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Is DNL appropriate for airport noise zoning?

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The use of the DNL metric in airport noise zoning is based in the works of Schultz, that were later improved by Fidell. The basic idea is to use the percentage of highly annoyed people as a parameter to organize the area around airports. In urban zoning it is recommended to use the equivalent sound level LAEQ, which uses different criteria to day and night periods to define the land use. With regards to airport noise one may use LAD and LAN metrics which are the equivalent sound levels determined for day and night period, respectively. In this case, the maximum levels chosen to the establishment of the zoning are based on the land use. It is possible, through a simple equation, to determine the DNL level associated to a LAD, LAN pair. The inverse problem, however, has not a unique solution, once this relation depends on the number of daily and night flights of the airport. Thus, the use of DNL in airport noise zoning may lead to completely different results for different airports. Examples are presented and discussed for two main brazilian airports: Recife and Congonhas.

1 Introduction

The use of DNL (Day Night Sound Level) metric in airport zoning was based on the idea of controlling the number of complains generated by the airport operation in its surroundings. DNL is said to be the best single system of noise measurement that can be uniformly applied in measuring noise in the communities and around airports, and for which there is a highly reliable relationship between projected noise and surveyed reaction of people to the noise. DNL takes into account the magnitude of the sound levels of all individual events that occur during the 24-hour period, the number of events, and an increased sensitivity to noise during typical sleeping hours. DNL is an average in that it accumulates all the noise exposure over a 24-hour period and divides the total by the number of seconds in a day [WYLE].

The relation between the DNL metric and the number of highly annoyed people was studied by Schultz [1] as shown in Figure 1.

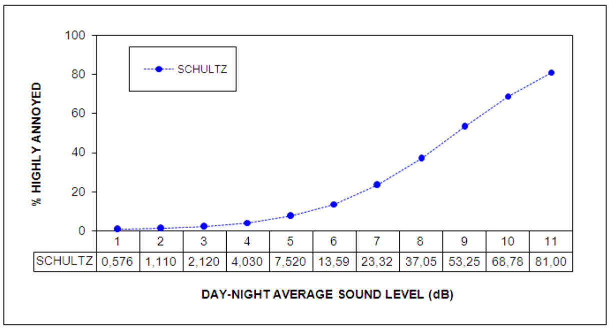

Figure 1: Relation between DNL and highly annoyed people

The DNL metric is defined as follows:

$$DNL = 10\log_{10}\{\frac{1}{3600 \times 24} \times \alpha\} \qquad (1)$$

on which:

$$\alpha = \int_{7am}^{10pm} 10^{\frac{L_A(t)}{10}} dt + \int_{10pm}^{7am} 10^{\frac{L_A(t)+10}{10}} dt \qquad (2)$$

Later, Fidell [1] presented new results on these relation. Thus, the airport zoning regulation in many countries in the world are based in the DNL metric. In Brazil, for example, residencies are authorized by the airport regulation to be placed in areas where the DNL $\leq$ 65dB(A).

2 Zoning comparison

In addition to the annoyance sensation, the airport noise has many adverse effects of which the most important are the interference on communication during the diurnal period and the sleep disturbance during the nocturnal period.

Urban noise produces the same adverse effects, and based on this characteristics the urban zoning regulation adopts different criteria to evaluate diurnal and nocturnal noise. The metric generally adopted is the equivalent sound level, LAeq. In order to calculate a sound level in a critical receiver using this metric it is necessary to define an evaluation period which will depend on the time characteristics of the considered noise.

In Brazil, the urban regulation for noise pollution control uses the criteria shown on 1 for the diurnal and nocturnal periods:

Table 1: Noise levels according to NBR 10151

L_{AeqD}	L_{AeqN}	Area Type
40	35	A_1
50	45	A_2
55	50	A_3
60	55	A_4
65	55	A_5
70	60	A_6

The area types shown on Table 1 are described below. The same notation will be used on the next tables on this paper.

- A_1 - Farm
- A_2 - Strictly urban residential, hospitals or schools
- A_3 - Mixed, predominantly residential
- A_4 - Mixed, commercial and administrative vocation
- A_5 - Mixed, recreational vocation
- A_6 - Mainly industrial

Because of the non stationary characteristics of the airport noise, if one tries to use the urban regulation and the LAeq metric in regions close to an airport, the evaluation periods must be all diurnal period (from 7h to 22h) and all nocturnal period (from 22h to 7h on the next day). We call L_{AeqD} and L_{AeqN} the equivalent sound levels calculated at a critical receptor during the diurnal and nocturnal periods, respectively, as shown on Eq. 3 and 4.

$$L_{AeqD} = 10\log_{10}\left[\frac{1}{3600\times 15}\int_{7am}^{10pm} 10^{\frac{L_A(t)}{10}}\,dt\right] \quad (3)$$

$$L_{AeqN} = 10\log_{10}\left[\frac{1}{3600\times 9}\int_{10pm}^{7am} 10^{\frac{L_A(t)}{10}}\,dt\right] \quad (4)$$

3 Conversion between L_{AeqD}, L_{AeqN} and DNL

It is important to note that a simple relation between DNL, L_{AeqD} and L_{AeqN} in one point near the airport exists. This relation is given by Eq. 5.

$$DNL = 10\log_{10}(\frac{1}{24}\left[15\times 10^{\frac{LAD}{10}} + 90\times 10^{\frac{LAN}{10}}\right]) \quad (5)$$

Thus, once LAD and L_{AeqN} levels are known, it is possible to calculate the equivalent DNL level. Considering values shown on Table 1 we are able to determine the DNL level for each type of area.

Thus, in an airport vicinity, considering that the urban regulation for noise pollution control is applicable, we have the values shown on Table 2:

Table 2: Equivalent DNL level for the criteria of NBR 10151

L_{AeqD}	L_{AeqN}	DNL	Area Type
40	35	42,57	A_1
50	45	52,57	A_2
55	50	57,57	A_3
60	55	62,57	A_4
65	55	65	A_5
70	60	70	A_6

Thus, considering $L_{AeqD} = 55dB(A)$ and $L_{AeqN} = 50dB(A)$ values, which is the criteria level for a mixed, predominantly residential area near an airport we find a correspondent DNL level of 58dB(A). Once that this type of area is the most noisy residential area according to Table 1, one can see that this level is much lower than that of the airport noise regulation (65dB(A)). It is verified that one should use a lower value.

Thus, considering the criteria DNL≤58dB(A) to authorize the implantation of residencies, one may think that the criteria $L_{AeqD} \leq 55dB(A)$, $L_{AeqN} \leq 50dB(A)$ are verified. However this is not the case once the relation between L_{AeqD} and DNL in a certain airport surroundings depends on the relation between the number of diurnal and nocturnal movements on the airport.

If we consider the "Acoustical Amplitude", which is defined by Eq. 6, we can find new relationships between DNL, L_{AeqD}, L_{AeqN} and Δ, as shown on Eq. 7 e 8 .

$$L_{AeqD} - L_{AeqN} = \Delta \quad (6)$$

$$L_{AeqD} = DNL - 10\log_{10}\left[1 + 6\times 10^{\frac{-\Delta}{10}}\right] + 2 \quad (7)$$

$$L_{AeqN} = DNL - 10\log_{10}\left[10^{\frac{\Delta}{10}} + 6\right] + 2 \quad (8)$$

Thus:

If $\Delta = 10$ then $L_{AeqD} = DNL$, $L_{AeqN} = DNL - 10$

If $\Delta = 0$ then $L_{AeqD} = L_{AeqN} = DNL + 6,4dB$

It is observed that on each airport the relation between DNL, L_{AeqD} e L_{AeqN} depends on the number of aircraft movements during the day and the night.

Example 1 *Congonhas Airport*

$$\begin{aligned} L_{AeqD} &= DNL - 0,5dB(A) \\ L_{AeqN} &= DNL - 19,5dB(A) \\ L_{AeqD} & -L_{AeqN} = 19dB(A) \end{aligned}$$

Thus, a DNL level of 58dB(A) corresponds to a L_{AeqD} of 57,5 dB(A) and a L_{AeqN} of 38,5 dB(A). In this case the diurnal condition $L_{AeqD} \leq 55dB(A)$ is not verified.

Example 2 *Recife Airport*

$$\begin{aligned} L_{AeqD} &= DNL - 6,6dB(A) \\ L_{AeqN} &= DNL - 6,3dB(A) \end{aligned}$$

Thus, a DNL level of 58dB(A) corresponds to a L_{AeqD} of 51,4 dB(A) and a L_{AeqN} of 51,7 dB(A). In this case the nocturnal condition $L_{AeqD} \leq 50dB(A)$ is not verified.

Thus, the use of the condition DNL ≤ 58dB(A) may lead to different conditions in different airport.

The fact of punishing the nocturnal period noise in 10dB(A) does not mean that the land use conditions are respected.

From the examples shown above it can be verified that the level DNL = 65dB(A) is not representative of the limit from residential and non-residential areas. It is important to reduce the current levels of Portaria 1141 GM5 in order to meke them compatible with the levels used on NBR 10151. In accordance with the value shown above, we suggest a reduction of initially 5 dB(A) over the levels of 65 dB(A) and 75 dB(A), lowering them to 60 dB(A) and 75 dB(A), trespectively.

More specific strategies are shown below.

4 Zoning based on L_{AeqD} and L_{AeqN} according with ABNT NBR10151 Standard

Considering the NBR 10151 Standard and adopting the L_{AeqD} to represent the equivalent sound level during the day and the L_{AeqN} to represent the equivalent sound level during the night, it is possible to develop a necessary logic condition for the interior of each area.

Table 3: Logic condition for the interior of each area

L_{AeqD}	L_{AeqN}	Logic Condition	Area Type
40	35	$L_{AeqD} \leq 70dB(A)$ $\wedge\ L_{AeqN} \leq 60dB(A)$	A_1
50	45	$L_{AeqD} \leq 65dB(A)$ $\wedge\ L_{AeqN} \leq 55dB(A)$	A_2
55	50	$L_{AeqD} \leq 60dB(A)$ $\wedge\ L_{AeqN} \leq 55dB(A)$	A_3
60	55	$L_{AeqD} \leq 55dB(A)$ $\wedge\ L_{AeqN} \leq 50dB(A)$	A_4
65	55	$L_{AeqD} \leq 50dB(A)$ $\wedge\ L_{AeqN} \leq 45dB(A)$	A_5
70	60	$L_{AeqD} \leq 40dB(A)$ $\wedge\ L_{AeqN} \leq 35dB(A)$	A_6

The complementary logic condition describes the complementary areas of the areas described on Table 3.

Table 4: Complementary logic conditions

L_{AeqD} L_{AeqD}	L_{AeqN} L_{AeqN}	Logic Condition Logic Condition	Area Types Near an Airport
40	35	$L_{AeqD} > 70dB(A)$ $\vee L_{AeqN} > 60dB(A)$	$\overline{A_1}$
50	45	$L_{AeqD} > 65dB(A)$ $\vee L_{AeqN} > 55dB(A)$	$\overline{A_2}$
55	50	$L_{AeqD} > 60dB(A)$ $\vee L_{AeqN} > 55dB(A)$	$\overline{A_3}$
60	55	$L_{AeqD} > 55dB(A)$ $\vee L_{AeqN} > 50dB(A)$	$\overline{A_4}$
65	55	$L_{AeqD} > 50dB(A)$ $\vee L_{AeqN} > 45dB(A)$	$\overline{A_5}$
70	60	$L_{AeqD} > 40dB(A)$ $\vee L_{AeqN} > 35dB(A)$	$\overline{A_6}$

Thus, we have the following relation:

$$A1 \subset A2 \subset A3 \subset A4 \subset A5 \subset A6$$

We adopted in the last paragraph the mixed, mainly residential area as the residential area most sensitive to noise and the mainly industrial area as the less sensitive to noise. The diurnal and nocturnal levels are on Table 5.

One may write the above table as logic condition and complementary logic condition which would be the exterior of the area defined to the initial logic conditions.

Area 1 definition: $L_{AeqD} > 70dB(A) \vee L_{AeqN} > 60dB(A)$

Area 2 definition: $[L_{AeqD} > 55dB(A) \vee L_{AeqN} > 55dB(A)] - Area1$

Table 5: Most and less noise sensitive areas

Area Type	Diurnal	Nocturnal
A_3	55	50
A_6	70	60

Table 6: Logic conditions for the most and less noise sensitive areas

Area Type	Logic Condition (interior of the area)	Complementary Logic (exterior of the area)
A_3	$L_{AeqD} \leq 55dB(A)$ $\wedge L_{AeqN} \leq 50dB(A)$	$L_{AeqD} > 55dB(A)$ $\vee L_{AeqN} > 50dB(A)$
A_6	$L_{AeqD} \leq 70dB(A)$ $\wedge L_{AeqN} \leq 60dB(A)$	$L_{AeqD} > 70dB(A)$ $\vee L_{AeqN} > 60dB(A)$

Area 3 definition (residential): $L_{AeqD} \leq 55dB(A) \wedge L_{AeqN} \leq 50dB(A)$

5 The case of L_{DEN}

Recently, Day-evening-night level has been adopted by the Europe as a general descriptor for urban noise. Day-evening-night level. is a descriptor of noise level based on energy equivalent noise level (L_{eq}) over a whole day with a penalty of 10 dB(A) for night time noise (22.00-7.00) and an additional penalty of 5 dB(A) for evening noise (i.e. 19.00-23.00). Similarly, for airport noise we introduce L_{AeqD}, L_{AeqE} and L_{AeqN} the equivalent sound levels calculated at a critical receptor during the diurnal, evening and nocturnal periods, respectively, Then it is possible to write the conversion equation.

$$L_{DEN} = 10\log_{10}(\frac{1}{24} \times \beta) \tag{9}$$

$$\beta = 12 \times 10^{\frac{L_{AeqD}}{10}} + 9.486 \times 10^{\frac{L_{AeqE}}{10}} + 90 \times 10^{\frac{L_{AeqN}}{10}} \tag{10}$$

Let us introduce ΔE and ΔN

$$\Delta E = L_{AeqD} - L_{AeqE} \tag{11}$$

$$\Delta N = L_{AeqD} - L_{AeqN} \tag{12}$$

We can write the equation:

$$L_{DEN} = L_{AeqD} + 10\log_{10}(\frac{1}{24} \times \theta) \tag{13}$$

$$\theta = 12 + 9.486 \times 10^{\frac{-\Delta E}{10}} + 90 \times 10^{\frac{-\Delta N}{10}} \tag{14}$$

6 Conclusion

The DNL metric is appropriate to develop environmental impact studies. However, the use of this metric on airport zoning does not seem adequate, once it may lead to distortions in the local noise situation.

It is recommended to use for zoning purposes, diurnal and nocturnal metrics that will allow to consider different adverse effects such as sleep disturbance and disturbance on oral communication.

It is observed that, by the nature of the noise sources involved, the use of DNL to evaluate the annoyance generated by land transport noise will lead to different relations between the levels of the metric and the number of highly annoyed people.

We presented two propositions for the revision of Portaria 1141 GM5 based on the NBR 10151. From these propositions, the second would be the most satisfactory, which is based on the use of L_{AeqD} and L_{AeqN} in a logic condition to define airport noise zoning. At first, it is recommended to adopt the first proposition which consist in continue to use the DNL metric and reduce the levels for each of the noise curves, lowering from 75 dB(A) to 70 dB(A) for curve 1 and from 65 dB(A) to 58 dB(A) for curve 2.

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References

[1] S. Fidell, "Assessment of the effectiveness of aircraft noise regulation", *Noise & Health*, 17-25 (1999)

[2] S. Fidell, L. Silvati "Parsimonious alternative to regression analysis for characterizing prevalence rates of aircraft noise annoyance", *Noise Control Eng. J. 52(2)*, 56-68 (2004)