

MINISTRY OF HEALTH OF UKRAINE
O.O. BOGOMOLETS NATIONAL MEDICAL UNIVERSITY

“Approved”
at the methodological conference of hygiene
and ecology department
Head of the department
correspondent member of NAMS of Ukraine,
M.D. Bardov V.G. _____

GUIDELINES
FOR STUDENTS

<i>Subject</i>	Hygiene and ecology
<i>Module № 1</i>	Assessment of the environment and its impact on the population health
<i>Submodule № 2</i>	Municipal hygiene
<i>Topic of the lesson</i>	Sanitary protection of the atmospheric air. Hygiene of settlements planning. Hygiene of residential and public buildings and constructions.
<i>Course</i>	6
<i>Faculty</i>	medical
<i>Author</i>	asst. prof Vavrinevych O.P., asst. prof. Zagorodniuk K.Yu.

1. Learning objective

1.1. Strengthen the student's knowledge about chemical composition of the air, the atmospheric and the indoor air pollution sources.

1.2. Master the main methods of sanitary and chemical analysis of the air samples.

1.3. Strengthen and enlarge theoretical knowledge of students about noise and vibration as elements of industrial environment and their influence on organism and health.

1.4. Master techniques and means of measurement and hygienic assessment of noise and vibration parameters.

2. Basics

2.1. You should know:

2.1.1. Physiological and hygienic significance of the air components and their influence on the human health and sanitary living conditions.

2.1.2. Atmospheric, indoor and working chemical air pollution factors and indices and their hygienic regulation.

2.1.3. Classification of the air sampling methods.

2.1.4. Principal scheme of the aspiration method of the air sampling for chemical analyses, devices and measures used for this procedure.

2.1.5. . Biological effect of noise and vibration, and prevention of their negative influence on human organism.

2.2. You should have the following skills:

2.2.1. To justify the choice of the air sampling method for sanitary and chemical research.

2.2.2. To calculate the air volume required for analysis and to convert its value to the value in the standard conditions. (0° C and 760 mm Hg).

2.2.3. To use sound level meter and noise-and-vibration spectrum analyzer.

3. Self-training questions

3.1. The atmospheric and expired air chemical composition.

3.2. Main sources, criteria and indices of the atmospheric, indoor, public and working chemical air pollution.

3.3. Influence of the air, polluted by chemical ingredients on the human health.

3.4. Indices and requirements to the air sampling for sanitary and chemical research purposes.

3.5. Calculation of the minimal air sample volume required for analysis. Measuring units.

3.6. Aspiration methods of the air sampling, the air aspiration devices.

3.7. Devices for the passed air volume determination. Significance and the methods of the conversion of the air volume to its value in the standard conditions.

3.8. Absorbing devices and the absorbing mass, their characteristics, types and purposes.

3.9. Air sampling into laboratory glassware with limited capacity.

3.10. Express-analyses (colorimetric, linear-colorimetric), determination of the chemical contaminants in the air. The universal gas-analyzer UG-2 (УГ-2), its construction and principle of functioning.

5. Structure and content of the lesson (duration of the lesson 160 min + 10 min break)

5.1. Preamble – 5-10 min.

5.2. Test control for assessment of students' knowledge datum level – 10-15 min

5.3. Theoretical training – 30-40 min.

5.4. Typical situational tasks “Krok-2” solution – 30-40 min.

5.5. State exams situational tasks solution – 30-40 min.

5.6. Test control for assessment of students' knowledge final level – 10-15 min.

Appendix 1

Methods and devices of the air sampling for chemical analysis

There are two groups of methods – laboratory and express. These methods were elaborated and are widely used in the sanitary inspection units for determination of the air pollution in the atmosphere, indoor and in factory working areas.

The aspiration method of the air sampling is one of the laboratory methods. Using this method of sampling the required air volume is passed through selected absorbing solutions in absorbing devices of different constructions (fig. 10.2) by an aqueous aspirator (fig. 10.1-a), a vacuum cleaner or the electrical aspirator (fig. 10.1-b). The investigated air is delivered into the absorbing solution through the long tube of this device, then it is passed by short tube of the aspirator. Crystal absorbing reagents located in tubes – allonges of special forms are widely used for this purpose.

The air volume passed through the absorbing solution or the allonge is determined using a gas meter, an aqueous rheometer (fig. 10.3) or a ball rotameter measuring the air aspiration speed in l/min. The gas meter or rheometer is concatenated between the absorbing device and the aspirator. The required air volume is determined for the particular chemical research (analyses) in accordance to the appendix 2.

The air sampling for laboratory analyses may be selected in tubes of definite capacities by blowing the investigated indoor air through them, or by pouring the water out from the tube inside the investigated room. Gas pipettes (fig. 10.4), flasks and other devices are used.

The universal gas-analyzer UG-2 (УГ-2) (fig. 10.5, appendix 3), the gas-analyzer GMK-3 (ГМК-3) (fig. 10.6) and other devices may be used for the express methods.

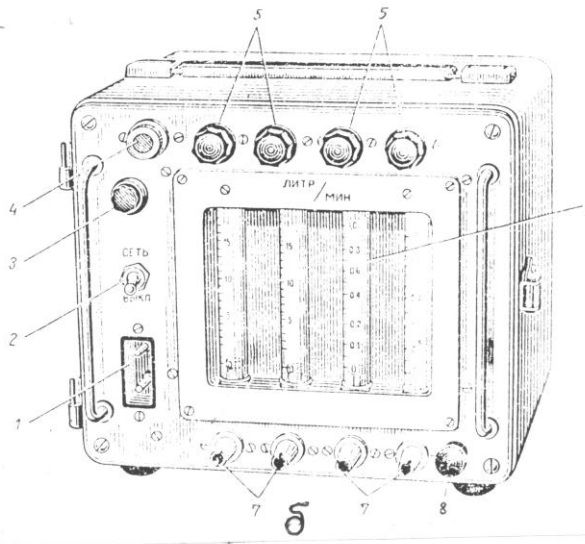
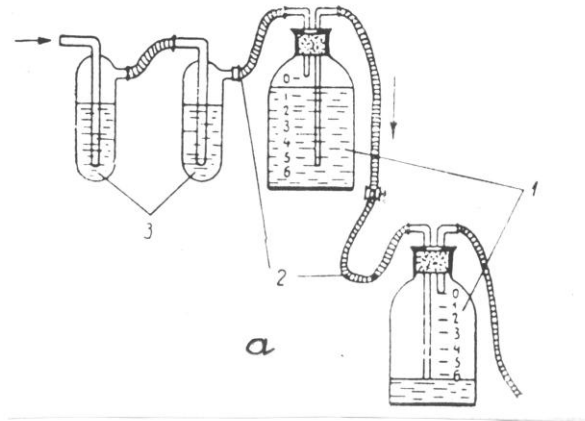


Fig. 10.1 a – Aqueous aspirator (1), connected by rubber tube (2) with absorbing devices; b – electrical aspirator „Liot”

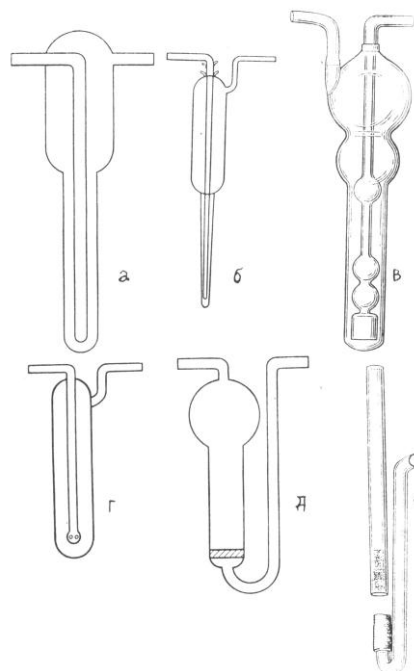


Fig. 10.2 Absorbing devices for the air sampling with liquid solutions

- a – Zaitzev (Зайцева);
 b – Polezhaev (Полежаева);
 d – Petri (Петри);
 e – with porous membrane (з пористою)

c – Rikhter (Ріхтера);

пластинкою);

f – with crystal reagent (з кристалічним реактивом).

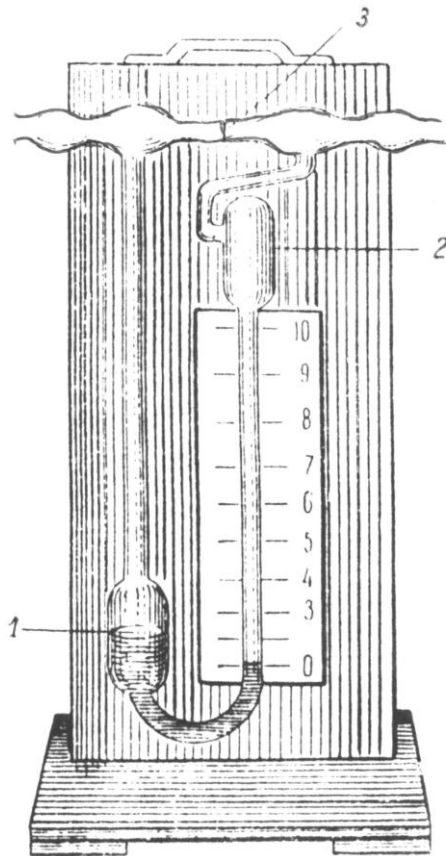


Fig. 10.3 Aqueous rheometer

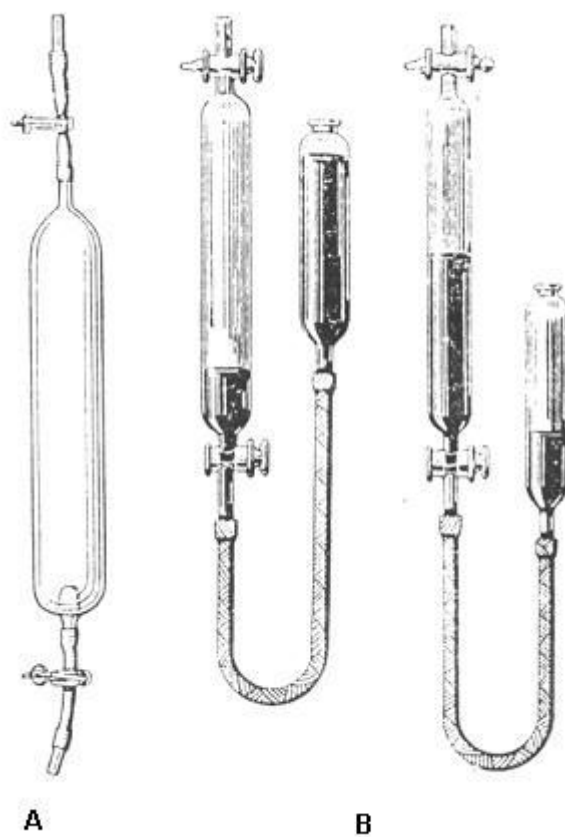


Fig . 10.4 Air sampling into gas pipettes:
 a – by air inflow (leak-in) or pouring out; b – by siphon method.

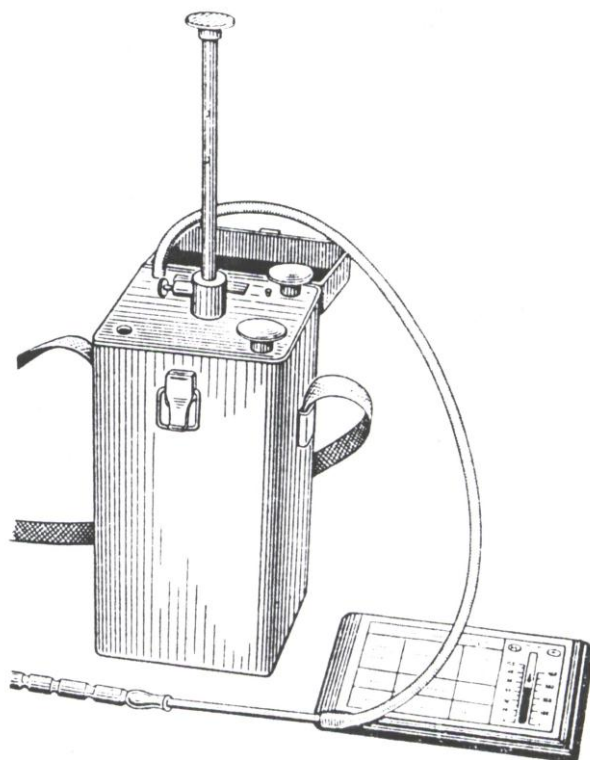


Fig. 10.5 Universal gas-analyzer UG-2 (YT-2) with the colorist scale

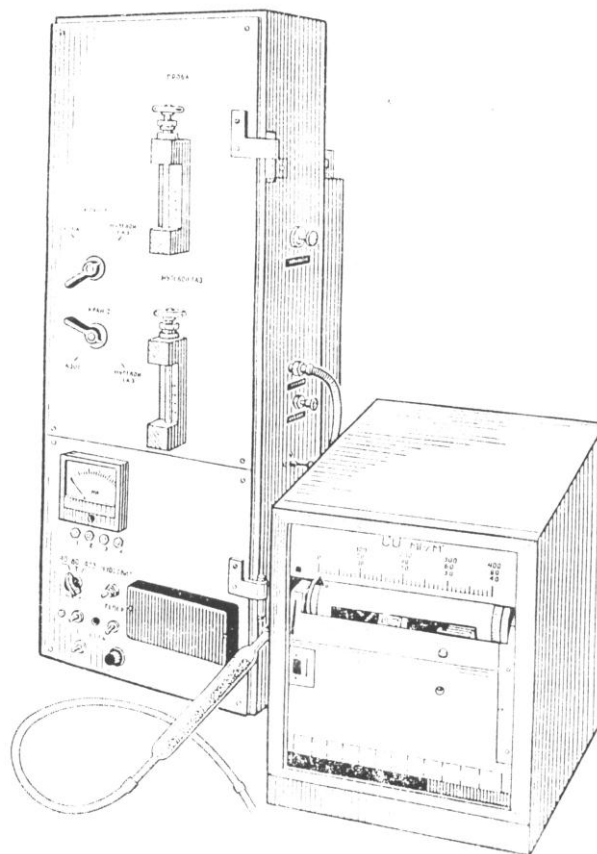


Fig. 10.6 Gas-analyzer GMK-3 (ГМК-3)

Appendix 2

Example of the calculation of the air volume required for chemical analysis and conversion of its value to the value in standard conditions

Calculate the required air volume for bromine vapors determination if method's determination limit is 0.002 mg, maximum one-off allowable concentration of the bromine vapours in the production department is 0.5 mg/m³ or 0.0005 mg/l. Total volume of absorbing solution is 4 ml and 2 ml of this solution is taken for the analysis. Coefficient determining the MAC portion for identification is 0.5.

The air temperature during the air sampling is 20°C, the atmospheric pressure - 750 Hg mm.

The required air volume is calculated by the following formula:

$$V_0 = \frac{a \cdot V}{K \cdot C_0 \cdot V_1},$$

where: a – method's determination limit (minimal quantity of the determining substance);

V – total volume of the absorbing solution in ml;

K – general coefficient determining the MAC portion for identification (1, 1/3 and others);

C₀ – maximum allowable concentration of the substance, milligrams per m³;

V₁ – the absorbing solution volume taken for analysis, milliliters.

$$\text{Solution: } V_0 = \frac{a \cdot V}{K \cdot C_0 \cdot V_1} = \frac{0.002 \times 4}{0.5 \times 0.0005 \times 2} = \frac{0.008}{0.0005} = 16 \text{ l.}$$

The formula (of the Charles' law or the law of combining volumes) is used for conversion of the selected air volumes in liters to their values in the standard conditions:

$$V_0 = V_t \times \frac{273}{(273+T)} \times \frac{B}{760},$$

where: V_0 – the air volume in liters converted to its value in the standard conditions (0° C and 760 Hg mm);

V_t – the air volume in liters sampled under certain temperature and atmospheric pressure;

273 – expansion factor;

T – the air temperature during the air sampling (° C);

B – the atmospheric pressure during the air sampling, Hg mm.

The values of the formula components $\frac{273}{(273+T)} \times \frac{B}{760}$ are determined using the table 1 to simplify the calculation.

Solution:

$$V_0 = V_t \times \frac{273}{(273+T)} \times \frac{B}{760} = 16 \text{ l} \times \frac{273}{(273+20)} \times \frac{750}{760} = 16 \times 0.932 \times 0.987 = 14.72 \text{ l}$$

Table 1

Coefficients for conversion the air volumes to their values in standard conditions

Temperature	$\frac{273}{(273+T)}$	Atmospheric pressure, Hg mm.	$\frac{B}{760}$	Temperature	$\frac{273}{(273+T)}$	Atmospheric pressure, Hg mm.	$\frac{B}{760}$
- 4	1.015	741	0.975	16	0.945	761	1.00
- 3	1.011	742	0.976	17	0.941	762	1.00
- 2	1.007	743	0.978	18	0.938	763	1.00
-1	1.004	744	0.979	19	0.935	764	1.00
0	1.000	745	0.980	20	0.932	765	0.00
1	0.996	746	0.982	21	0.929	766	1.00
2	0.993	747	0.983	22	0.925	767	1.00
3	0.989	748	0.984	23	0.922	768	1.0
4	0.983	749	0.986	24	0.919	769	1.0
5	0.982	750	0.987	25	0.916	770	1.0
6	0.979	751	0.988	26	0.913	771	1.0
7	0.975	752	0.989	27	0.910	772	1.0
8	0.972	753	0.991	28	0.907	773	1.0
9	0.968	754	0.992	29	0.904	774	1.0
10	0.965	755	0.993	30	0.901	775	1.0
11	0.961	756	0.995	31	0.898	776	1.0
12	0.958	757	0.996	32	0.895	777	1.0
13	0.955	758	0.997	33	0.892	778	1.0
14	0.951	759	0.999	34	0.889	779	1.0
15	0.948	760	1.000	35	0.886	780	1.0

The sample form of the protocol of the air sampling

Date of sampling: _____ year _____ month _____
_____ date _____

1. Name of the manufacture _____
(place of the air sampling)
2. The air research for _____
(to indicate what is determined)
3. Meteorological factors during the air sampling: temperature _____ °C, relative air humidity (outside the apartment) _____ %, temperature _____ °C, relative air humidity in the air sampling place _____ %
4. Work operations during the air sampling _____
5. Ventilation type, its action _____
6. Absorbing device, its № _____
7. Distance between the device and the source of pollution _____ meters
8. Time of the air sampling: from _____ h _____ min till _____ h _____ min
9. Extending air volume _____ liters
Speed per minute _____ liters
10. Who performed the air sampling _____
11. Where was the air sample sent to analysis _____
12. Additional information _____
Date _____

Signature _____

Appendix 3

Determination of chemical pollutants in the air using gas-analyzer UG-2 (YF-2)

The gas-analyzer is built using the linear-colorimetric principle: concentration of a chemical pollutant in the air is determined by the coloring of the indicating reagent in a glass pipe after blowing the certain volume of the investigated air through this. The indicating tube with the reagent is put on to the colorimetric scale. The different scale is provided with the device for each air pollutant. Concentration of the searched substance is pointed on this ruler in mg/m^3 .

14 chemical pollutants, usually met at manufacture may be determined using this device: ammonia, acetone, acetylene, benzene, benzole, xylol, carbon oxide, nitric oxides, sulfurous anhydride, hydrogen sulfide, toluol, oil hydrocarbons, chlorine, ethylic ether.

The indicating tubes with crystal reagents are prepared for the analyses and are added to the device.

Order of testing. Using rod with the required air volume for certain analysis the air is blown from the air inlet siphon (rubber camera stretched by the spring) at the place of investigation (on the department, on the working place, at the pollution outburst spots). The certain indicating tube is connected to the rubber tube of the device and the required air volume is blown through the rubber tube after releasing the rod from holding clamp. The indicating tube is put onto the colorimetric ruler. The

investigated pollutant concentration is determined by the changing of the length of the reagent portion, that changes its color (becomes darkened).

Note. The indicating tubes and air pollution simulation by certain substance are prepared by the laboratory of the department because of the limited working time.

It is highly recommended to organize the lesson in the real manufacture conditions.

Table 2

Maximum allowable concentrations (MAC) of hazardous substances in the working zone air (extract from the industrial safety standards “General sanitary and hygienic requirements for the working zone air condition”, State standard 12.1.005-88)

<i>Substance</i>	<i>MAC, mg/m³</i>	<i>Usual aggregate state in factory conditions</i>	<i>Hazard type</i>	<i>Impact on human</i>
Acetylene	5	vapours	III	
Ammonia	20	vapours	IV	
Acetone	200	vapours	IV	
Benzene	100	vapours	IV	
Benzole	15/5*	vapours	II	Carcinogen
Xylol	50	vapours	III	
Carbon oxide (CO)	20	vapours	IV	Acute effect on the blood
Nitric oxide (recalculation to NO ₂)	5	vapours	III	Acute effect on the blood
Sulfurous anhydride	1	aerosol	II	
Hydrogen sulfide	10	vapours	II	Acute effect
Toluene	50	vapours	III	Acute effect, allergen
Oil Hydrocarbons				
Chlorine	1	vapours	II	Acute effect, allergen
Ethylic ether	10	vapours	III	

* in numerator – maximum, in denominator – average monthly

Appendix 4

Hygienic characteristics of the indoor sanitary condition and ventilation

The chemical composition of the atmospheric air is: nitrogen – 78.1%; oxygen – 21.0%; carbon dioxide – 0.03-0.04%; inert gases – 0.7-1.0%; moisture usually from 40-60% till the full saturation; dust, microorganisms, natural and anthropogenic pollutions depending on the industrial development of the region, surface type (desert, forest-covered region etc.)

The main air pollution sources of the inhabited regions and industrial areas are the production plants, motorized transport; industrial dust and gas; meteorological factors (winds) and surface type of the regions (dust storms of arid settlements without green plantations).

The main air pollution sources of the residential, communal, domestic and public premises are the products of the human metabolism, generated by skin and respiration (sweat, skin fat, necrotic epidermis degradation products and others). These products are thrown out into the indoor air proportionally to the number of people present and duration of their stay indoor and carbon dioxide volume. The carbon dioxide is accumulated in the air in proportion to the listed pollutants and may be used as an indicator of the pollution with these products.

The organic metabolic products are extracted through the skin and by respiration generally. That is why the air oxidability was suggested as the other pollution indicator for the assessment of the indoor air pollution induced by human. The oxidability index is measured as the atomic oxygen volume required for oxidization of organic products in 1 m³ of the air using the solution of potassium dichromate K₂Cr₂O₇ for titration.

The air is pure if this index doesn't exceed 4-6 mg/m³. The oxidability air index may be 20 and above mg/m³ in the rooms with the adverse sanitary state.

5. Indoor carbon dioxide concentration is increased proportionally to the number of people and duration of their stay inside. Although it normally does not reach the hazardous levels, nevertheless it does indicate the level of the air pollution with the other metabolism products. The carbon dioxide concentration may reach the hazardous for human organism or even life level only in the enclosed non-ventilated areas (dug-outs, submarines, underground openings, industrial areas, sewer systems etc.) due to fermentation, combustion, putrefaction.

The increase of the CO₂ concentration by 2-2.5% does not cause noticeable deviations in the human health and work ability, according to the research by M.P. Brestkin and other authors. Concentrations up to 4% may cause the increase in the respiration intensity, the cardio-vascular functions and reduction of the work capacity. Concentrations up to 5% are accompanied with dyspnea, increase of the cardiac function, decrease of workability. 6% CO₂ concentration causes the mental activity decrease, the headaches, dizziness; 7% causes the inability to control oneself, fainting and even death. 10% concentration results in rapid, and in 15-20% cases - sudden death because of the respiratory paralysis.

Some methods were elaborated for CO₂ concentration determination in the air: method with barium hydrate by Subbotin-Nagorskiy, methods by Reberg-Vinokurov, Kalmikov, interferometrical method. The portable express method by Lunge-Zeckendorf modified by D.V. Prokhorov is the most widely used in the sanitary practice (see appendix 2).

Appendix 5

Carbon dioxide determination in the air using the express method by Lunge-Zeckendorf, modified by D.V. Prokhorov

The method is based on blowing the investigated air through the sodium carbonate (or ammonia) volumetric solution in presence of the phenol-phthalein. The $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2 = 2\text{NaHCO}_3$ reaction takes place in this case. Pink in the alkaline medium, the phenol-phthalein is discoloured after the contact with CO₂ (acid medium).

The raw solution is prepared by dilution of 5.3 g chemically pure Na₂CO₃ into 100 ml of distilled water and 0.1% solution of phenol-phthalein is added to the raw

solution. Before analysis the work solution is prepared by dilution of 2 ml raw solution to 10 ml by distilled water.

The solution is poured into Drechsel's bottle by Lunge-Zeckendorf method (fig. 11.1-a) or into Janet's syringe in Prokhorov's modification (fig. 11.1-b). In the first case the rubber syringe with valve or small aperture (hole) is connected with the long tube of Drechsel's bottle with thin beak. The investigated air is blown through the solution by slow compression and fast release. The bottle is shaken up till the total absorption of CO₂ from the air sample after each blowing. In the second case (Prokhorov's modification) the total air volume is collected into the Janet's syringe, filled with 10 ml of the work soda solution with phenol-phthalein and held with the cannula up, the syringe is also shaken up. The air volumes for discoloring of the solution are calculated. The air analysis is carried out indoor and outside (atmospheric air).

The result is calculated by the inverse proportion under comparison of the used syringe volumes quantities and CO₂ concentration in the atmospheric air (0.04%) and unknown CO₂ concentration in the certain investigated indoor premise. For example, 10 syringes were used indoors and 50 - outdoors. *CO₂ concentration indoors* = $(0.04 \times 50) : 10 = 0.2\%$

CO₂ maximum allowable concentration (MAC) of the indoors (premises of various purpose) is determined at the level 0.07-0.1%, in industrial premises where CO₂ is accumulated during manufacture processes - 1-1.5%.

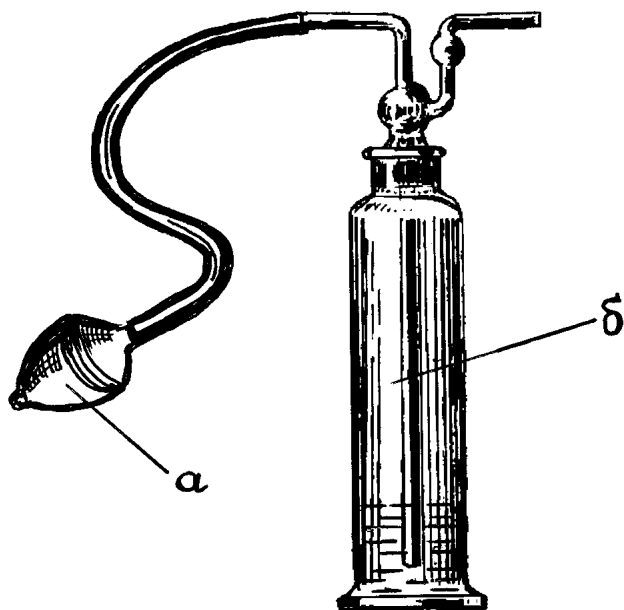


Fig.11.1-a. Device for determination of CO₂ concentration by Lunge-Cekkendorf (a – rubber syringe for the air blowing with valve; δ – Drechsel's bottle with soda solution and phenol-phthalein)

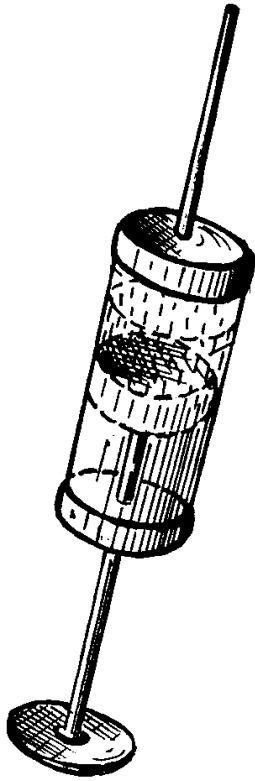


Fig. 11.1-b. Janet's syringe for determination of CO₂ concentration by D.V. Prokhorov

Appendix 6

Methods of determination and hygienic assessment of the air circulation and indoor ventilation

The indoor air is considered pure if CO₂ concentration does not exceed the maximum allowable concentrations – 0.07% (0.7‰) by Pettencofer or 0.1% (1.0‰) by Flugge.

In accordance to this statement the required ventilation volume is calculated. The *required ventilation volume* is the volume of the fresh air, which is to be drawn inside so, that CO₂ concentration does not exceed the allowable value. This volume is calculated using the following formula:

$$V = \frac{K \cdot n}{P - P_1}$$

where: V – ventilation volume, m³/hour;

K – volume of CO₂, expired by one person per hour (in calm conditions 21.6 l/hour; while sleep – 16 l/hour; performing the job of different heaviness – 30-40 l/hour);

n – the number of people inside;

P – CO₂ maximum allowable concentration in pro mil (0.7 or 1.0‰);

P₁ – CO₂ concentration in the atmospheric air in pro mil (0.4‰).

The calculation of the CO₂ volume expired by one person per hour is based on the CO₂ concentration in the expired air (4%), inspiration and expiration rate (under calm conditions – 18 inspirations per minute × 60 = 1080 per hour) and expired air volume – 0.5 l per one expiration, and this totals to:

$$1080 \times 0,5 = 540 \text{ l/hour.}$$

Using the following proportion: 4 l – 100 l, x – 540 l, the expired CO₂ volume may be calculated:

$$x = \frac{540 \times 4}{100} = 21.6 \text{ l/hour}$$

The respiration rate, expired CO₂ volume and required ventilation volume are increased during the physical activity in proportion to their heaviness and intensity.

Required ventilation rate (air exchange rate) is the number, demonstrating how many times the indoor air has to be completely renewed by the ventilation so, that CO₂ concentration does not exceed the maximum allowable concentration (MAC).

Required ventilation rate (air exchange rate) is found by dividing the calculated required ventilation volume by the indoor cubature.

Actual ventilation volume is found by determination of the ventilation source area and the speed of the air movement through it (e.g. transom, wicket). The air volume equal to the indoor cubage (cubature) is drawn inside through the wall perforations, windows slits and doors, and it must be added to the volume of the air, drawn through the ventilation.

Actual ventilation rate (air exchange rate) is calculated by dividing the actual ventilation volume by the indoor cubage (cubature).

The indoor air change efficiency may be determined comparing the required and actual volumes and ventilation rates.

Appendix 7

The air ventilation rate standards for different premises

Type of premises	Ventilation rate, per hour	
	outlet ventilation	inlet ventilation
<i>Building norms and rules 2.08.02-89 – patient care institutions</i>		
Adult ward	80 m ³ per 1 bed	
Prenatal ward, dressing ward	1.5 times/hour	2 times/hour
Delivery room, preoperative and operative wards	8 times/hour	
Postnatal ward	80 m ³ per 1 bed	
Children ward	80 m ³ per 1 bed	
Box, semi-box	2.5 times/hour into corridor	2.5 times/hour
Consulting room	1 time/hour	1 time/hour
<i>Building norms and rules 2.08.01-89 – residential premises</i>		
Living room		3 m ³ /hour on 1 m ² of the area
Gasified kitchen		90 m ³ /hour
Lavatory, bathroom		25 m ³ /hour
<i>State building norms and rules 2.2-3-97 – Buildings and constructions of educational institutions</i>		
Classrooms, study area	16 m ³ per 1 person	1 time/hour
Workshop	20 m ³ per 1 person	1 time/hour
Gym	80 m ³ per 1 person	1 time/hour
Teacher's common room		1.5 times/hour

The required volume and ventilation rate are also assumed to be a scientific basis of residence area standards. Assuming, that the air volume equal to the room cubage (cubature) is drawn inside through the wall perforations, windows slits, and doors (the ventilation rate is ~ once per hour), and the average ceiling height is 3 m, the “normal” area for 1 person is:

- by Flugge (MAC CO₂ = 1‰) $S = \frac{K \cdot n}{(P - P_1) \cdot h} = \frac{21.6 \times 1}{(1 - 0.4) \times 3} = 12 \text{ m}^2/\text{person};$
- by Pettenkoffer (MAC CO₂ = 0.7‰) $S = \frac{21.6 \times 1}{(0.7 - 0.4) \times 3} = 24 \text{ m}^2/\text{person}.$

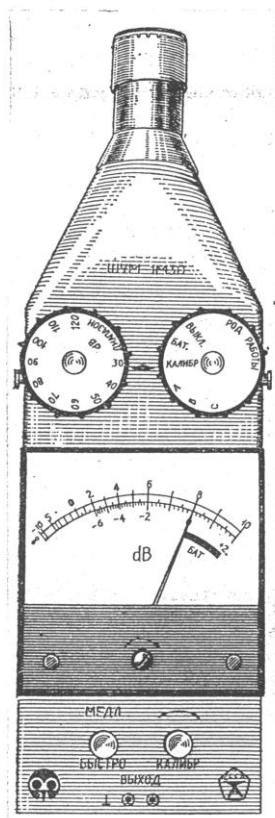


Fig. 33.3. Sound level meter „ЛШУМ-1М” (SHUM-1-M)

Setting-up procedures

1. An instrument is located close to the source of noise.
2. Capsule of microphone is screwed up on the electronic module.
3. Switch "Fast - Slow" is set in the position "Fast".
4. Required sound level is selected by switch "Band".
5. Switch «Operation mode» is moved to position «Battery» (needle must be located at the left side of the black sector, otherwise, battery should be replaced).
6. Switch «Operation mode» is set in the position of «Calibration» and with the help of button «Calibration» set a needle to the reference level of microphone capsule.

MEASUREMENTS

7. Switch "Operation mode" is set to characteristic A (if necessary – on characteristic B or C).
8. Switch «Band» is turned to the left, or to the right, to place the needle in the range of 0 - 10 dB.
9. Measurement result is read as follows: add (if the needle on the scale of the instrument is located from the right of zero) or deduct (if the needle on the scale of the instrument is located from the left of zero) dB indication of the needle of the instruments' scale to dB indication of the switch «Band». For example, 60 dB of switch «Band» + 3.5 dB of scale = 63.5 dB.
10. On completion of measurements «Operation mode» switch is set to "Turn off" position.

on noise and vibration level meter BIIIB-003 (NVD-003) (see fig. 33.4) operation

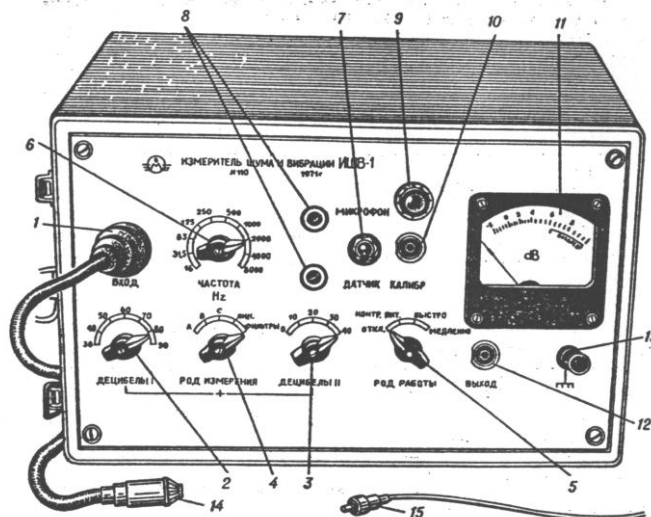


Fig. 33.4 Noise and vibration analyzer „BIIIB-003” (“NVD-003”)

Assignment of the instrument – This instrument is used for frequency analysis of noise and vibration parameters at scientific research works for permanent noise control according to SS 12.1.003-76 and for vibration control in the production areas.

Operational mode of the instrument. Analyzer BIIIB-003 (NVD-003) is designed on the principle of conversion of sound and mechanical vibrations of the objects under investigation into proportionate to them electric signals that later on are amplified and metered.

Preparation of the instrument for noise and frequency measurement. Instrument BIIIB-003 (NVD-003) can be operated from cells 373 or from 220 V electric mains. In this case the instrument is earthed through socket I. The needle of the instrument is set on zero scale indication with the help of mechanical equalizer (if required).

Switch «Operation mode» is set to the position -||- for voltage control of power supply elements. If voltage suffices the needle of the instrument must place between 7 and 10 scale divisions - + 10 (in lower scale divisions are marked by green strokes). Voltage presence is indicated by light of one of light-emitting diodes (LED) of the switch "Divider - dB 1, 2". Switch "Operation mode" is turned to positions F or S. The instrument is ready for operation.

Operation procedure. Before start of sound level measurement (and periodically in the process of measurement) electric calibration of the instrument BIIIB-003 (NVD-003) is carried out (according to special procedure).

Measurement of sound pressure levels at frequency characteristics of "Line", C. B. A:

- buttons "V", "1 kHz", "Octave filters", "H" must be switched off (unburied). Switch «Operation mode» is turned off.

- switches of the measuring instrument are set to position "Divider dB 1" - 80, "Divider dB II" - 50. Filters - to "Line", «Operation mode» - to F.

With this, a rightmost light-emitting diode lights up that corresponds to scale value 130 dB MI01 (the upper on the board). The instrument warms up during 2 minutes.

During measurements preamplifier ПМ-3 (PM-3) (microphone) should be held on a stretched hand in the direction to the source of the sound. If the needle of the instrument is located at the beginning of the scale (the lower), then it is moved to sector - 10 of dB scale, first by switch «Divider dB I», and then by switch «Divider dB II». If indicator "Overheat." lights up, «Divider dB I» should be switched over to a higher level.

When measuring sound low-frequency compounds oscillations of the needle of the instrument can occur. In this case switch «Operation mode» should be moved from F position to S position.

For getting measurement results, it is necessary to sum indications of light-emitting diode according to scale dB MI01 on the front board of the instrument and indications according to dB scale.

Sound pressure levels in octave bands of frequencies are measured only in frequency characteristic of "Line" (i.e., when switch "Filters" is positioned to "Line").

A button "Octave filters" is pressed. Required octave filters are switched on with the help of the switch "Octave filters", each time setting the needle of dB scale to the range of 0-10 dB with the help of switch «Divider dB II».

Switch «Divider dB I» must remain in the same position that it was when total amount of sound was measured (at characteristic of "Line").

At sound pressure in wind conditions, when wind speed exceeds 1 m/sec, screen П-II (for wind protection of capsule MI01) should be used. Sound pressure is measured as described above.

Based on the results a spectrogram is drawn (or ready-made form with standard curve is used), actual results are put in and frequencies that exceed standard ones are evaluated (fig. 33.2)

Appendix 10

TRAINING INSTRUCTION

on pure tone audiometry by polyclinic audiometer (AP) (see fig. 33.5)

Hearing loss because of in-plant noise, depending on its degree, is diagnosed as auditory fatigue, auditory adaptation, cochlear neuritis (noise disease), occupational deafness.

Hearing loss among the workers because of in-plant noise is determined by audiometry method according to SS 12.0.067-78 "Noise. Determination methods of hearing loss of a person".

For assessment of the state of the auditory analyzer, method of determination of temporary and permanent shift of sensitivity threshold (TSST and PSST correspondingly) is used.

For assessment of the functional state of the auditory analyzer audiometers are used: clinical (AC) – for detailed clinical examination; polyclinic (AP) – for examination of auditory function of a person in polyclinic; mass (AM) – for mass rough assessment of auditory functions. Besides, audiometers of other manufacturers are used: "Elsa", "AU-5", "AM-31", audiometer - "PA-31" etc.

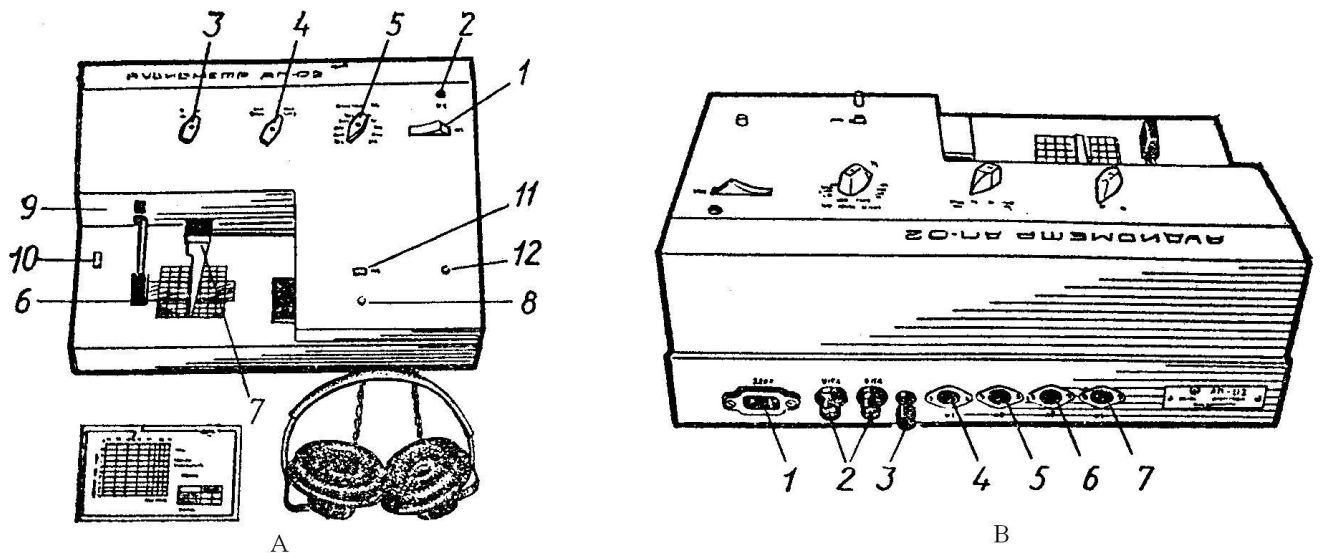


Fig. 33.5 Audiometer AP-02

a – physical configuration;

(1 – power connection key; 2 – indicating light; 3 – operation mode switch; 4 – switch telephones of air sound conduction; 5 – switch of masking noise intensity; 6 – tone intensity switch; 7 – frequency switch; 8 – button for audiogram freeze; 9 – indicating lamp of patient's replies; 10 – switch „Conversation”; 11 – switch of tone feed break; 12 – button of tone feed break);

b – rear view;

(1 – plug for power connection; 2 – fuse box; 3 – bonding point; 4 – socket for connection of patient's button; 5 – socket for telephones of bone sound conduction; 6 – socket for air conduction telephone; 7 – socket for microphone).

Pure tone audiometry procedure conducted with polyclinic audiometer (AP)

First of all it should be noted that audiometry must be conducted in the free-field room (a room, where a full silence is ensured). Procedure of pure tone audiometry measuring is as follows:

During the air conductivity examination, sounds of different levels are transmitted to the ear of the tested person through air telephone. Researches start from sound (tone) of frequency 1000 Hz transmission and sound energy flux density, which is much higher than hearing threshold is. Duration of tone sound transmission is about 1-2 seconds. Sound level is gradually being lowered until it becomes inaudible and then increased to the level of hardly heard. Thus audible sensitivity is determined at frequencies of 500, 200, 125, and later on - of 2000, 4000, 8000 Hz.

To determine bone sound conductivity bone telephone-vibrator is used, which must be pressed to mastoid process. At the same time in order to prevent auditing by another (untestable) ear, masking flat (white) noise is transmitted to that ear by a special device.

Measurement order for hearing threshold at bone sound conductivity is the same as at the air one.

To determine resistance of hearing organ in intensive in-plant noise conditions Paser's test is used. At the same time after hearing threshold through air and bone sound conductivity of the tone of 1000 Hz determination, the same tone of 1000 Hz and density of 100 dB is being transmitted through air conduction telephone to the ear during 3 minutes. After 15 seconds of sound loading, hearing threshold at the same frequency is determined once again. In an hour of rest the examination is repeated but sound loading of the same density and duration is transmitted through bone sound

telephone. In 15 seconds after insonation, hearing threshold through bone sound conductivity of the tone of 1000 Hz is determined. Test results are assessed according to data of table 2.

Table 3

1. Assessment of steadiness of hearing organs

<i>Increase in hearing threshold (dB after loading according to conductivity)</i>		<i>Assessment</i>
air	bone	
5	0	Resistant to noise
6-10	0	Inclined to suffering from
10	5	Hypersensitive to noise

2. Degree of hearing loss

<i>Degree of hearing loss</i>	<i>Value of hearing loss, dB</i>	
	<i>On speech frequencies (500, 1 000, 2 000Hz)</i>	<i>On frequency 4 000 Hz</i>
Signs of hearing organ noise effect	below 10 (500 Hz - 5; 1000 Hz - 10; 2000 Hz - 10 dB)	below 40
First stage (slightly diminished hearing)	10-20	60±20
Second stage (medium diminished hearing)	21-30	65±20
Third stage (considerably diminished hearing)	31 and above	70±20

Appendix 11

Physical characteristic and classification of vibrations

V i b r a t i o n is a rhythmic oscillation of solid bodies of different frequency and intensity, at which alternate relatively time increase and decrease of characterizing values take place.

Vibrations are characterized by amplitude of vibration, speed of vibration in mm/sec, vibration acceleration in m/sec^2 .

Vibration is distinguished as:

- transport vibration, which affects the operators of mobile machines and carriers for movement on the roads and locality;

- transport and process induced vibration, which affects operators of machines of limited motion in a workshop, mine opening etc.;

- process induced vibration, which affects the operators of stationary machines and carriers and other workers through the floor:

- a) at permanent workplaces of industrial premises;

- b) at workplaces in storages, eating establishments, alimentary and other premises without vibration sources;

c) at workplaces in plant management premises, medical posts ... and other premises for mental work people.

According to mechanism of action, vibration is distinguished as:

- general vibration of workplace (floor, seat) that can be vertical ("up and down") and horizontal ("onward - backward", "lateral");

- local vibration of control mechanisms (scales, handles of instruments), which affects hands and legs, and often a chest when it is necessary to press instrument both by hands and the chest.

Vertical vibration acts along the axis of the body that is denoted by Z, and horizontal vibration, onward, backward and lateral - by X and Y.

Local vibration is expressed by letters X_L that corresponds the axis that runs through the place, an instrument, where a steering wheel is grasped and axes Z_L and Y_L correspond to direction of hand's force application.

According to frequency compound, vibration can be divided into low frequency (in the range of octaves of 2, 4, 8, 16 Hz), medium frequency (8, 16, 31.5, 63 Hz) and high frequency (31.5, 63, 125, 250, 500, 1 000 Hz).

Vibration is measured in three mutually perpendicular directions (according to 3 axes) with the help of the same instrument BIIIB-003 (NVD-003) (see fig. 33.4) according to the instruction of Appendix 7.

Hygienic assessment of local vibration is given in octave bands of medium-geometric frequencies of 8, 16, 31.5, 63, 125, 250, 500 and 1000 Hz, and assessment of general vibration is given in octave bands with frequencies of 1, 2, 4, 8, 16, 31.5, 63 Hz or in third-octave bands from 0.8 to 80 Hz. (table 3).

Table 4

Maximum allowable levels of vibration
(abstract from State Sanitary Rules 3.3.6.039-99)

1. Standards for local vibration

Vibration speed,	Octave bands with average geometric frequencies, Hz							
	8	16	31.5	63	125	250	500	1000
m/sec·10 ⁻²	2.8	1.4	1.4	1.4	1.4	1.4	1.4	1.4
dBA	115	109	109	109	109	109	109	109
Vibration acceleration	Octave bands with average geometric frequencies, Hz							
	8	16	31.5	63	125	250	500	1000
m/sec ²	1.4	1.4	2.7	5.4	10.7	21.3	41.5	85.0
dBA	73	73	79	85	91	97	103	109

2. Standards for general vibration

		Average geometric frequencies, Hz						
		1	2	4	8	6	31.5	63
<i>Transport vibration</i>								
Vibration speed	m/sec·10 ⁻²	20.0	7.1	2.5	1.3	1.1	1.1	1.1
	dB	132	123	114	108	107	107	107
Vibration acceleration	m/sec ²	1.12	0.8	0.56	0.56	1.12	2.24	4.50
	dB	71	68	65	65	71	77	83
<i>Transport and processed induced vibration</i>								
Vibration speed	m/sec·10 ⁻²	-	3.5	1.3	0.63	0.56	0.56	0.56
	dB	-	117	108	102	101	101	101
Vibration acceleration	m/sec ²	-	0.4	0.28	0.28	0.56	1.12	2.25
	dB	-	62	59	59	65	71	77
<i>Process induced vibration</i>								

<i>a) at permanent work places in industrial premises</i>								
Vibration speed	m/sec·10 ⁻²	-	1.3	0.45	0.22	0.20	0.20	0.20
	dB	-	108	99	93	92	92	92
Vibration acceleration	m/sec ²	-	0.14	0.10	0.10	0.20	0.40	0.80
	dB	-	53	50	50	56	62	68
<i>b) in storage, eating establishment, alimentary and other premises</i>								
Vibration speed	m/sec·10 ⁻²	-	0.50	0.18	0.089	0.079	0.079	0.079
	dB	-	100	91	85	84	84	84
Vibration acceleration	m/sec ²	-	0.056	0.04	0.04	0.08	0.16	0.32
	dB	-	45	42	42	48	54	60
<i>c) at workplaces in plant management premises, medical posts ... and other premises for mental work people</i>								
Vibration speed	m/sec·10 ⁻²	-	0.18	0.063	0.032	0.028	0.028	0.028
	dB	-	91	82	76	75	75	75
Vibration acceleration	m/sec ²	-	0.02	0.014	0.014	0.028	0.056	0.112
	dB	-	36	33	33	39	45	51

Table 5

Standard levels of vibration in residential premises

	Average geometric frequencies of octave bands, Hz					
	2	4	8	16	31.5	63
Vibration speed, dB	79	73	67	67	67	67
Vibration acceleration, dB	25	25	25	31	37	43
Vibration displacement, dB	133	121	109	103	97	97

Long-term vibration influence on organism leads to vibration disease development. Main manifestation symptoms of this disease are the following: vasospasm of fingers (local vibration influence) or toes (general vibration influence), their temperature decrease, numbness sensation, losing of tactile (touch) and temperature sensation. Vasospasm is accompanied with severe pain. Then the muscle atrophy, contractures, finger deformations may develop.

Appendix 12

INSTRUCTION

on noise and vibration level meter BIIIB-003 (NVD-003) operation during vibration measurement

1. Instrument preparation

At the beginning of measurements electric calibration of the instrument is carried out. Type of detector of piezoelectric vibropack is selected: either ДН-3 (DN-3) (at frequencies of 10-4000 Hz and dynamic range of $5 \cdot 10^{-3} - 10^3$ m/s), or ДН-4 (DN-4) (at frequencies of 10 - 10 000 Hz and dynamic range of $5 \cdot 10^{-2} - 10^3$ m/s²).

Preamplifier ПМ-3 (PM-3) is connected to the instrument by cable (5 m) and adapter. Adapter input is connected to the socket 50 m of the measurement instrument by cable (0.5 m).

Electric calibration switches of the instrument are set at the positions: - «Divider I" - 40; «Divider P" - 5; "Filters" - "Line"; «Operation mode» - F (fast) or S (slow).

After pressing button «Calibration» in 2 min. After operation mode setting by potentiometer Δ the needle of the indicating device is moved to the scale mark of 0-10 according to table 7.2, which is given in the Certificate of the instrument.

1. Vibration acceleration measurement

Initially, measurement of vibration acceleration in octave frequency bands is carried out based on general level on "Line" characteristic. At that, buttons "V" and "1 kHz" are switched off.

Detector - vibropack ДН-3 (DN-3) or ДН-4 (DN-4), mounted and fixed by wax on the measuring surface is connected to the adapter and preamplifier ПИМ-3 (PM-3).

Switch of the instrument is set in the position: - «Divider I" — 80; «Divider II" - 50; "Filters" - "Line"; «Operation mode» - F or S.

Such position of the switch is indicated by LED opposite figure 10 m/sec² for vibropack ДН-3 (DN-3). It means that at measurement of vibration acceleration reading should be done according to scale 0-10 taking into consideration given scale of measurement, i.e. 0-100 m/sec². When needle of the indicator, for example, points to figure 8, acceleration equals 800 m/sec². At operation it is necessary to use first «Divider I" switch, and then «Divider II" switch.

For convenience of values of vibration acceleration reading light indication of «Divider I" and «Divider II" is used. Simultaneously, it indicates both the scale and scale readings 0-10 or 0-31.6.

During work with vibropack ДН-4 (DN-4), technique of vibropack reading is analogous to one already described. At that, scale factor is multiplied by 10.

During work with vibropack ДН-3 or ДН-4 (DN-3 or DN-4), for gage probe indication the button "1 kHz" must be pressed.

When measuring vibration acceleration according to octave bands a switch "Octave filters" must be set on the required octave filter by pressing button "Hz". When operating with octave filters only switch «Divider II" is used, whereas «Divider I" stays in the position that is chosen on general level.

3. Vibration speed measurement

Before commence of vibration speed measurement the instrument is calibrated. Chosen vibropack ДН-3 (DN-3) (at frequency of 10-2800 Hz and dynamic range of 0.05 mm/sec, and at frequency of 10-16 Hz and dynamic range of 0.05-10 000 mm/sec), or ДН-4 (DN-4) (at frequency of 10-2800 Hz and dynamic range of 0.5-57mm/sec, and at frequency of 10-16 Hz and dynamic range of 05-10 000 mm/sec) is mounted and fixed on the tested object by wax and connected with preamplifier ПИМ-3 (PM-3) through adapter "5F5.282.167.

Switches of the instrument are set in the positions: «Divider I" - 80; «Divider II" - 50; "Filters" - "Line"; «Operation mode» - S. In two minutes after operation mode setting first measurements of vibration speed on general level are taken by button "V" pressing. Later with the help of switch «Divider II" deflection is achieved in scale sector 0-10, and «Divider I" is left in the position that was set for measurement of vibration speed on general.

For instrument reading in speed units mm/sec according to lit LED vibration speed scale is determined.

For example, for vibropack ДН-3 (DN-3) use LED opposite figure 0.3 on the scale mm/sec lights up. It means that at the needle position of the indicator on mark 2 of lower scale 0-31.6 value of vibration speed will be equal to 0.2 mm/sec.

During work with vibropack ДН-4 (DN-4), technique of vibration speed reading is analogous. At that, scale factor is multiplied by 10.

Measurements of vibration speed in frequency octave bands are taken similarly to vibration acceleration measurement.

When measuring vibration speed or vibration acceleration in dB it is necessary to summarize indications of LED on the scale dB and MI01 with readings of the scale - + dB, and then to add to the received result or to deduct from it the following values in db:

- during measurement of vibration acceleration by vibropack ДН-3 (DN-3) 10 dB is added;
- during measurement of vibration acceleration by vibropack ДН-4 (DN-4) 10 dB is added;
- during measurement of vibration speed by vibropack ДН-3 (DN-3) 26 dB is added;
- during measurement of vibration speed by vibropack ДН-4 (DN-4) 46 dB is added;

4. Hygienic assessment of vibration

Measurement and hygienic assessment of vibration is carried out on the basis of GS 12.1.012-78 "Vibration. General safety requirements". According to that document, vibration is normalized individually for every direction vertically and horizontally in every octave band.

Basic frequency for boundary spectrum for general vibration is 63 Hz, and for local vibration is 125 Hz.

Hygienic norms for vibration are set for 8 hours-long working shift for general transport vibration, transport–technical vibration, and different kinds of technological vibrations as well as for local vibration (see table 3).

7. Literature

6.1. Principal:

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6.1.6. Lecture materials.

6.2. Additional:

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3. Medicine of emergency situations: textbook for students of higher medical institutions / V.V. Chaplyk, P.V. Oliynyk, S.T. Omelchuk, V.V. Humenyuk. – Vinnytsia: Nova Knyha, 2012. – 344 p.

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5. Гигиена и экология: учебник для студентов высших медицинских учебных заведений. – Винница: НОВА КНИГА, 2008ю – 720 с.

7. Equipment required for the lesson

1. Electrical aspirator.
2. Aqueous aspirator.
- 3 Absorber devices by Polizhaev, Petri, with porous membrane and others.
4. Filter holder with aerosol filters, allonges (adapters).
5. Aqueous rheometer, rotameter.
6. Gas pipettes.
7. Universal gas-analyzer UG-2 (УГ-2) with the indicated tubes.
8. Formula for determination of the air sample volume, required for analysis and reduction this volume to its value in the standard conditions.
9. Table: Maximum allowable concentration of harmful substances in the air.
10. Situational tasks for the students' self-training.