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.

J.H. Ettema and J.W. Kalsbeek [13]

report on a reduction in the sinus arrhythmia with a noise level of 80 and 90 dBA. In a study of the effect of white noise with a level of 75–110 dBA on the HCR and its variability, S.G. Danev [5] did not discover any significant changes in these indices for an exposure time of from 2 to 3 hours.

S.S. Stivens [15], in a long term experiment with 5 people exposed for 1 year to the effect of aircraft noise of 90 and 115 dB for 7 hours a day, could not with accuracy determine any effect of the noise on the breathing rate (BR). The author notes that in this experiment the effects of many factors were mixed and therefore it is impossible to come to any definite conclusion.

E. Grandjean [11] expressed the opinion that under the effect of noise the BR can be increased for a short time before or after ovulation. On other days this type of reaction was not recorded or was negligible. M.V. Strumzu [16] observed under constant noise of intensity less than 80 dB and shortening a rate increase in the breathing.

B. Griepfhahm [12] was of the opinion that the breathing rate increases under the effect of noise but does not confirm this view experimentally.

T.A. Orlova [9] analysed the opinions of a number of authors in relation to the changes which occur in different organs and systems under the influence of noise. According to the data, noise leads to a reduction in attention and memory, lengthens the motor reaction time to audio and light signals, leads to fatigue of the visual analyser, changes the electrical sensitivity of the eye, reduces the stability of the visual acuity, and changes the sensitivity of the eye to various light spectra and to daylight. In the presence of noise there is deterioration in the responsive reactions to visual and audio signals, the coordination of motions, the accuracy in judging distances with movement of the hands, and the muscular force required in particular operations and manipulations [8].

The action of noise leads to a lengthening of the time taken for problem solving. There is an increase in the number of errors. This reaction is observed for a relatively small noise intensity of 75 dBA. An increase in the latency period was observed for a noise level of 94–120 dBA. L.R. Hartley [14], in considering the effect of noise on performance, found negative changes–continuous noise produced twice as high an increase in the number of errors in the motor reaction of responses as impulsive noise. Noise also produced a negative effect in relation to the processing of information. For a level of 75–90 dBA, the amount of visual information processed (expressed in bits/s) was significantly reduced. In the solution of problems with an intellectual load under exposure to the noise factor, there is an increase in the number of errors made and a lengthening of the time taken to carry out the tasks.

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.

For this purpose we carried out experimental and industrial studies of people exposed to noise of a continuous and interrupted nature. Under laboratory condi ons, we arranged exposure to continuous noise of levels 94–97 and 96–99 dBA with linear characteristics. The impulsive noise had rapidly increasing and decreasing energies in the individual exposure periods with equivalent levels of 84.2, 88 and 60 dBA. We examined 12 normally healthy people. The experimental scheme included the following stages: 1) adaptation– 10 min. 2) noise free conditions – 5 min; 3) noise load – 15 min; 4) noise free conditions – 5 min. In addition, control studies were made without a noise load.

Under industrial conditions the noise levels varied over a wide range: I) L_{eq} of 60–65 dBA, 2) L_{eq} of 66–70 dBA, 3) L_{eq} of 72–92 dBA, 4) L_{eq} of 92–100 dBA. We examined 156 control board operators. In the experiment we studied the following indices:

1. Analysers: auditory differential modulation perception threshold; differential sound force perception threshold via tonal threshold audiometry; visual threshold of electrical sensitivity by means of a rheobasometer.
2. Cardiovascular system: HCR and its variability by means of a recording of the electrical potentials, AP (systolic, diastolic, pulse).
3. Respiratory system: BR, recorded by means of a thermistor device.
4. Central nervous system: perception and processing of visual information by the Medvedev, Genkin and Shek method .

All the studies were carried out under experimental conditions – with and without the noise – and under industrial conditions as a time variation (at the beginning and end of the working day).

In order to establish the changes in the indices of the functional state of the auditory analyser, we used the “differentiating capability”, which can be expressed as the increase in the differential threshold (DT) of the height and strength of the sound. The DT of modulation perception is normally ± 0.5–1.0. After 8 h of exposure to noise it increases sharply and remains at a high level after work. Thus, for a noise intensity L_{eq} of 100 dBA, the DT increases to 1.8; for an L_{eq} of 98 dBA to 1.7 and for varying noise can be as high as 1.96 ($p < 0.005$).

An increase in the DT of perception of modulation leads to a weakening of the internal delay processes in the auditory analyser under the effect of noise.

In order to find the changes in the indices of the differentiating capability of the ear in the perception of sound we carried out tonal audiometry on 156 operators. We found the maximum reduction in hearing in the group of operators with the greatest length of service under noisy conditions. Thus, at a frequency of 4000 Hz, the auditory threshold was 34.4 dB; at 2000 Hz it was less – 24.6 dB and at 1000 Hz, still less – 12.5 dB. At 500 Hz it was practically unrecordable at 7.5 dB.

It was found that as the noise exposure increased, the number of operators with good hearing decreased and in the group with more than 20 years of exposure reached 48.48%, i.e. in more than half the subjects we recorded changes in the DT of sound perception indices in the principal speech frequency range. The correlation obtained was direct and high (K = 0.81).

A moderate and significant reduction in the functional capability of hearing [9] was noted mainly in the group with a considerable length of service under conditions of noise. We also recorded a high degree of positive correlation between the length of the noise exposure and the number of cases with degrees III and IV of loss of hearing.

The changes in the indices of the functional state of the visual analyser are expressed in terms of a reduction in visual acuity, which indirectly revealed itself in a significant increase in the threshold of electrical sensitivity of the eye after a noise exposure from 52.13 to 65.7 MA with $\rho < 0.001$. These changes are most pronounced for a noise regime of 66–70 dBA intensity. The deterioration in the threshold of electrical sensitivity of the eye (TES) in the operators correlates with the noise intensity. Thus, the TES increases from 0.77 arb. units at an L_{eq} noise level of 60 dBA to 1.42 at an L_{eq} of 65 dBA ($t = 3.84$), to 1.36 at an L_{eq} of 75 dBA ($t = 4.12$). These facts s uggest that intensive noise plays a decisive role in the deterioration of the TES.

Under the effect of the continuous noise used in the experiments, the HCR decreases significantly. There is no proof that this relative reduction (on average by 2–3) has any special significance for the body. With interrupted noise we noted a minimal, but statistically significant, slowing down of the HCR ($\rho < 0.05$). In the noise free regime following the noise load, the initial values of the HCR were re–established.

Continuous noise did not give a stronger effect than interrupted noise. In the determination of the variability of the HCR by the Ettema–Kalsbeek method [13], we found that continuous noise does not have any effect on the sinus arrhythmia while interrupted noise does and the arrhythmia decreases significantly but does not reach its initial value during thc 5 minutes after the end of the noise exposure.

Under the laboratory conditions in the study of continuous noise we recorded statistically significant differences of 6.3 mm Hg st. ($\rho < 0.005$) in the diastolic AP indices before and after the exposure to noise. There was no significant change in the systolic AP indices. Significant changes of 5 mm Hg st. ($\rho < 0.005$) in the AP indices under noise load conditions and in the noise free regime after it, were again found only in relation to the diastolic pressure.

Statistically significant differences ($\rho < 0.01$) of 9.3 mm Hg st. were obtained in relation to the pulse AP in the noise free regime before the load and in the regime with the noise load. Also significant ($\rho < 0.005$) were the differences (87.1 mm Hg st.) in this index in the regime with the noise load and in the noise free regime after it. With exposure to interrupted noise, we found statistically significant differences between the noise regime before the load and the regime with a load in terms of the following indices: diastolic pressure (+ 4.5 mm Hg st.), systolic (–4.8 mm Hg st.) and pulse (–9.3 mm Hg st.). In the study of the AP such differences were recorded between the regime with the noise load and the noise free regime after it only in relation to the systolic (4.2 mm Hg st.; $p < 0.05$) and pulse (7.3 mm Hg st; $p < 0.05$) AP.

We believe that the diastolic AP changes in the study of the action of these types of noise, i.e. it increases under exposure to noise. It is also worth noting that in the short noise free period after the noise load, it does not recover, i.e. it does not reach the initial values. In our opinion, the increase in the diastolic AP after the noise exposure and the residual effect which is observed after the end of this exposure have a definite influence on the state of the health of the subjects. The results of our studies suggest that noise is a potential factor capable of causing hypertension in humans. Under industrial conditions, where other factors are also acting on the people, considerable individual differences are recorded, and the AP and the pulse rate are not indicative (see Table 1).

Under the effect of the types of noise used there is a significant increase for the experimental conditions of 1.3–2.6 per minute in the BR.

The results of the studies of the visual information processing by the Ettema–Kalsbeek method (600 signals/15 min) under exposure to continuous noise show a difference of 1.3% ($\rho < 0.005$) between the incorrect answers in the noise free and noise regimes. With exposure to interrupted noise we observed statistically significant differences in the indices for the control studies in the noise free regime and in the noise regime:

a) in relation to false answers – an increase in the number of on aver age: –2.9,–8,–12 ($p < 0.05$);
b) in relation to the absence of differences in the answers – an increase on average of –3.3, –1, –8 ($p < 0.005$);

c) in relation to inaccurate answers – an increase in the number on average of –6.3, –5, –20 ($p < 0.005$).

It should be noted that there are no qualitative or quantitative differences between the results of the processing of visual information (especially in the study of this effect) under the action of noise of a continuous or interrupted nature of various levels: L_{eq} of 94–97 dBA and L_{eq} of 84 dBA. In both cases the noise levels exceeded the limiting permissible norms for industrial noise in populated places.

In a study of the effect on the automated process operators, it was found that for noise conditions in the range of Leq of 72–92 dBA one can observe a reduction in the rate of perception of processed information from 1.74 to 1.64 bits/s. Simultaneously, there is also a reduction in the quantitative index of the perception of visual information from 706.5 symbols before the noise exposure to 583 symbols after it. These changes in the information processing indices under noise exposure show that intensive noise impairs the rate and quality of work and this is a precursor for impairment of the optimum operator–machinemedium systemrelation.

Conclusions.

1) The most informative indices of exposure to noise are:

- for analysers: the auditory differential threshold of modulation perception and the strength of the sound; the visual threshold of electrical sensitivity;
- for cardiovascular system: the diastolic arterial pressure, the variability of the pulse rate; the respiratory system – the breathing rate; central nervous system – the perception of processing of visual information.

2) The dependence of the changes in the indices investigated on the nature of the noise has been found.

3) The changes in the most informative indices can be used in the determination of criteria for assessing the action of noise.

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LEARNING INHIBITED

The steady rumble of traffic or a continuous murmur of urban background noise can be enough to raise children's blood pressure, affect motivation and lead to “learned helplessness” syndrome, scientists report. A study commissioned by the Austrian Ministry of Health found that children in areas with average residential noise levels had raised blood pressure, heart rate and levels of stress hormones. “Non-auditory effects of noise appear to occur at levels far below those required to damage hearing,” said Peter Lercher, associate professor of social medicine at the University of Innsbruck's Institute of Social Medicine. Previous research has been on the effects of excessively loud noise on health. The latest study, conducted with Gary Evans, professor of human environment relations at Cornell University in New York state, is the first to look at low intensity noise. “We are really not looking at loud kinds of noise. They are typical levels found throughout neighbourhoods in Europe,” said Prof Evans. Prolonged exposure to noise that children have no control over appeared to lead to learned helplessness syndrome, the researchers report. People who suffer from learned helplessness syndrome do not respond to stressful situations, becoming listless, depressed and demoralised. “Girls seem to be a little more vulnerable to learned helplessness,” said Prof Evans.