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BSI Standards Publication

Acoustics — Software for the calculation of sound outdoors

Part 1: Quality requirements and quality assurance

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National foreword

This British Standard is the UK implementation of ISO 17534-1:2015.

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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

Reference number
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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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.

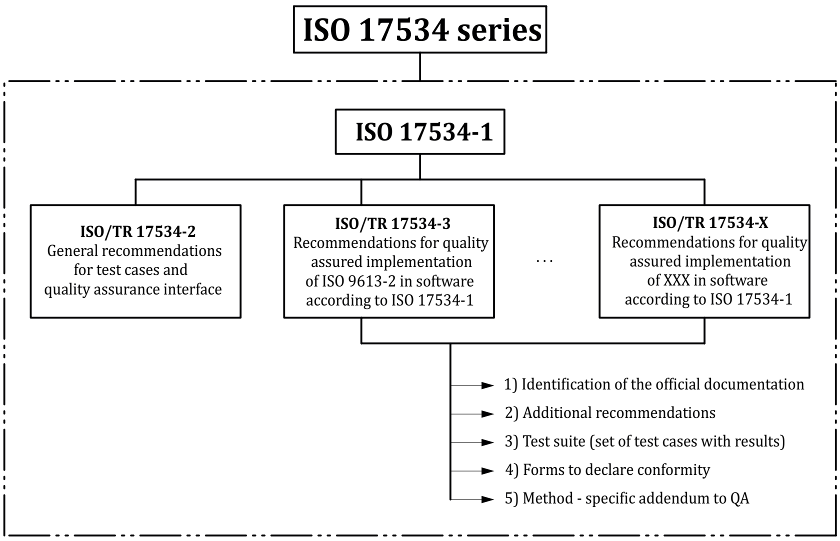


Figure 1 — Structure of the ISO 17534 series consisting of the main Part 1 and subordinated Technical Reports

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.

Such a P2P module is in accordance with ISO 17534-1 if the following conditions are fulfilled:

— The module calculates the attenuation along one geometrically defined path from a point source to a receiver (see 2.10). Input are the positions of source and receiver and the polygon line of the terrain with all objects in a vertical cross section above the 2D ray path in developed view with the relevant acoustical attribute values. Output is the attenuation on this propagation path.

— The responsibility for development, maintenance, and support of problem solving for this module is clearly defined and declared.

— The source code is open and can be checked to support the understanding of the documentation.

— The implementation in any software program is free and the rights of use allow the activation by the software user to compare the results with those obtained with the software specific implementation of the calculation method.

Compiled software modules as “Black box” solutions with no insight into the source code are not in accordance with ISO 17534-1.

5 Quality requirements for software products

5.1 Product description and user documentation

5.1.1 Functionality

The documentation provided with software products shall state clearly the implemented calculation methods with dated references. It shall be indicated whether the implementation is complete and in accordance with ISO 17534-1 and the method specific Technical Report — if it exists. The forms to declare conformity of an implemented calculation method with the normative documentation of the method (see 2.6 and Annex B) filled out by the software producer are necessary part of the documentation.

If calculation methods are implemented in parts, this shall be declared in the documentation. The parts of the method not implemented shall be specified.

General strategies and procedures that are not part of the standardized calculation methods shall be explained if they can influence the interpretation of results.

NOTE Examples are the general procedure (particles, rays), the geometric construction of rays or sound propagation paths (angle scanning or ray tracing), or the methods to construct reflections (mirror images or statistical particle or ray tracing).

It is a matter of course that all functionalities that can increase the applicability of the software shall be described. This includes all possible operations that modify the input parameters and the model, all features simplifying the model, and accelerating the calculation.

5.1.2 User guidance and user support

The software user shall be informed about all approximations and accelerations due to the applied configuration that can cause deviations from the complete calculation according to the selected calculation method (reference configuration) e.g. by a protocol.

If the model, like it is defined by the input data, is internally modified before the calculation is performed, this modification shall be described. It is absolutely necessary that a software user can get all information that can influence the calculated results.

If there are alternatives in the configuration of the software, a reference configuration shall be documented. It shall be clear to select this reference configuration explicitly.

If in the course of development the software is modified and updated, all modifications that can influence the result shall clearly be indicated and explained.

5.2 Properties of the software to support quality assurance

5.2.1 General

It is the freedom of the software producer to rank possible features and to decide what shall be realized and how it will be realized.

5.2.2 Control of the model and the calculation

Tools shall be offered to enable the software user to check all steps of a calculation. These are the effective source emission and all attenuation and correction values relevant for a calculation ray from the source to the receiver. This shall enable the user to identify all calculation rays (see 2.4) included in the calculation. For extended sources, the subparts treated like single-point sources in the calculation shall be identifiable.

5.2.3 Determination of uncertainty caused by the application of approximation procedures

Software in accordance with ISO 17534-1 shall offer the possibility to determine the uncertainties caused by deviation of the selected configuration from the reference configuration applying the method specified in Annex C. It shall be possible for the user to create a sample of randomly distributed receiver points, to calculate the first set of result levels at these points applying the reference configuration and to calculate again with the "modified configuration". The uncertainty caused by the approximations and acceleration techniques of the project configuration are then calculated by statistical analysis of the level differences according to Annex C.

The receiver points created in the first step can be distributed randomly

— in an area that is generally the calculation area for a noise map. The resulting deviations can be used to qualify the uncertainty of the noise map caused by the acceleration techniques applied with the project configuration.

— along a specified line of equal level. The resulting deviations can be used to qualify the uncertainty of the level given by the line under test.

NOTE This procedure will not only check the accuracy due to acoustical aspects. For example, not standardized procedures to model the terrain can influence the result.

5.2.4 Quality assurance interface (QA) to allow data exchange

Software in accordance with ISO 17534-1 shall be able to read and write data in accordance with the QA-format (see Annex D). This QA-format supports the exchange of most of the geometric and acoustic data of complete models. Method-specific supplements shall be covered in the method-specific Technical Report.

6 Declaration of Conformity (DoC)

For each calculation method implemented in a software product in accordance with ISO 17534-1, a declaration of conformity similar to the example shown in Annex B has to be supplied and is part of the product specification. By signing the declaration of conformity of an implemented calculation method with the relevant documentation or standard, the software producer declares that the deviations by calculating the test cases with the reference configuration will not exceed the acceptable limits as published in the method documentation or in the method-specific Technical Report.

7 Checks to be done by the program user

7.1 Applying the software with test cases

The test cases shall be supplied as importable data files together with the software. The software user can check the correct implementation with each new installation or update by solving these test cases in the method-specific reference configuration of the software and comparing the results with the maximal acceptable intervals.

7.2 Determination of the uncertainty at receiver points introduced by a modified configurations

A noise map shows the 2D-distribution of levels calculated with a grid of receiver points. Due to the huge numbers of receivers necessary to get an acceptable spatial resolution, it is often not possible to perform the final calculations for the complete map in the reference configuration of the selected calculation method, but to enforce acceptable calculation times by applying special acceleration configurations. These acceleration configurations are different according to technical progress with different software products, but the general philosophy is always to neglect the contribution of sources and propagation paths probably not relevant in relation to acceptable limits of uncertainty. But the uncertainties depend on the individual project and therefore they shall be checked in each case and with a configuration that shall be used to calculate the final noise map ("modified configuration").

With the statistical analysis of level differences (see Annex C), the software user can determine characteristic values of the uncertainty caused by deviations from the reference configuration and by interpolation techniques and include them in a legend of graphic presentations (noise maps) or/and in accompanying reports.

Annex A
(normative)

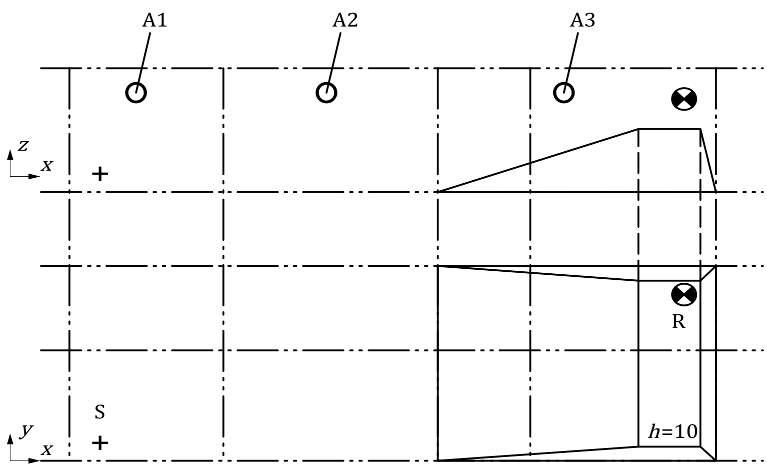
Test cases/scenarios

A.1 General

Test cases and test scenarios shall cover the relevant algorithms and procedures of a calculation method, present key nominal results and acceptable tolerances, and comprise a clear definition of the input data needed to create them unambiguously. They contain a complete data set with sources and receivers. Test cases comprise simple scenarios and contain intermediate and final results with acceptable tolerances, while test scenarios are more complex and therefore intermediate results cannot be given. If test scenarios are designed to determine the spread of results with a method implemented in different software products, final results and acceptable tolerances are expendable.

A.2 Example of a Test Case (T XX) with detailed step-by-step results for ISO 9613-2

The following example demonstrates only the principle.



Key

A1 area with porous ground
A2 area with mixed ground
A3 area with reflecting ground
S source
R receiver
h height in metres

Figure A.1 — Different ground properties and different heights (upper part: side view, lower part: top view)

Table A.1 — Source and receiver data

Point	x	y	z_{rel}	z_{grd}
Unit	in m	in m	in m	in m
Source	...	...	...	...
Receiver	...	...	...	...

Table A.2 — Sound power level of the source

Quantity	Unit	Values							
f	Hz	63	125	250	500	1 000	2 000	4 000	8 000
L_W	dB	...	...	...	...	...	...	...	...

Table A.3 — Edge coordinates of rectangular areas with different ground properties

Ground factor G	Coordinates of areas							
	x_1 in m	y_1 in m	x_2 in m	y_2 in m	x_3 in m	y_3 in m	x_4 in m	y_4 in m
porous ground	...	...	...	...	...	...	...	...
mixed ground	...	...	...	...	...	...	...	...
reflecting ground	...	...	...	...	...	...	...	...

Table A.4 — Contour lines with different heights (defining the cross section shown in Figure A.1)

Contour lines	Coordinates											
	x_1 in m	y_1 in m	z_1 in m	x_2 in m	y_2 in m	z_2 in m	x_3 in m	y_3 in m	z_3 in m	x_4 in m	y_4 in m	z_4 in m
1	...	...	...	...	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	...	...	...	...	...	...
3	...	...	...	...	...	...	...	...	...	...	...	...

The frequency-dependent band levels and the A-weighted levels at the receiver shall be calculated for T = ...°C and F = ...%.

For the precisely defined test cases, the step-by-step results are given to two decimal places and a lower and an upper limit for results acceptable as correct are given to one decimal place. In cases where the final result given to two decimal places is $x,x5$, an interval of 0,1 is always included for rounding purposes. In some cases where even with correct calculation a certain variation of results is possible due to open issues in the definitions, an adequate interval ±x dB is given. Larger intervals come into play if extended sources are subdivided if this partitioning can be performed in different ways according to the method under test.

Table A.5 — Frequency dependent step-by-step and final results

Quantity	**Unit**	**Values**								
Frequency	in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W	dB	...	...	...	...	...	...	...	...	
α-atm (...°C,...%)		...	...	...	...	...	...	...	...	
A_{atm}	dB	...	...	...	...	...	...	...	...	
a', b', c', d' for r	—	...	...	...	...	...	...	...	...	
A_{gr_s}	dB	...	...	...	...	...	...	...	...	
A_{gr_r}	dB	...	...	...	...	...	...	...	...	
A_{gr_m}	dB	...	...	...	...	...	...	...	...	
A_{gr}	dB	...	...	...	...	...	...	...	...	
A_{div}	dB	...	...	...	...	...	...	...	...	Total
L	dB	...	...	...	...	...	...	...	...	...
A-weighting	dB	...	...	...	...	...	...	...	...	
L_A [a]	dB	...	...	...	...	...	...	...	...	...

[a] The result values in frequency bands and for the total level are considered to be correct if the deviation does not exceed ±0,05 dB.

α-atm atmospheric attenuation coefficient for ...° C temperature and ...% relative humidity

a', b', c', d' for r factor (see factors ISO 9613-2:1996, Table 3, Note) in dB

A_{atm} attenuation due to atmospheric absorption in dB

A_{div} attenuation due to geometrical divergence in dB

A_{gr} attenuation due to ground effect in dB

A_{gr_s} attenuation due to ground effect for source region s in dB

A_{gr_m} attenuation due to ground effect for middle region m in dB

A_{gr_r} attenuation due to ground effect for receiver region r in dB

L level in dB

L_A A-weighted level in dB

A.3 Example for a complex Test scenario – TestCity

A typical test scenario is the data-set of a city or a part of it. An example is the data-set “TestCity” (see Reference [6]).

Figure A.2 shows an inner part of this TestCity with 100 of the total of 400 receiver points distributed randomly over the total area. These receiver positions are in accordance with the conditions formulated in C.2 and therefore their horizontal distance to sources and obstacles is not smaller than 2 m.

Figure A.2 — Part of the Test scenario “TestCity” with 400 receiver points

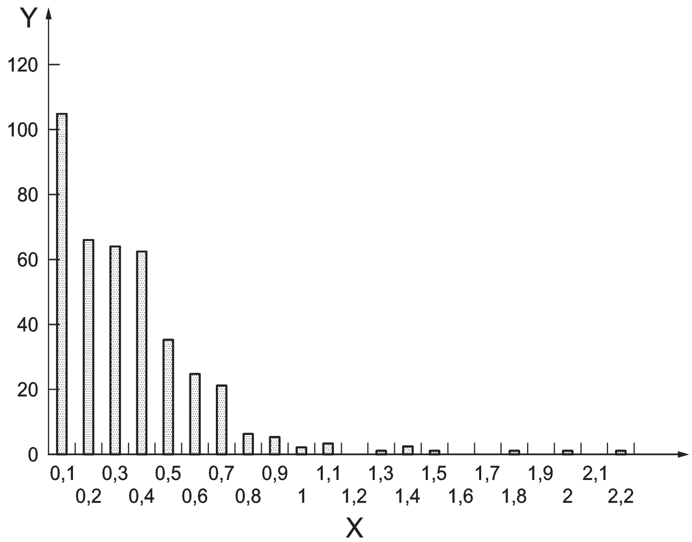
Example 1 Checking the precision of a calculation method by a round robin test with four participants based on the calculation of a specified method

The participants agree on the calculation method to be applied and on the modified configuration if this is not the reference configuration.

where

$L_{n,m}$	calculated level at receiver n by participant m in decibel
$\overline{L_n}$	arithmetic mean of the levels calculated by all participants at receiver n in decibel
$\mathrm{d}L_{n,m}$	deviation between level calculated by participant m at receiver n and the mean value $\overline{L_n}$ in decibel $\mathrm{d}L_{n,m} = L_{n,m} - \overline{L_n}$
$\lvert \mathrm{d}L_n \rvert_{\max}$	maximum of the absolute value deviations $\mathrm{d}L_{n,m}$ at receiver n in decibel

For each of the receivers the maximal absolute value of $\mathrm{d}L_{n,m}$ and from these N numbers the quantile $q_{0,9}$ according to C.4 is determined. It is a value showing up the precision of the calculation method applied with the different software applied.



Key

X classes – the values are upper interval limits (and larger) in decibel

Y number of samples

Figure A.3 — Example of the distribution of maximum of the absolute value of deviations $|\mathrm{d}L_n|_{\max}$ determined in a round robin test with four participants applying the same calculation method (only shown to demonstrate the principle)

Annex B
(normative)

Declaration of Conformity (DoC)

We

....

(producer's name)

....

(address)

declare under our sole responsibility that the product

....

(company name, trade mark/software name, software, or update package, version No.
File description: Major version. Minor version. Release. Build, release date)

to which this declaration relates is in conformity with the following calculation method

....

(Title and/or number and date of issue of the calculation method)

following the provisions of ISO 17534-1 *"Acoustics — Software for the calculation of sound outdoors — Quality requirements and quality assurance"*

The declared conformity applies to any situation covered by the above calculation method.

or

The declared conformity applies to situations covered by the above calculation method except the situations specified in the enclosed Test Case Results Comparison Form (TRC-Form) and with limitations according to the enclosed Grade of Implementation Form (GOI-Form).

....

(Place and date of issue) (Name and signature or equivalent marking of authorized person)

B.1 Test-Case-Results-Comparison form (TRC)

Table B.1 is an example showing the structure. The detailed table is part of the method-specific Technical Report of this International Standard.

Table B.1 — TRC form to show the grade of agreement between correct results and results calculated in reference configuration

Test suite	**Title**					
	Place and date of publication:					
Calculation method	**Title**					
	Place and date of publication:					
Test case No.	**Centre frequency of octave band**	**Limits of certified results (A-weighted) in dB**		**Software calculation result (A-weighted) in dB**	**Result inside tolerances**	**Comments**
		Upper[a]	**Lower**		**yes/no**	

[a] Test cases shall mark the largest acceptable deviation. If there are reasons to exceed them, it shall be commented.

An example based on the Test Case T XX (see A.2) is shown in Table B.2

Table B.2 — TRC-Form with data of Test case T XX (A.2)

Test suite	**Title**	ISO/TR 17534-3 — Addendum for ISO 9613-2				
	Place and date of publication:	**Geneva, International Organization for Standardization, 2015-01**				
Calculation method	**Title**	ISO 9613-2 "**Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation**"				
	Place and date of publication:	**Geneva, International Organization for Standardization, 1996**				
Test case No.	**Centre frequency of octave band**	**Limits of certified results (A-weighted) in dB**		**Software calculation result (A-weighted) in dB**	**Result inside tolerances**	**Comments**
		Upper[a]	**Lower**		**yes/no**	
T XX						
	63 Hz	13,75	13,65	13,7	yes	—
	125 Hz	19,55	19,45	19,5	yes	—
	250 Hz	21,15	21,05	21,1	yes	—
	500 Hz	26,05	25,95	26,0	yes	—
	1 000 Hz	34,85	34,75	34,8	yes	—
	2 000 Hz	37,05	36,95	37,0	yes	—
	4 000 Hz	34,15	34,05	34,1	yes	—
	8 000 Hz	21,65	21,55	21,6	yes	—
	Total (63 Hz up to 8 000 Hz)	40,65	40,55	40,60	yes	—

[a] Test cases shall mark the largest acceptable deviation. If there are reasons to exceed them, it shall be commented.

B.2 Grade of Implementation form (GoI)

This GoI-form is method-specific and is presented in the Technical Report for the method. Table B.3 shows the principle.

The boxes checked by the producer of the software are part of the declaration.

Table B.3 — Principle of the GoI-form

In the reference configuration for application of the program, it is possible to calculate	Yes [a]	To a limited degree [a]	No [a]
(listing of all calculation steps with all special features and choices)			
XXX	☐	☐	☐
XXX	☐	☐	☐
[a] Check as applicable; if necessary marked with an index number and explained on an extra page.			

Annex C
(informative)

Estimation of uncertainty by statistical evaluation of level differences

C.1 General

Here, the differences of levels resulting from two different calculation runs are examined, e.g.

— for comparing a pair of calculations made with the reference configuration and a configuration deviating therefrom, where said comparison shall be made to determine the accuracy for the deviating configuration;

— for comparing sound-contours which are determined as smoothing functions through interpolation of levels at grid points, with results of the calculation for receiver points among the sound-contours;

— for comparing a pair of variants, where this comparison serves to evaluate the noise impact or the efficiency of noise control measures; or

— for comparing a pair of calculations with different configurations of the program options.

C.2 Designation of a group of single points

To describe a group of level differences, the 0,1-quantile $q_{0,1}$ and the 0,9-quantile $q_{0,9}$ are statistically estimated for distinguishing the value range of the aligned deviations from a random sample.

NOTE 1 For example, the single points can be situated on a uniform grid for describing the noise receiver points in an area or along a street in front of the row of houses.

NOTE 2 10 % of all collective values are less than the 0,1-quantile while 10 % of all collective values are greater than the 0,9-quantile. This is a designation deviating from that usually used for data given in acoustics. For more information, see ISO 3534-1.

Receiver points having a horizontal distance of less than 2 m from sources and obstacles are excluded from the set of the level differences designated. Random sample points are uniformly distributed across the set of all remaining single points. If a random sample size M is defined, e.g. by consecutive numbering of all N remaining single points, a uniform distribution of the random sample points can be achieved by including the single points having the ordinal numbers of $\mathrm{IP}((i - 0{,}5) \times (N/M))$ in the random sample. Therein, i ranges from 1 to M, and IP is the integer part of the argument.

NOTE 3 The distance is determined by examining the horizontal plane through the single points.

The random sample size shall be at least 20.

It is recommended to select a ratio of random samples to number of single points of at least 1:100.

This method does not provide an accuracy factor for the calculation at single points.

If level differences originating from comparison with a calculation in the reference configuration are examined, the 0,1-quantile and the 0,9-quantile designate the accuracy of the results which are determined with a configuration deviating from the reference configuration.

Characteristic values $q_{0,1}$ and $q_{0,9}$ are determined according to C.4.

C.3 Designation of sound-contours

If sound-contour levels deviate from the levels that result from calculations at receiver points on these sound-contours, then these deviations shall be designated.

NOTE Sound-contours are often used as smoothing functions based on calculations at discrete single points (which are often arranged in the grid), so that level limits can be graphically represented on maps.

Random samples of the levels of the sound-contours at uniformly distributed receiver points are compared with the results of single-point calculations at these receiver points, and the differences are specified. To designate the group of potential differences on the sound-contours, the 0,1-quantile and the 0,9-quantile from the random sample are estimated statistically. If a random sample size M is defined, e.g. by consecutive kilometerage of all sound-contours to be designated, a uniform distribution of the random sample points on the sound-contours can be achieved by arranging the random sample points – with a total length of L – at the kilometerages IP($(i - 0{,}5) \times (L/M)$). Therein, i ranges from 1 to M, and IP is the integer part of the argument.

Sections of sound-contours having a horizontal distance of less than 2 m from sources and obstacles are excluded from the designation. The random sample points are uniformly distributed over the length of all remaining sound-contours to be designated.

The random sample size shall be at least 20.

If the sound-contours are determined on the basis of calculations in the reference configuration, the 0,1-quantile and the 0,9-quantile designate the accuracy of these calculations for the purpose of this part of ISO 17534.

Characteristic values are determined according to C.4.

C.4 Determination of characteristic values

Quantiles are determined from the random sample of the values of the random sample group, with the random sample being sorted in ascending order. The ranking positions R listed below (see Table C.1) are based on $L_{x,90}$ for the 0,1-quantile $q_{0,1}$ and $L_{x,10}$ for the 0,9-quantile $q_{0,9}$.

Table C.1 — Ranking positions *R*

N: Number of random sample values	$R(q_{0,1})$	$R(q_{0,9})$	N: Number of random sample values	$R(q_{0,1})$	$R(q_{0,9})$
20	2	19	36	4	33
21	2	20	37	4	34
22	2	21	38	4	35
23	2	22	39	4	36
24	2	23	40	4	37
25	2	24	41	4	38
26	3	24	42	4	39
27	3	25	43	4	40
28	3	26	44	4	41
29	3	27	45	4	42
30	3	28	46	5	42
31	3	29	47	5	43
32	3	30	48	5	44
33	3	31	49	5	45
34	3	32	50	5	46
35	3	33			

If the number of random samples N is >50, the following applies:

$$R\left(q_{0,1}\right)=\mathrm{IP}\left(\frac{N+4}{10}\right) \tag{C.1}$$

$$R\left(q_{0,9}\right)=\mathrm{IP}\left(\frac{(9\times N)}{10}\right)+1 \tag{C.2}$$

where IP is the integer part of the argument.

EXAMPLE

The following 25 random sample values (sorted in ascending order) resulted for the level differences between two calculation variants from the calculation area:

R	1	2	3	4	5	6	7	8	9	10	11	12	13
ΔL in dB	−1,4	−1	−0,4	0,8	1	1	1	1,2	1,4	1,4	1,4	1,6	1,8

R	14	15	16	17	18	19	20	21	22	23	24	25	
ΔL in dB	1,8	2	2	2	2,2	2,2	2,4	2,6	2,8	2,8	3	3,4	

With the number of random samples N = 25, the ranking positions are as follows: $R(q_{0,1})$ = 2 and $R(q_{0,9})$ = 24.

As a result, the quantiles are as follows: $q_{0,1}$ = −1 dB and $q_{0,9}$ = 3 dB. It shall be expected that 10% of all level differences in the calculation area are each below −1 dB and above +3 dB. Therefore, 80 % of the level differences shall be expected to be between −1 dB and +3 dB.

C.5 Remarks on the determination of uncertainty according to ISO/IEC Guide 98-3

The estimated standard deviation of the difference groups is specified as uncertainty for error propagation calculations according to ISO/IEC Guide 98-3. The average value of the difference groups is specified for considering a systematic deviation.

C.6 Testing criteria

The manufacturer verifies the availability of statistical evaluations. The user is responsible for performing the comparative calculations and averaging the results of the tests.

Annex D
(informative)

Quality Assurance Interface (QA)

The Quality Assurance Interface (QA) pursuant is used to exchange data between different calculation programs and to record data in a QA project file comprising the QA model file and all QA object files of a project variant.

Table D.1 is an excerpt to show the structure of the data format. For the complete QA, see Technical Report Test cases and QA.

Table D.1 — Object building

Object building			
3D-polygon, (z = upper edge of object) NOTE To ensure an unambiguous terrain interpretation at the building corners, additional height information is required. For this purpose, additional height points of the terrain are to be assigned to the supporting points of the building.			
attribute	**Name**	**Type**	**Fixed values/*remarks***
block 0			
See “all objects”			
block 1			
Reflection loss	RL	N5.1	= –200: No reflection [dB]
block 2			
Height of building (for documentation)	BLDG_H	N6.1	= –200: No declaration
Original height reference (*for documentation*)	BLDG_HREF	N1	= 0: Reference terrain, [m]; = 1: Reference sea level, [m]; Ground reference point: first point of the polygon

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[3] ISO 3534-1, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

[4] ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

[5] DIN 45687, *Akustik-Software-Erzeugnisse zur Berechnung der Geräuschimmission im Freien — Qualitätsanforderungen und Prüfbestimmungen (Acoustics — Software products for the calculation of the sound propagation outdoors — Quality requirements and test conditions)*

[6] Dokumentation zur Qualitätssicherung von Software zur Geräuschimmissionsberechnung nach DIN 45687 4. Dokumentation — Testaufgaben mit der Musterstadt QSDO — DIN_45687:2013-03.1 Documentation for Software Quality Assurance for Noise Emission Calculation according to DIN 45687 4th Documentation — Test cases with the test_city_QSDO — Test city QSDO, DIN_45687:2013-03, Beuth Verlag, Berlin (http://www.beuth.de/de/publikation/dokumentation-zur-qualitaetssicherung-von-software-zur-geraeuschimmissionsberechnung-nach-din-45687/189451155?SearchID=517020725)

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