# POSSIBLE GUIDELINES FOR HELICOPTER NOISE ASSESSMENT

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## 1. INTRODUCTION

Helicopters are one of the few noise sources for which generally accepted assessment criteria do not exist and the tendency is to apply the same standards as for the noise from fixed wing aircraft. However, while there are obvious similarities between the two sources, there are also important differences.

While both conventional aircraft and helicopter noise spectra normally exhibit significant tonal features at frequencies of the order of 1 kHz, helicopters also typically produce substantial peaks at very low frequencies (20 to 40 Hz) due to their main rotors. This low frequency content may cause particular disturbance due to the relatively poor insulation provided by building elements and, possibly, resonances within rooms. In addition, helicopter noise, unlike that of other aircraft is highly impulsive - a feature well established as increasing disturbance. Other factors peculiar to helicopters, at least compared to commercial aircraft, are relatively low flying height, long duration of noise due to low speed and, often, landing and take off points in close proximity to densely populated areas.

A major reason for the absence of separate assessment criteria for helicopters may lie in the shortage of social survey data relating their noise to community response. In the UK the main attempt at such a survey, the Civil Aviation Authority's Helicopter Disturbance Study [1], was limited by the rarity of communities exposed to significant helicopter noise which were not also exposed to substantial noise from fixed wing aircraft and did not have economic ties with those operating the helicopters (as may be the case close to the bases used by helicopters servicing North Sea oil rigs, for example).

Despite the present day rarity of exposed communities there are increasing demands for helicopter landing facilities, especially in major cities, and it is useful to consider their impact separately from conventional aerodromes.

As an alternative to simply applying the guidelines used for fixed wing aircraft, this paper approaches the derivation of assessment criteria for helicopters by applying standard methods and criteria established for other noise sources and attempts to adapt these to allow for the features peculiar to helicopters. It will concentrate on the situation where helicopter noise is to be introduced to existing buildings - which is likely to be both a more common and a more sensitive circumstance than where new buildings are proposed for an already exposed location.

Various possible indices or rating systems are considered and their suitability for helicopter noise examined. In many locations, assessments will have to be made by reference to particular circumstances (the use of a building, its noise insulation, the existing background noise level etc.) but certain situations permit the suggestion of specific guidelines. In particular, a set of external noise criteria considered appropriate to domestic residences is proposed and its application to other types of building is discussed.

## 2. GENERAL CONSIDERATIONS

In setting possible standards or guidelines, there are basically two types of index or rating system which might be considered. The most widely proposed is the "average" measure $L_{Aeq,T}$, or, alternatively, indices which may be used to assess the impact of individual events such as Speech Interference Level or maximum level. While an "average" index may be appropriate to gauging the general response of an exposed community, there is good reason to consider the possible disruption of specific activities separately, especially speech-related ones, and to make use of "event" indices.

Another question is the setting of a guideline as either an internal or an external noise level. Clearly what matters to those affected is the actual noise level within the building, but in terms of measurement or prediction it is often easier to consider external noise levels.

Dwellings are often regarded as the most vulnerable to disturbance from many types of noise although schools, hospitals and similar institutions are normally more noise sensitive in themselves. However, because there are likely be relatively few such premises compared to the number of houses or flats in a residential area, there is some justification for the latter being the main factor in determining a general guideline. Furthermore, domestic buildings often have lower levels of facade insulation and the installation of additional sound insulation, such as secondary glazing, is likely to be easier and more acceptable in institutional buildings than in domestic ones. There is thus a strong argument for trying to limit the noise exposure of dwellings in terms of external levels and this may result in lower limits for the external noise than in the case of (potentially) better insulated but more noise sensitive institutional buildings. The setting of an external noise limit will also help to protect open spaces such as parks.

## 3. EQUIVALENT CONTINUOUS SOUND LEVEL

Some would suggest that $L_{Aeq,T}$ is inappropriate to an intermittent noise such as that from helicopters. However, $L_{Aeq,T}$ is now used in many countries for measuring a wide variety of noise sources including fixed wing aircraft and railway trains which generate similar time histories to helicopters. It has the advantage over more specialized indices (such as the Noise and Number Index used until recently for aircraft noise in the UK) of allowing comparison with other noise sources, and methods for the prediction of $L_{Aeq,T}$ are well established.

In applying $L_{Aeq,T}$ to helicopter noise the key question is the selection of an appropriate period (T). For conventional aircraft at large commercial airports in the UK the value used is 16 hours, based on average mode of operation during the summer months when flights are at their peak. At such locations flights are likely to be fairly evenly spread throughout the 16 hours. For heliports, both seasonal and hourly variations may be significant as flights tend to be unscheduled with, possibly, considerable commuter use. A choice of a typical peak hour for the $L_{Aeq,T}$ period therefore seems a reasonable choice.

## 4. THE MAXIMUM LEVEL

The maximum sound level, $L_{Amax}$, is one of the simplest parameters of helicopter noise which can be measured or predicted. It is often felt to be of great importance, although there is no evidence to suggest that it relates well to any of the normal subjective criteria such as the apparent noisiness of an environment. It can of course be used to make comparisons with other noise sources, for example road traffic, although this can be highly misleading due to differences in duration, frequency spectra and so on.

$L_{Amax}$ is commonly held to be important in predicting sleep disturbance, and $L_{Amax}$ may also be of use where it is possible to show that a certain significant level would be exceeded. For example, 65 dB(A) $L_{Amax}$ internally would be a positive indication that telephone usage would be prevented at times.

## 5. SPEECH INTERFERENCE LEVEL (SIL)

SIL is clearly of particular relevance to classrooms and conference rooms, and might be expected to relate well to disturbance in domestic or general office situations too. This method has an advantage over many other indices of probably being more readily appreciated by non-acousticians since it lends itself to qualitative descriptions - for example, "the speaker would have to shout for 10 seconds during each fly-over to make his or her self heard". In the case of helicopter noise even this type of approach may be limited, however, by the variability of noise levels, time histories and spectra generated by different machines and operations.

SIL assessment is specific to the particular voçal effort considered acceptable, the communication distance, the acoustic environment and so on. Thus the number of factors to be taken into account means that no single level or range could be proposed as a general criterion for acceptability, although it is an important technique of assessment which should be applied when appropriate.

## 6. NOISE RATING AND NOISE CRITERIA CURVES (NR, NC)

Noise Rating curves are widely used for evaluating the steady internal noise climate in offices, along with the similar Noise Criterion curves. One particular advantage of such curves in the case of commercial premises is that many such buildings will have been designed to meet certain NR/NC criteria and so assessment of the detriment due to the new noise can be made in a direct manner. Also, the published criteria relating to such curves have the advantage of being comprehensive in covering a wide range of building uses and so better account can be taken of the precise needs of each receiver.

A particular drawback with NR or NC is the need for spectral analysis over a wide frequency range and as in the case of SIL this poses difficulties with helicopters due to spectral variations between different machines and manoeuvres, especially where predicted noise levels must be used. Rough approximations of A-weighted sound pressure level to NR or NC can be made for steady noise, but this reduces the methods to little more than alternative sources for $L_{Aeq}$ criteria.

## 7. POSSIBLE CRITERIA FOR DWELLINGS

One of the clearest guides available in the UK using $L_{Aeq,T}$ is British Standard 8233 "Sound Insulation and Noise Reduction in Dwellings" [2]. For dwellings BS 8233 suggests the acceptable internal levels should be 30 to 40 dB(A) for bedrooms and 40 to 45 dB(A) for living rooms, measured as $L_{Aeq}$'s of unspecified period. The World Health Organisation's Environmental Health Criteria [3] suggest that for good speech intelligibility indoors, a level below 45 dB(A) $L_{Aeq,T}$ is required.

In most cases helicopter movements will not take place at night and the 40 to 45 dB(A) range for living rooms is most appropriate. As argued above, a typical peak one hour appears a good choice for the averaging period. As it is desirable to derive guidelines in terms of external noise levels, an immediate question which arises is what level of facade insulation to assume for a typical domestic building. It is reasonable to assume that most dwellings will only be equipped with single glazing in average condition. As ventilation will normally rely on open windows a value of 10 dB(A) [2] will be taken. Additional points in favour of assuming a low level of insulation are that roofs may be a significant path for helicopter noise intrusion into the upper floors and frequently offer poor insulation, and the greater low frequency content of helicopter noise means that even closed windows allow greater noise penetration than normally expected.

If the facade attenuation is taken to be 10 dB(A), the acceptable external noise standard would thus be 50 to 55 dB(A) $L_{Aeq,1hr}$. This is in line with the WHO recommendation that general daytime noise levels of less than 55 dB(A) $L_{Aeq}$ are "desirable to prevent any significant community annoyance" [3].

Work by Dr.J.Ollerhead of the Civil Aviation Authority (CAA) and others, has been cited in Reference [4] as suggesting that the onset of disturbance at small airfields begins at 48 to 52 dB(A) $L_{Aeq,12hr}$, and most heliports probably correspond in capacity to a small airfield. As this refers to daytime noise, the range can be compared to the proposed standard of 50 to 55 dB(A) $L_{Aeq}$ for a peak hour which might correspond in a typical case to a situation where the 12 hour average was two or three decibels lower.

Another means of testing the validity of this standard is by comparison with the step in some indicators of subjective response found by the CAA's United Kingdom Aircraft Noise Index Study [5]. This study showed a sharp increase in adverse response at between 55 and 60 dB(A) for a 24 hour $L_{Aeq}$ for fixed wing aircraft. Given that both the impulsiveness of helicopter noise and its greater low frequency content can be expected to increase disturbance, the peak one hour (daytime) criterion of 50 to 55 dB(A) does not seem excessively strict.

Where significant noise is expected during evening and night time hours an internal limit between 30 and 40 dB(A), $L_{Aeq,1hr}$ - giving a limit of 40 to 50 dB(A) externally - will be needed to avoid sleep disturbance according to BS 8233 [2]. The World Health Organisation [3] also suggests an internal $L_{Aeq}$ limit for the same period of 35 dB(A), along with an internal $L_{Amax}$ of 60 dB(A) - ie. 70 dB(A) $L_{Amax}$ externally.

## 8. POSSIBLE CRITERIA FOR OTHER TYPES OF BUILDING

### 8.1 Offices.

It has been suggested above that in many locations the criteria for acceptability of the (external) noise levels will be those appropriate to dwellings. If these criteria are met then it is unlikely that any but the most sensitive offices with poor sound insulation will be exposed to unacceptable noise.

In some locations, however, offices alone may be exposed to helicopter noise and modern offices in particular may have higher standards of noise insulation than assumed for dwellings. A good standard would be $L_{Aeq,T}$ values for private offices of 40 to 45 dB(A) internally and for large offices 45 to 50 dB(A), according to BS 8233 [2]. In accord with the argument developed above for dwellings, the most appropriate time period for $L_{Aeq}$ measurement would be 1 hour. Insulation values could range from below 10 dB(A) to 35 dB(A) or more for the extremes of open single glazed windows or sealed double units, although the higher values may be difficult to achieve given the predominance of low frequencies in helicopter noise.

8.2 Educational Buildings.
For educational buildings special guidelines for general noise have been developed in the UK. One study, cited at the recent inquiry into the proposed City of London Heliport [6] and published by the Building Research Establishment indicated the percentage of teachers bothered "quite a lot" and "very much" by aircraft noise measured as a "short term" external $L_{Aeq}$. At an external $L_{Aeq}$ of 50 dB(A) the percentage bothered was 10% rising to 20% at 55 dB(A).

BS 8233 [2] uses $L_{Aeq,T}$ for educational premises. As already suggested for dwellings it may be reasonable to use a value of one (peak) hour for T. Recommended internal $L_{Aeq}$ values range from 30 dB(A) in music and drama spaces to 50 dB(A) in practical, workshop and circulation areas, with a medium sized classroom at 40 dB(A). If a single glazed facade with open windows is assumed this latter value would become 50 dB(A) externally - ie. at the bottom of the (one hour) range of acceptable levels derived above for dwellings.

The 35 NC curve has been used as a maximum for continuous noise, but intermittent noise such as that from helicopters may be better tolerated on the assumption that a time period of more than a few minutes will elapse between events. This is equivalent to a value of 41 dB(A) internal or 51 dB(A) external if the usual open window attenuation is assumed. Given that higher levels may be tolerated for short periods, it would seem that the 50 to 55 dB(A) $L_{Aeq,1hr}$ external standard suggested for dwellings is again not unreasonable as a maximum for general classrooms from the point of view of Noise Criteria.

8.3 Hospitals.
One recommendation [7] for hospitals is a maximum NC value of 30, ie. about 37 dB(A) (internal), which is just below the lower end of the range normally suggested as appropriate for living rooms. In many cases even this standard will not be met due to internally generated noise and it is to be expected that much of this noise will, like that from helicopters, consist of

intermittent high levels caused by human activity. As a result, the noise limits proposed above for dwellings may in practice be adequate to protect hospitals, even where the buildings are old and lack any special noise insulation.

## 9. CONCLUSIONS

In deriving guidelines for the assessment of helicopter noise impact, it is suggested that the key consideration in many cases will be the effect of newly introduced helicopter noise on existing residential areas.

Having considered various possible indices or rating methods, it is proposed that the equivalent continuous sound level, $L_{Aeq}$, for a peak hour is the most generally appropriate, although other indices may also be useful in particular instances. A daytime peak hour noise limit in the range of 50 to 55 dB(A) $L_{Aeq,1hr}$ externally is felt to represent the point at which significant disturbance is likely to commence and this therefore forms the proposed basic guideline.

## 10. REFERENCES

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[7] "Fundamentals of Acoustics", L.E.Kinsler, A.R.Frey et al, Wiley, (3rd Edition).