TECHNICAL REPORT

ISO/TR 17534-4

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Acoustics — Software for the calculation of sound outdoors —

Part 4: Recommendations for a quality assured implementation of the COMMISSION DIRECTIVE (EU) 2015/996 in software according to ISO 17534-1

Acoustique — Logiciels de prévision de bruit dans l'environnement —

Partie 4: Recommandations pour l'assurance qualité de la mise en œuvre de la DIRECTIVE (UE) 2015/996 de la COMMISSION EUROPÉENNE dans les logiciels selon l'ISO 17534-1

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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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

A list of all parts in the ISO 17534 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The structure of the ISO 17534 series is shown in Figure 1. ISO 17534-1 describes the general approach of the ISO 17534 series, aiming to facilitate a standardized interpretation and a verifiably consistent software implementation of outdoor sound calculation methods. ISO/TR 17534-2 contains general recommendations for test cases and for a quality assurance interface. Further parts of the ISO 17534 series each address a specific outdoor sound calculation method for which they provide an agreed interpretation of ambiguous aspects, a set of illustrative test cases along with reference solutions, and an example of a template form for the declaration of conformity for software developers.

This document addresses the calculation method laid down in the COMMISSION DIRECTIVE (EU) 2015/996, hereafter referred to as CNOSSOS-EU:2015.

The European Commission developed Common NOise aSSessment methOdS (CNOSSOS-EU) for road, railway, aircraft and industrial noise for the purpose of strategic noise mapping. CNOSSOS-EU aims at improving the consistency and comparability of noise assessment results across the EU Member States which are performed on the basis of the data becoming available through the consecutive rounds of strategic noise mapping in Europe.

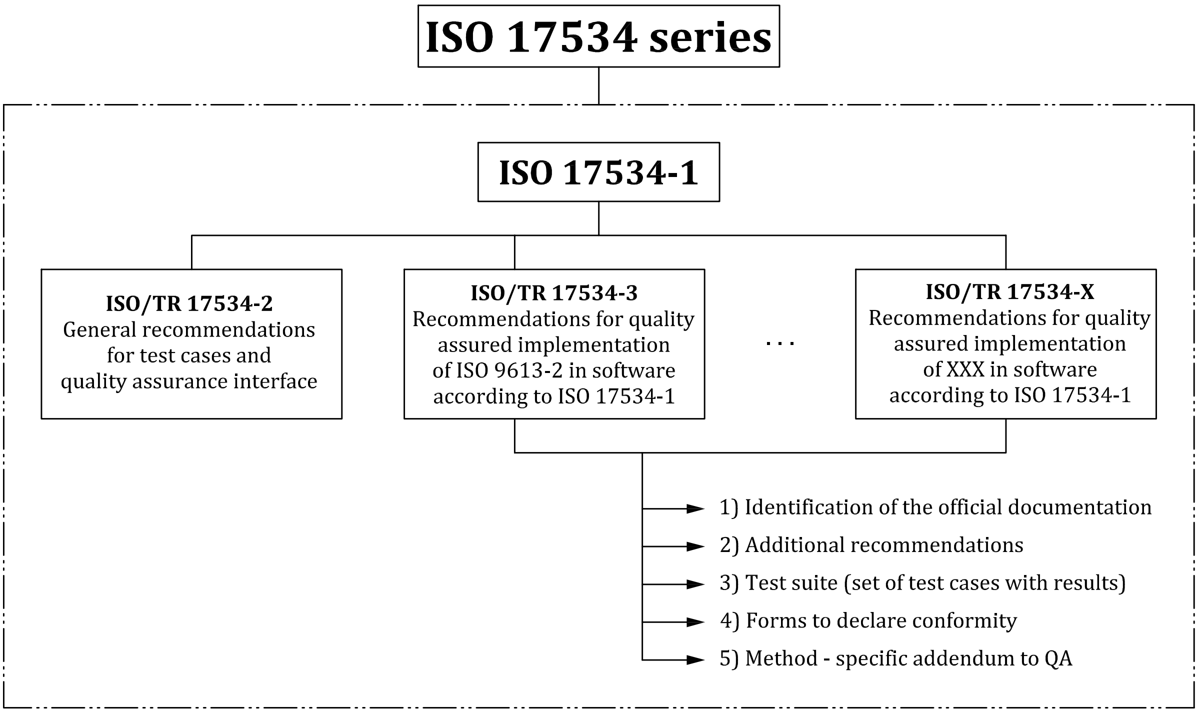

Figure 1 — Structure of the ISO 17534 series

Acoustics — Software for the calculation of sound outdoors —

Part 4: Recommendations for a quality assured implementation of the COMMISSION DIRECTIVE (EU) 2015/996 in software according to ISO 17534-1

1 Scope

This document facilitates a standardized interpretation and a verifiably consistent software implementation of the sound propagation part of the calculation method CNOSSOS-EU:2015 according to ISO 17534-1. Other parts of CNOSSOS-EU:2015, such as the source models or the calculation method for aircraft noise, are beyond the scope of this document. This document provides an agreed interpretation of ambiguous aspects of the sound propagation part of CNOSSOS-EU:2015, a set of illustrative test cases along with reference solutions, and an example of a template form for the declaration of conformity for software manufacturers.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 17534-1, *Acoustics — Software for the calculation of sound outdoors — Part 1: Quality requirements and quality assurance*

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

COMMISSION DIRECTIVE (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council, Official Journal of the European Union, L 168/1

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CNOSSOS-EU:2015, ISO 17534-1, and ISO/TR 17534-2 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Identification of the official documentation

COMMISSION DIRECTIVE (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council, Official Journal of the European Union, L 168/1, herein referred to as CNOSSOS-EU:2015.

In its Chapter 2.5, “Calculation of noise propagation for road, railway, industrial sources”, CNOSSOS-EU: 2015 describes a method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources.

5 Uniform and agreed interpretation of ambiguities

5.1 General

The propagation of sound outdoors in CNOSSOS-EU:2015 is calculated with a ray-based energetic model. Attenuations are calculated in eight octave bands, and separately for two idealized meteorological conditions labelled homogeneous and favourable. Finally, the A-weighted exposure level at a receiver position is given as the weighted energetic sum over all sources, paths, meteorological conditions, and octave bands.

Some aspects of the sound propagation model of CNOSSOS-EU:2015 are not described in sufficient detail to be unambiguous; in other aspects, in some part the official documentation is misleading. For each of these problematic topics, an agreed interpretation is given in 5.2 to 5.15 to allow for a standardized understanding of CNOSSOS-EU:2015.

The abbreviations are not explained when they are identical to those described in CNOSSOS-EU:2015.

Symbols are not defined when they are identical to those applied in CNOSSOS-EU:2015.

5.2 Sloping objects

Topic: CNOSSOS-EU:2015 states in subclause 2.5.1 that “obstacles sloping, when modelled, more than 15° in relation to the vertical are out of the scope of this calculation method”. This restriction does not constitute a general restriction of the method. Rather, it applies only to reflectors: obstacles sloping more than 15° in relation to the vertical are not considered as reflectors.

Agreed interpretation:

Objects sloping more than 15° in relation to the vertical are not considered as reflectors, but are taken into account in all other aspects of propagation such as ground effects and diffraction.

5.3 Equivalent heights

Topic: CNOSSOS-EU:2015 states in subclause 2.5.3, under the headline "Significant heights above the ground", that “If the equivalent height of a point becomes negative, i.e. if the point is located below the mean ground plane, a null height is retained, and the equivalent point is then identical with its possible image.” For points located below the mean ground plane, the equivalent height is set to zero in the calculation of A_{ground}. For the calculation of path length differences, it is irrelevant whether points lie above or below a mean ground plane, no points are shifted. For the calculation of $\Delta_{\mathrm{ground(S,O)}}$ and $\Delta_{\mathrm{ground(O,R)}}$ special care has to be taken in the case that one of the respective end points lies below the mean ground plane.

Agreed interpretation:

The first major step in the algorithm is to decide whether A_{ground} or A_{dif} must be calculated. The step is based on real coordinates, not equivalent heights. If a point lies below the mean ground plane, its equivalent height is set to zero in the calculation of A_{ground}. Equations (2.5.31) and (2.5.32) of CNOSSOS -EU:2015 apply only in the most common case that both S and R lay above the mean ground plane. If either S or R lies below the mean ground plane, the following simplified Equations apply:

$\Delta_{\mathrm{ground(S,O)}} = A_{\mathrm{ground(S,O)}}$ (CNOSSOS-EU:2015, 2.5.31)

$\Delta_{\mathrm{ground(O,R)}} = A_{\mathrm{ground(O,R)}}$ (CNOSSOS-EU:2015, 2.5.32)

For the calculation of path length differences, the original coordinates are used and no points are shifted, i.e. in the calculation of $\Delta_{dif(S,R)}$ the original heights of S and R are used.

5.4 Alternative statistical approach

Topic: CNOSSOS-EU:2015 mentions in subclause 2.5.5, under the headline "Statistical approach inside urban areas for a path (S, R)", a statistical approach for calculations inside urban areas beyond the first line of buildings. This approach is not described in sufficient detail to be subjected to the quality assurance methodology of ISO 17534-1.

Agreed interpretation:

A statistical approach is not appropriate in the calculation of sound propagation beyond the first line of buildings.

5.5 Octave band centre frequency f_m

Topic: CNOSSOS-EU:2015 is somewhat ambiguous about whether nominal centre frequencies or exact centre frequencies should be used in the calculation of the atmospheric attenuation coefficient α_{atm}.

Agreed interpretation:

In the calculation of the atmospheric attenuation coefficient α_{atm}, ISO 9613-1 is followed, and exact centre frequencies are used. In all other calculations, the nominal centre frequency, denoted f_m, are used.

The tabulated values in ISO 9613-1 are based on the pressure at sea level.

5.6 Ground factor of the source area, G_S

Topic: CNOSSOS-EU:2015 introduces G_S in subclause 2.5.6 as the ground factor G of the source area. For industrial sources, it is left open how exactly G_S is to be calculated.

Agreed interpretation:

For industrial point sources, G_S is calculated as the average of the ground factor G over a distance of 1 m beginning at the vertical projection point below the source and proceeding along the direction source-receiver.

5.7 Distances in Figure 2.5.b of CNOSSOS-EU:2015

Topic: In CNOSSOS-EU:2015, it is unclear whether the distances d displayed in Figure 2.5.b are 3D-distances along the ground or 2D-projection onto a horizontal plane.

Agreed interpretation:

Figure 2.5.b displays a 2D-projection onto the horizontal plane. The distances d used in the calculation of G_{path} are measured in this horizontal plane.

5.8 Equivalent heights in Equation (2.5.20) of CNOSSOS-EU:2015

Topic: CNOSSOS-EU:2015 explains that modified equivalent heights should be used in the calculation of $A_{ground,F}$. But it is unclear whether these modified equivalent heights or unmodified equivalent heights should be used in the calculation of $A_{ground,F,min}$ according to Equation (2.5.20) of CNOSSOS-EU:2015.

Agreed interpretation:

Unmodified equivalent heights are used in the calculation of $A_{ground,F,min}$ according to Equation (2.5.20) of CNOSSOS-EU:2015.

5.9 Rayleigh's Criterion

Topic: CNOSSOS-EU:2015 states that no diffraction should be calculated if the ray path passes "high enough" over the diffraction edge. In this context, CNOSSOS-EU:2015 refers to Rayleigh's Criterion without providing details or formulae. The circumstances under which diffraction is calculated should be defined unambiguously.

Agreed interpretation:

In the unique vertical plane containing source and receiver, the line of sight from source to receiver is defined, under homogeneous conditions, as the straight line connecting source and receiver. Under favourable conditions, the line of sight is defined as the arc of radius Γ, given by Equation (2.5.24) of CNOSSOS-EU:2015, connecting source and receiver.

The decision whether diffraction must be calculated is made separately for homogeneous and favourable conditions respectively. If the line of sight is blocked, diffraction is always calculated. If the line of sight from source to receiver is unobstructed, Rayleigh's Criterion is employed as follows: first, that point D of the terrain profile including obstacles is identified, which gives the largest δ_D, i.e. the δ_D with the smallest absolute value. Then δ_D* is calculated as the path length difference from S' to R' via D, where S' and R' are the respective images of source and receiver constructed with the appropriate mean ground planes containing source or receiver. Diffraction is calculated only if $\delta_D > -\lambda/20$ and $\delta_D > \lambda/4 - \delta_D^*$ (Rayleigh's Criterion), where λ is the wavelength at the nominal centre frequency and calculated with a speed of sound of 340 m/s.

5.10 Parameter *e*

Topic: CNOSSOS-EU:2015 introduces the parameter *e* as the total distance along the path from the first to the last diffraction edge according to the "rubber band method". It is unclear how the parameter *e* is calculated for favourable propagation conditions.

Agreed interpretation:

The parameter *e* is defined as the total distance along the path from the first to the last diffraction edge. Under homogeneous conditions, straight lines are used as ray segments, while under favourable conditions, arcs of uniform radius are used as ray segments. Different diffraction edges may be relevant under homogeneous and favourable conditions respectively.

5.11 Diffraction under favourable conditions

Topic: CNOSSOS-EU:2015 explains diffraction under favourable propagation conditions. The text contains too little details to be unambiguous. In particular, the scale of Figure 2.5.f of CNOSSOS-EU: 2015 is chosen such that the ray segments appear to be straight lines while they should be arcs of radius Γ, given by Equation (2.5.24) of CNOSSOS-EU:2015.

Agreed interpretation:

Under favourable conditions, the propagation path in the vertical plane always consists of segments of a circle whose radius is given by the 3D-distance between source and receiver according to Equation (2.5.24) of CNOSSOS-EU:2015, i.e. all segments of a propagation path have the same radius of curvature. If the direct arc connecting source and receiver is blocked, the propagation path is defined as the shortest convex combination of arcs enveloping all obstacles. Convex in this context means that at each diffraction point, the outgoing ray segment is deflected downward with respect to the incoming ray segment (see ISO 9613-1).

To illustrate the principle of constructing the ray path with multiple diffractions under favourable conditions, Figure 2 is a slightly modified version of Figure 2.5.f of CNOSSOS-EU:2015, scaled such that the curvature of the rays is apparent.