

ICAO

CIRCULAR

CIRCULAR 205-AN/1/25



RECOMMENDED METHOD FOR COMPUTING NOISE CONTOURS AROUND AIRPORTS

*Approved by the Secretary General
and published under his authority*

**INTERNATIONAL
CIVIL AVIATION
ORGANIZATION
MONTREAL • CANADA**



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Foreword

The material for this circular was developed by the Committee on Aviation Environmental Protection at its first meeting held in Montreal in June 1986. It is intended to assist States in the computation of noise contours around airports. The scope of this circular is explained in Chapter 2.

The issuance of this circular was approved by the Council on 11 March 1987.

Comments on the contents of this circular, particularly with respect to its application and usefulness, would be appreciated from all States. These comments will be taken into account in the preparation of subsequent editions. Comments concerning this document should be addressed to:

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Chapter 1

Introduction

1.1 The noise at points on the ground from aeroplanes flying into and out of a nearby airport depends on a number of factors. Principal among these are the types of aeroplanes and their powerplants; the power, flap and airspeed management procedures used on the aeroplanes themselves; the distances from the points concerned to the various flight paths; and local topography and weather, affecting sound propagation. Airport operations generally include different types of aeroplanes, various flight procedures and a range of operational masses. Because of the large quantity of aeroplane-specific data and airport operational information that would be required to compute the noise of each individual operation, it is customary in airport noise studies to make certain simplifications, leading to estimates of noise index values which are averages over long periods of time, typically several months. Calculations are usually repeated at each of a series of points around the airport and then interpolations are made to trace lines of equal noise index values (noise "contours") which are used for study purposes.

1.2 In view of the large number of variables involved and the simplifications usually made in the calculations, it is desirable to recommend a single procedure for computing airport noise contours. The aim of this document is to provide an outline for such a recommended method, identifying the major aspects and supplying specifications in respect of each. An explanation of terms is given, covering those terms where confusion might arise. A complication is that the calculation method has to allow for the use of different noise descriptors as bases for national noise indices. Given this proviso, the method of calculation described should allow States to compute noise contours which are consistent with one another.

1.3 There are a number of noise-generating activities on operational airports which are excluded from the calculation procedures given here. These include use of thrust reversal by landing aeroplanes, taxiing, engine testing and use of auxiliary power-units. In practice, the effects of these activities are unlikely to affect the noise contours in regions beyond the airport boundary.

Chapter 2

Scope

This circular describes the major aspects of the calculation of noise contours for air traffic at an airport. It is primarily intended to be applied to civil, commercial airports, where the aeroplanes in operation are mostly either jet-engine powered or propeller-driven heavy types. If appropriate noise and performance data are available for propeller-driven light aeroplanes, these may also be included in the evaluation. Where the noise impact derives mostly from helicopters, however, this document is not applicable — the operational patterns for such aircraft often differ markedly from those covered here and the aircraft themselves have different noise directivity patterns from the other types.

Chapter 3

Explanation of Terms and Symbols

3.1 DEFINITIONS OF TERMS

Basic noise and performance data. The data for different aeroplane types, including measurements where these have been made, extrapolations where necessary and a statement of the quality of the data. Estimates have to be given for projected new aeroplane types.

Extra noise attenuation (lateral attenuation). Additional attenuation of noise in propagation away from the aeroplane, over and above that included in the noise-power-distance data, deriving from all the effects of non-ideal conditions. The causes include absorption of sound in transmission over a partially absorptive surface and source installation effects.

Flight path. The path of an aeroplane through the air, defined in three dimensions, usually with reference to an origin at the start of take-off roll or at the landing threshold.

Flight profile. The elevation of the flight path, showing the variation of aeroplane height along the ground track.

Flight track (or ground track). The vertical projection of the flight path onto the ground plane.

Format of aeroplane noise and performance data. The framework or skeleton according to which data are to be derived and presented.

Noise contour. A line of constant value of a noise index around an airport, due to the noise of a traffic mix of aeroplanes under normal operating conditions and using normal flight paths.

Noise descriptor. A quantity used to represent the noise of a single "event", such as an aeroplane fly-past, as experienced by an observer. There are two ways commonly used to quantify the noise of the single event: either the maximum level is assumed, or the sound pressure levels from instant to

instant during the course of the event are combined, with time, to give a measure of the total sound energy.

Noise index. An expression used to rate noise in terms of subjective annoyance over a defined period of time; an index can incorporate weightings of the single-event levels according to the time of day or night at which they occur and/or a weighting of the number of events occurring within the time period. The time limits and weightings are chosen to conform with public opinion, as determined from surveys.

Noise-power-distance data. Noise levels over a range of distances from the aeroplane, for each of a number of engine power settings. The levels include allowance for the effects of sound attenuation due to spherical wave spreading (inverse-square law) and atmospheric absorption. The distance parameter is defined by the perpendicular distance to the aeroplane flight path (sometimes termed the slant distance or the slant range).

3.2 SYMBOLS

Noise

L_A	A-weighted sound pressure level
L_{Amax}	maximum value of L_A
L_{AE}	sound exposure level
L	L_{Amax} or L_{AE} , under conditions identified by means of a subscript (see Chapter 6)
L_p	1/3-octave band sound pressure level
p	sound pressure
t	time
$G(\ell)$	overground lateral attenuation
$\Lambda(\beta)$	air-to-ground lateral attenuation

Aeroplane performance

p	take-off coefficient
Q	flight speed coefficient
R	climb/descent coefficient
X_N	net thrust, all engines
X_N	net thrust averaged over segment
γ	climb angle
RC	rate of climb
W	aeroplane weight
M	aeroplane mass
V	aeroplane speed
V	aeroplane speed averaged over segment
v_w	wind velocity (head wind positive)
f	acceleration factor
f_w	wind factor
s	horizontal distance over a flight path segment
h	aeroplane height
g	gravitational acceleration
h_p	pressure-altitude

H_ξ	temperature coefficient
C_{M_t}	propeller tip rotational Mach number coefficient
A_v	noise constant
B_v	thrust coefficient
c_v	speed-altitude coefficient
Y	second order engine speed coefficient
ξ	representation for parameters X_N/δ , $N/\sqrt{\theta}$, $SHP/\delta\sqrt{\theta}$ or N_p
$\Delta\xi$	difference in ξ due to temperature difference representing parameters $\Delta X_N/\delta$ or $\Delta SHP/\delta\sqrt{\theta}$
M_t	propeller tip rotational Mach number
N	low pressure rotor speed or fan speed
N_p	propeller rotational speed
SHP	shaft horse power
v	representation for parameters $N/\sqrt{\theta}$, $SHP/\delta\sqrt{\theta}$, EIS

Engine indicators

EIS	engine indicator setting
EPR	engine pressure ratio
EPD	engine pressure difference

Subscripts

L	take-off roll directivity
T	aeroplane turn
r	reference conditions
g	take-off roll
AP	approach
CL	climb
FR	flap retraction
TO	take-off
TAS	true airspeed
EAS	equivalent airspeed

Atmosphere

ISA	International Standard Atmosphere
T	ambient air temperature
p	ambient air pressure
q	ambient air density
θ	T/T_0
δ	P/P_0
σ	q/q_0 (also δ/θ)

Engine noise-related thrust parameters

E_ξ	thrust/noise constant
F_ξ	flight speed coefficient
G_ξ	altitude coefficient

Mathematical and algebraic quantities

		β	angle of elevation from an observation point to a point on the flight path
log	logarithm to base 10	s	standard deviation
Δ	change in value of a quantity, or a correction (as indicated in the text)	r	radial distance
d	perpendicular distance from an observation point to the flight path (slant distance or slant range)	ϕ	angle from the aeroplane ground track to a radial passing through an observation point
ℓ	perpendicular distance from an observation point to the ground track	ψ	angle of turn of an aeroplane ground track.

Chapter 4

Calculation of Contours

4.1 SUMMARY AND APPLICABILITY OF THE METHOD

Note.— Noise indices which involve the perceived noise level or the effective perceived noise level can be derived from measurements of frequency-weighted noise level by use of the appropriate methods given in Appendix B.

4.1.1 For an airport noise study, the calculations comprise the following, in order:

- a) determination of the noise levels from individual aeroplane movements at observation points around the airport;
- b) addition or combination of the individual noise levels at the respective points according to the formulation of the chosen noise index; and
- c) interpolation and plotting of contours of selected index values.

4.1.2 The numbers of aeroplane movements to be included in a study and the operational details for each are matters for selection. Clearly, a set of calculated noise contours is valid only for the traffic assumptions on which it is based. At all airports, the pattern of operations varies from day to day, depending on the weather, scheduling and many external factors. Generally the noise index for which the contours are calculated is defined in terms of long-term average daily values, typically over a period of some months. It follows that the contours intended to show noise exposures around an airport defined in terms of such an index should similarly depict long-term average conditions. The traffic and operational patterns used in the study are then selected accordingly.

4.1.3 The noise levels from individual movements are calculated, for given atmospheric conditions, from noise-power-distance and aeroplane performance data (see 5.2.5).

The conditions for the noise data are defined by atmospheric attenuation rates, for which the yearly averages drawn from several major world airports are assumed. The performance data are for defined atmospheric temperature and humidity, airport altitude and wind speed. However, given that the calculated noise contours depict long-term averages, the same basic data are assumed to apply over specified ranges of conditions. The form of presentation, methods of derivation and reference conditions for the aeroplane data are given in Chapter 5.

4.1.4 The specification for noise data in Chapter 5 includes two noise descriptors. These are the maximum A-weighted sound pressure level occurring at some instant during an aeroplane movement, and the sound exposure level, which is the level of an integral with time of the square of the A-weighted sound pressure during the aeroplane movement (see 5.1.2). The two descriptors selected are believed to be sufficient to permit the calculation of most noise indices in use within ICAO Contracting States, either directly or with the use of empirical adjustments. The formulations for different noise indices are given in Appendix A. The summation process for noise levels from individual aeroplane movements and interpolation of noise index values for contour plotting are computer-programming matters only and are left to the discretion of the user.

4.2 INPUT INFORMATION REQUIREMENTS

For an airport noise study, the organization making the calculation will require the following information:

- a) the aeroplane types which operate from the airport;
- b) noise and performance data for each of the aeroplane types concerned, supplied in accordance with the specifications of Chapter 5;
- c) the routes followed by arriving and departing aeroplanes;

- d) the numbers of movements on each route within the period chosen for the calculations;
- e) the operational data and flight procedures relating to each route (including aeroplane masses, power settings, speeds and configurations during different flight segments); and
- f) airport data (including average meteorological conditions, number and alignment of runways).

4.3 NOISE FROM INDIVIDUAL AEROPLANE MOVEMENTS

4.3.1 For a movement on an arrival or departure route, aeroplane positional information and corrected engine thrusts are computed throughout the various flight operational segments (see Chapter 5). From a selected point (co-ordinates x, y) on a grid arranged on the ground around the airport, the shortest distance to the flight path is calculated and the noise data (L) are interpolated for the distance (d) and thrust (ξ) concerned (see Chapter 6). The aeroplane positional information should allow for some lateral displacement of the actual ground track in a particular case, relative to the nominal route, due to inexact track-keeping which occurs in practice. Corrections are applied (see Chapter 6) for extra attenuation of sound during propagation lateral to the direction of aeroplane movement (Λ), for directivity behind

the start of take-off ground roll (Δ_L) and, in the case of the sound exposure level, for aeroplane speed (Δ_V) and changes in the duration of the highest noise levels where an aeroplane makes a turn in its flight path (Δ_T). Hence the noise level at the point on the grid, from the individual aeroplane movement, $L(x, y)$, is derived. The calculation is expressed in mathematical symbols as follows:

$$L(x, y) = L(\xi, d) + \Lambda(\beta, \ell) + \Delta_L + \Delta_V + \Delta_T \quad (1)$$

where Δ_L is evaluated only behind the start of take-off ground roll, being zero everywhere else, and Δ_V and Δ_T are only evaluated where the descriptor L is the sound exposure level.

4.3.2 The above process is repeated at the same point for all the movements of all the aeroplane types occurring within the time period over which the noise contours are to be calculated, and then again at all the other grid points. In an airport noise study, it may not be practicable to account for each individual aeroplane type separately when calculating flight profiles and noise levels. In such cases, different aeroplane types having similar noise characteristics and also similar performance at a particular airport may be categorized or grouped as, effectively, a single type at that airport. This is especially likely to be the case in studies with future fleet mix scenarios. For such categorized or grouped types on a given route, the calculations as above need only be made once and the resultant noise levels at the grid points are then factored according to the number of movements of the type in the noise index summation.

Chapter 5

Aeroplane Noise and Performance Data

5.1 NOISE-POWER-DISTANCE DATA

5.1.1 Form of presentation

The noise data should cover a range of noise-related thrust parameter values and perpendicular distances to the flight path. For each noise-related thrust parameter value from approach to take-off, the data should be given in numerical tabular form, as illustrated in Figure 5-1. In addition, a graphic presentation may be used for reference. The following information should also be provided:

Aeroplane: _____
 Engines: _____
 Configuration — flap angle: _____
 — slat angle: _____
 — landing gear up/down: _____
 Engine thrust — parameter specified: _____
 — "corrected" parameter value: _____
 Aeroplane mass: _____
 Airspeed: 160 kt

The noise levels given should be those occurring directly under the flight path during steady flight, that is, a constant speed of 160 kt, constant configuration and thrust setting, without banking. The aeroplane configuration and flight speed to which the noise levels correspond should be identified on the tables and graphs.

The physical quantity selected for the noise-related thrust parameter should be directly compatible with that presented in the performance information (see 5.2). Typical parameters are, amongst others, corrected net thrust, fan speed, propeller speed and shaft horse power.

In the noise tables, the intervals of the relevant parameters should be adequately spaced to ensure that the deviation from directly obtained graph readings is less than 0.1 dB, assuming a linear interpolation. The number of thrust parameter values for which data are to be tabulated depends on the aeroplane type, but data must be provided at least for the approach and take-off values of the thrust parameter.

Slant distance (m)	80	100	125	160	200	250	315	400	500	630	800
L_{Amax} (dB)											
L_{AE} (dB)											

Slant distance (m)	1 000	1 250	1 600	2 000	2 500	3 150	4 000	5 000	6 300	8 000
L_{Amax} (dB)										
L_{AE} (dB)										

Note.— All noise levels are to be normalized to conform with the attenuation rates of Table 5-1.

Figure 5-1. Format of noise data