



**MINISTRY OF EDUCATION AND SCIENCE
OF UKRAINE**

National University "Zaporizhzhia Polytechnic"

METHODICAL GUIDELINES

to the laboratory lesson

***«Investigation of Air Dustiness of Industrial and
Administrative Premises»***

for the discipline «Securitology of Specialist and Basics of Occupational
Safety» for students of all specialties and forms of education

Methodical guidelines to the laboratory lesson «Investigation of Air Dustiness of Industrial and Administrative Premises» for the discipline «Securitology of Specialist and Basics of Occupational Safety»: for students of all specialties and forms of education / O.L. Skuibida – Zaporizhzhia : National University «Zaporizhzhia Polytechnic», 2021. – 15 p.

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1 AIM OF THE LESSON

During carrying out of the laboratory lesson it is necessary to get acquainted with the influence of dust on a human body; to study the main criteria that characterize air dustiness; to get acquainted with the classification of chemically dangerous substances; to assimilate the methods of air dustiness investigation; to master the weight method and its practical application; to get acquainted with measures of protection against industrial dust; to evaluate the results of the experiment in accordance with regulations; draw conclusions.

2 GENERAL PROVISIONS

2.1 Dust and its effect on human body

Air quality is one of the major environmental health concerns all over the world. The main goal of Securitology and Occupational Safety is to achieve levels of air quality that do not result in unacceptable risks to human health.

The condition of air in industrial or administrative premise is called **indoor climate (microclimate) or meteorological conditions**. Microclimate is determined by such parameters as temperature, humidity, air velocity and pressure. Adverse indoor climate conditions can cause superheating or supercooling (hypothermia), various physiological disorders in human body, reduction of working capacity, diseases etc.. Depending on the chemical composition of the air, its physical properties and meteorological conditions, as well as the presence of other pollutants in the form of dust, fog and smoke, the ***air environment can be favorable, unfavorable or dangerous***. Chemical substances that enter the human body in industrial premises, even in relatively small quantities, cause disturbance of normal life conditions and occupational poisonings. The common air contaminants of industrial and administrative premises include airborne particles, volatile organic compounds, tobacco smoke, asbestos, formaldehyde, radon, combustion gases, ozone etc..

The purity of air from dirt and dust, which are formed during the grinding, granulation and transportation of solid, bulk materials, welding of metals, their processing by cutting and other operations is very important. Dust fills the pores of human skin, making it difficult to sweat, which leads

to dry skin, its degreasing and the development of diseases. Dustiness is of particular concern because it is associated with a wide range of industries (metallurgy, mining, building, chemical, pharmaceutical production etc.) and causes occupational lung disease known as pneumoconiosis.

According to ISO 4225 **dusts** are small particles which settle out under their own weight but which may remain suspended for some time. Dust in premises is present in the form of aerosol and aerogel. **Aerosol** is formed by small particles that hang in air (remain suspended). Particles the size of which is larger than 10^{-3} sm are dust; particles the size of which is nearly $10^{-5} \dots 10^{-3}$ sm form fog. **Aerogel** consists of dust particles that sediment on walls, ledges of furniture and equipment, floor. In most cases a dust cloud that is visible to the naked eye may represent a hazard. A coating of dust on a horizontal surface shows that there is or has been dust in the air. From the other side the lack of a visible cloud doesn't represent safe conditions. *The most dangerous for human being is dust formed by particles with the size from 3 to 10 μm [3].* Such particles penetrate the lungs through breathing, accumulate in the lungs and cause various diseases. Particles that are larger than 10 μm remain in nose and throat; particles, smaller than 3 μm are exhaled.

By origin, dusts are divided into **organic** (wood, cotton, bone aerosol plastics, aerosol of pesticides), **inorganic** (cement, asbestos, sand, iron, zinc, lead) and **mixed**.

Aerosols are particularly dangerous; by the nature of their effect on human body they are divided into non-toxic (irritating) and toxic (poisonous). **Toxic dusts** dissolve in biological environment of human body and cause as acute as chronic poisonings. According to GOST 12.1.005-88 «OSSS. General sanitary requirements for working zone air» lead, cadmium, beryllium, manganese cause systemic poisonings, cobalt and cement cause allergic reactions and dermatoses, asbestos and silica cause cancer, nickel and chromium cause asthma.

Non-toxic dusts irritate skin, mucous membranes, upper respiratory tract, lymph nodes, lungs and cause pneumoconiosis. Non-toxic dust can absorb toxic or radioactive substances and have increased hazardous influence on human body.

Pneumoconiosis is an occupational lung disease caused by the inhalation of organic or nonorganic airborne dust and fibers. Depending upon the type of dust the disease is given different names: ***anthracosis, asbestosis, silicosis, berylliosis, siderosis*** and others. The three most deadly

chronic diseases among them are silicosis, asbestosis and anthracosis.

According to damaging effect on human body, dusts are divided into dusts of *fibrogenic* (respiratory damage), *general toxic* (act on the central nervous system, blood and blood-forming organs), *carcinogenic* (lead to cancer), *irritant* (act on the mucous membranes of the eyes, nose, larynx, skin), *sensitizing* (lead to allergies), *mutagenic* (lead to changes in hereditary information) action and dusts, which *suppress reproductive function*.

Dust fills the pores of human skin, makes it difficult to sweat and leads to dry skin, its degreasing and the development of diseases. When in contact with the skin, the dust has an irritating, sensitizing and photodynamic effect (causes dermatitis, allergic dermatosis, eczema, folliculitis, photodermatitis, etc.).

The harmful effects of dust on the body depend on the dispersion (size), shape of dust particles, their chemical composition, meteorological conditions, the amount of inhaled dust, the duration of exposure, individual human characteristics etc..

A cloud of dust of a combustible material behaves similar to a flammable gas-air mixture; in a limited small space it can produce an explosion. Typical combustible dusts may be obtained from natural, synthetic and inorganic materials. In general a high risk of explosion exists where concentrations of combustible dust exceed 10 mg/m³. Sources of ignition include accidental fires, sparks from electrical apparatus, static electrification and others. Dust clouds in a working area considerable reduce visibility and increase the risk of accidents. It may also affect the quality of products. Dust deposition on machines, apparatus and mechanisms may cause damages of equipment and, therefore, injuries of the stuff.

2.2 Hygienic estimation.

Assessment of air dustiness in premises

Standards DSN 3.3.6.042-99 «Sanitary standards for microclimate of industrial premises» and GOST 12.1.005-88 «Occupational safety standards system. General sanitary requirements for working zone air» set exposure limits for more than 700 types of harmful substances (Appendix A).

Noxious (harmful) substance - a substance that in contact with the

human body can cause disease or health disorders during direct exposure of such substance or in the subsequent period of life of a victim or his descendants. To prevent acute and chronic occupational poisonings and diseases due to the effects of noxious substances on the human body, occupational exposure limits (OEL) of noxious substances are set (table 2.1).

Occupational Exposure Limit (OEL) of a noxious substance in working zone air - the maximum concentration of a substance to which a worker may be exposed to over a given period of time.

Table 2.1 – Classification of noxious substances
(GOST 12.1.007-76 «Occupational safety standards system.
Noxious substances. Classification and general safety requirements»)

Indicator	Norms according to hazard classes			
	1 – <i>extremely dangerous</i>	2 – <i>highly dangerous</i>	3 – <i>moderately dangerous</i>	4 – <i>low dangerous</i>
OEL of noxious substances in working zone air, mg/m^3	less than 0,1	0,1...1,0	1,1...10,0	more than 10,0

Time Weighted Average Exposure Limit is the limit of a noxious substance for the average exposure over a specified period of a standard work shift (8 hours; not more than 40 hours per a week) that does not cause diseases or deviations in health conditions registered by modern research methods during work experience or in the remote period of life of the present and next generations.

Maximum Permissible Concentration – a ceiling exposure limit; a concentration of noxious substance that should not be exceeded for any period of time.

The control of the concentration of noxious substances in working zone air is carried out in laboratory conditions by express chemical analysis or by the use of indicators. The ***laboratory method*** consists in taking air samples at workplaces or other designated places, delivering them to special laboratories, where the analysis of these samples is performed in order to determine the chemical composition of the air and the

concentration of harmful substances.

When **express chemical analysis** is used, the control results become known directly at the time of analysis. It is performed using special measuring devices, the principle of which is based on certain physical and chemical phenomena: changes in electrical conductivity, photoelectric effect, color change of substances during a chemical reaction etc.

Measuring dust exposure is performed by the following methods of express chemical analysis:

- **weight** - determination of concentration of dust, which is delayed on a special filter after passing through it a certain volume of dusty air;

- **counting (conimetric)** - determination the concentration of dust particles, their size and shape under a microscope after a preliminary sedimentation of dust which is in particular air volume, on a microscope slide (glass);

- **sedimentation** - determination of dust concentration of dust which naturally settled from the limited or unlimited volume of dusty air, by means of dust counters;

- **photometric** - determination of the total number of dust particles in a certain air volume according to the difference of light fluxes before and after the passage of dusty air;

- **electrometric** - electrification of aerosol dust particles in the field of negative corona discharge and subsequent measurement of the electric charge that accumulates on the walls of the measuring chamber and is proportional to the dust content in the air.

With the help of **indicators**, it is possible to quickly detect the presence of some harmful substances in the air without determining their concentration (by smell or by using certain chemicals that change their properties, such as color).

In sanitary-hygienic practice of Ukraine the standard method for dust control and assessment is the weight method. To assess the dustiness of working zone air, it is necessary to know the following basic indicators: the concentration of dust in the premise, the size of dust particles, their shape, chemical composition of dust and its toxicity.

To protect against dust, ventilation (local and general exchange), pressurization of dust sources together with aspiration (local suction), moisturization of dusty materials, briquetting and granulation of dusty materials, individual protection means etc. are used.

3 TASKS FOR PREPARATION TO THE LABORATORY LESSON

During the laboratory classe students should:

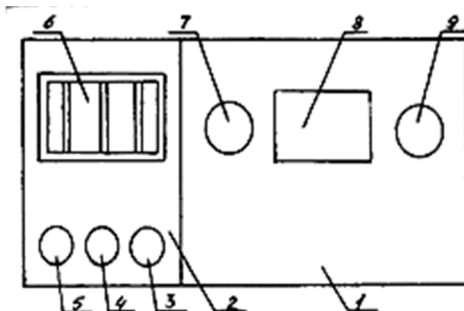
- get acquainted with the effect of dust on human body;
- get acquainted with types and classification of dust;
- get acquainted with the definitions of occupational exposure limit, time weighted average exposure and maximum permissible concentration ;
- get acquainted with the main methods for determining the concentration of harmful substances in the air;
- get acquainted with the methods of protection against dustiness of working zone air;
- master the weight method of investigation of air dustiness;
- learn the basic safety requirements during control of air dust.

4 CONTROL QUESTIONS

1. What is dust?
2. What are the different types of dust?
3. How is dust classified by origin?
4. How is dust classified by the impressive effect on human body?
5. What substances belong to non-toxic (irritating) dust?
6. What substances belong to toxic (poisonous) dust?
7. What is pneumoconiosis?
8. What are the main types of pneumoconiosis?
9. What is noxious substance?
10. Determine occupational exposure limit.
11. Determine time weighted average exposure concentration.
12. Determine maximum permissible concentration of noxious substance.
13. What are the main methods to control of the concentration of noxious substances in working zone air?
14. What method of determining the concentration of harmful substances in working zone air is considered standard in the sanitary-hygienic practice of Ukraine?
15. What are the main dust protection methods?

5 DESCRIPTION OF DEVICES

Research of a dust content of the air environment in this work are carried out by weight (gravimetric) method. The general view of the device for dust concentration determination is given in fig. 5.1. The analytical scales, aneroid-barometer, thermometer and clock are also used.



- 1 – dust chamber; 2 – instrumental compartment; 3 – toggle switch on the fan;
 2 – toggle switch on the aspirator; 5 – toggle switch on the device; 6 – aspirator;
 7 – bunker-dispenser; 8 – viewing window; 9 – filter holder

Figure 5.1 – The scheme of the device for dust sample selection

The dust chamber 1 simulates the premise to which by means of the bunker-dispenser 7 a portion of dust is poured out and dispelled by fan. On the front wall of the chamber there is a hole with an allonge-filter holder 9 for fixing a filter for dust sampling. In the instrument compartment there is an aspirator 6, which is used to pump dusty air through the filter. Plastic filterholder with a quantitative filter АФА (АФА) is used. In occupational premises air samples are taken, as a rule, in the breathing zone of the worker (at a height of 1.5 ... 2.0 m from the floor level). At each point of the working zone several samples (at least three) are taken.

6 SAFETY INSTRUCTIONS

6.1 Students who have passed the primary instruction on occupational and fire safety in the laboratory are allowed to perform the

laboratory lesson only.

6.2 Do not start implementing practical issues without getting acquainted with the procedure for their implementation.

6.3 Do not include without the permission of the teacher devices and equipment that are not relevant to the work performed.

6.4 Work on acquaintance with a structure and purpose of primary means of fire extinguishing should be carried out under the direct supervision of the teacher.

7 THE ORDER OF LESSON PERFORMANCE

The lesson is performed using a dust chamber, the scheme of which is shown in Fig. 5.1, in the following order:

7.1 Plug the analytical scales into the mains and make sure that they are locked by the handle on the front panel; unfold the filter bag, open the protective rings and with tweezers place the filter on the left cup of the scales. Unfold the scales and, by manipulating the turns of the larger ring (hundreds of milligrams) and the smaller ring (tens of milligrams) on the front panel of the scales, achieve a minimum deviation of the scale arrow from 0, and then calculate the weight of the filter.

7.2 Insert the weighed filter with tweezers into the protective rings and secure in the filter holder 9.

7.3 Switch on the electric current with toggle switch 5 and the aspirator with toggle switch 4. Using the fan handle connected to the filter holder, set the air sampling speed to 10...20 l/min along the upper section of the float on the scale and turn off the aspirator.

7.4 Switch on the fan with the toggle switch 3 and turn the handle of bunker-dispenser 7 to supply dust to the chamber.

7.5 After the formation of a sufficient level of dust in the chamber, the fan is turned off, at the same time turn on the aspirator 1 and select a sample of dusty air during 1...3 min.

7.6 Remove the dusty filter from the filter holder, place on the scales and weight.

7.7 Using aneroid-barometer and thermometer set the barometric pressure and temperature at the sampling place and write down in table 7.1.

Table 7.1 – Results of research of a dust content

1	Experiment number	
2	Place of air sampling	
3	Air temperature in premise, °C	
4	Place of air sampling, mmHg	
5	Mass of the filter before sampling, mg	
6	Mass of the filter after sampling, mg	
7	Mass of delayed dust, mg	
8	Duration of a sampling, min	
9	Speed of a sampling, l/min	
10	Air volume which passed through the filter, m ³	
11	Air volume which passed through the filter given to normal conditions, m ³	
12	Concentration of dust in air, mg/m ³	
13	Maximum permissible concentration of dust, mg/m ³	
14	Notes	

7.8 Determine the volume of air that has passed through the filter V , (m³) according to formula (7.1) given to normal conditions:

$$V = \frac{V_t \cdot 273 \cdot P_t}{(273 + t) \cdot P_0} \quad (7.1)$$

where V_0 – air volume which passed through the filter given to normal conditions, m³;

V_t – Air volume which passed through the filter under temperature t and pressure P , m³;

P – barometric pressure at the sampling place, mmHg;

t – air temperature at sampling place, °C. 7.9 Calculate mass concentration of dust, mg/m³ according to the formula (7.2):

7.9 Calculate mass concentration of dust, mg/m³ according to the formula (7.2):

$$C = \frac{q_2 - q_1}{V_0} \quad (7.2)$$

where q_1 – mass of the filter before sampling, mg;

q_2 – mass of the filter after sampling, mg.

7.10 Write the results of the research and the calculated data should be recorded in a table. 7.1. Assessment of the level of dust in the premise is carried out by comparing the results of the research with the requirements of hygienic standards GN 1.1.2.123-2006 «List of Substances, Products, Production Processes, Household and Natural Causes, Carcinogenic to Human Beings» (Appendix A). If the concentration of harmful substances in the air exceeds the maximum permissible concentration, it is necessary to propose measures to lead the concentration of dust to the requirements of *hygienic standards*.

7 CONTENT OF THE REPORT

The following issues should be noted in the report: the purpose of the lesson, the main points of the general theoretical provisions for the laboratory lesson, the scheme of the device for dust sample selection conclusions, results of the research, conclusions.

8 RECOMMENDED LITERATURE

1. Гігієнічна класифікація праці за показниками шкідливості та небезпечності факторів виробничого середовища, важкості та напруженості трудового процесу, [Електронний ресурс]. – На заміну ГН 3.3.5-8.6.6.1-2002 ; чинний від 2014-05-30. – К. : МОЗ України, 2014. – 37 с. – URL: <http://zakon2.rada.gov.ua/laws/show/z0472-14>. – (Державні санітарні норми та правила).

2. Санітарні норми мікроклімату виробничих приміщень [Електронний ресурс] : ДСН 3.3.6.042-99. – Чинний від 1999-12-01. – К. : МОЗ України, 1999. – 106 с. – Режим доступу: <http://zakon2.rada.gov.ua/rada/show/va042282-99>. – (Державні санітарні норми).

3. Андрейчук Н. І. Охорона праці [Текст] : навч. посібник / Н.І. Андрейчук, Ю.В. Кіт, С.В. Шибанов, О.В. Шерстньова; Нац. ун-т «Львівська політехніка» – Львів: Видавництво Львівської політехніки, 2012. – 276 с. : іл., табл. – ISBN 978-617-607-195-2.

4. Дементій Л. В., Юсіна Г. Л., Санталова Г. О. Безпека життєдіяльності й охорона праці. Частина 2. Лабораторний практикум [Текст] : Навч. посіб. – Краматорськ : ДГМА, 2012. – 172 с.

5. Жидецький В. Ц. Основи охорони праці [Текст] : підручник / В. Ц. Жидецький. – 5-те вид., доп. – К. : Знання, 2014. – 373 с. + 1 ел. опт. диск (CD-ROM). – ISBN 978-617-07-0134-3.

6. Жидецький В. Ц. Практикум із охорони праці [Текст] : навч. посібник / В. Ц. Жидецький В. С. Джигирей, В. М. Сторожук [та ін.] ; ред. В. Ц. Жидецький ; Українська акад. друкарства, Український держ. лісотехн. ун-т. – Львів : Афіша, 2000. – 352 с. : іл., табл. – ISBN 966-7760-09-X.

7. Катренко Л. А., Кіт Ю. В., Пістун І. П. Охорона праці. Курс лекцій. Практикум. [Текст] : Навч. посіб. – Суми: Університетська книга, 2009. – 540 с.

Appendix A

Maximum permissible concentration MPC of noxious substances of working zone air (GN 1.1.2.123-2006 «List of Substances, Products, Production Processes, Household and Natural Causes, Carcinogenic to Human Beings»)

№	Substance	MPC, %	Hazard class
1.	Dust containing silicon dioxide more than 70%	1.0	3
2.	Dust containing silicon dioxide less than 2%	10.0	4
3.	Silicates and silicate-containing dusts: - natural and artificial asbestos; - asbestos cement; - talc, flagonite mica, muscovite; - mineral and glass fiber	2.0 6.0 4.0 4.0	3 3 3 3
4.	Copper	1.0	2
5.	Metallic mercury	0.1	1
6.	Lead and its compounds	0.1	1
7.	Manganese	0.3	2
8.	Iron and nickel concentrate (dust)	4.0	3
9.	Cast iron	6.0	3
10.	Coal (dust)	10.0	3
11.	Coke pitch, shale, electrode	6.0	3
12.	Chlorine	1.0	2
13.	Caustic meadows	0.5	2
14.	Hydrochloric acid	5.0	3