COMBINED EFFECTS OF ENVIRONMENTAL FACTORS

BOOK OF ABSTRACTS

RESEARCH PROGRAM ON THE COMBINED EFFECTS OF ENVIRONMENTAL FACTORS

Tampere, Finland 1984
The First International Conference on The Combined Effects of Environmental Factors is held in Tampere, Finland at the Hotel Cumulus, on 22-25 September 1984.

The practical arrangements are taking care of an interdisciplinary research team (i.e. Research program on the combined effects of environmental factors) whose work is financed by the Academy of Finland. Members of the team are: Mr. Olavi Manninen (director), Mrs. Kirsti Aalto, Mrs. Tiina Ikonen, Miss Merja Lehmusto, Mrs. Ritva Manninen, Mr. Seppo Perkiö, Mr. Antti Perttula, Miss Päivi Suojanen, Mrs. Aulikki Uusi-Panula and Mr. Seppo Siuro. Mrs. Ritva Manninen acts as secretary-general of the meeting, and she also assumes responsibility for the social program. Mr. Jouko Kankaanpää sees to the safe and comfortable transportation of our guests.

This Book of Abstracts consists of 36 reviewed, accepted, and edited abstracts involving presentations at the conference.
ACKNOWLEDGEMENTS

The following institutions and companies have contributed to the success of the Conference by rendering practical or financial support:

Suomen Akatemia The Academy of Finland
A-Engineers
Ahti-Rakennusosakeyhtiö Construction Company
Asuntokeskuskunta Tampereen Haka Construction Company
Brüel & Kjaer
Hotel Cumulus
Oy Finlayson Ab
Kalle Kaibari Counselor of Commerce
Kansa-Yhtiöt - Kansa Corporation Ltd
Oy Keskuspaino Ab Central Printing House
Kansallis-Osake-Pankki - The Leading Finnish International Bank
Oy Lehtimiehet Ab Publishing Company
Oy Nokia Ab
Osuuskunta Pirkanmaan Haka Cooperative Society of Building Operations
Oy Pyyunikki Brewery
Oy Rauma-Repola Ab
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Suomen Yhdyspankki Oy - Union Bank of Finland Ltd
Oy Tampella Ab
Tampereen kaupungin liikennehenkilökunta Society of Traffic Force of the City of Tampere
Tampereen kaupunki The City of Tampere
Oy Tampereen Konttorikone Wulff Ab Data Machines
Tampereen Yliopisto University of Tampere
Työsuojeluballitus The National Board of Labour Protection
Antti Tähtinen Architectural Office
Wärtsilä Nuutajärven Lasi Wärtsilä Nuutajärvi Glass
[1] PHYSICAL AND TECHNOLOGICAL ASPECTS OF NOISE-REDUCTION OF MACHINE TOOLS FOR WOOD CARRIED OUT BY THE "ERGONOMIA" COOPERATIVE

Arentowski A
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The paper presents projects aimed at reduction of acoustic power of machine tools for wood; results of their implementation, as well as remarks on their operation and durability. The analysis of effectiveness of the projects was carried out. Also the method enabling proper selection of parameters of the projects aimed at complex noise-reduction of rooms is put forward. It applies to the case when the projects are implemented simultaneously with other projects (reducing noise of machine tools or increasing acoustic absorption of rooms).

[2] UPPER EXTREMITY DISORDERS IN INDUSTRY

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Musculoskeletal disorders have, during the past few years, become a major occupational safety and health problem in many countries. This paper focuses on soft tissue disorders of the upper extremities, assessing their relationships to work and methods of controlling their occurrence and subsequent impact in industry. Results of a worldwide literature review will be summarized, showing the multi causality of the ailments and evaluating the preventive measures recommended. A multidisciplinary study investigating the prevalence of the disorders in specific industrial jobs and the role of the combined effects of biomechanical and environmental stresses will detailed. An integrated program, designed to bring the problem under control, will be described, and experience obtained from pilot implementations of the control program in several manufacturing plants will be discussed.
[3] ECONOMIC AND BIOLOGICAL EFFECTS OF ACOUSTIC ADJUSTMENTS DESIGNED BY A RESEARCH TEAM OF THE "ERGONOMIA" COOPERATIVE FOR FURNITURE FACTORIES

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The economic calculus of obtained effects is based on the costs related to: allowance due to strenuous conditions; probability of occurrence of professional handicap of hearing; increase of production, as well as on an additional profit resulting from: decrease of costs and increase of production. Biological effects were considered based on audiometric examinations. The highest number of workers (24 %) has left ear handicapped. They work in the Pre-Treatment and Cutting-Room Divisions. Based on the foregoing results a statistical analysis of distribution of personal sensitivity related to the Gauss curve was carried out. It permitted to select noise-resistant workers. The conclusions are: a high percentage of workers are characterized by high noise-sensitivity and only a few percentages are characterized by noise - resistance.

[4] COMBINED EFFECT OF NOISE AND VIBRATION ON THE HEALTH OF SAWYERS EMPLOYED IN FORESTRY

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The combined effects of noise and vibration on the health of the sawyers employed by felling were determined. There have been determined the level of intensity of noise and the speed of vibration of chainsaws used in forestry. The sawyers operating these machines have been subjected to several close medical examinations. It has been found out that chainsaws produce noise and vibration greatly exceeding the allowable standards. With 42.6 % sawyers there are occurring permanent hearing defects in the range 20 - 80 dB.
With 55.3% sawyers there have been diagnosed morbid changes caused by vibration. There has been discovered distinct increase of morbid changes caused by noise and especially vibration after a lapse of many years of operating a chainsaw. The author comes to the conclusion that operating chainsaws in forestry is a serious professional danger for sawyers’ health causing a great per cent of indvertible morbid changes which can lead to lifelong disability.

**[5] HEART RATE VARIABILITY (HRV) AS AN INDICATOR OF COMBINED EFFECTS**

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An addition of one more factor to already present one(s) does not necessarily double the response of an organism. In majority of cases, the functional state of the organism changes only slightly. It follows that at present the primary aim is to find methods and indicators sensitive enough to recognize the minute changes. In the last two decades the HRV is used as an indicator of strain, particularly in mental load research. HRV in fact presents quantitative expression of instantaneous heart rate instability. The higher the strain the more stable is the heart rate. The presented method is not factor specific, is noninvasive, and using computer is fast enough for ascertaining current state of the organism, namely the state of autonomous nervous system. An experiment with exposition of subject to mental work (Bourdon’s test), to noise (white noise of 80 dBA), and to their combination showed that HRV spectrum at combined load contains less peaks, and that the main spectral components are shifted to lower frequencies.
[6] COMBINED ACTION OF ORGANIC SOLVENTS OR NOISE ON PHYSIOLOGICAL SYSTEMS

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Rats have been exposed to the combination of 1, 1, 1-trichloroethane (ICE, the most used organic solvent) and noise for a period of 84 days. Dosages were in the range of accepted limit values or 15 times above. A specially constructed exposition chamber is shown which simultaneously contains the combined exposed population, both single exposed populations, and a control population. Urine is collected over the exposition period from which 7 endogenic metabolites are quantified. At the end of exposition time body and organ weights are determined and especially some liver parameters. In both groups exposed to the higher TCE level 3, 4 dihydroxyphenylglycol from urine and liver microsomal cytochrome P-450 content are significantly increased. Only in the combined exposed group the liver/body weight and the liver microsomal monooxygenase activity are increased significantly. From that we conclude that the membranes of nerve cells and of the endoplasmic reticulum in liver cells are involved. Chemical effects will be discussed under the presumption that the chemicals used are combinations themselves.


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The aim of the work was to study the interaction between two factors of different nature in chronic experiment on rats followed by the application of the obtained data for the development of the approaches for standard setting. It was found that the effect of combined exposure had complex dependency on the duration of exposure and might both to increase and to decrease concerning the isolated action.
It is proposed to make paired comparisons and to select maximum values of unfavorable deviations of every index for standard setting. The combination ratio is calculated by the formula where M₁ - is the effect of combined exposure, M₂ - the effect of isolated exposure, and N - the number of indices. The hygienic standard for combined exposure is calculated as the product of the standard value for the isolated effect and the combination ratio.

[8] HEAT ILLNESS - AN EXAMPLE FOR THE COMPLEX INTERPLAY BETWEEN ENVIRONMENTAL FACTORS AND MAN

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An analysis of 9 occupational heat illnesses, 8 of which were fatal, permitted an insight into the interaction of various environmental, physiological, medical and psychological factors in their development. In 2 of the fatal cases ambient air temperature was relatively low (29.9 and 31.7⁰ C) and it was the radiant heat, emitted from molten metal and the sun, respectively, which made the environmental conditions intolerable. The metabolic heat generated by high level of physical exertion was an important source of overloading in 7 cases, 4 of the victims were un-acclimatized to heat and at least 2 of them were probably dehydrated; in 5 cases they were obese; 3 of them were alcoholic; 2 had surgery in their recent medical history and 1 each had rheumatoid arthritis and hypertension, respectively. One of them was deaf-mute. Being a new worker on the job or being a veteran increased the risk for becoming overheated because the new workers had to prove themselves in front of their peers while the workers with many years of employment in the same job became complacent. In addition to heat, 5 victims were exposed to noise, vibration and toxic gases, vapors and dust which are known to be an additional stress to the organism.
[9] EFFECT OF THE ENVIRONMENTAL NOISE ON THE AUDITORY SYSTEM IN MAN. ELECTROPHYSIOLOGICAL STUDIES

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Electric action potentials were recorded from the different levels of the auditory system in persons professionally exposed to noise and in free of noise persons. Experimentally induced auditory fatigue and adaptation were analyzed. Sonomotor reflex was investigated as a model of the influence of the central nervous system (CNS). It was concluded as follow: 1 the noise-induced auditory fatigue originates within the cochlea and is transferred to the auditory pathway, 2 the influence of the CNS on this process should be considered, 3 so called pathological adaptation precedes probably the noise-induced structural damages and therefore may be useful for the early diagnosis of hearing impairment, and 4 temporal auditory fatigue, measured as TTS (temporal threshold shift) may be a good indicator of the individual sensitivity to noise, but prognosis on the presumed permanent damages based on the evaluation of TTS seem doubtful.

[10] METHODOLOGICAL APPROACH OF AN OVERALL COMFORT INDICATOR FOR RAILWAY COACHES

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To show up the combined effect of environmental factors upon passenger comfort of railway coaches, an original methodology was developed. To evaluate the comfort of subjects in real situations of transport, experimentations were carried out during several long time journeys (8 h). Each hour, subjects’ responses to comfort scales in five points were registered (general comfort, noise comfort, vibration comfort and thermal comfort).
Evaluation of "feeling fatigue" along the travel was evaluated by auto estimation questionnaires of fatigue. The well-being of the subjects was evaluated in terms of sociability, dynamism, and optimism by psychological approach. During all the time of the comfort evaluation, the environmental factors were measured (Fanger-PMV for thermal parameters, Leq for noise, acceleration measurements for vibration). Some physiological parameters were equally registered (EMG of the back muscles and objective changes of posture). Results showed the time dependence of the comfort sensation and the interactions between the environmental factors and this sensation. A comfort model was developed which makes it possible to assess overall comfort taking into account time duration effect of the travel and the effects of synergy between the environmental factors.


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There exist clinical observations and field studies that CO - intoxication and noise may have combined effects on hearing. In our first study 20 subjects were exposed to 200 ppm CO over a period of 4 hours, combined with 105 dB octave-band noise (middle frequency of 2 000 Hz) for the last 15 minutes. TTS-values were compared between CO exposure and normal air. Differences were statistically not significant. This seems to indicate that there are no gross peripheral hearing changes induced by the combination of such mild environmental stressors. In a further step of investigation we now look for disturbances of central information processing, which might be a more sensitive parameter. In this connection we are testing the influence of biologically relevant sound exposure and CO on brain potentials in the rat. We found a negative DC shift over the whole 28 seconds of sound exposure when breathing normal air, but only an "on effect" and a suppression of the DC shift when breathing 1000 ppm CO. The mechanism will be discussed on the basis of our series of studies on CO - dependent changes of functions in the waking and sleeping brains.
[12] A MODEL FOR THE INVESTIGATION AND EVALUATION OF COMBINED EFFECTS OF ENVIRONMENTAL FACTORS ON ORGANISM

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A method for studying the combined influence of physical and chemical factors on biological systems is described. This method includes two variants of investigation, namely the "input" and the "output" procedure. In both cases formulas for the evaluation of the superadditive, additive or subadditive effects are given. The method is applied in the examples of the combined influence of noise and vibration on test persons and of vibration and cyclohexanone on rats. In the 1st example an output-superadditive effect for the pulse rate and output-subadditive effects for the breathing rate and the systolic blood pressure are obtained. In the 2nd example an input-subadditive effect is found on the basis of lethal exposure tests.

[13] COMBINED EFFECT OF SOME PHYSICAL AND TOXIC ENVIRONMENTAL FACTORS

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In previous studies an interaction effect of combined noise and organic solvents (DMF; xylen) exposure, as well as WBV and noise, T (35°C; - 4°C), Pb, on rat myocardium was found. This study aimed investigation of combined noise and CS₂ (part I) and N, WBV, Pb and Mn (part II) in field conditions, on 411 workers, by assessment of subjective state, biochemical determination of lipids, cholesterol, triglycerides, HUA, GAG, GI, HP, PbB and MnB and ECG (Minnesota code). Higher prevalence of biochemical and ECG disorders were obtained in workers, exposed to combined CS₂ and noise, particularly in those with type A behaviour.
Greater number of significant correlations (sum scores of subjective symptoms subcategories and length of employment) was found in workers exposed full time to N, Pb and Mn, vs part-timely exposed; similar tendency was obtained in workers exposed to intensive WBV, N, Pb and Mn, vs those, exposed to the same combination but WBV within the norm. The same was valid for the connective tissue components disorders observed. No significant correlation between PbB and Mn and the length of exposure was found. The results obtained might be indicative for early health impairment.

[14] COMBINED EFFECTS OF ENVIRONMENTAL FACTORS AND MENTAL LOAD

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This paper refers to examples of laboratory investigations by which the impact of mental strain on metabolic parameters in combined adverse conditions were studied. In one experiment subjects had to perform mental tasks (arithmetics) repeatedly, for one hour a day, being exposed to intermittent noise and insufficient lighting condition. The blood concentrations of glucose, FFA, triglycerides and cholesterol were analyzed for experimental as well as for control sessions (rest). In an independent sample the same blood parameters and different "stress" hormones were analyzed while subjects were performing mental tasks (arithmetics) in comfortable thermal and lighting conditions resp. in rest. There occurred clear differences in metabolic stress indicators: glucose levels exhibited the most significant effect of combined stressors compared to the environmentally neutral mental load situation. FFA reactions pointed in the same direction. In cholesterol and triglyceride concentrations only slight differences appeared. The second experiment included uncontrollable, emotionally arousing phases. Concerning blood parameters, this situation did not differ markedly from the simple task condition. So in this experimental setting the combination of mental load with environmental stressors produced stronger metabolic effects than the uncontrollability of the situation.

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Studies performed by us showed that CNS neurons have special properties (convergence heterochemical postsynaptic membrane) which permit them to receive and integrate the information about physical factors of environment (light, sound, nociceptive stimulation). But functional characteristics of neurons and character of heterochemical organization of their postsynaptic membrane can be changed by conditions of their functioning. Electric stimulation of mHpt - negative emotional trigger zone leads to changes of functional and chemosensitive properties of neurons. In these conditions systemic mobilization of neuronal receptive formations is supposed to take place and participate in the formation of adaptive behavior in changed conditions. Further interpretation of concrete mechanisms of this process will be made in future.

[16] COMBINED EFFECTS OF IMPULSE AND STEADY STATE NOISE ON INNER EAR FUNCTIONS

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Only few studies have dealt with effects of combined exposure to impulse (impact) and steady state (continuous) noise. The results of these studies were contradictor with respect to the effects of the combined conditions on Temporary Threshold Shift (TTS) in relation to the single component condition.
While several studies showed a protective effect of the superimposed impulses ascribed to an activation of the acoustic reflex other studies failed to show such effects. In our study 11 male normal hearing subjects were exposed to five different noise conditions: a 30 min exposure to 95 dBA broad band noise was followed by 120 min exposure to one of the following conditions: 1) 130 dBA impulse noise (0.5 cps), 2) 85 dBA broad band noise, 3) 95 dBA broad band noise, 4) 85 dBA broad band noise (like condition 2) combined with impulse noise (like condition 1), and 5) 95 dBA broad band (like condition 3) combined with impulse noise (like condition 1). Presentation of exposure conditions and threshold measurements were computer controlled. Results indicate that combination effects depend on exposure duration. Combined exposure of short (<30 min) duration indicates slight protective effects of the superimposed impulses. Longer duration results in synergetic adverse effects of noise components.

[17] COMPLEMENTARY STUDIES ON HUMAN REACTIONS TO COMPLEX EXPOSURES

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In this report the most recent research results are discussed which shed additional light on complex human reactions in complex exposure situations. The studies are related to a research program extending over a number of years and aiming at the clarification of the combined effects of environmental factors on the various functions of the human organism. The results to be introduced were obtained from six experiments realized in a special exposure chamber. The experiments were carried out either as block design or factorial experiments.
During the experiments the subjects were exposed to various kinds of exposure combinations, which consisted of noises, dry bulb temperatures, vibrations of the whole body and mentally or physically loading tasks of many kinds. The functional changes in the organism caused by the different exposure combinations were characterized with the aid of body upright posture sway, heart rate, systolic and diastolic blood pressure, pulse pressure, hemodynamic index, body surface temperature, results of stressfulness ratings, results of noise intensity ratings, changes in voice intensity and fundamental frequency. In general, the results showed that the combined effects of two, three or four environmental factors occurring simultaneously differ significantly from the effects caused in the human organism by the same environmental factors when they occur alone. It would therefore seem to be very well grounded and important to aim at pursuance of research work on a broad basis and at simultaneous scrutiny of the characteristics of several factors in order to ensure correct conclusions.

[18] HYGIENIC SIGNIFICANCE OF COMBINED EXPOSURE TO NOISE, VIBRATION AND MICROCLIMATE IN AGRICULTURAL PRODUCTION

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The combined effect of noise, local and whole-body vibration, temperature and the air flow velocity on the state of some physiological functions and operators’ activity specific for the tractor-drivers and simulated on the vibrating stand have been studied. The ability to follow accurately the sinusoidal signal at various velocity of its transference was recorded. Mathematical planning of multifactorial experiment was carried out. It allows evaluating quantitatively the effect of each studied factor and their interaction. Under combined exposure to the studied factors the reliable decrease in accuracy of the operator’s performance and the peculiarities of some physiological functional changes of both additive and antagonistic characters were found.
The results of the above studies have confirmed the dependence of the specific reaction changes on separate factors and allowed to reveal some effects of their interactions.

[19] EXPERIENCE OF THE USE OF SOME MULTIDIMENSIONAL STATISTICAL METHODS FOR THE ANALYSIS OF THE COMBINED EFFECTS OF LABOUR LOAD, PHYSICAL AND CHEMICAL FACTORS

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The combined effect of the industrial environment factors on the efficiency and health and on the formulation of efficiency at various levels of physiological and psychological functions has been studying by us for more than 25 years. Multifactorial variance linear and non-linear regression, discriminatory analyses have been used. The variance analysis of simultaneous effect of 2-3 factors result in the distinct data on the objectives of their action and on the features of their combined effect. The increase in the number of factors makes the analysis of their interaction more difficult and the regression models for summing up the effects acquire practical significance. Epidemiological studies of the long-term exposure to some individual factors similar in intensity of the hygienic standard levels are of particular concern. The mathematical model to account for the threshold levels of the factors and the duration of the effect has been proposed.

[20] INDEPENDENCY BY ENVIRONMENTAL FACTORS IN WOOL INDUSTRY

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In production systems of wool industry plants concentration and intensity of environmental factors were measured. The values obtained were transformed into a common linear scale. The results of that transformation made it possible to define the hazards caused by those factors in the production systems analyzed.
[21] SPECIFYING THE MAXIMUM EXPOSURE TIME OF SERVICING PERSONNEL TO ENVIRONMENTAL FACTORS (ON THE BASIS OF SALT MINES)

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It was assumed that the time of exposure of the servicing personnel to the environmental factors is inversely proportional to the values of existing hazards. The paper presents maximal times of exposure of salt mine production system servicing personnel to environmental factors.

[22] A MODEL FOR STUDIES ON CERTAIN PHYSIOLOGICAL FUNCTIONS OF HUMAN ORGANISM

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People are in their work exposed to different kinds of environmental conditions which may have an adverse effect on them. In such cases it is important to determine the magnitude of the effects of environmental stimuli. In connection with this work a time series model was developed which can be used to examine changes in a person's hearing thresholds and sublingual temperature under varying conditions of noise, vibration and air temperature. At the initial stage of the work, a basis was established for modelling and simulation and a person's hearing and thermal regulation were described. Likewise, the kind of a measuring material on which the model is based was clarified. Two identification programs based on the sum of the least squares method were prepared: with the aid one of these, MIMO models are obtained and with the aid of the other, MISO models are obtained. The accuracy of the models was examined using the square of the difference of measurements and using the simulation results.
With the aid of different models, simulation tests were made aimed at clarifying the effects of vibration on hearing and sublingual temperature. Although a time series model could be developed on the basis of the material measured in advance, when using the models, it should be noted that the deviations from linearity caused by vibration and air temperature have not been included in the models. This impairs the accuracy of the simulation results. In order to improve the accuracy of the model, many more measurements should be used for the modelling, or at least, the nonlinearity should be clarified.

[23] COMBINED EFFECT OF WHOLE BODY VIBRATION AND NOISE ON BRAIN NOREPINEPHRINE

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The experimental study was undertaken to investigate the effect of whole body vibration, noise and their combined stress on the central nervous system. Rats were exposed to whole body vibration, with a frequency of 20 Hz and acceleration of 5.0 G, and to recorded traffic noise of 100 dBA. And moreover, rats were exposed to a combined stress of whole body vibration and noise. Immediately after exposure, rats were decapitated and brains were removed from the cranium. The brain was divided into 7 regions. In every region the levels of norepinephrine (NE) were measured using the fluorometric methods. 1) When the whole body vibration was administrated, the mean level of NE in whole brain was decreased to 57.0 % of that of the control. This NE depletion was observed in the hypothalamus and the hippocampus. 2) When the noise was administrated, the level of NE in whole brain was decreased to 50.0 % of the control. The NE depletion was observed in the hypothalamus and midbrain. 3) When whole body vibration and noise were combined and administered, in whole brain the NE was decreased to about the same degree of the whole body vibration exposure. The NE depletion was observed in the hypothalamus and the hippocampus. Thus, the combined effects of whole body vibration and noise were not additional one.
[24] COMBINED EFFECT OF VIBRATION AND NOISE

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In this presentation, the effects of separate and simultaneous exposure to vibration and noise are summarized. The investigation was carried out in the form of a field survey to measure the annoyance level caused by vibration and noise. The investigation was performed under three conditions: 1) simultaneous exposure to vibration and noise, 2) exposure to vibration alone and 3) exposure to noise alone. As a result: 1) Annoyance by noise was twice as large as that by vibration. 2) When the subjects were simultaneously exposed to vibration and noise, at lower vibration level, the annoyance was induced only by noise. 3) Noise acts as a masking for the perception of vibration sensation. The vibration sensation became more sensitive without masking. In addition, experimental studies were performed on the temporary threshold shift (TTS). TTS caused by noise is enhanced by vibration. Simultaneous exposure to noise (steady-state 101 dB) and vibration (500 cm/sec², 5 Hz) made the TTS more severe than either noise or vibration alone. Animal experiments regarding the combined effects vibration and noise will also be presented.

[25] EFFECTS OF NOISE AND VIBRATION IN VISUAL ORIENTATION

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Eye movements and EEG were recorded in intact rabbits during an optokinetic test when the animals were exposed to pure tone noise (85 dB at 4 000 Hz), impulse noise 159 dB) and vibration directed to the abdomen, (acceleration of 10 m/s² at frequencies of 40, 60, 100, 120 and 140 Hz). The frequency and velocity of optokinetic nystagmus (OKN) significantly increased with these stimuli.
The increase seen with vibration was greater than that from noise, and when combining noise and vibration, the response was the strongest. The increase of OKN seen with induced vibration was successive and dependent on the frequency. The increase was weakest during vibration 40 Hz and strongest during vibration at 140 Hz. EEG of the amygdaloid complex, dorsal hippocampus, midbrain reticular formation and frontal motor cortex all were activated during noise and vibration exposure, but activation of the hippocampal EEG was most closely related to the increase of OKN. Thus, vibration and noise, when excessive, may interfere with visual orientation and hence disturb the equilibrium system. Findings can be related to the unspecific dizziness found in aerospace workers exposed to excessive noise and vibration.

[26] COMBINED EFFECTS OF NOISE AND VIBRATION ON EMPLOYEES IN THE RHENISH BROWN COAL OPENCAST WORKING

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In an earlier study the working condition on heavy engines in the Rhenish brown coal opencast working and the effects on health of the exposed workmen were examined. A comparable sample of workmen from a different work place was chosen for a control. The state of health was judged by a questionnaire about health disorders by evaluating the medical records of the medical service and by biochemical and physiological data which were gained during a working shift. The working situation was characterized by technical data concerning noise and vibration exposure. By multiple determination the connection between the influences of the work place and the state of health were examined.
**[27] THE COMBINED EFFECT OF CLIMATE AND NOISE ON LABOUR EFFICIENCY AND STRESS**

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At a laboratory experiment, the effect of climate and noise on labour efficiency and stress at sensomotorial and complex mental work requirements is investigated. The aim consists in determining limits for simultaneously occurring environmental factors relevant for practical work. As experimental method a 3-dimensional set up is used including quantitative and qualitative parameters of labour efficiency, physiological and psychological indicators. Work models with sensomotorial and mental requirements are applied. The results secured statistically indicate additive effects of heat and noise, i.e. the influence on labour efficiency and stress is higher at the simultaneous effect of heat and noise than at stress induced by single factors. This could also be confirmed by an increase of the TTS. Concerning heart rate, a superposition of the influence of noise and thermo-regulatory conditioned influence could be stated.

**[28] ENVIRONMENTAL FACTORS IN BROWN COAL MINING**

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A linear scale transformation of the values of concentration and intensity of environmental factors on the work-stand of operators of basic machinery in brown coal mining was carried out. The obtained results made it possible to determine the work stands where there is the highest strenuousness caused by the combined effects of the environmental factors.
Vibration hazards, as a combined effect of vibration, noise and cold, was analyzed the interrelationships of age, operating time, hearing loss, recovery rate of skin temperature and variation of blood pressure for 20 minutes by the 10 minute immersion test in 10°C cold water, and changes in blood plasma and urinary catecholamines after the 10 minute chain saw work. On the other hand, the relation between attention and auditory evoked response (AER), visual evoked potential (VEP) or the combined effects of auditory and visual stimuli were clarified in this investigation. As the results showed, recovery rate of skin temperature by the immersion test did no correlate to the operating time, but the age. Excellent group of recovery rate of skin temperature showed a big variation of blood pressure by the cold pressor test. Blood plasma and urinary norepinephrine increased after the chain saw work, and the former recovered 10 minutes after the stop of work. Under concentrating attention to a given stimulus, reaction to the stimulus of different nature increase in the amplitude of evoked potential. Above results suggest that central and autonomic nervous reactions due to combined stimuli are connected to the stress bringing about the hazards.
[30] EFFECTS OF EXPOSURE TO WHOLE-BODY VIBRATION AND NOISE ON THE TTS, PERFORMANCE, POSTURAL SWAY, AND AUDITORY EVOKED BRAIN POTENTIALS

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Experiment 1 (6 subjects; exposure 2 hours) aimed at the examination of the combined exposure to noise (62 or 100 dB) and whole-body vibration (wbv; 1 or 4 Hz) in comparison with the effects due to single factors. TTS, performance tests, the assessment of the subjective well-being, and posturography were applied. Experiment 2 aimed at elucidating changes of acoustical information processing during wbv (1, 2, 4, 8 Hz; 2 levels; 5.5 min) by means of evoked potentials. Results of experiment 1 indicate weak differences of the combined effects vs the single ones. Moderate synergistic adverse effects were confirmed by the TTS only. Interindividual differences of the susceptibility are important. Experiment 2 exhibited more pronounced changes with lower frequencies and a higher intensity of wbv. Combined exposures should be evaluated by a set of methods with regard to individual responses. ISO 2631 underestimates the effects of wbv with 1 and 2 Hz.

[31] COMBINED EFFECTS OF NOISE AND VIBRATION IN THE GENESIS OF HEARING LOSS AMONG FOREST WORKERS

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The connection of noise-induced permanent threshold shifts (NIPTS) and the vasospastic component in vibration syndrome (VWF) was examined in a longitudinal study.
In addition the noise level and vibration of chain saws used at present and in the early 1960s were measured. When the forest workers were classified according to exposure time the subjects with VWF in groups of 5 000 to 9 900 operation hours and 10 000 to 14 900 operation hours NIPTS was 10 to 15 dB greater than in subjects without VWF. The difference was statistically highly significant. Three different chain saw generations were included to the measurements. First generation chain saw manufactured in 1958 produced the highest value of noise NR 108 and weighted acceleration 14 m/s². In the second (manufactured 1972) and third generation chain saw (manufactured 1982) the NR curve 105 was not exceeded and equivalent noise levels during normal work were from 95 to 107 dBA. Weighted acceleration was about 2 m/s² in both chain saws. The findings indicate that the vasospastic phenomenon in the finger circulation has a connection with occupational hearing loss. The harmful effects of local vibration are thus not only limited into the hand-arm system.

[32] PRINCIPLES OF ASSESSMENT OF COMBINED EFFECTS OF NOISE, VIBRATION AND WORKING ACTIVITY ON THE BASIS OF BIOLOGICAL EQUIVALENCE CONCEPT

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The working process of different occupational groups is often accompanied by noise and vibration. Noise and vibration at work places are characterized by physical parameters such as frequency spectrum, equivalent level or dose, while working activity by ergonomic indices in categories of heaviness for physical labour and tension for nervous-emotional work or their combination.
Proceeding from the effect of environmental factors and working load on an organism as a whole it is necessary to take it to account both specific and non-specific changes, including those mediated via nervous system, which determine the state of health and working ability. The concept of biological equivalence of the effects of noise and vibration (especially at low non-damaging, but fatiguing levels) and working load permits the substantiation of the optimum levels of these factors within the frames of differential hygienic rating. The mentioned principles are useful not only for the rating of factors during the working shift, but also for the assessment of their daily effect with regard for the periods of vital activity (work, rest and sleep). Thus the quality of occupational and general environment can be integrally assessed and through prophylactic measures worked out.

**[33] COMBINED EFFECTS OF ORGANIC SOLVENTS, A REVIEW**

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Combined effects of organic solvents are plausible, as adjacent processes at working places often require several solvents and solvent mixtures. These effects can be based on interactions at various levels of compound actions: at kinetic levels as altered absorption, distribution, biotransformation and excretion; at the level of the effects on the effector organs. The interactions of solvents are mainly shown on the metabolic level. The competition for the activated solvent metabolizing enzyme systems both in oxidation and conjugation, and the induction of microsomal mixed-function oxidases may contribute to the combined toxic effects of solvents. The toxicities of e.g. tetrachloromethane, trichloromethane and carbon disulphide are potentiated by the induction mechanism as a consequence of the increase of free radical intermediate metabolic products.
Combined chronic exposures to different solvents as well as combined chronic intake of alcohol and drugs may cause membrane damage and thus decrease the biotransformation capacity. The central nervous effects are considered the most common organ effects.

[34] CHANGES OF PARALINGUISTIC FEATURES UNDER COMPLEX EXPOSURE CONDITIONS

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Preliminary results are presented of the variation in paralinguistic features of reading samples in an investigation of exposure to three environmental factors (dry bulb temperature, noise and sinusoidal as well as stochastic whole body vibration). The study was carried out as a factorial experiment of the 2 x 2 x 3 type. The voice samples consisted of one control (rest) sample and one exposure sample, in both morning and afternoon session. Test subjects (n=60) read a text which was easy, familiar, and emotionally neutral. Statistical significant differences were found between different exposure groups, both in fundamental frequency and in voice intensity. Simultaneous exposure to wide band stochastic whole body vibration and 90 dBA noise at 35⁰C lowered fundamental frequency and voice intensity. On the contrary, a rise in fundamental frequency and intensity was brought about by a combination of noise of 90 dBA and either 5 Hz sinusoidal vibration or 35⁰C dry bulb temperature. In general, the changes in intensity and frequency under the various experimental conditions were in the same direction - the one exception being the group exposed to noise only.
The authors state that simultaneous analyses of several prosodic features of speech might be of use in the definition of emotional and arousal conditions in this type of study. However, further research is needed to help shed light on the relations existing between variations in voice quality at the individual and group levels, and psychophysical indicators and emotional conditions.

**[35] BEHAVIOURAL EVIDENCE FOR THE INTERACTION OF ENVIRONMENTAL PARAMETERS IN BUILDING**

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The results of three different experiments are summarized as evidence that the combined effects of two or more environmental factors on behaviour and sensation are not necessarily additive, and can be quite complex, depending on the mechanism: ¹The widespread discomfort caused by dry air (RH 20 %) at normal indoor temperatures can be almost eliminated by reducing the air temperature by as little as 20⁰C, or by ensuring that the air is extremely clean. The mechanism is probably that air temperature and humidity can both impair the function of the mucous membranes in removing air pollutants. ²Loud noise (85 dBA) counteracts both the positive and the negative effects of moderate heat stress on mental performance, but increases the negative effects of extreme heat stress. The mechanism is probably that noise and extreme heat stress increase arousal, while moderate heat stress reduces arousal. ³Bright lighting (1 000 lux) always improves the performance of visually demanding tasks, but the performance of more ordinary tasks is negatively affected by bright lightning if air temperatures are slightly raised. The mechanism is probably that brightly-lit surroundings are distracting when attention is less concentrated due to lowered arousal in the heat.
[36] METHODOLOGICAL ASPECTS OF INFLUENCE OF ENVIRONMENTAL TOXICAL FACTORS ON ORGANISM

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The peculiarities of the system approach to an analysis of physiological processes of an organism and especially goal-directed behavior, which is based on the principles of the Anokhin functional theory, are demonstrated in present paper. An investigation of biological motivations from the point of view of the functional system theory in response to intravenously administrated ethanol (0.5 g/kg) is used to show the possible application of this methodological approach for the analysis of effects of environmental factors on an organism. Data obtained on disorders of physiological and neurochemical mechanisms in feeding and escape reactions after ethanol administration are discussed from the systemic approach in direction to increase the tolerance of an organism to ethanol.