The Method of Assessing the Acoustic Safety of the Crew of an Aircraft of State Aviation

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***Abstract*— The technique of acoustic safety assessment of the crew of the aircraft of state aviation, developed for solving the problems of applied aviation medicine, requiring information on the functional reliability of the professional activities of aviation specialists in the context of aircraft noise, is presented.**

Keywords*— *acoustic safety of aviation specialists; reliability of aviation specialists; aviation acoustics; aviation medicine; automated environmental monitoring

I. Introduction

A scientific and technological progress contributes to the increase in the capacity of industrial equipment, accompanied by an increase in unfavorable factors in the conditions of personnel. The leading place among such factors is noise: more than two million Russians work in conditions of increased impact of acoustic fluctuations (noise, infrasound and ultrasound), about 25% of workplaces of the industry personnel do not meet the noise standards [1, 2].

In most cases, it is not possible to ensure the acoustic safety of personnel by reducing the noise level in the source of education, since a decrease in the capacity of the equipment reduces its productivity. In this case, the most acceptable way to increase the acoustic safety of personnel are technologies that ensure its individual and collective protection against noise [3].

The most acute problem of ensuring the acoustic safety of personnel is in aviation, the progress of which leads to an increase in the intensity and exposure time of aircraft noise that has characteristic features [4–6]:

- broadband spectrum with the presence of several maxima of power spectral density in low-, medium- and high-frequency sound ranges with a pronounced infrasound component;
- the sound pressure levels in almost all octave frequencies exceed 100 dB, which makes it possible to classify noise as high-intensity;
- the noise effect is cyclical – the periods of the active load last from several tens of minutes to several hours and alternate with pauses, the duration of which varies within the same limits.

The technical progress in engine building, which resulted in a significant increase in the power density of aircraft, led to a significant increase in the power of adverse (for human) acoustic effects in the infrasonic and sound frequency bands. The available data make it possible to consider aircraft noise as an unfavorable production factor, which can cause aircraft incidents due to erroneous flight operations, caused by a decrease in their performance due to uncompensated noise influence [1–6].

It is known that due to the influence of noise, not only does workability decrease, but also the functional reliability of professional activity [7–10]. The quantitative basis of this measure of the influence of external production factors on the reliability of workers' activities is the risk of adverse effects (disruption of activity, erroneous actions, etc.) – potential unreliability of activity (PND) [11–17].

The purpose of the work: to assess the possibility of using the indicator – the potential unreliability of the action - as a criterion for assessing the performance of aviation professionals under the influence of high-intensity noise.

II. Methods of Research

Monitoring acoustic safety involves evaluating environmental noise, including specific (associated with the investigated noise sources) and residual (ambient noise without the presence of specific noise) [4]. An obligatory part of any program to provide acoustic safety is the conduct of objective acoustic measurements. The rules and standards define the indicators that are to be measured and, in most cases, set

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recommendations for tuning the measuring equipment depending on various factors (meteorological, climatic).

Typical are acoustic measurements that perform: at a great distance from the facades of buildings and obstacles, on the leeward side, in dry weather at a wind speed of less than 5 m / s, with the placement of a microphone at an altitude of 1.2–1.5 m above ground level.

As an indicator of industrial noise, the International Standard ISO 1996-2 defines the magnitude of the noise effect, corrected taking into account a number of factors that increase the degree of stimulation (pulsed nature of noise, time of day, etc.) and it is established that boundary estimates should be determined depending on time intervals, related to the characteristics of the source / sources and the receiver / receivers of noise. The calculation of noise levels due to the large amount of data, characteristic for acoustic measurements in real time, is automated.

During acoustic monitoring, computer environment models are frequently used, indicating identified noise sources, topographic parameters and terrain features that affect the propagation of noise to the points of interest (receiver).

Modern automated equipment for acoustic measurements can function in the field in the absence of maintenance personnel, record environmental noise levels by sending reports via a wireless protocol. The operator's participation in the acoustic measurement procedure is necessary when monitoring acoustic acoustics in difficult conditions: time is limited, access to the measurement site is difficult, it is impossible to connect the equipment to the network or the power supply is supplied in pulsed mode, an unexpected event occurs or the measurement is interrupted and the operator can not perform repeated measurement.

In most cases of monitoring the acoustic safety of personnel, a combination of measurements with the participation of the operator with measurements in automatic mode is rational. In this case, the presence of the operator during the measurements in the experimental studies and in the instantaneous checks on the measuring platform is mandatory, and the automated measurement mode is used for long-term or continuous monitoring of acoustic safety.

The PND indicator was used as a performance criterion. It was shown in [11-17] that the PND reflects the degree of noise influence on the reliability of the activity. To calculate this indicator, mathematical models have been developed that determine its dependence on the level of aircraft noise in the workplace:

$$\mathrm{PND} = \begin{cases} 0,5 - \Phi\left[\left(L - 134,02\right)/42\right], \left(L - 111,33\right) \le 0, \\ 0,5 - \Phi\left[\left(L - 116,03\right)/8,67\right], \left(L - 111,33\right) > 0, \end{cases}$$

where Φ – is the Laplace function, L – is the noise level, dBA.

The curve of the event probability model with an increase in the noise level to 110 dBA is of a hollow-ascending nature, and at higher levels it acquires an exponential form.

This model was used to calculate the PND estimate for flight crews exposed to noise during flights and for engineering personnel serving aircraft on ground conditions during preflight preparation.

III. Noise influence on the reliability of professional activity of aviation specialists

To calculate the PND, the results of acoustic measurements at workplaces of the flight-lift during the flight of the aircraft were used: the sound level is in the range of 84–104 dBA, and the sound pressure level from 59 to 112 dB. In most cases, the values of these parameters exceeded the maximum permissible levels. For aircraft of military transport aviation (AN-12, AN-24, AN-22, IL-76), helicopters (Mi-4, Mi-8) and fighters used the maximum permissible sound levels (85 dBA) change from 4 to 8 hours. Exceeding the maximum permissible sound levels for these types of aircraft was from 7 to 19 dBA, from 4 to 18 dBA and 18 dBA, respectively. The value of PND ranged from 0,12 to 0,24 units.

For long-distance aircraft, the maximum permissible levels for the sound pressure level and sound level were chosen for the duration of the noise impact for more than 12 hours, which corresponds to the time of the combat missions assigned to this type of aircraft. In all octave bands, ultrasound devices exceeded the maximum permissible levels from 2 to 18 dB. The excess of the sound level was 22 dBA in comparison with the maximum permissible level (75 dBA). The probability of errors (the PND index) in the crews of long-range aviation did not exceed 0,23 units.

The conducted measurements of aircraft noise in the cockpit of one of the long-range aircraft after modification of the engines showed that the aircraft noise levels in the cockpit during the flight were in the range from 111 to 120 dBA, which exceeds the maximum permissible sound level for a duration of exposure from 12 hours and more. Calculation of the PND index has shown that its value lies in the range from 0,28 to 0,62, that is, there is a high probability of a danger of erroneous actions on the part of crew members and can lead to negative consequences in flight.

IV. The discussion of the results

Noise, being a general biological irritant, affects all organs and systems of the body. This provision fully applies to aircraft noise due to its specific features [4, 5, 18, 19]. In the study, mathematical models were used to calculate the PND estimate for aviation specialists exposed to high-intensity noise during the flight shift. The conducted measurements of aircraft noise in aircraft cabins showed that the noise levels at the flight-and-lift workplaces during the flight were in the range from 84 to 120 dBA, which in most cases is higher than the maximum permissible levels. Calculation of the PND index has shown that it is in the range from 0,28 to 0,62, that is, there is a high probability of the danger of erroneous actions by flight crews and can lead to negative consequences in flight, especially for long-distance crews when flying for many hours.

A similar situation is observed in the engineering and technical staff, at workplaces where the sound level reaches 120 dBA, and the PND values fluctuate from 0,27 to 0,67 units. The maximum value of the PND is reached by the engineering and technical staff of long-range, fighter and assault aircraft.

The impact of acoustic factors has an adverse effect not only on the operability and reliability of the action of aviation specialists, but also contributes to the development of occupational pathology, which, in turn, can exacerbate adverse noise effects [4–7]. The study of the health status of aviation specialists showed that they have an increased incidence of hearing, vision, cardiovascular system, respiratory organs, etc. The main cause of this pathology development is the presence of harmful factors in working conditions, among which noise and infrasound occupy a leading position.

V. Conclusion

The conducted research indicates that aircraft noise is a source of potential danger, which causes an increased risk of erroneous actions by aviation specialists. The development of professional and professionally conditioned diseases as a consequence of the impact of aviation noise leads not only to early professional disqualification, but also is one of the reasons for the decrease in efficiency and reliability of the action.

The results of the study make it possible to draw a conclusion about the applied significance of the mathematical model for calculating the potential unreliability of activity. This indicator can be used to predict the operability and reliability of the flight-lifting and engineering-technical staff when operating under noise conditions, and also as a criterion for evaluating the acoustic efficiency of collective and individual noise protection devices designed to maintain professional performance and prevent harmful The effects of noise on the health of staff.

High levels of aircraft noise in the workplaces of specialists testify to the need to develop and implement special means and methods for ensuring the acoustic safety of the professional activities of personnel as an integral part of the system for ensuring the safe operation of air transport.

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