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SOVIET NOISE RESEARCH LITERATURE
From the F.F. Erisman Scientific Research Institute for Hygiene Moscow, USSR

APRIL 1974

U.S. ENVIRONMENTAL PROTECTION AGENCY
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PREFACE

The following are six reports translated from the original Russian and German. These reports were provided by Dr. I. L. Karagodina, of the F.F. Erisman Research Institute of Hygiene, Moscow, USSR, through the good offices of Paul N. Borsky, Director of Noise Research at Columbia University.

TABLE OF CONTENTS

PAGE

Preface i

REPORT

A. Effectiveness of Noise Reduction Measures for Pneumatic Looms ... L. I. Maksimova, I. T. Anreyev, A. Ye. Zapsepin, and R. J. Suhkova, 1968 2

B. Hygienic Importance of the Problem of Noise Abatement in The Cities ... I. L. Karagodina, 1971 8

C. Several Procedural Questions in the Study of the Effect of Noise on the Human and Animal Organisms ... L. I. Maksimova, Ye. A. Geltishcheua, and I. L. Kargedina 12

D. Effect of Industrial Noise With Different Parameters on the Auditory Analyzer and the Central Nervous System of Working Juveniles ... Ye. A. Galtisheva, 1973 20

E. Data for a Hygienic Evaluation of Urban Noise ... S. A. Soldatkina, Yu. V. Novikov, and T. V. Yudina, 1973 27

F. Standard Requirements Concerning Aviation Noise in the Community ... I. L. Karagodina, A. Putlinia, and S. A. Soldatkina, 1973 30

Effectiveness of Noise Reduction Measures For Jet Air Rapier Looms

L.I. Maksimova, I.T. Andreyev, A. Ye. Zatsepin, and R.I. Suchkova

The high noise levels in weaving shops, which are produced by modern looms, demand the use of individual protective measures, in addition to a search for means of combatting noise at its source. The Special Bureau for Weaving Equipment and the All-Union Scientific Research Institute of Textile Machine Construction have worked our measures for reducing the noise of jet air rapier looms.

A comprehensive health-noise evaluation was conducted in weaving shops equipped with jet air rapier looms; automatic, P-105, non-shuttle looms; and AT-100-5M shuttle looms. The physical character of the noise was established for a single jet air rapier loom before and after implementing noise reduction measures. In particular, an evaluation of sound absorption level is presented for a metal protective housing, lined with Porolon. The sound absorption effectiveness of seven types of muffling material was studied - AKS, ENIMS, TsNIIMAShDETAL', rubber, felting (35 and 55 mm thick), and felt-rubber. The physical noise characteristics were determined for a jet air rapier loom in which the metal idler gears were replaced by composition ones (Textelite) and the steel blades were replaced by aluminum ones.

[1] Gigiona i Sanitariya, 12, 1965, pp. 87-89.

The noise levels were measured three times using Sh-63 IRPA sound level meter. In view of the steady character of loom noise, an ASh-2M analyzer was used for the noise analysis. During the operation of single looms, all the measurements were made in four places: in front, to the left, behind, and to the right of the loom, at the level of the operator's head. In shops, the noise levels were measured at several points, equally spaced not more than 20 m apart.

As has been established, the over-all noise level in a weaving shop equipped with 1226 AT-100-5M looms was equal to 105-106 dB and was almost identical in all areas. High-frequency spectral components (SPL) predominate. In the 4000 and 8000 Hz octave bands, they reached 98-101 dB. In the mid- and -low frequency ranges, a gradual decrease in SPL is noted, to 90-95 dB, with a more pronounced decrease to 76 dB in the octave centered at 63 Hz. In the high frequency range the levels exceed permissable levels by 10 to 33 dB.

Over-all noise level in a shop equipped with 168 non-shuttle, automatic P-105 looms is 98 dB. The predominant SPL in the noise spectrum occurs in the octaves centered at 125 and 2000 Hz and are equal to 92-95 dB. In the remaining areas, SPL is somewhat lower, 84-88 dB.

Consequently, during the operation of non-shuttle, automatic, P-105 looms, over-all noise level is 7-8 dB less. The most pronounced difference in SPL, 13 - 18 dB, is in the 4000 Hz octave band. However, SPL in high-frequency octave bands exceed permissible levels by 5-15 dB.

In view of the fact that one of the weaving shops was equipped with nine jet air rapier looms, it is only possible to compare roughly its sound levels with those in shops with more than 100 looms. During the operation of the nine looms, SPL in certain octave bands exceed by 9 - 10 dB the SPL during the operation of 168 P-105 looms. It is well known that during the operation of 100 looms with identical noise levels, the overall level in the shop increases 20 dB in comparison with noise occurring during the operation of a single loom. Practically speaking, as was observed in the weaving shop equipped with AT-100-5M shuttle looms, the over all level may increase only 10 dB, since the noise levels of the separate looms differ and their joint operation does not yield an increase over the noise level of a single loom which is equal to 20 dB. But under these conditions also, the noise levels in the shop equipped with jet air rapier looms will significantly exceed the permissible levels.

The data obtained are the basis for proposing measures for reducing the noise of jet air rapier looms. In particular, in an experimental model of a loom, metal idler gears were replaced with Testolite ones, steel gears were replaced by aluminum, and the housing was covered with Porolon. The effectiveness of measures for noise reduction of jet air rapier looms was evaluated in a relatively quiet room in a weaving shop, in an area 150 sq m in size (10 x 15). The measurements and noise analyses were made during the operation of one loom.

During the operation of a jet air rapier loom before the application of soundproofing material, noise of 94-96 dB occurs, with the level at 8000 Hz predominating (90-92 dB). At 63 Hz, the noise level is equal to 75-77 dB, i.e. 15 dB lower than at 8000 Hz. At other frequencies, the difference is less by 3-10 dB. Noise levels range between 78 and 90 dB. In the high frequency region, they exceed permissible limits by 5-15 dB. High SPL at 8000 Hz occurs because of the operation of the blade drive gear, evidently, partially due to the movement of the blades themselves as well as measurement data from the operation of the jet air rapier loom, without the blade drive gear, and the blades and heddle movements in operation. According to this, the noise level is lower at 8000 Hz

Lining the protective metal housing with Porolon secures the lowering of the SPL in the 8000-Hz octave band by 3-6 dB. During the operation of the jet air rapier loom in which the steel gears were replaced by composition ones and the steel blades by aluminum. SPL at 8000 Hz are lower by 5-9 dB. Overall noise levels behind and to the right of the loom are 1-2 dB lower. The protective metal housing without the lining of sound-absorbent materials does not affect the SPL.

With the use of AKS muffling material, SPL at 8000 Hz increase 4-9 dB and the overall level is decreased by 1 dB.

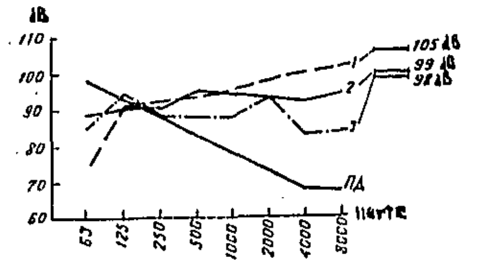
The application of ENIMS muffling material leads to a decrease in levels in the 63-hZ octave band by 3-7 dB, while lowering the overall levels by 1-2 dB. Using different types of muffling, an insignificant (1-2 dB) decrease is also attained for overall noise level, while decreasing levels at 63 Hz by 2-6 dB. With the use of felt-rubber muffling, an increase in SPL is noted at 8000 Hz by 4-10 dB.

Thus, the majority of soundproofing methods did not yield satisfactory results. Noise absorption of about 6 dB in the 8000 Hz octave band is not sufficient. Noise absorption in the 63-Hz octave band, which is observed with the application of muffling material, is unsuitable, since in this range the noise in weaving shops already usually conforms to permissible levels. It is necessary to note that the use of muffling can lead to an increase in SPL in the 8000-Hz octave band.

CONCLUSIONS

1. During the operation of jet air rapier looms in shops, noise is produced which exceeds the permissible levels established for industrial establishments. Noise in the operation of such looms is due, in the 8000-Hz octave band, mainly to the blade drive gear and the heddle movement.

2. The lining of the loom's protective metal housing with a layer of Porolon 1 cm thick provides insignificant noise absorption. The replacement of steel loom gears by composition (Textolite) provided a noticeable reduction in SPL in the 800-Hz octave band. The use of muffling causes an insignificant loom noise reduction.



Spectral Characteristics of Noise in Weaving Shops.

(1) Shuttle looms AT-100-5M
(2) Air jet rapier looms
(3) Shuttleless automatic looms P-105
(PD) Maximum permissible noise (per Temporary Sanitary Norms for Industrial Noise 205-56)

Translation From the German

Seventh International Congress on Acoustics, Budapest, 1971

Hygienic Importance of the Problem Noise Abatement in the Cities

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During the last decade the task of noise reduction gained increased social and economic importance. The rapid growth of cities, industry, and traffic causes a steady increase of background noise in residential areas. The major sources of urban noise are traffic vehicles such as heavy trucks, trains, and airplanes. The noise proportion contributed to the urban noise level by street traffic is on the order of 80 percent. A direct relationship was found between increase of noise level and increasing traffic density and the efficiency of vehicle motors and speed of traffic. During the last few years these factors only caused a noise level increase in cities of 12 - 14 dB, i.e., 1 dB per year. At present the urban traffic noise level is on the order of 100 dBA. High noise levels are prevalent in working places in industrial plants, offices, apartment and hospital buildings, on the streets and in the parks; people are under the influence of noise for a lifetime.

Urban noise is studied by experts in various research institutes: e.g., by physicians, acoustical engineers, architects, etc.

Noise maps were developed for several large cities in Russia that serve as a basis for the set-up of perspective traffic plans and for the development of possibilities for noise reduction in urban planning. Studies have shown that one-third of the residential areas with small housing complexes are subject to high noise levels.

Large-scale population surveys documented that 50 - 100 percent of apartment residents living in apartment buildings 100 meters off highways reported their living quarters to be very noisy. During the day and with the windows open the noise level in these apartments reached up to 60 - 80 dBA.

In order to investigate the character of urban noise physiologic and hygienic studies were conducted both under natural conditions (in apartments, in residential areas, on streets, in hospitals), and in the laboratory (in soundproof chambers). Samples of all population groups were studied (housewives, retirees, students, intellectuals, workers, healthy and sick persons, and children). In addition the mechanism of noise effects was studied on reaearch animals (white rats). Modern electrophysiologic, biochemical, and histologic research methods were employed.

Studied were the objective characteristics of the organism's conditions, the subjective counter-reactions to noise, and the frequency of disease among population groups subjected to various noise levels present in their area of residence (i.e., urban traffic noise of varying intensity, and airport noise).

Traffic noise causes a steady strain on hearing which leads to an increase of the sound perception threshold by 10 - 25 dB. Noise levels over 70 dBA interfere with speech perception. In the brain noise has inhibitory effects that lead to changes in continued reflexes. Effects on the cardiovascular system are decreased of the systolic and increase of diastolic blood pressure. The arterial pressure variation may be 20 and 30 mm Hg.

Shifts of the electrocardiogram have been found to be due to an increase in heart cycle and decrease in pulse rate due to noise. Decrease of the pulse frequency amplitude may be due to arterio-constriction.

Study of the sleep pattern among inhabitants of apartments adjacent to major traffic arteries in Moscow showed that the time required to go to sleep was increased by as much as 1-1½ hours at noise levels of 50-60 dBA. Depth of sleep decreased by 60 percent. After awakening the people felt tried, had heart palpitations and headaches. Sleeping criteria are normal if the noise levels do not exceed 30-35 dBA. Under these conditions the average time spend going to sleep in 15-20 minutes and stage-of-sleep level criterion is 85 percent.

Lack of normal recovery time after a working day and sleeping disturbance led to chronic fatigue, which in turn causes a variety of diseases, e.g., central nervous system, cardiovascular, (hypertension), and hearing disorders. Studies proved a relationship between increase of total disease frequency on one hand and traffic and airplane noise, and residence in a noisy environment on the other hand.

Physiologic and hygienic research determined the threshold of harmful influences to lie between 30-35 dBA and led to the establishment of standards for urban noise limits. The Department of Health in the USSR has ratified "Sanitary Standards for Permitted Noise Levels in Apartment Buildings, Public Buildings, and Zones of Residential Areas" (No. 872-70) that are obligatory for urban planners and construction organizations.

Several Procedural Questions in the Study of the Effect of Noise on the Human and Animal Organisms[1]

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The authors consider a number of factors in the study of noise effects on human beings and animals, using procedural approaches which differed from those of previous studies. The effect of noise on the organism was investigated in the areas of occupational health, the health of children and adolescents, and community hygiene.

The study of the effects of noise pursue various aims. Most common are studies pertaining to the human organism, in which the responded reaction is analyzed in relation to the character and duration of the noise, individual and age features, state of health, etc. These have significance in working out health standards for different groups of the general and working populations (adults, adolescents), and for residences, public buildings, and areas of industrial and residential construction. Studies are conducted as a basis for developing measures for limiting noise impact.

[1] Gigiena i Sanitariya, 7, 1973, pp. 30-34.

The subjects are chosen for a study in relation to the problem to be investigated. In industrial establishments and in physiological studies on the effect of industrial noise, a group of persons is selected, who have no chronic illness, and, in addition, age, sex, length of time worked, and profession are taken into account. It is therefore necessary to consider an age group classification scheme, with boys 13-16 years of age and girls 12-15 corresponding to the age of adolescence and young men 17-21 and young women 16-20 corresponding to the age of youth. Subjects of this age must be divided from adults in separate groupings. In addition, in order to work out recommendations on rational organization of labor and a basis for contraindications to work, the effect of noise on functional reactivity of the organism in healthy and ill persons must be studied.

Studies in the area of community health are conducted with different groups of the population - healthy and ill persons, including children, adolescents, youth, grownups, and old people. People in mental and physical types of occupations are represented, as well as housewives and retired persons.

In physiological studies under industrial conditions, it is expedient to choose a group of eight to ten people of the same sex, age, and occupation, and to make observation for a minimum of three to five days. It is necessary to try for a greater number of persons observed for a shorter length of time, rather than a smaller number of people observed for a longer time. This permits the consideration of different individual features which are leveled out in statistical analysis.

Under industrial conditions, physiological studies are conducted prior to the start of work, during work, and after the working day. Simultaneously, methods are used which are directed toward revealing the effect of the work process itself on functional state, as in the muscle system. Under the laboratory experimental conditions, a group of subjects is chosen who are identical in sex and age and who are not exposed to the effect of harmful external factors. The number of persons can be limited to five to ten for an observation of no less than five to ten days. At the beginning of the physiological studies, the baseline indices decrease in the course of several days, and training is conducted according to each method of study until stable indices are obtained. Under real-life conditions in a health experiment, observations are carried out in industry, schools, residences, and other noise impact areas during the work and school day, sleep and rest, various types of day, week, month, year, and over several years.

Control studies are obligatory for noise-effect studies. Under lab conditions the controls may be persons observed in a room not affected by noise and under various other conditions. In this case, background noise in the rooms must be no higher than 30 dBA. Control studies on animals are conducted on independent groups under identical conditions with no noise exposure. Under industrial conditions, the control may be a group of workers with similar character and working conditions, but with significantly lower noise levels, or the same group of workers using individual means of noise protection. In the area of community studies, the control can be groups of the population which are not subject to the action of intrusive noise (industrial, urban, aviation, railroad, etc.) i.e., groups of people who live in relatively quiet conditions.

In the laboratory experiment, orientation studies are conducted with single or repeated exposure from 3 to 30 minutes. The studies have indicated that optimal exposure is one hour. A very sharp increase in auditory threshold is observed toward the end of a one-hour noise impact. With longer exposure to noise, an insignificant decrease in hearing sensitivity is noted. The functional state of other organs and systems may worsen with longer exposure, even without exposure to noise. In studies of urban noise at relatively low levels, real-life conditions must be used. Therefore the duration of the experiment may be increased up to eight hours, as in sleep studies.

The exposure of animals to noise may last from five minutes to eight hours a day of even round-the-clock in the course of several months. It is expedient to continue observations in the recovery period, especially in experimental studies.

The effect of noise on workers and the general population ought to be studied by an assortment of different objective and subjective methods which characterize the functional state of the separate organs and systems, as well as the organism as a whole. Subjective methods include surveys using specially prepared questionnaires and analyses of annoyance. They are widely used in the USSR and abroad to analyze the effect of industrial and urban noise on a large group of people in the same social conditions. The questionnaires contain questions on social hygiene, and are analyzed by age, sex, and occupational indices, by professional experience, as well as the length of exposure to noise.

The number of people questioned is determined by statistical requirements.

In using objective methods of study, special attention is given to the state of the auditory analyzer, the central nervous system and cardiovascular system.

Hearing, as the principal function of the auditory analyzer, is studied from different points of view. In relation to hygiene, hearing studies are conducted as indicators of the harmful effect of noise. The method of dynamic tone and speech audiometry and auditory adaptation is used for this purpose. Speech audiometry is indicative for certain groups for which speech and hearing are occupational functions and noise masks signal reception. Noise enters various parts of the brain through transmission paths in the auditory analyzer, changing the normal interdependent processes of higher nervous activity. Intense noise disrupts the balance of stimulation and inhibition processes. The reflex reactions are altered, pathological phase status are evoked, and vegetative reactions are disrupted. Long-term action of noise activates structures of the reticular formation as a result of which persistent disruptions occur in the activities of a number of systems in the organism, in particular, the circulatory system. Changes are noted in electrical brain activity. Therefore during studies of functional state in the central nervous system, it is expedient to use electroencephalographic, nystagmographic, oculographic, and chrono reflexometric studies, and to determine conditioned reflex activity.

Numerous studies give evidence of changes in EKGs, arterial pressure and vascular tonus, especially in capillaries. For low-level (urban) noise, a decrease in systolic and an increase in diastolic blood pressure are recorded. Plethysmography has revealed substantial changes in vascular tonus during high-frequency noise. The study of the functional state in the cardiovascular system is conducted by recording EKG, blood pressure, pulse, plethysmograms, and sphygmograms. The study of blood flow in separate areas and organs can be done by rheography.

The long-term effect of industrial and transportation noise lessens the capacity for mental work, and lowers work productivity due to the longer time needed to complete tasks, a decrease in the work tempo, distraction, and an increase in the number of errors. Studies are widespread on mental work capacity, attention, and memory using various psycho-physiological tests. The effect of noise on the visual and vestibular analyzers, and on the respiratory and muscle systems, has been studied. Functional changes in the analyzer systems are noted under the influence of noise. In particular, electrical and light sensitivity in the visual analyzer change during the process of dark adaptation, the stability of clear vision decreases, and dilation of the pupils occurs, lending to a reduction in visual activity.

Shifts are observed given urban noise of 50-60 dB, and, these increase with noise level. Noise changes the functional state of the endocrine system and exchange processes. Therefore indicators for industrial noise are biochemical studies which reflect the functional state of the adrenal cortex, the sympathetic adrenal systems, in particular the content of 17-deto steroids and catecholamines (adrenalin and noradrenalin) in the blood and their removal from the urine (in people), as well as oxidation - reduction processes (content of sugar, pyruvic and ascorbic acids, and vitamins in the blood and tissues of animals).

To determine the compensation potential of the organism in the study of various organs and systems, it is expedient to use corresponding functional samples (the multivariate sample of Masters, the orthoclinical statistical sample, etc.).

It is necessary in noise-effect studies to use methods reflecting the functional state of no fewer than three systems (central nervous and cardiovascular, auditory analyzer or central nervous and sympathetic adrenal systems, oxidation-reduction processes, etc.) The number of methods is limited by the time of the study, which must be within five to seven minutes. First are conducted the functional studies, which are characterized by rapid recovery (auditory, cardiovascular, higher nervous activity). It is advantageous to use electrophysiological methods of study which permit recording indices of a great many functions and observing the dynamics of their changes. Multichannel recorders, electrocardiographs, electroencephalographs, etc. can be used for this.

The statistical and physiological criteria for evaluating functional state are different and are determined by the problems and methods of the study, and by age, and social grouping. However it is necessary to consider the direction, frequency, and degree of shifts, the complex evaluation of all the physiological functions studied, their character evaluation of all the physiological functions studied, their character and occurrence, and their restoration. In evaluating the effect of noise on the organism, one must proceed from the physiological nature and statistical reliability of the shift and the necessity of exceeding the inherent error in the measurement instruments. Thus, in studying the auditory threshold using tone audiometry using equipment consisting of a sound generator, dynamic telephones, and a lamp voltmeter, in measuring the accuracy of the apparatus, + or - 1 dB from the reaction shift may be taken for a 3-5 dB change in hearing, and 10 dB or more as a significant shift. In determining the auditory threshold with audiometers, the accuracy of which is + of - 5 dB, a 10dB threshold shift is a significant shift, and more than 10 dB is a substantial shift.

Even small shifts is one or more physiological systems must be considered undesirable, since they disrupt the organisms functional balance and the normal interrelationship with the environment. A longer recovery time for the specific functions in association with small shifts may be evaluated as negative indicators during longterm exposure of relatively low noise levels. They are evidence of the stress of protective-adaptive mechanisms of the human organism and of the development of inhibition in the brain cortex, which subjectively is manifested by fatigue.

Low noise levels may increase the functional activity of certain systems during short-term exposure. In the absence of reaction to noise, it is still not possible to say it is not harmful to man. Habituation is characterized by removal of strong subjective and objective sumptoms for some time, at the end of which pathological phenomena may be revealed on the part of the various organs and systems.

We presume that the recommendations set forth here will facilitate studies on the effects of noise and the choice of approaches to solve various methodological problems.

Effect of Industrial Noise With Different Parameters on the Auditory Analyzer & the Central Nervous System of Working Juveniles[1]

Ye. A. Gel'tischeva

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There are no studies which throw light on the effect on working juveniles of high-frequency industrial noise with parameters permissible for adults (PS-80)[2] and higher than permissible parameters (PS-85). Information is also lacking on the effect of industrial noise with parameters permissible for juveniles (PS-65)[3]. (PS-80 = ISO Curve N. 80, or about 85 dBA.)

In this article data are presented from studies of the effect of industrial noise of maximum permissible level on the functional state of the auditory analyzer and the central nervous system of working juveniles aged 16-19 years during the work day, in order to work out prophylactic measures directed toward protecting the labor force. The studies were conducted in a machine-construction factory. The

[1] Gigiona Truda: Professional'nyye Zabolevaniya, 7, 1973, pp. 5-8.

[2] Sanitary Standards and Regulations for Limiting Noise in the Territories and at Industrial Sites, No. 785-69.

[3] Procedural Rules for the Prophylaxis of the Harmful Effect of Industrial Noise on the Juvenile Organism, No. 765-687.

frequency characteristics of the noise were measured by Chief Engineer G.N. Botiniy, using a sound level meter and RFT (East German) analyzer at all the work sites of juveniles.

Analysis of the frequency range of the industrial noise and a comparison of the results obtained with the present standard SN-785-69 permitted the separation of the juvenile work sites into three groups: 1) industrial noise meets the standard for adults (PS-80); 2) higher-than-standard noise for adults (PS-85); and 3) industrial noise meets the standard for juveniles (PS-65). At the last levels, juveniles worked temporarily on the research days. On the remaining days they may have been subjected to the effect of noise of higher intensity. 56 juveniles who had worked up to two years were under observation (turners, millers, slicers and drillers, electricians). They worked on the first shift from 7:20 a.m. to 3-4 p.m. with a lunch break of 40 minutes. All the youths under-went a preliminary medical check-up.

The physiological studies were conducted in health stations before work, before the lunch break (about 3-3½ hours later), and immediately after work. Each juvenile was observed from one to five days. First, before the examination, questions were asked about the state of health, sleep at night, activities the preceding evening, etc. Juveniles with good health were chosen for the studies.

Our observations indicate that some juveniles in the first and second groups suffered from ringing in the ears, headache, increased fatigue, and poor tolerance of industrial noise. Auditory thresholds were determined two minutes after leaving the shop, using a semiautomatic audiometer at seven fixed frequencies: 125, 250, 1000, 2000, 4000, and 8000 Hz. Temporary threshold shift was determined, based on the difference between indices taken before the noise exposure (before work), before lunch, and at the end of work.

An analysis of individual data showed that generally a change in hearing sensitivity is determined by parameters of the noise and by its duration, and is also greatly determined by individual peculiarities. A clear dependence of threshold shift for the same noise parameters on age was not indicated. All this made necessary the statistical evaluation of auditory threshold indices in relation to the industrial noise parameters studied. About 200 audiometric examinations were conducted.

The greatest changes in auditory threshold were noted at high frequencies, especially at 4000 and 8000 Hz, at the end of the work day for noise parameters equal to PS-80 and PS-85. This is evidence of the manifest fatigue of the auditory analyzer and the absence of adaptation to the noise parameters indicated. Analogous data were obtained for a significantly high sound pressure level (95-105 dB) of high-frequency industrial noise in juveniles undergoing industrial training in the factory. Less obvious were changes after noise exposure not exceeding the standard for juveniles, PS-65. Auditory threshold shift is detected by the frequency character of the noise and agrees with data obtained by various other authors.

The results of the studies of auditory threshold in juveniles in the first and second groups attest to the potential danger of hearing loss. Threshold shift at the high frequencies sometimes reaches high amounts (25-30 dB). The auditory threshold indices sometimes do not recover after 16 hours of rest or even after two days off. This is evidence of the manifest cumulative effect of industrial noise corresponding to the limits of PS-80 and PS-85. After one year of (and in certain noise sensitive youths, after 2-4 months), a threshold shift was observed with no recovery after two to four weeks of rest. All this shows the disruption of auditory analyzer reaction and, in the presence of a permanent threshold shift, in all probability, an earlier organic injury to the organ of Corti, in the period of auditory analyzer formation of a young age.

As a result of the industrial noise (PS-80 and PS-85), a decrease occurs in auditory analyzer excitability by virtue of the development of the process of inhibition in the central nervous system, which is confirmed by the results of chrono-reflexometric investigations. The latent reaction time was determined for light and sound stimuli for reflex motor reactions with spoken instruction beforehand.

An analysis of the investigations indicated high values of latent reaction time to light and sound stimuli even before work, in comparison with the results obtained for middle-school students in the upper classes. The average time was obtained before work and during the work day was greater for sound stimuli than for light stimuli, which is proof of the disruption of inter-central relationships.

Toward the end of a work day in noise at PS-80 and PS-85 levels, the number of persons (13 percent) increased with disrupted intercentral relationships, especially in the second group. More obvious shifts in simple reaction indices to light and sound were noted for PS-80 and PS-85 noise than for PS-65. The number of adolescents who made mistakes in differentiation increased. Especially clear was the number of errors in PS-80 and PS-85 noise for a sound stimulus. An analysis of individual data showed that 16 hours of rest or even two consecutive days were almost insufficient to revice the functional state of the central nervous system.

Industrial noise equal to the permissible standard (PS-80) or above the standard (PS-85), acting on working adolescents daily, five days a week, leads to a sharp decrease in the excitability of the central nervous system, a weakening of the strength of internal inhibition, and a disruption of intercentral relationships between analyzers, as manifested by the development of fatigue and overwork. Thus, industrial noise permissible for adults (PS-80) or of higher level (PS-85) is a strong stimulus for adolescents. It leads to extensive changes in functional state, as evidenced by the disruption of the possibility of compensation and by the manifest additive effect of industrial noise. Noise just meeting the standard for juveniles (PS-65) evokes less obvious changes, indicating the development of inhibition in the auditory analyzer and central nervous system.

The disruption of intercentral relationships in juveniles working in noise corresponding to PS-65 is evidently explained by noise exposures on preceding days, when they worked under higher intensity noise. On the basis of the data obtained, recommendations were worked out to improve working conditions and to introduce means of individual protection.

Table 1

Group No.	Time of day	Threshold shift, dB						
		125	250	500	1000	2000	4000	8000
1	Before lunch	3,6±1,05	5,6±1,19	5,8±0,8	3,5±1,00	3,0±1,00	11,5±1,00	7,0±1,28
	After work	4,6±1,44	7,2±1,04	7,6±1,04	5,06±1,06	6,3±1,53	14,4±1,55	9,8±1,35
2	Before lunch	3,8±1,41	4,1±1,56	7,1±1,77	7,4±1,70	6,8±2,01	14,7±2,73	8,2±1,92
	After work	6,6±1,71	7,1±1,64	9,4±2,02	8,7±1,98	9,2±2,17	17,1±2,00	12,9±1,44
3	Before lunch	3,3±0,24	1,7±0,24	5,0±1,58	0,8±0,80	1,7*±1,67	0,6*±1,54	1,7*±1,05
	After work	1,7*±3,55	1,67*±2,08	5,0±2,05	7,5±2,5	3,3*±2,88	5,8*±3,0	4,2*±4,36

Change in threshold of hearing of juveniles in the course of a working day as a function of exposure to industrial noise. (Average data.) (Threshold shift relative to initial data.) (* = unreliable data.)

Table 2

Stimulus	Response	Higher than Noise Standard for adults (PS-65)			Noise standard for adults (PS-80)			Noise standard for juveniles (PS-65)		
		before work	before lunch	after work	before work	before lunch	after work	before work	before lunch	after work
Light	Simple	342,57±0,25	320,68±0,27	396,18±0,35	360,00±0,34	365,62±0,32	370,71±0,31	343,50±0,41	288,53±0,30	316,76±0,34
	After differentiation	385,00±0,42	438,24±0,48	447,73±0,47	397,16±0,30	405,61±0,34	435,00±0,43	414,47±0,39	367,35±0,63	385,59±0,51
	Number of breaks	1,50±0,16	3,00±0,01	2,85±0,22	3,08±0,13	1,49±0,32	3,55±0,35	2,90±0,46	3,53±0,84	1,82±0,29
Sound	Simple	386,25±0,41	413,11±0,54	473,82±0,68	421,80±0,33	455,62±0,48	455,71±0,44	390,79±0,56	405,00±0,70	401,46±0,85
	After differentiation	460,38±0,54	502,94±0,59	595,00±0,77	559,53±0,46	589,29±0,59	572,56±0,51	457,94±0,51	453,75±0,83	479,12±0,90
	Number of breaks	3,10±0,20	5,11±0,24	2,88±0,24	3,92±0,37	3,42±0,46	3,60±0,40	1,90±0,39	2,06±0,24	2,71±0,33

Change in latent reaction time (1/1000 sec.) to light and sound stimuli of juveniles in the course of a working day as a function of exposure to industrial noise.

Data for a Hygienic Evaluation of Urban Noise[1]

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Health questions concerning the effect of urban noise on the organism are very real. Studies of animals have indicated not only the dynamics of biological changes but the character of the unpleasant effects of noise as well. However, there are only a few experimental studies on the effect of transportation noise on animals.

In our studies, the effect of 80 dBA noise on animals was determined by physiological and biochemical methods. 130 male white rats were used in the experiment. The functional state of the central nervous system was evaluated based on the value of latent reaction time to an electrical skin stimulus; functional state of the cardiovascular system was based on arterial pressure reaction. The animals (the control and experimental groups) were subjected for two to three weeks to conditions in which noise level did not exceed 40 dBA. During this time, baseline indices of the physiological functions were taken in the animals. Then the experimental group was subjected to the effect of 80 dBA low-frequency transportation noise for a period of one month, for six hours a day. During this time the studies were repeated every day. In each series of observations, the indices of physiological functions in the experimental group were compared with the baseline and the control group.

[1] Gigiena i Sanitariya, 3, 1973, pp. 16-20

The biochemical studies included the determination of ascorbic acid content in the tissues, a study of sorption capacity of cells, and a determination of histamine in the brain. The studies were conducted on the 15th and the 30th days of noise exposure and for 15 days after its cessation. A study of the permeability of histo-hematic barriers using tagged atoms was conducted on the 30th day of noise exposure. The data obtained from the experimental animals were compared with the controls. The results of the studies are presented as the group average and were treated statistically.

The first indication of noise impact on the experimental animals was motor agitation in the first hours of its action. Toward the end of the first day, all the rats collected together in a corner of the cage away from the noise source and went to sleep. In the course of several days they remained restrained; in the final stage their behavior did not differ from that of the control group. Noise had no effect on growth or weight of the animals.

In the study of the long-term effect of noise on animals, the method used was that of determining latent reaction time to an electrical skin stimulus as an index of the functional state of the central nervous system. Toward the end of the first day, the effect of 80 dBA noise which was noted was a somewhat lengthened latent reaction time. From the second week until the end of the experiment, the noise increased the background indices significantly, although the behavior of the experimental animals did not differ from that of the controls. Arterial pressure under noise sharply increased (by 20 mm) and remained so to the end of exposure. Thus, a noise level of 80 dBA harmfully affected the animals unconditional reflex activity and cardio-vascular system.

Disruption of nervous system function was associated most closely with shifts in the exchange of substances. The quantity of bio-chemical studies which throw light on this question are very limited. They revolve mainly on separate aspects of the exchange. The important role in substance exchange was played by ascorbic acid. Based on its content in the adrenal glands, we determined the functional state of the endocrine system. A decrease in ascorbic acid content in the adrenal glands, as well as their weight increase, under the influence of noise is believed to indicate the occurrence of protective reactions of the general adaptation syndrome type. Chronic noise exposure leads to a deficiency in the tissues (brain, liver, skin, muscles) of ascorbic acid as a result of its passage with urine; so that in rats it may be considered a result of reduction in the synthesizing function.

Ascorbic acid was determined by the colorimetric method in the adrenal glands, brain, liver, kidneys, spleen and testicles.

In the adrenal glands, a 12 percent decrease in ascorbic acid content was noted at first with 80 dBA noise, then a 28 percent increase, and in the recovery period somewhat of a decrease again (seven percent). In the other organs (brain, liver, spleen, kidneys, testicles), the changes bore an analogous phasic character. In the first half of the exposure period (up to the 15th day), the quantity of ascorbic acid decreased 10-33 percent. Toward the end of the noise exposure (on the 30th day) it increased 8-32 percent, and two weeks after the conclusion of noise exposure, it decreased 6-11 percent.

To determine the functional state of the central nervous and endocrine systems, the method of vital staining was used, which allowed for determining the state of active cells. Changes in the quantity of associated stained cells occur even in very slight noise exposure. Therefore such a procedure has found application in studies of the biological effect of ultrasound. As the studies indicated, the greatest amount of staining occured in the adrenal glands, then the pituitary body, and somewhat less in the brain. Lease cell activity was noted in the testicles.

With 80 dBA noise during the first half of the exposure time, the sorption capacity of brain cells increased 25-36 percent, but it hardly changed (one to three percent) in the pituitary and adrenal glands. Toward the end of exposure (the 30th day), a decrease of 33-38 percent was recorded for sorption of cells in the organs studied. In the recovery period, sorption activity of cells differs only insignificantly from the control group (10-15 percent). The effect of noise was observed on the adrenal and pituitary glands and the brain, while in the parietal region of the brain, the process of sorption proceeded more actively than in the temporal region.

The quantity of histamine in brain tissue of rats subjected to 80 dBA noise increased 87% over the control group up to the 15th day of exposure. By the 30th day, this difference was reduced significantly (8.7 percent).

Barrier mechanisms serve as an indicator of the state of the organs and physiological systems which maintain the constancy of the internal organs and tissues. The importance of the state of the histo-hematic barriers for the living organism points up the necessity for studying the effect of noise on their permeability. Studies have been conducted on the effect of 100 dBA noise on such barriers in the brain, especially in the temporal region.

(See attached for Table 1)

An analysis of the data presented in the table above indicated that 80 dBA noise causes an increase in the permeability of the histo-hematic barriers in the kidneys (P less than 0.05). The barrier permeability for the other organs did not change compared to the control group.

Conclusions

The animal studies indicated that the long-term effect of transportation noise causes physiological and biochemical changes which are evidence of the development of a general, non-specific reaction to noise.

Table 1. Effect of 80 dBA Noise on the Permeability of Histo-Hematic Barriers in the Organs of White Rats

Organ	M* Control Group	Exper. Group	Reliability Coeff.	Level of Confidence. P
Brain	29.2 ± 3.0	29.9 ± 2.7	0.1	over 0.05
Pituitary	134.1 ± 1.0	116.6 ± 12.5	1.0	over 0.05
Thyroid	320.0 ± 67.4	341.7 ± 53.5	0.2	over 0.05
Adrenal	491.3 ± 42.1	499.7 ± 49.0	0.1	over 0.05
Spleen	362.8 ± 28.8	409.9 ± 80.2	0.5	over 0.05
Kidneys	609.5 ± 59.3	889.7 ± 70.5	3.0	under 0.05
Liver	891.7 ± 68.8	1042.3 ± 126.5	1.0	over 0.05

$$M = \frac{\text{(radioactivity of tissue)}}{\text{(radioactivity of blood)}} \times 100$$

STANDARD REQUIREMENTS CONCERNING AVIATION NOISE IN THE COMMUNITY

At: 3rd National Conference Against Noise, Varna, Bulgaria, Oct. 27-29, 1973

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The stormy development of aviation transportation in recent years has involved an increase in the number of powerful, fast aircraft, which has led to a sharp increase in noise radiation into the external medium and a worsening of the acoustic regime in residential areas. The construction and expansion of airports is becoming all the more a perceptible barrier to the planned development of a number of cities.

Standards are being used at the present time to limit aviation noise in residential areas to levels of 110-112 PNdB (perceived noise level in decibels), or 100 dBA by day; and to 100-102 PNdB (88-90 dBA) at night, levels which are excessively high and cannot be considered acceptable from the point of view of health.

The F.F. Erisman Scientific Research Institute of Hygiene has been conducting a study for a number of years on noise propagation from different classes of airports and its effect on the state of health of the populace, with the aim of formulating guidelines for airport distribution in city planning.

The effect of aviation noise on the human organism is determined to a significant degree by the maximum level, duration, flight density and distribution during a 24-hour period, time of the year, etc., which are all considered in the equivalent sound level in dBA. This level is taken at the present time to evaluate non-continuous noise in residential areas which is produced by various modes of transportation.

Physiological and health studies under laboratory conditions of healthy subjects have indicated that noise levels of 70-80 dB from aircraft in flight evoke changes in the bioelectrical activity of the brain and a significant increase in latent reflex reaction time to light and sound stimuli, in addition to which work decreases and attention strays. In the cardiovascular system, arrhythmia and reduction in systole are noted, as well as an increase in arterial pressure and peripheral vascular tonus.

Observations of young school-age children at dispensaries in small villages situated near airports revealed functional changes in the cardiovascular and nervous systems, as well as distrubance of hearing. Noise evokes increased fatigue and headache, and it decreases success in school children.

A study of general morbidity, in the adult population living at distances up to ten kilometers from airports, indicated an increase by two to four times in the frequency of disease in the auditory organ, the cardiovascular and nervous systems, and the gastrointestinal tract. The increase in morbidity which was noted affects persons of young and middle age.

An interview survey of 4000 persons, in a population living at 33 settled areas at a distance of 5-10 km from airports, was conducted on the annoyance of aviation noise, using a specially formulated questionnaire. The survey indicated that the major complaints involved loss of sleep and rest (30-51%), and the remaining forms of disturbance in daily activities (disturbance of conversation, mental activity, and physical work, startle, fear, etc.) made up 10-22 percent of the complaints.

In round-the-clock airport operation, the annoyance due to noise is sharply increased. The intensive movement of aircraft during the entire 24 hour period creates, for the populace living adjacent to such areas, extremely unbearable levels to which 81 percent of the complaints were evidence.

The general number of complaints occur in direct proportion to the value of the equivalent level in the area of the population points: with an increase in equivalent sound level, the number of complaints and the sharpness of the populace's reaction increase. Thus, for $L_{eq} =$ 58.4 dBA, 49 percent of those questioned complained of noise. For $L_{eq} =$ 60.8 dBA, 50 percent complained, for $L_{eq} =$ 62.3 dBA = 56 percent, and for $L_{eq} =$ 77 dBA, 81 percent.

Aviation noise, like no other, causes annoyance and fear due to its unexpected occurrence in a quiet interior background, especially at night and to children. The populace notes that aviation noise fatigues, annoys, disrupts sleep and rest, and does not permit the possibility of concentrating at work.

The effect of maximum levels for single aircraft flights were evaluated under laboratory conditions based on subjective evaluation data, using the method of "mass observations". Aviation noise was used as the annoyance factor and had been recorded on magnetic tape in the form of a noise scenario during the take-off of a TU-104 turbojet aircraft. Levels from 70 to 100 dBA were studied. Noise was evaluated on a five-point scale; no annoyance, tolerable, disturbing, annoying, unbearable. 79-dBA noise was evaluated as "tolerable" in 32 percent of the cases. With an increase in noise intensity, the answers "disturbing" and "annoying" increase and, correspondingly, the number of "no annoyance" evaluations decrease. For aviation noise levels of 85 dBA, 59 percent of the answers were negative, and 90-dBA noise "annoyed" in 61 percent of the cases. 100-dBA noise in subjectively unacceptable, according to 88 percent of the answers received.

Thus, the results of studies conducted under actual and laboratory conditions indicated that aviation noise levels of 70-85 dBA are acceptable for people's daily activities, $L_{eq} = 90$ dBA is the limit of tolerability, and $L_{eq} =$ levels of 95 dBA and higher exert an unpleasant influence on the populace and cannot be permitted in a residential area.

On the basis of these data, the Erisman Institute, together with the State Scientific Research Institute of Civil Aviation and the State Scientific Research Institute of Building Physics, State Department of Construction, have worked out standards, in accordance with which equivalent noise levels of L = 65 dBA (day) and 55 dBA (night) in residential areas, corresponding to 75 and 85 dBA. Three land use zones were also established in the neighborhood of airports.