Doc 9911
First Edition
Corrigendum No. 1
(English only)
13/7/09

RECOMMENDED METHOD FOR COMPUTING NOISE CONTOURS AROUND AIRPORTS

CORRIGENDUM NO. 1

1. Please replace existing pages 4-2, 5-3, App A-1, App A-2, App C-5, App C-6, App C-7, App C-8 and App E-2 with the attached new pages bearing the notation "Corr. 1" and dated 13/7/09.

2. Please make the following corrections by hand:

   a) Page 2-5, 2.5.8 c), *amend* the reference to "3.3.4" to read "3.4.4"
   b) Page 2-6, 2.6.6 c), *amend* the reference to "Appendix H, 3.5" to read "Appendix H, 3.7"
   c) Page 4-8, Footnote 5), *amend* the reference to "2.4 and 3.3" to read "2.5.8 and 3.4.4"
   d) Page 4-15, 4.6.6.12, *amend* the reference to "equation 4-13b" to read "equation 4-10c"
   e) Page 4-16, 4.6.7.4, *amend* the reference to "4.6.7" to read "4.6.8"
   f) Page 6-1, 6.1.2, subparagraph 4), second line of the equation, change the symbol "<" to read ">"
   g) Page App C-12, 9.2, *amend* "9.3" to read "0.95"
   h) Page App C-13, 9.4, first line, *amend* $|h_2 - h_2|$ to read $|h_2' - h_2|$
   i) Page App F-1, 1.1, *amend* the reference to "4.5.6" to read "4.6.7"
   j) Page App H-7, 3.9.2, *amend* the reference to "3.6.1" to read "3.7.2" and the reference to "Appendix 3.8" to read "Appendix H, 3.10"

3. Record the entry of this corrigendum on page (iii).

Chapter 4

NOISE CALCULATION FOR A SINGLE EVENT

4.1 INTRODUCTION

4.1.1 The core of the modelling process, described here in full, is the calculation of the event noise level from the flight path information described in Chapter 3.

4.2 SINGLE EVENT METRICS

4.2.1 The sound generated by an aeroplane movement at the observer location is expressed as a "single event sound (or noise) level", which is an indicator of its impact on people. The received sound is measured on a decibel scale [refs. 14, 15].

4.2.2 The metrics most commonly used to encapsulate entire aeroplane events are "single event sound (or noise) exposure levels", L_{AE}, which account for all (or most of) the sound energy in the events. Making provisions for the time integration that this involves gives rise to the main complexities of segmentation (or simulation) modelling. An alternative metric is L_{Amax}, which is the maximum instantaneous level occurring during the event, and is simpler to model. In the future, practical models can be expected to embody both L_{Amax} and L_{AE}. Either metric can be measured on different scales of noise and in this document only A-weighted sound level is considered. This applies a frequency weighting (or filter) to mimic a characteristic of human hearing. Symbolically, the scale is usually indicated by extending the metric suffix, i.e. L_{AE}, L_{Amax}. Appendix A provides a description of the various noise metrics in use in ICAO Contracting States.

4.2.3 The single event sound (or noise) exposure level is expressed as

$$L_E = 10 \cdot \log\left(\frac{1}{t_0}\int_{t_1}^{t_2} 10^{L(t)/10}\,dt\right) \qquad (4\text{-}1)$$

where t_0 denotes a reference time. The integration interval $[t_1,t_2]$ is chosen to ensure that (nearly) all significant sound in the event is encompassed. Very often, the limits t_1 and t_2 are chosen to span the period for which the level $L(t)$ is within 10 dB of L_{max}. This period is known as the "10-dB down" time. Sound (noise) exposure levels tabulated in the ANP database are 10-dB down values[1].

4.2.4 For aeroplane noise contour modelling, the main application of equation 4-1 is the standard metric sound exposure level (SEL) L_{AE} [refs. 14, 15]:

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1. 10 dB down L_E may be up to 0.5 dB lower than L_E evaluated over a longer duration. However, except at short slant distances where event levels are high, extraneous ambient noise often makes longer measurement intervals impractical and 10-dB down values are the norm. As studies of the effects of noise (used to "calibrate" the noise contours) also tend to rely on 10-dB down values, the ANP tabulations are considered to be entirely appropriate.

$$L_{AE} = 10 \cdot \log\left(\frac{1}{t_0}\int_{t_1}^{t_2} 10^{L_A(t)/10}\,dt\right) \text{ with } t_0 = 1 \text{ second} \tag{4-2}$$

4.2.5 The exposure level equations above can be used to determine event levels when the entire time history of *L(t)* is known. Within the recommended noise modelling methodology, such time histories are not defined; event exposure levels are calculated by summing segment values. These are partial event levels, each of which defines the contribution from a single, finite segment of the flight path.

4.3 DETERMINATION OF EVENT LEVELS FROM NPD DATA

4.3.1 The principal source of aeroplane noise data is the international aircraft noise and performance (ANP) database which is described in Appendix H. This tabulates L_{max} and L_E as functions of propagation distance d – for specific aeroplane types, variants, flight configurations (approach, departure, flap settings), and power settings P. They relate to steady flight at specific reference speeds V_{ref} along a notionally infinite, straight flight path[2].

4.3.2 In a single look-up with input values P and d, the output values required are the *baseline levels* $L_{max}(P,d)$ and/or $L_{E\infty}(P,d)$. Unless values happen to be tabulated for P and/or d exactly, it will generally be necessary to estimate the required event noise level(s) by interpolation in the ANP database. A linear interpolation is used between tabulated power settings, but a logarithmic interpolation is used between tabulated distances (see Figure 4-1). If P_i and P_{i+1} are engine power values for which noise level versus distance data are tabulated, the noise level $L(P)$ at a given distance for intermediate power P, between P_i and P_{i+1}, is given by

$$L(P) = L(P_i) + \frac{L(P_{i+1}) - L(P_i)}{P_{i+1} - P_i}\cdot(P - P_i) \tag{4-3}$$

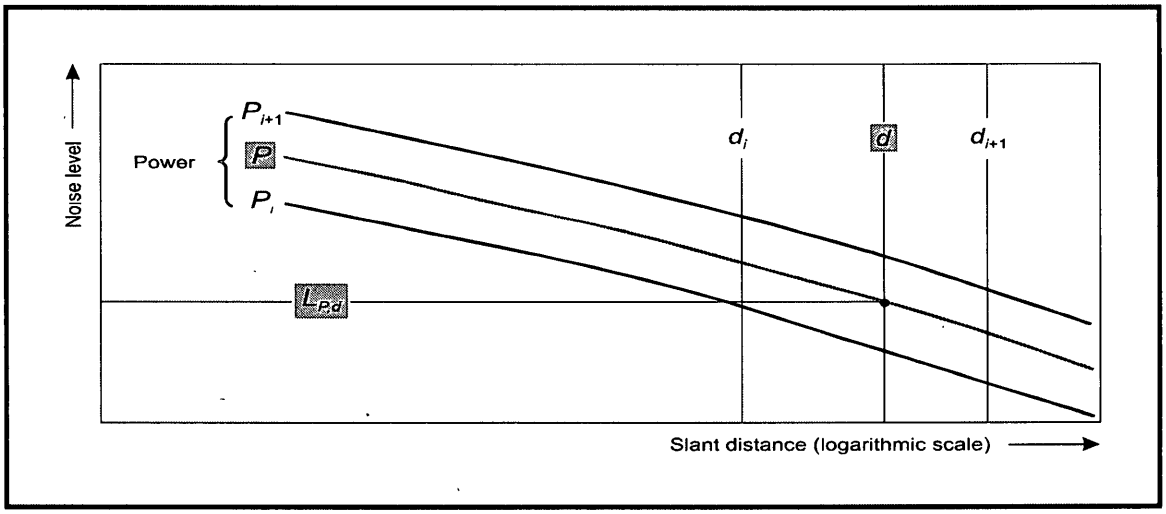

Figure 4-1. Interpolation in noise-power-distance curves

2. Although the notion of an infinitely long flight path is important to the definition of event sound exposure level L_E, it has less relevance in the case of event maximum level L_{max}, which is governed by the noise emitted by the aircraft when at a particular position at or near its closest point of approach to the observer. For modelling purposes, the NPD distance parameter is taken to be the minimum distance between the observer and segment.

maximum sound level is tied to a single noise event. However, a single aeroplane movement can generate more than one sound event at a given observer location (when its flight path causes more than one rise and fall in the received sound intensity).

5.4.2 Additionally, different metrics assign different meanings to the generic expression "maximum sound level" as illustrated by the following alternative definitions:

a) the average maximum sound level, defined by equation 5-2, of all noise events occurring at the observer location;

b) the average maximum sound level, defined by equation 5-2, of all noise events exceeding a specified threshold level L_T at the observer location; or

c) the absolute maximum level (i.e. the "highest maximum" level). In this case, the noise contribution is from only one noise event.

This indicates the need for metric-specific aggregation of the maximum sound levels.

5.4.3 With no threshold, the average maximum sound level (5.4.2 a)) occurring at the observer location (x,y) can be expressed as

$$\overline{L_{max}}(x,y) = 10 \cdot \log\left[\sum_i \sum_j \sum_k 10^{L_{max,ijk}/10} \cdot u(k)\right] - 10 \cdot \log\left[\sum_i \sum_j \sum_k M_{ij} \cdot u(k)\right] \quad (5\text{-}6a)$$

where

$$u(k) = \begin{Bmatrix} 0 \\ 1 \end{Bmatrix}$$

$$\text{if } L_{max,ijk} \begin{Bmatrix} \text{is not} \\ \text{is} \end{Bmatrix} \text{ the maximum level of a noise event} \quad (5\text{-}6b)$$

where the function u(k) determines whether the maximum segment level $L_{max,ijk}$ is the maximum level of a noise event or not (the derivation this function is described in detail in Appendix F).

5.4.4 With a threshold L_T, the average maximum sound level (5.4.2 b))

$$\overline{L_{max}}(x,y) = 10 \cdot \log\left[\sum_i \sum_j \sum_k 10^{L_{max,ijk}/10} \cdot v(k)\right] \left[\sum_i \sum_j \sum_k M_{ij} \cdot v(k)\right] \quad (5\text{-}7a)$$

where

$$u(k) = \begin{Bmatrix} 0 \\ 1 \end{Bmatrix} \text{ if } \begin{Bmatrix} L_{max,ijk} < L_T \\ L_{max,ijk} \geq L_T \end{Bmatrix} \quad (5\text{-}7b)$$

which guarantees that only noise events with maximum levels reaching or exceeding the threshold value L_T are included into the summation process.

5.4.5 If only the highest maximum level (5.4.2 c)) of all noise events occurring at the observation point has to be calculated, the corresponding equation is quite simple: