

CHAPTER 8

HELICOPTER ENVIRONMENTAL EFFECTS

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Introduction

1. The environmental problems encountered by the helicopter crew are not new; most of them are found to some degree in conventional aircraft. In the helicopter not only are all these problems present simultaneously but also the helicopter frequently has to be flown "hands on" for long periods of time. (Only those with autostabilizers or autopilots can be flown hands off and this precludes most light helicopters.) Accident risk is higher than in conventional aircraft, escape possibilities are limited and, in some helicopters, crash survivability is poor.

Temperature

2. Even within the European theatre, a helicopter may have to operate in OATs from -30°C to $+36^{\circ}\text{C}$. Within the UK, the seasonal temperature change may exceed 30°C . Such cabin conditioning as is fitted to current helicopters is inadequate; the situation is made worse as many roles require the helicopter to be flown with the windows open and some (mainly RN) with the doors removed.

3. For helicopters operating with windows and doors closed the possibility of incorporating cabin conditioning systems similar to those used in fixed-wing aircraft is being examined. Meanwhile, cabin heating modifications have been successfully tested in helicopters detached to the Northern flank of NATO.

4. Until substantial improvements in cabin conditioning are available the only practical approach to thermal problems is to provide personal protection to aircrew. Under cold conditions this includes the wearing of insulating under-coveralls and the use of electrically heated gloves and socks for which many aircraft have been modified to provide supplies.

Whole body electric suits are being remanufactured on a limited scale for possible application to RN helicopters and could be applied, if required, to some RAF helicopters. Under hot conditions the solution is more difficult since the air ventilated suit cannot be used. This situation will be aggravated by the wearing of chemical defence clothing assemblies and the only foreseeable satisfactory solution is the provision of liquid conditioned coveralls and supply systems.

Noise

5. Ambient noise levels of 115dB inside a helicopter are quite common. Some of the noise is aerodynamic, but most comes from the power train *ie* engine, gearbox and rotor blades. Another important source of noise is in the communications system. As the majority of the noise is of low frequency, conventional microphones are frequently unsuitable. The majority of helicopters use throat microphones and these cause considerable distortion of speech, although their signal/noise ratio is good. A boom microphone is usable if the helicopter is well soundproofed, but it would be unusable near open doorways or outside because of its limited noise cancelling properties. A further possibility is the use of a voice-operated electronic switch to improve the overall signal/noise ratio and intelligibility; such a system should incorporate individual automatic level controls, so that the switch will operate at a given point above the local noise level.

6. Even if the signal/noise ratio from the microphone is good, it is not possible to produce an acceptable ratio at the ear simply by presenting the signal at a very high level; the ear becomes non-linear in its response at high level and in any case, ear damage can result. It

is therefore vitally important to maximize the attenuation provided by the helmet.

Vibration

7. Helicopter aircrew are exposed to vibration with significant linear and angular acceleration components in the three orthogonal axes. The dominant frequency is a function of rotor speed and the number of rotor blades, and ranges from 12 to 18 Hz (dependant on aircraft type). The magnitude of the linear vibration is usually greatest in the g_z (vertical) axis and can be of the order of 6 m/s^2 ($0.6g$) in some aircraft during certain phases of flight. Vibration occurs mostly on transition to the hover but may also be substantial whilst in the hover and during high speed flight.

8. Vibration can give rise to the following:
 - a. Difficulty in reading aircraft instruments.
 - b. Difficulty in reading hand-held maps and charts.
 - c. Impaired ability to make fine positioning and control movements.
 - d. Generalized discomfort and early onset of fatigue.
 - e. Specific symptoms viz backache, teeth chatter and flutter of facial muscles.

Thus vibration may impair operational effectiveness of helicopter aircrew by degrading performance, increasing work load and engendering fatigue.

Comfort and Controls

9. The combination of current AEAs and crew seats give rise to discomfort, particularly backache. Present seat and yaw pedal adjustment are often insufficient to cater for the extremes of pilot size. Thus there is considerable scope for improving crew comfort and the position of the pilot's controls. All the following points could be incorporated in future helicopters and some in current designs:

- a. The development of a standard crew seat which would incorporate provision for a hard shell PSP and a parachute pack as standard.
- b. If armour is required for the crew it should be designed into the seats rather than being added on as an afterthought. This would result in a significant saving of weight.
- c. Five-point harness for all crew seats, to minimize the effect of vibration and prevent "submarining" in an accident.
- d. Re-locate the collective lever on the side of the pilot's seat.

- e. Reduction of the range of control movements.

10. In larger Service helicopters in which mechanical reversion is impossible an improved control configuration could be obtained by discarding the present controls. They could be replaced by a single miniature controller which could control the helicopter via the autopilot. Such a controller could, for instance, provide the cyclic function in the conventional sense, the collective function by a thumbwheel and the yaw function by rotating the knob. This concept is not new; a miniature controller is fitted to the gunners cockpit of the Huey Cobra, although this carries out the cyclic function only. The collective control is also miniaturized and mounted on the left hand side of the seat.

Disorientation

11. Helicopter aircrew experience illusory sensations of aircraft motion and attitude which are, in general, similar to those reported by pilots of fixed wing aircraft. However, because the helicopter lacks inherent aerodynamic stability, recovery from an abnormal attitude or control error precipitated by disorientation, must be actively pursued by the pilot. In addition, because flight is commonly at low altitude, there may be little time in which to make the necessary recovery action.

12. When in the hover, the pilot has to maintain attitude in pitch, yaw and roll, as in a fixed wing aircraft, but also has to minimize translational motion in three orthogonal axes. Without reliable visual cues the pilot is unable to maintain accurate and stable hover, because the angular and linear motion stimuli are below the threshold for detection by his sensory system. Thus disorientation commonly occurs when the pilot attempts to hover in conditions where external visual references are degraded, or absent, as when flying at night, or in cloud, fog, snow, dust or smoke. In such conditions, correct orientation requires the use of instruments but scan can be disturbed and disorientation ensue when the pilot transfers from instrument to external visual reference and vice versa. His difficulties can be compounded by vibration which may impair visibility of the aircraft instruments.

13. In order to maintain accurate hover without using instruments, the pilot must have a stable and discernable ground reference. At night, a single light on the ground is inadequate for the correct appreciation of height, and it may give rise to a false perception of motion

due to the "autokinetic illusion". Flight near moving light sources (eg on a motor vehicle or on another aircraft) can also disorientate because of error in the appreciation of relative motion. Even when the ground is illuminated by lights on the helicopter, problems can arise if only a small area of ground is picked out by a narrow beam of light; furthermore at heights, typically greater than 100ft, ground texture is lost and other visual cues should be employed. When hovering over the sea, the wave pattern generated by rotor downdraught can, by its relative motion, produce an illusory sensation of backward motion. Likewise, when at low altitude over water or snow, the movement of spray or snow downwards through the rotor can be interpreted as ascent of the helicopter.

14. Blade flicker is more commonly a cause of distraction and irritation than disorientation, though at times the repetitively moving pattern of light within the cockpit does give rise to an illusory sensation of rotation (vertigo) in the opposite direction to that of the visual stimulus. A more frequently reported cause of disorientation and distraction when flying in cloud, fog, rain, snow *etc* is the back scatter of light from the helicopter's anti-collision beacon into the cockpit. In such flight conditions the reflected light, apart from giving inappropriate visual motion stimuli, degrades visibility of external visual cues and may necessitate transfer to flight instruments. Flicker induced epilepsy is a very rare condition and susceptible individuals are not accepted for aircrew training.

15. Illusions reported by helicopter aircrew attributable to physiological limitations of inner ear (vestibular) mechanisms are similar in character and incidence to those described by pilots of fixed wing aircraft. The 'leans' (a false sensation of roll attitude) is by far the most common, though an illusory sensation of turn on recovery from a sustained turn is also a frequent occurrence. In addition, false sensations of turn and attitude change are evoked when a head movement is made in a helicopter which is turning or when the aviator is exposed to an abnormal force environment (*ie* linear acceleration other than 1 g). Typically, these varied manifestations of vestibular disorientation are experienced only when flying on

instruments or when flying by marginal external visual references as at night or in poor visibility conditions.

16. Feelings of detachment, isolation and estrangement (the "Break-Off" phenomenon) are experienced by helicopter pilots, typically, during the more monotonous phase of a sortie when flying solo in conditions where external visual references are not well defined (*eg* smooth sea, hazy indistinct horizon) and there are few cues of relative motion. The flight environment conducive to the induction of sensations characteristic of the "Break-Off" phenomenon is similar to that found in fixed wing aircraft, though, notably, in helicopters "Break-Off" is not confined to high altitude flight but can occur quite low (500 ft agl). The commonest sensation is one of being "suspended in space" or "balanced on a knife edge", though the feeling of detachment can be more severe and the aviator may even feel that he is separated from the aircraft. Coupled with such "dissociative" sensations there is frequently a heightened awareness of changes in aircraft orientation, though frank disorientation with illusory sensations of attitude and motion are quite rare.

Accidents

17. Overall, the risk of fatalities in helicopter accidents is 3 times that in fixed wing aircraft. Half of helicopter accidents have occurred at heights of less than 100 ft and a further 30% between 100 ft and 500 ft. Provided that a crewmember could be clear of his helicopter by 500 ft agl, a conventional parachute would ensure survival, but this would be of use in only 20% of accidents. Below this height, some means of assisted escape should be fitted or the helicopter design should ensure that the ensuing impact is survivable. Further details of helicopter escape systems are given in Part 2 Sect 3 Chap 4 of this volume.

18. **Impact Survivability.** Present helicopters are built to low standards of crash impact survivability, much lower than fixed wing aircraft. In particular the seats and associated fixtures are designed to fail at a quarter of the force that the human frame can withstand. If the strength of the seats, harness and aircraft structure were brought up to fixed wing standards, the survivability of impact accidents would be nearly doubled.

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