Correcting DNL so It Works--Better

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Introduction

Day-night average sound level (DNL), first developed by the US Environmental Protection Agency [1], is commonly used to quantify and assess environmental noise in the USA. A keystone to noise assessment is the dose-response relationship. With such a relationship, one can relate community response to noise level. Since the seminal work by Schultz [2], "high annoyance" has been the response measure of choice—especially in the United States. One hallmark of Schultz's data, and studies like it, is the large amount of scatter to the data. The 90 percent prediction intervals are quite large. For Schultz, the 90 percent prediction intervals are about 20 to 25 percent wide at mid levels.

The USEPA [3] adopted the use of DNL for noise assessment. In their report they again attempted to relate noise levels with community reaction as measured by complaints and legal actions. Figure 1 shows basic data available at that time showing community reaction versus DNL. Obviously there is a great deal of scatter to these data. In an attempt to reduce the scatter to the DNL data, the EPA suggested the use of "normalized" DNL. Normalized DNL is the basic DNL value with a number of adjustments added to account for specific characteristics and factors of the sound. Figure 2 shows the data from Fig. 1 after they have been normalized using this procedure. Clearly, in Fig. 2 the data compress and there is much less scatter to the data than in Fig. 1.

Today, the same issues exist as in the 1950s, 60s and 70s. Dose-response relationships are used to relate DNL to high annoyance and to complaints, but there is great uncertainty to these relationships. Figure 3 shows a more recent analysis by Fidell *et al.* [4] of attitudinal survey data including the original Schultz-studied surveys and many additional surveys. If anything, with more data, the scatter is greater and the prediction intervals are larger still. Yet few have pursued the concept of normalized DNL even though the indication is that it will reduce scatter and afford a better prediction of the reactions in any given community. The purpose of this paper is to review and report on the current recommendations for the normalization of DENL or DNL.

ISO Informative Correction Factors

The recent ISO 1996-1:2003 includes several normalization factors that are to be applied to DENL or DNL. These are adjustments that are to be applied to measurements or predictions (Table 1).

Equation D1 in ISO 1996-1 gives the percent highly annoyed versus DNL for road traffic noise. Annex D of ISO 1996-1 also contains notes for the application of Eq (D1) that are paraphrased below:

Equation D1 is applicable only to long-term environmental sounds such as the yearly average. It should not be used with shorter time periods like weekends, a single season, or "busy days". Rather, the annual average or some other long-term period should be used. The equation is not applicable to a short-term environmental sound such as from an increase in road traffic due to a short-duration construction project, and it is only applicable to existing situations. In newly created situations, especially when the community is not familiar with the sound source in question, higher community annoyance can be expected. This difference may be equivalent to up to 5 dB. Research has shown that there is a greater expectation for and value placed on "peace and quiet" in quiet rural settings. In quiet rural areas, this greater expectation for "peace and quiet" may be equivalent to up to 10 dB. These last two factors are additive. A new, unfamiliar sound source sited in a quiet rural area can engender much greater annoyance levels than are normally estimated by relations like equation (D.1). This increase in annoyance may be equivalent to adding up to 15 dB to the measured or predicted levels.

Type	Description	Adjustment (dB)
Sound Source	Road Traffic Airports Railroads Industry	0 3 to 6 -3 to –6 0
Sound Character	Regular impulsive Highly impulsive High-energy impulsive	5 12 See Annex B of ISO 1996-1
	Prominent tones	3 to 6
Time period	Evening Night Weekend daytime	5 10 5

Table 1— Typical level adjustments based on sound source category, sound character, and time-period

NOTE 1 Weekend adjustments on sources subject to regulation may be applied to permit adequate rest and recuperation, and to account for the greater numbers of people at home.

NOTE 2 If more than one adjustment applies for source type or character to a given single sound source, only the largest adjustment shall be applied. However, time period adjustments always are added to the otherwise adjusted levels.

NOTE 3 Adjustments for impulsive source character should only be applied for impulsive sound sources that are audible at the receiver location. Adjustments for tonal character should only be applied when the total sound is audibly tonal at the receiver location.

Two Additional Factors

Two very important factors not included in ISO 1996-1 are the presence of audible building rattles and the relations the noisemaker has with the community. Fields [5] and many others have looked at items like “noise prevention beliefs” and the concept of “misfeasance” and shown that poor community relations correlates negatively with community satisfaction. It is estimated that this can be equivalent to 5-dB penalty. On the other hand items like noise monitors, joint planning committees and the like can contribute to positive community relations that has been estimated to be equivalent to a 5-decibel bonus.

Schomer has specifically studied the equivalent increase in annoyance when there is noticeable noise induced vibrations that can be heard by the subjects. The subjects need only hear elements rattle, there is no tactile perception of vibration. In one study, Schomer and Averbuch [6] presented simulated blast sounds were both with and without noticeable rattle sounds to subjects. The blast-sound induced rattle noise was virtually unmeasurable compared with the blast sound yet it increased the equivalent annoyance by 6 dB at low blast levels and by 13 dB at the highest blast levels used in that study. In another study, Schomer and Neathammer [7] used real helicopters to generate the test sounds. The mere addition of noticeable rattle sounds increased the subjective annoyance judgements by 10 to 20 dB. Again, the rattle sounds were virtually unmeasurable compared with the helicopter sound. Several subsequent studies also show an increase in annoyance when A-weighted levels are accompanied by vibration. At this time, +10 dB is recommended as the normalization factor for noticeable rattle sounds

Conclusions

It is concluded that normalization of DNL can remove much of the scatter in results from community to community and from setting to setting. Further, normalization will provide for better, more precise assessments.

It is noted that a clear understanding of the psychosocial variables is far more important than, for example, the difference between a Type I and Type II Sound Level Meter. If, as the evidence suggests, psychosocial variables control more of the variance in community response than acoustic variables, then the active and proper inclusion of normalization factors and procedures represents one of the most important dimensions to environmental noise assessment and analysis.

References

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[3] USEPA, “Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety,” US Environmental Protection Agency, Office of Noise Abatement and Control (ONAC), Rpt. EPA550/9-74-004, (Washington D.C., 1974)

[4] Fidell, S, D.S. Barber, and T.J. Schultz, “Updating a dosage—effect relationship for the prevalence of annoyance due to general transportation noise,” *J. Acoust. Soc. Am.* **49**(1), 221-233 (1991)

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[7] Schomer, P.D., and R.D. Neathammer, “The role of helicopter noise-induced vibration and rattle in human response,” *J. Acoust. Soc. Am.* **81**(4), 966-976 (1987)

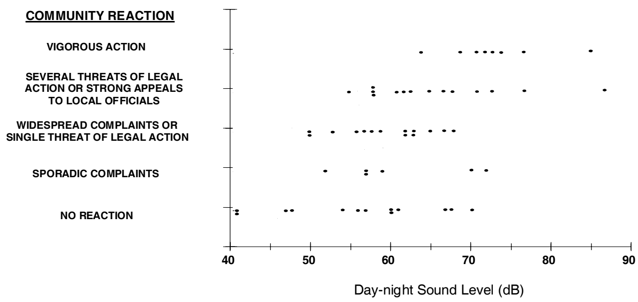

Figure 1. Community reaction for the non-normalized DNL indicated. [Ref. 3]

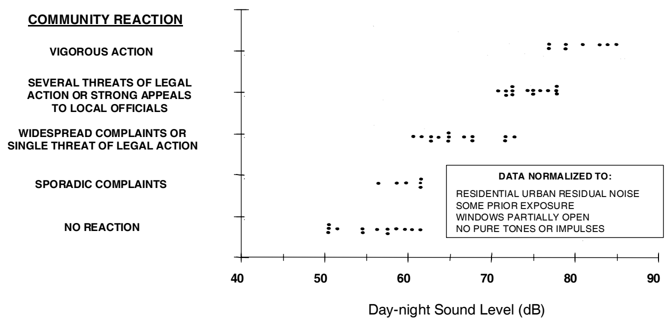

Figure 2. Community reaction for the normalized DNL indicated. [Ref. 3]

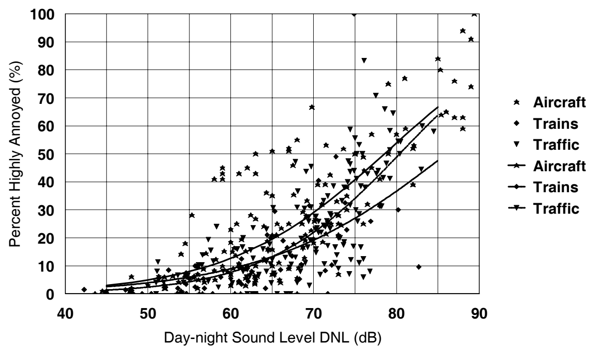

Figure 3. A recent compilation of attitudinal survey data. Note the large amount of scatter to the data. [Ref. 4]