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Modern Approaches to the Problem of Noise as an Ecological Factor in Aviation Medicine

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The aim of our work was to assess the specific effect of noise on the body of aviation specialists servicing modern aircraft by means of a dose related approach; the determination of ND24; the search for correlation dose effect relationships and the development of a system of preventing the effect of noise on the specialists.

In aviation the problem of preventing the harmful effect of noise and protecting the flight and technical engineering staff and also the civil population living near airports is of high current importance 12. 3. 5. 7]

The effect of noise has noticeably increased in recent years in connection with the rise in the engine power of modern aircraft [4]. The noise which reaches levels of 130–140 dBA in the near sound field acts not only on the hearing but also on the body as a whole reducing the quality and reliability of the activities of aviation experts [6. 7]. The most unfavourable acoustic conditions are experienced by engineering service ersonnel (ESP) since they spend a long time in the zone of action of intense aviation noise [5 6]. In addition to the acoustic load during the period of work a considerable fraction of aviation personnel are also subjected to the effect of noise in the off–work time because of the increase in noise levels particularly in residential towns situated near airfields.

In this connection all approach to noise as an ecologically significant factor has been formulated in recent decades. It foresees calculation of the total 24–hour average noise dose (ND_{24}) with allowance for the nature of the work rest and sleep of the subject ($ND_{24} = ND_{wrk} + ND_{rest} + ND_{slp}$) [1. 8]. However at present the approach to noise as an ecologically significant factor using the concept of ND_{24} has not receive the necessary development in aviation medicine.

The aim of our work was to assess the specific effect of noise on the body of aviation specialists servicing modern aircraft by means of a dose related

Table 1. Diurnal distribution of Noise Load for ESOP

Indicator, unit of measurement	Work period		Rest period	Sleep period
	technical aircraft crew	ESP service group personnel		
L_{eq}LPL, dBA	$\frac{98–107}{80}$	$\frac{87–94}{80}$	$\frac{64±3}{60}$	$\frac{59±3}{40}$
D_{24}/LPD, Pa^2.h	$\frac{20 – 160}{0,32}$	$\frac{1,6 – 8}{0,32}$	$\frac{4x10–16x10}{3,2x10}$	$\frac{13x10–51x10}{3,2x10}$
L_{eq}–L_{LPL}, dBA	18–27	7–14	4±3	10±3

approach; the determination of ND_{24}; the search for correlation dose–effect relationships and the development of a system of preventing the effect of noise on the specialists.

Method.

The equivalent noise levels at the work places of ESP were determined in accordance with the "Methodological indications for making measurements and health related assessment of noise at work places" No. 1844–78 (Ministry of Health of the USSR) by precision equipment from Bruel and Kjer (Denmark). The measurement on a housing site were carried out in accordance with GOST 22283–88 "Aviation noise. Permissible noise levels on housing sites and methods for their measurement" and in buildings in accordance with GOST 22337–78 "Noise. Methods of measurement on a housing site and in residential and common buildings". On the basis of the measurements we calculated the service total noise levels in accordance with D. Robinson's equation, which is included in "Methodological indications on the dose assessment of industrial noise" (Ministry of Health of the USSR), the noise doses during work, rest and sleep and also ND_{24} in accordance with "Methodological recommendations on the health related assessment of industrial and non–industrial noise load" (Ministry of Health of the USSR). The audiometric study was made using the OB–70 audiometer produced by Madsen Elektronics (Denmark). We examined 208 ESP servicing modern aircraft. They were divided into two groups: technical aircraft crew and service personnel. The impedansometry was carried out by means of a Madsen Elektronics model Z 073 A instrument with an Z 710 B x–y automatic plotter from Hewlett Packard (USA). This method was used to study 156 ESP and 121 people from a control group having no exposure to aviation noise.

Under laboratory conditions involving 12 otologically healthy volunteers we simulated the action of acoustic loads equivalent to the ND_{24} of the ESP. In 24–hour experiments we carried out dynamic audiometry and recorded a number of indicators of the psycho–physiological status–the critical light flicker frequency, reactions to a moving object and a simple sensorimotor reaction.

Results.

In the analysis of the noise load over a working shift using a noise analyser and individual dosimeters we found that the equivalent level at the work places of the ESP forming part of the technical crew (first group) was from 98 to 107 dBA and for ESP of various service groups (second group) it was from 87 to 94 dBA. The equivalent noise levels in periods of rest and sleep were 64 + 3 and 59 + 3 dBA respectively in our studies. The amount by which the limiting permissible levels were exceeded were from 7 to 27 dBA during work, 4 + 3 dBA during rest and 10 + 3 dBA during sleep. We calculated the noise doses during work, rest and sleep and also ND_{24}. The average data for the equivalent levels and the noise doses are given in Table 1. For all three periods the permissible doses are exceeded. The total ND24 for those in the technical aircraft crews was 105.3–664 Pa^2.h and for service group ESP it was 49.3–178 Pa^2.h. The most significant periods in relation to the magnitude of the noise exposure are work and sleep.

Thus, the use of the ND24 concept makes it possible to more fully characterise the actual acoustic load on the different categories of aviation personnel. We carried out tonal

Table 2. Indicators of the Permanent Shift in the Hearing Thresholds of ESP (M ± m)

Occupational group	Length of service (years)	Noise dose level, dBA	PSH indicator at frequencies	
			Average over sum of frequencies . . . $\frac{500+1000+2000}{3}$	4000 Hz
Technical aircraft crew	up to 1	100	7,5±0,6	12,5±1,8
	1–4	107	13,4±0,7	17,0±1,0
	5–9	112	14,1±0,5	22,6±1,4
	10–14	114	17,8±0,7	33,5±3,0
	> 15	116	21,4±0,6	40,9±2,1
ESP service group personnel	up to 1	88	7,2±0,7	10,8±1,4
	1–4	95	10,3±0,4	12,8±1,1
	5–9	100	11,7±0,6	17,3±1,2
	10–14	102	16,4±1,2	24,3±2,7
	> 15	104	17,1±0,5	32,0±3,5

Table 3. Impedansometry Indicators of ESP and Control Group

Indicator	Control group	ESP
Timpanogram amplitude, mm	93,0±2,4	79,9 ± 2,0 *
Relative gradient, rel. units	0,44±1,2	0,43 ± 0,12
Shift of timpanogram, mm water st.	-25,0±1,2	-28,0 ± 1,4
Threshold of ipsilateral AP, dB	88,3±0,5	91,4 ± 0,4 *
Threshold of contralateral AP, dB	90,6±0,8	94,4 ± 0,5 *
Average amplitude of ipsilateral AP, mm	15,7±0,6	13,5 ± 0,5 *
Average amplitude of contralateral AP, mm	15,4±0,6	13,8 ± 0,5 *

threshold audiometry to determine the dynamics of the hearing thresholds as functions of the length of service and the total service doses. The permanent shifts in the hearing thresholds at speech frequencies (PSH_{sp}) and at a frequency of 4000 Hz (PSH 4000) as functions of the length of service and total service doses are shown in Table 2.

For ESP servicing modem aircraft there is a statistically average increase in the hearing threshold at speech frequencies of more than 10 dB even for 1–4 years of work, which corresponds to the first degree of loss of hearing according to GOST 12.4.062–78. Audiometric symptoms of the second degree of hearing loss were found in technical aircraft crew who had worked for 15 years and more.

The correlation analysis revealed a significant positive relation between PSH_{sp} and PSH 4000 and the levels of total service noise dose; in this connection we calculated the corresponding regression equations of the thresholds of hearing (y) against the average total service noise dose levels (x). They have the form:

- for technical aircraft crews: at speech frequencies—y = ~ 70.1 ± 0.77x; at a frequency of 4000 Hz—y = ~ 157.2 ± 1.66x
- for technical service group ESP: at speech frequencies—y = ~ 47.5 ± 0.6x; at a frequency of 4000 Hz—y = ~ 97.4 ± 1.2x.

In the impedansometry after 7 h of work in noise, we recorded in ESP an increase in the threshold of the acoustic reflex and a reduction in its average amplitude at stimulating signal intensities of + 10, + 15 and + 20 dB over the threshold (signal frequency of 1000 Hz). The average values of the principal impedansometry indicators obtained in an examination of ESP are shown in Table 3 in comparison with the control group of people. The data indicate the development in the ESP under the action of noise of disturbances in the neuromuscular apparatus of the middle ear, which impair the physiological defence of the organs of hearing against intense noise. These changes progress with increase in length of service and service noise doses. To analyse the interconnection between the temporary shifts in the hearing thresholds and the noise dose, we carried out dynamic audiometry under laboratory conditions with simulation of ND_{24} equivalent to the actual acoustic loads of ESP servicing modern aircraft. We found that the noise dose adequately reflects the specific reaction of the auditory analyser during the work period. However, in the non–work period, despite the increase in the total noise dose, there is restitution of the hearing thresholds. In this connection, together with the noise dose, we have suggested that for the analysis of the specific effect on the organ of hearing the dose increment coefficient should be used. The value of this indicator is proportional to the change in the noise dose per unit time and can be calculated from the equation:

$$K(t) = |ND(t_1) - ND(t_2)|/|t_2 - t_1|,$$

Where K(t) is the noise dose increment coefficient; and $ND(t_1)$ and $ND(t_2)$ are the noise doses after time.s t_1 and t_2.

The noise dose increment coefficient adequately reflects the specific reaction of the auditory analyser in response to the acoustic load in all three periods (work, rest, sleep).

The calculations showed that the probability of loss of hearing as a function of the length of service varies amongst the ESP from 0.1 (1 year of service) to 0.96 (27 years of service) and the probability of the appearance of neuro–vascular disorders varies from 0.2 to 0.7 for 1 and 27 years of service respectively. Earlier appearance may be noted under the action of noise of neuro–vascular disturbances which are more widespread than loss of hearing for service times greater than 6 years. After this time, the probability of hearing disturbances developing takes the first place.

The main positive measures for prophylactics include:

- improving standards, including the assessment of the noise dose and ND_{24};
- relating specific chances in the organs of hearing under exposure to noise with the noise dose increment coefficient;
- allowing for the stressfulness and severity of work of aviation personnel in the determination of the limiting permissible noise levels;
- limiting the intensity of flights and transport movement at night;
- introducing architectural planning measures. the most important of which is limitation of construction near airports;
- Improving means of individual and collective protection.

Conclusions.

1) A study has been made of the actual acoustic load on aviation specialists connected with the technical servicing of modern aircraft. It has been shown that the health related noise norms are exceeded during the different periods of activity of this set of people, especially during work and sleep.

2) The audiometry indicators of the ESP have revealed the dependence of the hearing thresholds on the total service noise dose. This has made it possible to calculate the correspondinc regression equations, which can be used for purposes of prognosis.

3) For a more adequate assessment of the relation between loss of hearing and noise dose it is convenient to use the noise dose increment coefficient.

4) Intense aviation noise has a significant harmful effect on the neuro–muscular apparatus of the middle ear, as recorded by means of impedansometry.

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Assessment of the Effect of Noise on the Functional State of the Human Body

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The aim of the work described here was to assess the effect of various noise parameters on a set of psycho physiological indices in humans and to determine the most informative indices for the action of the different noise characteristics.

The noise factor and its effect on the human body has been the subject of a number of recent studies. A relatively large number of communications consider the vegetative changes caused by noise, with particular attention given to the peripheral blood supply, the arterial pressure (AP) and the heart contraction rate (HCR). However, the data quoted by the different authors are contradictory. An increase in the AP under exposure to noise has been established by many authors [1, 3, 4, 6, 9], but a reduction in this index has also been noted in a number of works [1, 7, 9, 10]. It should be noted that the majority of these studies refer to workers subject to different noise levels and different sets of factors specific for the various working conditions and processes. Contradictory data are also found for the effect of noise on the HCR. A.A. Arkad'evskii [2] found a reduction in the HCR in 85% of people participating in an experiment. The tendency established by Ya.l. Moskov [8] for a reduction in the HCR under noise exposure confirms the observations of A.A. Arkad'evskii [2] and T.A. Orlova [8, 9].

In a study of the variability in the HCR (sinus arrhythmia), considerable individual differences are noted in the degree of severity.

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