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SUBJECTIVE EVALUATION OF HELICOPTER NOISE

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INTRODUCTION

It is well known that certain types of helicopters, in particular those which generate high levels of blade slap (impulsive main rotor noise) or tail rotor noise, invoke more annoyance than others. Studies within Westland Helicopters Limited (WHL) based on steady state hover signals, have shown that when helicopter noise is dominated by either of these sources a correction is required to quantify the subjective impression of the signal when it is measured in terms of dB(A) or EPNdB. A large number of studies within the USA, France and other UK establishments, have similarly shown the need for a blade slap correction. Doubt has, however, been shed on the need for a correction by full scale flight studies by NASA. An independent evaluation within WHL of the NASA recordings has shown that although the results of the NASA experiment are consistent within themselves, a correction (relative to the level associated with a Wessex helicopter, which generates a non-impulsive broadband signal) is required to account for the impulsive nature of the helicopter used in the study. Recently in an attempt to clarify this situation a further series of tests have been conducted at WHL using real and simulated helicopter flyover noise signals as well as real and simulated hover signals. The findings are reported in this paper together with some of the earlier results.

TEST TECHNIQUE

The majority of the tests conducted within WHL have been based on the Method of Adjustment Test (MoA) where the subjects are simply asked to adjust a test sound so that it was equally annoying to a reference sound. For the reference a Wessex (S58) helicopter recording - either hover or flyover - has been used since this does not contain any marked impulsive main rotor noise or tail rotor noise components. In addition this helicopter represents the minimum level of these two sources likely to be obtainable in practice. The test sounds were either simulated helicopter recordings, obtained by superimposing impulses on to a Wessex recording or real helicopter recordings. Depending on the frequency content and repetition rate of the impulses either blade slap or tail rotor noise(which has a characteristic whine) can be simulated.

The subjective tests were conducted using headphones and, depending on the nature of the test, based on between 20 to 40 subjects in the age range 16 to 50 years with the major portion (over 75%) being male. Most of the subjects were given audiometric tests to ensure that their hearing was within the 'normal' (20 dB) limits.

RESULTS

In the earlier studies using steady signals, tests were conducted using a series of recordings with different levels of simulated blade slap and tail rotor noise. The results, obtained in terms of dB(A), are shown in Figure 1 and 2 respectively as a function of the 'peak of pulse - mean peak of broadband noise' level. Also indicated on the Figures are the results of comparing real helicopter signals. In the blade slap case, a Chinook recording was used while a section of a Scout flyover recording, looped to form a steady state sound, was used to evaluate tail rotor noise. In both cases the Wessex (S58) was used as the reference sound. The tail rotor data has also been analysed in terms of PNdB and this scale is also shown on Figure 2.

A major concern during these early studies was associated with the difficulty of reproducing to a satisfactory standard the sharp blade slap impulses. Prior to conducting the tail rotor noise study from which the results shown in Figure 2 were obtained, a detailed review and evaluation of available headsets was conducted and a STAX Electrostatic unit selected for subsequent tests. These have superior impulse response and frequency characteristics and subjectively give a more realistic impulse: these have been used for all the tests conducted since then.

In the most recent series of tests using hover and flyover signals, simulated and real helicopter recordings corresponding to severe blade slap and tail rotor conditions were used. A Wessex recording was again used as the reference sound. The results are shown in Figures 3 and 4 for the hover and flyover, the results being presented in terms of dB(A) and PNdB (hover) and dB(A) and EPNdB (flyover). It will be observed, particularly in the case of the Bell 212 with high blade slap, that the correction determined is higher than suggested by earlier work. This is considered to be a direct result of the improved quality of the reproduction and the fact that the recording represents an extremely severe blade slap condition.

DISCUSSION

The studies conducted over a number of years have shown that neither blade slap nor tail rotor noise is adequately represented by the standard dB(A) or EPNL measured. This is an important aspect since, if present, blade slap and/or tail rotor noise can dominate the noise generated by a helicopter in far field approach and during landing (Fig 5). For extreme blade slap in the hover situation the studies have indicated a need for correction up to 10 dB(A) or EPNdB, while for severe tail rotor noise the corresponding maximum corrections are in the order of 6 dB(A) or 5.5 EPNdB. Flyover signals require higher corrections than hover by 2 to 3 dB(A) or EPNdB, and it would appear from the more recent studies that females are more sensitive to impulsive noise and require approximately 2 dB higher corrections.

The above results refer to the most severe cases ever likely to occur. In practice the magnitude of the blade slap or tail rotor noise will usually be less and as a result typical corrections to the order of 8 dB(A) or 6 EPNdB would be expected.

CONCLUDING REMARKS

Corrections for impulsive helicopter noise are required to account for subjective impression of blade slap and/or tail rotor noise. For high levels of blade slap or tail rotor noise, corrections of 10 dB(A) or EPNdB, possibly more, are required.

ACKNOWLEDGEMENTS

The work reported in this paper is based on detailed studies reported in WHL Reports: AA 1147 - 'The Rating and Subjective Assessment of Helicopter Blade Slap' (May 1976); RP 576 - 'The Subjective Assessment of Tail Rotor Noise' (July 1978); and RP 616 - 'Evaluation of Subjective Reactions to Blade Slap and Tail Rotor Noise' (May 1980). The Studies reported in RP 576 and a major part of RP 616 were carried out under contract support by the Department of Industry.

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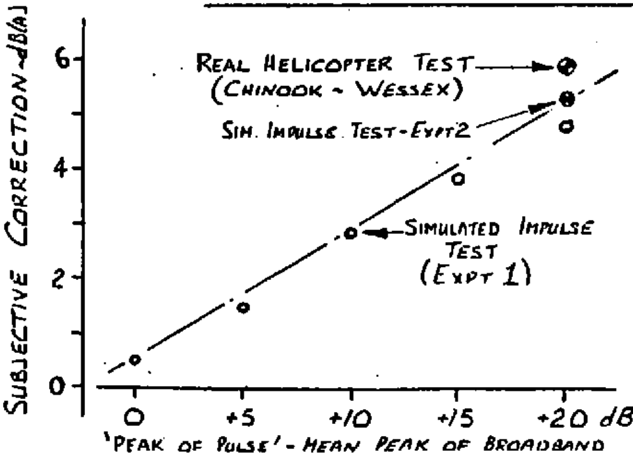

FIGURE 1

BLADE SLAP

FIGURE 2

TAIL ROTOR NOISE

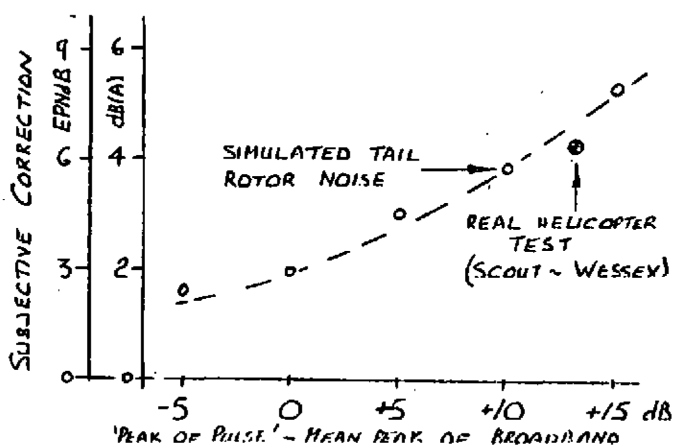

FIGURE 3

HOVER

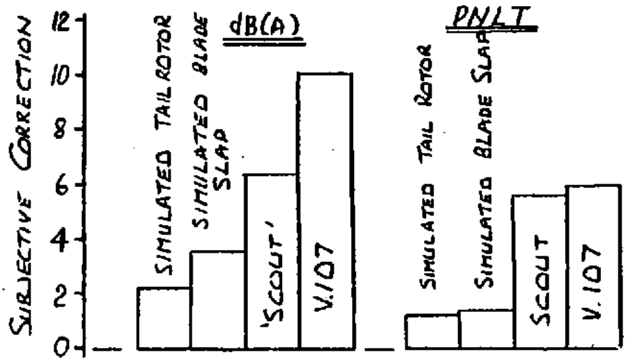

FIGURE 4

FLYOVER

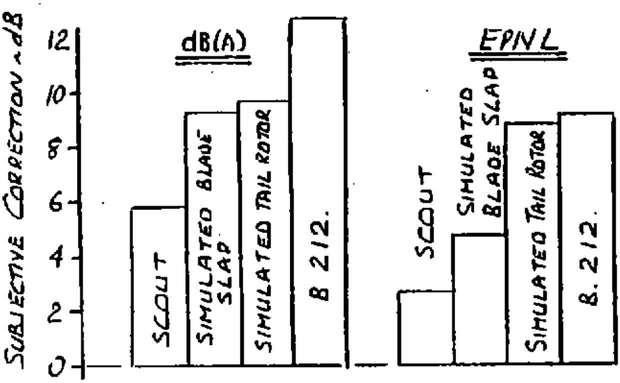

FIGURE 5: FLYOVER TIME HISTORY