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Acoustics — Software for the calculation of sound outdoors —

Part 1: Quality requirements and quality assurance

Acoustique — Logiciels de prévision de bruit dans l'environnement — Partie 1: Exigences de qualité et assurance qualité

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

ISO 17534 consists of the following parts, under the general title *Acoustics — Software for the calculation of sound outdoors*:

— *Part 1: Quality requirements and quality assurance*

— *Part 2: General recommendations for test cases and quality assurance interface* [Technical Report]

— *Part 3: Recommendations for quality assured implementation of ISO 9613-2 in software according to ISO 17534-1* [Technical Report]

Introduction

Noise calculation methods are a mathematical description on how to determine noise levels at receivers from the emission data of sources and from data describing the acoustically relevant environment along the propagation paths. In some cases, they include the determination of the sound emission from the technical parameters of the sources. Even if knowledge about the physics of sound propagation grows continuously driven by research and experience, the standardized calculation methods are adapted to this increasing state of the art stepwise and remain constant some years for reasons of planning stability. If obviously relevant influences on sound emission and sound propagation cannot, with sufficient accuracy, be derived from physical models with existing knowledge, empirically constructed mathematical formulations are often applied as a time-limited agreement. Such a compromise between experts needs careful consideration of pros and cons and is generally derived and periodically reconsidered by standardization or similar groups.

In some cases, software programs are designed and developed to apply a certain documented method. Software products with more than one alternatively selectable calculation method implemented are software platforms, often organizing many other important jobs and operations like the user interfacing, the data input and output facilities, the tools to inspect and modify the input data, and last but not least, the tools to present and analyse the result data.

The illustration in Figure 1 shows the structure of the ISO 17534 series. Such a subdivision generated by the introduction of a row of Technical Reports is necessary because in many cases, existing standards or alternative documentations of calculation method are not complete in the sense that certain situations occurring in real scenarios are not or not sufficiently covered. Existing specifications are often unclear and allow different interpretations — in such cases, it is necessary to reduce the degrees of freedom and varying interpretations by writing down the best possible compromise as an "interim solution" as long as the responsible standardization committee or another responsible body will not fill the gap.

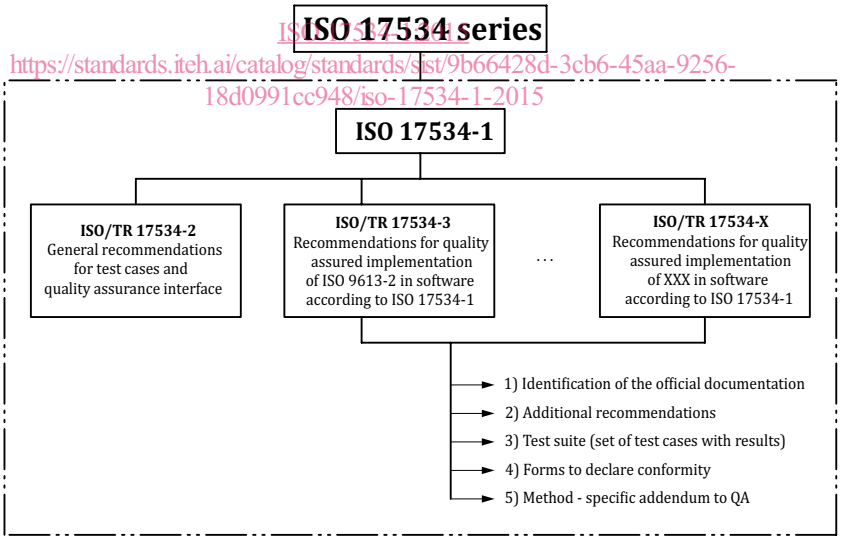

Figure 1 — Structure of the ISO 17534 series consisting of the main Part 1 and subordinated Technical Reports

Acoustics — Software for the calculation of sound outdoors —

Part 1:
Quality requirements and quality assurance

1 Scope

ISO 17534-1 describes quality requirements and measures to ensure, to indicate, and to verify the degree of conformity of a software program with a consistently implementable calculation method/procedure.

The main objective of ISO 17534-1 is to ensure that applying a consistent implementable calculation method with different quality assured software products on an identical set of input data will produce the same results within a defined range of acceptable deviations.

ISO 17534-1 enables the producer of this type of software to declare and to proof the correct implementation of a calculation method and the software user to verify it without the necessity of a third-party certification. It takes into account that software developers and software users are members of the same scientific-technical community and offers means and measures for a transparent and open communication between them.

ISO 17534-1 does not cover the aspect of correctness of the calculation method itself, i.e. especially the agreement of calculated results with results obtained with measurements will not be touched.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
accuracy
agreement of results calculated with a software with those obtained by strict obedience of the method according to its official documentation

2.2
beta version
version of the software not yet ready for release but sent to a selected group of users for testing and comment

2.3
calculation method
complete set of algorithms, simulations, and other routines necessary to determine a result in accordance with the scope of the method on the basis of a complete set of input data

Note 1 to entry: A set of input data that quantifies and describes the noise sources output and position, the geometric and acoustic properties of the environment that influence sound propagation, and the positions of the receivers.

Note 2 to entry: For the purpose of ISO 17534-1, "calculation", "prediction", or "computation" has the same meaning.

2.4
calculation ray
polygon line representing a propagation path from a point source to a receiver taken into account to calculate the corresponding sound contribution

2.5
correct results
results calculated with *reference configuration* (2.12) that are in agreement with the published results or intervals

Note 1 to entry: In this sense, a result is correct if it is obtained by exactly applying the calculation method according to its official documentation.

Note 2 to entry: Other aspects of correctness are beyond the limits of the normative definitions of ISO 17534-1. This includes the error propagation with uncertain input data, uncertainties caused by simplifications in the calculation model or other influences caused by shortcomings in the physical understanding, or mathematical formulation.

2.6
declaration of conformity
Test Case Results Comparison Form (TRC-form) stating that the results calculated for the test cases obtained by means of the software are within the tolerances specified and a Grade of Implementation Form (GoI-form) stating the grade of agreement of the implementation with the official documentation

2.7
modified configuration
configuration of the software where one or more steps according to the *official documentation of a consistently implementable calculation method* (2.9) necessary to obtain a result in the frame of its scope are approximated, neglected, or otherwise simplified

Note 1 to entry: The reason to select such configurations is often to accelerate the calculation and to perform it in less computational capacity.

2.8
new release
version of software made available to end-users having a version or release number or date different from the previously available version

Note 1 to entry: Beta versions of new releases are not included.

2.9
official documentation of a consistently implementable calculation method
clear and unambiguous documentation sufficient to perform a calculation covered by the scope of the *calculation method* (2.3)

2.10
point to point calculation
P2P
calculation of the sound contribution or attenuation based on one calculation ray either in case of a direct ray from the source to the receiver or a reflected ray with direction changes

2.11
quality assurance
securing of an agreed acceptable quality of a software implemented *calculation method* (2.3) by following the requirements and recommendations

2.12
reference configuration
configuration of the software where all steps according to the *official documentation of a consistently implementable calculation method* (2.9) necessary to obtain a result in the frame of its scope are performed and none of these steps is approximated, neglected, or otherwise simplified

2.13
software
programs, procedures, rules performed by an information processing system based on a set of routines operated by computers to determine a result from a set of input data by performing a consistently implemented *calculation method* (2.3)

2.14
test case
unambiguous description of a scenario with one or more sources and one or more receivers by a complete set of input data with intermediate and final results and intervals of acceptable deviations calculated in the *reference configuration* (2.12)

Note 1 to entry: According to this definition, a test case is always related to a well-defined calculation method.

Note 2 to entry: See 4.5 about requirements for such test cases.

2.15
test scenario
complete description of a complex scenario to check the precision of a method implemented in different software products operated in a specified configuration or to evaluate the uncertainty caused by applying a *modified configuration* (2.7) instead of the *reference configuration* (2.12)

2.16
test suite
set of test cases to check the correct implementation of a *calculation method* (2.3) in software

2.17
uncertainty
statistical description of potential deviations of calculated results from those obtainable with best possible *accuracy* (2.1) due to ambiguous or unclear descriptions in the *calculation method* (2.3), or in the software through, for example, the application of acceleration techniques based on model simplification or other software strategies which neglect sources or calculation steps

2.18
user documentation
information about use, features, interfaces, *calculation methods* (2.3), and obtainable results

Note 1 to entry: The user documentation can also support the solving of problems. Documentation can be supported as data-files or in paper form. Examples are user manuals, reference handbooks, online help, or websites.

2.19
verification
process of running *test suite* (2.16) calculations and comparing computational results with published *correct results* (2.5)

3 Quality assurance of software with calculation methods implemented

Quality assurance according to ISO 17534-1 is based on a clear separation between the software platform in the sense of the licensed product on one side and the implemented calculation methods on the other side. Many features and operations supporting the modelling and the presentation and analysing of results are independent from the calculation method applied. Calculation methods and software technologies have been developed progressively the last decades and therefore nearly all predictions and simulations are based on the application of software. Experience shows that weaknesses or even faults in the calculation methods are often earliest detected if the method has been implemented in software and can be applied with realistic scenarios and input data. In such cases, it shall be avoided that each software producer creates and implements his own solution as long as these problems are not solved and included in official documentation. If this is not possible or as an intermediate step, agreed solutions shall be described as “Additional recommendation” in a method-specific Technical Report according to Figure 1.

Calculation methods shall be complete in the specified range of application and need a clear and unambiguous documentation. Under view of quality assurance, it is not acceptable that unspecified terms and procedures shall be interpreted during software implementation with an inevitably large spread of different solutions. The developer implementing a calculation method in software shall be supported by test cases with correct results and preferably with step-by-step results. The documentation, the existence

of such test suite with results, and a standardized form for the declaration of conformity of an individual implementation are a minimum requirement for consistently implementable calculation methods.

Software products in accordance with ISO 17534-1 shall also offer a clear documentation where the conformity of the implemented calculation methods with the underlying documentation is declared in standardized form. They shall support the user checking the uncertainty of calculated noise maps and noise contours caused by approximations and interpolations. They shall further allow the exchange of data using a specified format.

This document is based on six main pillars, namely:

1) general requirements for calculation methods to be consistently implementable;

2) in that frame a set of test cases with acceptable result intervals;

3) general requirements for software platforms to allow the quality assured implementation;

4) a methodology to determine the uncertainties of noise maps and sound contours due to modified configurations of the software;

5) the definition of a data format to allow the exchange of geometric and acoustic data;

6) a form to declare conformity of the implemented calculation method with its official documentation.

The organization, group, or person responsible for the official release of a consistently implementable calculation method (e.g. a standardization committee, working group, or administration) should take care that the method-specific parts of tools according to pillars 1, 2, 5, and 6 above are published as part of the method. If this is not the case in the official documentation, it should be included in a Technical Report as a method-specific addendum or method-specific additional recommendation of ISO 17534-1.

While the requirements related to the software and to all calculation methods generally are treated in this main document, all parts related to a specific calculation method are treated in the Technical Report related to the method.

4 Requirements for consistently implementable calculation methods

4.1 Documentation

The method shall completely be documented. If it consists of more than one document, a dated main document shall give clear reference to all other documents. The parts of these documents that are not part of the method completely to be implemented shall be indicated.

This documentation shall include all mathematical routines, equations, and other information necessary to avoid different interpretations if the method is implemented in software by different groups. To ensure the necessary participation and control by a representative group of experts, such calculation methods shall finally be published as standards or as comparable technical guides in English. This is even the case with methods developed in the frame of a public or otherwise financed project. The form to declare conformity of the calculation method implemented in software shall be part of this documentation or part of the method-specific Technical Report according to ISO 17534-1.

4.2 Completeness

The range of application shall be defined clearly and unambiguously. It shall show up the frame within which the method is completely defined to ensure an acceptable precision if it is applied by different persons or groups with no further information but this documentation.

In many standards dealing with sound propagation, the relevant physical phenomena are treated sequentially in different sections. It is an important first step to structure the possible occurrences of the phenomena taking into account all possible environments that are in accordance with the range of application.

A section about diffraction and the calculation of barrier attenuation is not complete, if the relevant equations are only given for one or two parallel barriers and shown in a cross section vertical to the barrier, if the calculation of sound pressure levels in residential areas caused by roads, or other sources is allowed inside the range of application. Information should be given on how to handle any possible arrangement of screening objects like buildings.

If the calculation method related to a certain phenomenon does not treat the effect of this phenomenon in certain cases occurring in typical environments, then clear specifications shall be given on how to take this into account. This is even necessary if nothing shall be calculated in such cases.

With elevated objects with a gap between their lower edge and the ground where sound can propagate through this gap, the method should specify if such gaps should be neglected, if straight geometrical transmission or even upward diffraction should be included in the calculation. In this latter case, the calculation procedure should be given for the specified calculation strategy. How to combine diffraction over the upper edge and lateral diffractions with many objects is also a common problem, where clear strategic specifications are necessary to avoid different interpretations with a corresponding large spread of results obtained with different software implementations.

4.3 Unambiguity

Unambiguous rules are necessary to minimize the deviations caused by different interpretations. This needs expertise in software design – it is therefore necessary to include the expertise of software specialists if physical principles are transformed to implementable equations and numerical procedures used in automated routines. With respect to programming, diffuse expressions like “near, far, parallel, first row of buildings…” shall be avoided, if they cannot further be specified and quantified to make them clear applicable without ambiguity in all practically occurring scenarios.

4.4 Consideration of software strategies

Most calculation strategies of the engineering type are an aggregation of specifications, explanations, and equations developed and decided by physicists, acousticians, and other scientists or technicians. Taking into account that all calculation methods will finally be transformed to or implemented in software, it is necessary that experts in computer science shall assist the final development of calculation methods.

4.5 Test cases — The verification of the correct implementation

4.5.1 The purpose of test cases

Test cases are an important tool to check the correctness of an implementation. An optimal set of test cases that covers all important parts of the method is a powerful support for the software developer in controlling step by step the implemented procedures. But it is also a tool for the software user to validate the correct calculation with the method selected. Test cases for a given calculation method are not an examination, but a support of software developers and users. The implementation of a calculation method without test cases cannot be quality assured according to this part of ISO 17534. It is the responsibility of the designers of a calculation method, of the authors of the standard, or other persons or groups finalizing a method to take care that such test cases are published together with the method. Missing test cases can be developed and published in the Technical Report in the frame of quality assurance of the calculation method according to ISO 17534-1.

4.5.2 The design of test cases and test scenarios

Test cases are designed to prove the correct implementation of equations and routines related to different phenomena like ground effect, diffraction, or reflection.

These test cases shall comprise scenarios as simple as possible and only as complicated as necessary to prove the correct calculation related to the issue under test. It is advantageous to include step-by-step results in the documentation to support the quick detection of the reason for a deviation. It is also helpful to apply spreadsheets or software individually programmed to apply the relevant parts of the

method on the case under test. For each test case where a sound pressure level shall be calculated, the step-by-step results and the final result shall be given to two decimal places and/or an interval with lower and upper limits shall be given to one decimal place. If there are no effective degrees of freedom to calculate the result, the lower and upper limit of the resulting interval depend only on rounding aspects (see Table A.5). In all cases, even where results can be unambiguously calculated in agreement with the official documentation, the intervals shall cover the possible range.

The "ideal" case where each equation and mathematical formulation is covered by a test case of this type might often not be possible. But the main applications and the most complicated parts of the method shall be covered.

Test scenarios comprise realistic situations covering many aspects not detectable with precisely defined situations as described above. With larger scenarios, the effects included in pure form in test cases can occur in combination and even in a way not overseen by the developers of the calculation method. If calculation methods applied with such large scenarios shall produce comparable results even if they are implemented in different software, it is fundamental in the frame of quality assurance to investigate their precision and the typical spread of results. These test scenarios can even be applied to improve the method under test by thoroughly investigating the reason for unacceptable deviations at the relevant points. A third aspect is to compare the results calculated with reference configurations and with a modified configuration and to determine the uncertainties caused by these modified configurations.

The determination of the spread of results and the precision of the method according to ISO 17534-1 with realistic a test scenario is best achieved with a confidential and reliable design of a round robin test performed according to the ISO 17534 series. The selection of software applied shall be representative and the requirements of ISO 17534-1 shall be respected. The test calculations shall be performed under control of producer of that software. With M participants and N receiver-positions, the result of such a round robin test is the quantile $q_{0,9}$ according to C.4 of the N maximal absolute differences between calculated level and the arithmetic average of all M levels.

NOTE A neutral and trusted person as a team leader independent from but accepted by the participants involved is necessary to analyse the data. Each participant sends his calculated data to this team person. He calculates the mean value of all results and the deviation of each calculated value from this mean value. Each participant is informed about the mean value and the deviation of all separate results in an anonymized form.

4.5.3 The definition of a set of test cases

In Annex A, an example of a test case (see A.2) and another example of a test scenario (see A.3) is shown. The test case A.2 is a step-by-step calculation with ISO 9613-2 for a precisely defined scenario. The main calculation procedures described in the official documentation of a method including the additional recommendations in the method-specific Technical Report (if these exist) shall be covered by such test cases.

The example shown in A.3 is a test scenario — a complex model where a detailed reporting of step-by-step results is impossible. With a round robin test using different quality assured software implementations of the method under test, the deviation of each calculated result from the mean value at each receiver can be determined. This allows to improve the method and the included software implementations in an iterative process and to estimate the probable spread of results. This test scenario can also be applied to perform calculations in the reference configuration (see 2.12) and in a modified configuration (see 2.7) and to determine the deviation or the decrease of accuracy caused by the modified configurations according to Annex C.

4.5.4 Single ray point to point calculation module P2P

The persons or groups responsible for a new calculation method can give some additional support for the correct implementation in different software programs by publishing the source code of a single ray point-to-point calculation module P2P (see 2.10). Such a software module does not replace the complete, clear, and unambiguous description of the method. If cases occur where the source code is not in line with the official documentation, this documentation takes precedence.

