Australian Government
Department of Defence

AIRCRAFT NOISE

Measurement of Aircraft Noise

1.1.1 Noise is described as unwanted sound. The two main components of a sound event are the loudness and pitch. The loudness is related to the energy of the sound wave and pitch is related to the frequency of the sound.

1.1.2 The human ear relates the loudness to the Sound Pressure, which is an easy parameter to measure with a noise measurement instrument. The loudness of actual sound levels is made by comparison to a standard pressure of $2x10^{-5}$ Pascals (Newtons per square metre) taken at a reference frequency of 1,000 Hz. This sound pressure has been set as the lower threshold of hearing; with the upper threshold of the hearing pressure range being 1,000 Pa, where permanent damage would be done to the eardrum. Because of this very large range of sound pressures, a logarithmic scale was developed which, for typical noise events, consolidated the range of sound pressures from 0 to 140 dB. This expression of the level of sound is referenced as the Sound Pressure Level (SPL) and is measured in decibels (dB).

1.1.3 Within the human auditory system, for similar pressure levels, the pitch, or technically the frequency, determines the interpretation of the loudness. At equal sound pressures, low frequencies are perceived as less loud than middle frequencies in the 1,000 to 4,000 Hz range. At frequencies above 4,000 Hz, sensitivity decreases.

1.1.4 The human ear of a young person corresponds to a frequency range of 20 Hz to 20,000 Hz. This is called the audible range. One general trend is that as people age they are less able to hear the higher frequencies, so that the high frequency limit may be reduced to 15,000 Hz or in extreme cases down to 10,000 Hz.

1.1.5 The human ear is better equipped to hear the mid frequency ranges and therefore people can find noises in this frequency band more annoying. The “A” filter approximates the sensitivity of the ear and relates the relative loudness of the various noises at different frequencies to the human’s ear response to those noises. The “A weighted” decibel scale, referenced as dB(A) has generally been adopted as the relevant parameter for the measurement of community noise and has been adopted for aircraft noise, due primarily to the simple nature of obtaining an A-weighted noise level.

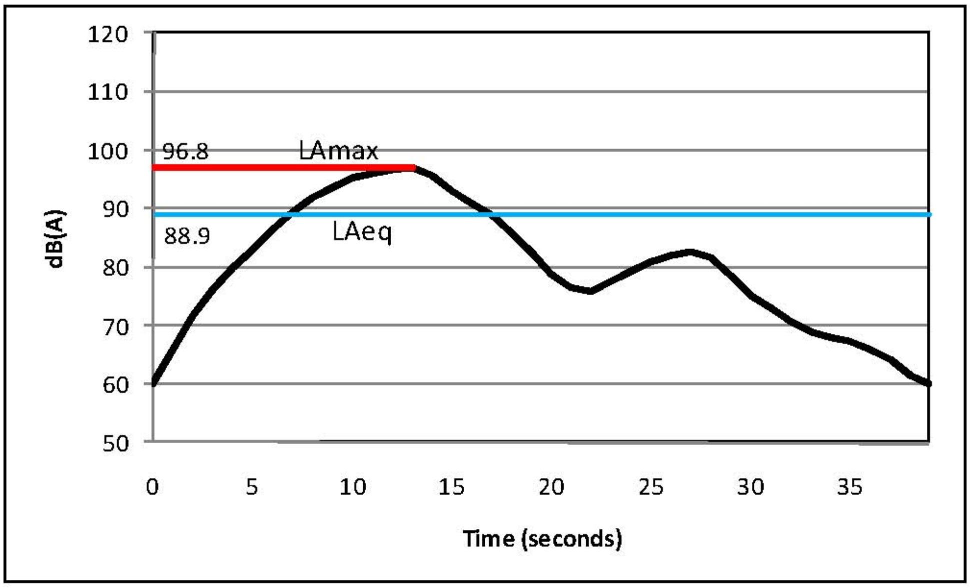
1.1.6 There are a large number of descriptors which have been developed to describe aircraft noise. These include:

a. single event descriptors which can be measured or calculated by a noise monitoring instrument; and
b. equal energy parameters which accumulate a number of noise events over time and need to be calculated.

1.1.7 Refer to Annex A – *Glossary* for a description of the common acoustic parameters used in the measurement of the community’s exposure to aircraft noise.

1.1.8 Two commonly used single event noise descriptors of aircraft and community noise are the "maximum" A-weighted sound pressure level (LAmax) and the "equivalent" A-weighted noise level (LAeq).

1.1.9 The LAmax and LAeq metrics for an actual single aircraft overflight are illustrated in the following diagram. The LAeq for the aircraft noise event is the "equivalent" noise level that has the same total sound energy as the actual varying measured sound pressure level over the aircraft movement. The LAeq value will normally be less than the LAmax value.



1.1.10 The above diagram illustrates that, as in this case, the noise from an aircraft overflight often has two peaks with only the higher peak being the LAmax value.

1.1.11 Other single event noise parameters commonly used in reporting aircraft noise include the Sound Exposure Level (SEL) and the Effective Perceived Noise Level (EPNL).

1.1.12 Equal energy noise descriptors include the "equivalent" A-weighted noise level averaged over a specified time (LAeq,T), the Australian Noise Exposure Forecast (ANEF), the Noise Exposure Forecast (NEF), and the Day Night Level (DNL). These parameters need to be calculated and cannot be directly measured by a noise monitor.

1.1.13 Numerous studies around the world have shown that the equal energy indices are more related to people's reaction to aircraft noise than single event parameters such as the LAmax, or SEL.

1.1.14 Australian Standard AS 2021-2000, "Acoustics – Aircraft noise intrusion – Building siting and construction" requires that land use planning around Australian civilian airports and military airfields be based on an endorsed ANEF. The ANEF is produced using the USA's Federal Aviation Administration's Integrated Noise Model (INM) which calculates the future noise exposure over a 24 hour period based on the averaged aircraft movements over the annual operational period of the aerodrome, ie the total number of aircraft movements divided by the number of operational days in a year.

1.1.15 AS 2021-2000 identifies in Section A2.4:

> *"In many cases the military flying activities conducted at Defence airfields may be limited to weekdays. Consequently, a daily movement average based on 365 days of activity per year, as assessed for civil aerodromes, may not be appropriate when producing the ANEF for military airfields and joint Defence/civil airports. When military flying activities at an airfield are expected to occur for less than 365 days per year, average daily movement numbers for military aircraft may be assessed on the basis of average aircraft movements during operating days only."*

1.1.16 AS2021 does not identify the determination of an average day for a mixed use aerodrome. As the intent of an ANEF map for a military aerodrome is to identify the noise impact of military operations, which tend to produce higher noise levels than for civilian operations at the same aerodrome, the average daily operations used for the ANEF must be different to a domestic or international civilian airport.

1.1.17 For the preparation of the Hawk LIF EIS the Commonwealth Department of Environment required the ANEF to utilise:

a. the average daily civil aircraft movements calculated by dividing the forecast annual civil aircraft movements by 365 flying days;
b. the average daily military aircraft movements calculated by dividing the forecast annual military aircraft military aircraft movements by 240 flying days at RAAF Base Williamtown; and
c. in the case of SAWR aircraft operations divided by 115 flying days (the limit of flying days at SAWR).

1.1.18 In a layman’s sense the ANEF for RAAF Base Williamtown (including SAWR) shows the aircraft noise exposure on days when military operations occur. Therefore on days when military operations do not occur, the noise exposure will be less, and for weekends may be further reduced by a lower number of civilian aircraft movements. The Leq and maximum levels appended to this report reflect that position.

1.1.19 The future exposure to aircraft noise is illustrated as ANEF contours drawn on a map of the environs around the aerodrome. The contours show increasing aircraft noise exposure from 20 ANEF to 40 ANEF. These ANEF contour numbers are not related to any value of the single event noise parameters and cannot be directly measured.

1.1.20 In addition to an ANEF, there is an Australian Noise Exposure Index (ANEI). The ANEI is produced using the INM and is a calculation of the noise exposure of actual aircraft operations from a previous year (as distinct from a forecast of future operations). The ANEI has the same units as the ANEF and is the average daily aircraft noise exposure around the aerodrome for that year. As the ANEI represents the predicted noise exposure for operations in the past, any comparison with existing aircraft noise levels can only relate to an ANEI rather than a future ANEF.

1.1.21 For the insulation of buildings within the 20 ANEF contour, the Australian Standard AS2021-2000 utilises the “Aircraft noise level” as the highest external level determined for each aircraft operation and mode. The “Aircraft noise level” is location specific. The maximum levels in Tables C4, C5 and C6 provide an arithmetic average, the minimum and the maximum of the range of aircraft maximum levels recorded for the different aircraft types. The aircraft maximum levels in Tables C4, C5 and C6 are not “Aircraft noise levels” as defined in AS2021-2000.

1.1.22 The inquiry by the Senate Select Committee on Aircraft Noise in Sydney (Falling on Deaf

Ears -1995) found that the ANEF System was not generally understood and recommended that the ANEF be supplemented by additional acoustic metrics.

1.1.23 Whilst not required by AS 2021-2000 for measuring noise exposure, the LAeq,T parameter may be used as a supplementary acoustic for the measurement of aircraft noise exposure in Australia. The LAeq,T parameter is the summation of all the LAeq values for each aircraft operation, logarithmically averaged over a period of time typically 16 or 24 hours. The LAeq may also be referenced as Leq. A 24 hour LAeq is often referenced as Leq 24.

1.1.24 Many acoustic studies around the world have confirmed that there is a direct relationship with the 24 hour LAeq parameter and people’s reaction to aircraft noise, with one study in the UK (The Aircraft Noise Index Study - 1985) identified a step in people’s reaction at a LAeq of 57 dB(A). Based on this report, the UK Government adopted the LAeq parameter as a measure of aircraft noise and used 57 dB(A) as the approximate value where there is general community annoyance from aircraft noise. Evidence from the study showed that people become moderately disturbed at LAeq 65 dB(A) and were considered highly disturbed at LAeq 70 dB(A).

1.1.25 The World Health Organisation (WHO) recommends that, for transportation activities, the noise exposure should be measured in terms of the average 24 hour LAeq and recommends an external 55dB(A) as the value where people start to became annoyed with aircraft noise.

1.1.26 The Leq and some derived parameters are used by many other countries around the world as the simplest means of measuring people’s reaction to aircraft noise. Most of Europe use the WHO LAeq recommendations. Canada uses the NEF system which is similar to the ANEF system but with a different night weighting. The USA and New Zealand use the DNL system which is a LAeq with a night weighting from 10 pm to 7 am.

1.1.27 Airservices Australia has reported (refer to pages 7-8 of the Q2 2005 NFPMS report for RAAF Base Williamtown) that an order of magnitude estimate for comparison with the ANEI value can be obtained by subtracting 35 dB(A) from the average 24 hour LAeq value. The WHO external noise recommendation of 55 dB(A) would therefore approximate an ANEI value of 20. An average 24 hour LAeq value of 60 dB(A) would approximate an ANEI value of 25 being the “unacceptable” limit for residential housing under AS 2021-2000. Similarly for comparison purposes, a LAeq value of 65 dB(A) would approximate ANEI 30 and LAeq 70 dB(A) would approximate ANEI 35.

1.1.28 Because the equal energy parameters are not easily understood, additional supplementary parameters have also been used to further describe aircraft noise. The LAmax metric is the most common supplementary aircraft noise parameter used around the world. The WHO recommends that for aviation operations, in addition to the LAeq, additional descriptors such as LAmax should also be reported.

1.1.29 In 2000, the then Australian Department of Transport and Regional Services (DOTARS) suggested the Number Above (NA) parameter also be used as an additional indicator of the community’s exposure to aircraft noise. This parameter provides an average daily number of aircraft noise events above a certain LAmax dB(A) level. The N70 parameter represents the daily average number of aircraft noise events greater than a LAmax of 70 dB(A), N85 for average aircraft noise events greater than 85 dB(A) etc. DOTARS recommended that the N70 parameter be used as 70 dB(A) is the LAmax level where speech communication can be disrupted by aircraft noise. The benefit of the NA parameter is yet to be quantified as the relationship between a particular NA value and people’s annoyance or disturbance has not been established.

1.1.30 This quarterly report on the noise exposure of existing aircraft operations on the local community documents the quarterly average 24 hour LAeq value. The NA parameters of N70 and N85 are also documented.

Factors Affecting the Propagation of Aircraft Noise

1.2.1 The noise level measured at each NMT can vary considerably between similar operations by the same aircraft type. The variation can be in excess of a sound pressure level of 10 dB(A) – a doubling of the subjective loudness of a particular sound.

1.2.2 The factors affecting the measured noise level at a particular location include the following:

a. thrust setting of the aircraft
b. attitude
c. configuration of the aircraft
d. flight track flown
e. distance of the monitor to the aircraft position
f. environmental (weather) considerations

1.2.3 The thrust setting of the engines of the aircraft is probably the most important consideration as this represents the noise power at the source. The thrust setting will be dependent on payload, range, configuration, pilot technique, weather conditions (particularly wind and temperature) and whether the aircraft is accelerating, decelerating or in a constant power setting. This is particularly important for military aircraft, which may use afterburner power which may significantly increase the noise level.

1.2.4 The attitude of the aircraft can also affect the propagation of the noise level from the aircraft. The noise level can be dependent on whether the aircraft is climbing, descending, banking or in level flight. Banking, in particular, can shield the noise output from the engines from the observer.

1.2.5 The configuration of the aircraft such as flap settings and exposed undercarriage alter the power settings and can affect the noise generated by the aircraft. The lowering of flaps and undercarriage will usually result in an increase in aircraft noise from the disturbed air flow, turbulence or additional engine thrust when compared with the situation of no flaps or exposed undercarriage. 3.2.6 The flight track flown and the distance of the noise monitor from the actual aircraft position also have a bearing on the recorded noise level. The noise is dissipated through the atmosphere in proportion to the square of the distance. A doubling of the distance will result in a decrease in the noise level by approximately 6 dB(A).

1.2.7 Environmental considerations affecting the propagation of aircraft noise through the atmosphere include the following:

a. atmospheric absorption
b. wind
c. temperature gradient
d. lateral attenuation

1.2.8 Atmospheric absorption influences the propagation of aircraft noise and hence the impact on the community. Temperature and humidity affect the absorptive properties of the atmosphere; this in turn affects change in the rate of the attenuation, which is not the same over the audible frequency spectrum. For example, over distances lower frequency sounds are less attenuated than higher frequency sounds. Cloud cover affects how aircraft noise is reflected and carried through the atmosphere. For example, cloud cover tends to reflect aircraft noise and therefore on a cloudy day aircraft noise will be carried over a longer distance.

1.2.9 Wind direction and strength can also impact on the propagation of the aircraft noise through the atmosphere. The propagation of noise from source to receiver will vary whether the receiver is upwind, downwind or crosswind from the source. Similarly, the strength of the wind can increase or decrease the sound depending on the relative positions of the source and the receiver.

1.2.10 Temperature gradient, particularly where there is an occurrence of temperature inversion, will also impact on the noise received at a monitor from a particular aircraft operation. Depending on the conditions existing at the time the sound waves may be dispersed upwards, downwards, towards or away from the receiver.

1.2.11 Lateral attenuation is described as being the absorption of aircraft noise from the ground, diffraction and directivity effects. Lateral attenuation is considered as excess attenuation, whereas by the same token the noise may be reflected from water bodies; expanses of hard surfaces etc. and cause an increase in the noise level thereby reducing the attenuation.

1.2.12 Weather data for RAAF Base Williamtown is collected by the Williamtown RAAF Meteorological Office. The relevant monthly weather data can be compared with the long term average over the last 70 years to determine whether there have been any abnormal weather conditions. Detailed weather information for RAAF Base Williamtown for the previous 14 months is available on the internet at the following site:

http://www.bom.gov.au/climate/dwo/IDCJDW2145.latest.shtml