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AERONAUTICAL NOISE: SESSION B: COMMUNITY NOISE

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HELICOPTER NOISE - CAN ITS ANNOYANCE OR LOUDNESS BE RATED USING EXISTING METHODS?

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INTRODUCTION

The character of helicopter noise is controlled largely by the noise from the rotors, although the high frequency compressor "whine" is subjectively important particularly at distances relatively close to the helicopter. Rotor noise, and hence helicopter noise, is essentially impulsive in nature and flight measurements indicate that typically the "peak-to-overall RMS" level is 10-15dB. On a helicopter subjected to severe blade slap (a "banging" noise associated with the main rotor) this value can be as high as 25dB. In addition to this distinctive blade slap noise, the tail rotor rotational noise is emitted as an annoying "whine" which is often the most pronounced noise on a helicopter during cruise flight and low speed manoeuvres.

Other well defined noise sources of a helicopter are main rotor rotational noise, main rotor broadband noise, low frequency broadband engine exhaust noise and to some extent transmission noise. With the exception of the influence of the rotational noise on the overall impulsive character of helicopter noise, these sources combine to produce a non-descript random type noise which is modulated slightly at the main rotor blade passing frequency i.e. at about 15Hz.

RATING METHODS

Helicopter noise is normally rated in terms of either the perceived noise level (PNL) or the dBA value. The former is based on the method developed for aircraft and is used extensively within the aircraft industry. The dBA unit has, however, recently become more widely used within the UK and "specification levels" for current helicopters are defined in terms of this unit. dBA values are also used when comparing helicopter noise with community and/or traffic noise levels. Even so the PNL approach has advantages since it is more sensitive to changes in spectrum characteristics and the recently introduced Effective Perceived Noise Level (EPNL) method allows "tone" and "duration" corrections to be applied. It is also apparent that the international bodies considering the possibilities of noise certification for V/STOL vehicles and helicopters favour the PNL concept.

In this short paper the use of the PNL approach, and by implication the dBA method, for rating helicopter noise is reviewed. Non-impulsive helicopter noise, blade slap or impulsive noise and tail rotor noise aspects are discussed separately and example results are presented.

ANNOYANCE (PNdB) RATING OF HELICOPTER NOISE

'Non-Impulsive' and Minimum Tail Rotor Noise Case

The time history of non-impulsive helicopter noise such as that generated by a Wessex helicopter takes the form indicated in figure 1 and, as can be seen, it is essentially random in character. If the tail rotor noise was low in level then on $\frac{1}{3}$ octave band analysis the spectrum would be fairly "uniform" in the mid-frequency region and would exhibit a "fall-off" in level at the higher frequencies(see figures 3 and 5). In the low frequency bands the spectrum tends to be 'peaky' due to the influence of the main rotor rotational noise peaks and at 8/10kHz the engine compressor "whine" gives rise to a "peak" as indicated on figures 3 and 5. Ignoring the "engine peak" it is fairly clear that the PNL value would be a fair representation of this noise, particularly when it is remembered that the PNL unit was originally based on broadband jet engine noise. In this context it should be noted that the "peaky" low frequency region has little or no effect on the computed PNL value.

The engine compressor "peak" is for all practical purposes identical to that associated with conventional aircraft engines and thus the PNL concept, particularly if the 'tone correction' of the EPNL method is taken into account, can be expected to give an accurate rating of its annoyance. It seems fair to conclude, therefore, that providing the helicopter noise is of the type described then the PNL rating method would be expected to give a good estimation of the overall annoyance/loudness.

Blade Slap Impulsive Noise Case

Blade slap occurs at the blade passing frequency and a typical time history which clearly illustrates the impulsive nature of the noise is reproduced as figure 2. The influence of the level of the blade slap impulse on the PNL value has been studied in detail by generating the 'bang' by electronic means and varying the 'peak' amplitude relative to that of the normal helicopter noise. Tests have also been carried out to verify that this approach is representative of blade slap on a real helicopter.

Figure 1 shows the time history for the non-blade slap condition and figure 2 represents the case where there is a 10dB difference between the 'peak' amplitude of the blade slap impulse and that of the normal helicopter noise. The corresponding $\frac{1}{3}$ octave band analyses for these conditions are given in figure 3, together with the $\frac{1}{3}$ octave band spectrum for the 'bang' alone. As can be seen blade slap only influences the spectrum in the low to mid frequency region. PNL calculations have been made for different cases and these are shown plotted as a function of the difference in peak amplitudes in figure 4. Results are presented for measurements obtained using RMS 'SLOW' and IMPULSE meter settings and, except for a difference in absolute PNdB level, the two sets of data exhibit similar trends. For the '10dB condition' the PNdB value only shows a 1dB increase although the noise is very much more impulsive and annoying. It is difficult to quantify the underestimation of the blade slap 'bang' noise, but some preliminary tests conducted at the ISVR suggest that on a 'loudness basis' it is at least 10dB. As can be seen from figure 4, even when the 'peak' of a bang is 20dB above the 'peak' of the normal helicopter noise the predicted difference is only 7PNdB. Thus it is considered that the PNL method is not really suitable for rating the impulsive noise content of blade slap.

Tail Rotor Noise Case

On $\frac{1}{3}$ octave band analysis the 'bands' which are a function of the tail rotor noise 'peaks' are normally those containing the fundamental and in some cases the 'second harmonic'. This is the case even though subjectively the tail rotor 'whine' is very noticeable and annoying. A $\frac{1}{3}$ octave band plot for a condition, which on analysis exhibits the maximum influence of tail rotor noise, is shown in figure 5. The PNL value for this has been compared with that when the 'tail rotor noise bands' have been subtracted and, the difference is only 1.3PNdB. When the 'tone correction' of the EPNL method is applied the rating is increased 1.7PNdB. to give a 3PNdB difference between the 'tail rotor' and 'non tail rotor' conditions; this is an extremely small value when compared to the subjective difference. In many cases, however, the tail rotor noise - even though it can be clearly detected - has even less effect on the $\frac{1}{3}$ octave band spectrum and it is not uncommon for the spectrum to be, for all practical purposes, independent of the tail rotor noise contribution. Again there is no real evidence available on the order of the subjective effect but it is worth noting that in the recommendation in the Wilson Report, which was later incorporated in BS4142, a correction of 5dBA was added to the measured value to take account of the tonal character of a noise which has a definite distinguishable continuous note such as a "whine". On a helicopter the tail rotor is normally very pronounced and hence an even higher correction may be required.

INFLUENCE OF 'AVERAGING TIME'

The results presented above have been derived largely using analogue equipment with an 'averaging time' corresponding to RMS SLOW, although in the case of the 'blade slap' study an IMPULSE setting was also used. As already indicated the only real difference in the results was a change in absolute amplitude. This is as expected since although the IMPULSE 'averaging time' is shorter than that of the RMS SLOW it is still relatively long when compared to the 'bang' duration.

A study into the differences and possible advantages of using a digital/real time system has been made. This has shown that there is very little difference between the two types of analysis and the results obtained are for all practical purposes identical.

CONCLUDING REMARKS

It is obvious that the PNL concept, and by implication the dBA method, is not really suited to the rating of helicopter noise since subjectively the annoyance value of helicopter noise is essentially a function of the tail rotor noise and the level of impulsive main rotor noise. Obviously a new approach is required, but it is not clear what form this should take. It may be desirable to consider modifying the PNL calculation procedure by the use of suitable correction terms. It is possible that the impulsive character of the noise could be taken into account by the use of a "bang factor" based on the blade slap 'pulse', but it is difficult to imagine how an allowance for the subjective annoyance of the tail rotor noise could be made. There is enough evidence, however, to indicate that these aspects must be taken into consideration when assessing and comparing the noise of helicopters.

TIME HISTORY

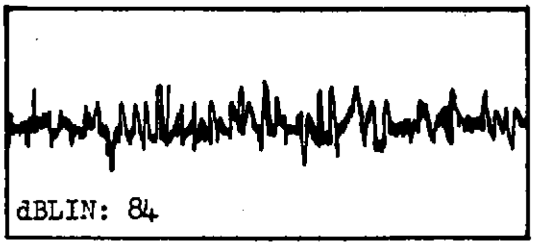

FIG. 1. NON IMPULSIVE HELICOPTER NOISE

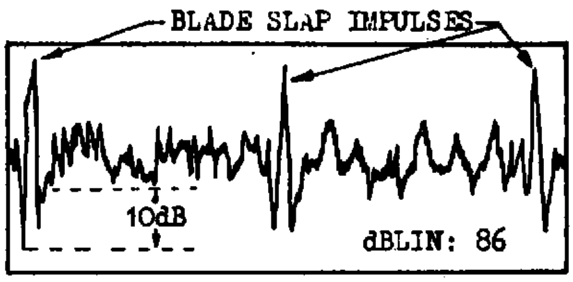

FIG. 2. HELICOPTER NOISE WITH BLADE SLAP

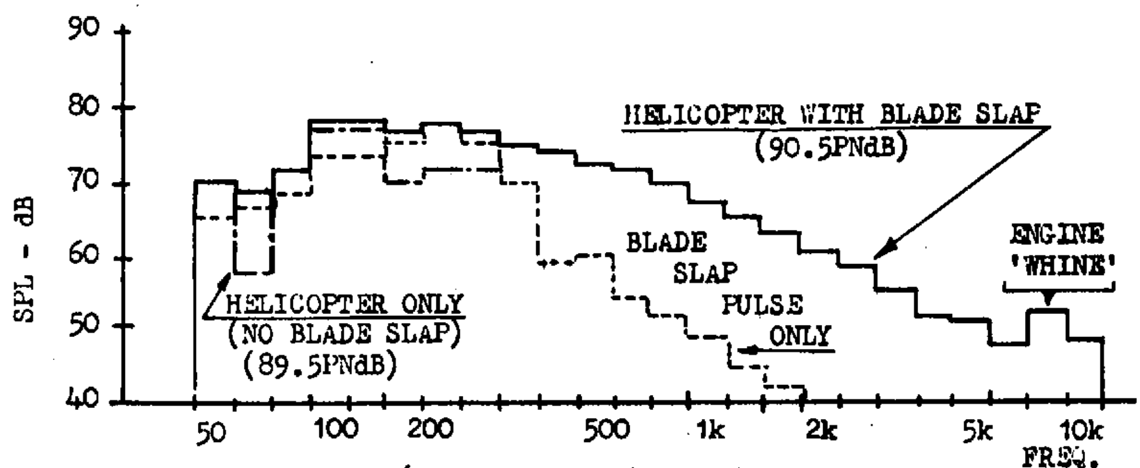

FIG. 3. BLADE SLAP - $\frac{1}{3}$ OCTAVE BAND SPECTRUM

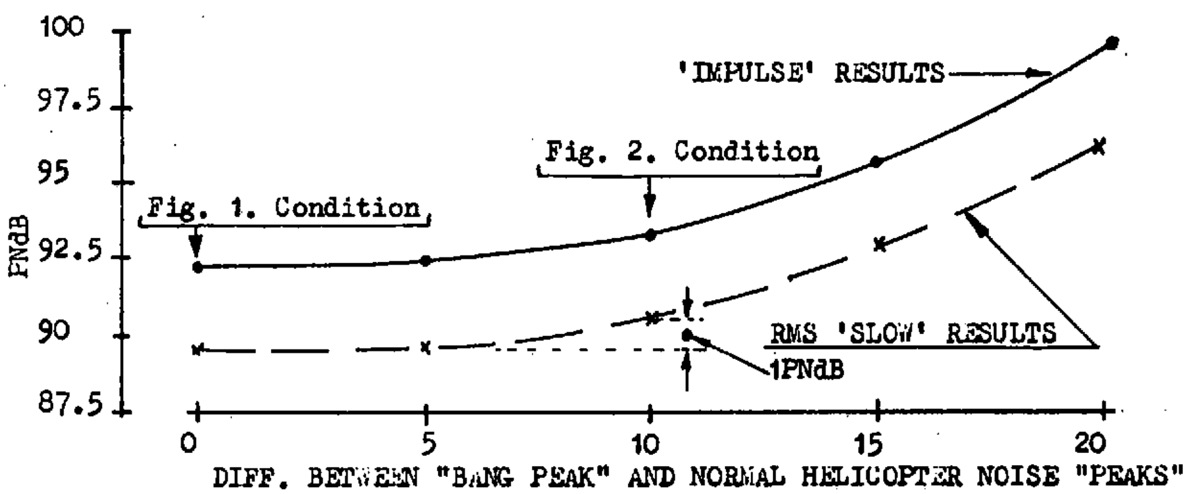

FIG. 4. INFLUENCE OF 'BANG' ON PNdB VALUE

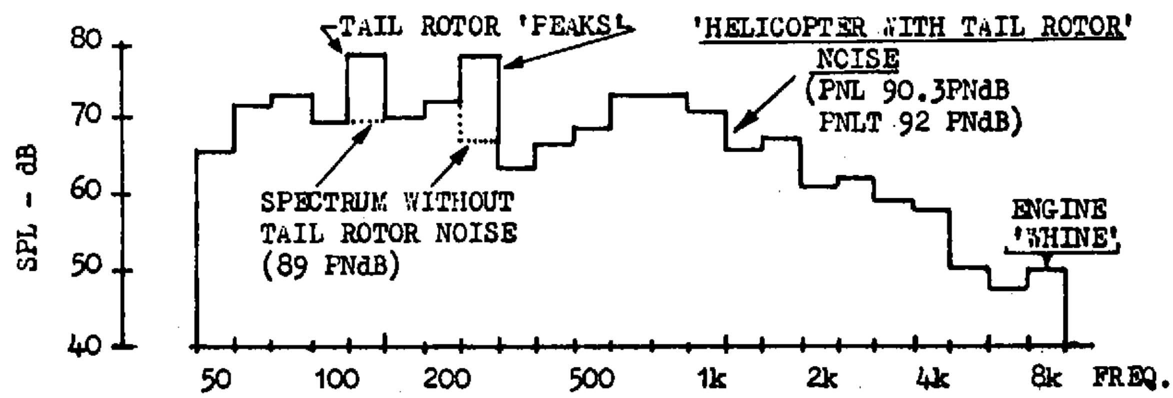

FIG. 5. TAIL ROTOR STUDY - $\frac{1}{3}$ OCTAVE BAND SPECTRUM