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Comparative Interior Helicopter Noise Analysis in Static and In-Flight Conditions

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ABSTRACT

In multi crew cockpit, the exchange of unaltered and straight-forward information is one of the crucial issues in safety of air operations. Therefore, the quality of speech communication between the crew inside the cockpit is extremely critical parameter. Due to generally high levels of interior noise, speech intelligibility is usually strongly impaired unless conducted through the interconnected headsets. The goal of this investigation was to evaluate the quality of straight voice communication inside the cockpit of two light helicopters, Bell 206 and R-44. Several static and in-flight measurements and post-process analysis of interior noise were made in order to collect necessary data for Speech Interference Level (SIL) and Speech Intelligibility Index (SII) calculations. The results, some of which are presented in this paper, have shown that levels of speech intelligibility are generally beyond the acceptable thresholds, which generally justifies the use of headsets, preferably of ANR type, during entire flight operations.

1. INTRODUCTION

Rotary wing aircraft (helicopters) are the sources of intense external noise, which is in some aspects similar to propeller noise in fixed wing aircraft (airplanes). However, the difference lies in main noise source alignment in respect to the relative airflow: in helicopters, both rotors that produce forces necessary for flight are in line with the direction of flight, while in airplanes rotor(s) are perpendicular to it. In addition, distinctive noise in helicopters, named "slapping", comes from the rotor cutting its own wake/vortex air inflow, particularly while descending[1,2].

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The significant portion of all the generated external noise eventually finds its way to the cabin space, becoming – now recognized as interior noise – severe health issue to pilots and cabin crew.

2. THE ERGONOMY AND LEGISLATION

The helicopter interior noise, as well as aircraft one, has not been stipulated so far regarding compliance with the homologation regulations, as, for instance, noise inside road vehicles. There are some recommendations and milestones though. For example, levels of up to 70 dBA are considered good for the acoustic conditions in the aircraft cabin, whereas levels above 90 dBA are definitely unacceptable. In the majority of today's commercial aircraft the level of cabin noise is generally lower than 80 dBA. However, in most helicopters the levels could be considerably higher, reaching the values beyond 100 dBA in some older production models and higher power settings.

The cabin noise vs. speech essentials are published in FAA Advisory Circular AC 20-133, while the measurement methods and procedures are established as international standard in ISO 5129, which specifies A-weighted, octave-band and 1/3 octave-band SPL measurements. However, the quest for the most suitable method for assessing the degree of speech interference is still on.

3. THE EXPERIMENT

A. The objects of Investigation

Two rotary wing aircraft were subjected to thorough external[3] and internal noise measurements:

1) Robinson R44 Clipper, single piston engined helicopter, 205 HP, (153 kW), 113 knots max speed (Fig. 1), and
2) Bell 206B, single turbine engined helicopter, 420 SHP (313 kW), 122 knots max speed (Fig. 2).

Fig. 1. Robinson R44 helicopter

Fig. 2. Bell 206B helicopter

B. Measurement Layout

A-weighted and octave-band noise measurements were conducted in a cabin space by means of B&K 2231 Sound Level Meter with octave filters. The microphone was spatially centered and leveled with pilot's ear position. Three typical power settings/flight regimes with no progressive speed were used as the most convenient for the experiment: idle, full correction and take-off power (hovering).

C. The Results

The collected data are presented in the following graphs: Fig. 3 shows internal octave-band and A-weighted internal noise measurement results in idle power setting, while Fig. 4 and Fig. 5 show the results under full correction and hovering power settings respectively.

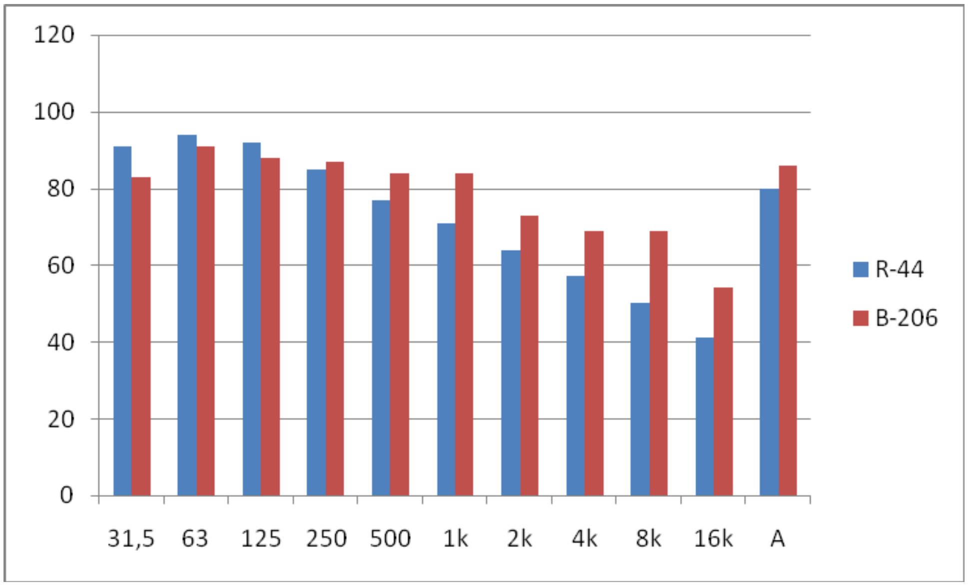

Fig. 3. Octave-band and A-weighted internal noise in dB, idle power settings

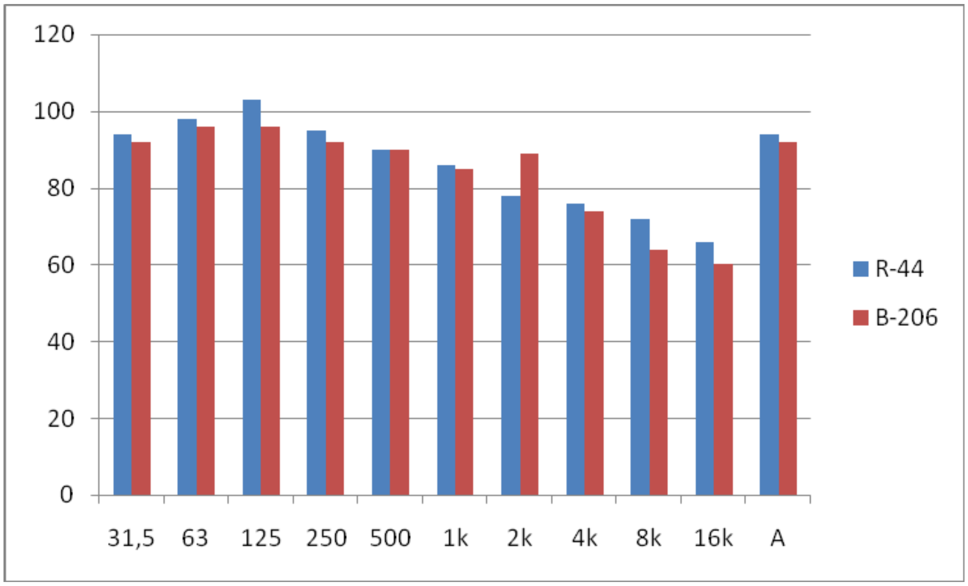

Fig. 4. Octave-band and A-weighted internal noise in dB, full correction power settings

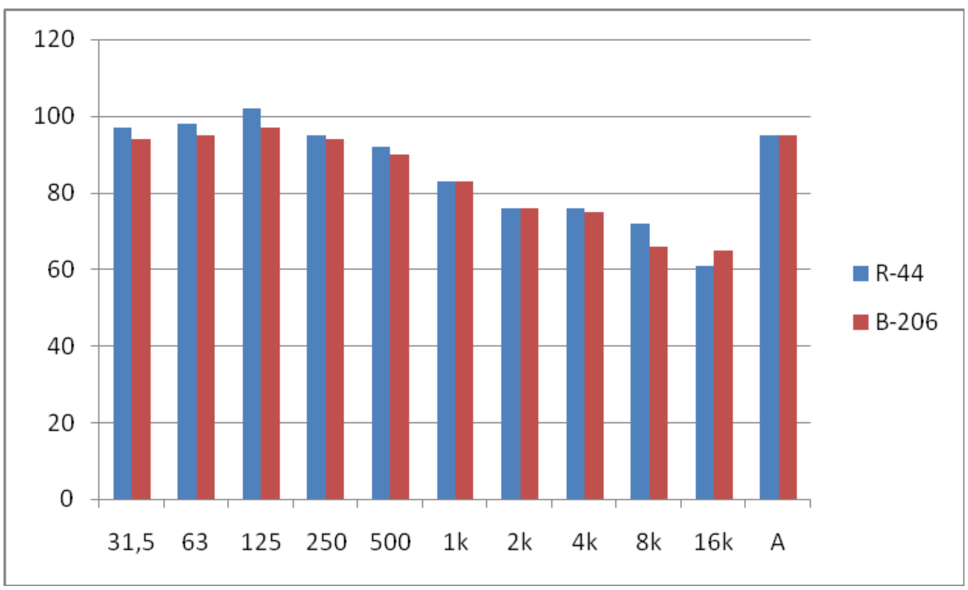

Fig. 5. Octave-band and A-weighted internal noise in dB, hovering power settings

D. SIL and SII Calculation

Speech Interference Level (SIL) represents the level of masking the speech by the surrounding noise and is based on the mean value of the 500 Hz-, 1 kHz-, 2 kHz- and 4 kHz-octave bands (ISO 9921-1 1996), while Speech Intelligibility Index (SII) method yields the level of speech intelligibility under various speech and surrounding noise conditions (ANSI S3.5-1997). The octave band SII calculations were made by using application web-published by J. Hou[4] and the results for four different speech levels (normal/raised/loud/shouted, i.e. 62/68/75/82 dB, respectively) are presented in Table 1. along with SIL values.

Table 1. Speech Intelligibility Index (SII) and Speech Interference Level (SIL) values

HELICOPTER TYPE	FLIGHT CONDITION	SII				SIL [dB]
		NORMAL	RAISED	LOUD	SHOUTED	
R 44	IDLE	0,02	0,22	0,45	0,66	67
	FULL CORR.	0	0	0,02	0,22	83
	HOVERING	0	0	0,06	0,25	82
B 206	IDLE	0	0	0,13	0,35	78
	FULL CORR.	0	0	0,01	0,16	85
	HOVERING	0	0	0,06	0,27	81

4. CONCLUSIONS

Two different types of helicopters by means of powerplant section were subjected to internal noise investigation: piston and turbine powered. Both helicopters are the sources of considerable interior noise, value of each exceeding comfortable levels. A-weighted values go beyond 8-hour noise exposure level recommended by OSHA (1910.95), which is critical for helicopter pilots as they are widely susceptible to noise-related disorders.

The results of speech-to-noise related parameters (SIL and SII values) quantify and prove the fact actually known from everyday's practice: no common speech is possible between the pilots due to high levels of interior noise. Therefore, the use of interconnected headsets, preferably of ANR type, is necessary to ensure the most accurate possible exchange of information critical for the safety of flight.

ACKNOWLEDGMENTS

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