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NOISE LEVELS AND COMMUNICATIONS ON THE FLIGHT DECKS OF CIVIL AIRCRAFT

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1. INTRODUCTION

Routine hearing tests suggest that some flight crew may have slight hearing losses, mainly in one ear. Such losses are considered to be noise related, and to result from the widespread practice of listening to radio communications through a headset covering one ear only, leaving the other ear uncovered to allow direct conversation between crew members on the flight deck. Ambient noise levels on flight decks and noise levels from crew headsets were therefore measured on a sample of aircraft including all types in the 1995 British Airways fleet.

2. MEASUREMENTS MADE

Measurements were made during scheduled flights within the UK and from the UK to Continental Europe, the USA and Canada. Throughout each flight a manikin, 'Kemar' [1], was strapped into the observer's seat behind the captain. Kemar wore a headset connected in parallel with the captain's so that Kemar and the captain heard the same communications through the same type of headset controlled by the same volume controls. The headset was placed over Kemar's left ear only, leaving the right ear uncovered. The outputs from both of Kemar's 'eardrum' microphones were recorded via a B&K microphone power supply, two B&K 2230 sound level meters and a Sony TCD-D10 DAT recorder. The recording chain was calibrated on the ground at normal atmospheric pressure before and after flights using a B&K Type 4231 calibrator. Recordings were continuous apart from brief interruptions to change tapes.

Sennheiser HME/HMD 410 'open ear' headsets were worn in all aircraft except Concorde and the ATP where Racal Astrolite and Peltor headsets are standard. In addition, five production or prototype Active Noise Reduction headsets were evaluated during flight in a Boeing 747-436.

A hand-held sound level meter (B&K Type 2236) was used to determine the spatial variation in sound level on each flight deck during cruise and to check the levels derived from recordings made using Kemar.

3. ANALYSIS AND RESULTS

Recordings were analysed to give one-third octave band spectra at each of Kemar's 'eardrum' microphones. 'Equivalent undisturbed field levels' for each ear were calculated by A-weighting the spectra, subtracting Kemar's diffuse-field-to-eardrum transfer response, and summing bands. The method is described by Rice et al [2]. For Kemar's open ear, the result is simply the ambient noise which would have been measured by a regular sound level meter in place of Kemar. For the ear covered by the headset, the result is the level of the notional diffuse sound field which would match the level and spectrum of the headphone output at the eardrum. This level can be directly assessed against existing damage risk criteria for work-place noise. Noise levels averaged over each flight are given in Table 1.

Table 1 Measured noise levels averaged over complete flights

Aircraft type	A-weighted noise levels, L_{Aeq}, dB(A)			
	Ambient flight deck noise only			With headset
	Kemar/ Observer	Captain/ First Officer	Flight Engineer	(equivalent undisturbed field levels)
Airbus A320-111	--; 74	--; 74		82; 85
Boeing 737-436	74; 74	77; 76		81; 80
Boeing 747-136	--; 75	– 79	--; 76	--; 85
Boeing 747-236	77; 76	79; 78	78; 76	85; 89
Boeing 747-436	74; –	75 to 79; –		77; -- †
Boeing 757-236	71; 71	73; 72		86; 87
(different aircraft)	73; 73	72; 72		81; 81
Boeing 767-336	71; 70	72; 71		80; 84
DC 10-30	74; 73	76; 75	74; 73	85; 88
BAe ATP (turboprop)	74; 72	–; –		75; 73 ‡
Concorde	74; 77	75; 78	74; 77	79; 80 ‡

Notes Values separated by semicolons are for outbound and return flights
† with Active Noise Reduction headsets ‡ circumaural headsets

Ambient levels at the Captain's or First Officer's seats were usually slightly higher than those at the observer's position. The relative levels at each seat measured with the hand-held sound level meter have been used to adjust the level at the observer's seat to give estimates of levels at the other seats The headset levels are independent of position.

4. DISCUSSION

The UK Noise at Work Regulations [3] specifically do **not** apply in aircraft. A proposed EC Directive on Physical Agents [4], if accepted, may remove this exclusion. But at present the Noise at Work Regulations, the published guidelines on their application, the proposed EC Directive, and recent scientific literature must be used as the best guidance on the effects of noise on hearing and on the good practice expected of the reasonable and prudent employer with a duty of care to employees.

The Noise at Work Regulations set the lowest noise exposure at which an employer must take some specified action, the First Action Level, at a daily exposure, $L_{EP,d}$ or $L_{EX,8h}$ of 85 dB(A). (This may be lowered to 80 dB(A) in the future). Guidance notes from the UK Health & Safety Executive state that there is "a quantifiable risk" of hearing damage from exposures between 85 dB(A) and 90 dB(A) and a "residual though small risk" below 85 dB(A) [5]. Robinson et al conclude that above 75 dB(A) but below 85 dB(A) "long-term exposure to noise has some effect but the amount of noise-induced threshold shift is so small as to be practically undetectable in individual cases and only measurable in a statistical sense. Moreover it is so small as to be overshadowed by the loss of hearing associated with advancing age, whether due to natural causes or the insults of daily living." [6]

Noise levels on the flight decks were between 70 dB(A) and 79 dB(A) L_{eq} averaged over a flight. Transatlantic flights (except on Concorde) were typically 7 to 10 hours in duration, and daily noise exposures ($L_{EP,d}$ or L_{EX}) would be numerically similar to the noise levels (L_{eq}) in dB(A). Short-haul flights were typically 5 to 6 hour round trips, including time on the ground, and noise exposures can be estimated by subtracting 1 or 2 from the noise levels. Such noise exposures would not be expected to pose a foreseeable risk of hearing damage.

Noise levels from headsets are the main concern. These were between 77 dB(A) and 89 dB(A) L_{eq}. On 80% of flights, levels were 80 dB(A) or higher, and on 40% of flights noise levels were 85 dB(A) or higher. Taking the duration of the noise into account, exposures over the working day will exceed 85 dB(A) $L_{EP,d}$ or L_{EX} on perhaps 30% - 40% of shifts. Such exposures, if regularly repeated over a long period of time, do present a risk of damaging the hearing of some flight crew. All potentially damaging exposures occurred with crew wearing the standard issue 'open ear' style of headset.

Although ambient levels on the flight deck may not directly damage hearing, the ambient levels do determine the minimum output level from a headset for satisfactory intelligibility. Crew members will set their volume controls above the minimum, according to personal preferences, other distractions, and the importance of incoming messages at each phase of the flight. Inspection of Table 1 shows that sound levels from headsets are not related to the ambient noise on the flight deck in any systematic manner: the higher headset outputs are distributed through the fleet and are not confined to 'noisier' aircraft. There is a need therefore to reduce noise exposures from headsets on all flights and aircraft types where the standard 'open-ear' headset is worn.

On those flights where circumaural headsets were routinely worn, and on the flight where the ANR headsets were trialed, the output sound levels of the headsets were 80 dB(A) or below. The passive or active attenuation of the background noise provided by these headsets permits a lower output volume to be used. The ANR headsets varied widely in performance. The two most effective, both lightweight supra-aural models, reduced A-weighted levels by 10 dB and 13 dB during flight. The model giving 10 dB reduction gave a consistent noise reduction which was very tolerant of variations in fit. That providing 13 dB had to be positioned very carefully on the ear to achieve its potential. Lightweight ANR headsets would be a more acceptable solution than a heavier passive headset for many flight crew on longer flights, but to achieve the maximum benefit, the headset will need to be worn on both ears.

5. CONCLUSIONS

Noise levels between 70 dB(A) and 79 dB(A) were measured on the flight decks of modern civil aircraft. Crew members in this environment select headset outputs which, in 30% to 40% of cases, will lead to daily exposures above 85 dB(A). Reducing noise at the ear by replacing the current 'open ear' headsets will permit lower headset outputs. A lightweight active headset would be a more acceptable solution to crew members than a heavier circumaural headset with passive attenuation.

6. REFERENCES

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