ON THE RELEVANCE OF SHOOTING-NOISE-INDUCED SLEEP DISTURBANCE TO NOISE ZONING

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Introduction To account for a presumed increase in the annoyance caused by environmental sounds, a 10 dB penalty is added to the noise exposure in the nighttime. At present, it is not clear whether such a rating system also sufficiently takes the annoying effects of sleep disturbance into account. Under contract with the Ministry of Defence, we explored in the present literature study the adequacy of this procedure for shooting sounds.

Methods We first studied the literature on (behaviorally-confirmed) noise-induced sleep disturbance. In the interest of a *tentative estimate* of the threshold for awakening by shooting sounds, expressed as the A-weighted sound exposure level (ASEL) of a single shooting event below which awakening responses are unlikely to occur, we analyzed the results from a number of laboratory studies, in which sleep disturbance had been investigated for traffic sounds and various impulsive sounds such as simulated bangs from supersonic aircraft, and rather artificial noise or tone bursts (Pearsons et al., 1989; 1995). Next, we analyzed the data obtained in three German field surveys on the reactions to artillery fire (I: Buchta et al., 1986; II: Buchta, 1988; III: Buchta, 1993, also see Buchta and Vos, 1998), and related the percentages of respondents who *reported* that they had *often* or *very often* been awakened by shooting noise to the (C-weighted) sound exposure levels of the bangs produced in their residential areas during the night.

Results From the literature study on noise-induced sleep disturbance it was concluded that specific studies on sleep disturbance caused by shooting sounds were lacking. From the nine reported field surveys considered, six were related to aircraft and three were related to road-traffic and/or railway sounds. In Pearsons et al. (1989, 1995), the relationship between ASEL and the awakening percentages obtained in the laboratory was only given for all sounds together. In Fig. 1, however, it is shown that the awakening threshold for impulsive sounds is higher than that for traffic and a few other sounds. By combining the results of the analysis of the laboratory studies with the prevalence of traffic-noise induced awakening responses obtained in field surveys, we cautiously concluded that the threshold for awakening by shooting noise, defined as the indoor ASEL, should have a value somewhere between 62 and 72 dB. This threshold is significantly higher than the overall awakening threshold for aircraft and other traffic sounds. The analysis of the German questionnaire data showed that the correlation between the percentages of *highly annoyed* respondents and the percentages of respondents who *reported* that they had *often* or *very often* been awakened by shooting noise was very high, ranging between r-values of 0.81 and 0.97. Next, it could be revealed that the growth in the awakening percentages described above, was high for outdoor CSELs higher than about 100 dB (see Fig. 2).

Discussion and Conclusions From the lower *tentative estimate* of the threshold for awakening (L_{AE} = 62 dB) we concluded that for the bangs produced by small firearms and bang simulators, noise-induced awakenings may not be expected for outdoor ASELs smaller than 80-90 dB. Dependent upon meteorological and façade attenuation conditions, these levels correspond to source-receiver distances of 100–200 m at most. For large firearms, the outdoor ASELs corresponding to the lower threshold range from about 75 to 85 dB, which is equivalent to C-weighted SELs between 95 and 105 dB. These levels can be found at distances between 0.5-2 km.

For the higher threshold (L_{AE} = 72 dB), indoor awakenings from the large firearm bangs are no longer expected at distances greater than 0.25−1 km. From the growth in the awakening percentages derived from the German questionnaire data, we tend to conclude that the estimated threshold for awakening responses is correct. However, because of the magnitude of the percentages, this awakening threshold might be too high. The high correlation between the percentages of *highly annoyed* respondents and the percentages of respondents who reported that they had *often* or *very often* been awakened by shooting noise suggests that it might be redundant to include the effects of sleep disturbance as a separate rating criterion. Moreover, even with one bang per night with a level of 10 dB above the lower awakening threshold, the rating sound level (including nighttime and impulse penalties) would be over 65 dB (small firearms) or over 70 dB (large firearms). Conditions with such rating sound levels will normally be avoided.The present study revealed interesting information on sleep disturbance and noise annoyance. However, the interpretation of the data was considerably hampered by the lack of specific information about shooting-noise-induced behaviorally-confirmed awakening. For satisfactorily answering the questions addressed here, more research is required.

Keywords: shooting noise, sleep disturbance, noise zoning

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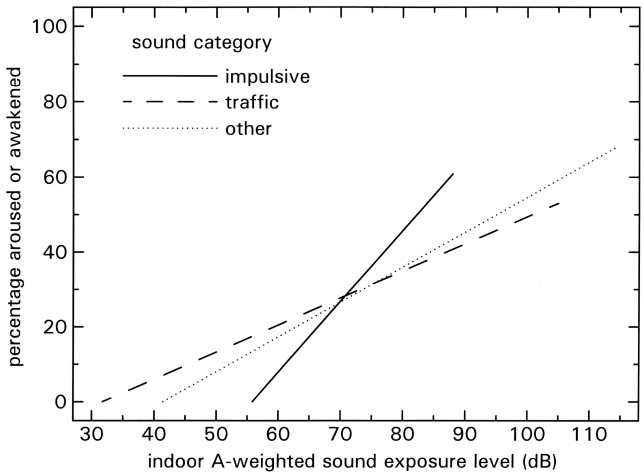

Fig. 1 Percentage awakened for various sound shooting categories

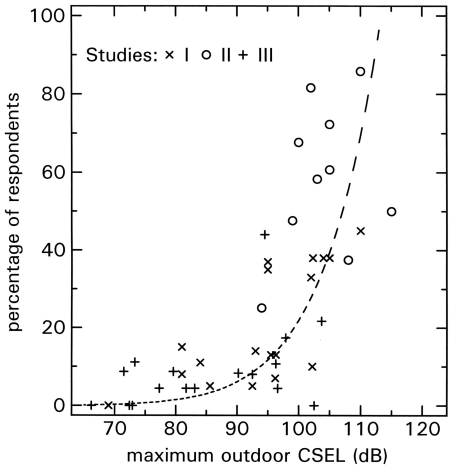

Fig. 2 Reported awakening for sounds in three field surveys