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CRITERIA FOR AIRPORT NOISE IN JAPAN

I Yamada & J Igarashi

Kobayasi Institute of Physical Research, Tokyo, Japan

1. INTRODUCTION

In July 1995, the Supreme Court made a decision to a lawsuit, which inhabitants living along a national road raised for compensation to noise damages caused by road traffic [1]. It was the first case the Supreme Court judged as to road traffic noise. At the side of the road, above which an elevated expressway was constructed, sound level never goes down 67 dBA even late at night. The Supreme Court sustained the High Court decision, so that the Government had to pay indemnities for past damages to the accusers who suffered from intolerable noise exposure greater than 65dB in L_{Aeq}. The judgment caused a sensation, since equivalent continuous sound level L_{Aeq} was used in the decision, although road traffic noise has long been evaluated using 50%-percentile level L_{50} according to 'Environmental Quality Standard for Environmental Noise'. Environment Agency has newly started an investigation to institute standards for environmental noise using energy concept from this fiscal year [2]. Note that Environment Agency has recently notified two guidelines for traffic noises; i.e. 'Provisional Guideline for Environment around Small Airfields' (L_{den}) in 1990 and 'Guideline of Countermeasures for Conventional Railways in case of New Construction or of Large-scale Repair' (L_{Aeq}) in December 1995.

2. STANDARDS AND LAWS FOR AIRPORT NOISE IN JAPAN

Brief Historical Review

Aircraft noise first became an object of public concern when people around airfield were exposed to severe noise due to flight operations of jet fighters at several air bases in 1950's after World War II. Questionnaire surveys and noise measurements using C-weighted maximum sound levels were carried out in Tokyo, Osaka, Fukuoka, etc. Based upon such investigation, sound proofing was applied to schools and hospitals since 1955.

Next was the introduction of jet airliners to civil aviation. In 1960's there was a high-growth of Japanese economy with the 1964 Olympic Games held in Tokyo; expressways, high speed railways Shinkansen were constructed one after another, accompanied by various environmental pollution. Many lawsuits were raised about pollution problems. Inhabitants residing around airports also filed lawsuits against the Government for compensation to noise damage, enforcement of noise abatement measures such as ban of nighttime flights, through into the middle of 1970's.

To solve such severe public pollution problems, 'Basic Law for Anti-Pollution Measures' was enacted in 1967, which was revised to the present 'Basic Law for Environment' in 1993. It provides that environmental standards should be established as desirable criteria to be maintained for people's health and living environment. Based upon this legislation, 'Environmental Quality Standard for Environmental Noise' was first specified in 1971. Since there were a lot of arguments how to evaluate intermittent or impulsive noise events, it was decided to make up standards independently for aircraft, rail and building construction [2], resulting in 'Environmental Quality Standard for Aircraft Noise' (EQS_AN) in 1973 and 'Environmental Quality Standard for Shinkansen Railway Noise' in 1975.

On the other hand, in order to fulfill measures for noise issues around airport, various laws and regulations have been enacted; e.g. 'Law for the Prevention of Troubles due to Aircraft Noise around Public Airdrome' (LAW_P) in 1967, 'Law for the improvement of Living Environment around Defense Facilities' in 1974, 'Law for Special Measures against Aircraft Noise around designated Airports' (LAW_S) in 1978, etc. Civil Aviation Law was also revised to include regulations for noise certification of large airplanes in 1975. Despite administrative endeavor, noise standards of EQS_AN are still not sufficiently satisfied outdoor around many airports. 4000 dwellings still exist in zone 2 of LAW_P without being treated. Note that zone 2 corresponds to L_{dn}~75 dB.

Environmental Quality Standard for Aircraft Noise (EQS_AN;1973)

Noise evaluation index. The institution of an environmental standard for aircraft noise was discussed by a council organized by the Government since 1970 [3]. The council started discussion with investigating the detail of a ICAO report published only half a year before [4]. The report recommended WECPNL for use as an internationally standardized noise evaluation index for land use planning. The council decided to introduce WECPNL to the standard, taking the internationalism of air transportation into consideration as the most important. However, the ICAO procedure required frequency analysis and was too much complicated to apply to usual noise measurements. The council derived an equation (1) from the following approximation of the ICAO definition; (a) replacement of PNL by PNL $\sim L_A + 13$ based upon experiments, (b) simplification of duration correction, which corresponds to an assumption of a fixed effective duration time 10 s (or a 10 dB-down duration time T~20 s) of a single noise event, (c) approximation of time zone penalty by replacing level addition with a correction to the number of events. These approximation does

not always hold; 10 dB-down duration time may be very short compared to 20 s at a site close to runway, while it becomes longer than 20 s far away from the airport. In those days was given, however, top priority to preserve a quiet environment in the vicinity of airport, and the council made the correction zero so as not to include negative correction.

$$WECPNL = \overline{LAmax} + 10 \log_{10} (N_d + 3N_e + 10N_n) - 27 \qquad (1)$$

$\overline{LAmax}$; energy average of all maximum sound levels $L_{Amax,slow}$ greater than background noise by 10 dB or more.

N_d, N_e, N_n; numbers of observed noise events during daytime (7 m - 7pm), evening (7pm - 10pm) and nighttime (10pm - 7am).

Note that duration correction of adding 10 $\log_{10}$ (T/20) to maximum sound levels has been applied to the calculation of WECPNL in case of noise evaluation around defence facilities in Japan.

Procedure of Evaluating Environment Quality. EQS_AN requires outdoor noise measurements, which will be basically carried out consecutive 7 days at points representative of the area concerned. WECPNL is calculated using the equation (1). Measurements are to be carried out in a time of the year, representing aircraft noise observed in the area concerned, taking flight and meteorological conditions into consideration.

Standard values. Standards were established for two categories of areas;
(category 1) '70 WECPNL or less' in area for exclusively residential use,
(category 2) '75 WECPNL or less' in area other than category 1, where ordinary living conditions should be preserved.

Airport Categories and Target dates. The council also discussed whether the standard could be applied not only to new construction, but also to existing airports and air bases and whether target dates until attainment should be described in the standard. Finally, the standard was written as follows; The standard was to apply to airports at which there were more than 10 airplane operations a day in yearly average. Target dates were 'immediately be attained' for new airports and 'be attained within 5 or 10 years for existing airports except major (Tokyo, Osaka and Fukuoka) International Airports. As it was expected difficult to satisfy the standard, a 5 year intermediate goal of achievement was also established as 'less than 65 WECPNL indoors in area exceeding 85 WECPNL outdoor', in order to encourage fulfillment of countermeasures so that quiet and comfortable living conditions could be recovered. As to the three major airports, it was expected to take more than 10 years before attainment, and a 10 year intermediate goal of achievement was added as 'less than 60 WECPNL indoors in area exceeding 75 WECPNL outdoor'.

Relationship of WECPNL with Ldn. Fortunately, the Japanese WECPNL matches the world-wide trend toward energy average concept owing to the approximation of PNL with L_{Amax}. Figure 1 shows results of regression analysis of measured L_{dn} and WECPNL. Data used were obtained by unattended noise monitoring systems in the surroundings of four major airports. With duration correction, WECPNL linearly relates to L_{dn} as WECPNL~L_{dn} + 14. Without duration correction, WECPNL seems to be

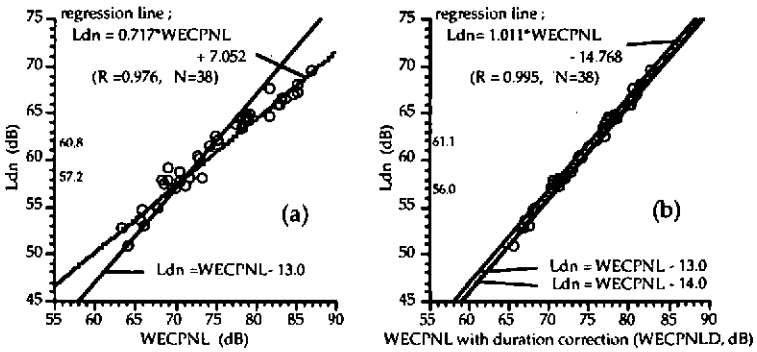

Fig.1 Relationship between Ldn and WECPNL (a) without and (b) with a duration correction $10 \log_{10}(T/20)$.

a little overestimate if greater than 75 dB and to be a little underestimate if less than 70 dB. Anyway, as far as concerned about intermittent noise such as aircraft noise, maximum sound level with duration correction can give a simple and precise estimate of energy-base noise indices.

Provisional Guideline for Environment around Small Airfields

This guideline was notified (1990) in order to cope with noise issues at small airfields, taking account of a rapid increase of helicopters in the latter half of 1980's. Application was limited to airfields that have at most 10 yearly average airplane operations a day. Noise evaluation index is L_{den}, which is evaluated from A-weighted sound exposure levels L_{AE} of noise events with time zone penalties (5 dB/evening and 10 dB/nighttime). Small airfields/heliports often adjoin dwellings closely. Long hovering and idling cause serious noise problems. Therefore, adding effects of static operations was indispensable for noise evaluation around such small airfields. Guidelines were established, as similar to EQS_AN, for two categories. (Category 1) '60 dB or less' at sites where environment should be especially kept quiet such as schools, hospitals and exclusive residential area. (Category 2) '65 dB or less' at sites other than category 1, where living conditions should be kept quiet. These guidelines were set to a little higher levels than the standards of EQS_AN because of inclusion of static operations.

LAW_P and LAW_S

Countermeasures around airports have been fulfilled, according to LAW_P, in the following three noise zones, so that the noise standards described in EQS_AN are to be satisfied;
(WECPNL≥75; zone 1) subsidization to sound-proofing of private houses, installation of air conditioners, etc.
(WECPNL≥90; zone 2) indemnification to the removal of houses, schools and hospitals, purchasing lands, preparation of substitute building sites.
(WECPNL≥95; zone 3) improvement of purchased land to green belts.
(WECPNL≥70) subsidization to sound-proofing of schools and hospitals.

LAW_P is applied to schools, hospitals and houses, which have already been built before the determination of the noise zones. The accumulated amount of cost expense amounted to about 1138 billion yen during 1967 - 1995 (695 billion for sound-proofing, 384 billion for removal). Roughly speaking, sound proofing was almost finished until 1985. Almost 95 % of applicants satisfying conditions have already been dealt with.

LAW_S was enacted in 1978, when Narita Airport has opened. It requires that people who wish to build houses in a noise zone (> 75) must apply sound-proofing to their houses with their own cost expense and that the construction of schools, hospitals and houses is prohibited in a noise zone (> 80). The reason for the enactment was that Narita Airport was constructed in a rural area with sparsely populated farmlands. It was convinced necessary to prevent noise problems beforehand. Up to now, LAW_S is not yet in force due to political reason. Recently, noise prediction was fulfilled for the investigation of noise zoning. In the calculation, factors affecting the prediction were estimated on the lower side so that area included a noise contour was calculated as narrow as possible because of compulsory character of LAW_S. It is in marked contrast to LAW_P. Noise zoning is estimated higher for LAW_P, which gives financial assistance. Noise prediction may be influenced by the purpose of evaluation.

3. WHAT IS NOISE STANDARDS ?

Noise issues on airport noise were brought action and the Government lost the cases, so that paid indemnity for past damage due to aircraft noise. The court judged tolerance limit as follows; (1) Osaka International Airport: no reference to WECPNL, (2) Fukuoka Airport: WECPNL≥80 for category 2 of EQS_AN, (3)Yokota Air base: WECPNL≥75 (category 1) and WECPNL≥80 (category 2), and (4) Atsugi Air base: WECPNL≥80 (category 1 & 2). The court may determine legality, taking every factor into consideration. However, judging from the past judicial decisions, tolerance limit of aircraft noise seems to be evaluated to become unbearably worse when WECPNL≥75~80 (i.e. Leq≥60~65). It suggests that the environmental standards established as desirable criteria being maintained for people's health and living environment in EQS_AN affected the court decisions. Note tolerance limit was judged to be Leq=65 dB for road traffic noise as stated in the beginning of this paper. It also seems to reflect standards of EQS (daytime 65dB/evening 65 dB/ nighttime 60 dB in area adjoining a main road that has more than two lanes).

4. HOW TO EVALUATE ENVIRONMENTAL NOISE

Possible countermeasures have almost been completed in area where impact of aircraft noise was overwhelming. Problem is now whether measures should be fulfilled in other area relatively far from the airport. Aircraft noise has decreased more than 10 dB since 1970 and has become as comparable as other noises due to road traffic, rail and so on. Under

such circumstances, it is indispensable to identify sources of individual noise events. Flight information is used as a means of source identification, but not sufficient because of many events similar to aircraft noise. On the other, acoustical methods have been successful in source identification.

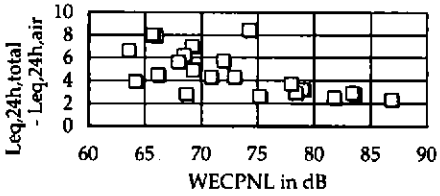

Fig.2 The contribution of background noise to the entire acoustical environment.

Evaluating the contribution of aircraft noise to acoustical environment is also essential [5], because we have no need to fulfill countermeasures if aircraft noise affects acoustical environment very little. If we measure aircraft noise correctly, we can evaluate the contribution of the rest by directly subtracting aircraft noise from the aggregate of environmental noise. In a measured example shown in Fig.2, the influence of background noise becomes important below WECPNL ~75. However, it might be difficult to measure aircraft noise due to background noise such as the singing of insects. In such case, we may use measurement and calculation together. That is, we measure total environmental noise and calculate the contribution of aircraft noise . It may give us a means to examine whether countermeasures for aircraft noise should be taken or not.

5. CONCLUDING REMARKS

A detailed explanation was given as to environmental standards and regulations for airport noise in Japan. Countermeasures taken for airport noise was also briefly reviewed. Then, we discussed the relation between the noise standards and tolerance limit judged by the court. Finally, we referred to the methodology for evaluating the contribution of aircraft noise to environmental noise. Environment Agency has started an investigation to revise Environmental Quality Standards for Environmental Noise from this fiscal year. It will accelerate the trend toward the energy-base evaluation of environmental noise in Japan. It may have an influence on the standards for aircraft noise, although the definition of Japanese noise index for aircraft noise WECPNL matches the concept of energy average noise evaluation. Another concern unsolved is the evaluation of aircraft noise under the condition that airplane operations are greatly biased in a short period such as the case of cross wind runway. Should it be evaluated the same as usual using energy average index, or differently ?

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