24th INTERNATIONAL CONGRESS ON SOUND AND VIBRATION
23–27 July 2017, London

EXPERIENCES WITH ISO 17534 AND RECOMMENDATIONS FOR CNOSSOS-EU

Erwin Hartog van Banda and Theo Verheij

DGMR consulting engineers, Software division, The Hague, The Netherlands
email: ha@dgmr.nl

Uncertainty in prediction is usually considered to be related to the accuracy of the input data and the accuracy of the prediction method. This paper addresses another very important kind of uncertainty that is related to the (un)clearness of the prediction method and decisions software developers are forced to make while implementing ambiguous prediction algorithms. This changed in 2015 with the release of ISO/TR 17534-3. Since then the uncertainty with implementing the ISO 9613 method in software according to the quality requirements described in ISO/TR 17534-3, is strongly reduced. However, there are still no similar quality requirements for CNOSSOS-EU. The ultimate benefit of similar quality requirements would be that the calculated results of different software programs, using the same data input, can be expected to show just about the exact same results within a narrow margin, hereby avoiding incorrect comparisons between EU member states. The question is if this is true and will this approach work for CNOSSOS-EU? This paper examines the experiences of DGMR, member of the ISO 17534 working group, while using the recommendations of ISO/TR 17534-3 for a fresh and new software implementation of ISO 9613. This paper makes recommendations based on these experiences for the quality requirements of CNOSSOS-EU.
Keywords: ISO 9613, ISO 17534, CNOSSOS-EU, SOFTWARE DEVELOPMENT

1. Introduction

The ISO 9613-2 standard is a well-known method for the calculation of industrial environmental noise [1]. The standard was published in 1996 and since then has been implemented in numerous commercial software applications. The standard however, does not contain quality requirements for applications, such as test cases and recommendations for implementation. Therefore, the calculated results of different implementations for the exact same situation cannot be expected to be the same. When comparing different software implementations of ISO 9613-2 the results of different applications can differ up to 5dB for simple situations and up to 10dB for complex situations. This makes the result of noise prediction software even more uncertain. Not because of bugs or errors in the software, but because of unclear text and ambiguous algorithms in the standard. For many years now this has been an inconvenient truth in the world of noise prediction. At the Forum Acusticum congress in 2005, special focus was put on uncertainties while implementing noise prediction standards [2]. More papers on quality requirements for software implementation [3] [4] were presented in the years following. This has all contributed to the quality standard ISO 17534 in 2015 [5]. In TR3 (ISO/TR 17534-3) test cases and recommendations for implementation of ISO 9613-2 are described in detail. This should make ISO 9613-2 unambiguous and makes it straight forward to implement in software. But to what extend is this true, and will this approach work for CNOSSOS-EU?

This paper describes the experiences of DGMR, member of the ISO 17534 working group, while using the recommendations of TR3 for a fresh and new software implementation of ISO 9613-2. Based on the experiences, this paper makes recommendations for quality requirements of CNOSSOS-EU.

2. What to expect from ISO/TR 17534-3

The main goal of ISO 17534 is to minimalize the differences in calculated results of different implementations of noise prediction standards. To examine the effect of ISO 17534, 2 independent and commercial software implementations were compared using the 19 test cases described in TR3. Both software packages have the calculation setting to include or exclude the recommendations of TR3.

The comparison could therefore be made for 2 cases; before and after applying the recommendations of TR3. The results of the comparisons are shown in figures 1 and 2

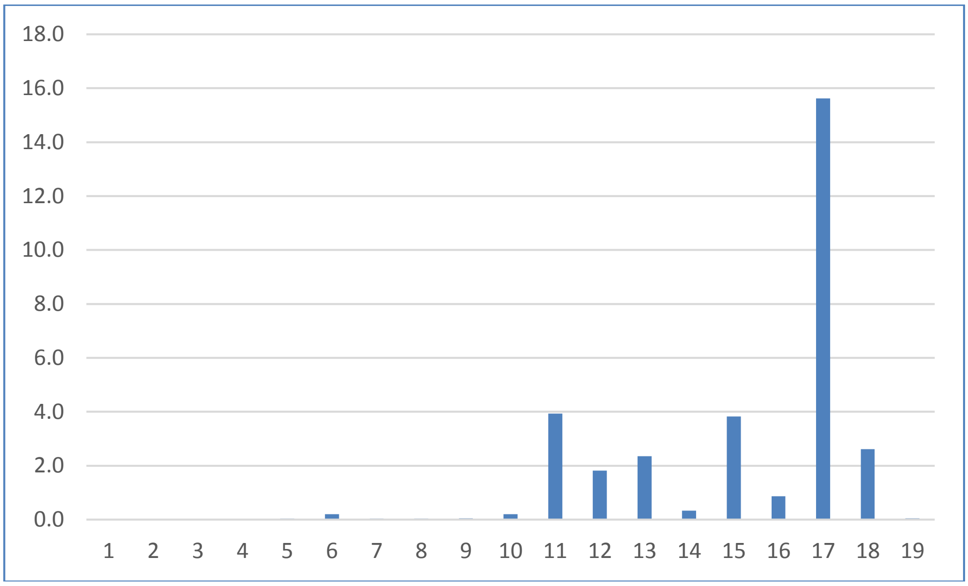

Figure 1: Absolute differences in dB between 2 software implementations before applying ISO/TR 17534-3

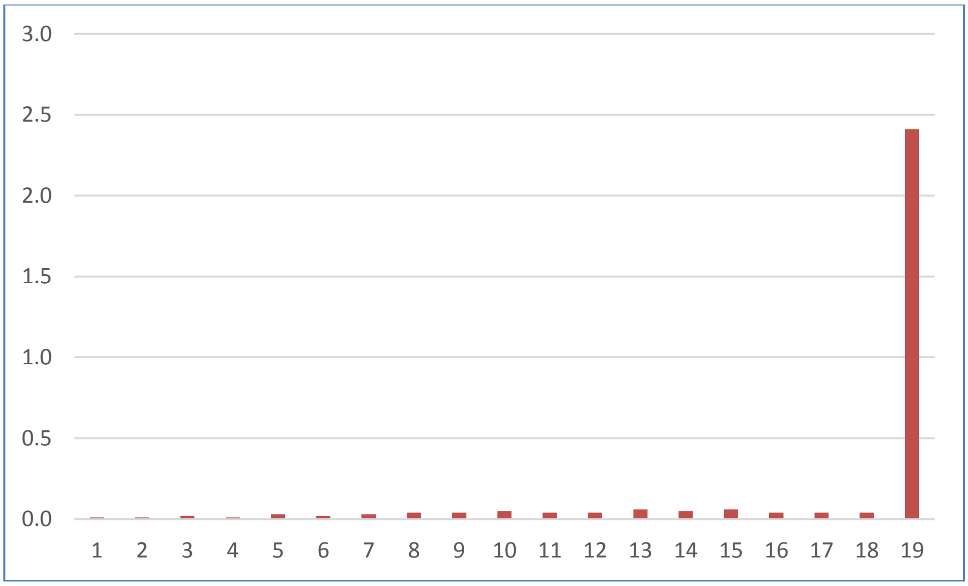

Figure 2: Absolute differences in dB between 2 software implementations after applying ISO/TR 17534-3

As displayed in Figures 1 and 2 there is a significant difference and a positive effect when applying TR3. The large difference of 15.62 dB in test case 17 is now reduced to 0.04 dB. The reason for this is the new unambiguous rubber band method to calculate lateral detours. In ISO 9613-2 objects that do not block the direct line between source and receiver don't affect the lateral detour. In ISO 9613 the left and right detours are in many cases unclear and ambiguous. One could choose to select the highest screening effect per screen or select the largest left and right detour. TR3 the rubber band method is always used as shown in Figure 3.

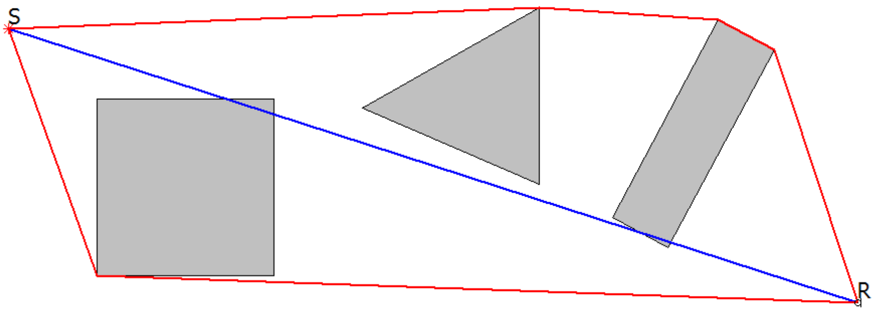

Figure 3: The red lines show the lateral detours using the rubber band method for test case 17.

The exception of 2.41 dB for test case 19 is caused by a contradiction between TR3 and ISO 9613-2. In test case 19 there is a reflection contribution for 500 Hz until 8000 Hz octave bands. However according the ISO 9613-2 this reflection should only occur for the 8000 Hz octave band due to the height of the barrier in respect to the wave length as described in formula 19 of ISO 9613-2. For 1 of the 2 applications used in this comparison, the calculation setting to include the recommendations of TR3, obviously also de-activated the wave length criterion for the height of reflecting barriers.

3. ISO/TR 17534-3, points for improvement

In this paragraph, several points for improvement are presented. Most of these points have been discussed bilaterally with other members of the ISO 17534 working group, but have not yet been published by the working group. An overview is given in table 1.

Table 1: points for improvement ISO/TR 17534-3

Subject	Type	ISO/TR 17534-3	ISO 9613	Recommendation
Nominal frequency	Conflict	62.5	63	63
Speed of sound	Unclear	Not defined	Not defined for direct path. 340 m/s for reflected path	Always 340 m/s or depending on temperature
Sub division of line and area sources	Unclear	Unclear	Not defined	Formula depending on distance to calculation point
Wavelength criteria for screening obstacles	Unclear	Unclear	Yes	Yes, as defined in ISO 9613
Negative detour	Conflict	No	Yes	Yes, as defined in ISO 9613
Accuracy of neglecting L/R detour for direct path	Conflict	Factor 8 versus 0.05 dB	Unclear	Use the path length difference z, not the perpendicular distance
T08 – L/R detour screen	Error	Yes	Unclear	No (factor 8)
T09 – R detour screen	Error	Yes	Unclear	No (factor 8)
T19 – Octaves reflections	Error	500 Hz– 8000 Hz	8000 Hz (no additional node at crossing height line)	8000 Hz no additional node at crossing height line)

3.1 Nominal frequencies

In Chapter 1 of ISO 9613-2 it is stated that the calculations are executed with nominal mid band frequencies from 63 Hz to 8 kHz for the octave bands. However, in all test cases the calculations are performed for 62.5 Hz and not the nominal frequency of 63 Hz.

3.2 Speed of sound

In ISO 9613-2 the speed of sound is not given but only a note on how the calculation of the wave-length for the reflection criterion is calculated in which 340 m/s is used. The speed of sound however depends on the air temperature. One could use the same temperature which is used to select/calculate the air absorption. A common formula according to the Taylor expansion (Wikipedia) to calculate the speed of sound at a given temperature is:

$$c = 331.3\sqrt{(1 + (\vartheta / 273.15))} \quad (1)$$

Where c is the speed of sound in m/s and ϑ is the air temperature in °C.

3.3 Subdivision of line and area sources

Chapter 4 of TR3 states that line sources (including road and rail) are divided into line segments, area sources are divided into area segments, each represented by a point source at its centre. There are no rules given on how to do so. This indicates that the check “with automatic subdivision of line and/or area sources under consideration of the distance to the receiver” in Table 71 should be removed as it is not based on ISO 9613-2, unless it were added as an additional recommendation. There are only rules described for grouping point sources (same Lw and height, same propagation and d<2Hmax). This check is not included in table 71.

3.4 Wavelength criteria for screening obstacles

ISO 9613-2 states in Chapter 7.4 that an object is only considered to be a screening obstacle when its horizontal dimensions perpendicular to the source-receiver line is larger than the wavelength. It is not specified in TR3 if this requirement is used. Test calculations seem to indicate it is not used. In case of reflections this can quickly result in high barrier effect for only a small object, as (according to the recommendations) in reflection calculations only the vertical detour is taken into account.

3.5 Negative detour

The use of the rubber band method seems to indicate that no barrier effect will be calculated in case of a negative detour (the top barrier is below the direct line source – receiver). This is not ac-cording to ISO 9613-2.

3.6 Accuracy of neglecting L/R detour for direct path

According to TR3 “lateral diffraction paths are neglected if the maximal distance of one or more diffracting edges contributing to the ribbon from the straight line source – receiver exceeds this max-imal distance in the plane EV by a factor more than 8”. The effect on the results for test case 08 and 09 is indeed within the required accuracy of 0.05 dB. However when the maximal perpendicular distance in the plane EV gets smaller, the effect of neglecting the lateral diffraction paths increases and can become 1 dB or more. This is in conflict with the required accuracy of 0,05 dB. A better approach could be to use the factor 8 for the path length differences instead of the perpendicular distances.

3.7 Test cases T08, T09 and T19

In test case T08 the left and right detours are calculated. According to the factor 8 criteria of TR3 these should be omitted.

In test case T09 the right detour is calculated. According to the factor 8 criteria TR3 this should be omitted.

In test case T19 a reflection is calculated in a barrier which is located on a slope and which length is larger than its height. It is only possible to replicate the results stated in TR3 when altering the model or calculation as follows:

1 - The test case does not use the correct definition of lmin in formula 19. According to ISO 9613-2 the definition of lmin is “the minimum dimension (length or height) of the reflecting surface.” In this test case the value lmin is determined by the height of the barrier and not by the length, thus, reflections are only possible for 8000 Hz.

2 - If this height criterion is ignored and only the length criterion is used, the test case still does not give correct results as no reflection is calculated for 250 Hz. This seems to be the result of adding a node to the barrier where it crosses the height line at the bottom of the slope and thus shortening the length of the barrier.

3.8 Other points

The described method for applying the rubber band method for lateral diffractions is not unambiguous as is stated on the top of page 3 of TR3. Also it is stated that “A common strategy will be developed and included in further revisions.”. ISO 17534-1 however states that unambiguous rules are necessary to minimize the deviations caused by different interpretations. It should on the contrary not introduce these ambiguous rules.

In Chapter 7.4 of ISO 9613-2 it is stated that for the calculation of Dz, multiple significant paths can be considered. These paths are not limited to the 3 illustrated in figure 5. In TR3 it is stated that there are only 3 paths: vertical, left and right. If this is seen as the preferred interpretation, then it obviously should be added as a recommendation. In this sense figure 3 in TR3 is not a clear example, as the line over the south buildings and around the north buildings might be more dominant than the line around the south buildings.

4. ISO 9613-2 versus ISO/TR 17534-3

On several points TR3 is different than the ISO 9613-2 method. Because of these differences TR3 is much more than a recommendation on how to interpret ISO 9613-2. One could argue that it is a complete new calculation method. This can lead to confusion when taking a case to court. The question that rises is why not adapt the ISO 9613-2 itself? This would also lead to a better consistency of the calculation standard when compared to a future erratum document. The errors and conflicts discussed in paragraph 3 would be less likely to occur. Definitions and nomenclature will not differ as there will be only 1. The same would apply for CNOSSOS-EU.

5. Conclusion and recommendations.

Conclusions: The ISO 71534 standard fulfils its aim. The differences in results between separate software applications for the same situation are strongly reduced. A similar positive affect can be expected when using this approach for CNOSSOS-EU. The ISO/TR 17534-3 report does contain some obvious errors, conflicts with ISO 9613-2 and unclear text. These could easily be fixed in a new revision. More importantly however the recommendations of ISO/TR 71534-3 include replacing existing unambiguous and clear algorithms of ISO 9613 with other unambiguous and clear algorithms. The scope of the ISO/TR 17534-3 report is therefore much wider than a recommendation on how to interpret the ISO 9613. It redefines the ISO 9613 and can therefore be considered as a new separate method.

Recommendations: Replace ISO/TR 17534-3 by a review of ISO 9613 that includes the recommendations and test cases of ISO/TR 71534-3. This will make ISO/TR 71534-3 obsolete. Fix the errors, conflicts and unclear text as discussed in paragraph 3. Make clear choices. For instance state that the method is not suited for area sources and line sources or, add a clear unambiguous algorithm on how to do so.

REFERENCES

1 ISO-9613-2, *Acoustics – Attenuation of sound during propagation outdoors – General method of calculation*, ISO (1996).

2 Hartog van Banda, S.E. and Stapelfeldt, H., *Implementing prediction standards in calculation software – the various sources of uncertainty*, Forum Acusticum (2005).

3 Hartog van Banda, S.E. and Stapelfeldt, H., *Software implementation of the Harmonoise/Imagine method, the various sources of uncertainty,* Internoise (2007).

4 Hartog van Banda, S.E. and Manvell, D., *Implementing noise prediction standards in software – challenges and experiences,* Internoise (2013).

5 ISO/TR 17534-3, *Acoustics – Software for the calculation of sound outdoors – Recommendations for quality assured implementation of ISO 9613-2 in software*, ISO (2015).