_{bar,eff}$ calculated with A_{gr} according to "General Method" (7.3.1) (ISO 9613-2:**2024**).

Obviously, the barrier effect converges against zero – the new equation works as it was intended.

4. Problem identification

It shall only be noted here that after publication of ISO 9613-2:2024 the complaints about level increases (see Table 2) with recalculated projects were the starting point for the following analysis.

Based on the comparison of Figures 4 and 6 it was clear that levels should in some cases increase up to approximately 5 dB caused by the transition from the previous version to version 2024 of the standard if the "General method" 7.3.1 is applied. But the complaints based on recalculated projects with the claim that measurements were in good agreement with the previous version gave reason to doubts. A possible explanation may be a thorough comparison of Figures 7 and 8.

These diagrams show the difference of the total A-weighted level (flat linear spectrum) for the given scenario shown in Figure 3 and the free-field level without any influence of ground and barrier.

The green curves in **Figure 7** describe the case when no barrier effect is included and therefore only the ground effect is significant. The dashed green line shows the result for the "Alternative Method" (7.3.2) with a value of – 1.7 dB at the largest distance of 1 km. This is nearly the center of the interval from -4,8 dB up to 0.5 dB

related to method 7.3.1 with different values of G and with barriers of any height (3 m – orange/red and 5 m blocking the straight ray - blue). As expected, the results calculated with the Alternative Method 7.3.2 and the low barrier with 3 m height (orange/red dashed curve), are identical to those calculated with this Alternative Method 7.3.2 and without a barrier (green dashed curve).

Important: the level increase relative to free-field at a distance dp of 1 km caused by the ground alone (green curves) with 0 dB for G = 1 up to 5 dB for G = 0 is reduced to – 4,8 dB up to 0,5 dB (orange/red curves) if a low barrier of 3 m height is inserted. Any barrier even with lower height will produce this level decrease of roughly 5 dB with any value of the ground index G.

The result: with a barrier of any height the levels at large distances are about 5 dB lower than those with ground alone and symmetrically above and below the value calculated with the "Alternative method".

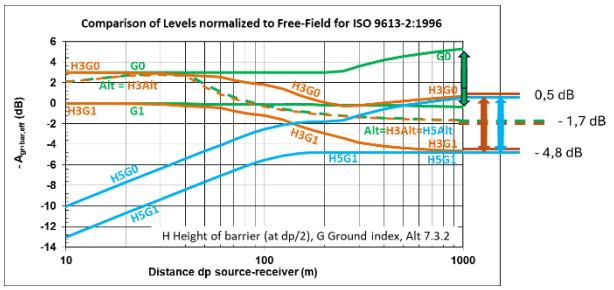


Figure 7: A-weighted levels normalised to free-field level ($\Delta LA = -A_{gr,bar\,eff}$) calculated with ISO 9613-2:**1996**

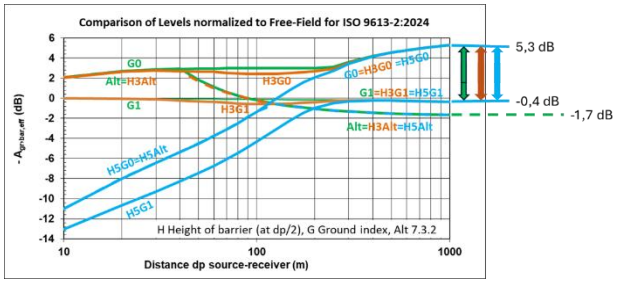


Figure 8: A-weighted levels normalised to free-field level ($\Delta LA = -A_{gr,bar\,eff}$) calculated with ISO 9613-2:**2024**

Figure 8, calculated with version 2024 shows that this property of the distribution – physically justified or not - is lost. The General Method (7.3.1) intervals for both barrier heights (blue and red curves) now converge against the green interval (no barrier) at large distance, becoming identical at d_p = 1 km. But the dashed line representing the result obtained with the Alternative Method (7.3.2) lies entirely outside this converged interval, however the level jump at large distance if a screen comes into play is eliminated, as the screen has no influence at these large distances.

The implication is significant. The residual 5 dB barrier effect under the General Method of the version 1996 may not be seen as a defect to be eliminated in isolation, but a deliberate, or at least functionally beneficial feature that compensated for the relatively high ground effect of the General Method and produced a smooth transition between the two procedures. The 2024 revision has eliminated this compensation.

5. K_{met} in ISO 9613-2:2024 – double diffraction

While the above treated modification of D_z with the version 2024 led to level increases up to 5 dB a further modification of the correction for meteorological effects K_{met} led to level increases up to 10 dB for some ray-paths. The modification was developed many years ago to reduce the level jump at the transition from single to double diffraction and was applied all these years with the calculation of sound propagation for traffic noise.

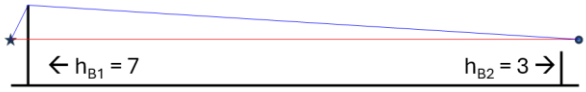


Figure 9: Scenario with 2 barriers, the level normalized with free-field level is determined as function of the height h_{B2}

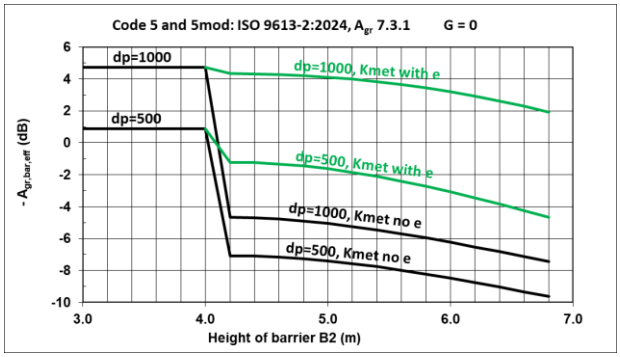


Figure 10: Black curves calculated with previous version, green curves with version 2024

Figures 9 and 10 show that the level jump with the transition from single to double diffraction was reduced with the new version (black -> green) but the levels are now about 10 dB higher after the transition from single to double diffraction with $h_{B2} \geq 4{,}2$ m at a distance d_p of 1 km.

6. Recalculation of large projects

Pending further clarification of the issues related to the two formulae for D_z and K_{met}, it is therefore recommended that ISO 9613-2:2024 be amended to ensure that these two formulae are used in accordance with the previous version. All the other modifications remain.

The software-platform CadnaA used for noise-calculations and acoustic surveillance of large industrial facilities since more than 30 years was applied to perform these comparative calculations – in the following only some results are presented.

Table 1 shows the extension of six industrial areas included in this investigation. Table 2 shows the increase of levels

caused by the transition to version 2024 and Table 3 proves that these level increases are avoided by switching back to the former version with the two formulas as it is formulated in the proposed amendment.

Table 1. Six different industrial areas with different plants completely modeled and calculated with DIN ISO 9613-2

Nr	Source area		
	Extension in m (approx.)	Number of sources (approx.)	Distance receiver - source-area (approx.)
1	200 m x 1,2 km	700	15 m - 150 m
2	550 m x 600 m	1000	15 m - 250 m
3	600 m x 1,2 km	750	30 m - 1 km
4	1 km x 3 km	6000	100 m - 1 km
5	1 km x 2 km	6000	100 m - 1,5 km
6	1,5 km x 2 km	6000	250 m - 2,5 km

Table 2. Level differences Version 1996 -> Version 2024

Nr	Comparison DIN ISO 9613-2 (1996) -> ISO 9613-2 (2024)		
	Deviation (dB) at the receiver of		
	the total level caused by all plants	the partial level of complete plants	the partial level of single sources
1	0,1 up to 1,2	1,8 up to 6,6	-0,2 up to 7,5
2	0 up to 1,0	-	-0,7 up to 8,9
3	0,8 up to 2,2	0,6 up to 4,8	0 up to 6,4
4	1,0 up to 3,5	0,2 up to 11,7	0 up to 13,7
5	0,9 up to 2,2	0,7 up to 7,2	-1,3 up to 12,5
6	0,8 up to 2,2	0,2 up to 6,4	-0,1 up to 10,5

Table 3. Level differences Version 1996 -> Version 2024 + Amd

Nr	Comparison DIN ISO 9613-2 (1996) -> ISO 9613-2 (2024) Amd1		
	Deviation (dB) at the receiver of		
	the total level caused by all plants	the partial level of complete plants	the partial level of single sources
1	< 0,1	-0,1 up to 0,1	-0,2 up to 0,1
2	-0,1 up to 0,1	-	-0,9 up to 0,1
3	< 0,1	< 0,1	-0,1 up to 0,1
4	< 0,1	-0,1 up to 0,1	-0,2 up to 0,1
5	-0,1 up to 0	-0,4 up to 0,1	-1,4 up to 0,1
6	< 0,1	-0,1 up to 0	-0,3 up to 0,1

The results shown in Table 2 were the catalyst for the detailed investigation partially presented here. Finally, Table 3 proves that these level increases can be avoided if the two formulas are reset to the state of the previous version according to the planned amendment.

7. Consequences

The deeply hidden and not easy to detect reason for the problem with the formula for D_z is the treatment of A_{gr} and A_{bar} as independent terms in the final summation equation while they interact differently in the two strategies 7.3.1 and 7.3.2. The analysis in Figures 7 and 8 can be the key for all further decisions and should be thoroughly investigated. Measurements around industrial facilities show better agreement with the previous formulation shown with the example presented with Table 3. To get the necessary time for a final clarification it seems to be the best procedure to apply the former version in accordance with the proposed amendment. Turning back, the equation for K_{met} is by far more clear and without alternative based on the findings presented with Figures 9 and 10.

ISO 9613 is a streamlined procedure that is often presented as relatively straightforward. This study once again confirms the established view that, even with this simple framework, considerable effort is required to implement the procedure in a precise and transparent manner and thus make it suitable for the field of legally regulated emission control. This should always be borne in mind before considering the inclusion of other physical phenomena that are only relevant in rare cases.

8. Acknowledgements

The author would like to thank the companies Currenta, BASF and Müller-BBM Industry Solutions, as well as their acoustic-experts responsible for carrying out the comparative calculations and for their support with the relevant investigations.