Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council (Text with EEA relevance)

ANNEX

Appendix E

The finite segment correction

E2 ESTIMATION OF THE ENERGY FRACTION

The basic concept of the energy fraction is to express the noise exposure E produced at the observer position from a flight path segment $\mathbf{P_1P_2}$ (with a start-point $\mathbf{P_1}$ and an end-point $\mathbf{P_2}$) by multiplying the exposure E_∞ from the whole infinite path flyby by a simple factor — the *energy fraction* factor F:

$E = F \cdot E_\infty$	(E-1)

Since the exposure can be expressed in terms of the time-integral of the mean-square (weighted) sound pressure level, i.e.

$E = const \times \int p^2(\tau)d\tau$	(E-2)

to calculate E, the mean-square pressure has to be expressed as a function of the known geometric and operational parameters. For a 90° dipole source,

$p^2 = p_p^2 \times \frac{d_p^2}{d^2} \times \sin^2\psi = p_p^2 \times \frac{d_p^4}{d^4}$	(E-3)

where p^2 and p_p^2 are the observed mean-square sound pressures produced by the aircraft as it passes points $\mathbf{P}$ and $\mathbf{P_p}$.

This relatively simple relationship has been found to provide a good simulation of jet aircraft noise, even though the real mechanisms involved are extremely complex. The term d_p^2/d^2 in equation E-3 describes just the mechanism of spherical spreading appropriate to a point source, an infinite sound speed and a uniform, non-dissipative atmosphere. All other physical effects — source directivity, finite sound speed, atmospheric absorption, Doppler-shift etc. — are implicitly covered by the $sin^2\psi$ term. This factor causes the mean square pressure to decrease inversely as d^4; whence the expression 'fourth power' source.

Introducing the substitutions

$$d^2 = d_p^2 + q^2 = d_p^2 + (V \times \tau)^2$$

and

$$\left(\frac{d}{d_p}\right)^2 = 1 + \left(\frac{V \times \tau}{d_p}\right)^2$$

the mean-square pressure can be expressed as a function of time (again disregarding sound propagation time):

$p^2 = p_p^2 \times \left(1 + \left(\frac{V \times \tau}{d_p}\right)^2\right)^{-2}$	(E-4)

Putting this into equation (E-2) and performing the substitution

$\alpha = \frac{V \times \tau}{d_p}$	(E-5)

the sound exposure at the observer from the flypast between the time interval $[\tau_1,\tau_2]$ can be expressed as

$E = const \times p_2^p \times \frac{d_p}{V} \times \int_{\alpha_1}^{\alpha_2} \frac{1}{(1+\alpha^2)^2} d\alpha$	(E-6)

The solution of this integral is:

$E = const \times p_2^p \times \frac{d_p}{V} \times \frac{1}{2} \left(\frac{\alpha_2}{1+\alpha_2^2} + \arctan \alpha_2 - \frac{\alpha_1}{1+\alpha_2^1} - \arctan \alpha_1 \right)$	(E-7)

Integration over the interval [–∞,+∞] (i.e. over the whole infinite flight path) yields the following expression for the total exposure E_∞:

$E_\infty = const \times \frac{\pi}{2} \times p_2^p \times \frac{d_p}{V}$	(E-8)

and hence the energy fraction according to equation E-1 is

$F = \frac{1}{\pi} \left(\frac{\alpha_2}{1+\alpha_2^2} + \arctan \alpha_2 - \frac{\alpha_1}{1+\alpha_2^1} - \arctan \alpha_1 \right)$	(E-9)