Dose-Response-Relationships (DRR) and the Environmental Noise Directive (END)

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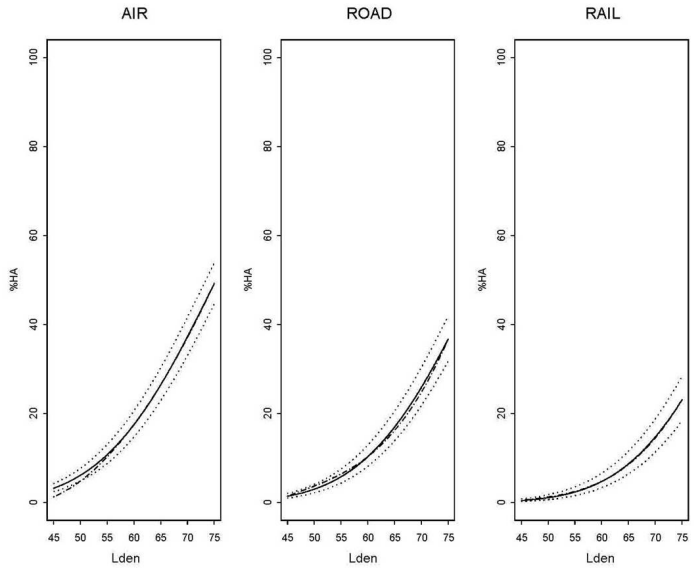
Introduction

With the directive 2002/49/EC a measure relating to the assessment and management of environmental noise was introduced. With the annex III "assessment methods for harmful effects" the use of dose-effect relations to estimate the effect of noise on populations are recommended. In particular the relation between annoyance and L_{den} as well as the relation between sleep disturbance and L_{night} for road, rail and air traffic noise, and for industrial noise should be established. But no other effects adverse health effects are mentioned.
In 2002 the European Commission published the "Position paper on dose response relationships between transportation noise and annoyance" [1]. This position paper recommends that the percentage of persons highly annoyed [%HA] or annoyed [%A] should be used as the measure of noise annoyance in a population. The well-known curves and the underlying equations are given. Figure 1 shows these curves for %HA.

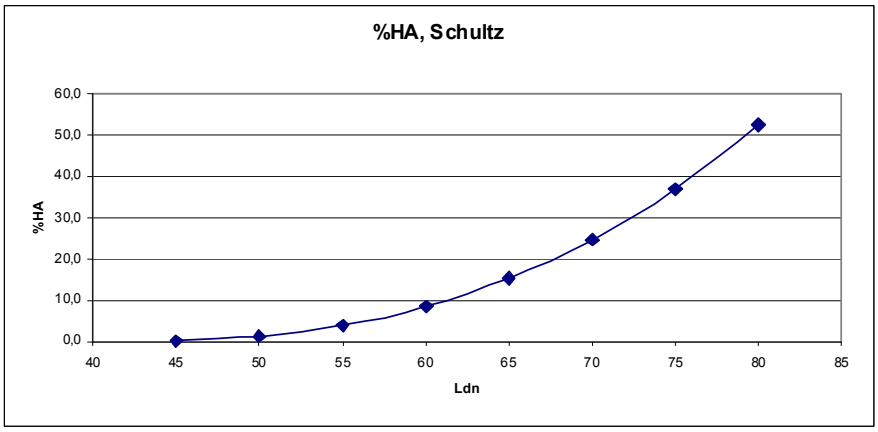
Figure 1: %HA, Position paper 2002



Where do these curves come from?

In 1978 Schultz [2] investigated in a meta-analysis 18 studies concerning the annoyance caused by road, railway and aircraft noise. He found a wide range of subjective responses to the same amount of noise, the correlation between the noise exposure and the individual subjective reactions was pure. The non-acoustical variables played an important role in determining the individual annoyance and complaint reactions. But he could achieve less scattering in the responses when noise-exposure is extreme: The effect of non-acoustical variables is reduced in these cases and the correlation between noise exposure and subjective reactions becomes higher. This lead him to introduce the concept of "highly annoyed" people, i.e. the upper 27-29% of the annoyance scale ranging from 0 to 100 %. For the data he made a third order fit resulting in a dose response relation shown in figure 2.

Figure 2: %HA, Schultz 1978

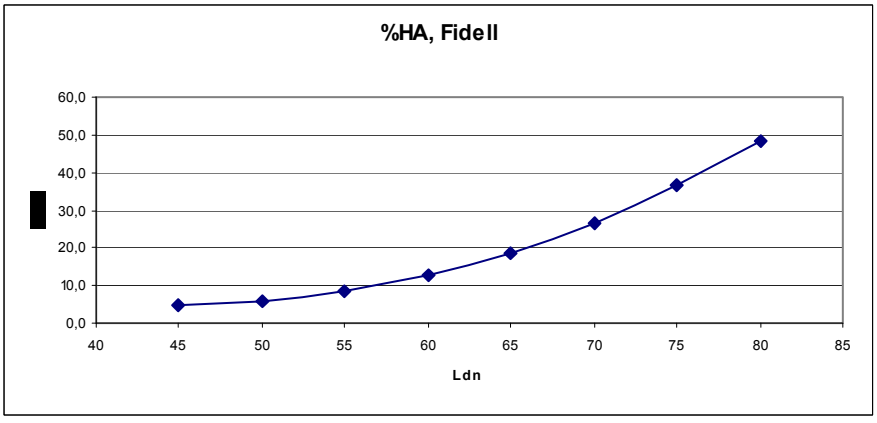


In 1991 this relationship was updated by Fidell et al. [3]. He additionally took into consideration 15 new studies and developed five criteria for comparability:

- Was there a question for long-term annoyance per se
- Consideration of transportation noise source only, measurements were strongly preferred
- The acoustic levels have to be convertible into L_{dn}
- An adequate sample size for estimating prevalence of annoyance with reasonable precision was necessary
- The scale used for annoyance had to permit the identification of "highly annoyed" persons

A quadratic fit was indicating a greater annoyance than the 1978 synthesis. Figure 3 shows the corresponding curve.

Figure 3: %HA, Fidell et al. 1991

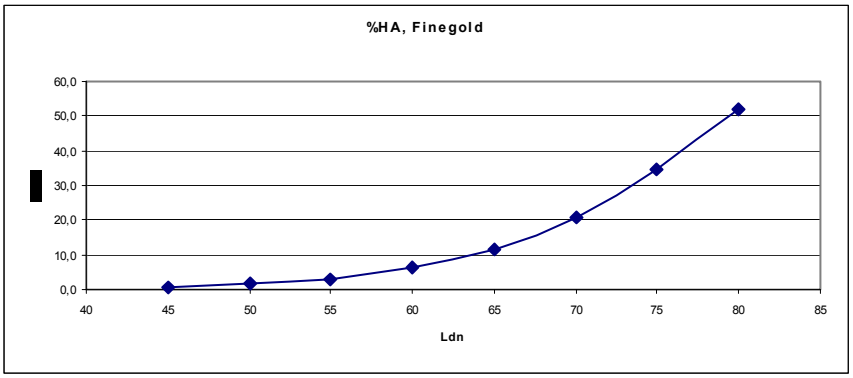


Finegold et al. 1994 [4] did a reanalysis of the data and implemented an additionally criterion:

- Whether or not there is a significant correlation between exposure and annoyance response.

With a logistic fit (see figure 4), guaranteeing an asymptotic behaviour, at least the same predictive utility as by Schultz and Fidell was given.

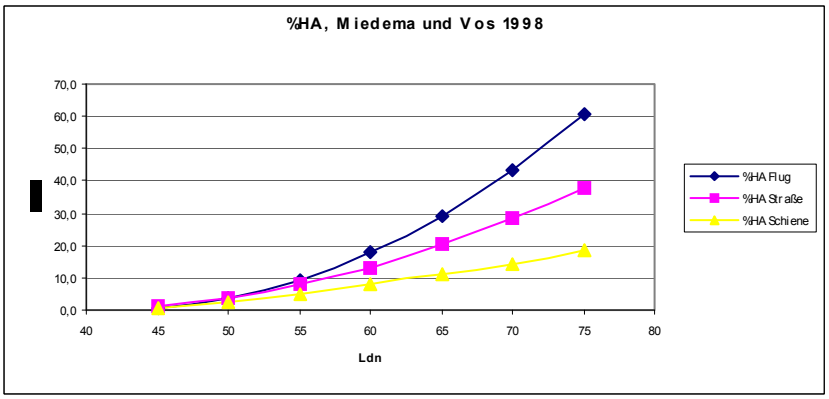
Figure 4: %HA, Finegold et al. 1994



This curve was implemented in ANSI.

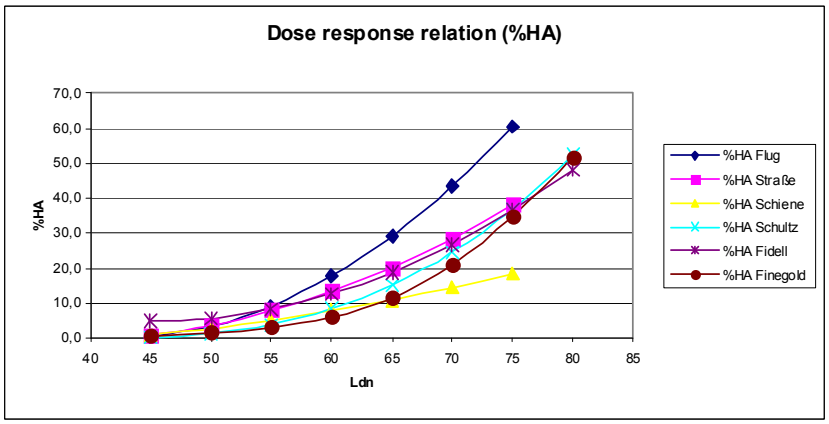
In 1998 Miedema and Vos [5] made a synthesis based on all studies examined by Schultz and Fidell et al. augmented with a number of additional studies. Altogether 20 studies for aircraft noise, 26 studies for road traffic noise and 9 studies for railway noise were included in this metaanalysis. The underlying studies were published between 1965 und 1993, the majority before 1990. The only 2 studies on aircraft noise published after 1991 concerned military aircraft noise. Only 2 studies on road traffic noise were published after 1990. Miedema and Vos made a definition of the "highly annoyed" (%HA) by choosing a cut-off-value of 72. Extreme exposure levels (< 45 dB(A), > 75 dB(A)) were excluded. They obtained different dose response relationships for aircraft, road traffic and railway noise (see figure 5).

Figure 5: %HA, Miedema and Vos 1998



A comparison of the relationships discussed so far is shown in figure 6.

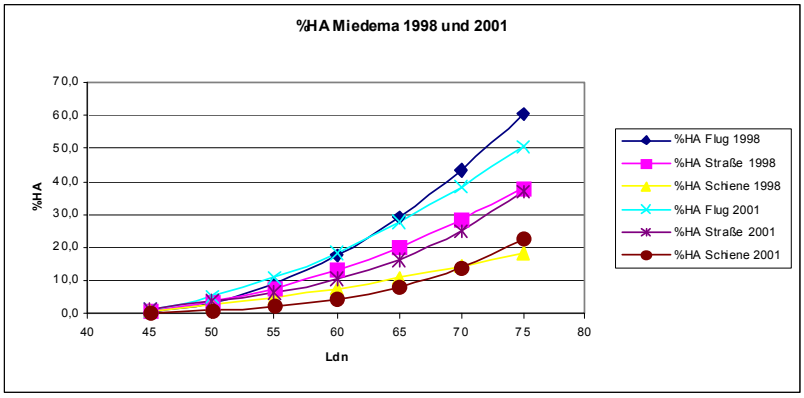
Figure 6: %HA, Schultz, Fidell, Finegold and Miedema



In 2001 Miedema and Oudshoorn [6] made again a reanalysis of the same data, but: "The model of the relationship between exposure and annoyance is more sophisticated and better suited for the data". They made a cubic fit, used the metric L_{den} and L_{dn} and introduced the definition of "annoyed" (%A) by choosing a cut-off-value of 50 and of 37 dB(A) for the exposition and furthermore of "little annoyed" (%LA) by choosing a cut-off-value of 28 and

of 32 dB(A) for the exposition. This was done without any argumentation – remember the difficulties for curve-fitting Schultz' mentioned and the excluded extreme data points (<45 dB(A)) in their paper from 1998. These dose response relations are the curves recommended in the position paper of the European Commission. Figure 7 compares the curves from 1998 and 2001.

Figure 7: %HA, Miedema 1998 and 2001



Conclusion

The data underlying the "Miedema-curves" and thus the position paper recommendations are old data. At the time the studies were done the calculation "procedures" (data, programs, PC) were hardly established; measurements were often preferred. Often no standardized questions for annoyance (like ICBEN) were used. The role of the most exposed façade and the window opening behaviour were not considered. The concept of %A and %LA is not firmed on data but is a mathematical cut-off. The role of non-acoustical parameters is not taken into account in an appropriate manner; so Brink et al. [7] claim that only 15% of annoyance can be explained by the exposition. The curves can only be applied for steady states, but not for changing conditions (like noise abatements measures in action planning).
DRR have to take into consideration noise annoyance and disturbance reaction as well as adverse effects of noise exposure on health, such as an increasing risk of myocardial infarction and hypertension.

Literature

[1] European Commission: Position paper on dose response relationships between transportation noise and annoyance, Luxembourg 2002
[2] Schulz T.J.: Synthesis of Social Surveys on noise annoyance, Journal of the Acoustical Society of America 64(1978)377-405
[3] Fidell S., Barber D.S., Schultz, T.J.: Updating a dosage-effect relationship for the prevalence of annoyance due to general transportation noise. Journal of the Acoustical Society of America 89(1991)221-233
[4] Finegold, L.S., Harris, S., von Gierke, H.: Community annoyance and sleep disturbance: Updated criteria for assessing the impacts of general transportation noise on people, Noise control Engineering Journal 42(1994)25-30
[5] Miedema, H.M.E., Vos, H.: Exposure-response relationships for transportation noise, Journal of the Acoustical Society of America 104(1998)3432–3445
[6] Miedema, H.M.E., Oudshoorn, C.G.M.: Annoyance from Transportation Noise: Relationships with Exposure Metrics DNL and DENL and Their Confidence Intervals, Environmental Health Perspectives, 109(2001)409–416
[7] Brink, M., Wirth, K., Rometsch, R., Schierz, Ch.: Lärmstudie 2000 Zusammenfassung. ETH Zürich, Zentrum für Organisations- und Arbeitswissenschaften 2005