Proceedings of the Institute of Acoustics

PRACTICAL MEASUREMENT OF GROUND NOISE AND ITS IMPLICATIONS ON PREDICTION TECHNIQUES

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INTRODUCTION

The control of noise arising from aircraft ground activities at an airport is becoming increasingly more important. Pressures for the development on land close to airports is ever increasing. In addition, with the advent of quieter aircraft, the building of airports within the hearts of cities is now becoming a reality and likely to increase in the years ahead. This demands that prediction methods provide an accurate reflection of the noise climate arising from ground activities.

In general, ground noise data for prediction work is not normally available from aircraft manufacturers. It is therefore often necessary to visit a site where the aircraft type is in use to obtain representative reference noise levels (RNL) and durations for aircraft events.

A typical ground noise prediction calculation sheet is shown in Table 1 for an aircraft departure. It demonstrates how the exposure, in terms of LAeq (12hr), is derived from RNL and duration data.

By way of practical examples, this paper identifies some of the factors to be considered when collecting ground noise data and demonstrates the effect these factors may have on ground noise assessment. It provides suggestions for obtaining representative field data for establishing RNL's for prediction work.

Some of the factors that must be considered when undertaking field tests to determine reference noise levels for ground noise predictions are:-

1) Wind effect

2) Distance attenuation

3) Directionality of aircraft noise

4) Pilot operational procedures

Each of these categories are discussed below in the context of field measurements carried out for the purpose of establishing reference noise levels for the prediction of ground noise from aircraft arrivals and departures.

PRACTICAL MEASUREMENT OF GROUND NOISE AND ITS IMPLICATIONS

1.0 WIND EFFECT

1.1 Propagation

Ground noise predictions do not normally account for any wind effect and therefore measurements of reference noise levels should ideally take place when their is negligible wind. In practice, this is not always possible. It is then necessary to be aware of the influence that the wind may have on measurements.

Figure 1 compares two noise traces of identical aircraft arrivals measured on different days. The upper trace A was obtained on a day when the vector wind velocity from receiver to source was zero, the lower trace on a day when the vector wind velocity was about +10 knots.

Although the source receiver separation distance was not great, 200m - 350m, the difference in noise level between traces ranged from about 6dB(A) to 20dB(A) with a difference in noise exposure (SEL) for the two events of 8dB(A). Some of this difference can be attributed to the wind, although precisely to what extent is uncertain due to the possible influence of other factors as discussed below.

1.2 Noise Source

Figure 2 illustrates how the noise output of a turbo propeller driven aircraft can be subject to significant variations due to the interaction of a strong and variable wind on the propeller blades.

It illustrates a 4-engined aircraft on arrival rolling past a microphone station and taxiing to the end of the runway (REGION A) where upon it turns onto the Holding Point and remains idling on two engines (REGION B). A marked increase in noise was observed as the aircraft turned off the runway, it's engines changing orientation relative to the wind direction, and while it remained idling at the Holding Point. This effect caused noise peaks about 6dB higher at the Holding Point, 1050m away, than during passby at only about 150m away.

2.0 DISTANCE ATTENUATION

Field tests to establish reference noise levels are normally taken, where possible, at the reference distance of 152m from the aircraft. If this is not possible, corrections for distance are required to normalise the measured noise level to this reference distance.

Figure 3 shows a successful case where a common RNL for taxiing/manoeuvring has been obtained by monitoring noise from a twin-engined turbo propeller aircraft at a provincial airport. The peak noise levels caused by the observed manoeuvres, measured at different distances up to 200m, can be seen to all normalise to the same RNL using a correction of 10 dB/doubling of distance. This attenuation rate is used in the DORA model for calculating NNI (1) at zero angles of elevation.

In the above case, the attenuation rate seems appropriate since the measurements were conducted over short grassland. If the RNL's are to be used in predictions for airports with differing ground conditions then some other attenuation rate may be appropriate. In such cases, the RNL's themselves may require adjustment. Attenuation rates typically varying from 6 - 12 dB(A) for doubling of distance have been used in ground noise work.

3.0 DIRECTIONALITY OF AIRCRAFT

3.1 Magnitude of Level

The directional characteristics of noise from an aircraft can give rise to large variations in noise level at different angles but equal distances from an aircraft.

This effect is apparent in Figure 1 where, during the manoeuvre labelled (1), and for the zero wind condition, an increase of about 4dB(A) was observed as the turbo propeller aircraft turned off the runway (Trace A). Under windy conditions, the directional effect was more pronounced and an increase of about 7dB(A) was observed for the same manoeuvre (Trace B).

3.2 Frequency

The frequency content of the noise level may also alter with direction of the aircraft relative to the receiver. Figure 4 illustrates the changing frequency spectrum, in 5 second intervals, for a 4 engined turbofan aircraft during a taxiing passby at 152m.

The figure shows for example how, at 63Hz, the noise level continues to rise after the aircraft has passed the microphone but at 1kHz, the peak level occurs before it reaches the microphone.

4.0 PILOT OPERATIONAL TECHNIQUE

It is important to address how the pilot can influence the assessment of ground noise by the way he operates the aircraft. A series of representative measurements conducted at a small city airport showed that the maximum variation in exposure level observed between identical scheduled movements on the same day rarely exceeded 3dB(A) when the aircraft followed the same taxi-route.

With reference to the airport plan in Figure 1, noise exposure levels of about 5dB(A) apart were observed between two identical arriving aircraft using different taxi-routes, one using taxiway A to reach the apron the other using taxiway B. The latter aircraft produced the higher exposure level at the shown mic position due mainly to the increased engine braking required to leave the runway by taxiway B.

IMPLICATIONS

These practical matters are not adequately researched to allow full account to be taken of them in airport ground noise predictions. The missing certification requirement for any data on ground noise means that there is no foreseen improvement in the data base on these operations.

The overall implication is that prediction accuracy is currently low, sufficient to make general assessments for overall planning decisions but not adequate to predict instantaneous values of exposure near an airport for a practical aircraft movement.

To improve the predictions, the measurement of ground noise should be standardised, and should start to take into account the practical features discussed above as well as others.

For conducting field measurements for determining reference noise levels for the prediction of ground noise, our initial suggestions are:-

- Undertake measurements during known wind conditions, including zero and typical for site under consideration.
- Ensure source/receiver separation distances are small, ie. no greater than 200m, and preferably not too close (so avoiding near field shielding effects).
- Undertake tests under ground conditions similar to those for which predictions are being made.

- Use sufficient measuring stations to record the directional characteristics of the aircraft.
- Obtain spectral information, for example to determine dominant frequency band for barrier calculations.
- Ensure tests are conducted with the pilot controlling the aircraft in a manner representative of that to be used at the site under investigation.

This paper has presented practical measurements of ground noise to demonstrate the complexities in determining RNL's from field measurements for prediction work. It also demonstrates the difficulties that can be expected in trying to verify earlier predictions. It has identified factors that ought to be addressed when undertaking field tests and presented suggestions to improve their accuracy.

REFERENCES

[1] L.I.C. Davies, "A Guide to the Calculation of NNI": DORA Communication 7908 (2nd Ed. 1981), Civil Aviation Authority, London.

Aircraft Operation	Ground Dist.	20log(x/152) for barrier	Reference Level	Peak Level	Barrier Atten. @ 500 Hz	Resultant Level	Duration of Event	No. of Events in 12 hrs	Total Duration of Event	LAeq (12 hr)
(westerly)	m	26.6log(x/152) no barriers	dB(A)	dB(A)	dB	dB(A)	T Hours	n	nxT/12 Hrs	dB(A)
Engine Start-up	75	-6.1	72	78.1	17.2	60.9	0.0333	44	0.122	51.8
Apron Manoeuvres	90	-4.6	77	81.6	16.8	64.8	0.0028	44	0.020	44.8
Taxiing Manoeuvres	225	3.4	77	73.6	15.4	58.2	0.0028	44	0.020	38.2
Taxiing Segment a)	90	-4.6	72	76.6	16.8	59.8	0.0019	44	0.007	38.3
b)	150	0	72	72	15.8	56.2	0.0050	44	0.018	38.3
c)	225	3.4	72	68.6	15.4	53.2	0.0036	44	0.013	34.3
d)	335	6.9	72	65.1	14.8	50.3	0.0083	44	0.030	35.1
e)	480	10.0	72	62	15.3	46.7	0.0083	44	0.030	31.5
f)	730	13.6	72	58.4	12.1	46.3	0.0081	44	0.030	31.1
g)	930	15.7	72	56.3	11.9	44.4	0.0081	44	0.030	29.2
									Total LAeq (12hr) for Departures	53.3

Note: Barrier calculations are based upon work by Z. Maekawa

Table 1 - Typical Calculation Sheet for Departure Ground Noise Assessment

PRACTICAL MEASUREMENT OF GROUND NOISE AND ITS IMPLICATIONS

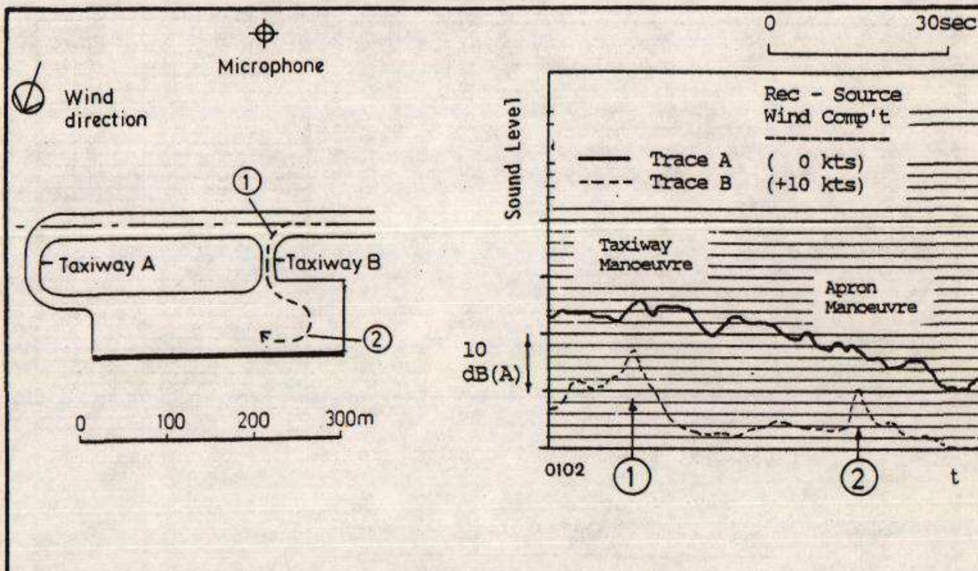


Figure 1 - Effect of wind on ground noise propagation

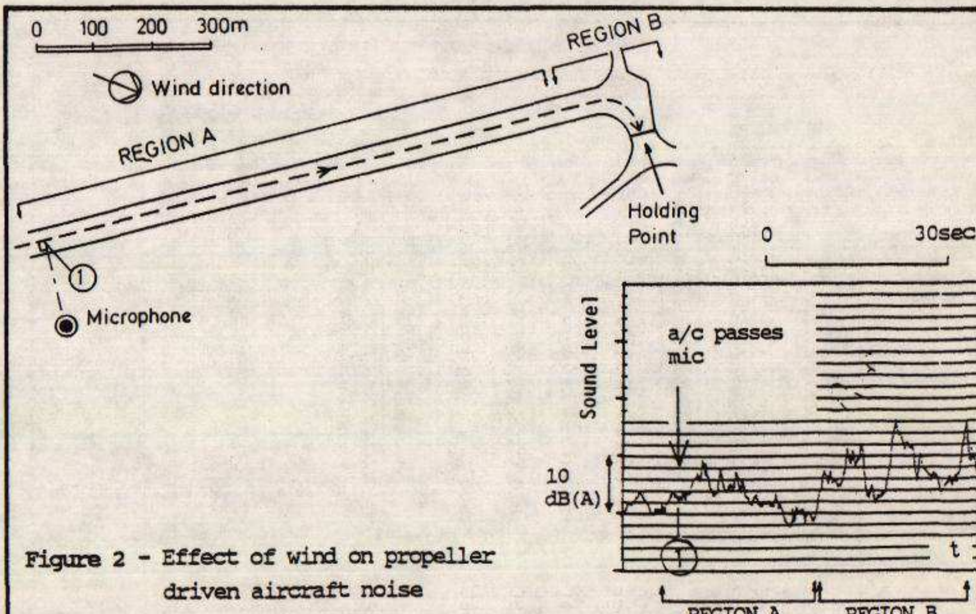
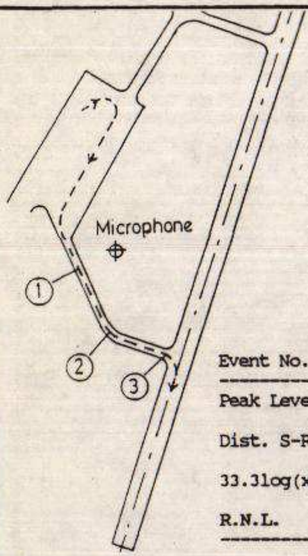
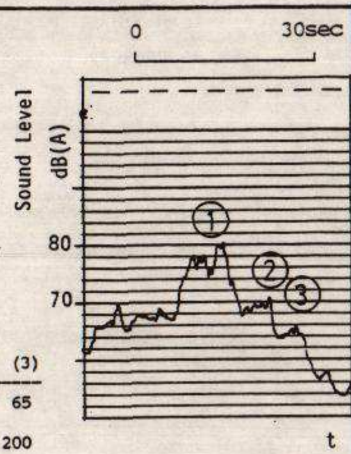


Figure 2 - Effect of wind on propeller driven aircraft noise

PRACTICAL MEASUREMENT OF GROUND NOISE AND ITS IMPLICATIONS





Event No.		(1)	(2)	(3)
Peak Level	dB(A)	80	70	65
Dist. S-R (x)	metres	70	140	200
33.3log(x/152)	dB	-11	-1	+4
R.N.L.	dB(A)	69	69	69

Figure 3 - Variation in taxiing/manoeuvring noise with distance from a propeller driven aircraft

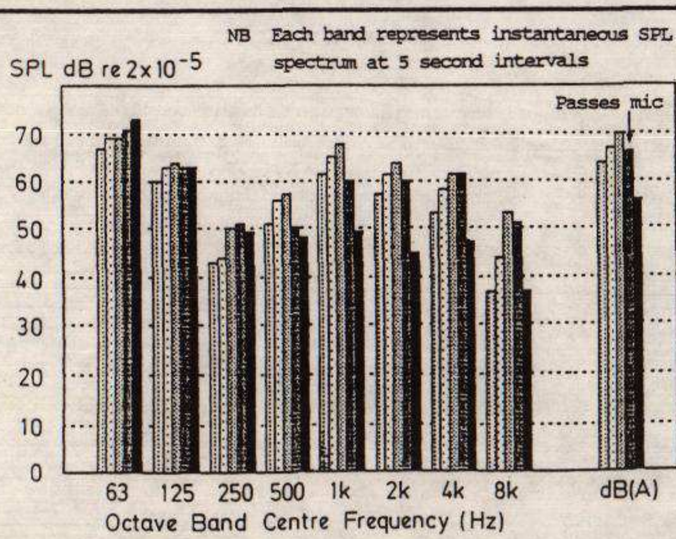


Figure 4 - Variation in frequency spectrum, in 5 second intervals during a turbofan aircraft taxiing passby at 152m