RATING SOUND LEVEL - AN OVERVIEW OF AMENDMENT 1 TO ISO 1996-2

C. A. Krajewski
Ontario Ministry of the Environment, 2 St. Clair Avenue West, 12th Fl. Toronto, Ontario, M4V 1L5

1. INTRODUCTION

Environmental noise is a composition of sounds from many sources. The contributing sources may be separate or in various combinations as well as capable of changing their temporal and spectral characteristics. The method and procedures for the description and measurement of environmental noise must be applicable to sounds from all sources which, individually and in combination, contribute to the overall noise at the site, as well it must be related to human response to noise. However, the precise exposure/response relationship continue to be the subject of the scientific debate, and practicality of the applied method should be viewed in the context of the social, economic and political climate. For these reasons a number of different methods is currently in use for different type of noise in various jurisdictions. The evaluation of long-term noise annoyance was addressed, during the last two decades, using the equivalent continuous A-weighted sound level as a basic quantity supplemented by corrections or other descriptors applicable in various noise situations. However, this evaluation method had limitations, specifically in application to the assessment of impulsive and tonal sounds. The concept of the rating sound level, developed in the recent years, incorporates, in addition to the equivalent continuous A- weighted level, the impulse adjusted A-weighted level based on the sound exposure level measurements, and specific adjustments for different characteristics of impulsiveness as well as tonality.

2. RATING LEVEL

The rating sound level is determined over reference time intervals related to the characteristics of the sources(s) and receiver(s). For impulsive sounds there are two cases to consider:

In Case 1 the impulsive sounds can be identified and separately measured as single events from distinct source(s). For this case, the rating level for each reference interval is given by:

$$(L_{Ar,T})_i = 10\lg[10^{0.1[(L_{Aeq,T})i + (K_T)i]} + 10^{0.1[(L_{ArK1,T})_i]}]\text{dB}$$

where:

$(L_{Aeq,T})_i$ - *equivalent continuous A-weighted SPL during the i th reference time interval*

$K_T)_i$ - *tone adjustment applicable to SPL during the i th reference time interval (5 to 6 dB if demonstrated* by 1/3 octave analysis, *2 to 3dB if demonstrated by narrow-band analysis)*

$(L_{A\,rK1,T})_i$ - *impulse adjusted A-weighted level ot the impulsive sound during the i th reference interval expressed by the following equation*:

$$(L_{ArK1,T})_i = 10\lg[(1/T\sum_{j=1}^{N}10^{0.1(L_{AErj})_i}]\text{dB}$$

In the above equation, $(L_{AE\ rj})_i$ represents the impulse adjusted sound exposure level as follows:

$$(L_{AE\ rj})_i = (L_{AE\ j})_i + (K_{1\ j})_i$$

where:

$(L_{AE\ j})_i$ - *sound exposure level of the j th impulse during the i th reference time interval*

$(K_{1\ j})_i$ - *impulse adjustment applicable to the j th impulse during the i th reference time interval (12 dB for each highly impulsive sound and 5 dB for each ordinary impulsive sound)*

The impulse adjustment applies when the equivalent sound level $(L_{Aeq,\ T})_i$ was measured inhibiting impulsive events. If the measured $(L_{Aeq,\ T})_i$ already includes the impulsive sound energy, the impulsive sound adjustment should be re-adjusted. The re-adjusted values K_{adj} can be calculated from the original values **K** by the equation:

$$K_{adj} = 10\ \lg\ (10^{0.1K} - 1)\ \text{dB}$$

For **K** = 12 dB K_{adj} = 11.7 dB

For **K** = 5 dB K_{adj} = 3 dB

In **Case 2** the impulsive sounds cannot be separately measured as single events from distinct source(s). For this case, the rating sound level for each reference time interval is given by:

$$(L_{A\ r,\ T}) = (L_{A\ eq,T})_i + K_{T\ i} + K_{1\ i}$$

where:

$K_{T\ i}$ - *tone adjustment applicable to the ith reference time interval*

$K_{T\ i}$ - *impulse adjustment applicable to the ith refer-*

ence time interval. The value of this adjustment is 5 dB.

3. IMPULSE ADJUSTMENTS

According to findings documented in a large body of research the exposure to impulsive sounds is more annoying than exposure to noise from other sources when each produces the same equivalent sound level. Therefore, impulsive sound adjustments were introduced to provide numerical guidance to ensure proper rating of impulsive sounds. These adjustments were specified for the following categories of impulsive sound:

- **highly impulsive sound**, typically generated by small arms fire, hammering, stamping, forging, punching, cutting, forming, moulding, rail yard shunting operations.
- **high energy impulsive sound**, typically generated by quarry and mining explosions, sonic booms, demolition, industrial processes using high explosive, industrial circuit breakers and military ordnance.
- **ordinary impulsive sound**, including sounds that are sometimes described as impulsive, but are not normally judged to be as intrusive as highly impulsive sounds. Typically, sound sources of this category are car door slams, outdoor ball games, church bells, very fast passbys of vehicles, trains or low flying military aircraft

Research results show that the impulsive sound adjustments are not constant. With the exception of high-energy impulsive sounds, where the adjustment may be significantly greater, adjustments for impulsive sound typically range from 2dB to 15 dB. The value of the adjustment change with the type and character of the sound. The concept of "highly impulsive sounds" was developed by CEC research (references [2}, [3], [4] and [5]). Data obtained in various field surveys and laboratory studies indicate that for highly impulsive sounds, the adjustment ranges from 8 dB to 15dB. Research data also show that for ordinary impulsive sounds typical adjustments range from 2 dB to 7 dB.

In the revised ISO-2 standard 1996 (reference [1]), adjustments of 12 dB and 5 dB are applied to the sound exposure level of highly impulsive sounds and ordinary impulsive sounds respectively. The two values , 5 dB and 12 dB, provide adjustments that normally will be within 3 dB of research measured values.

For assessment of high-energy impulsive sounds, some countries use C-weighted sound exposure level, or peak level to determine a rating level. In other countries A-weighted sound exposure level is used. When the A-weighting is used, the value of the adjustment should be significantly greater than 12 dB. However, at the present time there is no agreement on the specific adjustment value.

4. TONAL ADJUSTMENTS

Tonal components in environmental sounds enhance noticeability or intrusion of those sounds within the general background of other non-tonal sounds. If tonal components are predominant characteristics of the sound within a specified time interval, an adjustment, $\mathbf{K_{Ti}}$, may be applied, for that time interval, to the measured equivalent continuous A-weighted sound pressure level. Procedures for assessing audibility of tones and specific correction factors to the measured data to account for the increased annoyance of the tonal components were developed by several researchers in the last four decades (references [6], [7], [8], [9] and [10]). In the revised ISO standard 1996 (reference [1]), it is suggested that, in practical case, a prominent tonal component may be detected in one- third octave spectra if the level of a one-third octave band exceeds the level of an average of the adjacent bands by 5 dB or more. However, a narrow-band frequency analysis may be required in order to detect precisely the occurrence of one or more tonal components in a noise signal.

If tonal components are clearly audible and their presence can be detected by a one-third octave analysis, the adjustments may be 5 dB to 6 dB.

If the components are only just detectable by the observer and demonstrated by narrow-band analysis, an adjustment of 2 dB to 3 dB may be appropriate. Tonal adjustment apply only to the part of reference interval during which tonal characteristics was present.

5. METHOD IMPLEMENTATION

A number of issues related to the method implementation is still subject to discussion by the ISO 1996 working group and further improvements to the standard are anticipated in future revised standard. The following are some issues subject to the working group discussions:

- In both Case 1 and 2, the reference time interval is specified as a time interval where specific impulse or tonal sound characteristics are clearly detectable. In practice, it may not be easy to separate time intervals with clearly determined sound characteristics.
- Relevance of the recommended impulse adjustments is based entirely on the source description, ignoring the range of the generated sound levels. Also, no consideration is given to the effect of impulse adjustments on assessment of impulse sources subjected to noise reduction; for a given category of impulse sound, the adjustment (penalty) will be the same with or without noise reduction measures.
- It is not clear that sounds from particular sources, at a distance from the sources, can be so definitely characterized as "impulsive", "highly impulsive" or "high-energy impulsive". The character of impulsive sound will change with distance from the source, as well when shielded, when under the influence of certain meteorological conditions and when propagated over different types of ter-

rain. It may be quite difficult to determine if the sound under investigation qualifies for assessment under Case 1 or Case 2, and what specific value of adjustment applies.. In practice, noise from some sources such as for example clay target shooting can exhibit characteristics typical for Case 1 and Case 2, even at the same receptor location and during a period of measurements as short as 30 minutes.

The perceived noise may be judged by a recipient in a different way. In implementing the method, discretion will have to be given to acoustic practitioners. However, it may be too complex for a layman to use.

- Categories of impulse sounds quoted in the standard are not inclusive enough. There is a lot of other sound sources having comparable characteristics and an equal degree of noisiness such as for example; metal processing plants (dropping of steel ingots), glass processing facilities, transportation sources ("jake" brakes), loading of transport containers, dock-yard rivetting and a variety of outdoor events (fireworks), etc.
- Reference is made in the revised ISO standard 1996 (reference [1]), to alternative methods of assessment for "high energy impulsive" sounds. However, specific recommendation on the selection of the sound descriptor for the assessment is not provided. Also, no specific adjustment value (higher than 12 dB) is recommended signifying that the status of the current research is insufficient to properly quantify the subjective effect of such sounds.

6. SUMMARY

An overview of the new method for description and measurement of environmental noise has been presented. Although some issues related to the method implementation remain, as yet, unresolved, the method represents a significant improvement over the currently used assessment procedures. A new approach to the assessment of impulsive noise is the main advantage of the method, as the existing impulse noise criteria tied to a number of impulses observed during the reference time period can be replaced by a single criterion based on the rating sound level.

The new method and all three Parts of the ISO 1996 standard were subject to review by the CSA 107.53 Working Group of the Industrial Noise Subcommittee over the past two years with the objective to endorse the ISO 1996 standard (references [11], [12] and [13]), and to assess its effectiveness for regulatory compliance. Alternative recommendations, supplementary notes/interpretations resulting from the CSA Working Group discussions were incorporated in a Prescriptive Annex to a proposed CSA standard.

In addition to the review work, the CSA Working Group developed tools for Round Robin Test of the rating sound level method, including selection of sample sound signals, instrumentation for the signals reproduction and development of computer spreadsheets for data analysis. An evaluation of results of the 1st phase of Round Robin Test is discussed in a companion paper.

7. REFERENCES

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