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PROPOSALS, SUGGESTIONS AND CONSIDERATIONS FOR THE REVISION OF ENVIRONMENTAL NOISE ASSESSMENT STANDARD ISO 1996-2:2017

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ABSTRACT

Since its first publication in 1971 of ISO/R 1996:1971 on Acoustics Assessment of Noise with Respect to Community Response, the International Organization for Standardization (ISO) has developed and published the ISO 1996 series of standards on Description, Measurement and Assessment of Environmental Noise in several phases. The latest publication consists of 2 parts, and the second part covering the determination of environmental noise levels, ISO 1996-2:2017, has just undergone a systematic review, and is under consideration for being revised.
This paper provides a brief overview of the history and the current edition of the standard, and, on the basis of a brief literature review, experience gained and discussions in the relevant ISO working group, provides some proposals, suggestions and considerations for the next stage of its development.

Keywords: environmental noise, noise assessment, standards, good practice

1. INTRODUCTION

First published as ISO/R 1996:1971 on Acoustics Assessment of Noise with Respect to Community Response [1], the International Organization for Standardization (ISO) series of standards on Description, Measurement and Assessment of Environmental Noise, ISO 1996, has been published in several iterations [2]. The latest edition consists of 2 parts, and the second part covering the determination of environmental noise levels, ISO 1996-2:2017, has just undergone a systematic review [11], and is under consideration for being revised.
This paper provides a brief overview of the history and the current edition of the standard, and, on the basis of a brief literature review, experience gained and discussions in the relevant ISO working group, provides some proposals, suggestions and considerations for the next stage of its development.

2. BACKGROUND OF THE STANDARD

2.1 A brief history of the standard

A more detailed history of the development of the standard can be found in an earlier paper by the author [12]. The development of the ISO 1996 series can be divided into 4 phases:

1. Gathering experience, leading up to ISO/R 1996:1971
2. Creating an actual standard – the 1980s
3. Updating and detailing – 1996 - 2007
4. Adding guidance and refining - since 2010

2.1.1 Gathering Experience - ISO/R 1996:1971

The first publication of the standard was published in 1971 as a recommendation. ISO/R 1996:1971 on Acoustics Assessment of Noise with Respect to Community Response

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was only 10 pages long. It introduced the adjusted L_{Aeq}, now called the Rating Level, as the primary parameter to be used to determine community response. Assessment through the use of exceedence/emergence of specific sound above the background noise level, defined as the L_{95}, was promoted for some situations.

2.1.2 Creating an Actual Standard - ISO 1996 in the 1980s

During the 1980's, ISO 1996 was developed into a full standard consisting of:

- ISO 1996-1:1982, Basic quantities and procedures
- ISO 1996-2:1987, Acquisition of data pertinent to land use
- ISO 1996-3: 1987, Application to noise limits

This series aimed to provide authorities with material for the description of noise in community environments to enable acceptable limits of noise to be specified and compliance with these limits controlled. In this series, the concept of assessing noise from a specific source was introduced, a noise assessment concept that is now almost universal.

The concepts of specific noise and reference time durations were defined. The use of prediction was introduced including how noise zones should be presented was standardized[1]. Guidance on setting noise limits including relevant time intervals, source operating conditions, locations and meteorological conditions were added.

2.1.3 Updating and Detailing - ISO 1996 from 1996 to 2007

Working Group 45 of ISO Sub Committee on Noise, of which the author is now convenor, was formed in 1996 to revise the entire ISO 1996 series. The same year, the EU Green Paper on Future Noise Policy [13] consolidated the L_{DEN} and the nighttime L_{Aeq}, L_{Night}, as the primary strategic parameters for environmental noise management. The following publications are part of this phase:

- ISO 1996-2:1987/AMD 1:1998
- ISO 1996-1:2003
- ISO 1996-2:2007

ISO 1996 now focused on ensuring general good practice and on helping emerging nations develop quality noise assessment legislation and standards. However, despite the variability of national assessment methods for specific sources and conditions, the series was successful in gathering and getting agreement on good practice that is globally applicable and the principles remain almost fully global.

ISO 1996-2:1987. AMD 1:1998 primarily updated the adjustments to be added for impulsive character to sound based on major research, categorizing the sources into highly, high-energy and ordinary impulsive sounds.

The main focus of Part 1 was on long-term community annoyance response, and rating levels were supplemented with composite whole-day rating levels such as L_{DEN} and L_{DN}. Requirements to the setting of noise limits were defined and the estimated percentage of a population highly annoyed as a function of adjusted day/night sound levels, also known as the dose-response curves, were introduced.

The 2007 edition of Part 2 developed significant additional guidance to meet the need to determine long term levels. In addition, measurement uncertainty was introduced, albeit in a simple form. Weather conditions were defined including those conditions favourable to sound propagation (the meteo window), and guidance on determining the average sound pressure levels under a range of weather conditions was added. The measurement procedure included guidance concerning the microphone location and the comparison of results to the reference conditions (eg the incident free-field). Importantly, this edition introduced the residual sound parameter, defined as all sound not belonging to the specific source under investigation and thus different to the L_N-defined background noise level. An objective reference method for assessing the audibility of tones in noise, based on narrow band analysis was defined, and the existing 1/3-octave objective method was updated such that tone detection based on the difference to the neighbouring bands now varied with frequency.

2.1.4 Phase 1, Gathering Experience - ISO/R 1996: Adding Guidance and Refining - ISO 1996 since 2010

An increasing amount of research, significantly assisted by the new results from the European Union's 2007 and subsequent strategic noise maps due to the European Noise Directive 2002/49/EC [14], resulted in a desire to revise Part 1. In addition, a need for additional guidance on determining the uncertainty of the assessment was identified. This resulted in the publication of:

- ISO 1996-1:2016
- ISO 1996-2:2017
- ISO PAS 1996-3:2022

[1] This was removed in the next edition

Part 1 was expanded with detailed estimation of the long-term annoyance response of communities as well as the variation in response from one community to another, quantified by the use of the Community Tolerance Index. Other refinements and clarifications were also added to provide further guidance on determining the long-term rating level.

In addition to significant additional and more robust guidance on uncertainty assessment, Part 2 was reorganized and updated with additional detailing and guidance to ease its use. This included revised guidance for determining weather conditions and their impact. More detail on the measurement of residual sound was added. For assessing the audibility of tones, the engineering method, previously called the reference method, was removed and an updated method published in ISO PAS 20065 [15][2].

An adjustment is added to the measured LAeq if prominent impulsive sound is present. In ISO 1996, three categories of impulsive sound have been found to correlate best with community response, and adjustments are given for each. As the list of sources of impulsive sound for each category is incomplete, ISO PAS 1996-3, based on Nordtest Acou 112 [17], was published to objectively measure the prominence of impulsive sound relative to residual sound. The resulting adjustments can be applied directly or may be used to categorize the impulsive sources. It complements the ISO 1996-2 measurement method for general purpose environmental noise assessment. Details of the method can be found in a Euronoise 2021 paper by Manvell & Pedersen [18].

2.2 A summary of the current edition of Part 2

ISO 1996 is now in 2 parts. Part 1 defines the basic quantities to be used for the description of noise in community environments and describes basic assessment procedures. It also specifies methods to assess environmental noise and gives guidance on predicting the potential annoyance response of a community to long-term exposure from various types of environmental noises. It uses the term “rating level” is used to describe physical sound predictions or measurements to which one or more adjustments for sounds that have different characteristics have been added. With these rating levels, the long-term community response can be estimated.

The characteristics with adjustments include the source, and its impulsiveness, tonality, and low-frequency content.

Part 2 describes how sound pressure levels intended as a basis for assessing environmental noise limits or comparison of scenarios in spatial studies can be determined by direct measurement and by extrapolation of measurement results by means of calculation. It is primarily intended to be used outdoors but also gives some guidance for indoor measurements. It provides guidance for the user to determine the measurement effort and its uncertainty, which is determined and reported in each case. Thus, no limits for allowable maximum uncertainty are set up. Often, the measurement results are combined with calculations to correct for reference operating or propagation conditions different from those during the actual measurement. It is applicable to all kinds of environmental noise sources, such as road and rail traffic noise, aircraft noise and industrial noise.

It includes requirements and guidance for:

- instrumentation for acoustical measurements including calibration and verification, and for long-term monitoring
- Two main strategies for environmental noise measurements. Either a single measurement under very well-defined meteorological conditions while monitoring the source operating conditions. Or either long-term measurement, or many sampled measurements spread out over time, while monitoring the meteorological conditions. This includes identification of when measurements are independent
- Operation of the source, both in general as well as for determining average and maximum levels for different sources
- Meteorological conditions including favourable propagation and effects of precipitation on measurements
- Measurement procedures including the selection of measurement time interval, long-term and short-term measurements, microphone location outdoors and indoors, long-term unattended measurements and short-term attended measurements, residual sound, frequency range of measurements, and measurements of meteorological parameters
- Evaluation of the measurement results, both in general and regarding specific parameters, including the treatment of incomplete or corrupted data, influence of wind sound, level correction for

[2] This has been updated to ISO TS 20065:2022 [16] to provide a clearer standard, additional background information, and to include audio files to help the implementation of software.

residual sound, the determination of standard uncertainty, the determination and of Lden from long-term Leq measurement, from long-term LE measurements of individual events, or from short-term measurements, the maximum level, Lmax,
- Extrapolation to other locations including by means of calculations or measured attenuation functions
- Calculation, including calculation methods and specific procedures
- Information to be recorded and reported

It also includes informative annexes on:
- Determination of radius of curvature
- Microphone locations relative to reflecting surfaces
- Selection of measurement/monitoring site
- Correction to reference condition
- Elimination of unwanted sound
- Measurement uncertainty including examples of uncertainty calculations
- Maximum sound pressure levels
- Measurement of residual sound
- Objective methods for assessing the audibility of tones in noise, both an Engineering method and a Survey method
- Bibliography

Some highlights worth mentioning are:
- Specific guidance on roads, railways, aircraft, industrial plants and low-frequency sound sources
- Weather conditions are defined including those conditions favourable to sound propagation (the meteo window), and guidance for determining weather conditions and their impact, and on determining the average sound pressure levels under a range of weather conditions are included
- The measurement procedure included guidance concerning the microphone location and the comparison of results to the reference conditions (eg the incident free-field).
- Importantly, the residual sound parameter, defined as all sound not belonging to the specific source under investigation and thus different to the L_N-defined background noise level, is described.
- The objective methods for assessing the audibility of tones in noise: the engineering method based on narrow band analysis as defined in ISO PAS 20065, and the survey method based on the difference to the neighbouring 1/3-octave bands that varied with frequency.
- uncertainty assessment, including worked examples to help users, is now more robust

3. REVIEW OF THE STANDARD

3.1 During Development and Reported at Conferences

During development of the revision, there were requests for more intuitive guidance for assessment of the main specific sources in order to make the standard more practically oriented as well as making it more accessible for the general user. This was not significantly addressed during the revision.

Since its publication, questions have been raised with the convenor regarding the measurement of and the impact of wind speed, and on how to deal with residual sound. In addition, at least one conference paper has been published on practical use of the standard's description for positioning the microphone [19].

3.2 ISO Systematic Review

In 2022, the ISO held a systematic review of the standard and this resulted in 33 specific comments and a number of countries requesting a revision. A decision on whether the standard will be confirmed or revised is planned to be made at the ISO Technical Committee TC43, SC1 "Noise" Plenary Meeting in May 2023. The comments received included:
- Further guidance on use in all kinds of weather conditions including assessment and reporting on meteorological variability and its impact on sound levels, and assessment of wind-induced noise on the microphone.
- Further guidance on long-term unattended measurements including tonal sound, impulsive sound, low-frequency sound, residual sound, C-weighted sound pressure levels and meteorological conditions, and better estimation of the drying time of the windscreen due to precipitation
- Develop guidance for windscreens, particularly to minimize wind induced noise on the microphone when the sound level is low or when the measurement must be performed in the presence of wind.
- A review of the guidance on uncertainty assessment with a number of issues raised.
- Additional guidance and background explanation on assessing residual sound

- Inconsistencies in the definition of "residual sound" between ISO 1996 Part 1 and Part 2.
- More guidance on aircraft noise regarding use of non-acoustical event-detection if available e.g. radar data, the applicability of short-term measurements, and low altitude aircraft.
- Updating the standard to align with the more recently published standards ISO/PAS1996-3 for impulsive sound and ISO/TS 20065 for tones.
- Further guidance on assessing long-term Lden for constant noise sources using measurements during one period only.
- More guidance on the objective assessment of intermittent noise
- Details regarding specific issues such as the measurement of reflection effects, assessment of low frequency sound, the statistical treatment of different sound level parameters, the uncertainty of calculated and measured results, the determination of the radius of curvature, noise contour grid spacing
- Updating the references and available methodology listed

3.3 ISO Convenor's Thoughts

The author, as convenor of ISO TC 43 SC1 WG45, published some considerations in the author's Internoise 2022 paper [12]. These are reported below.

Despite the variability of national assessment methods for specific sources and conditions, the series was successful in gathering and getting agreement on good practice that is globally applicable. However, this work and the resulting consensus resulted in limited specific guidance and this proved problematic for some users. Thus, during development of the latest Part 2 revision, there were requests for more intuitive guidance for assessment of the main specific sources, in order to make the standard more practically oriented as well as making it more accessible for the general user. This was not significantly addressed in the latest revision.

Development of more detailed, specific guides on dealing with specific sources and particular assessment methods, including help to determine uncertainty, would help make the standard more accessible and help spread good practice. This could be done as a series of separate Technical Specifications or informative annexes. This could help ensure widespread support while not being in conflict with existing, robust, national standards. Part 2 does provide some specific guidance on roads, railways, aircraft, industrial plants and low-frequency sound sources. However, it does not provide specific guidance re wind turbines, recreational noise, shooting ranges, heat pumps, etc. These are important sources and adding clauses to cover these to the standard would be beneficial. There have been some papers written and feedback given on use of the particular aspects of the standard, especially concerning microphone positioning, and this could also be addressed.

In addition, requirements for noise zones should be presented, included in the 1996 edition, were removed from the 2007 edition. Since then, developments by Weninger [20] that have been taken up by DIN 45682 [21], provide an intuitive format with a scientific basis. It is worthwhile considering the reintroduction of noise contour presentation format requirements based on this recent work.

4. THE FUTURE

As international standards draw on experience and maturing assessment methodology, it is possible to look into developments over the last years, identify trends, and draw up a number of proposals for potential new and improved standardization. In addition to the topics raised by the reviews that are described in the previous section, the following provides suggestions for further research and proposals for further development of the standard for discussion within the relevant ISO working group and with ISO's Acoustics technical committee management.

4.1.1 Inclusion/referral to IEC PT 61400-11-2

The development of the IEC assessment of noise from wind turbines at receiver positions [22] included discussions on and application of ISO 1996-2 to this application. Topics included requirements for windscreens, managing residual sound, and managing the impact of weather conditions on long-term measurements, as well as tone and impulse assessments which refer to other ISO standards referred to by ISO 1996. In addition, the common ISO and IEC strategy is to refer to the IEC document, expected published sometime in 2023, and a natural place to do this would be within Part 2.

4.1.2 Long-term monitoring

ISO 1996 covers general principles of the use of long-term monitoring for environmental noise assessment.

The ISO standard for airport noise monitoring, ISO 20906, is often referred to for other applications. However, there are dedicated city-noise monitoring standards in China [23] and Korea [24] and these may perhaps have guidance that is suitable for inclusion in ISO 1996.

4.1.3 Impulse detection research

With the publication of ISO PAS 1996-3 and the recommendations for further research that are included in it, it could be foreseen that there is additional experience and new research that could also impact ISO 1996-2. In particular, experience of managing and reporting uncertainty and managing residual sound may help refine Part 2.

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