inter·noise 96
25th Anniversary Congress – Liverpool

INCE: 56

# MEASUREMENTS AND RATINGS OF ENVIRONMENTAL NOISE IN JAPAN

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## 1. INTRODUCTION

Japanese environmental quality standards for noise were established in 1971. The standard value is defined by $L_{A50}$ (median value of A-weighted sound level). On the other hand Japanese Industrial Standard employs $L_{Aeq}$ as well as $L_{A50}$. Thus the difference between these two noise indices must be taken into consideration invariably.

We began to measure environmental noise $L_{Aeq}$ in Nagoya city in 1982. And since 1987 we added to measure $L_{A50}$ as well as $L_{Aeq}$. Here we report the survey in the city and discuss the criteria for environmental noise based on $L_{Aeq}$ and $L_{A50}$ concerning residents' reactions against noise.

## 2. SURVEY OF ENVIRONMENTAL NOISE

Nagoya lies midway between Tokyo and Osaka. It has about 2 million population and area of 330km$^2$. In various area of the city measurement of environmental noise around residence was made using sound data logger that records noise level over 24 hours. First we divided the city area into approximately 1km square blocks according to longitude and latitude. In the first year we measured at one point a block. Number of measured points amounted to 315. The survey is continuing and about 2000 samples have been collected. Sound data logger used in the first 5 years deals only $L_{Aeq}$. But we changed the device in 1987 and after that $L_{A50}$ has been obtained simultaneously. In this paper we mainly concern about the samples after 1987.

The whole area of Nagoya is categorized into eight types of land use

Table 1. Land use in Nagoya and distribution of samples

| Categorized land use | area(km²) | proportion (%) | samples | proportion (%) |
|---|---|---|---|---|
| Exclusive residence | 81.9 | 25.1 | 254 | 21.7 |
| Residence | 104.4 | 32.0 | 434 | 37.2 |
| Commercial | 47.9 | 14.7 | 118 | 10.1 |
| Industrial | 67.2 | 20.5 | 348 | 29.8 |
| Others | 25.0 | 7.7 | 14 | 1.2 |
| All | 326.4 | 100.0 | 1168 | 100.0 |

Table 2. Contents of the database

| $L_{Aeq\ 1/8}$ , $LA_{50\ 1/8}$ | $L_{Aeq}$ and $L_{A50}$ every 10 minutes |
|---|---|
| Residence | Type and structure of residence |
| | Living story, structure of window |
| | Distance to a road and a railway nearby |
| | Land use, Outstanding noise source |
| Inhabitant | Sex, Age, Occupation |
| | Reaction to outside and inside noise |
| | Sleep disturbance |
| Secondary calculated data | $L_{Aeq}24$, $L_{Aeq}$M, $L_{Aeq}$D, $L_{Aeq}$E, $L_{Aeq}$N, $L_{dn}$, $L_{den}$, $L_{A50}24$, $L_{A50}$M, $L_{A50}$D, $L_{A50}$E, $L_{A50}$N |
| Others | Date, Time, Weather, Device number, etc. |

based on city planning law. We re-classified these into four categories (exclusive residential, residential, commercial, industrial). Numbers of measured points in each category shown in Table 1 are almost proportional to areal ratio.

A sound data logger is hung at porch or other place in the garden to measure typical noise environment of each residence. This device measures sound level every 0.2 second over 10 minutes and calculates $L_{Aeq\ 1/8}$ and $L_{A50\ 1/8}$. Since this process is repeated over 24 hours, 144 (6/hour x 24) pairs of $L_{Aeq\ 1/8}$ and $L_{A50\ 1/8}$ are stored into memory.

Just before or after the measurement we recorded some information around the residence such as distance to trunk road, density of buildings etc. At the same time several questions concerning noise environments in and around residence were posed to inhabitants.

## 3. DATA PROCESSING

After 24 hours measurement, values of $L_{Aeq\ 1/8}$ and $L_{A50\ 1/8}$ in the device are read out by a personal computer. Then all the values are displayed graphically on the screen and checked. After the process $L_{Aeq}24$, $L_{dn}$, $L_{den}$ and some other mean values of $L_{Aeq}$ and $L_{A50}$ are calculated as secondary data. A day is divided into Morning (6:00-8:00), Daytime (8:00-19:00), Evening (19:00-22:00) and Nighttime (22:00-6:00) and mean values for each time section are denoted with suffix M,D,E,N such as $L_{Aeq\ M}$. Here $L_{Aeq}$ x is a power average but $L_{A50}$ x is an arithmetic average of $L_{A50\ 1/8}$ in time section X. In addition, associated information about inhabitants and their answers to the questionnaire

are coded and fed into the computer by keyboard. All the data is checked again and sent to a database of computation center. So we can analyze the data on both personal computer and large scale computer. The contents of the database are shown in Table 2.

## 4. NOISE EXPOSURE AROUND RESIDENCE

Noise level varies from moment to moment. Fig.1 shows averaged time patterns of $L_{Aeq\ 1/6}$ and $L_{A50\ 1/6}$. Both $L_{Aeq\ 1/6}$ and $L_{A50\ 1/6}$ in every 10 minutes are arithmetically averaged over all samples in the city. $L_{Aeq\ 1/6}$ grows about 12dB from 4:00 to 8:00 and keeps almost constant level 60dB in daytime except for lunch hour. From 18:00 to 2:00 the level decays gradually and holds bottom level 47dB in the midnight. Both patterns are synchronous, but value of $L_{A50\ 1/6}$ is about 6dB lower.

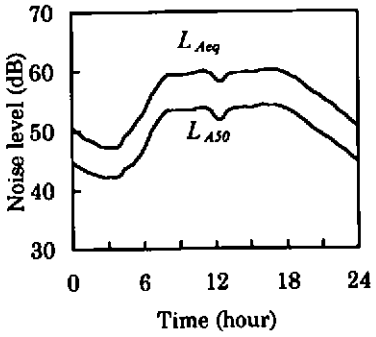


Fig.1 Time variation of averaged noise level

Table 3 shows the values of noise indices in different time section and land use. To begin with time sections, levels of daytime are the highest and those of night are the lowest. The level differences between day and night are almost 10dB in every land use. This holds for Both $L_{Aeq}$ and $L_{A50}$ . In regard to the land use, the levels are highest in commercial area and the lowest in exclusive residential area excluding "others". And the disparity of land use affects on

Table 3. Averaged $L_{Aeq}$ and $L_{A50}$ classified by land use and time section

(in dB)

| | | Exclusive Residential | Residential | Commercial | Industrial | Others | All |
|---|---|---|---|---|---|---|---|
| $L_{Aeq}$ | 24 | 58.0 | 59.8 | 61.6 | 60.7 | 56.4 | 59.8 |
| | M | 55.2 | 57.9 | 60.4 | 59.2 | 54.6 | 58.0 |
| | D | 60.1 | 61.7 | 63.3 | 62.7 | 58.6 | 61.8 |
| | E | 56.5 | 57.9 | 60.4 | 58.3 | 54.0 | 57.9 |
| | N | 50.2 | 52.7 | 55.3 | 53.4 | 47.3 | 52.6 |
| | $L_{dn}$ | 60.6 | 62.6 | 64.8 | 63.5 | 59.0 | 62.7 |
| $L_{A50}$ | 24 | 47.1 | 49.5 | 52.8 | 51.2 | 46.5 | 49.8 |
| | M | 47.1 | 50.4 | 53.4 | 51.9 | 47.0 | 50.4 |
| | D | 50.7 | 53.1 | 56.8 | 55.4 | 50.1 | 53.6 |
| | E | 48.1 | 50.1 | 54.1 | 50.9 | 47.2 | 50.3 |
| | N | 41.7 | 44.0 | 46.9 | 45.5 | 41.5 | 44.2 |
| Samples | | 254 | 434 | 118 | 348 | 14 | 1168 |

$L_{A50}$ more conspicuously than on $L_{Aeq}$ .

## 5. REACTION OF INHABITANTS TO NOISE ENVIRONMENT

Several questions about noise environment in and around residence were posed to inhabitants. The questions concerning exterior noise are listed in Table 4. They ask about loudness(A), noisiness(B), annoyance(C) and mental attitude(D). The distribution of answers to each question are summarized in Fig.2 . Here dark gray, light gray and white indicate positive, neutral and negative reaction respectively. About 30% of the people express intense reaction in every question.

## 6. CRITERIA FOR ENVIRONMENTAL NOISE

As mentioned before the quality standards for environment noise in Japan are based on $L_{A50}$. Table 5 shows the details. Apart from this, we examine criteria based on $L_{Aeq}$ and $L_{A50}$ with respect to inhabitants' reactions on loudness of outdoor noise. The scaling of reactions has been carried out using various method. In some cases criteria for environmental noise are obtained from noise levels which correspond

Table 4 Questions on noise environment

| | |
|---|---|
| A | How do you find noise around your residence?<br>1:loud(+) 2:medium(0) 3:low(-) |
| B | Are you annoyed by the noise?<br>1:very annoyed(+) 2:annoyed(+) 3:little annoyed(0) 4:not annoyed(-) |
| C | Do you feel it is noisy around your residence?<br>1:very noisy(+) 2:pretty noisy(+) 3:noisy(+)<br>4:little noisy(0) 5:quiet(-) 6:very quiet(-) |
| D | What do you think about the noise?<br>1:should be abated(+) 2:desirable to be abated(+)<br>3:pay no much attention(0) 4:pay no attention(-) |

Answers are labeled as follows, according to degree of complaints:
(+) :positive reaction (0):neutral reaction (-):negative reaction

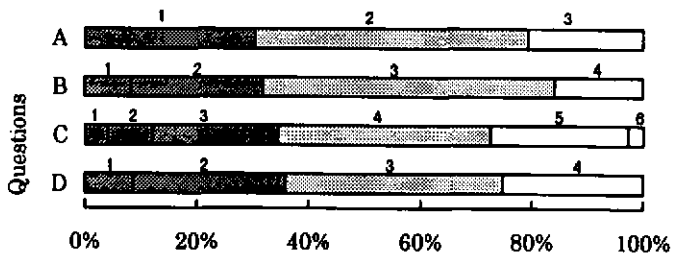


Fig.2 Response rate to each question on Table 4.

Table 5 Japanese environmental quality standards for noise based on $L_{A50}$ (in dB)

| Category of area n:lanes | Time division | | |
|---|---|---|---|
| | Daytime | Morning Evening | Nighttime |
| General area | Not more than | Not more than | Not more than |
| AA | 45 | 40 | 35 |
| A | 50 | 45 | 40 |
| B | 60 | 55 | 50 |
| Roadside area | Not more than | Not more than | Not more than |
| A n=2 | 55 | 50 | 45 |
| A n≧3 | 60 | 55 | 50 |
| B n≦2 | 65 | 60 | 55 |
| B n≧3 | 65 | 65 | 60 |

Note. Standard values vary according to the area type. Therefore, classification of areas is left to the discretion of prefectural governors.
**AA** : Areas which require particular quiet (for instance areas in which medical facilities are concentrated) **A** : primary residential areas **B** : Areas where a substantial number of residences are located among shops and factories.

to 30% in cumulative distributions for annoying inhabitants. That is the level above which 70% of annoying inhabitants exist.

Fig.3 is an example to explain how to decide the level using the answers of question A in table 4. In this case, 52.5dB($L_{A50\ D}$) corresponds the level below which there are 30% of inhabitants who fell "loud". In the same way the levels are calculated for every time section and land use and are shown in Table 6. Where one new category "roadside" is added. It includes all samples acquired within 20m from trunk road. And they are excluded from other categories of land use (general area). The values in the table are rounded down by 5dB steps. For reference, levels that correspond to median value of $L_{Aeq}$ and $L_{A50}$ for neutral reaction are also examined. They are consistent with above-mentioned levels with the exception of few values shown in parenthesis in Table 6.

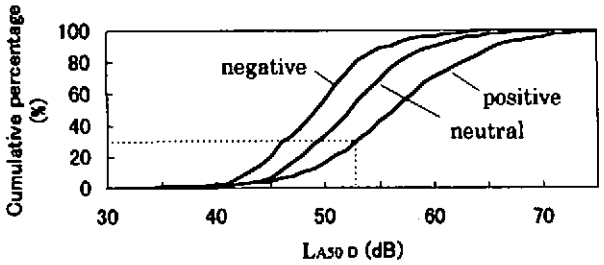


Fig.3 Cumulative distribution of $L_{A50\ D}$ in each reaction to "loudness"

Table 6 Proposed criteria for noise environment based on $L_{Aeq}$ and $L_{A50}$ (in dB)

| | exclusive residential | residential | commercial | industrial | roadside | total |
|---|---|---|---|---|---|---|
| $L_{Aeq24}$ | 55 | 55 | 55 | 55 | 65(60) | 55 |
| $L_{AeqM}$ | 55 | 55 | 55 | 55 | 65(60) | 55 |
| $L_{AeqD}$ | 60 | 60 | 60 | 60 | 65 | 60 |
| $L_{AeqE}$ | 55 | 55 | 55 | 55 | 60 | 55 |
| $L_{AeqN}$ | 45(50) | 50 | 50 | 45 | 60(55) | 50 |
| $L_{dn}$ | 60 | 60 | 60 | 60 | 65 | 60 |
| $L_{A5024}$ | 45 | 45 | 50 | 45 | 55 | 45 |
| $L_{A50M}$ | 45 | 45 | 50 | 45(50) | 55 | 45 |
| $L_{A50D}$ | 50 | 50 | 50(55) | 50 | 60 | 50 |
| $L_{A50E}$ | 45 | 45 | 50 | 45 | 55 | 45 |
| $L_{A50N}$ | 40 | 40 | 40 | 40 | 45 | 40 |

The results are summarized as follows.

(1) Level differences of $L_{A50}$ among land use in general area are at most 5dB. Regarding $L_{Aeq}$ the levels are almost same.

(2) In many cases levels of $L_{A50}$ and $L_{Aeq}$ in roadside area are higher by about 10dB than those in general area.

(3) Difference between $L_{Aeq}$ and corresponding $L_{A50}$ is about 10dB.

(4) Difference between daytime and nighttime is 10dB in common. But the difference in $L_{Aeq}$ is smaller in roadside area.

(5) The values of $L_{A50}$ for residential area are consistent with the ones for A area defined by the quality standard for noise in Japan(Table 5). And the values of $L_{A50}$ for roadside area are almost equal to the ones for B area in the above standard.

(6) Levels higher than 65dB in $L_{Aeq}$ , 60dB in $L_{A50}$ are unacceptable for noise environment irrespective of time of day and area.

## 7. CONCLUSION

Criteria for environmental noise were examined using the noise levels and inhabitants' reactions that we have surveyed since 1987 in Nagoya. The criteria in $L_{A50}$ are almost consistent with the standards in Japan. However, it is contrary to the standard that there is little difference by land use in "non-roadside" area. The criteria based on $L_{Aeq}$ are consistent with the standards in other countries[1]. They also confirm the result of our previous study[2][3].

## REFERENCES

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