The assessment and quality-assured implementation of methods for the calculation of sound propagation outside

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Introduction

The quality of software-implemented prediction methods for the noise from planned infrastructure projects can be described by properties like accuracy, precision, transparency and performance. Unfortunately it is often neglected that the optimization of one of these properties at the cost of the others may reduce the quality of the final result. From the implementation in software and the application with complex environments follow requirements that are often outside the professional view of noise experts being more interested in physical aspects of sound propagation. Especially with engineering methods where the propagating sound waves are approximated by few geometrically well defined ray paths the geometric and numeric strategies applied are of large influence on the accuracy of the final result. To ensure an acceptable balance between the above mentioned properties with a calculation method implemented in different software-platforms some measures have been developed and are described in the draft of the International Standard ISO 17534. With this contribution some core contents and background information is discussed.

The structure of the ISO 17534 - series

One of the main targets of quality assurance in the implementation of calculation methods in software is to ensure identical or with an acceptable frame of uncertainty comparable results. Consultants or other noise experts applying one of the commercially available software-packages must rely on the correct implementation even if they are not able to check this in each individual case themselves. Checking the correctness of an implementation is easier with clear and consistent calculation procedures, but on the other side there is a tendency to include more and more acoustically relevant phenomena and thus to make calculation strategies more complex.

The drafts of ISO 17534 – series try to solve this balancing act by introducing adequate measures. The structure of this series is shown in figure 1 – it takes into account that there is one group of basic and generally prevailing measures and another group of method specific actions.

The core standard is ISO 17534-1 [1]. It describes 6 blocks of actions that set up requirements for calculation methods that shall be implementable quality assured and for the software package as a platform where even more calculation methods can be offered alternatively.

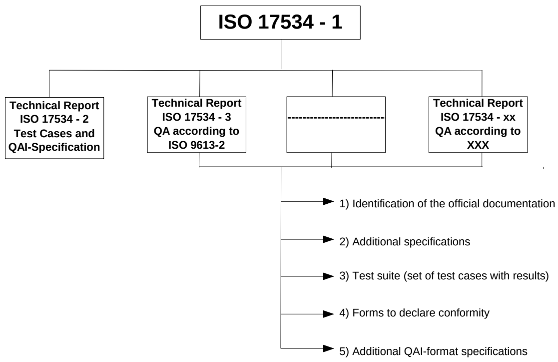

Figure 1: The structure of the drafted ISO 17534 – series

For each calculation method that shall be included in that framework of quality assurance an own Technical Report is foreseen. As a first example the Technical Report ISO 17534 – 3 [3] was drafted for the calculation method ISO 9613 -2. It is required for a method specific Technical report to identify clearly and unambiguously the official documentation, even if the relevant algorithms and strategies are spread over more publications. Secondly the Technical Report may contain “Additional recommendations” being a decided supplement if the method according to the official documentation is not complete or ambiguous in some aspects. Such additional specifications may also be necessary if open and undefined issues require all software developers to find an own solution – in such cases the working group decides for a common solution as long as there is not a responsible standardization group taking this action. Summing up the Additional recommendations are preliminary advices to ensure the necessary precision (same results with the same test case) and finally to make a calculation method fit to be quality assurable despite these undefined parts. A further important part of the method specific Technical Report is a suite of test cases with step by step and final results. With these results an interval with acceptable deviations to rank the calculated values as correct is given. It shall only be mentioned that these test cases shall be as simple as possible to facilitate the necessary checks and only as complex as necessary to prove the correct calculation of the algorithms under test. There is also a form to be applied by the software developer to declare conformity. Finally the data exchange by a common format may need some method specific supplements – these are also included in the method specific Technical Report.

The test cases without solutions and those parts of the exchange format that are independent from the method applied, e.g. geometric data of ground and objects like buildings or barriers are included as a sort of library in the Technical Report ISO 17534 – 2 [2]. They can be used as a pool for the development of further method specific Technical Reports.

Example: Additional recommendations for ISO 9613-2

ISO 9613-2 is a standard used worldwide especially to calculate industry noise, but unfortunately some open issues are responsible for deviating results with different software implementations. Further about 18 years of experience with the method showed that the calculation of barrier attenuation need some amendment statements to adapt the method to precise software realizations.

These additional recommendations are the following.

Screening: If acoustically impervious objects like barriers or buildings are blocking the direct straight line from source to receiver, generally 3 contributing ray paths should be taken into account in the calculation, one over top and two laterally diffracted around the objects. The ray over top is constructed in a vertical plane EV, the lateral diffracted rays in a plane EL. Both planes contain source and receiver, plane EV is perpendicular to the reference plane x-y and plane EL is perpendicular to plane EV. The ray path in plane EV connects source and receiver like a ribbon enveloping the diffracting edges as shown in Figure 2. The two ray paths in plane EL left and right from plane EV are shown in Figure 3. These lines are also polygon lines as formed by ribbon band. 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 maximal distance in the plane EV by a factor more than 8. The path length difference z of each of these relevant contributions is the difference in length of the ribbon and the straight direct line from source to receiver. The length of the polygon-segments between the first and the last diffracting edge is the parameter e needed in Equation (15) of ISO 9613-2.

Maximal possible attenuation by barriers: The restriction of D_z not to be taken greater than 20 dB in the case of single diffraction and 25 dB in the case of double diffraction in any octave band should only be applied for diffraction over the upper edges.

Calculation of the path-length difference: Equation (14) in ISO 9613-2 should be applied in two steps. First the argument of the logarithm is calculated, and only if it is equal or larger 1 the log-function is evaluated. Otherwise the result is taken as 0.

Diffraction with barrier on reflecting ground: Equation (12) in ISO 9613-2 should not be applied with $A_{gr} < 0$.

No level increase caused by barriers: If the direct ray is screened, the three barrier attenuations $A_{bar,top}$, $A_{bar,side1}$ and $A_{bar,side2}$ and an effective value should be calculated. If the result of this A_{bar} is negative, the effective A_{bar} is 0.

Ground effect: The ground effect A_{gr} in ISO 9613-2, 7.3 is determined for each pair source-receiver from the path in the vertical plane EV – the paths of lateral diffracted sound in plane EL are not considered.

No lateral diffraction with elevated ground screening the direct ray: If at least one contour line of the ground is relevant for the screening and influences the shape of the rubber band from source to receiver lateral diffraction is not calculated.

Multi-reflection: If reflections of higher order shall be calculated, the mirror image source of order n+1 is the mirror image of order n. The method can be expanded consistently to any order of reflection.

Example: Test case for diffraction with varying ground

Test cases in the Technical report ISO 17534-3 are exactly defined pure situations where all relevant input parameters are given.

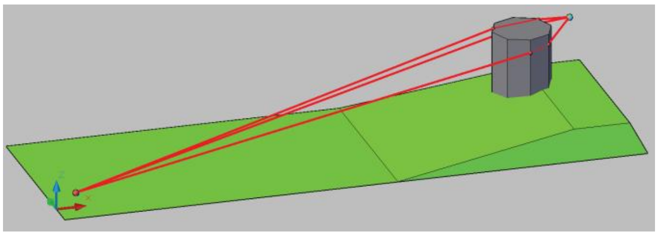

Figure 2: Test case with source-receiver and diffracting object on ground with varying height and ground index G

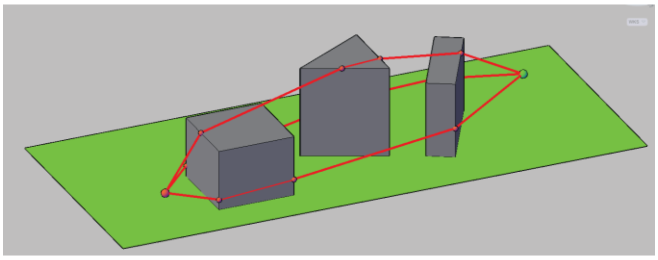

Figure 3: Test case with source-receiver and 3 diffracting objects

The coordinates of the relevant ray paths and the step by step results in octave bands are given in the standard. This is an effective support of software developers to verify the correct implementation of the standard in agreement with the requirements of ISO 17534.

Literature

[1] ISO/CD 17534-1: Acoustics – Software for the calculation of sound outdoors – Part 1: Quality requirements and quality assurance

[2] ISO/TR 17534-2: Acoustics – Software for the calculation of sound outdoors – Part 2: General recommendations for test cases and quality assurance interface

[3] ISO/DTR 17534-3: 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,