HEALTH IMPLICATIONS DUE TO SLEEP DISTURBANCES AROUND AIRPORTS: A NEW NOISE METRICS SYSTEM

Ir. F.D. van der Ploeg and Ir. W.M. Schuller

Peutz & Associés B.V., P.O. Box 407
NL-6500 AK Nijmegen NETHERLANDS

1. INTRODUCTION

Aircraft noise in the vicinity of airports is a problem recognised worldwide.

This paper discusses possible health implications for the population due to the impact of aircraft noise during the night on sleep; aircraft noise annoyance is dealt with elsewhere in the various (national) noise metrics systems (NNI, NEF, KE, etc.). To solve the quoted problem, we need a dosis-effect relation, in which the aircraft noise in the bedroom is the dosis and the harmful health implication for the population is the effect. Because the impact of changes in the sleeping pattern on health is mostly unknown, most research-workers assume each statistically significant change in the sleeping pattern induced by noise as possible harmful; almost all research concerns the changes in the sleeping pattern due to the impact of noise, so in fact only part of the problem has been investigated.

Studying literature one can find a quantification of the changes in the sleeping pattern, particularly awakening reactions, as a function of noise levels. These awakening reactions are defined by the brain-activity as measured by EEG recordings. These "EEG-awakenings" are <u>not</u> so called behavioural-awakenings; the next morning the test person is normally not aware of these EEG-awakenings.

Studying literature on the impact of noise on sleep, it is conspicous that various procedures for correction of sponteneous awakening-reactions are used (sometimes no correction at all!) and that the influence of habituation (to lab sleeping condition, to the noise, etc.) is not dealt within a standard manner. Some authors (as

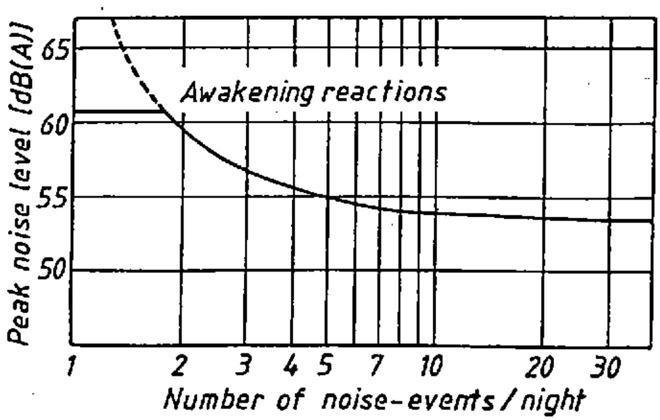
Griefahn, see 2.) try to generalise the lab results to noise limits that have to be met in real life; most of the time this is a "worst-case" conversion.

2. THE GRIEFAHN CRITERION

The criterion as developed by Griefahn [1] sets a limit to the peak noise levels in a bedroom, as a function of the number of noisy events. The criterion corresponds with a total risk per night of 10 % for a noise induced awakening, for the most vulnerable group (71 year old people) in their most sensitive sleeping-stage, after six nights of habituation, based on lab sleeping tests.

The acceptable peak noise level according to Griefahn varies from 60.7 dB(A) for 1 event per night to 53.2 dB(A) for 30 events per night. Figure 1 gives the criterion in a graphical form.

Fig. 1 The Griefahn criterion



If the Griefahn criterion is applied in a very strict manner to a complicated situation as e.g. Amsterdam Airport, it leads to a gross exaggeration of the areas with a significant health risk.
This Griefahn contour is given in figure 2.

Fig. 2 Griefahn contour around Amsterdam Airport with positions 1 to 8

As a matter of fact any position where a peak noise level (due to aircraft) inside a bedroom over 60.7 dB(A) might occur, is situated within the contour. In this approach it is irrelevant whether this event occurs every night or only once a year.

At Amsterdam Airport in 1990 some 8000 nightflights have occured, 2500 of which were take-offs. Take-offs prove to be the most significant noise events in the Griefahn contours.
About 91 % of the take-offs during the night are form runway 24; 7 % of the take-offs during the night are from runway 01, in 53 different nights.
The impact of nightflights on runway 01 is exaggerated when using a strict application of the Griefahn criterion:

- there are 176 take-offs in 53 nights;
- 25 of these take-offs are in the loudest type of aircraft;
- these take-offs split in several flighttracks, as shown in figure 3;

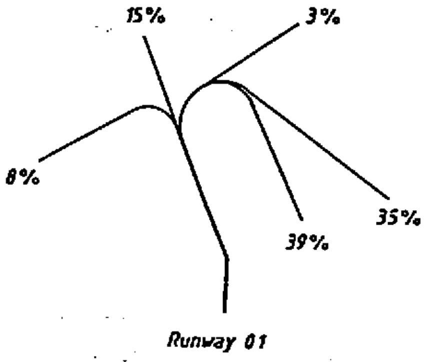


Fig. 3 Possible flighttrack from runway 01 and there relative use

- when we consider the 15 % flighttrack, we have to take into account that 10 % of the take-offs on this track are in the longest distance-class (or take-off weight), and are therefore decisive for the Griefahn contours;
- the Griefahn value near this track is therefor determined by a specific take-off that occurs 25 x 0,15 x 0,10 = 0,38 times a year;
- the nominal flighttracks in figure 3 are furthermore split, due to actual flighttrack deviations, in 5 out tracks in a 5 %, 20 %, 50 %, 20 %, 5 % scheme;
- in a position near a 5 % deviation sub-track the Griefahn value then determined by a specific take-off that occurs an average 0,38 x 0,05 = 0,02 times a year.

Table 1 gives some more details for positions in or on the contour as given in figure 2.

Table 1: Griefahn calculations

Position	Take-off/ Approach	Griefahn-value dB(A)	Number of events/year that causes the Griefahn value	Number of noise induced awakenings per person/year
1	TO	0	0.9	1.7
2	TO	0	9.2	10
3	TO	+2.1	9.2	22.4
4	TO	0	2.9	0.5
5	TO	0	28.1	5.6
6	APP	0	6.7	1.3
7	APP	0	22.4	4.3
8	TO	+6.5	0.07	2.2

E.G. in position 8 there are about 12,000 dwellings of which the noise insulation should be improved by 6.5 dB(A) to meet the Griefahn criterion.

Without insulation improvement the annual number of noise induced awakenings can be calculated on 2.2 for the most vulnerable group (71 year old) and in the most sensitive sleep stage according to Griefahn. So there seems no justification on that area for insulation improvement from the point of view of health implications for the population. Within the Griefahn-contour there are areas with an equal Griefahn-value, but with a completely incomparable impact on health. The strict interpretation c.q. calculations of the Griefahn-criterion leads, in a complicated situation as Amsterdam Airport, to worst-case, non realistic results. Because the purpose is to assess health implications, the calculation method should be refined. The annual number of noise induced awakenings calculated according to the dosis-effect relation as specified by Griefahn should play a major role in such a refinement.

3. ANNA

The Annual Number of Noise induced Awakenings (ANNA) is proposed as the criterion for determining the areas with possible health implications for the population. Griefahn allows about 40 awakenings a year equally spread in time, as there is a rebound-effect. Fundamentally it is possible to approach statistically the risk of having more than one noise induced awakening in one night, or in adjacent nights. However in such a statistical approach there is no criterion whether or not a certain risk of awakenings in adjacent nights is acceptable.
As a practical approach, avoiding this complication, we propose to use a lower number of awakenings per year then Griefahn allows, due to the fact that in reality the awakenings will not be (completely) equally spread in time.
On this basis calculations have been made e.g. for 12, 24 or 36 awakenings a year in a certain flight scheme around Amsterdam Airport, see figure 4.

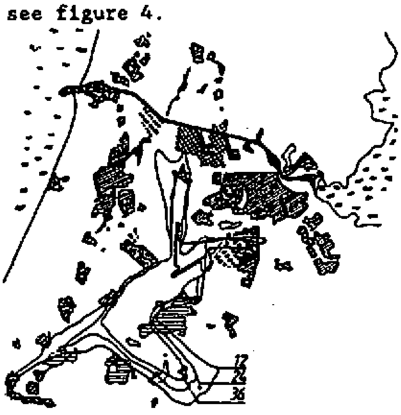


Fig. 4 Contours of 12/24/36 ANNA (71 year old, in most sensitive sleeping stage)

4. CALCULATIONS OF ANNA

The calculation of the annual number of noise induced awakenings (ANNA) is, based on the Griefahn statements, rather simple.

In a position on the ground (bedroom) the indoor peak noise level of every airplane movement has to be calculated. The noise level is directly related to a probability of a noise induced awakening (or the mean number of awakening reactions).
The calculation scheme per event is:

L_{peak} in dB(A) of a noise event	Probability P of noise induced awakening due to the noise event
< 53.1	0 %
$53.1 < L_{peak} < 60.7$	$[(L_{peak} - 53.1) / 11.2] \times 10$ %
> 60.7	$1.32 \times (L_{peak} - 60.7) + 10$ %

These figures are valid for people, 71 year old, during the entire night in the most sensitive sleep stage, lab sleeping, six nights of habituation.

The annual number of noise induced awakenings (ANNA) can then be calculated as:

$$ANNA = \sum_i 0.01 \times P_i \times N_i$$

where N_i = the number of types of events in a year
P_i = the probability of noise induced awakening due to type of event i in %
$\sum_i$ = the summation over all types of events in a year

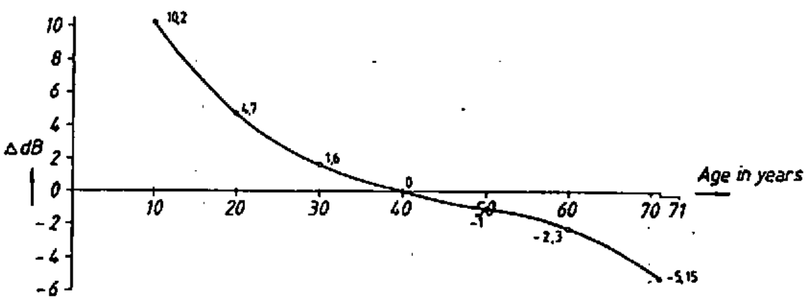
As type of event, every possible combination of type of aircraft, distance-class, flighttrack and flighttrack deviation is considered.

For a more average group, 40 years old (5.1 dB(A)) in a normal sleep pattern (2.1 dB(A)), Griefahn allows 7.2 dB(A) higher noise levels per event for the same awakening probability (and therefor also the same value for ANNA).

In the formulae for awakening probability the values of 53.1 and 60.7 change into 60.3 and 67.9 dB(A).

In figure 5 the influence of age on awakening probability is shown.

Fig. 5 Relative noise level for equal awakening probability as a function of age



These effects may play an important role in the economy of the insulation of dwellings; e.g. in the decision whether or not to insulate a roof, one might consider normally 71 year old people are not living in garrets.

5. LITERATURE

[1] Griefahn, B ; Präventivmedizinische vorschläge für den nachtlichen Schallschutz. Z für Lärmbekämpfung 37 (1990), 7-14